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BEGA RIVER
ESTUARY MANAGEMENT PLAN

July 2011

Bega River Estuary Management Study and Plan

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Prepared For:	Bega Valley Shire Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

DOCUMENT CONTROL SHEET

BMT WBM Pty Ltd BMT WBM Pty Ltd 126 Belford Street BROADMEADOW NSW 2292 Australia PO Box 266 Broadmeadow NSW 2292 Tel: +61 2 4940 8882 Fax: +61 2 4940 8887 ABN 54 010 830 421 003 www.wbmpl.com.au	***Document :*** R.N1088.003.02.Revised0711.docx ***Project Manager :*** Philip Haines ***Client :*** Bega Valley Shire Council ***Client Contact:*** Danny Madigan, Derek van Bracht ***Client Reference***

Title :	Bega River Estuary Management Study and Plan
Author :	Dr Philip Haines, Verity Rollason
Synopsis :	This document presents a Plan of Management for the short and long term management of the Bega River Estuary. The document presents goal and objectives for management, followed by a series of prioritised strategic actions in order to meet these objectives. Actions are assigned responsibilities, timing and potential funding sources.

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FOREWORD

29 estuaries are located within the Bega Valley Shire. These estuaries are arguably the Shires premier natural assets and have vital ecological, recreational, social and environmental values. There is a unique diversity of estuary types represented within Bega Valley Shire; ranging from large riverine estuaries (Bega & Bermagui Rivers), large coastal lakes (Wallaga, Merimbula and Pambula lakes) and small ICOLLs (Baragoot Lake, Middle Lake and Bournda Lagoon).

Bega Valley Shire Council has been running an Estuary Program for over a decade. In that time Council has invested over 2 million dollars to the protection of our coastal zone's important natural assets. This investment in the Estuary Management Planning process, reflects Council's commitment to ensuring that all our estuarine assets and their individual values are recognised and conserved.

The Bega River Estuary has important environmental, recreational and economic values that are important to local residents and the many tourists who visit the Tathra area throughout the year. From its entrance at Mogareeka inlet to the Jellat Jellat flats, the Bega River Estuary is a popular recreational destination for recreational fishing, boating and canoeing, water sports and passive recreation. The forested catchment of the estuary also has important biodiversity values and provides a significant landscape backdrop to the Tathra, Mogareeka and Kalaru settlements.

The Bega River Estuary Management Plan aims to balance the pressures and demands placed on the Bega River, both from a human perspective and from an environmental perspective, in particular, the pressure for future urban growth. Council, in partnership with State Agencies and our community, will ensure that the aims and strategies of this plan are supported and implemented to ensure that the special qualities of the Bega River Estuary are protected and will continue to be enjoyed by future generations.

Clr Pat Campbell
Chair, Coastal Planning and Management Committee
Bega Valley Shire Council

BACKGROUND

The estuaries of NSW represent a priceless natural resource. Collectively, they are immensely valuable from an ecological, social and economic perspective. NSW has 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.

The Bega River is a highly valued estuary on the south coast of NSW, and as such, requires special protection to conserve its natural values. This document represents the Estuary Management Study and Plan for the Bega River, and has been prepared by environmental consultants BMT WBM, with assistance from Peter Spurway and Associates, on behalf of Bega Valley Shire Council and the Office of Environment and Heritage (formerly the Department of Environment, Climate Change and Water). The methods followed in preparing the report are consistent with the framework outlined in the NSW Government's Estuary Management Manual.

This document also includes a detailed description of the estuarine processes of the Bega River, and is supported by a previous Data Review Report prepared by the then Department of Infrastructure, Planning and Natural Resources (2004). Processes described include the hydraulic, sedimentation, water quality and ecological characteristics of the estuary, and the impacts of human activities on these processes.

Existing values of the estuary have been considered, along with issues that have been identified through consultation with the community and through a technical appraisal of the current condition of the estuarine environment.

The Estuary Management Plan comprises a suite of short and long term strategies, which address the needs for future sustainable management of the Bega River. State government agencies and other stakeholders have been designated responsibility and authority, and have agreed to implement these strategies to the best of their abilities.

Our knowledge of the Bega River, and estuaries in general, will continue to improve in the future. It is therefore essential that this Estuary Management Plan be reviewed and amended periodically to account for our expanding knowledge as well as to adapt to changing environmental conditions, and to varying management directions.

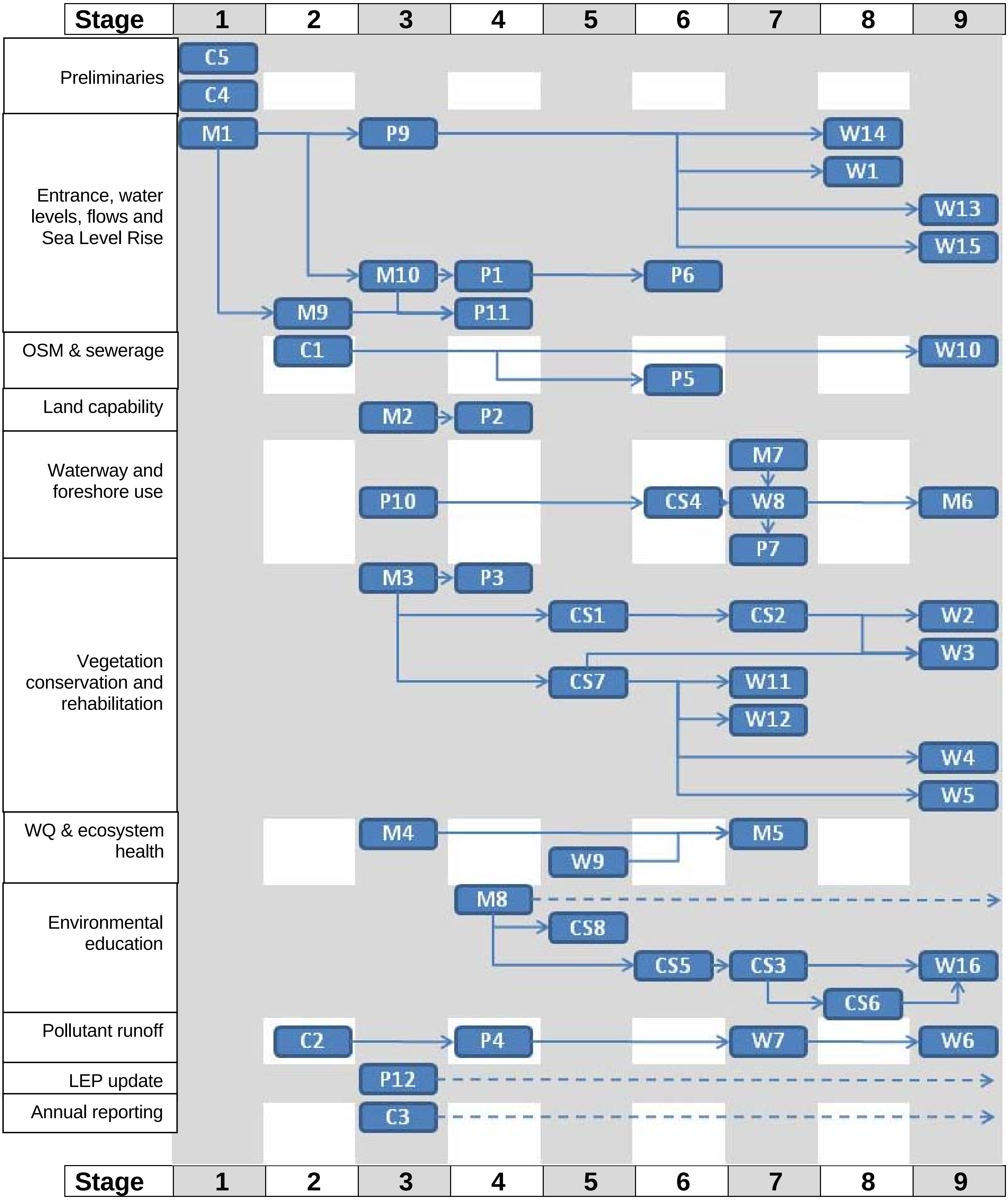
Dr Philip Haines
BE(Hons) MEngSc PhD MIEAust MEIANZ RPEQ CPEng,
Project Manager,
BMT WBM Pty Ltd

BEGA RIVER ESTUARY MANAGEMENT PLAN SUMMARY

Purpose	This Estuary Management Plan for Bega River Estuary is to guide future decision making regarding long term management of the estuary, its foreshores and its broader catchment area.
Principles	1. The healthy, diverse and viable ecosystems of the Bega River Estuary shall be maintained and protected for future generations 2. The scenic beauty and wilderness character of the Bega River Estuary shall be preserved for enjoyment by residents and visitors now and in the future 3. The Bega River Estuary shall remain a place of great recreational and tourism value, with minimum impacts on the natural environment
Objectives	Twenty-two (22) issue specific objectives have been established under the following general headings: Ecology and Biodiversity; Amenity; Development; Heritage; Economics; Water Quality and Sediments; Bank Erosion; Entrance Management; Climate Change; and Management Mechanisms. The objectives were offered to the community and to members of the BREWG (representing key stakeholders and government representatives) for prioritisation The top three priority objectives are: *"Maintain a hydrological regime that maintains estuarine processes, through sufficient freshwater inflows, ocean interactions and backswamp inundation."* *"Future development shall be prohibited from areas of unsuitable capability (e.g. steep slopes, highly erosive soils, sensitive adjacent environments, important existing habitats, prominent visual landmarks etc)."* *"Enhance and protect the vegetation and natural habitats of the estuary, its riparian zone and the broader catchment landscape, including wildlife corridors."*
Context	This Estuary Management Plan has been developed under the NSW Government's Estuary Management Program. It complies with the requirements of the NSW Estuary Policy 1992, the NSW Coastal Policy 1997, and the Southern Rivers Catchment Action Plan (Management Target CM2). It is also consistent with the NSW Government's Sea Level Rise Policy Statements and generally accords with the new Guidelines for Preparation of Coastal Zone Management Plans. The Plan contains a summary of estuary processes, which describes the environmental processes within the estuary and its interactions with the local and extended river catchment and the ocean.
Status	This Plan has been adopted by Council, has been reviewed by relevant stakeholders and government agencies through the Bega River Estuary Working Group. This Plan should be consulted during the all reviews of Environmental Planning Instruments, including the Bega Valley LEP. Implementation of this Plan, particularly the natural resource management strategies, is a key action the Southern Rivers Catchment Action Plan (SRCMA, 2007).
Relationship to other plans	This Plan is to be read in conjunction with the SRCMA's Catchment Action Plan, the Bega Valley LEP and Development Control Plan Nos 18, 19, and 21.

Strategies	50 individual strategies have been developed to help to achieve stated objectives for the Bega River Estuary. These strategies have been grouped into categories comprising: Planning (P), Capital and on-ground works (W), Community Services (CS), Research, Investigations and Monitoring (M), and Compliance (C). Based on the likely effectiveness of the strategy, costs, and the priorities of the objectives being addressed, the strategies have been classified as: Critical, Very High; High; and Medium Priorities. Strategies have also been defined in terms of relative timeframe for implementation: Immediately (start within 12 – 18 months); Short Term (start within 1 – 3 years); Medium Term (start within 3 – 5 years). These timeframes are indicative only and are subject to available funding and resources held by the responsible authorities. The proposed order of implementation for the different strategies takes into consideration the priority of the strategy as well as the relative timeframe in which it should be undertaken. The implementation order also considers where some strategies need to be completed before other strategies can commence. Implementation of this Plan has been set-out into nine (9) stages, as presented overleaf.
Implementation responsibilities	Responsibilities for implementation have been defined. Primary responsibility for the majority of strategies rests with Bega Valley Shire Council. Assistance to Council, and implementation of some ancillary strategies and tasks, is to be provided by key stakeholders and relevant government agencies including: SRCMA, OEH (formerly DECCW), DPI (Fisheries, Ag, Forests, Crown Lands) and DoPI. Implementation is also to be facilitated through the assistance of landholders, local community groups / volunteer organisations and the Local Aboriginal Lands Council and Elders Groups.
Program of actions	Suggested actions for each strategy have been provided, and are detailed within individual implementation schedules (see Chapter 8). Sub-Plans have also been developed specifically for Sewage Management, Entrance Management, and Future Development, as provided in Chapter 7.
Costs and funding	19 of the 50 strategies require staff time input only, including most of the critical and very high priority works. In total, more than $4.2m is required to fully implement the strategies outlined in this Plan. Two thirds of the total cost of the Plan is attributed to just 6 strategies, typically involving investment in major infrastructure, or broad catchment-wide landuse management initiatives.
Indicators for success	The ultimate success of this EMP is to be gauged by how well the Plan objectives have been met. Given that the objectives are broad and likely to response over long timescales, a series of Performance Measures have been incorporated into the Implementation Schedules for each strategy.
Consultation	Community and stakeholder consultation has underpinned the development of this Plan. The community has also reviewed the Plan during a public exhibition period.
Review and amendment provisions	This Plan has an indicative 5 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 5 years, and should redress outstanding issues, new environmental management practices, new scientific data, and changed governance and administrative arrangements.

STAGE OF IMPLEMENTATION OF STRATEGIES



ACKNOWLEDGEMENTS

Members of the Bega River Estuary Working Group and Bega Valley Shire Council staff are gratefully acknowledged for input into this Estuary Management Plan.

Appreciation is also extended to all members of the community who participated in the community consultation process, through attendance of the drop in sessions, workshops, and meetings, or in providing responses to requests for input in the brochure, and/or provided feedback on the draft Plan and preceding documents. Dave Gallan is also acknowledged for use of his photographs during the course of the project.

Photo: Dave Gallan

DEFINITIONS

Agencies

BoM	Bureau of Meteorology
BVSC	Bega Valley Shire Council
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECCW	former Department of Environment, Climate Change and Water
DET	NSW Department of Education and Training
DoPI	NSW Department of Planning and Infrastructure
DPI	NSW Department of Primary Industries (comprising Fisheries, Agriculture, Mineral Resources, Forests and Crown Lands)
NOW	NSW Office of Water
OEH	NSW Office of Environment and Heritage
RFS	NSW Rural Fire Service
SRCMA	Southern Rivers Catchment Management Authority

Other

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
ASS	Acid Sulfate Soil
BASIX	Building Sustainability Index (see www.basix.nsw.gov.au)
BRE	Bega River Estuary
BREWG	Bega River Estuary Working Group
CAMBA	China Australia Migratory Bird Agreement
CAP	Catchment Action Plan
CCA	Comprehensive Coastal Assessment
CZMP	Coastal Zone Management Plan
DA	Development Application
DCP	Development Control Plan
EEC	Ecologically Endangered Community
EMP	Estuary Management Plan
EMS	Environmental Management System
EPI	Environmental Planning Instrument (e.g., REP, LEP, DCP, SEPP)
ESD	Ecologically Sustainable Development
GPT	Gross Pollutant Trap
ICOLL	Intermittently Closed and Open Lake or Lagoon
IPCC	Intergovernmental Panel on Climate Change
IWCM	Integrated Water Cycle Management
JAMBA	Japan Australia Migratory Bird Agreement
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging
LGA	Local Government Area
OSSM	On-Site Sewage Management
PVP	Property Vegetation Plan
PWC	Personal Watercraft (eg jetski)
REP	Regional Environmental Plan

RL	Reduced Level
SEPP	State Environmental Planning Policy
SoE	State of Environment (reporting by Council and other Agencies)
STP	Sewage Treatment Plant
TBCC	Tathra Beach Country Club
TRE	Tathra River Estate
VCA	Voluntary Conservation Agreement
WSUD	Water Sensitive Urban Design

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1 INTRODUCTION AND STRATEGIC CONTEXT OF PLAN

1.1 Purpose of this Management Plan

The Bega River Estuary Management Plan has been prepared on behalf of Bega Valley Shire Council and the NSW Office of Environment and Heritage (formerly Department of Environment, Climate Change and Water). Its preparation has been overseen by the Bega River Estuary Working Group, which contains representation from various government agencies as well as stakeholder groups and community individuals.

The Estuary Management Plan has been developed in accordance with the State Government's Estuary Management Program (refer Section 1.6) to satisfy the objectives of the NSW Estuary Management Policy 1992 and the NSW Coastal Policy 1997. It also helps to satisfy *Coastal and Marine Management Target C2: Protecting and Rehabilitating Estuaries* of the SRCMA's Catchment Action Plan (CAP) 2007 and contributes to the implementation of target E4 of the NSW State Plan. Since the start of preparation of this document, the NSW Government has introduced reforms to coastal management, including the Sea Level Rise Policy Statement (2010) and new Guidelines for Preparation of Coastal Zone Management Plans. It is considered that the Bega River Estuary Management Plan still satisfies the intent and objectives of these new reforms and initiatives taken by the NSW Government.

The purpose of the Bega River Estuary Management Plan is to provide strategic direction and specific focus for the short and long term sustainable management of the Bega River estuary waterway, its tributaries, its surrounding foreshore lands, and its catchment in so far as catchment activities impact on the condition of the waterway. The Plan is designed to be used as a 'user manual' for undertaking activities and implementing strategies that will result in improved environmental conditions and a better balance between human and ecological demands on the estuary.

The Plan should be used to inform other strategic documents that aim to manage and rationalise human activities and development within the catchment, such as Regional Strategies, Urban Structure Plans, Development Control Plans (DCPs), the proposed review of the Bega Valley Local Environmental Plan (LEP) and the development of the Floodplain Risk Management Study and Plan for the Bega River.

The Plan aims to fulfil Council's requirement for applying the principles of Ecologically Sustainable Development (ESD) to Bega River Estuary and its catchment. The Plan also provides an opportunity for future climate change to be considered in the strategic management and planning of the estuary and surrounding sensitive coastal lands.

1.2 Bega River Locality

The Bega River Estuary Management Plan covers the tidal section of the Bega River (i.e. the estuary). This extends from the river entrance at Mogareeka Inlet to Jellat Jellat and the Penooka Wetlands (refer Figure 1-1). Activities beyond the banks of the estuary can have a significant impact on its health. Therefore, the entire water catchment has also been considered as part of the Plan, depending on the issue. The entire catchment of the Bega River covers an area of 1,930km^2.

A unique feature of the Bega River Estuary (BRE) is that the ocean entrance to the river is usually closed, or heavily shoaled with sand (refer Figure 1-2). This means that, unlike similar riverine estuaries, tides cannot move easily in and out of the river, and natural tidal flushing of the river is limited. This reduced tidal flushing makes it particularly vulnerable to pollutant inputs from the catchment.

Additional maps and details of the Bega River and its catchment are provided in Appendix B, and discussed further in Section 2.

Note: imagery taken after floods in early 2010, highlighting floodplain storages and wetland areas.

Figure 1-1 Bega River Estuary catchment and study area (source: BVSC)

Figure 1-2 Lower Reaches of the Bega River, showing the shoaled entrance at Mogareeka Inlet (Source: OEH)

1.3 Why do we need an Estuary Management Plan?

Coastal areas of NSW are experiencing considerable pressure for further development. The south coast region is projected to grow by 36% over the next 25 years, requiring 45,600 new dwellings (DoP, 2007). Growth is expected to occur along the coast at Merimbula, Tura Beach, Bermagui and Eden. However, Bega township is also planned to accommodate much of the area's future growth.

Long term strategic planning and management are necessary to ensure that future development is carried out in a way that does not degrade the very values that make the area popular. For example, there is likely to be demand for greater development in Tathra due to its attractive coastal location and close proximity to Bega (this demand is starting to be realised through the development of Tathra River Estate). There needs to be careful consideration and planning to determine the feasibility of future development. Maximising available land around current urban centres and minimising urban zones around environmentally sensitive locations and productive agricultural land is seen as the most environmentally and socially sustainable plan for development by DoP (2006).

The Bega River catchment in entirety has a long history of European use and modification resulting from agriculture in the region. Despite these modifications, the BRE continues to sustain a diverse ecosystem and affords many ecological and social values. Many of these values would be threatened if development on the rivers edge and within the catchment was to proceed without consideration or compassion for the ecological and social functions and values of the estuary.

A long-term strategic management plan for the BRE is the only way that the values of the estuary can be protected and conserved in the future. The management plan should be used to guide appropriate future development in the catchment and to define necessary development controls, such as buffers and vegetation requirements, to prevent, or at least minimise, the degradation of the natural environment. The potential impacts of climate change and ways to accommodate the anticipated changes are identified in Section 10.

Specific sub-plans addressing issues such as appropriate sewage management, future development controls and entrance management has also been prepared and are included in this Estuary Management Plan to assist future strategic planning of the estuary and its catchment, within a long-term environmental, social and economic framework.

1.4 Existing Management and Strategic Planning Framework

The Bega River Estuary and its catchment are subject to a myriad of environmental planning and management instruments and legislation. Despite this plethora of planning and management instruments, they tend to be disparate, potentially limiting the opportunity for effective planning.

The existing environmental planning and strategic management frameworks relevant to the BRE are summarised below, with further information provided in Appendix A.

1.4.1 Environmental Planning Instruments

There are three main types of statutory environment planning instruments (EPIs): Local Environmental Plans (LEPs), Regional Environmental Plans (REPs) and State Environmental Planning Policies (SEPPs). Non statutory EPIs include Development Control Plans (DCPs) and Estuary Management Plans.

EPIs that are applicable to the BRE catchment are listed below, and have been described in further detail in Appendix A:

- Bega Valley Local Environmental Plan 2002;
- South Coast Regional Strategy 2007;
- SEPP 71 – Coastal Protection; and
- SEPP 14 – Coastal Wetlands.

The document that currently prescribes future development and management of the BRE is the Bega Valley Shire LEP 2000, summarised briefly below.

1.4.1.1 Bega Valley Local Environmental Plan (LEP) 2002

The Bega Valley LEP 2002 is applicable to the Bega River estuary and catchment. The Bega River Estuary Management Plan (EMP) needs to be consistent with the existing Bega Valley Shire Council planning framework, which is built around the LEP, or provide clear directions for modification of the LEP (with appropriate justification).

The BRE catchment mainly consists of Agricultural Land (Rural 1A – general, Rural 1C – small holdings), National Parks (8) and State Forest (Rural 1F – Forestry), with the remainder in Urban

Land (Residential 2A – Low Density, Residential 2C – Tourist, and Residential 2V - Village), and Special Uses (5A) Community Purposes zonings, with some areas protected under Environmental Protection (7B – Foreshore, and 7D - General) Habitat and Catchment and Existing Open Space (6A). A map of the landuse zonings for the BRE catchment is presented in Figure B-18, Appendix B.

The Bega Valley LEP 2002 specifies development that is suitable (with or without consent) and not suitable (i.e. prohibited development) for each landuse zoning.

Planning reforms currently underway by the NSW Government requires every Council to review their LEP and to re-establish landuse zonings consistent with a specified LEP template (NSW Government, 2006). Bega Valley Shire Council is in the process of reviewing its LEP.

1.4.2 State and Commonwealth Legislation and Policies

There are a number of NSW Parliamentary Acts that are relevant to the management of the Bega River estuary and catchment. Key Acts are listed below, while further details are given in Appendix A:

- Water Management Act 2000;
- Threatened Species Conservation Act, 1995;
- National Parks and Wildlife Act, 1974;
- Fisheries Management Act, 1994;
- Protection of the Environment Operations Act, 1997;
- Catchment Management Act, 2003;
- Natural Resource Management Act, 2003;
- Coastal Protection Act, 1979;
- Local Government Act, 1993;
- Crown Lands Act 1989; and
- Native Vegetation Act 1987

The Environmental Protection and Biodiversity Conservation Act 1999 is the only major Commonwealth legislation applicable to the Bega River Estuary and catchment. The Act provides protection to flora and fauna that occurs within areas that are owned and controlled by the Commonwealth, or are of national significance specifically threatened, marine and migratory species. Further details of this act are provided in Appendix A.

Descriptions of the Estuary Management Policy 1992 and the NSW Coastal Policy 1997, which are fundamentally important and relevant to the management of the Bega River Estuary and catchment, have also been detailed in Appendix A, as are the NSW Sea Level Rise Policy Statement and recent changes to the Coastal and Estuary management Process, as directed by amendments to the Coastal Protect Act.

The NSW State Plan – Priority E4 'Better Environmental Outcomes for native vegetation, biodiversity and coastal waterways' and the Natural Resource Commission's Standards and Targets are also important considerations for the management of the Bega River Estuary.

1.4.3 Other Relevant Planning and Management Documentation

The following planning and management documents and reports are relevant to the future management of Bega River Estuary and catchment, and are detailed in Appendix A:

- Southern Rivers CMA Catchment Action Plan (CAP) 2007;
- Bega Valley Urban Stormwater Management Plan;
- Development Service Plan for Water Supply;
- Development Service Plan for Sewerage;
- Tathra Structure Report; and
- Healthy Rivers Commission Independent Inquiry into the Bega River.

1.5 Land Tenure

The overwhelming majority of land in the catchment is under private freehold ownership, including the majority of land adjacent to the estuary waterway. There are small sections of the immediate catchment within Mimosa Rocks National Park and Tanja State Forest on the northern side of the river. On the southern side of the river, tenure includes areas of Council managed Crown Land to the north west of Tathra through to Black Ada Swamp, Racecourse Creek and Tathra Country Club and Bournda National Park to the south of Evans Hill. There are large areas of former Crown Land to the west of Tathra that have been granted to the Bega Local Aboriginal Lands Council.

The remainder of public land exists as small lots owned by BVSC for various purposes, such as foreshore, bushland and watercourse reserves, or for infrastructure for waste, water or sewage. Public land ownership in the BRE catchment is illustrated in Figure B-19, Appendix B.

1.6 NSW Government's Estuary Management Program

In 1992, the NSW State Government introduced the *Estuary Management Policy*, aimed at managing the growing pressures on estuarine ecosystems. The Policy is implemented through an Estuary Management Program, which is co-ordinated by the Office of Environment and Heritage (OEH) (formerly Department of Environment, Climate Change and Water: DECCW), in co-operation with local government and the community. The Estuary Management Program also implements actions of the Coastal Policy 1997 insofar as they relate to the estuarine components of the NSW Coastal Zone. The Bega River Estuary Management Plan has been prepared in accordance with the Estuary Management Program.

The process of managing an estuary is documented in the Estuary Management Manual (NSW Government, 1992). State Government is in the process of reviewing and updating this manual, and combining it with the Coastline Management Manual (NSW Government, 1990) to produce a new Coastal Zone Management Manual. The general estuary management process, as established by the NSW Government, is shown in Figure 1-3.

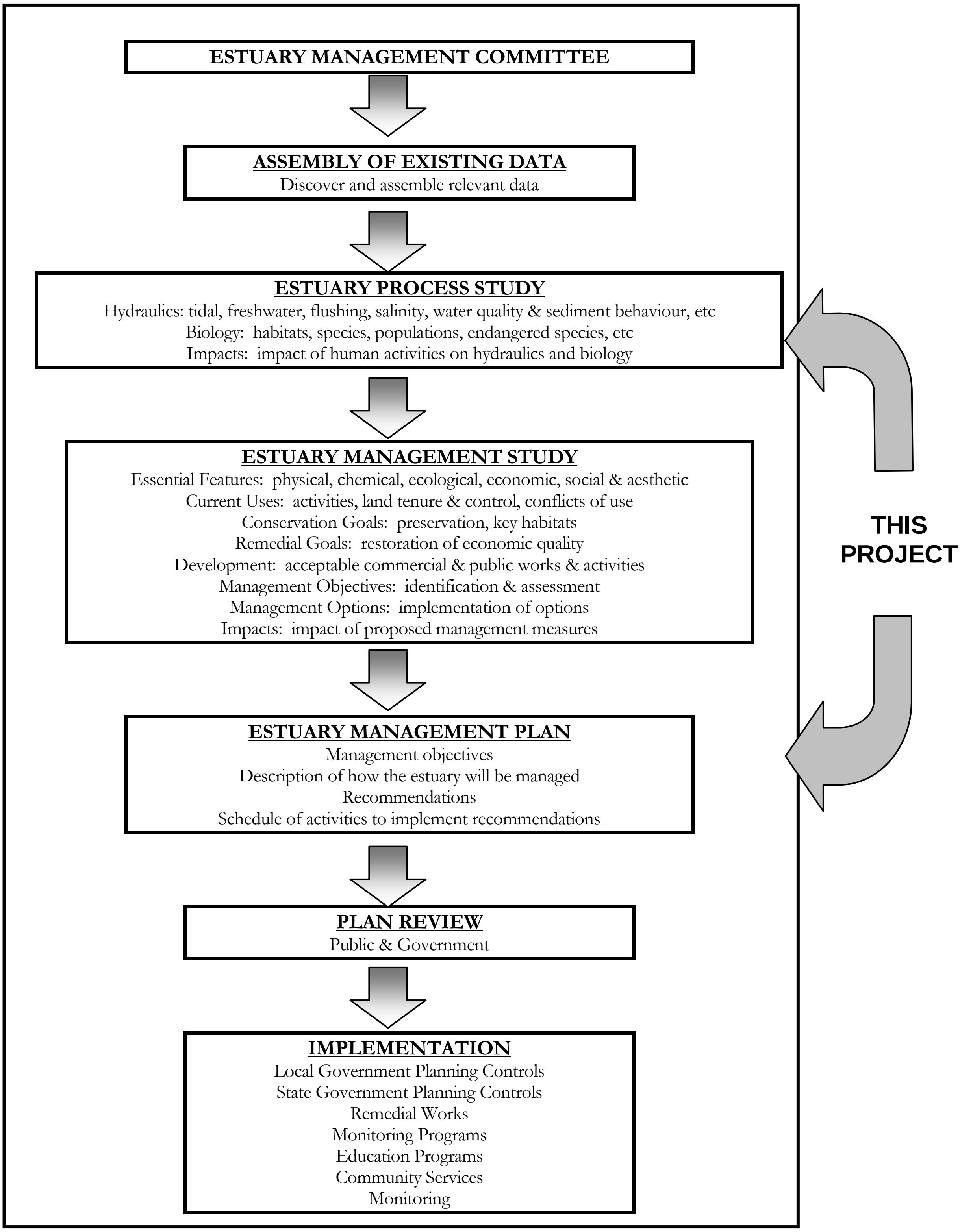

Figure 1-3 The NSW Estuary Management Process (Source: NSW Government, 1992)

Formal management of an estuary is initiated by the establishment of an Estuary Management Committee. This Committee is then responsible for the development of an Estuary Processes Study, which outlines the hydraulic, sedimentation, water quality and ecological processes within the estuary, and the impacts of human activities on these processes.

The Estuary Processes Study provides the necessary understanding of physical and biological processes for the preparation of an Estuary Management Study. The Management Study identifies the essential features and the current uses of the estuary, and determines the overall objectives required for management of the estuary. The Management Study also identifies options for meeting these objectives, and determines hydraulic and ecological impacts of the proposed options.

From the findings of the Management Study, an Estuary Management Plan is prepared. The Plan describes how the estuary will be managed, gives recommended solutions to management problems, and details a schedule of activities for the implementation of the recommendations. Once the Plan has been accepted by the community, Council and the relevant Government Departments, the Plan can be implemented through planning controls, works programs, monitoring programs, and education services.

The Bega River Estuary Working Group (BREWG) was established by Bega Valley Shire Council for the purpose of preparing and implementing a management plan for Bega River Estuary. The primary objective of the management plan is to address the major issues identified by the committee and community along with other issues that have become evident through the preparation of the Estuary Processes Study. The management plan is adaptive in nature, enabling other issues to be addressed as they become apparent. Also, the plan provides a mechanism for Council to implement and promote the principles of Ecologically Sustainable Development (ESD), to ensure the long-term sustainable use of the estuary.

1.7 Recent Changes to Estuary Management in NSW

As outlined above, the estuary management process in NSW has historically been guided by the Estuary Management Policy (1992) and draft Estuary Management Manual (1992). In early 2011, the NSW Government released new *Guidelines for Preparing Coastal Zone Management Plans* (the CZMP Guidelines), which replace the Estuary Management Manual and combines the coastal and estuary management processes.

Under the new CZMP Guidelines, estuary management shall focus upon addressing risks to the health of estuaries through practical management actions. Focus is guided towards estuary health as this is not explicitly investigated or managed through any other council or state statutory or planning process.

Although finalised in 2011, the Bega River Estuary planning process commenced under the guidance of the former Estuary Management Manual (1992). As such, this project has sought, as best as possible, to comply with both (1992 and 2011) guideline processes. The two processes are not mutually exclusive, and the majority of the aims and investigations are the same.

1.8 Structure of this Report

This document comprises three stages of the Estuary Management Program, viz: the Estuary Processes Study; the Estuary Management Study; and the Estuary Management Plan (refer Figure 1-3). The key deliverables from this document are series of strategic management **strategies** that, if implemented, will result in the long-term ecological, economic and social sustainability of Bega River Estuary. The strategies have been determined following consideration of the scientific / environmental values and issues, as well as the human-related values and issues of the lake, and through a process of community consultation.

Chapter 1 provides an **introduction** to the river, and a **summary of the strategic planning framework** in which the river is managed at present.

Chapter 2 presents details of the **Estuary Processes Study**. This describes the key biophysical processes of the estuary, and the anthropogenic pressures that impact on these processes.

Chapter 3 describes the **community consultation** that was carried out during the preparation of this Plan.

Chapter 4 presents the **Existing Uses and Values** of the estuary, as established by the scientific assessment, the community and stakeholders. This chapter also details the **Key Management Issues** that need to be addressed when providing management responses, in order to effectively maintain a healthy and sustainable estuarine environment into the future.

Chapter 5 defines and prioritises specific **Management Objectives** for the Bega River Estuary. These objectives essentially relate to the key management issues.

Chapter 6 presents and assesses a range of **Possible Management Options / Strategies** that could be used to address the management objectives. The options were evaluated and ranked using community feedback and a multi-criteria analysis.

Chapter 7 contains **Sub-Plans** for key future strategic management elements. These Sub-Plans have been prepared to help advise and direct other strategic planning initiatives to be undertaken by Council in the future, essentially providing 'considerations' in relation to estuary values.

Chapter 8 contains **Implementation Schedules** for the proposed short-listed strategies. It provides details of specific actions, who is responsible for implementation of the various strategies, and relevant timeframes for implementation.

Chapter 9 provides details of **opportunities for funding** of the Plan.

Chapter 10 describes requirements and considerations for accommodating future **climate change**.

Chapter 11 details a **Monitoring and Evaluation** program to ensure that the Plan remains effective and current, and

Chapter 12 presents details of references cited in the Plan.

Additional information is also provided in the Appendices to this document.

2 BIOPHYSICAL PROCESSES OF THE BEGA RIVER ESTUARY

2.1 Introduction

2.1.1 Background

This chapter outlines the catchment and coastal processes, ecological characteristics and anthropogenic uses that shape the environment of the Bega River Estuary (BRE). Flood and tidal hydrodynamic processes, the geomorphology of the catchment, estuary and entrance, and the interactions between hydrodynamics and geomorphology through sediment transport are discussed. Inputs to water and sediment quality and its impact upon the ecology and recreational amenity are also outlined. The ecology of the catchment, including flora and fauna of the river and surrounds, threatened and vulnerable species, and conservation areas such as national parks and state forests are detailed. The human uses of the estuary such as landuse and industries, recreational activities and tourism and the impacts of anthropogenic activities on the estuary are also detailed within this chapter.

Information presented in this Chapter is supported by a Bega River Estuary Data Compilation Study (Kinred, 2003), which detailed available reports and summarised the data from these reports. The Data Compilation Study comprises Stage 2 of the NSW 1992 *Estuary Management Program* (refer Figure 1-3). As well as the Data Compilation Study, this Estuary Processes assessment is based upon new data and information compiled since its release in 2003.

2.1.2 Locality

The Bega River catchment has a total area of approximately 1930 km^2, and its main tributaries are the Brogo River and Double Creek in the north, the Bemboka River, Tantawangalo Creek, Sandy Creek, Candelo Creek and Wolumla Creek in the south, and the Bega River and Bega River Estuary in the centre of the catchment, as shown in Figure B-1, Appendix B. In detail, the Bemboka River becomes the Bega River 15 km upstream of the Bega township at its confluence with the Tantawangalo Creek and the Brogo River joins the Bega River at the Bega township (Willing & Partners, 1987). Bega township is situated 24 km upstream of the ocean entrance (Willing & Partners, 1987). The area of the Bega River waterway is 3.4 km^2 (PWD 1993).

The Bega River catchment is comprised of 9 subcatchments, shown in Figure B-1, Appendix B and the size of all subcatchments is given in Table 2-1. The BRE subcatchment to which this plan applies is highlighted in Table 2-1, and has an area of 88.6 km^2.

The BRE extends 12 km inland from the coast to Jellat Jellat and the Penooka Wetlands, which represent the tidal limit of the estuary. The estuary enters the ocean at Mogareeka Inlet, which consists of rocky outcrops overlain by extensive marine sand (CMG 2000). The estuary entrance is intermittently open to the ocean making it more representative of an Intermittently Open and Closed Lake or Lagoon (ICOLL) rather than a permanently open riverine estuary.

Features of the BRE include Penooka and Betunga Swamps, which combined form a considerable area of SEPP14 Wetland connected to the BRE via Jellat Jellat Creek, and smaller areas of SEPP14 Wetlands such as Horseshoe Lagoon, Blackfellows Lagoon, Zecks Lagoon, Chinnock Lagoon, and

Black Ada Swamp, the last of which is located immediately upstream of Hancock Bridge at the edge of Mogareeka Inlet.

Table 2-1 Subcatchments within the Bega River Catchment

Subcatchment	Size (km^2)
Brogo River	398.3
Upper Brogo River	394.6
Bemboka River	362.8
Tantawanglo Creek	213.1
Wolumla Creek	130.9
Bega River	128.8
Candelo Creek	113.4
Sandy Creek	98.3
Bega Estuary	88.6
TOTAL	**1928.8**

2.2 Geomorphology

2.2.1 Catchment Geomorphology

The broader Bega River catchment may be divided into three geomorphic regions as follows (Brooks, 1994; Brierley and Fryirs, 1997; Fryirs and Brierley, 1998b):

- the western uplands, a largely forested dissected plateau region, comprising around 15 % of the catchment;
- a steep escarpment separating the uplands and lowlands, and with floodplain deposits of varying depth at its base, covering 15 % of the catchment; and
- rounded foothills and lowlands cover the remaining 70% of the catchment, consisting of rounded hills and slopes of 8 – 15^0, and the lowlands, a smaller area of flat land adjacent to the lower Bega River.

The escarpment forms a major control on the shape and behaviour of the Bega River, with many sediment deposits formed at its base over possibly tens of thousands of years (Brooks 1994). It has a noticeable break in slope, starting at 1200m in height in the west, tapering to 700m high south of Wolumla township, and then 350m on the coastal range east of Wolumla (Brooks 1994). Topographic shape and contours of the BRE catchment are displayed in Figure B-2, Appendix B.

European settlement has focused on the lowlands and foothills, hence these areas are largely cleared for agricultural practices, particularly dairy farming. The majority of wetlands exist within the foothills and lowlands between the escarpment and the ocean (Fryirs and Brierley, 1998b).

2.2.2 River Geomorphology

The Bega River has been assessed to have nine distinctive geomorphic styles along its length (Brierley and Fryirs, 1997; Fryirs & Brierley 1998a; 1998b), which are largely determined by the geomorphic units of the catchment (Section 2.2.1). The four main geomorphic styles represented in the estuary are discussed below.

- The western uplands are characterised by v-shaped valleys with bedrock controlled, laterally stable channels. These channels are characterised by pools, riffles, runs and cascades, with occasional short floodplain segments between bedrock channel sections.
- Escarpment river channel sections are bedrock controlled with no floodplain. The base of the escarpment tends to consist of cut and fill channels, through both deep and shallow valley fill sections, and the bed is commonly covered with sand sheets, with occasional pools and bedrock sections.
- The foothill river segments tend to be wide and shallow with discontinuous floodplain between bedrock controlled or gravel sections, and in this region, the river acts as a conveyor of sediment to lower sections of the river. Some areas of the foothills also consist of sinuous channels through the meandering valley sections, again transferring sediment through them, with no net change in sediment balance.
- The lowlands are characterised by wide channels and extensive continuous floodplain, and is typically choked with sand, which accumulates as extensive sand sheets, point bars and mid channel bars, and through which the river braids during low flow periods. Distal backswamps form within the lowland floodplain sections. The last of the swamps in the Bega catchment usually occur within a wide valley area, and are accumulation zones for sediment, directly upon intact valley fill.

The floodplain widths highlight the change in channel morphology from upstream to downstream, with floodplain widths of 10 m in the confined upstream areas compared with 1500 m in the lowland areas downstream (DLWC 1998).

2.2.3 Estuarine Geomorphology

The Bega River Estuary falls into Group IV (intermittent estuaries): Type 8 (or group iii type 5) of the estuary classification developed Roy *et al.* (2001). The Estuary is a mature barrier estuary based upon its advanced stage of infilling with sediment (CMG 2000, Roy *et al* 2001). Tathra Beach is a prograded beach ridge barrier that forms the seaward boundary of the Estuary. The entrance to the estuary is shoaled or closed for the majority of the time, however, the entrance and the factors that control its open or closed status are extremely dynamic and prolonged openings can occur as highlighted by the 12 month long opening of the entrance from early 2007 to 2008, following a large flood event.

A small marine tidal delta exists behind the entrance berm, in Mogareeka Inlet, ending just downstream of Hancock Bridge (CMG 2000). Just upstream of Hancock Bridge is a small fluvial depositional shoal, and both this and the marine delta are supplied with sediment from the upper catchment. Further upstream of the fluvial shoal, the geomorphology is typical of the lowland river geomorphology described in Section 2.2.2, that is, the river channel typically has point and mid channel bars, and a wide floodplain. The geomorphology of the Estuary is further illustrated in a Digital Elevation Model, provided in Figure B-3, Appendix B.

Estuary infilling is thought to have occurred over a long period of time, with Holocene estuarine deposits found as far inland as the Bega-Brogo River confluence, approximately 20 km inland from the present day coast (CMG 2000). The relict estuarine mud basin upstream of Bottleneck Reach is partially covered with Holocene river sediments (CMG 2000).

The coastal embayment adjacent to the BRE shows evidence of multiple coastal barriers. The current barrier is thought to have developed in the Holocene since stabilisation of the sea level some 7000 years ago. Behind the current barrier is evidence of a more ancient barrier, of Pleistocene age, which would have been established during previous interglacial periods. The Tathra Golf Course is located on this relict barrier, and is marginally higher than current sea levels. Black Ada Lagoon has formed in the inter-barrier depression between the Holocene and Pleistocene coastal barriers.

The BRE is considered to be a particularly unique system for a number of reasons. First, it is one of very few systems that are considered to be supplying terrigenous sediment to the coast, although the sediment appears to be retained within the local Tathra coastal compartment (CMG, 2000). Second, it is unusual for a fully mature barrier estuary to have an intermittent connection to the ocean. Extensive infilling of the estuary paleovalley has occurred despite the relatively small catchment that supplies sediment runoff. Most other intermittently open estuaries in south-east Australia are immature barrier lakes and lagoons (ICOLLs). The entrance is thought to have been previously located at least 1.5 km south in a topographic low point (termed the “old spit”), and has subsequently migrated north to its present position under prevailing southerly wave conditions and longshore sediment transport (CMG 2000). CMG (2000) believe that under natural conditions, without artificial opening, flood waters would bank up behind the entrance barrier and preferentially breakout at this low point (i.e., the “old spit”).

Breaching of the entrance barrier during a single major flood event may erode and transport millions of cubic metres of sediment offshore (CMG 2000). The strong longshore drift of marine sand from south to north along Tathra Beach provides a source of marine sand to be reworked back into the estuary entrance by wave action. Re-establishment of the entrance sand spit typically occurs over a periods of months following a major breakout (CMG 2000). An open entrance is rarely maintained and requires a series of moderate floods (of < 10% AEP recurrence interval) within a short period of time (CMG 2000).

2.3 Hydrodynamics

2.3.1 Tidal Hydrodynamics and Entrance Condition

Tidal behaviour is observed between the entrance and Jellat Jellat, some 12km upstream of the entrance. The tidal prism is reportedly 702 ML (DIPNR, 2004). When the entrance is heavily shoaled, tidal flushing is reduced greatly (with only the upper stages of the tide penetrating the estuary). Tidal behaviour within the estuary ceases completely when the height of the berm exceeds the high tide water level.

The sand berm across the mouth of the River is formed by a number of processes interacting together, including (i) ocean waves transporting marine sand onshore, (ii) northerly longshore sand transport along Tathra Beach, (iii) tidal movement of sand in the lower reaches of the river, and (iv) aeolian sand transport from the beach berm at Tathra (PWD 1980; CMG 2000). The River has been noted to be closed more often in recent years, with assessment by the Bega Valley Shire Council (BVSC) indicating the entrance was closed for 50% to 75% of the time between 2002 and 2004, compared with 25% between 1999 and 2000. As noted earlier, however, under the right conditions the entrance can be open for an extended period of time. Lower than average rainfall conditions have been experienced in the south coast of NSW for a number of years and may account for this difference.

The magnitude and duration/persistence of fluvial discharge through the BRE is also likely to be a key determinant of entrance state. When open, the relative magnitude and duration of flood and ebb tidal flows will influence sediment transport dynamics within the entrance delta region, which will also influence entrance state.

Large floods open the entrance naturally, and redistribute sand within the river entrance (PWD, 1980). However, it is more common for the entrance to be artificially opened by the Council to relieve upstream flooding, particularly the inundation of roads and the Tathra Golf Course (CMG 2000, DLWC, 1999a). When the water level exceeds a defined opening mark on Hancock Bridge (at 1.36 m AHD), a permit is obtained from NPWS (if threatened shorebirds are present), as well as a licence from DPI-Crown Lands (formerly Department of Lands). and an excavator brought in to initiate a breakout (pers. comm., Derek Van Bracht, BVSC 2004). Information on potential flood impacts is limited and an assessment of entrance state and management options needs to be incorporated into a future flood study and Floodplain Risk Management Study.

Continued long term erosion of the beach face at Tathra, south of the Bega River entrance, was predicted by PWD (1980) modelling. Flood events that breached the entrance were believed to depositing sand too far offshore to be reworked by wave processes onto the Tathra beach face (PWD 1980). The impact of this beach erosion upon the entrance condition, such as a change in berm height or breakout frequency, was not assessed by PWD (1980).

Any change in the entrance condition, such as an increase in breakouts, or the length of time for which the entrance remains open, will change the relative influence of tidal and wave processes compared with flood processes on the hydrodynamics, sediment transport and hence the geomorphology of the Estuary.

2.3.2 Fluvial Hydrodynamics

The annual average rainfall in the Bega catchment, calculated with over 100 years of rainfall records, is 865.7 mm year (BOM, 2005). Annual rainfall across the entire catchment varies from more than 1200 mm on the eastern edge of the escarpment to 800 mm in the middle of the catchment (DLWC 1999a). The majority of annual rainfall occurs during one or two large storm events (Willing & Partners 1987; DLWC 1999a).

Floods are thought to occur relatively frequently, are of relatively short duration, and may occur in any month of the year (Willing & Partners 1987; DLWC 1999a). Mean annual flow in the Bega catchment is 350,000 ML, however, flow may be extremely variable, with mean annual flow in the Bemboka River ranging from 12,000 ML to more than 400,000 ML in the 55 years of records assessed (DLWC 1999a).

Lowest stream flows typically occur in the summer months, which is also the period of greatest demand (and drawdown) of water for irrigation (DLWC 1999a) (see Section 2.3.3 for further details). During dry periods, freshwater flows and associated bed load transport is minimal, and hydrodynamics are instead dominated by tidal effects (under open entrance conditions), and to a lesser extent, wind and density effects (CMG 2000).

Flood hydrodynamics are largely controlled by the geomorphologic features of the River. Upstream of the BRE, Bega and Brogo River floodplains and the 100+ floodplain wetlands provide some overbank storage during floodflows. Within the BRE, there are three major controls on flood flow:

- Bottleneck Reach is very narrow and restricted, hence flood waters may back up upstream on the floodplains (CMG 2000). Jellat Jellat Flats and the swamplands form a significant storage area for overbank flood flow (Willing & Partners 1987);
- Hancock Bridge may affect water flow during very large flood events, when a hydraulic gradient may develop between the Bridge and the ocean (CMG 2000); and
- Downstream of Bottleneck Reach to the ocean, flood water levels can also be governed by the height of the entrance berm, hence significant flooding may occur during relatively minor events if the entrance is closed (Willing & Partners 1987).

The 1 in 100-yr flood level, determined by data from the 1971 floods, would inundate both sides of the lower Bega River to adjacent swamplands (Willing & Partners 1987), Figure B-4, Appendix B. However, most urbanised areas, except for parts of North Bega, would be unaffected, with flooding tending to occur on low occupancy rural lands (Willing & Partners 1987).

Flood water levels between Bottleneck Reach and the ocean are mostly controlled by the state of the entrance berm (Willing & Partners 1987). Hence it was recommended that flood level standards for the BRE be governed by the potential height of the entrance berm (Willing & Partners 1987). BVSC's flood information and floodplain risk management policies all appear to rely on assessments more than twenty years old, meaning they are overdue for review via a formal, contemporary Flood Study and Floodplain Risk Management Plan consistent with the NSW Government's Floodplain Development Manual (2005). Consideration of sea level rise and other climate change factors would be an essential component of any future Flood Study and Floodplain Risk Management Plan.

A significant flood event occurred within the Bega River in March 2011. The water levels recorded at Hancock Bridge (Figure 2-1) show the 'flashy' nature of the flood, with levels rising more than 2.5m in just 18 hours, and falling after the flood peak at an equally rapid rate. Some 134mm of rain in 24 hours fell in the Bega district causing the flood in the river. Interestingly, the river entrance was open at the time of the flood, however, it is considered that with such a large volume of floodwater during the event, the entrance would have quickly breached and scoured out had it been closed initially. The large tidal signature in the water level trace immediately following the flood is the result of a very large, scoured, entrance allowing tides to easily penetrate back into the estuary. A photograph of Hancock Bridge and the entrance area at the peak of the March 2011 flood is shown in Figure 2-2.

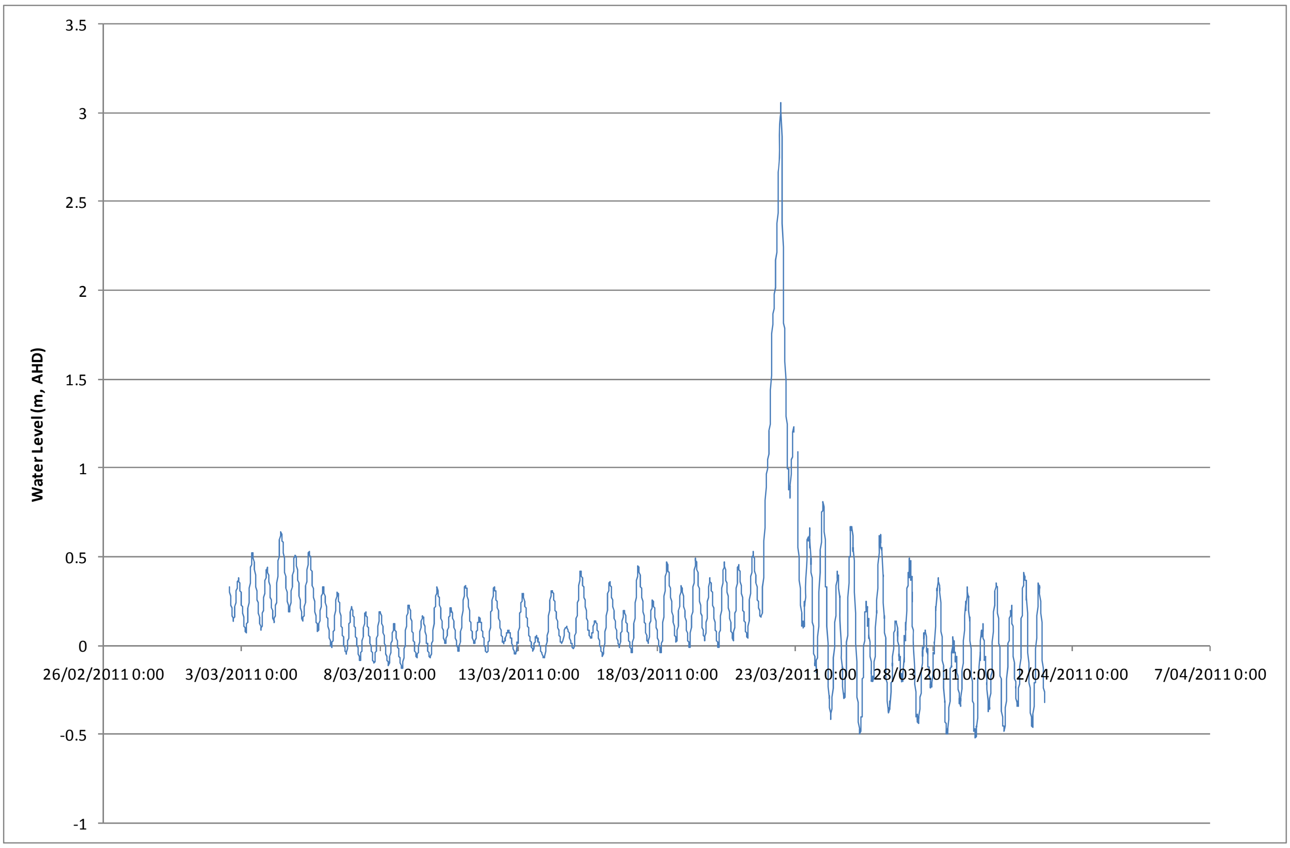

Figure 2-1 Water levels at Hancock Bridge, March 2011 flood event

Figure 2-2 Hancock Bridge and Bega River entrance, March 2011 flood event

2.3.3 Hydrogeology / Groundwater

Assessment of the hydrogeology below Tathra Golf Course, Tathra Sewage Treatment Plant (STP) and Tathra Beach sand dunes was undertaken by Ian Grey Groundwater Consulting (IGGC) (2004a) as part of the Bega Valley Sewerage Program (BVSP). IGGC was engaged by BVSP to determine the likely impact upon water quality in the BRE associated with the irrigation of treated effluent from an upgraded Tathra STP onto the Tathra Golf Course.

The sand deposits below the Tathra STP, Golf Course and sand dunes form a single unconfined aquifer (IGGC, 2004a). IGGC (2004a) assessed groundwater to form recharge "mounds", one beneath the golf course, and one beneath the sand dunes backing Tathra Beach. Groundwater flows radiate outward into Black Ada Swamp and the BRE from the mound beneath the Golf Course and into the BRE and the ocean from the mound beneath the sand dunes (IGGC 2004).

Groundwater levels are controlled by the water level in the BRE and in the ocean. High water levels within the Estuary generate high groundwater levels, forcing the groundwater gradient to flow from the Golf Course into and through the dunes and into the ocean.

The IGGC (2004) report noted the hydraulic conductivity to be between 53 and 800 m per day, with a mean of 204 m/day, and median of 154 m/day. The highest hydraulic conductivity values were reported beneath the northern area of Black Ada Swamp, the STP, and the northern area of the frontal dunes. Groundwater flow velocity was calculated to be 0.75 to 1.2 m/day, based upon an effective soil porosity of 20 %, hydraulic conductivity of between 150 and 400 m/day, and a hydraulic gradient of 0.0001 and 0.0006 (IGGC 2004).

Water level loggers were installed at four groundwater monitoring wells around Tathra Golf Course on 16 December 2004 by IGGC (2005a). The locations of the monitoring wells (MW26, MW35, MW40 & MW44) are shown in Figure B-10, Appendix B. A hydrograph of groundwater level data taken from IGGC (2005) is provided in Figure 2-3. Groundwater levels close to the mouth of the BRE are strongly influenced by the state of the river mouth (IGGC 2005a). Water levels are found to be generally higher when the entrance is closed, and are more noticeably influenced by tides when the entrance is open (IGGC 2005a). The gradual closure of the entrance is noticeable as a slow rise in groundwater levels, such as between April and July 2005, and again between August and October 2005.

Groundwater levels are also recharged during rainfall, as illustrated by larger fluctuations between January and April 2005 and in particular, the two large peaks in July, refer Figure 2-3. Entrance breakout is seen as a swift fall in groundwater levels, such as following the initial July 2005 rainfall, and in mid-November 2005 in Figure 2-3.

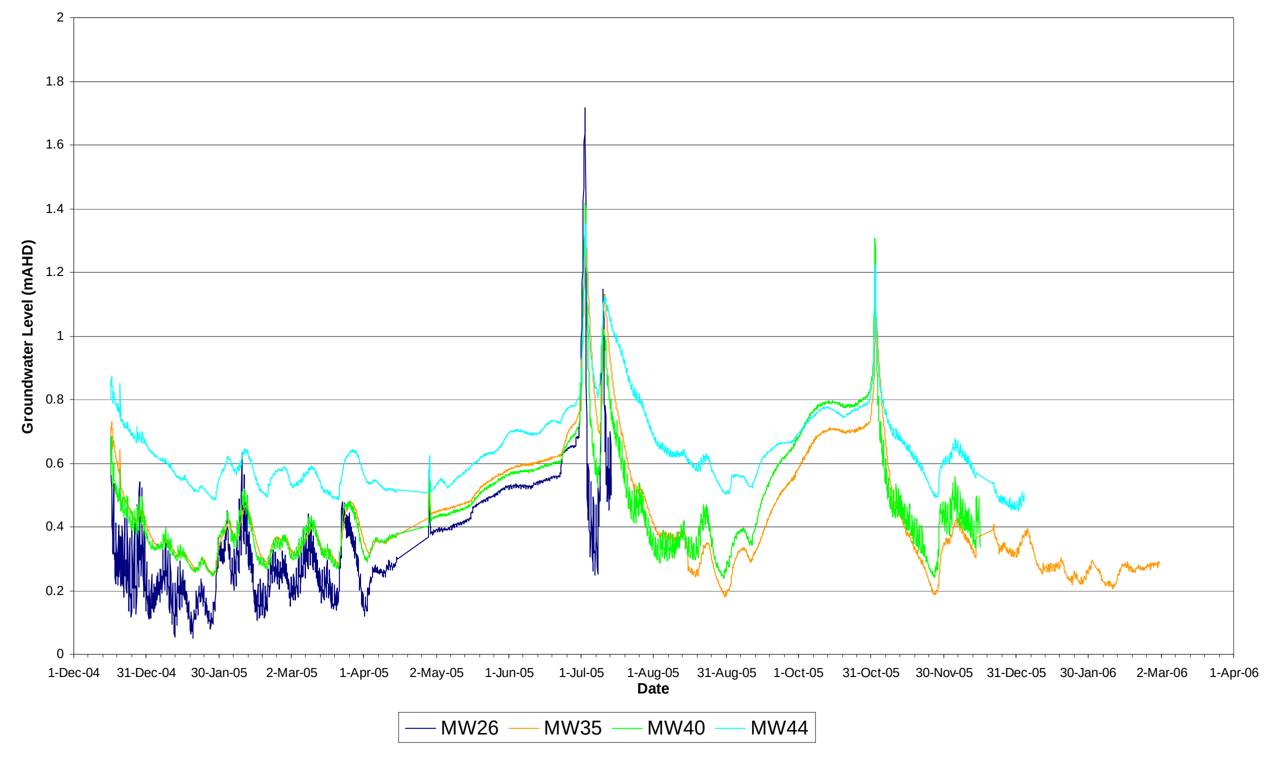

Figure 2-3 Groundwater level data (IGGC 2005)

Groundwater levels are higher along the ridgeline (MW44, MW40 & MW35), with the highest groundwater levels in MW44 which is located closest to the recharge mound (IGGC 2005b). The lowest water levels are found at MW26, which typically exhibits the tidal variation in water level due to its proximity to the Estuary.

2.3.4 Water Extraction and Use

The major user of water from the catchment is agriculture, with water extracted from the catchment used primarily for irrigation (Green, 1999; BVSC 2004b). Water extraction volumes for irrigation vary dramatically and are governed by stream flow and allowable extraction under the new Bega and Brogo Rivers Area Water Sharing Plan.

Water is extracted for town water supply from Tantawanglo Creek, the Bega borefield at Bega, Bemboka River near Bemboka and the Brogo River downstream of Brogo Dam. These sources provide water to the Tantawanglo-Kiah, Bega-Tathra, Bemboka and Brogo-Bermagui water supply systems, respectively. The four systems and the average annual volume of water extracted from each of the sources in the catchment are shown in Table 2-2.

River flows in the Brogo River are attenuated to a large extent by the Brogo Dam. Brogo Dam is controlled by State Water and is used to regulate flow for irrigation extraction downstream to Jellat Jellat. Brogo Dam is the largest dam in the catchment with a storage capacity of 9000 ML.

Table 2-2 Water supply services in the Bega Valley Shire

System	Water Source in the catchment	Towns/Villages Serviced	Average annual water extracted (ML)
Tantawanglo-Kiah	Tantawanglo Creek	Candelo, Wolumla, Merimbula, Tura Beach, Pambula Beach, Pambula and South Pambula	1100
Bega-Tathra	Bega River alluvial aquifer (bores)	Bega, Nth Bega, Tarraganda, Kalaru, Tathra, Tathra River Estate and Mogareeka	1100
Brogo-Bermagui	Brogo River	Quaama, Cobargo, Bermagui, Wallaga Lake	350
Bemboka	Bemboka River	Bemboka	40

River flows, particularly low flows, in the Bega-Bemboka River are attenuated by Cochrane Dam across Georges Creek. Cochrane Dam is operated by Eraring Energy for the generation of electricity (BVSC 2004b), however, it is also used to regulate flows during certain times of the year for downstream irrigation. Cochrane Dam was designed without consideration of the impact of its operation on river flows (DLWC 1999a), however, it also has a relatively small storage capacity, of 2700 ML (BVSC 2004b), suggesting its impact on river flow is limited to regulating low flows. These arrangements for environmental flow releases and water sharing have been organised by Bega Valley Shire Water Users Association with Eraring Energy. Water extraction and environmental flows for the Bega and Brogo River catchments are managed under the Water Sharing Plan for the Bega and Brogo Rivers.

Water extractions impact mostly on base flow magnitudes and persistence, and hence channel and entrance morphodynamics. Flood impacts of these changes require assessment within a Flood Study and Floodplain Risk Management Study.

2.3.5 Jellat Jellat Tidal Barrage

The tidal limit of Bega River occurs at Jellat Jellat, at the eastern end of the river flats. When the river entrance has been closed for a prolonged time or when water entering the river from the ocean dominates river flow, saline water can intrude into the upper tidal reaches of the Bega River. This area is utilised for irrigation and stock watering purposes by the agricultural industry. Consequently, saltwater inundation of these sections of the river is problematic for users / extractors. During these periods, it has been customary for a temporary sand barrage to be constructed across the river at Jellat Jellat, thus preventing saline intrusion into these upper reaches used for extraction (DLWC 2005).

The barrage inhibits the movements of migratory fish species between the estuary and the freshwater reaches. In NSW, there are known to be 44 native freshwater fish species which are migratory, and a further 9 freshwater and 15 estuarine fish species whose migratory needs are unknown (NSW Fisheries 2001). Fish migration is important for fish survival, by allowing access to food, shelter and new habitats, for reproduction, for maintaining population distribution and for ensuring genetic variability (NSW Fisheries 2001).

In 2000 a working group of the Bega Valley Water Management Committee produced draft rules for the operation of Jellat Jellat Tidal Barrage (DIPNR 2004), to provide a path for fish migration. The barrage is to be breached: 2 – 3 weeks after construction, if flows were high during the previous winter; or 4 – 6 weeks after construction if flows were not high during the previous winter (DIPNR 2004). The barrage is permitted to be rebuilt 2-3 days after the breach (DIPNR 2004). Observations by NSW Fisheries (2001) of a similar tidal barrage in Tuross River indicated that an artificial breach is quickly detected by fish populations, triggering mass migration of a variety of fish species.

2.3.6 Russells Creek Weir

A floodgated structure "weir" was constructed in Jellat Jellat (Russell) Creek near Russells Bridge. The structure is known as "Russells Creek weir" (refer Figure 2-4). The structure was designed to impede the backwater inundation of Penooka Swamp (located upstream of the weir) from elevated water levels in the downstream section of Jellat Jellat Creek. Penooka Swamp is a gazetted SEPP-14 coastal wetland (refer Section 2.7.2). Penooka Swamp is considered to be valuable agricultural land, and as such, steps have been taken to minimise risks associated with saline intrusion and frequent freshwater inundation.

The SRCMA, in partnership with adjoining landowners who manage the weir, have upgraded the structure to make it more fish friendly. In addition, the SRCMA are assisting the upstream landowner to improve the riparian and in stream habitat for fish species to complement the weir project.

The impacts of the weir on flood behaviour are uncertain and require detailed assessment as part of a future Flood Study and Floodplain Risk Management Study. Future management of the structure should consider the wider implications to estuarine function and condition and the detrimental effects of altering the hydrological regime of the SEPP14 wetland.

The structure has implications for ecology, estuary flushing and flood hydrodynamics. Penooka Swamp has the capacity to store large volumes of floodwater. By removing this storage area, flood waters are constrained to the remaining Estuary and floodplain area, which would lead to more responsive flooding (i.e. flood levels rising quicker and higher) and thus more frequent entrance breakouts. During large flood events, Russell Creek weir and surrounding floodplain areas would be overtopped, resulting in minimal impact on flood hydrodynamics. Further, fish passage through the structure would only be possible during outflowing periods (when the floodgates are open).

Figure 2-4 The original Russell Creek Weir when downstream water levels are low (top photo: Nov. 05) and high (bottom photo: Nov. 04) (high water levels as the result of a closed ocean entrance)

2.4 Sediment

2.4.1 Sediment Transport

Bega River is one of the few coastal rivers in NSW that delivers sand from the estuary to the ocean (CMG, 2000). This is a relatively rare phenomenon for rivers in Australia due to the tectonic stability and geological age of the continent (Brooks 1994). Reworking of a large quantity of sediment at the base of the escarpment, accumulated over possibly tens of thousands of years, began in the last 130 years, supplying sediment to the Bega River system (Brooks 1994).

The Bega River Estuary is considered to be in a mature stage with little capacity to store further sediment (HRC, 2000; CMG 2000). Slow infilling occurs during low flow conditions, and periodic large flood events serve to mobilise bed load sediments and scour out the estuary, delivering this material to the ocean (HRC 2000; CMG 2000).

The majority of the sediment in the Bega River system is fine grained muddy material which may remain in suspension even under low flow conditions (CMG 2000). This fine sediment tends to be transferred through to the ocean rather than deposited in the estuary, or is deposited on the floodplain during floods (CMG 2000). The coarser grained sand sediment remains in the system during low flow conditions. During flood events, bed load transport of this coarser grained material is initiated by the larger flow velocities associated with the flood (CMG 2000).

In detail, the uplands and escarpment river channel sections tend to have limited sediment, the minority of which is stored in vegetated banks and mid channel bars, and the majority is flushed downstream (Brierley and Fryirs, 1997). Some sediment is stored along the bed and mid channel bars at the base of the escarpment, however, this section of river is typically associated with sediment supply as the river cuts through deep valley fills that have accumulated over possibly thousands of years (Brooks 1994). Below the base of the escarpment within the undulating foothill regions, sediment continues to pass through rather than accumulate. Sediment accumulation begins in the lowland sections of the river, from a few kilometres downstream of the Wolumla confluence to Bottleneck Reach (Brooks 1994). The lowland sections of the river are considered to be choked with sand, deposited as extensive sand sheets, point bars and mid channel bars, through which the low flow of the river is braided. Around 14.2 million m^3 of bed load sediment has been delivered to the lowland floodplain, of which 16% (3.7 million m^3) has been deposited in the estuary (Fryirs and Brierley 1998a).

During large flood events, this accumulated sediment is remobilised by the high velocity flood waters, and when the entrance is breached, it is delivered to the coast and forms an offshore bar seaward of the surfzone (PWD 1980; CMG, 2000). When flood events coincide with storm ocean conditions, the greatest amount of entrance scour and offshore sediment transport occurs, as strong rips and downwelling processes are generated along the coast offshore of the entrance outflow (CMG 2000).

When the estuary is open to the ocean, sediment transport at the entrance and inlet channel may be dominated by waves and tides. Wave and tidal sediment transport processes form the entrance berm and transport marine sand onto the flood tide delta in the entrance inlet.

Brooks and Brierley (1994, 1997) believe the rates of sediment transport in the Bega River have been accelerated by the widening of the channel, and the widespread clearing of native vegetation. In particular, they believe the mobilisation of valley fills at the base of the escarpment has been initiated by settlement activities such as forest clearing for wood and grazing (Brooks & Brierley, 1997; Brooks, 1994). While this may be the case, both DLWC (1998) and CMG (2000) state the rate of sediment accumulation in the Estuary has not significantly increased due to European settlement and associated catchment erosion, except for in off-channel embayments. While sedimentation of the estuary occurs during low flow conditions, periodic large flood events scour out the estuary and transport the scoured material to the ocean, and so the Estuary remains in balance over the long term (DLWC 1998; CMG 2000).

2.4.2 Sediment Type

The geology of the Bega region is dominantly coarse grained granites and granodiorites of Mid-Lower Devonian age (Brooks, 1994; Kidd 1978). The remainder of the catchment consists of Quaternary metasediments and Upper Devonian conglomerates at the headwaters of Bemboka River and Pollacks Flat, and Tertiary basalts in the upper Candelo, Tantawangalo and Bemboka subcatchments (Brierley and Fryirs, 1997). The geology of the Bega River Catchment and Estuary Subcatchment is shown in Figure B-5, Appendix B.

Sediments of the Bega River, some of its tributaries and swamps in the Bega catchment consist mostly of Holocene alluvial sediments, and Quaternary sands and minor gravels (Tulau 1997; Brierley and Fryirs, 1997). The Bega River is rare in that it actively contributes a plentiful supply of sediment to the offshore compartment of Tathra Beach. Previous investigations have found Bega River Catchment derived sediments as far north as Nelsons Beach.

A large variety of soils types exist in the Bega River Catchment, as shown in Figure B-6, Appendix B. Typically, soil types adjacent to channel sections of the BRE consist of alluvial soils (of the Bega River and Towamba River soil landscapes), which are mostly deep (>100 cm), erodible and unvegetated. The remainder of the Estuary, Bega River and its major tributaries are abutted by transferral sediment. Bemboka River soils lie adjacent to part of the Bega River and its southern tributaries, and the length of the Bemboka River. Soils of the Lower Brogo type lie adjacent to the southern end of the Brogo River, its junction with the Bega River and eastwards towards the entrance.

2.4.3 Acid Sulfate Soils

Acid sulfate soils (ASS) have been investigated near the Bega River entrance. Three sites of high probability ASS were identified, including Black Ada Swamp, with ASS areas displayed in Figure B-7, Appendix B. Soils around the entrance of the Estuary and two lagoons, Chinnock and Blackfellows, have a low probability of ASS. The remainder of the area investigated had no known occurrence of potential ASS. Most sites with potential ASS are not zoned for future development (BVSC, 2005a).

2.5 Bank Erosion

Between Jellat Jellat flats and the ocean, the estuary winds through a narrow gorge (paleovalley), carved from bedrock during times of low sea level (i.e. glaciations). The present high sea level has flooded this gorge, resulting in alluvial deposition of the channel and within side embayments. Over the past 6000 years (since sea level stabilised at its present position), sufficient sediment has been deposited within the paleovalley for the river to establish a ‘regime’ condition. That is, the size of the river channel is such that sediment originating from the upslopes remains in transit through the estuary prior to discharge to the ocean.

The estuary does, however, temporarily store sediment, particularly during less significant flood events when sediment transport rates are reduced. The sediment is stored in the form of mid-channel shoals, point bar shoals and sand islands that are sometimes vegetated. During smaller flood events, these shoals are not always remobilised, and in fact, can cause local redistribution of flood flows, which sometimes results in flows impinging on alluvial deposits along the river banks. It is considered that the 'mature' condition of the BRE can result in areas of naturally active bank erosion, in response to the relatively high rates of coarse sediment transport along the waterway channel.

Figure B-8, Appendix B, shows areas of alluvial deposition along the estuary banks. These areas are typically found between areas of bedrock control. Field inspections carried out by WBM found some of these alluvial foreshore deposits were undergoing active erosion (refer Figure B-8). In particular, erosion was found in areas adjacent to mid-channel shoals / islands, where flood flows would be increased close to the riverbanks. Photos taken at Sites A to D (refer Figure B-8) are presented in Figure 2-5 to Figure 2-8. It is considered that the alluvium, being relatively recently deposited sediment, does not have much resistance to erosion, particularly if foreshore vegetation has been cleared (see Section 2.7.3).

The majority of bank erosion within the BRE appears to be associated with the natural 'dynamic' nature of the estuary. The possible exception to this is erosion along the golf course foreshore and in the vicinity of the Mogareeka boat ramp, where wave action may also contribute to erosion processes. Waves at these locations may be caused by wind and/or boat wake. These locations are considered the only high priority erosion sites, requiring remediation, within the BRE.

The erosion depicted in Figure 2-8 is believed to be as a result of past clearing of riparian vegetation and uncontrolled cattle access. The SRCMA have recently undertaken a rehabilitation and fencing program with the current landowner, which has focused on cattle exclusion, erosion control, bank stabilisation and placement of woody debris to reduce wave energy and enhance fish and bird habitat.

Foreshore erosion has also been reported at Lions Park on the downstream side of Hancocks Bridge. It is understood that this erosion was accelerated following artificial entrance breakouts in the late 1990's, when the breakout channel was excavated in the centre of the entrance bar and subsequently migrated too far to the south. Under these circumstances, the channel conveying the outflowing water from the estuary impinges on the Lions Park foreshore, which comprises unconsolidated dune sands, resulting in rapid foreshore retreat. For artificial opening of the entrance during non-flood times, the discharge channel needs to traverse the fans of marine sand deposited just inside the entrance.

Since 1999 Bega Valley Shire has carried out all artificial entrance openings at the extreme northern end of the entrance bar. This has resulted in the stabilisation of the entrance bar dune vegetation and a reduction in the rate of foreshore erosion adjacent to Lions Park.

Figure 2-5 Bank Erosion: Site A (refer Figure B-8)

Figure 2-6 Bank Erosion: Site B (refer Figure B-8)

Figure 2-7 Bank Erosion: Site C (refer Figure B-8)

Figure 2-8 Bank Erosion: Site D (refer Figure B-8)

2.6 Water Quality

The following section provides a summary of available water quality data. The conclusions provided are limited by the limitations of the water quality data (spatially and temporally) with respect to both the in-stream and inflow contributions to the biophysical processes of the Bega River estuary. The implementation of improved estuarine health monitoring programmes is seen as a major priority for the Bega River.

2.6.1 Available Data for Assessment of Water Quality

Data from the following water quality monitoring programs conducted in the Bega River has been used to analyse water quality issues in the BRE:

2.6.1.1 Catchment Water Quality Monitoring Programs:

- Turner *et al*.,1998: a dry weather water quality 'snapshot' study, which involved the collection of samples from 150 sites across the Bega and Brogo River catchments during the week commencing 11 August 1997. Sample analysis included EC, turbidity, nutrients (TN & TP), metals and major cations (calcium, magnesium and potassium).
- Resource Allocation, 2000: a wet weather water quality 'snapshot' study, which involved the collection of samples from 14 sites across the Bega and Brogo River catchments over a 10 day period, before, during and after 120 mm of rain was recorded in Bega. Sample analysis included EC, pH, turbidity, nutrients (TN & TP) and faecal coliforms.
- Department of Land and Water Conservation, 2001: the Bega Brogo Swimming Hole monitoring project, which involved the collection of samples from 14 sites in 2001. Sample analysis included DO, pH, nutrients (TN, TP and NO_X) and faecal coliforms.

2.6.1.2 Estuary Water Quality Monitoring Programs:

- Elgin Associates, 2008: Assessment of water quality and algal growth at three sites in Racecourse Creek and one site in Mogareeka Wetland on three occasions (April 2008, July

2008 and December 2008). Sample analysis included EC, pH, turbidity, DO, redox potential, nutrients (NH_3, NO_X, PO_4 and TP), chlorophyll a and macroalgae species identification. Locations of sample sites are given in Figure B-10, Appendix B.

- Ian Grey Groundwater Consulting (IGGC) 2004-2006: investigative monitoring undertaken at 5 surface water sites and 6 groundwater bore sites on the Tathra golf course on 3 separate occasions. Samples were collected in December 2004 prior to the Tathra STP upgrade and in August 2005 and May 2006 after the STP upgrade. Surface water sample analysis included pH, EC, temperature, dissolved oxygen, faecal coliforms, faecal streptococci, e-coli, enterococci and nutrients including (NH_3, NO_X, TN, PO_4 and TP). Groundwater sample analysis included the same parameters plus redox potential and major ions. The locations of the water quality monitoring sites are given in Figure B-10, Appendix B.
- Bega Valley Shire Council, 2006-2010: Ongoing quarterly operational monitoring (continuation of IGGC monitoring, see above) undertaken at 5 surface water sites and 6 groundwater bore sites on the Tathra golf course on 16 separate occasions (comprising 8 occasions when the river entrance was open, and 8 occasions when the river entrance was closed). Surface water sample analysis included pH, EC, temperature, dissolved oxygen, faecal coliforms, faecal streptococci, e-coli, enterococci and nutrients (NH_3, NO_X, TN, PO_4 and TP). Groundwater sample analysis included the same parameters plus redox potential and major ions. The locations of the water quality monitoring sites are given in Figure B-10, Appendix B, while results statistics are presented in Tables C-10 and C-11, Appendix C.
- Bega Valley Shire Council, 1999-2000: Investigative monitoring undertaken at surface water sites in the estuary between 23 December 1999 and 13 February 2000 whilst the entrance was closed, then again on 17 March 2000 seven days after the entrance broke out during heavy rainfall. Sample analysis included salinity, temperature, faecal coliforms, chlorophyll-a and nutrients, (NH_3, NO_X, TN, PO_4 and TP).
- Bega Valley Shire Council, 2006: in-situ water quality monitoring undertaken at Hancock Bridge, the tidal Sand Barrage and Russell's Creek Floodgates on one occasion in June 2006 for EC. This data has been combined for analysis with in-situ water quality water testing conducted by MHL on 5 July 2001, in similar locations: the location of the Sand Barrage whilst it was not constructed; Penooka Floodgates; and the entrance to Jellat Jellat Creek.
- Manly Hydraulics Laboratory (MHL), 2005-2006: Surface water quality monitoring from 2 sites from 18 November 2005 to 13 March 2006 with a probe logging electrical conductivity (EC), temperature, salinity and pH. The locations of the water quality monitoring sites are given in Figure B-9 Appendix B.
- Department of Land and Water Conservation, 2002: monitoring undertaken at 13 sites at various depths and times between 24 and 26 September 2002. Sample analysis included salinity, pH, temperature, DO, turbidity, chlorophyll-a, density and PAR. The locations of the water quality monitoring sites are given in Figure B-9 Appendix B.
- WBM, 2005: Water quality monitoring at 8 sites at 3 depths on one occasion in November 2005. In situ sample analysis included pH, DO, turbidity, temperature, EC and salinity. The locations of the water quality measurements are given in Figure B-9 Appendix B.
- Tathra Landcare Waterwise Group, 1994-1996: monitoring undertaken at 4 sites on 29 occasions between December 1994 and April 1996. Samples were collected 2 to 4 hours after

high tide and analysed for pH, turbidity, DO, biochemical oxygen demand (BOD), EC, TP, nitrate, faecal coliforms and temperature. Samples were analysed using a Streamwatch kit and other community monitoring equipment, and as such, the accuracy and robustness of these data is less than the laboratory-based analysis undertaken for most other data collection campaigns.

The above list represents a disparate and varied range of sampling programs, with different objectives, varying quality controls etc, and as such these data sets cannot be relied upon to make system wide assessments.

Results from each of these studies are discussed as appropriate in the sections below. It should be noted that groundwater water quality data is discussed separately in Section 2.6.7.

2.6.2 ANZECC Guidelines

In lieu of site specific estuarine water quality guidelines for the Bega River Estuary, this report has utilised the Australian and New Zealand Environment Conservation Council (ANZECC) *Australian Guidelines for Fresh and Marine Water Quality 2000*, herein "the ANZECC Guidelines", for analysing estuarine water quality. The guidelines relevant to the BRE are the values for physico-chemical parameters for protection of aquatic ecosystems of south-east coast estuaries of Australia.

It should be noted that, while the ANZECC guidelines provide some value in analysing water quality in the BRE, the guideline values are designed as a rough guide for all estuaries, and therefore may not be an accurate representation of typical, natural water quality conditions within the BRE. This Estuary Management Plan recommends that site specific water quality trigger levels be developed for the estuary (refer Section 6.1.3.4, M-5), as per the recommendations of the ANZECC Guidelines and the State-wide MER Strategy.

The ANZECC Guideline values for primary and secondary recreational contact have been utilised in analysing pH, ammonia, faecal coliforms and enterococci results from the BRE. The recreational contact guidelines have been determined based upon ideal values for maintaining human health across all waterways.

2.6.3 Physico-chemical parameters

2.6.3.1 Salinity and Electrical Conductivity

The BRE entrance was opened to the ocean following heavy rainfall at the start of November 2005 and water quality data collection by MHL began shortly after this, on 18 November 2005. The entrance closed around 24^{th} February 2006 (MHL 2006), although high tides were still able to overtop the entrance berm for some period following this. A summary table listing the monthly mean, maximum and minimum concentrations for each analyte at both sites are provided in Table C-3, Appendix C.

To some degree concentrations of EC and salinity over the measurement period reflect the opening of the River entrance and rainfall inputs from the catchment. Rainfall, water surface elevation (WSEL) at Site 5 and EC concentrations at both sites have been graphed concurrently in Figure 2-9. Rainfall data from the Bureau of Meteorology (BOM) weather station at Bega was compared with rainfall data from the BOM weather station at Merimbula and found to be similar, hence the Bega rainfall data was considered representative for the BRE. Trends in salinity concentrations were the same as that of EC concentrations for both sites outlined below, and salinity is graphed in Figure C-1, Appendix C.

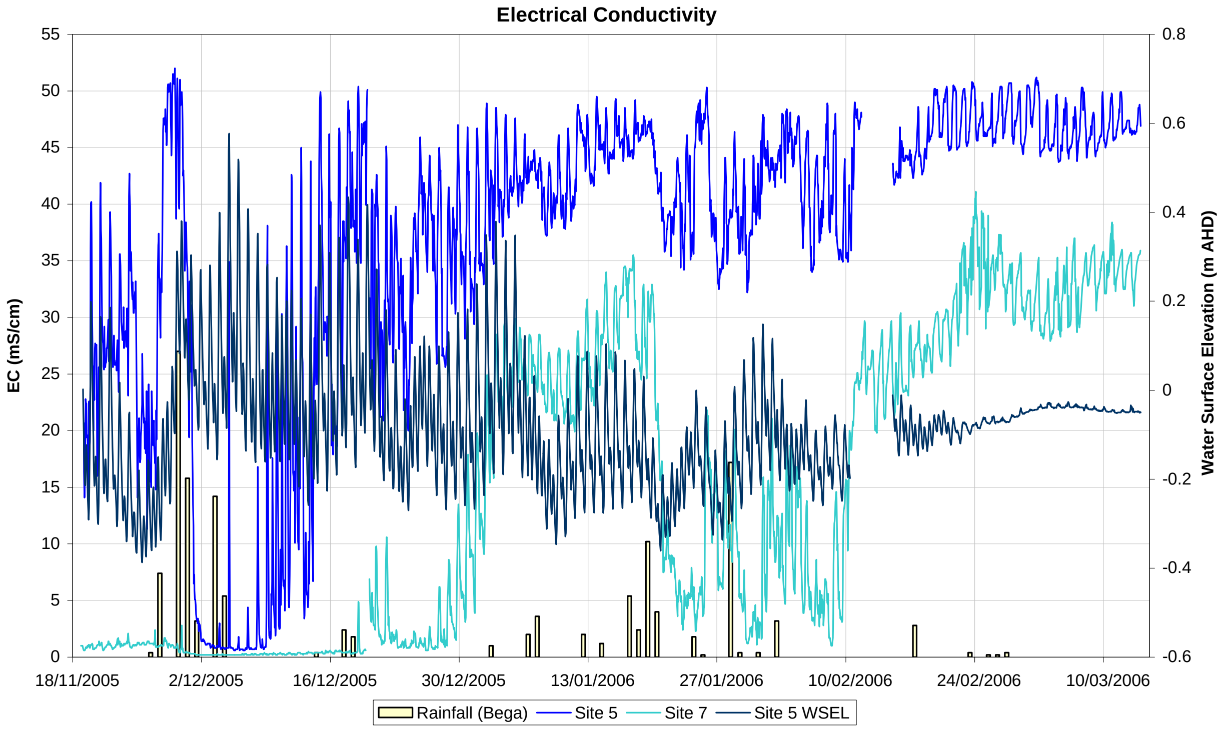

Figure 2-9 Electrical Conductivity Measurements in BRE (Data source: MHL 2006)

EC readings at Site 5 were significantly greater than at Site 7, reflecting the closer proximity of Site 5 to the open ocean entrance. A significant drop in EC levels occurs at Site 5 at the end of November to beginning of December, which coincides with a notable period of rainfall over this period. EC concentrations at Site 5 dip briefly again after a period of higher rainfall in mid January 2006, but quickly recovered to near oceanic concentrations, which persist for the remainder of the measurement period.

