Lake Curalo

Estuary Management Study and Plan

Final

April 2002

Summary

The Estuary Management Plan for Lake Curalo was prepared under the direction of the Lake Curalo Estuary Management Committee (the EMC has since been incorporated in the Eden Foreshore Committee) and was jointly funded by Bega Valley Shire Council (BVSC) and the Department of Land and Water Conservation (DLWC), under the State Government's Estuary Management Program.

The Management Plan was developed from existing background information; including investigations carried out as part of the preceding Estuary Processes Study (ESE et al 2001) and through community and stakeholder consultation.

This document was prepared by Nelson Consulting and Lawson & Treloar (L&T), with input from Environmental Science and Engineering (ESE), The Ecology Lab (TEL) and Coastal and Marine Geosciences (CMG).

The Plan is the application of the State Government's *Estuary Management Policy* to Lake Curalo. The general goal of this policy is to achieve an integrated, balanced, responsible and ecologically sustainable use of the State's estuaries.

THE SPECIFIC GOALS FOR THE MANAGEMENT OF LAKE CURALO ARE TO:

- IMPROVE WATER QUALITY WITHIN LAKE CURALO AND ITS TRIBUTARIES;
- ENSURE ENTRANCE OPENING FOLLOWS AS NATURAL A REGIME AS POSSIBLE WITHIN THE CONTRAINTS OF PROPERTY INUNDATION, FLOODING, WATER QUALITY AND ODOUR PROBLEMS;
- PROTECT AND CONSERVE AQUATIC HABITATS, FAUNA AND FORESHORE VEGETATION;
- INCREASE OPPORTUNITIES FOR LOW-IMPACT RECREATIONAL USE OF THE LAKE AND FORESHORES; AND
- ENSURE FUTURE DEVELOPMENT DOES NOT ADVERSELY IMPACT ON THE VALUES OF LAKE CURALO.

Management Plan recommendations include:

- water quality monitoring, particularly for nutrient levels and faecal coliforms during the swimming season;
- measures to improve stormwater quality;
- an entrance management policy to improve flushing, while addressing flooding;
- a path/boardwalk around the lake, incorporating interpretive signs;
- environmental guidelines for management of foreshore reserves; and
- development guidelines to protect Lake Curalo, which would be incorporated in existing Development Control Plans and Management Plans.

Table of Contents

1 Introduction 1

1.1 Study Area 1
1.2 Regional Context 1
1.3 Statutory Planning Framework 2

2 Values of Lake Curalo 3

2.1 Ecological Values 3
2.2 Scenic Values 3
2.3 Recreation and Tourism Values 4
2.4 Cultural Heritage 4

3 Background 5

3.1 Land Use and Management 5
3.2 Water Quality 5
3.3 Lake Sediments and Sedimentation 6
3.4 Entrance Closure and Breakout 7
3.5 Flora and Fauna 7
3.5.1 Aquatic Vegetation 7
3.5.2 Foreshore Vegetation, Habitat and Waterbirds 8
3.6 Recreation 8

4 Discussion of Major Management Options 10

4.1 Catchment and Stormwater Management 10
4.2 Foreshore and Waterway Planning 11
4.2.1 Flora and Fauna 11
4.2.2 Recreational Facilities 11
4.3 Dredging 12
4.4 Entrance Management 13
4.4.1 Water Quality and Odours 13
4.4.2 Flooding 13

5 Action Plan 15

6 Description of Major Actions 23

6.1 Further Investigations 23
6.1.1 Water Quality Monitoring 23
6.1.2 Sediment Testing 23
6.1.3 Flood and Tidal/Wind Modelling 24
6.2 Stormwater Management 25
6.3 Education Packages 26
6.3.1 Industry Package 26
6.3.2 Residential Package 26
6.4 Path/Boardwalk 27

7 Guidelines for Management 29

7.1 Entrance Breakout Procedures and Monitoring 29
7.2 Reserves/Turf Management 31

8 Additions/Changes to DCPs and Management Plans 33

8.1 Water Sensitive Urban Design 33
8.2 Specific Guidelines for Development Around Lake Curalo 34
8.3 Management Plans 38

9 Assessment of Actions 39

10 References and Bibliography 40

Figures

Figure 1.1 Study Area and Location

Figure 1.2 Bathymetry and Foreshore Areas

Figure 2.1 SEPP 14 Wetlands, Community and Crown Land, National Park and State Forest land

Figure 2.2 Visual Amenity Map

Figure 3.1 Land Use Zoning - Eden Urban Area

Figure 3.2 Land Use Zoning – Eden Cove Subdivision Area

Figure 3.3 Open and Closed Entrance Conditions

Figure 4.1 Inundation Extent for Different Entrance Opening Levels

Figure 5.1 Summary of Management Plan

Appendices

Appendix A Background Information
- Land Use and Management
- Future Development
- Tourism

Appendix B Plans, Policies and Responsibilities Relating to Estuary Management

Appendix C Acknowledgements and Community Questionnaire Results

Appendix D Visual Amenity Report

Appendix E Ecosystem Health Report Card

1 Introduction

1.1 Study Area

Lake Curalo is located on the far south coast of NSW within Bega Valley Shire, which extends from Wallaga Lake in the north to the Victorian border. The lake is adjacent to Aslings Beach and Calle Calle Bay, immediately north of Twofold Bay and the Eden town centre. See **Figure 1.1**, which shows the study area and location.

Lake Curalo is intermittently open and has a waterway area of approximately 0.7 km^2 and catchment area of approximately 31 km^2. The lake consists of a shallow entrance channel, located at the northern end of Aslings Beach; main basin with depths up to about 2 m below AHD (AHD is approximately equal to mean sea level); and a smaller, shallow northern basin (see **Figure 1.2**).

Two ephemeral streams, Freshwater Creek and an unnamed creek, drain into Lake Curalo from the west. The main tributary, Palestine Creek, enters the lake from the north-west.

Recreational use of the lake is mainly for fishing from the shore, prawning, swimming and canoeing. Commercial fishermen use Lake Curalo as a "back-up" waterway when the larger surrounding estuaries fail to yield satisfactory catches (on average, only two commercial fishers have operated in the lake between 1988 and 1998). Fish species caught include black bream, mullet and luderick (Public Works 1992, TEL 1999).

Sportsfields are concentrated on the southern side of the lake, with residential development, adjoining a foreshore reserve (mostly grassed with some areas of foreshore vegetation) on the western side of the lake. To the north is an area of partly cleared land where a new subdivision is proposed. Further to the north lies the northern section of Ben Boyd National Park and to the west, Nullica State Forest.

1.2 Regional Context

Approximately 70% of the population of Bega Valley Shire live in urban areas. Eden along with Bega and Merimbula are the main centres. The major industries are tourism, fishing, forestry and agriculture (BVSC 1999a). The former is focused on Eden, Bermagui, Tathra, Merimbula and Pambula, with the population of these coastal towns estimated to increase threefold during the peak summer season (Sapphire Coast Tourism 1999).

Eden is the major port for the South Coast Region servicing the:

- fishing industry - primarily marine, trawler-based and estuarine netting;
- timber industry - sawmill and woodchip export;
- petroleum; and
- tourism industry (DUAP 1997, BVSC et al 2000).

At the last census (1996) Eden had a population of 3,106. This figure represents a decline of 5.3% from the previous census (1991), which can be attributed to a decline in the traditional industries of forestry and fishing. Tourism is a growing industry with the peak summer season seeing a large influx of tourists/visitors into the town and the caravan parks around Twofold Bay. The area's attractions include historic sites, its whaling heritage, the fishing industry and coastal environment (BVSC 1999a, BVSC et al 2000). Activities include sport and game fishing, diving and whale watching.

1.3 Statutory Planning Framework

The main planning instruments controlling land use around Lake Curalo are:

- *Lower South Coast Regional Environmental Plan No.2;*
- *Bega Valley Local Environmental Plan (LEP) 1987*;
- *Development Control Plan (DCP) No. 38 - Eden Urban Area*; and
- *Draft DCP No. 89 - North Eden Small Holdings*.

More information on the latter three plans is provided in **Appendix A**.

Other local plans are:

- *Eden Sportsground Reserves Plan of Management* (BVSC 1997)
- *Eden Local Urban Reserves Plan of Management* (BVSC 1997).

