

**LAKE CONJOLA ENTRANCE MANAGEMENT
DREDGING WORKS
REVIEW OF ENVIRONMENTAL FACTORS**

Report No. MHL 1161

**NSW Department of Public Works and Services
Manly Hydraulics Laboratory**

Report No. MHL1161
DPWS Report No. 01116
ISBN 0 7347 4113 8
MHL File No. LRE6-0115
First published January 2003

© Crown copyright 2003

This work is copyright. The *Copyright Act 1968* permits fair dealing for study, research, news reporting, criticism or review. Selected passages, tables or diagrams may be reproduced for such purposes provided acknowledgment of the source is included. Major extracts or the entire document may not be reproduced by any process without written permission. Enquiries should be directed to the Publications Officer, Manly Hydraulics Laboratory, 110B King Street, Manly Vale, NSW, 2093.



Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:1994.

Foreword

This Review of Environmental Factors (REF) has been prepared by Manly Hydraulics Laboratory, NSW Department of Public Works and Services, on behalf of Shoalhaven City Council. The REF evaluates the environmental impact of entrance works associated with the management of the entrance of Lake Conjola on the NSW south coast. The dredging works will be carried out under State Environmental Planning Policy (SEPP) 35, - *Maintenance Dredging of Tidal Waterways* for assessment under Part V of the *Environmental Planning and Assessment Act 1979* (NSW).

Shoalhaven City Council, NSW Fisheries and the Department of Land and Water Conservation are the Determining Authorities for the activity.

Summary

The activity considered in this Review of Environmental Factors is the entrance dredging works and sand nourishment of the entrance spit associated with a long-term plan to manage the entrance to Lake Conjola. Lake Conjola is a coastal lake located about 50 km south of Nowra on the NSW south coast. While the lake is classified as a predominantly open lake, over the past 60 years the lake has experienced eight closures. Entrance closures are of major concern to the local community, primarily due to the increased potential for flooding and degradation of lake water quality.

Community concerns regarding lake closures resulted in the Lake Conjola Entrance Study (1999). The study found lake closures were precipitated by severe storm washover deposits in the entrance channel. In order to increase entrance stability, the study recommended the best option would be to implement a 'Managed Entrance' Plan. This plan will involve a system of active monitoring of tides to provide Council with an early warning of lake closure. When lake closure is considered imminent, Council will organise to undertake dredging and dune nourishment works in order to ensure the lake entrance stays open.

Two maintenance dredging works have been previously undertaken within Lake Conjola with the aim of maintaining an open entrance. The most recent, Stage 1 (Interim Works), was undertaken in 1999 as an urgent corrective measure to realign the main ebb channel and arrest the ongoing erosion of the ancient high dunes on the southern shore. Stage 2 (Managed Entrance) is the focus of this REF and will involve larger-scale dredging works in order to prevent entrance closure whenever the lake approaches imminent closure.

The primary planning instrument applying to this activity is State Environmental Planning Policy 35 (SEPP 35) – Maintenance Dredging of Tidal Waterways. This policy enables councils to carry out maintenance dredging of tidal waterways without development consent, provided they commit to a public consultation process. More recently, it has been recommended by the Department of Urban Affairs and Planning, now Planning NSW, that environmental assessment be undertaken for entrance openings. This should consist of an Entrance Management Plan and an Environmental Impact Statement (EIS) or Review of Environmental Factors (REF). In this case, an Entrance Management Plan (MHL1159 2003) has been prepared for Lake Conjola to provide the strategic framework for Stage 2 works, and this REF will assess the impacts of that proposal under Part 5 of the Environmental Planning and Assessment Act.

The timing of the works will be dependent upon the entrance channel conditions. A decision support system has been developed to alert stakeholders of approaching closure. The decision support system will indicate when the trigger level of entrance constriction has been reached and this will activate the appropriate stakeholders to begin seeking approvals and funding, carrying out the necessary pre-construction activities, and engaging appropriate contractors. Once these tasks have been finalised, dredging and subsequent placement works will begin.

The assessment of activities associated with the proposed maintenance of a permanently open entrance indicates that environmental impacts due to the entrance works should be localised and short term (provided the mitigative measures outlined in this REF are adhered to).

The main long-term benefit of a permanently open entrance is mitigation of flood impacts on development along the foreshore area and reduction of the potential for adverse impacts on the water quality and the flow-on effects on recreational amenity and tourism.

Table of Contents

1. INTRODUCTION	7
1.1 Site Description and Existing Entrance Processes	7
1.2 Project Background	8
1.3 The Lake Conjola Entrance Study 1999	8
1.4 Lake Conjola Entrance Management Plan	9
1.5 Stage 1 Entrance Works 1999	9
2. THE ACTIVITY	11
2.1 Description of the Proposed Activity	11
2.2 Objectives of the Proposed Activity	12
2.3 Alternatives to the Proposed Activity	12
2.4 Indicative Cost	14
3. ENVIRONMENTAL ISSUES FOR CONSIDERATION	15
3.1 Identification of Issues	15
3.1.1 <i>Public Consultation</i>	15
3.1.2 <i>Authority Consultation</i>	15
3.1.3 <i>Is an EIS Required?</i>	17
3.2 Permissibility, Planning and Statutory Matters	18
3.2.1 <i>Environmental Planning and Assessment Act 1979</i>	18
3.2.2 <i>State Environmental Planning Policy 35 (SEPP 35) – Maintenance Dredging of Tidal Waterways</i>	18
3.2.3 <i>Crown Lands Act 1989</i>	19
3.2.4 <i>Fisheries Management Act 1994</i>	19
3.2.5 <i>Coastal Protection Act 1979</i>	20
3.2.6 <i>Protection of the Environment Operations Act 1997</i>	20
3.2.7 <i>River and Foreshores Improvement Act 1948</i>	21
3.2.8 <i>National Parks and Wildlife Act 1974: Protection of Aboriginal Objects</i>	21
3.2.9 <i>Heritage Act 1977</i>	21
3.2.10 <i>Water Management Act 2000</i>	22
3.2.11 <i>Local Government Act 1993</i>	22
3.2.12 <i>Threatened Species Conservation Act 1995</i>	22
3.2.13 <i>Shoalhaven City Council Local Environmental Plan 1985</i>	22
3.3 Summary of Major Issues	23

4. THE EXISTING ENVIRONMENT, POTENTIAL IMPACTS AND MITIGATING MEASURES	24
4.1 Physical or Pollution Issues During Construction and Operation	24
4.1.1 <i>Physical or Pollution Issues During Construction and Operation – Air</i>	24
4.1.2 <i>Physical or Pollution Issues During Construction and Operation – Water</i>	24
4.1.3 <i>Physical or Pollution Issues During Construction and Operation – Soil</i>	28
4.1.4 <i>Physical or Pollution Issues During Construction and Operation – Noise and Vibration</i>	28
4.2 Biological Issues During Construction and Operation	29
4.2.1 <i>Biological Issues During Construction and Operation – Flora</i>	29
4.2.2 <i>Biological Issues During Construction and Operation - Fauna</i>	31
4.3 Resource Use Issues During Construction and Operation	34
4.3.1 <i>Community Resources</i>	34
4.3.2 <i>Natural Resources</i>	34
4.4 Community Issues During Construction and Operation	35
4.4.1 <i>Community Issues During Construction and Operation - Socio-economic Factors</i>	35
4.4.2 <i>Community Issues During Construction and Operation - Heritage, Aesthetic and Cultural Factors</i>	35
4.4.3 <i>Community Issues During Construction and Operation - Land Use Issues</i>	36
4.4.4 <i>Community Issues During Construction and Operation - Transportation Issues</i>	36
5. EVALUATION OF THE SIGNIFICANCE OF IMPACTS	37
5.1 General	37
5.2 Physical and Pollution Impacts	37
5.3 Biological Impacts	37
5.3.1 <i>Benthic Invertebrates</i>	37
5.3.2 <i>Caulerpa taxifolia Infestation</i>	38
5.3.3 <i>Migratory Nesting Birds</i>	38
5.4 Resource Use Impacts	38
5.5 Community Impacts	38
5.6 Summary of the Significance of Impacts	39
6. CONCLUSIONS AND RECOMMENDATIONS	40
6.1 Adverse Impacts and Mitigative Measures	40
6.2 Beneficial Effects	41
6.3 Monitoring	42
6.4 Statement of Environmental Effects for Dune Works	43
6.5 Land Assessment	43
7. REFERENCES AND BIBLIOGRAPHY	44

Appendices

- A Government Agency Consultation
- B Independent Public Inquiry into Coastal Lakes: Draft Paper, Healthy Rivers Commission of New South Wales, Appendix 5: Coastal Lake Entrances: Effective Regulatory Processes
- C Table 1 and Table 3 of *Is an EIS required?* Department of Urban Affairs and Planning
- D Ecological Assessment, Proposed Stage 1 (Interim) Works, Conjola Lake Entrance, City of Shoalhaven, Kevin Mills & Associates Pty Limited
- E Lake Conjola Entrance Management Plan, Review of Environmental Factors, Aquatic Ecology, The Ecology Lab Pty Ltd

List of Tables

2.1	Estimated Dredging Frequency to Maintain Entrance Stability	13
2.2	Assessment of Entrance Management Options for Different Selection Criteria	13
3.1	Summary of Issues Raised	16
4.1	Flood Level Comparisons	25
4.2	Proportion of Total Load Contributed by Each Pollutant Input Location	27
4.3	Commercial Fisheries Production for Lake Conjola	34
5.1	Review of Environmental Factors Summary	39
6.1	Summary of Potential Environmental Impacts	40
6.2	Summary of Recommended Impact Mitigative Techniques	41
6.3	Benefits of a Permanently Open Entrance	42

List of Figures

- 1.1 Locality Plan
- 1.2 Oblique Aerial Photo – pre-1998
- 1.3 Oblique Aerial Photo – 31 August 1999
- 1.4 Stage 1 Entrance Works 1999

- 2.1 Proposed Works
- 2.2 Entrance Management Options

- 4.1 Conceptual Model of Coastal Processes

1. Introduction

1.1 Site Description and Existing Entrance Processes

Lake Conjola is a coastal lake located about 50 km south of Nowra on the NSW south coast (Figure 1.1). The lake has a surface area of approximately 4.3 km² and a catchment area of 145 km². Lake Conjola is classified as a predominantly open lake and historically has remained open for 62% of the time. A shallow sandy inlet some 3 km long separates the main lake, which has water depths up to 10 m, from the ocean. The inlet itself is shallow with extensive intertidal muddy sand flats and an average channel depth of the order of 1 m (Figures 1.2, 1.3).

The marine delta has pronounced sand lobes which are elevated up to 1 m AHD (Australian Height Datum). The sands of the delta constantly change due to the dynamic interchange between floods, tidal flows, storm waves, littoral sand supply and wind-blown sand from Conjola Beach. The restrictive effect of the shallow inlet, plus storage attenuation of the main lake, reduces tidal range in the lake to approximately 20% of ocean range under typical entrance conditions.

Average tidal flows maintain a relatively small entrance channel which is typically located against the northern foreshore. The entrance is prone to periodic closures; over the last 60 years there have been eight closures. The entrance can remain closed for years until opened by floods, usually assisted by mechanical excavation of a pilot channel. When the entrance is closed, the lake level builds up in freshes and there can be a marked decline in overall water quality.

Analysis of aerial photographs (SCC 1999) showed that, in the vicinity of the downstream caravan park and southern boat ramp, the main channel has never moved south of its present-day location. The channel has temporarily moved northwards due to flood scour across the entrance shoals. Downstream of the boat ramp, it was noted that the high dunes are eroded periodically when the channel is forced against the dunes by the extensive build-up of the entrance shoals.

Several villages and caravan parks line the lake shoreline and are popular tourist destinations during summer holiday periods. Some properties are flood-affected, resulting in inundation of septic disposal systems and dwellings. The area is subject to continuing urban growth and the lack of a modern sewerage system results in bacterial pollution during peak occupational periods and flows due to rainfall events. As a result Shoalhaven City Council has a policy of opening the lake when water levels reach 1 m AHD to principally relieve flooding, as well as water quality concerns.

1.2 Project Background

The ocean entrance to Lake Conjola is usually open but is prone to periodic closures which can last from many months to years. The frequency of such closures is quite irregular and reflects the variable nature of large storms which have been found to be a necessary precursor to entrance closure (SCC 1999).

Closure of the entrance to Lake Conjola generates concern among residents due to the increased risk of elevated flood levels in the township. Closure of the entrance can also cause environmental/habitat decline and brings hardship and concern to the local communities. The last closure which occurred towards the end of 1994, after the entrance had been open for approximately five years, is reported to have had several deleterious consequences, namely:

- loss of oyster production
- emergence of algae along inlet foreshores
- public health issues related to elevated bacteria and virus levels
- loss of tourism income
- degradation of foreshore habitat along the inlet
- decline in fish and crustacean catches
- decline in sea birds
- decline in aesthetics of lake.

In response to these problems, Council commenced works to reopen the entrance in June 1998. The lake was opened on the southern side as a trial alternative, but this opening was only effective in the short term. In August 1998, a flood occurred that enlarged the opening and had the unwanted effect of accelerating the erosion along the high dunes of the southern shore.

Shoalhaven City Council perceived that there was a need for further investigations into existing lake processes, in order to better manage the lake entrance. The draft 1998 Estuary Management Plan was amended to reflect the community's heightened concern about entrance stability and called for an investigation into the costs and benefits of various strategies to alleviate flooding and water quality problems. The Lake Conjola Entrance Study was published in 1999 and presented its findings on different management options to maintain entrance stability.

1.3 The Lake Conjola Entrance Study 1999

The Lake Conjola Entrance Study was commissioned by Shoalhaven City Council with the following objectives:

- 1) to develop an understanding of existing lake processes
- 2) to determine the effect of existing entrance conditions on flood behaviour and water quality (*particularly faecal contamination*)
- 3) to determine the relative impacts of different entrance channel manipulations on lake flood behaviour and water quality

- 4) to discuss other options for alleviating water quality and flooding concerns
- 5) to undertake an economic assessment of the various management options in terms of their cost, reduction in flood damages and improvements in water quality.

With respect to entrance stability the study concluded:

- entrance closures are caused by severe coastal storms
- periods of entrance stability corresponded with periods of little storm activity
- the key to improving entrance stability is preventing storm washover deposits.

Six basic options for the long-term management of the entrance to Lake Conjola were identified:

- 1) entrance breakwaters
- 2) stub groyne and internal training wall
- 3) stub groyne and internal groyne field
- 4) stub groyne with partial spit stabilisation
- 5) managed entrance
- 6) existing opening policy.

The Council's Estuary Management Task Force for Lake Conjola considered these options and selected the managed entrance as the preferred option. This option involves a proactive system of monitoring, an effective decision-making process and planned maintenance dredging at the appropriate time.

1.4 Lake Conjola Entrance Management Plan

The Entrance Management Plan (MHL1159 2003), which this Review of Environmental Factors (REF) accompanies, provides the strategic framework for carrying out entrance dredging to prevent closure. An information management system monitors the condition of the entrance and runs a predictive model that will signal when entrance closure is imminent. A work plan outlining the maintenance dredging procedures has been established in readiness to be implemented once the predictive model signals that closure is becoming imminent. The Entrance Management Plan is described further in Chapter 2.

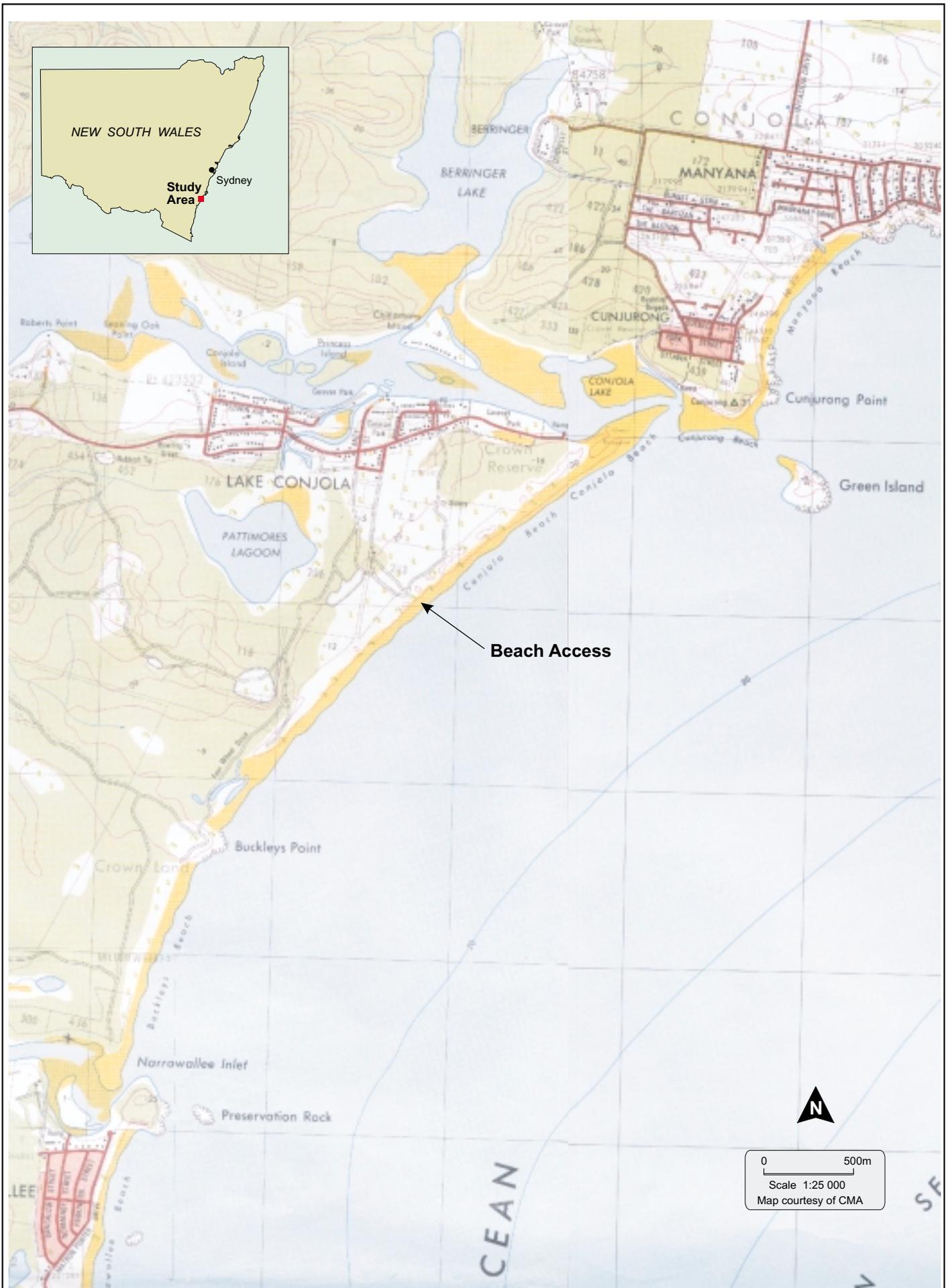
1.5 Stage 1 Entrance Works 1999

The 1999 Entrance Study recommended that regardless of what other works were carried out in the future, immediate action needed to be taken to raise the level of the entrance sandspit to inhibit wave washovers. Stage 1 (Interim Works) was a one-off venture designed to address these concerns. The objectives were to:

- decrease the current risk of closure by storm washover
- realign main ebb channel
- arrest erosion of south shore high dunes.

The Interim Works were carried out from November to December 1999. The location of major works are shown in Figure 1.4. The main steps involved:

- 1) *Realignment of the main ebb channel* – the main ebb channel was by dredging a channel through the internal delta shoals in alignment with the southern boat ramp and the northern entrance channel. Approximately 9,500 m³ of sediment were removed.
- 2) *Dredging disposal area* - sediment removed from the dredging areas was discharged to a disposal area on the southern side. The level of sand disposal area was raised to RL 1.0 m above AHD.
- 3) *Creation of an artificial entrance dune* – the entrance dune was raised to a crest level of approx 3.0 to 3.5 m AHD with side slopes 1 in 5, over a length of approximately 200 m. Approximately 6,500 m³ of sand fill was sourced from channel dredging within the marine delta.
- 4) *Northern boat ramp access channel* - navigable access to the northern boat ramp at Cunjurong Point was improved by dredging a channel with a width of 20 m at a bottom depth of approximately 2 m below AHD and length of approximately 100 m.



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE LOCALITY PLAN

MHL
Report 1161

Figure
1.1

DRAWING 1161-01-01.CDR



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

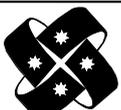
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
OBLIQUE AERIAL PHOTO - PRE-1998

MHL
Report 1161

Figure
1.2

DRAWING 1161-01-02.CDR



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

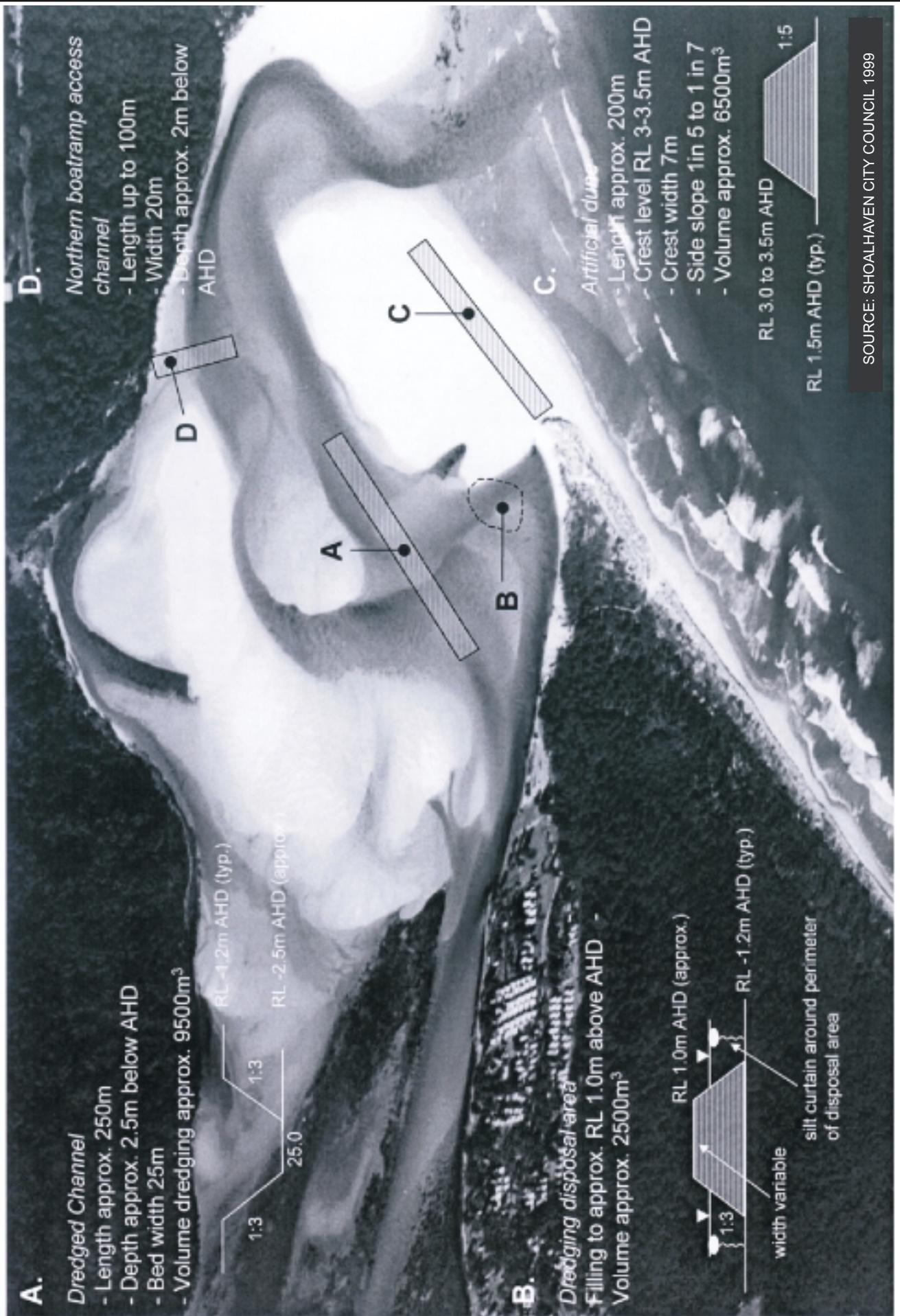
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
OBLIQUE AERIAL PHOTO - 31 AUGUST 1999

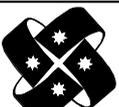
MHL
Report 1161

Figure
1.3

DRAWING 1161-01-03.CDR



SOURCE: SHOALHAVEN CITY COUNCIL 1999



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
STAGE 1 ENTRANCE WORKS 1999

MHL
Report 1161

Figure
1.4

DRAWING 1159-01-04.CDR

2. The Activity

2.1 Description of the Proposed Activity

This REF is for the entrance works which will be an essential part of the Managed Entrance strategy for Lake Conjola. The strategy requires dredging of an entrance channel and placement of the sand on the southern sand spit when the decision support system signals that closure is imminent. The managed entrance required the preparation of a formal Entrance Management Plan which includes:

1. A description of the proposed works including the dredging of a channel along the path of historic flood cuts and the placement of dredged sand on the entrance spit, which will then be re-shaped and revegetated as appropriate. Final design of the works to suit the current conditions will be carried out immediately prior to implementation.
2. A decision support system to evaluate the state of entrance shoaling and trigger initiation of entrance works
3. A commitment document between Council, the community and the relevant government agencies to ensure sustained commitment to the maintenance of an open entrance
4. An REF to define any environmental constraints to be accommodated in the Plan and expedite the environmental approval process. The REF may need some updating at the time of the works.

The entrance works required by the Managed Entrance strategy when entrance closure is imminent are shown in Figure 2.1. They include:

- dredging a channel along the path of historic flood cuts, approximately 1,000–1,200 m long, 40 m wide to a depth of approximately 2 m (RL –2.5 m AHD). The channel to the northern boat ramp would also be restored by dredging an access channel 25 m wide and 1.5 m deep (RL –2.0 m AHD). The estimated volume of sand to be dredged is of the order of 100,000 m³. During the final design of the works, there will be an opportunity to refine the design based on additional data from the entrance monitoring program. This may allow a significant reduction in the volume to be dredged
- deposit the dredged sand on the southern part of the entrance spit and stabilise with vegetation to reduce storm washover. Maintain northern tip of spit at a level of RL 1.0 m – RL 1.5 m AHD as a fuse plug to be washed out by large floods
- deposit some sand along southern shoreline of channel to reclaim the area scoured in the 1998 entrance opening.

It would be specified in the tender documents that dredging be carried out with a cutter suction dredge. The size of dredge will be determined by the tender process but based on the experience of the Stage 1 dredging it is likely that a 200 mm dredge would be the optimum size. The dredge may require a booster pump to deliver sand over the longer distances required for the most western extent of dredging. The dredge would be expected to deliver

500 m³ of sand a day. At this rate the duration of the dredging would be 200 days or approximately 30 weeks assuming dredging is carried out seven days a week. Other considerations may introduce time constraints that make it necessary to utilise two dredges to reduce the dredging period.

Dredged sand will be discharged to the entrance spit directly from the delivery line in the area where the dune is to be constructed. Sand will be allowed to build up to the approximate required level (RL 7.0 m AHD) over the southern area of the spit. The dune will be subsequently shaped to the natural dune shapes of the area by a bulldozer. Sand fencing will be installed and natural vegetation planted according to agreed guidelines from the Department of Land and Water Conservation. The approximate area covered by the raised dune will be 40,000 m².

2.2 Objectives of the Proposed Activity

To ensure entrance stability, the Managed Entrance Plan has the following objectives:

- open the entrance when closure is imminent
- manage and contain windblown sand
- reduce littoral sand infeed
- locate entrance to the north
- reduce or modify wave penetration of entrance
- prevent entrance closure, and
- nullify effect of storm washover.

2.3 Alternatives to the Proposed Activity

The Lake Conjola Entrance Study (SCC 1999) presented six options for the long-term management of the entrance to Lake Conjola. These were:

1. entrance breakwaters
2. a stub groyne and internal training wall
3. a stub groyne and internal groyne field
4. a stub groyne with partial spit stabilisation
5. a managed entrance
6. the existing opening policy.

The options are shown in Figure 2.2. The estimated frequency of dredging to maintain a stable entrance for each option is shown in Table 2.1.

Table 2.1 Estimated Dredging Frequency to Maintain Entrance Stability

Entrance Option	Approximate frequency for corrective dredging works
Entrance Training Walls	>> 20 years
Stub Groyne and Internal Training Wall <i>(without wave/sand trap)</i>	≈ 15 years
Stub Groyne and Internal Training Wall <i>(with wave/sand trap)</i>	15-20 years
Stub Groyne and Internal Groyne Field <i>(without wave/sand trap)</i>	≈ 15 years
Stub Groyne and internal Groyne Field <i>(with wave/sand trap)</i>	15-20 years
Stub Groyne with Partial Spit Stabilisation <i>(without wave/sand trap)</i>	≈ 10 years
Stub Groyne with Partial Spit Stabilisation <i>(with wave/sand trap)</i>	≈ 10 years
Managed Entrance <i>(without wave/sand trap)</i>	> 10 years
Managed Entrance <i>(with wave/sand trap)</i>	10-15 years
Maintain existing protocol	≈ 5 years

Source: Patterson Britton and Partners (1999)

A comparison of the entrance management options for different selection criteria is shown in Table 2.2 from SCC (1999).

Table 2.2 Assessment of Entrance Management Options for Different Selection Criteria

	Assessment of Options				
	Entrance Stability	Flooding	Water Quality	Benefit/Cost	Ease of Implementation
Entrance Training Walls		×××		××	×××
Stub Groyne and Internal Training Wall <i>(Without Wave/Sand Trap)</i>		××		×	××
Stub Groyne and Internal Training Wall <i>(With Wave/Sand Trap)</i>		××		×	××
Stub Groyne and Internal Training Wall <i>(With Wave Trap and Comm Extraction)</i>		××		×	××
Stub Groyne and Internal Groyne Field <i>(With Wave/Sand Trap)</i>		××		×	××
Stub Groyne and Internal Groyne Field <i>(With Wave Trap and Comm. Extraction)</i>		××		×	×××
Stub Groyne and Internal Groyne Field <i>(Without Wave/Sand Trap)</i>		××		×	××
Stub Groyne with Partial Spit Stabilisation <i>(Without Wave/Sand Trap)</i>		×		×	×

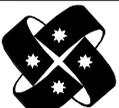
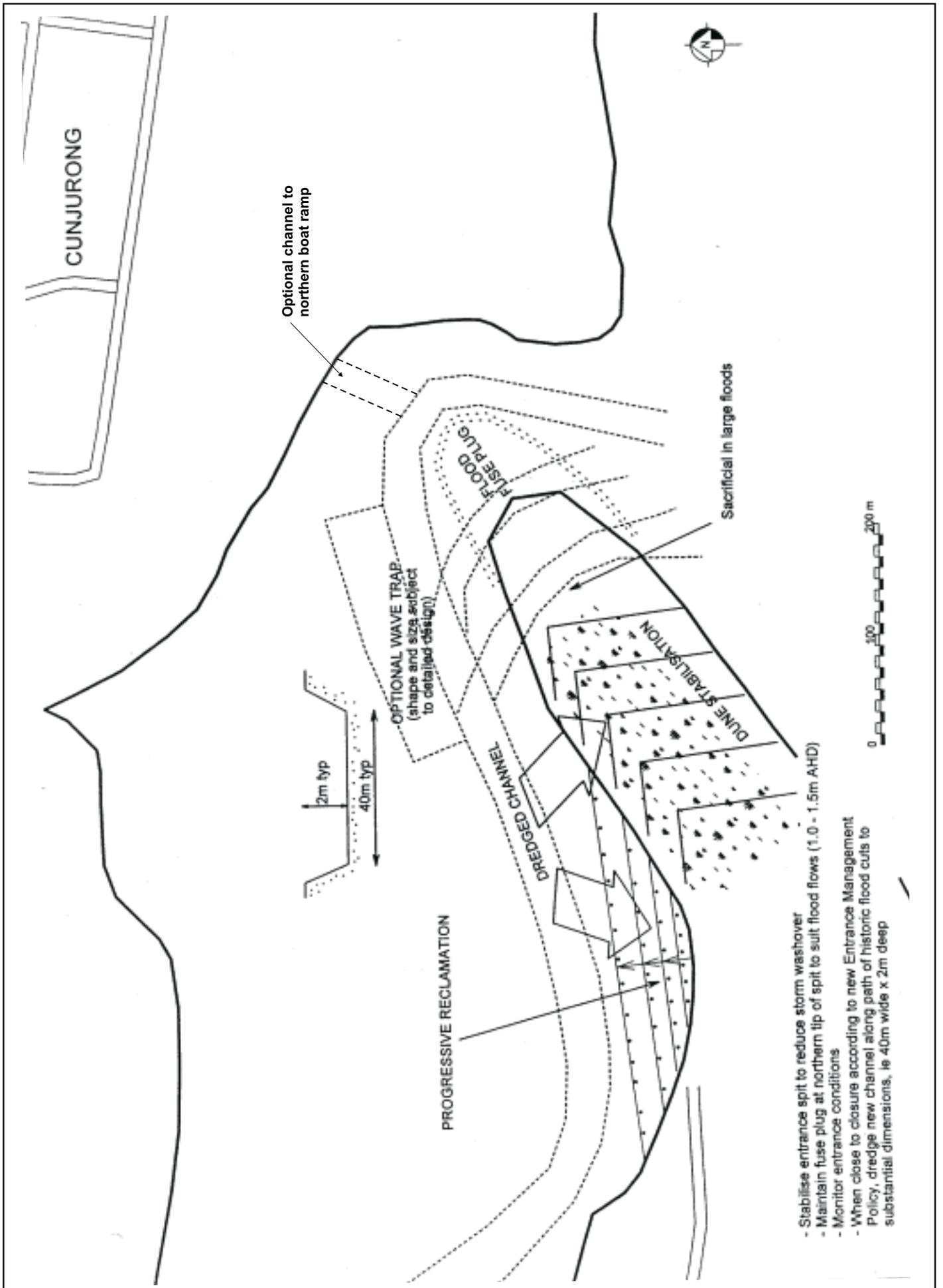
	Assessment of Options				
	Entrance Stability	Flooding	Water Quality	Benefit/Cost	Ease of Implementation
Stub Groyne with Partial Spit Stabilisation (<i>With Wave/Sand Trap</i>)		×		×	×
Stub Groyne with Partial Spit Stabilisation (<i>With Wave Trap and Comm. Extraction</i>)		×		×	×
Managed Entrance (<i>Without Wave/Sand Trap</i>)					
Managed Entrance (<i>With Wave/Sand Trap</i>)					
Managed Entrance (<i>with Wave Trap and Comm. Extraction</i>)					×
Maintain Existing Protocol	-	-	-	-	-

Legend

- Favourable
- × Unfavourable

2.4 Indicative Cost

The indicative cost of dredging is \$50,000 for establishment/disestablishment and \$6/m³ for dredging, giving a total estimated cost of dredging of \$700,000. The indicative cost of dune grooming and stabilisation is \$3/m², giving a total cost of \$120,000.