EC concentrations at Site 7 are below 2.5 mS/cm until the middle of December when concentrations begin to rise significantly. The rise may reflect the shoaling of the entrance channel and a reduction in tidal flushing, with concentrations then exacerbated by the hotter summer period when catchment inputs may be restricted. Site 7 EC concentrations then drop noticeably around the middle of January 2006 following the period of higher rainfall, which presumably delivered freshwater from rainfall runoff on the catchment. EC Concentrations at Site 7 rise again around the middle of February when the Estuary entrance becomes shoaled from the ocean, hindering tidal flow, and EC remains high for the rest of the measurement period. The entrance closed around February 24th 2006, however, tidal flow from high tides overtopping the berm remained possible, as shown small variations in water level after this time (Figure 2-9).

EC measurements were also taken at sites in and around Black Ada Swamp by IGGC (2004a, 2005, 2006) prior to and after upgrade of the Tathra STP. EC results tended to reflect recent rainfall events in the Estuary and the condition of the river mouth. Prior to background sampling in December 2004, the river mouth was open, and recent heavy rainfall had occurred. Not surprisingly, the EC concentrations were brackish to saline, ranging from 8998 µS/cm (at SW3) to 15430 µS/cm (at SW1).

The river mouth remained open for sampling in August 2005, however, the lack of recent rainfall was reflected in the higher EC concentrations reported, of between 23570 µS/cm (SW5) and 36680 µS/cm (SW4). EC concentrations were higher again in May 2006, reflecting the closed entrance condition and the reduced tidal influx. EC concentrations would also have increased due to evaporation and a lack of rainfall inputs.

Between 2006 and 2010, EC measurements of surface water around Tathra Golf Course (BVSC, 2006-2010) were variable, although the site within Black Ada Swamp (SW5) was generally less saline than the other surface water sites. The variability in surface EC reflects the relative influences of oceanic flushing and catchment runoff, which vary with time. In contrast, groundwater EC around Tathra Golf Course is much more consistent with time, but still varies from site to site (refer Section 2.6.7.1).

Salinity concentrations collected by WBM on 8 November 2005 were graphed to illustrate the relationship between salinity, distance from the entrance (which was open to the ocean at this time) and water depth. As can be seen in Figure 2-10, salinity concentrations decreased with distance from the entrance and ocean, ranging from 34.5 parts per thousand (ppt) at the river mouth to 0.2 ppt at 16 km upstream. Salinity concentrations also tended to increase with depth, refer Figure 2-10. For locations between 1 and 5 km upstream, salinity concentrations at the surface (0.3 - 0.6 m water depth) ranged from 2.9 to 0.4 ppt at 5 km, compared with 34.8 to 27.8 ppt at 5 km at bed level.

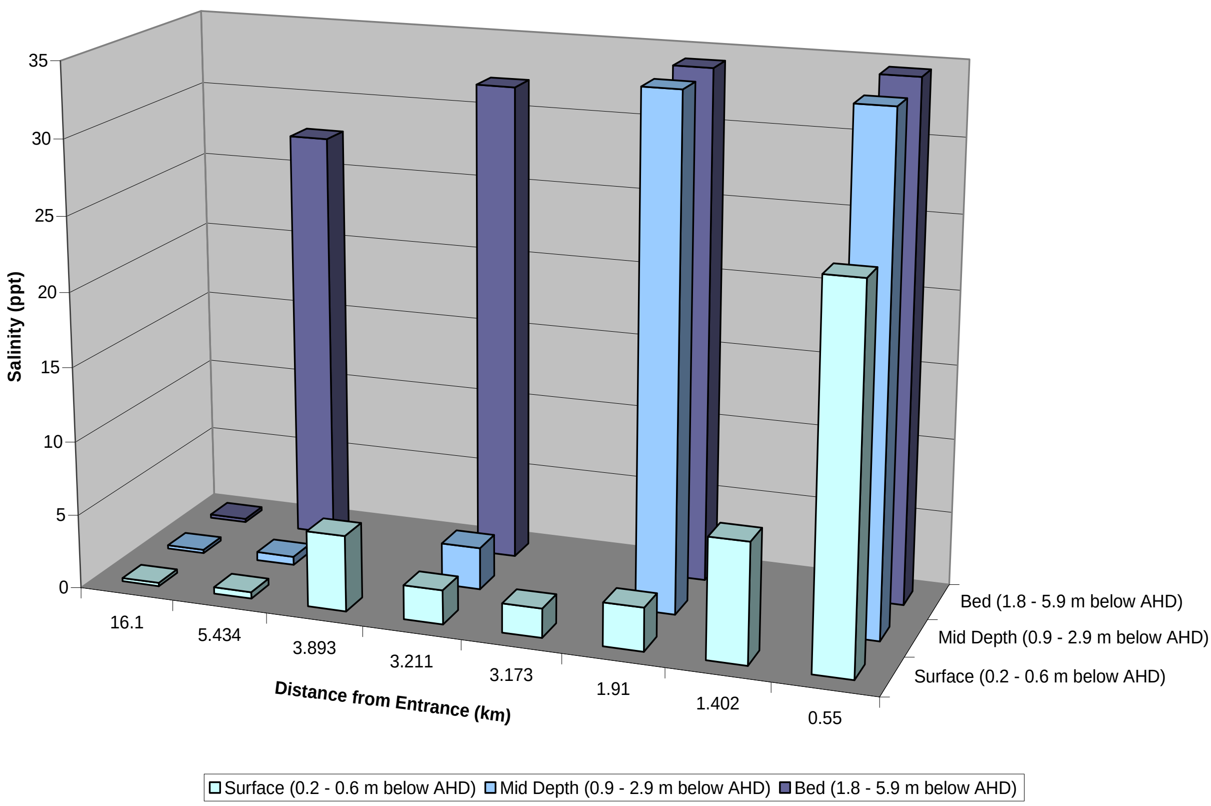

Figure 2-10 Salinity, Depth & Distance from the ocean, WBM 2005 Data

Salinity concentrations at various depths and locations in the BRE were also measured by DLWC during three data collection runs: between 8 am and 11 am on 24 September; 12.30 pm and 3 pm on 24 September; and 8 am and 9 am on 26 September, 2002. The salinity results have been graphed to display the relationship between salinity, depth and distance from the entrance, in Figure 2-11. The Estuary entrance was closed during the data collection period, constraining tidal flushing. As such, the time of the data collection can be ignored in the analysis. This is supported by a review of the data showing that the concentrations of salinity (and pH) at the same depth but different times at a location varied by less than 3 %, refer Table C-2, Appendix C. Other parameters did show greater than 10% variation because they are affected by non-tidal factors which also vary over time, such as sunlight, refer Table C-2, Appendix C.

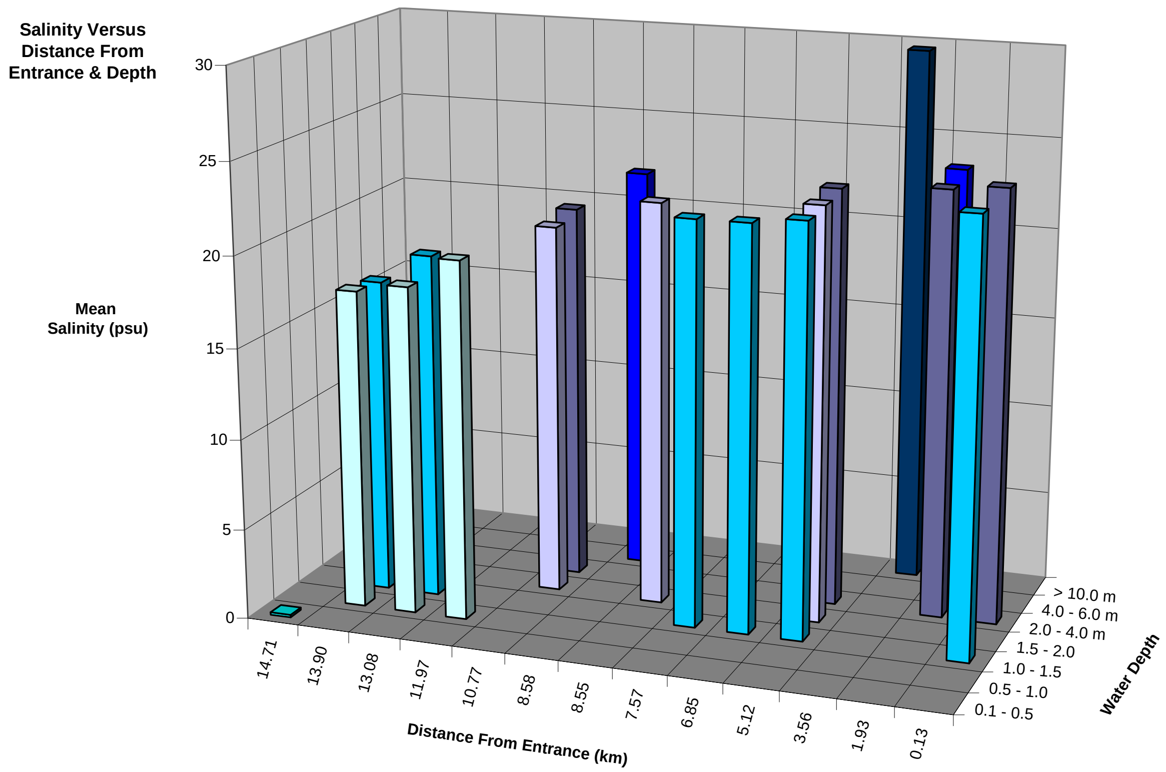

Figure 2-11 Salinity, Depth & Distance From the ocean, DLWC (2003) Data

The DLWC (2003) data supports that of WBM (2005), with salinity decreasing with distance from the ocean, refer Figure 2-11. The highest salinity of 29.6 psu was found at the deepest depth measured of 12.2m, located 3.6 km upstream. At locations between the entrance and 10 km upstream and water depths of 1.5m and 6m, salinity values remain similar, ranging between 22.28 & 23.95 psu. At locations greater than 10 km upstream, salinity falls progressively from 20.8 to 17.4 psu, before reaching its lowest value of 0.14 psu at 14.7 km upstream.

From the DLWC (2003) results, salinity roughly appears to increase with depth, as was likewise shown in the WBM (2005) results.

EC results taken by MHL in 2001 and BVSC in 2006 are compared to illustrate the relationship between salinity (as indicated by EC) and depth in Figure 2-12. EC clearly increases with depth at Hancock Bridge, near to the entrance of the Estuary. Similarly, the increase with depth is apparent upstream of the Bridge at the Sand Barrage, and further upstream again at the Russell Creek and Penooka Floodgates and particularly at the mouth of Jellat Jellat Creek. This trend is consistent with that seen in the WBM (2005) and DLWC (2003) data.

The various data sets highlight that stratification is occurring within the estuary, with a pronounced 'salt wedge' extending from the entrance area to the western extent of the estuary.

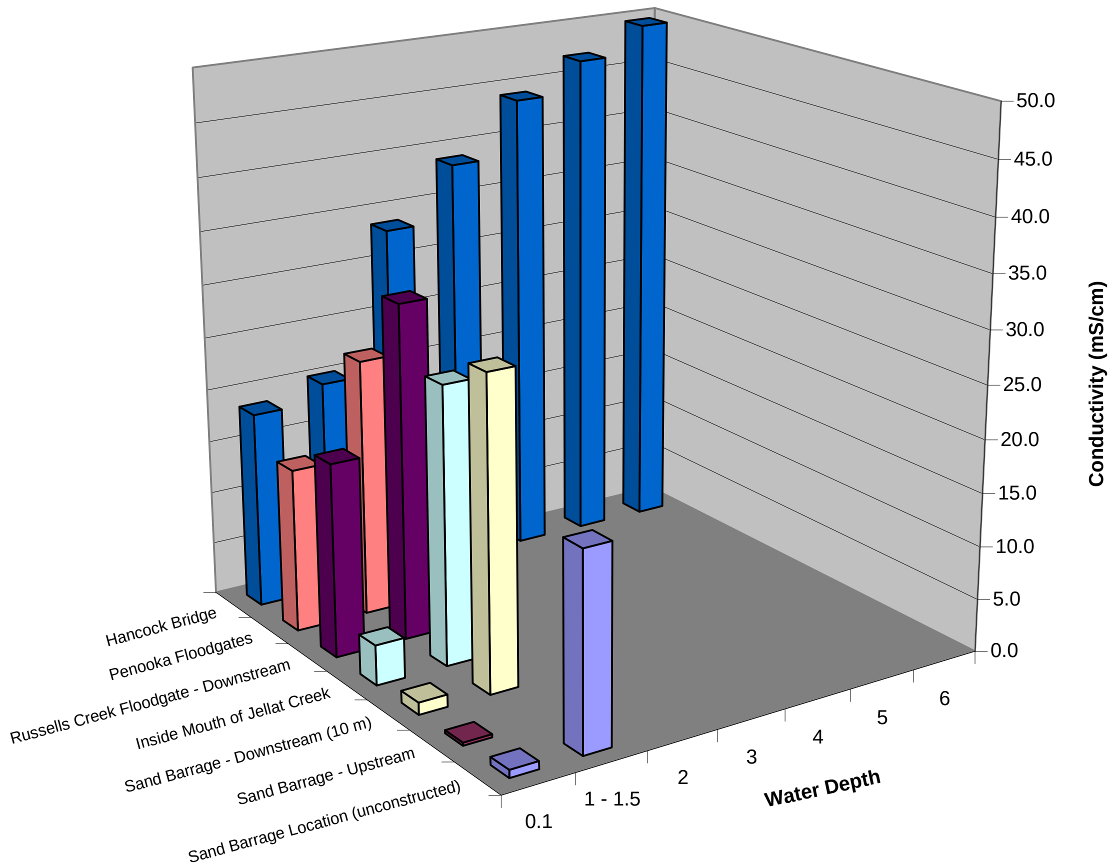

Figure 2-12 Saltwater Intrusion in Bega River Estuary

EC upstream and downstream of the Sand Barrage can only be discussed for surface measurements, as no measurement was taken at depth upstream. The Barrage does appear to reduce the upstream conductivity at the water surface. A table of water quality results measured by BVSC and MHL is provided in Table C-6 Appendix C.

2.6.3.2 Other physico-chemical parameters

The MHL 2006, IGGC (2004, 2005, 2006), Brogo Swimming Hole study, Tathra GC study (2006 – 2010) and WBM study all found pH levels to be generally within ANZECC Guideline bounds. Small deviations outside the normal range are not seen as problematic. When the entrance is open, semidiurnal variations in pH are recorded within the estuary, reflecting the influence of the more alkaline seawater on flooding tides (refer Figure 2-13).

MHL (2006) show that water temperature reflect diurnal variations (day and night) (refer Figure C-2, Appendix C), as well as longer term seasonal temperature variation from spring to summer, with January exhibiting the highest temperatures at both sites. The on-going quarterly monitoring at Tathra GC shows that summer temperatures are typically around 25 degrees C, while winter temperatures are around 15 degrees C. Late summer 2010 reached temperatures of approximately 30 degrees C.

Links between water quality and land use are apparent in the turbidity monitoring results of the Turner *et al* (1998) study, with dairy farming, and to a slightly lesser extent, grazing practices, associated with higher concentrations. In this regard, turbidity results for streams adjacent to areas used for dairy farming were four times greater than those from streams within native forest, and streams within land used for grazing was shown to have twice the level of turbidity than those samples from streams in native forest (Turner *et al* 1998). WBM data (2005) indicated turbidity remained stable with depth, with the highest concentration (135 NTU) reported at Blackfellows Lagoon (refer Table C-5, Appendix C).

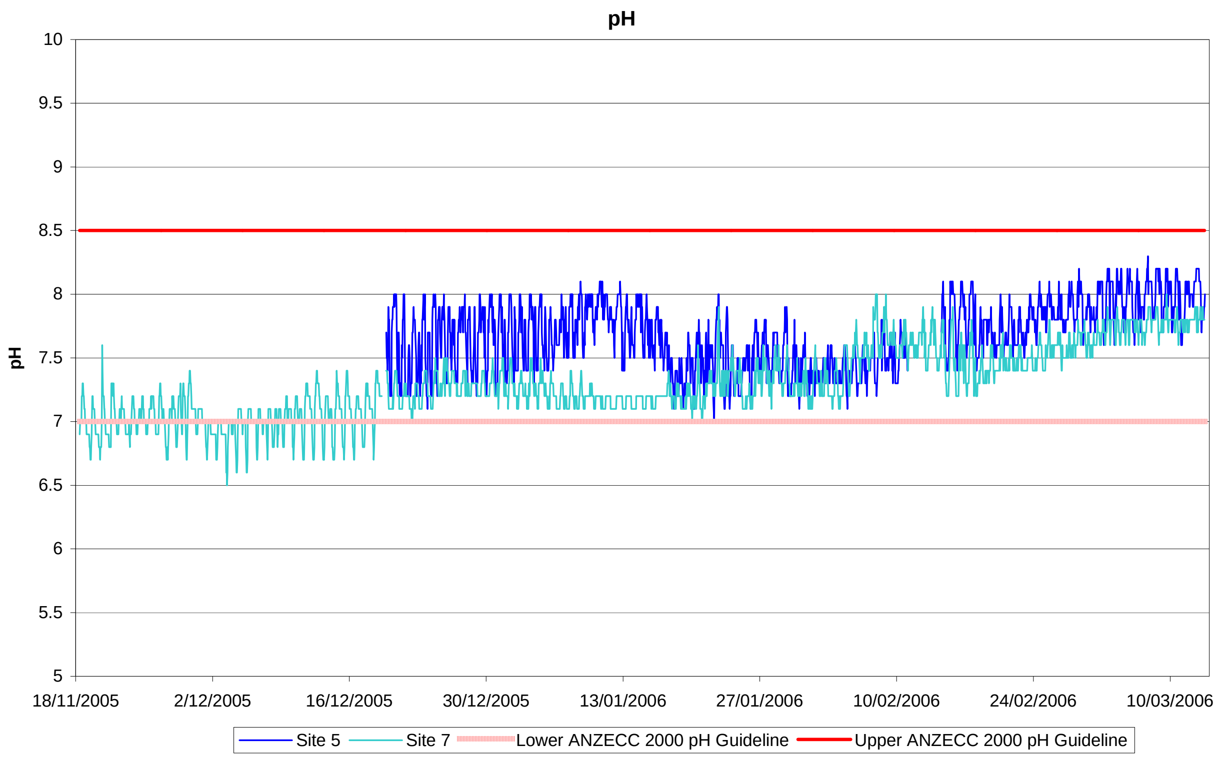

Figure 2-13 pH Concentrations in the BRE (Data source: MHL 2006)

DO concentrations collected by WBM (2005) indicated relatively healthy and oxygenated conditions within the estuary, with levels close to or above full saturation (at 8 mg/L). The Bega Brogo Swimming Hole study also did not identify any problems with DO within the estuary during the monitoring in 2001. The Tathra GC data, however, shows very high (super-saturated) DO levels at sites within Black Ada Swamp, mostly during summer months. It is considered that this reflects the high rates of photosynthesis occurring within the swamp by extensive macroalgae rafts (refer Section 2.6.5). It is hypothesised that the equally high rates of respiration of the macroalgae blooms would result in very low DO levels within Black Ada Swamp overnight and in the early morning period during summer.

2.6.4 Nutrients

Increasing trends in the concentration of TN and TP in runoff associated with the level and intensity of development have been demonstrated by a number of authors (e.g. Baginska et al, 2004). For example, runoff from areas of agricultural and urban development tends to have relatively larger concentrations of TN, TP and TSS than forested areas. Within the BRE catchment, agricultural activities, particularly cattle grazing alongside drainage lines and runoff from paddock areas, are thought to be a major source of faecal material and nutrients (particularly nitrogen) to the waterway (WBM 2005; HRC, 2000).

Samples collected for the Bega Brogo Swimming Hole study were compared with the ANZECC Guidelines for ammonia of 10 µg/L for recreational contact and 15 µg/L for aquatic ecosystems. The concentrations of ammonia were above the ANZECC Guidelines for recreational contact 27 times and above the Guidelines for aquatic ecosystems 22 times in all samples collected (WBM 2005).

The Bega Brogo samples were also compared with the ANZECC Guidelines for aquatic ecosystems for TN, TP and NO_X of 300 µg/L, 30 µg/L, and 15 µg/L, respectively. Concentrations of TN, TP and NO_X were generally found to be below the ANZECC Guidelines except during August 2001. During this month only, TN, TP and NO_X exceeded the ANZECC Guidelines at 3, 4, and 14 sites respectively, suggesting a significant contamination event may have occurred at this time (WBM, 2005).

Higher nutrient values were noted to occur in winter in the Bega Brogo study, however, due the variability in the rainfall patterns across the Bega catchment, this cannot be considered to be typical of the system. Winter may also affect a slower uptake of nutrients by plants and phytoplankton as well as a reduction in sediment and water column nutrient processing and denitrification, all of which generates greater nutrient levels during the winter season (WBM, 2005).

Monitoring of the BRE by BVSC in 1999 / 2000 found concentrations of nutrients were low during the sample period except following heavy rainfall in December. Nutrient levels were above the ANZECC Guidelines for aquatic ecosystems following this rainfall event in Black Ada Swamp, located adjacent to Tathra STP and the land used for effluent irrigation, at the Tathra Country Club Golf Course (WBM 2005). Surface water concentrations of nutrients (ammonia, NO_X, TN, TP and FRP) were all found to exceed the ANZECC Guidelines for monitoring conducted by IGGC prior to the Tathra STP upgrade, in December 2004. Nutrient concentrations reported in August 2005 and May 2006, were lower than the December 2004 results, and while still variously exceeding the ANZECC Guidelines, the number of exceedances was also reduced.

Monitoring in December 2004 was conducted immediately after rainfall, and so the Estuary would have received an influx of nutrients from runoff. The lack of rainfall prior to sampling is reflected in lower nutrient levels in August 2005 and May 2006. There are likely to still be nutrient inputs associated with the irrigation of the Golf Course by treated effluent, which may have significant localised impacts on the adjacent Black Ada Lagoon and Racecourse Creek, whilst the main river body would be expected to receive inputs from sources within the wider catchment (agricultural, rural road network and urban runoff).

Continuation of the IGGC monitoring at Tathra GC by BVSC over the period 2006 – 2010 indicate that nutrients are variable within the lower estuary and backwater swamps, but generally relatively low. The exception to this, however, was the Black Ada Swamp site (SW5), where TN was very high during summer periods, with an overall increase in concentrations (both summer and winter values) across this four year sampling period. TP concentrations were also slightly elevated at this site compared to other sites. Comparable low concentrations of dissolved nutrients (NH_3, NO_x, PO_4) suggest that the high TN is due to organic nitrogen, which most likely would be in the form of macroalgae. High TN and TP concentrations were also observed at SW5 in the previous IGGC monitoring for Aug 05 and May 06. Assessment of the Tathra GC data over the four year period also shows that there is no significant difference in water quality between periods when the entrance is open compared to when the entrance is closed (refer Table C-10, Appendix C).

Nutrients also enter the river from unlicensed discharges, the loads from which are currently unknown (BVSC, 2005a).

2.6.5 Algae

Algae have not been recorded regularly within the estuary. DLWC sampled for chlorophyll-a during a three day monitoring campaign in September 2002, with results indicating a general increase in chlorophyll-a concentrations with distance upstream (refer Figure 2-14). Chlorophyll-a concentrations within the upper half of the estuary typically exceed ANZECC Guideline values.

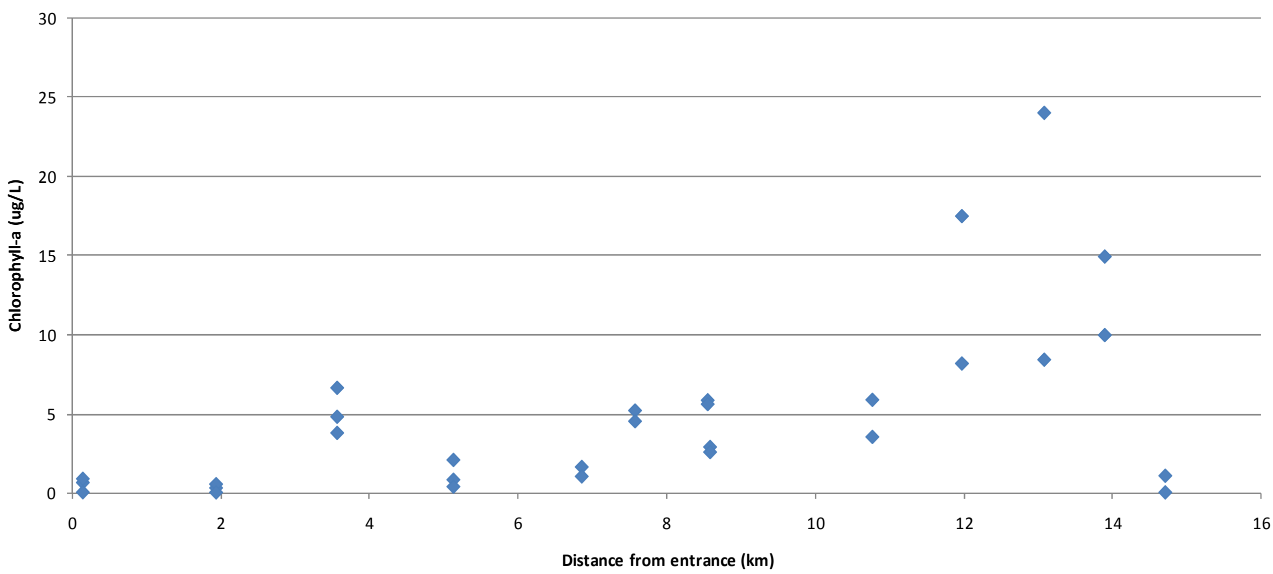

Figure 2-14 Chlorophyll-a concentrations along the estuary in Sept 2002 (DLWC, 2003)

Macroalgae blooms have been reported on a regular basis within the backswamps adjacent to the lower reaches of the estuary, including Racecourse Creek and Mogareeka Wetland. BVSC commissioned a water quality and algal assessment of these backwater areas in 2008 (undertaken by Elgin Associates). The results of this assessment indicate that macroalgae rafts covered approximately 50% of the waterways of Racecourse Creek and Mogareeka Wetland in April 2008, however, the algae was notably absent in July 2008 given the cooler temperatures and reduced sunlight. By December 2008, macroalgae had again established, covering 30% of Racecourse

Creek and 25% of Mogareeka Wetland. The macroalgae, which comprised several floating and attached species (including Enteromorpha, Chaetomorpha, Cladophora and Oscillatoria), were measured up to 1 metre thick in some locations. Low rates of tidal flushing, combined with localised recycling of nutrients from macroalgae into sediments and then back into the water column, are likely to contribute to the perseverance of macroalgae blooms in these locations.

2.6.6 Pathogens

The main source of pathogens in the Bega River is faecal material from effluent discharges from sewage treatment plants, on-site sewage disposal, agricultural activities or stormwater runoff (HRC, 2000). It is noted that there is no stormwater discharge from Tathra to the estuary or any direct stormwater outlets from the urban areas of Bega to the Bega River. The stormwater system at Tathra discharges water through six stormwater outlets directly onto the beach, and not into the BRE. Sediment, litter and debris accumulate near the beach outlets, particularly in holiday periods (BVSC, 2003). Water quality results from sampling conducted in relation to the Tathra STP are discussed further below.

The ANZECC Guideline for primary contact recreation is 150 faecal coliforms per 100mL. Bega Brogo Swimming Hole monitoring indicated faecal coliform concentrations exceeded the ANZECC 2000 Guideline for primary contact on 46 occasions during the 2001 year long sampling period.

Following heavy rainfall in December 1999 concentrations of faecal coliforms collected as part of the BRE monitoring program were above the ANZECC Guidelines for primary contact in Black Ada Swamp (WBM 2005). This is likely sourced from the adjacent Tathra STP and effluent irrigation site and Tathra Golf Course. At other times during the sampling period faecal coliforms levels were low (WBM 2005).

There are three STPs within the BRE subcatchment: Tathra STP (6100 Equivalent Persons (EP) capacity), Bega STP (8000 EP capacity) and Kalaru STP (800 EP capacity). Bega and Tathra STPs have recently undergone upgrades, while Kalaru is a newly commissioned plant. All reclaimed water from Tathra STP is irrigated onto the Tathra Golf Course and the majority of reclaimed water from the Bega and Kalaru STP's is used to irrigate a dairy farm in Bega and the Sapphire Coast Turf Club in Kalaru, respectively. Only a small volume of reclaimed water unable to be beneficially used on the dairy farm in Bega is discharged direct to the Bega River in Bega, predominantly during winter or during wet times. All water treated at the three STPs is disinfected with chlorine and/or ultra violet light. Direct discharges in Bega and any throughflow to groundwater from the irrigation sites in Tathra, Bega and Kalaru to the Bega River potentially adds nutrients (such as phosphorus and nitrogen) to the Bega River, which may stimulate algal blooms.

Pathogens were monitored around Tathra GC by IGGC prior to and after the upgrade of the Tathra STP. Results prior to the STP upgrade in December 2004 showed that FC were present at all sites, and just exceeded the ANZECC Guideline at SW3. Sampling results from August 2005 and May 2006, following the STP upgrade, exceeded the ANZECC Guidelines for enterococci, at SW5 (in Black Ada Swamp) on both dates, and at SW1 (in Black Ada Lagoon) in May 2006. The levels of other indicator bacteria remain at similarly low levels to that reported in December 2004.

Continuation of the IGGC monitoring program by BVSC (2006 – 2010) shows that FC and enterococci have remained mostly below the ANZECC Guidelines, with the exception of one occasion (20/6/07, immediately following 50mm of rainfall), when concentrations were high at all sites. SW5 (in Black Ada Swamp) appears to have a higher typical concentration of FC and enterococci compared to other sites in the lower BRE.

2.6.7 Groundwater Quality

The BVSC engaged IGGC to collect water quality samples from six groundwater bores on the Tathra Country Club Golf Course. As noted in Section 2.6.1, groundwater samples were collected in December 2004 prior to the Tathra STP upgrade to provide background water quality data, and in August 2005 and May 2006 to assess water quality impacts from irrigation of the Golf Course with treated effluent from the upgraded Tathra STP. BVSC has continued this groundwater monitoring at the six sites on a quarterly basis (2006 – 2010).

The STP upgrade involved an improvement in the quality of treated effluent. There have also been major changes to the management of reclaimed water, including:

- lining of the reclaimed water storage pond to stop infiltration of water into the groundwater system;
- use of reclaimed water for irrigation of both the higher and lower halves of the Golf Course, equaling 10 ha each, using automated controls based on the soil moisture deficit; and
- forced irrigation[1] upon the higher half (furthest from Black Ada Swamp and the BRE) of the Golf Course, which is automated to start once the reclaimed water storage pond has reached capacity (IGGC, 2004a).

The direction and speed of groundwater movement below the Tathra Golf Course and Tathra sand dunes will affect the potential for reclaimed water in groundwater to degrade the receiving waters of Black Ada Swamp and the BRE. As outlined in Section 2.3.3, groundwater flows from the recharge mound below the Golf Course into Black Ada Swamp and the BRE, and into the BRE and the ocean from the recharge mound below the Tathra sand dunes (IGGC, 2004a). Periods of high water level in the Estuary generate high groundwater levels. In this case a gradient develops such that groundwater flows from the Golf Course into and through the sand dunes then into the ocean. Clearly, the water quality of the groundwater has implications for the ecology and recreational users of both the Estuary and the ocean adjacent to Tathra Beach.

Groundwater flow velocity was calculated to be between 0.75 and 1.2 m/day below the Golf Course, and 0.5 m/day specifically from the area of forced irrigation (IGGC 2004). Given that the nearest distance from the forced irrigation area to a discharge zone is around 30 m, it would take 60 days for the forced irrigation waters to reach a receiving water body. This calculation does not include the time it takes for the irrigated water to percolate from the surface into the aquifer stream (IGGC, 2004a). Pollutants may be attenuated in the soil zone, thus the quantity of pollutants reaching the Estuary may be reduced from 60 days travel through the water table.

Groundwater samples have been collected from six groundwater bores on and around the Golf Course. The six wells were considered sufficient coverage for the initial assessment, however, IGGC (2004b) noted the selection of groundwater monitoring wells was limited by the small number of bores

[1] Forced irrigation refers to the over irrigation of ground beyond the needs of plants based on the soil moisture deficit (IGGC, 2004a).

available on the Golf Course. In particular, there are currently no monitoring bores on the western side of the main ridge of the Golf Course, and it was suggested that a bore be located in this area in the future (IGGC 2005a).

Groundwater water quality results (both IGGC and BVSC) are compared with the ANZECC Guidelines to provide an indication of its impact upon the receiving waters of Black Ada Swamp and the BRE. All groundwater water quality data is presented in Table C-9 and Table C-11, Appendix C. As shown in these tables, groundwater quality did not vary significantly between periods when the entrance was open compared to periods when the entrance was closed.

2.6.7.1 Physico-chemical parameters

The baseline groundwater monitoring results from December 2004 describe the proximity of bores to the Estuary by the concentration of EC reported. MW35, MW40 and MW44 are relatively fresh, located near the ridge, with EC likely to have been further reduced by recent rainfall. MW25 and MW26 are slightly brackish, describing their closer proximity to the Estuary. MW32 is located closest to the Estuary and receives regular salt water inundation, and as expected, is relatively saline. This spatial distribution of EC is recorded consistently throughout the 2006 – 2010 sampling period.

The pH levels of groundwater bores are quite consistent throughout the monitoring period, at values generally between 7 and 8. DO levels are generally very low and have been similarly consistent for the period 2006 – 2010. The low DO levels are typical of groundwater as it is not exposed to open air and wind conditions, and are not considered to be of concern to the Estuary. The reduction-oxidation potential (Redox) conditions are consistently oxidising below the main ridge (MW40, MW44) and reducing at remaining locations (MW35, MW25, MW26, MW32).

Major ion concentrations are noted to reflect the salinity concentrations measured (i.e. higher ions at sites that have high salinity, viz: high concentrations at MW32, moderate concentrations at MW26 and MW25, and low concentrations at remaining sites). High alkalinity levels across all sites is likely to indicate shell matter in the sediments (IGGC 2005a), which is typical of marine and estuarine sediments. The concentrations of major ions remain consistent across all sampling events (2005 – 2010, including both IGGC and BVSC programs).

2.6.7.2 Nutrients

Nutrients within the groundwater around Tathra GC vary spatially, but a quite consistent temporally, including consistency between the period before and after Tathra STP upgrade. Sites in the ridge (MW44 and MW40) are characterized by high concentrations of TN, with most of the TN comprised of oxidized nitrogen (and little to no ammonia). These sites also have low TP and PO4 concentrations.

In contrast, the lower sites (MW35, MW25, MW26, MW32) all have lower TN, but high Ammonia (Ammonia can represent up to half of the TN). The lower sites also have higher TP and PO4, with the majority of TP in dissolved form. IGGC (2004b) comments that the elevated nutrient levels likely reflect agricultural land use, particularly use of fertilisers on the site and reclaimed water reuse.

2.6.7.3 Pathogens

The IGGC data and follow-on BVSC data indicate that Faecal Coliforms and E. Coli are not problematic within the groundwater surrounding Tathra GC. The very occasional high value for pathogens within an isolated sample (eg August 2005 at MW32, or March 2007 at MW26) is likely be related to localized factors, such as the large number of kangaroos and birds which live in this area, rather than from irrigation of the Golf Course (IGGC, 2004b).

2.6.8 Discussion of Water Quality

The major findings of water quality monitoring and analyses are:

- Salinity / EC vary considerably in response to freshwater runoff events and tidal flushing. Monitoring by MHL (2006) shows that the recovery of salt within the estuary occurs over a period of weeks following catchment runoff. Monitoring by WBM in 2005, DLWC in 2002, MHL in 2001 and BVSC in 2006 showed that recovery occurs as a wedge of saltwater, with salinity concentrations increasing with water depth, and decreasing with distance upstream. Isolated deep holes within the Estuary may also retain saline water during small freshwater events, but are likely to be completely flushed out during major floods. The large variation in salinity is typical of estuarine conditions.
- Elevated concentrations of sediment, nutrients, bacteria / pathogens and other pollutants are recorded during and immediately after rainfall and catchment runoff conditions (WBM, 2005, IGGC 2004, BVSC 2006-10). Water quality within the lower reaches of the BRE may recover to background levels within 24 to 48 hours of the rainfall event (WBM 2005).
- Land use and water quality in adjacent streams is clearly linked, as illustrated in the Turner *et al* (1998) study. This study showed that turbidity, EC and nutrient concentration in streams adjacent to dairy farming, and to a slightly lesser extent grazing practices, was greater than those in streams within native forest.
- The link between land use and adjacent water quality was also illustrated by the results of the BRE monitoring study. Locations adjacent to STPs and on-site septic systems were found to contain high concentrations of nutrients and faecal coliforms, such as Black Ada Swamp located next to the Tathra STP and exfiltration site, and Mogareeka Inlet which frequently receives discharges of high in ammonia from nearby septic systems (WBM 2005).
- Backswamp areas where flushing and water movement is restricted are prone to poor water quality (WBM 2005). Unfortunately, such areas also tend to be those closest to a number of contamination sources, such as Black Ada Swamp (Tathra STP), Blackfellows Lagoon and Mogareeka Inlet (Septic Tanks). These backswamp areas therefore are prone to macroalgae blooms, which can dominate during warmer summer months, covering up to 50% of the waterway areas (Elgin, 2008).
- Monitoring within the lower estuary, around Tathra GC, shows that water quality within the estuary does not change significantly as a direct consequence of entrance closure.
- Groundwater monitoring data indicated that irrigation of the Golf Course with treated effluent from the STP has not had a significant impact upon the groundwater environment and subsequently the receiving water environment of the BRE. All groundwater quality results remained very consistent with time, and have not changed as a result of the STP upgrade.

2.7 Ecology

2.7.1 Habitat Health

An assessment of the riverine habitat of the Bega River and catchment *upstream* of the Estuary was undertaken by DLWC (1998). The assessment concluded that two thirds of the total stream length was in moderate to good condition, with no sections of the river system found to be in very good overall condition (DLWC, 1998). The diversity of channel habitats of the Bega River was rated moderate to very poor, caused by the low flow conditions and sediment deposition along many stream sections (DLWC, 1998). Grazing was found to be the most common riparian disturbance, and 32% of sites showed evidence of water extraction (DLWC 1998).

The DLWC (1998) assessment surveyed only one site within the BRE, at the western end of the estuary. Overall the condition of the survey site was very poor. The stream bank, bed and bars were aggraded heavily with sand, resulting in shallow flows and poor channel shape (DLWC 1998). Subsequently, aquatic vegetation and diversity was restricted, and there was little availability for the establishment of new aquatic plants (DLWC 1998). Riparian vegetation was also in very poor condition, with a width of 5-10 m and minimal species diversity and structure reported (DLWC 1998).

The habitat health downstream of Jellat Jellat would be classed as moderate to good, with some areas pristine. The vast majority of riparian vegetation communities on either side of the river are intact and in some cases are untouched. On the northern side of the river in particular there is continuous vegetation cover fronting the river bank, through the various private properties to the adjacent Tanja State Forest and Mimosa Rocks National Park. The major exception to this is the Tathra River Estate western peninsula, which has been extensively cleared and farmed for a long period of time.

There are numerous sand shoals within the estuary, some being vegetated. These sand shoals can provide excellent habitat or foraging ground for a range of avifauna. Within the lower part of the estuary there are extensive seagrass beds, wetland areas and saltmarsh communities.

2.7.2 Aquatic Flora

Seagrasses and wetlands are vital habitats within the estuary, providing the major source of detritus that comprises the basis of the estuarine food chain, and providing food and shelter for juvenile fish and invertebrates (NSW Fisheries 2001). Seagrasses also trap sediments providing some protection to substrate from wave-induced erosion (NSW Fisheries 2001). Unfortunately seagrass beds also tend to be sensitive and adapt poorly to changes in their environments.

The distribution of aquatic vegetation within the Bega River is patchy, particularly submerged and floating species (DLWC, 1998; West & Jones, 2001). This is thought most likely to be due to the high level of disturbance in the catchment area (West & Jones, 2001) and large sediment loads along the middle and lowland reaches (DLWC, 1998).

Seagrass and saltmarsh areas were mapped in May 2006 or the Comprehensive Coastal Assessment by the Department of Primary Industries (Williams, et al. 2006). Seagrass and saltmarsh areas within the BRE are shown in Figure B-11, Appendix B. The DPI (2006) mapping identified a total of 0.53 km^2 of saltmarsh and 0.26 km^2 of *Zostera* seagrass in the BRE. This is consistent with

BRE saltmarsh and seagrass estimates by West & Jones (2001), of 0.4 km^2 and 0.3 km^2, respectively. Coastal saltmarsh is listed as an endangered ecological community in the south east bioregion under the Threatened Species Conservation Act.

Aquatic vegetation, wetland or intertidal species noted in the BRE includes: *Zostera capricorni* seagrass; *Sarcocornia quinqueflora* (Samphire) and *Sporobolus virginicus* (Salt Couch) saltmarsh species; and rush species such as *Juncus kraussii* (Sea Rush), *Baumea juncea* (Slender Twig Rush), *Phragmites australis* (Common Reed), *Samolus repens* and *Lobelia alata* (SKM 1997). The most common aquatic plants are emergent species including rushes (*Juncus* species) and sedges (*Cyperus* species), while algae were identified at 24% of sites surveyed (DLWC, 1998).

There are no significant stands of mangroves recorded within the BRE, with only isolated pockets of mangroves identified in Mogareeka Inlet (pers.comm., Darren O'Connell, DNR 2006). The lack of substantial mangrove communities in the Bega River is the result of the predominantly closed entrance conditions of the Estuary.

In addition to providing important food and shelter for fish and invertebrate species, wetlands also maintain estuarine water quality by acting as filters to trap sediments and contaminants and by absorbing nutrients (NSW Fisheries 2001). Commercial fishers have observed a constraint in fish harvests in line with the loss of wetland areas in NSW, which is estimated at 60% in the 200 years since European Settlement (Fisheries Research Institute 1996). While areas of BRE foreshore wetlands are zoned as Environment Protection Zones under the BVSC LEP, this zoning does not prohibit grazing in wetland areas (DIPNR 2004). The Integrated Bega River Health Package aims to fence and manage 100 wetlands on farm land (DIPNR 2004). The removal of grazing pressure (through minor fencing programs for example) has been shown to result in rapid recovery of wetland vegetation and condition.

The floodplain wetlands of the lower Bega River collectively comprise a large complex of about 100 wetlands. There are 25 SEPP 14 wetlands within the entire Bega River catchment, of which 19 occur in the Bega River Estuary, as shown in Figure B-12, Appendix B. SEPP 14 Wetlands that drain into the Estuary include Black Ada Swamp, Horseshoe Lagoon and Penooka Swamp (PWD 1993). Areas around these swamps are known to have high salinity and frequent flood inundation, with grazing by cattle only possible during dry periods (PWD 1993).

Black Ada Swamp (Racecourse Creek) comprises the following vegetation units (SKM 1997), which may be indicative of vegetation in other BRE wetlands:

- Tidal inlet, consisting of *Zostera capricorni* seagrass;
- Shallow ponds, containing no vegetation due to their shallow depths (< 0.5 m) and high salinity;
- *Sarcoconia – Sporobolus* Herbland, containing small patches of low (< 0.2 m) saltmarsh vegetation;
- *Juncus – Baumea* Rushland in low saline areas experiencing infrequent water logging, and reaching heights of 0.5 – 1 m;
- *Juncus – Baumea – Phragmites* Rushland, similar to above but co-dominated by *Phragmites australis*, which is a freshwater species tolerating low salinity and water-logging in this location and subsequently showing stunted growth (1 – 1.5 m heights);

- *Phragmites* Reedland, containing a monotype of 2 – 2.5 m *Phragmites australis* in good conditions, indicating dominantly freshwater conditions;
- *Melaleuca* Scrub, containing monotypic stands of *Melaleuca ericifolia* (Heath-leaved Paperbark); and
- *Banksia* Scrub, dominantly *Banksia integrifolia* (Coast Banksia), with lesser presence of *Acacia Longifolia* (Sydney Golden Wattle) and *Monotoca elliptica* (Tree-Broom-heath), and an understory of smaller native shrubs (mostly *Rhagodia candolleana* (Coastal Saltbush)), grasses, herbs and weeds (mostly *Myrsiphyllum asparagoides* (Florists Smilax)).

The Directory of Important Wetlands in Australia includes Nunnock Swamp and Bega Swamp, which are located in the Bega River Catchment, but not within the BRE subcatchment (DEH 2006). Nunnock and Bega swamps are inland wetlands, located in the uplands above 900 m ASL and within the Bemboka River subcatchment. Variously, these wetlands were included in the Directory because: it is a good example of a wetland type particular to their biogeographical region (Nunnock and Bega Swamps); it has habitats or species which are nationally endangered or vulnerable (Nunnock Swamp); it has outstanding historical or cultural significance (Bega Swamp); it has important hydrological and ecological roles in a wetland system complex (Nunnock Swamp); and it supports a species at a vulnerable life cycle stage and provides refuge to species during drought periods (Nunnock Swamp) (DEH 2006).

Green (1999) identified 2,597 ha of wetlands in the Bega Valley, and classified this into four major types based on location: estuarine, occurring within the tidal reaches of the River (209 ha); floodplain (713 ha); upper pluvial, defined by its green appearance and small size; and upper phreatic, noted by the well defined change in vegetation between an upper phreatic wetland and its surrounds. Upper pluvial and upper phreatic wetlands combined cover 1674 ha. A majority of both flood plain and upper pluvial wetlands have been highly modified by the extensive clearing of native vegetation and grazing, the degradation of ground storey communities by exotic weeds and grass species, and poor water quality resulting from runoff containing sediment, fertilisers, pesticides and cattle faeces (Green, 1999).

The current river regulation at Cochrane and Brogo Dams and extraction on unregulated rivers is not thought to be significantly affecting the large flows required to fill floodplain wetlands (Green 1999). However channelisation, flood plain structures and water extraction may be restricting some degree of flow to other wetlands (Green 1999) and HRC (2000) recommended water extraction from the wetlands be controlled.

2.7.3 Riparian Vegetation

Riparian vegetation is very important to river habitat health as it provides protection from bank erosion and changes to stream behaviour by stabilising banks, habitat and refuge for fish and invertebrates, shade from light penetration, and inputs of organic carbon to the river from leaf and twig litter (BVSC, 2004b).

Riparian vegetation upstream of the estuary mostly consists of eucalypt/apple, tree acacia, shrub acacia, casuarina, lomandra and tea tree (DLWC, 1998). Infestation by weeds is evident throughout most of the riparian zone, and includes species such as willows, blackberries, herbs and grasses (DLWC 1998), “basket willow” (Brooks, 1994), perennial ragweed, groundcover plants such as Blue

Periwinkle, and climbing vines including Cape Ivy (DLWC, 1999a). Additional weeds requiring attention include Paddys Lucerne, Turkey Rhubarb, African Lovegrass, Prickly Pear and Bitou Bush.

Along the Bega River, the condition of the riparian vegetation is best in the relatively untouched upper reaches of the river and poor in the middle section (above the estuary), where European settlement has had the most impact (HRC, 2000). The restoration of riparian vegetation was a key objective for the health of the river corridor recommended for the majority of rivers and streams in the Bega Valley Catchment (HRC, 2000).

High priority activities such as weeding and revegetation of riparian areas are being carried out by community groups (BVSC, 2004b). The BVSC has also incorporated management of riparian areas into zoning objectives in the Local Environment Plan (LEP), such as provisions under rural zoning for the protection and proper use of rivers and riparian corridors (BVSC, 2004b). Some regeneration of riparian vegetation has been observed in areas that were once accessible to livestock but are now fenced off (Miles, 2000).

Along the BRE, the steep valley sides and relative inaccessibility has assisted in preserving natural riparian vegetation for a significant component of the foreshore (particularly along the northern bank). Degraded foreshores, where riparian vegetation has been cleared or significantly denuded, is largely restricted to the frontage of the Tathra River Estate, and private lands near the entrance to Blackfellows Lagoon (refer Figure B-13, Appendix A). Floodplains around Jellat Jellat Flats and upstream have a thin riparian vegetation corridor (comprising one or two trees only), which would have limited value from an ecological perspective or for bank erosion mitigation.

2.7.4 Terrestrial Flora

Of the 187 vegetative communities within the Bega Valley, there are 12 communities listed as Endangered Ecological Communities under the NSW Threatened Species Conservation Act (1995). These communities are poorly represented within the National Park Estate and have generally been significantly impacted by agricultural and development pressures since settlement. Miles (2006) lists Lowland Grassy Woodland (formerly Bega Dry Grass and Candelo Dry Grass Forest), Brogo Wet Vine Forest, Dry Rainforest of the south east forests, River-flat Eucalypt Forest on Coastal Floodplains, Swamp Oak Floodplain Forest, Freshwater Wetlands on Coastal Floodplains, Coastal Saltmarsh, Littoral Rainforest, Themeda Grassland on Seacliffs and Coastal Headlands, Bangalay Sand Forest, Montane Peatlands and Swamps and Swamp Schlerophyll Forest on Coastal Floodplains. Several of these communities occur within the BRE with Coastal Saltmarsh, Littoral Rainforest, Swamp Oak Forest and Freshwater Wetlands on Coastal Floodplains being particularly significant.

Preliminary mapping of terrestrial vegetation around the river entrance shows areas of coastal gully shrub forest to the north of the river entrance and dune scrub along Tathra Beach to the south of the river entrance (Dilworth, in prep.). Further investigations into the diversity, extent and health of vegetation within the estuary, would be of great value. Recent vegetation surveys (Peel 2007, unpublished) have identified pockets of Littoral rainforest on the northern side of the estuary. Littoral rainforest is listed under the Commonwealth EPBC Act.

Terrestrial weed species noted in the Bega Valley include Fireweed, African Love Grass, Hawthorn, Privet, Cotoneaster, African Boxthorn, African Scurf-pea and Milkwort, and vines and groundcovers such as the Wandering Jew, Periwinkle, Moth Plant, Bridal Veil, Honey Suckle and Cape Ivy (Bournda Field Studies Centre, 1997).

Of particular concern in the BRE are Bitou Bush, Bridal Creeper, Fireweed and Prickly Pear. Coastal Sea Spurge is present at the entrance, but is well controlled.

2.7.5 Aquatic Fauna

A literature study by AWT (1997) revealed that 21 fish, 18 amphibians, 1 tortoise, 14 water-associated reptiles and 3 aquatic mammal species occur in the Bega River catchment. The Eastern Long Neck Tortoise and the Platypus have been observed throughout the river system, and several threatened or vulnerable frogs are also expected to occur in the catchment (HRC, 2000).

2.7.5.1 Fish Species

Fish populations in the BRE are relatively high considering the small size of the catchment and environmental stresses, however, the diversity of fish species varies throughout the river system (HRC, 2000). Environmental stresses on fish include sedimentation, catchment clearing and changes in hydrology (DIPNR 2004; HRC, 2000). Commercial fishing is no longer permitted in the BRE, with the Estuary declared a Recreational Fishing Haven in May 2002, in part to provide greater protection for fish habitats (DIPNR 2004). Two species of threatened fish are known to occur in the BRE (HRC, 2000).

Many fish species spend only part of their life cycle in the BRE and although local fish have adapted to the entrance conditions, they are still affected by other connectivity issues (HRC, 2000). The passage of fish is impeded at several points within the Bega river system, in particular, at Brogo Dam, Cochrane Dam, when the temporary sand barrage is in place at Jellat Jellat Flats (HRC, 2000) and by the weir at Russell's Creek. Fish passage is also prevented when streams and rivers have insufficient water to flow or are completely dry. Allowances for environmental flows could mitigate this impact, however, occasional low flows occur naturally and may give native fish an advantage over introduced fish that are not adapted to this condition (HRC, 2000).

Fish species identified in the entrance to the Bega River between February and July 1999 by West & Jones (2001), and throughout the river by AWT (1997) are shown in Table D-1, Appendix D. Data collected by the Fisheries Research Institute (1995) indicates the most dominant fish species caught has varied over time. The total estuarine production of the Bega River for the 1991-1992 fiscal year, as recorded by NSW Fisheries (1995), is provided in Table D-2, Appendix D. This table lists all species recorded in the Estuary at any time between 1954 and 1992, even if not caught in the 1991-92 period, to provide a guide to those fish species that may exist in the Estuary from time to time.

2.7.5.2 Macroinvertebrates

Macroinvertebrates are sensitive to different chemical and physical conditions. As such, they can be used as an indicator of the water quality and level of disturbance at a site. Data on macroinvertebrate species in the BRE is limited to commercial catch statistics for crustaceans listed by Fisheries Research Institute (1995), of which significant numbers, primarily of prawns, were caught during 1995. In addition, the BRE has the most southerly distribution of the Queensland Mud Crab, *Scyllis spp*. (*pers.comm*. Darren O'Connell, DNR, 2006).

2.7.6 Terrestrial Fauna

2.7.6.1 Avifauna

The Estuary is used by many bird species to gather food, rest and breed (DIPNR 2004), and is an important nesting site for shorebirds. The Estuary is home to Glossy Black Cockatoos, listed as endangered under the *Threatened Species Conservation Act (1995)*, and White-bellied Sea-eagles, which use the upper reaches of the Estuary to hunt and rear fledglings (DIPNR 2004). The Estuary is also home to bird species listed under the Japan Australia Migrating Birds Agreement (JAMBA) (HRC, 2000).

Shorebird nesting sites are concentrated in the sand shoals at the Bega River mouth (DIPNR 2004). Species found here include the Little Tern and Hooded Plover, listed as endangered under the *Threatened Species Conservation Act (1995)* and Sooty Oystercatcher and Pied Oystercatcher, listed as vulnerable under the Act, refer Figure B-14, Appendix B. White-faced Herons and Silver Gulls also use the river mouth as a resting place (Kinred, 2003; HRC 2000).

There are a number of anthropogenic and natural threats to the survival of shorebirds in the BRE. Human disturbance was identified as a key threat to shorebird survival (HRC 2000), particularly the use of jet skis and other motorised personal water craft. Nests, eggs and fledglings have been destroyed by king tides and storm surges overtopping the berm, as well as predation by foxes and crows.

Inappropriate development in the catchment has the potential to impact on species dependent on the estuary for foraging and habitat, through degradation of the estuary resulting from sediment, nutrient or chemical pollutants.

To protect and monitor shorebird species, the National Parks and Wildlife Service initiated the South Coast Shorebird Recovery Program (2001-present) and the Far South Coast Region Little Tern Recovery Program (1999-2001).

2.7.6.2 Other Fauna

Little data is available on other faunal species occurring in the BRE. Species identified from threatened fauna lists (refer Section 2.7.7) include the green and golden bell frog, koala, eastern bentwing bat, spotted-tailed quoll, long-nose potoroo, yellow-bellied glider, southern brown bandicoot, white-footed dunnart, brush-tailed phascogale, eastern pigmy possum, grey-headed flying fox, large-footed myotis, eastern false pipistrelle, and greater broad-nosed bat.

2.7.7 Threatened Species

There are 35 plant species, 70 vertebrate species and one invertebrate species recorded in the Bega Valley Shire listed as vulnerable or endangered in NSW under the *Threatened Species Conservation Act (1995)* or Australia under the *Environment Protection and Biodiversity Conservation Act (1999)* (BVSC, 2004b). Data on native species in Bega is not comprehensive and it is predicted that an additional 25 threatened plant and animal species occur in the shire (BVSC, 2004b).

The location of threatened flora species in the entire Bega River catchment is presented in Figure B-15, Appendix B, with a list of all species in Table D-3, Appendix D. The locations tend to be small, isolated pockets some distance from the nearest urban settlement, of which none are known to occur directly within the BRE. There are, however, a number of estuarine vegetation communities in the BRE which are listed as endangered ecological communities under the *Threatened Species Conservation Act (1995)* namely Coastal Saltmarsh, Swamp Oak Forests and Littoral Rainforest.

Threatened fauna are spread throughout the catchment but are most concentrated along the east and west catchment boundary, with 36 of the 71 threatened and endangered fauna species found near the Tathra peninsula or at Mogareeka (ERM, 2005). Threatened fauna within the entire catchment and also specifically within the BRE are shown in Figure B-14, Appendix B, with all species shown listed in Table D-4, Appendix D.

The Stuttering Frog, classified as vulnerable, and the Green and Golden Bell Frog, classified as endangered under the *Threatened Species Conservation Act 1995*, have been identified in the BRE (AWT, 1997).

The Koala population, protected under SEPP 44, is concentrated in sections of the Bega Dry Grass Forest and Candelo Dry Grass Forest ecosystems. In both ecosystems the dominant eucalypt, Forest Red Gum (*Eucalyptus tereticornis*) is believed to be the major food source for local Koalas. The decline in numbers of Koalas in the Bega Valley has been linked to the degradation of these ecosystems (Cunningham 1999).

As discussed previously, BRE is an important habitat for the endangered Little Tern, Hooded Plover and the vulnerable Pied and Sooty Oyster Catcher. The forested corridor between Tathra and Tathra River Estate is home to populations of the Yellow Bellied Glider. Other observed threatened species include local recordings of Glossy Black Cockatoos, and Powerful and Sooty Owls around Black Fellows Lake (pers. comm. D McPhee).

2.8 Human Uses and Demands on the Estuary

2.8.1 Aboriginal Heritage

The Djiringanj, Thaua, Bidawahal and Ngarigo peoples, known collectively as the Yuin–Monaro nation, resided on the land that is now known as the Bega Valley Shire (BVSC, 2000). Aboriginal sites throughout the Shire demonstrate indigenous occupation for over 6,000 years (BVSC, 2004a).

The Aboriginal community used the BRE and its surrounds as a place to live, gather food and occasionally to hold ceremonies (HRC, 2000). The river and tributaries were in some cases used to delineate clan areas.

The BVSC has a protocol for consultation with the Local Aboriginal Land Councils for development proposals (BVSC, 2005a). The DLWC proposed increased involvement of Aboriginal communities in natural resource management, particularly water and vegetation issues (DLWC, 1999). BVSC has recently formed a shire wide Coastal Planning and Management Committee, which has representation from each of the three Local Aboriginal Land Councils that cover the Shire.

Bega Valley Shire Council is currently undertaking an Aboriginal Heritage Study which will provide valuable information as the location of the archaeological sites within the estuary.

2.8.2 European Heritage

George Bass was the first to explore the Bega River and the southern NSW coastline on an exploration trip from Sydney to the Bass Strait in 1797 (Kidd, 1978). The first European settlers arrived in the Bega Valley during the 1830's when William Tarlinton, followed by the Imlay brothers, settled and began farming cattle, initiating the beef industry in the Bega Valley (BVSC, 2000). Twofold Bay was used to export live cattle and became the site of a whaling station operated by Benjamin Boyd in 1843 (PWD, 1980).

Dairy farming began in the region during 1848. During the 1860's the population of the Bega Valley increased significantly as did the practice of dairy farming in the area (Brooks, 1994). The population of the Bega Valley continued to grow throughout the late 1800's on the strength of the dairy and beef industries (BVSC, 2000). The Bega Dairy Cooperative Limited was formed in the late 1800's and continues to operate, receiving milk from approximately 100 farms, with around 80 of those being in the Bega River Catchment in the Bega Valley.

The long history of the Bega Valley Shire has resulted in 304 places listed on heritage registers, including the Tathra Wharf, built in 1862 (BVSC, 2004b). Prior to the development of the Princes Highway the Tathra Wharf was a vital link to the outside world for the exporting and importing of produce and other goods and travel to the major centres such as Sydney. The Bega River has played a key role in the development of the Bega Valley through provision of water for irrigation, stock water and urban water supplies.

2.8.3 Land Use

The major industries within the Bega River Catchment are agriculture (dairy and beef) and tourism, with forestry operations occurring in the remaining areas of State Forest. (see Figure B-17, Appendix B). Bega is well known for its cheese produce and the majority of agriculture in the catchment consists of dairy farming, with some 80 operating dairies and 30,000 head of dairy cows. The Bega Valley's long agricultural history has seen the majority of the catchments lower slopes and valleys (Wolumla, Candelo, Bemboka and Brogo) heavily cleared, with little remnant vegetation remaining.

Within the immediate catchment the majority of the land is under forest cover within various tenures (including National Park, State Forest, public reserve or private land). The upper reaches of the estuary catchment in the Jellat, Kalaru and Penooka Swamp areas have been heavily cleared for agriculture, primarily dairy farming or fodder production.

Prior to its declaration as a Recreational Fishing Haven in 2002 (DIPNR 2004), the Bega River supported local professional fisherman, who supplied both local and Sydney markets.

2.8.3.1 Development within the estuary

<u>*Kalaru*</u>

Between Jellat and Blackfellows Lagoon there are areas of rural residential development along the southern side of the river, which have resulted in varying levels of clearing of the existing forest. In recent years clearing requirements for new development have increased as a result of changes to the Rural Fires Act and related bushfire development requirements. Whilst the village of Kalaru is within the catchment of the estuary, it has no formal stormwater system and any runoff from Kalaru, must pass through vegetated creeks, paddocks and the Penooka Swamp wetlands and Jellat Creek before reaching the Bega River. As such, stormwater run-off from Kalaru is not seen as a major threat to the health of the estuary at this stage.

Mogareeka

The village of Mogareeka on the northern side of the estuary entrance area, currently has 40 dwellings, with approximately 6 vacant lots. The village is unsewered and as such the maintenance of existing septic systems is of vital importance in protecting the health of Mogareeka Inlet.

Tathra River Estate

Urban development is currently a minor landuse in the catchment but presents a significant and growing threat to the health of the Estuary (HRC, 2000). The Tathra River Estate (TRE) located inland of Tathra village adjacent to the BRE, shown in Figure 2-15, has been the only major new urban development. Stage 1 of the development comprised 60 rural residential allotments (HRC, 2000). Stage 2 of the development was for 60 lots but was subsequently the subject of a Major Project Application to the NSW Department of Planning. At the time of writing, the Major Project Application had been withdrawn by the proponents of the development.

As part of the draft Tathra Structure Report, the capacity of the Tathra STP is being investigated. Given that the current holiday population demand is barely covered by the recent STP upgrade, it is unlikely that the addition of dwellings from future urban development would enable the STP to continue to effectively process effluent until 2022 without a further upgrade. In addition, the area of land available to dispose of the treated effluent is currently insufficient to accommodate a further upgrade of the STP (pers. comm., David Searle 2004).

2.8.3.2 State Forests and National Parks

State Forests encompass 33% of the Bega Valley Shire (BVSC, 2000) but only 4% of the Bega River Catchment (HRC, 2000). Glenbog, Mumbulla, Tanja and Tantawangalo State Forests (SF) all have land within the Bega River Catchment, but only Tanja SF has land in the BRE subcatchments as shown in Figure B-16, Appendix B.

National Parks (NPs) within the entire Bega catchment include Mimosa Rocks, Bournda, Biamanga, Wadbilliga and South East Forest NPs shown in Figure B-16, Appendix B. Bournda and Mimosa Rocks NPs flank the BRE on its southern and northern sides, refer Figure B-16.

The Eden Regional Forest Agreement (RFA) was established in 1999 as a 20-year agreement between State and Federal governments to protect environmental values in national parks and other reserves, and manage all native forests in an ecologically sustainable way, whilst encouraging growth in forest-based industries, tourism and minerals industries (DAFF, 2004). Most of the Bega Valley is included in the Eden RFA (Gillespie Economics, 1997), with the protection of the Bega Wet Shrub Forest, Bega Dry Grass Forest and Candelo Dry Grass Forest ecosystems given high priority.

Figure 2-15 Location of Tathra River Estate

2.8.3.3 Contaminated Sites

There are 15 potentially contaminated sites within the Bega River catchment including a garbage depot and nightsoil depot at Tathra in the BRE, as described in Table 2-3 (BVSC, 2004b). Other as yet unidentified contaminated sites may also exist in the area (BVSC, 2004b).

Landfill sites exist at Candelo, Bemboka, Bega and Tathra (Resource Allocation 1996). Leachate generated from these sites can infiltrate groundwater or surface water (as rainfall runoff). Landfill leachate typically contains high concentrations of ammonia, turbidity and biochemical oxygen demand, which can pollute receiving waters, potentially causing algal blooms and fish kills.

Table 2-3 Contaminated Sites in the Bega River Catchment

Location	Type of site
Angledale	Nightsoil Depot
Angledale	Garbage Depot
Bega	Garbage Depot
Bega	Gasworks Site
Bemboka	Garbage Depot
Bemboka	Garbage Depot
Bemboka	Nightsoil Depot
Bemboka	Nightsoil Depot
Candelo	Rubbish Depot
Candelo	Nightsoil and Garbage Depot
North Bega	Nightsoil Depot
North Bega	Nightsoil Depot
Tathra	Nightsoil and Garbage Depot
Tathra	Garbage Depot
Wolumla	Rubbish Depot

2.8.4 Recreational Usage

The diverse range and quality of environments within the Bega River Estuary make it a popular recreational destination offering a range of passive and active recreation opportunities. Recreation within the estuary is focussed in the Mogareeka area, which is a popular location for swimming, boating and fishing. The Mogareeka boat ramp and recently installed floating pontoon jetty are the primary boating facilities on the Bega River Estuary and are heavily patronised by fisherman and waterskiers. The Mogareeka area is also popular with other recreational watercraft such as canoes, kayaks and windsurfers.

Facilities such as barbeques, a playground and amenities are also located at the Inlet, making it a popular picnic spot (BVSC 2006). The Bega River is also a popular location for fishing (recreational fishing is discussed in Section 2.8.4.1). There is also a small earthen ramp on the southern edge of Blackfellows Lake, which is popular for small recreational boats, canoes and kayaks.

The major recreational facility within the BRE is the Tathra Beach Country Club (TBCC). The TBCC incorporates a 13 hole golf course, tennis courts, sporting fields, clubhouse and restaurant. The golf course is located between the Black Ada Lagoon, Black Ada Swamp / Racecourse Creek and the Bega River. Low lying sections of the golf course are subject to inundation during periods of entrance closure and can result in the closure of 3 holes for lengthy periods of time.

Tathra Beach is a popular swimming, surfing and fishing location, and has the only remaining beach wharf on the South East Coast, namely Tathra Wharf. Sightings of dolphins, fur seals and fairy penguins are known to occur at Tathra Wharf and the area is frequented by scuba divers and snorkellers (BVSC 2006). Kianinny Bay has a boat ramp which provides access to the ocean for boats, particularly for recreational fishing.

Recreational activities associated with National Park and State Forest areas within the catchment include picnicking, fishing, swimming, mountain biking, bushwalking, scenic drives and camping (Gillespie Economics, 1997; BVSC, 2006).

2.8.4.1 Recreational Fishing

Recreational fishing is permitted in the BRE, and off Tathra Beach. Tathra Beach is a popular location for beach and rock fishing, and game fishing and reef fishing enthusiasts access the ocean via the boat ramp at Kianinny Bay. The Bega River is a popular fishing spot, with access within the Estuary via the boat ramp at Mogareeka and an unformed boatramp in Blackfellows Lagoon. Recreational fishing occurs throughout the year for a variety of species including Blackfin, Yellowfin, Bream, Dusky Flathead, Jewfish, Whiting, Mullet, Tailor, Estuary Perch, Bass and Luderick (BVSC, 2006). Bait fishing within the river includes netting for prawns, pumping for nippers and bloodworms and catching poddy mullet (BVSC, 2006).

As stated previously, commercial fishing is no longer permitted in the BRE, since its declaration as a recreational fishing haven in 2002.

2.8.5 Tourism

Fishing and scenery are some of the key attractions of the BRE to tourists (BVSC, 2006). Over 1995/1996, Tourism NSW estimated there were 750,000 visitors to the Bega Valley, staying for 4 nights on average and spending $183,000,000 (Gillespie Economics, 1997).

The BVSC website (2006) lists 190 accommodation providers, 106 attractions, and 32 food (café and restaurant) providers and 24 shopping outlets for tourist visitors to the area. Apart from recreational activities, the Bega Shire offers visitors access to historical sites and tours, cruises and cultural tours, cheese and wine producers and outlets, and local art and craft galleries.

Due to its coastal location, Tathra is the fishing, recreation and tourism centre of the Bega River Catchment (HRC, 2000). The population of the coastal Tathra village increases by 70% during peak tourist season (BVSC, 2005a). Other towns within the catchment experience smaller population increases during the holiday seasons. The economies of coastal towns in the Bega Valley such as Tathra have become increasingly dependent on tourism.

The recent inclusion of the Bega Valley Shire Coastline in the “Wilderness Coast” by Tourism Australia, has reinforced the importance of the protection of areas such as the Bega River Estuary. The natural qualities of the local coastal zone have the potential to provide a distinct marketing advantage to the local tourism industry.

2.9 Anthropogenic Impacts on Estuarine Processes

Since European settlement, agriculture has been the major economic activity in the Bega River catchment, providing employment and prosperity for the population. The effects of European activities include:

- Widespread clearing of native vegetation for agriculture (particularly dairying) and forestry (however this trend has been reversed through current revegetation programs);
- Increased sediment loads in runoff from cleared and eroded lands, causing increased turbidity in waterways and the widening and shoaling of channels;
- Erosion and instability of stream channels, from reduced riparian vegetation and trampling by grazing cattle;

- Introduction of exotic floral species, and domestic pet and farm species;
- Weed species out-competing native vegetation, especially willows in riparian zones;
- Alteration of bushfire regimes, reducing the ability of native species to compete with weeds, and ecological abundance and diversity;
- Reduction in streamflow due to water extraction, which diminishes water quality, bird and fish habitats, and fish passage;
- Increased pathogens and nutrients in waterways sourced from fertilisers and animal faeces in agricultural runoff, and discharges from STPs and on-site septic systems; and
- Reduction in water quality, ecological health and recreational amenity caused by increased pathogens and nutrients in runoff.

The HRC (2000) concluded the majority of subcatchments within the Bega River catchment to be stressed due to geomorphic instability, loss of riparian vegetation and high water demand.

In terms of geomorphology, the Bega river system has been modified from a suspended/mixed load river system of relatively deep channels with fine grained banks and floodplain, into a mostly bedload sediment system of broad sandy channels, mid channel bars and islands, and a sandy floodplain (CMG 2000). Brooks and Brierley (1997) state that between 1850 and 1926, channel width increased by nearly 340%, while channel depth decreased by several metres, and this demonstrates the extent of impact caused since the beginning of European settlement. Human activities which have had the greatest impact upon the BRE environment are discussed in detail below.

2.9.1 Agriculture

The introduction of agriculture to the Bega Valley is associated with the clearing of large areas of native forests and the introduction of exotic plant and animal species which outcompete native flora species and reduce habitat availability for native animals. Agriculture is also associated with the degradation and erosion of land, particularly riparian zones by cattle grazing. Waterways are then delivered with excess sediment and nutrient loads in catchment runoff from cleared land surfaces, and fertilisers and animal faeces washed from agricultural land.

By the start of 1997 over 113,000 ha of vegetation in the Bega Valley Shire had been cleared or modified, which equates to 21% of land in the Bega Shire by area, particularly in the lowlands (BVSC, 2000). Much of this clearing is believed to have occurred in the early stages of settlement (AWT 1997). Dairy farming is the main agricultural activity, and has required extensive land clearing of the lowland foothills to provide grazing areas for cattle (Kinred, 2003).

Flood plain and upper pluvial wetlands have been highly modified by extensive clearing and their ground storey communities degraded by the introduction of exotic plant species and allowing animals to graze unfenced from the wetland (Green, 1999). Infestation by exotic species is evident throughout most of the riparian zone (DLWC, 1998). The condition of riparian vegetation is very poor in the lower reaches where European settlement has had the most impact (HRC, 2000).

Cattle grazing along stream banks and beds has resulted in trampling of the bed and vegetation, and grazing upon the vegetation also, causing degradation of riparian and mangrove areas (HRC, 2000). This is reflected by the assessment by AWT (1997) that 75% of stream banks studied were in poor condition. Cattle access, particularly to riparian zones, accelerates erosion and contributes to sediment levels in runoff, compounding the problem of sedimentation in waterways (BVSC, 2003; HRC 2000).

The SRCMA and Bega Cheese are currently implementing the Bega River Health Package, which aims to work with land holders to reduce the impact of stock on waterways. The NHT has provided Bega Cheese with over $320,000 to carry out on-ground works to help farmers manage stock near rivers and wetlands, reduce the impact of farm effluent on water quality, reduce erosion and carry out re-vegetation. The program commenced in 2005 and to date has more than 40 participating land holders. Through this program over 90% of dairy farmers have engaged in detailed nutrient budgeting across their farmland and there has been a major investment in farm nutrient management improvements, which will progressively improve river health.

The condition of banks was reported by DLWC (1998) to be in good to very good condition along 84% of stream length. However, more than half of the sites exhibited bank erosion, and unstable sediments, primarily caused by stock damage and vegetation clearing (DLWC 1998). AWT (1997) reported similar findings with 15 of the 20 sites in the Bega catchment assessed found to have poor bank condition, again due to the extensive use of land for cattle grazing.

The bed condition was typically fair to excellent, with only 4 sites found to be in poor condition (AWT 1997), such as downstream of the Bega STP. In contrast, the DLWC (1998) found bed and bar condition to be poor to very poor along two thirds of stream length, with bed stability at 56% of sites affected by agriculture and grazing. The two assessments have essentially described the same riverine conditions, but provided a different final assessment based upon the differing assessment methods used by AWT[2] and DLWC[3].

The clearing of native vegetation for agriculture can be linked with an increase in turbidity in streams throughout the Bega catchment, as shown by water quality results in which turbidity concentrations were up to four times greater in streams adjacent to dairying and grazing compared with those adjacent to native forest (Turner *et al* 1998). Without the protection of native forests or vegetation, the lands used for dairying and grazing are more susceptible to erosion, as runoff velocities and volumes during rainfall are increased, and the unprotected land and sediments are easily mobilised by the higher flow velocities. Land clearing is believed to be the major factor in the mobilisation of large amounts of sediment from the deep valley fills at the base of the escarpment (Brooks 1994). Increased sedimentation may affect habitat diversity and productivity (AWT 1997).

Agricultural activities are thought to be a major source of faecal material and nutrients (particularly nitrogen) to the waterway (WBM 2005; HRC, 2000). Nutrients entering the Bega River system are predominantly sourced from dairy farms and cattle grazing (Turner et al., 1998). In particular, management of effluent from dairy farms commonly consists of spray irrigation directly on pastures with raw or primary treated effluent (DIPNR 2004). Dairy laneways often contain large amounts of

[2] The AWT (1997) assessment was based upon: the completeness of native vegetation on riverbanks, riparian zone and land immediately beyond the riparian zone; the bed channel depth, disturbance, vegetation and detritus, and used a modified version of the riparian, channel and environmental inventory (RCE) by Petersen (1992) and Chessman *et al* (1997), where a range of descriptors is given a score between 1 and 4, and the sum of all scores defines a rating of excellent, good, fair or poor.

[3] The DLWC (1998) assessment used the Anderson method adapted for the different climate, soils, geomorphology, hydrologic patterns and native flora and fauna which exist in southern NSW river systems, such as the Bega River.

manure (DIPNR 2004). Fertiliser and pesticide residue in addition to faecal material from livestock enters the waterway via catchment runoff from agricultural land, contributing large amounts of nutrients and pathogens to the waterway. Nutrient and pathogen concentrations levels in the Bega River system are generally satisfactory, except following significant rainfall events, following which large spikes in concentration occur.

Clearly, agricultural land use is associated with a number of activities that negatively impact the health of the BRE catchment and waterway. Management of certain agricultural practices, for example stipulating best practice application of fertiliser and pesticides, and fencing off riparian zones and revegetation to create riparian vegetative buffers, are considered to be effective options to reduce the impact of agricultural activity and improve the health of the river corridor. The Bega Cheese partnership with SRCMA has developed a pilot Environmental Management System (EMS) for dairy farms, which is now being expanded across the supplier base in the Bega River catchment and beyond. Adoption of the EMS will reinforce the adoption of best environmental practice on dairy farms, which will contribute significantly to improved river health over time.

2.9.2 Water Extraction

Most stream ecosystems in the Bega River Catchment suffer from prolonged periods of low or zero flows (HRC 2000). It has been suggested by HRC (2000) that water extraction is associated with poor river health due to the reduction in natural river flow. Environmental flows would improve water quality and help maintain ecological health (AWT, 1997).

Low flow periods involve the loss of aquatic habitat as the river is reduced to small pools which may become stagnant and dry up completely without further flow input. Low flow periods are natural in the river system to a certain extent, however water extraction during dry periods extends the period of low flow in some streams and the negative impacts.

The effects of periods of low or no flow are minimised by the maintenance of small pools in the river, which provide areas for invertebrate species to establish refugia (AWT 1997). Small freshes (that is, brief influxes of freshwater) are important to improving water quality in pools which may have low oxygen due to stagnation, or for moisture to animals which are aestivating (AWT 1997). During high flow periods, species from the refuges can recolonise those areas which had become uninhabitable during the low flow period.

It was a major recommendation of the HRC (2000) that the conditions of water extraction licenses be changed and operating procedures of Cochrane and Brogo Dams be modified to allow greater flow in the trunk streams of the Bega and Brogo Rivers, and improve river and estuarine health. The former South Coast Water Management Committee has negotiated the release of environmental flows from Cochrane Dam with its operator, Eraring Energy and BVSC has implemented upgrades to water supply infrastructure to lessen reliance on low flow water from Tantawanglo Creek, since the HRC (2000)... The remaining recommendations are beyond the influence of the BRE.

The *Water Sharing Plan (WSP) for the Bega and Brogo Rivers Area unregulated, regulated and alluvial water sources 2010* provides for the sharing of water between the environment, town water supplies, basic landholder rights and commercial uses of water. The area covered by the WSP is the Bega River Catchment (1,940 km^2) and comprises all the sub catchments of the Bega and Brogo Rivers. The WSP establishes a total entitlement, or share component, for each category of access licence and provision for available water determinations (AWDs) to be made each year that define how much of the share component will be available for extraction. Importantly for low flow protection, the WSP defines Total Daily Extraction Limits (TDELs) for stream reaches and Individual Daily Extraction Limits (IDELs) for individuals based on stream flow classes. The TDELs and IDELs reduce water extraction as stream flow declines into lower flow classes and cease extraction all together below certain stream flows for some categories of licences.

In the Bega River catchment, the total volume licenced for water extraction is approximately 62,000 ML per year for surface and groundwater combined (BVSC 2004b). This amount would lead to over extraction from the catchment during a dry year if it was to occur, however, such volumes are not extracted in any year because many licences are inactive and locally developed water sharing and rostering arrangements implemented before the WSP have helped to manage extraction during dry times. The WSP 2010 will continue to limit water extraction during dry times.

The NSW Office of Water (NOW) is responsible for issuing water access licenses in NSW under the Water Management Act 2000 and maintaining water allocation accounts. Example categories of access licences include local water utility, domestic and stock, regulated river, unregulated river, aquifer and Aboriginal cultural. Purposes such as irrigation are covered under regulated river, unregulated river and aquifer categories of access licences. NOW has placed an embargo on issuing new water extraction licences within the Bega catchment, to protect water supplies for existing users and for environmental purposes.

The impact and general aim of the WSP is to shift extraction from the more environmentally sensitive low flow classes to higher flow classes. This requires infrastructure to capitalise on higher flows, such as high flow pumps, high capacity transfer pipelines and large off-stream storages. Some water extractors are investing in such infrastructure, as is BVSC which in 2011 will commission a $28 million 20km pipeline and pumping station from Bega to Yellow Pinch Dam. However, many small to moderately sized farm irrigation operations will likely find the transition difficult, for financial as well as technical reasons (e.g. there may be no suitable sites for off-stream dams on many properties). The WSP process recognised this and compromises, such as TDELs being determined based on the high flow end of the flow classes, were adopted.

Brogo Dam decreases moderate flows and flow variability compared with natural conditions, however, the impacts of the Dam are thought to be dampened by its low storage capacity (AWT 1997). The invertebrate community at the River's edge and bed immediately downstream of the Brogo Dam had a low diversity, and was deemed to be in a poor condition due to the Dam's influence (AWT 1997). However, assessment 10 km downstream of the Dam indicated the River to be in fair to good condition, suggesting the impacts of Brogo Dam are localised (AWT 1997). Currently, State Water operates Brogo Dam, and management includes environmental flow releases and releases to meet WSP requirements.

Sites downstream of Cochrane Dam were found to be in fair to excellent condition by AWT (1997), and this is also thought to be due to its low storage capacity. AWT (1997) notes, however, that the operation of Cochrane Dam is for electricity generation, resulting in rapid rises and falls in water levels downstream in the Bemboka River. This is thought likely to have impacts on species abundance, but was not analysed during the AWT (1997) assessment. Cochrane Dam was not constructed with any consideration of environmental flow needs of the river downstream (DLWC 1999a)., As discussed previously, the Bega Valley Water Users Association has negotiated the release of environmental flows and water sharing with the Dam's operator, Eraring Energy (BVSC 2004b).

Low flow Bega River @ Kanoona

Low flow Bemboka River @ Morans Crossing

High flow Bega River @ Kanoona

High flow Bemboka River @ Morans Crossing

Figure 2-16 Low and high stream flows at two locations in the Bega River Catchment.

Local water management aims are to shift water extraction from low stream flows to high stream flows. Pumping infrastructure to off-stream storages are required to achieve this.

2.9.3 Sewage Treatment

Effluent discharges, from sewage treatment plants or on-site septic systems, are understood to be a major source of pathogens to the BRE. Following rainfall, peaks in nutrient and pathogen concentrations to levels above the ANZECC 2000 Guidelines for recreational contact and aquatic ecosystems are reported in Black Ada Swamp, which is adjacent to effluent irrigation sites. Algal blooms have been observed in receiving waters near STP effluent discharge outlets.

Lyall & Macoun (1998) noted that the Tathra STP was close to maximum capacity, and was unable to handle the increased load from summer visitors to the area. The stress placed on the local environment by the methods of effluent disposal at that time was also noted, as was the need for expanded wet weather effluent storage, for later use as irrigation (Lyall & Macoun 1998).

Following recommendations by HRC (2000), BVSC implemented the Bega Valley Sewerage Program (BVSP). This has involved the upgrade of five existing STPs (Tathra, Bega, Tura Beach, Merimbula and Bermagui) and the construction of a further five STPs (Kalaru, Cobargo, Wolumla, Candelo and Wallaga Lake) in the Bega Valley Shire LGA (BVSP 2006). Of particular interest to the BRE are the upgrades of the Tathra STP and the Bega STP, and installation of an STP at Kalaru.

The Tathra STP upgrade, completed in 2005, involved increasing plant capacity to 6200 equivalent persons (ep) (or, 1360 kL/day), compared with 2000 ep prior to the upgrade (BVSP, 2005). Effluent processing systems were improved, including the installation of two sludge drying beds, and a fully automated system, with anemometer control, was installed to irrigate all of the Tathra Country Club golf course and the adjacent sporting ground (BVSP, 2005). A fully lined wet weather storage pond of 18 ML capacity was also constructed (BVSP, 2005, 2006).