Other plans and strategies by Bega Valley Shire Council (BVSC), which are relevant to the management of Lake Curalo, include:

- *Bega Valley Shire Stormwater Management Plan*;
- *The Coastal Zone Management Project Action Plan*; and
- *Twofold Bay and Hinterlands Co-ordinating Strategy*.

Other plans and policies relevant to the management of Lake Curalo and estuary management in general are listed in **Appendix B**.

The EPA (2000) Water Quality and River Flow Interim Environmental Objectives are also relevant.

Objectives for Lake Curalo include the maintenance of water quality for:

- aquatic ecosystems;
- visual amenity;
- secondary contact recreation;
- primary contact recreation; and
- aquatic foods (cooked).

River flow objectives include to:

- maintain wetland and floodplain inundation;
- manage groundwater for ecosystems;
- minimise effects of weirs and other structures; and
- maintain or rehabilitate estuarine processes and habitats.

2 Values of Lake Curalo

The key values of Lake Curalo were identified from:

- background information including the Estuary Processes Study (ESE et al 2001);
- feedback from the community through consultation with stakeholders and the community questionnaire (see **Appendix C**); and
- site inspections.

As values range from social (ie what the community values) to scientific, the basis for the assessment of the significance (or uniqueness) of these values differs.

2.1 Ecological Values

Habitat

The rocky and sandy shorelines of Twofold Bay, Towamba River and Nullica River estuaries, Lake Curalo and the seabed of Calle Calle Bay, Quarantine Bay, Nullica Bay and East Boyd Bay have been included in *A Directory of Important Wetlands in Australia* (EA 2001). As an integral part of this area, the ecological values of Lake Curalo have been recognised at a national level.

The lake supports a variety of habitats including six wetland areas which have been listed under State Environmental Planning Policy (SEPP) No. 14 (see **Figure 2.1**). Of most note are the areas of saltmarsh. Although the overall area of saltmarsh in NSW has declined in the last few decades (mostly due to filling for sportsfields), in some areas the extent of saltmarsh around Lake Curalo appears to have increased since the mid 1980s. Saltmarsh plays an important role in the productivity of associated estuarine ecosystems including trapping and recycling nutrients and filtering silt from catchment run-off.

The bushland around the lake is also valued by members of the community for its diversity and variety of flowering plants.

Birds

A total of 33 species of birds have been recorded for Lake Curalo including four species listed under international agreements for the protection of migratory birds. Although not listed as an important coastal wetland for waders in NSW (Smith 1991), exposed sand/mud flats in Lake Curalo provide habitat for waders and other water birds.

In addition to scenic and aesthetic values, the most important values identified by the community related to the ecology of Lake Curalo. In particular waterbirds and birdlife in general are highly valued by the community, with birdwatching being the fourth most popular activity at the lake (see **Appendix C**).

2.2 Scenic Values

On a local scale, areas of high visual amenity were identified by David Beaver (2000) and include Lake Curalo itself, Aslings Beach and the areas to the north and west of the lake, which have retained a high proportion of native vegetation cover (see **Figure 2.2** and **Appendix D**). The views over the lake and bushland setting are highly valued by the community (as indicated by the questionnaire results) and have been described as ‘inspirational’ by members of the EMC.

2.3 Recreation and Tourism Values

The results of the questionnaire identified the most popular activities at Lake Curalo (in order) as walking, prawning, relaxing, birdwatching and fishing from the shore. The main recreational fish caught are bream and flathead and the lake is noted as an excellent prawning area in summer (TEL 1999). As noted in responses to the questionnaire, the lake's safe and sheltered waters also provide an ideal place for children to paddle and to learn to swim.

Lake Curalo offers residents a relaxed and peaceful lifestyle and for visitors, traditional caravan park or motel accommodation based around a 'holiday by the beach' (see **Appendix B** for more information on tourism). Tourism has become the most important tertiary industry within the coastal zone, with the Bega Valley Shire coastal towns becoming increasingly dependent on tourist and visitor dollars (BVSC et al 2000).

Several respondents highlighted the potential to increase the value of Lake Curalo for nature study and passive recreational pursuits (see **Appendix C**).

2.4 Cultural Heritage

Aboriginal Cultural Heritage

Bell and Edwards (1980) noted several well preserved open midden sites in the Lake Curalo area. Robert Paton Archaeological Studies Pty Ltd (1994) indicated that ridgelines and spurs around Lake Curalo have moderate to high archaeological potential, along with the lower slopes of the Eden Cove area, due to the proximity to wetlands associated with Lake Curalo.

Non-indigenous Cultural Heritage

The general cemetery, located immediately to the south of Lake Curalo, is classified as an historic cemetery by the National Trust.

3 Background

3.1 Land Use and Management

The management of 'community' (Council owned public open space), 'operational' and Crown reserves around Lake Curalo is the responsibility of Bega Valley Shire Council (BVSC). State Forests manage approximately 64% of the catchment of Lake Curalo and the National Parks and Wildlife Service (NPWS) approximately 6%. Other authorities with a management role are the Department of Land and Water Conservation (DLWC) (unreserved Crown land, including the bed of Lake Curalo), NSW Environment Protection Authority (EPA) and NSW Fisheries. More information on authority roles and legislation relevant to Lake Curalo and estuary management in general can be found in **Appendix B**.

Figure 2.1 shows areas of Council land, Crown land, Crown reserves, National Park and State Forest lands in the vicinity of Lake Curalo. **Figures 3.1** and **3.2** show land use zones around Lake Curalo. These include residential zones (low density residential, dwelling houses, multi-unit housing, motels and rural-residential), business, tourist uses, industrial, special uses and open space. To the north of Lake Curalo, along the Princes Highway, are rural small holdings.

Development around Lake Curalo includes sportsfields, passive recreational areas, two caravan parks, Eden Technology High School and immediately to the south-east, Eden historic cemetery. Within the catchment are a plant nursery, golf course, sawmill and old petroleum drum depot. Treated effluent from the Eden Sewage Treatment Plant (STP) is used to irrigate the golf course.

More information on land use and management can be found in **Appendix A**.

3.2 Water Quality

Water quality in Lake Curalo is influenced by catchment runoff, the shallowness of the lake, entrance conditions and the degree of mixing and flushing of the lake waters (see **Figure 3.3** which shows the characteristics of the lake under open and closed conditions). For example, the concentration of dissolved oxygen decreases as salinity and temperature increase; warmer waters promote biological activity; and high salinity levels assist in the flocculation and deposition of sediments on the lake bed.

Turbidity levels in Lake Curalo recorded by the EPA (monthly surface water samples from December 1994-June 1995) were generally high. Data logger monitoring of bottom waters in the main basin of Lake Curalo (1996-98) indicated that turbidity generally decreases within a few days after rainfall/runoff from the catchment. Strong winds also affect turbidity through the re-suspension of fine bed material (organic material and fine silt particles) (ESE et al 2001).

During 1996-98 water temperatures reflected the shallow nature of the lake, peaking at 27^{o}C in January or February and dropping to about 8^{o}C in August. The average pH (8.04) was typical of marine waters (as the lake was mostly open to the ocean during this time) and ranged from 7.3 to 8.5 (ie slightly alkaline). The average salinity was 31.7 parts per thousand (ppt) and ranged from about 15 ppt to about the salinity of seawater (35 ppt) (ESE et al 2001).

In April 1997 salinity concentrations were taken through the water column. Strong vertical stratification was recorded, ie separation of the water column with denser seawater on the bottom of the lake and lighter 'freshwater' at the surface. When an estuary is well-mixed the salinity distribution is almost uniform with depth (ESE et al 2001). Mixing occurs through tidal and wind induced currents and through

freshwater inflows, with any substance dissolved in the water (eg oxygen), also being mixed.

Strong vertical stratification is likely to be accompanied by oxygen depletion of bottom waters, particularly as the muddy sediments of Lake Curalo are organic rich (the break-down of organic material uses up oxygen). Periods of oxygen depletion are also suggested by the dominance of particular benthic fauna (which are tolerant of low dissolved oxygen conditions) in the muddy habitats (TEL 1999).