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

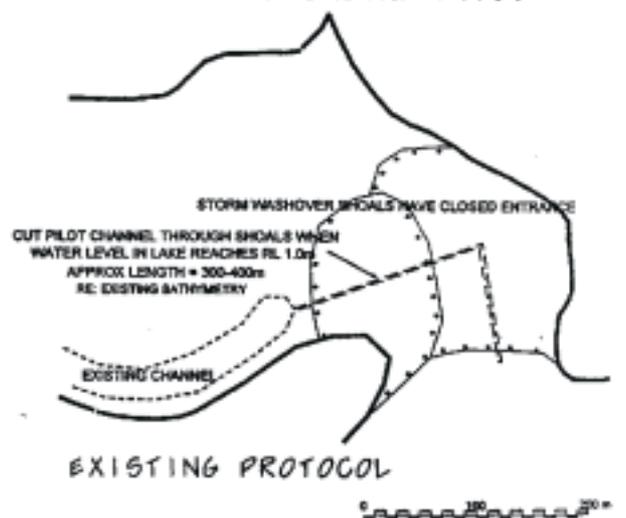
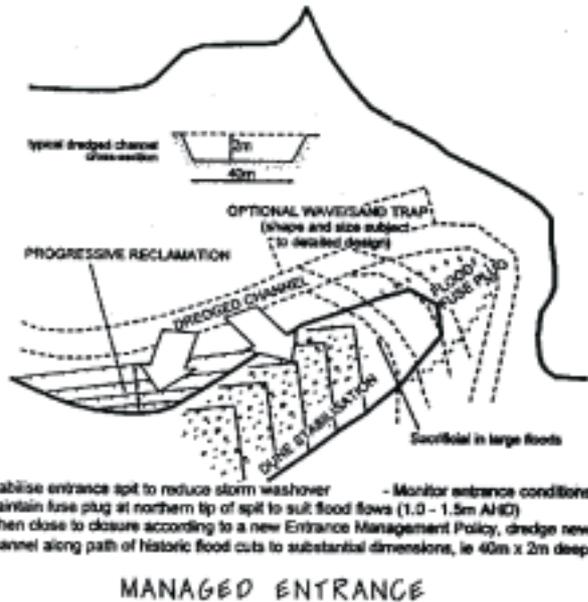
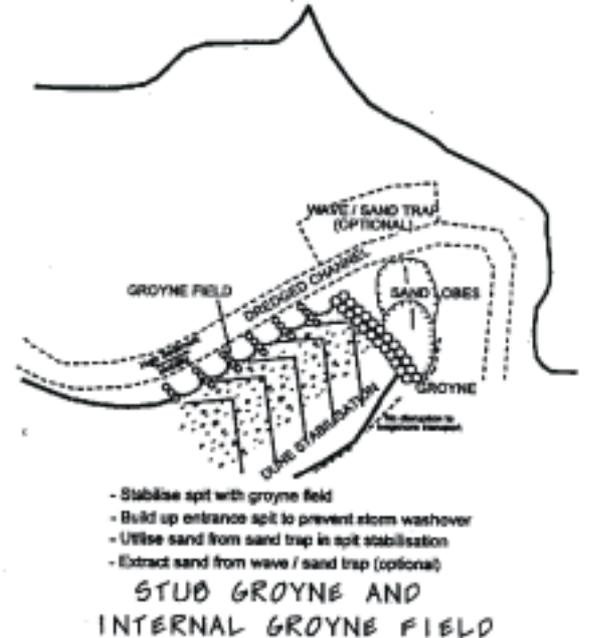
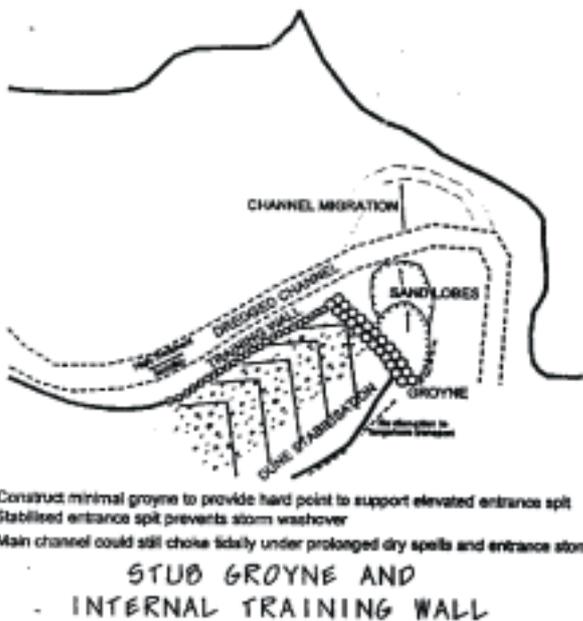
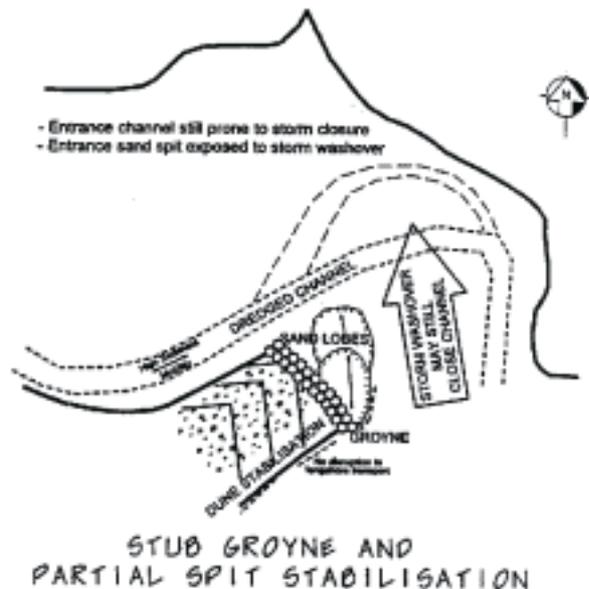
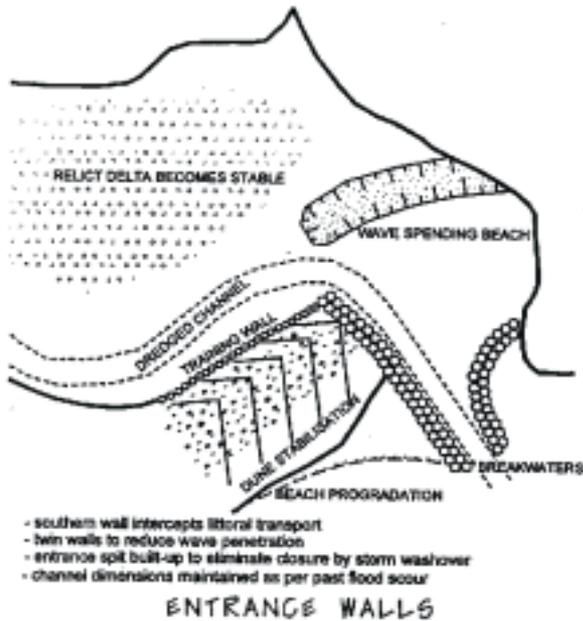
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE PROPOSED WORKS

MHL
Report 1161

Figure
2.1

DRAWING 1159-02-01.CDR



Source: Patterson Britton & Partners Pty Ltd 1999

3. Environmental Issues for Consideration

3.1 Identification of Issues

3.1.1 Public Consultation

The public consultation that has taken place during the development of the Managed Entrance Plan is outlined below.

- The Entrance Study (SCC 1999) was reviewed and the preferred option selected by the Lake Conjola Estuary Management Task Force. The majority of the Task Force are community members representing all major interest groups from the various communities around the lake.
- A public meeting was held on 25 August 1999 to consider the findings of the Entrance Study. The meeting unanimously endorsed the preferred option provided the urgent Stage 1 entrance works were carried out.
- An overview of the project to develop the Entrance Management Plan was presented to the Task Force on 13 December 2001.
- Newsletter No. 1 was distributed to the local community in December 2001. It outlined the major aspects of the proposed works, the decision support system, commitment document and community education package.
- Overviews of the draft Entrance Management Plan and Review of Environmental Factors were presented to the Task Force and later to a public meeting on 19 April 2002.
- Newsletter No. 2 was distributed to the local community in April 2002. This contained an overview of the draft Entrance Management Plan and Review of Environmental Factors.
- A public-accessible Web site describing the project was maintained during the duration of the project.

3.1.2 Authority Consultation

Comments were invited from the following government authorities for the preparation of this REF:

- Waterways Authority
- Ulladulla Local Aboriginal Land Council
- Department of Land and Water Conservation
- National Parks and Wildlife Service
- NSW Fisheries
- NSW Environment Protection Authority.

Responses received from these parties are included in Appendix A. A summary of issues raised is listed below together with the report section relating to the discussion of each issue.

Table 3.1 Summary of Issues Raised

Agency and Issues Raised	Report SectionSection
NSW Fisheries	
• impacts on fish and prawn communities and their migration passages	4.2.2, 5.3 and Appendix E
• impacts on aquatic vegetation	4.2.1, 5.3 and Appendix E
• impacts on <i>Caulerpa taxifolia</i> and potential to spread	4.2.1, 5.3 and Appendix E
• impacts on riparian vegetation	4.2.1, 5.3 and Appendix E
• impacts on water quality	4.1 and 5.2
• impacts on aquatic habitats including gravel beds and snags	4.2, 5.3 and Appendix E
• impacts on water flow, velocity and hydraulics	4.1.2
• details of sediment and erosion controls during and after works	4.1.2
• impacts on commercial and recreational fisheries	4.3.2, 4.4.3, 5.4 and Appendix E
• impacts on threatened species (eight part test)	4.2.2.1 and Appendix E
• approval required for dredging	3.3
• permit required to harm marine vegetation	3.3
NPWS	
• how a sustained opening to Lake Conjola can meet the ecologically sustainable development (ESD) objective within the EP&A Act (s.5(a)vii)	
• impacts of more enduring saline regime on lake	Chapters 4 and 5
• impacts of sustained opening of the lake on SEPP 14 wetlands and foreshore habitats of Conjola National Park	4.2, 5.3 and Appendix E
• impacts of sustained openings on drainage lines and the flora and fauna that utilise/occupy these drainage lines	4.2, 5.3 and Appendix E
• short- and long-term impacts on flora and fauna and their habitats (including substrate condition, food sources, nesting and refuge areas, water quality and composition)	4.2, 5.3 and Appendix E
• impacts on threatened species and those subject to international treaties	4.2, 5.3 and Appendix E
• cultural heritage assessment to include the wide range of Aboriginal interests in the area	4.4.2
• details of the monitoring regime	Appendix E
EPA	
• statutory requirements with respect to dredging activities	Chapter 3
• best practice measures for dredging activities and disposal of dredged spoil.	Chapters 2, 4 and 5

3.1.3 Is an EIS Required?

The Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act, *Is an EIS required?*, published by the Department of Urban Affairs and Planning, is frequently used to determine the level of environmental significance of proposed activities. Table 1 of the guidelines was used in this REF as a checklist to identify issues relevant to the proposal. Table 3 was later used to evaluate the likely environmental significance of the impacts. The relevant impacts are analysed in Chapter 4 of this REF. Tables 1 and 3 of *Is an EIS required?* are included as Appendix B.

With regard to this project, the following potential environmental impacts have been identified to be relevant to this REF:

Physical Impacts

- disturbance to the seabed
- effect on water quality in a natural waterbody
- proposal is affected by tides
- generation of waste i.e. dredge spoil
- noise generation.

Biological Impacts

- modification of seagrasses
- disturbance to fauna.

Natural or Community Resource Impacts

- use of fuel resources for dredging and transportation of spoil
- use of road infrastructure for transportation of equipment.

Community Impacts

- temporary restrictions on access to parts of the waterway and spit
- temporary reduction in amenity of a recreational area
- generation of short-term noise nuisance.

Effects on areas sensitive because of physical factors

- affecting a natural waterbody.

Effects on areas sensitive because of biological factors

- affecting seagrass beds.

Effects on areas sensitive because of community factors

- affecting a community with a strong sense of identity
- affecting an area of high recreational value.

The major environmental issues identified were the potential effect of the activity on seagrasses, the seabed, aquatic fauna, noise, water quality and recreation.

3.2 Permissibility, Planning and Statutory Matters

3.2.1 Environmental Planning and Assessment Act 1979

The objective of the Environmental Planning and Assessment Act (EPAA) is to encourage proper management, development and conservation of natural and man-made resources. The Act outlines provisions for allowing development to take place in an environmentally and socially acceptable manner. Environmental assessment of proposed projects (apart from 'exempt development') is carried out under either Part 4 or Part 5 of the Act. If a project requires development consent under Part 4, then the environmental assessment provisions of Part 4 apply. If the relevant environmental planning instrument does not require development consent then environmental assessment is carried out under Part 5.

Part 3 of the EPAA defines three types of Environmental Planning Instruments (EPIs) - State Environmental Planning Policies (SEPPs), Regional Environmental Planning Policies (REPs) and Local Environmental Plans (LEPs). A development may only proceed subject to the conditions of these EPIs. An EPI may apply depending on the site at which development is proposed or due to the nature of the development.

The relevant EPI applying at this site is State Environmental Planning Policy No. 35 (SEPP 35) – Maintenance Dredging of Tidal Waterways. The proposed project does not require development consent under this EPI (see next Section 3.2.2) and therefore will be assessed under Part 5 of the Act. Under Part 5 the determining authority must consider the likely environmental significance of a proposed activity prior to approving the activity. In this situation a Review of Environmental Factors is prepared to identify and evaluate the impacts of a proposed activity and to assist in deciding if the impacts are likely to significantly affect the environment. In this case Shoalhaven City Council will be the proponent of the activity and will also be the Determining Authority. In some cases a determining authority, which is also the proponent undertaking the activity itself, requires approval from another determining authority. In this situation there may be more than one determining authority.

3.2.2 State Environmental Planning Policy 35 (SEPP 35) – Maintenance Dredging of Tidal Waterways

The following discussion has been extracted from HRC (2001). A summary of effective regulatory processes affecting coastal lake entrances outlined in that report is included in Appendix C.

SEPP 35 enables councils to carry out maintenance dredging of tidal waterways, without development consent, provided they undertake an identified public consultation process. That process includes notifying the listed agencies and considering comments made by them within 28 days of giving notice. However, this SEPP does not eliminate the need to obtain relevant approvals. This includes the need for councils to obtain a licence under the *Crown Lands Act 1989* before proceeding with an entrance opening.

The circular issued by the Department of Urban Affairs and Planning (now Planning NSW) in relation to the SEPP suggests the required environmental assessment for entrance openings. It states that councils should undertake an entrance management plan as a form of strategic environmental assessment, and that it be accompanied by an Environmental Impact Statement (EIS) or Review of Environmental Factors (REF) that assesses the impacts with respect to the requirements of the Environmental Planning and Assessment Act, and avoids the need for a full assessment each time an estuary opening is proposed.

3.2.3 Crown Lands Act 1989

This following discussion of the Crown Lands Act is sourced from HRC (2001).

The Crown Lands Act states that it is an offence to ‘*clear, dig up or cultivate public land*’ or ‘*interfere with any substance, whether on or in, or forming part of, public land,*’ without a licence or lease granted under the Act. In most cases lake entrance beds are defined as ‘public land’ by the Act. The Minister for Crown Lands may issue a licence or lease under the Act, but must consider an EIS or REF before granting a licence for entrance management works.

The Act provides for a program of land assessment that is to consist of preparation of an inventory of Crown land, an assessment of the capabilities of the land and identification of suitable uses for the land and where practicable, the preferred uses. The Minister is to maintain an inventory of the physical characteristics of the land and other matters affecting the land, as are necessary to assess the capabilities of the land. These are to be used in identifying suitable or preferred uses.

As the bed of Lake Conjola is Crown land, dredging will require a lease or licence. Before this lease or licence is issued DLWC must be satisfied that the use is consistent with the land assessment. As there is not an existing land assessment for Lake Conjola, approval will require a waiver from the Minister for Land and Water Conservation (or someone with ministerial delegation, such as a Deputy Director General). Rob Michely (2002, pers. comm.) of DLWC Nowra suggested that this could be put together based on the information provided in the Review of Environmental Factors and the Entrance Management Plan. In order to avoid having to repeat this exercise, an ongoing licence should be sought, which would require payment of an annual fee (fees start at \$70 p.a.)

3.2.4 Fisheries Management Act 1994

The objectives of the Fisheries Management Act are to conserve the biodiversity of fish and aquatic vegetation and to protect fish habitat by providing for the management of dredging and reclamation work, consistent with the objectives of ecologically sustainable development.

It is an offence for Council to carry out dredging works without prior approval from the Fisheries Minister, unless they have an approval under the Crown Lands Act. The Minister also has the power to order remedial work considered necessary to rectify the damage caused by any dredging or reclamation work to protected marine vegetation in a protected area, other marine vegetation and to spawning areas of salmon, trout or other place provided for in the regulations.

To assist in the protection of key fish habitats, the Act provides for the Minister for Fisheries to make Habitat Protection Plans to protect habitat ‘*whenever the habitat is critical for the survival of the species or required to maintain harvestable populations of fish.*’ Two Habitat Protection Plans that apply throughout NSW may affect the proposed activity. Habitat Protection Plan No.1 deals broadly with dredging, reclamation, fish passage, mangroves, other marine vegetation and snags. Habitat Protection Plan No.2 relates specifically to the protection of seagrasses.

The Act states that *'A person must not cut, remove, damage or destroy marine vegetation in public water and/or an aquaculture lease, or on the foreshore of any land or lease, except under the authority of a permit issued by the Minister under this section (205) or of an aquaculture permit.'* Marine vegetation is defined as any species of plant that at any time in its life must inhabit water (other than fresh water). These include mangroves, seagrasses and most types of microalgae. Where a development has the potential to damage seagrass beds, consultation should take place with an officer of NSW Fisheries to determine if the proposed activity requires any consent, such as a permit. Specific approval is required before a person can harm mangroves or seagrasses, and there is power to order rectification work if harmed without consent. There are also special provisions relating to the protection of threatened species, population or ecological community of marine vegetation.

Under the Fisheries Management Act, an approval for dredging and reclamation is required for excavation and filling below mean high water level, unless the contractors are specifically authorised under the Crown Lands Act or by a public authority (excluding local government authorities) for dredging or reclamation works. If there are any seagrass, mangroves or marine microalgae present, then a permit will be required to harm marine vegetation under Section 205 of the Fisheries Management Act.

3.2.5 Coastal Protection Act 1979

This following discussion of the Coastal Protection Act is sourced from HRC (2001).

The Coastal Protection Act, administered in part by the Department of Public Works and Services, specifies that if a council proposes to carry out development in the coastal zone, including altering entrance opening, the concurrence of the Minister administering the Coastal Protection Act is required: *'if in the opinion of the Minister, as advised from time to time by the Minister to the public authority, the development or the use or occupation, may in any way:*

(c) 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, or
(d) adversely affect any beach or dune or the bed, bank, shoreline, foreshore, margin or flood plain of the sea or an arm of the sea or any bay, inlet, lagoon, lake, body of water, river, stream or watercourse'.

These provisions apply unless the Minister has declared, by an order in the gazette, that these provisions will not apply to specified areas in the coastal zone. The Minister can also, by order published in the gazette, direct that a public authority shall not carry out development of a specified class or description, if satisfied that it would affect the lake in the way described above. The Minister can direct a public authority having functions under any Act relating to the use or carrying out of development in the coastal zone, to exercise those functions in such a way and at such time, as may be specified in the direction.

3.2.6 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act replaces the *Clean Air Act 1961*, *Clean Waters Act 1970*, *Noise Control Act 1975*, *Pollution Control Act 1970*, *Environmental Offences and Penalties Act 1989* and regulatory provisions of the *Waste Minimisation Act 1995*. The Act makes it an offence to pollute the environment without an environment protection licence issued by the Environment Protection Authority.

Schedule 1 of the Act lists scheduled activities which require a licence. These include dredging works in which materials of more than 30,000 cubic metres per year are obtained from the bed, banks or foreshores of any waters. As the Lake Conjola project will involve dredging more than 30,000 cubic metres an environment protection licence will be required.

3.2.7 River and Foreshores Improvement Act 1948

The River and Foreshores Improvement Act (RFIA) states that anyone who excavates or removes material from 'protected land' or does anything to interfere with the flow of 'protected waters' must first obtain a permit under this Act. Protected waters are defined in the legislation as '*rivers, lakes into, or from which, rivers flow, and coastal lakes/lagoons along with their channels to the sea*'. Protected land includes the bed, bank or shore of protected waters and land within 40m. In practice, the main activities dealt with by this legislation are sand and gravel extraction and canal subdivisions. The Water Corporation, Minister for Public Works and Services and Maritime Services Board have the responsibility for deciding whether or not permission should be given.

There are a number of cases where the provisions of the RFIA do not apply. Under s.22H of the Act, local councils and other public authorities are not bound by the Act when carrying out works themselves. Also, those in possession of a licence or lease under the Crown Lands Act do not have to seek consent under this Act. However, in the above circumstances, the relevant authority under the RFIA can still play a role. It can direct the person or body responsible for undertaking the activity to implement remedial works where the excavation or removal of soil is likely to harm protected land or interfere with the flow of protected waters.

3.2.8 National Parks and Wildlife Act 1974: Protection of Aboriginal Objects

The National Parks and Wildlife Service (NPWS) has a statutory responsibility for the care and protection of sites of Aboriginal heritage throughout NSW. The National Parks and Wildlife Act (NPWA) covers 'deposits, objects or material evidence' relating to 'indigenous and non-European habitation' in New South Wales, both before and after European settlement, excluding handicrafts made for sale (s. 5(1)).

The archaeological sensitivity of the development site should be considered as part of the REF and should include assessment based on consideration of topography, context, degree of disturbance, and the distribution and types of known Aboriginal sites in the local area.

Should any Aboriginal artefacts be discovered, these relics may be placed in the hands of the Australian Museum (s. 88) or alternatively, the area in which the relics are found may be constituted an Aboriginal area or a protected archaeological area. It is a criminal offence to knowingly destroy, damage a relic or Aboriginal place unless consent is first obtained (s.91). Touching or interfering with relics without authorisation is also an offence.

3.2.9 Heritage Act 1977

The Heritage Act provides for the conservation of environmental heritage, that is, places, buildings, works, relics, moveable objects or precincts of State or local heritage significance (s.4(1)). The Act does not apply to Aboriginal heritage. Under the Act recommendations can be made to the Minister for Urban Affairs and Planning for the issue of conservation orders to protect buildings, relics, works and places. An item protected by a heritage order cannot be demolished, redeveloped or altered without the approval of the Heritage Council.

3.2.10 Water Management Act 2000

The Water Management Act contains provision for approvals for ‘controlled activities’ that would include works by councils to open the entrances of coastal lakes. This part of the Act will commence in 2002.

3.2.11 Local Government Act 1993

This Act determines the operation of local councils and requires councils to have regard to the protection of the environment when carrying out their responsibilities.

3.2.12 Threatened Species Conservation Act 1995

The Threatened Species Conservation Act (TSCA) is administered by the National Parks and Wildlife Service. The Act protects certain classes of threatened species and places obligations on developers and consent authorities during the development consent process. Unless a licence has been obtained under the NPWA or TSCA, it is an offence under the National Parks and Wildlife Act to harm any animal or plant that is a threatened species, population or ecological community (NPWA s.118(1)(b)).

3.2.13 Shoalhaven City Council Local Environmental Plan 1985

The bed of Lake Conjola, including the delta, is Crown land in the care and control of the State Government. The bed of the lake to a line approximately 100 m west of the end of the spit is subject to Amendment 127 under the Shoalhaven City Council Local Environmental Plan 1985 (LEP 1985). The objectives of the plan under Amendment 127 are:

- a) to provide an overall city-wide rural planning framework which is based on recognised land use principles and underpinned by the principles of ecologically sustainable development
- b) to implement national, State and regional policies in a manner which enhances the unique characteristics of the City of Shoalhaven to the advantage of its present and future residents and visitors
- c) to implement Shoalhaven City Council’s various policies and strategies for rural areas which have evolved through public consultation, and
- (d) to introduce new definitions and provisions, and to rename certain zones, to assist in interpreting City of Shoalhaven Local Environmental Plan 1985.

The spit, including the southern high dunes, is Crown Land Reserve gazetted on 26 September 1930 under the care and control of Council. Under LEP 1985 the land is zoned 6(a) (Open Space – Recreation ‘A’ (Existing)). The objectives of the zone are to identify land where existing recreation facilities for the general use of the community are provided.

As the bed of Lake Conjola and the spit are Crown land, the entrance works will require a lease or licence which would require a land assessment or a waiver from the DLWC. This is covered more fully in Section 6.2.

Under LEP 1985 works on the spit would also require submission of a Development Application to Council, accompanied by a Statement of Environmental Effects (SEE). This REF, prepared as MHL1161, will provide a basis for the preparation of the SEE.

3.3 Summary of Major Issues

In order to carry out the entrance management works several permits are required:

- A licence or lease under the Crown Lands Act is required to carry out dredging and reclamation works. Acquiring this licence will exempt Council from obtaining similar licences under the Fisheries Management Act and the River and Foreshores Improvement Act.
- A aquaculture permit needs to be obtained under the Fisheries Management Act, as dredging works have the potential to harm marine vegetation, in particular, seagrasses.

4. The Existing Environment, Potential Impacts and Mitigating Measures

4.1 Physical or Pollution Issues During Construction and Operation

4.1.1 Physical or Pollution Issues During Construction and Operation – Air

Two main types of air quality impacts could potentially occur from the proposed project - dust generation and odour generation. As the sediments will be coarse grained clean sand and will be wet when dredged and transported, the potential for dust generation is considered insignificant.

There is little potential for odour generation from the excavated sediments, such as by generation of hydrogen sulphide (H₂S) as the sediment is clean, washed sand. Therefore, it is not expected that odour generation will be a significant problem during dredging.

4.1.2 Physical or Pollution Issues During Construction and Operation – Water

Lake water quality will be affected by the actual dredging process and the tidal flushing and flooding characteristics that will result after the construction phase. Dredging activities will cause short-term impact on water quality by suspending sediments in the water column, with the possibility that some contaminants may be released into the water column. The use of appropriate dredging techniques will minimise disturbance to the surrounding seabed and remove sediment with a low water content.

Flood Behaviour

The managed entrance will have a similar impact on flood behaviour to the existing entrance condition as it does not affect scouring of the entrance. The hydrologic analysis (Patterson Britton and Partners 1999) found the critical storm duration for Lake Conjola catchment is nine hours. Peak outflow discharges were found to be :

- minor flood – 1,000 m³/sec
- major flood – 2,100 m³/sec

Table 4.1 shows flood level predictions under various entrance conditions.

Table 4.1 Flood Level Comparisons

Location	Existing Closed Condition	Existing Heavily Shoaled	Existing Open Condition	Entrance Walls	Stub Wall	Managed Entrance
Downstream Caravan Park	2.97 2.59 (-)	2.81 2.41 (0.48)	2.62 2.24 (1.45)	4.00 2.48 (1.70)	2.90 2.47 (1.45)	2.62 2.24 (1.45)
Post Office	3.22 2.59 (-)	3.06 2.51 (0.48)	2.87 2.34 (1.45)	4.20 2.58 (1.70)	3.15 2.57 (1.45)	2.87 2.34 (1.45)
Canal Entrance	3.52 2.79 (-)	3.36 2.61 (0.48)	3.17 2.44 (1.45)	4.45 2.68 (1.70)	3.45 2.67 (1.45)	3.17 2.44 (1.45)
Edwin Avenue	3.67 2.94 (-)	3.51 2.76 (0.48)	3.32 2.59 (1.45)	4.60 2.83 (1.70)	3.60 2.82 (1.45)	3.32 2.59 (1.45)
Main Lake	4.37 3.24 (-)	4.21 3.06 (0.48)	4.02 2.89 (1.45)	5.20 3.13 (1.70)	4.30 3.12 (1.45)	4.02 2.89 (1.45)
Berringer Lake	3.17 2.69 (-)	3.01 2.51 (0.48)	2.82 2.34 (1.45)	4.15 2.58 (1.70)	3.10 2.57 (1.45)	2.82 2.34 (1.45)

Legend:

2.97 major flood scenario involving 1-in-100-year freshwater flow coinciding with 1-in-5-year storm surge

2.59 minor flood scenario involving 1-in-5-year freshwater flow coinciding with 1-in-5-year storm surge

(-) flood level due to 1-in-5-year storm surge only.

Source: SCC (1999)

Water Quality

The Lake Conjola Entrance Study (Patterson Britton and Partners 1999) examined water quality parameters and came to the following conclusions:

- median faecal coliforms levels between 1989 and 1998 within the lake generally meet ANZECC primary contact recreation guidelines
- during 1996/97 (*entrance closed*) elevated faecal coliform counts were recorded in swimming areas at the boat ramp near the lake inlet and adjacent to Edwin Avenue, Lake Conjola. These elevated coliform counts correlated to rainfall events
- sample sites adjacent to the boat ramp and the outlet from Pattimores Lagoon recorded high enterococci values (*1996/97*) particularly after rainfall events
- recent viral analysis commissioned by the local community detected adenovirus, enterovirus and reovirus in one of three water samples and three of five sediment samples. The presence of viruses in these samples indicates that sewage effluent has found its way into the lake
- elevated phosphorus values are reported around urban and agricultural areas (e.g. boat ramps Pattimores Lagoon, Yooralla Bay, Kidgee Point and Conjola Creek downstream of Fishermans Paradise).

It was determined that the relative weighting (*i.e. magnitude*) of pollutant inputs around the lake can be apportioned as follows:

- Downstream Caravan Park - 12%
- Post Office/Canal Entrance - 50%
- Adjacent to Edwin Avenue - 1%
- Killarney - 5%
- Conjola West - 12%
- Fishermans Paradise - 20%

Tidal Flushing

Under existing open entrance conditions (*1993 bathymetry*) the dry weather natural tidal flushing time at various locations is as follows (SCC 1999):

- Post Office - 1 day
- Edwin Avenue - 1 day
- The Steps - 5-10 days
- Killarney - 20-30 days
- Lake Conjola West - 30-40 days
- Fishermans Paradise - >70 days
- Berringer Lake - 10-20 days

The entrance condition determines the extent of tidal flushing. The existing entrance was considered as a time varying amalgam of three entrance states based on analysis of entrance stability, viz:

- closed - 15% of time
- heavily shoaled - 23% of time
- open - 62% of time

When the entrance is open, the inlet from the mouth to Conjola Island is 80-100% flushed and 60-80% from Conjola Island to 'the Steps'. Lake Berringer is approximately 30-40% flushed. Apart from a tongue extending along the northern shore to Station Point, the main body of Lake Conjola is flushed less than 10%. The minimal evacuation of the reference pollutant from the majority of the main lake (*in eight tide cycles*) reflects the long flushing times noted above.

When the entrance is heavily shoaled, the area of 80-100% flushing is limited to downstream of Chinamans Island. Berringer Lake is flushed less than 10% and the western half of Lake Conjola is not flushed at all.

Dispersion of Storm Pollutants

When the existing entrance is open, good flushing of the inlet (*i.e. up to 'the Steps'*) prevents any significant buildup of pollutants in the Lake Conjola township area.

Berringer Lake has no pollution because it is relatively isolated from the pollution sources in the short time available for them to disperse. This is consistent with the results of testing of oysters which have shown high bacteria counts in the flesh of oysters growing in the main channel after runoff producing rainfall but negligible bacteria in the oysters of Berringer Lake (SCC 1999).

Even with an open entrance, pollutants are not dispersed from the Fishermans Paradise area due to the shallow water depth, which restricts dilution, and the small tidal exchange. Pollutant inputs at Conjola West and Killarney are dispersed and diluted rapidly within 24 hours after a storm event. It should be noted, however, that the analysis assumes vertical mixing in the water column and therefore there could be some potential for concentration of bacteria in surface water depending upon ambient salinity levels in the lake.