A significant reduction in the pollutant loads in groundwater from reclaimed water used for irrigation is predicted, and this is without including the potential attenuation of pollutants in the soil zone, which is likely to further reduce the pollutant loads as the water travels to the Estuary. Overall, by 2022 there is predicted to be a 93% and 29% reduction in nitrogen in Black Ada Swamp and Lagoon respectively, and a 74% decrease and 127% increase in phosphorous in Black Ada Swamp and Lagoon respectively (IGGC, 2004). Further, no change in nitrogen and phosphorous loads to the Bega River are predicted compared with pre-upgrade nutrient loads (IGGC, 2004). The predicted improvement in the water quality of effluent, and in receiving waters for before and after the STP outlined by IGGC (2004a) are reproduced in Table C-12, Table C-13 and Table C-14 in Appendix C.

Water quality results for pathogens and nutrients measured by IGGC in 2005 and 2006 do show some reduction in nutrient levels below background levels (refer Section 2.6.4, 2.6.6 & 2.6.7). However, there is still insufficient data to fully assess the potential improvements in BRE water quality from the Tathra STP upgrade, and if the predicted reductions in nutrient loads for 2022 can be met.

The recent upgrade was planned to accommodate the projected populations of 2022, but not planned to include either Stage 1 or Stage 2 of the TRE or Mogareeka due to cost constraints (BVSP, 2005). The TRE Stages and Mogareeka may be included at a later time and the inclusion of 200 or more dwellings from the TRE is being investigated as part of the Tathra Structure Report (BVSC, 2005a). Given that current holiday populations require 5000 ep capacity, it appears unlikely the STP could effectively process both projected and holiday populations and the TRE developments, unless a further upgrade was completed. The major constraint on any further upgrade of the Tathra STP is land area to dispose of treated effluent, rather than a mechanical limitation (pers. comm., David Searle 2004).

The Bega STP upgrade involved a small relocation of the STP to enable components of the existing STP to be incorporated, and the installation of a Sequencing Batch Reactor (SBR), which has an aeration cycle and a UV disinfection unit and produces high quality effluent which, in particular, is lower in faecal coliform content (ERM, 2005b). The SBR is designed for an average dry weather flow in 2022 of 22 L/s, and can be adapted to wet weather flows of up to 108 L/s. Flows exceeding 108 L/s will be diverted into a “storm tank” for later processing. Up to 49% of reclaimed water by 2022 will be used as irrigation on the adjacent dairy farm, and the remainder discharged to the Bega River.

The TP and TN loads released to the River are expected to be reduced by 91 % and 6 % respectively by 2022 (ERM, 2005b). It is recommended that further investigations for beneficial re-use of all effluent from the Bega Plant be undertaken.

Kalaru village was previously serviced by on-site septic systems, which are considered ineffective due to the number of households in the area and the area's soil type (BVSP 2006). The Kalaru STP includes a pressure system to collect and reticulate sewage; a membrane bioreactor for treatment of sewage at the plant; and the use of reclaimed water to irrigate the Sapphire Coast Turf Club, maximising the use of water in effluent prior to discharge to the Penooka Wetlands (BVSP 2006).

The impact of such improvements to the water quality of BRE will be apparent in the future monitoring results. The BVSP works are generally designed to accommodate only 15 to 20 years of projected population growth.

2.9.4 Entrance Management

The Council periodically opens the entrance at Mogareeka to relieve upstream flooding (mainly flooding across the coastal road to Mogareeka). Despite community perception of poor water quality during times of entrance closure, recent studies such as the BVSC Bega Estuary monitoring program (WBM, 2005) and Turner *et al* (1998) have shown that water quality remains relatively stable whilst the entrance is closed and catchment inputs are minimal. Council therefore does not automatically open the entrance upon closure on the presumption of ailing water quality.

The water quality studies (WBM, 2005; Turner *et al*., 1998) have shown that catchment runoff delivers nutrients, sediment, pathogens and other pollutants to the waterway. Water quality within the estuary would therefore be better managed through reducing catchment inputs, for example, by minimising STP discharges, stormwater runoff, and the application of fertilisers, and by rehabilitating riparian buffers, rather than artificially breaching the entrance.

Furthermore, the health of fish populations may be adversely affected if the frequency of artificial opening is increased (DIPNR 2004). Fish populations have adapted to the frequency of closure of the BRE, and this may provide an advantage for local species over introduced species (DIPNR 2004).

It is predicted that climate change will have a significant impact on sea levels, coastal processes and rainfall patterns. Consequently there may be significant change in entrance behaviour and a subsequent need for Council to amend its management of the entrance in the future (see Section 10).

2.9.5 Future Population Growth and Urban Development

Population growth is associated with a growth in housing, employment and recreation needs from the new regional occupants, which places significant pressure on the environment to accommodate such needs. The future population growth increases the pressure to the environment from those anthropogenic impacts already outlined. The likely impacts of population growth on the BRE include:

- An increase in demand for urban development land, in particular, land around the Estuary itself. Pressure for urban development comes from the housing, employment and tourism needs of the new population. In accommodating the urban development:
    - a loss of either terrestrial habitat or of productive agricultural land occurs;

  - sedimentation of the waterway is increased during construction activities;
  - vegetated lands are replaced with paved surfaces that results in an increase in the volume and flow velocity of runoff, as rainfall is no longer attenuated by the vegetation;
  - sediment, nutrient and pollutant loads in runoff are increased as it flows through developed land, rather than vegetated land as previously;
  - the subsequent impact of pollutants and runoff volumes on water quality and hydrodynamics has negative flow on effects to the ecology of the Estuary;
  - the associated reduction in water quality also negatively impacts the recreational value of the Estuary for the new and existing residential and tourist population; and
  - the domestic pets accompanying the new urban population may impact fauna in surrounding natural areas.

- Waterfront developments are known to result in the destruction of estuarine habitats; the decline in water quality through increased siltation and turbidity in catchment runoff; and the restriction of public access (Fisheries Research Institute, 1985, NSW Fisheries, 1999).
- An increase in the demand placed on STP resources, as well as in on-site sewage treatments. These may effect a reduction in water quality and therefore the ecological health of the Estuary. The recreational value of the Estuary is also directly impaired by an increase in pathogens.
- An increase in demand on water resources. The upgrading of water supply systems, introduction of water conservation practices and further application of water restrictions will be common in the future to ameliorate the impacts of population growth and climate change (BVSC, 2004b). Furthermore, the subsequent reduction in environmental flows will reduce the ecological habitat area, diversity and health of the Estuary.
- Increased demand for waterway access, such as jetties, boat ramps, marinas, or dredging of the waterway for access by recreational users. Frequent constructions or dredging activities drastically degrades seagrass. The degradation of such habitats particularly impacts the fish populations for which many recreational users have come to enjoy. NSW Fisheries (1999) has stated that developments and activities occurring within or near estuaries should be strictly controlled to provide optimal water quality conditions for fish and wildlife. In addition, constructions or dredging activities improve the accessibility, and so popularity of the waterway for recreational activity, further exacerbating the impact and pressure on the estuarine environment.

2.9.6 Climate Change

It is now widely accepted that climate change as a response to increased greenhouse gases in Earth's atmosphere as a result of anthropogenic activities is inevitable. The likely impacts of climate change in south east Australia, such as sea level rise, drought frequency, annual and extreme rainfall events, and land temperatures are documented in Chapter 10 of this Plan. Specific implications for the BRE manifesting from the impacts of climate change are also discussed in Chapter 10, while the recommended future management strategies (Chapter 6) have aimed to incorporate and accommodate predicted future climate change wherever possible.

2.10 Interactions between Estuary Processes

The Inter-relationships and connections between the different estuarine processes within the BRE are summarised in Figure 2-17. A description of each of the connecting links between the various estuarine processes is provided below. At the top of the 'estuary processes tree' are Catchment Inputs and Entrance Conditions. Both of these primary drivers are modified by human activities within the Bega River, highlighting the wide-reaching impacts of humans on overall estuarine processes. Climate change is also likely to have a significant impact on individual processes (including those at the top of the 'processes tree') as well as the inter-relationships and connections between estuarine processes.

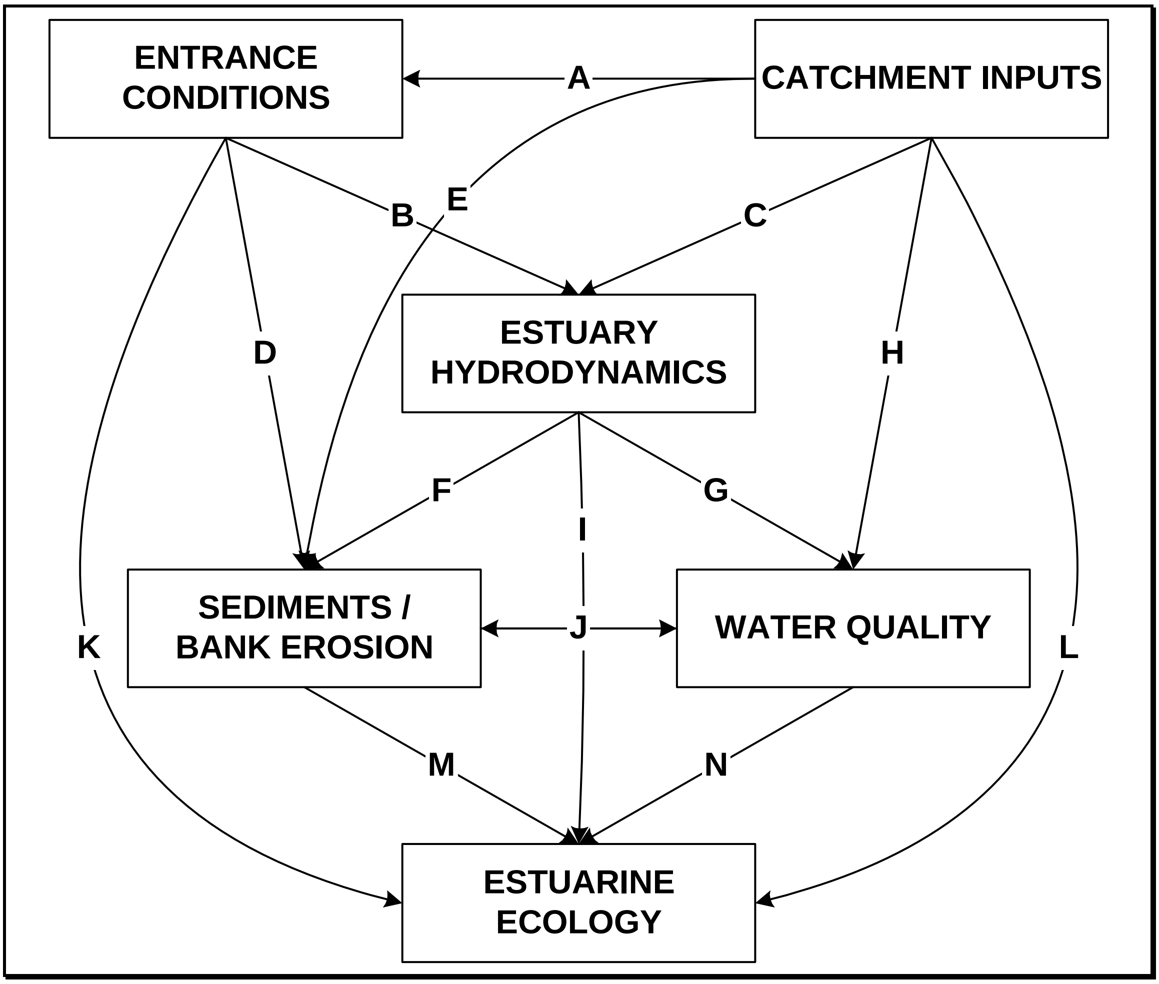

Figure 2-17 Bega River Estuary Process Interaction

A. Catchment Inputs ⇨ Entrance Conditions: The condition of the entrance is controlled by a balance between longshore sediment transport processes along Tathra Beach feeding marine sand into the entrance, and flood events in the catchment that are capable of scouring sediment from entrance to form offshore sand bars. Climate change impacts such as altered ocean swell direction, increased coastal and catchment storms, and sea level rise are likely to alter this balance.

B. **Entrance Conditions ⇨ Estuary Hydrodynamics:** The tidal regime of the estuary is dependent upon the condition of the entrance. The more scoured the entrance, the greater the tidal range. The more shoaled the entrance, the smaller the tidal range. When the entrance is completely closed, there is no tidal variation within the estuary. Climate change is likely to increase periods of closure of the entrance (Haines & Thom 2007).

C. **Catchment Input ⇨ Estuary Hydrodynamics:** Flood discharges push estuarine waters to the ocean, replacing the estuary with freshwater runoff from the catchment. The return of saltwater into the estuary following a fresh event occurs as a wedge, and occurs relatively rapidly following the flood event (a matter of weeks). When the entrance is closed, water levels within the estuary respond to evaporation and catchment runoff events. Depending on the relative balance, water levels increase until they overtop the entrance sand berm, or until they reach the trigger for artificial entrance breakout (RL 1.36m AHD measured at Hancock Bridge). Catchment inputs are expected to change with climate change.

D. **Entrance Conditions ⇨ Sediments:** When the entrance is scoured following a flood event, marine sand is pushed back into the entrance channel under tide and ocean swell action. As sand builds up in the entrance, the tidal range is progressively reduced, and the ability of the flood tide to convey additional marine sand into the estuary is reduced. Climate change is likely to increase periods of closure of the entrance (Haines & Thom 2007).

E. **Catchment Inputs ⇨ Sediments:** Catchment-derived alluvial sediments are delivered to the estuary via catchment runoff, where they are mostly deposited within the estuary. During large flood events, the sediment built-up within the estuary is expelled to the ocean or the overbank floodplains. Climate Change is likely to result in less frequent but more intense catchment flood events.

F. **Estuary Hydrodynamics ⇨ Sediments / Bank Erosion:** Sediment deposition within the estuary is dependent on flow conditions. Deposition occur where velocities reduce (to below sediment transport thresholds). Marine sediment is deposited within the entrance, under the accentuated action of ocean swell. Terrestrial sediment is deposited throughout the estuary, particularly when the entrance is closed (i.e. the estuary behaves like a coastal lake, retaining 100% of inputs).

Floods erode the deposited sediment within the estuary, reworking the material downstream. The increased sediment load and volumetric runoff from the catchment as a result of land clearing and human development have enlarged the estuary channel profile through channel deepening and progressive bank recession. In essence, the river is trying to establish a new 'regime' state that represents a balance between the catchment conditions and the geotechnical properties of the bank material.

The flood impacts of system morphodynamics need to be assessed within a Flood Study and Floodplain Risk Management Study. Climate change impacts such as altered ocean swell direction, increased coastal and catchment storms, and sea level rise are likely to alter estuary hydrodynamics.

G. **Estuary Hydrodynamics ⇨ Water Quality:** Water quality within the estuary is dependent on the ability of the estuary to flush pollutants out of the system (replacing it with 'clean' ocean water). Tidal flushing is relatively efficient near the river entrance. Given the long linear form of the waterway, the upper reaches of the estuary, on the other hand, would be comparatively poorly flushed. Open entrance condition also allows water quality inputs from the ocean (e.g.

marine algae blooms).

When the entrance is completely closed, the river retains 100% of pollutant inputs. Some of these pollutant inputs are stored, some are assimilated and some are internally processes to form organic matter (e.g. algae). Climate change impacts such as altered ocean swell direction, increased coastal and catchment storms, and sea level rise are likely to alter estuary hydrodynamics.

H. **Catchment Inputs ⇨ Water Quality:** The water quality of the estuary represents a balance between pollutant inputs from the catchment and the cleansing effect of tidal exchange (when the entrance is open). Generally, the more degraded and developed the catchment, the higher pollutant inputs will be. Water quality in the BRE will be largely influenced by rural development within the upper catchment areas, as well as the urban precincts spread throughout the catchment, and their associated point source inputs (e.g. sewage treatment plant disposal).

I. **Estuary Hydrodynamics ⇨ Estuarine Ecology:** The overall ecology of the estuary is dependent on the key hydrodynamics factors, including the propensity of tidal flows and the different relative balance between saltwater and freshwater in the system.

J. **Sediments ⇔ Water Quality:** Under certain environmental conditions, estuarine sediments can act as a source of nutrients and other pollutants to the water column, with associated water quality and biological implications. Under other conditions, fine-grained sediments can act as a sink for pollutants within the water. The geochemical processes controlling nutrient exchange between the finer estuarine sediments and the water column are dependent on many factors, including carbon and oxygen availability and temperature.

Acid sulfate soils occur in low-lying swampy land around the estuary. Drainage of the land and subsequent exposure and oxidation of the soil can lead to acidic runoff entering the estuary during period of heavy rainfall and catchment runoff flows. The acidic runoff can reduce the pH of the water and in extreme cases, can cause fish kills through metal toxicity.

K. **Entrance Conditions ⇨ Estuarine Ecology:** Recruitment of fish and other aquatic species into the estuary is dependent on the condition of the entrance. Mangroves do not occur within the estuary as a consequence of the intermittently closed nature of the entrance. When the entrance is closed for extended periods of time, particularly with elevated water levels, the mangroves can be deprived of oxygen (as peg roots are mostly submerged) and essentially ‘drown’. There are very few intermittently open estuaries within NSW that contain mangroves.

L. **Catchment Inputs ⇨ Estuarine Ecology:** Catchment inputs will also affect the structure of aquatic habitats within the estuary, through the dominant sedimentary and water quality processes associated with catchment runoff. The direct input of organic matter to the estuary could trigger biological responses at a primary production level, which may then have impacts on higher order species.

M. **Sediments ⇨ Estuarine Ecology:** Sediment characteristics will determine the type of plants and benthic organisms that will use it. Areas of finer sediment tend not to have filter feeder such as bivalve molluscs, instead being dominated by deposit feeders, while areas of coarse sediment can have both deposit feeders and filter feeders. Opportunistic feeders and carnivores are likely to be present in both sedimentary environments. .

N. **Water Quality ⇨ Estuarine Ecology:** The overall health of an estuarine community is strongly related to the quality of the water. Changes in the salinity regime of an estuary can alter the structure of a community (e.g. type of microalgae and presence of seagrasses), while degradation of water quality can stress individuals, or result in the dominance of one or more species. For example, nutrient enrichment can result in increased epiphytic load on seagrass fronds, which can limit light penetration to the seagrass, and eventually affect its overall health.

3 COMMUNITY CONSULTATION

3.1 Initial Consultation

Consultation with the local community of Bega River was initially carried out through a public drop-in session and community workshop. Invitations to the workshop were distributed to the community accompanying an initial newsletter that presented the outcomes of the Estuary Processes investigations (as described in Chapter 2). A copy of the newsletter and invitation is provided in Appendix E. The community drop-in session occurred between 4 and 7pm, Thursday 24th August, 2006 at Tathra Surf Club. During this time, community members were invited to discuss their knowledge and appreciation of the estuary and its processes with WBM and Council, to assist in preparing the EMP.

Immediately following the drop-in session, a community workshop was held at Tathra Hall. The focus of the workshop was to determine community values of the BRE, and the issues the community perceived the estuary to face. The workshop attendees were split into groups of approximately 10 people, and given three worksheets. The worksheets contained the following questions, and are provided in Appendix E:

- What are the values of the estuary?;
- What are the issues facing the estuary?; and
- What are the management options for the estuary?

In groups, workshop attendees listed their values, issues and potential management options for maintaining values or addressing issues upon the worksheets. As a group, attendees then ranked the top three values of the estuary, top three issues facing the estuary, and the top three methods for protecting the estuary. In this manner, a prioritised list of values and issues was collated, and a list of potential management options was generated for further assessment in this plan. The information gained in the workshop is discussed in Chapter 4.

3.2 Follow-up consultation

Following the workshop, a brochure detailing the outcomes of the workshop was developed (provided in Appendix E). In this brochure, prioritised lists of estuary values and issues, and a set of principles for future management of the BRE were provided. Discussion of management options during the workshop were used to develop a set of management objectives. These objectives were also listed in the brochure, grouped according to the general area to which they applied (e.g., reducing weeds was listed as an option for ecology and biodiversity).

The community was invited to provide comments upon the management objectives and directions presented in the brochure. A form listing all the objectives was provided in the brochure, to enable community members to rank the objectives. The community was asked to submit the form and any additional comments. A small number of submissions were received from the community and members of the BREWG.

4 EXISTING USES, VALUES AND ISSUES

4.1 Uses

The BRE and its surrounds are used by the community for:

- swimming,
- fishing,
- walking, bushwalking and hiking,
- passive watersports (canoeing and windsurfing),
- boating, jet skiing and personal water craft use,
- golf
- picnicking, barbequing and other passive recreation, and
- cycling.

Good access to public foreshores is important to community members. The beach side of the entrance sand spit, along Tathra beach, is also used for surfing, swimming, fishing and boat launching to the ocean.

4.2 Values

4.2.1 Community values

As part of the community workshop, the community was asked to list their perceived values of the Bega River estuary. In small groups, the attendees were then asked to rank their top three values of the estuary. The list of community values and their rankings are provided in Table 4-1.

Table 4-1 Community Values

Community Values (from workshop Aug '06)	Community ranking (from workshop Aug '06)
'Naturalness' (biodiversity and abundance of life, including birds, fish, and threatened species)	✓✓
Natural beauty (feeling of wilderness and isolation) and scenic amenity	✓✓
Recreation / leisure (safe swimming [especially for children], fishing, waterskiing, prawning, canoeing, walking, picnicking, etc)	✓✓
Economic opportunities (especially tourism, which is reliant on other existing estuary values, and agriculture)	✓✓
Educational opportunities	✓✓
Aboriginal cultural sites	✓
Unique heritage sites (e.g. Vimy Ridge Mines)	✓
Surrounding forest / National Parks	✓
Existing riparian vegetation	✓
Good public access to foreshores	✓

Community Values (from workshop Aug '06)	Community ranking (from workshop Aug '06)
Small boat access along river	✓
Good water quality	✓
Existing wildlife corridors	✓
Lack of existing development along foreshores	✓

Note: two ticks (✓✓) means that these values were identified by the community as being the highest priority, or most important.

The results indicate that the estuary's naturalness, beauty, recreation/leisure, economic opportunities and educational opportunities were ranked most highly by the community. Other aspects of the natural and scenic environment, such as existing riparian vegetation, public access to the foreshores, and lack of foreshore development was also valued by the community.

The results from the community suggest that, generally, the community prefers the BRE and its surrounding environment to remain in its naturally beautiful state, free from extensive future development which may detract from its scenic beauty. It is important to recognise, however, that these results reflect only the opinions of those community members who chose to attend the community workshop, and are not necessarily reflective of the whole Bega River community or other stakeholders of the estuary.

4.2.2 Environmental values

The BRE supports a variety of habitats that are of high environmental value. The BRE is an important nesting site for shorebirds, which includes a community of Little Terns who nest on the sand spit at the BRE entrance. Migratory birds use the estuary to feed, rest and breed. Of the migratory birds who utilise the BRE, many are listed on the JAMBA agreement, as well as the TSC Act 1995, and EPBC Act 1999.

There are more than 35 plant species and 71 fauna species listed as vulnerable or endangered under the NSW *Threatened Species Conservation Act (1995)* or the Commonwealth *Environment Protection and Biodiversity Conservation Act (1999)* reported to be present within the Bega Valley Shire (BVSC, 2004b). Many of these plants and animals exist in or utilise the natural areas of the BRE. There are two National Parks (Mimosa Rocks and Bournda) adjoining the BRE, in which many plant and animal species are protected.

The scientific assessment of the BRE (Chapter 1) likewise found a number of the community values listed in Table 4-1 to be valued in a scientific / environmental sense also. These multi-values are listed in Table 4-2.

Table 4-2 Multi-Values of the BRE, important to both Science and the Community

Multi – Values
'Naturalness' (biodiversity and abundance of life, including birds, fish, and threatened species)
Recreation / leisure (safe swimming [especially for children], fishing, waterskiing, prawning, canoeing, walking, picnicking, etc)
Economic opportunities (especially tourism, which is reliant on other existing estuary values, and agriculture)
Aboriginal cultural sites
Unique heritage sites (e.g. Vimy Ridge Mines)

4.2.3 Socio-Economic Value

As noted in Table 4-1 and Table 4-2 above, the economic opportunities provided by the BRE are of high value. These economic opportunities include tourism, agriculture (in floodplain adjacent to the estuary) and other commercial enterprises. The natural beauty of the BRE and its waterway area provide high social value to both residents and visitors. For example, Mogareeka Inlet provide access to the waterway for swimmers, boaters, fishers and passive watercraft (along the boat ramp), and amenities are popular for picnicking and barbequing. Tathra is also a focal point for recreation by residents and holiday makers, with the population increasing by 70% during holiday periods.

4.2.4 Educational Values

The BRE provides opportunities for the study and appreciation of:

- The geological evolution of the south coast of NSW;
- The biological significance of the coastal environment and the interactions between estuaries and the open coast waters;
- The impact of human activities on natural estuarine ecosystems;
- The importance of coastal wetlands and dune environments; and
- The importance of the area to the Aboriginal community, both in a traditional context and in relation to contemporary use.

Field trips by universities (such as the University of Sydney) to study the geological formations on Tathra beach occur periodically. Programs to conserve the environment, such as Little Tern breeding sites on the sand spit below Lions Park, have also enabled local residents to improve their understanding of the importance of the estuary to native fauna.

4.2.5 Aboriginal and European heritage values

The BRE contains sites which demonstrate Aboriginal occupation of the area for at least 6,000 years. As outlined in Section 2.8.1, the Djiringanj, Thaua, Bidawahal and Ngarigo tribes collectively known as the Yuin-Monaro are the traditional owners of lands in the Bega Valley Shire, including the BRE. Significant sites of Aboriginal occupation and cultural significance are typically preserved on naturally vegetated land, such as in the national parks adjoining the BRE. These sites are valuable to the cultural history of the Bega area.

The history of European settlement in the Bega Valley began when the area was settled in the 1830s. There are 304 sites listed on the Heritage Register of the Bega Valley Shire, including Tathra Wharf. European heritage values are typically associated with the practise of dairy farming, including the establishment of the Bega Dairy Cooperative Limited. The cultural heritage significance of dairy farming still exists to the present day.

4.3 Issues

4.3.1 Scientific perspective

The assessment of estuary processes indicated a number of pressures faced by the BRE in relation to anthropogenic activities (refer Section 2.9). Agriculture, population pressures, urban development and future climate change are placing significant pressure upon the BRE's natural environment. These pressures include:

- water extraction, clearing of native vegetation, degradation of riparian and other natural areas, and pollutants (sediment, nutrients and pathogens) in runoff, all associated with agriculture;
- sewage treatment and the impacts of holiday populations causing sewage system failure, leakage and failure of on-site sewage systems;
- demand for entrance management;
- population growth and urban development, resulting in modifications to hydrologic regimes, sediment and pollutant runoff, loss of natural vegetation and / or high quality agricultural land, and further pressure on sewage and other waste management; and
- climate change, which may further exacerbate the impacts outlined above due to reduced annual rainfall, increased storminess, and sea level rise which may increase entrance berm height and subsequent water levels during entrance closure.

A number of the issues outlined in the scientific assessment of the BRE were similarly outlined by the community during the workshop, refer Section 4.3.2. The combined list of issues outlined by the community and during the scientific assessment is provided in Table 4-3.

4.3.2 Community perspective

As for the values, during the community workshop, the community was also asked to list the important issues they felt the Bega River estuary faced, then rank the top three issues for the estuary. The issues and the rankings defined by the community are provided in Table 4-3.

Table 4-3 Community Issues and Scientific Issues

Issue	Community ranking (from workshop Aug '06)	Scientific Issues (from Chapter 2)
Existing catchment management practices, e.g. stock watering from the river, unfiltered sediment and nutrient runoff, sediment runoff from cleared bushfire Asset Protection Zones (APZ) around rural-residential development, especially on steep slopes	✓✓	✓
Loss of riparian vegetation along foreshore, especially on private lands	✓✓	✓
Excessive and inappropriate development (especially visible / obtrusive) around the estuary and the associated results of population growth, water quality impacts, effluent disposal and loss of social and recreational amenity	✓✓	✓
Public infrastructure (existing condition, need for additional infrastructure)	✓✓	
Overfishing by recreational fishers (i.e. bag limits too high given the sensitivity of the estuary)	✓✓	
Artificial entrance management to balance competing human and environmental needs	✓✓	✓
Potential poor water quality given catchment and point source inputs of pollutants	✓✓	✓
Climate change, including sea level rise, wave climate (and associated entrance dynamics) and rainfall / evaporation	✓✓	✓
Lack of effective planning instruments to protect estuary values	✓✓	
Protection of threatened species from recreation	✓	✓
Unnatural hydrological regime of SEPP-14 wetlands	✓	✓
Salt intrusion when entrance is closed	✓	
Road inundation when entrance closed and river water level is high	✓	
Odours at Mogareeka and near Tathra STP	✓	
Algae near Tathra STP	✓	
Bank erosion and loss of trees (eg at Lions Park)	✓	
Hazards to recreation (including segments of the old bridge where people swim)	✓	
Lack of public access to foreshore, particularly at Thompsons Corner	✓	
Recreational user conflicts on foreshores (including fish waste disposal)	✓	
Recreational user impacts on foreshore (e.g., walking tracks, litter)	✓	
Inappropriate use and noise related to waterskiing,	✓	

Issue	**Community ranking (from workshop Aug '06)**	**Scientific Issues (from Chapter 2)**
powerboating, PWCs etc		
Past catchment development	✓	
Lack of data (especially on water quality)	✓	
Lack of financial resources in Council / Government to implement actions and undertake management works	✓	
Loss of native forests and habitats due to past catchment development		✓
Water extraction and lack of environmental flows		✓
Weed infestation		✓
Temporary tidal barrage limiting migration of fish		✓
Bank erosion due to boat wake		✓

Notes:

Two ticks (✓✓) means that these issues were identified by the community as being the highest priority, or most important.

Some issues may not be identified specifically by the scientific research because they are social, cultural or economic issues.

5 MANAGEMENT OBJECTIVES

5.1 Principles for Future Management

Future management of the Bega River Estuary will accord to the following overarching principles. These principles represent the desires of the community, stakeholders and government agencies to preserve existing environmental and social values through sustainable future development.

Management Principles

1. The healthy, diverse and viable ecosystems of the Bega River Estuary shall be maintained, enhanced and protected for future generations
2. The scenic beauty and wilderness character of the Bega River Estuary shall be preserved for enjoyment by residents and visitors now and in the future
3. The Bega River Estuary shall remain a place of great recreational and tourism value, with minimal impacts on the natural environment

5.2 Specific Management Objectives

Specific objectives to guide future management of the BRE have been developed. Each of these objectives is to be addressed through a program of strategic works and actions.

The objectives have been grouped into a number of categories covering the main focus areas for future management need.

5.2.1 Ecology and biodiversity

(A) Enhance and protect the vegetation and natural habitats of the estuary, its riparian zone and the broader catchment landscape, including wildlife corridors.

(B) Establish, maintain and protect healthy populations of native estuary species (including fish, prawns, birds), especially threatened species, such as Little Tern and Hooded Plover.

(C) Establish a hydrological regime that maintains estuarine processes, through sufficient freshwater inflows, ocean interactions and backswamp inundation.

(D) Reduce the prevalence and impacts of weeds and pests on the estuary.

5.2.2 Amenity

(E) Enhance or modify public access and infrastructure to meet recreational needs without impacting on the estuary and its habitats.

(F) Rationalise multiple recreational usages of the estuary to maximise enjoyment by all users without impacting on the estuary and its habitats.

(G) Educate the residents and visiting public regarding the values and importance of the estuary.

5.2.3 Development

(H) Future development shall not degrade the scenic amenity of the estuary.

(I) Future development shall be ecologically sustainable and have a net positive impact on the estuarine environment.

(J) Future development shall be prohibited from areas of unsuitable capability (e.g. steep slopes, highly erosive soils, sensitive adjacent environments, important existing habitats, prominent visual landmarks etc).

5.2.4 Heritage

(K) The unique Aboriginal and European heritage of the estuary shall be recognised, protected and appreciated by current and future generations.

5.2.5 Economics

(L) Support and encourage economic industries and associated practices that do not impact on the environmental values of the estuary (including tourism, agriculture, recreation).

5.2.6 Water quality and sediments

(M) Water quality of the estuary shall meet requirements for maintaining environmental health and for minimising risks to human health.

(N) Reduce the inputs of sediment and pollutants from areas of past land clearing and development (including rural residential, agriculture, urban, Sewage Treatment Plants, golf courses and bushfire buffers (APZs).

5.2.7 Bank erosion

(O) Stabilise existing areas of bank erosion, where appropriate, and limit potential for future erosion.

5.2.8 Entrance management

(P) Achieve a sustainable entrance management regime that minimises artificial entrance manipulation for maximum ecological benefit whilst recognising and accommodating social and economic impacts of foreshore flooding when water levels are high.

5.2.9 Climate change

(Q) Ensure that future climate change is considered when making long-term decisions regarding the estuary and its catchment (e.g. development, landuse changes, and construction of roads, stormwater treatment measures and other infrastructure).

5.2.10 Management mechanisms

(R) Relevant environmental planning provisions shall consider and protect the environmental values of the estuary.

(S) Relevant agencies shall provide sufficient financial and personnel resources to fulfil this Plan and shall be held accountable for its implementation.

(T) Monitoring and evaluation of Plan outcomes will guide periodic modifications and adaptations of this Plan.

(U) The community shall be informed periodically on implementation of the Plan, and will continue to be engaged regarding future management of the estuary.

(V) Continue to collect and share information and knowledge to promote on-going learning about the Bega River Estuary and its catchment.

5.3 Prioritisation of Management Objectives

The management objectives were considered and prioritised by members of the Bega River Estuary Working Group. The prioritisation reflects the average ranking given to the individual objectives. The final list of management objectives, in relative priority order, is provided in Table 5-1.

In terms of their relative score, the objectives were fairly evenly spaced. The highest ranking was given to (C) *ensuring sufficient river flow to maintain ecosystems*. This was closely followed by (J) *controls on future development* and (A) *preserving the quality of natural habitats contained in the estuary and catchment*, *and the plants and animals which are sustained by these habitats*.

The rankings of these objectives reflect well the higher priority issues found during the estuary processes summary as well as highlighted by the community, namely ensuring flows for ecosystem health, preserving the natural beauty of the estuary, and controlling future development and other anthropogenic impacts.

Table 5-1 Prioritisation Order for Management Objectives

Rank	Objective	Relative Score
1	(C) Establish a hydrological regime that maintains estuarine processes, through sufficient freshwater inflows, ocean interactions and backswamp inundation.	17.9
2	(J) Future development shall be prohibited from areas of unsuitable capability (e.g. steep slopes, highly erosive soils, sensitive adjacent environments, important existing habitats, prominent visual landmarks etc).	17.3
3	(A) Enhance and protect the vegetation and natural habitats of the estuary, its riparian zone and the broader catchment landscape, including wildlife corridors.	16.9
4	(B) Establish, maintain and protect healthy populations of native estuary species (including fish, prawns, birds), especially threatened species, such as Little Tern and Hooded Plover.	16.3
5	(F) Rationalise multiple recreational usages of the estuary to maximise enjoyment by all users without impacting on the estuary and its habitats.	14.6
6	(P) Achieve a sustainable entrance management regime that minimises artificial entrance manipulation for maximum ecological benefit whilst recognising and accommodating social and economic impacts of foreshore flooding when water levels are high.	14.3
7	(R) Relevant environmental planning provisions shall consider and protect the environmental values of the estuary.	13.9
8	(M) Water quality of the estuary shall meet requirements for maintaining environmental health and for minimising risks to human health.	13.6
8	(N) Reduce the inputs of sediment and pollutants from areas of past land clearing and development (including rural residential, agriculture, urban, Sewage Treatment Plants, golf courses and bushfire buffers (APZs).	13.6
10	(D) Reduce the prevalence and impacts of weeds and pests on the estuary.	13.3
11	(K) The unique Aboriginal and European heritage of the estuary shall be recognised, protected and appreciated by current and future generations.	13.2
12	(H) Future development shall not degrade the scenic amenity of the estuary.	13.1
13	(E) Enhance or modify public access and infrastructure to meet recreational needs without impacting on the estuary and its habitats.	12.9
13	(I) Future development shall be ecologically sustainable and have a net positive impact on the estuarine environment.	12.9
15	(Q) Ensure that future climate change is considered when making long-term decisions regarding the estuary and its catchment (e.g. development, landuse changes, and construction of roads, stormwater treatment measures and other infrastructure).	11.6
16	(O) Stabilise existing areas of bank erosion, where appropriate, and limit potential for future erosion.	11.5
17	(G) Educate the residents and visiting public regarding the values and importance of the estuary.	10.9
18	(S) Relevant agencies shall provide sufficient financial and personnel resources to fulfil this Plan and shall be held accountable for its implementation.	9.9
19	(L) Support and encourage economic industries and associated practices that do not impact on the environmental values of the estuary (including tourism, agriculture, recreation).	9.1
20	(V) Continue to collect and share information and knowledge to promote on-going learning about the Bega River Estuary and its catchment.	8.7
21	(T) Monitoring and evaluation of Plan outcomes will guide periodic modifications and adaptations of this Plan.	8.6
22	(U) The community shall be informed periodically on implementation of the Plan, and will continue to be engaged regarding future management of the estuary.	7.4

6 STRATEGIES FOR ESTUARY MANAGEMENT

6.1 Development of Management Options

6.1.1 Community suggestions

As part of the community workshop, participants were also asked to formulate ideas on how to address future management of the highest priority estuary values and issues. A listing of those ideas developed by the community is provided below.

- Gazettal of EMP and incorporation into LEP and other relevant instruments
- Include sewage management plan as part of gazetted plan
- Moratorium on development until relevant studies have been completed
- Landholder incentives for estuary management
- Implement effective water quality monitoring program
- Better definition of management responsibilities
- Regular reporting to community on management (accountability)
- Prevent development on steep slopes
- Limit clearing on rural residential lots through better planning mechanisms
- Education strategy on recreational use
- Source funding from Federal government
- Formalise an entrance management policy
- Raise level of road to reduce inundation
- Foreshore revegetation, establish riparian buffers and filter strips
- Effective soil and water management
- Preserve and enhance current recreational opportunities
- Engagement and education of landholders
- Minor foreshore works: Sealing southern carpark and other carparks, landscaping and revegetation (such as along carpark at Lions Park)
- Control runoff from foreshores
- Signage at foreshore and recreational areas
- Land reclamation at Lions Park by dredging sand from entrance
- Additional recreational infrastructure, such as a bikepath to Mogareeka, fish cleaning tables
- Improved management of Russell Creek floodgate
- Buyback headlands / foreshores to protect from development
- Rezoning lands along foreshores as buffers from development

- Allow for strategic raising of areas of golf course subject to regular inundation, in return for the protection and enhancement of areas of saltmarsh and wetland currently within golf course area.
- Revegetation of riverbanks
- Fox / feral animal control
- Release more water from Brogo Dam
- Maintenance of firetrails (silt traps on rollovers)
- Conserve and commemorate (as appropriate) Aboriginal and European Heritage
- Water Sharing Plans to demonstrate that groundwater and surface water extractions will not adversely impact provision of environmental flows to the river
- Reporting of plan implementation and progress via SoE and through CMA reporting
- Reticulated sewage system provided to Mogareeka.
- Subdivision of Mogareeka restricted to existing blocks with entitlements
- Control personal watercraft (PWC) use east of Hancocks Bridge, to minimise conflict with other recreational users and wildlife.

The above suggestions were considered, along with other general principles of sustainable estuary management, when preparing management strategies and actions for the BRE.

6.1.2 Additional Options

In addition to the community suggestions, a number of additional options were developed by the study team to address the specific management objectives, based on a detailed understanding of the estuary processes. These additional options included:

- Limit runoff and pollutant loads from new developments
- Incorporate appropriate controls for climate change impacts into existing planning frameworks
- Require development applications to demonstrate the development will not adversely impact the long term health of the estuary
- Require compensatory revegetation to offset future development
- Conserve revegetated private lands
- Require new developments to be environmentally sensitive
- Require developer contributions to infrastructure and recreational facilities
- Promote the conservation of privately owned vegetation
- Exclude cattle from stream banks and revegetate foreshore buffers on private land
- Achieve the provision of adequate flows to maintain ecosystem functions along the river
- Review and improve the management of structures and flow impediments along tributary creeks and the river
- Agencies to incorporate EMP strategies into short and long term works programs

- Use the EMP as a basis for relevant landuse zonings and development controls in the preparation of the new standard LEP
- Audit construction sites for compliance with sediment and erosion and vegetation clearing controls
- Audit existing on-site sewage systems and upgrade as necessary
- Revegetate degraded/cleared areas in catchment
- Assess bank erosion sites and rehabilitate as required
- Establish and support community volunteer groups for participation in conservation activities
- Develop and implement a weed management strategy for the estuary
- Raise public awareness of the environmental values of the Bega Estuary
- Raise public awareness of heritage and cultural values
- Compile a centralised database of all past and in-progress studies on the estuary for use in future planning, management and research activities
- Complete studies to determine the estuary's sustainability
- Conduct a study to determine environmental flow requirements
- Complete studies of catchment habitats to determine areas requiring conservation and rehabilitation
- Monitor and periodically re-map aquatic vegetation in estuary
- Periodically monitor a range of biological indicators to determine health, long term trends and outcomes of EMP strategies

6.1.3 Short-listed options

In considering the objectives of the Estuary Management Plan and potential wider environmental impacts, a short-list of potential future management options was established for further investigation and assessment. The options suggested by the community (6.1.1) and the study team (6.1.2), were short-listed in part by reworking and combining the list of options to better address the specific management objectives, and by a first pass qualitative assessment of the potential benefits and impacts on estuarine processes.

The short-listed potential management options are described below based on the primary implementation mechanisms, that is: **Planning (P), Capital and on-ground works (W), Community Services (CS), Research, Investigations and Monitoring (M), and Compliance (C).**

6.1.3.1 Planning

P-1 Preserve foreshore land to provide a riparian buffer from development and climate change impacts.

Foreshore buffers which preserve the ecologically significant riparian zone are required. Riparian vegetation is ecologically important, providing transition between aquatic habitats and terrestrial habitats. Riparian vegetation in estuaries is unique in that it has adapted to varying environmental conditions, including water levels and salinity. In addition to its ecological importance, riparian buffers may also assist in providing visual screening of development from the waterway.

The width of the riparian buffer should be at least 50 to 100 m. Where the riparian buffer will also be used as a wildlife corridor or refuge, the width should be at least 200m. Bega Valley Shire Council is proposing the zoning of all estuary riparian zones as E2 Environmental Protection (in the new LEP), generally to a distance of 100m. The E2 zoning will largely prohibit development and landuses that may impact the riparian zone or adjacent waterway.

No development should occur within the riparian buffer zone, with the exception of minor environmental facilities or minor recreation infrastructure. Stormwater treatment facilities, effluent irrigation or asset protection zones (bushfire buffers) should be located landward of the riparian zone buffer.

The riparian buffer may need to be revegetated in some areas such as Tathra River Estate where riparian vegetation has been removed or degraded.

The riparian buffer should be measured landward from the 2.0 m AHD contour, rather than MHW, property boundaries or the top of the riverbank. The use of this contour ensures that adequate provision is made for variations in estuarine condition as a consequence of future sea level rise (e.g. landward migration of estuarine vegetation and habitats), and allows the ability to progressively increase artificial entrance opening heights, as part of a Entrance Management Policy (Strategy P-9) in the future.

Timeframe: Short (1 – 3 years), integrating with review of LEP.

Priority: Very High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Planning changes - minimal, staff time only, to be undertaken as part of new CLEP review. Revegetation – costs dependent on size of project area etc

P-2 Prevent development on steep slopes.

The natural beauty of the Bega River Estuary is due partly to the extent of vegetation on surrounding hillslopes. As such, controls should be placed upon future development of these areas, such that the aesthetic and scenic values afforded by these lands are preserved.

In addition to the scenic value, vegetation on the hillslopes is limiting erosion. Unvegetated slopes have a greater potential for erosion, which is particularly manifested during construction stages of development. In order to protect downstream waterways from sedimentation and turbidity and its associated impacts, all steep and erodible land should be identified in a Land Overlay in the revised LEP to avoid development of steep slopes within the catchment, and especially in areas in close proximity to the estuary.

Topographic assessments should be carried out as part of an overall land capability study to determine areas unsuitable for development. Where land is clearly too steep for development, Council should rezone such land to environment protection or similar, to ensure development is prevented. For example, it is recommended that all the steep, vegetated land on the north side of the river is zoned E2 / E3 and that no further subdivision is permitted in this area.

Visual impact assessments should also be a requirement for future development applications wherein removal of any existing substantial vegetation is required. From an aesthetic perspective, Council should ensure sufficient screening of all future developments from the estuary, while prominent ridgelines should be excluded from all development. Ridgelines should only be permitted for use as roads with adequate native streetscape vegetation.

Changes to Development Control Plans will be required to incorporate the proposed development restrictions.

Timeframe: Short (1 – 3 years), integrating with the review of the LEP, and to be preceded by an extensive land capability assessment of the areas surrounding the estuary.

Priority: Very High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, staff time only

P-3 Prevent clearing and inappropriate vegetation removal.

At present, there remain forested areas in the catchment outside of environment protection zones and reserves. There is a need to protect these significant habitats, particularly where they contain endangered ecological communities (EECs). Retaining vegetation will ensure that existing values associated with habitat and scenic amenity are not lost.

The Native Vegetation Act (NVA) is the primary legislative tool with regard protecting native vegetation. The NVA requires landholders (outside of residential zones) to prepare a Property Vegetation Plan (PVP) as part of any proposal to clear native vegetation. A significant limitation in the Native Vegetation Act is that it has a list of exemptions known as Routine Agricultural Maintenance Activities (RAMAs) that permit the removal of native vegetation without assessment or approval.

A large amount of clearing has occurred since European settlement and it is important that remaining habitats are preserved. In addition vegetation cover greatly assists in reducing soil erosion and its associated impacts on water quality and sedimentation in downstream waterways.

Appropriate rezoning and planning controls can protect existing native vegetation on private land. This could include rezoning of forested land under private ownership where the land is not being used for another purpose (to E2 Environmental Conservation under the new LEP Standard Instrument). This may require compensation for private land holders. Rezoning of lands would also need to consider other factors.

The preparation of Property Vegetation Plans, zoning or the inclusion of vegetation protection clauses on the title of private property are seen as the primary methods of protecting native vegetation within the BRE.

Timeframe: Short (1 – 3 yrs), integrating with the review of the LEP, and to be preceded by an extensive land capability assessment of the areas surrounding the estuary.

Priority: Very High (refer Section 6.2).

Key Responsibility: BVSC, SRCMA

Other Partners: , OEH, DoPI

Indicative Cost: Minimal, staff time only

P-4 No net increase in runoff and pollutant loads from future developments.

Future development within the BRE catchment should aim to maintain or improve the condition of the estuary. In conjunction with other controls for environmental management outlined for future developments, controls on site specific runoff are required. All future development within the BRE catchment should aim to protect downstream water quality and flow by ensuring that the development generates:

- *no net increase* in pollutant loads (TN, TP, TSS); and
- *no net increase* in runoff volume (particularly if discharge is to fringing estuarine wetland area).

This should be achieved by incorporating a range of on-site treatment measures, and should begin at the construction phase. These measures should follow the basic principles of Water Sensitive Urban Design (WSUD) and Integrated Water Cycle Management, and should incorporate a combination of lot-based, streetscape and end-of-line treatment measures and devices. End-of-line devices should be installed prior to land development works to control sediment runoff during construction stages, as part of the appropriate Sediment and Erosion Control Plan for the construction.

Targets for volumetric runoff and pollutant load reductions should be established on a development by development basis, and should aim to achieve *no net increase* (i.e. the same or lower pollutant loading to receiving waters) compared to the existing conditions. Details of volumetric runoff controls should be established within a Floodplain Risk Management Study. Treatment of existing catchment runoff (particularly existing urban runoff) may be considered by developers as a means to help achieve a net positive environmental outcome for the estuary.

Implementation of this strategy would primarily be through amendments to Development Control Plans, and would require future developers to provide a report that demonstrates how this goal has been achieved.

Timeframe: Short (1 – 3 yrs)

Priority: Very High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

P-5 Ensure the use of appropriate sewage treatment measures for all new developments.

As noted previously, STPs and on-site septic systems are reported to be a source of pollutants in the Bega River. Stringent planning controls regarding sewage management (ideally across the whole LGA) may ensure that pollutant impacts from future developments are reduced.

For all new developments, the sewage treatment measures to be adopted must be compatible with the limitations and constraints of the site. Planning controls should stipulate that:

- All proposed use of on-site systems must be verified by an assessment of soils and topographic suitability. The use of on-site systems must also consider the scale of the development, and must be consistent with stormwater management targets for the site, as per Strategy P-4;
- All new urban development with lot sizes smaller than 2000m^2 must be connected to a reticulated sewerage network;
- Where connection to the reticulated sewerage network is proposed, the developer should contribute to upgrades required to trunk mains and at the STP to maintain or improve the quality of treated effluent from the plant;
- Where treated effluent is to be used for irrigation on site, the developer must demonstrate that the effluent irrigation will not conflict with achieving stormwater treatment targets (refer Strategy P-4), and will not result in leaching of pollutants to the estuary or other natural waterways.

The above planning controls should be considered as part of proposed planning reforms by BVSC, and incorporated into DCPs that support the revised LEP in the future. It is recommended that a lands capability assessment be carried out to determine the appropriateness of soils and topography to support on-site sewage treatment in targeted areas around the estuary and throughout the wider catchment area (ideally being extended to the whole LGA for consistency) (refer Strategy M-2).

<u>Timeframe</u>: Short (1 – 3 yrs)

<u>Priority</u>: High (refer Section 6.2).

<u>Key Responsibility</u>: BVSC

<u>Other Partners</u>: OEH

<u>Indicative Cost</u>: Minimal, staff time only

P-6 Require all future developments to be eco-friendly and energy efficient.

Future developments within the catchment should be compassionate to the environmental sensitivity of the area, with positive steps taken to foster a bond between future residents and the natural environment. This includes appropriate fire, weed and wildlife management, and energy efficient design. This action applies to urban, rural residential and rural homestead constructions.

This strategy is supported by other strategies including best practice stormwater treatment (Strategy P-4), sewage management (Strategy P-5), adequate riparian buffers (Strategy P-1) and preservation of terrestrial vegetation (Strategy P-3).

Additional controls on future development should be considered to meet the aims of this strategy, including:

- The use of endemic species only in household or site gardens and landscaping;
- Strict controls or prohibition of domestic pets, as appropriate;
- Asset protection zones are to be determined as part of a bushfire plan developed with the Rural Fire Service;
- Housing design should maximise energy efficiencies, including the manipulation of natural elements such as sunlight, prevailing winds and ventilation and solar power to reduce the consumption of electricity for light, air conditioning, and water heating;
- Housing design should incorporate water reduction devices, rainwater tanks and other such methods to reduce demand on the town water supply.
- New dwellings should be encouraged to go beyond BASIX requirements with regard the innovative use of solar passive design and alternative energy generation.

Timeframe: Short (1 – 3 years)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: RFS, OEH

Indicative Cost: Minimal, staff time only

P-7 Require developer contributions to recreational and foreshore facilities.

Future development will result in an increased demand on existing recreational facilities and amenities around estuary foreshores. The increased usage of the estuary will also impose an increased demand for better access to the estuary foreshore and along the estuary edges.

Currently developers are required to make Section 94 contributions towards the costs of new infrastructure that is needed to meet the demands of new residents / population that the particular development brings. Councils may also impose fixed development levies or enter into developer agreements for a particular development.

A new section 94 plan should be developed that encompasses the Bega River Estuary and Tathra Beach foreshore areas. The plan should aim to ensure that major recreational facilities throughout the Tathra area are able to be funded by developments throughout the Bega River Estuary and Tathra areas.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, staff time only

P-8 Not Used

Note: Earlier versions of this document included a Strategy P-8: Ensure adequate environmental flows to maintain ecosystem functions along the river.

It is considered that this strategy is essentially now addressed through the new Bega and Brogo River Areas Water Sharing Plan (NOW, 2011). A key outcome of the Plan is to determine and deliver the level of freshwater flow required to adequately protect estuarine environments of the Bega River Estuary. The NOW undertake ongoing detailed monitoring and assessment of the current hydrologic regime of the rivers and also regulate water extraction. The installation and use of data from appropriately located water level gauges within the estuary itself (refer Strategy W-9) may assist in this regard.

As part of the development of the Water Sharing Plan, NOW have undertaken assessments of salinity levels in several different estuaries (including the Bega River) and determined "normal levels" of salinity and examined departures from these levels and related changes in catchment inflows. The NOW has clearly recognised the importance of freshwater inflows to the Bega River Estuary by incorporating environmental flows into the Water Sharing Plan.

P-9 Adopt an Interim Entrance Management Policy.

At present, the Bega River entrance is opened artificially when water levels at Hancock Bridge reach RL 1.36 m AHD. This is undertaken by Council on an as-need basis, and although consultation with some stakeholders usually precedes the works (e.g. check with OEH regarding the status of Little Terns and Hooded Plovers on the entrance sand spit), there is currently no formal policy that has been ratified by Council or State Government that outlines processes and protocols.

A formal review of the 1.36 m AHD opening height should be conducted. The review should consider the ecological needs of the estuary as well as inundation of property (including upstream agricultural land) and roads. Based upon the review, a formal Entrance Management Policy is to be developed and adopted until the flooding issues that trigger entrance opening are more thoroughly addressed in a Flood Study and Floodplain Risk Management Study and Plan (see Strategy M-1).

The interim policy will detail the optimal water level for opening and the conditions under which this should occur, such as impending rainfall, the location at which the berm should be breached, and tidal conditions at the time of opening, all of which may interact to vary the effectiveness of the opening. The Policy will also identify actions required to reduce the pressure to artificially open the entrance, such as raising or relocating assets and infrastructure. Indicative contents of an Entrance Management Policy for intermittently open entrances are given in Haines (2008).

Further details regarding considerations for entrance management are provided in the Entrance Management Policy Sub-Plan (refer Section 7.2).

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $30,000 for review and Policy preparation

P-10 Control PWC use east of Hancocks Bridge to minimise conflict with other recreational users, residents and wildlife.

The use of personalised water craft (PWCs) has been noted by community members to be at times be noisy and dangerous to other recreational users and some residences near to the waterway, and potentially, endangered birds (Little Tern, Hooded Plover) nesting in the entrance sand bar.

It is recommended that the permissibility of PWC use in this locality is reviewed. Options to be considered include prohibition of PWCs, or permission for PWC to transit through the area, at idle speed only, in order to gain access to the ocean from the most downstream boatramp in the river.

Any changes to PWC permissibility would need to be mirrored in NSW Maritime maps, and on signage at boatramps and along the riverbanks.

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2).

Key Responsibility: NSW Maritime

Other Partners: BVSC, OEH

Indicative Cost: Staff time only for assessment, plus $5,000 for signage etc.

P-11 Incorporate appropriate planning controls for climate change impacts into existing planning frameworks

Future sea level rise will increase mean water levels within the estuary. Future development must therefore be excluded from any area which is likely to be affected by future changes to the estuary's hydrodynamic regime (including possible changes to the entrance conditions). Sufficient land along the foreshores should be preserved and allocated for the future upslope migration of habitats, particularly riparian vegetation, in response to increased water levels. The provision of adequate setbacks for habitat migration has been discussed in Strategy P-1.

The potential for sea level rise to cause inundation/flooding on land outside of the buffer zones outlined in Strategy P-1 also needs also be considered. It is suggested that the existing Flood Planning Level around the estuary be re-assessed to incorporate sea level rise impacts, through the production of a Floodplain Risk Management Study and Plan in accordance with the principles in the NSW Floodplain Development Manual (2005).

Existing Flood Planning Levels in Bega Valley have not been identified in accordance with Floodplain Development Manual (2005). Planning controls should stipulate that future developments are to adopt an interim Flood Planning Level of 0.5 metres above the existing Flood Planning Level, or RL 4 m AHD (if no existing Flood Planning Levels have been established),until the Flood Study and Floodplain Risk Management Study and Plan have been adopted (see Strategy M-1).

Planning controls should refer to investigations into the vulnerability of the BRE and its associated assets and infrastructure to future climate change (refer Strategy M-9).

Timeframe: Short (1 – 3 years)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, DoPI

Indicative Cost: Staff time only for incorporating changes into planning controls.

P-12 Use the EMP to assist in determining relevant landuse zonings and development controls in the preparation of the new standard LEP

This Plan has outlined a number of actions which relate to land use in the BRE catchment. Further, studies to be completed as actions within this EMP, in particular, land capability to support different land uses (Action M-2), and the extent and condition of habitats (Action M-3), will be vital to effectively reviewing and upgrading existing zonings throughout the catchment.

This strategy aims to ensure the purpose and intent of the EMP, such as to protect significant ecological habitats (EECs) on land and in water, water quality for ecology and recreation and reduce catchment inputs, through planning controls for future developments and other landuses, effectively translated into statutory controls administered though the LEP.

Timeframe: Immediately (6 months)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, Staff time only

6.1.3.2 Capital and On-Ground Works

W-1 Review and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir.

As outlined in Sections 2.3, there are a number of structures and impediments which impede the natural flow of Bega River so as to reduce salt intrusion and inundation of some agricultural lands. Such structures are now understood to impede fish passage and fish spawning patterns and lifecycles, and may also reduce water exchange. In the case of the Russell Creek Weir, current management of the weir may not be adequately enabling the inundation required in the upstream wetlands. It is possible that other structures on tributary streams also exist, and an investigation into their management should also be undertaken as part of this strategy.

Each structure should be investigated for its impact upon ecology (particularly fish passage and the inundation required for the health of upstream wetlands), water exchange and flood behaviour. Recommendations regarding the management of the structures should be made to ensure that the ecological needs of the estuary are met, without unduly compromising the function of the structure, or the livelihood of upstream landowners. The structure, operation and potential failure of these structures may have significant impacts on flood hydrodynamics, which need to be investigated in a Floodplain Risk Management Study and Plan.

In addition, any review of the management of the structures will need to consider and allow for a potential reduction in artificial entrance opening levels (as part of an Entrance Management Policy, Strategy P-9) and likely increases in estuary water levels due to sea level rise.

Close coordination and cooperation between SRCMA, Council and local landholders is required. Incentives and compensation for local landholders to implement the recommendations may also be required.

Timeframe: Medium (3 – 5 yrs)

Priority: High (refer Section 6.2).

Key Responsibility: DPI –Fisheries, NOW

Other Partners: BVSC, landholders, SRCMA

Indicative Cost: $50,000 for assessment of structures. Costs for modifications or compensation are unknown.

W-2 Provide assistance to rural land managers to reduce pollutants and sediment in runoff

A significant issue highlighted in the scientific study was the impact of agricultural practices (particularly dairying and grazing) on downstream water quality. Pollutants in agricultural runoff may include large amounts of animal waste, particularly where areas utilise effluent for irrigation, where fencing of waterways is not provided, and where cattle access roads are not maintained.

Better land management for soil erosion, stock effluent, and filtration of runoff is required. In addition to targeted education (which is detailed in Strategy CS-2), there is a need to provide assistance to rural land managers, through financial incentives, provision of expertise or even labour, in order to improve the management of agricultural runoff.

Current programs by the SRCMA and other partners such as Bega Cheese are supported by Council and should be further promoted within the wider community. There are current projects underway on dairy farms within the Jellat area. Furthermore, other innovative methods to source funding and resources for such programs should be investigated, for example, the reintroduction of the dedicated environmental levy, a sustainability accreditation program, or philanthropic / corporate donations (of both time and money – e.g., Westpac, Macquarie Bank).

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: SRCMA

Other Partners: BVSC, OEH, DPI-Ag

Indicative Cost: Dependant on the extent and scope of assistance provided, but likely to be several hundred thousand dollars for the entire Bega River catchment. Note: expenditure throughout the catchment to date is likely to have been in the millions of dollars. This work strategy will take many years to fully implement across the catchment.

W-3 Revegetate degraded/cleared areas in catchment

There has been a significant amount of vegetation clearing within the Bega catchment over the history of European settlement, and this has been linked to increased turbidity, sedimentation, and the mobilisation of large volumes of sediment from deep valley fills (refer Section 2.9.1). Some land currently used for dairying is grazing is highly susceptible to erosion due to the lack of natural vegetation. Areas on public and private property which are currently disused or degraded should be targeted for revegetation. In addition, revegetation should target areas that re-establish wildlife corridors between forested areas across the landscape.

Lands on public property may be revegetated with the assistance of volunteer conservation groups. For cleared/degraded lands on private property, incentives should be provided to assist in their revegetation. There may be assistance through current programs run by the SRCMA. The possibility of providing the services of volunteer conservation groups to conduct revegetation upon private land where permitted by the landholder should also be considered.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: SRCMA

Other Partners: BVSC, OEH

Indicative Cost: Likely to be several hundred thousand dollars, depending on extent and scope of works required.

W-4 Revegetate foreshores and streambanks

As noted in Figure B-13, there are a number of locations in the BRE that have sparse or little natural riparian coverage. Some of this may be the result of clearing for agriculture. Foreshore areas, such as those outlined in Figure B-13, should be targeted for revegetation.

The SRCMA has outlined targets for revegetation of areas with sparse riparian habitat. Possible compensatory revegetation requirements of any new development (for example, the Tathra River Estate), could also be utilised to revegetate foreshore areas along the estuary. Revegetation of riparian habitats could also be conducted by volunteer conservation groups.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: SRCMA

Other Partners: BVSC, landholders

Indicative Cost: likely to be in excess of $100,000, depending on scope and extents of works required

W-5 Assess sites of river bank erosion and rehabilitate as required.

Sites of active bank erosion have been broadly outlined in Figure B-8. A detailed assessment of river banks throughout the estuary and upper river areas should be performed. The assessment should guide the rehabilitation of priority bank erosion sites, in particular, those sites where significant assets are at risk if erosion continues.

This assessment and rehabilitation program could be coordinated with complementary programs that may be currently underway by SRCMA.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: SRCMA

Other Partners: BVSC, OEH, landholders

Indicative Cost: $100,000 for riverbank assessment throughout catchment, plus the cost of works, as required (several hundred thousand dollars if rock armouring is required at one or more locations). This cost would likely be in the millions when taken across the whole catchment.

W-6 Reduce erosion and sediment runoff from firetrails, driveways, road verges and carparks

Unsealed firetrails, driveways, road verges and carparks may be contributing to sediment runoff into downstream waterways. Roads should be maintained to ensure runoff is managed to minimise erosion and that drainage is diverted through bushland before discharging into natural waterways. Where appropriate, approaches to creeklines and other areas contributing large amounts of sediment to BRE should be sealed.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: SRCMA, OEH, landholders, DPI-Forests

Indicative Cost: $300,000 - $500,000, depending on the scope of works required throughout the BRE catchment

W-7 Assess existing stormwater treatment devices and improve the level of pollutant removal from stormwater

The area within the catchment currently occupied by development (residential or commercial purposes) is relatively minor. However, these areas still discharge rainfall runoff to the estuary and its tributaries, with little or no prior treatment. An assessment of the adequacy of existing stormwater quality improvement structures should be undertaken.

Congruent with treatment of existing urban stormwater, all future urban development should be required to treat stormwater to current best practice standards (e.g. through Water Sensitive Urban Design), as recommended in Strategy P-4.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: To be considered as part of a stormwater management plan for the Bega LGA. Costs likely to be in excess of several hundred thousand dollars, when including construction of all necessary works.

W-8 Assess and improve current recreational infrastructure and foreshore access (including minor works e.g. sealing carparks, landscaping and revegetation).

As noted by the community, there is a need to assess the current level and condition of recreational facilities provided for users of the BRE. Facilities should be assessed for their ability to adequately meet existing and future recreational demands, and also, the impact of the facilities on the estuary. An appropriate level of recreation and foreshore access to help maintain long term sustainability of the estuary should be determined.

Those sites found to be suitable for recreation and access should be upgraded and/or maintained as appropriate. Upgrades should include revegetation (using endemic species only), other landscaping, modification or sealing of carparks as required.

The number of sites around the estuary should be rationalised, to limit the potential impacts of recreation on the estuary. If considered inappropriate, some existing recreational facilities could be removed, or relocated to more appropriate locations.

Access to and around the foreshore should also be rationalised, in order to minimise impacts on sensitive environments, such as wetlands, habitats for threatened species, and areas of locally or regionally important vegetation.

The community has indicated that a bikepath between Tathra and Mogareeka is desirable, along with additional fish cleaning tables, and improved facilities and amenities at popular locations such as Mogareeka.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: DPI, OEH, NSW Maritime

Indicative Cost: More than $100,000 for rationalisation and improvement of recreational facilities

W-9 Install flow gauges in appropriate locations to monitor environmental flows.

Greater knowledge and understanding of the catchment inflows to the Bega River estuary is required. The installation of flow gauges in strategic locations throughout the estuary would greatly assist in quantifying the impacts of river flows and extraction rates on the estuary, etc. A more accurate record of river flows would also assist with improved management of environmental flows throughout the system through the water sharing plan process and provide data for the Flood Study and Floodplain Risk Management Study (Strategy M-1).

Timeframe: Immediately (12 – 18 months)

Priority: Medium (refer Section 6.2).

Key Responsibility: NOW

Other Partners: BVSC

Indicative Cost: $80,000, depending on the number of locations, telemetry, site difficulties etc.

W-10 Connect Mogareeka Village to reticulated sewerage system.

It has been suggested that Mogareeka Village is contributing to the degradation of the waterway through inadequate on-site septic systems. Algal blooms have been reported in the inlet, although the source of nutrients that prompted these blooms has not been confirmed. Connection of Mogareeka to the reticulated sewage network may assist in reducing pollutant loads to the estuary.

As noted in the Sewerage Sub-Plan (Section 7.1), Tathra STP cannot accept further residential connections without either an increase in suitable land for effluent disposal, or vastly increased water quality treatment. This issue would need to be addressed (such as by methods noted in Section 7.1), prior to the connection of Mogareeka Inlet.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, NOW

Indicative Cost: In excess of $1m depending on the infrastructure requirements, and upgrades at the STP in order to accept the sewage.

W-11 Develop and implement a weed management strategy to eradicate weeds in the estuary.

A weed management strategy is required to guide specific eradication programs and priority locations for management of target weed species across the catchment. The strategy should include the following:

- An assessment of existing weed impacts, in terms of weed species and locations requiring management;
- Prioritised targets for specific weed species and for affected areas;
- An outline of volunteer groups to assist with weed eradication activities, and ways in which to encourage volunteer participation;
- An outline of education and incentive activities for private rural land owners, to assist in the remediation of significantly weed affected areas, and to demonstrate methods for weed management which reduce the reliance on chemical control;
- An outline of education activities for urban areas, which detail target weed species, ways to reduce weed impacts, and methods to establish endemic species in household gardens

Programs for weed eradication may be linked with existing programs by the SRCMA and the regional weeds management strategies.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: SRCMA, DPI-Ag, OEH, DPI-Crown Lands

Indicative Cost: $30,000 for developing a program – assume mostly volunteers to implement, in addition to other concurrent strategies, e.g. community education.

W-12 Develop and implement a program to eradicate pests in the estuary

Feral animals and other introduced pest species should be managed to minimise impacts on the environment. A program should be developed which outlines:

- Investigate impacts of specific species on the estuary and its ecosystems;
- Target pest species for eradication, and prioritised localities to conduct programs;
- Education activities for residents outlining priority pest species, methods to assist their eradication, and proper controls for domestic pets; and
- Activities to encourage the assistance of the community volunteers in pest control.

Programs for pest eradication may be linked with existing programs by the SRCMA and the Rural Lands Protection Board.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: RLPB

Other Partners: BVSC, OEH, DPI-Crown Lands, LALC, landholders

Indicative Cost: $30,000 for developing a program – assume mostly landholders to implement on private land, in addition to other concurrent strategies, e.g. community education

W-13 Raise level of road to reduce inundation during estuary closure.

Sections of the coastal road between Tathra and Mogareeka (north of the Tathra STP) become inundated during times of high water levels in the estuary, particularly when the entrance is closed. Projected sea level rise may result in more frequent inundation of this road in the future. Subject to further investigation and management recommendations in a Floodplain Risk Management Study and Plan (Strategy M-1), it is recommended that the surface level of this road be raised. In determining the amount of road raising required, consideration should be given to the future entrance management policy requirements, as well as the likely timeframe for manifestation of future sea level rise conditions.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Depending on the length of road required to be raised, assuming that roadworks over 1000m are required, costs would exceed $500,000.

W-14 Support strategic raising of sections of the golf course in return for protection and rehabilitation of high value habitat.

The Tathra Beach Country Club (TBCC) provides a recreational resource to the community, including a 12 hole golf course. The golf course is located between the SEPP14 Wetlands of Black Ada Lagoon and Black Ada Swamp / Racecourse Creek and the Bega River. Low lying areas of the golf course footprint encompass areas of saltmarsh, containing *Juncus* rushes, and wetlands that are part of the adjacent SEPP14 Wetlands.

The low lying sections of the golf course are subject to natural inundation during periods of high water levels and entrance closure. However, this inundation may result in the closure of 3 holes of the course for lengthy periods of time. In addition, the saltmarsh and wetlands adjacent to these holes are in a poor state of repair, as they are considered part of the course, but the muddy nature of these areas means they are not particularly suited or valuable as part of the golf course.

The TBCC has expressed an interest in rejuvenating the adjacent areas of saltmarsh, in keeping with the SEPP14 Wetlands of which they are part, in return for raising adjacent hole(s) of the course to be viable for play during entrance closure.

Effluent from the Tathra STP is used for irrigation on the adjacent TBCC Golf Course. Given the existing inundation issues, higher estuary water levels in the future may result in this effluent disposal method becoming unsuitable. Raising of sections of the golf course may allow for an improvement in the effectiveness and the land area available for effluent disposal. There would be a greater volume of soil through which irrigated effluent must filter prior to reaching the groundwater table and subsequently the estuary. This may increase the residence time of effluent on the site, and potentially improve the quality of water leaving the site. There would also be a greater area of land available for irrigation, as the raised land would remain viable for irrigation throughout entrance closure periods. Potential improvements to water quality leaving the site will need to be confirmed by assessments of impacts on groundwater quality from effluent irrigation of the proposed raised land (including the type of material and construction).

The potential raising of sections of the golf course should be considered within the context of a Floodplain Risk Management Study, which addresses the potential for higher estuary water levels in the future as a result of sea level rise and any progressive increase in the artificial entrance opening level under a future Entrance Management Policy (Strategy P-9). The assessment of land raising options must also identify the rehabilitation actions and ongoing management regime for the SEPP14 wetlands as well as thoroughly investigating and mitigating the potential impacts of raising the adjacent land on the hydrology of the wetland.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2)

Key Responsibility: BVSC, Tathra Beach Country Club

Other Partners: OEH

Indicative Cost: For BVSC, staff time only to facilitate the strategy.

For TBCC, costs will depend on the area of land to be raised, the volume of material required, the method of construction and compaction etc, as well as wetlands to be rehabilitated, and are roughly estimated to be between $100,000 and $500,000.

W-15 Reclaim eroded land at Lions Park using sand dredged from entrance.

The foreshore of Lions Park was severely eroded during an artificial entrance breakout in the late 1990's.

Future entrance management may require the removal of some sand from within the entrance compartment (refer Entrance Management Sub-Plan, Section 7.2). If such dredging works are carried out, then any dredge spoil should be placed onto the foreshore of Lions Park and regenerated to restore recreational values and riparian vegetation. Any dredging or removal of floodtide shoal sand bars would need to consider the impact on shorebirds and waders.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: If carried out as part of a formal dredging program (for entrance management purposes), then additional costs to place the spoil and regenerate Lions Park would be in the order of $50,000, depending on the volumes involved.

W-16 Protect and promote (as appropriate) Aboriginal and European Heritage sites and places of significance.

A number of Aboriginal and European heritage sites are documented throughout the BRE catchment. In collaboration with the Local Aboriginal Land Council, the management of Aboriginal places of significance within the BRE catchment should be reviewed. The restoration or potential promotion of certain sites should be agreed upon by the LALC, and works undertaken as required.

The management of sites of European heritage should also be reviewed, and required restoration, promotion and protection tasks undertaken.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: OEH, BVSC

Other Partners: LALC, historical societies

Indicative Cost: less than $10,000, depending on the scope of specific works required. This costing would not include any significant restoration of sites of significance.

6.1.3.3 Community Services

CS-1 Promote the conservation of privately owned vegetation, including revegetated private lands.

Areas of significant native vegetation and wildlife corridors on privately owned land within the catchment, particularly areas containing EECs, should be identified. Relevant landowners should then be encouraged, through provision of incentives, to conserve these vegetated areas through formal conservation agreements with SRCMA or OEH. Conservation agreements should incorporate the re-establishment of an appropriate vegetated buffer around the existing vegetation stands to help reduce the impacts of edge effects. Areas of privately owned vegetation in the BRE catchment are shown indicatively in Figure 6-1.

Timeframe: Immediately (12 – 18 months)

Priority: Medium (refer Section 6.2).

Key Responsibility: OEH

Other Partners: BVSC, SRCMA, landholders

Indicative Cost: Minimal, staff time only through direct liaison with landholder, but excluding any incentives or compensation for conservation of land

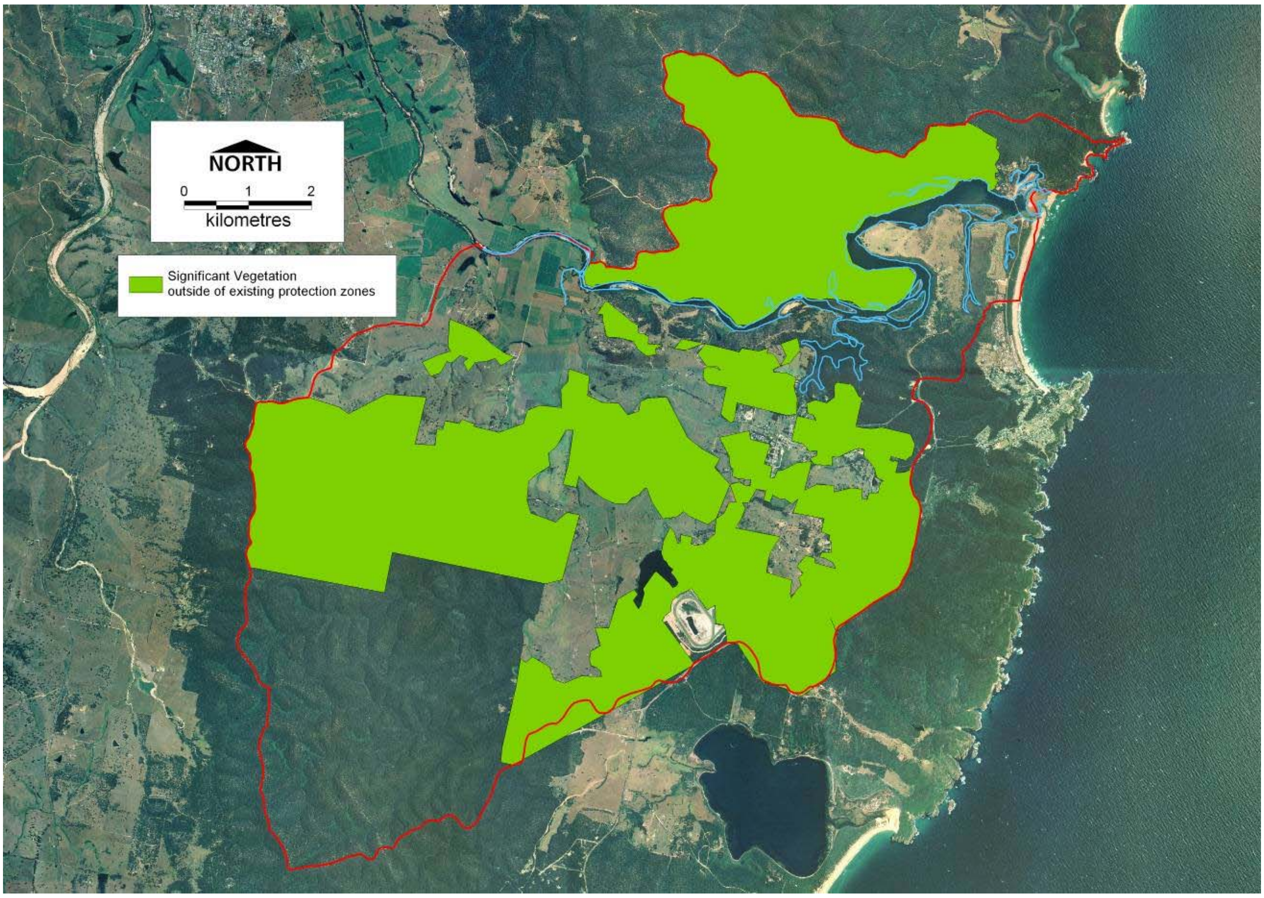

Figure 6-1 Significant vegetation under private freehold title or State Forest

CS-2 Conduct a rural education program promoting best practice techniques for environmental management, based on the Bega Cheese EMS Program.

As noted in Section 2.9.1, agriculture is likely to have a significant impact upon water quality and habitats in the BRE. SRCMA, Bega Cheese and BVSC have implemented a successful Dairy Farm EMS project. This project has been a great success and has potential to be expanded to all rural landholders.

The key objectives of the program should include the reduction of soil erosion and impacts of cattle in riparian zones, improve filtration of runoff and improve stock effluent management. As a minimum, the following components should be included in the education program:

- the removal of cattle access to streambanks, through stock exclusion and providing alternative water supply, and the rehabilitation of vegetation along streambanks and watercourses;
- best practice use of pesticides and fertilisers to reduce chemical residues in runoff;
- best practice land management to reduce soil erosion from paddocks, gully erosion, and from unsealed laneways and roads;
- the use of filter strips, diversion devices and detention basins, to reduce sediment loads in runoff; and
- best practice effluent treatment, management and re-use.

Activities such as field days for land owners to display best practice management techniques and promote the spread of knowledge could be incorporated into the education program. The education program should be linked with similar programs conducted through the SRCMA and DPI-Ag.

There is potential for the development of catchment landowner accreditation program as is currently being proposed for the Wallaga Lake catchment and introduced by the Hunter-Central Rivers CMA. The accreditation program should focus on highlighting the potential economic benefits to the landowner of providing ecosystems services to the wider community, in this case high quality run-off to, ultimately, the Bega River Estuary.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: SRCMA

Other Partners: DPI-Ag, BVSC

Indicative Cost: Likely to cost in excess of $50,000 annually, depending on the avenue of delivery, the number of targeted landholders, and promotional expenses.

CS-3 Develop general information brochures for residents and visitors.

The Bega estuary is an asset to the local community, largely valued for its ‘natural’ beauty and tranquil setting. It supports a diverse and valuable ecological environment and contains significant cultural heritage.

Brochures should be developed and distributed to local residents and visitors to the region to raise awareness of the environmental and cultural values of the Bega Estuary. They should include the following content as a minimum:

- estuary values and natural estuarine processes, including ecological and cultural aspects;
- impacts of human activities upon estuarine processes and values;
- appropriate recreational behaviour and access to reduce littering and impacts upon sensitive habitats (e.g. mangrove, saltmarsh and seagrass), including boat speeds, fishing bag limits, appropriate boating/fishing activities etc;
- appropriate residential behaviour (such as stormwater, on-site septic system management, rainwater tanks, noxious weeds/pests, native species for gardens, domestic pet management, bushfire management etc) to reduce impacts upon the estuary;
- threatened species and conservation activities (including promotion of local volunteer conservation groups).

The brochures should be made available through local stores, hotels, real estate agents, private accommodation venues, Caravan Parks and Council’s website.

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: $20,000 for brochure preparation, design, printing and distribution

CS-4 Develop and install educational signage to promote estuary values.

Eco-educational signage should be installed at strategic locations along the estuary foreshore. Signs could be developed as a series, in a continuing story-book fashion, and connected via public foreshore tracks / paths. Signs should aim to highlight significant local features of different sections of the estuary. The installation of signage could occur in concert with improvements to foreshore facilities (Action W-8).

Signage should include information of the local ecology and Aboriginal and European cultural significance of the estuary and its surrounding areas. Signage should also be used to highlight areas of boating safety and navigation hazards, particularly signage placed at boatramps.

Further consultation would be required to develop appropriate content of the signs, particularly in respect to Aboriginal cultural significance, and early European settlement.

Timeframe: Short (1 – 3 years)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: $40,000 for design and construction of signs

CS-5 Develop primary and secondary school education kits.

A school education kit focussing on the estuarine processes and human impacts in the Bega Estuary should be developed, using information compiled for the community brochures. Existing resources from other agencies (OEH, SRCMA) could also be utilised in the kits. The kits could be further complemented by guided school excursions of the estuary (refer CS-6).

Different school kits could be prepared depending on curricula (i.e. primary school curricula would differ significantly to secondary school curricula), and tailor made to assist with the specific requirements of school curricula. The kits would then be distributed to local and regional public and private schools.

Timeframe: Short (1 – 3 years)

Priority: High (refer Section 6.2).

Key Responsibility: Department of Education, Bournda EEC

Other Partners: SRCMA, BVSC, OEH, DPI

Indicative Cost: $50,000 for developing, printing and distributing a range of kits for different curricula.

CS-6 Guided tours and excursions

The Bega River estuary is an ideal location for hosting guided tours and excursions that focus on estuarine processes and ecosystem. In addition to its natural beauty, riparian vegetation, SEPP14 Wetlands and seagrass beds, the BRE also contains significant Aboriginal and early European cultural heritage, all of which can be highlighted via tours / excursions. Such activities would link well with local promotion of the area as the 'Wilderness Coast' by Tourism Australia and BVSC.

The tours could be an addition to the OEH-National Parks Discovery Rangers Program, or could be set-up via joint input between BVSC, OEH, SRCMA, DPI and Bega Local Aboriginal Lands Council. As well as specific pre-arranged school excursions, the tours could be hosted more frequently during the summer school holiday period, and could complement other commercial tourism activities. The tours could also extend to include workshops on sustainable recreational fishing practices, as established under the DPI Fishcare program.

Timeframe: Medium (3 – 5 yrs)

Priority: High (refer Section 6.2).

Key Responsibility: OEH

Other Partners: BVSC, SRCMA, DPI, local education centres

Indicative Cost: minimal (assuming tours can be accommodated by existing staff resources).

CS-7 Support existing community volunteer groups participating in conservation activities.

This strategy aims to support existing community-based volunteer groups across the BRE catchment that would be able to assist in some of the on-ground works recommended by this Plan (in particular, revegetation of foreshores and degraded/cleared areas - W-3, weed/pest removal - W-11, W-12, and other land management activities, where appropriate). In doing so, participants of the groups would foster a greater appreciation of the natural environment.

Government Agencies should provide assistance to groups in the management of volunteers and instructions to ensure works are carried out appropriately and with appropriate financial and resource support. At present, there are already a number of pro-active volunteer conservation groups in the BRE, including the Tathra Landcare Group, and a group protecting the yearly nesting of Little Terns along the entrance berm through OEH's Sharing the Shoreline program. The Far South Coast Landcare Association and Conservation Volunteers Australia are two groups that could be engaged in the support of volunteer conservation activities.

Timeframe: Immediately (12 – 18 months)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, SRCMA, Far South Coast Landcare Association, CVA Australia

Indicative Cost: say $20,000 per annum for provision of resources to support conservation works.

CS-8 Distribute periodic newsletters to community detailing implementation and progress of Estuary Management Plan.

Many of the residents in the BRE catchment are genuinely concerned and interested in the future of the estuary. Periodic newsletters should be distributed to interested community members regarding the progress of this Estuary Management Plan. The newsletters, which should aim to be prepared annually (and possibly distributed via rates notices or similar), should indicate what has been achieved and completed during the previous 12 months, and what is proposed to be done in the immediate future by Council and the other responsible agencies.

If there is little progress on the Plan, then an informed community may be able to lobby Council representatives to ensure that suitable funding and resources are allocated to the Plan in order to achieve the desired long-term objectives for the Bega River estuary.