The limited water quality data on nutrients suggests that ANZECC guidelines may be exceeded. As the lake flushing time (ie time to replace the lake water volume with sea water) is relatively long (approximately 60 days when the lake is open), it is likely that most nutrient inputs are either taken up by aquatic plants or are stored in the bed of the lake, rather than being flushed out to sea (ESE et al 2001). During periods of oxygen depletion nutrients, which are normally bound to fine sediments, may be released into the water column. Note that the lake may be closed for extended periods of time and no tidal flushing occurs during those periods.

High nutrient concentrations can cause algal blooms. There have been no studies of microalgae in Lake Curalo (eg phytoplankton), however, anecdotal evidence and aquatic vegetation surveys indicate excessive growth of larger species, ie epiphytic algae (eg algae attached to seagrasses) and macroalgae (see **Section 3.5.1**).

There is no information available on the water quality of creeks and drains flowing into Lake Curalo. The EMC advised that stormwater laden with fine sediment has been observed in Palestine Creek, near Government Road (one source is unsealed road shoulders), and in the golf course creek. Algal blooms have also been observed in the golf course ponds (pers. comm. Jonathon Pike, BVSC) (possibly blue-green algae but not tested). Pollution of the open drain between the soccer and AFL fields and Freshwater Creek (which runs through the Garden of Eden Caravan Park and Eden Technology High School) has also been identified by the EMC, Council staff and in community submissions. A spill from the old Caltex drum depot occurred in September 2000 and tannin problems have been apparent at Storey Avenue (pers. comm. Jonathon Pike).

3.3 Lake Sediments and Sedimentation

Sediments within and around Lake Curalo comprise clean quartzose marine sands along the seaward margin; fine-grained, organic-rich sandy muds from the catchment in the main basin of the lake, with coarser grained sediments along the western shore in the vicinity of Palestine Creek.

Vibrocoring of the lake basin (sediment samples obtained by vibrating a pipe into the lake bed, then splitting the pipe to view sediment layers) showed a relatively thin layer (about 2 m deep) of organic-rich sandy muds which have been deposited within the last 10,000 years.

Long-term estimates of sediment delivery from the catchment to Lake Curalo were made using the plan area of deposited material, thickness of sediments estimated from the vibrocores and a start date of 6,500 before today (when the lake formed as the sea level rose to present day levels). The results indicate a sediment delivery rate within, but at the upper end of, estimates for other undisturbed South Coast estuaries (ESE et al 2001).

Anecdotal advice suggests that substantial infilling of the lake has occurred and that this became particularly noticeable in the early 1970s. A reduction in water depth of about 1 m has been suggested. If this was the case the average sedimentation rate, since development in the catchment commenced, would have had to be ten times higher than the few millimetres per year which is typical of NSW estuaries.

Rather than a substantial increase in the bed level of the lake through sedimentation, there has been a reduction in the average water level due to the artificial opening of the entrance for flood mitigation purposes (see **Section 3.4**).

3.4 Entrance Closure and Breakout

The major mechanisms leading to closure of Lake Curalo are the transport of marine sand along Aslings Beach, net movement of marine sand by tide and wave action into the entrance channel and sand drift (ie deposition of wind-blown sand in the entrance channel).

Following entrance closure, along-shore sand movement contributes to a gradual build-up and extension of the Aslings Beach foredune. Under natural conditions (assuming no large rainfall event occurred over a reasonable period of time) the foredune across the entrance would be expected to reach a height of approximately 2.5 m above mean sea level, similar to the existing dune height immediately to the south of the lake. Before water levels in the lake were high enough to cause a break-out (ie breach the dune and scour a channel to the ocean), there would have been widespread flooding of low-lying areas around the lake, which have now been developed for sportsfields, caravan parks and housing (ESE et al 2001).

To prevent property flooding, a channel is excavated through the entrance dune when the water level in the lake reaches approximately 1.2 m above mean sea level (see **Appendix A** which provides more information on break-out procedures). Accordingly, the lake is open to the ocean more frequently than under natural conditions. When the entrance is open, the spring (highest tides during a month) tidal range in the lake is typically 0.3 m compared to the adjacent ocean range which is over 1 m. However, during neaps (the lowest tides during a month) the tidal range may diminish to zero as the long, shallow entrance channel prevents the influx of seawater.

Once floodwaters have been released, the volume and velocity of water moving out of the lake under tidal action is not sufficient to maintain an open entrance indefinitely.

In addition to lowering the average water level, artificially opening the lake is likely to have resulted in:

- a reduction in the depth of entrance channel scour (the difference in height between the lake water level and ocean water level at a break-out has been reduced, reducing the velocity and hence scour potential of outgoing flood waters);
- a shallower entrance channel may mean that the lake entrance closes more quickly than in the past; and
- due to increased opportunities for tidal exchange the lake, on average, may have become more marine in character.

3.5 Flora and Fauna

3.5.1 Aquatic Vegetation

Differences were found in the distribution of seagrasses when compared to historical maps. For example, during 1999 small, scattered patches of the seagrass *Ruppia* sp. were observed within Palestine Creek extending out into the creek mouth. However, the large expanses of *Ruppia* sp. recorded in 1988 and to a lesser extent in 1985 were not present.

Epiphytic and benthic algae were recorded in 1988 as growing on and amongst most seagrasses in Lake Curalo and, in some areas, algae were the only vegetation

present. This is consistent with observations by TEL in 1999. One notable difference, however, was the absence of *Chara* sp. in 1999.

High salinity conditions favour the growth of macrophytes (large aquatic plants) such as the seagrass *Zostera* sp. (eelgrass) and macroalgae such as *Enteromorpha* sp. When the entrance is closed the system is more brackish and favours *Ruppia* sp. and freshwater macroalgae, such as *Chara* sp.

Accordingly, it appears that variations in salinity (and hence entrance conditions) are responsible for the changes in the distribution of seagrasses and the type of algae present. In addition, the current levels of macroalgae are thought to limit the density and percentage cover of eelgrass (TEL 1999).

In 1999, TEL noted that the shoreline and substratum of the eastern end of the lake nearer the entrance were covered with *Enteromorpha* sp, that in many cases clogged the entire water column. This was also the case for the foreshores of the small island at the mouth of Palestine Creek. During periods of low water level, decaying vegetation and exposure of mud flats can cause odours. The EMC advised that this was last a major problem during the drought in the 1980s.

In the case of saltmarsh, some areas were more extensive than previously mapped in 1985 and 1988. In particular, the northern foreshore of the lake consisted of a continuous band of saltmarsh which extended from the mouth of Palestine Creek to the entrance channel.

The distribution of saltmarsh on the small island near the mouth of Palestine Creek was also different from that mapped in both the previous surveys. The area that was recorded as saltmarsh in 1985 and 1988 was dominated by wetland forest in 1999 and included paperbarks and she-oaks. Moreover, the southern edge of this island, which was noted as *Ruppia* sp. in 1985 and 1988, now consists of saltmarsh (TEL 1999).

It is probable that changes in habitat distribution and characteristics evident between 1985 and 1999 are due to the deposition of sediments during floods, which have raised the bed levels around the island and lead to a gradual progression from *Ruppia* sp to saltmarsh, and from saltmarsh to wetland forest.

3.5.2 Foreshore Vegetation, Habitat and Waterbirds

Members of the EMC have noted a decline in the extent of foreshore vegetation over the past six years. Reasons for this have been identified as control burning for fire hazard reduction, mowing to maintain grass areas, clearing of informal tracks to the lake edge, trimming/removal of trees for views, replacement of foreshore vegetation with other plant species and tea-tree die-back. Invasion of riparian vegetation by blackberry has also been identified as a growing problem.

Illegal filling of low-lying land near the cemetery was identified as destroying frog habitat. The EMC also reported that black swans nesting at Lake Curalo have been caught in rabbit traps and other birds have been caught in fishing nets in Palestine Creek.

3.6 Recreation

Active recreational use of the Lake Curalo foreshores is concentrated on the southern side of the lake. Lake Curalo Reserve, a mown reserve on the western side of the lake, provides opportunities for walking, picnics, fishing from the shore and small boat launching. Facilities are limited to a small jetty, wooden seats, two footbridges over creeks/drainage lines and a shared walkway/cycleway to the highway.