When the entrance is heavily shoaled, high bacteria levels could occur in the canal leading to Pattimores Lagoon, justifying the general warning from Council that the public should not swim in the area for two days after rainfall runoff.

When the entrance is closed pollutant concentration increases between the entrance and ‘the Steps’ and there is a tendency for pollutant levels to be slightly elevated in Berringer Lake.

When the relative contribution of loads is considered, Table 4.2 shows that under existing open entrance conditions, the majority of pollution within the inlet, which is the main swimming and primary contact area, comes from the input load at the Post Office/canal entrance area. It can be seen that the water quality in the main lake is relatively less sensitive to pollutant sources from Lake Conjola township than it is to inputs from the areas of Killarney, Lake Conjola West and Fishermans Paradise.

Table 4.2 Proportion of Total Load Contributed by Each Pollutant Input Location

Location	Pollution Load (%)*					
	1	2	3	4	5	6
Downstream Caravan Park	15.9	81	1.4	1.0	0.7	0.0
Post Office	12.6	83.7	1.6	1.2	0.9	0.0
Canal Entrance	11.0	85.1	1.8	1.2	0.9	0.0
Edwin Avenue	10.3	84.1	1.9	2.1	1.7	0.0
The Steps	2.5	47.9	2.5	22.3	24.2	0.6
Main Lake (500 m u/s of The Steps)	1.3	29.9	1.9	24.0	41.2	1.6

Legend:

1. Downstream Caravan Park
2. Post Office/Canal Entrance
3. Edwin Avenue
4. Killarney
5. Lake Conjola West
6. Fisherman’s Paradise

Turbidity from Dredging and Deposition of Sand

Dredging activities will cause a short-term adverse impact on water quality by suspending sediments in the water column. The dredged material is well-washed marine sand with no fines. No turbidity was observed during the 1999 interim works either adjacent to the dredging or where the sand was deposited. In the unlikely event that turbidity is caused by dredging it can be contained by the use of silt curtains. The discharge point for deposition of sand on the spit should be arranged so that excess water is ponded to encourage seepage into the dunes.

4.1.3 Physical or Pollution Issues During Construction and Operation – Soil

The Entrance Study (Patterson Britton and Partners 1999) analysed and described the hydraulic and sedimentary processes of the lake entrance. Figure 4.1 describes the concept model developed by the study and illustrates the interaction between the nearshore coastal, marine delta, wind transport and flood regimes. The Entrance Study identified the following key findings:

- Northerly net longshore transport along Conjola Beach drives the northward growth of the entrance spit and forces the entrance channel against the northern shoreline.
- Because of the net northerly longshore transport, there are always extensive nearshore shoals opposite the entrance spit and entrance channel. These shoals produce a wide surf zone and considerable dissipation of wave energy opposite the entrance spit.
- The northern shoreline has reduced exposure to waves due to the wave shadow of Green Island and the dissipative effects of the nearshore shoals
- The entrance spit is always low and therefore susceptible to storm washover. Storm washover fans are a trigger for entrance closure.
- Wind-blown sand from Conjola Beach adds to the build up of the entrance spit, entrance dunes and tidal delta shoals. Wind-blown sand can build up the entrance to 3-4 m above sea level, requiring a major flood to scour a closed entrance.
- When the entrance is well scoured, tidal range is greatest and tidal flows are strong causing sand to be transported to the western extremity of the delta shoals.
- As the entrance shoals build up, tidal range and tidal flows reduce and the area of active sand transport retreats towards the entrance.
- Floods periodically scour the surface of the tidal delta and expand the entrance channel, thereby rejuvenating tidal flows and sediment infeed.
- Secondary flood tide channels convey sand towards the southern edge of the flood tide delta, in the vicinity of the boat ramp. Southerly propagation of the delta in this area deflects ebb tide and flood flows against the high dunes, causing bank erosion.

4.1.4 Physical or Pollution Issues During Construction and Operation – Noise and Vibration

The nearest populated areas to the proposed activity are the residential area of Cunjurong and the Council caravan park. The main noise sources for these areas are:

- very low level traffic noise from residential and holiday traffic in urban streets and the caravan park
- noise generated by breaking waves on the beach
- boating-generated noise
- wind noise.

The NSW Environment Protection Authority *Environmental Noise Control Manual* (EPA 1994) has drafted a schedule of recommended LA₉₀ background noise levels which it considers appropriate for various zoning descriptions. For residences in residential areas (approximately R1-R2 in AS 1055) the recommended daytime background noise levels at residences are an Acceptable Limit of 45 dBA and an Extreme Limit of 50 dBA. The *Environmental Noise Control Manual* also provides noise control guidelines for construction sites where there is the likelihood of annoyance due to noise. For construction periods of 4-26 weeks the noise level should not exceed the background by more than 10 dBA.

During the construction phase of the proposal, additional noise will arise while the dredger is in operation. However, it will be specified in the contract for dredging that all possible steps should be taken to silence equipment. It will also be specified that noise from the site must comply with the noise control guidelines in Chapter 171 of the *Environmental Noise Control Manual*. These require the LA₁₀ noise level measured over a period of not less than 15 minutes during dredging to not exceed the background (LA₉₀) noise level by more than 10dB(A) when assessed from any sensitive noise receiver if dredging continues beyond four weeks. It will also be specified that working hours be limited to 7.00 a.m. to 7.00 p.m. seven days a week.

4.2 Biological Issues During Construction and Operation

4.2.1 Biological Issues During Construction and Operation – Flora

The vegetation of Lake Conjola consists of saltmarshes, mangroves and seagrasses. The area has been infested by the invasive marine plant, cold tolerant *Caulerpa taxifolia*. An ecological assessment of vegetation impacts has been conducted by The Ecology Lab (2002) and is included in Appendix D of this report. The main aspects of this assessment are summarised below.

Seagrass

Based on aerial photography from 1979 and a field survey undertaken in 1982, West et al. (1985) mapped the distribution of saltmarsh, mangroves and seagrasses of Lake Conjola.

The Ecology Lab (1993) inspected aquatic habitats in Lake Conjola and observed that at several sites there had been declines in the amount of seagrass present compared to that mapped by West et al.(1985).

Patterson Britton and Partners (1999) summarised a study which compared the extent of seagrasses in the lake based on aerial photos taken in 1945, 1959, 1971, 1985, 1993 and 1997 (Heycox 1994). They emphasised the large variability in the amount of seagrasses present in the lake through time and concluded that the condition of the entrance was a main factor in causing the variability in the size of seagrass beds, with nutrient and sediment input and boat traffic also being contributing factors. They noted that the January 1997 aerial photographs showed significantly more seagrass present than in photos from 1982–1985. They further noted that the health or condition of the seagrass should also be considered when assessing seagrass in the lake, not simply the amount present (Patterson Britton and Partners 1999). The results of their site assessments suggested that in September 1998 *Zostera* in the lake showed a range of conditions from short, immature leaves to fully grown but bleached specimens.

There are no seagrasses in the immediate vicinity of the proposed dredging activities. The proposed dredging area is confined to the main channel, a habitat characterised by highly mobile sand. If the entrance remains open, it is unlikely that seagrasses would colonise this habitat in the future. It is therefore predicted that the proposal would have no direct effects on seagrasses in Lake Conjola.

Increases in turbidity can reduce the production of seagrasses and promote the growth of epiphytes on seagrass blades (Borowitzka & Lethbridge 1989). Based on observations during the Stage 1 (Interim) works, no increase in the turbidity of water due to entrance channel dredging would be expected.

Patterson Britton and Partners (1999) suggested that under permanently open entrance conditions the extent of seagrass may not be as great as in previous years (e.g. 1945, 1971 or 1997), but that the health of existing seagrasses might improve. They predicted that one effect of a permanently open entrance would be the dieback of seagrasses that had become opportunistically established during periods of elevated water levels. The extent of the dieback would depend on the location of the newly colonised beds, with seagrasses colonising channel edges, areas closest to the entrance and those above the tidal range likely to dieback as a consequence of scouring, burial or exposure (Patterson Britton and Partners 1999).

Another effect on seagrasses of a permanently open entrance channel is likely to be the increased opportunity for estuarine-dependant organisms to colonise seagrass beds. Continuous tidal flushing would increase the chances of recruitment of juvenile fish and their invertebrate food, increasing the diversity and, potentially, the abundance of organisms living in the seagrass beds.

Saltmarsh and Mangroves

Saltmarsh vegetation was described from Pattimores Lagoon by Finley (1988). A variety of typical vegetation communities occurred, including *Sarcocornia* samphire flats in the small embayment around the perimeter of the lagoon, extending into *Juncus* and *Phragmites* reed beds. A few mangroves (*Avicennia marina*) were recorded, but seagrasses were not (Finley 1988).

Infestation of *Caulerpa taxifolia*

A large proportion of Lake Conjola is infested with the invasive marine alga, *Caulerpa taxifolia* (Grey 2001). The population in Lake Conjola is thought to have become established between 1987 and 1995 and is most closely related to populations from Moreton Bay, Queensland. The method of transfer to Lake Conjola is not known, but it may have been introduced by boats, fishing equipment or released from an aquarium. The alga can survive in damp conditions for more than a week, and can spread from small fragments (Grey 2000/2001). In an effort to halt or limit the spread of the invasive alga, NSW Fisheries introduced new fishing restrictions on 14 June 2001. Haul netting was banned entirely in the lake, but mesh netting is allowed to continue on the basis that the nets are used only in Lake Conjola. Other recommendations include avoiding boating in areas near the infestation to reduce the incidence of fragmentation of existing beds. NSW Fisheries is currently experimenting with methods to control existing infestations, including applying salt to the plants.

The factors that influence the growth of *Caulerpa taxifolia* are not well known. If, as NSW Fisheries suspects, the alga became established between 1987 and 1995, then it did so in a period when the lake was mainly open. The lake closed on 1 November 1994 after an open period of more than 18 months, and was subsequently closed for nearly four years until 4 June 1998. As the lake has been open since mid-1998 and a large patch of algae has been only relatively recently identified and mapped, it would appear that the alga can flourish regardless of the state of the entrance. While it is possible that increased flushing of the estuary since the entrance opened in June 1998 has increased the fragmentation of the algae, spreading the

infestation, there is no evidence to assess the validity of this mechanism. On the basis of these, largely anecdotal, observations, it is predicted, therefore, that the impact of keeping the entrance open would have no measurable effect on the infestation of the alga. It must be emphasised, however, that more information on the ecology of the alga in Lake Conjola is required to confirm this prediction.

The most recent information from NSW Fisheries indicates that the infestation has currently (January 2003) been reported throughout most of Lake Conjola, including the main entrance channel (Kylie Russell, NSW Fisheries, pers. comm.) If the alga was present within the main entrance channel and dredging were to commence within this area, possible translocation and fragmentation of existing plants may occur. This could be detrimental to the health of nearby seagrass beds that are currently unaffected by *Caulerpa taxifolia*, and also increase the problem already present within the lake. Should the alga be found near the area to be dredged, a dredging methodology to minimise potential adverse impacts should be adopted. For example, it may be possible to initially skim dredge the surface of the channel bed to remove and then treat any *Caulerpa taxifolia* prior to the main dredging.

The contract documents will specify the protection measures required to be implemented and the dredging contractor will be specifically instructed on the importance of the measures. The Principal's Representative will be instructed to ensure that protective measures are implemented and maintained throughout the project.

4.2.2 Biological Issues During Construction and Operation - Fauna

The wetland habitats on Lake Conjola include sandy shoals, saltmarsh and fringing sandflats and mudflats. An ecological assessment of fauna impacts has been conducted by The Ecology Lab (2002) and is included in Appendix D of this report. The main aspects of this assessment are summarised below.

Benthic Invertebrates

Assessment of benthic invertebrates is restricted by the lack of information in any part of Lake Conjola and has been reliant on patterns of distribution and abundance of benthic organisms in other estuaries, and the known effects of dredging in sandy marine habitats.

Benthic invertebrates in dredged sediments will die. Based on studies of the effects of dredging on benthic communities in sandy sediments, it is predicted that the benthic community in the dredged channel would recover, as a result of migration of surrounding animals into the sediment and the recruitment of new organisms to the new habitat (The Ecology Lab 1993b, Newell et al. 1998). The time required for this recovery is unknown, but likely to vary from as little as a few months to two years (Jones 1986, The Ecology Lab 1993b, Newell 1998). Shorebirds are expected to benefit from a short-term increase in food supply in sand deposited on the sand flat. There are not expected to be any odour impacts.

Fish

Pollard (1994a) sampled fish communities in April 1984 and May 1985. One hundred species of fish were captured, of which 73 were found in *Zostera* beds, 76 in shallow sandy habitats and 33 over the deeper part of the lagoon. Almost half the species were of some economic importance to commercial and recreational fisheries. Pollard (1994a) considered the fish community of Lake Conjola to be one typical of an estuary with a permanently open entrance, despite the periods of closure the estuary experiences.

The Environment Research Institute (1999) sampled fish from seagrass beds in the entrance, middle region and upper regions of Lake Conjola in spring 1998, summer and autumn 1999 using a small seine net. They collected a total of 42 species, including 16 of commercial importance. They found the greatest numbers of fish in the upper region of the estuary, but a greater diversity in the entrance and mid-estuary regions (ERI 1999). The entrance was open during their sampling (spring 1998), but had been preceded by a four-year period of closure.

The activities of the cutter suction dredge are likely to disturb fish using the entrance channel, but fish are able to avoid the dredger by swimming in other parts of the entrance channel. The main feature of the fish community, in comparison to estuaries that are predominantly closed, was a greater diversity of species and the presence of some species that appear to require a permanent or almost permanent opening to the sea. As the aim of the proposed works is to maintain the estuary's connection to the sea, it is predicted that a long-term effect may be to increase fish species diversity in the lake compared to its present state.

Section 4.2.2.1 discusses threatened fish species of Lake Conjola.

4.2.2.1 Threatened Species

An ecological assessment of threatened species impacts has been conducted by The Ecology Lab (2002) and is included in Appendix D of this report. The main aspects of this assessment are summarised below

The following fish species listed as protected under the EPBC Act 1999 have been collected in Lake Conjola:

- black pipefish (*Stigmatopora nigra*) (Pollard 1994a, ERI 1999)
- hairy pipefish (*Urocampus carinirostris*) (Pollard 1994a, ERI 1999)
- spotted pipefish (*stigmatopora argus*) (Pollard 1994a)
- mother-of-pearl pipefish (*Vanacampus margaritifer*) (Pollard 1994a).

These pipefish are known to use seagrass beds as their primary habitat. No fish species currently listed on Schedule 4 or 5 of the Fisheries Management Act has been recorded from Lake Conjola in the published literature. As discussed in Section 4.2.2, the proposed works are not expected to impact on fish.

A search of the NSW National Parks and Wildlife Atlas resulted in the following numbers of Endangered or Vulnerable species which were observed within approximately 10 km of Lake Conjola.

Type of Animal	Number of Endangered Species	Number of Vulnerable Species
Amphibians (frogs)	1	0
Aves (birds)	4	14
Mammals	1	9
Reptiles	0	1

The relatively shallow water in the vicinity of the entrance provides important feeding habitat for many bird species. The exposed sandflats are used by shorebirds for feeding and nesting. The higher dry sandflats between the sea and the lake are used for nesting by a few species. High water level usually has a negative impact on many wetland birds, because it reduces the

abundance and diversity of habitats available. For example, when the water level reaches 1.0m AHD, there are virtually no entrance shoals, which are important feeding areas for waders (K. Mills 2000).

Three threatened bird species are fairly regularly observed in Lake Conjola; these are the Hooded Plover, Little Tern and Pied Oystercatcher. Other threatened fauna that may occur there less frequently include the Sooty Oystercatcher, Lesser Sand Plover and Sanderling. The Hooded Plover and Little Tern are listed as endangered species under Schedule 1 of the Threatened Species Conservation Act.

Within NSW, the Hooded Plover occurs along the southern coast, north to Jervis Bay. Occasional vagrants may be sighted further north at Wollongong. The Hooded Plover is most often found on long stretches of sandy shore, backed by sparsely vegetated sand dunes for shelter and nesting. The species is both diurnal and nocturnal, foraging on beaches in wave-wash, lagoons and saltpans. It is considered to be under threat because of disturbance to its nesting sites during the breeding season in summer, when coastal areas are intensively utilised for recreational activities (NPWS 1999). The Hooded Plover has been spotted on a regular basis foraging on Lake Conjola entrance and Conjola Beach (K. Mills 2000).

In NSW, the Little Tern is found along the eastern coast. While the species was once common in NSW, breeding individuals now only exist in small threatened populations. Its habitat is exclusively coastal with sheltered environments preferred. The Little Tern nests in small, scattered colonies on sandy beaches or shingle pits. These nesting sites are particularly vulnerable to human disturbance, predation and natural catastrophes. The species forages by plunging in the shallow water of channels and estuaries, and in the surf on beaches. They are threatened due to nesting in flood-prone locations, predation and human disturbance. Lake Conjola was a nesting site for up to 10 pairs on a sand spit at the lake entrance in the late 1940s and early 1950s. Then, there were no subsequent records until three pairs were observed in 1995/96 and four pairs in 1996/97.

The Pied Oystercatcher is listed on Schedule 2 of the Threatened Species Conservation Act. This species has been severely reduced, and its distribution is limited. In Australia, the Pied Oystercatcher is distributed along the entire coastline, but it is more prominent in Victoria, Tasmania and South Australia. Its habitat includes intertidal mudflats, large marine embayments and ocean beaches. It usually roosts at high tide on open sandy spits. Its nest is a scarp in the sand, just above the high tide mark. Threats to the Pied Oystercatcher include nesting failure caused by predation, disturbance by people, off-road vehicles and domestic animals. Lake Conjola provides ideal habitat for the species and it has been regularly recorded there. Outside the breeding season, up to seven birds have been observed at Lake Conjola. Breeding probably occurs somewhere within the lake but the exact locations have not been identified. The Pied Oystercatcher mainly uses moist sandflats, which are used for feeding and resting.

Kevin Mills & Associates (2000) has detailed potential effects on bird species affected by the Stage 1 (Interim) works, including recommendations for mitigating impacts on threatened bird species. As the works proposed for the Entrance Management Plan involve the same suite of activities in the same locations, the analysis provided by Kevin Mills & Associates (2000) also applies for this REF. The most important method of mitigating impacts on nesting birds would be to avoid undertaking works in their breeding season, September to March.

Kevin Mills & Associates (2000) also considered the impact on birds (Pied Oystercatcher, Hooded Plover, Little Tern) of sand placement on the existing sand dunes. He noted that dunes are naturally dynamic habitats, but the proposed addition of sand would provide suitable nesting habitat for Little Terns if it were levelled and supplied with natural debris to hide nest sites and eggs. The provision of fencing to discourage access by people would provide a safe retreat which would encourage breeding.

Kevin Mills & Associates (2000) predicted that the deposition of sand on the sandflat was not likely to disrupt the lifecycle of Pied Oystercatchers and Hooded Plovers, as alternate sites were available for feeding and, potentially, breeding for these species.

4.3 Resource Use Issues During Construction and Operation

4.3.1 Community Resources

Several villages and caravan parks line the lake shoreline and are popular tourist destinations during the summer holiday periods. Lake Conjola entrance has two boat ramps and is a popular destination for fishing, swimming and boating. Dredging operations will have a minimal impact on tourists and residents during the working hours 7.00 a.m. to 7.00 p.m.

The implementation of the Entrance Management Plan will enhance access to community resources by ensuring the lake remains open and therefore maintains healthy water quality. The plan will also mitigate erosion of the southern shoreline.

4.3.2 Natural Resources

The major commercial fishing methods in Lake Conjola are haul netting, mesh netting and eel traps. As of 1993, six licensed fishermen were reported to operate in Lake Conjola, but they did not fish there regularly (Wayne Currie, Ulladulla Fisheries Inspector, pers. comm.) On 14 June 2001, NSW Fisheries introduced new fishing restrictions which included a complete ban on haul netting.

Areas closed to commercial fishing and distribution of oyster leases are shown in Appendix E, Figure 2.

Table 4.3 gives statistics for production in the commercial fisheries for Lake Conjola.

Table 4.3 Commercial Fisheries Production for Lake Conjola

Year or Average for Period	Number of tonnes	Source
1972 to 1982	9	West et al. 1985
July 1987 to June 1991	8	Pollard (1994a)
1993/1994	17	NSW Commercial Fisheries Statistics 1993/94 to 1997/98
1994/1995	18	NSW Commercial Fisheries Statistics 1993/94 to 1997/98
1995/1996	15	NSW Commercial Fisheries Statistics 1993/94 to 1997/98
1996/1997	5.8	NSW Commercial Fisheries Statistics 1993/94 to 1997/98
1997/1998	5.8	NSW Commercial Fisheries Statistics 1993/94 to 1997/98

NSW Fisheries statistics for 1997/1998 indicate that commercial landings of finfish accounted for 99.5% of estuarine production and was dominated by catches of silver biddy, sand whiting and sea mullet. The average number of fishers for 1997/1998 was eight, while the number of days of fishing effort (all fishing methods) was 102.

Oyster leases cover an extensive area from Roberts Point to Berringer Lake. Oyster production between 1972 and 1982 averaged 23 tonnes (West et al. 1985), but dropped to an average of 7.7 tonnes for the period 1983 to 1992. This drop continued between 1994 and 1997, with the average yearly production of oysters being approximately 3.5 tonnes (NSW Fisheries 1998).

Oyster farms and fishing resources can be adversely affected by the turbidity plumes caused by dredging. Turbidity plumes smother seagrasses and benthic communities.

The predicted increase in fish diversity discussed in Section 4.2.2 does not necessarily translate to an increase in overall productivity for recreational or commercial fishers. Pollard (1994a) noted that lagoons with intermittent openings supported more valuable fisheries compared to Lake Conjola. This was largely due to the value of prawns, which in lagoons with intermittent openings are more easily harvested before they can return to the sea. Thus, it is predicted that the value of the finfish industries (recreational and commercial) may benefit from a permanent opening, but that the prawn fishery may not.

The nearest oyster beds are approximately 1 km upstream of the proposed dredging area. As the turbidity of the water running off the dredged sand has been previously observed to be low, there are no detrimental impacts on oysters predicted.

Keeping the entrance channel open is expected to increase tidal flushing in the estuary, which is likely to improve water quality overall. Improved water quality would be expected to benefit the commercial oyster industry by producing better quality oysters. The open entrance would also reduce the effects of flooding, which would also improve the quality of commercial oysters.

As discussed in Section 4.2.2, it is expected that benthic invertebrate communities would recover through recolonisation.

4.4 Community Issues During Construction and Operation

4.4.1 Community Issues During Construction and Operation - Socio-economic Factors

A minor benefit to the local community should result from the construction phase due to low level expenditure in local businesses. A low level of temporary disruption at the site would also occur during construction. During operation there may be a small financial benefit to tourism operators due to the benefits of clean waterways.

4.4.2 Community Issues During Construction and Operation - Heritage, Aesthetic and Cultural Factors

The entrance sand spit is an ephemeral feature which 'comes and goes' with floods and storms. The existing sand spit is less than two years old. As this is an intrinsic geomorphological trait of this area, there are no areas of Aboriginal or archaeological interest.

No detailed surveys have been carried out in the Lake Conjola District, however the NPWS have indicated that Aboriginal activity was high in the Ulladulla district and that the immediate foreshore environment of Lake Conjola would contain sites of Aboriginal significance. The erosion of the high dunes along the southern shore of the lake exposed ancient Aboriginal remains likely to be of Pleistocene Age (>20,000 years). This event illustrates that the erosion along the southern shore potentially threatens other Aboriginal remains and artefacts. By reducing the erosion of high dunes on the southern shore, the proposed works should protect these remains.

4.4.3 Community Issues During Construction and Operation - Land Use Issues

4.4.3.1 Recreational Fishing

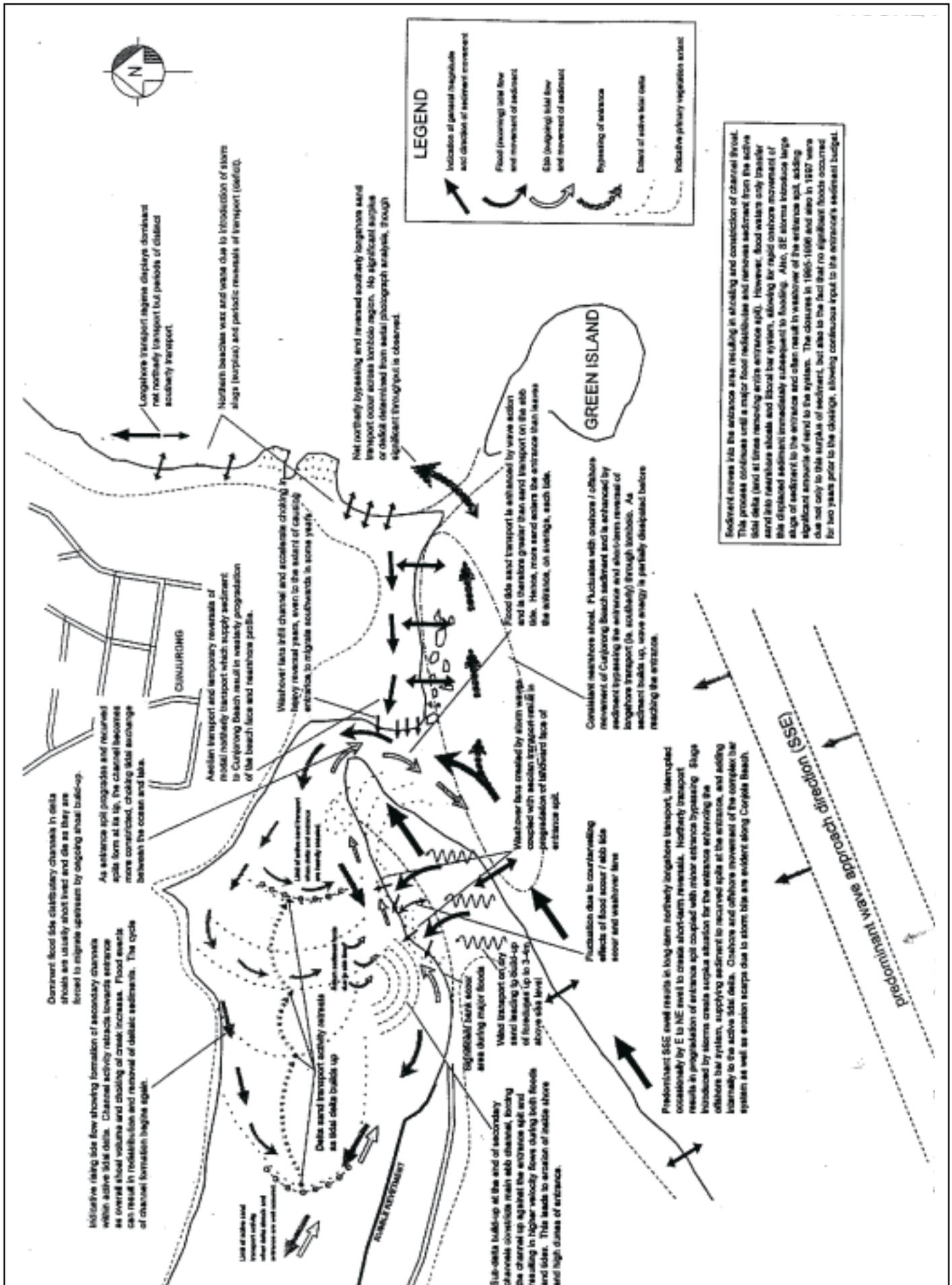
The recreational fish catch from Lake Conjola was assessed by creel surveys during summer of 1983/84 and 1984/85 (Henry 1986). The estimated summer fish catches from Lake Conjola were 16,524 for 1983/84 and 17,046 fish for 1984/85. The catch-per-unit-effort (CPE) was 0.59 and 0.63 fish per fishermen hour. The recreational fish catch was greatest in January. CPE was lower in the upstream region of Lake Conjola. Boat fishermen had a higher CPE than shore fishermen and CPE was higher during weekdays than weekends. Twenty-one species of fish were captured, with dusky flathead, sand mullet, bream, garfish and luderick being the most prominent species. A decline in the catches of popular angling species (flathead, bream) and an increase in less popular species (mullet, garfish, leatherjackets) was found for 1984/85, but whether this shift is due to natural variation or the effects of human activities is unknown.

As with commercial fisheries (Section 4.3.2), the predicted increased in fish diversity (discussed in Section 4.2.2), does not necessarily translate to an increase in overall productivity for recreational fishers.

4.4.4 Community Issues During Construction and Operation - Transportation Issues

As there will be no transport of material offsite, traffic movements will be limited to supply and removal of the dredge, working barge, dredge pipelines by low loader and one or two trucks. The total dredge crew is likely to be no more than four people. Hence, there will be little traffic generated by the project.

The dredging equipment would be transported to site by low-loader and assembled at the southern ramp. Two semi-trailer loads would be required for the dredge and one for pipes. The total number of truck loads would be approximately five. A mobile crane would be required for assembly. A week would be required for set-up at the commencement of the project and a week for disestablishment at the end of the job.



Source: Patterson Britton & Partners Pty Ltd 1999

5. Evaluation of the Significance of Impacts

5.1 General

In order to evaluate the likely significance of potential impacts of the proposal on the environment it is necessary to consider three factors:

1. the extent of the impacts
2. the nature of the impacts, and
3. the level of adverse impacts on environmentally sensitive areas.

5.2 Physical and Pollution Impacts

Air and soil impacts are considered to be minimal as the dredging operations will take place underwater, and the dredged material is clean marine sand. The main water impact of concern is turbidity at the point of dredging. Turbidity would be minimal due to the nature of the sediment.

Noise impacts from dredging will be localised. Works will be limited to between 7.00 a.m. and 7.00 p.m. Residential properties nearest the site will not be significantly affected due to limits placed on noise levels, limits on the time of day of dredging and distance from the activity.

5.3 Biological Impacts

Biological impacts are expected to be short term and localised. The assessment carried out by The Ecology Lab (2002) suggested that the main issues to be considered are benthic invertebrates, *Caulerpa taxifolia* infestation and habitat for migratory nesting birds. A number of measures to ensure minimal impacts have been suggested by The Ecology Lab (2002).

5.3.1 Benthic Invertebrates

Benthic invertebrates living in the proposed dredging channel will die as a result of being removed with dredge sand, but are expected to recolonise the dredged areas within a time frame of up to two years. Measures to minimise these impacts include:

- Plan dredging for winter months to reduce the numbers of benthic animals affected. Such timing would correspond with mitigating the impacts on migrating nesting birds and allow for spring recruitment of invertebrate larvae into the new habitat.
- Monitor runoff from dredging activity. If runoff water is turbid, consider placing silt curtains around dredge to reduce potential for spread of turbid water.

5.3.2 *Caulerpa taxifolia* Infestation

At this stage the introduced species *Caulerpa taxifolia* has been reported throughout most of Lake Conjola, including the main entrance channel. During final design of the dredging project NSW Fisheries should be consulted to establish if the alga is present in the proposed dredging area and in nearby seagrass beds. If the alga is present in the dredging area, a method of dredging which minimises any possible adverse impacts should be considered. For example, it may be possible to skim dredge the surface of the channel bed and then treat any *Caulerpa taxifolia* prior to the main part of the dredging.

5.3.3 Migratory Nesting Birds

The recommendations for mitigating impacts on migratory nesting birds are the same as identified for the Stage 1 (Interim) study (Kevin Mills & Associates 2000). They included:

- consultation with NPWS regarding the current breeding status of Little Terns
- avoiding undertaking the work between September and March when Little Terns and Hooded Plovers may be nesting
- minimising the area of sandflat disturbed by the bulldozer
- fencing off the newly placed sand on the dune to exclude people and make the nesting area more attractive to Little Terns
- providing natural debris such as seaweed, shells and timber across the top of the dune to encourage nesting
- limit the route of the bulldozer to the existing walkway route and traverse the route as few times as possible.

5.4 Resource Use Impacts

The commercial oyster industry and recreational and commercial finfish industry are expected to benefit from a permanent opening. The prawn fishery may not.

5.5 Community Impacts

It is proposed to implement an Environment Management Plan and an Occupational Health and Safety Plan to cover dredging operations and to monitor water and air quality during the project. It will also be necessary to obtain a Dredging and Reclamation Permit and a Marine Vegetation Permit from NSW Fisheries for the project. An Environment Protection Licence will be required for the project as the volume of dredging is greater than 30,000 m³.

5.6 Summary of the Significance of Impacts

Table 5.1 shows the overall significance of impacts for each environmental issue of concern. It can be seen this project overall will present low community impacts. The main areas of concern are biological impacts on threatened migratory birds and seagrass communities. However, these impacts are predicted to be relatively low once mitigation measures have been implemented.

Table 5.1 Review of Environmental Factors Summary

Impacts	Potential significance considering the <u>extent</u> of the impacts (L,M,H)	Potential significance considering the <u>nature</u> of the impacts (L,M,H)	Potential significance considering the level of adverse impacts on <u>environmentally sensitive areas</u> (L,M,H)
Physical and pollution			
a) air impacts	Low	Low	Low
b) water impacts	Medium	Low-Medium	Low-Medium
c) soil impacts	Low	Low	Low
d) noise and vibration impacts	Low	Low	Low
Biological			
a) fauna	Low-Medium	Medium	Low-Medium
b) flora	Medium	Medium	Low-Medium
c) ecological	Low-Medium	Medium	Low-Medium
Resource use			
a) community resources	Low	Low	Low
b) natural resources	Low	Low-medium	Low-medium
Community			
a) social impacts	Low	Low	Low
b) economic impacts	Low	Low	Low
c) heritage, aesthetic, cultural impacts	Low	Low	Low
d) land use impacts	Low	Low	Low
e) transportation impacts	Low	Low	Low
Activity as a Whole	Low-Medium	Low-Medium	Low-Medium

6. Conclusions and Recommendations

6.1 Adverse Impacts and Mitigative Measures

The works considered in this Review of Environmental Factors have been assessed as having some minor short-term and localised adverse impacts on the environment. These are associated with the operation phase of the project (i.e. dredging and subsequent placement). The adverse environmental impacts are summarised in Table 6.1.