Timeframe: Immediately (12 – 18 months)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only, excluding printing and distribution costs.

6.1.3.4 Monitoring, Further Investigations and Research

M-1 Prepare a Flood Study and Floodplain Risk Management Study & Plan for the Bega River.

The flooding issues affecting the BRE are not solely linked to the condition of the entrance, and should be investigated thoroughly in a contemporary Flood Study and Floodplain Risk Management Study, consistent with the principles of the NSW Floodplain Development Manual (2005). Recommendations on ways to mitigate the flood risk should be made in a Floodplain Risk Management Plan. Critical to the Flood Study will be the dynamic modelling of entrance breakout (i.e. fully integrated hydrodynamic and sediment morphodynamic modelling) under high flows conditions.

A range of issues dealt with in this Plan have flood implications and require further investigation in a Flood Study and Floodplain Risk Management Study and Plan, such as:

- Flow and water extraction management in the Bega River catchment;
- Management of flow control structures in the Bega River catchment;
- Vegetation management in the Bega River catchment;
- Land filling proposals in the Bega River catchment;
- Entrance management for the Bega River;
- Planning for climate change; and

- The modification of road infrastructure and flood planning levels.

Timeframe: Immediately (12 – 18 months)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $200,000 (50:50 funding available through the OEH Flood Management Program)

M-2 Conduct an assessment of land capability (based on air, water, soil and vegetation constraints) and determine sustainable levels of land use activities (including development).

While urban development is currently limited within the catchment, projected population increases, as outlined in the South Coast Regional Strategy, may place increased pressure upon BRE resources in the future. In addition, the current level of agricultural use is also noted to be having a large impact upon water quality and habitats of the BRE.

This strategy recommends a comprehensive study to determine the capacity of existing land areas to sustain various land uses, e.g. increased intensity in agricultural activity, or increased urban development. The assessment of capacity should consider not only physical soil properties and topography (including flood risk), but also increased demands on water resources and for recreational facilities, and the impacts on vegetation and habitats which may occur as a result of the land use.

The outcomes of this land capability study should guide potential future changes in land use and changes to land zonings as part of the upcoming review of the Bega Valley LEP (to accord to the LEP standard instrument). The proposed LEP review indeed provides an excellent opportunity to ensure that the estuary's resources are managed sustainably, providing that due consideration is given to the estuary during the rezoning process.

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2)

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: $150,000 for the BRE catchment, however, if the methodology is successful it should be applied across other catchments within BVSC LGA for consistency

M-3 Map extent and condition of EECs and habitats of Threatened Species within estuary catchment and determine areas requiring conservation or rehabilitation.

As noted previously, there is a need for improved conservation, understanding of the distribution and quality of EECs, Threatened Species habitats and remaining wildlife corridors across the Bega River catchment. In order to further knowledge of the Bega River Estuary and its immediate catchment, it is recommended that a flora and fauna study of the BRE be undertaken as a high priority.

This study would help guide conservation activities, inform landuse planning and provide a basis for potential public reserve acquisitions. Conservation activities such as preservation/rezoning, rehabilitation, weed management and endemic species planting lists may all be based upon the mapping conducted as part of this action.

It is envisaged that mapping of vegetation and associated habitats across the catchment would also assist with rezoning of land as part of the current and future LEP reviews.

Habitat mapping could be carried out as a component of the more generalised land capability assessment, as described in Strategy M-2.

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $150,000, incorporating air photo interpretation and ground truthing.

M-4 Expand Water Quality Monitoring Program for recreational health.

The Bega River estuary is a popular location for swimming, kayaking, boating, water skiing and other water-based recreational activities. However, at times, the estuary experiences poor water quality events, such as high faecal coliforms or algal blooms, particularly following rainfall, which delivers greater pollutant inputs.

BVSC currently undertakes water quality monitoring within the Bega River as part of its summer ‘Beachwatch Program’. Due to the popularity of the Bega River Estuary for recreational activities throughout the year, it is recommended that a year round program of water quality monitoring should be carried out in order to provide a better indication of the suitability of the waters for primary contact recreation activities, such as swimming. The proposed water quality monitoring program should target indicators for the risks to human health, such as enterococci, faecal coliforms and/or faecal sterols.

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $10,000 per annum, depending on the number of sites sampled and extent of laboratory analyses

M-5 Implement an Ecosystem Health Monitoring Program.

In addition to monitoring the estuary for human health reasons, ecological monitoring of the estuary should also be undertaken and evaluated to provide an indication of the overall environmental health of the system, and to improve our appreciation and understanding of the environmental processes that occur within the estuary. Traditional water quality and water level monitoring should be undertaken to compliment the ecological monitoring program to further enhance the contextual information for the overall health of the estuary.

The Southern Rivers Catchment Management Authority has produced a guide for the Development of an Ecosystem Health Monitoring Program for the Estuaries and Coastal Lakes. This program is based on the use of biological (ecological) indicators that represent ecosystem condition, and physical and chemical indicators representative of stressors that may cause ecological indicators to change. Ecological indicators are scientific measures (parameters or values) that can be used to assess the ecological status and trends in the health of ecosystems and their component parts. Useful ecological indicators inform the scientific community, the decision makers, and the public about the overall state of an ecosystem and how it may be changing due to anthropogenic and other pressures, and integrate environmental information to enable better informed decision making.

No single ecological indicator though will unambiguously measure the interactions between ecosystem form and function, resilience and stability of biological communities and response of the estuarine system to anthropogenic stress, and a suite of indicators are needed. The repeated measurements with a benchmark condition or guideline provides the basis for detecting change and allowing trend analysis over time and triggering management responses or interventions.

Water quality and water level data covering both the river and the tributaries can be used to determine the condition of the in-situ waters of the estuary, as well as determine the contribution of pollutants to the river from the catchment. Flow gauging within the upstream tributaries (as recommended by Strategy W-9) would also assist in interpretation of water quality results, by quantifying volumetric input (and thus loads) to the estuary. Improved knowledge on pollutant sources and loads will improve opportunities for mitigation and management in the future.

It is essential that ecological indicators and water quality guidelines specifically relevant to the BRE are developed and used as part of the monitoring program.

Timeframe: Short (1 – 3 years)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: $30,000 per annum, depending on the number of sites sampled and extent of laboratory analyses

M-6 Monitor and periodically re-map aquatic and riparian vegetation.

On a periodic basis, the aquatic and riparian vegetation around the BRE should be mapped via detailed on-ground survey and air photograph interpretation. Comparisons with previous vegetation maps can provide an indication of trends in vegetation behaviour, particularly in relation to other environmental variables, such as rainfall patterns, water levels, and water quality.

The Department of Primary Industries (Fisheries) have recently completed estuarine vegetation mapping of Bega Estuary as part of a state-wide Comprehensive Coastal Assessment (CCA) Project. Re-mapping of the vegetation should be carried out approximately every 5 years.

Timeframe: Medium (3 – 5 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: DPI-Fisheries

Other Partners: SRCMA, BVSC

Indicative Cost: $30,000 every 5 years

M-7 Periodically monitor the use of estuary's waterway, foreshores and recreational facilities.

Future urban development will result in an increase in demand on recreational facilities offered around the estuary's foreshores. Prior to the update of existing recreational and foreshore facilities, monitoring should be conducted to determine the types of activities, numbers of users, and areas most utilised. The assessment should also determine the viability of current facilities and locations to sustain existing and future use levels. This monitoring should guide any major investment into amenities and facilities around the estuary in order to provide facilities which are appropriate to the recreational levels, but also the environmental sensitivity of the estuarine environments.

Periodic monitoring of recreational use of the estuary should also be carried out, so as to guide requirements made of any future development to provide adequate facilities, and enable better management of the demands placed on resources and facilities associated with recreational use in and around the estuary.

Timeframe: Short (1 – 3 yrs)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC

Other Partners:

Indicative Cost: $20,000

M-8 Compile an ongoing and centralised database of all past and in-progress studies and data on the estuary for use in future planning, management and research activities

The details of all research projects conducted about the estuary in the past, present and future should be compiled into a centralised database. This should include projects completed by all agencies (including the SRCMA, OEH, HRC etc) as well as Council. In addition, the database should provide links to data from water quality monitoring, habitat mapping, water level gauging etc, such that it provides a comprehensive reference to all information about the estuary. This database should continue to be maintained as new studies and data is completed.

Such a database will be important for a number of uses. It may greatly assist in determining the level of information currently held that may then direct the requirements of future research activities, including those outlined in actions within this Plan. It will also assist in reporting of Plan progress and performance, as well as SoE reports and other Council reporting requirements. Furthermore, a coordinated and complete record of research studies pertinent to the estuary may greatly assist managers and planners when assessing future subdivisions (like the TRE development), and also, in the LEP review. The record of past studies will also be useful in developing material for use in the education programs outlined in this Plan.

Timeframe: Short (1 – 3 years)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: Minimal, staff time only

M-9 Investigate the assets and infrastructure around the BRE that are vulnerable to future sea level rise and ocean storm inundation. Develop adaptation solutions for managing climate change impacts.

Future climate change will impact on a wide range of estuarine processes, as discussed further in Chapter 10. The specific assets and infrastructure associated with the BRE that will be potentially impacted by future climate change inundation will depend on its topography, location and existing management arrangements.

A more detailed investigation should be carried out that aims to identify the assets and infrastructure most vulnerable to future climate change. It is expected that an inventory style assessment would be required that documents and systematically assesses all estuary assets and infrastructure. Critical information about the assets and infrastructure for this inventory (e.g. AHD height of assets and infrastructure) may require additional surveys (e.g. ground surveys).

Information collected as part of this investigation is likely to feed into the Flood Study and Floodplain Risk Management Study and Plan, and may also be of use in the development of a Coastal Zone Management Plan for the Bega Valley Shire coastline. The information collected as part of this investigation should be incorporated into future planning controls and provisions (refer Strategy P-11) in order to help accommodate future climate change within the BRE. Other appropriate methods to ameliorate the likely impacts on assets and infrastructure, and a prioritised timeframe for such actions, should be provided. Such actions may include the acquisition of property, or relocation of infrastructure.

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $50,000

M-10 Investigate and document the predicted impacts of climate change on the natural values of BRE (e.g. entrance condition, wetland inundation, etc.)

The impacts of future climate change are likely to lead to a wide range of environmental responses by the Bega River Estuary. These are likely to manifest throughout the physical, chemical and ecological processes that drive local estuarine ecosystems. Management for future climate change will involve facilitating adaptation of natural ecosystems to the new climate, without imposing additional constraints. For example, wetland and riparian vegetation will slowly migrate up-slope in response to increasing mean sea level and storm surges – management of this adaptation will involve ensuring that the vegetation migration will not be inhibited by other constraints, such as retaining walls, road embankments, private development etc (Haines, 2008).

Timeframe: Short (1 – 3 years)

Priority: Medium (refer Section 6.2).

Key Responsibility: BVSC, OEH, DPI

Indicative Cost: $50,000

6.1.3.5 Compliance

C-1 Audit existing on-site sewage management systems (OSM) and enforce Council OSM Policy.

All on-site sewage systems within the BRE catchment, and those located close to natural watercourses should, as a priority, be critically appraised in accordance with BVSC OSM policy (2009). The Bega River Estuary is specifically identified in the policy as having “Critical Risk” areas adjacent to the waterway. OSM systems within the critical risk areas need to be inspected by Council annually to ensure that they are operational and that they are not posing a risk to water quality or human health.

All deficient systems should be upgraded by the landholder. Where systems are found to be inadequately sited or low-lying, the landholder should be required to replace the system with one utilising storage tanks and periodic pump-out, or connect to the reticulated system, whichever is more applicable.

Greywater reuse schemes should be encouraged through education and incentives, to minimise the total volume of effluent discharged to the environment.

Timeframe: Immediately (12 – 18 months)

Priority: Very High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

C-2 Audit construction sites for compliance with sediment and erosion controls, vegetation preservation, stormwater controls etc.

Regular auditing of construction sites should be undertaken to ensure compliance with consent conditions and relevant guidelines. During construction, sites should be audited for compliance with sediment and erosion controls, as outlined in an appropriate control plan. Where non-compliances are found or controls are inadequate, developers should be required to update their controls to achieve water quality and erosion control objectives.

Where vegetation must be preserved as part of consent conditions, such as riparian buffers or terrestrial vegetation on site, an audit should be performed at the construction phase to ensure the vegetation is being adequately protected during construction activities. Penalties should be applied where vegetation has been removed, or if protection is not improved following audit recommendations.

All compensatory re-vegetation activities, stormwater treatment devices, eco-friendly design and other environmentally focussed consent conditions will need to be audited at the completion of the development. Enforcement should be considered where non-compliance with consent conditions after audit recommendations have been made, continues.

Timeframe: Immediately (12 – 18 months)

Priority: Very High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

C-3 Provide annual report on plan implementation and review of monitoring data to assess the ongoing health of the estuary

An annual report of the progress of implementation of this EMP should be prepared, to provide transparency in the process and to provide greater incentives to responsible parties to undertake EMP actions. Annual summaries of water quality and biological monitoring conducted as part of the Plan should be included, with comparisons to previous years and long term trends. The annual report, or a summary of such, could be provided as a sub-section of Council's State of Environment Reports, or as part of SRCMA reporting.

The report should also provide recommendations regarding implementation of strategies and actions in the future (effectively providing an update / review or the EMP). The report should ideally be conducted by Council, with input from state agencies and stakeholders as to their activity in implementing actions. Summaries of the annual reports would form the basis for periodic community newsletters, as per Strategy CS-8.

Timeframe: Immediately (12 – 18 months)

Priority: High (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: Minimal, staff time only

C-4 Agencies to incorporate relevant EMP strategies into short and long term works and investment programs.

An Estuary Management Plan will only be effective once all relevant agencies have made substantial efforts to carry out those tasks that they are responsible for. To ensure that agencies make sufficient effort, it is important that the strategies outlined in this Plan are transferred across to the individual short and long term works and investment programs of these agencies. This way, sufficient funds and resources can be allocated to the actions as part of routine forward planning by these agencies.

It is presumed that endorsement of this Plan by the relevant agencies indicates a willingness to assist with implementation of the various strategies within the timeframes nominated by the Plan.

Timeframe: Immediately (12 – 18 months)

Priority: Critical (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, DPI, NSW Maritime

Indicative Cost: Minimal, staff time only

C-5 Consider gazettal of the EMP by the NSW Government.

Council should aim for this Estuary Management Plan to be gazetted by the Minister for the Environment. By having the EMP gazetted, it becomes a statutory document. Recent amendments to the provisions under the Coastal Protection Act 1979 now enable Estuary Management Plans (under the specific title of Coastal Zone Management Plans) to be gazetted. This means that agencies are obliged to implement the Plan. If the EMP is not gazetted, it may still be used to guide other statutory plans and policies prepared by Council and other agencies. Implementation of a non-gazetted EMP is less certain, and is generally constrained by funding and resourcing limitations.

Timeframe: Immediately (12 – 18 months)

Priority: Critical (refer Section 6.2).

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: Minimal, staff time only

6.1.4 Strategies – Objectives Matrix

The short-listed options described above have been developed to address one or more of the specific objectives for future management of the Bega River Estuary (as established in Section 5.2). Table 6-1 provides a matrix of the short-listed options / strategies and the relevant objectives to which they satisfy. The objectives are numbered according to their prioritised ranking, refer Table 5-1. Two ticks (✓✓) within the matrix indicates that the option / strategy meets the objective directly, whereas, one tick (✓) indicates that the option / strategy meets the objective in an indirect manner or only partially satisfies the objective.

Table 6-1 shows that all objectives are satisfied by at least one option / strategy. Some objectives are addressed by a large number of options / strategies, while some strategies help to satisfy multiple objectives.

Strategies C-4 and C-5 are reported as addressing all objectives. Strategy C-4 requires all relevant agencies to incorporate the EMP strategies into forward planning program, while Strategy C-5 requires the EMP to be gazetted by the Minister for the Environment. Consequently, if one or both of these strategies are achieved, then the chance of success for the remaining strategies will be increased significantly.

Of the other strategies, CS-2 (rural education program), M-2 (land capability assessment), M-8 (centralised database of information), P-1 (foreshore buffers) and P-3 (prevent clearing/veg removal) addressed the most number of objectives, either directly or indirectly. Meanwhile Objectives A (vegetation and habitats), B (populations) and V (information collection and sharing) were addressed by the largest number of strategies.

Table 6-1 Objectives and Options / Strategies Matrix

		Management Objectives	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
		Mgt Obj priority rank	3	4	1	10	13	5	17	12	13	2	11	19	8	8	16	6	15	7	18	21	22	20
Code	Timeframe	Management Options																						
P-1	Short	Preserve foreshore land to provide a riparian buffer from development and climate change impacts	✓✓	✓						✓✓		✓✓						✓	✓✓	✓✓				
P-2	Short	Prevent development on steep slopes	✓✓	✓						✓		✓✓			✓					✓✓				
P-3	Short	Prevent clearing and inappropriate vegetation removal	✓✓	✓✓					✓	✓✓		✓✓					✓			✓✓				
P-4	Short	No net increase in runoff and pollutant loads from future developments	✓	✓	✓						✓✓				✓✓					✓✓				
P-5	Short	Ensure the use of appropriate sewage treatment measures for all new developments		✓							✓✓				✓					✓✓				
P-6	Short	Require all future development to be eco-friendly and energy efficient	✓	✓		✓			✓	✓	✓			✓		✓			✓	✓✓				
P-7	Short	Require developer contributions to recreational and foreshore facilities					✓✓	✓			✓													
P-8	Medium	Not used																						
P-9	Immediately	Adopt an Interim Entrance Management Policy		✓	✓✓										✓			✓✓	✓	✓				
P-10	Immediately	Control PWC use east of Hancocks Bridge, to minimise conflict with other recreators, residents and wildlife.		✓				✓✓	✓															
P-11	Short	Incorporate appropriate planning controls for climate change impacts into existing planning frameworks	✓		✓							✓						✓	✓✓					
P-12	Immediately	Use the EMP to assist in determining relevant landuse zonings and development controls in the preparation of the new standard LEP								✓	✓	✓							✓	✓✓				
W-1	Medium	Review and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir		✓✓	✓✓									✓				✓	✓					
W-2	Medium	Provide assistance to rural land managers to reduce pollutants and sediment in runoff	✓											✓	✓✓	✓✓								
W-3	Medium	Revegetate degraded/cleared areas in catchment	✓✓	✓✓		✓										✓✓								
W-4	Medium	Revegetate foreshores and streambanks	✓✓	✓✓		✓										✓✓	✓✓							
W-5	Medium	Assess sites of river bank erosion and rehabilitate as required	✓														✓✓							
W-6	Medium	Reduce erosion and sediment runoff from firetrails, driveways, road verges and carparks													✓✓	✓✓								
W-7	Short	Assess existing stormwater treatment devices and improve the level of pollutant removal from stormwater				✓									✓✓	✓✓	✓							
W-8	Short	Assess and improve current recreational infrastructure and foreshore access (including minor works eg sealing carparks, landscaping and revegetation)					✓✓	✓✓		✓	✓													
W-9	Immediately	Install flow gauges in appropriate locations to monitor environmental flows		✓	✓✓																	✓✓		✓✓
W-10	Medium	Connect Mogareeka Village to reticulated sewage system		✓											✓✓	✓✓								
W-11	Short	Develop and implement a weed management strategy to eradicate weeds in the estuary	✓✓	✓		✓✓																		
W-12	Short	Develop and implement a program to eradicate pests in the estuary	✓	✓✓		✓✓																		
W-13	Medium	Raise level of road to reduce inundation during estuary closure																✓✓	✓✓					
W-14	Medium	Support strategic raising of golf course sections in return for protection and rehabilitation of adjacent high value habitat	✓✓				✓✓	✓						✓		✓		✓	✓					
W-15	Medium	Reclaim eroded land at Lions Park by dredging sand from entrance		✓✓																				
W-16	Medium	Protect and promote (as appropriate) Aboriginal and European Heritage sites and places of significance							✓				✓✓											
CS-1	Immediately	Promote the conservation of privately owned vegetation, including revegetated private lands	✓✓	✓✓		✓			✓															
CS-2	Short	Conduct a rural education program promoting best practice techniques for environmental management, based on Bega Cheese EMP Program	✓		✓	✓✓			✓✓					✓✓	✓✓	✓✓	✓							✓
CS-3	Short	Develop general information brochures for residents and visitors	✓	✓				✓	✓✓				✓✓			✓								✓✓
CS-4	Short	Develop and install educational signage to promote estuary values	✓	✓				✓	✓✓				✓✓											✓
CS-5	Short	Develop primary and secondary school education kits	✓	✓					✓✓				✓✓											✓✓
CS-6	Medium	Guided tours and excursions	✓	✓					✓✓				✓✓	✓✓										✓✓
CS-7	Immediately	Support community volunteer groups participating in conservation activities	✓✓	✓		✓			✓✓							✓								✓
CS-8	Immediately	Distribute periodic newsletters to community detailing plan implementation and progress							✓														✓✓	✓
M-1	Immediately	Prepare a Flood Study and Floodplain Risk Management Study and Plan for the Bega River									✓	✓✓						✓✓	✓✓			✓		✓✓
M-2	Immediately	Conduct an assessment of land capability (based on air, water, soil and vegetation constraints) and determine sustainable levels of land use activities (including development)	✓	✓						✓✓	✓	✓✓		✓✓					✓	✓✓				✓✓
M-3	Immediately	Map extent and condition of EECs and habitats for Threatened Species, and determine areas requiring conservation or rehabilitation	✓✓	✓✓		✓		✓				✓							✓	✓		✓		✓✓
M-4	Immediately	Expand Water Quality Monitoring Program for recreational health						✓							✓✓							✓✓		✓✓
M-5	Short	Implement an Ecosystem Health Monitoring Program		✓											✓✓							✓✓		✓✓
M-6	Medium	Monitor and periodically re-map aquatic and riparian vegetation.	✓																			✓✓		✓✓
M-7	Short	Periodically monitor use of the estuary's waterway, foreshores and recreational facilities					✓	✓														✓✓		✓✓
M-8	Short	Compile an ongoing a centralised database of all past and in-progress studies and data on the estuary for use in future planning, management and research activities	✓	✓					✓	✓	✓	✓	✓		✓				✓	✓		✓		✓✓
M-9	Immediately	Investigate the assets and infrastructure around the BRE that are vulnerable to future SLR and ocean storm inundation. Develop adaptation solutions	✓		✓							✓						✓	✓✓					✓✓
M-10	Short	Investigate the predicted impacts of climate change on the natural values of BRE (eg entrance conditions, wetland inundation etc)	✓	✓	✓						✓	✓						✓✓	✓✓					✓✓
C-1	Immediately	Audit existing on-site sewage systems and enforce recommended upgrades		✓					✓						✓✓	✓✓						✓		
C-2	Immediately	Audit construction sites for compliance with sediment and erosion controls, vegetation preservation, stormwater controls etc	✓						✓						✓✓	✓✓						✓		
C-3	Immediately	Provide annual report on plan implementation and review of monitoring data to assess the ongoing health of the estuary	✓	✓	✓				✓						✓							✓✓	✓✓	✓✓
C-4	Immediately	Agencies to incorporate EMP strategies into short and long term works and investment programs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓✓	✓	✓	✓
C-5	Immediately	Consider gazettal of the EMP by the NSW Government	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓✓	✓✓	✓	✓	✓

6.2 Assessment and Prioritisation of Management Strategies

The short-listed strategies have been assessed and prioritised in order to provide a proposed ranking for implementation. The greatest benefits to the Bega River Estuary will be gained if the most effective strategies are implemented first. A multi criteria decision making process has been adopted to compare and prioritise the short listed management options.

Preferred management options have been determined by consideration of the following benefit and cost criteria:

1. Effectiveness of the option in addressing specific management objectives;
2. Acceptance of the option by community and stakeholders;
3. Cost of implementation of the option;
4. Number and priority of objectives that the option meets;
5. Timeframes for implementation based on perceived risks of doing nothing.

The different timeframes considered, include:

- Immediately (12 – 18 months);
- Short Term (1 – 3 years); and
- Medium term (3 – 5 years).

Much of the information used in the decision making process was obtained during consultation with the community and stakeholder groups.

The preferred order of implementation basically represents the most efficient and effective approach to management of the estuary from an outcomes viewpoint.

The results of the multi criteria assessment are shown in Appendix F.

Figure 6-2 shows a graphical representation of the relative benefit / cost score for the short-listed management strategies. The scores presented in Figure 6-2 take into consideration the number of objectives addressed by each option, the relative priority, or importance, of each objective addressed (refer Section 5.3), the relative cost of implementation, and the relative effectiveness and acceptability of the option.

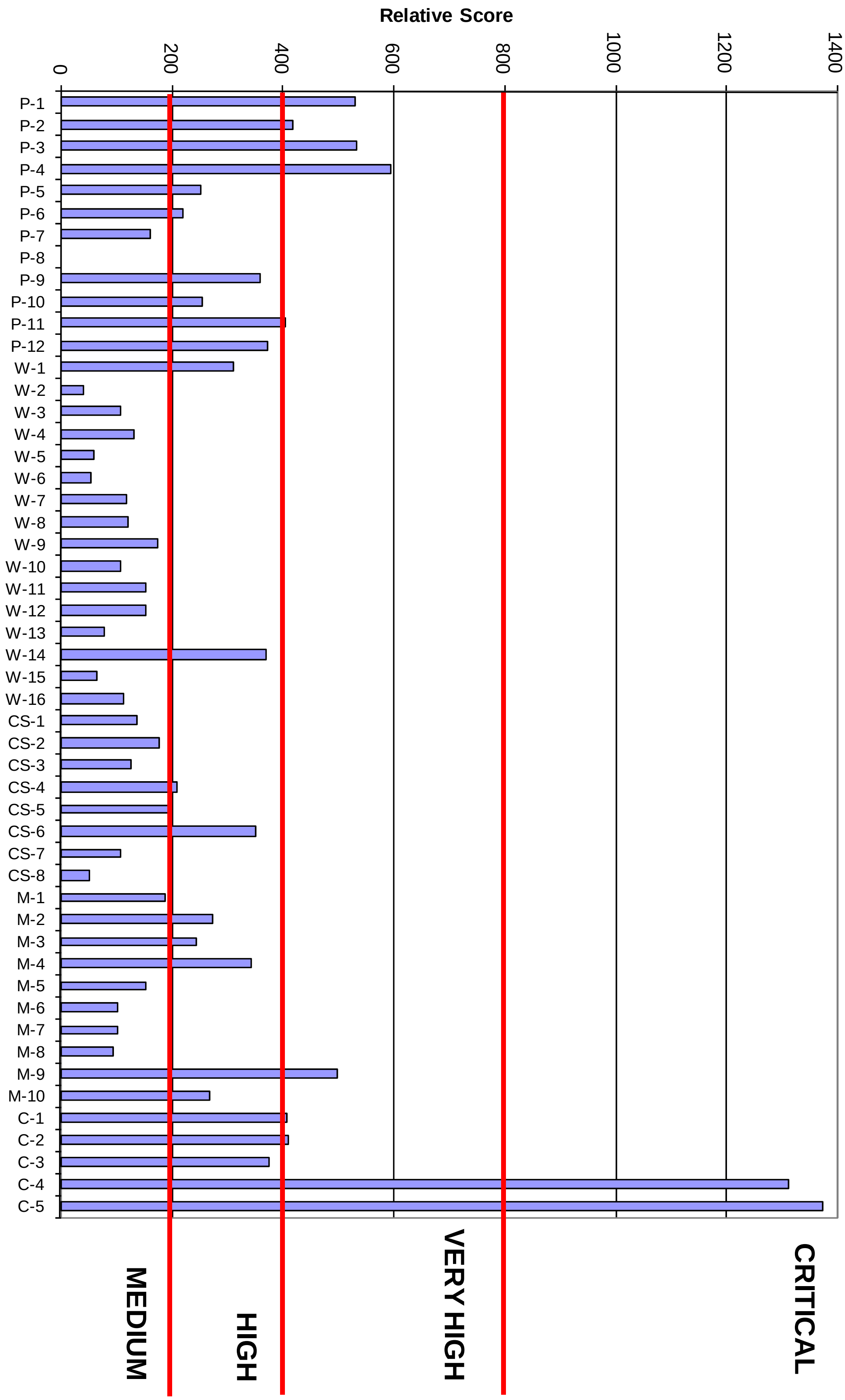

Figure 6-2 Relative score / ranking of short-listed strategies

Strategy prioritisation has been assigned the following levels:

- Critical: indicating that implementation of these particular strategies must generally take precedence over other strategies within existing funding and resource limitations;
- Very High: indicating that these strategies are also very important and should take precedence over lower order strategies;
- High: indicating that these strategies are not as crucial as the higher order strategies. These strategies should still be implemented when funding and resources become available; and
- Medium: indicating that these strategies have the least potential to make significant difference to the BRE environment. These strategies will, however, still benefit many aspects of the estuary, and as such, should still be implemented when funding and resources becomes available.

Strategy prioritisation is independent of the prescribed timeframes. The proposed order of implementation is presented in Table 6-2. This prioritisation assumes that all proposed works can be achieved within the nominated timeframes. If delays in implementation occur, then this prioritisation should be modified to ensure that very high and high priority strategies are still carried out within the timeframes nominated in the Plan, at the expense of lower order priority tasks.

Table 6-2 Order of implementation for short-listed strategies / options

Strategies

	Immediate	Short Term	Medium Term
Critical	C-5 C-4		
Very High	M-9 C-2 C-1	P-4 P-3 P-1 P-2 P-11	
High	C-3 P-12 P-9 M-4 M-2 P-10 M-3	P-5 P-6 CS-4 CS-5 M-10	W-14 CS-6 W-1
Medium	M-1 W-9 CS-1 CS-7 CS-8	CS-2 P-7 W-11 M-5 W-12 CS-3 M-7 M-8 W-8 W-7	W-4 W-16 W-3 W-10 M-6 W-13 W-15 W-5 W-6 W-2

Order of implementation

	Immediate	*Short Term*	*Medium Term*
Critical	***1***	***3***	***6***
Very High	***2***	***5***	***9***
High	***4***	***8***	***11***
Medium	***7***	***10***	***12***

7 ESTUARY SUB-PLANS: CONSIDERATIONS FOR FUTURE STRATEGIC PLANNING

Council and other agencies undertake strategic planning and management in order to improve landuse management and achieve a balanced outcome with respect to environmental, economic and social considerations.

This chapter of the Bega River Estuary Management Plan provides a series of Sub-Plans, which describe specific considerations that need to be accounted for when undertaking future strategic planning. The considerations relate to potential impacts on the Bega River Estuary, and the long-term sustainability of its environment. Estuary-specific considerations have been provided in respect to Sewage Management, Entrance Management, and Future Development (including the Tathra River Estate Stage 2).

SEWAGE

7.1 Sewage Sub-Plan

The recently completed Bega Valley Sewerage Program (BVSP) involved the upgrade and construction of a number of STPs across the Shire. Within the BRE catchment, the BVSP has involved upgrades to the Bega and Tathra STPs (now completed) and the construction of an STP at Kalaru. However, there still remain a number of considerations with respect to ensuring sewage in the catchment is managed in order to improve water quality inputs to the BRE. Outlined below, these considerations should be incorporated into the strategic planning for sewage infrastructure to protect the long term health of the estuary.

7.1.1 Tathra

The recent upgrade of the Tathra STP has increased the capacity of the plant from 2,000 to 6,200 ep. This upgrade is projected to sustain the population until 2022. At present, however, there is currently a demand upon the plant of 5,000 ep during holiday periods, suggesting that the recent upgrade has only increased its capacity to meet existing demand. Furthermore, the upgrade was not envisaged to incorporate connection of any stage of the Tathra River Estate (TRE) development to the plant. Currently, treated effluent from the Tathra STP is disposed of through forced irrigation on the adjacent Tathra Country Club golf course. There is essentially no capacity remaining at the golf course to accept greater volumes of treated effluent for irrigation. This is obviously a major constraint on the future operation of the Tathra STP and needs to be a primary consideration in planning for future development in the Tathra area, including future proposals for TRE.

Studies have been undertaken to suggest that discharges from Tathra STP to the golf course have only minor impacts upon groundwater quality and surface water quality in the adjacent Black Ada Lagoon and Swamp (refer Section 2.6.7). However, macro algae blooms have been reported in the Lagoon and Swamp (refer Section 2.6.5), suggesting that impacts may be highly variable, and influenced by other environmental and meteorological conditions.

The following actions should be considered as part of any future strategic planning sewerage program in order to mitigate potential impacts on estuarine waters from effluent discharges and reclaimed water from the Tathra STP:

- An additional upgrade of the plant to reasonably accommodate future populations which includes both resident and holiday populations;
- All future large scale development proposals which require connection to the Tathra STP should fund upgrade of the system to ensure either no net increase or reduction in pollutants in treated effluent;
- Upgrades to treated effluent should aim to achieve water quality of drinking standard, mitigating potential impacts from effluent discharge or reclaimed water use on the waterway;
- A review of the usage of irrigation control devices upon the Tathra Country Club golf course should be undertaken to ensure that irrigation is appropriate to soil constraints, and to ensure no forced irrigation occurs, except when capacity of the reclaimed water storage pond is reached;
- As the current golf course disposal option is at capacity and future climate change impacts are likely to further constrain the use of the estuary area for effluent disposal, Council will need to consider alternative re-use options. A new re-use site should be identified, e.g. farm or sports ground through an intensive environmental and site suitability assessment process. The costs involved in transportation and wet weather storage for alternative re-use locations are likely to be high due to the geographic separation of the current plant from the likely inland re-use options.
- Dual reticulation systems on new urban developments should be encouraged where the site soils, topography, sensitivity of surrounding habitats and stormwater discharge requirements are appropriate to allow effluent irrigation.
- Consideration of the impacts of climate change and subsequent higher estuarine and adjacent groundwater levels when determining the suitability of any new re-use site, or effluent irrigation on developed land (e.g., TRE).

7.1.2 Bega

Bega STP has been upgraded to improve the quality of treated effluent. Treated effluent from the plant is used to irrigate neighbouring dairy farms, with approximately 5-10% of effluent discharged to the Bega River.

The following actions with respect to the Bega STP should be considered as part of any future strategic sewerage planning program in order to mitigate potential impacts on the Bega River:

- Greater area of suitable land to receive treated effluent from the site should be sought, so as to minimise and eventually negate the need for direct disposal of treated effluent to the river. This may also assist in reducing demand for water supply from existing land uses;
- Over the long term, treated effluent from the STP should be improved to achieve drinking water quality, to reduce potential impacts from disposal into the river or runoff from reclaimed water sites, and potentially provide an additional water resource;
- Future development in proximity to the Bega STP should preferentially be connected to the reticulated sewage network and the Bega STP, to reduce the impacts from on-site systems upon receiving waters;

- Existing OSM's should be connected to the Bega STP on a priority basis, such that all high risk OSM's are ultimately sewered.

7.1.3 Mogareeka

The small village of Mogareeka, located just north of Tathra, is currently serviced by OSMs. Large macro-algae blooms have been observed in Mogareeka Inlet since 2006. It has been suggested that failing on-site systems in Mogareeka Village may have contributed to this algal bloom condition.

It was noted in the community workshop that connection of Mogareeka Village to the reticulated network would remove potential threats from leaching nutrients from OSMs in this location.

The following actions should be considered as part of any future strategic sewerage planning program in order to mitigate potential impacts on the Bega River Estuary:

- Undertake a feasibility study into a range of difference sewage treatment options for servicing the village of Mogareeka. Some of the potential options worth considering in this feasibility study would include:
  - Connection to Tathra reticulated sewage network;
  - Centralised treatment and transport (centralised management using advanced on-site systems can achieve the same (or better) water quality levels as conventional municipal STPs, but with the added feature of being a local, more sustainable solution);
  - Decentralised (cluster) treatment and transport;
  - Upgrading existing on-site treatment from passive to active (such as Aerated Wastewater Treatment System);
  - Hybrid systems (using existing passive septic tank for settling after which liquid pumped off top is piped to a central treatment area, instead of individual absorption pits);
  - Sand filters;
  - Low pressure system; and
  - Composting toilets and grey water reuse.

7.1.4 Kalaru

The construction of the STP at the village of Kalaru, located just west of Tathra, has provided an opportunity to connect existing on-site systems to a new reticulated network, in addition to any future development.

The following actions should be considered as part of any future strategic sewerage planning program in order to mitigate potential impacts on the Bega River Estuary:

- All OSMs in the Kalaru area be connected to the Kalaru STP on a priority basis, so that all high-risk OSMs are connected ultimately to the sewerage system; and
- Future development in the Kalaru area should preferentially be connected to the reticulated network, particularly in areas near to sensitive habitats or receiving waters.

ENTRANCE MANAGEMENT

7.2 Entrance Management Sub-Plan

Strategy P-9 (refer Section 6.1.3.1) recommends the immediate preparation and adoption of an interim Entrance Management Policy. In addition to providing guidelines on when and how to open the entrance, the Policy should also map out a process for progressively increasing the intervention level and reducing the need to artificially open the entrance in the future (refer Haines, 2008 for detailed contents of an Entrance Management Policy). The policy should be written in consultation with the BVSC Coastal Committee.

The policy would provide a legal framework for undertaking entrance opening works, and should be accompanied by an environmental impact assessment, which documents the impacts of the periodic works on the biophysical environment of the estuary.

As flooding of low-lying infrastructure and farmland is generally the trigger for artificially opening the entrance, a Flood Study and Floodplain Risk Management Study and Plan should also be developed to identify an appropriate management response to the inundation (refer Strategy M-1, Section 6.1.3.4). Entrance management will be just one of the management responses considered in the Floodplain Risk Management Study and Plan to manage the flood risk. The interim Entrance Management Policy should be adopted until such time that the Floodplain Risk Management Study and Plan have been completed, and a more formal entrance management policy developed, if required.

7.2.1 Objectives

The Entrance Management Policy should provide clear direction to Council with respect to physical works within the entrance of Bega River. The Policy should address:

- Maintaining acceptable water quality within the estuary for recreational purposes;
- Limiting inconvenience to the community (including agricultural landholders upstream) resulting from extended periods of elevated water level;
- Minimising environmental impacts of artificially opening the entrance at levels lower than the expected natural maximum water level;
- Accommodating future sea level rise;
- Strategies for returning to a natural entrance condition; and
- Meeting all existing legislative requirements.

Works associated with entrance management would be triggered by conditions relating to water level and/or water quality (these triggers may vary on a seasonal basis).

7.2.2 Licences and Legislative Framework

Under the exiting LEP, the entrance sand berm of the Bega River is Unzoned Land. As such, in accordance with Clause 73 of the LEP, all works are permissible, but require development consent. As part of the proposed LEP review, it will be important that the proposed zoning to be applied to the

Bega River entrance area still allows entrance opening works with consent. The consent process should involve preparation of an environmental impact assessment (such as a Statement of Environmental Effects), and assessed in accordance with heads of consideration under Part 79C of the *Environmental Planning and Assessment Act, 1979*.

The entrance area of the Bega River is Crown land under the care and control of the NSW Department of Lands. Under Part 4, Division 4 of the *Crown Lands Act 1989*, a Crown land licence would need to be obtained from the NSW Department of Lands[4]. Licencing should be for a fixed duration only, thus necessitating the need for re-application in the future, at which time a re-assessment of environmental impacts could be carried out (taking into consideration monitored environmental responses to actions carried out during preceding licencing periods).

The Bega River entrance is not located within a gazetted SEPP-14 wetland (Figure B-12, Appendix B), which means that entrance opening works will not be undertaken on land subject to SEPP-14 provisions. In accordance with clause 7(1) of the Policy, only works carried out within the gazetted boundary are affected by the Policy, even if the works modify water levels within the SEPP-14 wetlands located inside the estuary.

The entrance area is an important habitat for internationally recognised migratory birds such as the Little Tern and other threatened and vulnerable shorebirds such as the Hooded Plover and Pied Oyster Catcher. The Little Tern is protected under the Commonwealth EPBC Act and is listed under two bilateral agreements relating to the conservation of migratory birds with Government of Japan (JAMBA 1974) and the People's Republic of China (CAMBA 1986).

The JAMBA and CAMBA agreements list terrestrial, water and shorebird species which migrate between Australia and the respective countries. In both cases the majority of listed species are shorebirds.

Both agreements require the parties to protect migratory birds by:

- limiting the circumstances under which migratory birds are taken or traded;
- protecting and conserving important habitats;
- exchanging information; and
- building cooperative relationships.

The JAMBA agreement also includes provisions for cooperation on the conservation of threatened birds.

If shorebirds are present and an artificial opening is required, BVSC will require a license from OEH, as has previously been the case.

[4] A dredging permit is required from DPI-Fisheries for any subaqueous excavation of bed material, under the provisions of the *Fisheries Management Act, 1994*, if a permit is not provided by another government authority (such as Department of Lands).

7.2.3 Entrance Breakout Trigger Levels

7.2.3.1 Water Level Criteria

Water levels are recorded within the Bega River (Hancocks Bridge) by Manly Hydraulics Laboratory every 15 minutes. This gauge should be maintained while ever formal entrance management is required in the estuary.

Initially, water level conditions that trigger artificial entrance opening should be as follows:

- RL 1.36m AHD

Trigger levels will be reviewed in the future with a view to reducing reliance on artificial management, and to accommodate impacts of future sea level rise. With sufficient lead-time, private landholders and local authorities will be provided sufficient opportunity to remove flood-prone assets and infrastructure that may be affected by the next level of permissible inundation. Effective communication will also assist in negotiating agreements with agricultural landholders to ensure impacts of increased water levels upon agricultural land will be fairly accommodated.

7.2.3.2 General Estuary Health Criteria

The entrance to the Bega River may be opened artificially for environmental management purposes, including for example fish kills or significant algal proliferation. Under these circumstances, entrance management works would be subject to agreement by DPI-Fisheries, and may be carried out at any time of the year. DPI may direct Council to undertake water quality monitoring within the estuary in support of possible artificial intervention using the general estuary health criteria.

7.2.4 Assets within the Inundation Zone

The interim Entrance Management Policy will need to address many issues that would normally be addressed in a Floodplain Risk Management Study, which has not yet been completed for the Bega River. All of the information described in this sub-section is required to inform a management policy that is designed to relieve flooding. However, if BVSC undertakes a Flood Study and Floodplain Risk Management Study and Plan (refer Strategy M-1) within the timeframe recommended in Section 6.1.3.4, the interim Entrance Management Policy could be completed with a sub-set of this data, determined in consultation with OEH.

The Interim Entrance Management Policy should provide maps of inundation under different entrance breakout levels, including maximum inundation under circumstances whereby the entrance is not artificially opened (i.e. natural inundation extents). An inventory of all land parcels included within the "Inundation Zones", along with all private and public assets and infrastructure within the Inundation Zones should be itemised within the Policy (see also Strategy M-9). The Policy should provide a commensurate timeline for addressing the assets and infrastructure (starting with the lowest-lying and working upwards) that allows for the progressive increase in entrance breakout trigger water levels.

Assets and infrastructure within the Inundation Zones should be removed, raised or flood-proofed to ameliorate any negative economic or amenity impacts of inundation by high water levels in the estuary.

Assets and infrastructure likely to be within the Inundation Zone include the coastal road to Mogareeka (raising of this road is recommended as part of Strategy W-13, refer Section 6.1.3.2), the Tathra Golf Course (raising of the golf course is recommended in Strategy W-14), the Tathra STP, and foreshore reserves around Mogareeka Inlet and along the estuary. Large areas of agricultural land, particularly upstream around Jellat Jellat Creek and which are inundated during entrance closure at current levels, will also fall within the Inundation Zone.

Effluent from the Tathra STP is used for irrigation on the adjacent Tathra Golf Course. It is likely that this effluent disposal method would be unsuitable under more elevated estuary water levels in the future given the potential groundwater interactions and low-lying nature of the golf course. This is likely to also to be potential issue for any proposal to irrigate areas on the river flats of TRE. Possible raising of land within the golf course (Strategy W-14) should be considered to enable the progressive increase in artificial breakout levels without compromising viable effluent irrigation and adjacent water quality.

The long-term goal to progressively increase entrance breakout levels as part of the Entrance Management Policy will need to give sufficient consideration to potential impacts on upstream farmland. Management of farmland to minimise estuary impacts has already been proposed through regulation of flow structures (such as Russell Creek Weir and Jellat Tidal Barrage, refer Strategy W-1). Increases in future estuary levels may have additional demands on these flow structures. As an alternative, agreements could be made with landholders (e.g., purchase of easements or property leases) to covers potential impacts of estuary inundation of agricultural land.

7.2.5 Opening Procedures

A detailed set of procedures will need to be included within an Entrance Management Policy. These procedures should outline the steps involved in carrying out entrance breakout works once the need to open the entrance has been confirmed. It is envisaged that the entrance opening procedure would incorporate the following, as a minimum:

1. Council officers will contact appropriate representatives of the Department of Environment and Climate Change (OEH) Department of Primary Industries (DPI – Fisheries), and the Department of Primary Industries (DPI – Crown Lands) to notify them of the need for artificial entrance intervention.

2. Arrangements are made for appropriate licences to be issued and the presence or absence of threatened shorebirds is established. In the absence of threatened shorebirds, proceed to Step 3. In the event of shorebirds being present, negotiate an appropriate course of action with OEH.

3. Council officers will arrange for appropriate earth moving equipment to be mobilised to Tathra for excavation of the entrance channel. Mobilisation of equipment should be timed to coincide with the most appropriate tidal conditions for entrance breakout.

4. Optimum tidal conditions for entrance breakout would be spring tides with a strong diurnal variation in consecutive highs and lows. If resources permit Council should conduct a ground survey of entrance conditions. Survey should cover the entire entrance berm area extending

from the beach swash zone at low tide to the estuarine channel upstream of the berm. Survey transects should be carried out at approximately 10 – 20 metre intervals.

5. A pilot channel should be excavated between the ocean and the river through the entrance berm. The channel should generally be positioned close to the northern headland. The channel shall grade towards the ocean and will have a width of approximately 2 metres. The invert of the channel shall be at a level of approximately -0.5m AHD. Break-through of estuary waters to the ocean should be timed to occur shortly after the ocean tide turns from high to low for the lowest tide predicted for that day. This will maximise the duration for water level difference between the estuary and the ocean, thus maximising the potential for natural scour of the channel before the next high tide. Appropriate actions should be carried out to ensure public health and safety during the breakout operations.

6. Following entrance breakout, ground surveys of entrance conditions should be carried out, particularly if pre-breakout surveys were undertaken. Surveys should be carried out immediately after breakout (i.e. within 1 day), and then repeated approximately 1 week later to determine the rate of initial marine infill within the new entrance channel. Subsequent surveys of the entrance, several weeks and months later should also be undertaken to help determine and quantify entrance dynamics and berm recovery processes.

7.2.6 Responsibilities

The primary responsibility for implementation of the Bega River entrance management protocols is with Bega Valley Shire Council. These responsibilities include direction and supervision of all works on site to ensure that they are carried out in accordance with these protocols and relevant standards and codes of practice. Bega Valley Shire Council's Environmental Services Section will be responsible for the implementation of these protocols. Council is also to notify various government agencies prior to undertaking entrance works. Relevant contact officers from these government agencies will need to be confirmed and identified in the policy.

7.2.7 Reporting

Entrance results will be reported to key agencies (OEH, DPI - Fisheries, DPI – Crown Lands) and the BVSC Coastal Planning and Management Committee on a regular basis. An annual report should be prepared by Council officers and presented to the BVSC Coastal Planning and Management Committee and Council regarding the effectiveness of the Policy and recommending modifications, as necessary.

7.2.8 Policy Review

It is recommended that the Entrance Management Policy is reviewed once the Floodplain Risk Management Study and Plan have been completed. If a policy is still required at that time, it is recommended that the policy be reviewed on a periodic basis, or approximately every 5 years. The Review would involve reassessing environmental impacts, and reconsidering environmental planning frameworks that may have been changed during that time. The Review would also enable the conditions of the policy to be amended with respect to progressively increasing the water level trigger for entrance breakout.

FUTURE DEVELOPMENT

7.3 Future Development Sub-Plan

Future development, including development around the immediate estuary foreshores (such as the Tathra River Estate), and within the wider BRE catchment (including rural residential developments and urban expansions), will need to meet certain criteria if they are to ensure they preserve the long term sustainable health of the estuary.

In addition to the Tathra River Estate (TRE), other developments within the catchment are expected in the Kalaru area, which contains various parcels of urban zoned land. The Bega township has also been identified in the South Coast Regional Strategy as the regional growth centre and has significant capacity for further urban development. Further development areas may be identified as Council reviews their LEP.

Outlined below are a series of considerations for future development, which aim to achieve long-term sustainability of the BRE.

7.3.1 Riparian vegetation

Riparian vegetation is recognised as being particularly ecologically significant by providing the transition zone between the terrestrial and aquatic environments. The ‘effective’ width of a riparian buffer generally instils debate between those wishing to maximise ecological opportunities and those wishing to maximise developable land. Generally, the effective width depends on the purpose of the buffer. Should the buffer be used as a wildlife corridor and/or refuge, then the width should be larger, particularly when edge effects are considered.

It is recommended that all existing riparian vegetation be retained on future foreshore development sites, or developments sites fronting tributary creeks/waterways. Where riparian vegetation is sparse, it is recommended that land be set aside within the riparian zone for riparian re-vegetation. Buffer widths of between 50 and 100 metres are typical. Larger buffers should be adopted where feasible and practical to do so, particularly where existing riparian vegetation extends beyond the typical width.

All asset protection zones (fuel-reduced bushfire buffer) should be located on the landward side of the riparian buffer zone.

The riparian buffer zone (incorporating existing vegetation and land set aside for future revegetation) should be zoned for environmental protection (e.g. E2 Environmental Conservation, in accordance with the LEP standard instrument).

The land peninsula incorporating the Tathra River Estate contains some sections of very good riparian vegetation, some sections of limited riparian vegetation, and some sections of no riparian vegetation. Good riparian vegetation is located along the western foreshore of the peninsula, and on the north-east corner of the site. These areas contain an existing vegetated riparian buffer of up to 100 metres, which should be preserved. For remaining areas, a minimum buffer width of 70 metres (measured from the SEPP-14 boundary) is considered reasonable.

7.3.2 Terrestrial vegetation

Terrestrial vegetation existing on any future development site should be retained wherever possible. All existing vegetation should be assessed for ecological significance. Adequate protection from disturbance or removal must be provided for habitats of high significance.

Compensatory revegetation should be provided for all vegetation removed from the development site, to ensure there is no net loss in native vegetation values or extent. Further, the revegetation is to occur within the BRE catchment boundary. Compensatory revegetation requirements should be determined in consultation with OEH and SRCMA, and may include revegetation within the riparian buffer zone or within the area of vegetation to be retained on site, as appropriate.

Extreme care should be taken to ensure vegetation being retained is not adversely impacted by construction activities associated with the development, including accidental removal of trees or branches, shading, smothering or trampling.

The importance of the forested areas on the southern side of the estuary in providing connectivity between the estuary and large areas of National Park to the south of the study areas and habitat for threatened species cannot be underestimated. The forested area to the south of Racecourse Creek is the only large section of publicly owned bushland on the southern side of the Bega River between the escarpment and the coast (approx. 80km) and as such has significant strategic and ecological value and needs to be protected as a high priority of this plan.

7.3.3 SEPP-14 wetlands

SEPP-14 was established under the provisions of the EP&A Act to ensure protection of environmentally sensitive wetlands along the NSW coast. The BRE SEPP-14 wetlands contain areas of endangered ecological communities such as Coastal Saltmarsh, as listed under the Threatened Species Conservation Act (1995), as well as protected marine vegetation (seagrasses) under the Fisheries Management Act.

Of particular concern regarding development of land surrounding SEPP-14 wetlands are potential changes to the hydrological regime of the wetlands, as wetlands are generally at the downstream receiving end of catchment runoff.

Future developments will need to consider not only SEPP-14 wetlands where they occur within the site boundary, but SEPP-14 wetlands downstream of the site which may be impacted by the development via changes to catchment runoff. The development will also need to limit pollutant loads to these areas.

Future development should aim to mimic the natural (existing) wetting cycles of wetlands to ensure viability of habitats and current community structure. Land developers should also meet performance criteria pertaining to pollutant loads. Future development should comply with the following conditions:

- For closed wetlands, the post-development *duration and frequency of wetting and drying* should match those for the pre-development case.

- For open wetlands the post-development flow duration curve[5] should match the curve for the pre-development case (+/- minor variations of about 10%).

New developments need to demonstrate compliance with these conditions, determined through the use of continuous catchment modelling using MUSIC or similar. Volumetric runoff from any future development will likely need to be managed through a suite of integrated water and stormwater management techniques, including Water Sensitive Urban Design (WSUD).

SEPP-14 coastal wetland no. 69 covers the eastern margin of TRE, including the whole of Black Ada Swamp, while SEPP-14 no. 67 is located within the TRE land on the northern river interface. As noted above, volumetric runoff from future development of the TRE will need to be managed through integrated water and stormwater management technique including WSUD. The TRE 2 concept plans initially proposed a new road from the existing estate through to Andy Poole Drive. The development of this road would have a potentially major impact on the terrestrial forest communities and adjacent SEPP-14 wetlands and EEC saltmarsh and potentially compromise the regionally significant wildlife corridor that links the Bega River Wetlands to Bournda National Park.

7.3.4 Floodprone lands

BVSC's flood information and floodplain risk management policies appear to rely on assessments that are more than twenty five years old, meaning they are long overdue for review and update in line with contemporary approaches to development of Flood Studies and Floodplain Risk Management Studies consistent with the Floodplain Development Manual (2005) (as recommended in Strategy M-1).

Development should not be located on lands that are considered excessively floodprone. Typically, residential development should be higher than the 1% AEP (1 in 100yr) flood level. Impacts of future climate change should also be considered when assessing flood risks and design flood conditions for any future development in a Floodplain Risk Management Plan. Results of computer modelling should be provided to demonstrate the potential susceptibility of development sites to flooding.

Floodprone areas within development sites should have a non-urban landuse zoning (e.g. rural, recreation or environmental protection).

7.3.5 Climate Change and Sea Level Rise

It is necessary to ensure that future development will not be placed at undue risk as a consequence of projected climate change impacts, particularly as most developments may remain for at least 100 years. The most apparent of these impacts in the vicinity of the estuary will be sea level rise and increased storminess increasing the potential flood risk.

It is considered that an increase in sea level in the future will translate directly to an increase in mean water levels within the Bega River estuary. As water levels increase, fringing vegetation around the estuary will migrate upslope to remain within the optimum inundation zone. It is crucial that development is not located within areas that are likely to become inundated in the future, or compromises the ability of riparian vegetation to migrate upslope in response to future sea level rise.

[5] This is a probability of exceedence curve, showing the proportion of time that flow into the wetland exceeds a given value.

It is recommended that appropriate Flood Planning Levels are identified in a Floodplain Risk Management Plan that considers the potential impacts of climate change.

7.3.6 Asset protection (Bushfire buffer)

Where future development is located in proximity to vegetation, an Asset Protection Zone (APZ), or bushfire buffer between the development and the vegetation will be required. The APZ should not occur within an area of vegetation proposed to be retained, or proposed for revegetation. The APZ should be located landward of any proposed riparian buffer zone (refer Section 7.3.1).

The NSW Rural Fire Service's 'Planning for Bushfire Protection' sets out standards for APZs and all new development must comply to these standards. The APZ must be contained within the site boundary (as per the title deed) and not on adjacent land of any description.

APZs should be designed to double as a roadway, wherever possible, as this allows access during bushfires. The APZ could also be utilised as a shared pathway (foot and cycle) or for stormwater treatment. The APZ may be also used for effluent irrigation so long as the irrigation does not encourage the growth of combustible vegetation (and the irrigation is appropriate to the land constraints and does not interact with stormwater treatment measures).

For any future development of the Tathra River Estate, it is recommended that APZ's be applied landward of the riparian buffer zone, and landward of the existing forested areas.

7.3.7 Urban stormwater management

All future developments must provide a high level of stormwater management that minimises the potential for degrading receiving waters. All runoff from the development site should aim to achieve:

- *no net increase* in pollutant loads (in particular, TN, TP, TSS); and
- *no net increase* in runoff volume.

Bega Valley Shire Council will not support the direct discharge of stormwater to, or the construction of stormwater management infrastructure in, receiving water bodies (estuaries, rivers, creeks, wetlands etc). For each future development, appropriate criteria for runoff pollutant loads and volumes should be assessed using an appropriate method, and clearly specified within Environmental Planning Instruments. Treatment measures required to meet the stormwater criteria are to be provided within either the urban development area or APZ and not within proposed riparian buffers and/or retained terrestrial habitats.

The treatment measures for urban runoff should incorporate Water Sensitive Urban Design (WSUD) principles, and should use a range of techniques in a 'treatment train' process. This process may include lot-scale, street-scale, and subdivision-scale measures operating in combination to meet runoff targets. For each scale of treatment, the following should be considered:

<u>At the lot-scale</u>, runoff from impervious areas should first be directed to a treatment measure, such as a rainwater tank, soakaway or swale, and not to be directly connected to the stormwater system.

At the street-scale, piped elements of the stormwater system should be minimised in preference to open grassed swales. Roads should preferably be aligned parallel to the land contours to maximise opportunities for use of grass swales and similar.

At the subdivision-scale, Where possible, treatment measures should be ephemeral to limit opportunities for internal biogeochemical processing. Re-establishment of vegetated ephemeral swales at natural drainage outlets should be considered where appropriate. Ponding and harvesting of stormwater for use in irrigation may be used to meet flow criteria. However, the siting of stormwater harvesting / quality control ponds will need to consider development conditions requiring the re-use of treated effluent, if they apply, to limit the potential for nutrient enrichment and bacterial contamination of the ponds.

7.3.8 Sewage management

Depending on the site constraints of the future development, either connection with the reticulated sewage network or the use of on-site sewage management systems may be appropriate. Preferably, all future development should be connected to a reticulated sewage network, particularly foreshore development where on-site systems pose high risk to the estuary. The receiving STP should have sufficient capacity to accept the additional effluent volume from the population of the new development, in addition to existing residential and holiday population loads. Where this is not the case, any proposed development should be required to fund the required upgrade to meet this requirement (as per the Sewage Sub-Plan, refer Section 7.1).

Connection to the Tathra STP poses particular issues, which are discussed in greater detail in the Sewage Sub-Plan (refer Section 7.1.1). Where the development is required to re-use treated effluent on site, the following constraints and considerations apply:

- Bega Valley Shire Councils Onsite Sewage Management Policy;
- An assessment of the land's capability (slope, soil structure, groundwater interactions) for effluent irrigation;
- Consideration of the potential impacts of effluent irrigation upon achieving the pollutant load criteria for stormwater runoff;
- Effluent irrigation shall not be permitted within the riparian buffer zone or areas of native vegetation being retained at the site;
- Effluent irrigation within the APZ may be permitted where it does not result in the establishment of combustible vegetation or interact with stormwater treatment measures; and
- The impacts of climate change upon increased water levels within the estuary and in adjacent groundwater levels will need to be considered when determining the appropriateness of effluent irrigation on the proposed development site.

For small scale foreshore developments that cannot be serviced by a reticulated sewerage system, the use of pump-out systems may be required, to ensure that there is no runoff into the estuary.

There are a number of constraints that potentially limit the suitability of the TRE land for high volume effluent irrigation (as is occurring at the Tathra Country Club), including slope, soil structure and groundwater interactions, particularly in view of likely increased estuary and groundwater levels in the future due to sea level rise and due to progressively increasing the artificial entrance breakout level (refer Section 7.2.3.1). However, small OSM's on large blocks may be suitable dependent on soil characteristics, slope etc.

7.3.9 Visual Amenity

The community places very high value on the existing visual amenity of the Bega River. In particular, the river has a current 'wild' and natural ambience that can be potentially compromised if development becomes prominent on the adjacent hillslopes and ridgelines.

Where the development is likely to be visible from the waterway, the development should be screened to preserve the visual amenity of the estuary, by ensuring:

- all existing riparian vegetation is retained, and riparian buffers re-established where required;
- maximum amounts of native terrestrial vegetation are retained on the site;
- additional native vegetation is re-established in strategic locations;
- buildings are not located on hillslopes directly facing the river where possible;
- buildings are excluded from the most prominent ridgelines, and such ridgelines are alternatively used for roadways with native streetscape vegetation; and
- detailed visual impact assessments are conducted to provide site specific recommendations for all future developments.

7.3.10 Recreational Amenity

Any proposed development will result in additional pressure upon the estuary and its limited facilities for recreation. Additional recreational facilities should be provided for the residents of the proposed development. Where possible, such facilities should be provided on-site otherwise, sufficient contribution should be provided to Council to upgrade existing facilities to accommodate the additional population. The additional recreational facilities should:

- Be sympathetic to the environmental sensitivity of the estuary;
- Facilitate the movement between major settlement areas via pedestrian or cycle links;
- Encourage types of recreational activities which have less potential to degrade estuarine environments;
- Ensure the design, location and capacity of the facility minimises the potential for bank erosion, disturbance of significant vegetation communities such as SEPP14 Wetlands, littering etc.

Some parklands and recreational / visual amenities within a proposed development can double as stormwater treatment measures, in accordance with best practice WSUD.

7.3.11 Aboriginal heritage

Land proposed for future developments should be assessed to determine if and where sites of Aboriginal significance are located. Sites of Aboriginal heritage should be excluded from development, and such sites should instead be incorporated into open space parkland or vegetated land, and disturbance of such areas prevented.

It is understood that there are many sites of Aboriginal significance within the TRE land. The location and significance of such sites will be investigated and appropriate actions taken to protect these sites through the development assessment process.

7.3.12 European heritage

Where sites of European heritage are found on site, appropriate assessment should be undertaken to determine the heritage value of such sites. In some cases, it may be possible to incorporate and promote the heritage asset as part of the proposed development. Liaison with Council and/or local heritage societies may assist in this assessment.

7.3.13 Pest and weed management

In order to protect the ecological value of native habitats adjacent to or downstream of future developments, the following considerations apply:

- The use of only endemic species in landscaping and gardens within proposed developments;
- The control or prohibition of domestic animals, depending on the proximity and potential threat of the proposed development to endangered native fauna and flora.
- Stormwater controls which trap exotic seeds will assist in minimising the establishment of weeds downstream of the development.

7.3.14 Studies and assessments required prior to development

A number of site-specific studies that assist in determining potential impacts on BRE should be carried out in consideration of future developments within the BRE catchment to help define constraints and limits on land. The studies are outlined below, and may form part of a Local Environmental Study or Development Application process as appropriate:

- <u>Cumulative impact</u> – to determine the total potential impact of a development, including impacts on the estuary, wetlands or other natural features, from the development itself or associated infrastructure;
- <u>Topography</u> – to determine areas that are too steep for urban development (housing, roads etc) and/or too steep for potential irrigation, wastewater reuse etc;
- <u>Soils</u> – to determine the capacity of the soils to accommodate potential wastewater options, such as on-site sewage management or on-site effluent reuse (infiltration / irrigation), as well as to determine the suitability of various stormwater treatment options;
- <u>Water management</u> – Larger scale developments will require continuous catchment-based modelling to determine the requirements for stormwater treatment, and thus the potential locations and footprints of treatment measures required. The modelling should aim to meet objectives the flow and pollutant loads or runoff volumes, as outlined in Section 7.3.3 and 7.3.7. Modelling would also need to consider the proposed wastewater reuse scheme as it pertains to the potential impacts on stormwater management;
- <u>Sewage management</u> – Determine the viability of either on-site sewage management or on-site treated effluent disposal (via reuse, irrigation, infiltration etc), given site limitations (e.g. slopes, soils etc) and stormwater treatment requirements. Investigations for effluent re-use should

include nutrient budgeting for irrigation of effluent, as well as potential impacts on groundwater given proposed irrigation rates;

- Flood management – Flood Planning Levels should be identified by carrying out a Flood Study and producing a Floodplain Risk Management Study and Plan for the BRE, in accordance with the NSW Floodplain Development Manual (2005). Modelling for the Flood Study should consider the entrance morphodynamics (which can have a significant impact on flooding behaviour). Allowances for future sea level rise (within an appropriate planning horizon, such as 100 years) and future entrance behaviour should be factored into the modelling.
- Habitat value – Vegetation on the proposed development site should be assessed for its existing habitat value. Recommendations for significant vegetation be retained on site and compensatory revegetation required where vegetation to be removed should be made in the assessment;
- Visual impact – Determine the site-specific appropriate setbacks required to prevent visual impacts on users of the estuary;
- Recreational amenity – Determine the potential demand on recreational facilities, both within the proposed development and further afield (regional facilities). Where new facilities can be provided within the proposed development, they should be planned for use by both residents of the development and the wider community. The design of new facilities will need to consider impacts upon the estuary from the recreational activities and facilities;
- Cultural heritage – Identify locations of Aboriginal and European heritage significance, and determine appropriate measures to ameliorate impacts of the development and opportunities to promote existing sites as part of the development.

8 IMPLEMENTATION SCHEDULES

As outlined in Table 6-2, the order of implementation is essentially based on the priority of the strategy and the associated recommended timeframe. However, the order of implementation also needs to consider the inter-relationship between strategies, as some strategies need to be implemented before others.

Implementation of the Plan can be segmented into nine (9) stages, as summarised in Figure 8-1. The stages generally accord to the theoretical implementation order described in Table 6-2, but with a few exceptions. For example, Strategy M-1 has been promoted to Stage 1, as the results of Strategy M-1 are required for input to Strategy M-9, which is a Stage 2 activity. Similarly, Strategy M-10 has been promoted to Stage 3 as it directly feeds into Strategies P-1 and P-11 (Stage 4 activities), while Strategy M-8 has been promoted to Stage 4 as it feeds into Strategies CS-8 (Stage 5 activity) and CS-5 (Stage 6 activity).

It is considered that Strategies C-3 (annual reporting), P-12 (LEP revisions), and M-8 (database updates) will have on-going implementation, and will require regular updating as other strategies are completed during subsequent stages of implementation.

Within Figure 8-1, the strategies have been loosely grouped, based on the inter-relationships between them, and their relative sequencing of implementation. In this way, a ‘critical path’ for implementation can be identified for each general area of management, as shown in Figure 8-1.

A program for implementation of the Bega River Estuary Management Plan has been developed with tasks spanning approximately 5 years. The implementation details for each separate estuary management strategy are provided in the following schedules.

The implementation details are presented in the form of ‘schedules’, and are grouped together under each of the nine (9) stages of Plan implementation. The schedules provide information on specific actions required to implement each strategy, as well as indicative costs, timeframes, maintenance requirements, responsibilities for implementation, and ‘performance measures’ to define the success of implementation. Comments are also provided for each strategy, which includes background information relevant to the implementation of the strategy and cross-references to other similar strategies.

The schedules are designed to provide the information in a ‘quick reference’ format to facilitate implementation and adoption by the responsible authorities.

A contents table for the implementation schedules is provided in Table 8-1.

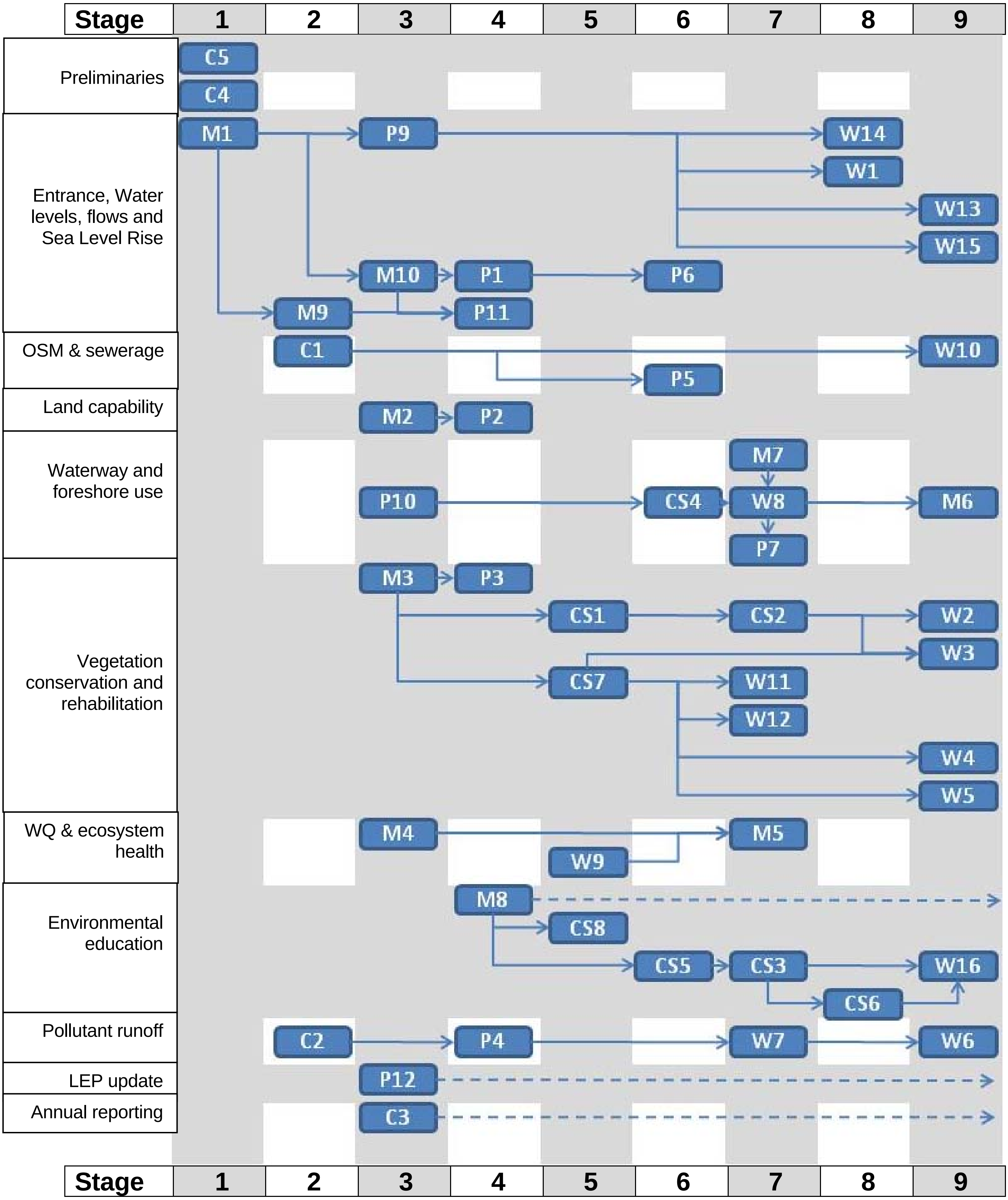

Figure 8-1 Implementation Staging

Table 8-1 Implementation Schedule Reference Table

	Strategy Name	Stage
P-1	Preserve foreshore land to provide a riparian buffer from development and climate change impacts	4
P-2	Prevent development on steep slopes	4
P-3	Prevent clearing and inappropriate vegetation removal	4
P-4	No net increase in runoff and pollutant loads from future developments	4
P-5	Ensure the use of appropriate sewage treatment measures for all new developments	6
P-6	Require all future development to be eco-friendly and energy efficient	6
P-7	Require developer contributions to recreational and foreshore facilities	7
P-8	Not used	
P-9	Adopt an Interim Entrance Management Policy	3
P-10	Control PWC use east of Hancocks Bridge, to minimise conflict with other recreators, residents and wildlife.	3
P-11	Incorporate appropriate planning controls for climate change impacts into existing planning frameworks	4
P-12	Use the EMP to assist in determining relevant landuse zonings and development controls in the preparation of the new standard LEP	3
W-1	Review and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir	8
W-2	Provide assistance to rural land managers to reduce pollutants and sediment in runoff	9
W-3	Revegetate degraded/cleared areas in catchment	9
W-4	Revegetate foreshores and streambanks	9
W-5	Assess sites of river bank erosion and rehabilitate as required	9
W-6	Reduce erosion and sediment runoff from firetrails, driveways, road verges and carparks	9
W-7	Assess existing stormwater treatment devices and improve the level of pollutant removal from stormwater	7
W-8	Assess and improve current recreational infrastructure and foreshore access (including minor works e.g. sealing carparks, landscaping and revegetation)	7
W-9	Install flow gauges in appropriate locations to monitor environmental flows	5
W-10	Connect Mogareeka Village to reticulated sewage system	9
W-11	Develop and implement a weed management strategy to eradicate weeds in the estuary	7
W-12	Develop and implement a program to eradicate pests in the estuary	7
W-13	Raise level of road to reduce inundation during estuary closure	9
W-14	Support strategic raising of golf course sections in return for protection and rehabilitation of adjacent high value habitat	8
W-15	Reclaim eroded land at Lions Park by dredging sand from entrance	9
W-16	Protect and promote (as appropriate) Aboriginal and European Heritage sites and	9

	Strategy Name	Stage
	places of significance	
CS-1	Promote the conservation of privately owned vegetation, including revegetated private lands	5
CS-2	Conduct a rural education program promoting best practice techniques for environmental management, based on Bega Cheese EMS Program	7
CS-3	Develop general information brochures for residents and visitors	7
CS-4	Develop and install educational signage to promote estuary values	6
CS-5	Develop primary and secondary school education kits	6
CS-6	Guided tours and excursions	8
CS-7	Support community volunteer groups participating in conservation activities	5
CS-8	Distribute periodic newsletters to community detailing plan implementation and progress	5
M-1	Prepare a Flood Study and Floodplain Risk Management Study and Plan for the Bega River	1
M-2	Conduct an assessment of land capability (based on air, water, soil and vegetation constraints) and determine sustainable levels of land use activities (including development)	3
M-3	Map extent and condition of EECs and habitats for Threatened Species, and determine areas requiring conservation or rehabilitation	3
M-4	Expand Water Quality Monitoring Program for recreational health	3
M-5	Implement an Ecosystem Health Monitoring Program	7
M-6	Monitor and periodically re-map aquatic and riparian vegetation.	9
M-7	Periodically monitor use of the estuary's waterway, foreshores and recreational facilities	7
M-8	Compile an ongoing a centralised database of all past and in-progress studies and data on the estuary for use in future planning, management and research activities	4
M-9	Investigate the assets and infrastructure around the BRE that are vulnerable to future SLR and ocean storm inundation. Develop adaptation solutions	2
M-10	Investigate the predicted impacts of climate change on the natural values of BRE (e.g. entrance conditions, wetland inundation etc)	3
C-1	Audit existing on-site sewage systems and enforce recommended upgrades	2
C-2	Audit construction sites for compliance with sediment and erosion controls, vegetation preservation, stormwater controls etc	2
C-3	Provide annual report on plan implementation and review of monitoring data to assess the ongoing health of the estuary	3
C-4	Agencies to incorporate EMP strategies into short and long term works and investment programs	1
C-5	Consider gazettal of the EMP by the NSW Government	1

8.1 Stage 1 Strategies

STAGE 1 STRATEGIES

C-5 Gazettal of the EMP

Priority: CRITICAL

Strategy: Provide the Bega Estuary Management Plan to the Minister for Environment to consider approval for the EMP to become a statutory document under recently amended provisions of the Coastal Protection Act 1979. The document would be called a Coastal Zone Management Plan. A few minor modifications may be required to the document in order to fully comply with the requirements for gazettal.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

Performance Measure: Gazettal of the EMP

Suggested Actions:

Action description	Underway	Complete
Compile appropriate documentation to support the gazettal of the EMP, stressing the importance of the estuary, and the need for gazettal of the EMP to preserve the estuary	☐	☐
Provide the completed EMP to the appropriate NSW Government Minister (along with appropriate supporting information) for signing	☐	☐

Comments:

Gazettal of this EMP document is seen as the most critical strategy for achieving long-term sustainable health of the estuary. Making the EMP a statutory document can increase the level of implementation by the range of agencies and groups responsible for the various strategies contained within the Plan. Gazettal will increase the likelihood of funding commitments from both BVSC and from State Government agencies and will also make applications for Federal Government funding more competitive.

See also: C-4

C-4 Agencies to incorporate relevant EMP strategies into short and long term works and investment programs

Priority: CRITICAL

Strategy: Government agencies are to incorporate relevant strategies from this Estuary Management Plan into their specific programs for short and long term works, investment strategies etc., as appropriate within their broader corporate responsibilities.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH, SRCMA, DPI, NSW Maritime, DPI-Crown Lands, NOW, DoPI

Indicative Cost: Minimal, staff time only

Performance Measure: EMP strategies become components of works programs etc for all government agencies.

Suggested Actions:

Action description	Underway	Complete
Agencies to endorse strategies recommended within this EMP	☐	☑
Agencies transfer relevant strategies to their own periodic works programs and allocate funding and resources with the aim to complete such strategies within the desired timeframes	☐	☐

Comments:

Modifications to some agency plans may be subject to formal review procedures. Sign-off of this EMP by the governmental agencies constitutes their acceptance of the strategies relevant to them and their commitment to undertaking the strategies to the best of their means.

See also:

All strategies

M-1 Prepare a Flood Study and Floodplain Risk Management Study and Plan for the Bega River

Priority: MEDIUM, however, this study is a prerequisite for undertaking Strategy M-9, which has a very high priority, so its implementation order will need to be elevated to ensure Strategy M-9 is not adversely delayed.

Strategy: A contemporary Flood Study and Floodplain Risk Management Study, consistent with the principles of the NSW Floodplain Development Manual (2005), should be developed for the Bega River. Recommendations on ways to mitigate the flood risk should be made in a Floodplain Risk Management Plan. Critical to the Flood Study will be the dynamic modelling of entrance breakout (i.e. fully integrated hydrodynamic and sediment morphodynamic modelling) under high flows conditions.

The flood model used for the Food Study should incorporate:

- Flow and water extraction management in the Bega River catchment;
- Management of flow control structures in the Bega River catchment;
- Vegetation management in the Bega River catchment;
- Land filling proposals in the Bega River catchment;
- Entrance management for the Bega River;
- Planning for climate change; and
- The modification of road infrastructure and flood planning levels.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC, OEH

Other Partners: BVSC

Indicative Cost: $200,000

Performance Measure: Flood Study and Floodplain Risk Management Plan completed, with all relevant strategies incorporated into other strategic documents and implemented as appropriate.

Suggested Actions:

Action description	Underway	Complete
Develop of consultant's brief that outlines the specific requirements of flood assessment and management in the Bega River. This includes the integrated hydrodynamic and sediment morphodynamics of the entrance to ensure entrance breakouts are appropriately incorporated.	☐	☐
Commission specialised consultant to prepare studies	☐	☐
Adopt and implement studies and actions recommended in studies	☐	☐

Comments:

The development of a Flood Study for the Bega River underpins several other Strategies proposed in this Plan, including the entrance management policy (P-9), climate change assessments and considerations (P-11, M-9, M-10) and landuse capacity considerations (P-12, M-2). It is considered that such a study should be undertaken prior to serious consideration of any future development around the foreshores of the BRE.

See also:

P-9, P-11, P-12, M-2, M-9, M-10

8.2 Stage 2 Strategies

STAGE 2 STRATEGIES

M-9 Investigate the assets and infrastructure around the BRE that are vulnerable to future climate change based inundation. Develop adaptation strategies to address climate change risks.

Priority: VERY HIGH

Strategy: Conduct an assessment of the vulnerability of assets and infrastructure to the future impacts of climate change. This would involve consideration of all aspects of climate change, including sea level rise, rainfall, temperature and coastal processes. The assessment should provide adaptation options for protection of assets and infrastructure, or relocation as appropriate.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $50,000 (excluding major survey costs)

Performance Measure: A completed assessment of climate change vulnerability of all assets and infrastructure around the BRE. The assessment is to include recommendations on ameliorating future impacts.

Suggested Actions:

Action description	Underway	Complete
Undertake LIDAR mapping of estuary to determine ground elevations of assets and infrastructure	☑	☐
Predict changes to estuarine processes as a consequence of climate change	☐	☐
Determine conflicts between assets and infrastructure and likely future estuarine processes as a consequence of climate change (eg water / flood levels, groundwater levels etc).	☐	☐

Comments: The assessments should base climate change predictions on latest CSIRO investigations (e.g. McInnes et al., 2007; Macadam et al., 2007) as described further in Chapter 10. The timeframe over which climate change impacts are expected to manifest should be incorporated into the assessment of remediation options. That is, there may not be any need to do anything within the expected lifetime of the existing asset, however, as it requires replacement or renewal, relocation to an alternative site may be necessary. Climate change will be considered in the development of a Flood Study and Floodplain Risk Management Plan for BRE and will also be addressed in a Coastal Zone Management Plan for the Bega Valley Coastline. Wherever possible, these analyses should be coordinated to ensure consistency between planning processes and to maximise data and understanding of climate change impacts in the BRE.

See also: P-11, M-1

C-2 Audit construction sites for compliance with sediment and erosion controls, vegetation preservation, stormwater controls etc

Priority: VERY HIGH

Strategy: Undertake regular auditing of construction sites to ensure compliance with consent conditions and relevant guidelines. All non-compliances with sediment and erosion control plans, vegetation conservation controls during construction, and stormwater controls and vegetation plans and all other requirements of development consent conditions should be repaired, modified or completed as appropriate. Fines under the various relevant Acts should be considered where appropriate.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

Performance Measure: Record of compliance / non-compliance for all construction sites, record of compliance / non-compliance for completed development sites and record of completed modifications / repairs for developments.

Suggested Actions:

Action description	Underway	Complete
Undertake audit / assessment of all construction sites in BRE catchment for compliance with sediment and erosion control plans, vegetation preservation, and other environmental controls on construction. Where non-compliances with controls are found, issue defect notice requiring construction company to repair / replace systems within a given timeframe.	☑	☐
Upon completion of development, audit site for stormwater controls, vegetation preservation etc as per development consent conditions. Where non-compliances are found, issue defect notice requiring landholder to amend the breach within a given timeframe.	☐	☐
Consider issuing fines under various Acts where non-compliances have not been rectified following suitable warnings and timeframes.	☐	☐

Comments:

Compliance with such controls will greatly assist in the long term prevention of pollution, excessive runoff volumes and velocities and vegetation preservation.

See also: Future Development Sub-Plan, P-4, P-3

C-1 Audit existing on-site sewage management systems (OSSMs) and enforce Council OSSM Policy

Priority: VERY HIGH

Strategy: All on-site sewage systems within the BRE catchment, and those located close to natural watercourses should, as a priority, be critically appraised in accordance with BVSC OSSM policy (2009). The Bega River Estuary is specifically identified in the policy as having “Critical Risk” areas adjacent to the waterway. The strategy should be expanded to the entire Bega River Catchment once the initial auditing program of the BRE catchment has been established. All deficient systems are to be repaired or replaced by the landholder.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

Performance Measure: Record of compliance / non-compliance for all on-site systems, and record of replacement of non-compliant systems, reducing pollutant runoff to the BRE.

Suggested Actions:

Action description	Underway	Complete
Undertake audit / assessment of all on-site sewage systems within the BRE catchment, and then the greater Bega River catchment.	☑	☐
For deficient systems, issue a defect notice requiring the landholder to repair / replace the system within a given timeframe.	☐	☐
Consider issuing fines under various Acts where serious non-compliances have not been rectified following suitable warnings and timeframes for repair.	☐	☐

Comments:

Much of the BRE catchment is serviced by on-site sewage systems, which are potentially a major source of bacteria, pathogens and nutrients (and thus algal blooms) to the estuary, particularly where the system is old and dysfunctional. Existing pollution issues have already been noted for Mogareeka Village.

In addition to maintenance / performance concerns, the audit should also assess the appropriateness of the onsite system with respect to its proximity to waterways and drainage lines. The audit process should initially focus on the BRE catchment, expanding to the greater Bega River catchment once an audit program has been established within the BRE catchment.