Prawning is undertaken in the summer months and, when the lake is open, small children may paddle in the entrance channel. Other activities at Lake Curalo include birdwatching, canoeing, jogging, sailboarding and swimming (see questionnaire results **Appendix C**).

There are no recreational facilities on the northern side of the lake. The applicants for the Eden Cove Estate have proposed the installation of a path/boardwalk on Crown land around the southern edge of the subdivision (BVSC 1999b).

The community questionnaire listed a range of issues for Lake Curalo. Respondents indicated that the most pressing issues were a lack of public access/public path around the lake (about 90% of respondents thought this was a problem) and lack of recreational facilities (see **Appendix C**).

Proposals for a path around the entire lake date back to at least 1988, but seem to have faltered due to a lack of funding and because not all foreshore land is public reserve (the latter problem has been overcome by the proposal to construct a boardwalk over the lake in front of the Garden of Eden Caravan Park and Eden Technology High School).

4 Discussion of Major Management Options

Following is a general discussion on management options for Lake Curalo. Recommended actions are contained in **Section 5**.

4.1 Catchment and Stormwater Management

Management strategies need to address both point and non-point sources of pollution. As noted in **Section 3.2** there is no information on the water quality of creeks and drains flowing into Lake Curalo, and the Bega Valley Stormwater Management Plan (Clark 2000) does not provide any details on pollutant sources.

Accordingly, potential sources were identified via an inspection of the catchment, review of current land use zonings and discussions with Council and State Forests representatives.

Potential point sources include:

- Eden STP (in rare events) (primarily nutrients and faecal matter)
- three sewage pumping stations around the lake foreshores (primarily faecal matter, nutrients and faecal coliforms)
- old Caltex Depot (illegal discharge occurred during September 2000) (hydrocarbons)
- sawmill in Storey Street - (tannin and other mill wastes)
- pollutants from other industries (possibly hydrocarbons, surfactants, pesticides and heavy metals - note that several industrial developments in the western part of the catchment close to the lake were built prior to licensing requirements and pollution control requirements, such as bunding of fuel storage areas)
- septic tanks (existing and disused) (nutrients and faecal matter)
- stormwater pipe discharges (nutrients, litter, suspended sediments, hydrocarbons and heavy metals from sealed roads).

Potential non-point sources include:

- Eden golf course (nutrients and suspended sediment)
- effluent disposal from STP onto golf course (primarily nutrients and faecal coliforms)
- runoff from the industrial area (includes potential for hydrocarbons, heavy metals and litter – nutrients and possibly herbicides and pesticides from the nursery)
- runoff from rural-residential areas (nutrients, suspended sediment, pesticides, herbicides)
- agricultural plot at Eden Technology High School (nutrients and suspended sediment, faecal matter from animals, possibly pesticides)
- tributary creek bank and bed erosion (eg Palestine Creek and the golf course creek)
- erosion from land clearing and earthworks (coarse and suspended sediment)
- sediment from unsealed roads within the catchment and unsealed road shoulders (eg adjacent to Government Road)
- road runoff (nutrients, suspended sediment, heavy metals, hydrocarbons)

- trail bike riding through the catchment - induced erosion (suspended sediment)
- lawn clippings washed into the lake (nutrients)
- unregulated fertiliser application of sportsfields around the edge of the lake (nutrients)
- Eden urban area (nutrients, litter, suspended sediment, including sediment from subdivisions such as the Eden Cove Estate, residential development and other types of construction).

Appendix A provides more details, including licence conditions for EPA Scheduled premises in the catchment (ie the STP and sawmill) and measures taken to minimise/prevent overflows from sewage pumping stations.

In addition to better understanding pollutant loads to Lake Curalo, measures to reduce pollution include:

- installation of stormwater quality improvement devices, eg trash racks, sediment ponds, 'mini-wetlands';
- preservation and re-establishment of vegetated buffer zones to the lake and tributary creeks;
- improved management of foreshore reserves and other open space;
- community and industry education to improve catchment management;
- rehabilitation of areas affected by erosion;
- more stringent control of activities likely to cause soil erosion; and
- effective emergency response procedures for pollution spills.

4.2 Foreshore and Waterway Planning

Council manages reserves for the provision of recreational opportunities, environments and facilities and the conservation of sensitive coastal ecosystems (BVSC et al 2000).

4.2.1 Flora and Fauna

As noted in **Section 3.5.2** human activities have resulted in a reduction in the extent of foreshore vegetation, weed invasion, adverse impacts on fauna habitats and harm to waterbirds. Measures to reduce adverse impacts on flora and fauna include:

- establishing different use areas, eg 'wildlife habitat', bush regeneration areas, foreshore buffer zones (which also provide water quality benefits), and specifying what activities are and are not permitted in these areas (eg park furniture/facilities not to be provided, dogs excluded);
- interpretation of the ecological values of Lake Curalo and community education on the impacts of inappropriate/thoughtless actions; and
- community involvement in 'environmental activities', eg weed control, indigenous tree planting, 'clean up' days.

4.2.2 Recreational Facilities

As noted in **Section 3.6** the Eden community sees the provision of access around the entire lake as a high priority. Opportunities for improved access include:

- a boardwalk from the soccer field, continuing over the lake in front of Eden Technology High School (the Department of Education and Training has agreed to this) and the Garden of Eden Caravan Park;

- continuation of the boardwalk adjacent to the area of dense vegetation and a path connecting to the reserve on the western side of the lake (Lake Curalo Reserve); and in addition
- the applicants for the Eden Cove Estate on the north side of the lake have proposed the installation of a path/boardwalk on Crown land around the southern edge of the subdivision, and the possible construction of a boardwalk and footbridge across the entrance to Lake Curalo connecting to Aslings Beach (the EMC are not in favour of a bridge over the lake entrance and, in any event, it is possible to wade through the entrance when it is open).

The path/boardwalk could also be used to prevent or direct pedestrian access away from 'sensitive' areas. Facilities for fishing, birdwatching, picnicking, swimming, interpretation of the natural and cultural features of the lake, and general viewing of the area could then be developed along the course of the path and boardwalk.

BVSC et al (2000) noted that *Twofold Bay's cultural heritage sites, be they Aboriginal or European, have the potential to provide interest to both locals and visitors alike, through the development of interpretive information/displays and incorporation into tourism development.* ERM Mitchell McCotter (1997) also identified the potential for the expansion of ecotourism, ie nature-based tourism that involves education and interpretation of the natural environment. Accordingly, Lake Curalo could become an integral feature of tours around the Eden area, focussing on the natural environment.

4.3 Dredging

Current and past land use activities may have impacted on the quality of sediments in Lake Curalo. Up until about 10 years ago the lake was subject to unregulated pollution from an abattoir, sawmill and sewage overflows.

There have been suggestions to dredge Lake Curalo to:

- remove silt and mud for aesthetic reasons;
- provide fill for low-lying areas of Eden Tourist Park and the sportsfields;
- reduce turbidity (when winds re-suspend fine sediments); and
- provide a more useable depth for watercraft, such as canoes and small sail boats.

The benefits of dredging for recreation are obvious, however, impacts on water quality would need to be investigated. If sediments are nutrient enriched their removal may provide water quality benefits (ie reduction in nutrients available to stimulate algal growth), however if the lake was deeper, stratification may occur more frequently and the associated depletion of oxygen in bottom waters may put more stress on aquatic animals.

As removal of the muddy sediments would be targeted for water quality improvements, these may not be particularly suitable for use as fill for the caravan park. The use of clean marine sands for this purpose may remove sediment which is part of the active beach system (as sand moves in and out of the entrance) and therefore has implications for shoreline recession of Aslings Beach.

Limited sediment analysis indicates that total phosphorous levels in the muddy sediments are low but total nitrogen levels in the deepest part of the lake may be elevated. However, most nitrogen and phosphorous is in the organic form which is not readily available to aquatic plants.

To assess the effectiveness of dredging in improving water quality, information is needed on:

- sediment quality;

- the role of sediment-nutrient release from sediments during periods of closure versus periods when the entrance remains open; and
- the influences of the shallow areas and wetlands on the nutrient budget (since vegetation die-off and decomposition as well as nutrient uptake from wetland plants is not well understood).

Further investigation through the use of two or three dimensional modelling to assess various dredging scenarios could be undertaken to assess the impact on flushing and stratification processes.