Table 6.1 Summary of Potential Environmental Impacts

Impact	Short or Long Term	Comments
Water quality (turbidity during dredging)	Short	<ul style="list-style-type: none"> • Due to the nature of the sediment turbidity impacts are expected to be minimal. • Use of silt curtains to contain turbidity in the unlikely event it occurs will minimise adverse impacts during dredging. • In the long term an increase in tidal flushing and a reduction in flood events should result in improved water quality.
Noise	Short	<ul style="list-style-type: none"> • Localised noise impacts will be experienced during dredging operations. • Work will be limited to reasonable hours.
Ecological	Short	<ul style="list-style-type: none"> • Benthic invertebrates removed during the dredging and placement exercise will die. Communities from surrounding areas are expected to re-colonise the site of dredging. • A permanently open entrance is not expected to have a negative impact on existing seagrass beds. • <i>Caulerpa taxifolia</i> may infest the dredging site prior to dredging. Dredging may be detrimental to any nearby unaffected seagrass beds or the lake as a whole. • Following the prescribed mitigation measures and avoiding dredge works between September and March should minimise any impacts on migratory nesting birds.
Fisheries	Long	<ul style="list-style-type: none"> • The commercial oyster and finfish industries are expected to benefit from a permanently open entrance. • There is not expected to be a benefit for prawn fishery.

A number of mitigative measures have been recommended to minimise impacts on the environment. These are summarised in Table 6.2.

Table 6.2 Summary of Recommended Impact Mitigative Techniques

Impact	Mitigation Measures
Water quality impacts (turbidity)	<ul style="list-style-type: none"> • Use of appropriate dredging methods which will minimise disturbance to the surrounding sea bed and remove sediment with a low water content. • Use of silt curtains to contain turbidity in the unlikely event that it occurs. • Sand should be deposited directly from the discharge pipe to the dunes. The discharge should be arranged so that excess water seeps directly into the dunes.
Noise during operation	<ul style="list-style-type: none"> • Dredging times to be minimised to 7 a.m. to 7 p.m.
Disruption of migratory nesting birds	<ul style="list-style-type: none"> • Consultation with NPWS regarding the current breeding status of Little Terns. • Avoiding undertaking the work between September and March when Little Terns and Hooded Plovers may be nesting. • Minimising the area of sandflat disturbed by the bulldozer. • Fencing off the newly placed sand on the dune to exclude people and make the nesting area attractive to Little Terns. • Providing natural debris such as seaweed, shells and timber across the top of the dune to encourage nesting. • Limit the route of the bulldozer to the existing walkway route and traverse the route as few times as possible.
Reduction in benthic invertebrates at dredge site	<ul style="list-style-type: none"> • Plan dredging for winter months to reduce the numbers of benthic animals affected. Such timing would correspond with mitigating the impacts on migrating nesting birds and allow for spring recruitment of invertebrate larvae into the new habitat.
<i>Caulerpa taxifolia</i> infestation	<ul style="list-style-type: none"> • The presence of <i>Caulerpa taxifolia</i> in the dredging area should be investigated during final design of dredging. If the alga is found a dredging methodology that minimises potential adverse impacts should be utilised.

6.2 Beneficial Effects

The major beneficial effects will be a reduction in flooding due to a closed entrance and improvement to the overall water quality of Lake Conjola. This will have flow-on effects for human health, recreational amenity, tourism and the oyster and finfish industries. The permanently open entrance will help to mitigate flood impacts for development along the foreshore area. The benefits are summarised in Table 6.3.

Table 6.3 Benefits of a Permanently Open Entrance

Benefit	Comments
Flood mitigation	<ul style="list-style-type: none"> • Several villages and caravan parks line the lake shoreline and are popular tourist destinations during summer holiday periods. An open entrance will result in less frequent flooding.
Improvement in water quality	<ul style="list-style-type: none"> • A closed entrance results in raised water levels, leading to inundation of septic disposal systems (this has human health impacts). • Build-up of freshes due to the removal of tidal flushing results in a reduction in overall water quality.
Maintenance of oyster production	<ul style="list-style-type: none"> • Improved water quality associated with tidal flushing and a reduction in flooding are expected to be advantageous for the oyster industry.
Maintenance of tourism	<ul style="list-style-type: none"> • Poor water quality in the lake may impact on the desirability of the area as a tourist destination.

6.3 Monitoring

In their assessment of the impacts on the aquatic ecology of the proposed activities (Appendix E), The Ecology Lab (2002) has recommended a monitoring program to assess the long-term impacts on:

- fish communities and seagrass
- *Caulerpa taxifolia* infestation
- benthic communities, and
- migrating nesting birds.

Monitoring of the entrance is essential to maintain a sustainable, long-term open managed entrance. Monitoring will provide additional data to facilitate management of the entrance environmental and hydrodynamic processes.

MHL currently operates a water level monitoring station and rain gauge on behalf of SCC in the entrance inlet, approximately 200 m upstream of the boat ramp. The water level data will provide the tidal data input to the decision support system to allow identification of increasing entrance constriction.

The Entrance Management Plan also recommended that the following environmental monitoring program be undertaken to provide data for the decision support system and to allow refinement of the final design of dredging:

- continue continuous water level monitoring
- continue continuous rainfall monitoring
- regular water quality monitoring in the entrance inlet
- annual hydrographic survey at key cross-sections across entrance channel
- annual survey of key sections across entrance spit
- annual small format aerial photography of entrance area.

6.4 Statement of Environmental Effects for Dune Works

As outlined in Section 3.2.13, LEP 1985 requires submission of a Development Application to Council, accompanied by a Statement of Environmental Effects for works on the spit. This REF should provide the basis for preparation of the SEE.

6.5 Land Assessment

As outlined in Section 3.2.3, an ongoing licence should be sought from the Minister for Land and Water Conservation to avoid the need for a land assessment prior to future dredging.

7. References and Bibliography

Bentley, K.W. 1976, Recent depositional morphology of a tidal inlet – Conjola Lake NSW. BA Hons. Thesis. University of Sydney, Dept. Geography, 57p.

Finley, A. 1988, The environmental history and trophic status of Pattimores Lagoon, Lake Conjola. BA Hons. Thesis, University of NSW, Dept. Geography and Oceanography, Canberra, 162p.

Gutteridge Haskins and Davey Pty. Ltd. 1996, *Lake Conjola, Stage 1: Estuary Processes Study*, prepared for Shoalhaven City Council and Department of Land and Water Conservation.

Healthy Rivers Commission 2001, Independent Public Inquiry into Coastal Lakes: Draft Paper.

Heycox, G. 1994, Lake Conjola Seagrasses. B. App. Sc. Report. University of Western Sydney – Hawkesbury.

Hunter, T, 1989, Late quaternary evolution of two estuaries, southern New South Wales Australia with particular reference to central basin mud facies. BA Hons. Thesis, University of Sydney, Dept. Geography, 206p.

Kevin Mills and Associates Pty. Ltd. 1996, *Supplementary Report Ecological Assessment Maintenance Dredging*.

Kevin Mills and Associates Pty. Ltd 2000, *Ecological Assessment Proposed Stage 1 (Interim) Works Conjola Lake Entrance*. Report prepared for Shoalhaven City Council, NSW.

Conjola Lake Entrance City of Shoalhaven, Report prepared for Shoalhaven City Council, NSW.

National Parks and Wildlife Service 1999, Threatened Species Profile: Hooded Plover.

National Parks and Wildlife Service 2000, Draft Recovery Plan: Little Tern (*Stern albifrons*).

NSW Fisheries 1999, *Status of Fisheries Resources 1997/98*, NSW Fisheries Research Institute.

NSW Department of Public Works and Services 2003, *Lake Conjola Entrance Management Plan*, Manly Hydraulics Laboratory Report No. 1159 (DPWS Report No. 01113).

Patterson Britton and Partners Pty. Ltd. 1999, *Lake Conjola Entrance Study*, prepared for Shoalhaven City Council.

Patterson Britton and Partners Pty. Ltd. 1999, *Lake Conjola Entrance Stage 1 (Interim) Works, Review of Environmental Factors*, prepared for Shoalhaven City Council.

Pollard, D.A. 1994, 'A Comparison of Fish Assemblages and Fisheries in Intermittently Open and Permanently Open Coastal Lagoons on the South Coast of New South Wales', *Wetlands (Australia)* 13:16-35.

Public Works Department 1993, *Conjola Lake Tidal Gauging 30th October 1992*. Report MHL 637 (PWD Report 92092).

Appendix A
Government Agency Consultation

File No. LRE6-00131



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

Telephone 02 9949 0275
Facsimile 02 9949 0299
RCook@mhl.nsw.gov.au

Dear Sir/Madam

Lake Conjola Entrance Management Works Review of Environmental Factors

Shoalhaven City Council has commissioned Manly Hydraulics Laboratory to prepare an Entrance Management Plan for a sustainable open entrance for Lake Conjola on the NSW south coast. Lake Conjola is predominantly open to the ocean but the entrance has a history of gradually shoaling over time and closing off. This leads to a decline in water quality and flooding problems. Currently the entrance is re-opened some period after closure by excavating a pilot channel across the closure spit.

An estuary processes study for the lake was prepared in 1996 and an estuary management plan prepared in 1998. The *Lake Conjola Entrance Study*, undertaken in 1999, investigated entrance dynamics and defined a number of options to maintain a sustainable entrance. Subsequently, following public consultation, a *preferred option* of a "Managed Entrance" was adopted by Council. The Entrance Management Plan will facilitate the change to the "Managed Entrance" strategy and will include:

- the layout and construction method for the works required for the strategy
- definition of the flow criteria to occur before implementing the strategy works
- future maintenance requirements
- environmental constraints
- setting up a decision support system to identify imminent closure and set in train the procedures defined in the plan.

The adopted option includes the following works to maintain a viable lake entrance:

- excavating a substantial channel approximately south to north across the inner sand flats, leading to the northern entrance throat
- building up the entrance spit to a level (approx RL 7.0 m AHD) above wave run up to limit coastal storm washover effects.

A figure showing the extent of the works is included with this letter.

Manly Hydraulics Laboratory (MHL) is preparing a Review of Environmental Factors (REF) for the proposed works to accompany the Management Plan. The REF would be submitted to the Determining Authority for the REF, the Department of Land and Water Conservation, when imminent closure is identified and the entrance works need to be initiated.

MHL seeks comments from your organisation identifying any matters that you wish to be considered in the preparation of the REF. In addition MHL seeks information regarding the following matters.

- The legislation under which your agency operates and specific provisions of the legislation relevant to this proposal.
- Any agency policies, guidelines etc relevant to the proposal.
- Criteria and the decision-making process relied upon by your agency in the issue of any statutory approvals, licences etc.

I look forward to receiving your comments regarding the proposed works. To expedite preparation of the REF it would be appreciated if you would forward comments as soon as possible to:

Attention: Bob Cook
Manly Hydraulics Laboratory
110 King Street
MANLY VALE NSW 2093

or by email to: RCook@mhl.nsw.gov.au

If you have any questions regarding this letter please contact Bob Cook on 9949 0275.

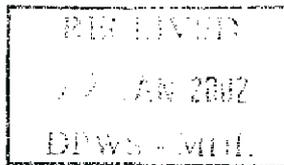
Yours faithfully

David van Senden
Principal Engineer

Encl.

d:\project\lake_camp\consultation letter.doc\cook

Manly Hydraulic Laboratory
(Attention: Mr Bob Cook)
110 King Street
MANLY VALE NSW 2093



WO167/04:WOF6856:VB

Contact: Veronica Boland (02) 4226 8100

Dear Sir

**LAKE CONJOLA ENTRANCE MANAGEMENT WORKS
REVIEW OF ENVIRONMENTAL FACTORS**

We are writing further to your letter dated 5 December 2001 requesting comments for the preparation of Review of Environmental Factors for the above proposed development.

We provide our comments in Attachment A and we also refer you to our previous correspondence (Attachment B) on this issue.

We advise that you should also bring this proposal to the attention of the Department of Land and Water Conservation for their comments.

If you have any further queries or comments, please contact the above officer at this office.

Yours faithfully

A handwritten signature in black ink that reads "Trevor Jones 16/1/02".

TREVOR JONES
Regional Manager South Coast

Att

(N:\VB\2002\WOF6856 LAKE CONJOLA DREDGING.DOC)

Environment Protection Authority

PO Box 513 Wollongong East NSW 2520 Australia

Telephone 61 2 4226 8100

Facsimile 61 2 4227 2340

ABN 43 692 285 758

www.epa.nsw.gov.au

Level 3 NSW Government Offices 84 Crown Street Wollongong NSW 2500

ATTACHMENT A
ISSUES TO BE ADDRESSED IN PREPARATION OF A REVIEW OF ENVIRONMENTAL
FACTORS FOR LAKE CONJOLA ENTRANCE MANAGEMENT WORKS

Statutory Requirements

All activities must be carried out in a manner that does not contravene Section 120 of the Protection of the Environment Operations Act 1997, which prohibits the pollution of waters. An Environment Protection Licence (EPL) for water is not required if appropriate best practice measures are implemented and strictly complied with, to ensure water pollution does not occur as a result of the proposed activity.

We advise that an EPL is required for:

‘dredging works being works in which materials or more than 30,000 cubic metres per year are obtained from the bed, banks or foreshores of any waters’.

Policies/Guidelines

We also recommend that you consult the following in preparing the Review of Environmental Factors:

- NSW Department of Urban Affairs and Planning (planningNSW) Environmental Impact Statement Guideline ‘*Extractive Industries Dredging and other Extraction in Riparian and Coastal Areas*’, and;
- State Environmental Planning Policy No 35 ‘*Maintenance Dredging of Tidal Waterways*’ – Circular No B29, 17 June 1997.

Dredging

The appropriate best practice measures for dredging activities typically include:

- The installation of silt curtains (where practicable and where needed) around the proposed dredging site to minimise the migration of turbid water to adjacent areas;
- If there are sea-grasses within or in the vicinity of the proposed area of dredging, the disturbance should be kept to a minimum.

In addition to the above best practice measures, the Environment Protection Authority also recommends the following:

- The Cutter-suction dredging technique should be used where possible, as this technique results in significantly less fine sediment pollution;
- Appropriate buffer distances around any sensitive areas must be maintained;
- Any potential Acid Sulfate Soils should be investigated and managed in accordance with the “Acid Sulfate Soil Manual – August 1998” prepared by the Acid Sulfate Soils Management Advisory Committee;
- Any likely impacts on the surrounding aquatic environment, including impacts to flora and fauna should be addressed.

Disposal of dredged spoil

The disposal of dredged spoil should be adequately addressed. The following points should be considered:

- Dredged spoil can contain fine sediments and/or contaminants. The quantity, quality and destination of all excavated sediments must be evaluated and determined. Any dredge spoil should be disposed of in a manner that does not cause air, water or land pollution;
- The disposal area for the sand should be of a sufficient size and in such a location to minimise any likely wind erosion;
- The disposal area will need to be constructed in such a manner so as to prevent pollutants running back into the waterway;

- Silt curtains should be installed around the proposed disposal/eroded area to minimise the turbidity that may be created while placing the dredged sand back into this area;
- Slope the profile of the newly placed sand to provide a more stable slope to help combat the erosion processes;
- Vegetate the newly placed sand with a native species appropriate for the site that propagates quickly. This is to provide short-term protection for the sand against erosion until other aquatic flora species can become established and propagate.



Facsimile Message

Attention : Bob Cook, NSW DPWS, Fax (02) 9948 6185
From : Maureen Veronese, South Coast, Telephone (02) 4226 8100, Fax (02) 4227 2348
Date : 23 Jan 2002
cc :
Number of Pages : (including this page) 3
Message LAKE CONJOLA ENTRANCE MANAGEMENT WORKS REF – WOF6856

Please find attached copy of correspondence – Attachment B as requested.

Regards,
Maureen

This facsimile may contain PRIVILEGED AND/OR CONFIDENTIAL INFORMATION intended only for the use of the addressee. If you are not the addressee, or the person responsible for delivering it to the person to whom it is addressed, YOU MAY NOT COPY OR DELIVER THIS MESSAGE TO ANYONE ELSE. If you receive this facsimile by mistake please telephone the nominated office (reverse charges). Thank you.

Environment Protection Authority

P.O. Box 513 Wollongong East NSW 2520 Australia

Telephone 61 2 4226 8100

Facsimile 61 2 4227 2348

www.epa.nsw.gov.au

EPA



Environment
Protection
Authority
New South Wales

NSW Environment Offices
84 Crown Street
Wollongong NSW 2500
PO Box 513
Wollongong East NSW 2520
Telephone: 042 26 8100
Facsimile: 042 27 2348

The General Manager
Shellhaven City Council
PO Box 42
NOWRA NSW 2541
ATTENTION: RODNEY WALLACE

Our Reference: WO167/1 CP:DK
Your Reference: 73/3525

Contact: Craig Patterson (02) 4226 8100

Dear Sir

**PROPOSED OPENING OF LAKE CONJOLA
DECEMBER 1997**

Thank you for your letter dated 2 December 1997 seeking advice on the above matter. The Environment Protection Authority (EPA) has reviewed the information and provides the following comments.

We understand that Lake Conjola is quite a popular tourist destination over the Christmas period. The EPA is concerned that the proposed opening of the lake's entrance is not the most effective solution to improve the water quality of the lake.

Unless the water quality of the lake does not meet the ANZECC Water Quality Guidelines for primary contact waters, or there is the potential for properties to become flooded, the natural tidal processes of the lake's entrance should not be altered. The conclusion from the report of the General Manager of Health and Community Services dated 2 September 1997 stated that:

"Lake Conjola experiences good water quality most of the time, however, rainfall events flush pollutants into the lake and this is reflected in higher bacterial levels. The entrance condition does not appear to have a major influence on water quality."

Altering the natural tidal flow of a river or lake by opening the entrance may cause other more serious environmental problems elsewhere within the water body. Therefore, should the proposed opening progress, a similar situation may arise.

As the water level is low, there is likely to be insufficient head for appropriate scour and thus the entrance is unlikely to be of sufficient cross sectional area to remain open for any length of time. Therefore, the perceived benefits of the proposed works may only be experienced for a short period of time.

The EPA recommends that Council consider a more permanent solution to improving the water quality within the lake which may include addressing the issue of on-site domestic effluent management.

As for the increase in erosion due to additional boating activity on the lake, this problem may also be initiated by the lowering of the lake's water level, which may result from the proposed opening.

With regards to the unsightly appearance of the build up of weed on the water's edge, Council should consider the costs involved in removing the weed during periods when excessive amounts becomes a problem. This may also solve the odour problem, which as stated in the letter, is the result of this excessive build up.

Should you have any further enquiries, please contact the above officer.

Yours faithfully,

Craig Lamberton
17/12/97

CRAIG LAMBERTON
Regional Manager South Coast
for Director-General

(NACPWO187-1A.DOC)

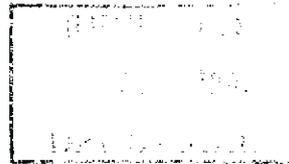
For Action/Approval

ORIGINATOR	CP	16/11
ASN	CP	16/12
Angie	OV	
mail	Olc	16/12/97
OB	DM	18/12/97
CP		18/12/97



NSW Fisheries

17th December 2001
Bob Cook
Manly Hydraulic Lab.
110 King St.
Manly Vale
NSW 2093



Dear Bob

RE: Lake Conjola Entrance Management Works REF

Thank you for inviting comments from NSW Fisheries regarding the preparation of a review of environmental factors. NSW Fisheries places particular importance upon the need to minimise the harm to the aquatic environment.

NSW Fisheries requirements for the preparation of environmental planning and assessment documents are outlined in *the Policy and Guidelines for Aquatic Habitat Management and Fish Conservation 1999*. Environmental planning and assessment documents should include the following information as an absolute minimum to allow staff from NSW Fisheries to make an informed decision about the potential impacts that proposed works may have on fish, aquatic species and their habitats.

- Location of works (on a topographic map)
- Description of works to be undertaken, including
 - **Aim** of works and definition of a "sustainable entrance".
 - **Justification** of proposed "progressive reclamation".
 - Construction/dredging methods.
 - Timing and duration of works.
- Potential impacts of the proposal upon the fish and prawn communities within the lake and identification of any works that will obstruct fish passage/migration.
- Potential impacts on aquatic vegetation, (including maps showing the distribution of seagrass within the lake entrance and extent to which these will be affected) particularly seagrass species such as *Posidonia* and *Zostera* and proposals to mitigate these impacts.
- Potential impacts on the noxious algal species *Caulerpa taxifolia* both within the lake and the potential for the spread of this algae along the coast via the lake entrance and proposals to mitigate such impacts.
- Potential impacts riparian vegetation and proposals to mitigate these impacts.

SHOALHAVEN FISHERIES OFFICE

64 North Street - PO Box 456 NOWRA NSW 2541
Telephone: (02) 4423 2200 Fax: (02) 4423 2007

SHOALHAVEN 1997-02

- Potential impacts upon water quality of the proposed works and proposals to mitigate impacts on water quality.
- Aquatic habitat conditions at the site. e.g. water depth, presence of gravel beds or "snags".
- Potential impacts of the proposal on water flow/velocity and hydraulics.
- Proposed sediment and erosion controls during and after completion of works.
- Potential impacts on commercial and recreational fisheries within the lake.
- An assessment of potential impacts that proposed works may have on threatened species (8 part test) listed under part 7A of the *Fisheries Management Act 1994*. (See Schedules 4 and 5 of the *Fisheries Management Act 1994*).

Approvals that may be required from NSW Fisheries under the *Fisheries Management Act 1994*. An approval for **dredging and reclamation** (under section 198-203 of the *Fisheries Management Act 1994*) is required for excavation or filling below mean high water level , unless the contractors are specifically authorised under the *Crown Lands Act 1989* or by a public authority (not a local government authority) for the dredging or reclamation aspects of the proposed works. If there is any seagrass, mangroves or marine macroalgae present then a permit will be required to **harm marine vegetation** under section 205 of the *Fisheries Management Act 1994*. These application forms can be obtained from NSW Fisheries.

If you have any further enquiries or wish to obtain application forms for permits, please do not hesitate to contact me on 02 44 232 080.

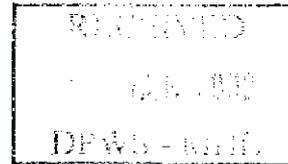
Yours sincerely



David Ward
Conservation Manager (Nowra)



David van Senden
Principal Engineer
Manly Hydraulics Laboratory
110 King Street
MANLY VALE NSW 2093



NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

ABN 30 841 387 271

ZF/0271
LRE6-0115

Our reference:

Your reference:

Attention: Bob Cook

Dear David

**Re: Lake Conjola Entrance Management Works – preparation of
Review of Environmental Factors (REF)**

I refer to your letter of 5 December 2001 in which you sought comments from NSW National Parks and Wildlife Service (NPWS) on the preparation of a REF for the above works. The following advice is provided in response to the matters you raised in your letter.

1. Legislation under which NPWS operates and relevant provisions

Included in this section is legislation that is relevant to the proposed works. As some of this legislation is undergoing amendment, and/or awaiting commencement, specific clauses have not been referred to in all cases.

(a) *National Parks and Wildlife Act, 1974 (NPW Act)*

In relation to environmental planning and assessment matters, under this Act, the NPWS has a statutory obligation to protect and manage Aboriginal sites and native plants and animals (including threatened species, populations, ecological communities, or their habitats) throughout the State. Therefore NPWS has a duty to provide advice on any activity or development which may impact on these responsibilities.

You may be aware that the National Parks and Wildlife amendment Bill 2001 was passed with amendments by the Legislative Council on Thursday 13 December 2001, and by the Legislative Assembly on Friday 14th December 2001. It has subsequently been given assent. A number of provisions in the Bill relate to Aboriginal cultural heritage. Of particular significance is the removal of "knowingly" from the

Conservation
Programs &
Planning Division
Southern Directorate
6 Rutledge Street
PO Box 2115
Queanbeyan
NSW 2620
Australia
Tel: (02) 6298 9700
Fax: (02) 6299 4281

Head Office
43 Bridge Street
PO Box 1967
Hurstville NSW
2220 Australia
Tel: (02) 9585 6444
Fax: (02) 9585 6555

current section 90 of the *National Parks and Wildlife Act 1974* that states that it is an "offence to **knowingly** destroy, deface or damage an Aboriginal place or relic without a consent from the DG of NPWS". That is, when the Act commences, it will not be necessary to prove prior knowledge of the presence of Aboriginal places or objects for a prosecution to proceed. However, a person who has undertaken reasonable precautions and has exercised due diligence **and** reasonably believes that their actions would not destroy, deface or desecrate the Aboriginal place or object, has a defence from prosecution under the new section 90.

(b) *Threatened Species Conservation Act 1995* (TSC Act)

The Act provides a legislative framework for the issuing of a section 91 licence to 'harm or pick' a threatened species, population or ecological community, and for the damage of the habitat of a threatened species, population or ecological community or the damage of critical habitat.

Division 2 of Part 6 of TSC Act specifies the requirements for a Species Impact Statement.

(c) *Environmental Planning and Assessment Act 1999* (EP&A Act)

Under Part 4 of this Act the NPWS's primary involvement is to provide advice to consent authorities when considering development proposals outside of reserves. The DG of NPW is a concurrence/consultation authority under the EP&A Act for developments/activities which are on land that is, or is part of critical habitat, or where there is likely to be a significant effect on threatened species, populations or ecological communities, or its habitats.

In relation to s.77A and s.112C of the EP&A Act, where there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats, or where a proposed development or activity is to occur on the land that is, or part of, critical habitat as declared under Part 3 of the TSC Act, the consent or determining authority must seek the concurrence of the DG of NPW.

The Service is frequently consulted by Shire Councils about the adequacy of assessments undertaken to meet the requirements of Section 5A of the EP&A Act in relation to the likelihood of an effect on threatened species, populations or ecological communities, or their habitats

2. Agency policies, guidelines etc relevant to the proposal

NPWS works to numerous principles, guidelines and policies. Among those relevant to this REF are:

- NPWS Environmental Planning and Assessment Manual (Vols. 1 & 2);
 - NPWS Review of Environmental Factors – Introduction July 2001;
 - NPWS Threatened Species Management Policy and Procedures;
 - Cultural Heritage Strategic Policy (2001), NPWS;
 - NSW Aboriginal Cultural Heritage Standards and Guidelines Kit;
 - Biodiversity Planning GUIDE for NSW Local Government (2001) NPWS;
3. **Criteria and decision-making process relied upon by your agency in the issue of any statutory approvals, licences etc.**

NPWS uses a range of sources during decision-making processes. The material used will, to some extent, depend on the issue under consideration. Among the sources of information are:

- planning instruments including State Environmental Planning Policies, Local Environmental Plans, etc;
- requirements of state, national, and international policies, agreements and treaties;
- Recovery Plans for threatened species and endangered communities;
- The *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*;
- the range of scientific literature;
- unpublished data which could be in the form of monitoring records;
- expert opinion both within and outside the NPWS;
- assessments undertaken by state/national/international committees, commissions, and expert groups;
- manuals prepared by other agencies eg. the *NSW Heritage Office Manual* which includes a *Statement of Heritage Impact* (1991); *Assessing Heritage Significance* (2000) NSW Heritage Office; a range of Department of Urban Affairs and Planning 'best practice' guidelines.

Further information on planning and assessment guidelines may be accessed via web sites of relevant organisations.

4. Any matters that NPWS wishes to be considered

NPWS has a long-term interest in the ecological and cultural values of Lake Conjola, and has previously forwarded a large amount of correspondence about management of the Lake to Shoalhaven City Council. The Healthy Rivers Commission's Independent Inquiry into Coastal Lakes Draft Paper (August 2001) also recognised the Lake's ecological values and identified it as warranting "significant protection". The management orientation for lakes identified for

"significant protection" include specifying intended outcomes "that are consistent with restoring and preserving critical natural ecosystem processes." Among the action indicated by the Commission to be effective in achieving restoration and preservation of natural processes is the implementation of "a program to progressively minimise intervention in natural entrance behaviour (with a view to full reinstatement over a period as long as 50 years)." In this context, NPWS considers that the following matters should be addressed in the REF (and further assessment should that eventuate):

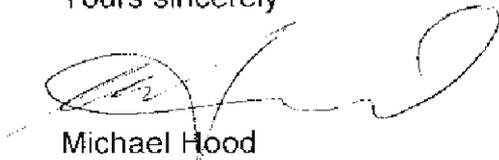
- how a sustained opening to Lake Conjola meets the ecologically sustainable development (ESD) objective within the EP&A Act (Section 5 (a) vii). In principle, NPWS considers that the water balance of coastal lakes, lagoons and estuaries should be permitted to function according to natural forces, without human intervention. NPWS considers that artificial opening and closure of coastal lagoons is a management practice that should only be used when no other options are available. In situations where it is agreed that intervention is warranted, and where the environmental impact assessment process has concluded that there is unlikely to be a significant impact, NPWS considers that managed brakeout and closure occur within the limits of natural variability of lake opening and closure patterns. Given the accepted ecological values of Lake Conjola, and the requirement to meet ESD principles, the entrance management policy should therefore include closed as well as open regimes for the Lake. During closed periods riparian foreshore, tributary habitats and floodplain wetlands have deep watering. Also, during high water levels, under closed entrance conditions, expansion of amphibian populations into brackish habitats is possible. Therefore the REF should consider alternatives to the current sustained opening proposal, and reasons for their rejection. In particular, the proposed sewerage of areas within the catchment of the Lake may lead to a reassessment of the case to maintain an open entrance to the Lake;
- the potential impacts of more enduring saline regime within the Lake;
- the impacts of sustained opening of the Lake on SEPP No 14 wetlands and foreshore habitats of Conjola National Park;
- the impacts of sustained opening on the drainage lines within the Lake's catchment. In particular, the reduction of periods of inundation due to reduced flooding, and the potential impacts on flora and fauna that occupy and/or utilise these drainage lines;
- the short and long-term impacts (as well as cumulative impacts), on flora and fauna and their habitats (including substrate condition,

food sources, nesting and refuge areas, water quality and composition);

- specific consideration of impacts on threatened species and those subject to international migratory treaties;
- a full cultural heritage assessment. The NSW and Commonwealth Governments recognise that the cultural heritage of the Aboriginal people is not confined to archaeological sites and artefacts but may include cultural biodiversity values such as flora, fauna and landforms. Furthermore, the concept of cultural heritage is being expanded beyond the conventional site-based approach to one which is more responsive to the social and environmental (landscape) dimensions of cultural heritage (Byrne et al., 2001). It is widely recognised now in a number of planning forums (for example, vegetation management committees), that conservation and planning outcomes that recognise the spiritual and belief systems, together with the dynamic nature of Aboriginal people's culture, need to be pursued. Therefore 'social significance assessment' in conjunction with consultation with the appropriate range of Aboriginal interests in the area should be included in the cultural heritage assessment.
- what ameliorative actions would be required to address potential impacts on flora and fauna and ecosystem functions within the Lake's ecosystem?
- what monitoring regime will be established? The monitoring regime should outline what baseline data is required, the most appropriate methodology for obtaining it within current resource constraints, how frequently monitoring will occur, who will undertake the work, what form of records will be maintained, how will the data be analysed to detect trends etc., and where will the analyses be published/presented?

If you would like to discuss the matter or require further information or advice, please contact Lyn Nelson, Conservation Planning Officer at the Southern Directorate office, on (02) 6298 9739.

Yours sincerely



Michael Hood
Manager
Conservation Planning Unit
Southern Directorate

14 January 2002

cc: Gary Currey, Manager, Aboriginal Heritage Unit (Southern)

Appendix B

**Independent Public Inquiry into Coastal Lakes: Draft Paper
Healthy Rivers Commission of New South Wales
Appendix 5: Coastal Lake Entrances: Effective Regulatory Processes**

Appendix 5: Coastal Lake Entrances: Effective Regulatory Processes

There are various statutory provisions affecting decisions to open the entrances of coastal lakes artificially. These include *State Environment Planning Policy 35 (Maintenance Dredging of Tidal Waterways)* and the *Environmental Planning and Assessment Act 1979*, *Crown Lands Act 1989*, *Fisheries Management Act 1994*, *Coastal Protection Act 1979* and *Water Management Act 2000*. Notwithstanding of the broad range of available controls, they have not been administered so as to lead to thorough assessments and balanced management responses to the impacts of entrance openings on lake ecosystems and dependent human activities and human assets. It is therefore important to consider how the statutory requirements interrelate and how they should be improved and integrated.

Current administrative problems include a common failure to undertake assessments under the environmental planning or crown lands legislation, for entrance management works. Often no more than a review of environmental factors is prepared, which is then relied on to support a series of entrance works. Councils may undertake some consultation with relevant public authorities as required by SEPP35. However, the Commission is informed councils do not always seek the necessary approval under the crown lands legislation for undertaking the works.

Government endorsement of the framework for managing coastal lakes would establish the context for managers to make informed decisions about whether to open the entrance of a coastal lake, and if so, under what circumstances. In addition, the Commission highlights the importance and recommends improved assessment processes for approving entrance openings. Any such processes must provide for the following requirements.