See also: Sewage Sub-Plan, P-4, P-5

8.3 Stage 3 Strategies

STAGE 3 STRATEGIES

C-3 Provide annual report on plan implementation and review of monitoring data to assess the ongoing health of the estuary

Priority: HIGH

Strategy: Complete reports annually which detail progress in plan implementation, provide a review of monitoring data, and describe the state of health of the estuary

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: Minimal, staff time only

Performance Measure: An annually produced report on plan implementation, review of monitoring programs and data, and analysis of the ongoing health of the estuary

Suggested Actions:

Action description	Underway	Complete
Undertake ongoing monitoring activities (strategies M-4, M-5, M-6, M-7, M-8) to provide information to inform the annual reports	☐	☐
Compile an annual report on plan implementation, and subsequent monitoring data as it becomes available through implementation of the plan, and provide assessment of the ongoing health of the estuary	☐	☐

Comments:

An annual report will provide a transparent ‘report card’ to assess the performance of all agencies in undertaking the relevant strategies. This transparency may provide an incentive to agencies to comply with strategies required in the plan. An annual report also provides opportunity to review the data and performance of monitoring programs being undertaken as part of the plan, such that monitoring frequencies and procedures are being audited, and a review of the information is being undertaken to ensure changes in estuarine health are flagged. This will ensure that positive outcomes from EMP strategies as well as also positive or negative changes in estuarine health are being reported and tracked.

See also:

M-4, M-5, M-6, M-7, M-8, M-3, and M-2, and Chapter 11.

P-12 Use the EMP to assist in determining relevant landuse zonings and development controls in the preparation of the new standard LEP

Priority: HIGH

Strategy: Utilise the recommendations of the EMP and findings of research and monitoring activities to inform the appropriate rezoning and drafting of development controls as part of preparation of the new standard LEP

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, Staff time only

Performance Measure: The new LEP for Bega Valley incorporates the appropriate zonings and development controls outlined in this EMP required to ensure the long-term sustained health of the BRE

Suggested Actions:

Action description	Underway	Complete
Undertake required studies as part of strategies M-2, M-3, M-6, M-9 and M-10, and review data to determine appropriate land use zonings for all land and waterways in the BRE and catchment which will ensure the long-term conservation of the estuary's ecological and community values	☑	☐
Prepare new LEP and supporting instrument utilising the findings of studies outlined above, and other land use recommendations, such as the future development sub-plan and planning strategies (P-1 to P-6 and P-12), contained within this EMP	☑	☐

Comments:

This EMP contains a number of strategies which prescribe appropriate land use activities for maintaining estuarine health. In particular, strategies such as M-2, M-3, M-6, M-9 and M-10 will accurately define the ecological, land and water resources of the estuary, which are an important consideration when determining the most appropriate land use and zoning for the various areas of the catchment. In addition, this EMP outlines a number of development controls and considerations that should be considered in the preparation of development controls in the standard LEP, as they explain the most appropriate actions (and prohibitions) for sustaining the estuary's values over the long term.

See also:

M-2, M-3, M-6, M-9, M-10, P-1, P-2, P-3, P-4, P-5, P-6, P-12, Future Development Sub-Plan, Sewage Sub-Plan

P-9 Adopt an interim entrance management policy

Priority: HIGH

Strategy: Conduct a formal review of the 1.36 m AHD opening height for the estuary, and develop a formal river entrance opening policy

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $30,000 for review and Policy preparation, or minimal if undertaken internally by Council and agency staff

Performance Measure: A completed formal entrance management policy

Suggested Actions:

Action description	Underway	Complete
Conduct a formal review of the1.36 m AHD river opening height	☐	☐
Compile an interim entrance management policy, which describes the appropriate opening level, and opening protocols (e.g., tidal state, rainfall forecast, etc) and measures to implement that will reduce pressure to artificially intervene in the entrance.	☐	☐

Comments:

As flooding of low-lying infrastructure and farmland is generally the trigger for artificially opening the entrance, a Flood Study and Floodplain Risk Management Study and Plan should be developed to identify an appropriate management response to the inundation (Strategy M-1). Entrance management will be just one of the management responses considered in the Floodplain Risk Management Study and Plan to manage the flood risk. The interim Entrance Management Policy should be adopted until the Floodplain Risk Management Study and Plan have been completed, when a new policy will be written, if required.

Aside from the water level within the river, there are a number of other factors which need to be considered when opening the river entrance. At present, Council conducts artificial opening of the river on an as needs basis, typically in consultation with some stakeholders. However, there is no formality to this process, and there has been no formal ratification of this process by Council or the State Government. Further, a review of the current opening procedure and formalisation of this process may uncover new information or goals which may improve the opening procedure, for example, changes in consideration of tidal level and impending rainfall in the timing of breaches; or potentially raising of infrastructure, negotiating agreements with agriculturalists upstream and other methods to minimise the need for artificial breaches in the future.

See also: Entrance Management Sub-Plan, W-13, M-1.

M-4 Expand Water Quality Monitoring Program for recreational health

Priority: HIGH

Strategy: Expand current summer 'Beachwatch Program' due to year round recreational popularity of the Bega River Estuary. The expanded water quality monitoring program should target indicators for the risks to human health, such as enterococci, faecal coliforms and/or faecal sterols.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $10,000 per annum, depending on the number of sites sampled and extent of laboratory analyses. Collection of samples to be undertaken by Council staff.

Performance Measure: Documented record of compliance of BRE water quality to human health standards

Suggested Actions:

Action description	Underway	Complete
Prepare and implement a pilot monitoring program (for a period of 12 months) to determine logistics, costs, suitable locations and monitoring feasibility.	☐	☐
Based upon outcomes of the pilot monitoring program, prepare and implement a long term water quality monitoring program that assesses the suitability of the BRE for primary recreational contact.	☐	☐

Comments:

The monitoring program should assess those locations of peak primary recreational contact, such as Mogareeka Inlet. The frequency of sampling should also reflect peak usage periods, such as weekly sampling during summer, and be consistent with ANZECC recreational water quality guidelines. Sampling results should also be compared with these guidelines to determine the suitability of water for primary contact. Where non-compliance with the guidelines is found, the public should be notified of the potential risks, and the source of pollutants should be identified and managed. Council should ensure resources are available to conduct additional sampling where necessary to identify pollutant sources.

See also: M-5

M-2 Conduct an assessment of land capability (based on air, water, soil and vegetation constraints) and determine sustainable levels of land use activities

Priority: HIGH

Strategy: Conduct a land capability assessment, which assesses land, soil, topography, water, and ecology resources throughout the catchment and its waterways. Utilise the information to recommend the appropriate type and sustainable level of land use activity for all catchment lands and waterways.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: $150,000 for the BRE catchment, however, application should extend across the whole LGA for consistency

Performance Measure: A completed assessment of all land, soil, topography, ecology and water resources across the catchment, with recommendations as to the most appropriate land use for all areas of the catchment and estuary waterbody.

Suggested Actions:

Action description	Underway	Complete
Conduct assessment of soils, topography, ecology, water etc for all land and waterways in the catchment	☐	☐
Determine appropriate type and sustainable level of land use activity for all land and waterways of the catchment.	☐	☐
Compile findings into a report for application to the LEP review	☐	☐

Comments:

Bega Valley Shire has been forecast to receive additional population as part of the South Coast Regional Strategy. In addition to this pressure to provide land for urban development, existing land use for agriculture may also be inappropriate to land characteristics (such as soils and water demands). In order to adequately prepare for the forecast increase in population in a manner which sustains the estuary's long term health, as well as to rationalise existing land use, it is important that a thorough appreciation of capability of the catchment is gained, including soils, water supply, topography and ecology.

The land capability assessment will provide a framework for guiding development within the catchment that is independent of existing landuse zonings. The land capability assessment should therefore be used to inform the LEP review process.

See also: P-12

P-10 Control PWC use east of Hancocks Bridge to minimise conflict with other recreational users, residents and wildlife

Priority: HIGH

Strategy: Review the current usage patterns and characteristics of PWC use east of Hancocks Bridge to determine where there may be conflicts with other recreational users, residents and wildlife. Modify or limit current PWC usage based upon the findings of this review.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: NSW Maritime

Other Partners: BVSC, OEH

Indicative Cost: Staff time only for assessment, plus $5,000 for signage etc.

Performance Measure: PWC usage east of Hancocks Bridge is restricted to an acceptable level on the basis of impacts on wildlife, other users, residents and PWC users.

Suggested Actions:

Action description	Underway	Complete
Review current PWC usage practices east of Hancocks bridges	☐	☐
Modify, restrict or prohibit the usage of PWC's as appropriate to the needs of wildlife, and to provide a balance between the various users and residents of the estuary	☐	☐

Comments:

PWC usage has been noted by community members to be potentially noisy for nearby residences, dangerous to other users, and may threaten endangered birds such as the Little Tern and Hooded Plover. A review of PWC usage will determine if and where noise and danger is being inflicted, and if there are restrictions to certain locations or times which may reduce the potential impacts.

See also: W-8

M-3 Map extent and condition of EECs and habitats of Threatened Species within the estuary catchment and determine areas requiring conservation or rehabilitation

Priority: HIGH

Strategy: Undertaking mapping of the extent and condition of habitats throughout the catchment. Utilise this mapping to recommend areas for conservation or rehabilitation.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $150,000, incorporating air photo interpretation and ground truthing.

Performance Measure: A record of the extent of all catchment habitats has been compiled, and recommendations have been made as to priority areas for conservation and rehabilitation

Suggested Actions:

Action description	Underway	Complete
Undertake flora and fauna study of the estuary catchment, including condition of EECs and Threatened Species habitats to identify areas of significant ecological value	☐	☐
Recommend areas for conservation, or rehabilitation, as appropriate to their significance and / or value as wildlife corridor. The recommendations should be used to assist strategies P-3, P-12, W-3, W-4, W-11, W-12, CS-1, CS-7.	☐	☐

Comments:

An up-to-date record of the ecological value of all remaining catchment habitat is highly important for the effective conservation of such areas. The forthcoming LEP review provides an opportunity to better conserve remaining habitats through appropriate zoning, and accurate mapping of such habitats and their significance will improve the ability to determine the extent of conservation required (see Strategy P-12). Furthermore, an accurate picture of habitat resources may assist in prevention of inappropriate vegetation removal (Strategy P-3) by decision makers.

In addition, information pertaining to the condition of remaining habitats may improve the dispensation of future rehabilitation and pest and weed eradication activities (see strategies CS-7, W-3, W-4, W-11, W-12, CS-1).

See also:

P-3, P-12, W-3, W-4, W-11, W-12, CS-1, CS-7

M-10 Investigate the predicted impacts of climate change on the natural values of BRE (e.g. entrance conditions, wetland inundation etc).

Priority: HIGH, , however, this study is a prerequisite for undertaking Strategies P-1 and P-11, which both have very high priorities, so its implementation order will need to be elevated to ensure these strategies are is not adversely delayed.

Strategy: Conduct an assessment of the vulnerability of natural values to the future impacts of climate change. This would involve consideration of all aspects of climate change, including sea level rise, rainfall, temperature and coastal processes.

Timeframe: Short term (1 – 3 years)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: $50,000 (excluding major survey costs)

Performance Measure: A completed assessment of climate change vulnerability of all natural values around the BRE.

Suggested Actions:

Action description	Underway	Complete
Undertake LiDAR mapping of estuary to determine ground elevations of natural features, wetlands, foreshores etc	☑	☐
Predict changes to estuarine processes as a consequence of climate change	☐	☐
Determine areas that are vulnerable to change, and areas that are required in order to allow the natural adaptation of ecological communities to climate change, including elevated estuary water levels.	☐	☐

Comments:

The assessment of climate change impacts on natural values could be carried out concurrently with the assessment of assets and infrastructure (Strategy M-9).

See also: P-11, M-1, M-9

8.4 Stage 4 Strategies

STAGE 4 STRATEGIES

P-4 No net increase in runoff and pollutant loads from future developments

Priority: VERY HIGH

Strategy: Planning provisions should be amended to ensure that all future developments should maintain or improve the condition of the estuary. This would likely be incorporated into Development Control Plans.

Timeframe: Short (1 – 3 yrs)

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: Minimal, staff time only

Performance Measure: All developments need to demonstrate ability to maintain or improve the condition of the estuary.

Suggested Actions:

Action description	Underway	Complete
For each future development, site specific objectives for runoff volumes and pollutant load reductions will be determined, and detailed in appropriate planning documents (e.g. DCP). The objectives must aim to achieve no net increase (i.e., the same or lower) in pollutant loads and runoff volumes compared with existing conditions	☐	☐
For each future development, the appropriate best practice means (e.g. WSUD) of achieving volumetric runoff and pollutant load objectives will be determined and detailed in relevant planning documents (e.g., DCP)	☐	☐
Ensure the appropriate measures and performance targets for each new development are implemented, through compliance audits (Strategy C-2) etc	☐	☐

Comments: Concerns over the potential impacts of the TRE Stage 2 development have prompted recommendations for ensuring the impact of this development in the estuary catchment can be minimised. One major recommendation is ensuring future development sites retain the same pollutant loads, runoff volumes and runoff characteristics as the existing land use. It is likely future development in the catchment will require planning controls under a site-specific DCP, and such controls should describe pollutant and runoff volume objectives with recommendations as to the methods required to achieve such objectives.

Other future development areas, such as Kalaru and the Bega township may also require similar assessment.

See also: Future Development Sub-Plan, C-2, P-3

P-3 Prevent clearing and inappropriate vegetation removal

Priority: VERY HIGH

Strategy: Consider rezoning existing large stands of significant vegetation and strengthen controls on vegetation clearing. Protect the integrity of the regionally significant wildlife corridors (as per Corridor Overlay in BVSC CLEP) that cover large areas of the Bega River Estuary catchment and provide important links between areas of National Park and State Forest.

Timeframe: Short (1 – 3 yrs), integrating with the review of the LEP, and to be preceded by an extensive land capability assessment of the areas surrounding the estuary.

Key Responsibility: BVSC

Other Partners: SRCMA, OEH, DoPI

Indicative Cost: Minimal, staff time only

Performance Measure: No excessive or broadscale removal of vegetation or inappropriate tree lopping throughout the catchment

Suggested Actions:

Action description	Underway	Complete
Undertake assessment of catchment habitats (Strategy M-3), and extensive land capability assessment (Strategy M-2) to determine areas requiring conservation or rehabilitation	☐	☐
Review the LEP and land use zonings for existing significant tracts of vegetation, and rezone such land to provide greater protection	☐	☐
Review and amend or prepare new supporting planning instruments (e.g. DCPs). All proposed vegetation clearing is to be assessed under the Native Vegetation Act / PVP model or the EP&A Act depending on zoning. Vegetation clearing to be refused or prohibited where it has been shown to be of high conservation value or have other physical values.	☐	☐
Consider actions to prosecute landholders who undertake vegetation removal without appropriate approvals	☐	☐

Comments:

The level of protection for vegetation is largely dependent upon the land zoning. There remain large and valuable tracts of vegetation across the BRE catchment, and existing zoning of such areas should be reviewed in order to provide the highest level of protection for such vegetation. Rezoning of such significant areas which exist on rural, urban or other inappropriate zonings should be performed. The zoning assessment should also consider follow-on works (e.g. rehabilitation and protection of wildlife corridors) to ensure linkage between significant habitat areas.

All proposed vegetation removal must be assessed by BVSC under the EP&A Act or the SRCMA under the Native Vegetation Act, comprehensive ecological assessments should be required. By use of such assessments and existing resources, decision makers should be equipped to prohibit or reduce the removal of significant vegetation on rural properties and proposed development sites. For future urban developments, such vegetation could instead be incorporated into proposed parkland on the development, and linked to other areas of existing vegetation through additional rehabilitation works.

See also:

Future Development Sub-Plan, M-2, M-3, CS-1, CS-7, P-1, P-2, W-3, W-4

P-1 Preserve foreshore land to provide a riparian buffer from development and climate change impacts

Priority: VERY HIGH

Strategy: Establish a riparian buffer around the Bega River Estuary that precludes any future development, including any works (e.g. stormwater treatment) or clearing (e.g. bushfire asset protection zones) associated with the future development

Timeframe: Short (1 – 3 years), integrating with review of LEP.

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, staff time only, to be undertaken as part of proposed LEP review

Performance Measure: A buffer zone surrounding the estuary that is included in the LEP and has been protected from any future development

Suggested Actions:

Action description	Underway	Complete
Rezone a buffer of width at least 80 -100m or the width of existing riparian vegetation, whichever is the greater. The buffer width shall be measured landward of the 2.0 m AHD contour around the entire estuary. This buffer will be rezoned to E2 Environmental Conservation as part of the development of the new standard LEP for Bega Valley Shire	☐	☐
No development should occur within the riparian buffer zone, with the exception of minor environmental facilities or minor recreation infrastructure. Stormwater treatment facilities, effluent irrigation or asset protection zones (bushfire buffers) should be located landward of the riparian zone buffer.	☐	☐

Comments:

The riparian zone is an ecologically significant habitat, providing the transition between aquatic and terrestrial environments, having adapted to varying conditions of salinity and saturation. The riparian zone typically supports a significant variety of plants and animals, comprising a major component of the ecological values of the estuary. The riparian zone often supports endangered ecological communities or comprises SEPP-14 Wetlands. An additional value is the screening provided by riparian vegetation from foreshore development.

The protection of riparian vegetation is paramount to ensuring the long-term ecological health of the estuary.

See also: Future Development Sub-Plan, P-3, W-4, CS-7, M-10, P-11

P-2 Prevent development on steep slopes

Priority: VERY HIGH

Strategy: Amend appropriate planning instruments to ensure the ridges and extensively vegetated hillslopes surrounding the Bega River Estuary are protected from inappropriate development.

Timeframe: Short (1 – 3 years), integrating with the review of the LEP, and to be preceded by an extensive land capability assessment of the areas surrounding the estuary.

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, staff time only

Performance Measure: Extensive vegetation on hillslopes surrounding the BRE is preserved

Suggested Actions:

Action description	Underway	Complete
Undertake topographic assessments (as part of strategy M-2) as part of identification of areas suitable for development.	☐	☐
Rezone areas of land found to be topographically unsuitable for development to E2 Environment Conservation as part of the new standard LEP.	☐	☐
Review and amend planning instruments (LEP, DCP) to ensure development is precluded from vegetated slopes visible from the estuary	☐	☐

Comments:

The community has noted the natural beauty of the BRE to be in part due to the largely vegetated slopes which overlook the estuary, providing a secluded and scenic atmosphere for those visiting for recreation and leisure. Appropriate control on development of slopes facing the waterway will ensure the secluded natural aesthetic of the estuary is preserved for the enjoyment of all estuary users.

Additionally, vegetated hillslopes assist greatly in preventing erosion from such areas, protecting downstream waterway and estuary water quality. Controls on the development of slopes will assist in protecting downstream waters from the impacts of erosion and pollutants typically associated with construction activities and urban development.

See also: Future Development Sub-Plan, M-2, P-1

P-11 Incorporate appropriate planning controls for climate change impacts into existing planning frameworks

Priority: VERY HIGH

Strategy: Update existing planning frameworks to ensure potential climate change impacts may be managed effectively

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: OEH, DoPI

Indicative Cost: Minimal cost for incorporating changes into planning controls.

Performance Measure: Climate change impacts are managed or reduced due to the provision for such impacts within planning frameworks

Suggested Actions:

Action description	Underway	Complete
Produce a Flood Study, Floodplain Risk Management Study and Plan that considers changes to flood behaviour from predicted sea level rise impacts upon estuary water levels (refer Strategy M-1)	☐	☐
Using information gathered as part of Strategy M-9, determine appropriate actions to ameliorate impacts of future climate change, including increased mean water levels, and potentially, flood water levels, and provide a timeframe for such actions. Such actions may include the acquisition of property or relocation of infrastructure	☐	☐
Update existing planning instruments (LEP, DCP, policies etc) to incorporate provision for accommodating increased mean estuary water levels and flood water levels resulting from future sea level rise, and other potential climate change impacts	☐	☐

Comments:

Predicted sea level rise will increase mean water levels throughout the estuary. Planning controls for future developments must therefore accommodate such rise in water levels and ensure riparian habitats are not compromised or lost. Flood planning levels should be updated to incorporate potential increases in mean water levels due to climate change. Changes in mean water levels may also modify the estuary's hydrodynamic processes, and potentially, entrance behaviour. Future development must be planned appropriately to ensure that conflicts do not arise within the foreseeable future between development and environmental processes.

See also: P-1, P-12, M-1, M-9

M-8 Compile an ongoing centralised database of all past and in-progress studies and data on the estuary for use in future planning, management and research activities

Priority: MEDIUM, although earlier implementation would benefit a number of education-based strategies by providing a central point of information that can be used and referenced for educational purposes.

Further, all new monitoring information and data should be incorporated into this database as it is collected to maximise referencing and reportability.

Strategy: Using the BRE Data Compilation Study as a starting point, compile a computerised database of all existing studies, as well as monitoring data (e.g. water quality results) and habitat mapping. Ensure the database is regularly updated to include the results of on-going and future studies, mapping exercises, and monitoring events (e.g. water quality and mapping recommended in this EMP). Also promote the database to other planning and management staff in Council and state agencies, such that existing information is used to guide future planning, management and research activities.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: Minimal, staff time only

Performance Measure: A regularly maintained database containing details of studies and monitoring and mapping data for the estuary, and that is referred to by planning, management and research staff when determining future management, planning and research activities in the estuary and its catchment.

Suggested Actions:

Action description	Underway	Complete
Construct a database system that contains references for all existing studies, monitoring data results, and habitat mapping data. The BRE Data Compilation Study (DIPNR 2004) provides as starting point for collating the available existing information.	☐	☐
As mapping exercises (i.e., strategies M-3, M-6), research activities (i.e., strategies M-1, M-2, M-9, M-10) and monitoring activities (i.e. M-4, M-5, M-7 and W-9) are completed, update the database to contain the results, references and information gained from such activities.	☐	☐
Promote the database, and make the information easily available to planners and managers when determining the future planning and management of the estuary and catchment, particularly in the preparation of the new standard LEP (Strategy P-12).	☐	☐
Utilise the database to guide and support ongoing education, research	☐	☐

Action description	Underway	Complete
and works activities in the estuary and catchment, e.g. W-3, W-4, W-8, W-11, W-12, W-16, CS-3, CS-4, CS-5, CS-6, CS-7, CS-8, C-3.		

Comments:

A centralised, regularly maintained database of all estuary studies and data, which is promoted for use and readily provides information to planners, managers, educators and researchers may prove invaluable in ensuring the sustainable use and adequate protection of the estuary's values. This is because decision makers will be adequately informed as to the potential impacts of their decisions, for example, enabling adequate assessment of the impacts of future subdivisions such as the TRE development. Additionally, a database may enable rationalisation of future research and works activities, by ensuring resources are channelled to those areas most requiring attention. Further, education activities, such as the compilation of school kits, guided tours and excursions, and community newsletters will benefit from data being readily available from a central base. Lastly, progress reporting for this EMP, as well as SoE and other environmental reporting may be streamlined by data availability through a central location.

See also:

P-12, M-1, M-2, M-3, M-4, M-5, M-6, M-7, M-9, M-10, W-3, W-4, W-8, W-9, W-11, W-12, W-16, CS-3, CS-4, CS-5, CS-6, CS-7, CS-8, C-3.

8.5 Stage 5 Strategies

STAGE 5 STRATEGIES

W-9 Install flow gauges in appropriate locations to monitor environmental flows

Priority: MEDIUM

Strategy: Install flow gauges in appropriate locations, including tributary streams where appropriate, to monitor environmental flows.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: NOW

Other Partners: BVSC

Indicative Cost: $80,000, depending on the number of locations, telemetry, site difficulties etc

Performance Measure: Flow gauges have been properly sited and installed, are maintained, and data is used to assess provision of adequate environmental flows

Suggested Actions:

Action description	Underway	Complete
Investigate suitable locations for flow gauges to be installed	☐	☐
Install gauges, and ensure they are maintained regularly to provide accurate data	☐	☐
Analyse data for use in support of the existing Bega-Brogo Water Sharing Plan,	☐	☐

Comments:

The installation of flow gauges in strategic locations will provide valuable data to quantify river flows and understand flow patterns from tributary creeks to the Bega River. The data may assist in supporting environmental flow requirements and the impacts of water extraction practises, as well assessing the impacts of modifications to extraction practises and flow impediments on flow quantity and behaviour.

See also:

M-5

CS-1 Promote the conservation of privately owned vegetation, including revegetated private lands

Priority: MEDIUM

Strategy: Encourage conservation of privately owned lands with significant native vegetation in partnership with OEH or SRCMA, through programs such as Voluntary Conservations Agreements (VCAs), Biobanking and Property Vegetation Plans (PVPs) and other incentives. The agreements are to cover areas of significant native vegetation of substantial habitat and environmental value located within the Bega River Estuary catchment. Additionally, require all compensatory revegetation conducted on future developments to be placed under Conservation Agreements.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: OEH

Other Partners: BVSC, SRCMA, landholders

Indicative Cost: Minimal, staff time only through direct liaison with landholder, but excluding any incentives or compensation for conservation of land

Performance Measure: The number and/or total area of private vegetation, and compensatory revegetation within the BRE catchment covered under VCA's, PVP's or Biobanking program contracts.

Suggested Actions:

Action description	Underway	Complete
Identify areas within the BRE catchment which are suitable for implementing conservation programs. The identification process should utilise findings of catchment habitat mapping (Strategy M-3)	☐	☐
Conduct one-on-one discussions with landholders of identified areas, and agree on terms of incentives for the particular conservation program selected.	☐	☐
Formally register VCA or PVP and undertake works/maintenance as agreed	☐	☐
Include in appropriate planning instrument (DCP) a requirement for all compensatory vegetation (revegetated as offsets for future development, such as Strategy P-3, Future Development Sub-plan) to be placed under a conservation agreement.	☐	☐
As necessary, provide on-going incentives to landholders to ensure revegetated and existing vegetated private lands are properly maintained and managed.	☐	☐

Comments:

Conservation programs would be based on private landholders managing their land for conservation purposes only, and would require:

- Active rehabilitation / revegetation of degraded sensitive areas and critical habitats;
- Establishment of vegetated buffers around existing vegetation to reduce edge impacts;
- Preventing stock access near waterways and critical habitat areas;
- Revegetation of riparian vegetation; and
- Weed and pest management.

Conservation programs should consider the provision of wildlife corridors between stands of vegetation across the catchment.

See also:

M-3, P-3, W-14, Future Development Sub-plan

CS-7 Support existing community volunteer groups participating in conservation activities

Priority: MEDIUM

Strategy: Continue to support local community-based volunteer conservation groups to assist with on-ground conservation works for the Bega River estuary.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: say $20,000 per annum for provision of resources to support conservation works.

Performance Measure: Active and well-attended volunteer group(s)

Suggested Actions:

Action description	Underway	Complete
Compile a list of tasks required for completion throughout the estuary. This would expand upon the existing activities of the pro-active Tathra Landcare Group	☐	☐
Advertise locally for interest in joining existing volunteer group, as appropriate. This may include signage around the estuary particularly where works are planned.	☐	☐
Prepare a works program for the volunteer group(s) with sufficient funds and resources to meet the program within the desired timeframe	☐	☐
Co-ordinate regular (e.g. monthly) working days for the volunteer group and provide with direction and support	☐	☐

Comments:

The assistance of volunteer groups will be extremely valuable for completing some of the on-ground land management activities, such as strategies W-3, W-11, W-12, outlined in this Plan. Such volunteer groups would require formal management and instruction, financial support and resources to ensure appropriate completion of tasks. It will need to be determined whether the works required will be more effectively completed through pooling of resources with the existing Tathra Landcare Group, or establishing new groups in other areas of the catchment. The other known volunteer group in the estuary monitors the breeding and survival of nesting Little Terns along the estuary entrance berm as part of OEH's Share the Shoreline Program.

See also:

W-3, W-11, W-12

CS-8 Distribute periodic newsletters to community detailing implementation and progress of Estuary Management Plan

Priority: MEDIUM

Strategy: Prepare and distribute periodic newsletters to the local Bega River Estuary community regarding the progress of the Bega Estuary Management Plan. The newsletter should include tasks completed, tasks underway and pending tasks.

Timeframe: Immediately (12 – 18 months)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only, excluding printing and distribution costs

Performance Measure: Newsletters are received periodically by local residents

Suggested Actions:

Action description	Underway	Complete
Design and prepare community newsletter regarding progress in the implementation of the Bega EMP. Tasks that have been completed should be highlighted, tasks underway discussed, and tasks listed that have financial commitment for commencement in the following 12 months.	☐	☐
Compile a distribution list and post the completed newsletter to all on the list. Depending on the preference of the recipient, the newsletter could be distributed electronically via email or in hard copy via mail.	☐	☐
Maintain and update the distribution list, and complete and distribute subsequent periodic (e.g. annual) newsletters.		

Comments: Newsletters should be prepared on an annual basis. They should include a financial summary of the works carried out as part of the EMP, as well as a checklist of tasks completed and to-do tasks. Where appropriate, a brief summary of water quality (or other) monitoring data could also be provided.

The newsletter should provide contact details for volunteer groups, to encourage community members to join and contribute to completing the plan. The newsletter should also contain a Council contact to enable feedback or for residents seeking further information.

The distribution list should initially include all residents within the catchment area, and other known community members concerned with the estuary. Additional hard copies of the newsletter should be made available at local newsagents, corner shops, post offices, libraries and Council offices.

See also: M-8

8.6 Stage 6 Strategies

STAGE 6 STRATEGIES

P-5 Ensure the use of appropriate sewage treatment measures for all future development

Priority: HIGH

Strategy: Ensure all future developments utilise appropriate sewage treatment measures

Timeframe: Short (1 – 3 yrs)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Minimal, staff time only

Performance Measure: All future developments utilise the sewage treatment measure with the lowest actual or potential pollutant impact upon the estuary.

Suggested Actions:

Action description	Underway	Complete
Require all proposed use of on-site systems to be verified with an assessment of soils, topography and additionally, consideration of the scale of the development and proximity of proposed on-site to natural drainage lines and waterways (i.e., potential for impacts upon nearby watercourses)	☐	☐
Require all new urban developments with lot sizes smaller than 2000 m^2 to be connected to the reticulated sewage network, where practical	☐	☐
Where connection to the reticulated sewage network is proposed, require developer contributions to upgrades required to trunk mains and STP to maintain or improve the quality of treated effluent from the plant	☐	☐
Where treated effluent is to be recycled on the development site, require the developer to demonstrate that effluent irrigation will not conflict with achieving stormwater treatment targets (as per Strategy P-4), and will not contribute pollutants to nearby watercourses via groundwater leaching or surface water runoff.	☐	☐
Incorporate the above actions into a DCP, and into development controls stipulated by the new standard LEP where appropriate	☐	☐

Comments:

Sewage treatment, via STPs, reclaimed water use and on-site sewage systems, have been noted to contribute pollutants to the estuary. This strategy aims to reduce potential pollutant impacts from future developments via stringent planning controls, as stipulated in the actions suggested above.

See also: P-4, C-1

P-6 Require all future developments to be eco-friendly and energy efficient

Priority: HIGH

Strategy: Ensure future development is compassionate to the environmental sensitivity of the estuary by placing controls on development with respect to environmental factors, such as appropriate fire, weed and wildlife management, and energy efficient design.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: SRCMA, RFS, OEH

Indicative Cost: Minimal, staff time only

Performance Measure: Eco-friendly and energy efficient concepts, designs and management are undertaken in all new developments.

Suggested Actions:

Action description	Underway	Complete
Include appropriate provisions within DCPs and other relevant instruments for use of endemic species in gardens, maximising pervious areas, controls on domestic animals, bushfire management and APZs, housing design to maximise energy efficiencies (sunlight, solar power, ventilation) and water reduction devices, in addition to strategies P-1, P-3, P-4, P-5.	☐	☐

Comments:

Eco-friendly and energy efficient development is considered to include, in addition to best practice stormwater treatment (Strategy P-4), sewage management (Strategy P-5), adequate riparian buffers (Strategy P-1), and vegetation preservation (Strategy P-3):

- Use of endemic species plantings in household gardens and site landscaping
- Bushfire plans, including provision for Asset Protection Zones
- Energy efficient housing design, maximising use of natural sunlight and ventilation, solar power etc
- New dwellings should be encouraged to go beyond BASIX requirements with regard the innovative use of solar passive design and alternative energy generation.
- Water reduction devices, to reduce demands on town water supply

See also:

P-1, P-3, P-4, P-5, Future Development Sub-plan

CS-4 Develop and install educational signage to promote estuary values

Priority: HIGH

Strategy: Installation of educational signage at strategic locations along the estuary foreshore which promote the values of the estuary.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: $40,000 for design and construction of signs

Performance Measure: Signage at strategic locations along the estuary foreshore promoting its values.

Suggested Actions:

Action description	Underway	Complete
Determine locations along estuary foreshore appropriate for educational signage, in connection with Strategy W-8 and public foreshore tracks/paths	☐	☐
Develop information for signs, such as a story-book style series which explains ecological, Aboriginal and European cultural, and local and regional significance of the estuary	☐	☐
Design and construct signage, incorporating community input as much as possible	☐	☐

Comments:

Signage could be connected in a story-book fashion, located strategically in relation to foreshore paths and tracks. Signage should include information as to the local ecology, Aboriginal and European cultural history, and other important factors of the estuary's local and regional significance.

Consultation should be conducted to develop appropriate content for the signs, particularly for Aboriginal and European components. The use of data sourced through the centralised database (strategy M-8) may assist in the development of sign content.

See also:

W-8, M-8, W-16

CS-5 Develop primary and secondary school education kits

Priority: HIGH

Strategy: Develop a school education kit focussing on estuarine processes and human impacts in the Bega River Estuary.

Timeframe: Short (1 – 3 years)

Key Responsibility: SRCMA

Other Partners: BVSC, OEH, DPI, local education centres, DEET

Indicative Cost: $50,000 for developing, printing and distributing a range of kits for different curricula

Performance Measure: School education kits produced and used which detail estuarine processes and human impacts upon the estuary

Suggested Actions:

Action description	Underway	Complete
Compile and review existing information and educational resources (including database as per Strategy M-8) on ecology and ecosystem processes in the BRE.	☐	☐
Rework and target for school students (primary and secondary students) according to NSW school curricula	☐	☐
Print as a stand alone kit and distribute to local and regional public and private schools	☐	☐

Comments:

Information compiled for the community brochures (Strategy CS-3) may provide a starting point for the schools education kits. Existing resources from other agencies (OEH, SRCMA) could also be utilised in the kits. The kits could be complemented by guided school excursions (Strategy CS-6).

Different school kits for primary and secondary school needs should be prepared. Kits should focus on promoting the ecological, cultural and scenic values, and the impacts of human activities upon such values.

See also:

M-8, CS-3, CS-6

8.7 Stage 7 Strategies

STAGE 7 STRATEGIES

CS-2 Conduct a rural education program promoting best practice techniques for environmental management, based on the Bega Cheese EMS Program

Priority: MEDIUM

Strategy: A targeted rural education program is to be developed aimed at achieving best-practice environmental management throughout the rural community

Timeframe: Short (1 – 3 years)

Key Responsibility: SRCMA

Other Partners: DPI-Ag, BVSC

Indicative Cost: Likely to cost in excess of $50,000 annually, depending on the avenue of delivery, the number of targeted landholders, and promotional expenses.

Performance Measure: Number of landholders involved in program, implementation of on-ground works, measurable reductions in sediment loads and nutrients entering the Bega / Brogo River Systems and ultimately the estuary.

Suggested Actions:

Action description	Underway	Complete
Building on existing programs (SRCMA, DPI Agriculture, OEH, BVSC) prepare a targeted education program addressing practices such as chemical and fertiliser use, sediment and erosion control, filtration of runoff, stock effluent management, off-stream watering, stock exclusion, gully erosion management and vegetation management	☐	☐
Implement education program through one-on-one discussions, focusing on economic benefits to landholders of providing ecosystem services via local field days and displays, brochures, information packs etc	☐	☐
Provide incentives to landholders to implement best practice techniques and provide ecosystem services (financial resources, certification etc)	☐	☐

Comments:

This program should build on existing programs currently underway by the SRCMA, DPI Agriculture, and OEH. The program should reward improvements in performance, and illustrate benefits to the landholder from best practise agricultural land management.

As a means of monitoring agricultural management practices and encouraging performance, SRCMA should consider introducing a property planning accreditation program. The accreditation program would focus on the ecosystem services that individual landholders area providing the wider community through improved farm practices.

See also: W-3, CS-1

P-7 Require developer contributions to recreational and foreshore facilities

Priority: MEDIUM

Strategy: Ensure that future recreational facilities and amenities required to meet the demands of increased population, that results from future development, are appropriated funded through developer contributions

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: DoPI

Indicative Cost: Minimal, staff time only

Performance Measure: Developer Contributions Plans are modified by Council to include requirements for contributions towards recreational facilities and amenities around the estuary foreshores, or regional locations as most appropriate

Suggested Actions:

Action description	Underway	Complete
Develop a new Section 94 plan that encompasses the Bega River Estuary and Tathra Beach foreshore areas. The plan should aim to ensure that major recreational facilities throughout the Tathra area are able to be funded by developments throughout the Bega River Estuary and Tathra areas.	☐	☐

Comments:

The extent of recreational facilities and amenities needs to be commensurate with the ability of the estuary to accommodate the additional population. Therefore, the contributions should supplement either local or regional facilities, such that the estuary's capacity for recreational use is not overstretched. The contributions should fund amenities and facilities around the estuary foreshore as part of works to improve current recreational infrastructure and foreshore access (Strategy W-8) or in regional locations as part of a regional plan for facilities across the LGA.

See also: W-8, P-6, Future Development Sub-plan

W-11 Develop and implement a weed management strategy to eradicate weeds in the estuary

Priority: MEDIUM

Strategy: Develop and implement a weed management strategy to guide specific eradication programs at priority locations, to manage weed impacts across the estuary catchment and waterways.

Timeframe: Short (1 – 3 years)

Key Responsibility: SRCMA, BVSC

Other Partners: DPI-Ag, OEH,

Indicative Cost: $30,000 for developing a program – assume mostly volunteers to implement, in addition to other concurrent strategies, e.g. community education.

Performance Measure: A weed management strategy has been developed and implemented, targeting priority weed species in priority locations

Suggested Actions:

Action description	Underway	Complete
Prepare a weed management strategy: • Assess existing weed impacts • Determine targets for priority weed species and priority locations requiring attention • Determine education and incentive activities for private land owners to assist remediation in significantly weed affected private lands • Focus on weed management methods which reduce the reliance on chemical control • Include activities which promote the establishment of endemic species in private (household) gardens • Include activities which encourage volunteer participation in weed management actions	☐	☐
Implement strategy, using identified volunteer groups and other labour resources as available.	☐	☐

Comments:

Program may be linked with existing programs by the SRCMA and BVSC. The weed management program should include areas in the upper catchment in addition to areas on the estuary foreshore. The current Coastal Weeds Program jointly funded by the SRCMA and BVSC, would be a useful model to adopt for any weed eradication proposals for the Bega River Estuary.

See also: M-3, CS-7, W-3, W-4, W-12, CS-3, P-6

M-5 Implement an Ecosystem Health Monitoring Program

Priority: MEDIUM

Strategy: Undertake ecological monitoring of the estuary to provide an indication of the overall environmental health of the system, and to improve our appreciation and understanding of the environmental processes that occur within the estuary. It is essential that ecological indicators and water quality guidelines specifically relevant to the BRE are developed and used as part of the monitoring program.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: OEH, SRCMA

Indicative Cost: $30,000 per annum, depending on the number of sites sampled and extent of laboratory analyses

Performance Measure: Documented reports of reviewed and analysed monitoring data detailing the ongoing ecosystem health of the BRE, based upon site specific trigger levels for estuarine health.

Suggested Actions:

Action description	Underway	Complete
Prepare and implement a monitoring program for ecosystem health (for a period of approximately 12 months), to determine logistics, costs, suitable locations, sample parameters, and feasibility of monitoring	☐	☐
Develop site specific trigger values describing estuarine health in the BRE	☐	☐
Pending outcomes of the pilot monitoring program, prepare and implement a long term ecosystem health monitoring program that provides specific data from the Bega River Estuary	☐	☐

Comments:

The regular monitoring of ecological indicators and water quality samples at consistent locations and times across the estuary will provide an invaluable resource for monitoring existing (background) conditions within the estuary, and determining ongoing ecosystem health. The monitoring program should be conducted to target the response of the estuary to catchment inputs. A number of rainfall events should be monitored, at consistent locations and a consistent spread of time periods following the event.

The monitoring program should work towards developing trigger levels for estuarine health specific to the BRE.

See also: M-4, W-9

W-12 Develop and implement a program to eradicate pests in the estuary

Priority: MEDIUM

Strategy: Develop and implement a pest management program to guide eradication of feral animals and other introduced species at priority locations across the catchment (and waterway).

Timeframe: Short (1 – 3 years)

Key Responsibility: Rural Lands Protection Board, SRCMA

Other Partners: BVSC, OEH

Indicative Cost: $30,000 for developing a program – assume mostly volunteers to implement, in addition to other concurrent strategies, e.g. community education

Performance Measure: A pest management program has been developed and implemented, targeting priority pest species in priority locations

Suggested Actions:

Action description	Underway	Complete
Prepare a weed management strategy: • Determine target pest species and priority locations requiring attention • Determine education and incentive activities for private land owners and residents outlining priority pest species, methods for eradication, and correct control of domestic pets • Include activities which encourage volunteer participation in pest management actions	☐	☐
Implement strategy, using identified volunteer groups and other labour resources as available.	☐	☐

Comments:

Program may be linked with existing programs by the Rural Lands Protection Board and SRCMA. The pest management program should include areas in the upper catchment in addition to areas on the estuary foreshore.

See also:

M-3, CS-7, W-3, W-4, W-11, CS-3, P-6

CS-3 Provide brochures to residents and visitors

Priority: MEDIUM

Strategy: Develop brochures to raise awareness of the environmental and cultural values of the Bega Estuary, and the potential impact that human activities can have on these values. Make brochures available through local stores, hotels, real estate agents and accommodation venues.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: SRCMA, OEH

Indicative Cost: $20,000 for brochure preparation, design, printing and distribution

Performance Measure: Brochures explaining estuary values and human impacts upon the estuary distributed to local stores, hotels, real estate agents and private accommodation venues.

Suggested Actions:

Action description	Underway	Complete
Design brochures based on the information presented in the data compilation study, estuary process chapter and other resources identified from the database (Strategy M-9) and other investigative and educational strategies (M-3, M-5, M-7, W-11, W-12, CS-4, CS-5).	☐	☐
Print and distribute brochures to accommodation providers, Tourist Information Centres, local stores, real estate agents, libraries etc	☐	☐

Comments:

The brochures should include description of:

- Ecological and cultural values of the estuary and natural estuarine processes
- Impacts of human activities upon the natural functioning of estuarine processes and estuary values
- Appropriate recreational behaviour and access (e.g., boat speeds, fish bag limits), and ways to reduce littering, trampling and other impacts upon sensitive habitats (especially mangroves, saltmarsh, seagrass)
- Appropriate residential behaviour (eg stormwater and on-site sewage management, rainwater tanks, noxious weeds/pests, endemic species planting, domestic pet control, bushfire management etc) to reduce human impacts on estuary values
- Volunteer conservation activities in the catchment, and promotion of guided tours/excursions

See also:

M-8, M-3, M-5, M-7, W-11, W-12, CS-4, CS-5

M-7 Periodically monitor the use of estuary's waterway, foreshores and recreational facilities

Priority: MEDIUM

Strategy: Undertake periodic surveys of recreational use of the Bega River Estuary waterway, foreshores and recreational facilities.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: DPI-Fisheries, Maritime Authority

Indicative Cost: $20,000

Performance Measure: A periodically completed survey program, with documented results and analysis of changes to BRE recreational use patterns and frequency over time.

Suggested Actions:

Action description	Underway	Complete
Prepare and implement a survey-based monitoring program targeting users of the Bega Estuary and foreshores, in order to gauge the number of users, types of activities, frequency of use and seasonal distribution of use.	☐	☐
Repeat survey-based monitoring on a periodic basis (e.g., every 5 years), depending on the speed of urban expansion and tourism growth within the catchment and greater LGA.	☐	☐

Comments:

Ideally, the survey program should be implemented prior to the completion of the TRE development, to gauge recreational demand prior and after this development is completed. The continuation of the survey program will also assist in determining impacts from other future developments and growth in tourism.

Additionally, survey data should support the assessment of improvements to current recreational facilities and amenities (Strategy W-8), to ensure sustainable recreational use within the capacity of the estuary and foreshore. The survey data would also assist in correct channelling of funds sourced from developer contributions to recreational amenities (Strategy P-7).

See also: W-8, P-7

W-8 Assess and improve current recreational infrastructure and foreshore access (including minor works e.g. sealing carparks, landscaping and revegetation)

Priority: MEDIUM

Strategy: Undertake an assessment of existing recreational facilities and foreshore access around the estuary, and determine a program of works to improve such facilities, within the sustainable capacity of the estuary to provide for recreational use.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: SRCMA, DPI, OEH

Indicative Cost: More than $100,000 for rationalisation and improvement of recreational facilities

Performance Measure: Completed improvements to foreshore access and recreational facilities that complement the sustainable recreational use of the estuary

Suggested Actions:

Action description	Underway	Complete
Assess existing facilities and foreshore access and determine: • the ability of the facility to adequately meet existing and future recreational demands, • the suitability of the facility to maintain sustainable recreational use of the estuary (both in terms of recreational activity type, and number of users) • access-ways to and along the foreshore which minimise impacts on sensitive environments (saltmarsh, seagrass, EECs etc)	☐	☐
Develop a program of works to rationalise and improve current recreational facilities (to limit impacts upon the estuary) and provide suitable access to and around the foreshore. The program may recommend removal or upgrade of existing facilities and access ways, and new sustainable facilities / access paths in appropriate locations.	☐	☐

Comments:

Community improvements suggested include improving the bike-path between Tathra and Mogareeka with additional links to the forested areas to the north and new developments, additional fish cleaning tables, and improved facilities / amenities at popular locations (i.e. Mogareeka). The program may include minor works such as sealing of carparks, revegetation with endemic species, landscaping etc.

See also: M-7, P-7

W-7 Assess existing stormwater treatment devices and improve the level of pollutant removal from stormwater

Priority: MEDIUM

Strategy: Assess the level of stormwater treatment from existing developments and road networks draining to the estuary, and implement recommendations (which may include installation of new devices in strategic locations) to improve the interception and treatment of surface water runoff prior to discharge to the BRE.

Timeframe: Short (1 – 3 years)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: To be considered as part of a stormwater management plan for the Bega LGA. The cost is likely to be in excess of several hundred thousand dollars, when including construction of all necessary works.

Performance Measure: Stormwater and road run-off intercepted and treated prior to discharge to the estuary or its tributaries

Suggested Actions:

Action description	Underway	Complete
Develop a stormwater management program for existing urban areas, to determine improvements or new treatment structures required. The use of WSUD treatments should be recommended as a preference.	☐	☐
Implement the stormwater management works program, including prioritised installation of treatment devices	☐	☐

Comments:

The extent of development in BRE catchment is relatively small however there is little or no treatment of runoff that originates from developments or existing road network. Improved treatment devices for existing developed areas should be complemented by best practise stormwater treatment requirements placed upon all future development, as in Strategy P-4.

See also:

P-4

8.8 Stage 8 Strategies

STAGE 8 STRATEGIES

W-14 Support strategic raising of golf course sections in return for protection and rehabilitation of adjacent high value habitat.

Priority: HIGH

Strategy: Strategic raising of section of the Tathra Beach Country Club (TBCC) should be given appropriate consideration by relevant agencies, if such earthworks aim to balance improved golfing amenity with rehabilitation and conservation of high value wetland communities surrounding the course.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: BVSC, Tathra Beach Country Club (TBCC)

Other Partners: OEH, SRCMA

Indicative Cost: For BVSC, staff time only to review and facilitate the strategy.

For TBCC, costs will depend on the area of land to be raised, the volume of material required, the method of construction and compaction etc, as well as wetlands to be rehabilitated, and are roughly estimated to fall between $100,000 and $500,000, based on a unit price of $30/m^3.

Performance Measure: Saltmarsh and wetlands within the golf course footprint are rehabilitated and protected under voluntary conservation agreements, and 1 to 3 holes of the golf course have been raised above the natural opening level (incorporating sea level rise and future artificial opening heights) of the estuary.

Suggested Actions:

Action description	Underway	Complete
Undertake discussions between TBCC, BVSC and OEH/SRCMA, to determine the area of land permitted to be raised on the course and the area of habitat to be rehabilitated and conserved. Future higher estuary water levels due to sea level rise or an increase in artificial entrance opening levels (Strategy P-9) must be considered when determining level to raise golf course to.	☐	☐
Assess impacts of effluent irrigation on proposed raised land (and its construction), and determine suitable regime for irrigation.	☐	☐
Assess potential impacts of raising golf course on adjacent wetlands – eg changes to hydrology.	☐	☐
Formally register a Conservation Agreement for the area of habitat to be rehabilitated, such that vegetation is protected under land title irrespective of change of ownership.	☐	☐
Once Conservation Agreement is in place, undertake agreed raising of golf course area and rehabilitation of habitat	☐	☐
Ensure continued maintenance of conservation area, and encourage promotion of TBCC's environmental actions and concern for estuary	☐	☐

Comments:

As part of the agreement to allow the TBCC to raise one or more holes (as appropriate) of the golf course, the saltmarsh and wetland areas should be placed under a voluntary conservation agreement attached to the land title, to ensure the protection of these lands under any future ownership.

In determining the height to which land on the golf course should be raised, the assessment should consider future higher water levels in the estuary (resulting from sea level rise, and increase in artificial opening height), so as to mitigate potential inundation of this land in the future.

The TBCC should undertake rehabilitation of the saltmarsh and other wetland habitat communities, in return for approval to raise land. TBCC should be encouraged to promote its status as an environmentally conscious golf course, for its actions to support the local and regional estuarine assets of the BRE and SEPP-14 Wetlands.

See also: CS-1, W-4, P-9, P-11

CS-6 Guided tours and excursions

Priority: HIGH

Strategy: Host guided tours and excursions that focus on estuarine ecosystem processes and values, and the impacts of human activities upon estuary values.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: OEH

Other Partners: SRCMA, DPI, local education centres

Indicative Cost: Minimal (assuming tours can be accommodated by existing staff resources)

Performance Measure: Regular and well attended guided tours that educate participants about the estuary's unique ecological and cultural values

Suggested Actions:

Action description	Underway	Complete
Set up a pilot program involving input from OEH, MPA, CMA, DPI, Council and Aboriginal Elders during a summer holiday period. Where possible, use resources already developed for similar programs. Aim the program at families and include information on a range of aspects such as ecology, hydraulics, history and human impacts.	☐	☐
Gauge the success of the pilot program, using surveys etc.	☐	☐
Following a review of the pilot program, expand to a broader geographical area or for extended time periods.	☐	☐
Consider creating a temporary position over the summer months to implement the program	☐	☐

Comments:

Bega River Estuary is an ideal location for hosting guided tours to educate residents and visitors about the estuary's ecosystem processes and values. The township of Tathra, located close to the estuary, is a popular summer holiday destination, providing a source of visitors (and locals) who may be interested in new and varied activities, such as a guided tour of the estuary.

Guided tours provide an excellent opportunity to educate both residents and summer visitors as to the unique values of the estuary (natural beauty, riparian vegetation, SEPP14 Wetlands, seagrass beds, Aboriginal and early European cultural heritage), and the impacts they may have upon such values.

The tours should be combined with existing promotion of the "Wilderness Coast" by BVSC.

See also: CS-5

W-1 Review, modify and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir

Priority: HIGH

Strategy: Review and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: SRCMA

Other Partners: BVSC, NOW, landholders, DPI

Indicative Cost: $50,000 for assessment of structures. Costs for modifications or compensation are unknown.

Performance Measure: Structures and flow impediments along tributary creeks and the Bega River are managed to allow adequate fish and other aquatic habitat and lifecycle requirements, and to allow for potentially higher estuarine water levels in the future.

Suggested Actions:

Action description	Underway	Complete
As a priority, investigate the management of Russell Creek Weir and work with landholders to achieve a balance between agricultural demands and aquatic habitat (fish passage, upstream wetland inundation) requirements. Higher water levels in the future (due to sea level rise and changes to entrance management) and potential impacts on and of flooding need to be considered. Compensation and incentives should be considered where necessary.	☐	☐
Investigate the management of remaining structures along tributary creeks and the Bega River, and modify to achieve balance between aquatic habitat (fish passage and lifecycle, wetland inundation), estuary water levels (entrance management and sea level rise) and agricultural landowners' requirements. Compensation and incentives should be considered where necessary.	☐	☐

Comments:

Flow impediments are understood to interfere with fish passage and lifecycle patterns. In addition, flow impediments, such as Russell Creek Weir, may also be interfering with natural inundation of the upstream SEPP14 Wetlands. There may also be water quality issues associated with flow impediments in some locations.

As part of negotiations, there will also need to be consideration given to the potential for higher water levels in the future, both as a result of sea level rise, and also any progressive increase in artificial breakout levels (as part of a Entrance Management Policy, Strategy P-9). The flood impacts of changes to flow impediments need to be analysed in a Floodplain Risk Management Study (Strategy M-1).

Coordination and consultation between SRCMA, BVSC and local landholders will be required to promote an understanding of the needs of the environment (particularly fish and wetland habitats) and balance these with the needs of local landholders. In some instances, incentives and compensation for local landholders may be required to achieve the necessary modifications to the management of flow structures.

See also: M-1, W-9, P-9

8.9 Stage 9 Strategies

STAGE 9 STRATEGIES

W-4 Revegetate foreshores and streambanks

Priority: MEDIUM

Strategy: Conduct revegetation in the ecologically important riparian buffers along the foreshore, tributaries and watercourses. Revegetation on private lands may require incentives.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: SRCMA

Other Partners: BVSC, landholders

Indicative Cost: likely to be in excess of $100,000, depending on scope and extents of works required

Performance Measure: Increased coverage of native vegetation along BRE foreshores, and streambanks of tributary watercourses

Suggested Actions:

Action description	Underway	Complete
Prepare a strategy for revegetation and rehabilitation, utilising findings of mapping exercises (M-3, M-6), that outlines prioritised works around estuary foreshores and tributary stream banks	☐	☐
Progressively implement strategy, utilising volunteer groups (as per Strategy CS-7) and additional resources where available through other agencies (e.g., SRCMA) and programs (e.g. Work for the Dole), and compensatory revegetation requirements for developers (Strategy P-3)	☐	☐
Hold one-on-one discussions with key landholders where revegetation of privately owned riparian lands is required, and agree on incentives to undertake works. This should be conducted in conjunction with Strategy CS-1	☐	☐

Comments:

Revegetation activities could be linked to existing SRCMA programs, or other conservation based training programs where appropriate. Revegetation activities could be implemented through volunteer groups (Strategy CS-7), as part of consent conditions for future developments (Strategy P-3), and negotiated as part of conservation agreements (Strategy CS-1). Indeed, all private lands revegetated should subsequently be protected through Conservation Agreements (Strategy CS-1).

See also:

M-3, M-6, CS-7, CS-1, P-1, CS-2

W-16 Protect and promote (as appropriate) Aboriginal and European Heritage sites and places of significance

Priority: MEDIUM

Strategy: Provide protection and promotion (where appropriate) of the Aboriginal and European sites of heritage and significance

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: OEH, BVSC

Other Partners: LALC, historical societies

Indicative Cost: less than $10,000, depending on the scope of specific works required. This costing would not include any significant restoration of sites of significance.

Performance Measure: All Aboriginal and European cultural heritage sites and places of significance within the BRE catchment are adequately protected, maintained, and promoted where appropriate

Suggested Actions:

Action description	Underway	Complete
In collaboration with the Local Aboriginal Land Council, review the management of known and undocumented sites and places of significance. Determine appropriate restoration and maintenance of sites, access, and potentially suitable sites to be shared and promoted.	☐	☐
In collaboration with local historical societies, review the management of European heritage sites, and determine appropriate restoration, management, use and access and promotion for these sites	☐	☐
Implement programs and works	☐	☐

Comments:

There are known to be a number of important Aboriginal sites and places of significance and European heritage sites throughout the BRE catchment. These sites should be maintained and protected. Where appropriate, such sites could be incorporated into programs to promote and educate about the estuary's values, such as guided tours and excursions (Strategy CS-6), school education kits (Strategy CS-5), community brochures (Strategy CS-3), estuary signage (Strategy CS-4), and foreshore access paths (W-8).

See also:

CS-3, CS-4, CS-5, CS-6, W-8

W-3 Revegetate degraded/cleared areas in catchment

Priority: MEDIUM

Strategy: Conduct revegetation in the ecologically important areas across the catchment, including provision for wildlife corridors across the catchment landscape. Revegetation on private lands may require incentives.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: SRCMA

Other Partners: BVSC, OEH

Indicative Cost: Likely to be several hundred thousand dollars, depending on extent and scope of works required.

Performance Measure: Increased coverage of native vegetation across the BRE catchment

Suggested Actions:

Action description	Underway	Complete
Prepare a strategy for revegetation and rehabilitation, utilising findings of mapping exercises (M-3), that outlines prioritised works in degraded areas of the catchment	☐	☐
Progressively implement strategy, utilising volunteer groups (as per Strategy CS-7) and additional resources where available through other agencies (e.g., SRCMA) and programs, and compensatory revegetation requirements for developers (strategy P-3)	☐	☐
Hold one-on-one discussions with key landholders where revegetation of private land is required, and agree on incentives to undertake works. This should be conducted in conjunction with Strategy CS-1	☐	☐

Comments:

There is known to have been a significant amount of clearing of vegetation within the BRE catchment as a result of European settlement. In addition to the loss of significant ecological values, this clearing has been associated with the mobilisation of large volumes of sediment, and cleared lands which are highly susceptible to erosion. Revegetation should focus on currently disused or degraded lands, and also should attempt to re-establish corridors between forested areas across the landscape.

Revegetation activities could be linked to existing programs, particularly SRCMA. Revegetation activities could be implemented through volunteer groups (Strategy CS-7), as part of consent conditions for future developments (Strategy P-3), and negotiated as part of conservation agreements (Strategy CS-1). Indeed, all lands revegetated should subsequently be protected through Conservation Agreements (Strategy CS-1).

See also: M-3, M-6, CS-7, CS-1, P-1, CS-2

W-10 Connect Mogareeka Village to reticulated sewerage system

Priority: MEDIUM

Strategy: Connect Mogareeka Village to the reticulated sewerage network, with suitable capacity increases at Tathra STP

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: BVSC

Other Partners: OEH, NOW

Indicative Cost: In excess of $1m depending on the infrastructure requirements, and upgrades at the STP in order to accept the sewage.

Performance Measure: Connection of Mogareeka Village to Tathra STP following the location of additional suitable land for effluent disposal and/or considerable increase in effluent quality from Tathra STP.

Suggested Actions:

Action description	Underway	Complete
Investigate options for effluent disposal from the Tathra STP that will not increase pollutant loads discharged to the estuary, or increased treatment for sewage at the STP	☐	☐
Undertake required upgrades to effluent quality, acquisition of suitable land and commissioning of infrastructure for effluent disposal at Tathra STP	☐	☐
Design and construct trunk sewerage mains, taking into consideration potential future population demands from Mogareeka Village upon mains.	☐	☐
Progressively connect Mogareeka Village households to reticulated sewerage network, with incentives	☐	☐

Comments:

Connection of further residences to the Tathra STP is limited by the lack of sufficient land to dispose of treated effluent, and the lack of capacity which is likely to occur within a short period of time during summer holiday demand periods, as has been noted in the Sewage Sub-plan. The issues for Tathra STP will need to be addressed prior to connection of Mogareeka Village to the STP.

See also:

Sewage Sub-plan

M-6 Monitor and periodically re-map aquatic and riparian vegetation

Priority: MEDIUM

Strategy: Conduct periodic monitoring and re-mapping of riparian and aquatic vegetation in the estuary.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: DPI-Fisheries

Other Partners: SRCMA, BVSC

Indicative Cost: $30,000 every 5 years

Performance Measure: Documented record of aquatic and riparian vegetation extents in the BRE and of changes to extents over time

Suggested Actions:

Action description	Underway	Complete
Using a range of techniques (detailed on-ground survey, air photograph interpretation) re-map the extents of aquatic and riparian vegetation, including mangroves, saltmarsh and seagrass, within the BRE	☐	☐
Repeat mapping exercise approximately every 5 years	☐	☐

Comments:

DPI Fisheries has recently completed estuarine vegetation mapping (mangroves, saltmarsh and seagrass) as part of the state-wide Comprehensive Coastal Assessment (CCA) Project. Re-mapping should be undertaken approximately every 5 years.

Comparisons between vegetation maps over time will allow an indication of trends in vegetation behaviour, particularly in relation to other environmental variables being monitored such as rainfall patterns, climate, water levels (including Strategy W-9), ecosystem health (Strategy M-5) and entrance conditions.

See also:

W-4, CS-7, P-3, W-9, M-5

W-13 Raise level of road to reduce inundation during estuary closure

Priority: MEDIUM

Strategy: Subject to further investigation and management recommendations in a Floodplain Risk Management Study and Plan, raise the surface level of the coastal road between Tathra and Mogareeka to reduce the impacts of inundation, including potentially increased frequency of inundation due to sea level rise

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: Depending on the length of road required to be raised, assuming that roadworks over 1000m are required, costs would exceed $500,000.

Performance Measure: The surface level of the coastal road between Tathra and Mogareeka has been raised to allow for greater water levels in the estuary and adjoining wetlands and adapt to future seal level rise

Suggested Actions:

Action description	Underway	Complete
Undertake an assessment to determine the amount required to raise the level of the road. This should include consideration of the future entrance management policy requirements (Strategy P-9) and the impact of future sea level rise predictions upon estuary water levels.	☐	☐
Raise the level of the road to the level determined to be suitable by the assessment	☐	☐

Comments:

Sections of the coastal road between Tathra and Mogareeka (north of the Tathra STP) are inundated during periods of high water levels in the estuary when the entrance is closed. Given predictions for increased water levels in the estuary, inundation is likely to become more frequent in the future.

See also:

P-9

W-15 Reclaim eroded land at Lions Park using sand dredged from entrance

Priority: MEDIUM

Strategy: Remediate the eroded land at Lions Park using dredged marine sand from the entrance berm as appropriate.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: BVSC

Other Partners: OEH

Indicative Cost: To be carried out as part of a formal dredging program (for entrance management purposes), with costs to place the spoil and regenerate Lions Park in the order of $50,000, depending on the quantities involved.

Performance Measure: The former land extent at Lions Park, prior to erosion, has been restored and remediated

Suggested Actions:

Action description	Underway	Complete
Investigate the extent of erosion at Lions Park, to determine the volume of dredged material required and logistics to reclaim land to the former dimensions of the park. The dredging proposal should be coordinated with the requirements stipulated as part of the preparation of a formal Entrance Management Policy (Strategy P-9).	☐	☐
Consider the hydrological and flood impacts of removing sand from entrance and depositing it at Lions Park, and modify proposal accordingly	☐	☐
Undertake proposed dredging and subsequent regeneration of reclaimed land to restore recreational values, ensuring there is no disturbance of areas within the flood tide shoals used by shorebirds for foraging and refuge.	☐	☐

Comments:

The northern foreshore of Lions Park has suffered severe erosion as a result of a poorly located artificial entrance breakout.

The investigation and proposed dredging should be coordinated with the requirements of a formal Entrance Management Policy (Strategy P-9). Dredging activities should seek to minimise disturbance to Little Tern and other shore bird nesting grounds and foraging areas.

See also:

P-9

W-5 Assess sites of river bank erosion and rehabilitate as required

Priority: MEDIUM

Strategy: Undertake rehabilitation at sites assessed to have experienced bank erosion

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: BVSC

Other Partners: SRCMA, OEH, landholders

Indicative Cost: $100,000 for riverbank assessment throughout catchment, plus the cost of works, as required (several hundred thousand dollars if rock armouring is required at one or more locations).

Performance Measure: Sites of bank erosion have been effectively remediated

Suggested Actions:

Action description	Underway	Complete
Conduct an assessment to determine sites of active bank erosion throughout the estuary and tributaries. Develop a program for prioritised remediation of affected areas	☐	☐
Implement program to remediate affected areas	☐	☐

Comments:

Sites of active erosion have been noted to exist, on a broad scale, at various locations throughout the estuary. The assessment should aim to identify and prioritise such sites, particularly where significant assets are at risk if erosion continues

See also:

W-4, CS-7

W-6 Reduce erosion and sediment runoff from firetrails, driveways, road verges and carparks

Priority: MEDIUM

Strategy: Intercept and capture sediment and reduce erosion from unsealed firetrails, driveways, road verges and carparks.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: BVSC

Other Partners: SRCMA, OEH, landholders, DPI-Forests

Indicative Cost: $300,000 - $500,000, depending on the scope of works required throughout the catchment

Performance Measure: Reduction in sediment runoff and erosion from unsealed firetrails, driveways, road verges and carparks in the BRE catchment

Suggested Actions:

Action description	Underway	Complete
Identify all firetrails, driveways, roadways, road verges and carparks in the estuary that potentially contribute sediment in runoff or are seen to be eroding. Prioritise the remediation of such areas, based on proximity to waterways, surface gradient, severity of erosion and other local features	☐	☐
On a prioritised basis, construct sediment filtering devices and remediate erosion, to intercept and reduce sediment runoff to waterways	☐	☐

Comments:

It is unknown the contribution of sediment from unsealed and eroding firetrails, driveways, road verges and carparks in proximity to the estuary and watercourses.

See also:

W-7

W-2 Provide assistance to rural land managers to reduce pollutants and sediment in runoff

Priority: MEDIUM

Strategy: Undertake a program to provide incentives to rural land managers to reduce pollutants and sediment in runoff from agricultural land.

Timeframe: Medium (3 – 5 yrs)

Key Responsibility: SRCMA

Other Partners: BVSC, OEH, DPI-Ag

Indicative Cost: Depends on the extent and scope of assistance provided, but likely to be several hundred thousand dollars for the entire Bega River catchment.

Performance Measure: Rural landowners have reduced pollutant and sediment loads in runoff to the estuary and its tributaries

Suggested Actions:

Action description	Underway	Complete
Based upon information and contacts obtained through the rural education program (CS-2), initiate discussions with landowners regarding runoff management practices, including animal waste management, effluent irrigation, fencing/removal of stock from waterways, maintenance of cattle access roads, sheet and gully erosion remediation, fertiliser and pesticide use.	☐	☐
As required, provide incentives to landholders to implement best practice techniques (financial resources, certification etc), on a priority basis	☐	☐

Comments:

The scientific study in this EMP has highlighted the potential impact of agricultural practises upon downstream water quality, streambank erosion etc. This program should be conducted in coordination with existing programs being implemented through the SRCMA.

See also:

CS-2

9 FUNDING OF THE PLAN

9.1 Funding requirements

The overall indicative cost of the Plan over the first 5 years is more than **$4.2 million** of capital investments, as well as up to $110,000 per annum of on-going commitments. Despite this relatively high cost, 19 strategies involve staff time costs only, and thus should be able to be implemented with little or no need for external funding.

The most expensive strategies involve major investment in infrastructure (e.g. stormwater treatment measures, Strategy W-7; sewerage management measures, Strategy W-10, and raising level of road, Strategy W-13), revegetation (Strategy W-3), erosion remediation (Strategy W-5), and reducing pollutant runoff from rural land (Strategy W-2).

Water quality and ecosystem health monitoring, and the support of community volunteer (Landcare) groups and on-going education campaigns require continuous funding, of up to $110,000/yr. Monitoring is an essential component of the Plan, as in one of the only methods of determining whether implementation of the Plan is having an effect and addressing the objectives for future management (refer Chapter 5).

Table 9-1 Funding requirements for Plan implementation

Stage	Capital Cost	On-going Cost (/yr)
1	$200,000	
2	$50,000	
3	$385,000	$10,000
4	-	-
5	$80,000	$20,000
6	$90,000	
7	>$500,000	$80,000
8	$50,000	
9	>$2,890,000	
TOTAL	**$4,245,000**	**$110,000 / yr**

9.2 Possible funding sources

Council is expected to fund parts of this Estuary Management Plan using environmental budget allocations of general revenue. Many of the strategies identified can be carried out in-house by Council, but this may be limited, at least in the short term, by resource constraints. Given the high costs of implementing the Plan, implementation will be reliant upon receiving external grants and funding. It is expected that some grant conditions will require matching funding from Council and/or other authorities.

Primary funding sources include the NSW Government's Estuary Management Program (refer Section 9.2.1), the Southern Rivers Catchment Action Plan initiatives (refer Section 9.2.3), and a suite of grant programs offered by local, state and federal government, as well as some private organisations (refer Section 9.2.4).

In-kind contributions could also come from various educational institutions (such as universities), who could use the estuary for specific data collection or research projects. In-kind contributions could also come from volunteer community groups, such as Landcare and schools.

Opportunities should also be explored to utilise environmentally-oriented volunteer teams, such as Greening Australia, Green Corps and Work for the Dole, to assist with elements of the Plan which can be used as training exercises, such as revegetation works.

Private industry may also contribute to various elements of this plan, through adjustments to Developer Contributions Plan and/or one-off works that may or may not be compensatory for other activities around the estuary (eg raising of the golf course).

Irrespective of external funding sources, it is envisaged that BVSC would still be required to contribute significantly to the implementation costs, to the value of at least $1.5 – 2 million over the next 5 years, subject to prioritisation against other portfolio investment requirements, and other natural resource management (including estuary and coastal zone management) demands throughout the LGA.

9.2.1 Estuary Management Program

Given that this Estuary Management Plan has been prepared in accordance with the NSW Government's Estuary Management Process, most works recommended by this Plan are eligible for part (50:50) funding under the NSW Estuary Management Program. Funding is allocated annually, with funds granted preferentially to higher priority actions in EMPs. OEH administers the Estuary Management Program, and is responsible for contributing in-kind support to many of the strategies indentified in this Plan. Estuary Management Program funding will be targeted to strategies that are not eligible for funding by other government agencies or funding sources.

There are likely to be some specific strategies that would not be funded under the Estuary Management Program, as there are other more suitable funding programs, such as the floodplain management program (refer Section 9.2.2), or the strategies are not considered to be within the domain of State Government financial support (eg sewerage works).

9.2.2 Floodplain Risk Management Program

The Floodplain Risk Management Program is administered by OEH. Eligible projects can be funded, on a competitive basis, for 50:50 contribution by the NSW Government. The preparation of a Flood Study and Floodplain Risk Management Study and Plan for the Bega River (Strategy M-1) would be eligible for part funding under this program.

9.2.3 Southern Rivers Catchment Management Authority

The Southern Rivers CMA has prepared a Catchment Action Plan (SRCMA, 2007) that outlines the aims, objectives and strategies for catchment management across the South Coast of NSW. *Coastal and Marine Management Target C2: Protecting and Rehabilitating Estuaries* of the SRCMA's Catchment Action Plan (CAP) 2007 pertains to the development and implementation of natural resource management plans including EMPs. The CAP also contains biodiversity and water themes, which would also be relevant to this Estuary Management Plan. In essence, the CMA could partly or wholly finance actions related to natural resource management, including the following strategies:

- W-9: Install flow gauges in appropriate locations to monitor environmental flows ($80,000)
- CS-7: Establish and support community volunteer groups participating in conservation activities ($20,000/yr)
- CS-2: Conduct a rural education program promoting best practice techniques for environmental management ($50,000/yr)
- W-11: Develop and implement a weed management strategy to eradicate weeds in the estuary ($30,000)
- W-12: Develop and implement a program to eradicate pests in the estuary ($30,000)
- W-1: Review and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir ($50,000)
- W-4: Revegetate foreshores and streambanks ($100,000)
- W-16: Protect and promote (as appropriate) Aboriginal and European Heritage sites and places of significance ($10,000)
- W-3: Revegetate degraded/cleared areas in catchment ($200,000 +)
- W-5: Assess sites of river bank erosion and rehabilitate as required ($300,000)
- W-6: Reduce erosion and sediment runoff from firetrails, driveways, road verges and carparks ($100,000)
- W-2: Provide assistance to rural land managers to reduce pollutants and sediment in runoff ($200,000)

Total = $1.1m (+ $70k/yr)

In addition to the above, the SRCMA have been nominated to assist with various strategies that would primarily involve staff time input. In particular, these include strategies related to education and liaison with private landholders within the catchment, and in particular, rural landholders.

9.2.4 Environmental Grants Programs

There are a number of state and federal government grant programs, and private foundations that should be explored for potential funding of various strategies outlined within this Estuary Management Plan. A number of these grant programs are outlined in Table 9-2.

Table 9-2 Environmental Grants Program Sources

	Funding authority	Example applicable strategies
Natural Resource Management		
Environmental Research Program	OEH	M-2, M-3, M-9, M-10
Forging Partnerships Program	National Resources Advisory Council	CS-2, CS-4, CS-6
Urban Sustainability Grants	OEH	C-2, CS-3, P-2, P-3, P-4, P-5, P-6, W-6, W-7, W-8
Envirofund	NHT	W-3, W-4, W-5, W-9, M-2, M-3, M-4, CS-4
Restoration and Rehabilitation Program	OEH	W-3, W-4, W-5, W-11, W-12, CS-1, CS-2, CS-7
Environmental Education		
Eco-Schools Program	OEH	CS-5, CS-6
Environmental Education Program	OEH	CS-2, CS-3, CS-4, CS-5, CS-6, CS-7
Commonwealth Environmental Education Grants Program	DEH	CS-2, CS-3, CS-4, CS-5, CS-6, CS-7
Invasive Species		
Local weed coordination and weed control	DPI	W-11, CS-7
State Priority Weed Projects	DPI	W-11
Regional Weeds Plans and Group Funding	DPI	W-11
Defeating the Weed Menace fund	Australian Government	W-11, CS-7
National Feral Animal Control program	NHT	W-12
Marine, Coasts and Floodplains		
Coastal Management Program	OEH	P-1, M-9, M-10
Estuary Management Program	OEH	All strategies, refer Section 9.2.1.
Floodplain Risk Management Program	OEH	M-1
Primary production		
Natural Resource Innovation Grants	National Landcare Program	CS-1, CS-2, CS-7, W-2
Environmental Management Systems	Cth DAFF	CS-1, CS-2, CS-7, W-2

	Funding authority	Example applicable strategies
Water efficiency		
Water Smart Australia Program	Australian Government Water Fund	P-8, W-1, W-9
General, planning and community		
Community support grants	National Landcare Program	CS-7, W-3, W-4, W-11, W-12
Corporate Community Program	BHP Billiton	CS-1, CS-3, CS-4, CS-7, W-3, W-4, W-6, W-11, W-12
Planning Reform Funding Program	Department of Planning	P-1, P-2, P-3, P-4, P-6, P-7, P-9, P-11, P-12
Project AWARE Foundation Grants	Project AWARE	CS-1, CS-7, W-3, W-4, W-11, W-12
Macquarie Bank Foundation	Macquarie Bank	CS-1, CS-7, W-3, W-4, W-11, W-12
Natural Environment Grants	Myer Foundation	CS-1, CS-7, W-3, W-4, W-11, W-12
Westpac Operation Backyard	Westpac Banking Corporation	CS-1, CS-7, W-3, W-4, W-11, W-12
Ian Potter Foundation Grants	Ian Potter Foundation	W-3, W-4, W-11, W-12

10 ACCOMMODATING FUTURE CLIMATE CHANGE

10.1 Background

Climate change, as a response to increased greenhouse gases in the Earth's atmosphere, is now a widely accepted phenomenon. Impacts of a changing climate are already beginning to emerge (Steffen, 2006). For example, WMO (2005) state that, with the exception of 1996, the 10 years between 1996 & 2005 were the hottest years on record (globally averaged). In Australia, 2005 was the hottest year on record, at a temperature of 1.09°C higher than the 1961-1990 average (BoM, 2007). The past nine years in Australia have been consistently hotter than the 1961-1990 average (refer Figure 10-1).

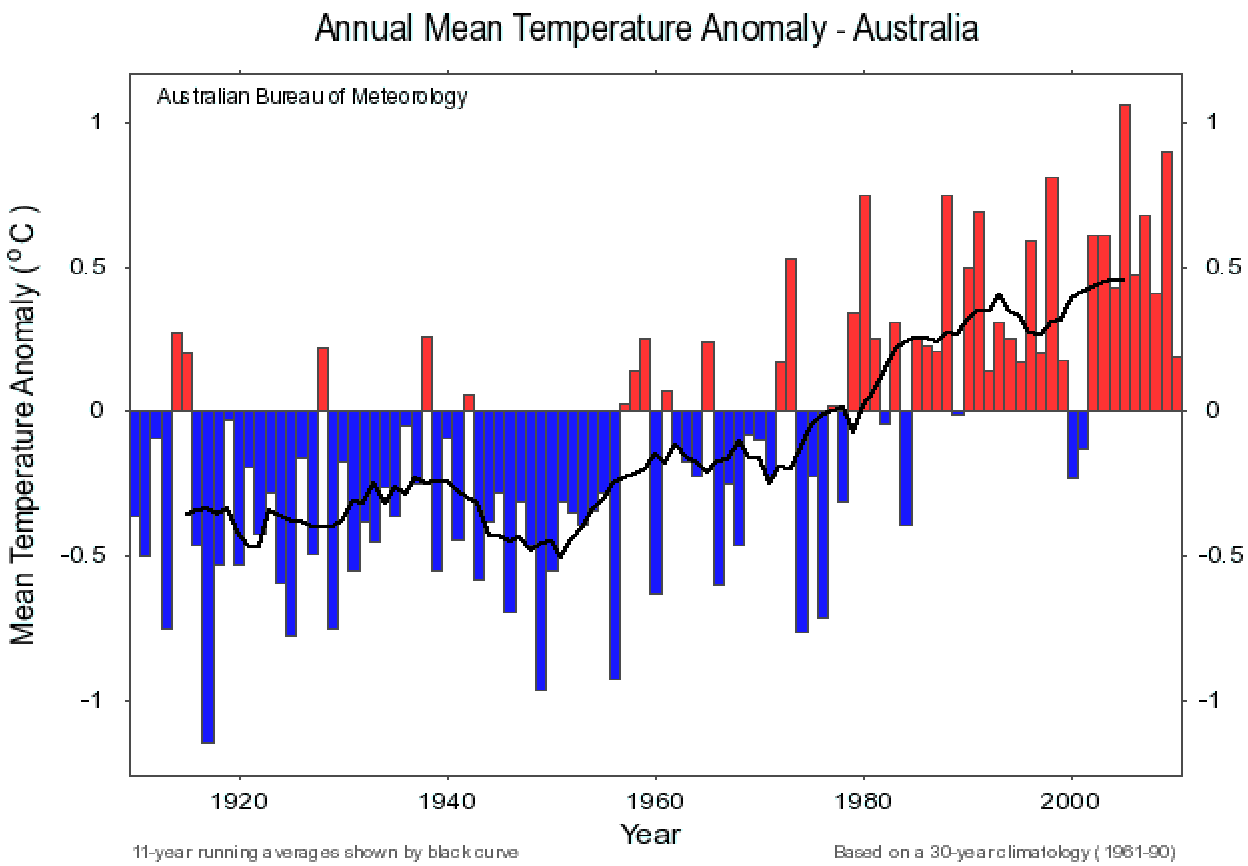

Figure 10-1 Australian average temperature variation, 1910 – 2010 compared to 1961-1990 average, black line shows running 11 year average (Source: BoM, 2011)

Increasing air temperatures across the globe in the future will cause a variety of climatic effects, including sea level rise, increased atmospheric and ocean temperatures, and changes to rainfall and drought patterns. Changes to climate in the next 30 – 50 years are considered inevitable, regardless of possible reductions in global greenhouse gas emissions (Lord *et al.* 2005).

Mean sea level, on a global scale, has been increasing over the past century, due primarily to the thermal expansion of the oceans as ocean temperature has increased (Cabanes et al., 2001), as well as glacial melting (Walsh et al., 2002). Over the past 50 years or so, the widely adopted average sea level rise has been approximately 1.8mm/yr (Walsh, 2004; Church et al., 2005). Sea level rise has not occurred consistently, however, with the most recent trend (since the early 1990s) having an accelerated rise or around 3 mm/yr, as measured by satellite data (refer Figure 10-2).

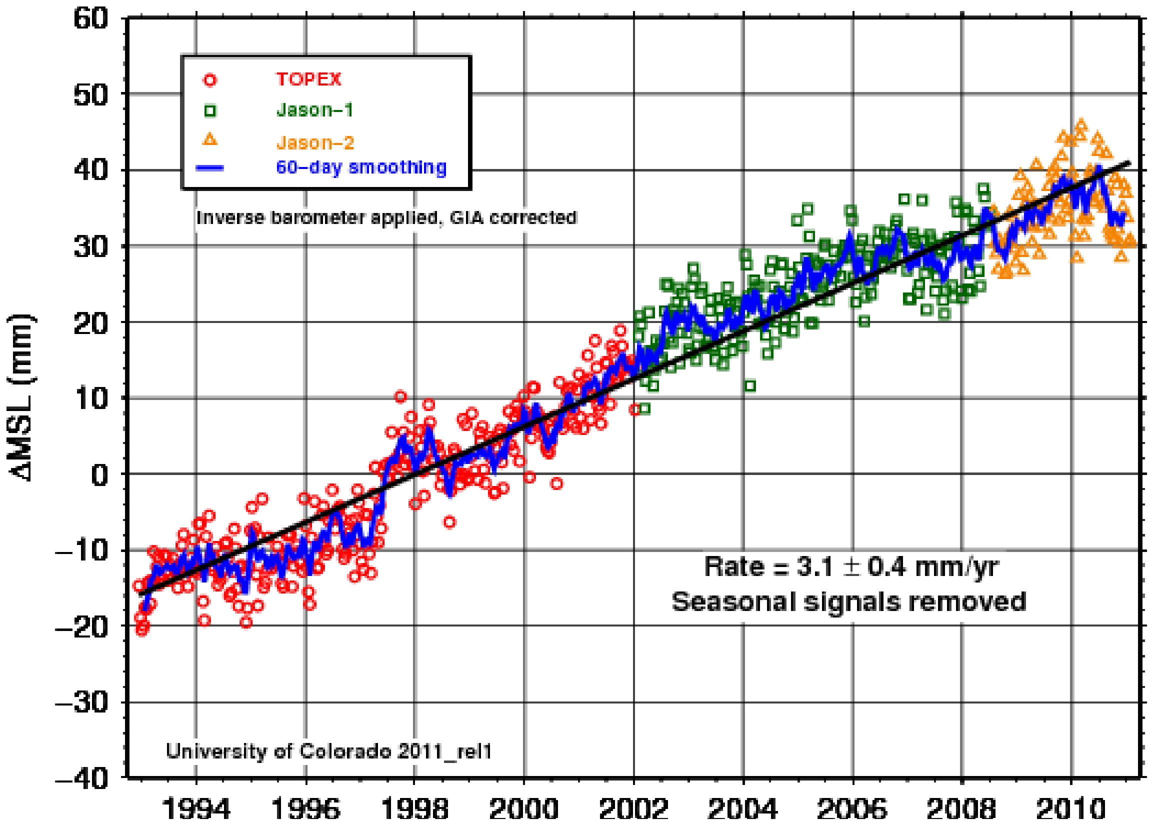

Figure 10-2 Global Mean Sea Level Rise, as measured by NASA satellites (Source: University of Colorado, 2011)

Climate change variables of particular concern to the coastal environment include:

- Mean Sea Level;
- Air and water temperatures;
- Rainfall patterns; and
- Wave climate, including storm surge.

Considerable research has been carried out in an attempt to quantify the extents of changes to these environmental variables, and consequences on the Australian coastline, including IPCC (2001, 2007), McInnes et al. (2007), Macadam et al. (2007), Hemer et al. (2008) and DCC (2009) to name a few. Changes to mean sea level are reasonably well predicted, with an expected range of sea level rise of 0.18 to 0.91m by the end of this century (McInnes et al., 2007), while a level of up to 1.4m above 1990 sea levels may be possible (Rahmstorf, 2007). The most current research, as presented at the Copenhagen climate congress in March 2009, projects sea-level rise of 0.75m to 1.9m between 1990 and 2100 (DCC, 2009).

Changes to air temperature are also reasonably well predicted, with the daily maximum air temperature on the NSW coast likely to increase by between 0.5 and 1.5°C by 2030, and by between 1.1 and 4.6°C by 2070 (annually averaged), while the annually averaged daily minimum air temperature is also likely to increase, by between 0.4 and 1.4°C by 2030, and by between 1.0 and 4.3°C by 2070 (Macadam et al., 2007). The likely changes to sea temperatures, however, are not as well understood.