Rather than dredging, an increase in the level at which the lake is artificially opened may be possible to increase the average lake water level. Measures to address ongoing and potential inputs of sediment from the catchment were outlined in **Section 4.1**.

4.4 Entrance Management

4.4.1 Water Quality and Odours

More frequent opening of the lake (which would mean break-outs at a lower water level) has been suggested to increase tidal exchange and hence improve water quality. Opening the lake to raise the water level has also been suggested to help reduce odours from rotting aquatic vegetation and exposed mud flats.

Conditions for the successful opening of the lake include:

- high lake water level;
- large difference between lake water level and ocean water level;
- moderate to heavy rainfall (recent and/or continuing);
- relatively large ocean tidal range; and
- relatively low wave action.

For the reasons outlined above, the success of opening the lake at a lower level would be short-lived (and could lead to adverse odour and ecological impacts). Also, as noted in **Section 3.4**, to achieve the influx of seawater to raise lake levels the break-out would have to occur during the highest tides of the month.

If the prolific growth of aquatic vegetation is due to elevated nutrient inputs from the catchment (and not a natural phenomenon), a short-term action to address odours would be the raking and removal of decaying vegetation from the foreshores.

To more fully understand water quality in Lake Curalo and assess management options, more information is needed on the impacts of different opening regimes and lake depths on tidal exchange.

4.4.2 Flooding

The entrance to Lake Curalo is currently opened at 1.2 m AHD. As buildings are not directly at threat when the lake reaches the level, there may be some scope to vary the level at which the lake is currently opened. **Figure 4.1** shows the extent of inundation for three other opening levels, ie 1.5 m, 2.0 m and 2.5 m AHD. Note that the extents are indicative being based on mapping interpreted from aerial photographs; a contour interval of 2 m; and a detailed survey of the Eden Tourist Park and spot levels around the Lake foreshore, both of which were provided by Council.

From this preliminary work it appears that there is scope to raise the entrance opening level to 1.5 m AHD, while primarily only affecting undeveloped land zoned

open space, apart from the foreshores of the Eden Tourist Park. For an opening level of 2.0 m AHD it appears that properties in Emblem Street, parts of the AFL field and Eden Technology High School sportsfields and substantial areas of the Eden Tourist Park would be affected. At this level the soccer field would be almost entirely inundated. At a level of 2.5 m, parts of the Garden of Eden Caravan Park, residential development around the lake and Barclay Street would also be affected.

In April 2001 a trial opening of the lake at 1.5 m AHD was proposed, however, it was found that two of the four netball courts adjacent to the lake started to flood when the lake level reached about 1.2 m AHD. The yard of the lowest house in Emblem Street began to flood at about 1.5 m AHD (survey work by the EMC indicates that the lowest floor level in Emblem Street is at about 1.9 m AHD).

A detailed ground survey (including house floor levels) and computer modelling within a flood study would be necessary to confirm the nature and extent of flooding around Lake Curalo. This would normally be followed by a floodplain management study and plan to identify options for flood mitigation, eg relocation of the netball courts, levee bank around the caravan parks, raising of houses along Emblem Street, voluntary purchase of affected properties and rezoning as public reserve, evacuation/relocation procedures for campers at Eden Tourist Park.

5 Action Plan

Goals and objectives for the management of Lake Curalo are set out on the following pages. The associated strategies and actions have been formulated to protect the identified values of Lake Curalo (see **Section 2**) and to address issues and problems (see **Sections 3** and **4**). Management Plan Actions are summarised in **Figure 5.1**.

The authority or organisation responsible for implementing individual actions is also indicated. The following abbreviations have been used.

BVSC	Bega Valley Shire Council
DLWC	Department of Land and Water Conservation
Planning	Planning NSW
EPA	Environment Protection Authority
EFC	Eden Foreshore Committee (which incorporates the Lake Curalo EMC)
Fisheries	NSW Fisheries
HS	Eden Technology High School
Eden LALC	Eden Local Aboriginal Land Council
NPWS	National Parks and Wildlife Service
RC	Reserves Committee
RLPB	Rural Lands Protection Board
SCT	Sapphire Coast Tourism
SF	State Forests
Waterways	NSW Waterways

Priorities for actions have been listed as:

- high implementation within one to five years
- medium implementation within six to 10 years
- low implementation within 11 to 15 years

Further information and indicative costs for major actions are provided in **Section 6**. **Section 7** provides guidelines for management of Lake Curalo and reserves and **Section 8** provides suggested changes to existing Development Control Plans and Management Plans. Measures to monitor the effectiveness of actions, which require evaluation, are outlined in **Section 9**.

5.1 Goal: to improve water quality within Lake Curalo and its tributaries

5.1.1 Objective: to gain a better understanding of water quality within Lake Curalo and feeder creeks and drains

Strategy	Action	Priority	Responsibility
Determine the contribution of stormwater to nutrient levels in Lake Curalo	Monitor nutrient levels in Lake Curalo, creeks and major drains during wet and dry weather, see **Section 6.1.1** for discussion.	high	BVSC
Determine the contribution of nutrient release from sediments to water quality in Lake Curalo	Undertake sediment sampling and analysis to assess the bioavailability of nutrients and potential for fluxing into the water column, see **Section 6.1.2**. Review available research on this matter.	low	BVSC
Determine compliance with EPA environmental objectives and ANZECC guidelines	Extend existing environmental monitoring program for faecal coliforms at Aslings Beach to Lake Curalo. Increase frequency of sampling during the swimming season.	high	BVSC
	Liaise with Eden Technology High School to undertake and make available Streamwatch information.	medium	BVSC, HS Streamwatch co-ordinator

5.1.2 Objective: to achieve water quality that meets ANZECC guidelines relating to the EPA (2000) water quality objectives

Strategy	Action	Priority	Responsibility
Reduce/eliminate sources of sewage pollution	Connect tennis clubhouse to the sewer.	low	BVSC
	Carry out annual environmental audits of septic tanks within the catchment to identify poor performance and any illegal discharges. Notify owners of required actions, eg desludging, pumpout.	ongoing	BVSC
Identify possible pollutant sources in commercial/ industrial areas	Carry out an environmental audit of industry/activities in the catchment of Lake Curalo for educational purposes and to identify practices which adversely impact on water quality. Prepare education package on good site practices (see **Section 6.3.1** for more details) and carry out follow-up inspections.	high	BVSC
Reduce pollutant loads from scheduled premises	Prosecute breaches of licence conditions and investigate pollution reduction programs.	as they arise	EPA
Formalise emergency spill response procedures	Prepare response plan for pollution spills and sewage pumping station failure in accordance with guidelines set out in the *Protection of the Environment Operations Act 1997*.	in prepara-tion	BVSC

Strategy	Action	Priority	Responsibility
Reduce accelerated input of sediments from the catchment	Undertake detailed survey of tributary creeks for active bank and bed erosion and identify sections for rehabilitation. Assist landowners/lessees with erosion control through Landcare.	medium	BVSC, DLWC, RLPB
	Identify problem areas and seal roads/road shoulders in the vicinity of creeks and drainage lines to reduce sediment wash-off during storms.	medium	BVSC
	Report any incidences of erosion/sediment laden runoff in the catchment to appropriate authorities.	as required	EFC
Improve foreshore management	Phase out grazing of animals on lake foreshores (apply principles of DCP No.24, ie 150 m buffer zone to Lake Curalo for animal grazing).	high	BVSC, RC, HS
	Liaise with Eden Technology High School on appropriate management of agricultural plot.	high	BVSC
	Develop guidelines for maintenance of sportsfields etc to reduce fertiliser (plus herbicides/pesticides) and other nutrient inputs (eg grass clippings) to Lake Curalo, see **Section 7.2** for more details.	high	BVSC
	Investigate need for bins for disposal of dog droppings.	low	BVSC
	In consultation with Eden Country Club and Fishermens Sports Club prepare Management Plan for golf course addressing creekline management, re-use of effluent and monitoring nutrient levels in the soil and water ponds, see also **Section 7.2** – Reserves and Turf Management.	high	BVSC
Investigate measures to improve stormwater quality	Revise Stormwater Management Plan to include investigation and identification of locations for pollution control devices, ie so that the stormwater plan includes a list and costings for treatment measures. Measures to be investigated include: - installation of constructed wetlands, sediment traps etc on the Bungo Street drainage system together with 'mini-wetland' and trash rack where it discharges to Lake Curalo between the soccer and AFL fields; - re-establishment of a more natural creekline through Eden Technology High School and the Garden of Eden Caravan Park (liaise with school and caravan park manager); and - establishment of 'mini wetlands' at stormwater outlets to tributary creeks and from King Place and Linton Street, together with re-grading of the Linton Street drain.	high	BVSC