- Decisions to approve entrance openings to be informed by the findings of lake specific Sustainability Assessments, within the context of the classification assigned to each coastal lake.
- An agreed entrance opening *regime* (ie a series of opening events over time), given the need to ensure that councils can respond promptly to protect assets subject to water damage and/or protect public health. For example, the crown lands legislation could be modified so that approval could be obtained for a series of events over time.
- Implementation of a program of actions to reinstate (partially or fully) the natural entrance behaviour, where this is determined to be practicable and necessary through lake specific Sustainability Assessments.
- Assign an approval role to one or more relevant Ministers, recognising the need to separate consent from operator roles.³⁹

Other issues include the role of SEPP35 and its continued relevance or appropriateness in its current form, if the need for sustainability assessments is endorsed and in light of other approval processes.

The Commission is seeking views from agencies, councils and citizens on the most effective regulatory processes for the management of entrance openings, including whether or how existing processes should be modified and improved.

To assist in the consideration of these issues, some background on existing statutory provisions are briefly discussed below.

³⁹ Such an approach is consistent with the Government's decision, in response to the Commission's Clarence Inquiry, to amend the *Fisheries Management Act 1994*, to extend the Minister for Fisheries concurrence powers over maintenance dredging in existing navigation channels.

State Environmental Planning Policy 35 (SEPP35) – Maintenance Dredging of Tidal Waterways

This Policy enables councils to carry out maintenance dredging within tidal waterways, without development consent, provided they undertake the identified public consultation process. That process includes notifying the listed agencies and considering comments made by them within 28 days of giving notice.

The circular issued by the Department of Urban Affairs and Planning in relation to the SEPP suggests the required environmental assessments for entrance openings. It states that councils should undertake an estuary management plan as a form of strategic environmental assessment, and that it be accompanied by an Environmental Impact Statement (EIS) or Review of Environmental Factors (REF) that assesses the impacts of activities including entrance opening. It notes that preparation of an estuary management plan *may* satisfy the requirements of the *Environmental Planning and Assessment Act 1979*, and avoid the need for a full assessment each time an estuary opening is proposed.

The SEPP does not eliminate the need to obtain relevant approvals. This includes the need for councils to obtain a licence under the *Crown Lands Act 1989* before proceeding with an entrance opening.

Crown Lands Act 1989

The *Crown Lands Act 1989* states that it is an offence to 'clear, dig up or cultivate public land' or 'interfere with any substance, whether on or in, or forming part of, public land', without lawful authority (licence or lease granted under the Act). In most cases lake entrance beds are 'public land' as defined by the Act. The Minister for Crown Lands may issue such a licence or lease under the Act and must consider an EIS or REF before granting a licence for entrance management works.

The Act provides for a program of land assessment that is to consist of preparation of an inventory of crown land, an assessment of the capabilities of the land and identification of suitable uses for the land and where practicable, the preferred uses. The Minister is to maintain an inventory of the physical characteristics of the land and other matters affecting the land, as are necessary to assess the capabilities of the land. These are to be used in identifying suitable or preferred uses. There is no formal link between this process and the issue of licences, or other approvals under the Act, though administratively such an assessment is usually required.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* specifies that a public authority (including the Minister administering the *Crown Lands Act 1989*) authorising the carrying out of dredging or reclamation work, must give notice of the proposed work to the Fisheries Minister and consider any matters raised. If the public authority wants to proceed despite any matter raised, the two Ministers are to attempt to resolve the dispute. Failing resolution, the dispute is to be referred to the Premier for resolution. This provision does not apply to dredging approved by the Minister administering the *Public Works Act 1912* for the restoration or maintenance of a navigation channel.

It is an offence for a council to carry out dredging without an approval from the Fisheries Minister, unless they have an approval under the crown lands legislation. The Commission has been informed that in practice some councils are obtaining an approval under this Act in lieu of a crown lands approval.

The Minister also has power to order remedial work considered necessary to rectify the damage caused by any dredging or reclamation work to protected marine vegetation in a protected area, other marine vegetation and to the spawning areas of salmon, trout or other place provided for in the regulations. (Protected area includes 'any public water land or aquaculture lease, or the foreshore of any such land or lease'. Marine vegetation will be protected marine vegetation where so declared by the regulations).

Specific approval is required before a person can harm mangroves or seagrasses, and there is power to order rectification work if harmed. There are special provisions relating to the protection of threatened species, population or ecological community of marine vegetation.

Coastal Protection Act 1979

The *Coastal Protection Act 1979*, administered in part by the Department of Public Works and Services, specifies that if a council proposes to carry out development in the coastal zone, including altering entrance opening, the concurrence of the Minister administering the *Coastal Protection Act* is required: "*if in the opinion of the Minister, as advised from time to time by the Minister to the public authority, the development or the use or occupation, may in any way:*

(c) 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, or

(d) adversely affect any beach or dune or the bed, bank, shoreline, foreshore, margin or flood plain of the sea or an arm of the sea or any bay, inlet, lagoon, lake, body of water, river, stream or watercourse".

These provisions apply unless the Minister has declared, by an order in the gazette, that these provisions will not apply to specified areas in the coastal zone. The Minister can also, by order published in the gazette, direct that a public authority shall not carry out development of a specified class or description, if satisfied that it would affect the lake in the way described above. The Minister can direct a public authority having functions under any Act relating to the use or carrying out of development in the coastal zone, to exercise those functions in such a way and at such time, as may be specified in the direction.

Water Management Act 2000

The *Water Management Act 2000* contains provision for approvals for 'controlled activities' that would include works by councils to open the entrances of coastal lakes. This part of the Act will commence in 2002. Consideration should be given to whether this approval process should be a central part of the overall approval process for entrance management with other approval processes complementary to this process.

Appendix C

**Table 1 and Table 3 of
Is an EIS required?
Department of Urban Affairs and Planning**

IS AN EIS
REQUIRED?

**TABLE 1
IDENTIFY THE ISSUES**

Characteristics of the Activity (during construction & operation)	Potential Issues
How is the proposal likely to affect the physical aspects of the environment or introduces pollution or safety risk factors?	
1. disturbs the topography or above or below ground features including filling, excavation, dredging, tunnelling; eg landforming, site preparation, quarrying, reclamation, creation of islands, waterbodies, etc; involves the disposal of large quantities of spoil	
2. affects a natural waterbody, wetland or groundwater aquifer or the natural water drainage pattern; affects the quality or quantity of water in the systems	
3. uses groundwater or surface water from a natural waterbody; stores water in a dam or artificial waterbody	
4. changes the flood or tidal regimes or be affected by the flooding or tides	
5. uses, stores, disposes or transports hazardous substances (flammable, explosive, toxic, radioactive, carcinogenic or mutagenic substances); uses or generates pesticides, herbicides, fertilisers or other chemicals which may build up residues in the environment	
6. generates or disposes of gaseous, liquid or solid waste (industrial, medical or domestic waste, sewage, sludge or effluent, spoil or overburden); generates greenhouse gas emissions or releases chemicals which affect the ozone layer or are precursors to photochemical smog; generates or disposes of hazardous waste	
7. emits dust, odours, noise, vibrations, blasts, electromagnetic fields or radiation in the proximity of residential areas or landuses likely to be affected.	
8. any other matters.	If no impacts identified; this section could be ignored in Table 2(a) and 2(c).
How is the proposal likely to affect the biological aspects of the environment?	
1. clears or modifies (including by modifying the drainage) native vegetation (including trees, shrubs, grasses, herbs or aquatic species)	
2. displaces or disturbs fauna (terrestrial or aquatic) ¹ or creates a barrier to fauna movement; clears remnant vegetation or wildlife corridors	
3. introduces noxious weeds, vermin, feral species or disease or releases genetically modified organisms	
4. undertakes activity which affects revegetation or replenishment of native species following a disturbance	
5. introduces high bushfire risk factors or change the fire regime	
6. any other issues.	If no impacts identified; this section could be ignored in Table 2(a) and 2(c).

¹¹ A Species Impact Statement will be required if the activity is likely to significantly affect the environment of critical habitats, threatened species, populations or ecological communities or their habitats

IS AN EIS
REQUIRED?

**TABLE 1 (continued)
IDENTIFY THE ISSUES**

Characteristics of the Activity (during construction & operation)	Potential Issues
How is the proposal likely to affect natural or community resources?	
1. uses or results in the use of community services or infrastructure including roads, power, water, drainage, waste management, education ,medial, social services	
2. uses or results in the use of natural resources including water (ground or surface), fuels, timber, extractive material, minerals, prime agricultural land, etc	
3. affects future potential of commercial deposits of minerals or extractive material or areas important for fishing, agriculture or forestry	
4. changes the demographics of an area	
5. changes in the transport requirements of an area	
6. creates a new route alignment for the provision of	
7. infrastructure (eg rail, roads, power, etc)	
8. any other issues.	
9.	If no impacts identified; this section could be ignored in Table 2(a) and 2(c).
How is the proposal likely to affect the community?	
1. generates population movements including influx or departure of the workforce;	
2. changes the workforce or industry structure of the area/region; affects employment opportunities	
3. affects areas of high population densities or established development patterns	
4. affects or affecting access to an area, building or items of aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific, recreational, aesthetic or social significance or other special value for present or future generations	
5. affects the visual or scenic landscape (including major cuts/fills, towers, projects on escarpments etc)	
6. affects sunlight or views of another property	
7. affects the amenity of publicly owned land (particularly recreational areas, national parks or reserves)	
8. changes land use from the surrounding uses as a direct or indirect result of the activity; forms a barrier to movement within the community or access to existing properties; leads to a loss of housing	
9. generates significant volume of traffic (road, rail, air, pedestrian etc)	
10. generates nuisance or health or safety risks including air pollution, odour, noise or vibration, blasting, electromagnetic fields or radiation or releases disease or genetically modified organisms or change the bush fire regime	
11. any other issues.	If no impacts identified; this section could be ignored in Table 2(a) and 2(c).

IS AN EIS
REQUIRED?

**TABLE 1 (continued)
IDENTIFY THE ISSUES**

Characteristics of the Activity (during construction & operation)	Potential Issues
How is the proposal likely to affect areas sensitive because of physical factors?	
1. coastline and dune fields, alpine areas, deserts, caves or other unique landforms	
2. land with high agricultural capability	
3. natural waterbodies, riparian zones, wetlands, drinking water catchments or flood prone areas	
4. groundwater recharge areas or areas where high water table	
5. erosion prone areas, areas with slopes of greater than 18 degrees,	
6. subsidence or slip areas	
7. areas where acid sulphate, sodic or highly permeable soils	
8. areas where salinity or potential salinity problems	
9. area with degraded air quality	
10. area with degraded or contaminated soil area with degraded or contaminated water (ground or surface)	
11. any sensitive areas.	
	If no impacts identified; this section could be ignored in Table 2(b).
How is the proposal likely to affect areas sensitive because of biological factors?	
1. corals and seagrass beds, wetland communities (coastal, peatlands or inland), native forests, urban bushland, arid and semi arid communities,	
2. critical habitats or the habitats of threatened fauna or flora species, populations or ecological communities (within the meaning of the TSC Act)	
3. habitat of species listed under international agreements including Japan-Australia Migratory Birds Agreement (Jamba) and China-Australia Migratory Birds Agreement (Camba)	
4. wildlife corridors and remnant vegetation	
5. habitat of protected aquatic species (within the meaning of Fisheries Management(General) Regulation 1994) or of aquatic species having conservation status under Conference on Australian Threatened Fishes	
6. fishing grounds and commercial fish breeding or nursery areas	
7. bushfire prone areas	
8. any other sensitive areas	
	If no impacts identified; this section could be ignored in Table 2(b).

IS AN EIS
REQUIRED?

TABLE 1 (continued)
IDENTIFY THE ISSUES

Characteristics of the Activity (during construction & operation)	Potential Issues
How is the proposal likely to affect areas allocated for conservation purposes?	
1. national parks and other areas reserved or dedicated under the National Parks and Wildlife (NPW) Act 1974	
2. land reserved or dedicated within the meaning of the Crown Lands Act 1989 for preservation or other environmental protection purposes	
3. world heritage areas	
4. environmental protection zones in environmental planning instrument or lands protected under SEPP 14 - Coastal Wetlands or SEPP 26- Littoral Rainforests	
5. land identified as wilderness under the Wilderness Act 1987 or declared as wilderness under the NPW Act	
6. aquatic reserves reserved or dedicated under the Fisheries Management Act 1994	
7. wetlands areas dedicated under the Ramsar Wetlands Convention	
8. heritage items identified on the Register of the National Estate, under the NSW Heritage Act or an environmental planning instrument	
9. community land under the Local Government Act (for which a plan of management has been prepared)	
10. land subject to a "conservation agreement" under the NPW Act	
11. any other factors.	
	If no impacts identified; this section could be ignored in Table 2(b).
How is the proposal likely to affect areas sensitive because of community factors?	
1. Aboriginal communities or areas subject to land rights claims	
2. communities with strong sense of identity	
3. disadvantaged communities (reduced economic, social or cultural indicators)	
4. areas with degraded amenity from noise, traffic congestion or odour	
5. areas or items of high anthropological, archaeological, architectural, cultural, heritage, historical, recreational or scientific value	
6. areas or items of high aesthetic or scenic value	
7. any other factors.	
8.	
	If no impacts identified; this section could be ignored in Table 2(b).

IS AN EIS
REQUIRED?

**TABLE 3
EVALUATE THE LIKELY SIGNIFICANCE OF
POTENTIAL IMPACTS ON THE ENVIRONMENT**

Impacts	Potential significance considering the extent of impacts	Potential significance considering the level of adverse impacts on environmentally sensitive areas	Potential significance considering the nature of the impacts
PHYSICAL & POLLUTION			
a) air impacts			
b) water impacts			
c) soil impacts			
d) noise and vibration impacts			
BIOLOGICAL			
a) fauna			
b) flora			
c) ecological			
RESOURCE USE			
a) community resources			
b) natural resources			
COMMUNITY			
a) social impacts			
b) economic impacts			
c) heritage, aesthetic, cultural impacts			
d) land use impacts			
e) transportation impacts			
Activity as a Whole			

This activity is not likely to significantly affect the environment. No EIS is required.	
This activity is likely to significantly affect the environment. An EIS is required.	

Person responsible for preparing the background information (eg REF):

Signature Date

Title

Person responsible for deciding if an EIS is required:

Signature Date

Title

Appendix D

**Ecological Assessment, Proposed Stage 1 (Interim) Works
Conjola Lake Entrance
City of Shoalhaven**

**ECOLOGICAL ASSESSMENT
PROPOSED STAGE 1 (INTERIM) WORKS
CONJOLA LAKE ENTRANCE
CITY OF SHOALHAVEN**

FEBRUARY 2000

A report prepared by
KEVIN MILLS & ASSOCIATES PTY LIMITED
ECOLOGICAL AND ENVIRONMENTAL CONSULTANTS ACN 003 441 610
114 NORTH CURRAMORE ROAD
JAMBEROO NSW 2533

for
SHOALHAVEN CITY COUNCIL
PO BOX 42, NOWRA NSW 2541

00/10

**ECOLOGICAL ASSESSMENT
PROPOSED STAGE 1 (INTERIM) WORKS
CONJOLA LAKE ENTRANCE
CITY OF SHOALHAVEN**

CONTENTS

1	INTRODUCTION	1
2	DESCRIPTION OF THE PROPOSAL.....	1
3	ECOLOGICAL ENVIRONMENT	2
	3.1 Conjola Lake	2
	3.2 Wildlife Habitats and Wetland Fauna	3
	3.3 The Lake Entrance Sandflat and Adjacent Dunes	5
	3.4 Dozer Access Routes.....	5
4	ASSESSMENT OF THREATENED SPECIES	6
	4.1 Threatened Fauna Species	6
	4.2 Threatened Plant Species.....	10
	4.3 The “Eight Part Test”	10
5	CONCLUSION	13
6	REFERENCES.....	15
 TABLES		
	1. Estuarine Vegetation Communities at Conjola Lake	2
	2. Wetland Birds observed at Conjola Lake Entrance.....	4
	3. Wetland Birds recorded at Conjola Lake, or expected to occur there	4
	4. Threatened Bird Species, and Bird Species protected by International Agreements	7
	5. Records of Threatened Wetland Fauna at or near Conjola Lake.....	7
 FIGURES		
	1. Proposed Works	after p.2
	2. The Conjola Lake Area	after p.2

**ECOLOGICAL ASSESSMENT
PROPOSED STAGE 1 (INTERIM) WORKS
CONJOLA LAKE ENTRANCE
CITY OF SHOALHAVEN**

1 INTRODUCTION

This report was prepared by Kevin Mills & Associates Pty Limited for Shoalhaven City Council. It supersedes two earlier reports by Kevin Mills & Associates that assessed the potential ecological impact of previous proposals to dredge the entrance channel of Conjola Lake (Kevin Mills & Associates Pty Ltd 1995a, 1996).

The purpose of this report is to assess the potential ecological impact of the following proposals outlined in a Review of Environmental Factors by Patterson Britton & Partners Pty Ltd (1999):

- (i) steepen the side slopes of the low dunes on the southern part of the entrance barrier;
- (i) extend these low dunes further to the north, for a distance of about 200 metres;
- (ii) level the top of the dunes to facilitate the installation of sand trap fences and maximise the efficiency of the sand trap fences;
- (iii) bring a D6 dozer onto the beach, via an access point on the sand dunes in Narrawallee Creek Nature Reserve.

2 DESCRIPTION OF THE PROPOSAL

Each component of the proposal is briefly outlined below; for full details, refer to the Review of Environmental Factors (REF) prepared by Patterson Britton (1999). The approximate location of the works is shown on Figure 5 in the REF; see Figure 1 in this report.

(i) Steepening the Side Slopes of the Low Dunes

The purpose of steepening the side slopes is to trap wind-blown and wave-washed sand, to prevent it from entering the lake and entrance channel. The proposal involves the use of a dozer to push sand from the area around the dunes and on the existing slopes, to steepen the gradient of the slopes. The sand around the dunes was dredged from the adjacent channel in November – December 1999. The height of the dunes is presently about four (4) metres; the surrounding sand is about 1.1 to 1.5 metres AHD. Steepening the sides of the existing dunes will increase the mass of the dunes, but will not increase the height of the dunes.

(ii) Extending the Dunes Northwards

It is proposed to use a dozer to extend the dunes northwards for a distance of about 200 metres, by pushing around the sand gained during dredging. The extended dunes are intended to reduce the chance of sand entering the lake.

The height of the extended dunes will be about 3.0 to 3.5 metres AHD, about the same height as the existing dunes after modification; see below.

The existing levels in the vicinity of the dunes are shown on the plan prepared by G.A. Goodman Surveys Pty Limited, entitled "Topographic Plan, Lake Conjola Entrance Spit, 23/12/99".

(iii) Leveling the Top of the Existing Dune

The top of the dune is to be flattened, enabling the erection of fencing to trap sand so that the dune will naturally become higher over time. It is hoped that, eventually, vegetation will regenerate on the dune.

(iv) Beach Access for the Dozer

It is proposed that the dozer will gain access to Conjola Beach from a sand track behind the dunes, south of Lake Conjola village. Two potential access points were considered; both cross Narrawallee Creek Nature Reserve, which is controlled by the National Parks and Wildlife Service (NPWS).

The NPWS has agreed to allow dozer access along the sand track at the end of Thorne Street and then along a walking track to the rear of the beach dunes. From there, two alternatives are possible:

- (i) across the dunes just north of the walkway leading to the beach, or
- (ii) along the walkway itself, in which case the existing wooden slat walkway and fencing would be temporarily removed.

3 THE ECOLOGICAL ENVIRONMENT

3.1 CONJOLA LAKE

Conjola Lake is a flooded river valley that has formed an estuary. It is deep and steep-sided and, except near the coast, there are only small areas of low-lying land near the foreshores. Following the flooding of the valley towards the end of the last sea level rise, about 5,000 to 6,000 years ago, an extensive sand barrier/dune system developed at the coastal end of the embayment, creating the almost enclosed lake that it is today. Pattimores Lagoon developed in the large system of sand dunes to the south of the entrance, and it is still linked to the lake.

The lake is usually tidal and is naturally open to the sea most of the time. The vegetation in and around the lake is typical of the estuaries on the South Coast. Kevin Mills & Associates mapped the vegetation in the vicinity of Conjola Lake (Kevin Mills & Associates 1995b). The estuarine communities identified in that study are summarised below, in Table 1.

Table 1
Estuarine Vegetation Communities at Conjola Lake¹

No.	Common Name	Dominant Plant Species
Co 12	Swamp Oak Forest/Woodland + Rushland (saltmarsh)	<i>Casuarina glauca</i> <i>Avicennia marina</i> <i>Juncus kraussii</i> <i>Baumea juncea</i> <i>Sarcocornia quinqueflora</i>
Co 13	Paperbark Shrubland	<i>Melaleuca ericifolia</i> <i>Phragmites australis</i> <i>Baumea juncea</i> <i>Casuarina glauca</i>
Co 14	Eel-grass Forbland (Seagrass)	<i>Zostera</i> sp. <i>Halophila ovalis</i>

Based on the report by Kevin Mills & Associates (1995b).



FIGURE 1
 PROPOSED WORKS

KMA KEVIN MILLS & ASSOCIATES
 ECOLOGICAL & ENVIRONMENTAL CONSULTANTS
 114 North Curramore Road, Jamberoo NSW 2533

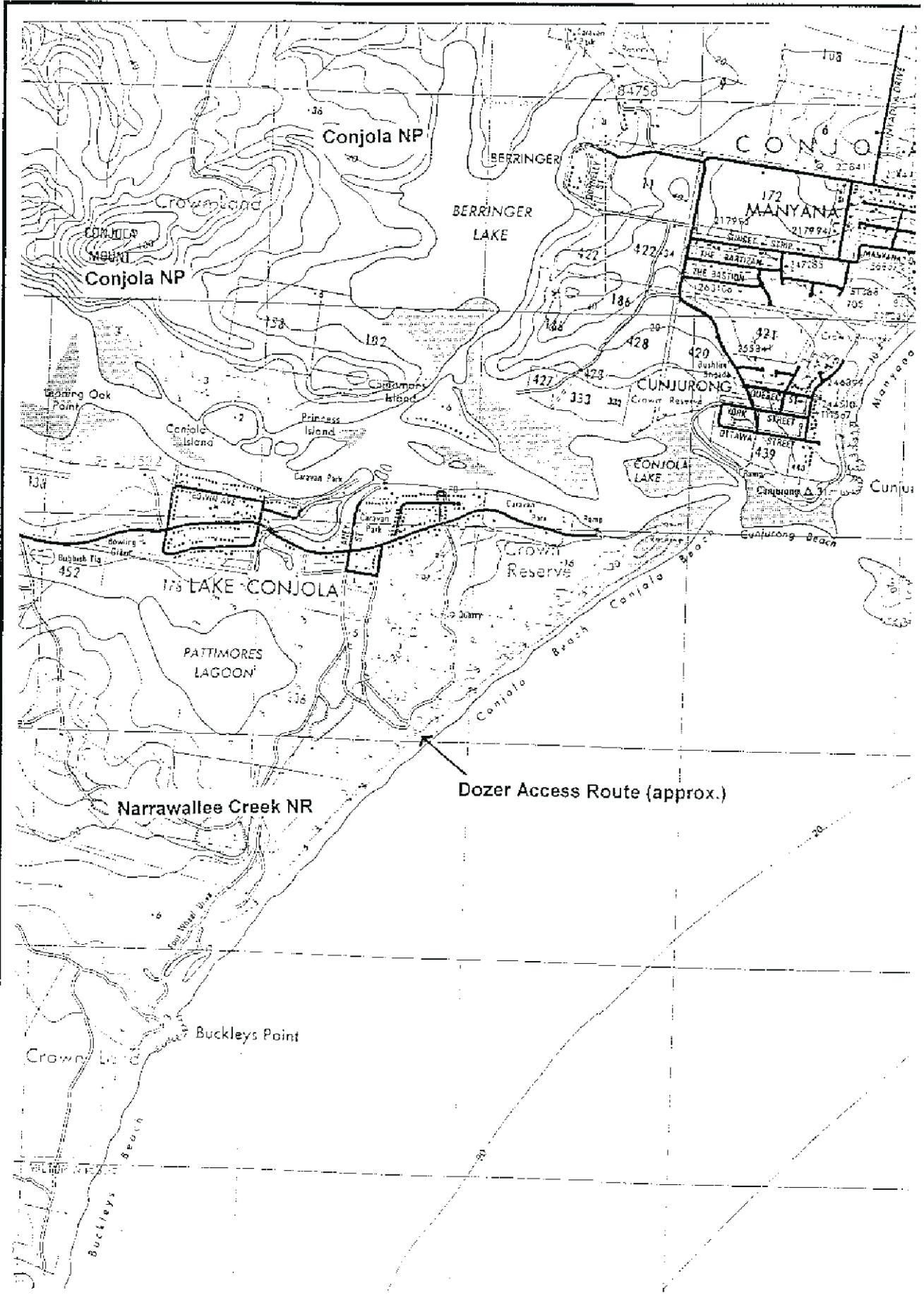


Figure 2 shows the general location of Conjola Lake and the surrounding features. Most of Conjola Lake is surrounded by Conjola National Park. Narrawallee Creek Nature Reserve, including Pattimores Lagoon, is to the south of Lake Conjola village.

Mangrove and saltmarsh vegetation are uncommon around the edge of Conjola Lake, because the surrounding terrain is steep. The largest areas are between Berringer Lake and Roberts Point. NSW Fisheries mapped the estuarine vegetation at Conjola Lake (West, Thorogood, Walford & Williams 1985); their work was reproduced on the vegetation map prepared by Kevin Mills & Associates (1995b).

The Illawarra Region Wetlands Study, undertaken by the Department of Environment and Planning (1983), provided a brief description of the Conjola Lake system and made a few general recommendations about development control. The map of the lake in the Regional Wetlands Study was not detailed.

The only wetlands at Conjola Lake listed under *State Environmental Planning Policy No.14 - Coastal Wetlands* are the small areas of saltmarsh in the upper reaches of the lake, near Fishermans Paradise (New South Wales 1985). None of the wetlands at the entrance were mapped under SEPP 14, although the whole of Pattimores Lagoon is protected under the Policy.

Disney (1979) reported the results of a bird survey on the South Coast and prepared a set of distribution maps. There appear to have been no detailed studies of the fauna and threatened fauna that occur at Conjola Lake.

3.2 WILDLIFE HABITATS AND WETLAND FAUNA

The wetland habitats on Conjola Lake include sandy shoals, saltmarsh, and fringing sandflats and mudflats. The relatively shallow water in the vicinity of the entrance is important feeding habitat for many species. The exposed sandflats are used by shorebirds for feeding and nesting. The higher, dry sandflats between the sea and the lake are used for nesting by a few species. Little Terns, Red-capped Plovers are known to nest there, and Hooded Plovers may also nest there. Wetland birds rarely use the higher, vegetated dunes.

A high water level usually has a negative impact on most waterbirds, because it reduces the amount of habitat present and diminishes the variety. For example, at the 1.0 metre AHD level there were virtually no entrance shoals, which are important feeding areas for waders.

The wetland birds recorded at the entrance on several visits between 1995 and 2000 are listed in Table 2. The data provide a good indication of the species that usually inhabit the lake entrance in spring and summer. This is the time of year that bird species diversity is at its highest. Most of the species are attracted to the low-lying sandy shoals.

Table 2

Wetland Birds observed at Conjola Lake Entrance

Common Name	Taxonomic Name ¹	1995		1996		2000
		11/10	12/10	19/12	20/12	25/2
Australian Pelican	<i>Pelecanus conspicillatus</i>	1	-	6	2	
Australian White Ibis	<i>Threskiornis molucca</i>					2
Bar-tailed Godwit	<i>Limosa lapponica</i>	1	1	12	7	5
Caspian Tern	<i>Sterna caspia</i>	1	-	2	1	
Cattle Egret	<i>Ardea ibis</i>	-	-	1	-	
Crested Tern	<i>Sterna bergii</i>	14	8	4	8	16
Eastern Curlew	<i>Numenius madagascariensis</i>	5	5	7	2	1
Great Cormorant	<i>Phalacrocorax carbo</i>	2	16	11	15	14
Great Egret	<i>Ardea alba</i>	-	1	1	-	
Hooded Plover	<i>Thinornis rubricollis</i>	-	-	3	3	
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	-	2	-	-	2
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	1	3	-	-	2
Little Tern	<i>Sterna albifrons</i>	-	-	6	6 (nests)	
Masked Lapwing	<i>Vanellus miles</i>	1	-	-	-	3
Pacific Black Duck	<i>Anas superciliosa</i>	-	-	2	-	
Pied Oystercatcher	<i>Haematopus longirostris</i>	-	2	2	2	
Red-capped Plover	<i>Charadrius ruficapillus</i>	-	-	9	10 (nest)	4
Red-necked Stint	<i>Calidris ruficollis</i>	-	-	5	6	
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	16	6	-	-	
Silver Gull	<i>Larus novaehollandiae</i>	8	1	30	33	34
Whistling Kite	<i>Haliastur sphenurus</i>	-	-	2	1	
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	1	-	1	-	
White-faced Heron	<i>Ardea novaehollandiae</i>	-	-	3	1	18

1. Nomenclature based on Christidis and Boles (1994).

Like other coastal lakes, Conjola Lake supports a diverse range of wetland birds. The wetland birds recorded at Conjola Lake, or expected to occur there, are listed in Table 3. Most of the species were recorded by the consultant. Many of the species require very shallow water, and sandflats or mudflats; when the water level is high, their habitats are flooded.

Table 3

Wetland Birds recorded at Conjola Lake, or expected to occur there

Common Name ¹	Taxonomic Name	Confirmed	Expected
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>		x
Australian Pelican	<i>Pelecanus conspicillatus</i>	x	
Australian White Ibis	<i>Threskiornis molucca</i>	x	
Australian Wood Duck	<i>Chenonetta jubata</i>	x	
Azure Kingfisher	<i>Alcedo azurea</i>	x	
Bar-tailed Godwit	<i>Limosa lapponica</i>	x	
Black Swan	<i>Cygnus atratus</i>	x	
Black-fronted Dotterel	<i>Elseyaornis melanops</i>		x
Black-winged Stilt	<i>Himantopus himantopus</i>		x
Caspian Tern	<i>Sterna caspia</i>	x	
Cattle Egret	<i>Ardea ibis</i>	x	
Chestnut Teal	<i>Anas castanea</i>	x	
Clamorous Reed-Warbler	<i>Acrocephalus stemmoreus</i>	x	
Crested Tern	<i>Sterna bergii</i>	x	
Curlew Sandpiper	<i>Calidris ferruginea</i>		x
Darter	<i>Anhinga melanogaster</i>		x
Double-banded Plover	<i>Charadrius bicinctus</i>		x
Dusky Moorhen	<i>Gallinula tenebrosa</i>		x
Eastern Curlew	<i>Numenius madagascariensis</i>	x	
Eurasian Coot	<i>Fulica atra</i>		x
Great Cormorant	<i>Phalacrocorax carbo</i>	x	
Great Egret	<i>Ardea alba</i>	x	

Grey Teal	<i>Anas gracilis</i>	x	
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	x	
Hooded Plover	<i>Thinornis rubricollis</i>	x	
Intermediate Egret	<i>Ardea intermedia</i>		x
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	x	
Little Egret	<i>Egretta garzetta</i>	x	
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	x	
Little Tern	<i>Sterna albifrons</i>	x	
Masked Lapwing	<i>Vanellus miles</i>	x	
Musk Duck	<i>Biziura lobata</i>	x	
Nankeen Night Heron	<i>Nyctocorax caledonicus</i>	x	
Pacific Black Duck	<i>Anas superciliosa</i>	x	
Pied Cormorant	<i>Phalacrocorax varius</i>		x
Pied Oystercatcher	<i>Haematopus longirostris</i>	x	
Red-capped Plover	<i>Charadrius ruficapillus</i>	x	
Red-necked Stint	<i>Calidris ruficollis</i>	x	
Royal Spoonbill	<i>Platalea regia</i>	x	
Ruddy Turnstone	<i>Arenaria interpres</i>		x
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	x	
Silver Gull	<i>Larus novaehollandiae</i>	x	
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>		x
Striated Heron	<i>Butorides striatus</i>	x	
Whimbrel	<i>Numenius phaeopus</i>		x
Whistling Kite	<i>Haliastur sphenurus</i>	x	
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	x	
White-faced Heron	<i>Egretta novaehollandiae</i>	x	

3.3 THE LAKE ENTRANCE SANDFLAT AND ADJACENT DUNES

The sandflats at the entrance to Conjola Lake are an important habitat area for shorebirds, including several threatened bird species. Shorebirds feed and rest on the sandflats, and a few species breed there. The area has several habitat components that attract different groups of birds; these include:

- shallow water
- moist sand shoals
- dry sandflats
- sand dunes (unvegetated).

The only terrestrial vegetation in this area is on the dunes, on the southern side of the sandflat. A large section of the vegetated dune on the southern edge of the entrance was destroyed during an erosion event in 1998/99.