Predicted changes to rainfall patterns and local wave climates on the coast of south-east Australia are subject to significant variability, as they are influenced by many different factors.

10.2 NSW Government Response

In recognition of the overwhelming scientific evidence of climate change and sea level rise in particular, the NSW Government adopted a Sea Level Rise Policy Statement (the Policy Statement) in 2009, which sets the planning standards for projected sea level rise to 2100 that must be adopted in all forms of coastal and estuarine assessment and management planning. The adopted benchmarks are 0.4 m rise in sea level by 2050 and 0.9 m by 2100. Most other states of Australia have adopted similar sea level rise benchmarks.

The Policy Statement outlines the recommended risk based management approach and the commitments of the NSW government to assist planning and managing sea level rise, including:

- promoting risk-based assessment approaches to sea level rise and coastal planning;
- providing guidance to councils to support adaptation planning initiatives;
- encouraging appropriate development on land at risk from sea level rise;
- providing continued emergency management support for damaging storms and floods; and
- providing ongoing updated information to the public about sea level rise and projected impacts.

With respect to managing sea level rise, the NSW Coastline Policy 1997 (refer Appendix A) has been updated by the new Sea Level Rise Policy Statement.

In compliance with the ‘Precautionary Principle’, as espoused by the NSW Coastal Policy, management of the Bega River Estuary over the next 50 to 100 years needs to accommodate the potential effects of climate change, despite the degree of uncertainty in many areas of climatic predictions. In particular, Objective 2.2 of the Coastal Policy requires the consideration of future climate change in the planning and management of coastal resources and development and promotes a ‘risk averse’ approach to decision making.

10.3 Likely Changes to Climate at Bega River Estuary

Investigations by CSIRO (Macadam et al., 2007; McInnes et al, 2007) have attempted to provide an Australian focus to climate change predictions in the coastal zone. Two pilot investigation areas by CSIRO for assessment of future climate change impacts upon estuaries were selected: the Clyde River/Batemans Bay estuary; and the Wooli Wooli River Estuary.

The CSIRO investigations have given particular attention to the uncertainty of climate response models. In providing predicted outcomes, CSIRO adopted the result of two different regional climate models (CCM2 and CCM3) that were found to have distinctly different responses with regard to wind (considered to be one of the principal climate variables, as it drives a number of processes that influence coastal response). Both regional climate models adopted by CSIRO utilise a future CO_2 emissions rise (from present levels of 370 ppm to 880 ppm by 2100) that is considered sufficiently conservative for a risk averse approach to future decision making (McInnes et al, 2007).

The Bega River Estuary is located about 120 km south of Batemans Bay, while the structure and function of the Wooli Wooli River is similar to the Bega River. The outcomes of the CSIRO investigations for these pilot investigations are therefore considered a good indication of the likely climate change outcomes for the Bega River Estuary, and are outlined below, followed by a discussion of how they will impact on BRE (section 10.3).

10.3.1 Average Temperature

Macadam et al (2007) report changes to average temperature based on previous work by Holper et al (2006), scaled by global warming values to produce projections of change for 2030 and 2070. Using the two climate models and a range of global warming values, the daily maximum air temperature at Batemans Bay is likely to increase by between 0.5 and 1.5°C by 2030, and by between 1.1 and 4.6°C by 2070 (annually averaged). The annually averaged daily minimum air temperature is also likely to increase, by between 0.4 and 1.4°C by 2030, and by between 1.0 and 4.3°C by 2070. Temperature ranges for the Wooli Wooli Estuary were similar to those for Batemans Bay.

Changes in ocean water temperatures are also predicted to occur as a result of climate change. This will have important implications for management of the estuary if the ecotone between tropical and temperate waters moves south and alters the species that utilise the ocean / estuary for part of their life cycle.

10.3.2 Average Rainfall

As for average temperature, average rainfall estimates were determined based on work by Holper et al (2006). The changes in rainfall are given as the change in total quantity of rain falling on a unit area over a year. Macadam et al (2007) reports that by 2030, average annual rainfall will either decrease by up to 8% or increase by up to 10% at Batemans Bay, according to the two model simulations, CCM2 and CCM3 respectively. By 2070, annual average rainfall will either decrease by up to 23% (as per model CCM2) or increase by up to 30% (as per model CCM3) at Batemans Bay. The scenarios considered by Macadam et al (2007) showed considerable variation, highlighting the lower degree of certainty associated with future rainfall projections.

These widely variable rainfall outcomes are still useful for consideration at the Bega Estuary system. Future planning for water usage would be prudent to accommodate the worst case outcome, ie up to 30% less rainfall by 2070.

10.3.3 Extreme Rainfall Events

Extreme rainfall events have been considered previously by CSIRO (Hennessy et al., 2004). Extreme daily rainfall is predicted to be modified by future climate change (Walsh 2004a,b; Hennessy *et al*., 2004) with potentially less frequent, but greater storm intensity, as part of an overall decline in annual precipitation.

Consideration was given to 1 in 40yr, 1 in 20yr, 1 in 10yr and 1 in 5yr rainfall events. Changes predicted by Hennessy et al. (2004) were averaged across return periods to give a single change for each simulation considered (Macadam et al., 2007). The intensity of extreme rainfall events in the vicinity of Batemans Bay, which may be applied to nearby Bega, is likely to change by -10 to +10% by the year 2030, and by -10 to 0% by the year 2070 (averaged annually). Typically the intensity of storms is more likely to increase during summer, and decrease during winter.

10.3.4 Drought Frequency

Macadam et al (2007) refer to investigations carried out by Mpelasoka et al (2007), using CSIRO and Canadian Climate Centre modelling. The results of Mpelasoka et al (2007) suggest that the Southeast Coast Drainage Division, containing the Bega River estuary, is likely to have an increase in the frequency of drought of up to 20% by 2030, and up to 40% by 2070. Drought is therefore projected to occur for up to 24% of months per decade by 2030, and up to 28% of months per decade by 2070.

10.3.5 Average Solar Radiation

Average solar radiation was assessed by Macadam et al (2007) based on previous work by Holper et al (2006). The solar radiation was defined as the energy transferred to a unit area by incoming shortwave electromagnetic radiation from the sun. It was assessed that the average solar radiation is likely to increase by between 0.1 and 0.3% by 2030, and by between 0.2 and 0.8% by 2070 (annually averaged). Considerable variability in the average solar radiation was recorded between the different models and global warming scenarios for each of the seasons, with some seasons reporting significantly greater increases (and even decreases) compared to the annual averaged values.

10.3.6 Wind Speed and Direction

McInnes et al (2007) used the CSIRO climate models to determine winds over 40 year periods centred on 1990, 2030 and 2070. A frequency analysis on daily average winds was carried out based on binned wind directions and wind speed classes. On an annual averaged basis, the models showed no difference in wind direction, indicating that any change in wind direction was less than 45° (the resolution of the model). For wind speed however, the percentages of time that winds from the dominant wind direction[6] were within the different wind classes were determined (McInnes et al 2007). The model results indicate only small differences (both positive and negative) in the percentage of time within each wind class for both 2030 and 2070 in the vicinity of Batemans Bay, when considered on an annual and a seasonal basis.

It is noted by McInnes et al (2007) that the wind analysis was conducted for a coarse grid (5^0 boxes) covering the ocean near Batemans Bay, and as such, the results do not represent localised wind conditions that are likely to be experienced on the land. The wind estimates, however, provide the basis of wave height and direction and storm surge predictions, as discussed below.

[6] Dominant wind direction is SE (annually), SE (summer), SE (autumn), S (winter) and N (spring)

10.3.7 Wave Height and Direction

The wind speed changes calculated by McInnes et al (2007) were used to estimate changes to the ocean wave climate at Batemans Bay. Winds close to the coast were used to generate a time series of storm waves, while winds offshore were used to generate swell waves – the two time series were then combined.

Storm waves originate most frequently from the south-easterly and southerly directions. Considerable variability in the models was found, with increases and decreases occurring in both climate models for different directions and time periods. However, the CCM3 model predicted an increase in the maximum storm wave height and period from the southerly, easterly and southeasterly directions in 2070 for both locations (Wooli Wooli estuary and Batemans Bay). Given the proximity of the Bega River entrance to Batemans Bay, the model predictions are considered relevant.

At Batemans Bay, the frequency of occurrence of swell waves from the SSE octant decreases in both model outputs, for both 2030 and 2070. This decrease is thought to possibly relate to the higher frequency of westerly winds at this latitude, as mid-latitude westerlies strength and contract to the south.

10.3.8 Storm Surge

A 50 year return period storm surge level of 0.66m +/- 0.13m was determined for Batemans Bay from extreme sea level residual data using a Generalised Pareto Distribution (GPD) (McInnes et al., 2007). The predicted change in frequency of storm waves was used to modify the GPD parameters. For 2070, the 50 yr return period storm surge increased to 0.68m +/- 0.14m using the CCM3 model, but decreased to 0.65m +/- 0.12m using the CCM2 climate model.

10.3.9 Mean Sea Level

Globally averaged sea level rise is provided by latest IPCC investigations. Using a wide range of scenarios, global average mean sea level is likely to increase by 0.18 to 0.59m by 2095, with potentially an additional contribution of 0.1 to 0.2m from the future rapid dynamic response of the ice sheets (melting etc) (IPCC, 2007). Local variations from this global average are expected. Based on the two CSIRO models, thermal expansion of local seas is predicted to be higher than global average values along the NSW coast. This is associated with stronger warming of the sea surface temperatures and a strengthening of the East Australian Current (McInnes et al, 2007). For the area around Batemans Bay, projected sea level rise is likely to be between 0 and 4cm higher than the global average sea level rise by 2030, and between 0 and 12cm higher than the global average rise by 2070.

As outlined in Section 10.2, the NSW Government has adopted a Sea Level Rise Policy Statement that sets sea level rise benchmarks of 0.4m by 2050 and 0.9m by 2100.

10.4 Impacts of Climate Change on Bega River Estuary

The impacts of future climate change are likely to lead to a wide range of environmental responses by the Bega River Estuary. These are likely to manifest throughout the physical, chemical and ecological processes that drive local estuarine ecosystems (see Figure 2-17).

One of the most significant climate change prediction for the Bega River is that of increase drought frequency as it will further degrade the river's already highly exhausted streamflow. As noted previously, during periods of low streamflow, the Bega River is reduced to small pools in which small numbers of aquatic species take refuge until streamflow is replenished. Without replenishment, the small pools may become stagnant and deoxygenated or dry up completely, extinguishing the aquatic refuges. Periods of reduced streamflow are already prolonged by current water extraction practices in the Bega River and its tributaries, causing significant stress upon the aquatic habitat. Periods of reduced streamflow are likely to become further exacerbated by the rainfall reductions predicted in future climate scenarios.

An increase in mean sea level would result in an upward and landward translation of ocean beach profiles (Bruun 1962, Dean and Maurmeyer 1983, Hanslow *et al.* 2000), thus causing net shoreline recession (refer Figure 10-3). The changed beach processes will result in a net upward shift in typical berm heights of coastal entrances, such as at Bega River.

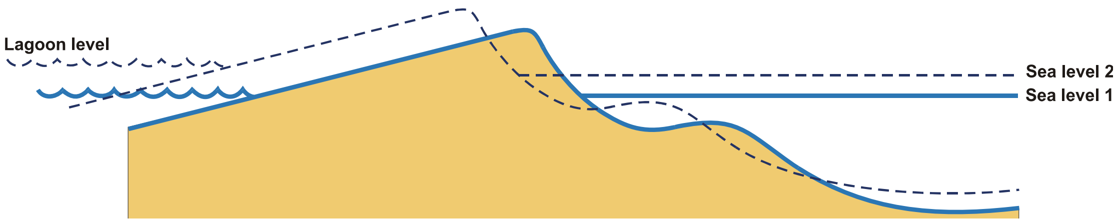

Figure 10-3 Shoreline response to increasing sea level (Hanslow *et al*., 2000)

A change in entrance berm processes is likely to result from the predicted sea level rise and changes to coastal storm intensity (Haines and Thom, 2007). From this change, a net upward shift in typical berm heights at the entrance may be expected, and therefore flood water levels will need to reach a higher level before inducing a natural breakout to the ocean (Haines, 2006; Haines and Thom, 2007).

The impact of sea level rise on the Bega River is summarised in Table 10-1.

Table 10-1 Sea level rise impacts on the Bega River (adapted from Haines, 2011)

Impact	Consequence	'Knock-on' effects
Increase in low tide level within the river *(that is, water level won't get as low following entrance breakout or during normal open entrance conditions)*	As the Bega River is opened artificially (and assuming no change to the existing opening policy), there will be less storage of water within the waterway before the trigger level is reached. This will result in a more frequent need to artificially open the entrance. This may, however, be offset by a reduction in breakout potential due to reduced catchment runoff (from lower rainfall predictions).	The typical water depth within the estuary will increase. This may have impacts on benthic ecology, which has adapted to existing light conditions, and geochemical processes within the sediments. Greater typical water depth over marine and fluvial deltas will result in vertical accretion of these primary deposition areas. Such accretion would likely occur at a rate consistent with the sea level rise (ie, up to ~10mm/yr). Additional shoaling of the marine delta is likely to counteract the additional tidal flows

Impact	Consequence	'Knock-on' effects
	Further, due to the reduced hydraulic head (difference between the river water level and the elevated ocean water level), the breakout process will be less effective, with less sand scoured from the entrance. Therefore the entrance will re-shoal and possibly re-close more quickly after a breakout.	through the entrance as a result of the increased waterway area of the estuary. This would result in a new dynamic balance of entrance conditions. Potential for elevation of local groundwater tables around the estuary foreshores. Greater water depths within the waterbody will reduce the potential for wind driven circulation and stirring of fine bed sediments, possibly resulting in an increased potential for stratification. Upward translation of low tide levels would potentially 'drown' existing fringing vegetation.
Shoreward translation and increase in berm height at entrance (see Figure 10-3). *(that is, the sand berm will move inland and will build up to a higher level relative to local topography)*	For natural breakouts, the increase in berm height will result in higher water levels before a breakout is induced (Haines, 2006; Haines and Thom, 2007). As the foreshores around estuary are generally flat, the estuary would actually store more water before a breakout occurs (there is a non-linear relationship between estuary volume and water level). Therefore the frequency of breakouts will reduce. *(This may be exacerbated by increased evaporation from the waterbody)*	More extensive inundation of foreshores, potentially changing composition of fringing vegetation. This may offset loss of vegetation due to increase in low tide levels. If vegetation communities cannot migrate upslope (due to obstructions or topography), then vegetation communities may be lost altogether. Changed connectivity with the ocean (because of reduced breakout frequency) may reduce the tidal flushing capacity of the estuary and the oceanic recruitment and dispersal behaviour for fish, prawns etc.

Planning for foreshore areas of the BRE will need to cater for the modified estuary water levels, in particular, development in low lying areas around the estuary should be avoided. The increase in mean water level, reduced catchment runoff and possibly altered entrance breakout frequency is likely to have an impact on the natural sensitivity of the Bega River to external (catchment) inputs (Haines *et al*., 2006). Further, under closed entrance conditions, increase air temperatures are likely to increase typical water temperatures in the estuary. This may degrade water quality, by reducing dissolved oxygen, and changing the solution of various salts and therefore dissolved nutrients, metals and pollutants in the water column. In turn, aquatic species will respond to changes in water chemistry, most notably, algal productivity may increase, causing flow on effects to higher trophic levels of ecology. The distribution of aquatic flora and fauna would also be expected to change in response to higher water temperatures.

10.5 Management of Climate Change Impacts

The issue of future climate change is a legitimate threat to future management of the NSW coastal zone, including estuaries such as Bega River. Lord and Gibbs (2004) report that if all greenhouse emissions ceased tomorrow, there would still be sufficient inertia in the system to result in significant impacts on existing coastal lifestyles for many decades to come. As a consequence, the time for mitigation has passed, and NSW coastal zone managers need to prepare for adaptation to changes in a future coastal climate (Lord and Gibbs, 2004; Pittock, 2003).

Management for future climate change will involve facilitating adaptation of natural ecosystems to the new climate, without imposing additional constraints. For example, wetland and riparian vegetation will slowly migrate up-slope in response to increasing mean sea level and storm surges – management of this adaptation will involve ensuring that the vegetation migration will not be inhibited by other constraints, such as retaining walls, road embankments, private development etc.

Ensuring adequate consideration is given to future climate change would be best achieved through incorporating appropriate provisions within the relevant local planning instruments. From a planning perspective, however, the imprecise nature of predictions is problematic, as the range of possible future conditions contains a range of probabilities of occurrence (Walsh *et al*., 2004; Cowell *et al*., 2006).

On-going review and updates to Council's LEP will provide an opportunity to identify areas that are likely to become important to ecosystems in the future, and protect these areas from future impacts through appropriate land use controls (refer Strategy P-11). As a precursor to any changes within planning instruments, and to overcome some of the imprecision associated with climate change, it may be necessary to undertake more detailed vulnerability assessments, to more accurately determine the areas that are most likely to be subject to change as a consequence of future climate change (refer Strategies M-9 and M-10). A risk-based assessment could then be undertaken to balance the risks with the expected likelihoods of occurrence based on the latest climate modelling data. The vulnerability assessments would build on the works that have been undertaken to date by CSIRO and others in quantifying the change to key climate variables expected within the estuary.

Measures in the BRE management plan to improve streamflow in the Bega River and mitigate the impacts of climate change are of great importance to sustaining the Estuary's ecology and therefore the recreational, social and economic value of the Estuary. The most effective way to improve streamflow is likely to be via a change in current water extraction practices, particularly the issuing of water extraction licences and amount of water extraction permitted with a licence. However, this will require significant negotiations between the SRCMA, OEH, NOW, DPI and landholders in the area.

In addition to natural assets, climate change may have an impact on built assets, particularly those located close to the foreshore such as the Golf Course and the Coastal Road. The vulnerability assessment (Strategies M-9 and M-10) and the Flood Study and Floodplain Risk Management Study (Strategy M-1) would need to cover all built assets to identify those assets likely to be affected and over what timescales, and appropriate actions to reduce future risks.

For the Bega River estuary, consideration of future climate change is further complicated by artificially opening of the entrance at 1.36 m AHD (refer Sections 2.3.1 & 7.2). Artificial management of the entrance should be considered as an interim strategy to address issues associated with existing development (refer Strategy P-9). Natural inundation and flooding issues need to be investigated through a flood study and a range of responses (which may include artificial breaches) identified in a Floodplain Risk Management Study and Plan (refer Strategy M-1).

When planning for future development, consideration should be given to conditions at the end of (and beyond) a realistic planning horizon (say 100 years for residential development). It is important that protection of property and infrastructure built today will not be reliant upon artificial entrance management to avoid inundation at some point in the future. Imposing such conditions on future generations of landuse managers is considered inconsistent with the principles of Ecologically Sustainable Development (which this Estuary Management Plan is required to satisfy, in accordance with the central theme of the NSW Coastal Policy).

At present, the maximum natural breakout level of Bega River would be about 2.5 m AHD (based on entrance berm heights). Sea level rise predictions for the end of this century suggest an increase in sea level (and thus an increase in natural entrance breakout level) of 0.9m, based on NSW Government Sea Level Rise benchmarks. This Estuary Management Plan recommends future development around the estuary should be above the RL 4.0 m AHD contour until such time that a formal Flood Study and Floodplain Risk Management Plan can be developed to better direct future development constraints (refer Strategy M-1). Recommended buffer widths for foreshore habitats also stipulate a minimum of 50 metres beyond the RL 2.0 m AHD contour (Refer Strategy P-1).

Future planning of foreshore buffers and development should consider the model described in Figure 10-4. The vertical buffer (refer Figure 10-4) applied to all future development will allow for the natural expansion of the estuary in response to sea level rise and will allow existing vegetation communities to migrate upslope without being inhibited by new infrastructure. Meanwhile, the horizontal buffer (refer Figure 10-4), applied to the landward extent of the vertical buffer, will maintain sustainable functioning of fringing riparian ecosystems and protect the waterway environment from the many potential impacts associated with adjacent urban development (including impacts associated with increased demand on amenity) (Haines, 2005).

Management of existing development within the vertical and horizontal buffer provisions will need to be on a site by site basis. Periodic review of this Estuary Management Plan will provide a mechanism for slowly modifying the management of existing assets and infrastructure in the future.

It is considered that the strategies of this Plan address the need for system adaptation associated with future climate change, and sea level rise in particular. A Coastal Zone Management Plan for the Bega Valley coastline would further address the potential impacts of climate change on BRE within the broader context of the far south coast.

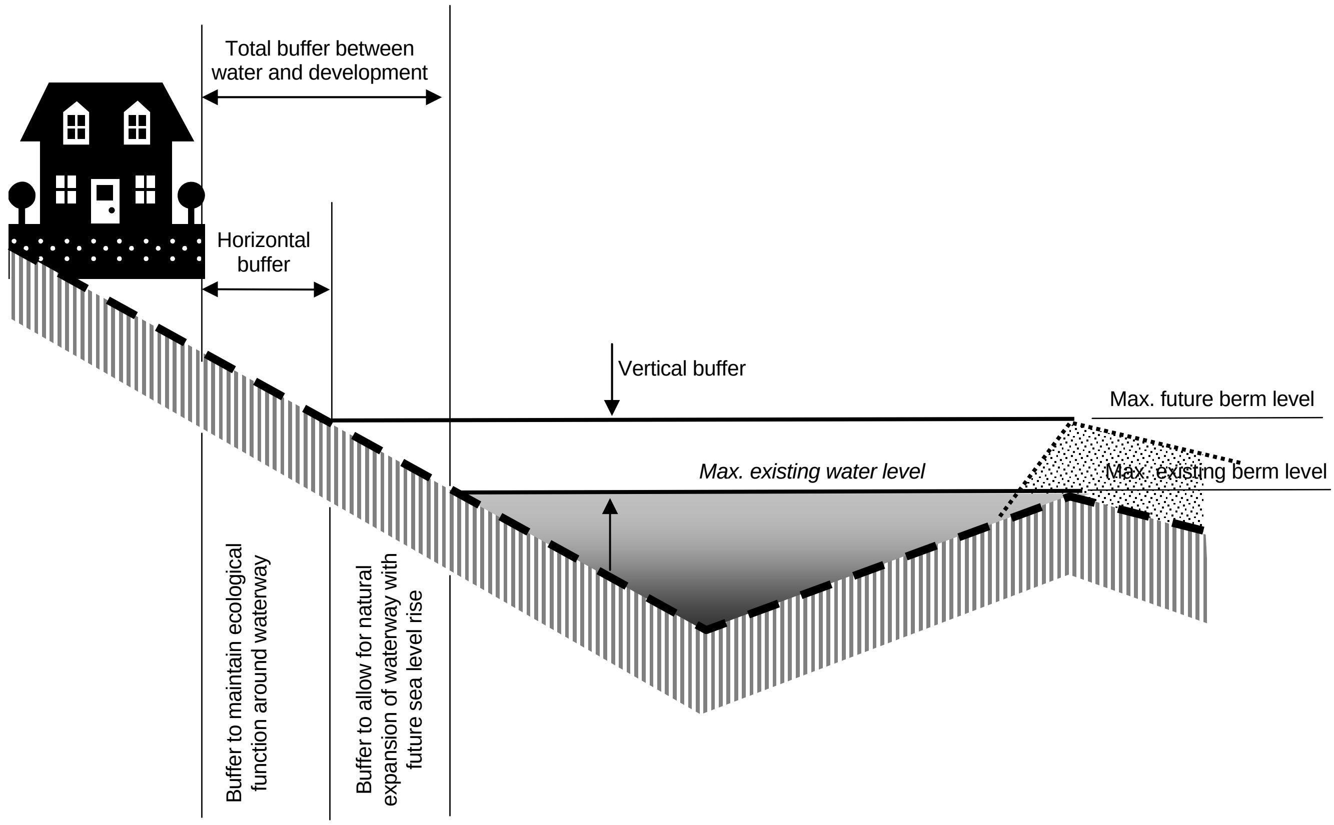

Figure 10-4 Vertical and horizontal buffers to accommodate future sea level rise (adapted from Haines, 2005)

11 MONITORING, EVALUATION AND AMENDMENTS

11.1 Monitoring of Plan Success

The success of the Estuary Management Plan should be gauged through its ability to achieve the designated targets. The overarching targets are the Management Objectives, as described in Chapter 5. However, the timeframe for achieving some of these objectives is long (given the slow rate of vegetation establishment and growth, for example). To gain a better appreciation for the relative success of the Plan, a series of evaluation measures can be assessed on a periodic basis. Different types of evaluation measures are discussed in more detail below.

11.1.1 Primary Evaluation Measures

The first set of evaluation measures should ascertain whether the strategies are being implemented within the timeframe designated in the Plan. As such, the primary performance measures are simply a *measure of implementation*.

The Estuary Management Plan recommends more than 50 different strategies over a period of 5 years. Many of these strategies will need to be carried out concurrently. Organisations responsible for implementation will need to review the Plan carefully and ensure that, where ever possible, adequate resources are allocated to the various strategies to ensure that the timeframe for implementation is achieved (as specified in Strategy C-4).

Clearly, a high degree of co-ordination will be required to manage the successful implementation of all the strategies within the designated timeframe. This co-ordination should be facilitated by Council's Coastal Committee), who would discuss and monitor the implementation of the EMP along with other EMP's in the Shire.

If it is determined that the strategies are not being implemented to the nominated timeframe then one or both of the following *contingencies* should be adopted:

i. Determine the cause for the delay in implementation. If delays are funding based, then seek alternative sources of funding, including a formal request to Council to increase contributions to the Plan. If delays are resource-based, seek additional assistance from stakeholder agencies and/or consider using an external consultancy to coordinate implementation of the Plan;

ii. Modify and update the Estuary Management Plan to reflect a timeframe for implementation that is more achievable. If significant changes are made, the revised Plan would need to be endorsed by all relevant stakeholders and agencies responsible for implementation and gazetted in order to replace the current Plan.

11.1.2 Secondary Evaluation Measures

The second set of evaluation measures relate to *measuring specific performance outputs* from the individual strategies, as appropriate. The specific outputs from each strategy, are provided within the Implementation Schedules (refer Section 8) under '**Performance Measure**'. These measures define what the specific outcome from each strategy should be. If these outputs are delivered as defined, then the strategy is considered to have been successful.

If the defined performance measures are not generated as a result of implementation of the strategy then the following *contingencies* need to be adopted:

i. Determine the reason for not producing the specified output. If the reason involves a lack of funding or resources, then similar contingency measures to those described for the primary evaluation measures (refer Section 11.1.1) should be adopted. If the reason is of a technical nature, then expertise in the area should be consulted to overcome the technical problem. OEH, SRCMA and other government agencies should have the necessary in-house expertise to assist in most cases.

ii. Review the appropriateness of the specific output of the management strategy, and if necessary, modify the output described in the Plan to define a more achievable product.

11.1.3 Tertiary Evaluation Measures

The third set of evaluation measures are aimed at *measuring the outcomes of the Plan*, and as such relate to the specific *management objectives* of the Plan (as described in Section 5), and how implementation of the Plan has made a difference to the biophysical and social environments of the Bega River Estuary (e.g. reduction in pollutant loads, improvement in swimming conditions, increase in biodiversity etc). The main mechanism for gauging whether these objectives have been achieved, or not, is monitoring. Therefore, monitoring of various elements of the physical, biological and social environment is an essential component of assessing the overall success of the Estuary Management Plan (refer Strategies M-4, M-5, M-6, M-7).

If, after a reasonable period of time (say 3 - 5 years), the specific objectives of the Plan are not being achieved by the strategies being implemented, then the following contingencies should be adopted:

i. Carry out a formal review of the implemented management strategies, identifying possible avenues for increasing the effectiveness of the strategy in meeting the Plan objectives;

ii. Commence implementation of additional management strategies that may assist in meeting Plan objectives (possibly ‘fast-track’ some longer term strategies as necessary);

iii. Reconsider the objectives of the Plan to determine if they set impossible targets for future estuary conditions, and adjust the Plan, as necessary. Any such changes to the Plan would need to be endorsed by the stakeholders and relevant government agencies, as well as the public and be gazetted in order to replace the current Plan.

11.2 Reviews and Amendments

Periodic reviews and amendments of this Estuary Management Plan are necessary to ensure that it remains current and relevant to the environmental management and planning framework in which it operates.

It is proposed that the Bega River Estuary Management Plan is reviewed on a regular basis, and completely updated within a period of about 5 years (ie before end 2012). A regular review of the Plan (which may occur annually, for example) is necessary to allow modifications / alterations to the management of the estuary, on an as-needed basis, within the context of an adaptive management framework. The annual review could be coordinated to coincide with the annual progress report (see Strategy C-3) and does not require gazettal.

The periodic Estuary Management Plan reviews should cover the topics described in Table 11-1. This table also outlines who is responsible for conducting the periodic reviews.

Table 11-1 Framework for Future Estuary Management Plan Review

Review Period	Review tasks	Responsibility
Annual	• Assess primary, secondary and tertiary evaluation measures, and determine appropriate contingencies if performance measures do not meet targets • Review funding arrangements and allocations for current and future management strategies • Review resourcing and staffing allocations for current and future management strategies • Provide report on progress of Estuary Management Plan implementation, results of annual review, and any modifications required to the Plan coming out of the review	Council, Coastal Committee and potentially a consultant To be coordinated through Council and reported to Council, relevant stakeholders and government agencies
5 Yearly	• Assess the overall effectiveness of each management strategy implemented to date • For strategies requiring on-going commitment, assess the value in maintaining implementation of those strategies • Reconsider the management options that were not short-listed and included in the original Plan • Provide implementation details of additional strategies that are to be included in the subsequent 5 year Plan • Update the Estuary Management Plan document to reflect proposed strategies for implementation over the next 5 year period, and seek endorsement by stakeholders, government agencies and the community.	Council, Coastal Committee and potentially a consultant To be coordinated through Council and reported to Council, relevant stakeholders government agencies and the general community

11.3 Amendment Record

This Plan was last reviewed and amended on ………………………………………………..

The next scheduled review is due ………………………………………………………………

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APPENDIX A: RELEVANT BEGA VALLEY SHIRE AND NSW ENVIRONMENTAL PLANNING FRAMEWORK

ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979 (EP&A ACT) AND ASSOCIATED PLANS

One of the key pieces of NSW legislation is the Environmental Planning and Assessment Act 1979. This Act provides a system of environmental planning and assessment for NSW, and involves developing plans to regulate competing land uses, through 'environmental planning instruments'.

The Act establishes three types of environment planning instruments (EPI):

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

The objectives of the EP&A Act are as follows:

- Appropriate management, development and conservation of natural and artificial resources so as to promote the social and economic welfare of the community and a better environment.
- Facilitation of the orderly and economic use and development of land.
- Ensure appropriate provision and management of communication and utility services.
- Provide land for public purposes.
- Provide for and coordinate community services and facilities.
- Encourage the protection of the environment and facilitate ecologically sustainable development.
- Enable the provision and maintenance of affordable housing.
- Share the responsibility for environmental planning and management between the State and local government.
- Facilitate increased opportunity for public involvement and participation.

Local Environmental Plans

Local Environment Plans (LEPs) are developed by local councils. LEPs divide the area they cover into zones and each zone has a list of objective and the types of development that are permissible with consent, permissible without consent and prohibited from the zone. Only one LEP is applicable to the Bega River estuary and catchment, this being the Bega Valley LEP 2002.

The Bega Valley LEP 2002 establishes a policy framework for land use decisions throughout the Bega Valley Shire LGA. It provides the community with rules on how land can and cannot be used. The implications of the LEP include physical structures, social, economic, and environmental factors.

The Bega River Estuary Management Plan needs to be consistent with, and fit into, the existing Bega Valley Shire Council planning framework, which is built around the LEP.

The objectives of the Bega Valley LEP 2002 are stated to be:

- To ensure a balanced approach to development which is sensitive to both the economic and social needs of the community;
- To protect and improve the economic, natural, social and cultural resources within the Council's area;
- To encourage the efficient and effective delivery of services;
- To recognise, protect and improve the inherent natural and built character of the Council's area; and
- To ensure that development has regard to the principles of economically sustainable development.

The BRE catchment mainly consists of Agricultural Land (Rural 1A – general, Rural 1C – small holdings), National Parks (8) and State Forest (Rural 1F – Forestry), with the remainder in Urban Land (Residential 2A – Low Density, Residential 2C – Tourist, and Residential 2V - Village), and Special Uses (5A) Community Purposes zonings, with some areas protected under Environmental Protection (7B – Foreshore, and 7D - General) Habitat and Catchment and Existing Open Space (6A). A map of the landuse zonings for the BRE catchment is presented in Figure B-17.

Regional Environmental Plans

Regional Environmental Plans (REP) are plans drafted by the Department of Planning and Infrastructure (DoPI) and apply to a specific region. REPs address matters of regional significance. The South Coast Regional Strategy 2007 is the only REP applicable to the BRE and catchment.

The South Coast Regional Strategy (SCRS) guides the preparation of all new LEPs, such as is currently underway by BVSC, to achieve sustainable future development. The plan applies to the Local Government Areas of Shoalhaven, Eurobodalla and Bega Valley.

The primary purpose of the SCRS is "to ensure that the significant natural and scenic assets that define the region's character and underpin its economy are not compromised by growth" (DP 2007). This will be achieved by ensuring land is available in appropriate locations to enable sustainable growth. The SCRS aims to sustainably coordinate the housing, employment, and infrastructure required for future population growth in the South Coast Region over the next 25 years.

The SCRS aims for the consolidation of existing centres, with infill development of current urban zones, priority given to subdivisions located next to existing centres, and for no new villages or towns to be developed unless compelling reasons are presented and they can satisfy the Sustainability Criteria in Appendix 1 of the Strategy. Key tourism sites, and tourism zones or 'precincts' are to be identified in Local Environmental Plans (LEPs). Any additional development proposed will need to demonstrate that it can satisfy the Sustainability Criteria.

The Strategy requires new development be prohibited in LEPs on land assessed as being of high conservation value and that appropriate planning controls be incorporated into LEPs to protect biodiversity values on land of lower conservation value. Existing rural residential zones have the capacity to meet the demands for rural lifestyle housing. Limited areas for additional rural residential must be located on cleared land unsuitable for urban or agricultural uses and will only be agreed to be the Department as part of an endorsed growth management strategy or structure plan.

Other actions required by local Councils as outlined in the Regional Strategy to protect natural resources include:

- Requiring local environmental plans to protect regionally significant corridors shown as ‘Indicative Habitat Corridors’ on Map 2. These corridors will be verified in the Regional Conservation Plan and development proposals in these areas will be required to maximise the retention of native vegetation and rehabilitate disturbed areas.
- Verifying the location and conservation significance of areas shown as ‘Biodiversity Assets Outside Conservation Areas’ on map 2 in consultation with the Department of Planning and Department of Environment and Conservation. New urban development is to be prohibited by local environmental plans on land assessed as being of high conservation value; and appropriate planning controls are to be incorporated into local environmental plans to protect biodiversity values on land of lower conservation value.
- Requiring local environmental plans to zone all coastal wetlands identified in SEPP 14 to achieve environmental protection, through zones such as ‘E2 Environmental Conservation’ or ‘W1 Natural Waterways’. Future development in these catchments will need to demonstrate no net impact on the hydrology, water quality or ecology of these wetlands.
- When planning new urban areas, adopting the ‘Strategic Assessments of Riparian Corridors’ methodology developed by the Department of Natural Resources in conjunction with Department of Planning by: incorporating the assessments into structure plans; appropriate zoning; and appropriate management through a development control plan.
- Requiring local environmental plans to include provisions on land fronting watercourses to limit the creation of additional water rights.
- Considering the Regional Conservation Plan prepared by the Department of Environment and Conservation to guide implementation of conservation outcomes.

The logistical problems of water, waste and energy service provision are to be met by: concentrating populations in existing urban areas to efficiently use existing infrastructure; promoting the use of harvested stormwater, treated effluent and other such water sources for potable / non-potable water supply where appropriate; supporting the development and use of renewable energy sources; and promoting waste avoidance and resource recovery, particularly on construction and demolition sites.

The Regional Strategy indicates that cultural heritage adds to the community identity, well being, sense of history and the local and regional character of an area. The Department of Planning and Councils will review the scope and quality of the existing statutory lists of heritage items and ensure that all places of significance are included in the heritage schedules of LEPs. LEPs will also include appropriate provisions to protect coastal towns and villages along with associated natural and cultural landscapes and curtilages. This aim will be to protect conservation values, Aboriginal cultural values and visual character, and reinforce their economic value for tourism.

State Environmental Planning Policies

SEPP 71 – Coastal Protection

State Environmental Planning Policy (SEPP) No. 71 was made under the Environmental Planning and Assessment Act 1979, and gazetted in November 2002. The policy aims to ensure that development in the NSW coastal zone is appropriate and suitably located. The policy provides protection of and improvement to public access for coastal foreshores, compatible with the natural attributes of the foreshore, and protects and preserves Aboriginal cultural heritage, visual amenities of the coast, the beach environment and amenity, native coastal vegetation, marine environment of New South Wales, and rocky platforms. In addition, the policy aims to carry out management of coastal zones in accordance with the principles of the Ecologically Sustainable Development (ESD).

Under this policy, the Minister for Planning becomes the consent authority for state significant development, and significant coastal development. State significant coastal development includes mining, extractive industry, industry, landfill, recreational establishments, marinas, tourist facilities (except bed and breakfast establishments, and farm stays) and buildings greater than 13 metres in height above the natural ground level. It also includes development, comprising subdivision of land:

- Within a residential zone into more than 25 lots;
- Within a rural residential zone into more than five lots; or
- Within any zone into any number of lots if the future development of any lot created by the subdivision will require effluent to be disposed of by means of a non-reticulated system.

The policy applies also to 'significant coastal development', which are development in 'sensitive coastal locations'. These locations include:

- land within 100 metres above mean high water mark of the sea, a bay or an estuary;
- land listed in Schedule 3 to the policy (no land is currently listed);
- coastal lakes (which includes Hearnes Lake), Ramsar wetlands and World Heritage areas;
- marine parks and aquatic reserves under the *Fisheries Management Act*;
- land within 100 metres of any of the above;
- land reserved under the *National Parks and Wildlife Act*;
- SEPP 14 coastal wetlands; and
- residential land within 100 metres of SEPP 26 littoral rainforests.

Master plans are required to be approves by the Minister before some consent can be granted. Generally a master plan is a document consisting of written information, maps and diagrams that outline proposals for development of land.

SEPP 14 – Coastal Wetlands

SEPP-14 has been designed to protect and preserve coastal wetlands for the environmental and economic interests of the State. The policy provides protection to specific wetland areas that have been mapped and gazetted by Department of Planning. Development that involves the following activities is not allowed to be carried out unless consent (designated development) is provided by local council or the Director General of Planning: clearing of land, construction of levees, draining of land, and filling of land. If this development is to be carried out, an Environmental Impact Statement first needs to be prepared.

The Director General of Planning must consider a number of matters prior to agreeing to the proposed development including:

- The environmental effect of the proposed development;
- Whether adequate safeguard and rehabilitation methods are proposed;
- Whether the development is consistent with the aims of the policy; and
- Whether any feasible alternatives have been considered and if so, the reason for choosing the proposed development.

A number of SEPP-14 wetlands are located within the BRE catchment, as shown in Figure B-12.

Development Control Plans

DCPs are normally prepared to guide specific types of development, or developments in specific areas within a Local Government Area (LGA). Generally, DCPs have been prepared to conserve particular values and attributes of the LGA and its natural environment.

Kalaru Village Development Control Plan No.18 (November 2002)

The aim of this plan is to develop a town structure for the village of Kalaru, with a specific intention to:

(a) define a commercial centre for the Kalaru area;

(b) set aside land for passive and active recreational uses and related development;

(c) maintain a suitable area as predominantly residential within the village zone; and

(d) maintain opportunities for light industrial development in appropriate sections of the village zone;

(e) allow for future subdivision should a sewerage service become available.

This DCP has little relevance to the BREMP.

Mogareeka Village Development Control Plan No.19 (November 2002)

The aims of this plan are to restrict urban development potential at Mogareeka by a plan:

(a) to address the limited capacity of the planned Tathra sewage system

(b) to preserve the current neighbourhood character

(c) to improve potential runoff water quality into the Bega River estuary

(d) to provide certainty of the development potential of existing lots

The DCP defines lots with potential for subdivision or dual occupancy. The DCP also makes provision for further development with the eventual sewering of the village.

Tathra Headland Development Control Plan No.20 (November 2002)

This plan aims to control development on the visually prominent part of the Tathra Headland by imposing a height limit of 7 meters and a maximum site coverage of 35%.

Tathra River Estate Stage 1 Development Control Plan No.21 (November 2002)

The aims and objectives of this plan are:

(a) To address the limited capacity of the planned Tathra sewage system

(b) To provide certainty of the development potential of existing lots

(c) To improve potential runoff water quality into the Bega River estuary.

This DCP prohibits subdivision of the existing allotments in TRE Stage 1 to create any additional lots for dwellings and development of dual occupancies.

OTHER IMPORTANT NSW PARLIAMENTARY ACTS

Threatened Species Conservation Act, 1995

The protection of species and ecological communities in New South Wales are administered by the Threatened Species Conservation Act 1995, the National Parks and Wildlife Act 1974 and the Fisheries Management Act 1994.

The Threatened Species Act is responsible for the protection of certain species, populations and ecological communities when they are a particular level of endangerment. These species are known as 'threatened species, populations and ecological communities' and include: endangered, critically endangered, and vulnerable species, endangered population, endangered ecological communities and vulnerable ecological communities.

The Threatened Species Conservation Act has established a committee that is responsible for determining species, population, ecological community or threatened process that should be included in Schedules 1, 2 or 3. Consequently, species, populations or ecological communities can be listed by the committee or upon request by the Minister.

Lists of flora and fauna species in the BRE and catchment which are listed on the TSC Act are given in Table D-3 and Table D-4.

National Parks and Wildlife Act 1974

The National Parks and Wildlife Act 1974 was responsible for the establishment of the NSW National Parks and Wildlife Services (NPWS) which is now part of the Department of Environment and Conservation.

The NPWS is responsible for the administration of national parks and other lands under the National Parks and Wildlife Act and the Wilderness Act. The NPWS are also responsible for the threatened species under the Threatened Species Conservation Act 1995.

The objectives of the National Parks and Wildlife Act 1974 are the:

- Conservation of habitats and ecosystems, biological diversity in the community, landforms of significance, and landscapes and natural features of significance; and
- Conservation of the objects, places or features of cultural values within the landscape, which would include Aboriginal and European heritage and places of historic, architectural or scientific significances.

The objectives of this Act would be achieved by applying the principles of ecologically sustainable development (ESD).

Under the National Parks and Wildlife Act, a management plan needs to be prepared for each national park. The plan needs to address the following issues:

- The conservation of wildlife and its habitat;
- The preservation of the national park and its special features, including historic structures, objects, relics or Aboriginal places;
- The encouragement and regulation of the appropriated use, understanding and enjoyment of the national parks; and
- The preservation of the national park as a water catchment area, and protection against uncontrolled fires and soil erosion.

Within a national park, the Minister is allowed to grant leases to provide accommodation and facilities and licences to carry out trade or business activities, however, leases and licences cannot be granted over land that is within a declared wilderness area.

It is an offence to prospect or mine for mineral in a national park, unless the mining activity is authorised by an Act of Parliament.

Fisheries Management Act 1994

The Fisheries Management Act 1994 is one of the most important state laws in relation to protected species. The Fisheries Management Act is responsible for the protection of freshwater and saltwater fish and invertebrates and saltwater plants. The Department of Primary Industries (DPI) is responsible for the protection of marine species.

The main aim of the Act is to conserve, develop and share the fishery resource of the State for the benefit of present and future generations. Conservation of fish species and habitats, threatened species, population and ecological communities, are dealt with under the Fisheries Management Act 1994. In addition, the Act is to promote ecologically sustainable development, including conservation of biological diversity.

Under the Fisheries Management Act it is considered an offence to harm any listed marine threatened species and damage a marine area declared to be critical habitat.

The Fisheries Management Act applies to all water in the State except for purposes relating to a fishery that is to be managed in accordance with the law of the Commonwealth pursuant to an arrangement under Division 3 of Part 5.

The main provisions of this legislation that relates to Estuary Management works are:

i) Habitat Protection Plans - which allow for the gazettal of management plans for the protection of specific aquatic habitats;

iii) Dredging and Reclamation Plans - which allows for the control and regulation of dredging and reclamation works, which may be harmful to fish and fish habitat. It establishes requirements to obtain a permit from or to consult with NSW Fisheries (now known as the Department of Primary Industries).

iv) Protection of mangroves and certain other marine vegetation, which requires permits to be obtained for the regulation of damage to or removal of certain marine vegetation including seagrass.

Of particular relevance to the Bega River Estuary Management Plan are provisions within the Act relating to the preparation of Habitat Protection Plans. Fish Habitat Protection Plans describe potential threats to fish habitat and recommend actions to mitigate the effects of potentially damaging activities. There are three habitat protection plans gazetted to date however only two of these plans are relevant to this study. These are outlined briefly below.

<u>Habitat Protection Plan No 1 General</u>

This is an advisory document summarising various protective measures in relation to dredging and reclamation activities, fish passage requirements, and the protection of mangroves, other marine vegetation and snags.

<u>Habitat Protection Plan No. 2 Seagrasses</u>

The Plan deals specifically with the protection of seagrasses across NSW, and discusses activities which impact on seagrasses, including the construction of jetties, wharves, and bridges, dredging and reclamation, and the collection of seagrasses.

Protection of the Environment Operation Act 1997

The Protection of the Environment Operations Act regulates water pollution, air pollution and noise pollution in New South Wales. The Act enables the Environment Protection Authority, an agency within the DEC, to issue pollution license and notices, to take legal action to enforce the law and to create a range of pollution offences and penalties. The Act also enables members of the public to take legal action to enforce laws.

Under the PEO Act it is considered and offence to pollute water without an environmental protection licence. Water pollution is the placement of any matter in a position where pollution enters or is likely to enter the water. There are a number of activities that require licence, which are detailed in Schedule 1 of the Act, including dredging works and extractive industry, although these activities must remove more than 30,000 m^3 per year to trigger the Act.

Pollution of a waterway is allowed if an environmental protection license is held, however, there are conditions of a licence.

Catchment Management Act 2003

The purpose of the Catchment Management Act 2003 is to establish catchment management authorities that would carry out certain natural resource management functions in their regions. There are thirteen catchment management authorities in New South Wales. The BRE lies in the Southern Rivers catchment area. The Act repeals the Catchment Management Act 1989 and amends various other Acts.

The objectives of the Act are:

- To provide natural resource planning on a catchment level;
- To ensure that the decisions about natural resources take into account appropriate catchment issues;
- To ensure that catchment level decisions take into account state standards and involve the Natural Resource Commission in catchment planning;
- To make use of the communities' knowledge and expertise and to involved them in decision making;
- To ensure proper management of natural resources from the social, economic and environmental issues; and
- To provide financial assistance and incentives to landholders in connection with natural resource management.

Under the Act each catchment authority is required to prepare a draft Catchment Action Plan (CAP) as soon as possible after the commencement of this Act and submit it for approval by the Minister. The Southern Rivers Catchment Action Plan was adopted in 2006.

Natural Resource Management Act 2003

The Natural Resource Management Act 2003 is responsible for the creation of the Natural Resources Commission. The objectives of the Act are:

- To establish a sound scientific basis for the informed management of natural resources in regards to the social, economic and environment interests of the State;
- To enable the adoption of State-wide standards and targets for natural resource management issues; and
- To advise in the circumstance where broad-scale clearing is regarded to be an improvement or maintenance of environmental outcomes for the purpose of the Native Vegetation Act 2003.

The Natural Resource Commission consists of a full time Commissioner and Assistant Commissioner. The role of the Commission is to provide the government with independent advice on natural resource management, in addition to recommending state-wide targets for natural resource management, approval of catchment action plans, and commenting on the effectiveness of these plans. The commission would also undertake natural resource management assessments, and would control investigations and inquires into natural resource management issues and research of the issues.

Coastal Protection Act 1979

The Coastal Protection Act 1979 was amended in 1998 and extended the coastal zone to include estuaries, coastal lakes and lagoons, islands and rivers in recognition of the strong connection between estuaries and the open coast. The coastal zone is delineated on maps approved by the Minister for Planning.

The Coastal Protection Act 1979 provides general supervision of the use, occupation and development of the coastal zone. This includes a requirement for public authorities to gain agreement from the Minister for Planning before any development is carried out or consent is given for the use, occupation or development of the coastal zone. It also provides for general supervision of development within the coastal zone that is not otherwise subject to the provisions of an environmental planning instrument (other than a State Environmental Planning Policy).

The Act requires that the Minister promotes ecologically sustainable development. The Minister may reject development or use of occupation of the coastal zone, that is inconsistent with the principles of ecologically sustainable development, or that may adversely affect the behaviour or be adversely affected by the behaviour of the sea or an arm of the sea or any bay, inlet, lagoon, lake, body of water, river, stream or watercourse.

Recent Amendments to the Coastal Protection Act and other Acts

The Coastal Protection and Other Legislation Amendment Act 2010 provided for reforms to coastal erosion management in NSW through amendments to *the Coastal Protection Act 1979*, the *Local Government Act 1993* and the *Environmental Planning and Assessment Act 1979*. The amendments relate to both emergency and permanent coastal protection works. The bill was passed in October 2010, and amendments came into effect in January 2011.

Amendments were made under Part 4C of the Coastal Protection Act outlining emergency coastal protection works that landholders or public authorities are permitted to carry out. The emergency coastal protection works must be consistent with a Code of Practise associated with this Part, which includes the Schedule of Authorised Locations for these works.

Amendments were made to the *Local Government Act 1993* (Section 553B) to allow local councils to levy a coastal protection service charge to landholders where they have contributed to the construction of new or expansion of existing coastal protection works.

Legislative amendments were made that permit landholders to submit applications to erect long term coastal protection works, with approval contingent on the landholders demonstrating that potential offsite impacts can be managed (for example, with beach nourishment), refer Section 55M of *the Coastal Protection Act 1979*. The works can be fully funded by the landholders who submit the application. Ongoing maintenance can be facilitated through an annual coastal protection service charge (as above).

Effectively, a mechanism is now available to Councils whereby residents may promote and undertake coastal protection works (with approval) at their own expense to protect private property and land. Council in approving the works can establish a levy on the benefitting landowners for the costs of the works, their future maintenance and for the amelioration of any adverse impacts from the works that may occur into the future. There is no need for any cost for the works to be borne by local government and no contribution or responsibility emanating from the State as a result of the works or the coastal hazards.

Amendments were also made under Part 2A of the *Coastal Protection Act 1979* to establish a joint state-local body called the NSW Coastal Panel. The Coastal Panel is to act as a consent authority for long term protection works development applications where a council does not have a certified CZMP and / or requires further technical assistance in assessing such development applications. The Coastal Panel shall also assist the Minister when requested, such as for reviewing CZMPs.

Local Government Act 1993

The Local Government Act 1993 creates local governments and grants them the power to perform their functions, which involve management, development, protection, restoration, enhancement and conservation of the environment for the local government area. The functions of the local government are to be performed in a manner that are consistent with and promote the principles of ecologically sustainable development.

The Local Government (Ecologically Sustainable Development) Act 1997 amends this Act, so that the guiding operational principles are ecologically sustainable development and sustainable use of resources.

Crown Lands Act 1989

The Crown Lands Act 1989 provides for the administration and management of Crown land, which includes most beaches, coastal reserves, nearshore waters and estuaries, including the BRE.

The Crown Lands Act 1989 requires a land assessment to be undertaken prior to the reservation, dedication, exchange, vesting or sale of Crown land, or the granting of easements, leases or licences in respect of such land. The process for land assessment is specified by the Act and the *Crown Lands Regulation 2000*. It requires the physical characteristics of the land to be identified, the land's capabilities to be assessed and suitable uses identified. A draft land assessment is publicly exhibited for 28 days for comment. The exhibited draft may indicate a preferred use or uses.

COMMONWEALTH LEGISLATION

Environment Protection and Biodiversity Conservation Act

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the main Commonwealth Law responsible for the protection of flora and fauna. The EPBC Act commenced on 16 July 2000 and replaced the Environmental Protection (Impact of Proposals) Act 1974 (Cth), the Act which formerly set out requirements for environmental assessment in Federal law.

This Act applies to:

- Flora and fauna within areas controlled or owned by the Commonwealth;
- Flora or fauna that may be harmed by the actions of the Commonwealth agency; and
- Actions that may have a significant effect on species on the national threatened species list.

The EPBC Act has increased the number of activities that will be subject to environmental assessment and approval by the Commonwealth government, and has given a more important role and broader powers to the Federal Minister for the Environment (the 'Minister'). Under the EPBC Act, it is necessary to obtain an approval from the Minister to carry out a 'controlled action', which is an activity that is likely to have a significant effect on the environment, or likely to have a significant effect on a "matter of national environmental significance".

The act provides protection to species and ecological communities by:

- Creating a process for the listing of protected species and ecological communities;
- Requiring the assessment and approval of proposals that are likely to have a significant impact upon threatened species, and ecological community or a migratory species; and
- Requiring permits for actions in a Commonwealth area that involve the killing, injury or taking of a listed threatened species or ecological community.

The EPBC Act provides protection for threatened species, migratory species that are listed under the JAMBA Convention, the CAMBA Convention or Bonn Convention, and listed marine species as detailed by the Department of Environment and Heritage.

The EPBC Act provides protection to Ramsar wetland from actions that would result in significant impact on the wetlands. However, an action that may have significant impact on the ecological character of a declared Ramsar wetland might take place outside the boundaries of the wetland. A declared Ramsar wetland is an area that has been designated under Article 2 of the Ramsar Convention or declared by the Minister for the Environment to be a declared Ramsar wetland in accordance with section 16 the Act.

The EPBC Act was amended in 2003 to include protection of National Heritage. This amendment involved, including ‘national heritage’ as new matter of national environment significance, and the establishment of a national heritage list.

RELEVANT NATURAL RESOURCE PLANS

Southern Rivers Catchment Management Authority Catchment Action Plan

The Southern Rivers Catchment Management Authority (SRCMA) was established by the NSW Government in 2004, to manage catchments from Wollongong to the Victorian border. The SRCMA was created to promote sustainable management of land, water and vegetation assets within the South Coast catchments. The Final Southern Rivers Catchment Action Plan (SRCAP) was released in 2007, and outlines the actions to be taken by the SRCMA to achieve sustainable management in the region.

The Southern Rivers Catchment Action Plan (SRCAP) aims to make improvements to a wide range of natural resource conditions including coast and marine waters, rivers and wetlands, soils, coastal lakes and estuaries, threatened species, and native vegetation.

The SRCMA has used the NSW Natural Resource Commission’s *State-wide Standards and Targets* to develop five program areas under the SRCAP. Catchment targets are desirable conditions of natural resources at a specified point in time that provides broad indicators of catchment health. Management targets are the level of action needed to achieve a catchment target within a specified time.

The SRCAP lists examples of the kinds of actions required to achieve these targets, although is not specific for particular areas as it has a broad, high-level perspective.

The management targets defined in the CAP are to be achieved by 2016. Those management targets relevant to the Bega EMP as cited from SRCMA (2007) include:

Community and Partnership Targets

- *Community and Partnership Catchment Target*: "By 2016 communities of the Southern Rivers region are willing and adequately supported to actively engage in natural resource management"

Biodiversity Targets

- *Biodiversity Catchment Target 1*: "By 2016 there is an improvement in native vegetation condition and an increase in connectivity and extent".
- *Biodiversity Catchment Target 2*: "By 2016 the regional status of priority threatened and regionally significant species, ecological communities and populations within the Southern Rivers catchment is maintained or improved".
- *Biodiversity Management Target B1*: by 2016 there will be an increase in the number of land managers who adopt management practices that conserve biodiversity and promote sustainable production.
- *Biodiversity Management Target B2*: "By 2016, through voluntary participation by land managers, the area of land actively managed to conserve priority vegetation types will increase from 11,000 hectares to at least 41,000 hectares".
- *Biodiversity Management Target B3*: "By 2016 through voluntary participation by land managers, an additional 10,000 hectares of native vegetation will be actively managed to build a resilient landscape with good connectivity that conserves biodiversity".
- *Biodiversity Management Target B4*: "By 2016 the priority recovery actions identified in the Southern Rivers threatened species strategy will have been implemented".
- *Biodiversity Management Target B5 and B6:* By 2016 vertebrate pest species and priority weed species will be controlled in key locations.

Coastal and Marine Targets

- *Coastal and Marine Catchment Target*: "By 2016 the condition of coasts, estuaries and the marine environment is maintained or improved through active management, best management practice and strategic research".

- *Coastal and Marine Management Target CM2: Protecting and Rehabilitating Estuaries*: "By 2016, the condition of estuaries will be maintained or improved through development and implementation of natural resource management plans (including estuary management plans)".

- *Coastal and Marine Management Target CM3 – Sustainable Management of Aquatic / Marine Resources*: "By 2016, best management practices will be developed and adopted by aquatic / marine industries".

- *Coastal and Marine Management Target CM4 – Protecting Aquatic / Marine Biodiversity*: "By 2016, active management will protect or improve key aquatic habitat areas (including for listed threatened / endangered species and ecological communities) in partnership with relevant authorities and user groups".

- *Coastal and Marine Management Target C5 – Conducting Strategic Coastal and Marine Research:* "By 2007, a research strategy will be developed to improve the scientific knowledge and understanding of coastal, estuarine and marine environments and processes; to be progressively implemented by 2016".

Water Targets

- *Water Catchment Target:* "By 2016 river and water body health is maintained or improved in priority stressed river sub-catchments and priority high conservation value rivers".

- *Water Management Target W1 – Water Sharing*: "By 2008, 80% of surface water sources and priority groundwater sources of the Southern Rivers region will be managed according to a water sharing/management plan".

- *Water Management Target W2 – Water Quality*: "By 2016 the quality of priority water bodies will be maintained or progressively improved".

- *Water Management Target W3 – Management of Water Supply and Wastewater:* "By 2016 all water utilities within the Southern Rivers CMA area will be managing their water systems consistent with the NSW Governments Best Practice Management of Water Supply and Sewerage Guidelines approach".

- *Water Management Target W4 – Water Conservation and Efficiency:*

    - "W4(a) By 2016 the residential consumption (per capita) of potable water in urban areas will progressively reduce from the 2001/02 benchmark (as per the NSW Water Supply and Sewerage Performance Monitoring Report).

    - W4(b) Water savings (through adoption of improved water use efficiency and conservation measures) will be progressively improved against the 2005 benchmark, so that by 2016 a 20% improvement in water conservation and use efficiency will be achieved by at least 80% of licensed irrigators within the Southern Rivers catchments."

- *Water Management Target W5 – River and Wetland Protection and Rehabilitation*:

    - "W5(a) By 2016 an additional 2000 ha of riparian vegetation will be actively managed for improved riverine ecosystem condition.

- o W5(b) By 2016, streambed and bank stability over 150 km of priority watercourse will be rehabilitated and protected through the construction of a minimum of 50 streambed and bank control structures.

- o W5(c) By 2016 in-stream habitat will progressively be improved by appropriate in-stream works, such as re-instatement of large woody debris, sandy riverbed reconfiguration and removal of a minimum of 15 barriers to fish passage in priority reaches.

- o W5(d) By 2016 priority actions and works will be implemented to protect and enhance 40 wetlands of national and regional importance identified as priorities.

- o W5(e) By 2011, local environment plans (LEPs) will incorporate minimum vegetated buffer distances to protect waterways from impacts of development."

Soil and Land Capability Targets

- *Soil and Land Capability Catchment Target:* "By 2016 the area of land that is managed within its capability and suitability is increased and the impacts of land degradation are systematically reduced on a priority basis".

- *Soils and Land Capability Management Target SLC2 – Development Controls:* "By 2008 there will be greater integration of natural resource management with planning instruments and processes to ensure that land use changes recognises land capability and suitability".

- *Soils and Land Capability Management Target SLC3 – Erosion:*

  - o "SLC3(a) By 2016 300 kilometres of gully erosion will be stabilised including:
    - 125 kilometres of minor and moderate gully erosion
    - 175 kilometres of severe and very severe gully erosion.

  - o SLC3(b) By 2016 a minimum of 10,000 hectares will be protected from the threat of erosion including land:
    - Identified as having a severe or very severe wind erosion hazard; and
    - Susceptible to severe and very severe sheet and rill erosion."

- *Soils and Land Capability Management Target 5 – Acid Sulfate Soils:* "By 2016 manage according to best practise:
    - all exposed acid sulphate soils; and
    - all land identified as having an active acid sulphate soil risk within its capability."

Urban Stormwater Management Plan (2003 Version)

This plan lists a number of generic actions and outcomes for the periods 2003-04 to 2005-06 for the Shire. They include development of stormwater policy and practices that include:

- Water sensitive urban design
- Building site erosion controls
- Public education

- Catchment audits
- Policy review
- Prioritising of erosion or sedimentation hotspots

Appendix A of the Urban Stormwater Management Plan lists specific sites and related erosion or sediment related issues within the Shire.

Bega River is mentioned as being under threat by sediment and high nutrient loads from dairy farms. Possible solutions are to:

- limit livestock to specific areas of the river
- fence remaining riparian areas
- revegetate using local native species

Tathra is mentioned in relation to six stormwater outlets which discharge directly to Tathra Beach. Sediment from building sites and litter are the major issues.

RELEVANT POLICIES

Estuary Management Policy 1992

The NSW Estuary Management Policy is one of a suite of policies under the umbrella NSW State Rivers and Estuaries Policy. The Estuary Management Policy was developed in response to the State Government's recognition of the social and economic importance of estuaries. The specified general goal of the policy is "to achieve an integrated balance responsible and ecologically sustainable use of the State estuaries which form a key component of coastal catchments".

Specific objectives can be summarised as:

- Protection of estuarine habitats and eco-systems in the long term;
- Preparation and implementation of a balanced long term management plan for the sustainable use of each estuary and its catchment;
- Conservation of habitats;
- Conservation of aesthetic values;
- Prevention of further estuary degradation;
- Repair of damage to the estuarine environment; and
- Sustainable use of estuarine resources.

The Estuary Management Policy is implemented through the State's Estuary Management Program. This Estuary Management Plan has been prepared in accordance with the program to help meet the objectives of the Estuary Management Policy, and the Coastal Policy, is described below.

NSW Coastal Policy 1997

The aim of the New South Wales Coastal Policy 1997 is to promote the ecologically sustainable development of the New South Wales coastline. To achieve this, the policy sets out various goals, objective and actions.

This policy applies to areas the fall into the coastal zone. The coastal zone is defined by the area that extends to:

- Three nautical miles seaward of the mainland and offshore islands;
- One kilometre inland of the 'open coast' High Water Mark;
- One kilometre around all the bays, estuaries, coastal lakes, lagoons and island; and
- In relation to tidal rivers, one kilometre around the tidal waters of the river to the limit of mangroves or the tidal limit (whichever is closer to the sea).

Based on the above definitions, the Bega River Estuary and its foreshores will fall within the defined coastal zone, therefore the Coastal Policy has been considered in the preparation of the Bega River Estuary Management Plan.

The relevance of the Policy to future development is that the council is required to implement the policy when making local environment plans applying to land within the coastal zone and to take the provisions of the policy into consideration when determining development applications in the coastal zone.

As the NSW Coastal Policy 1997 applies to the Bega River, Council is required to reflect the principles of ecologically sustainable development in planning and management decisions. Also, Council is committed to the principles of ecologically sustainable development through the Local Government Act 1993 (amended 1997), which are embodied within Council's Environmental Policy 2002.

The Bega River Estuary Management Plan outlines a series of actions that are fundamentally aligned with the ESD principles. Therefore, the Plan provides a framework for implementing these principles as they apply to the estuaries, and their associated catchments.

Objectives

The Coastal Policy has nine goals, each underpinned by objectives that are to be achieved by strategic actions. Responsibilities for these actions have been assigned to appropriate agencies, councils and other bodies. OEH is wholly or partly responsible for nearly half of the strategic actions in the Coastal Policy, with many of these involving a partnership with local councils.

The nine goals of the NSW Coastal Policy 1997 are:

1. To protect, rehabilitate and improve the natural environment;
2. To recognise and accommodate natural processes and climate change;
3. To protect and enhance the aesthetic qualities;
4. To protect and conserve cultural heritage;

5. To promote Ecologically Sustainable Development;
6. To provide for ecologically sustainable human settlement;
7. To provide for appropriate public access and use;
8. To provide information to enable effective management; and
9. To provide for integrated planning and management.

With regard to the Bega River, the Policy specifically recommends that detailed management plans for estuaries be prepared and implemented in accordance with the NSW Government's Estuary Management Manual.

Ecologically Sustainable Development

The four principles of Ecologically Sustainable Development (ESD) are:

1. The precautionary principle: The lack of full scientific evidence should not be used as a justification for the postponement of the introduction of measures to prevent or mitigate environmental degradation. This principle is fundamental to adaptive management. Monitoring and prevention are central to the precautionary principle – monitoring to measure progress, and prevention to minimise costs and risks. Decisions can and should be refined as ongoing monitoring and research provides better understanding.

2. Intergenerational equity: Each generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for future generations. This principle points to institutional and community responsibilities for integrated management, to ensure quality of life is maintained and enhanced.

3. Conservation of biological diversity and ecological integrity: Measures should be taken to prevent and protect against the extinction or loss of viability of plant and animal species due to human activities.

4. Improved valuation and pricing of environmental resources: The quality and value of environmental resources should be maintained and enhanced through appropriate management and pricing, preventing degradation and damage.

The NSW Sea Level Rise Policy Statement (2009)

The NSW (2009) Sea Level Rise Policy Statement (the Policy Statement) sets the planning standards for projected sea level rise to 2100 that must be adopted in all forms of coastal assessment, from development applications to coastal hazards definitions studies and coastal zone management plans. The adopted benchmarks are 0.4 m rise in sea level by 2050 and 0.9 m by 2100.

The Policy Statement outlines the recommended risk based management approach and the commitments of the NSW government to assist planning and managing sea level rise, including:

- promoting risk-based assessment approaches to sea level rise and coastal planning;
- providing guidance to councils to support adaptation planning initiatives;
- encouraging appropriate development on land at risk from sea level rise;

- providing continued emergency management support for damaging storms and floods; and
- providing ongoing updated information to the public about sea level rise and projected impacts.

The Sea Level Rise Policy Statement (2009) supersedes the 1988 Coastline Hazards Policy. Most of the objectives from that policy were included in the NSW Coastal Policy 1997, which remains current. With respect to managing sea level rise, NSW Coastline Hazard Policy was updated by the Sea Level Rise Policy Statement.

The Policy Statement also outlines the NSW Government's continued commitment to provide funding assistance to local councils for coastal hazard studies and management planning. Similarly, they shall continue to provide guidance and assistance to local councils on reducing the risk to private and public property from coastal hazards. However, when allocating funding assistance to local councils for coastal protection works, the Government will now give priority to public safety and protecting valuable publicly-owned assets, and then to private land. The criteria now to be applied to councils to voluntarily protect private property will include the:

- magnitude of current and future hazards
- cost-effectiveness of management actions
- contribution to the project's costs from the local council and benefiting landowners, taking into consideration genuine hardship for affected coastal residents
- effectiveness of the proposed arrangements for maintaining any proposed works
- ability of the project to accommodate sea level rise.

Where assistance is provided to reduce the impacts of coastal hazards, the Government does not assume any responsibility for these hazards.

Guidelines for Preparing Coastal Zone Management Plans (2010)

Guidelines for preparing Coastal Zone Management Plans (CZMP Guidelines) were finalised by OEH (formerly DECCW) in December 2010, and adopted in early 2011. The CZMP Guidelines specify the requirements for preparing a coastal zone management plan (CZMP) in accordance with the *Coastal Protection Act 1979*, including requirements additional to those specified in the Act. The guidelines specify the use of a risk based approach to preparation of a CZMP and actions for managing coastal hazards. The CZMP Guidelines documents the ISO 31000:2009 risk process which requires the likelihood and consequence of coastal risks to be analysed and combined to determine the level of risk. The highest risks are then treated as a priority over lower risks.

The CZMP Guidelines outline the steps for preparing CZMPs, with further technical notes to be released by the NSW Government in the near future.

Under Section 733 of the *Local Government Act 1993*, councils are taken to have acted in 'good faith' and receive an exemption from liability where their actions were done substantially in accordance with the coastal management principles given the CZMP Guidelines, as summarised below. Intended changes to the section 117 of the *Environmental Planning and Assessment Act 1979* will require the

CZMP Guidelines be taken into consideration when councils prepare their local environment plans (LEPs).

The coastal management principles that underpin the CZMP guidelines are given below.

	Coastal Management Principles
Principle 1	Consider the objectives of the Coastal Protection Act 1979 and the goals, objectives and principles of the NSW Coastal Policy 1997 and the NSW Sea Level Rise Policy Statement (2009)
Principle 2	Optimise links between plans relating to the management of the coastal zone
Principle 3	Involve the community in decision-making and make coastal information publicly available
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
Principle 5	The priority for public expenditure is public benefit; public expenditure should cost effectively achieve the best practical long-term outcomes
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
Principle 7	Adopt an adaptive risk management approach if risks are expected to increase over time, or to accommodate uncertainty in risk predictions
Principle 8	Maintain the condition of high value coastal ecosystems; rehabilitate priority degraded coastal ecosystems
Principle 9	Maintain and improve safe public access to beaches and headlands consistent with the goals of the NSW Coastal Policy
Principle 10	Support recreational activities consistent with the goals of the NSW Coastal Policy

RESEARCH / REPORTS

Healthy Rivers Commission Independent Inquiry into the Bega River System

The Healthy Rivers Commission (HRC) inquiry into the Bega River system aimed to provide information and advice to local and state governments and the community, to assist in making informed management choices about the ecological, social and commercial goals for the river system. The HRC inquiry included 18 months of interaction with the Bega catchment community.

The inquiry attempted to identify and focus on those issues most crucial to the future health of the river, or that may not have received attention during prior inquiries. The inquiry outlined four critical river health issues.

- Management of river corridors;
- Managing water use;
- Managing the estuary; and

- Managing wetlands.

Other matters were also found to be important and were considered in lesser detail in the report, such as water quality, sewage and stock effluent, groundwater and forestry. The HRC considered that either these additional issues may not prove to be as critical as the major issues (above) for long term river health, or that present management processes are adequate, with some improvements (noted in report) (HRC, 2000).

The report found many of the river corridors to be seriously degraded due to erosion and sedimentation processes (which began during European Settlement), loss of native vegetation and proliferation of weeds (e.g., willows). This degradation was found to result in a reduction in water flows and ecology in some streams, reduction in bird, animal and fish habitats, blockage to fish passage, and stream instability (HRC, 2000).

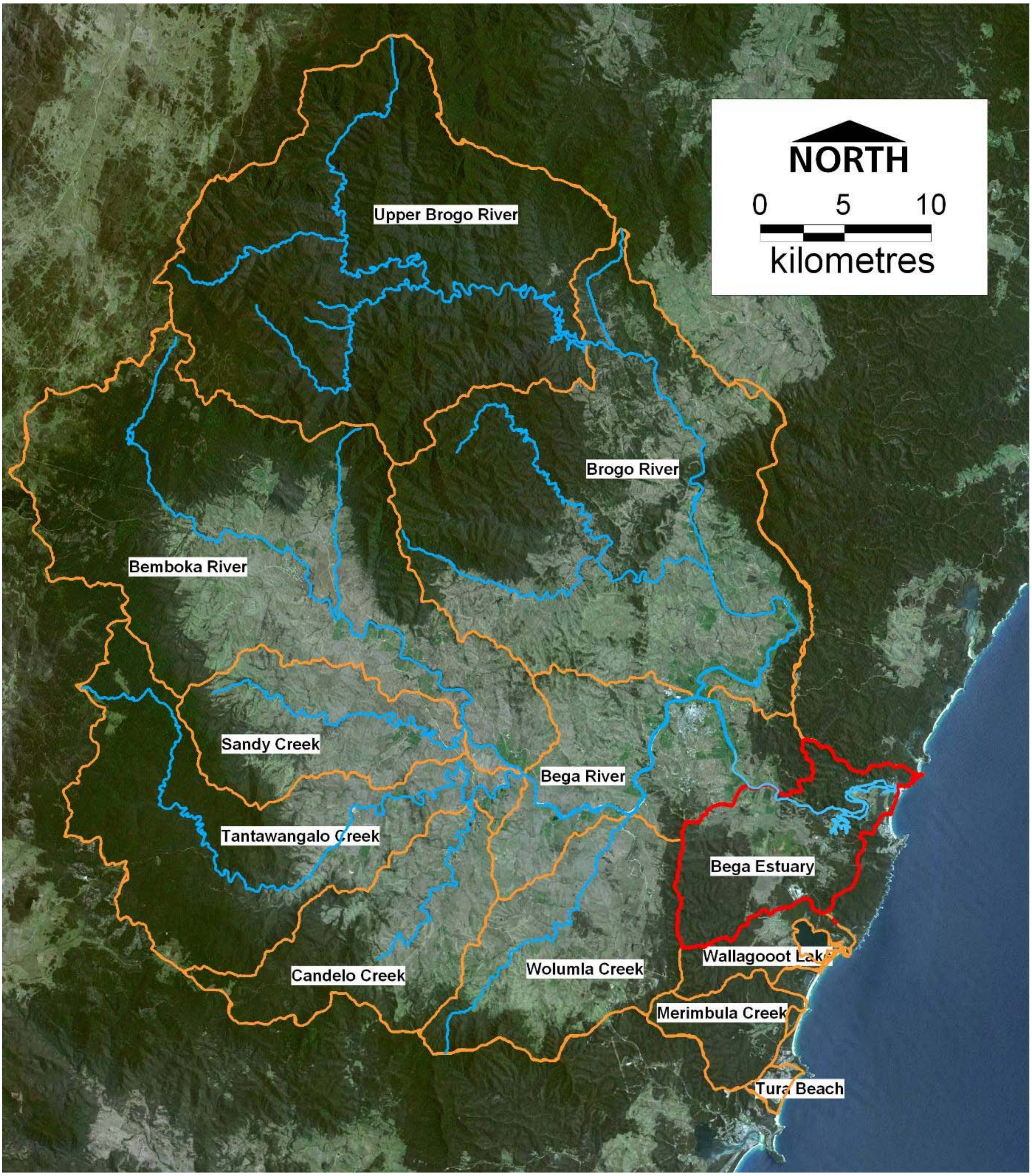
Water extraction was found to be greatest in the Bega River system compared with all other streams in the South Coast catchment. Signs of environmental stress, reduced aquatic habitats, and constriction of normal spawning cycles for fish were evident in many streams as a result. However the report noted that water extraction was mainly for one of the catchments major industries, dairy farming, and which was also faced with the economic pressure of deregulation and restructuring of markets (HRC, 2000).

The estuary was noted to be an important component of the system, linking the catchment with the ocean, and thus impacted by the management of both the catchment and coast. Estuarine processes respond to stream flows, tides, wind and waves, and are dynamic complex systems driven by the interaction of both catchment and marine processes. As there are many different agencies involved in the management of the catchment and coast, estuaries are not often managed with a whole of system approach (HRC, 2000).

The inquiry found that wetlands remained in sections of the catchment from upland to the coast, in spite of significant modifications to the Bega catchment since European settlement. For this reason, the HRC chose to focus on wetland management. While wetland management may not be as critical in an overall catchment sense, wetlands are an important part of the catchment ecology; the role of wetlands is rarely well understood; and the preservation of wetlands in the Bega catchment is as much due to good fortune as good management (HRC, 2000).

The HRC (2000) made recommendations on how to address the major issues in practical manner, and in a manner which is integrated across the catchment and with other components of river health. The report outlined goals for the future integrated management of the Bega/Bemboka River, Brogo River, tributary streams, lower Bega River and Bega River Estuary (HRC, 2000).