5.2 Goal: to ensure that entrance opening follows as natural a regime as possible within the constraints of property inundation, flooding, water quality and odour problems

5.2.1 Objective: to optimise entrance management for water quality purposes

Strategy	Action	Priority	Responsibility
Investigate measures to manage the lake entrance to improve flushing, while managing flooding	Undertake a detailed survey of lake foreshore reserves, foreshore properties and building floor levels to establish at what level these areas are likely to be affected by flooding. Also identify what interim measures might be implemented to reduce the affect of that flooding.	high	BVSC

Strategy	Action	Priority	Responsibility
Investigate measures to manage the lake entrance to improve flushing, while managing flooding (continued)	Develop entrance management policy in consultation with foreshore residents, local stakeholder groups and relevant government authorities.	medium	BVSC

5.2.2 Objective: to ensure development is compatible with the flood risk around the lake

Strategy	Action	Priority	Responsibility
Relocate recreational facilities currently affected by flooding when the lake level reaches 1.2 m AHD	Investigate moving the netball courts so they are unaffected up to at least a level of 1.5 m AHD.	medium	BVSC
Ensure new development is compatible with the known flood risk	As noted under Objective **5.5.2** include guidelines for development of flood affected properties (based on existing information) in DCP No.38. See **Section 8.2** for more details.	medium	BVSC
Quantify the nature and extent of flooding around Lake Curalo and identify flood mitigation options	Undertake a flood study and floodplain management study, see **Section 6.1.3**. If a 2D model was used or a 3D model with options to collapse to 2D by considering a single layer, this model could be utilised for both flooding and water quality purposes.	high	BVSC
	Based on the results of the flood study, review guidelines for flood affected properties in DCP No.38, including design floor levels.	high	BVSC

5.2.3 Objective: to mitigate odour problems

Strategy	Action	Priority	Responsibility
When lake level is low monitor odour complaints and take action if required	Liaise with NSW Fisheries regarding raking and removal of decaying algae exposed on foreshores.	as required	BVSC
	Attempt breakout of lake to induce tidal exchange if favourable conditions exist and water quality monitoring investigations (see **Section 6.1.1**) indicate that this would be beneficial.	as required	BVSC

5.2.4 Objective: to formalise entrance management

Strategy	Action	Priority	Responsibility
Ensure information on breakout procedures is available to all relevant staff	Develop formal written procedures for entrance breakouts and monitoring, including log sheet, see **Section 7.1**.	high	BVSC

Strategy	Action	Priority	Responsibility
Fulfill requirements under SEPP 35	Prepare interim Review of Environmental Factors for entrance management.	high	BVSC
	Prepare more detailed Review of Environmental Factors for entrance management under State Environmental Planning Policy (SEPP) No.35.	medium	BVSC

5.3 Goal: to protect and conserve aquatic habitats, fauna and foreshore vegetation

5.3.1 Objective: to establish a foreshore reserve around the entire lake and protect and enhance native foreshore vegetation and habitats

Strategy	Action	Priority	Responsibility
Continue to pursue opportunities to transfer foreshore land into public ownership	Negotiate easement, or as part of any development/subdivision application require dedication of foreshore land for: - land zoned R1 (nursery) on the western foreshore of Lake Curalo - land zoned R2 on the south-west corner of Lake Curalo (see **Figure 3.1**).	as opportun-ities arise	BVSC
Provide formal protection to Lake Curalo wetlands	Review boundaries of SEPP 14 wetlands and amend accordingly in view of 1999 TEL survey which showed changes in the extent of saltmarsh.	high	Planning
Protect areas of high ecological value and rehabilitate lake foreshores	Update Eden Local Urban Reserves Plan of Management to include open space on the north side of the lake, and the lake itself.	medium	BVSC
	Develop guidelines for management of foreshore reserves including weed control, indigenous species for planting programs, unmown buffers, see **Section 7.2** for more details. Include Aslings Beach dunes and Palestine Creekline in planting programs.	high	BVSC
	Install low-key fencing (eg stakes and tape) to protect foreshore vegetation and install explanatory signage, eg “bush regeneration area”.	high	BVSC

5.3.2 Objective: to increase awareness of the habitat and water quality values of foreshore buffer zones and encourage community participation in appropriate management of these areas

Strategy	Action	Priority	Responsibility
Co-ordinate activities of Fire Brigade & EFC	Encourage cross membership of committees to increase the understanding of Estuary Management Plan actions and to assist in their implementation.	high	BVSC
	Request Fire Brigade to liaise with EFC if hazard reduction burning is proposed around the lake.	high	BVSC
	Hold annual training/liaison day for volunteers, EFC, Council staff and Fire Brigade to ensure management objectives are consistent/ compatible.	high	BVSC

Strategy	Action	Priority	Responsibility
Establish volunteer bush regeneration group	Develop a program for weed control and re-planting indigenous species. Resources may also be available through the Green Corps and the Natural Heritage Trust which funds various programs including Landcare.	medium	BVSC
Provide information to residents on appropriate environmental management practices	Develop educational package for residents, see **Section 6.3.2** for more details.	medium	BVSC

5.3.3 Objective: to ensure that the overall health of the lake improves

Strategy	Action	Priority	Responsibility
To monitor the health of the lake over time	For each indicator identified in the report card in the Estuary Processes Study (see **Appendix E**) examine the current value against the reference value to determine whether or not trends are improving.	high	BVSC

5.4 Goal: to increase opportunities for low-impact recreational use of the lake and foreshores

5.4.1 Objective: to improve recreational facilities and foreshore access to the lake

Strategy	Action	Priority	Responsibility
Provide pedestrian access around entire lake	As per 1988 proposal construct path/boardwalk around lake, with security gate to Eden Technology High School. To protect middens, involve Eden LALC in route selection and construction.	high	BVSC
Provide for a range of passive recreational activities	Construct viewing/fishing platforms/bird hides in association with path/boardwalk, including fishing platforms/pontoons opposite the ends of King Place and Linton Place and viewing area at the entrance to Lake Curalo.	medium	BVSC
Provide launching points for small boats	Designate area behind tennis courts for boat launching with location selected to minimise disturbance of saltmarsh (retain existing boat launching area at the end of Lakeside Drive).	high	BVSC

5.4.2 Objective: to interpret the features of the lake for tourism and educational purposes

Strategy	Action	Priority	Responsibility
Make information on ecological values readily available to residents and visitors	Incorporate interpretive signs in proposed path/boardwalk around the lake.	low	BVSC, SCT
	Develop walking track pamphlet and make available at the caravan parks and Tourist Information Centre.	medium	

Strategy	Action	Priority	Responsibility
Promote the Eden Historic Cemetery	Include cemetery as a short spur walk from foreshore path/boardwalk and include information on Eden pioneers in walkway pamphlet.	medium	BVSC, SCT
Interpret past Aboriginal use of Lake Curalo and the Eden area	Develop most appropriate means of interpretation, eg signs as part of path/boardwalk, tours or talks.	low	Eden LALC, SCT, BVSC

5.4.3 Objective: to address potential adverse impacts of recreational use on wildlife and foreshore reserves

Strategy	Action	Priority	Responsibility
Encourage responsible dog exercising	Monitor dog exercise and passive use of reserves. Consider designating areas for leashed and unleashed exercise, depending on proximity to picnic facilities and bird roosting or nesting areas. Include in reserves plans of management.	ongoing medium	BVSC
Address practices which adversely impact on wildlife	Police littering laws/clean-up reserves, particularly with regard to discarded fishing lines and nets in which waterbirds can become entangled.	as required	BVSC

5.4.4 Objective: to ensure boating is compatible with conservation values and the shallow nature of the lake

Strategy	Action	Priority	Responsibility
Review boating controls with regard to safety and to minimise conflicts with waterbirds and passive recreation	Consider 4 knot speed limit for entire lake and install advisory signage at launching areas and other appropriate locations around the lake.	high	Waterways