3.4 DOZER ACCESS ROUTES

The proposed access route for the dozer is along the sand track at the end of Thorne Street, to the southeast of Lake Conjola village. Once used by vehicles, the track terminates at the rear of the beach. It has been barred to vehicles in recent years, but is still used as a walking track. The track passes through hind dune forest dominated by Bangalay *Eucalyptus botryooides* and Old Man Banksia *Banksia serrata*. The community is referred to as Bangalay Forest (Mills 1998). Other species present include Coast Banksia *Banksia integrifolia* Red Bloodwood *Eucalyptus gummifera* and Hickory *Acacia implexa*. Near the rear of the dunes behind the beach, the forest only grows to about five metres in height. The understorey is rather open in most places, because of fires in recent years. The understorey species include Golden Wattle *Acacia longifolia*, Tree

Broom-heath *Monotoca elliptica*, Lance Beard-heath *Leucopogon lanceolatus*, Prickly Moses *Acacia ulicifolia*, Shrubby Platysace *Platysace lanceolata*, Blady Grass *Imperata cylindrica*, Spiny-headed Mat-rush *Lomandra longifolia* and Common Bracken *Pteridium esculentum*.

Access onto the beach from the end of the track is either over the dunes to the north of the existing walkway, or along the walkway itself, in which case the walkway and fences would be temporarily removed. The dunes in the area are relatively undisturbed, and are vegetated with native species. Coast Wattle Shrubland (Mills 1998) grows on the higher parts of the dunes, so they are dominated by Coast Wattle *Acacia sophorae*. Other native species are present such as Coastal Beard-heath *Leucopogon parviflorus*, Coastal Boobialla *Myoporum boninense*, Spiny-headed Mat-rush *Lomandra longifolia*, Prickly Couch *Zoysia macrantha* and Snake Vine *Stephania japonica*. There are also scattered clumps of Bitou Bush *Chrysanthemoides monilifera*.

Spinifex Grassland occurs on the lower dunes immediately behind the beach. The species in that area include Hairy Spinifex *Spinifex sericeus*, Coast Wattle *Acacia sophorae*, Native Stork's-bill *Pelargonium australe*, Coast Stackhousia *Stackhousia spathulata*, Pig Face *Carpobrotus glaucescens*, Coastal Beard-heath *Leucopogon parviflorus*, Knobby Club-rush *Isolepis nodosa*, Dune Fan-flower *Scaevola calendulacea* and Dune Thistle *Actites megalocarpa*, and the introduced plants Coastal Gladiolus *Gladiolus gueinzii* and Pennywort *Hydrocotyle bonariensis*.

The use of the northern route would cause the destruction of the dune vegetation along the route. The vegetation would be destroyed by the dozer as it comes from and goes to the beach. Even if the dozer comes and goes to the beach only a few times during the life of the project, then considerable damage would also be caused to the structure of the dunes and the vegetation they support.

The use of the existing walkway for access would be much less destructive, because the walkway is in a corridor that has already been disturbed. Most of the vegetation has already been removed in the vicinity of the walkway. It appears to already be wide enough to accommodate the dozer.

4 ASSESSMENT OF THREATENED SPECIES

4.1 THREATENED FAUNA SPECIES

Threatened fauna species in New South Wales are listed on Schedules 1 and 2 of the *Threatened Species Conservation Act 1995*. Other species requiring protection are listed on the Agreement between the Governments of Australia and Japan for the *Protection of Migratory Birds and Birds in Danger of Extinction and their Environment* (JAMBA) and the agreement with the People's Republic of China for the *Protection of Migratory Birds and their Environment* (CAMBA) (Australia 1974, 1986).

Table 4 presents a list of the bird species, protected under the *Threatened Species Conservation Act 1995* and the international agreements, that occur at Conjola Lake or could reasonably be expected to occur there. Three threatened bird species are fairly regularly recorded at Conjola Lake; these are the Hooded Plover, Little Tern and Pied Oystercatcher. The Sooty Oystercatcher is also expected to occur there from time to time, although it is more likely to be on the rocky shores around Green Island. The Lesser Sand Plover and the Sanderling, while not expected to occur there, may do so from time to time.

Table 4**Threatened Bird Species and Bird Species protected by International Agreements**

Species	JAMBA	CAMBA	TSC Act	Conjola Lake
Bar-tailed Godwit	Yes	Yes	No	Confirmed
Caspian Tern	Yes	Yes	No	Confirmed
Cattle Egret	Yes	Yes	No	Confirmed
Common Greenshank	Yes	Yes	No	Expected
Curlew Sandpiper	Yes	Yes	No	Expected
Eastern Curlew	Yes	Yes	No	Confirmed
Great Egret	Yes	Yes	No	Confirmed
Hooded Plover	No	No	Yes	Confirmed
Lesser Golden Plover	Yes	Yes	No	Expected
Lesser Sand Plover	Yes	Yes	Yes	Possible
Little Tern	Yes	Yes	Yes	Confirmed
Pied Oystercatcher	No	No	Yes	Confirmed
Red-necked Stint	Yes	Yes	No	Confirmed
Ruddy Turnstone	Yes	Yes	No	Expected
Sanderling	Yes	Yes	Yes	Possible
Sharp-tailed Sandpiper	Yes	Yes	No	Confirmed
Sooty Oystercatcher	No	No	Yes	Probably
Whimbrel	Yes	Yes	No	Confirmed
White-bellied Sea-Eagle	No	Yes	No	Confirmed

All records of the three threatened bird species are listed below, in Table 5. This is followed by a profile of each species and an assessment of its potential to be adversely affected by the proposed works.

Table 5**Records of Threatened Wetland Fauna at or near Conjola Lake**

Species/Record	Date	Source of Record
Hooded Plover		
Narrawallee Creek Nature Reserve	1 October 1989	Morris and Burton (1992)
Narrawallee Creek Nature Reserve	November 1989	NPWS Wildlife Atlas
Conjola Beach (2)	29 June 1990	Burton and Morris (1993)
Conjola Lake entrance (3)	19 & 20 December 1996	K. Mills
Conjola Lake entrance (2)	27 December 1996	K. Mills
Conjola Lake entrance (2)	6 October 1997	K. Mills
Conjola Lake entrance (9)	20 May 1998	NSW FOC No. 168
Little Tern		
Conjola Lake Entrance (nesting)	early 1950s	Morris (1989); Smith (1990)
Narrawallee Creek Nature Reserve	November 1989	NPWS Wildlife Atlas
Lake Conjola (2 pairs)	15 January 1996	<i>Aust. Birds</i> 31:4.
Conjola Lake entrance (6, 3 nests)	19 & 20 December, 1996	K. Mills
Conjola Lake entrance (5, 3 nests)	27 December 1996	K. Mills
Conjola Lake entrance (4, 3 nests)	3 January 1997	K. Mills
Conjola Lake entrance (4)	13 November 1999	K. Mills
Conjola Lake entrance (10, 4 nests)	4 December 1999	NSW FOC No. 177
Pied Oystercatcher		
Narrawallee Creek Nature Reserve (2)	6 September 1987	K. Mills
Pattimores Lagoon (2)	19 March 1990	K. Mills
Lake Conjola (2)	14 January 1996	A. Morris
Conjola Lake entrance (2)	12 October 1995	K. Mills
Conjola Lake entrance (2)	19 & 20 December 1996	K. Mills
Conjola Beach (2)	27 December 1996	K. Mills

Conjola Lake entrance (2)	3 January 1997	K. Mills
Conjola Lake entrance (2)	28 September 1997	K. Mills
Conjola Lake entrance (2)	6 October 1997	K. Mills
Conjola Lake entrance (4)	8 March 1999	K. Mills
Conjola Lake entrance (7)	13 March 1999	K. Mills
Conjola Lake entrance (6)	5 August 1999	K. Mills
Conjola Lake entrance (1)	13 November 1999	K. Mills
Conjola Lake entrance (1)	28 January 2000	K. Mills
Pattimores Lagoon (2)	28 January 2000	K. Mills

Hooded Plover

Status: Endangered; this species was listed on Schedule 1 of the *Threatened Species Conservation Act 1995* because its population has been reduced to a critical level, the threatening processes are severe and it is an ecological specialist (NPWS 1992).

Distribution: The Hooded Plover *Thinornis rubricollis* is endemic to Australia, where it occurs along the southern coastline and in Tasmania. In New South Wales, where it mainly occurs south of Jervis Bay, it is solely a coastal species; until the 1940s, the Hooded Plover occurred as far north as Sydney and Port Stephens.

Habitat, etc.: The habitat requirements of the Hooded Plover are long sandy beaches with large amounts of seaweed washed ashore and dunes covered by tussocks and creepers. The plovers sometimes use inlets and coastal lakes with broad areas of sandflats. The nest is "a shallow scrape of sand or fine shingle on the beach or in the dunes behind" (Smith 1991).

Threats: The species is considered to be under threat because of disturbance at its breeding sites (Morris et al. 1981; Garnett 1992), usually by people and dogs. In 1988, the population size in New South Wales was estimated to be 62 birds (Morris 1989). The population appears to be declining and the species' range in New South Wales is contracting, probably because breeding is being interrupted.

Local Occurrence: The Hooded Plover occurs at Conjola Beach, and on most other beaches between Ulladulla and Sussex Inlet. It probably occurs fairly regularly at the entrance of Conjola Lake.

Habitat in the Study Area: The coastal beaches and shoals at the entrance of Conjola Lake provide resting and feeding habitat for the Hooded Plover. Some parts of the barrier are also suitable for breeding, although breeding has never been recorded. There is probably only one breeding pair in the area.

Potential Impact on the Species: Hooded Plovers are mainly threatened by the loss of breeding areas and disturbance at breeding areas. The proposal to build the sand dune may lead to the removal or modification of potential breeding habitat or the work may disturb the plovers during the breeding season.

Impact Mitigation: The potential impact on breeding can be reduced by undertaking the work on the sandflat outside the breeding season, which is from September to March, and by confining the work to as small an area as possible.

Little Tern

Status: Endangered; this species was listed on Schedule 1 of the *Threatened Species Conservation Act 1995* because its population has been reduced to a critical level, the species concentrates in particular areas, the potential for recovery is poor, the threatening processes are severe and it is an ecological specialist (NPWS 1992).

Distribution: The range of the Little Tern *Sterna albifrons* extends along the coast from Port Headland in Western Australia, to the Northern Territory and Queensland, and down the east coast of the mainland. It also occurs in Tasmania. There are few records from South Australia.

Smith (1991) provided the following information about the population in New South Wales:

"Present status in NSW: Migratory, present chiefly September - May. Consists of a large non-breeding population and a small threatened breeding population, which is probably a separate subspecies. The breeding population, estimated at about 340 pairs in the 1950s, has now declined to about 110 pairs. Nesting has been recorded at 60 sites along the coastline but only 33 of these have been used during the last decade."

Habitat: The Little Tern occurs on sandy islands and beaches, bays, inlets and lakes, in salty or brackish water. It nests on beaches above the high water mark, in a depression in the sand. Nesting birds require "a sandy substrate, flat to gently sloping topography, abundant shells or pebbles and very little, if any, vegetation" (Smith 1990). Shells, seaweed and other natural debris provide camouflage for the eggs. Low shrubs and driftwood nearby provide cover for the runners when the chicks have left the nest.

Threats: In *Threatened Animal Species of New South Wales*, Klippel (1992) noted that the Little Tern is "susceptible to disturbance by human activities (i.e. recreation, urbanization, industrial development). It is also threatened by feral carnivores, poor breeding success rate, pollution and pesticide accumulation."

Local Occurrence: A few pairs of Little Terns were breeding at the entrance to Conjola Lake in the 1950s, at Burrill Lake in the 1950s (Morris 1989) and at the entrance to Narrawallee Creek in 1984/85. Nesting has taken place at the entrance to Conjola Lake since 1995/96, but there are no other nesting records from the local area.

Habitat in the Study Area: The sand barrier at Conjola Lake entrance is ideal nesting habitat for Little Terns, although disturbance and predation by feral animals are continuing problems. There have been three or four nests in the area each summer since 1995/96.

Potential Impact on the Species: The proposal to build the sand dune on the sandflat, where the terns nest, would remove or adversely affect part of a sandflat used for nesting. The work may also disrupt birds during the breeding season.

Impact Mitigation: The terns usually nest on the northern and central parts of the sandflat. Extending the sand dunes northwards may remove part of the sandflat. Creating the dune will not destroy all of the nesting habitat, for Little Terns will nest on low dunes (Smith 1990; K. Mills pers. obs.).

The potential impact on breeding can be avoided by reduced by undertaking the work on the sandflat outside the breeding season, which is between October and March.

Pied Oystercatcher

Status: Vulnerable; this species was listed on Schedule 2 of the *Threatened Species Conservation Act 1995* because its population has been severely reduced, its distribution is limited, the potential for recovery is poor, the threatening processes are severe and it is an ecological specialist (NPWS 1992).

Distribution: The Pied Oystercatcher *Haematopus longirostris* occurs in Australia, New Zealand and New Guinea. In Australia, it is distributed along the entire coastline. It is more prominent in Victoria, Tasmania and South Australia.

Habitat: The Pied Oystercatcher inhabits intertidal mudflats, large marine embayments and ocean beaches. It usually roosts at high tide on open sandy spits. Its nest is a scrape in the sand, just above the high tide mark.

Threats: The threats to the Pied Oystercatcher include nesting failure caused by predation, disturbance by people, off-road vehicles and domestic animals. These threats are greater in highly developed areas. The size of the population in New South Wales was estimated in 1991 to be 250 birds (Smith 1991). It is declining because of disturbance at nesting sites.

Local Occurrence: The Pied Oystercatcher is regularly observed at the entrance to Burrill Lake, at Sussex Inlet and at Narrawallee Inlet, where there are usually one or two birds. The species has also been regularly recorded at Conjola Lake and at Pattimores Lagoon. Local breeding sites are unknown.

Habitat in the Study Area: Conjola Lake provides ideal habitat for the Pied Oystercatcher; it is regularly recorded there. Outside the breeding season, up to seven birds have been observed at Conjola Lake. Breeding probably occurs somewhere on Conjola Lake, but has not been observed.

Potential Impact on this Species: The Pied Oystercatcher mainly uses the moist sandflats, which are used for feeding and resting. The proposed works may result in these areas being reconfigured, but the impact on the Pied Oystercatcher should be negligible.

4.2 THREATENED PLANT SPECIES

No threatened plant species are known to occur in the Conjola Lake entrance area. *Syzygium paniculatum* (Myrtaceae), which grows in Conjola State Forest, is the only threatened species known to occur in the vicinity of Conjola Lake.

There are few plant species on the sand dunes and sandflats where the works are to be undertaken. No threatened plants were found. The access routes were also searched for threatened plant species, but none were found.

4.3 THE EIGHT PART TEST

The *Threatened Species Conservation Act 1995* conserves threatened species, endangered populations and endangered ecological communities in New South Wales. Threatened flora and fauna species are listed on the schedules attached to the Act, and are classified either as

"endangered" (Schedule 1 species), "vulnerable" (Schedule 2 species) or "presumed extinct" (Schedule 1, Part 4). Endangered populations and endangered ecological communities are listed on Schedule 1, in Parts 2 and 3, respectively.

The *Threatened Species Conservation Act 1995* amends the *Environmental Planning & Assessment Act 1979* (New South Wales 1979), requiring that the factors set out in section 5A of the Act be considered in deciding whether there is likely to be a significant effect on threatened species, endangered populations or endangered ecological communities, or their habitats and, hence, whether a Species Impact Statement is required. This process is commonly referred to as the "eight part test"; the test is applied below.

Construction of the Dune on the Sandflat

(a) in the case of threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Pied Oystercatcher

The proposed work is not likely to disrupt the life cycle of the Pied Oystercatcher to such an extent that the local population is likely to be placed at risk of extinction. Although the proposed works will change the sand shoals at the entrance, such changes in the location and configuration of the shoals are unlikely to significantly disrupt the life cycle of the Pied Oystercatcher. Sand shoals are naturally dynamic, and are constantly being modified by tides and weather conditions.

Hooded Plover

The proposed work is not likely to disrupt the life cycle of the Hooded Plover to such an extent that the local population is likely to be placed at risk of extinction. Hooded Plovers occur on the sandflat and low dunes, and a pair of Hooded Plovers may nest on the sandflat at the entrance to Conjola Lake, for a large area of sandflat and low dunes is available. However, nesting has not been confirmed and the proposed changes to the sandflat are unlikely to result in the loss of all potential nest sites. Provided that the work is undertaken outside the breeding season, the Hooded Plover is unlikely to be affected to such an extent.

Little Tern

The proposed work is not likely to disrupt the life cycle of the Little Tern to such an extent that the local population is likely to be placed at risk of extinction. Although the Little Tern may not nest on the same sites in future, the proposed works are unlikely to cause them to abandon the area altogether. Extending the dune will not make the area unsuitable for nesting, unless it becomes densely vegetated. If the top of the dunes are fairly level, nesting may take place there; the drift fences on the dunes may create a relatively safe retreat.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

There are no endangered populations in the study area.

(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The sandy shoals and sandflats to be affected are considered to be a significant area of habitat for the Pied Oystercatcher, Hooded Plover and Little Tern, because such estuarine habitat is not

common in the Shoalhaven region. The proposed works would be unlikely to result in the removal or significant modification of this "area of known habitat".

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

The proposed works will not cause threatened species habitat to become isolated.

(e) whether critical habitat will be affected

No "critical habitat" declared under Part 3 of the *Threatened Species Conservation Act 1995* occurs in the area.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region

The estuarine and coastal habitats used by the threatened species discussed in this report are not adequately reserved in the region; few tidal areas are in nature conservation reserves.

(g) whether the development or activity is of a class of development or activity that is recognised as a threatening process

The proposed work is not specified in Schedule 3 of the *Threatened Species Conservation Act 1995* as a key threatening process. The work has the potential, however, to modify and remove habitat, and disrupt nesting on the nearby sandflats; these are recognised threats to the Little Tern and Hooded Plover.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution

None of the three threatened fauna species discussed in this report is at the geographic limit of its range; all species occur to the north and south.

Dozer Access Route to the Beach

(a) in the case of threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

The proposed dozer access route to the beach is well away from the habitat used by the threatened fauna discussed in this report. No threatened plants were found along either of the route options.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

There are no endangered populations along the routes.

(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

Not applicable. The route is not "known habitat" for any threatened species, population or ecological community.

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

Not applicable. The use of either route will not cause threatened species habitat to become isolated.

(e) whether critical habitat will be affected

No "critical habitat" declared under Part 3 of the *Threatened Species Conservation Act 1995* occurs in the area.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region

Not applicable. There is no threatened species habitat along either route.

(g) whether the development or activity is of a class of development or activity that is recognised as a threatening process

The proposed work is not specified in Schedule 3 of the *Threatened Species Conservation Act 1995* as a key threatening process.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution

Not applicable. No threatened species, etc, are likely to occur along either route.

5 CONCLUSION

Three threatened bird species could be affected by the proposed Stage 1 (Interim) Works at Conjola Lake Entrance. These are the Pied Oystercatcher, Hooded Plover and Little Tern. The potential impact of the proposed works on these species was assessed by applying the "eight part test". Although the work will result in the modification of habitat utilised by threatened species, it is not likely that it will have a significant effect on those species. The work is not likely to disrupt their life cycle to such an extent that the local population would be placed at risk of extinction. The preparation of a Species Impact Statement is therefore not considered to be necessary.

The following recommendations are made to reduce the potential impact of the work on flora and fauna, including threatened species.

Lake Entrance

(i) If work is undertaken between October and March, when Little Terns may be nesting in the area, then measures must be taken to avoid disturbing them. The NPWS should be consulted, because they will know whether the birds are nesting and will advise on protective measures that

should be taken. Preferably, the NPWS should fence the nests so that Council workers and the public will know their location.

(ii) The total area of sandflat disturbed by the dozer should be kept to a minimum.

(iii) The new dune should be fenced with post and wire fencing, to discourage people from entering the area. Excluding people will make the dune more attractive to Little Terns, and other coastal species, for nesting.

(iv) Natural debris on the beach is important for beach nesting species, because they use it to disguise the nest and their young, and to provide shelter. It is therefore recommended that timber, seaweed, shells and other natural debris be scattered across the top of the dune to encourage nesting in it.

(v) The installation of drift fences should be discussed with the NPWS, because the fencing may deter Little Terns from nesting. On the other hand, the fencing may deter people from walking across the area.

Beach Access

(vi) It is recommended that the dozer access route should be along the existing walkway. This route is far preferable to the northern route, which crosses undisturbed dune vegetation.

(vii) The dozer should be strictly confined to the walkway route, and it should traverse the route as few times as possible. It is advisable to accurately mark the route on site, so that there is no misunderstanding about the route the dozer should take.

(viii) Liaison with the NPWS should be maintained at all times, because they have responsibility for the management of Narrawallee Creek Nature Reserve.

* * * * *

6 REFERENCES

- Australia (1974). Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment.
- Australia (1986). Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment.
- Burton, A. C. G. & Morris, A. K. (1993). New South Wales Bird Report for 1990. *Australian Birds* 26(4):89-120.
- Christidis, L. & Boles, W. (1994). *The Taxonomy and Species of Birds of Australia and its Territories*. Royal Australasian Ornithologists Union, Victoria.
- Department of Environment and Planning (1983). Illawarra Region Wetlands Study. The Department, Sydney, 52pp.
- Disney, H. J. (1979). Royal Australasian Ornithologists Union Pilot Atlas Scheme in *Corella* (Journal of the Aust. Bird Study Ass.), Vol.2, Supplement, July.
- Garnett, S. (1992). *Threatened and Extinct Birds of Australia*. RAOU Report No. 82, Royal Australasian Ornithologists Union, Melbourne, 212p.
- Kevin Mills & Associates Pty Limited (1995a). Ecological Assessment, Maintenance Dredging, Conjola Lake Entrance, City of Shoalhaven.
- Kevin Mills & Associates Pty Limited (1995b). The Vegetation, Cudmirrah National Park, Conjola National Park, Cudmirrah Nature Reserve. Prepared for the National Parks and Wildlife Service, Nowra, June.
- Kevin Mills & Associates Pty Limited (1996). Supplementary Report. Ecological Assessment, Maintenance Dredging, Conjola Lake Entrance, City of Shoalhaven. Prepared for Shoalhaven City Council, Nowra, December.
- Klippel, K. (1992). *Threatened Animal Species of New South Wales*. Total Environment Centre, Sydney, 149p.
- Mills, K. (1998). Vegetation Survey Methods and Natural Vegetation Types in the Coastal Parts of the City of Shoalhaven, New South Wales. *Illawarra Vegetation Studies* (7). Coachwood Publishing, Jamberoo, NSW.
- Morris, A. K. (1989). The Declining Status of the Little Tern in New South Wales in *Corella* (Journal of the Aust. Bird Study Ass.), 3(5):105-110, December.
- Morris, A., McGill, A. R. & Holmes, G. (1981). *Handlist of Birds in New South Wales*. NSW Field Ornithologists Club, Sydney, 79p.
- Morris, A. K. & Burton, A. C. G. (1992). New South Wales Bird Report for 1989. *Australian Birds* 26(2):41-70.

National Parks and Wildlife Service of New South Wales (1992). Reasons for Decisions of the Scientific Committee in relation to the Revision of Schedule 12. Dated 26 March 1992; has been adopted for Schedules 1 and 2 of the *Threatened Species Conservation Act 1995*.

New South Wales (1979). *Environmental Planning and Assessment Act 1979*. NSW Government Printer, Sydney.

New South Wales (1985). *State Environmental Planning Policy No. 14 - Coastal Wetlands*. NSW Government Printer, Sydney.

New South Wales (1995). *Threatened Species Conservation Act 1995*. Government Printer, Sydney.

Patterson Britton & Partners Pty Ltd (1999). Lake Conjola Entrance Stage 1 (Interim) Works Review of Environmental Factors. Prepared for Shoalhaven City Council, November.

Smith, P. (1990). The Biology and Management of the Little Tern *Sterna albifrons* in NSW. Species Management Report No. 1. National Parks and Wildlife Service.

Smith, P. (1991). The Biology and Management of Waders (Suborder Charadrii) in NSW. *Species Management Report No. 9*. National Parks and Wildlife Service.

West, R. J., Thorogood, C., Walford, T. & Williams, R. J. (1985). An Estuarine Inventory for New South Wales, Australia. Fisheries Bulletin 2, Department of Agriculture, September.

Appendix E

**Lake Conjola Entrance Management Plan
Review of Environmental Factors
Aquatic Ecology**

The Ecology Lab Pty Ltd

Report to:

Manly Hydraulics Laboratory

Lake Conjola Entrance Management Plan
Review of Environmental Factors – Aquatic Ecology

FINAL

January 2003

Report prepared by:

The Ecology Lab Pty Ltd

Lake Conjola Entrance Management Plan

Review of Environmental Factors – Aquatic Ecology

January 2003

Report Prepared for:

Manly Hydraulics Laboratory
110B King St
Manly Vale, NSW, 2093

Report Prepared by:

The Ecology Lab Pty Ltd
4 Green Street
Brookvale, NSW, 2100
Phone: (02) 9907 4440

Report Number – 16/0102A

Report Status – Final, January 20, 2003

© This document and the research reported in it are copyright. Apart from fair dealings for the purposes of private study, research, criticism or review, as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without written authorisation. Direct all inquiries to the Director, The Ecology Lab Pty Ltd at the above address.

Table of Contents

1.0 Introduction.....	1
1.1 Background.....	1
1.2 Aims.....	1
2.0 Existing Information.....	3
2.1 Aquatic Habitats and Vegetation.....	3
2.1.1 Seagrasses.....	3
2.1.2 Saltmarshes.....	4
2.1.3 Algae.....	4
2.2 Fauna	4
2.2.1 Fish Communities	4
2.2.2 Benthic Communities.....	7
2.3 Commercial Fisheries	7
2.4 Recreational Fisheries.....	9
2.5 Water Quality	9
2.6 Other Recreational Uses of the Lake	10
2.7 Threatened and Introduced Species.....	10
3.0 Assessment of Impacts.....	12
3.1 Description of the Proposed Entrance Management Plan	12
3.2 Impacts on Seagrass Beds.....	13
3.2.1 Direct effects.....	13
3.2.1 Indirect Effects.....	13
3.3 Effects on the Existing Infestation of <i>Caulerpa taxifolia</i>	14
3.4 Benthic Communities in the Dredged Area	14
3.5 Fish Communities, Recreational and Commercial Fishing.....	15
3.6 Impacts on Migratory Nesting Birds.....	16

4.0 Amelioration of Impacts.....	18
4.1 <i>Caulerpa taxifolia</i> infestation.....	18
4.2 Benthic Communities Affected by Dredging.....	18
4.3 Migratory Nesting Birds.....	18
5.0 Recommendations for Monitoring.....	19
5.1 Long-Term effects on Fish Communities and Seagrass.....	19
5.2 <i>Caulerpa taxifolia</i> infestation.....	19
5.3 Benthic communities.....	19
5.4 Migrating Nesting Birds.....	20
6.0 Acknowledgements.....	21
7.0 References.....	22
Tables.....	24
Figures.....	34

1.0 INTRODUCTION

1.1 Background

Lake Conjola is a tidal estuary that is, historically open to the sea for 62% of the time. The entrance to the lake is subject to periodic closures which can last for months or years. Each instance of closure has been preceded by a severe storm which deposited sand that blocked the entrance channel (Shoalhaven City Council 1999). Periods of prolonged closure have been associated with the following:

- Loss of oyster production,
- Habitat decline including mangrove and seagrass dieback,
- Emergence of algae along inlet foreshores,
- Public health concerns relating to elevated levels of bacteria and viruses,
- Loss of tourist income,
- Degradation of foreshore habitat along inlet,
- Decline in fish and crustacean catches,
- Decline in sea birds,
- Decline in aesthetics of lake,
- Increased flooding of low lying areas (Shoalhaven City Council 1999).

As part of the Estuary Management Process, an Estuary Management Plan has been developed and amended to include the development of strategies for stabilisation of the entrance and strategies to alleviate flooding and water quality concerns (Shoalhaven City Council 1998).

1.2 Aims

A formal plan for the long-term management of the lake's entrance (Entrance Management Plan) is being developed by Manly Hydraulics Laboratory (MHL), and its impacts are to be examined by means of an REF (Review of Environmental Factors). The Ecology Lab Pty Ltd was commissioned by MHL to contribute to the REF in areas relating to the aquatic ecology of the lake. The aims of this document are to:

- Review existing literature on:
 - Key habitats such as mangroves and seagrasses;
 - Flora and fauna communities;

- Status of commercial and recreational fisheries;
- Changes in water quality;
- Other recreational uses of the lake;
- Threatened and introduced aquatic species, populations or habitats.
- Assess potential impacts of the proposed entrance management plan;
- Suggest potential amelioration of impacts;
- Make recommendations for monitoring.

2.0 EXISTING INFORMATION

2.1 Aquatic Habitats and Vegetation

Aquatic habitats in Lake Conjola include saltmarshes, mangroves, seagrass beds, sandy shoals, deep unvegetated habitats, rocky outcrops and walls and timber pilings.

Information on the distribution of saltmarshes, mangroves and seagrasses was detailed in West *et al.* (1985), based on 1979 aerial photos and a field survey in 1982. The reported combined area of saltmarsh and the mangrove *Avicennia marina* was 0.013 km², and patches of the seagrasses *Zostera* spp. and *Halophila* spp. had a total area of 0.5 km². The seagrass beds were patchy near the mouth of the lake, with small areas at the end of each sheltered bay and relatively large patches near Fishermens Paradise. Seagrasses were limited to water depths of less than 2 m in Lake Conjola.

2.1.1 Seagrasses

The Ecology Lab (1993) inspected aquatic habitats in Lake Conjola and observed that at several sites there had been declines in the amount of seagrass present compared to that mapped by West *et al.* (1985) (Figure 1). They noted the presence of the seagrass *Halophila* sp. in the middle reaches of the lake where there was a relatively deep, sandy basin, upstream of "The Step" (i.e. the landward edge of the marine delta). The Ecology Lab (1993) also observed a relatively large saltmarsh in the upper region of the estuary near Fishermen's Paradise which was not shown by West *et al.* (1985) (Figure 1).

Patterson Britton and Partners (1999) summarised a study which compared the extent of seagrasses in the lake based on aerial photos taken in 1945, 1959, 1971, 1985, 1993 and 1997 (Heycox 1994). They emphasised the large variability in the amount of seagrasses present in the lake through time and concluded that the condition of the entrance was a main factor in causing the variability in the size of seagrass beds, with nutrient and sediment input and boat traffic also being contributing factors. They noted that the January 1997 aerial photographs showed significantly more seagrass present than in photos from 1982 – 1985, which were used by West *et al.* (1985) to estimate seagrass cover, a baseline against which subsequent comparisons are commonly made. They further noted that the health or condition of the seagrass should also be considered when assessing seagrass in the lake, not simply the amount present (Patterson Britton and Partners 1999). The results of their site

assessments suggested that in September 1998 *Zostera* in the lake showed a range of conditions from short, immature leaves to fully grown but bleached specimens.

2.1.2 Saltmarshes

Saltmarsh vegetation was described from Pattimores Lagoon by Finley (1988). A variety of typical vegetation communities occurred, including *Sarcocornia* samphire flats in the small embayment around the perimeter of the lagoon, extending into *Juncus* and *Phragmites* reed beds. A few mangroves (*Avicennia marina*) were recorded, but seagrasses were not (Finley 1988).

2.1.3 Algae

A large proportion of Lake Conjola is infested with the invasive marine alga, *Caulerpa taxifolia* (Grey 2001). The quick-growing, cold-tolerant plant smothers seagrasses and alters marine habitats. The feathery, bright green seaweed emerges from a long stolon that is anchored to the bottom via rhizoids. The population in Lake Conjola is thought to have become established between 1987 and 1995 and is most closely related to populations from Moreton Bay, Queensland. The method of transfer to Lake Conjola is not known, but it may have been introduced by boat, fishing equipment or released from an aquarium. The alga can survive in damp conditions for more than a week, and can spread from small fragments (Grey 2000/2001). In an effort to halt or limit the spread of the invasive alga, NSW Fisheries introduced new fishing restrictions on June 14, 2001. Haul netting was banned entirely in the lake, but mesh netting is allowed to continue on the basis that the nets are used only in Lake Conjola. Other recommendations include avoiding boating in areas near the infestation to reduce the incidence of fragmentation of existing beds. NSW Fisheries is currently experimenting with methods to control existing infestations, including applying salt to the plants. These experiments are being done on a smaller algal infestation in Pittwater, north of Sydney.

2.2 Fauna

2.2.1 Fish Communities

Pollard (1994a) sampled fish communities in April 1984 and May, 1985 using gill nets and between August 1984 and September 1986 using beach seines, beam trawls and rotenone ichthyocide. Beam trawls and rotenone sampling were done in *Zostera* beds (Pollard 1994a).

One hundred species of fish were captured, of which 73 were found in *Zostera* beds, 76 in shallow sandy habitats and 33 over the deeper part of the lagoon (using gill nets). Almost half the species were of some economic importance to commercial and recreational fisheries. The fauna of *Zostera* beds was sampled using rotenone and comprised mainly small species of no commercial importance and some juveniles of species of commercial importance.

Abundant non-commercial species included:

- Perchlets (*Ambassis jacksoniensis*; Ambassidae),
- Bridled goby (*Arenigobius frenatus*; Gobiidae),
- Fortescue (*Centropogon australis*; Scorpaenidae),
- Krefft's goby (*Bathygobius krefftii*; Gobiidae),
- Flathead gudgeon (*Philypnodon grandiceps*; Eleotridae) and,
- Swan River goby (*Pseudogobius olorum*; Gobiidae).

Species of commercial importance present included:

- Juvenile luderick (*Girella tricuspidata*; Girellidae),
- Tarwhine (*Rhabdosargus sarba*; Sparidae),
- Eastern striped trumpeter (*Pelates sexlineatus*; Terapontidae) and
- Six-spined leatherjacket (*Meuschenia freycineti*; Monacanthidae).