APPENDIX B: DATA AND INFORMATION MAPS



See Figure 1-1 in Chapter 1 for detailed map of Bega Estuary catchment and Study Area

Figure B-1 Subcatchments and Tributaries of the Bega Valley Catchment

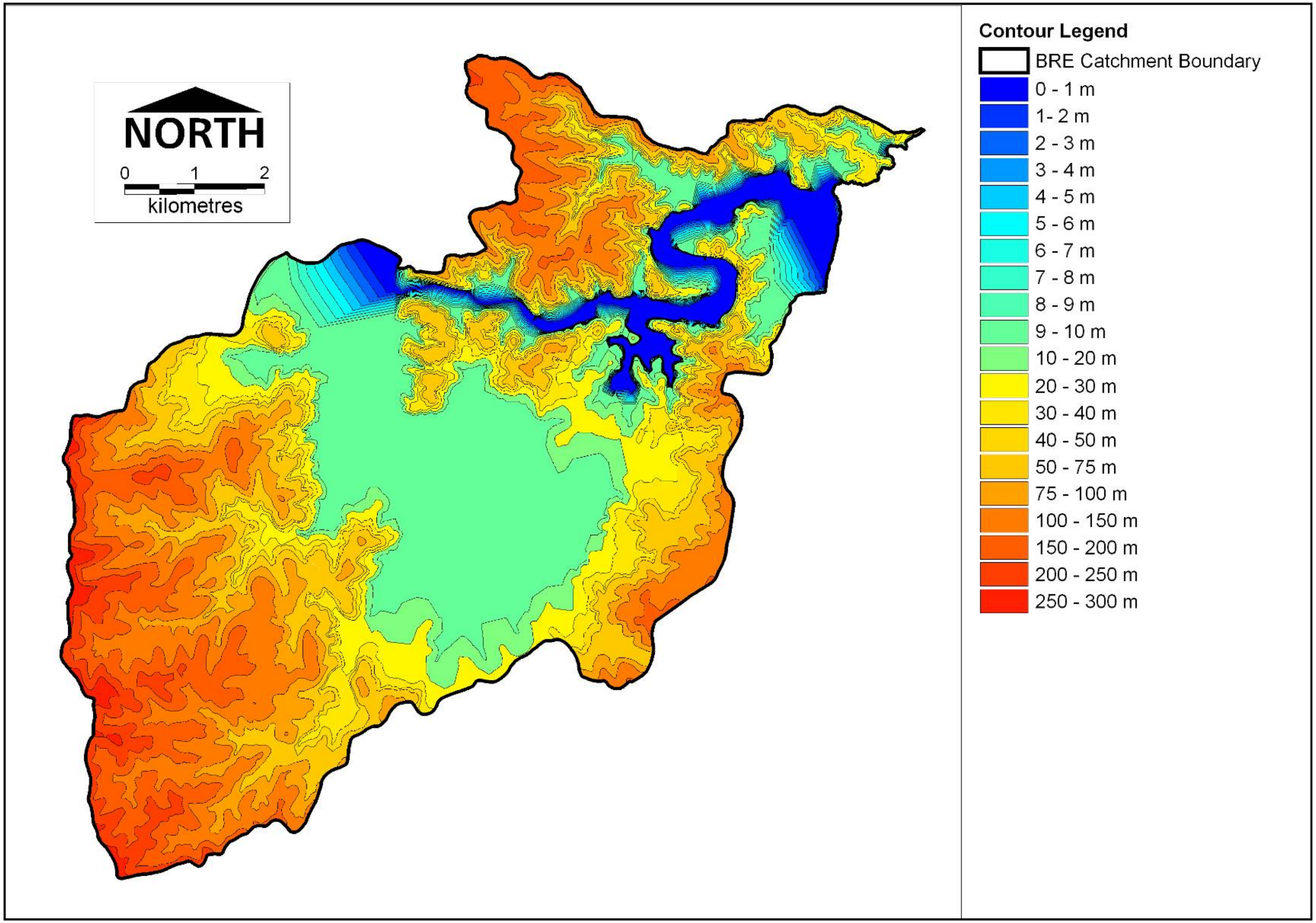


Figure B-2 Topographic Contours of the BRE

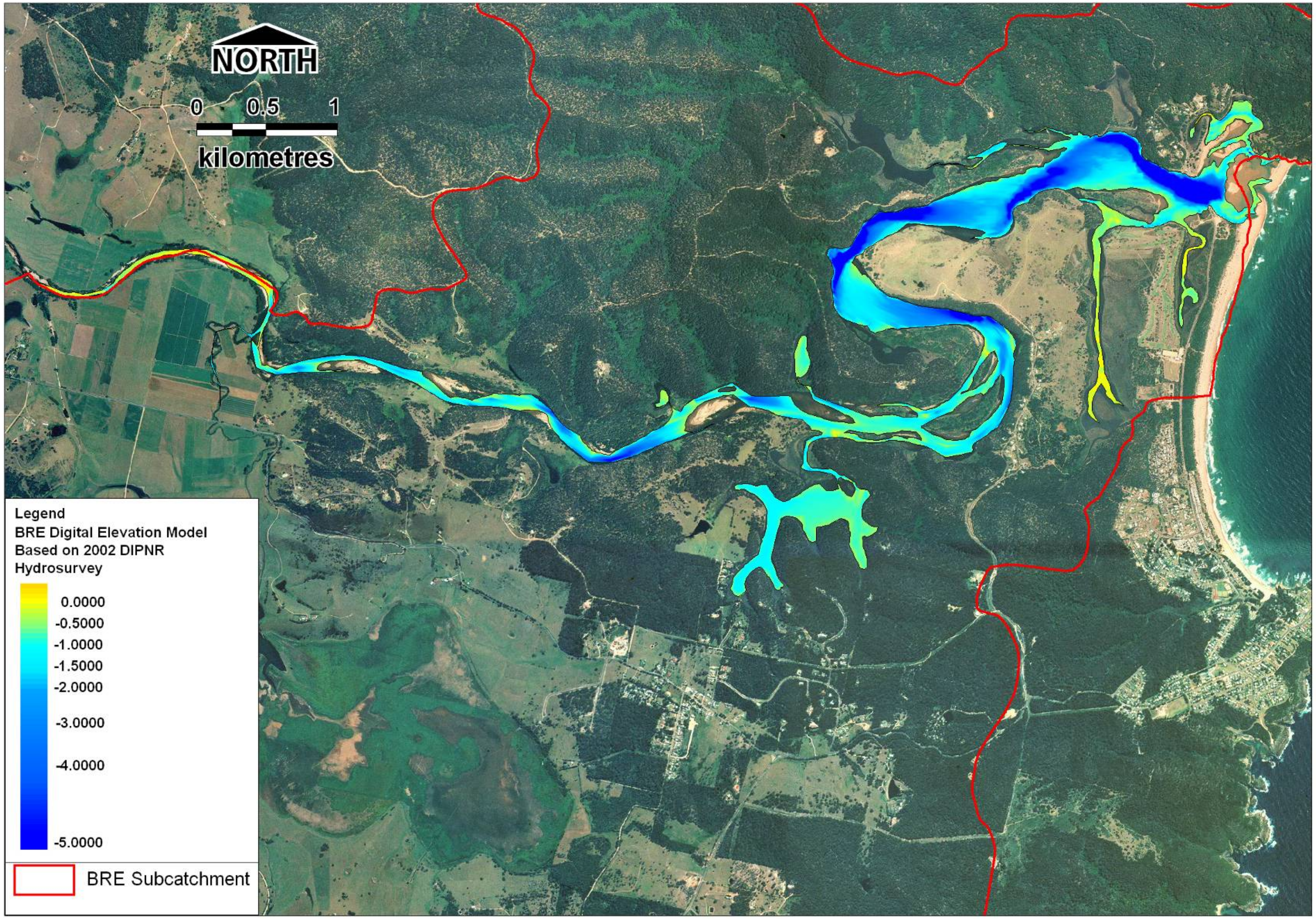


Figure B-3 Digital Elevation Model of the Bega River Estuary

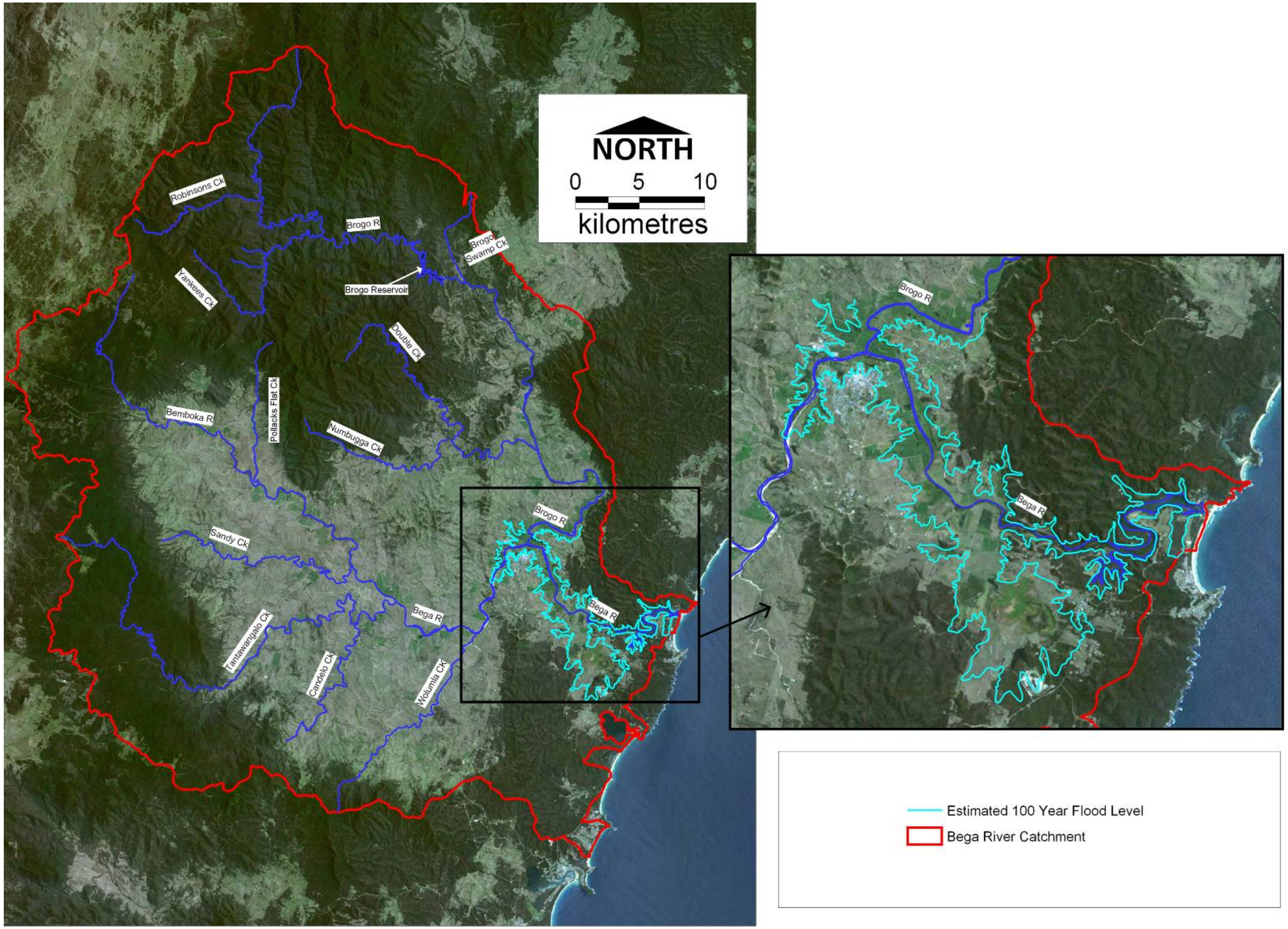


Figure B-4 100 Year Flood Level for the BRE

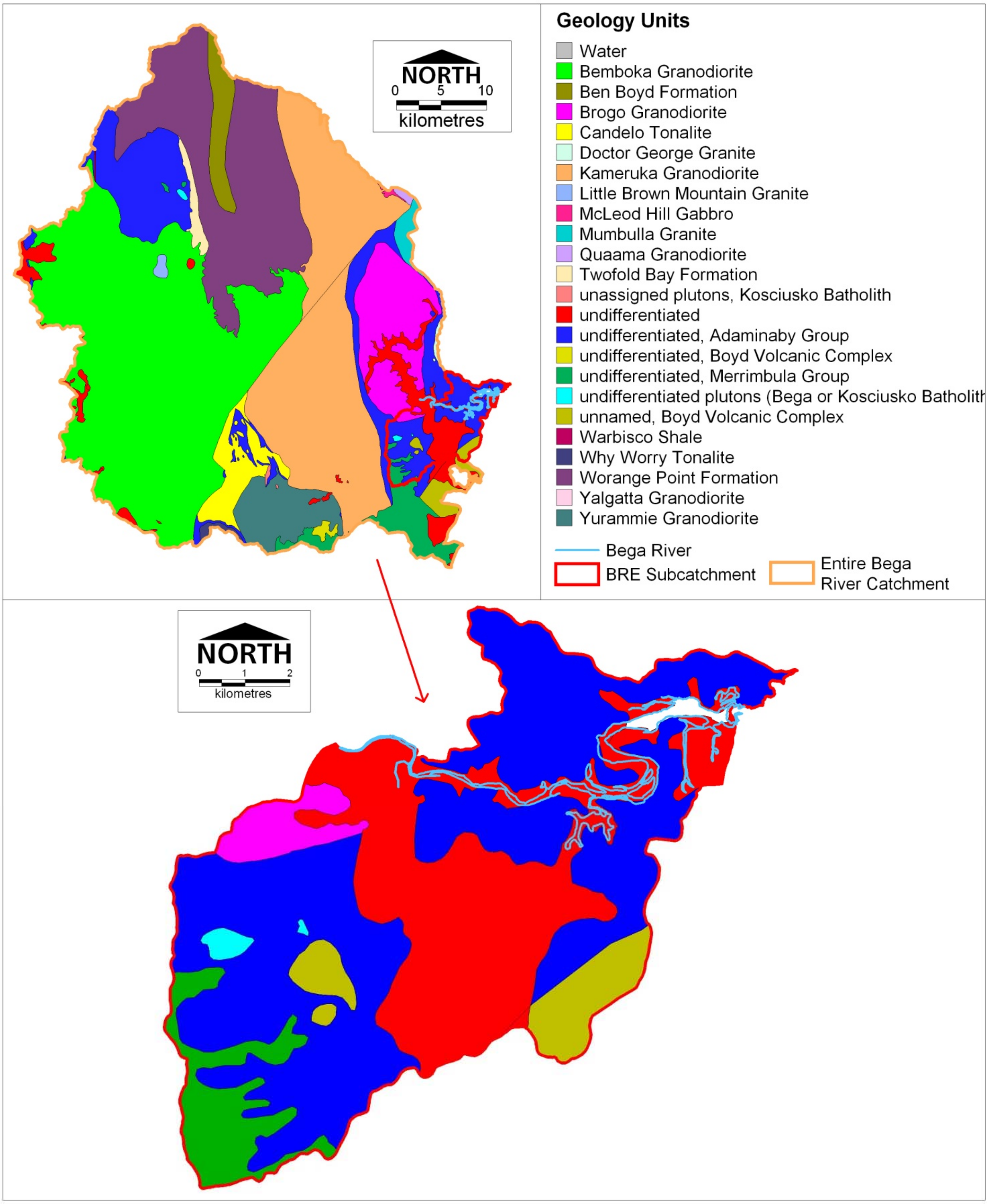


Figure B-5 Geology of the Bega River Catchment

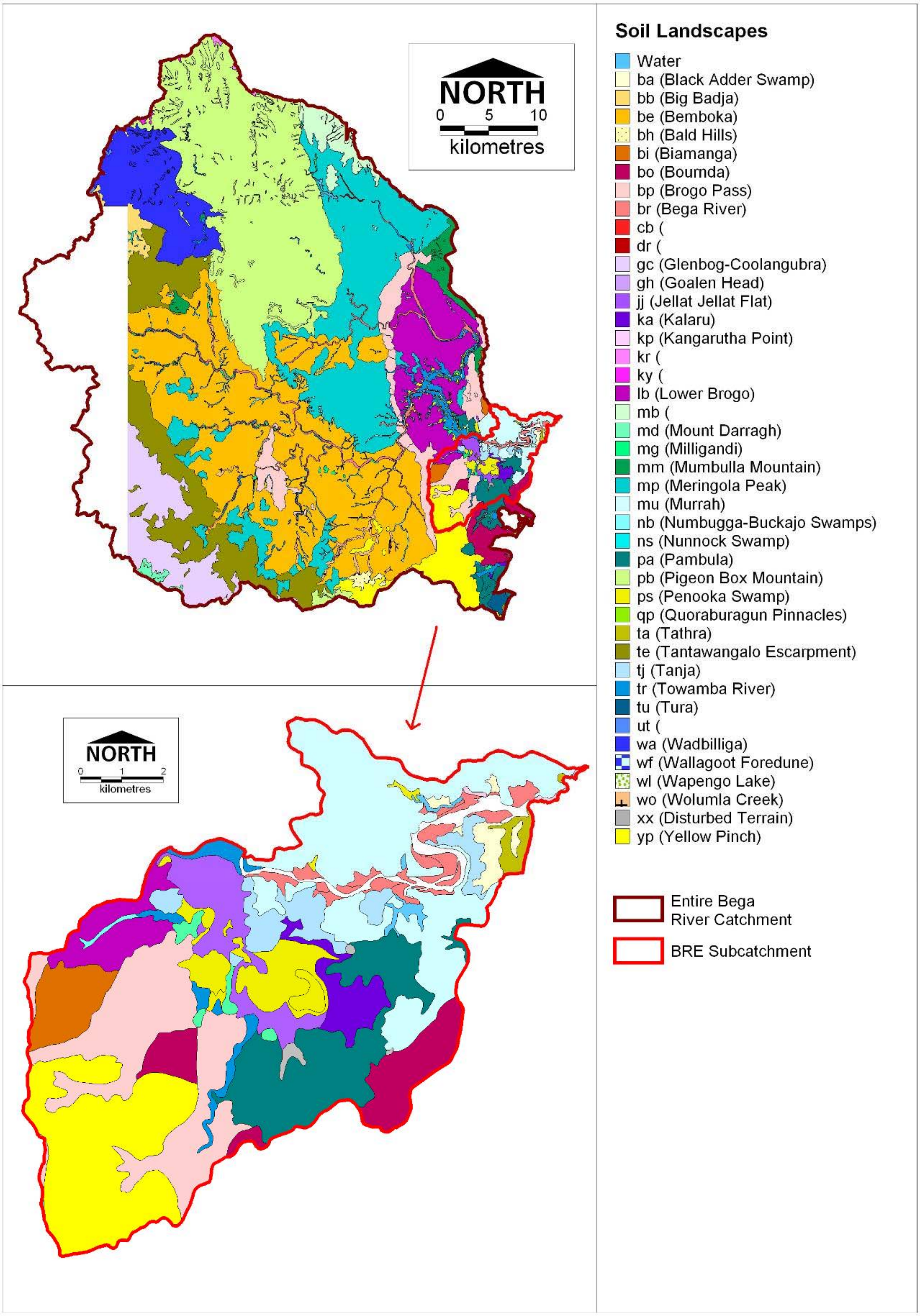


Figure B-6 Soil Landscapes of the Bega River Catchment

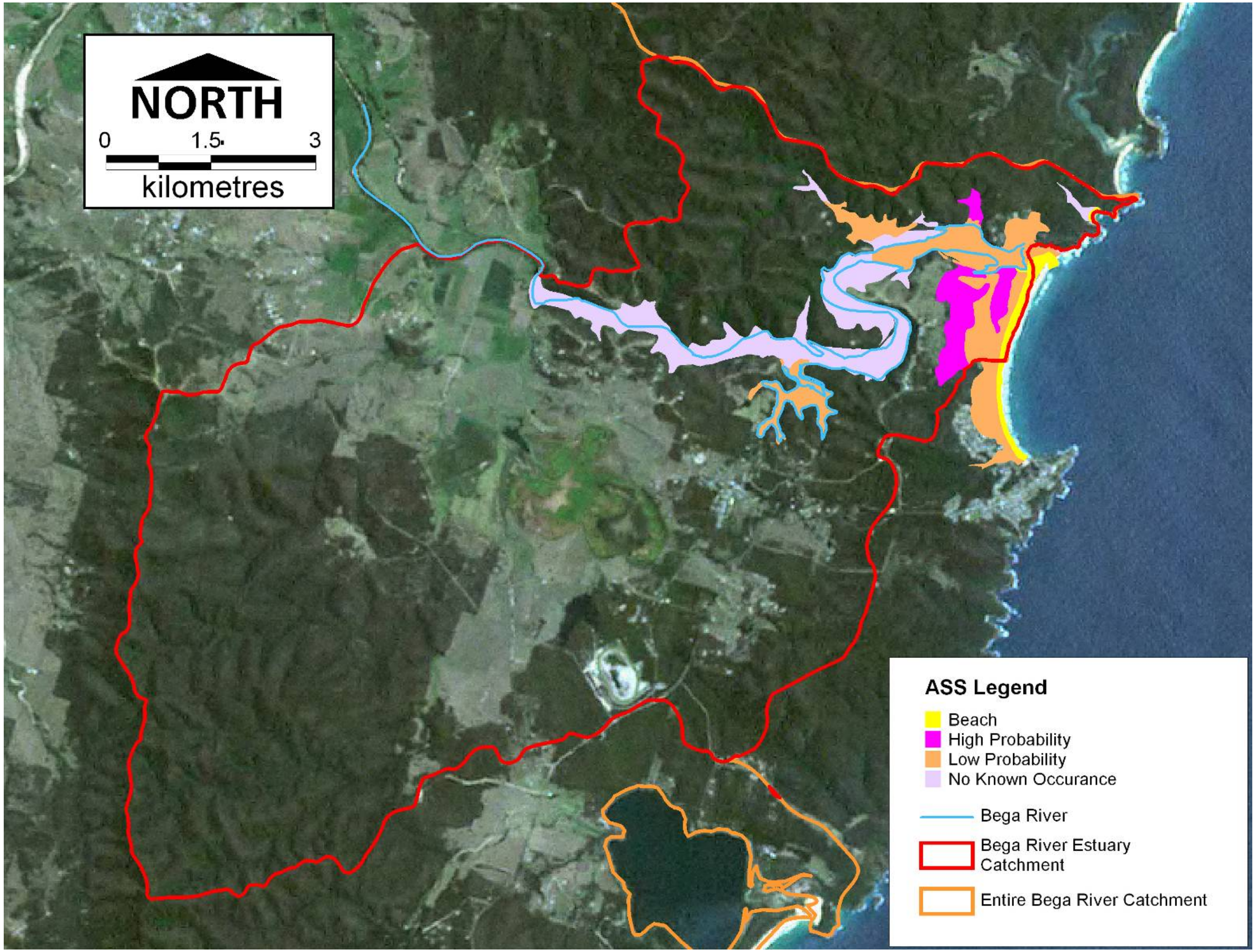


Figure B-7 Acid Sulfate Soils in the Bega River Estuary

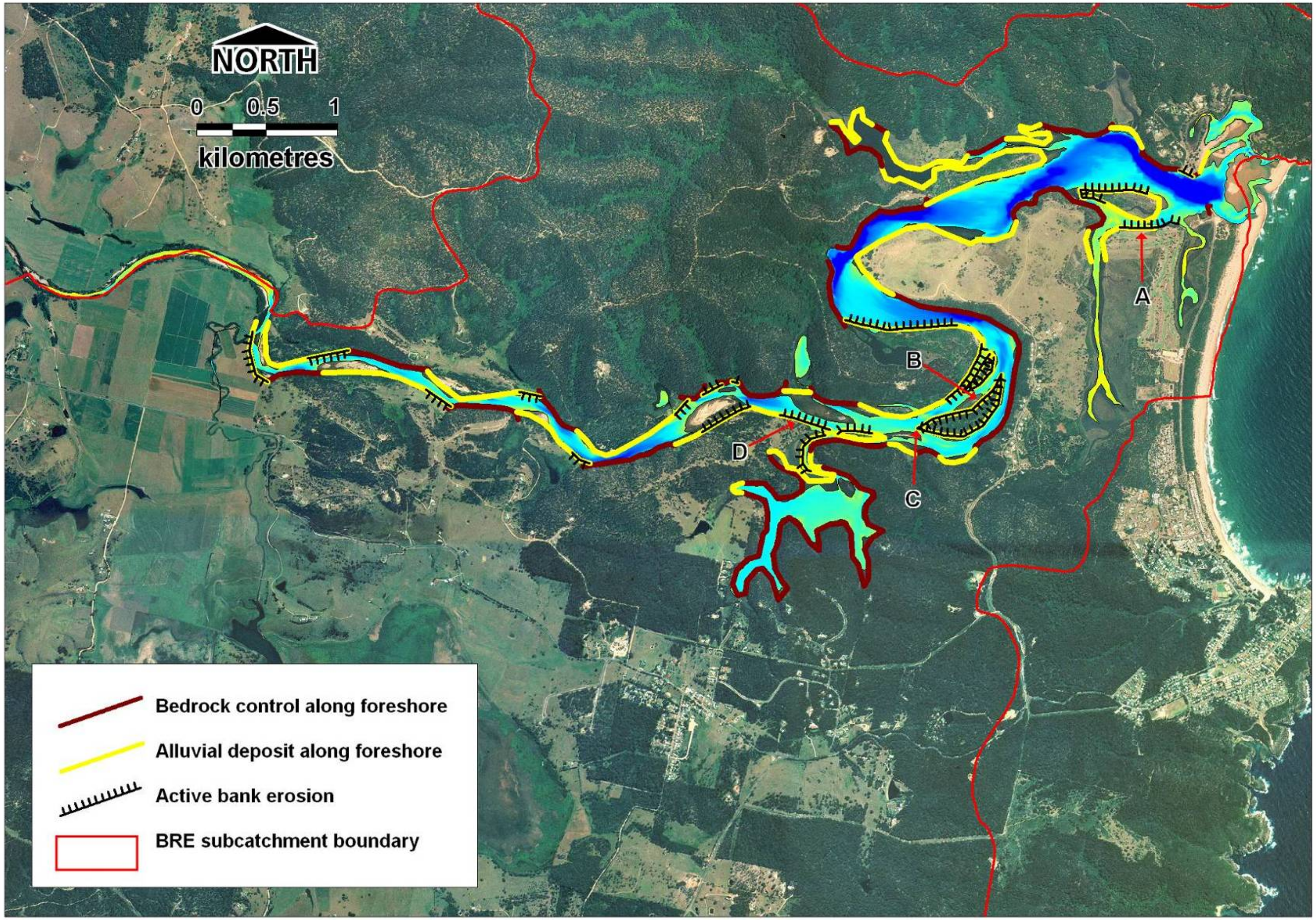


Figure B-8 Bank Erosion along the Bega River Estuary

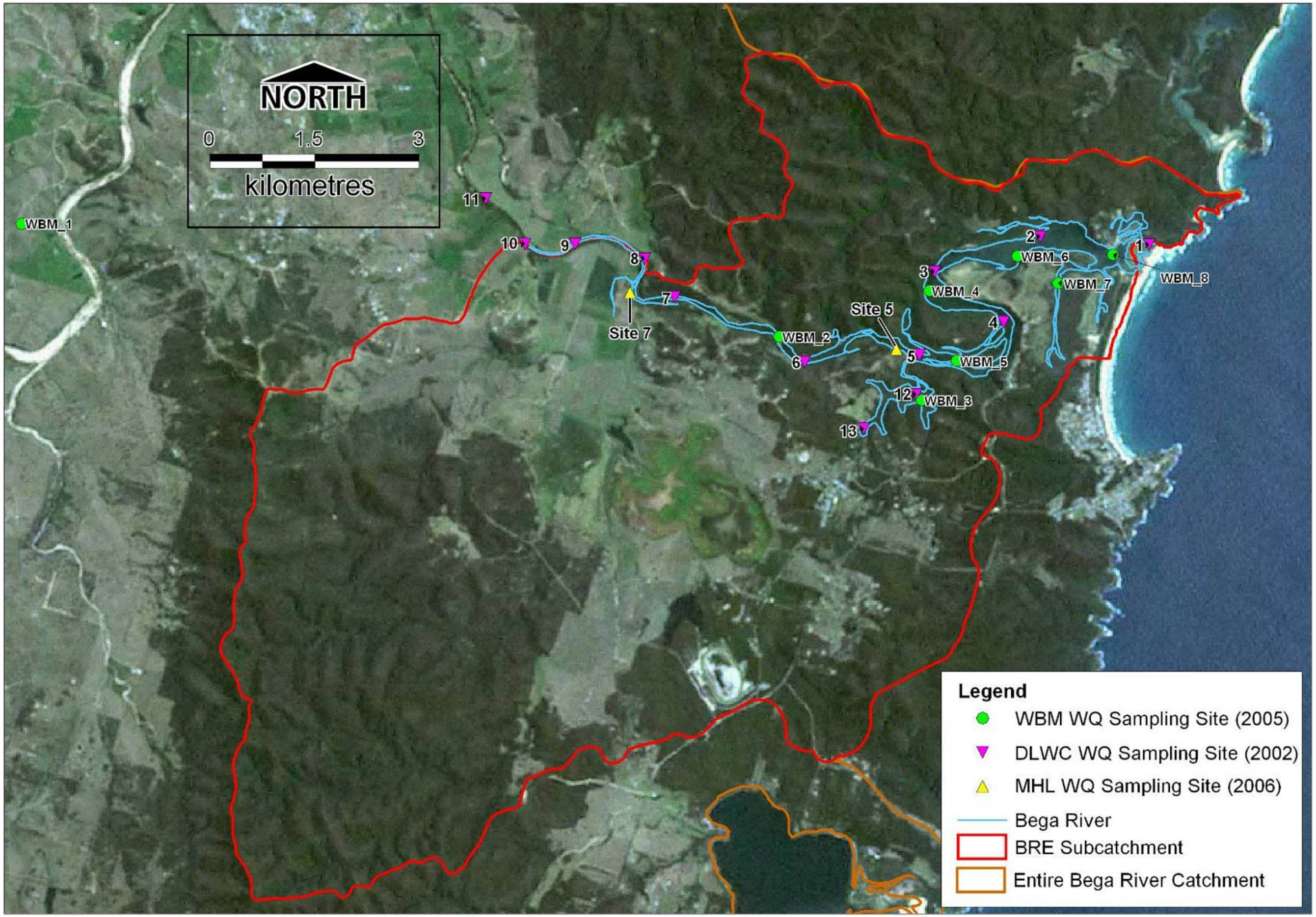


Figure B-9 Water Quality Sampling Locations for DLWC (2002), WBM (2005) and MHL (2006)

Figure B-10 Tathra STP Groundwater and Surface Water Monitoring Sites

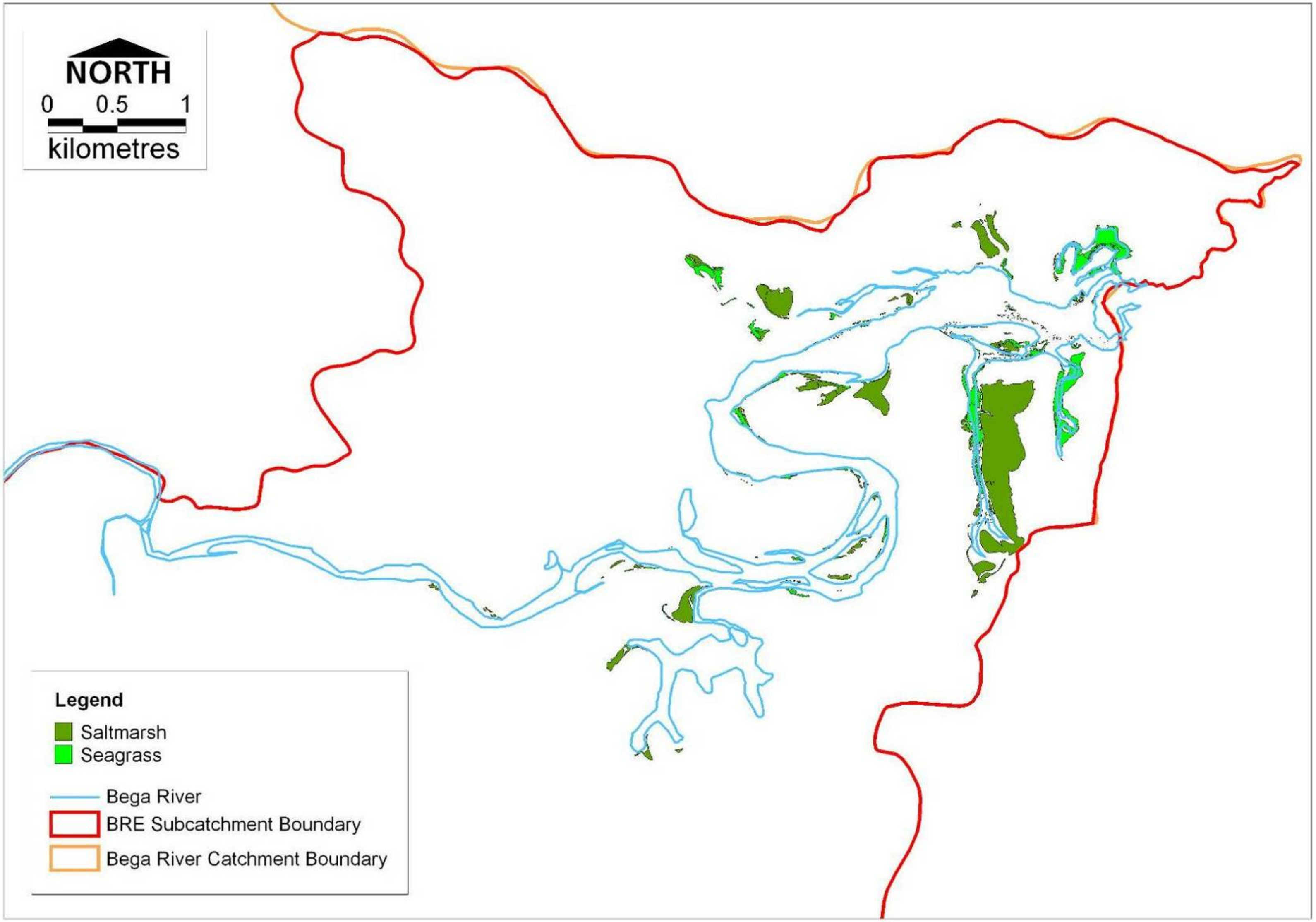


Figure B-11 Saltmarsh and Seagrass in the BRE, mapped by DPI May 2006.

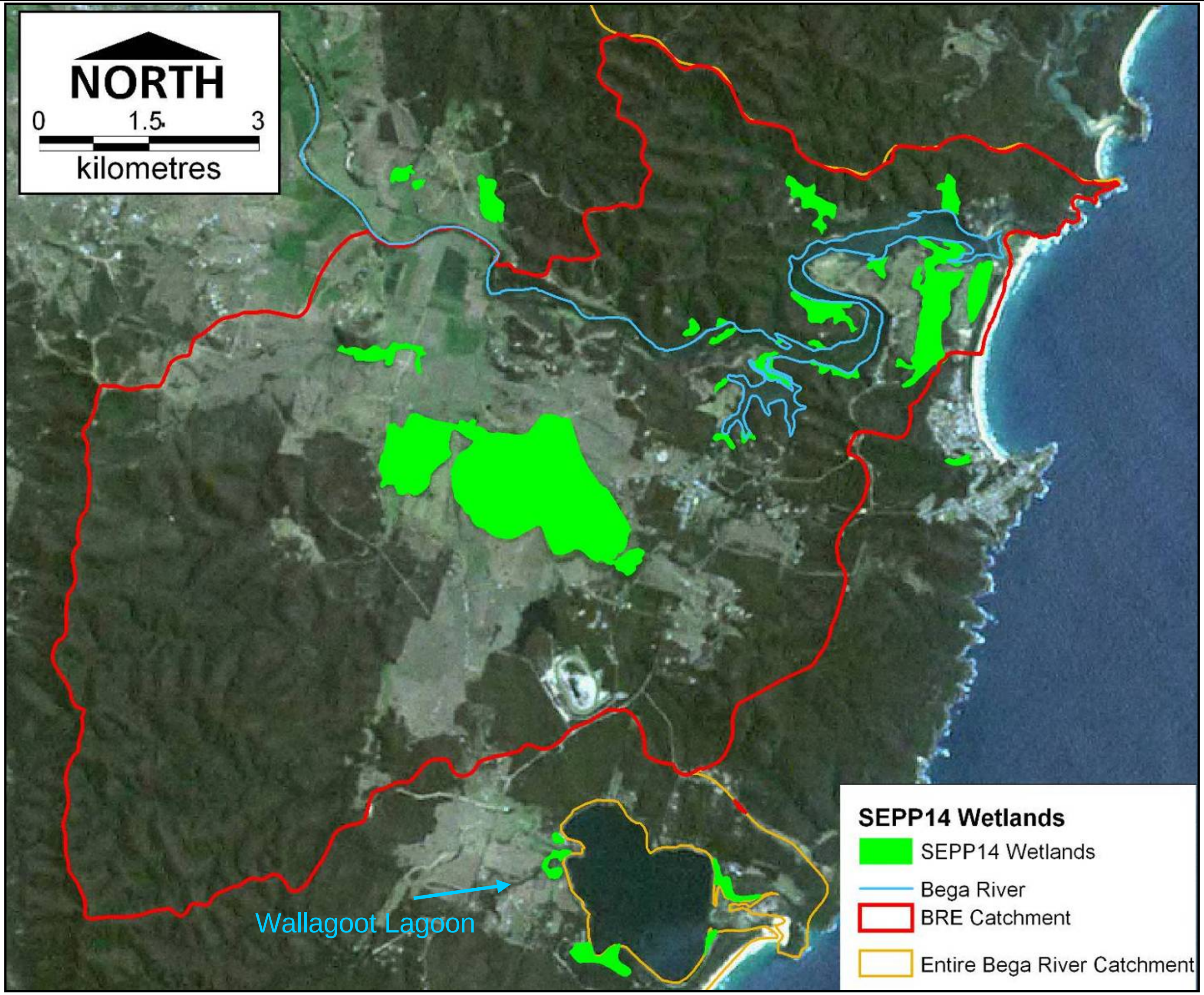


Figure B-12 SEPP 14 Wetlands in the Bega River Estuary and Catchment

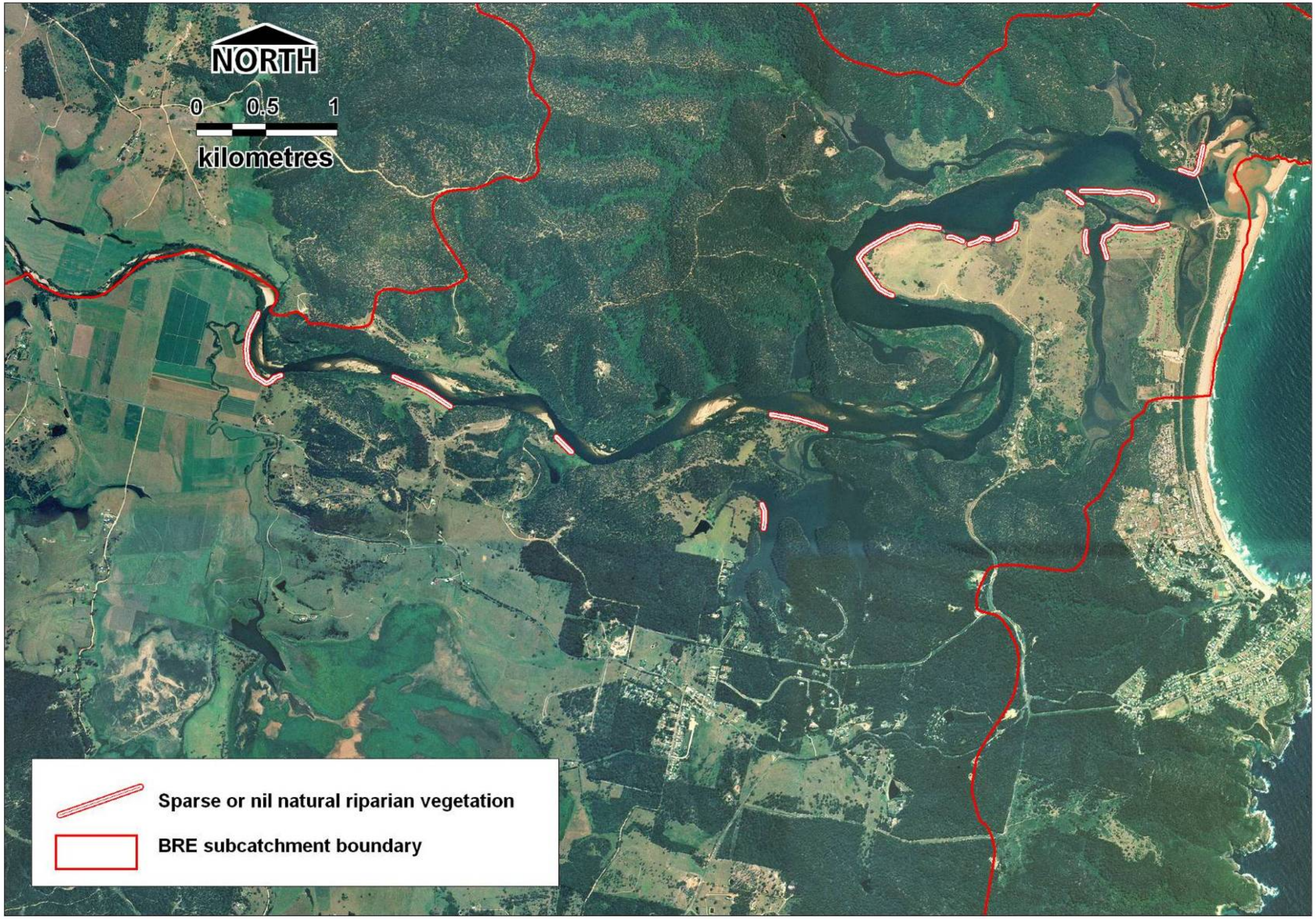


Figure B-13 Areas of Poor Riparian Vegetation Condition along the Bega River Estuary

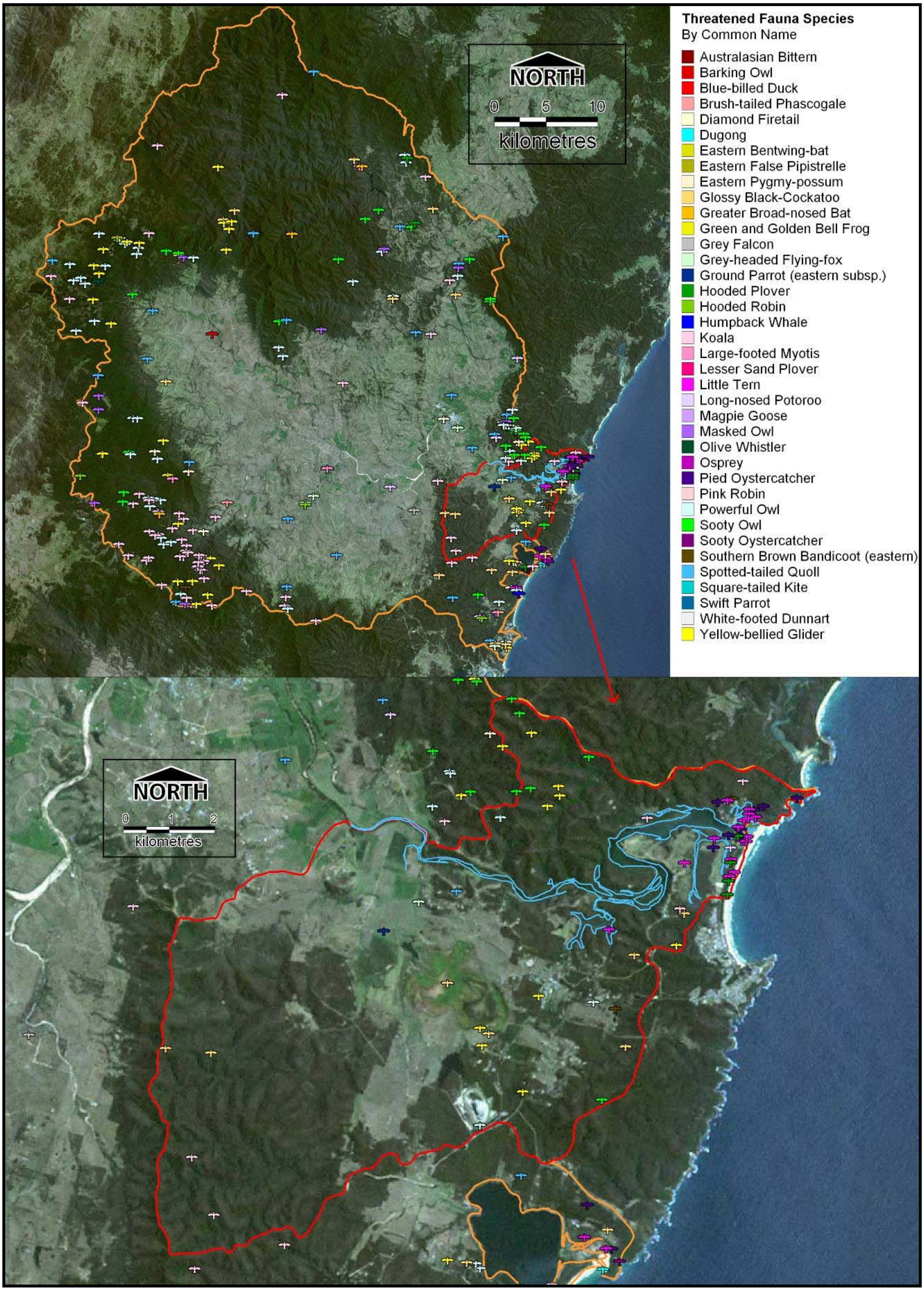


Figure B-14 Threatened Fauna Species within the Bega River Catchment

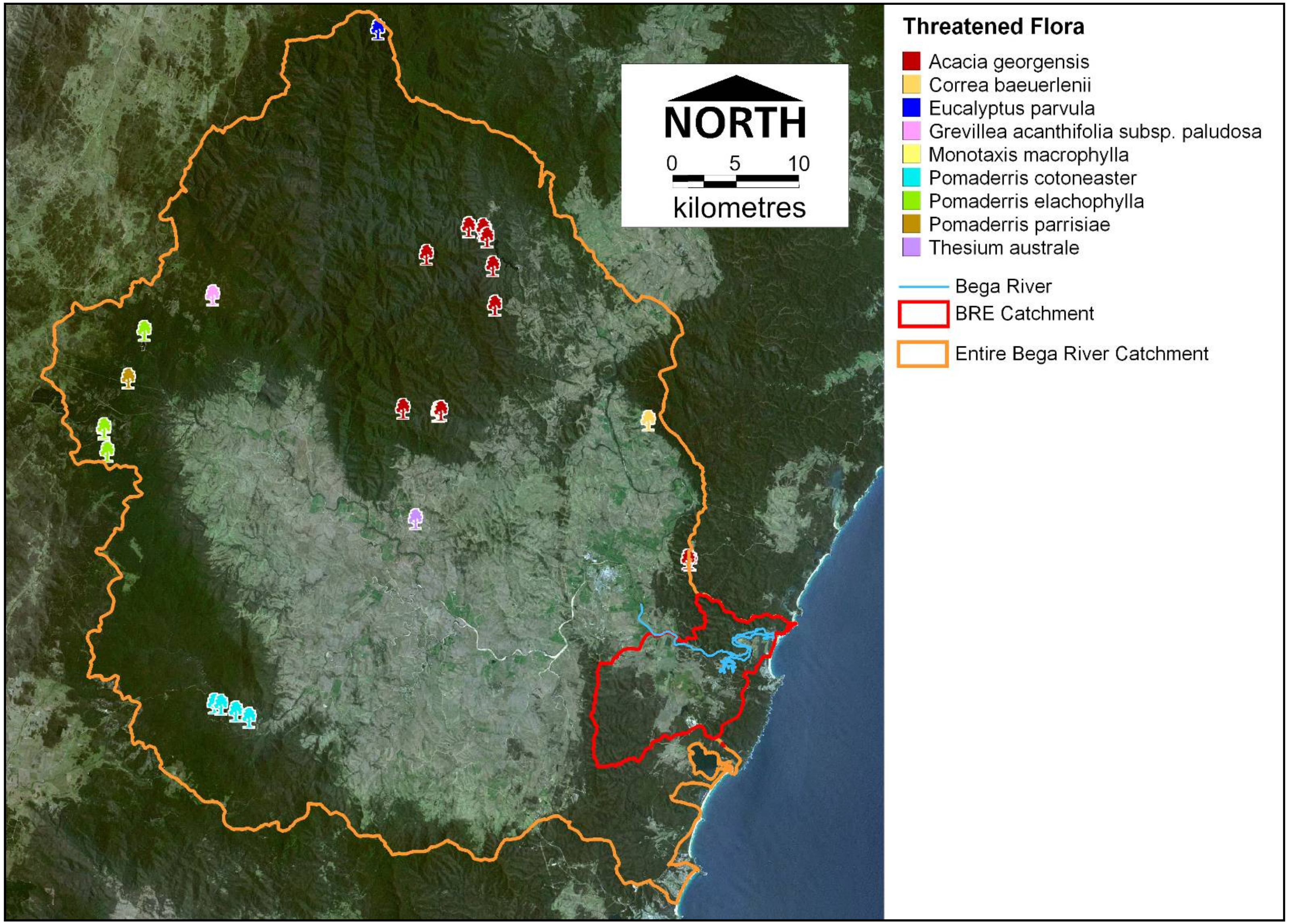


Figure B-15 Threatened Flora Species Locations

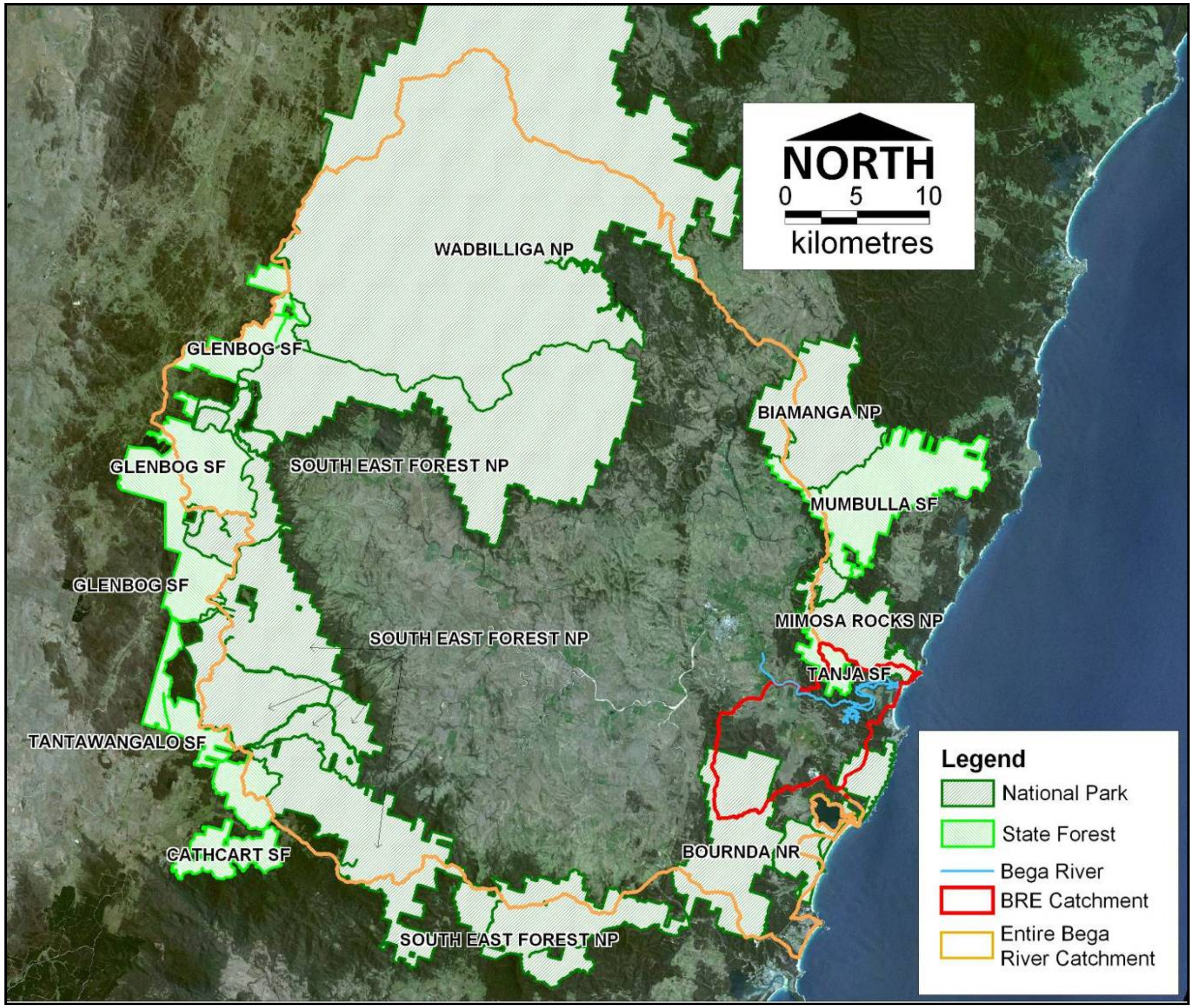


Figure B-16 National Parks and State Forests

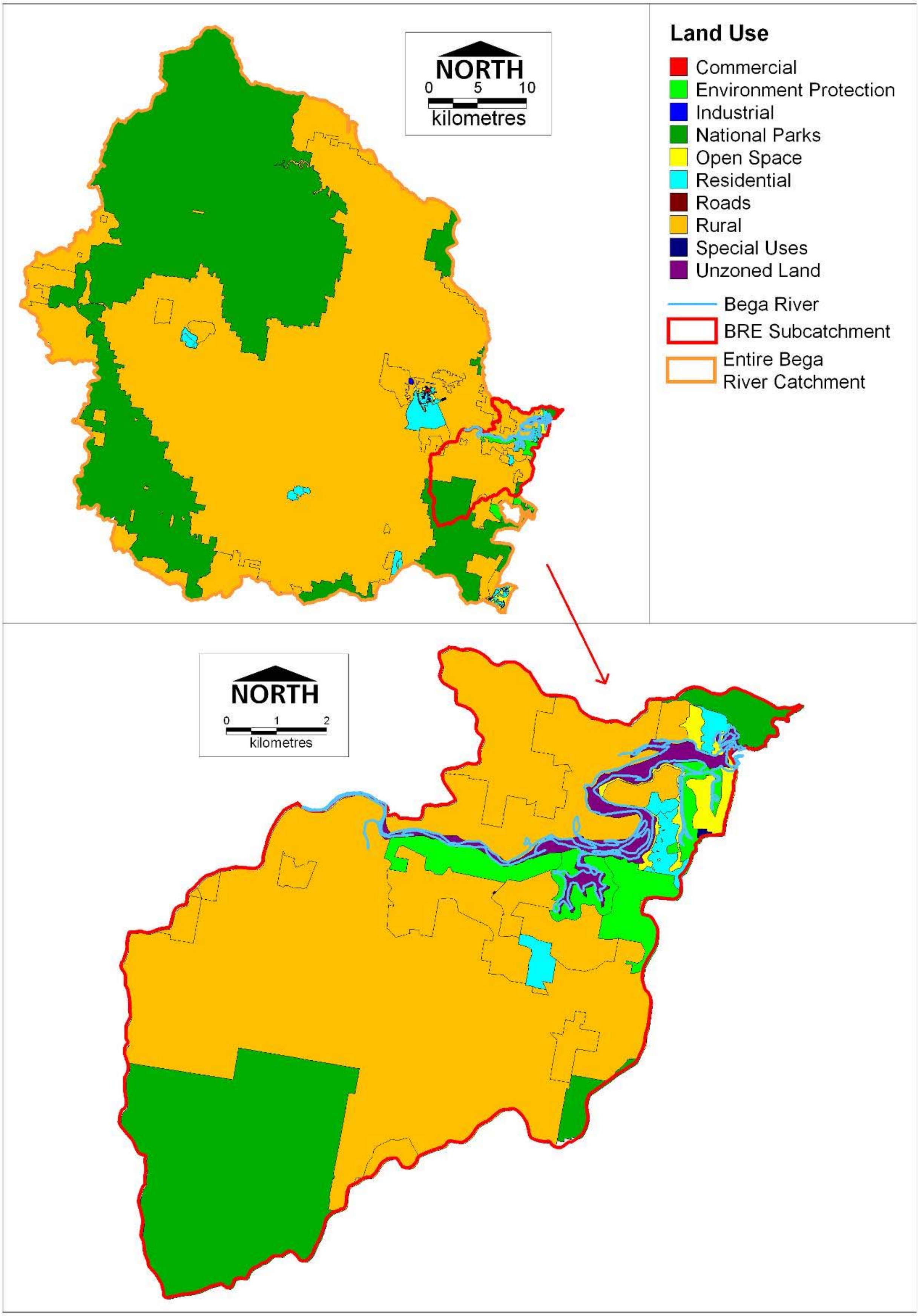


Figure B-17 Major Landuses in Bega Valley Shire

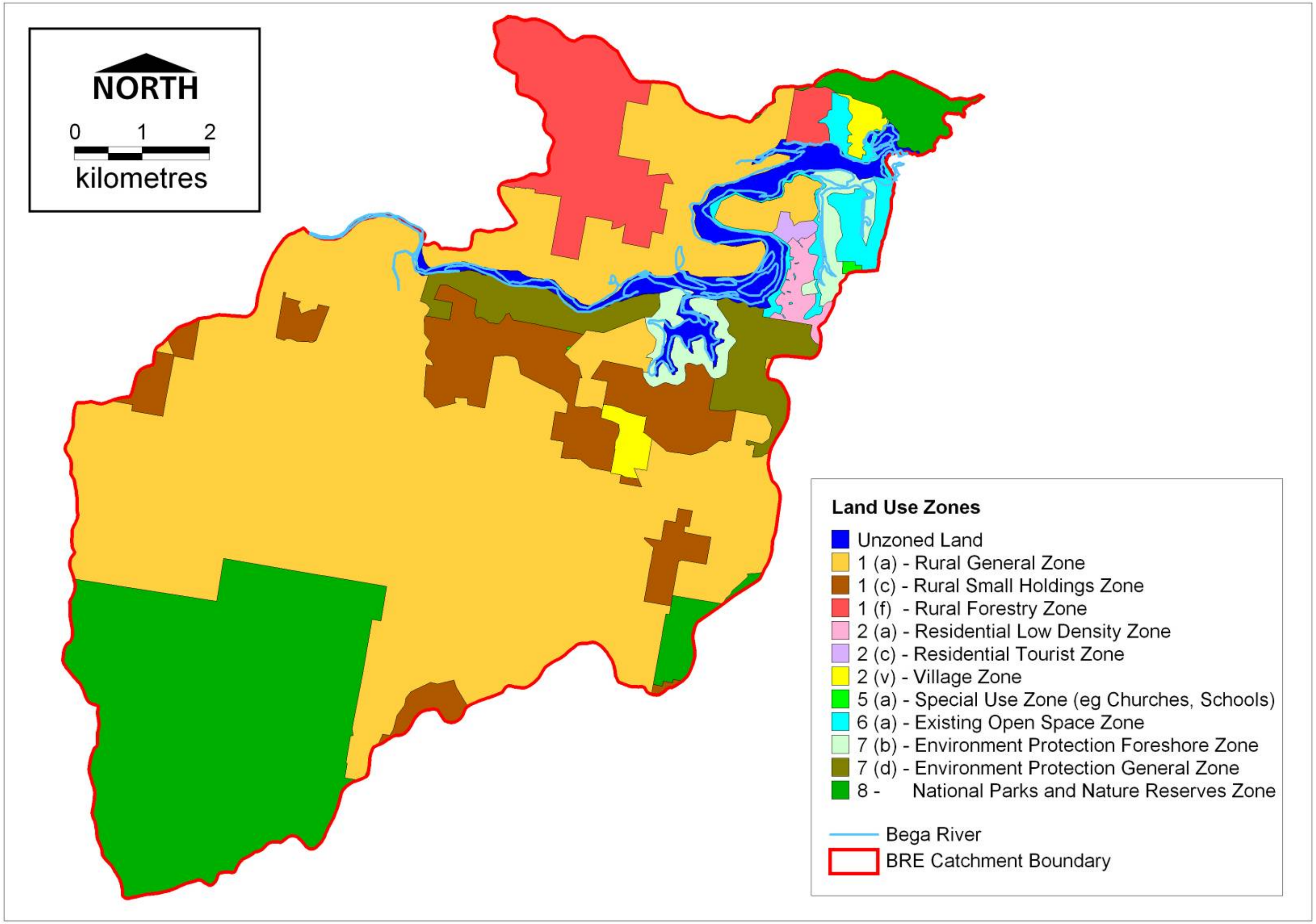


Figure B-18 LEP Zoning of the BRE Subcatchment

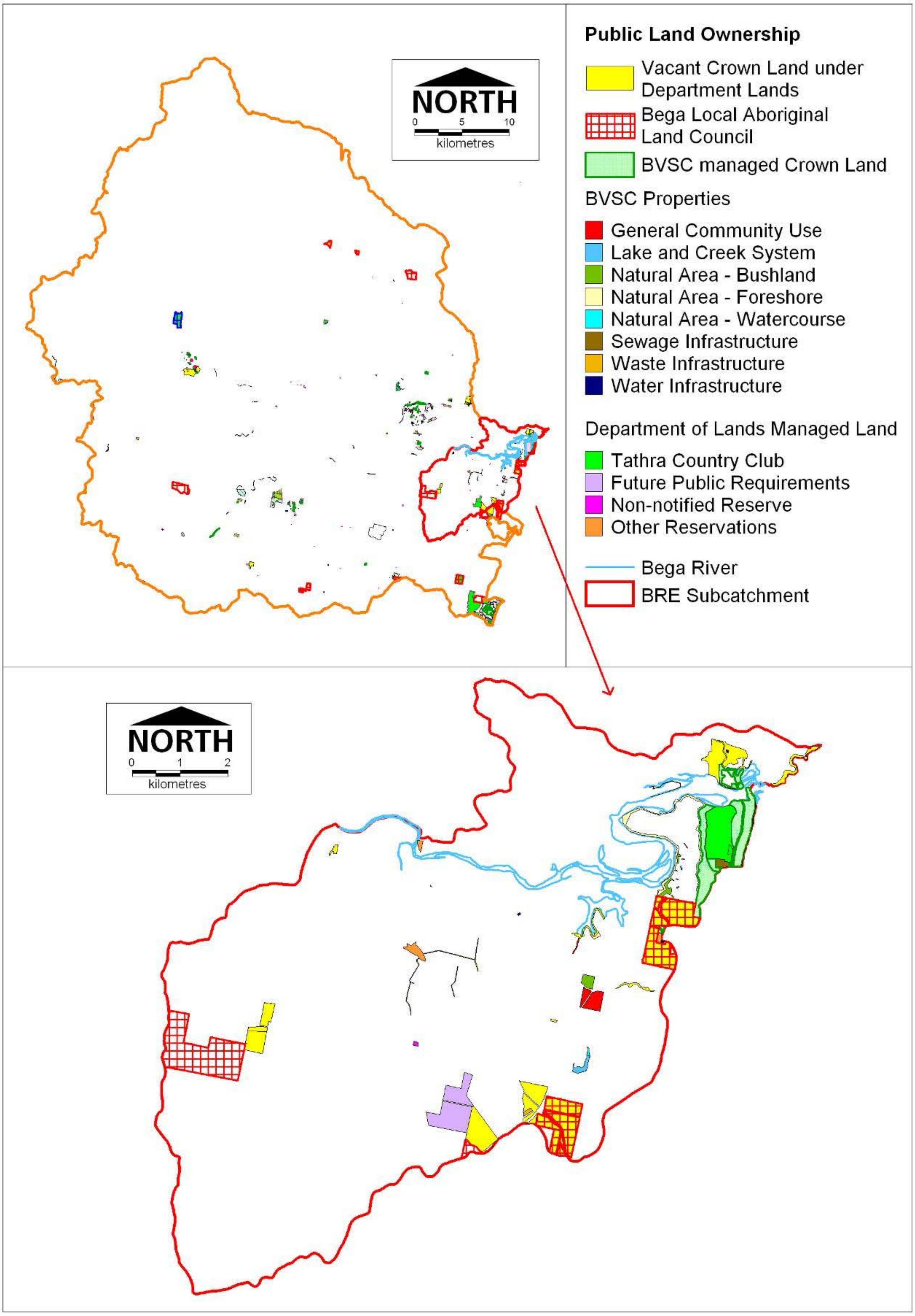


Figure B-19 Public Land Ownership in the Bega River Estuary

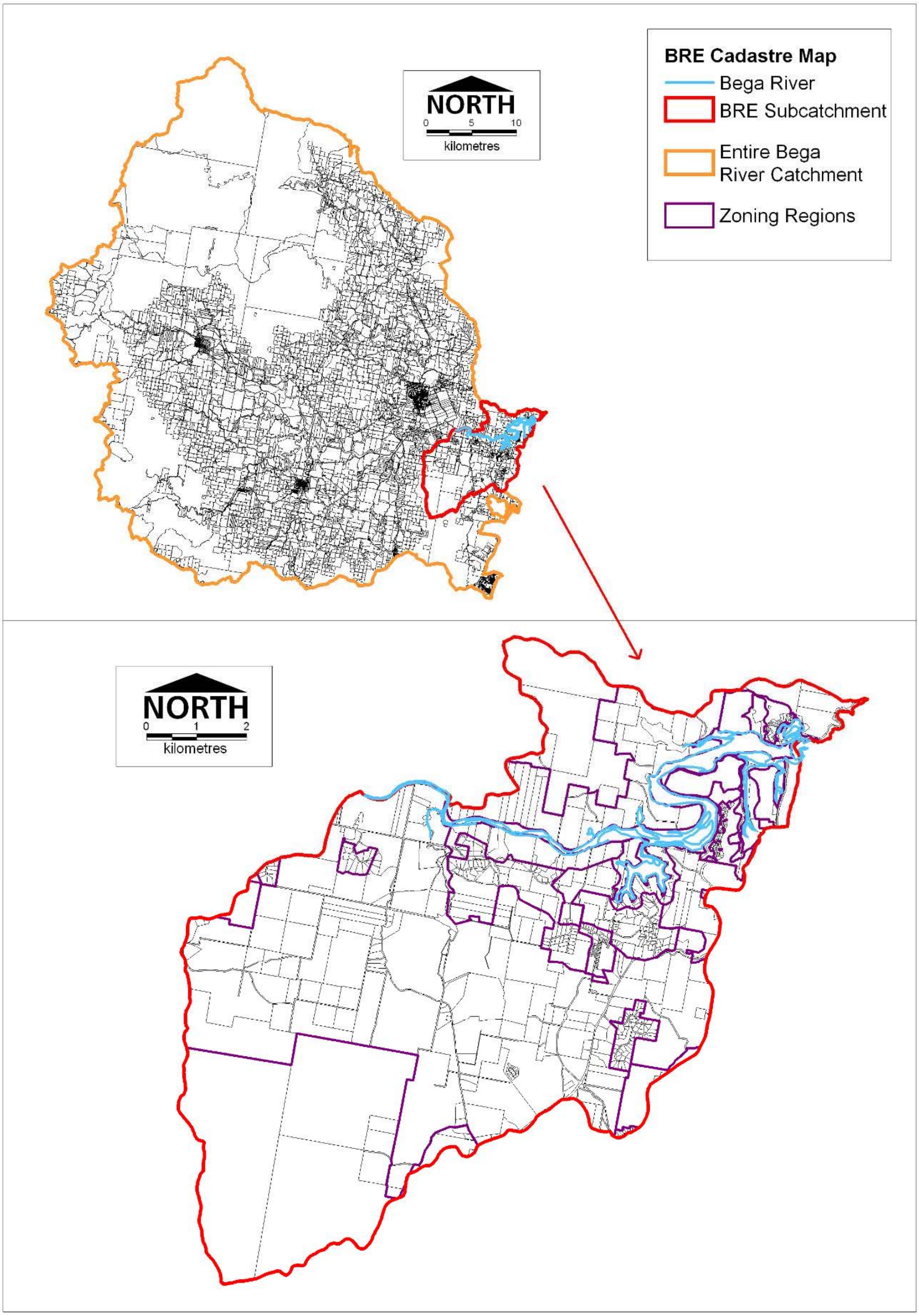


Figure B-20 Cadastral Map of the Bega River Estuary

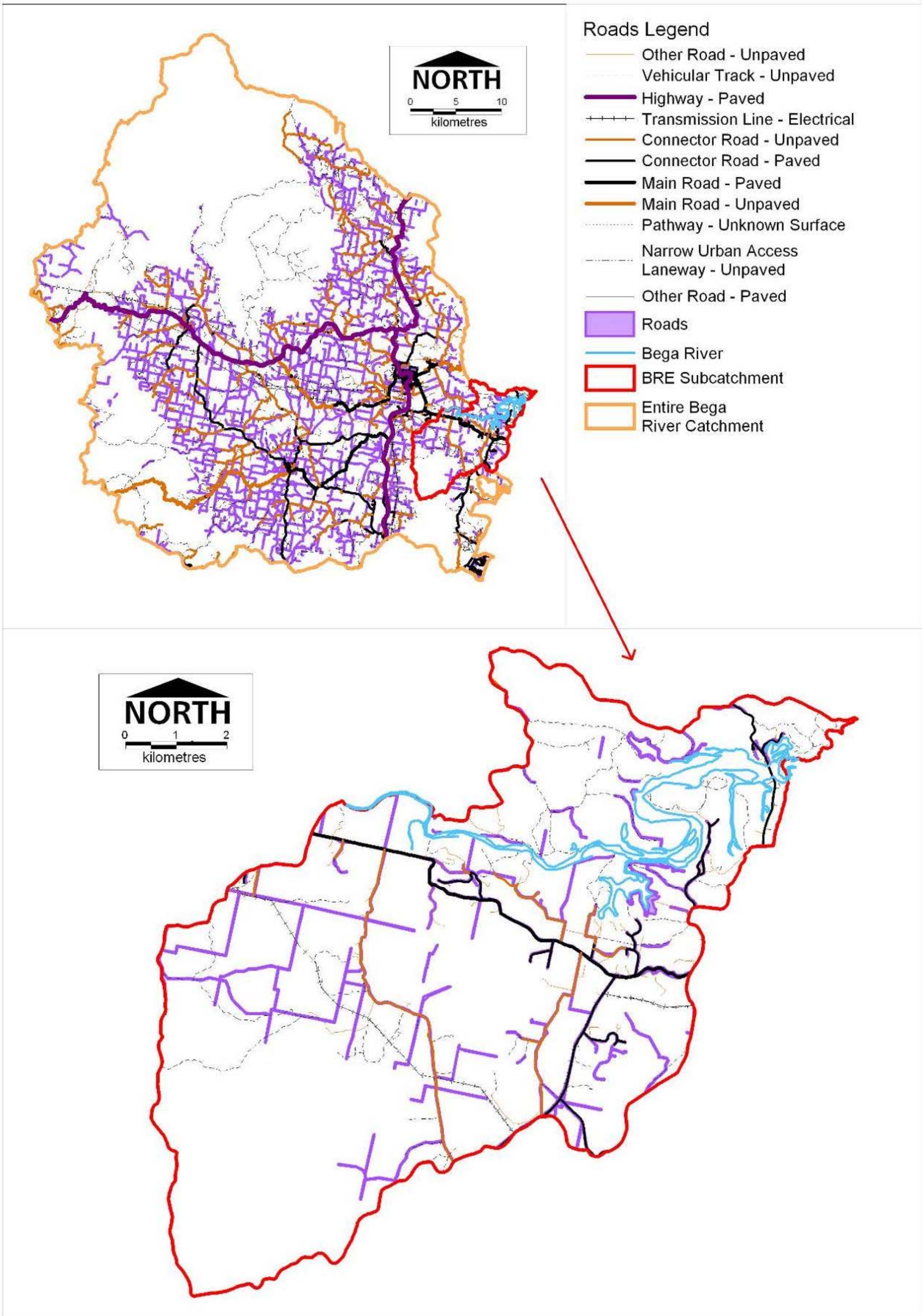


Figure B-21 Map of Roads in the Bega River Estuary

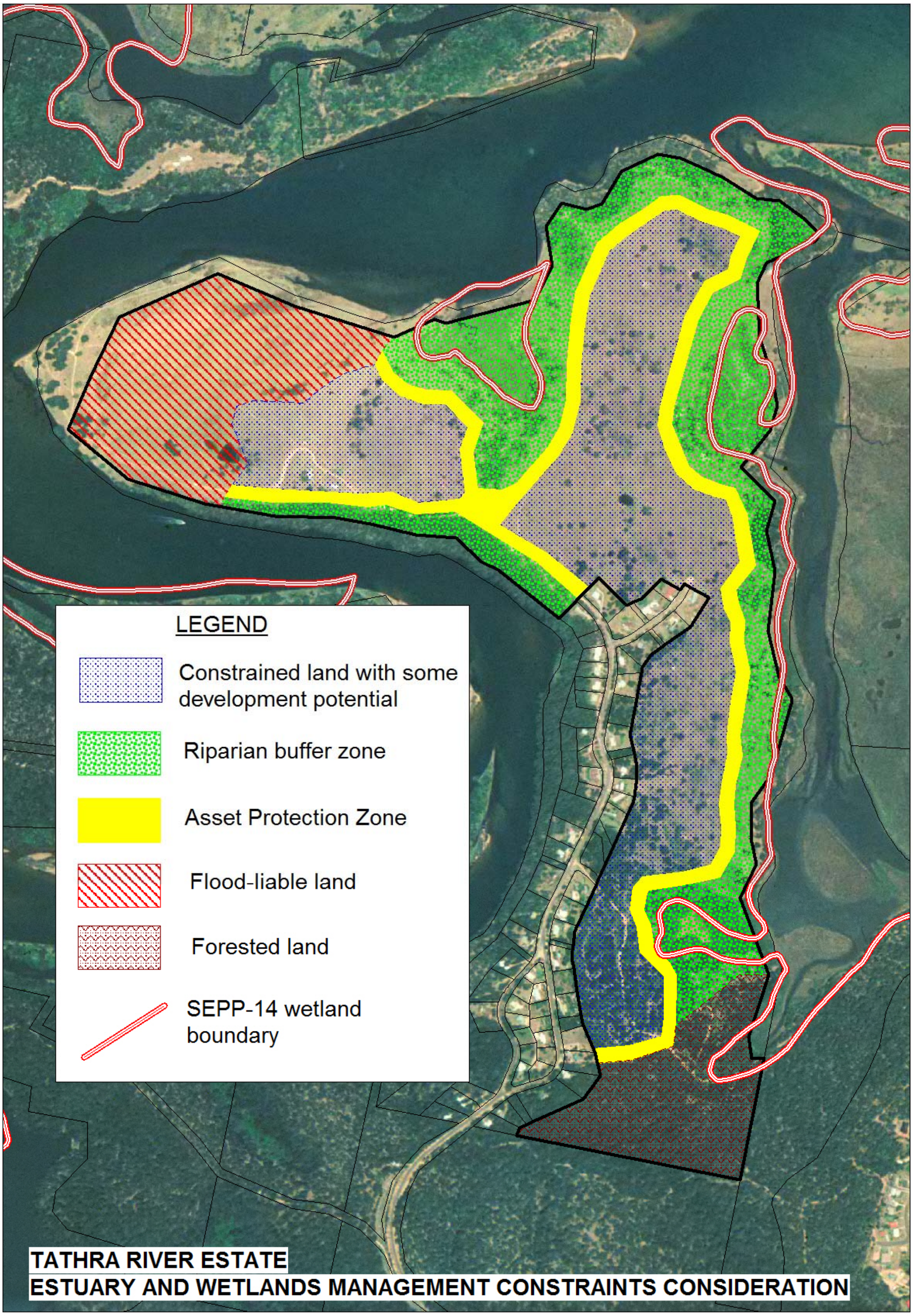


Figure B-22 TRE Management Constraints Consideration

APPENDIX C: WATER QUALITY RESULTS

Table C-1 DLWC (2003) Water Quality Results

Date	Time (EST)	Station No.	Chainage (km)	Depth (m)	Salinity (psu)			pH			Temperature (°C)			Dissolved O_2 (% sat)		
					Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
24/09/2002	8:26	1	0.13	1.3	23.63	23.79	23.71	7.79	7.81	7.8	15.15	15.64	15.34	85.49	97.04	87.48
24/09/2002	8:36	2	1.925	4.8	23.15	27.63	23.95	7.72	7.82	7.78	16.26	18.68	16.77	67.66	85.73	72.96
24/09/2002	8:45	3	3.556	11.7	22.86	34.18	29.49	7.26	7.77	7.54	15.91	19.81	17.85	3.15	81.22	44.58
24/09/2002	8:55	4	5.122	2.3	22.38	23.87	23.1	7.69	7.71	7.7	16.4	17.45	17.01	64.93	85.6	77.46
24/09/2002	9:05	5	6.851	1.5	20.81	23.36	22.44	7.6	7.64	7.61	16.34	17.5	16.94	75.46	80.36	78.08
24/09/2002	9:14	6	8.58	6	17.33	27.41	22.52	7.36	7.6	7.54	16.44	17.5	17.21	26.08	81.41	64.96
24/09/2002	9:24	7	10.766	2.2	14.59	21.85	20.84	7.39	7.49	7.42	16.61	17.77	17.51	63.82	77.83	68.54
24/09/2002	9:32	8	11.973	0.8	18.42	20.91	19.94	7.31	7.41	7.34	17.85	18.26	18.09	59.76	70.1	64.77
24/09/2002	9:40	9	13.082	1.5	18.06	19.36	19.1	7.1	7.19	7.14	18.86	19.09	18.94	44.03	53.1	47.9
24/09/2002	9:52	10	13.898	1.1	16.04	17.92	17.4	6.88	7.24	6.93	19.04	19.51	19.41	20.91	32.81	25.52
24/09/2002	10:10	11	14.713	0.2	0.14	0.14	0.14	7.47	7.48	7.47	14.28	14.3	14.29	44.85	46.16	45.5
24/09/2002	11:10	12	7.569	1.5	22.25	22.32	22.29	7.48	7.5	7.49	16.72	17.31	16.95	76.43	79.69	78.24
24/09/2002	11:17	13	8.548	1.9	22.27	22.29	22.28	7.36	7.41	7.4	16.9	17.23	16.98	70.27	76.05	74.72
24/09/2002	12:44	1	0.13	2.3	23.68	24.08	23.74	7.88	7.89	7.89	15.59	16.36	15.93	88.71	93.41	90.09
24/09/2002	12:51	2	1.925	2.4	23.3	23.66	23.52	7.77	7.78	7.78	16.51	17.11	16.71	81.01	83.73	82.48
24/09/2002	12:57	3	3.556	12.2	22.54	34.17	29.51	7.26	7.79	7.56	16.49	19.83	17.72	4.44	90.83	46.56
24/09/2002	13:04	4	5.122	1.5	21.97	23.77	22.66	7.67	7.71	7.69	16.53	17.58	16.94	75.01	87.92	81.69
24/09/2002	13:12	5	6.851	1.5	20.51	23.33	22.18	7.61	7.68	7.64	16.87	17.83	17.28	80.1	83.57	81.88
24/09/2002	13:18	6	8.58	5.3	17.97	24.09	22.35	7.53	7.61	7.56	16.81	17.72	17.58	55.05	80.37	70.55
24/09/2002	13:35	7	10.766	1.7	14.31	21.9	20.48	7.5	7.55	7.52	17.62	18.7	17.88	72.03	81.44	76.69
24/09/2002	13:40	8	11.973	0.8	16.44	21.05	19.64	7.47	7.56	7.49	18.03	18.62	18.38	72.01	83.97	76.45
24/09/2002	13:48	9	13.082	0.7	16.16	19.48	18.1	7.16	7.44	7.27	19.14	19.63	19.4	69.21	75.59	71.43
24/09/2002	13:54	10	13.898	1	17.01	17.82	17.61	7	7.03	7.01	19.58	19.89	19.68	26.25	43.26	32.6
24/09/2002	14:07	11	14.713	0.1	0.14	0.14	0.14	7.52	7.52	7.52	15.65	15.65	15.65	70.2	70.2	70.2
24/09/2002	14:59	12	7.569	1.4	22.26	22.33	22.27	7.49	7.51	7.5	17.1	17.88	17.25	81.3	83.78	82.54
24/09/2002	15:05	13	8.548	1.8	22.26	22.3	22.28	7.24	7.41	7.37	17.04	17.99	17.69	49.29	80.21	74.05
26/09/2002	8:39	1	0.13	2.3	23.71	23.98	23.85	7.86	7.88	7.87	15.32	15.94	15.46	72.25	74.23	73.42
26/09/2002	8:48	2	1.925	2.3	23.36	23.71	23.47	7.8	7.82	7.81	16.87	17.25	16.95	78.68	82.87	81.95
26/09/2002	8:56	3	3.556	12.2	22.87	34.16	30.01	7.27	7.8	7.54	16.78	19.94	17.95	3.35	85.75	41.15
26/09/2002	9:04	4	5.122	1.8	22.52	23.59	22.83	7.71	7.76	7.74	17.1	18.21	17.36	74.1	85.73	81.43

Date	Time (EST)	Station No.	Chainage (km)	Depth (m)	Backscatterance (NTU)			Chlorophyll-a (ug/L)			Density (kg/m3)			PAR		
					Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
24/09/2002	8:26	1	0.13	1.3	1.04	1.52	1.42	0.43	0.86	0.62	1017.1	1017.3	1017.2	106.8	510.9	203.2
24/09/2002	8:36	2	1.925	4.8	1.04	3.48	1.69	0	0.17	0	1016.4	1019.5	1017.1	31.5	625.3	127.2
24/09/2002	8:45	3	3.556	11.7	0.06	3.48	1.41	0	18.89	3.76	1016.2	1025	1021.1	1	498	42.5
24/09/2002	8:55	4	5.122	2.3	1.52	2.5	1.89	1.28	3.87	2.05	1016	1016.9	1016.4	75.1	620.8	187.7
24/09/2002	9:05	5	6.851	1.5	1.52	2.99	2.1	1.12	2.56	1.61	1014.8	1016.5	1015.9	113.7	675.5	264.9
24/09/2002	9:14	6	8.58	6	1.52	3.97	2.19	1.34	4.59	2.55	1012.1	1019.7	1015.9	11.7	551.9	76.2
24/09/2002	9:24	7	10.766	2.2	1.52	2.5	1.96	1.54	6.2	3.51	1010	1015.4	1014.6	117.1	1294	291.7
24/09/2002	9:32	8	11.973	0.8	2.01	2.99	2.5	5.88	10.72	8.15	1012.6	1014.6	1013.8	205.4	1172	610.4
24/09/2002	9:40	9	13.082	1.5	2.99	3.97	3.38	4.64	10.64	8.39	1012.1	1013.2	1012.9	101.5	721.7	236
24/09/2002	9:52	10	13.898	1.1	3.48	35.71	5.96	1.28	17.63	9.94	1010.6	1011.9	1011.5	188.8	1674	709.3
24/09/2002	10:10	11	14.713	0.2	4.94	4.94	4.94	0	0	0	999.3	999.3	999.3	142.8	163	152.9
24/09/2002	11:10	12	7.569	1.5	4.94	11.29	7.55	2.67	6.3	4.5	1015.7	1015.9	1015.8	284.9	2288	943.5
24/09/2002	11:17	13	8.548	1.9	5.92	11.29	6.73	3.96	7.07	5.58	1015.7	1015.8	1015.8	140.7	1638	410.3
24/09/2002	12:44	1	0.13	2.3	0.55	1.52	1.12	0.1	3.09	0.86	1017	1017.4	1017.1	396.5	1849	687.8
24/09/2002	12:51	2	1.925	2.4	1.04	2.01	1.6	0.07	1.58	0.52	1016.5	1016.9	1016.8	344.8	1897	543
24/09/2002	12:57	3	3.556	12.2	0.06	3.48	1.38	0	16.85	6.61	1016	1025	1021.2	4.2	3291	332.6
24/09/2002	13:04	4	5.122	1.5	1.52	3.48	2.03	0.12	2.08	0.8	1015.6	1016.8	1016.1	336.1	2296	700.7
24/09/2002	13:12	5	6.851	1.5	1.52	2.99	2.11	0.39	1.88	1.01	1014.3	1016.4	1015.6	450.9	2545	941.7
24/09/2002	13:18	6	8.58	5.3	1.52	3.97	2.8	1.28	4.06	2.87	1012.4	1017.2	1015.7	27.4	2536	460.6
24/09/2002	13:35	7	10.766	1.7	1.52	9.34	2.35	1.32	12.98	5.85	1009.3	1015.4	1014.2	233.6	1997	641.5
24/09/2002	13:40	8	11.973	0.8	2.01	2.99	2.67	7.33	24	17.46	1011	1014.6	1013.5	291.2	1718	877.3
24/09/2002	13:48	9	13.082	0.7	2.5	4.46	3.29	11.07	34.49	23.99	1010.6	1013.2	1012.1	190.9	1058	582.3
24/09/2002	13:54	10	13.898	1	3.48	3.97	3.61	3.77	22.31	14.91	1011.1	1011.8	1011.6	36.9	412.9	118.3
24/09/2002	14:07	11	14.713	0.1	3.48	3.48	3.48	1.05	1.05	1.05	999.1	999.1	999.1	331.2	331.2	331.2
24/09/2002	14:59	12	7.569	1.4	3.48	11.29	6.27	2.5	9.42	5.17	1015.6	1015.8	1015.7	292.3	2915	513.2
24/09/2002	15:05	13	8.548	1.8	4.94	36.69	6.89	4.33	8.08	5.82	1015.6	1015.8	1015.6	118.4	1711	378.4
26/09/2002	8:39	1	0.13	2.3	0.06	1.52	0.89	0	0.25	0.01	1017.1	1017.4	1017.3	190.9	3969	404
26/09/2002	8:48	2	1.925	2.3	0	189.56	4.05	0	1.36	0.28	1016.6	1016.9	1016.7	683	5627	1983.9
26/09/2002	8:56	3	3.556	12.2	0	3.48	1.16	0	16.85	4.78	1016.2	1025	1021.5	3.8	5424	587.6
26/09/2002	9:04	4	5.122	1.8	1.04	86.51	2.44	0	1.31	0.36	1015.9	1016.5	1016.1	206.9	4073	542.8

Table C-2 Percentage difference for DLWC (2003) data at same location & depth, different times.

Date (2002)	Time (EST)	Station No.	Chainage (km)	Depth (m)	Salinity (psu)		pH		Temperature (°C)		Dissolved O_2 (% sat)		Backscatterance (NTU)		Chlorophyll-a (µg/L)		Density (kg/m^3)		PAR	
					Mean	% Differ - ence	Mean	% Differ - ence	Mean	% Differ - ence	Mean	% Differ - ence	Mean	% Differ - ence	Mean	% Differ - ence	Mean	% Differ -ence	Mean	% Differ - ence
24/09	1244	1	0.13	2.3	23.74	0.46	7.89	0.25	15.93	2.95	90.09	18.50	1.12	20.54	0.86	98.84	1017.1	0.02	687.8	41.26
26/09	839	1	0.13	2.3	23.85	0.46	7.87	0.25	15.46	3.04	73.42	22.70	0.89	25.84	0.01	8500.00	1017.3	0.02	404	70.25
26/09	848	2	1.925	2.3	23.47	0.21	7.81	0.38	16.95	1.42	81.95	0.65	4.05	60.49	0.28	85.71	1016.7	0.01	1983.9	72.63
24/09	1251	2	1.925	2.4	23.52	0.21	7.78	0.39	16.71	1.44	82.48	0.64	1.6	153.13	0.52	46.15	1016.8	0.01	543	265.36
24/09	1257	3	3.556	12.2	29.51	1.69	7.56	0.26	17.72	1.30	46.56	11.62	1.38	15.94	6.61	27.69	1021.2	0.03	332.6	76.67
26/09	856	3	3.556	12.2	30.01	1.67	7.54	0.27	17.95	1.28	41.15	13.15	1.16	18.97	4.78	38.28	1021.5	0.03	587.6	43.40
24/09	1304	4	5.122	1.5	22.66	0.75	7.69	0.65	16.94	2.48	81.69	0.32	2.03	20.20	0.8	55.00	1016.1	0.00	700.7	22.53
26/09	904	4	5.122	1.8	22.83	0.74	7.74	0.65	17.36	2.42	81.43	0.32	2.44	16.80	0.36	122.22	1016.1	0.00	542.8	29.09
24/09	905	5	6.851	1.5	22.44	1.16	7.61	0.39	16.94	2.01	78.08	4.87	2.1	0.48	1.61	37.27	1015.9	0.03	264.9	255.49
24/09	1312	5	6.851	1.5	22.18	1.17	7.64	0.39	17.28	1.97	81.88	4.64	2.11	0.47	1.01	59.41	1015.6	0.03	941.7	71.87
24/09	1459	12	7.569	1.4	22.27	0.09	7.5	0.13	17.25	1.74	82.54	5.21	6.27	20.41	5.17	12.96	1015.7	0.01	513.2	83.85
24/09	1110	12	7.569	1.5	22.29	0.09	7.49	0.13	16.95	1.77	78.24	5.50	7.55	16.95	4.5	14.89	1015.8	0.01	943.5	45.61
24/09	1505	13	8.548	1.8	22.28	0.00	7.37	0.41	17.69	4.01	74.05	0.90	6.89	2.32	5.82	4.12	1015.6	0.02	378.4	8.43
24/09	1117	13	8.548	1.9	22.28	0.00	7.4	0.41	16.98	4.18	74.72	0.90	6.73	2.38	5.58	4.30	1015.8	0.02	410.3	7.77
24/09	932	8	11.973	0.8	19.94	1.50	7.34	2.04	18.09	1.60	64.77	18.03	2.5	6.80	8.15	114.23	1013.8	0.03	610.4	43.73
24/09	1340	8	11.973	0.8	19.64	1.53	7.49	2.00	18.38	1.58	76.45	15.28	2.67	6.37	17.46	53.32	1013.5	0.03	877.3	30.42
24/09	1354	10	13.898	1	17.61	1.19	7.01	1.14	19.68	1.37	32.6	21.72	3.61	65.10	14.91	33.33	1011.6	0.01	118.3	499.58
24/09	952	10	13.898	1.1	17.4	1.21	6.93	1.15	19.41	1.39	25.52	27.74	5.96	39.43	9.94	50.00	1011.5	0.01	709.3	83.32
24/09	1407	11	14.713	0.1	0.14	0.00	7.52	0.66	15.65	8.69	70.2	35.19	3.48	41.95	1.05	100.00	999.1	0.02	331.2	53.83
24/09	1010	11	14.713	0.2	0.14	0.00	7.47	0.67	14.29	9.52	45.5	54.29	4.94	29.55	0	100.00	999.3	0.02	152.9	116.61

Table C-3 Water Quality Results Summary of MHL (2006) records

	EC (mS/cm)		Salinity (ppt)		pH		Temperature (Deg C)		Monthly Rainfall (mm)
	Site 5	Site 7	Site 5	Site 7	Site 5	Site 7	Site 5	Site 7	Bega#
Total*									185
Mean	36.8	14.9	23.1	9.1	7.9	7.3	25.3	25.2	
Maximum	52.0	41.1	34.3	26.3	14.0	8.0	31.5	30.8	
Minimum	0.6	0.2	0.3	0.1	2.4	6.5	18.7	16.0	
St Dev	13.6	13.4	10.1	8.4	1.8	0.3	2.3	3.0	
Nov-05									90.2
Mean	29.3	1.0	18.3	0.5	5.8	7.0	22.3	20.2	
Maximum	52.0	2.8	34.3	1.5	9.7	7.6	25.0	23.8	
Minimum	2.3	0.2	1.2	0.1	2.4	6.7	18.7	16.0	
St Dev	11.8	0.4	8.0	0.2	1.4	0.2	1.5	1.7	
Dec-05									27.4
Mean	23.8	1.8	10.2	1.0	9.9	7.1	23.7	22.7	
Maximum	50.4	19.8	33.1	11.8	14.0	7.5	28.1	28.8	
Minimum	0.6	0.2	0.3	0.1	7.1	6.5	18.8	18.0	
St Dev	16.2	3.3	10.9	1.9	2.6	0.2	1.8	2.0	
Jan-06									51.8
Mean	42.3	19.2	26.6	11.6	7.6	7.2	26.5	27.1	
Maximum	50.3	35.5	33.1	22.4	8.1	7.9	31.5	30.8	
Minimum	32.2	1.1	20.1	0.6	7.0	7.0	22.5	22.9	
St Dev	3.9	9.9	3.2	6.2	0.2	0.1	1.9	1.5	
Feb-06									7.2
Mean	44.9	22.8	29.1	13.9	7.6	7.5	26.7	26.9	
Maximum	50.8	41.1	33.4	26.3	8.2	8.0	29.8	30.1	
Minimum	34.0	1.0	21.3	0.5	7.1	7.1	23.4	22.6	
St Dev	3.9	10.6	2.8	6.8	0.2	0.2	1.0	1.2	
Mar-06									8.4
Mean	46.9	32.8	30.5	20.5	8.0	7.7	26.4	27.7	
Maximum	51.2	38.4	33.7	24.4	8.3	8.0	27.6	29.3	
Minimum	43.7	27.9	28.3	17.2	7.6	7.5	25.1	26.1	
St Dev	1.8	2.4	1.3	1.7	0.2	0.1	0.5	0.6	

* - Total for measurement period = 18 November 2005 to 13 March 2006.