5.5 Goal: to ensure future development does not adversely impact on the values of Lake Curalo

5.5.1 Objective: to set aside areas as appropriate for different land uses and recreational activities

Strategy	Action	Priority	Responsibility
Review Eden DCP No. 38 zonings	Provide an open space buffer zone between land zoned R1, R2 and S and Lake Curalo. Include triangular portion of land fronting Barclay and Lake Streets in DCP No. 38, ie repeal DCP No.20.	high	BVSC
Develop 'zoning map' for lake and foreshore use and activities	Incorporate 'zoning map' in Eden Local Urban Reserves Plan of Management delineating areas for bush regeneration, wildlife protection, passive recreation, waterway use (eg boating, fishing) etc based on ecological values, eg remnant bushland, SEPP 14 wetlands etc. See **Section 8** for more details and **Figure 5.1** which shows wetland areas and waterbird habitat.	medium	BVSC, DLWC, Waterways, Fisheries

5.5.2 Objective: to ensure development is ecologically sustainable

Strategy	Action	Priority	Responsibility
Revise Eden DCP No. 38(A7) and DCP No. 89	Expand aims and objectives of plans to include more environmental objectives.	high	BVSC
	Incorporate controls and design guidelines relating to: - water sensitive design - on-site stormwater detention - soil and water management - acid sulfate soils - flooding - filling - setbacks - building height and form - view sharing - landscaping - fences - retention and enhancement of natural environment See **Section 8** for more details.	high	BVSC

6 Description of Major Actions

6.1 Further Investigations

6.1.1 Water Quality Monitoring

Water quality monitoring in Lake Curalo to date has been very infrequent and undertaken on an ad-hoc basis. It is not possible from the existing data set to determine long-term trends as lake water quality depends on the season, entrance condition and the length of time the entrance has been open or closed. This means that in addition to water quality monitoring, data is also required on lake water level, inflow discharge from various tributaries and entrance condition in order to provide a meaningful interpretation of the data.

Ongoing monitoring is required to:

- identify sediment-nutrient fluxes during stratified conditions in late summer;
- determine nutrient pools within the water, phytoplankton, macroalgae and other vegetation; and
- quantify inflow loads from the tributary creeks during wet and dry weather.

To allow development of an understanding of the process regimes affecting water quality, monitoring of dissolved nutrients must be coupled with estimates of the nutrients stored in the lagoon macroalgae, phytoplankton and sediments.

The impact of the wetlands and shallow areas on nutrient release to the main waterbody of the lake remains unknown. The exchange of water between lake and shallow areas could be estimated from detailed salinity measurements following rainfall. Nutrient sources within the wetlands and underlying groundwater could be monitored through piezometers located across the edge of the wetlands.

In addition to physical and chemical parameters, human health indicators should be monitored during periods of high lake usage, particularly when the entrance is closed and following rainfall. As noted in **Appendix A**, the Eden Sewage Treatment Plant licence conditions include sampling and analysis of faecal coliform levels at Aslings Beach from November to March. This sampling program could be expanded to include a number of sites in Lake Curalo.

Council's laboratories have the facilities to undertake analysis of water samples for most parameters to be monitored and analysis of other parameters could be undertaken at an external laboratory at Currambene (near Merimbula). Storm event monitoring linked to land uses was undertaken by Council last year for other estuaries (eg Merimbula Lake) and a similar program could be implemented for Lake Curalo to quantify stormwater pollution loads for the lake.

Accordingly, costs associated with water quality monitoring may be largely staff time. Costs for external laboratories would depend on the number and type of parameters analysed.

6.1.2 Sediment Testing

As noted in **Section 4.3** there is little information available on sediment quality. Accordingly, sampling and testing is needed to:

- characterise the physical and chemical properties of the material (including soil contamination levels);
- confirm whether dredging the lake would remove a significant source of nutrients;
- assess the suitability of the material for re-use on public reserves; and

- identify amelioration measures which may be required (eg treatment/capping, including agronomic considerations).

A pilot sampling and analysis program is recommended. Should contamination of sediments be apparent, a more intensive sampling and analysis program would be required. The indicative cost for a pilot sediment sampling program is $6,000 - $12,000. Costs depend on the number of samples analysed and the range of parameters tested.

Vibrocoring would be undertaken to a depth of about 2 m (previous work has shown that this is the depth of the layer of organic-rich sandy muds on the lake bed, see **Section 3.3**). Samples would be taken and tested for a range of parameters based on potential pollutant sources (see **Section 4.1** which identifies land uses and associated potential pollutants).

Nutrient analysis would include determination of the various forms of nitrogen, eg concentration of organic nitrogen which is not readily available to aquatic vegetation (oxidation is required to convert organic nitrogen to nitrate nitrogen before it is readily assimilated).

Contaminant testing and classification would be carried out in accordance with EPA guidelines for sediment quality in relation to effects on biota and, if dredging was proposed, guidelines relating to disposal/re-use. Current disposal/re-use guidelines classify material as either inert, solid, industrial or hazardous waste. The classification of the material dictates remediation requirements and the ultimate end use of the material.

Acid sulfate soils testing would also be required to determine requirements for managing potential acid runoff from dredged sediments (eg neutralisation with lime). Testing and assessment of acid sulfate risk would be carried out in accordance with the *Acid Sulfate Soil Manual* (ASSMAC 1998).

The characteristics of the sediments, particularly if acid sulfate run-off or contamination are issues, has cost implications for any proposed dredging work.

6.1.3 Flood and Tidal/Wind Modelling

To date there have been no investigations of the flooding behaviour of Lake Curalo under the auspices of DLWC's Floodplain Management Program. In a similar manner to the Estuary Management Program, the Floodplain Management Program follows a series of stages for the management of flood affected areas for lands at risk from flooding up to, and including, the Probable Maximum Flood (PMF) event. A preliminary assessment has been undertaken as part of this study to assess the areas of foreshore likely to be affected by inundation due to various entrance opening levels. However, a detailed flood study is required to assess the flooding behaviour of Lake Curalo. This would be followed by a floodplain management study and floodplain management plan. DLWC funds studies of this kind on a 2:1 basis in partnership with councils.

Additional survey work would be required for a flood study and may consist of aerial photography and photogrammetry, or a detailed ground survey of the lake foreshores and adjacent areas up to about 3 m AHD (this level would need to be reviewed following a preliminary estimate of the likely level of the Probable Maximum Flood) to complement the existing bathymetric survey. Using this information a two dimensional model would be developed to predict the flood levels for different flood discharges and ocean levels and could account for the flooding and drying of the wetland areas, as well as entrance breakout. Such a study would need to consider the condition of the entrance at the start of the event and the likely occurrence of high ocean levels coinciding with heavy rain and large stream flow into the lake. A model

of this type could also be used to estimate the tidal exchange characteristics and hence the impacts of different opening regimes and dredge depths on water quality.

It has been suggested that EPA licensing requirements for the sawmill (overflows from storage dams permitted in a 1 in 5 year or greater storm event, see Section 1.3.4, **Appendix A**) be linked to entrance break-out events. Given the level of investigation of the entrance behaviour undertaken to date, it is not possible to quantify what recurrence interval storm event would be necessary to open the lake. This is coupled with the complexities of the amount of sand build-up at the entrance which is determined by wave action and other coastal processes. The time between events also determines significantly the level and volume of water required to breakout the entrance. Thus the linkage of EPA licensing to breakout character would be a tenuous one. Further investigation via a flood study would be required.

Survey costs for a flood study for Lake Curalo are likely to be of the order of $20,000 and a flood study is likely to cost in the order of $50,000.

6.2 Stormwater Management

The Stormwater Management Plan (Clark, 2000) prepared for Bega Valley Shire Council is a generic document that covers the issue of stormwater management as required under the Section 12 directive from the NSW EPA to all local councils in NSW. The broad nature of the document means that it contains limited reference to, and limited specific actions for, Lake Curalo itself. However, there are actions identified for the Lake Curalo area in the Stormwater Plan such as a catchment audit and education.