The fauna of sandy shallows collected in beach seines comprised a large proportion of juveniles and subadults of commercial species and non-commercial species. This assemblage was dominated by the non commercial species:

- Perchlets (*A. jacksoniensis*),
- Silverfish (*Atherinosoma presbyteroides*; Atherinidae) and,
- Long-finned goby (*Favonigobius lateralis*; Gobiidae).

Commercial species present included:

- Sand mullet (*Mxus elongatus*; Mugilidae),
- Sand whiting (*Sillago ciliata*; Sillaginidae) and
- Flat-tail mullet (*Liza argentea*; Mugilidae).

The lagoon bed fauna collected using gill nets comprised only commercial species. This assemblage was dominated by:

- Sandy sprat (*Herklotsichthys castelnaui*; Clupeidae),
- Sand mullet (*Myxus elongatus*; Mugilidae),
- Flat-tail mullet (*Liza argentea*; Mugilidae),
- Tailor (*Pomatomus saltatrix*),
- Silverbidy (*Gerres subfasciatus*; Gerridae),
- Dusky Flathead (*Platycephalus fuscus*; Platycephalide)
- Sand whiting (*Sillago ciliata*; Sillaginidae),
- Eastern striped trumpeter (*Pelates sexlineatus*; Terapontidae)
- Yellow-finned bream (*Acanthopagrus australis*; Sparidae), and
- Sea mullet (*Mugil cephalus*; Mugilidae).

Despite periods of closure, Pollard (1994a) considered Lake Conjola to be an estuary with a permanent connection to the sea. In comparing the fish fauna of Lake Conjola to two other lagoons that were open intermittently to the sea, Pollard (1994a) concluded that Lake Conjola supported more than twice the number of species of fish, although lower commercial catches than estuaries that open only intermittently. Pollard (1994a) identified the following species as those that appeared to require a permanent or almost permanent connection to the sea:

- Eastern striped trumpeter (*Pelates sexlineatus*; Terapontidae),
- Silverfish (*Atherinosoma presbyteroides*; Atherinidae),
- Ogilby's hardyhead (*Atherinomorus ogilbyi*; Atherinidae),
- Sandy sprat (*Herklotsichthys castelnaui*; Clupeidae) and,
- Blue sprat (*Spratelloides robusta*; Clupeidae).

The Environment Research Institute (1999) sampled fish from seagrass beds in the entrance, middle region and upper regions of Lake Conjola in Spring, 1998, Summer and Autumn 1999 using a small seine net. They collected a total of 42 species, including 16 of commercial importance. They found the greatest numbers of fish in the upper region of the estuary, but

a greater diversity in the entrance and mid-estuary regions (ERI 1999). The entrance was open during their sampling (Spring 1998), but had been preceded by a four-year period of closure.

2.2.2 Benthic Communities

No information on the benthic communities present in Lake Conjola was found by The Ecology Lab (1993), and no studies have been found since that date.

2.3 Commercial Fisheries

The major commercial fishing methods in Lake Conjola are haul netting, mesh netting and eel traps. As of 1993, six licensed fishermen were reported to operate in Lake Conjola, but they did not fish there regularly (Wayne Currie, Ulladulla Fisheries Inspector, pers. comm.). On June 14, 2001, NSW Fisheries introduced new fishing restrictions which included a complete ban on haul netting.

Areas closed to commercial fishing and distribution of oyster leases are shown in Figure 2.

Pollard (1994a) reported that the annual fish catch from July 1987 to June 1991 was dominated by sea mullet (*Mugil cephalus*), luderick (*Girella tricuspidata*), bream (*Acanthopagrus* spp), flat-tail mullet (*Liza argentea*), silver biddy (*Gerres subfasciatus*), sand whiting (*Sillago ciliata*), dusky flathead (*Platycephalus fuscus*), garfish (*Hyporhamphus regularis*), eels (*Anguilla* spp.) and tailor (*Pomatomus saltatrix*) (Pollard 1994a). Catches of crustaceans averaged 300 kg per annum of school prawn (*Metapeneus macleayi*) and eastern king prawn (*Penaeus plebejus*) and 100 kg per annum of mud crab (*Scylla serrata*) and blue swimmer (*Portunus pelagicus*). A large (1600 kg) catch of "miscellaneous shellfish" reported was probably the Sydney cockle (*Anadara trepezia*) (Pollard 1994a). Pollard (1994a) did not report on any oyster production.

The following statistics for production in the commercial fisheries are available for Lake Conjola (tonnes):

Year or Average for Period	Number of tonnes	Source
1972 to 1982	9	West et al, 1985
July 1987 to June 1991	8	Pollard (1994a)
1993/1994	17	NSW Commercial Fisheries Statistics, 1993/94 to 1997/98
1994/1995	18	NSW Commercial Fisheries Statistics, 1993/94 to 1997/98
1995/1996	15	NSW Commercial Fisheries Statistics, 1993/94 to 1997/98
1996/1997	5.8	NSW Commercial Fisheries Statistics, 1993/94 to 1997/98
1997/1998	5.8	NSW Commercial Fisheries Statistics, 1993/94 to 1997/98

For the period 1990-1996, the average commercial catch in Lake Conjola was dominated by finfish (12,804 kg); the average catch of crustaceans was 127 kg and for molluscs 690 kg, with an average for all categories of 13,632 (Gibbs 1997). The average number of commercial fishers and crew for the same period was 21.6, while the average number of boats was 23.

The average yearly fishing effort in days for the period 1990/1991 to 1995/1996 was:

- Prawning: 3.3
- Trapping: 30.2
- Meshing: 147.5
- Fish Hauling: 61.2
- Hand fishing: 6.7

- Other methods: 17.2. Total: 266

NSW Fisheries statistics for 1997/1998 indicate that commercial landings of finfish accounted for 99.5% of estuarine production and was dominated by catches of silverbiddy, sand whiting and sea mullet. The average number of fishers for 1997/1998 was 8, while the number of days of fishing effort (all fishing methods) was 102.

Oyster leases cover an extensive area from Roberts Point to Berringer Lake. Oyster production between 1972 and 1982 averaged 23 tonnes (West *et al.* 1985), but dropped to an average of 7.7 tonnes for the period 1983 to 1992. This drop continued between 1994 and 1997, with the average yearly production of oysters being approximately 3.5 tonnes (NSW Fisheries 1998).

2.4 Recreational Fisheries

The recreational fish catch from Lake Conjola was assessed by creel surveys during summer of 1983/84 and 1984/85 (Henry 1986). The estimated summer fish catches from Lake Conjola were 16,524 for 1983/84 and 17,046 fish for 1984/85. The catch-per-unit-effort (CPE) was 0.59 and 0.63 fish per fishermen hour. The recreational fish catch was greatest in January. CPE was lower in the upstream region of Lake Conjola. Boat fishermen had a higher CPE than shore fishermen and CPE was higher during weekdays than weekends. Twenty-one species of fish were captured, with dusky flathead, sand mullet, bream, garfish and luderick being the most prominent species. A decline in the catches of popular angling species (flathead, bream) and an increase in less popular species (mullet, garfish, leatherjackets) was found for 1984/85, but whether this shift is due to natural variation or the effects of human activities is unknown.

2.5 Water Quality

Historical water quality data for Lake Conjola are summarised by Scribner *et al.* (1985). Those data showed Lake Conjola to be little affected by pollution and eutrophication up to the mid 1980's (Gibbs 1997). Basic temperature and salinity data for Lake Conjola are presented in Pollard (1994b). He recorded average salinities near the mouth of the lake of 34-35 ppt, and at the two upstream sites (6 - 7km from the mouth), around 30-32 ppt. Water temperatures were high in mid summer (24°C) and low in mid winter (13°C). There was generally very little (< 1°C) temperature stratification at the sampling sites in Lake Conjola, except at the upstream sites after heavy rain.

The Lake Conjola Progress Association (1990) identified stormwater outlets, drainage canals, weir, development and effluent disposal as sources of pollution into Lake Conjola. The condition of the canal estates and adjoining waterways leading to Pattimores Lagoon was described by the LCDPA as a "cesspool" (Morrison 1987 cited in Finley 1988). The major source of pollution appeared to be originating from illegal discharge from septic tank installations or some other unauthorised means of disposal of effluent. The environmental history and trophic status of Pattimores Lagoon were investigated by Finley (1988).

2.6 Other Recreational Uses of the Lake

The Ecology Lab (1993) observed damage from boat propellers in seagrass beds at the northern end of the lake. Boating activities that could cause such damage included recreational fishing and water skiing. Informal boating access may also contribute to bank erosion and stability, particularly along the southern shore adjacent to the township of Lake Conjola. Such bank destabilisation may have follow-on impacts on fringing aquatic vegetation and water quality (Shoalhaven City Council 1999).

2.7 Threatened and Introduced Species

Table 1 lists the fish, birds, amphibians, mammals, reptiles and plants likely to occur in the vicinity of Lake Conjola protected under the EPBC Act (1999). Of the fish species listed in the table, four have been collected in Lake Conjola:

- black pipefish (*Stigmatopora nigra*) (Pollard 1994a, ERI 1999),
- hairy pipefish (*Urocampus carinirostris*) (Pollard 1994a, ERI 1999),
- spotted pipefish (*stigmatopora argus*) (Pollard 1994a),
- mother-of-pearl pipefish (*Vanacampus margaritifer*) (Pollard 1994a).

These pipefish are known to use seagrass beds as their primary habitat.

No fish species currently listed on Schedule 4 or 5 of the Fisheries Management Act 1994 has been recorded from Lake Conjola in the published literature.

Table 2 lists birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola and their protected status under the TSC Act (1995), based on a search of the NSW National Parks and Wildlife Atlas. The list includes the following numbers of Endangered or Vulnerable species:

Type of animal	Number Endangered species	Number Vulnerable species
Amphibians (frogs)	1	0
Aves (birds)	4	14
Mammals	1	9
Reptiles	0	1

A summary of the bird species likely to be affected by the proposal is given in Kevin Mills & Associates (2000). He concluded that the Stage 1 (Interim) work would modify the habitats of three threatened bird species (Pied Oystercatcher, Hooded Plover and Little Tern), but that it was not likely to have significant effects on those species. After completing the Eight Part Test for each species he concluded that the preparation of a Species Impact Statement was not necessary. He made recommendations for mitigating the impacts of the proposal which included:

- Consultation with NPWS regarding the current breeding status of Little terns,
- Avoiding undertaking the work between September and March when Little Terns and Hooded Plovers may be nesting,
- Minimising the area of sandflat disturbed by bulldozing,
- Fencing off the newly placed sand on the dune to exclude people and make the nesting area more attractive to Little Terns,
- Scatter natural debris such as seaweed, shells and timber across the top of the dune to encourage nesting,
- Limit the route of the bulldozer to the existing walkway route and traverse the route as few times as possible.

3.0 ASSESSMENT OF IMPACTS

3.1 Description of the Proposed Entrance Management Plan

The overall aim of the proposed Entrance Management Plan is to establish a series of indicators that will trigger a sequence of actions aimed at maintaining water flow through the entrance of Lake Conjola. Details of the triggers for action are given in the main Entrance Management Plan (MHL 2002). Because the actions may be triggered within timeframes ranging from months to years, considerations of their potential effects on aquatic ecology will be made from a general, rather than a time-specific viewpoint. From the point of view of potential effects on aquatic ecology, the main components of the actions to keep the entrance channel open are:

- The dredging of sand from the main entrance channel,
- The deposition of the sand on the spit on the southern side of the high dunes and,
- The placement of the dredged sand on the existing high dunes in the south-east corner of the lake and subsequent shaping and planting to stabilise the placed sand.

The channel proposed to be deepened by dredging would follow the mid-line of the existing tidal channel (the historic flood cut), and would be dredged to a width of 40 m and depth of 2 m in typical conditions. The length of the dredged channel would vary depending on channel and entrance conditions, but is estimated to range from 1000 m to 1200 m long. This would correspond to an estimated range of sediment volume from 50,000 m³ to 100,000 m³ (MHL 2002). It is understood that the dredging would be done using a cutter suction dredge and a bulldozer would be used to place and shape the sand on the dunes.

Works involving similar activities in the same locations as for this proposal were completed as part of the Stage 1 (Interim) works, for which a REF was completed (Shoalhaven City Council 1999). These initial works have provided relevant, specific information on the effects of the works proposed for this REF, which will be detailed in the appropriate sections below.

3.2 Impacts on Seagrass Beds

3.2.1 Direct effects

There are no seagrasses in the immediate vicinity of the proposed dredging activities. The proposed dredging area is confined to the main channel, a habitat characterised by highly mobile sand. If the entrance remains open, it is unlikely that seagrasses would colonise this habitat in the future. We would therefore predict that the proposal would have no direct effects on seagrasses in Lake Conjola.

3.2.1 Indirect Effects

Potential Effects during Construction

Based on observations during the Stage 1 (Interim) works, we would not expect any increase in the turbidity of water due to entrance channel dredging. The dredging operator for those works reported that the sediment was loosely packed, clean sand, and that the water running off the sand deposited on the spit was very nearly clear. We would therefore not expect any increase in turbidity of the lake's waters due to the proposed dredging. Increases in turbidity can reduce the production of seagrasses and promote the growth of epiphytes on seagrass blades (Borowitzka & Lethbridge 1989).

Potential long-term Effects

Patterson Britton and Partners (1999) have discussed the potential impacts of a permanently open entrance on seagrass distribution and health. They suggested that under permanently open entrance conditions the extent of seagrass may not be as great as in previous years (e.g. 1945, 1971 or 1997), but that the health of existing seagrasses might improve. They predicted that one effect of a permanently open entrance would be the dieback of seagrasses that had become opportunistically established during periods of elevated water levels. The extent of the dieback would depend on the location of the newly colonised beds, with seagrasses colonising channel edges, areas closest to the entrance and those above the tidal range likely to dieback as a consequence of scouring, burial or exposure (Patterson Briton and Partners 1999).

Another effect on seagrasses of a permanently open entrance channel is likely to be the increased opportunity for estuarine-dependant organisms to colonise seagrass beds. Continuous tidal flushing would increase the chances of recruitment of juvenile fish and

their invertebrate food, increasing the diversity and, potentially, the abundance of organisms living in the seagrass beds. This predicted increase in organisms associated with seagrass beds would likely have a flow-on effect to the productivity of recreational and commercial fishing industries based in the lake.

3.3 Effects on the Existing Infestation of *Caulerpa taxifolia*

Potential Effects during Construction

The infestation has currently been reported throughout most of Lake Conjola, including the main entrance channel (Kylie Russell, NSW Fisheries, pers. comm.). If the alga was present within the main entrance channel and dredging were to commence within this area, possible translocation and fragmentation of existing plants may occur. This could be detrimental to the health of nearby seagrass beds that are currently unaffected by *Caulerpa taxifolia*, and also increase the problem already present within the lake.

Potential Long-term Effects

The factors that influence the growth of *Caulerpa taxifolia* are not well known. If, as NSW Fisheries suspects, the alga became established between 1987 and 1995, then it did so in a period when the lake was mainly open. The lake closed on 1/11/94 after an open period of more than 18 months, and was closed until 4 June, 1998. As the lake has been open since mid 1998 and a large patch of algae has been only relatively recently identified and mapped, it would appear that the alga can flourish regardless of the state of the entrance. While it is possible that increased flushing of the estuary since the entrance opened in June 1998 has increased the fragmentation of the algae, spreading the infestation, we have no way of knowing if this occurred. We would predict, therefore, that the impact of keeping the entrance open would have no measurable effect on the infestation of the alga, however, more information on the ecology of the alga in Lake Conjola is required to confirm this prediction.

3.4 Benthic Communities in the Dredged Area

The following discussion is restricted by the lack of information on benthic communities in any part of Lake Conjola. The following discussion and predictions rely on patterns of distribution and abundance of benthic organisms in other estuaries, and the known effects of dredging in sandy marine habitats.

Potential Effects during Construction

Benthic organisms living in the proposed dredging channel will die as a result of being removed with dredged sand and deposited on the sand flat and then moved to the sand dune. The densities of benthic organisms in highly mobile sandy sediment sediments are generally lower than that in more protected areas with sediments containing finer particles and a larger component of organic material (Dexter 1984, Newell 1998). Therefore, it is not expected that the deposition of dredged sand on the sand flat will result in foul odours, as is sometimes the case when quantities of algae wash up on a beach. In the short term, wading shore birds may benefit from an increased supply of food.

Potential Long-term Effects

Based on studies of the effects of dredging on benthic communities in sandy sediments, we predict that the benthic community in the dredged channel would recover, as a result of migration of surrounding animals into the sediment and the recruitment of new organisms to the new habitat (The Ecology Lab 1993b, Newell *et al.* 1998). The time required for this recovery is unknown, but likely to vary from as little as a few months to 2 years (Jones 1986, The Ecology Lab 1993b, Newell 1998).

3.5 Fish Communities, Recreational and Commercial Fishing

Potential Effects during Construction

The activities of the cutter suction dredge are likely to disturb fish using the entrance channel, but fish are able to avoid the dredger by swimming in other parts of the entrance channel.

The nearest oyster beds are approximately 1 km upstream of the proposed dredging area. As the turbidity of the water running off the dredged sand has been previously observed to be low, there are no detrimental impacts on oysters predicted.

Potential Long-term Effects

Pollard (1994a) considered the fish community of Lake Conjola to be one typical of an estuary with a permanently open entrance, despite the periods of closure the estuary experiences. The main feature of the fish community, in comparison to estuaries that are predominantly closed, was a greater diversity of species and the presence of some species that appear to require a permanent or almost permanent opening to the sea. As the aim of

the proposed works is to maintain open the estuary's connection to the sea, we predict that a long-term effect may be to increase fish species diversity in the lake compared to its present state.

However, a predicted increase in fish diversity does not necessarily translate to an increase in overall productivity for recreational or commercial fishers. Pollard (1994a) noted that lagoons with intermittent openings supported more valuable fisheries compared to Lake Conjola. This was largely due to the value of prawns, which in lagoons with intermittent openings are more easily harvested before they can return to the sea. Thus, we predict that the value of the finfish industries (recreational and commercial) may benefit from a permanent opening, but that the prawn fishery may not.

Keeping the entrance channel open is expected to increase tidal flushing in the estuary, which is likely to improve water quality overall. Improved water quality would be expected to benefit the commercial oyster industry by producing better quality oysters. The open entrance would also reduce the effects of flooding, which would also improve the quality of commercial oysters.

3.6 Impacts on Migratory Nesting Birds

Kevin Mills & Associates (2000) has detailed potential effects on bird species affected by the Stage 1 (Interim) works, including recommendations for mitigating impacts on threatened bird species. As the works proposed for the Entrance Management Plan involve the same suit of activities in the same locations, the analysis provided by Kevin Mills & Associates (2000) also applies for this REF. The most important method of mitigating impacts on nesting birds would be to avoid undertaking works in their breeding season, September to March.

Kevin Mills & Associates (2000) also considered the impact on birds (Pied Oystercatcher, Hooded Plover, Little Tern) of sand placement on the existing sand dunes. He noted that dunes are naturally dynamic habitats, but the proposed addition of sand would provide suitable nesting habitat for Little Terns if it were levelled and supplied with natural debris to hide nest sites and eggs. The provision of fencing to discourage access by people would provide a safe retreat which would encourage breeding.

Kevin Mills & Associates (2000) predicted that the deposition of sand on the sandflat was not likely to disrupt the life cycle of Pied Oystercatchers and Hooded Plovers, as alternate sites were available for feeding and, potentially, breeding for these species.

40 AMELIORATION OF IMPACTS

4.1 *Caulerpa taxifolia* infestation

- Alternative methodology for dredging should be considered should the algae be found near the channel to be dredged. For example, it may be possible to skim dredge the surface of the channel to remove (then treat) any *Caulerpa taxifolia* prior to commencing the main part of the dredging.

4.2 Benthic Communities Affected by Dredging

- Plan dredging for winter months to reduce the numbers of benthic animals affected. Such timing would correspond with mitigating the impacts on migrating nesting birds (above) and allow for spring recruitment of invertebrate larvae into the new habitat.
- Monitor run-off from dredging activity. If run-off water is turbid, consider placing silt curtains around dredge to reduce potential for spread of turbid water.

4.3 Migratory Nesting Birds

The recommendations for mitigating impacts on migratory nesting birds are the same as identified for the Stage 1 (Interim) study (Kevin Mills & Associates 2000). They included:

- Consultation with NPWS regarding the current breeding status of Little Terns,
- Avoiding undertaking the work between September and March when Little Terns and Hooded Plovers may be nesting,
- Minimising the area of sandflat disturbed by the bulldozer,
- Fencing off the newly placed sand on the dune to exclude people and make the nesting area more attractive to Little Terns,
- Providing natural debris such as seaweed, shells and timber across the top of the dune to encourage nesting,
- Limit the route of the bulldozer to the existing walkway route and traverse the route as few times as possible.

5.0 RECOMMENDATIONS FOR MONITORING

5.1 Long-Term effects on Fish Communities and Seagrass

- Monitoring of fish communities and seagrass health should be done to establish the long-term effects of the permanently-open entrance channel. Prior to dredging activities baseline conditions for seagrass health and fish community status should be determined using accepted, non-destructive survey methods. Methods for sampling fish should follow those outlined by ERI to allow for long-term comparisons of data sets. If possible, the monitoring should include surveys of fish and seagrass health in at least two other estuaries in the region in order to isolate coast-wide changes from those restricted to Lake Conjola.
- Data on commercial and recreational fishing should be compiled and reviewed every year after dredging to detect trends that may affect these industries.

5.2 *Caulerpa taxifolia* infestation

- Consultation with NSW Fisheries should be held prior to commencement of dredging and regularly during dredging to determine the status of infestation. Examine the area to be dredged to determine if *Caulerpa taxifolia* is present. Monitor sand being deposited on sand flat during dredging to ensure no invasive algae is being removed.

5.3 Benthic communities

- A background survey should be undertaken prior to the commencement of dredging. The survey should include sampling of benthos from the entrance channel, middle and upper regions in at least two time periods prior to commencement of works. Such monitoring would provide a baseline which can be used to determine if the recovered community is similar to the one that existed prior to dredging. Ideally, the survey would include sampling benthic communities from external reference estuaries such as Lake Burrill and/or Sussex Inlet to identify patterns of variations in community diversity and abundance that are attributable to large-scale phenomenon rather changes within Lake Conjola.

- Benthic communities of dredged areas in the entrance channel should be monitored to determine the time period required for the community to recover from dredging activities. A suitable design for the monitoring would include replicated sampling at regular time intervals after dredging for a period of at least two years after dredging.

5.4 Migrating Nesting Birds

- Consult with NPWS regarding the status of Little Tern populations in the area and, in particular to determine if the birds are breeding. Monitor and maintain wire fencing under direction of NPWS.
- The status of the bird's nesting grounds should be examined regularly during sand placement operations to ensure creation of flat-topped dune for breeding birds.

6.0 ACKNOWLEDGEMENTS

This report was written by Peggy O'Donnell and reviewed by Marcus Lincoln Smith.

7.0 REFERENCES

- Borowitzka, M. A. and Lethbridge, R. C. (1989). Seagrass epiphytes. In: *Biology of Seagrasses - A treatise on the biology of seagrasses with special reference to the Australian region*, Larkum, A. W. D.; McComb, A. J., and Shepherd, S. A., (eds). Elsevier Science Publishers, Amsterdam. pp. 458-499.
- Dexter, D.M (1984). Temporal and spatial variability in the community structure of the fauna of four sandy beaches in south-eastern New South Wales. *Australian Journal of Marine and Freshwater Ecology* **35**, 663-672.
- ERI: Environmental Research Institute (1999). *Fish in Shallow Waters of NSW South Coast Estuaries: 2nd Year Milestone Report*, FRDC project, 97/204. Prepared for FRDC. Environmental Research Institute, Wollongong.
- Finley, A. (1988). The environmental history and trophic status of Pattimores Lagoon, Lake Conjola. University of N.S.W, Canberra. 162pp.
- Gibbs, P. (1997). A review of information on NSW South Coast estuarine fisheries. NSW Fisheries Research Institute, Cronulla, NSW 2230.
- Grey, D. (2000/2001). Invasive weed prompts response actions. *Fisheries New South Wales, Spring 2000/Summer 2001*: 4-5.
- Henry, G. (1986). Creel surveys of recreational fishermen in the Conjola estuary. Internal Report to NSW Department of Agriculture and Fisheries. 14pp.
- Heycock, G. (1994). Lake Conjola Seagrasses. Report. B. App. Sc. University of Western Sydney – Hawkesbury.
- Jones, A. R. (1986). The Effects of Dredging and Spoil Disposal on Macrobenthos, Hawkesbury Estuary, N.S.W. *Marine Pollution Bulletin* **17**, pp. 17-20.
- Kevin Mills and Associates (2000). Ecological Assessment, Proposed Stage 1 (Interim) Works, Conjola Lake Entrance, City of Shoalhaven. Prepared for Shoalhaven City Council, February 2000.
- Lake Conjola Progress Association (1990). Report and recommendation arising from Lake Conjola Progress Association and Shoalhaven City Council Meeting to inspect siltation and pollution in and around Lake Conjola. July 10th 11pp.
- Newell, R.C., Seiderer, L.J. and Hitchcock, D.R.(1998). The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanography and Marine Biology Annual Review* **36**, 127-178.
- NSW Fisheries (1995). New South Wales Commercial Fisheries Statistics 1940 to 1992. B.C. Pease and A. Grinberg. NSW Fisheries Research Institute, Cronulla, NSW 2230.
- NSW Fisheries (1998). *1996/1997 Oyster Production Data from Oyster Farms in New South Wales*. NSW Fisheries, Sydney NSW.
- NSW Fisheries (1999). Status of Fisheries Resources 1997/1998. NSW Fisheries Research Institute, Cronulla, NSW 2230.
- NSW Fisheries (2000). Status of Fisheries Resources 1998/1999. NSW Fisheries Research Institute, Cronulla, NSW 2230.

- Patterson, Britton and Partners (1999). Lake Conjola Entrance Study: Technical Appendix 16: Ecological Assessment. Prepared for Shoalhaven City Council. Issue No. 2, May 1999.
- Pollard, D. A. (1994a). A comparison of fish assemblages and fisheries in intermittently open and permanently open coastal lagoons on the south coast of New South Wales, South-eastern Australia. *Estuaries* **17**, 631-646.
- Pollard, D.A. (1994b). Opening regimes and salinity characteristics of intermittently opening and permanently open coastal lagoons on the south coast of New South Wales. *Wetlands*, **13**: 16-35.
- Scribner, E.A., Kastl, A. and Rast, W. (1985). Water quality data for nine estuaries on the New South Wales Coast: September 1984 to May 1985. Fisheries Research Institute, NSW Department of Agriculture.
- Shoalhaven City Council (1999). Lake Conjola Entrance Stage 1 (Interim) Works. Review of Environmental Factors. Issue No. 1, November 1999.
- The Ecology Lab (1993). Lake Conjola Management Plan, Marine Biological Assessment. Stage 1. June, 1993.
- The Ecology Lab (1993b). Marine aggregate proposal: marine ecological investigations. Volume 1. Prepared for Metromix Pty Ltd.
- West, R.J., Thorogood, C.A., Walford, T.R. and Williams, R.J. (1985). An estuarine inventory of New South Wales, Australia. Fisheries Bulletin No. 2, NSW Department of Agriculture, Sydney.

TABLES

Table 1: List of fish, birds, amphibians, mammals, reptiles and plants likely to occur within the vicinity Lake Conjola protected under the EPBC Act (1999). The list includes species classed as threatened ecological communities, threatened species, marine protected species and migratory species.

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Table 1. List of fish, birds, amphibians, mammals, reptiles and plants likely to occur within the vicinity Lake Conjola protected under the EPBC Act (1999). The list includes species classed as threatened ecological communities, threatened species, marine protected species and migratory species.

	Scientific Name	Common Name	Legal Status
Threatened Species			
Amphibia	Heleioporus australiacus	Giant Burrowing Frog	Vulnerable
	Litoria aurea	Green and Golden Bell Frog	Vulnerable
Aves	Diomedea amsterdamensis	Amsterdam Albatross	Endangered
	Diomedea antipodensis	Antipodean Albatross	Vulnerable
	Diomedea dabbenena	Tristan Albatross	Endangered
	Diomedea exulans	Wandering Albatross	Vulnerable
	Diomedea gibsoni	Gibson's Albatross	Vulnerable
	Lathamus discolor	Swift Parrot	Endangered
	Macronectes giganteus	Southern Giant-Petrel	Endangered
	Macronectes halli	Northern Giant-Petrel	Vulnerable
	Pterodroma neglecta neglecta	Kermadec Petrel (western)	Vulnerable
	Thalassarche bulleri	Buller's Albatross	Vulnerable
	Thalassarche cauta	Shy Albatross	Vulnerable
	Thalassarche chrysostoma	Grey-headed Albatross	Vulnerable
	Thalassarche impavida	Campbell Albatross	Vulnerable
	Thalassarche salvini	Salvin's Albatross	Vulnerable
	Thalassarche steadi	White-capped Albatross	Vulnerable
	Xanthomyza phrygia	Regent Honeyeater	Endangered
Chondrichthyes	Carcharias taurus	Grey Nurse Shark	Vulnerable
	Carcharodon carcharias	Great White Shark	Vulnerable
Mammalia	Balaenoptera borealis	Sei Whale	Vulnerable
	Balaenoptera musculus	Blue Whale	Endangered
	Balaenoptera physalus	Fin Whale	Vulnerable
	Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	Vulnerable
	Dasyurus maculatus maculatus	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll	Vulnerable
	Eubalaena australis	Southern Right Whale	Endangered
	Isodon obesulus obesulus	Southern Brown Bandicoot	Endangered
	Megaptera novaeangliae	Humpback Whale	Vulnerable
Potorous tridactylus tridactylus	Long-nosed Potoroo (SE mainland)	Vulnerable	
Osteichthyes	Prototroctes maraena	Australian Grayling	Vulnerable
Plant	Caladenia tessellata	Thick-lipped Spider-orchid, Daddy Long-legs	Vulnerable
	Cryptostylis hunteriana	Leafless Tongue-orchid	Vulnerable
	Thesium australe	Austral Toadflax, Toadflax	Vulnerable
Reptilia	Dermodochelys coriacea	Leathery Turtle, Luth	Vulnerable

Marine birds covered by migratory provisions of the EPBC Act, 1999

Aves	Diomedea amsterdamensis	Amsterdam Albatross
	Diomedea antipodensis	Antipodean Albatross
	Diomedea dabbenena	Tristan Albatross
	Diomedea exulans	Wandering Albatross
	Diomedea gibsoni	Gibson's Albatross
	Macronectes giganteus	Southern Giant-Petrel
	Macronectes halli	Northern Giant-Petrel
	Thalassarche bulleri	Buller's Albatross
	Thalassarche cauta	Shy Albatross

Table 1. List of fish, birds, amphibians, mammals, reptiles and plants likely to occur within the vicinity Lake Conjola protected under the EPBC Act (1999). The list includes species classed as threatened ecological communities, threatened species, marine protected species and migratory species.

	Scientific Name	Common Name	Legal Status
	<i>Thalassarche chrysostoma</i>	Grey-headed Albatross	
	<i>Thalassarche impavida</i>	Campbell Albatross	
	<i>Thalassarche melanophris</i>	Black-browed Albatross	
	<i>Thalassarche salvini</i>	Salvin's Albatross	
	<i>Thalassarche steadi</i>	White-capped Albatross	
Marine species covered by migratory provisions of the EPBC Act, 1999			
Chondrichthyes	<i>Rhincodon typus</i>	Whale Shark	
Mammalia	<i>Balaenoptera musculus</i>	Blue Whale	
	<i>Eubalaena australis</i>	Southern Right Whale	
	<i>Megaptera novaeangliae</i>	Humpback Whale	
Reptilia	<i>Dermodochelys coriacea</i>	Leathery Turtle, Luth	
Terrestrial species covered by migratory provisions of the EPBC Act, 1999			
Aves	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	
	<i>Hirundapus caudacutus</i>	White-throated Needletail	
	<i>Monarcha melanopsis</i>	Black-faced Monarch	
	<i>Myiagra cyanoleuca</i>	Satin Flycatcher	
	<i>Rhipidura rufifrons</i>	Rufous Fantail	
	<i>Xanthomyza phrygia</i>	Regent Honeyeater	
Wetland species covered by migratory provisions of the EPBC Act, 1999			
Aves	<i>Gallinago hardwickii</i>	Latham's Snipe, Japanese Snipe	
	<i>Rostratula benghalensis</i>	Painted Snipe	
	<i>Thinornis rubricollis rubricollis</i>	Hooded Plover (eastern)	
Species covered by marine provisions of the EPBC Act, 1999			
Aves	<i>Catharacta skua</i>	Great Skua	Listed
	<i>Diomedea amsterdamensis</i>	Amsterdam Albatross	Listed
	<i>Diomedea antipodensis</i>	Antipodean Albatross	Listed
	<i>Diomedea dabbenena</i>	Tristan Albatross	Listed
	<i>Diomedea exulans</i>	Wandering Albatross	Listed
	<i>Diomedea gibsoni</i>	Gibson's Albatross	Listed
	<i>Gallinago hardwickii</i>	Latham's Snipe, Japanese Snipe	Listed
	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	Listed
	<i>Hirundapus caudacutus</i>	White-throated Needletail	Listed
	<i>Lathamus discolor</i>	Swift Parrot	*
	<i>Macronectes giganteus</i>	Southern Giant-Petrel	Listed
	<i>Macronectes halli</i>	Northern Giant-Petrel	Listed
	<i>Monarcha melanopsis</i>	Black-faced Monarch	Listed
	<i>Myiagra cyanoleuca</i>	Satin Flycatcher	Listed
	<i>Rhipidura rufifrons</i>	Rufous Fantail	Listed
	<i>Rostratula benghalensis</i>	Painted Snipe	Listed
	<i>Thalassarche bulleri</i>	Buller's Albatross	Listed
	<i>Thalassarche cauta</i>	Shy Albatross	Listed
	<i>Thalassarche chlororhynchos</i>	Yellow-nosed Albatross, Atlantic Yellow	Listed
	<i>Thalassarche chrysostoma</i>	Grey-headed Albatross	Listed
	<i>Thalassarche impavida</i>	Campbell Albatross	Listed

Table 1. List of fish, birds, amphibians, mammals, reptiles and plants likely to occur within the vicinity Lake Conjola protected under the EPBC Act (1999). The list includes species classed as threatened ecological communities, threatened species, marine protected species and migratory species.