- Rainfall data taken from Bega Weather Station (BOM 2006). Weather data from Merimbula, the other closest station to the BRE, was also assessed. Both sites reported similar rainfall data, suggesting Bega is representative of rainfall in the BRE.

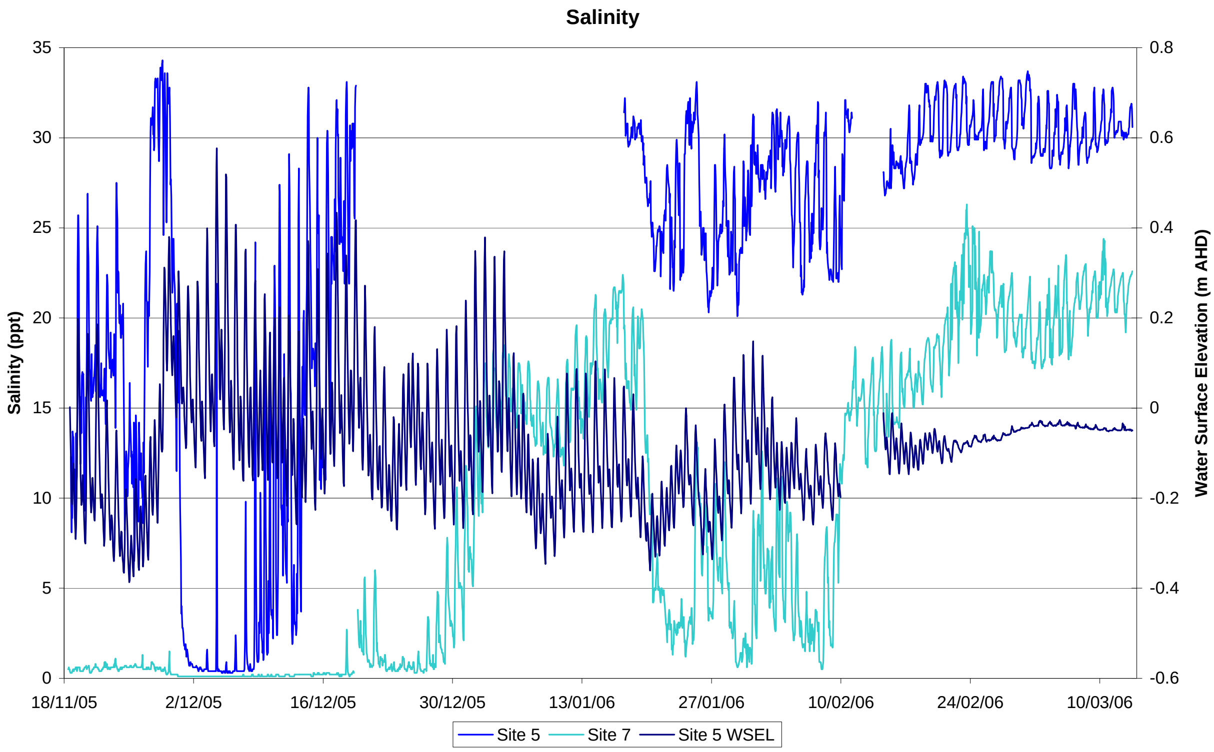


Figure C-1 Salinity Concentrations in BRE

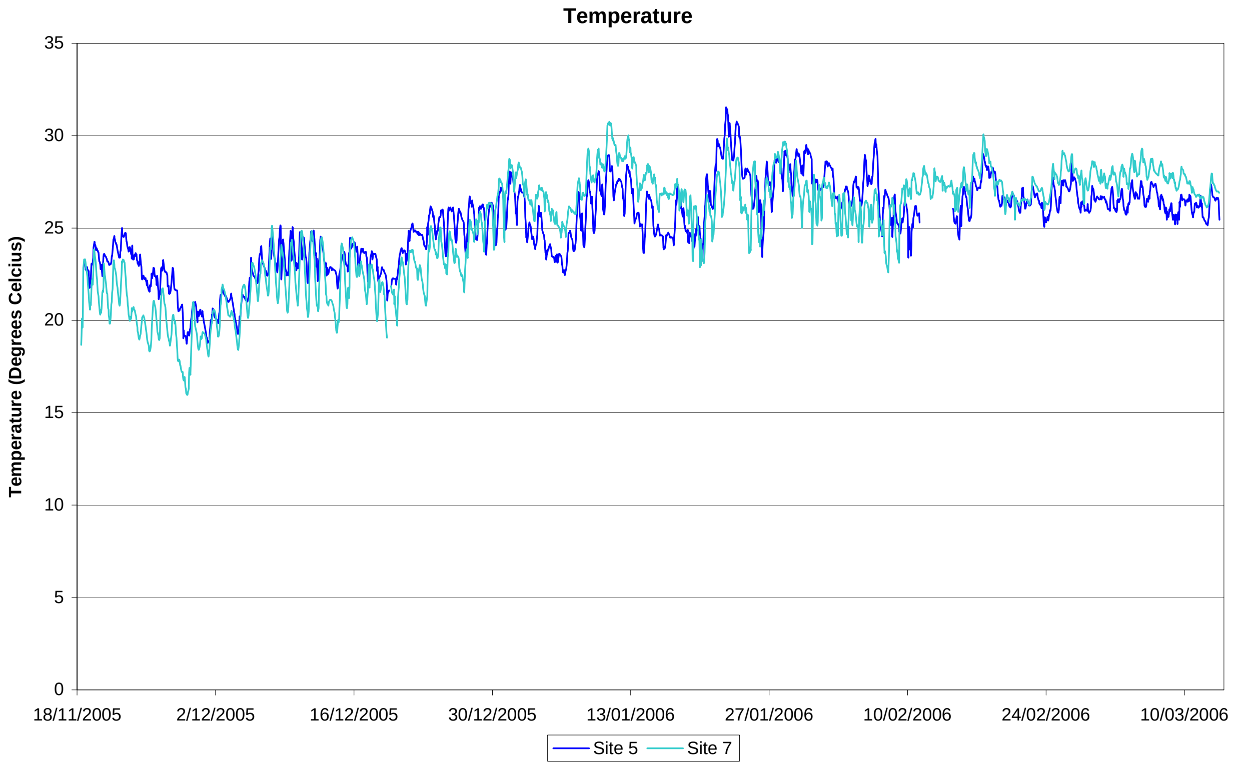


Figure C-2 **Temperature in BRE**

Table C-4 Tathra Waterwise Group Summary of Dec-95 to Apr-96 Results

Analyte	Site 1	Site 2	Site 3	Site 4
DO (mg/L)				
Median	6	7.5	8	8
Maximum	25	10	10	10
Minimum	1	5	3	2
Mean	6.89	7.64	7.43	8.11
BOD (mg/L)				
Median	2	1	1	1
Maximum	24	4	32	5
Minimum	0	0	0	0
Mean	3.73	1.26	2.63	1.22
Total Phosphorous (mg/L)				
Median	2	0.25	0.25	0.25
Maximum	8	2.5	3.5	2.5
Minimum	0.25	0.1	0.1	0
Mean	2.24	0.55	0.56	0.46
pH				
Median	8	8	8	7.5
Maximum	10	9	8	8
Minimum	7	7	7	7
Mean	7.64	7.59	7.57	7.50
Temperature (^{0}C)				
Median	18.5	19	19	19
Maximum	27	26	24	24
Minimum	12.5	11.5	13	12
Mean	18.46	18.93	18.21	18.45
Nitrate (mg/L)				
Median	0.2	0	0	0
Maximum	0.5	0.1	0.1	0.1
Minimum	0	0	0	0
Mean	0.22	0.03	0.04	0.03
Turbidity (mg/L)				
Median	15	2	0	0
Maximum	95	40	18	45
Minimum	0	0	0	0
Mean	23.02	6.76	1.43	3.04
Electrical Conductivity (mS/cm)				
Median	15.85	32	41.5	18.75
Maximum	55	92	81	56
Minimum	2	6	9	4.2
Mean	18.26	34.68	39.71	24.48

Table C-5 In-situ Water Quality Results Taken by WBM, 8 November 2005.

	Distance from entrance (km)	Depth	Salinity (ppt)	EC (mS/cm)	Turbidity (NTU)	DO (mg/L)	pH	Redox Potential (mV)	Temperature (^{O}C)
Location 1									
Surface	16.1	0.3	0.22	0.4	4.7	7.7	7.92	335	20.66
Mid depth		1.2	0.23	0.5	5	7.7	7.99	338	20.62
Bed		2.3	0.23	0.5	8.8	8	8.2	340	20.66
Location 2									
Surface	5.434	0.3	0.43	0.9	4.5	5.2	8.29	194	20.48
Mid depth		2.9	0.57	1.1	4	3.5	8.67	165	19.62
Bed		4.9	27.75	43.1	19.4	5.9	7.37	214	19.12
Location 3									
Blackfellows Lagoon Surface	3.893	0.4	5.1	9.1	134.8	5.4	7.88	293	22.35
Location 4									
Surface	3.211	0.2	2.3	4.3	23.4	7.4	8.37	408	21.8
Mid depth		0.9	2.84	5.3	34	7	8.48	407	21.62
Bed		1.8	32.15	49.2	51.8	6.8	8.23	426	17.16
Location 5									
Surface	3.173	0.6	1.95	3.7	16	8.4	7.81	334	22.34
Location 6									
Surface	1.91	0.3	2.89	5.4	7.9	8.6	8.67	423	21.54
Mid depth		2.6	34.12	51.9	36.5	8.6	8.44	444	17.16
Bed		4.7	34.27	52.1	29.8	8.6	8.4	450	17.19
Location 7									
Surface	1.402	0.3	8.02	13.9	64.9	8.1	8.21	383	23.27
Location 8									
Surface	0.55	0.3	33.98	51.7	33.6	10.4	8.52	367	15.94
Mid depth		2.8	25.08	39.4	25.5	9.9	8.5	364	18.15
Bed		5.9	34.57	52.5	35.9	10.1	8.51	371	15.99

Table C-6 In-situ Water Quality results taken by BVSC (in 2006) & MHL (in 2001)

Location	Sampling By	Date	Water Depth (m)	EC (mS/cm)	pH	Temp (^oC)	DO	Turbidity (ntu)	TDS (g/L)
Hancock Bridge	BVSC	13/06/2006	0.1	18.6	8.18	10	6.3		
Hancock Bridge	BVSC	13/06/2006	1	20.2					
Hancock Bridge	BVSC	13/06/2006	2	33.7					
Hancock Bridge	BVSC	13/06/2006	3	38.9	8.32	15.1	2.21		
Hancock Bridge	BVSC	13/06/2006	4	44.1					
Hancock Bridge	BVSC	13/06/2006	5	47					
Hancock Bridge	BVSC	13/06/2006	6	49.6	8.12	16.8	0.4		
Sand Barrage Location – Not constructed	MHL	5/07/2001	0.1	0.733	6.48	9.3		5	0.47
Sand Barrage Location – Not constructed	MHL	5/07/2001	1	18.3	7	14.9		7.8	11
Sand Barrage - Upstream	BVSC	13/06/2006	0.1	0.28	7.51	9.5	5.5		
Sand Barrage - Downstream (10 m)	BVSC	13/06/2006	0.1	1.14		10.5	5.4		
Sand Barrage - Downstream (10 m)	BVSC	13/06/2006	1	29.2	7.7	15.3	3.7		
Jellat Jellat Creek Mouth	MHL	5/07/2001	0.1	3.75	7.5	11.7		8.6	2.1
Jellat Jellat Creek Mouth	MHL	5/07/2001	1.5	26.1	7.75	16.7			15
Penooka Floodgates	MHL	5/07/2001	0	15.4					9
Penooka Floodgates	MHL	5/07/2001	1.5	24.3					15
Russells Creek Floodgate - Downstream	BVSC	13/06/2006	0.1	18.2	7.42	11.9	2.46		
Russells Creek Floodgate - Downstream	BVSC	13/06/2006	1.5	31.5	7.52	15.5	0.46		

Table C-7 Licences for Effluent Disposal (DIPNR 2004; DLWC 1999c)

Location Name	Main Effluent Type	Disposal Method	Receiving Water	Licence No
Bega Co-op Society Ltd – North Bega	Wastewater	Irrigation	Bega River	1511
"The Pines" Piggery – Springvale	Wastewater	Irrigation	Bega River	3079
Countryside Caravan Park – Kalaru	Sewage	Irrigation	Bega River	3606
Malcom Slater Pty Ltd Caltex Depot – Bega	Wastewater	Irrigation	Bega River	5808
"Happy Valley Farm" – Bega	Wastewater	Irrigation	Bega River	5166

Table C-8 Surface Water Quality Data From IGGC (2004, 2005 & 2006)

Date:					16 December 2004					15 August 2005					17 May 2006				
Comments:		ANZECC Guidelines			River mouth open, heavy rain prior to sampling										River mouth closed				
	Units	Triggers	Primary	Secondary	SW1	SW2	SW3	SW4	SW5	SW1	SW2	SW3	SW4	SW5	SW1	SW2	SW3	SW4	SW5
Field Measurements:																			
pH	pH units	**7 to 8.5**	*5 to 9*	5 to 9	8.13	7.69	7.74	7.95	7.47	8.26	8.21	8.16	8.25	7.93	7.91	8.23	8.34	8.43	7.21
Electrical Conductivity	µS/cm				15430	7756	8998	10100	11490	32510	33070	33180	36680	23570	39800	39900	40400	42400	34000
Dissolved Oxygen	% Saturation	**80 to 110**			101	88.3	88.6	105.3	92.7	**147**	99	102.8	97.5	NA	**45.11**	**71.33**	81.11	**73.44**	143.33
Redox Potential	mV				132	106	94	73	12	26	37	41	41.7	8					
Temperature	ºC				21.8	23.8	23.3	25.3	28.9	16.9	15.3	14.3	14.6	14.3	17.2	15.9	15.3	16.8	18.6
Laboratory Results:																			
Nutrients																			
Ammonia	mg/L	*0.015*			0.01	*0.02*	*0.02*	*0.03*	*0.02*	*0.02*	0.01	0.01	ND	*0.04*	0.1	*0.04*	*0.04*	*0.06*	*0.04*
Total Oxidised Nitrogen	mg/L	*0.015*			*0.09*	0.01	*0.09*	*0.09*	0.01	*0.33*	*0.07*	0.01	ND	ND	*0.03*	*0.02*	0.01	0.01	0.01
Total Nitrogen	mg/L	*0.3*			*0.55*	*1*	*0.73*	*0.61*	*1*	*0.88*	*0.31*	*0.33*	0.29	*4.8*	*0.44*	0.25	0.23	*0.31*	*2.1*
Orthophosphate	mg/L	*0.005*			*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	ND	*0.01*	ND	ND	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*
Total Phosphate	mg/L	*0.03*			*0.54*	*0.04*	*0.06*	*0.05*	*0.04*	0.02	0.03	0.03	0.03	*0.47*	0.02	0.01	0.01	0.02	0.1
Pathogens																			
Faecal Coliforms	CFU/100mL		*150*	1000	12	62	*180*	60	130	0	36	2	0	98	6	6	ND	ND	66
E.coli	CFU/100mL				12	41	180	60	130	0	36	2	0	98	6	6	ND	ND	66
Faecal Streptococci	CFU/100mL				NA	NA	NA	NA	NA	1	16	4	1	270	42	12	2	ND	500
Enterococci	CFU/100mL		*35*	230	NA	NA	NA	NA	NA	1	16	4	1	*270*	*42*	12	2	ND	*500*

Table C-9 Groundwater Water Quality Data From IGGC (2004, 2005 & 2006)

Date:					16 December 2004						9 August 2005						17 May 2006					
Comments:		ANZECC Guidelines			River mouth open, heavy rain prior to sampling												River mouth closed					
	Units	Triggers	Primary	Secondary	MW25	MW26	MW32	MW35	MW40	MW44	MW25	MW26	MW32	MW35	MW40	MW44	MW25	MW26	MW32	MW35	MW40	MW44
Field Measurements:																						
pH	pH units	7 to 8.5	5 to 9	5 to 9	7.42	7.4	6.97	7.93	7.54	7.49	7.43	7.28	7.16	7.8	7.33	7.33	7.47	7.44	7.08	7.63	7.13	6.93
Electrical Conductivity	µS/cm				9110	7381	25110	933	857	1056	8389	6400	23570	936	1183	1075	8730	6450	28500	1070	1070	1160
Dissolved Oxygen	% Saturation	80 to 110			17.1	17.3	26.2	11.7	19.5	18.1	37.2	27.7	54.3	27.9	28.5	11.3	1.67	1.44	2.56	1.00	7.22	2.56
Redox Potential	mV				-193	-98	-17	-99	142	107	-129	-99	-19	-106	40	-3	-227	-84	-117	-99	250	257
Temperature	ºC				17.4	16.9	17.6	18.3	17.5	17.9	16.6	16.2	14.3	17.4	17.4	17.5	18.6	18.3	16.8	18.0	17.3	17.2
Laboratory Results																						
Major Ions																						
Alkalinity (as CaCO3)	mg/L				299	315	541	220	242	282	298	293	550	220	291	327	310	310	550	220	290	330
Chloride	mg/L				2900	2200	8500	150	100	150	2900	2100	10000	150	170	140	2600	1800	9400	150	120	110
Sulphate	mg/L				310	260	1,100	35	38	37	290	220	1,200	44	89	74	300	220	1200	53	53	68
Calcium	mg/L				180	160	370	58	110	120	160	140	340	59	120	120	150	130	360	62	100	110
Magnesium	mg/L				200	150	610	13	7	16	160	120	580	11	12	13	160	120	620	13	7.4	17
Potassium	mg/L				70	59	280	9	12	7	77	63	180	13	20	12	75	62	160	17	15	11
Sodium	mg/L				1,700	1,300	5,800	120	65	78	1,400	1,100	4,300	110	110	100	1400	1000	5200	120	99	96
Nutrients																						
Ammonia	mg/L	*0.015*			*0.66*	*0.4*	*0.06*	*0.35*	ND	ND	*0.96*	*0.68*	*0.06*	*0.49*	ND	ND	*0.89*	*0.7*	*0.12*	*0.59*	ND	ND
Total Oxidised Nitrogen	mg/L	*0.015*			0.01	*0.02*	ND	*0.02*	*1.9*	*4.7*	ND	ND	ND	ND	*3.9*	*4.4*	0.01	0.01	0.01	0.01	*2.2*	*5.4*
Total Nitrogen	mg/L	*0.3*			*1.8*	*1.7*	*0.54*	*1.6*	*2.3*	*5.3*	*2*	*1.8*	*0.84*	*1.6*	*4.9*	*5.8*	*1.9*	*1.8*	*0.68*	*1.6*	*2.8*	*5.7*
Orthophosphate	mg/L	*0.005*			*0.11*	*0.04*	*0.13*	*0.12*	*0.04*	*0.02*	*0.19*	*0.06*	*0.12*	*0.12*	*0.03*	*0.02*	*0.19*	*0.07*	*0.18*	*0.14*	*0.05*	*0.03*
Total Phosphate	mg/L	*0.03*			*0.2*	*0.13*	*0.18*	*0.17*	*0.05*	*0.05*	*0.21*	*0.11*	*0.19*	*0.16*	*0.06*	0.03	*0.2*	*0.08*	*0.18*	*0.16*	*0.06*	0.03
Pathogens																						
Faecal Coliforms	CFU/100mL		*150*	1000	0	0	0	0	0	0	0	1	110	0	0	0	14	4	ND	ND	ND	ND
E.coli	CFU/100mL				0	0	0	0	0	0	0	1	110	0	0	0	14	4	ND	ND	ND	ND
Faecal Streptococci	CFU/100mL				NA	NA	NA	NA	NA	NA	2	1	86	0	1	0	ND	ND	ND	ND	ND	2
Enterococci	CFU/100mL		*35*	230	NA	NA	NA	NA	NA	NA	2	1	*86*	0	1	0	ND	ND	ND	ND	ND	2

Table C-10 Surface Water Quality Data from BVSC (2006 - 2010: 16 occasions, 8 entrance open / 8 entrance closed)

		SW1				SW2				SW3			
Parameter	**units**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**
pH	pH units	**8.33**	0.48	8.33	8.33	**8.43**	0.53	8.46	8.41	**8.38**	0.51	8.47	8.36
EC	mS/cm	**38.90**	11.63	36.75	43.20	**38.85**	13.15	35.95	44.75	**38.90**	13.56	35.70	44.80
DO	mg/L	**8.87**	2.39	8.17	10.04	**9.68**	2.35	9.05	10.45	**9.52**	2.10	9.27	10.72
DO %sat	%age	**102.10**	17.12	96.40	117.90	**119.80**	15.10	117.80	121.40	**115.80**	14.26	107.50	121.20
Temp	Deg. C	**19.90**	4.72	19.90	21.35	**19.90**	4.89	19.90	20.30	**17.70**	4.83	17.70	19.70
Redox Potential	mV	**118.50**	47.28	114.00	123.00	**115.00**	42.14	105.00	125.00	**97.00**	37.87	83.00	121.00
Ammonia	mg/L	**0.02**	0.03	0.04	0.01	**0.02**	0.02	0.03	0.02	**0.02**	0.02	0.02	0.02
Nox	mg/L	**0.03**	0.06	0.05	0.01	**0.01**	0.07	0.01	0.01	**0.01**	0.07	0.01	0.01
TN	mg/L	**0.48**	0.20	0.53	0.46	**0.27**	0.14	0.23	0.27	**0.27**	0.14	0.26	0.28
PO4	mg/L	**0.02**	0.03	0.02	0.02	**0.02**	0.01	0.02	0.02	**0.02**	0.01	0.02	0.01
TP	mg/L	**0.04**	0.05	0.05	0.04	**0.02**	0.02	0.03	0.02	**0.02**	0.01	0.03	0.02
FC	CFU/100mL	**2.00**	163.61	2.00	5.00	**2.00**	173.94	2.00	2.00	**2.00**	373.75	2.00	2.00
Ecoli	CFU/100mL	**2.00**	163.80	2.00	3.00	**2.00**	139.00	2.00	2.00	**2.00**	298.77	2.00	2.00
Stretococci	CFU/100mL	**6.00**	88.39	12.00	4.00	**4.00**	58.35	3.00	4.00	**2.00**	52.59	2.00	2.00
Enterococci	CFU/100mL	**6.00**	88.50	12.00	4.00	**2.00**	58.39	3.00	2.00	**2.00**	52.32	2.00	2.00

		SW4				SW5			
Parameter	**units**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**
pH	pH units	**8.58**	0.64	9.03	8.42	**8.46**	1.05	9.07	7.75
EC	mS/cm	**39.45**	13.62	33.85	46.10	**20.85**	13.82	16.75	23.50
DO	mg/L	**11.90**	3.73	15.05	9.94	**12.90**	5.01	13.86	8.59
DO %sat	%age	**131.10**	40.80	174.20	110.20	**122.70**	59.29	164.30	78.80
Temp	Deg. C	**19.80**	4.98	19.80	20.45	**23.80**	5.86	23.80	21.55
Redox Potential	mV	**86.00**	35.64	89.00	83.00	**108.50**	49.23	82.00	129.00
Ammonia	mg/L	**0.02**	0.02	0.02	0.02	**0.02**	0.03	0.02	0.04
Nox	mg/L	**0.01**	0.04	0.01	0.01	**0.01**	0.00	0.01	0.01
TN	mg/L	**0.50**	0.22	0.50	0.49	**2.35**	1.26	2.05	2.55
PO4	mg/L	**0.02**	0.01	0.02	0.02	**0.02**	0.01	0.02	0.01
TP	mg/L	**0.03**	0.03	0.04	0.03	**0.08**	0.06	0.07	0.10
FC	CFU/100mL	**2.00**	151.45	3.00	2.00	**11.00**	158.34	6.00	59.00
Ecoli	CFU/100mL	**2.00**	151.54	3.00	2.00	**11.00**	158.34	6.00	59.00
Stretococci	CFU/100mL	**2.00**	75.24	5.00	2.00	**25.00**	144.09	3.00	37.00
Enterococci	CFU/100mL	**2.00**	75.24	5.00	2.00	**18.00**	144.50	3.00	30.00

Table C-11 Groundwater Quality Data from BVSC (2006 - 2010: 16 occasions, 8 entrance open / 8 entrance closed)

		MW44				MW40				MW35			
Parameter	**units**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**
pH	pH units	**7.39**	0.52	7.30	7.40	**7.50**	0.66	7.64	7.47	**8.03**	0.40	8.02	8.03
EC	mS/cm	**1.34**	0.19	1.42	1.24	**1.24**	0.18	1.25	1.21	**1.26**	0.16	1.33	1.25
DO	mg/L	**0.59**	0.30	0.65	0.59	**1.03**	0.58	1.12	0.81	**0.59**	0.37	0.68	0.51
DO %sat	%age	**6.50**	2.56	6.90	6.35	**11.10**	4.87	11.70	8.50	**6.60**	3.96	7.40	5.45
Temp	Deg. C	**17.40**	0.61	17.50	17.30	**17.50**	0.61	17.30	17.55	**17.60**	0.57	17.10	17.60
Redox Potential	mV	**152.00**	54.57	142.00	157.00	**155.00**	38.66	152.00	180.00	**-85.00**	55.22	-102.00	-81.00
Total Alk	mg/L	**370.00**	30.52	375.00	365.00	**315.00**	37.21	320.00	295.00	**240.00**	16.54	230.00	240.00
Chloride	mg/L	**130.00**	29.18	145.00	115.00	**135.00**	29.55	130.00	140.00	**190.00**	18.96	200.00	180.00
Sulphate	mg/L	**97.00**	21.12	104.50	93.50	**75.50**	20.36	76.00	69.00	**100.00**	22.32	100.00	102.00
Dica Calcium	mg/L	**135.00**	25.00	145.00	125.00	**120.00**	19.48	120.00	120.00	**78.00**	12.83	74.50	81.50
Diss Mg	mg/L	**16.00**	3.63	14.50	16.50	**11.00**	1.89	10.35	11.00	**12.50**	1.54	12.00	13.00
Dis Na	mg/L	**100.00**	21.39	115.00	95.00	**95.00**	22.92	90.50	99.50	**140.00**	19.93	140.00	135.00
Dis K	mg/L	**17.00**	3.74	17.50	17.00	**11.50**	3.02	11.50	11.50	**29.00**	6.45	28.50	29.00
Ammonia	mg/L	**0.01**	0.01	0.01	0.01	**0.02**	0.01	0.02	0.03	**0.31**	0.14	0.37	0.30
Nox	mg/L	**4.20**	1.66	4.35	4.15	**1.35**	0.83	1.60	0.84	**0.01**	0.01	0.01	0.01
TN	mg/L	**4.50**	1.65	4.85	4.50	**1.70**	0.92	2.00	1.26	**1.30**	0.22	1.30	1.25
PO4	mg/L	**0.03**	0.01	0.04	0.03	**0.05**	0.01	0.05	0.04	**0.12**	0.01	0.12	0.12
TP	mg/L	**0.04**	0.01	0.04	0.04	**0.06**	0.01	0.06	0.06	**0.15**	0.01	0.15	0.15
FC	CFU/100mL	**2.00**	0.00	2.00	2.00	**2.00**	0.00	2.00	2.00	**2.00**	0.00	2.00	2.00
Ecoli	CFU/100mL	**2.00**	0.00	2.00	2.00	**2.00**	0.00	2.00	2.00	**2.00**	0.00	2.00	2.00
Streptococci	CFU/100mL	**2.00**	15.94	2.00	2.00	**2.00**	0.99	2.00	2.00	**2.00**	7.80	2.00	2.00
Enterococci	CFU/100mL	**2.00**	2.11	2.00	2.00	**2.00**	0.99	2.00	2.00	**2.00**	7.80	2.00	2.00

		MW25				MW26				MW32			
Parameter	**units**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**	**Median**	**SD**	**Median (open)**	**Median (closed)**
pH	pH units	**7.74**	0.28	7.82	7.74	**7.59**	0.42	7.67	7.55	**7.08**	0.29	7.12	7.06
EC	mS/cm	**9.00**	0.96	8.75	9.05	**8.19**	1.15	8.18	8.22	**31.50**	2.62	31.75	31.10
DO	mg/L	**0.52**	0.50	0.52	0.53	**0.59**	0.24	0.44	0.62	**0.55**	0.32	0.67	0.49
DO %sat	%age	**5.90**	5.72	6.30	5.75	**6.30**	2.13	6.10	6.95	**6.10**	1.81	7.10	5.70
Temp	Deg. C	**17.10**	1.23	17.00	17.55	**16.80**	1.34	16.80	17.30	**15.70**	1.55	15.60	15.80
Redox Potential	mV	**-111.00**	84.09	-133.00	-68.50	**-89.00**	26.84	-97.00	-85.00	**-44.00**	38.44	-60.00	-16.00
Total Alk	mg/L	**285.00**	76.71	260.00	302.00	**300.00**	88.37	295.00	300.50	**590.00**	164.04	590.00	610.00
Chloride	mg/L	**2800.00**	198.22	2800.00	2900.00	**2350.00**	358.64	2300.00	2450.00	**10300.00**	513.90	10150.00	10400.00
Sulphate	mg/L	**320.00**	21.60	325.00	320.00	**315.00**	50.45	300.00	320.00	**1500.00**	6603.32	1500.00	1400.00
Dica Calcium	mg/L	**160.00**	10.95	155.00	160.00	**160.00**	23.24	155.00	175.00	**400.00**	33.48	395.00	400.00
Diss Mg	mg/L	**170.00**	13.89	170.00	175.00	**150.00**	22.17	140.00	155.00	**660.00**	59.02	665.00	650.00
Dis Na	mg/L	**1400.00**	108.78	1300.00	1450.00	**1100.00**	135.00	1100.00	1200.00	**5200.00**	386.31	5100.00	5200.00
Dis K	mg/L	**71.50**	13.32	66.50	76.50	**69.50**	14.94	61.00	78.00	**190.00**	39.80	190.00	190.00
Ammonia	mg/L	**0.83**	0.12	0.73	0.86	**0.72**	0.07	0.69	0.80	**0.09**	0.02	0.08	0.11
Nox	mg/L	**0.01**	0.00	0.01	0.01	**0.01**	0.01	0.02	0.01	**0.01**	0.01	0.01	0.01
TN	mg/L	**1.75**	0.22	1.55	1.80	**1.80**	0.28	1.75	1.90	**0.75**	0.31	0.73	0.79
PO4	mg/L	**0.17**	0.04	0.15	0.18	**0.06**	0.02	0.06	0.04	**0.17**	0.01	0.16	0.17
TP	mg/L	**0.19**	0.03	0.17	0.19	**0.12**	0.02	0.11	0.12	**0.18**	0.02	0.18	0.18
FC	CFU/100mL	**2.00**	3.10	2.00	2.00	**2.00**	79.49	2.00	2.00	**2.00**	1.07	2.00	2.00
Ecoli	CFU/100mL	**2.00**	3.10	2.00	2.00	**2.00**	79.49	2.00	2.00	**2.00**	1.07	2.00	2.00
Streptococci	CFU/100mL	**2.00**	1.12	2.00	2.00	**2.00**	88.14	2.00	2.00	**2.00**	23.19	2.00	2.00
Enterococci	CFU/100mL	**2.00**	1.12	2.00	2.00	**2.00**	86.94	2.00	2.00	**2.00**	5.35	2.00	2.00

Table C-12 Proposed Median Water Quality for Tathra STP (IGGC 2004)

STP Status	Nitrogen (mg/L)	Phosphorus (mg/L)	BOD (mg/L)
Former STP	24	7.7	11.5
Upgraded STP	10	0.7	10

Table C-13 Proposed Nutrient Loads in Groundwater (IGGC 2004)

Scenario	Reclaimed Water Volume (ML/year)			Nutrient Load to Groundwater (kg/year)	
	Exfiltration	Reuse	Forced Irrigation	Nitrogen	Phosphorous
Former STP	126	50	0	3024	970
BVSP, 2004	0	100	74	740	52
BVSP, 2022	0	100	160	1600	112

Table C-14 Proposed Nutrient Loads in Receiving Waters (IGGC 2004)

		Current STP Load	Runoff Load	Total Current Load	BVSP 2004 Load Scheme	BVSP 2004 Load Total	BVSP 2022 Load Scheme	BVSP 2022 Load Total	% Load Change 2004	% Load Change 2022
Location		kg	kg	kg	kg	kg	kg	kg		
Black Ada Swamp	P	679	16	695	15.6	31.6	33.6	49.6	-95%	-93%
	N	2,117	110	2,227	222	332	480	590	-85%	-74%
Black Ada Lagoon	P	48.5	2.3	50.8	15.6	17.9	33.6	35.9	-65%	-29%
	N	151.2	16	167.2	222	238	480	496	42%	197%
Bega River	P	48.5	6,000	6,049	15.6	6,016	33.6	6,034	-1%	0%
	N	151.2	140,000	140,151	222	140,222	480	140,480	0%	0%

APPENDIX D: FLORA AND FAUNA SPECIES LISTS

Table D-1 Fish Species in Bega River System (AWT 1997; West & Jones 2001)

Family	Genus/Species	Common name	Location and Source
Ambassidae	*Ambassis jacksoniensis*	Glassy perchlets	Bega River Entrance (West & Jones, 2001)
Anguillidae	*Anguilla australis*	Short-finned lamprey	Brogo River (AWT 1997)
	Anguilla reinhardtii	Long-finned eel	Brogo River; Bemboka River (AWT 1997)
Aplochitonidae	*Prototroctes maraena*	Australian greyling	Bemboka River, Brogo River, Tantawangalo Creek (AWT 1997)
Bovichthyidae	*Pseudophritis urvillii*	Congoli	Brogo River (AWT 1997)
Cyprinidae	*Carassius auratus*	Goldfish	Brogo River (AWT 1997)
Eleotridae	*Gobiomorphus coxii*	Cox's gudgeon	Bega River; Brogo River; Bemboka River; Colombo (AWT 1997)
	Gobiomorphus australis	Striped gudgeon	Brogo River; Tantawangalo Creek (AWT 1997)
	Hypseleotris compressa	Empire gudgeon	Brogo River (AWT 1997)
	Philypnodon gradiceps	Flathead gudgeon	Brogo River, Bega River (AWT 1997)
	Philypnodon sp.	Dwarf flathead gudgeon	Brogo River (AWT 1997)
Galaxiidae	*Galaxias brevipennis*	Climbing galaxias	Brogo River; Brogo Dam (AWT 1997)
	Galaxias maculates (=attenuatus)	Jollytail/Common galaxias	Brogo River (AWT 1997)
Gerreidae	*Gerres subfasciatus**	Silver biddy	Bega River Entrance (West & Jones, 2001)
Girellidae	*Girella tricuspidata**	Luderick	Bega River Entrance (West & Jones, 2001)
Gobiidae	*Phylipnodon grandiceps*	Flathead Gudgeon	Bega River Entrance (West & Jones, 2001)
	Favonigobius lateralis	Long-finned goby	Bega River Entrance (West & Jones, 2001)
	Amoya bifrenatus	Bridled Goby	Bega River Entrance (West & Jones, 2001)
	Redigobius macrostroma	Large-mouth Goby	Bega River Entrance (West & Jones, 2001)
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove Jack	Bega River Entrance (West & Jones, 2001)
Monacanthidae	*Acanthelutres spilomelanurus*	Bridled leatherjacket	Bega River Entrance (West & Jones, 2001)
	Scobinichthys granulatus	Rough leatherjacket	Bega River Entrance (West & Jones, 2001)
	Meuschenia trachylepis	Yellow-finned Leatherjacket	Bega River Entrance (West & Jones, 2001)
	Meuschenia freycineti	Six-spined leatherjacket	Bega River Entrance (West & Jones, 2001)

Family	Genus/Species	Common name	Location and Source
	Nelsetta ayraudi	Chinaman leatherjacket	Bega River Entrance (West & Jones, 2001)
Mugilidae	*Mugil cephalus*	Bully mullet, Sea Mullet	Brogo River (AWT 1997), Bega River Entrance (West & Jones, 2001)
Percichthyidae	*Percalates colonorum*	Estuary perch	Bega River (AWT 1997)
	Macquaria novemaculeata	Australian bass	Bega River; Brogo River (AWT 1997)
Petromyzontidae	*Mordacia mordax*	Short-headed lamprey	Tantawangalo Creek (AWT 1997)
	Mordacia praecox	Non-parasitic lamprey	Brogo River (AWT 1997)
Pomatomidae	*Pomatomus saltator*	Tailor	Bega River Entrance (West & Jones, 2001)
Retropinnidae	*Retropinna semoni*	Smelt	Bemboka River; Brogo River (AWT 1997)
Salmonidae	*Salmo trutta*	Brown trout	Tantawangalo Creek (AWT 1997)
Scorpaenidae	*Notesthes robusta*	Bullrout	Brogo River (AWT 1997)
Sparidae	*Acanthopagris australis**	Bream	Bega River Entrance (West & Jones, 2001)
	*Rhabdosargus sarba**	Tarwhine	Bega River Entrance (West & Jones, 2001)
Syngathidae	*Urocampus carinirostris*	Pipefish	Bega River Entrance (West & Jones, 2001)
	Vanacampus phillipi		Bega River Entrance (West & Jones, 2001)
Teraponidae	*Pelates quadrilineatus*	Trumpeter Whiting	Bega River Entrance (West & Jones, 2001)

Table D-2 Commercial Fishing Catch for 1991-92 Fiscal Year* (NSW Fisheries 1995)

* Only those species that have ever been caught between 1954 and 1992 are listed, even if not caught in 1991-1992 year.

Species	Catch (tonnes)
Silver Biddy	
Black and Yellow Fin Bream	1438
John Dory	
Eels	498
Dusky Flathead	185
Sand Flathead	
Unspecified Flathead	20
Flounder	
River Garfish	26
Sea Garfish	
Shortbeak Garfish	
Leatherjacket	
Luderick	1457
Blue Mackeral	
Unspecified Mackeral	
Rubberlip Morwong	
Unspecified Morwong	
Flat-tail Mullet	
Sand Mullet	
Sea Mullet	4215
Mulloway	171
Pilchard	
Australian Salmon	15
Shark	
Snapper	
Tailor	
Tarwhine	
Teraglin	
Silver Trevally	197
Sand Whiting	442
Trumpeter Whiting	
Yellowtail	
Unspecified Fish	582
Total Finfish	**9246**
Octopus	
Total for all Molluscs	**0**
Mud Crab	
Sand Crab	
Unspecified Crab	
Rock Lobster	4
Greasyback Prawn	162
King Prawn	
School Prawn	295
Unspecified Prawn	
Total For all Crustaceans	**461**
Total for all species	**9707**

Table D-3 Threatened Flora Species in the Bega River Catchment (BVSC 2005)

Family Name	Species Name	Legal Status
Fabaceae (Mimosoideae)	*Acacia georgensis*	V
Rutaceae	*Correa baeuerlenii*	V
Myrtaceae	*Eucalyptus parvula*	V
Proteaceae	*Grevillea acanthifolia subsp. paludosa*	E1
Euphorbiaceae	*Monotaxis macrophylla*	E1
Rhamnaceae	*Pomaderris cotoneaster*	E1
Rhamnaceae	*Pomaderris elachophylla*	E1
Rhamnaceae	*Pomaderris parrisiae*	V
Santalaceae	*Thesium australe*	V

Table D-4 Threatened Fauna Species in the Bega River Catchment (BVSC 2005)

Family Name	Species Name	Common Name	Legal Status
Hylidae	*Litoria aurea*	Green and Golden Bell Frog	E1
		Stuttering Frog	V
Anseranatidae	*Anseranas semipalmata*	Magpie Goose	V
Anatidae	*Oxyura australis*	Blue-billed Duck	V
Ardeidae	*Botaurus poiciloptilus*	Australasian Bittern	V
Accipitridae	*Pandion haliaetus*	Osprey	V
Accipitridae	*Lophoictinia isura*	Square-tailed Kite	V
Falconidae	*Falco hypoleucos*	Grey Falcon	V
Haematopodidae	*Haematopus longirostris*	Pied Oystercatcher	V
Haematopodidae	*Haematopus fuliginosus*	Sooty Oystercatcher	V
Charadriidae	*Thinornis rubricollis*	Hooded Plover	E1
Charadriidae	*Charadrius mongolus*	Lesser Sand Plover	V
Laridae	*Sterna albifrons*	Little Tern	E1
Cacatuidae	*Calyptorhynchus lathami*	Glossy Black-Cockatoo	V
Psittacidae	*Pezoporus wallicus wallicus*	Ground Parrot (eastern subsp.)	V
Psittacidae	*Lathamus discolor*	Swift Parrot	E1
Strigidae	*Ninox strenua*	Powerful Owl	V
Strigidae	*Ninox connivens*	Barking Owl	V
Tytonidae	*Tyto novaehollandiae*	Masked Owl	V
Tytonidae	*Tyto tenebricosa*	Sooty Owl	V
Petroicidae	*Melanodryas cucullata*	Hooded Robin	V

Petroicidae	*Petroica rodinogaster*	Pink Robin	V
Pachycephalidae	*Pachycephala olivacea*	Olive Whistler	V
Estrildidae	*Stagonopleura guttata*	Diamond Firetail	V
Dasyuridae	*Sminthopsis leucopus*	White-footed Dunnart	V
Dasyuridae	*Dasyurus maculatus*	Spotted-tailed Quoll	V
Dasyuridae	*Phascogale tapoatafa*	Brush-tailed Phascogale	V
Peramelidae	*Isoodon obesulus obesulus*	Southern Brown Bandicoot (eastern)	E1
Phascolarctidae	*Phascolarctos cinereus*	Koala	V
Burramyidae	*Cercartetus nanus*	Eastern Pygmy-possum	V
Petauridae	*Petaurus australis*	Yellow-bellied Glider	V
Potoroidae	*Potorous tridactylus*	Long-nosed Potoroo	V
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying-fox	V
Vespertilionidae	*Myotis adversus*	Large-footed Myotis	V
Vespertilionidae	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	V
Vespertilionidae	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	V
Vespertilionidae	*Scoteanax rueppellii*	Greater Broad-nosed Bat	V
Dugongidae	*Dugong dugon*	Dugong	E1
Balaenopteridae	*Megaptera novaeangliae*	Humpback Whale	V

APPENDIX E: COMMUNITY NEWSLETTERS AND WORKSHOP OUTCOMES

Bega River
Estuary Management Plan

NEWSLETTER NO. 1

August 2006

How the estuary works...

This is the first in a series of community newsletters about the Bega River Estuary Management Plan. This newsletter describes the environmental processes occurring within the Bega River Estuary, or 'how the estuary works!'

The Bega River Estuary Management Plan is being developed by Bega Valley Shire Council and State Government (Department of Natural Resources) to guide future management of the estuary, keeping it healthy and productive.

Council is holding a **public workshop** to get feedback from the community on the values of the estuary (ie what's good about it) and issues that need to be addressed (ie what's bad about it). The Estuary Management Plan will then target these aspects when developing future strategies and actions. ***All readers of this newsletter are invited to attend the workshop. Further details are provided at the end of this newsletter.***

Area covered

The Bega River Estuary Management Plan covers the tidal section of the Bega River (ie the estuary). This extends from the river entrance at Mogareeka Inlet to Bottleneck Reach near Jellat Jellat flats. Activities beyond the banks of the estuary can have a big impact on its health. Therefore, the entire water catchment will also be considered as part of the Plan depending on the issue. The entire catchment of the Bega River covers an area of 1,940km^2.

Tides, floods and the entrance

A unique feature of the Bega River is that the ocean entrance to the river is usually closed, or shoaled with sand. This means that tides cannot move easily in and out of the river, and natural tidal flushing of the river is limited.

Periodic closure of the entrance is a natural process for the Bega River. Waves stirring up sand on Tathra Beach produce a 'sand spit' across the river entrance. When the sand spit covers the whole entrance, it acts like a dam and holds back water within the river. Water levels in the river need to get high enough to overtop the sand spit (usually as a result of heavy rainfall). This causes a 'breakout' event, which scours a new channel through the spit.

Russell Creek Weir and floodgates, stops brackish estuarine water from backing up into Penooka Swamp.

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When the entrance is closed for an extended period, a temporary sand barrage (dam) is constructed near the upper reaches of the estuary to stop saltwater pushing into areas that are usually freshwater, and used for stock watering, irrigation etc. A floodgated weir on Jellat Jellat (Russell) Creek also prevents estuarine water from inundating the SEPP-14 wetland in Penooka Swamp.

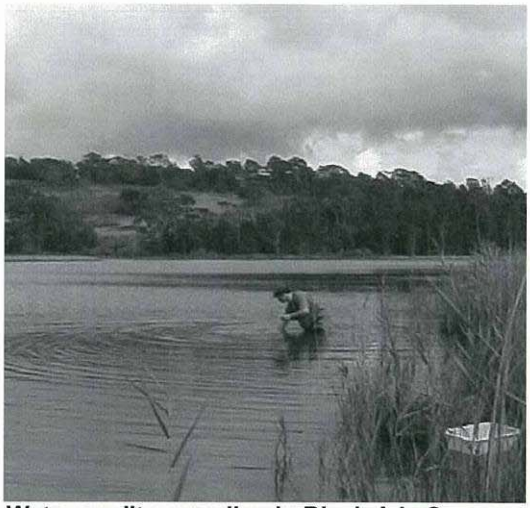
If, when the entrance is closed, water levels in the estuary get too high, and thus represent a flooding risk, Council will artificially construct a channel through the sand spit. The water level at which the entrance is artificially opened is RL 1.36m AHD, measured at Hancock Bridge. A permit from National Parks and Wildlife is required before the entrance can be opened.

Large floods in the river can completely remove all sand from the entrance area, with the sand pushed out to form offshore bars just beyond the wave breaker zone. Waves usually return this sand back onto the beach and into the entrance over a period of weeks to months after the flood.

Water quality

Water quality within the estuary is dependent on two main factors, (i) the condition of the entrance, and (ii) runoff from the water catchment.

The degree of natural tidal flushing is dependent on how 'open' the entrance is. After a flood, the entrance is usually deep and wide, which allows for regular (twice daily) tidal flushing. When closed, there is no tidal flushing and everything that enters the river is completely retained. The process of entrance closure, in isolation, does not necessarily result in water quality degradation. Water quality becomes degraded only after it receives inputs from the catchment or other sources.



Water quality sampling in Black Ada Swamp, carried out as part of the Tathra STP upgrade works

The estuary is at the very downstream end of the whole Bega River catchment. Rainfall within the catchment will result in runoff into the estuary. This runoff can contain pollutants (eg, sediment, nutrients and bacteria). Water quality in the estuary therefore becomes poor after catchment rainfall (which can be amplified if the entrance remains closed during the event).

The amount of pollutants washing off the catchment depends on the type of landuse. Forests and native vegetation do not produce many pollutants. Urban and agricultural lands on the other hand tend to produce relatively high pollutants, especially if lands are managed poorly.

Pollutants can also enter the estuary from direct sources, such as through Sewage Treatment Plant (STP) discharges and overflows, and septic tank leachate. Council is currently upgrading their STPs to reduce the impacts of sewage effluent on the environment.

Excess pollutants (especially nutrients) in the estuary may cause algae blooms, which can have a range of follow-on effects, including fish kills. Excess bacteria can also pose a significant health risk to swimmers.

Sediments

When the entrance is closed or heavily shoaled, sediment washed off the catchment is stored within the estuary channel. Periodic flood events then flush this sediment out of the estuary and into the ocean. The Bega River is one of only very few rivers on the south-east coast of Australia that delivers coarse sediment to the ocean (most other rivers retain the sediment within estuary channels and floodplains).

The amount of sediment washing off the catchment is also dependent on landuse. Some agricultural practices can expose soils that are more susceptible to erosion during rainfall. Stock watering directly from the riverbank can also result in bank erosion and sedimentation within the river.

It is believed that clearing and development within the catchment since European settlement has unleashed a large amount of sediment from the catchment over the past 50 – 100 years, which is now being transported through the river system.

Bank erosion

The alluvial nature of many of the estuary's riverbanks makes them susceptible to erosion, particularly when mobile sand shoals in the river channel temporarily force floodwaters to impinge onto the banks. Bank erosion in the estuary is therefore indicative of the estuary's mature geological state and the relatively high rate of sediment transport through the system.

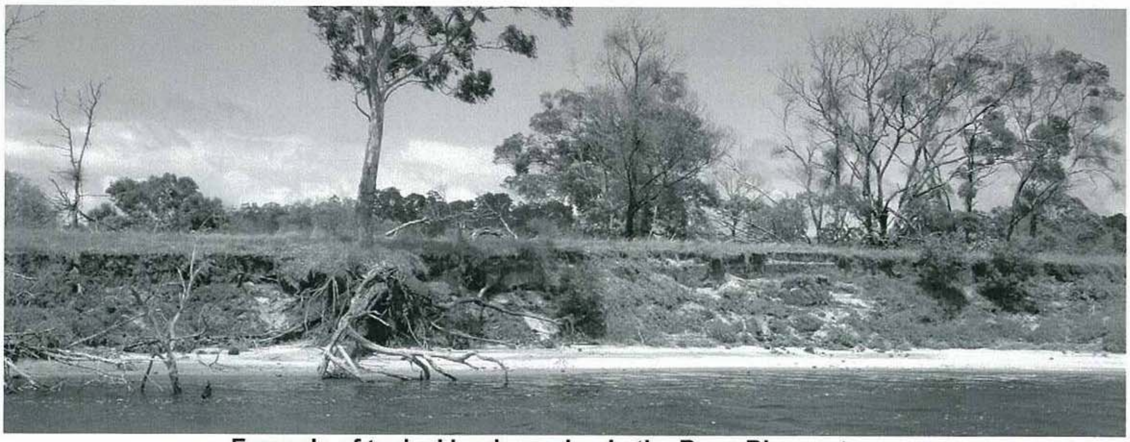
In some locations at the downstream end of the estuary, namely along the golf course foreshore and adjacent to the Mogareeka boatramp, bank erosion has been amplified by wind and/or boat wake wave action.

Ecology

The Bega River Estuary is an important location for a number of threatened and migratory bird species. Little Tern regularly nest on the river entrance sand spit, while Hooded Plover and Oystercatchers also utilize the entrance shoals.

The upper catchment of the Bega River remains in a mostly forested condition, with creeks and tributaries generally in good health. Land clearing within the lower catchment and along riverbanks has degraded the condition of the lower river and estuarine reaches. Weed infestation also degrades areas of native vegetation.

Along the river are emergent reeds and sedges, while some seagrasses are found on the channel bed. There is limited information regarding the relative abundance of plants and animals throughout the estuary and the wider landscapes.



Example of typical bank erosion in the Bega River estuary

Waterway usage

The Bega River Estuary is an important recreational resource to locals and visitors alike, offering opportunities for a range of activities including swimming, boating, fishing, sailboarding and water-skiing, particularly during the summer holidays. The population of Tathra village increases by 70% during the peak tourist season.

The most heavily used part the estuary is Mogareeka Inlet, between the mouth of the river and Hancock Bridge.

Human impacts on the estuary

All environmental processes occurring within the estuary are inter-related. Therefore, small changes to one aspect of the environment may result in significant impacts to other aspects.

Humans have unfortunately changed many aspects of the environment. Catchment development, pollutant inputs, waterway usage and entrance modifications are expected to have altered virtually every environmental process within the estuary to some degree. Fortunately, most environmental processes are reasonably robust and can adapt to some change, although once a threshold is surpassed, consequences can be disastrous. The Bega River Estuary Management Plan aims to protect the estuary from further environmental degradation, and to promote sustainable industries and development in a balanced and responsible manner.

WORKSHOP INVITATION

You are cordially invited to attend a **Community Drop-in Session and Workshop** regarding the Bega River Estuary Management Plan.

Display panels will present the outcomes of the Bega River Estuary Processes Study, while an evening workshop is also planned involving an interactive discussion regarding:

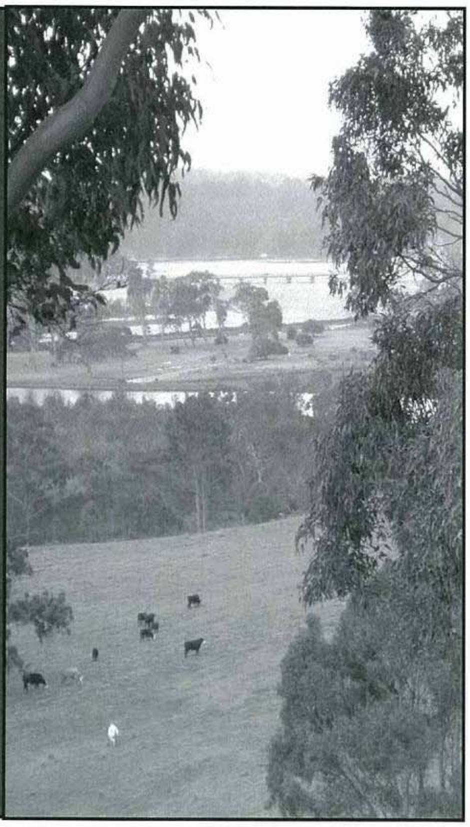
- The ecological, social and commercial values of the estuary;
- The issues that need to be addressed by future management; and
- Possible management options to address issues.

Place: **Tathra Hall**
9 Bega Street, Tathra

Date: **Thursday 24 August 2006**

Time: Drop-in session from 4pm
Workshop starting 7pm

For further details, please contact Verity Rollason or Philip Haines on (02) 4940 8882, or by email at vrollason@wbmpl.com.au



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What are the values of the estuary? These are the <u>positive</u> aspects that are worth protecting in the future (eg, migratory bird roosting habitat, good fishing spots, good views etc)

Put a mark next to the top three values

- Naturalness (1)
  - Unspoilt Beauty
  - Natural Diversity
  - Isolation
  - Surrounding forest

- Recreational values (2)
- Economic (3)
  - Low intensity
  - Tourism

- Educational (4)
- Visual amenity
- Small estuary
- Public access
- Threatened Species
- Good water quality
- Safe recreation area (swimming)
- Wildlife corridor
- Aboriginal cultural sites
- Unique heritage sites, Vimy Ridge Mines
- Relatively undeveloped
- Economic value
- Fishing/Fish population
- Water quality

- Many popular recreation spots all along river
- Close to town but unspoilt
- Education value
- Fish life and abundance of bird life in estuary good habitat
- Scenic values
- Recreational activities/leisure (fishing, waterskiing, prawning, canoeing, children, safe clean entrance area, sightseeing - ???? from town on bikes Lions Park, walking, picnic (2)

- Clean water good quality when open
- Trees on banks - scenic value
- Abundant birdlife undisturbed
- Both sides of bridges at Mogareeka used for families
- Small boats access up river
- Recreation area at Mogareeka inlet (jetty at mogareeka)
- Keeping entrance open
- Ferns on berms and Lions Park
- Golf Course around estuary
- Clean water (2 days after rain, river is brown, take a week to clear)
- Safe swimming in differing depths (2)
- Islands
- Feeling of wilderness along entire foreshore and isolation (1)
- Tourism to local economy (3)

Bega River Estuary Management Plan: Community Workshop 24 August 2006

What are the issues facing the estuary? These are the negative aspects that need to be fixed in the future (eg, bank erosion, future development, pollution, poor access to foreshore, etc)

Put a mark next to the top three issues

- Water quality/management issues (1)
- No effective protective instrument to protect Estuary/values (2)
- Potential for inappropriate development (3)
- Climate change (4)

- Recreation activities -vs- threatened species
- Further development on estuary
- Recreation conflict (inappropriate use of ?????
- Recreation impact on foreshore
- Green algae near STP
- Erosion/sedimentation from private tracks
- Odours from STP
- Climate change/sea levels
- Reduced rainfall
- Excessive clearing of ????? on steep north slopes
- More public access
- Pedestrian access/walking tracks
- Dumping of fishing waste attracting silver gulls
- Lack of constant water quality data
- No effective planning instrument to protect estuary and values
- Lack of financial resources

Rec overfishing - fish quotas too high for closed Estuary (4)

- No public access thru Thompson (private land)
- Lack of vegetation along foreshore
- Waterskiing, powerboats = noise

- Foreshore development threat - over population pressure on Estuary and pollution aspects
- Boatramp at bridge - need another ramp further up river
- Gravel carpark and bridge adds sediment to estuary (3)
- Fish offal and ramp peak times if closed (3)
- Fish cleaning tables needed
- Rural Res ??? and APZ ???? on

  - Peer soils Goats Knob Road one example (1)
  - Sediment runoff to Blackfellows lagoon
  - Riparian ???? last row of trees at a number of locations - private land (2)
  - Russels Creek floodgate closed unnatural feature

- Entrance opening (keeping open) (1)
- Siltation
- Salt backing up when mouth is closed
- Dirt runoff - brown water after rain water quality for swimming (3)
- Appropriate/No development (2)
- Begins to smell at Mogareeka
- Golf Course
- Lions Park (loss of trees) pieces of old bridge near where people swim
- Flooding - road being cut when water level high
- Development - don't want to see from River (2)
- Keep development further from Estuary
- Paint colour of toilet block at Mogareeka

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What are the options for the estuary? These are the <u>solutions</u> that will protect the values and fix the issues (eg, on-ground works, planning controls, new conservation areas, etc). Options can be targeted towards the values and issues identified, or can be more general.

Put a mark next to the top three options

- Estuary Plan incorporated in LEP and other government instruments (Gazettal) including sewerage (no development until relevant studies done) (1)
- More funding for estuary incentives for landholders
- Effective water quality monitoring (2)
- Define management responsibilities
- Report to community on management
- No development on steep slopes
- Recreation/education strategy
- Sourcing Federal funding
- River opening policy
- Education
- Political will
- Sound recommendations for riparian buffers/filter strips
- Effective soil and water management
- Preserve and enhance current recreation opportunities
- Limit clearing on Rural Res - better planning mechanisms (1)
- Identify issue to attract funding to support landowners (2)
  - ????? land holders
  - education
- Foxes/feral animal control
- Raising Road
- Seal southern carpark, landscaping and foreshore vegetation:-
  - Control runoff
  - Signage, education
- Bike path continue to Mogareeka
- Fish cleaning table and ramp
- No need for new boatramp on south side too low
- Russell Creek open floodgate to manage levels
- Buying back headlands/foreshore so it is not developed
- Land zoning along banks, buffer zones along creeks
- Protecting foreshores
- Revegetation of riverbanks
- Maintenance of trails (silt traps on ????)
- More frequent opening, opening policy to keep as is (1.36m)
- Siltation
- Release more water from Brogo
- Keep Mogareeka natural
- Keep water quality
- Lions Park revegetate along carpark
- Cost of dredging to replace sand at Lions Park

Bega River Estuary Management Plan: Community Workshop 24 August 2006

Bega River
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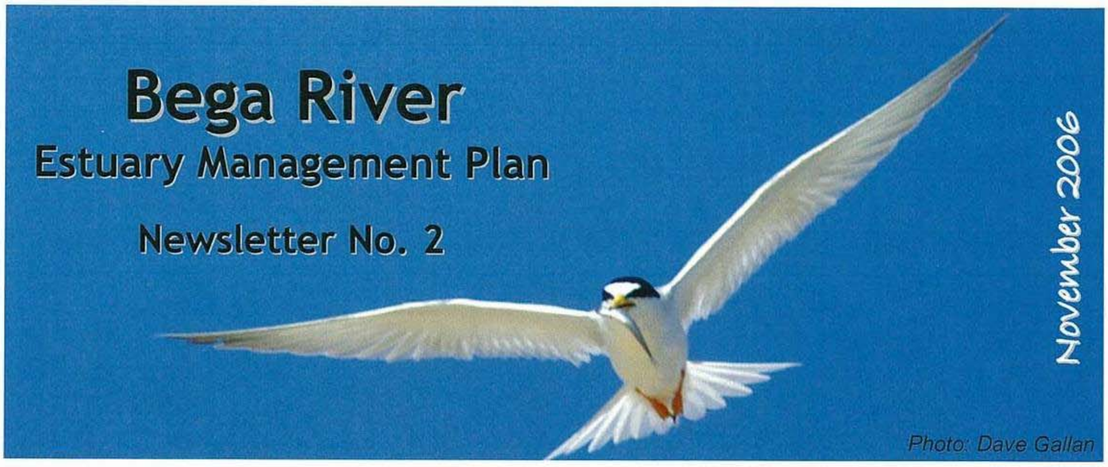
Newsletter No. 2



Directions for future management...

Introduction

This is the second in a series of community newsletters about the Bega River Estuary Management Plan. The Management Plan is being developed by Bega Valley Shire Council and State Government (Department of Natural Resources) to guide future management of the estuary, keeping it healthy, productive and sustainable.

This newsletter describes the outcomes of a recent community workshop, and presents some suggested directions and objectives for future management of the Bega River Estuary. Management objectives have also considered the findings of the Bega River Estuary Processes Study, which is available on Council's web-site and was summarised in the first community newsletter.

Process followed

Future management of the Bega River Estuary should be directed towards preserving the positive aspects of the estuary (that is, its 'values'), and remediating the negative aspects of the estuary (that is, its 'issues').

Values and issues of the Bega River Estuary were identified through the community workshop and a review of existing scientific data and information.

Goals and Objectives defining management directions were then established on the basis of these estuary values and issues.

It is intended that a series of management strategies be developed for the Bega River Estuary following confirmation and endorsement of the proposed management objectives. The strategies would address each management objective through a program of strategic works and actions. Some strategies have already been suggested by the community during the recent workshop.

Estuary values

Values of the Bega River Estuary were identified through the community workshop process. The values that were considered to be most important were:

- 'Naturalness' (biodiversity and abundance of life, including birds, fish, and threatened species);
- Natural beauty (feeling of wilderness and isolation) and scenic amenity;
- Recreation / leisure (safe swimming [especially for children], fishing, waterskiing, prawning, canoeing, walking, picnicking, etc);
- Economic (especially tourism, which is reliant on other existing estuary values, and agriculture); and
- Educational opportunities.

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Other values identified by the community include Aboriginal cultural sites, unique heritage sites (eg Vimy Ridge Mines), the surrounding forest / National Parks, existing riparian vegetation, good public access to foreshores, small boat access along river, good water quality, existing wildlife corridors, and the existing lack of development along foreshores.

Estuary issues

Twenty eight (28) separate issues were identified through the community workshop and a review of the existing technical data (as highlighted in the previous Estuary Processes Study). The most important issues have been identified as:

- Existing catchment management practices, eg stock watering from the river, unfiltered sediment and nutrient runoff, sediment runoff from cleared bushfire Asset Protection Zones (APZ) around rural-residential development, especially on steep slopes;
- Loss of riparian vegetation along foreshore, especially on private lands;
- Excessive / inappropriate development (especially visible / obtrusive) around the estuary and the associated results of population growth, water quality impacts, effluent disposal and loss of social and recreational amenity;
- Public infrastructure (existing condition, need for additional infrastructure);
- Overfishing by recreational fishers (ie, bag limits too high given the sensitivity of the estuary);
- Artificial entrance management to balance competing human and environmental needs;
- Potential poor water quality given catchment and point source inputs of pollutants;
- Climate change, including sea level rise, wave climate (and associated entrance processes) and rainfall / evaporation;
- Lack of effective planning instruments to protect estuary values;
- Protection of threatened species from recreation; and
- Unnatural hydrological regime of SEPP-14 wetlands.

Remaining issues covered a wide variety of topics, including salt intrusion, inundation of roads when the entrance is closed, odour, algae, bank erosion, recreational user conflicts and impacts, past catchment development, lack of data (especially water quality data), weeds, and Council's / Government's financial capacity to undertake management works.

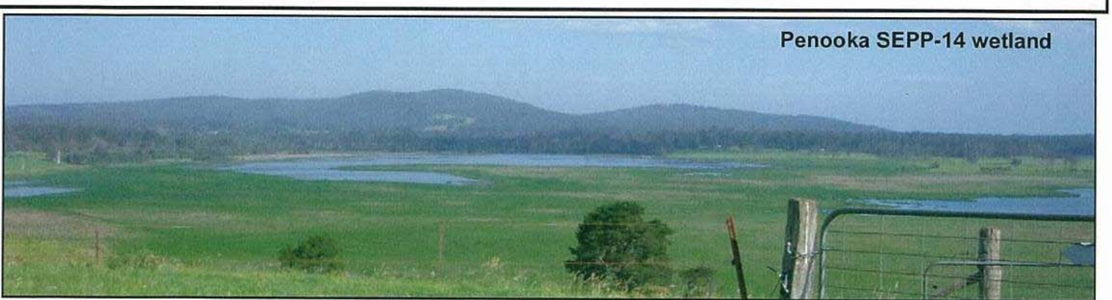
Management goals/principles

Management of the Bega River Estuary will accord to the following overarching goals, or principles:

1. The healthy, diverse and viable ecosystems of the Bega River Estuary shall be maintained and protected for future generations

2. The scenic beauty and wilderness character of the Bega River Estuary shall be preserved for enjoyment by residents and visitors now and in the future

3. The Bega River Estuary shall remain a place of great recreational and tourism value, with minimum impacts on the natural environment


Penooka SEPP-14 wetland

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Management objectives

A series of specific objectives to guide future management of the Bega River Estuary has been developed.

The objectives have been grouped into a number of categories covering the main areas for future management need.

Ecology and biodiversity

1. Enhance and protect the vegetation and natural habitats of the estuary, its riparian zone and the broader catchment landscape, including wildlife corridors.

2. Establish, maintain and protect healthy populations of native estuary species (including fish, prawns, birds), especially threatened species, such as Little Tern and Hooded Plover.

3. Establish a hydrological regime that maintains estuarine processes, through sufficient freshwater inflows, ocean interactions and backswamp inundation.

4. Reduce the prevalence and impacts of weeds and pests on the estuary.

Amenity

5. Enhance or modify public access and infrastructure to meet recreational needs without impacting on the estuary and its habitats.

Little Tern nesting on Bega River entrance shoals

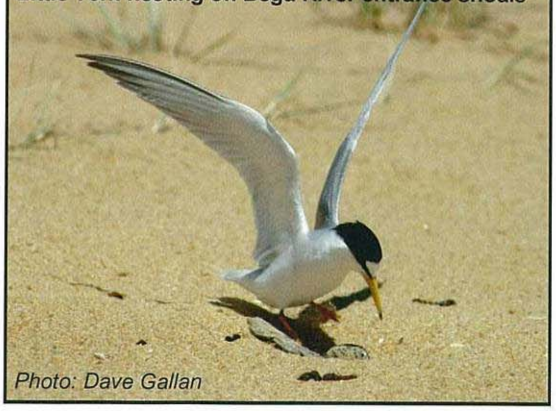

Photo: Dave Gallan

6. Rationalise multiple recreational usages of the estuary to maximise enjoyment by all users without impacting on the estuary and its habitats.

7. Educate the residents and visiting public regarding the values and importance of the estuary.

Development

8. Future development shall not degrade the scenic amenity of the estuary.

9. Future development shall be ecologically sustainable and have a net positive impact on the estuarine environment.

10. Future development shall be prohibited from areas of unsuitable capability (e.g. steep slopes, highly erosive soils, sensitive adjacent environments, important existing habitats, prominent visual landmarks etc).

Heritage

11. The unique Aboriginal and European heritage of the estuary shall be recognised, protected and appreciated by current and future generations.

Economic

12. Support and encourage economic industries and associated practices that do not impact on the environmental values of the estuary (including tourism, agriculture, recreation).

Water quality and sediments

13. Water quality of the estuary shall meet requirements for maintaining environmental health and for minimising risks to human health.

14. Reduce the inputs of sediment and pollutants from areas of past land clearing and development (including rural residential, agriculture, urban, Sewage Treatment Plants, golf courses and bushfire buffers (APZs).

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Bank erosion

15. Stabilise existing areas of bank erosion, where appropriate, and limit potential for future erosion.

Entrance management

16. Achieve a sustainable entrance management regime that minimises artificial entrance manipulation for maximum ecological benefit whilst recognising and accommodating social and economic impacts of foreshore flooding when water levels are high.

Climate change

17. Ensure that future climate change is considered when making long-term decisions regarding the estuary and its catchment (e.g. development, landuse changes, and construction of roads, stormwater treatment measures and other infrastructure).

Management mechanisms

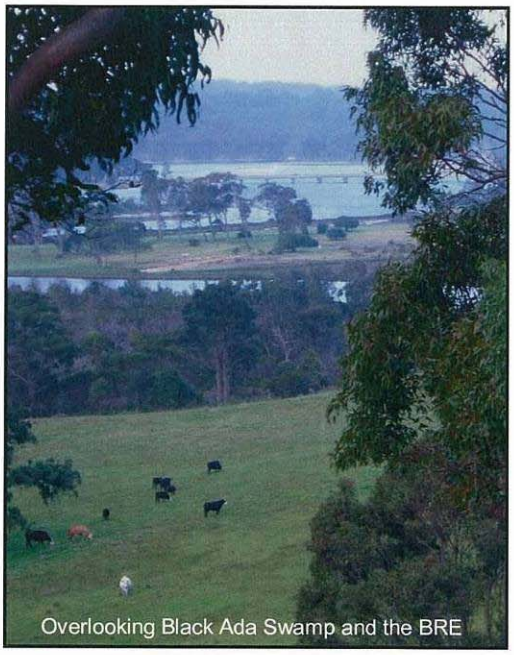
18. Relevant environmental planning provisions shall consider and protect the environmental values of the estuary.

19. Relevant agencies shall provide sufficient financial and personnel resources to fulfill this Plan and shall be held accountable for its implementation.

20. Monitoring and evaluation of Plan outcomes will guide periodic modifications and adaptations of this Plan.

21. The community shall be informed periodically on implementation of the Plan, and will continue to be engaged regarding future management of the estuary.

22. Continue to collect and share information and knowledge to promote on-going learning about the Bega River Estuary and its catchment.



Overlooking Black Ada Swamp and the BRE

What happens next...

The community is now invited to provide comments on the objectives and directions for future management of the Bega River Estuary.

Further, the community is invited to suggest a priority ranking for the objectives (using the attached return page). This ranking will be used to help establish an order for undertaking specific works in the future.

Where possible, the community should also provide suggestions for ways to meet the objectives. These suggested actions can be site-specific, or more strategic in nature. It is expected that a wide range of strategies will be required to meet the future management need of the estuary and ensure its long term sustainability.

Community comments should be provided to:

Dr Philip Haines
WBM Pty Ltd
PO Box 266 BROADMEADOW NSW 2292

Deadline for submissions: 1 December, 2006

For further information, please contact Philip on (02) 4940 8882 or phaines@wbmpl.com.au

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Management Objectives	Proposed ranking (from 1 to 21, 1 being most important, 21 being least important)
Ecology and biodiversity	
1. Enhance and protect the vegetation and natural habitat values of the estuary, its riparian zone and the broader catchment landscape.	
2. Establish, maintain and protect healthy populations of native estuary species (including fish, prawns, birds), especially threatened species.	
3. Establish a hydrological regime that maintains estuarine processes, through sufficient freshwater inflows, ocean interactions and backswamp inundation.	
4. Reduce the prevalence and impacts of weeds and pests on the estuary.	
Amenity	
5. Enhance or modify public access and infrastructure to meet recreational needs without impacting on the estuary and its habitats.	
6. Rationalise multiple recreational usages of the estuary to maximise enjoyment by all users without impacting on the estuary and its habitats.	
7. Educate the residents and visiting public regarding the values and importance of the estuary.	
Development	
8. Future development shall not degrade the scenic amenity of the estuary.	
9. Future development shall be ecologically sustainable and have a net positive impact on the biophysical environment of the estuary.	
10. Future development shall be prohibited from areas of unsuitable capability (e.g. steep slopes, highly erosive soils, sensitive adjacent environments, important existing habitats, prominent visual landmarks etc).	
Heritage	
11. The unique Aboriginal and European heritage of the estuary shall be appreciated and enjoyed by current and future generations.	
Economic	
12. Support and encourage economic industries and associated practices that do not impact on the environmental values of the estuary (including tourism, agriculture, recreation).	
Water quality and sediments	
13. Water quality of the estuary shall meet requirements for maintaining environmental health and for minimising risks to human health.	
14. Reduce the inputs of sediment and pollutants from areas of past land clearing and development	
Bank erosion	
15. Stabilise existing areas of bank erosion, where appropriate, and limit potential for future erosion.	
Entrance management	
16. Achieve a sustainable entrance management regime that minimises artificial entrance manipulation for maximum ecological benefit whilst recognising and accommodating social and economic impacts of foreshore flooding when water levels are high.	
Climate change	
17. Ensure that future climate change is considered when making long term decisions regarding the estuary and its catchment	
Management mechanisms	
18. Relevant environmental planning provisions shall consider and protect the environmental values of the estuary.	
19. Relevant agencies shall provide sufficient financial and personnel resources to fulfill this Plan and shall be held accountable for its implementation.	
20. Monitoring and evaluation of Plan outcomes will guide periodic modifications and adaptations of this Plan.	
21. The community shall be informed periodically on implementation of the Plan, and will continue to be engaged regarding future estuary management.	
22. Continue to collect and share information and knowledge to promote on-going learning about the Bega River Estuary and its catchment	

Additional comments (eg possible changes to wording of objectives, additional objectives, and suggestions on ways to meet the objectives).

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APPENDIX F: MULTI CRITERIA ASSESSMENT OF SHORT-LISTED MANAGEMENT STRATEGIES

	Objective score	17.9	17.3	16.9	16.3	14.6	14.3	13.9	13.6	13.6	13.3	13.2	13.2	12.9	12.9	11.6	11.5	10.9	9.9	9.1	8.7	8.6	7.4							
	Management Objectives	C	J	A	B	F	P	R	M	N	D	K	H	E	I	Q	O	G	S	L	V	T	U							
	Objective rank	1	2	3	4	5	6	7	8	8a	10	11	12	13	13a	15	16	17	18	19	20	21	22	OBJ_SCORE	cost_factor	cost descrtn	COST_SCORE	Effect_factor	OVERALL_SCORE	Overall_rank
Code	Management Options																								1=h,2=m,3=l			3=h,2=m,1=l		
P-1	Preserve foreshore land to provide a riparian buffer from development and climate change impacts		1.0	1.0	0.5		0.5	1.0					1.0			1.0								88.2	3	Minimal	264.6	2	529.2	5
P-2	Prevent development on steep slopes		1.0	1.0	0.5			1.0	0.5				0.5											69.65	3	Minimal	208.95	2	417.9	7
P-3	Prevent clearing and inappropriate vegetation removal		1.0	1.0	1.0			1.0					1.0				0.5	0.5						88.8	3	Minimal	266.4	2	532.8	4
P-4	No net increase in runoff and pollutant loads from future developments	0.5		0.5	0.5			1.0	1.0						1.0									65.95	3	Minimal	197.85	3	593.55	3
P-5	Ensure the use of appropriate sewage treatment measures for all new developments				0.5			1.0	0.5						1.0									41.75	3	Minimal	125.25	2	250.5	21
P-6	Require all future development to be eco-friendly and energy efficient			0.5	0.5			1.0		0.5	0.5		0.5		0.5	0.5		0.5		0.5				72.8	3	Minimal	218.4	1	218.4	23
P-7	Require developer contributions to recreational and foreshore facilities					0.5								1.0	0.5									26.65	3	Minimal	79.95	2	159.9	29
P-8	Not used																													
P-9	Adopt an Interim Entrance Management Policy	1.0			0.5		1.0	0.5	0.5							0.5								59.9	2	$30000	119.8	3	359.4	14
P-10	Control PWC use east of Hancocks Bridge, to minimise conflict with other recreators, residents and wildlife.				0.5	1.0												0.5						28.2	3	$5,000 for sign	84.6	3	253.8	20
P-11	Incorporate appropriate planning controls for climate change impacts into existing planning frameworks	0.5	0.5	0.5			0.5									1.0								44.8	3	Minimal	134.4	3	403.2	10
P-12	Use the EMP to assist in determining relevant landuse zonings and development controls in the preparation of the new standard LEP		0.5					1.0					0.5		0.5	0.5								41.4	3	Minimal	124.2	3	372.6	12
W-1	Review and improve the management of structures and flow impediments along tributary creeks and the river, in particular, Russell Creek Weir	1.0			1.0		0.5									0.5				0.5				51.7	2	$50,000	103.4	3	310.2	17
W-2	Provide assistance to rural land managers to reduce pollutants and sediment in runoff			0.5					1.0	1.0										0.5				40.2	1	>$300,000	40.2	1	40.2	50
W-3	Revegetate degraded/cleared areas in catchment			1.0	1.0					1.0	0.5													53.45	1	>$300,000	53.45	2	106.9	40
W-4	Revegetate foreshores and streambanks			1.0	1.0					1.0	0.5						1.0							64.95	1	>$100,000	64.95	2	129.9	34
W-5	Assess sites of river bank erosion and rehabilitate as required			0.5													1.0							19.95	1	>$300,000	19.95	3	59.85	47
W-6	Reduce erosion and sediment runoff from firetrails, driveways, road verges and carparks								1.0	1.0														27.2	1	>$100,000	27.2	2	54.4	48
W-7	Assess existing stormwater treatment devices and improve the level of pollutant removal from stormwater								1.0	1.0	0.5						0.5							39.6	1	>$300,000	39.6	3	118.8	37
W-8	Assess and improve current recreational infrastructure and foreshore access (including minor works eg sealing carparks, landscaping and revegetation)					1.0							0.5	1.0	0.5									40.55	1	>$100,000	40.55	3	121.65	36
W-9	Install flow gauges in appropriate locations to monitor environmental flows	1.0			0.5																1.0	1.0		43.35	2	$80000	86.7	2	173.4	28
W-10	Connect Mogareeka Village to reticulated sewage system				0.5				1.0	1.0														35.35	1	>$1,000,000	35.35	3	106.05	41
W-11	Develop and implement a weed management strategy to eradicate weeds in the estuary			1.0	0.5						1.0													38.35	2	$50,000	76.7	2	153.4	30
W-12	Develop and implement a program to eradicate pests in the estuary			0.5	1.0						1.0													38.05	2	$50,000	76.1	2	152.2	32
W-13	Raise level of road to reduce inundation during estuary closure						1.0									1.0								25.9	1	>$500,000	25.9	3	77.7	45
W-14	Support strategic raising of golf course sections in return for protection and rehabilitation of adjacent high value habitat			1.0		0.5	0.5			0.5				1.0		0.5				0.5				61.4	3	$10,000	184.2	2	368.4	13
W-15	Reclaim eroded land at Lions Park by dredging sand from entrance				1.0																			16.3	2	$50,000	32.6	2	65.2	46
W-16	Protect and promote (as appropriate) Aboriginal and European Heritage sites and places of significance											1.0						0.5						18.65	3	<$10,000	55.95	2	111.9	38
CS-1	Promote the conservation of privately owned vegetation, including revegetated private lands			1.0	1.0						0.5							0.5						45.3	3	Minimal	135.9	1	135.9	33
CS-2	Conduct a rural education program promoting best practice techniques for environmental management, based on Bega Cheese EMP Program	0.5		0.5					1.0	1.0	1.0						0.5	1.0		1.0	0.5			88	2	>$50,000	176	1	176	27
CS-3	Develop general information brochures for residents and visitors			0.5	0.5	0.5				0.5		1.0						1.0			1.0			63.5	2	$40,000	127	1	127	35
CS-4	Develop and install educational signage to promote estuary values			0.5	0.5	0.5						1.0						1.0			0.5			52.35	2	$40,000	104.7	2	209.4	24
CS-5	Develop primary and secondary school education kits			0.5	0.5							1.0						1.0			1.0			49.4	2	$50,000	98.8	2	197.6	25
CS-6	Guided tours and excursions			0.5	0.5							1.0						1.0		1.0	1.0			58.5	3	Minimal	175.5	2	351	15
CS-7	Support community volunteer groups participating in conservation activities			1.0	0.5					0.5	0.5							1.0			0.5			53.75	2	$20,000 pa	107.5	1	107.5	39
CS-8	Distribute periodic newsletters to community detailing plan implementation and progress																	0.5			0.5		1.0	17.2	3	Minimal	51.6	1	51.6	49
M-1	Prepare a Flood Study and Floodplain Risk Management Study and Plan for the Bega River		1.0				1.0								0.5	1.0					1.0	0.5		62.65	1	200000	62.65	3	187.95	26
M-2	Conduct an assessment of land capability (based on air, water, soil and vegetation constraints) and determine sustainable levels of land use activities (including development)		1.0	0.5	0.5			1.0					1.0		0.5	0.5				1.0	1.0			91.05	1	$150,000	91.05	3	273.15	18
M-3	Map extent and condition of EECs and habitats for Threatened Species, and determine areas requiring conservation or rehabilitation		0.5	1.0	1.0	0.5		0.5			0.5					0.5					1.0	0.5		81.55	1	$150,000	81.55	3	244.65	22
M-4	Expand Water Quality Monitoring Program for recreational health					0.5			1.0												1.0	1.0		38.2	3	$10,000 pa	114.6	3	343.8	16
M-5	Implement an Ecosystem Health Monitoring Program				0.5																1.0	1.0		25.45	2	$30,000pa	50.9	3	152.7	31
M-6	Monitor and periodically re-map aquatic and riparian vegetation.			0.5																	1.0	1.0		25.45	2	$30,000/5yrs	50.9	2	101.8	43
M-7	Periodically monitor use of the estuary's waterway, foreshores and recreational facilities					0.5								0.5							1.0	1.0		25.75	2	$20000	51.5	2	103	42
M-8	Compile an ongoing a centralised database of all past and in-progress studies and data on the estuary for use in future planning, management and research activities		0.5	0.5	0.5			0.5	0.5			0.5	0.5		0.5	0.5		0.5			1.0	0.5		31.05	3	Minimal	93.15	1	93.15	44
M-9	Investigate the assets and infrastructure around the BRE that are vulnerable to future SLR and ocean storm inundation. Develop adaptation solutions	0.5	0.5	0.5			0.5									1.0								82.9	2	$50000	165.8	3	497.4	6
M-10	Investigate the predicted impacts of climate change on the natural values of BRE (eg entrance conditio	0.5	0.5	0.5	0.5		1.0								0.5	1.0					1.0			44.8	2	50000	89.6	3	268.8	19
C-1	Audit existing on-site sewage systems and enforce recommended upgrades				0.5				1.0	1.0								0.5				0.5		45.1	3	Minimal	135.3	3	405.9	9
C-2	Audit construction sites for compliance with sediment and erosion controls, vegetation preservation, stormwater controls etc			0.5					1.0	1.0								0.5				0.5		45.4	3	Minimal	136.2	3	408.6	8
C-3	Provide annual report on plan implementation and review of monitoring data to assess the ongoing health of the estuary	0.5		0.5	0.5				0.5									0.5			1.0	1.0	1.0	62.5	3	Minimal	187.5	2	375	11
C-4	Agencies to incorporate EMP strategies into short and long term works and investment programs	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5	0.5	0.5	0.5	145.75	3	Minimal	437.25	3	1311.75	2
C-5	Consider gazettal of the EMP by the NSW Government	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5	0.5	0.5	0.5	152.7	3	Minimal	458.1	3	1374.3	1