	Scientific Name	Common Name	Legal Status
	<i>Thalassarche melanophris</i>	Black-browed Albatross	Listed
	<i>Thalassarche salvini</i>	Salvin's Albatross	Listed
	<i>Thalassarche steadi</i>	White-capped Albatross	Listed
Osteichthyes	<i>Acentronura tentaculata</i>	Pipehorse	Listed
	<i>Cosmocampus howensis</i>	-	Listed
	<i>Heraldia nocturna</i>	-	Listed
	<i>Hippocampus abdominalis</i>	Eastern Potbelly Seahorse	Listed
	<i>Hippocampus breviceps</i>	Short-head Seahorse	Listed
	<i>Hippocampus whitei</i>	Crowned Seahorse	Listed
	<i>Histiogamphelus briggsii</i>	Briggs' Pipefish	Listed
	<i>Kimblaeus bassensis</i>	Trawl Pipefish	Listed
	<i>Lissocampus runa</i>	Javelin Pipefish	Listed
	<i>Maroubra perserrata</i>	Sawtooth Pipefish	Listed
	<i>Notiocampus ruber</i>	Red Pipefish	Listed
	<i>Phyllopteryx taeniolatus</i>	Weedy Seadragon, Common Seadragon	Listed
	<i>Solegnathus spinosissimus</i>	Spiny Pipehorse	Listed
	<i>Solenostomus cyanopterus</i>	Blue-finned Ghost Pipefish	Listed
	<i>Stigmatopora argus</i>	Spotted Pipefish	Listed
	<i>Stigmatopora nigra</i>	Black Pipefish	Listed
	<i>Syngnathoides biaculeatus</i>	Alligator Pipefish	Listed
	<i>Urocampus carinirostris</i>	Hairy Pipefish	Listed
	<i>Vanacampus margaritifer</i>	Mother-of-pearl Pipefish	Listed
	<i>Vanacampus phillipi</i>	Port Phillip Pipefish	Listed
Reptilia	<i>Dermodochelys coriacea</i>	Leathery Turtle, Luth	Listed

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Class	Family	Scientific Name	Common Name	Legal Status	Count		
Amphibia	Hylidae	<i>Litoria aurea</i>	Green and Golden Bell Frog	E1	9		
		<i>Litoria citropa</i>	Blue Mountains Tree Frog	P	1		
		<i>Litoria dentata</i>	Bleating Tree Frog	P	16		
		<i>Litoria freycineti</i>	Freycinet's Frog	P	2		
		<i>Litoria jervisiensis</i>	Jervis Bay Tree Frog	P	3		
		<i>Litoria lesueuri</i>	Lesueur's Frog	P	1		
		<i>Litoria peronii</i>	Peron's Tree Frog	P	5		
		<i>Litoria phyllochroa</i>	Leaf Green Tree Frog	P	3		
		Myobatrachidae	<i>Crinia signifera</i>	Common Eastern Froglet	P	115	
			<i>Limnodynastes dumerilii</i>	Eastern Banjo Frog	P	2	
			<i>Limnodynastes peronii</i>	Brown-striped Frog	P	5	
			<i>Paracrinia haswelli</i>	Haswell's Frog	P	6	
			<i>Pseudophryne bibronii</i>	Brown Toadlet	P	4	
			<i>Uperoleia laevigata</i>	Smooth Toadlet	P	1	
			<i>Uperoleia tyleri</i>	Tyler's Toadlet	P	1	
		Aves	Accipitridae	<i>Accipiter cirrhocephalus</i>	Collared Sparrowhawk	P	1
				<i>Accipiter fasciatus</i>	Brown Goshawk	P	4
<i>Accipiter novaehollandiae</i>	Grey Goshawk			P	5		
<i>Aquila audax</i>	Wedge-tailed Eagle			P	24		
<i>Circus approximans</i>	Swamp Harrier			P	2		
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle			P	32		
<i>Haliastur sphenurus</i>	Whistling Kite			P	5		
<i>Hieraaetus morphnoides</i>	Little Eagle			P	4		
<i>Pandion haliaetus</i>	Osprey			V	2		
Aegothelidae	<i>Aegotheles cristatus</i>			Australian Owlet-nightjar	P	9	
Alcedinidae	<i>Alcedo azurea</i>			Azure Kingfisher	P	24	
Anatidae	<i>Anas castanea</i>			Chestnut Teal	P	10	
	<i>Anas gracilis</i>			Grey Teal	P	2	
	<i>Anas platyrhynchos</i>		Mallard	U	1		
	<i>Anas superciliosa</i>		Pacific Black Duck	P	4		
	<i>Chenonetta jubata</i>		Australian Wood Duck	P	11		
	<i>Cygnus atratus</i>		Black Swan	P	5		
	Anhinga		<i>Anhinga melanogaster</i>	Darter	P	7	
Apodidae	<i>Apus pacificus</i>		Fork-tailed Swift	P	2		
	<i>Hirundapus caudacutus</i>		White-throated Needletail	P	13		
Ardeidae	<i>Ardea alba</i>		Great Egret	P	1		
	<i>Ardea intermedia</i>		Intermediate Egret	P	1		
	<i>Ardea pacifica</i>		White-necked Heron	P	1		
	<i>Butorides striatus</i>		Striated Heron	P	1		
	<i>Egretta garzetta</i>		Little Egret	P	3		
	<i>Egretta novaehollandiae</i>		White-faced Heron	P	28		
	<i>Egretta sacra</i>		Eastern Reef Egret	P	2		
	<i>Nycticorax caledonicus</i>	Nankeen Night Heron	P	1			
Artamidae	<i>Artamus cyanopterus</i>	Dusky Woodswallow	P	2			
	<i>Artamus superciliosus</i>	White-browed Woodswallow	P	2			
	<i>Cracticus torquatus</i>	Grey Butcherbird	P	36			
	<i>Gymnorhina tibicen</i>	Australian Magpie	P	37			
	<i>Strepera graculina</i>	Pied Currawong	P	45			
Cacatuidae	<i>Strepera versicolor</i>	Grey Currawong	P	3			
	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	P	1			
	<i>Cacatua roseicapilla</i>	Galah	P	24			
	<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	P	39			
	<i>Calyptorhynchus funereus</i>	Yellow-tailed Black-Cockat	P	60			
	<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V	58			
Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	P	21			

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Class	Family	Scientific Name	Common Name	Legal Status	Count
		<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike	P	2
		<i>Coracina tenuirostris</i>	Cicadabird	P	1
	Caprimulgidae	<i>Eurostopodus mystacalis</i>	White-throated Nightjar	P	4
	Charadriidae	<i>Charadrius bicinctus</i>	Double-banded Plover	P	3
		<i>Charadrius ruficapillus</i>	Red-capped Plover	P	3
		<i>Elseynornis melanops</i>	Black-fronted Dotterel	P	2
		<i>Erythronyctes alba</i>	Red-kneed Dotterel	P	2
		<i>Thinornis rubricollis</i>	Hooded Plover	E1	19
		<i>Vanellus miles</i>	Masked Lapwing	P	20
	Cinlosomatidae	<i>Cinlosoma punctatum</i>	Spotted Quail-thrush	P	4
		<i>Psophodes olivaceus</i>	Eastern Whipbird	P	40
	Climacteridae	<i>Climacteris erythroga</i>	Red-browed Treecreeper	P	8
		<i>Climacteris picumnus</i>	Brown Treecreeper	P	1
		<i>Cormobates leucophaea</i>	White-throated Treecreeper	P	45
	Columbidae	<i>Chalcophaps indica</i>	Emerald Dove	P	2
		<i>Columba leucomela</i>	White-headed Pigeon	P	2
		<i>Columba livia</i>	Rock Dove	U	1
		<i>Leucosarcia melanoleuca</i>	Wonga Pigeon	P	23
		<i>Lopholaimus antarcticus</i>	Topknot Pigeon	P	2
		<i>Macropygia amboinensis</i>	Brown Cuckoo-Dove	P	8
		<i>Ocyphaps lophotes</i>	Crested Pigeon	P	3
		<i>Phaps chalcoptera</i>	Common Bronzewing	P	2
		<i>Phaps elegans</i>	Brush Bronzewing	P	10
		<i>Ptilinopus superbus</i>	Superb Fruit-Dove	V	2
		<i>Streptopelia chinensis</i>	Spotted Turtle-Dove	U	6
	Coraciidae	<i>Eurystomus orientalis</i>	Dollarbird	P	9
	Corcoracidae	<i>Corcorax melanorhamphos</i>	White-winged Chough	P	1
	Corvidae	<i>Corvus coronoides</i>	Australian Raven	P	43
		<i>Corvus melleri</i>	Little Raven	P	3
	Cuculidae	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	P	19
		<i>Cacomantis variolosus</i>	Brush Cuckoo	P	12
		<i>Chrysococcyx basalis</i>	Horsfield's Bronze-Cuckoo	P	1
		<i>Cuculus pallidus</i>	Pallid Cuckoo	P	2
		<i>Eudynamis scolopacea</i>	Common Koel	P	4
		<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	P	10
	Dicaeidae	<i>Dicaeum hirundinaceum</i>	Mistletoebird	P	8
	Dicruridae	<i>Grallina cyanoleuca</i>	Magpie-lark	P	8
		<i>Monarcha melanopsis</i>	Black-faced Monarch	P	14
		<i>Myiagra cyanoleuca</i>	Satin Flycatcher	P	4
		<i>Myiagra inquieta</i>	Restless Flycatcher	P	1
		<i>Myiagra rubecula</i>	Leadend Flycatcher	P	10
		<i>Rhipidura fuliginosa</i>	Grey Fantail	P	56
		<i>Rhipidura leucophrys</i>	Willie Wagtail	P	6
		<i>Rhipidura rufifrons</i>	Rufous Fantail	P	17
	Diomedeidae	<i>Diomedea cauta</i>	Shy Albatross	V	2
		<i>Diomedea melanophrys</i>	Black-browed Albatross	V	1
	Falconidae	<i>Falco berigora</i>	Brown Falcon	P	1
		<i>Falco cenchroides</i>	Nankeen Kestrel	P	6
		<i>Falco longipennis</i>	Australian Hobby	P	2
		<i>Falco peregrinus</i>	Peregrine Falcon	P	1
	Haematopodidae	<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V	23
		<i>Haematopus longirostris</i>	Pied Oystercatcher	V	27
	Halcyonidae	<i>Dacelo novaeguineae</i>	Laughing Kookaburra	P	39
		<i>Todiramphus sanctus</i>	Sacred Kingfisher	P	15
	Hirundinidae	<i>Hirundo neoxena</i>	Welcome Swallow	P	9

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Class	Family	Scientific Name	Common Name	Legal Status	Count
		<i>Hirundo nigricans</i>	Tree Martin	P	4
	Hydrobatidae	<i>Pelagodroma marina</i>	White-faced Storm-Petrel	P	1
	Laridae	<i>Chlidonias hybridus</i>	Whiskered Tern	P	2
		<i>Larus dominicanus</i>	Kelp Gull	P	1
		<i>Larus novaehollandiae</i>	Silver Gull	P	15
		<i>Larus pacificus</i>	Pacific Gull	P	1
		<i>Stercorarius parasiticus</i>	Arctic Jaeger	P	1
		<i>Sterna albifrons</i>	Little Tern	E1	13
		<i>Sterna bergii</i>	Crested Tern	P	12
		<i>Sterna caspia</i>	Caspian Tern	P	2
		<i>Sterna fuscata</i>	Sooty Tern	V	1
	Maluridae	<i>Malurus cyaneus</i>	Superb Fairy-wren	P	43
		<i>Malurus lamberti</i>	Variiegated Fairy-wren	P	32
		<i>Stipiturus malachurus</i>	Southern Emu-wren	P	8
	Meliphagidae	<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill	P	54
		<i>Anthochaera carunculata</i>	Red Wattlebird	P	20
		<i>Anthochaera chrysoptera</i>	Little Wattlebird	P	26
		<i>Epthianura albifrons</i>	White-fronted Chat	P	1
		<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater	P	46
		<i>Lichenostomus leucotis</i>	White-eared Honeyeater	P	5
		<i>Lichenostomus melanops</i>	Yellow-tufted Honeyeater	P	1
		<i>Lichmera indistincta</i>	Brown Honeyeater	P	1
		<i>Meliphaga lewinii</i>	Lewin's Honeyeater	P	34
		<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater	P	4
		<i>Melithreptus lunatus</i>	White-naped Honeyeater	P	8
		<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater	P	7
		<i>Philemon corniculatus</i>	Noisy Friarbird	P	42
		<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	P	5
		<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	P	37
		<i>Phylidonyris pyrrhoptera</i>	Crescent Honeyeater	P	5
		<i>Xanthomyza phrygia</i>	Regent Honeyeater	E1	6
	Menuridae	<i>Menura novaehollandiae</i>	Superb Lyrebird	P	28
	Motacillidae	<i>Anthus novaeseelandiae</i>	Richard's Pipit	P	1
	Muscicapidae	<i>Zoothera dauma</i>	Unidentified Ground Thr	P	2
		<i>Zoothera lunulata</i>	Bassian Thrush	P	20
	Neosittidae	<i>Daphoenositta chrysoptera</i>	Varied Sittella	P	8
	Oriolidae	<i>Oriolus sagittatus</i>	Olive-backed Oriole	P	15
	Pachycephalidae	<i>Colluricincla harmonica</i>	Grey Shrike-thrush	P	44
		<i>Falcunculus frontatus</i>	Crested Shrike-tit	P	12
		<i>Pachycephala pectoralis</i>	Golden Whistler	P	34
		<i>Pachycephala rufiventris</i>	Rufous Whistler	P	21
	Pardalotidae	<i>Acanthiza lineata</i>	Striated Thornbill	P	38
		<i>Acanthiza nana</i>	Yellow Thornbill	P	5
		<i>Acanthiza pusilla</i>	Brown Thornbill	P	57
		<i>Acanthiza reguloides</i>	Buff-rumped Thornbill	P	2
		<i>Calamanthus fuliginosus</i>	Striated Fieldwren	V	9
		<i>Dasyornis brachypterus</i>	Eastern Bristlebird	E1	4
		<i>Gerygone mouki</i>	Brown Gerygone	P	6
		<i>Hylacola pyrrhopygia</i>	Chestnut-rumped Heathwr	P	1
		<i>Origma solitaria</i>	Rockwarbler	P	2
		<i>Pardalotus punctatus</i>	Spotted Pardalote	P	30
		<i>Pardalotus striatus</i>	Striated Pardalote	P	7
		<i>Pycnoptilus floccosus</i>	Pilotbird	P	2
		<i>Sericornis frontalis</i>	White-browed Scrubwren	P	42
		<i>Sericornis magnirostris</i>	Large-billed Scrubwren	P	1

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Class	Family	Scientific Name	Common Name	Legal Status	Count
		<i>Smicrornis brevirostris</i>	Weebill	P	2
	Passeridae	<i>Neochmia temporalis</i>	Red-browed Finch	P	26
		<i>Passer domesticus</i>	House Sparrow	U	1
		<i>Stagonopleura bella</i>	Beautiful Firetail	P	4
	Pelecanidae	<i>Pelecanus conspicillatus</i>	Australian Pelican	P	19
	Petroicidae	<i>Eopsaltria australis</i>	Eastern Yellow Robin	P	46
		<i>Microeca fascinans</i>	Jacky Winter	P	6
		<i>Petroica multicolor</i>	Scarlet Robin	P	1
		<i>Petroica phoenicea</i>	Flame Robin	P	4
		<i>Petroica rodinogaster</i>	Pink Robin	V	4
		<i>Petroica rosea</i>	Rose Robin	P	21
	Phaethontidae	<i>Phaethon lepturus</i>	White-tailed Tropicbird	P	1
	Phalacrocoracidae	<i>Phalacrocorax carbo</i>	Great Cormorant	P	13
		<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant	P	21
		<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant	P	13
		<i>Phalacrocorax varius</i>	Pied Cormorant	P	9
	Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth	P	2
	Procellariidae	<i>Daption capense</i>	Cape Petrel	P	1
		<i>Macronectes giganteus</i>	Southern Giant-Petrel	P	1
		<i>Macronectes halli</i>	Northern Giant-Petrel	P	1
		<i>Pachyptila turtur</i>	Fairy Prion	P	1
		<i>Puffinus gavia</i>	Fluttering Shearwater	P	1
		<i>Puffinus tenuirostris</i>	Short-tailed Shearwater	P	12
	Psittacidae	<i>Alisterus scapularis</i>	Australian King-Parrot	P	32
		<i>Glossopsitta concinna</i>	Musk Lorikeet	P	10
		<i>Glossopsitta pusilla</i>	Little Lorikeet	P	8
		<i>Pezoporus wallicus</i>	Ground Parrot	V	9
		<i>Platycercus elegans</i>	Crimson Rosella	P	61
		<i>Platycercus eximius</i>	Eastern Rosella	P	7
		<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	P	19
	Ptilonorhynchidae	<i>Ailuroedus crassirostris</i>	Green Catbird	P	18
		<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird	P	31
	Recurvirostridae	<i>Himantopus himantopus</i>	Black-winged Stilt	P	1
	Scolopacidae	<i>Arenaria interpres</i>	Ruddy Turnstone	P	1
		<i>Calidris melanotos</i>	Pectoral Sandpiper	P	1
		<i>Limosa lapponica</i>	Bar-tailed Godwit	P	1
		<i>Numenius madagascariensis</i>	Eastern Curlew	P	3
		<i>Numenius phaeopus</i>	Whimbrel	P	2
	Strigidae	<i>Ninox novaeseelandiae</i>	Southern Boobook	P	31
		<i>Ninox strenua</i>	Powerful Owl	V	36
	Sturnidae	<i>Acridotheres tristis</i>	Common Myna	U	4
		<i>Sturnus vulgaris</i>	Common Starling	U	4
	Sulidae	<i>Morus serrator</i>	Australasian Gannet	P	6
	Sylviidae	<i>Cinclorhamphus mathewsi</i>	Rufous Songlark	P	1
	Threskiornithidae	<i>Threskiornis molucca</i>	Australian White Ibis	P	3
	Turnicidae	<i>Turnix varia</i>	Painted Button-quail	P	1
	Tytonidae	<i>Tyto novaehollandiae</i>	Masked Owl	V	7
		<i>Tyto tenebricosa</i>	Sooty Owl	V	18
	Zosteropidae	<i>Zosterops lateralis</i>	Silvereye	P	36
Mammalia	Balaenidae	<i>Eubalaena australis</i>	Southern Right Whale	V	2
	Balaenopteridae	<i>Megaptera novaeangliae</i>	Humpback Whale	V	1
	Burramyidae	<i>Acrobates pygmaeus</i>	Foothill Glider	P	1
		<i>Cercartetus nanus</i>	Eastern Pygmy-possum	P	6
	Canidae	<i>Canis familiaris</i>	Dingo and Dog (feral)	U	7
		<i>Vulpes vulpes</i>	Fox	U	15

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Class	Family	Scientific Name	Common Name	Legal Status	Count
	Dasyuridae	<i>Antechinus agilis</i>	Agile Antechinus	P	1
		<i>Antechinus flavipes</i>	Yellow-footed Antechinus	P	2
		<i>Antechinus stuartii</i>	Brown Antechinus	P	37
		<i>Antechinus swainsonii</i>	Dusky Antechinus	P	18
		<i>Sminthopsis leucopus</i>	White-footed Dunnart	V	1
	Delphinidae	<i>Delphinus delphis</i>	Common Dolphin	P	2
		<i>Dolphin sp.</i>	Unidentified Dolphin	P	2
		<i>Globicephala melas</i>	Long-finned Pilot Whale	P	1
		<i>Lissodelphis peronii</i>	Southern Right Whale Dolp	P	1
		<i>Orcinus orca</i>	Killer Whale	P	1
		<i>Tursiops truncatus</i>	Bottlenose Dolphin	P	1
	Leporidae	<i>Oryctolagus cuniculus</i>	Rabbit	U	1
	Macropodidae	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	P	31
		<i>Macropus rufogriseus</i>	Red-necked Wallaby	P	23
		<i>Wallabia bicolor</i>	Swamp Wallaby	P	32
	Molossidae	<i>Mormopterus loriae</i>	Little Freetail Bat	P	2
		<i>Mormopterus sp</i>	mastiff-bat	P	1
		<i>Nyctinomus australis</i>	White-striped Mastiff-bat	P	1
	Muridae	<i>Mus musculus</i>	House Mouse	U	1
		<i>Rattus fuscipes</i>	Bush Rat	P	75
		<i>Rattus lutreolus</i>	Swamp Rat	P	2
		<i>Rattus rattus</i>	Black Rat	U	1
	Otariidae	<i>Arctocephalus pusillus</i>	Australian Fur-seal	P	1
		<i>Arctocephalus sp.</i>	Unidentified Fur-seal	P	8
		<i>Seal sp.</i>	Unidentified Seal	P	2
	Peramelidae	<i>Isodon obesulus</i>	Southern Brown Bandicoot	E1	1
		<i>Perameles nasuta</i>	Long-nosed Bandicoot	P	28
	Petauridae	<i>Petauroides volans</i>	Greater Glider	P	28
		<i>Petaurus australis</i>	Yellow-bellied Glider	V	26
		<i>Petaurus breviceps</i>	Sugar Glider	P	37
		<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum	P	12
	Phalangeridae	<i>Trichosurus sp.</i>	brushtail possum	P	1
		<i>Trichosurus vulpecula</i>	Common Brushtail Possum	P	13
	Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	V	1
	Phocidae	<i>Hydrurga leptonyx</i>	Leopard Seal	P	3
	Physeteridae	<i>Physeter macrocephalus</i>	Sperm Whale	V	1
	Potoroidae	<i>Potorous tridactylus</i>	Long-nosed Potoroo	V	18
	Pteropodidae	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	P	3
		<i>Pteropus scapulatus</i>	Little Red Flying-fox	P	1
	Rhinolophidae	<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe-bat	P	1
	Tachyglossidae	<i>Tachyglossus aculeatus</i>	Short-beaked Echidna	P	7
	Vespertilionidae	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	P	5
		<i>Chalinolobus morio</i>	Chocolate Wattled Bat	P	45
		<i>Miniopterus schreibersii</i>	Common Bent-wing Bat	V	3
		<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	P	18
		<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat	P	19
		<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	1
		<i>Scotorepens orion</i>	Eastern Broad-nosed Bat	P	5
		<i>Vespadelus darlingtoni</i>	Large Forest Bat	P	13
		<i>Vespadelus vulturnus</i>	Little Forest Bat	P	89
	Vombatidae	<i>Vombatus ursinus</i>	Common Wombat	P	27
	Ziphiidae	<i>Hyperoodon planifrons</i>	Southern Bottle-nosed Wha	P	1
Reptilia	Agamidae	<i>Amphibolurus muricatus</i>	Jacky Lizard	P	31
		<i>Physignathus lesueurii howi</i>	Gippsland Water Dragon	P	6
		<i>Tympanocryptis diemensis</i>	Mountain Dragon	P	19

Table 2. List of birds, amphibians, mammals and reptiles observed within approximately 10 km of Lake Conjola (NSW NPWS Wildlife Atlas) and their protected status under the TSC Act (1995). E1 = Endangered, V= Vulnerable, I = Introduced, P = Protected (NSW Wildlife Act, 1974), U = Unprotected. (nb: These data are only indicative and cannot be considered a comprehensive inventory, and may contain errors). Vulnerable and endangered species have been shaded.

Class	Family	Scientific Name	Common Name	Legal Status	Count
	Elapidae	<i>Drysdalia rhodogaster</i>		P	1
		<i>Notechis scutatus</i>	Eastern Tiger Snake	P	4
		<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake	P	23
		<i>Pseudonaja textilis</i>	Eastern Brown Snake	P	2
		<i>Rhinoplocephalus nigrescens</i>	Eastern Small-eyed Snake	P	2
	Pygopodidae	<i>Pygopus lepidopodus</i>	Common Scaly-foot	P	4
	Scincidae	<i>Bassiana platynota</i>	Red-throated Skink	P	1
		<i>Cryptoblepharus virgatus</i>	Wall Lizard	P	2
		<i>Ctenotus taeniolatus</i>	Copper-tailed Skink	P	8
		<i>Cyclodomorphus casuarinae</i>	She-oak Skink	P	1
		<i>Eulamprus heatwolei</i>		P	5
		<i>Eulamprus quoyii</i>	Eastern Water Skink	P	27
		<i>Lampropholis delicata</i>	Grass Skink	P	52
		<i>Lampropholis guichenoti</i>	Garden Skink	P	18
		<i>Saproscincus mustelinus</i>	Weasel Skink	P	3
		<i>Tiliqua scincoides</i>	Eastern Blue-tongued Lizard	P	4
	Varanidae	<i>Varanus rosenbergi</i>	Heath Monitor	V	1
		<i>Varanus varius</i>	Lace Monitor	P	4

FIGURES

Figure 1: Seagrass distribution in Lake Conjola reproduced from West *et al*, 1985

Figure 2: Restricted areas for commercial fishing and oyster leases in Lake Conjola.

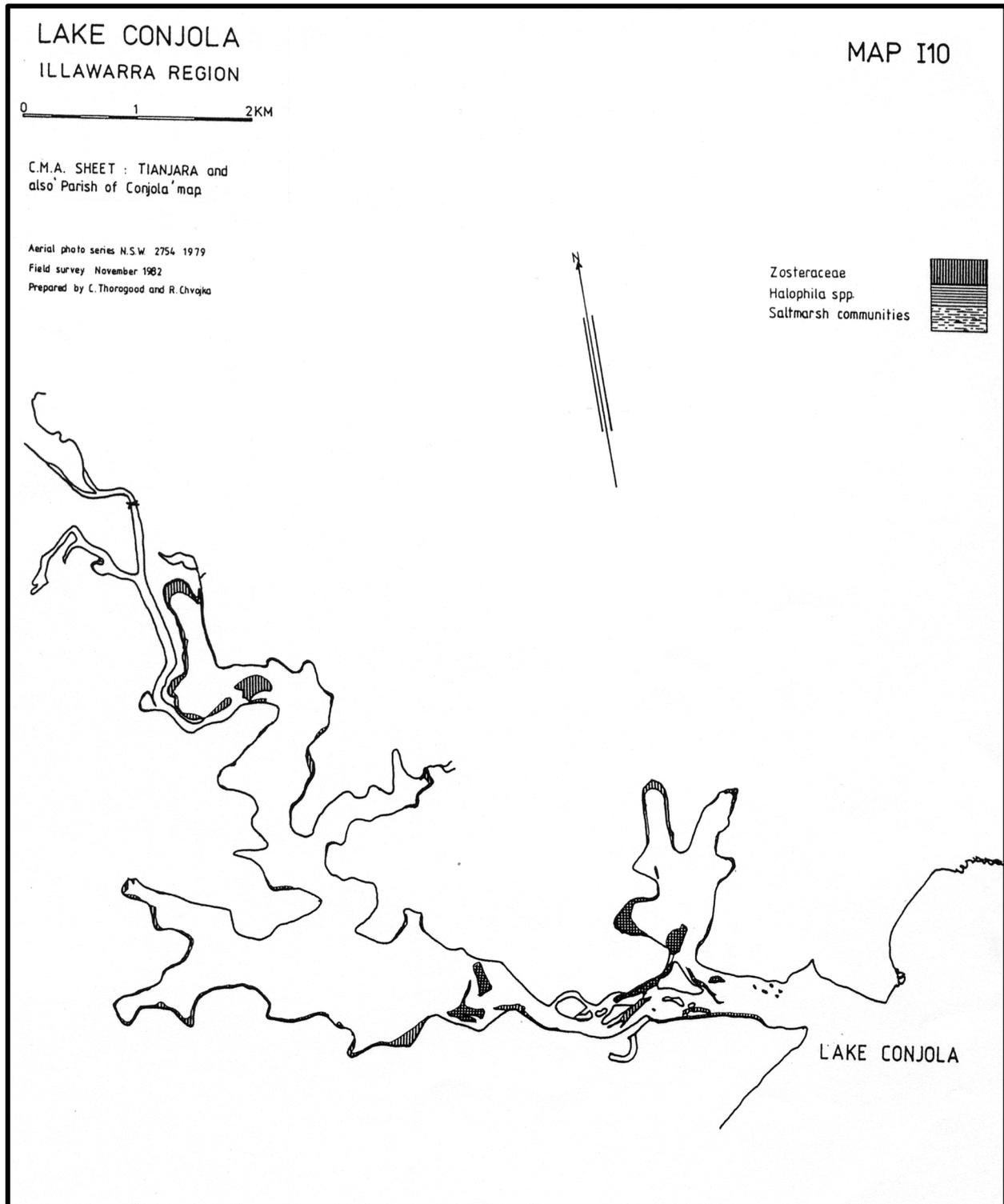


Figure 1: Seagrass distribution in Lake Conjola reproduced from West *et al.*, 1985.

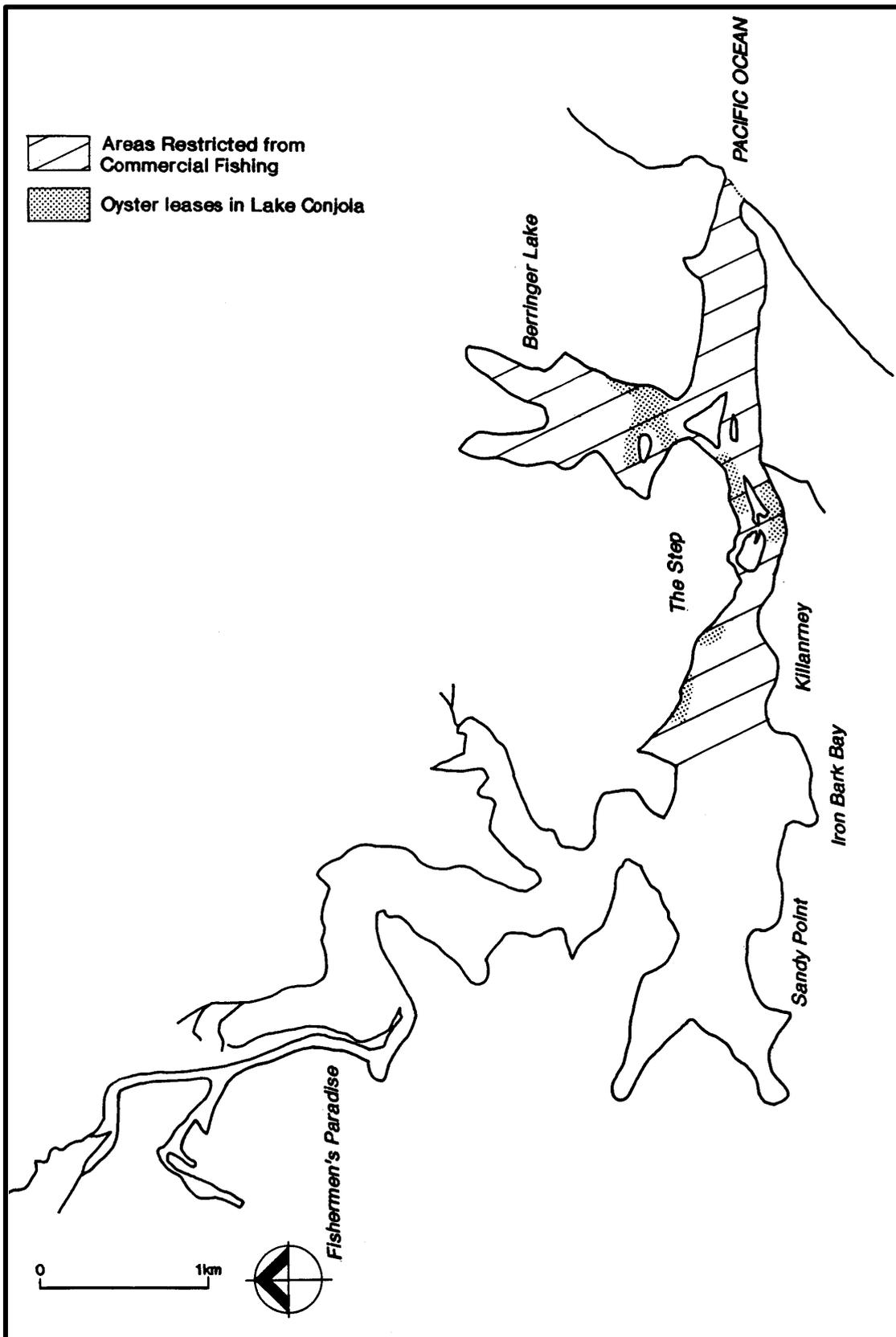


Figure 2: Restricted areas for commercial fishing and oyster leases in Lake Conjola.