Based on the findings of the Estuary Management Study, priority areas to be addressed include:

- targeting various industries/activities within the catchment to reduce pollution loads and incidences of spills via a catchment audit and education strategy (see **Section 6.3.1**)
- the installation of stormwater quality improvement devices (SQIDs) to capture pollutants such as gross pollutants (litter and sediment) as well as nutrients and finer sediments in constructed wetlands around the edge of the lake. It is recommended that sites including the following be further investigated for the application of SQIDs:
  - the inflow from the southern parts of the catchment near Eden Technology High School (gross pollutants and finer pollutants)
  - the inflow off the major road through the catchment (controlled with a fine sediment and oil and water separator on road transverse drainage within the road reserve)
  - various controls sized according to current best management practice guidelines within new subdivision areas (such as the area on the northern side of the lake)
- stringent erosion and sediment control requirements for all development within the catchment
- as noted in **Section 6.1.1** monitoring of the inflows to the lake (on an event and land use basis) to better quantify the existing pollutant loads.

Based on SQIDs constructed elsewhere, construction costs range from approximately $20,000 for a small retrofitted proprietary device up to $400,000 and over for a large constructed wetland. Costs depend on a number of factors including the size and nature of the catchment to be treated, topography and site conditions.

DLWC suggests constructed wetland costs are in the order of $200,000 per hectare. These costs do not include an allowance for detailed survey, design or geotechnical assessments that would be required prior to construction.

Further details on the costs and types of devices available can be found in the Department of Public Works and Services' (DPWS) Contract 19 document, which is periodically updated. Note that funding for any device which treats runoff from Roads and Traffic Authority (RTA) maintained roads is eligible for partial or full funding under the RTA's Stormwater Environment Improvement Program, if it is listed in Council's Stormwater Management Plan. As per **Section 5.1.2** it is recommended that the *Bega Valley Shire Urban Stormwater Management Plan* be revised to include a list and costings for stormwater improvement measures, in accordance with the EPA's *Managing Urban Stormwater: Council Handbook*. Other funding, such as for buffer/filter strips could be sought from the Commonwealth's Natural Heritage Trust.

The nature of the piped drainage system and the variety of overland flow paths into the lake make it a complex issue to strategically target areas for SQIDs since the whole foreshore requires some level of control. This indicates that some type of foreshore buffer/filter strip would be a good means of dealing with the issue of stormwater control on a lake-wide basis (see **Sections 7.2** and **8** for further discussion).

6.3 Education Packages

6.3.1 Industry Package

It is recommended that an education package be prepared and distributed to industries, as well as managers of other potentially polluting activities within the catchment of Lake Curalo. This should cover:

- Sign posting internal stormwater drains to indicate that they should carry clean water only, as they ultimately discharge to the lake.
- Promoting dry sweeping methods to prevent polluted waters from washing down activities entering the stormwater system.
- Confining wash down activities to bunded areas where waste water can be treated, recycled or discharged to the sewer as approved by Council.
- Storing bulk liquids away from stormwater drains in a bunded area or on trays so accidental spills or leaks do not enter the stormwater system (this also makes spills or leaks easier to clean up).
- Providing information on waste management/recycling services, eg oil separating equipment, waste oil recycling services.
- Publicising procedures in case of a pollutant spill and contact numbers for organisations that can provide advice/assist in containment/clean-up (eg provision of absorbent booms). Council is currently formalising emergency spill procedures and this information could be adapted for industry.

6.3.2 Residential Package

It is recommended that a residential environmental package be developed covering:

- measures residents can take to prevent water pollution (the Sydney Coastal Council's brochure *Water Pollution it's Your Choice* could be used, or a pamphlet could be based on this) such as:
  - washing vehicles on the grass

  - composting grass clippings and garden refuse
  - collecting animal waste and disposing of it in the garbage
  - collecting and recycling oil
  - sweeping driveways and footpath areas and collecting and disposing debris in the garbage
  - covering and containing stockpiled material
  - applying chemicals (eg fertilisers, herbicides) sparingly and as directed
- removal of noxious weeds; and
- suitable indigenous plants for gardens (species lists could be developed by Council in consultation with the National Parks and Wildlife Service (NPWS) and State Forests).

6.4 Path/Boardwalk

As noted in **Section 5.4.1**, the route of the path/boardwalk around the lake would be confirmed in consultation with the Eden LALC to minimise/avoid impacts on middens. The path/boardwalk would generally be located within land currently zoned open space under DCP No.38. The boardwalk would need to be designed to take into account the impacts of flooding. Other matters which need to be considered at the planning and design stage are the security of Eden Technology High School and other premises along the route of the path/boardwalk, as well as disabled access.

As informal access is available from the lake entrance along Aslings Beach Road and through the Eden Showground Reserve, no formed path is proposed in this area. In front of the Eden Technology High School and Garden of Eden Caravan Park the path would be in the form of a boardwalk over the lake. Access to the school would be via security gates (the school prefers the current gate location near the boatshed, to maintain access for marine studies boating activities). Interpretive signs, on for instance waterbird species, could be incorporated into handrails on an associated viewing platform(s).

A boardwalk would continue around the dense stands of melaleucas and casuarinas in the southern section of Lake Curalo Reserve. A 2.5 m wide shared cycle/pedestrian path provides a link from the Princes Highway to this area. The two sections of Lake Curalo Reserve (on the western side of the lake) are separated by privately owned land zoned R1. The location of the path in this section is yet to be determined but is likely to be a combination of concrete path and boardwalk.

A path with bridges over Palestine Creek and the smaller creek to the south would need to be constructed from the northern end of Lake Curalo Reserve, with the path continuing through melaleuca/casuarina stands and eucalypt forest on the northern side of Lake Curalo. This area may also be suitable for a spur track to a viewing platform which could incorporate interpretive signs on the gradation of foreshore vegetation from saltmarsh to Eucalypt forest. A section of this land, although zoned open space, is currently in private ownership. Public access over this land would need to be negotiated with the owner.

On the northern side of Lake Curalo, informal access could be permitted over existing cleared land adjacent to the Eden Cove Estate and then to steps and a viewing platform, or viewing area on a rock ledge above the lake entrance.

On the northern side of Lake Curalo it is recommended that a less formal walking track (ie natural or cement stabilised surface) of reduced width be installed, consistent with the existing and proposed bush character of this area. The NPWS (undated) publication *Walking Track Construction Guidelines* provides a reference for

appropriate walking track and boardwalk construction. Prefabricated boardwalks and bridges are available from companies such as *Landmark*.

Current costs for boardwalk construction, based on projects in Sydney's northern beaches area, are about $500 per metre (1.5 m wide boardwalk without handrails) up to about $1,000 per metre with handrails and integral interpretive signs (pers. comm. Paul Hardy, Pittwater Council). Geotechnical conditions have a large influence on costs as they affect the length of piles required. Geotechnical investigations for Lake Curalo could be carried out in conjunction with sediment testing as described in **Section 6.1.2**.

Note that it is proposed to construct 2.5 m wide paths/boardwalks (consistent with RTA standards for shared cycle/pedestrian paths) around Lake Curalo and that commercial costs can be substantially reduced when the local community is involved in construction (pers. comm. Doug Mein, BVSC).

Large interpretive signs, eg photo-etched aluminium signs, can cost up to about $8,000 (which includes research for text and photographs, graphic design, sign manufacture, mounting structure and installation).

7 Guidelines for Management

7.1 Entrance Breakout Procedures and Monitoring

Current entrance breakout procedures are described in **Appendix A**. When the water level reaches the top of the green paint (corresponding to a level of about 1.2 m AHD) on the peg in the entrance channel, artificial breakout procedures are initiated.

As noted in **Section 4.4.2** flooding at this level is restricted to the inundation of grassed low-lying areas along the foreshore and two of the four netball courts. Accordingly, there may be some scope to increase the level (potentially to 1.5 m AHD, see **Section 4.4.2**) at which the lake is artificially opened. This may increase the longevity of entrance openings and hence tidal exchange. The EFC proposes to trial entrance openings at 1.5 m AHD, pending relocation of the netball courts.

As there is little historical information on conditions during entrance breakouts a formal recording procedure is proposed for both artificial and natural breakouts (this would also provide data for the proposed modelling, described in **Section 6.1.3**), together with the installation of survey staff gauges to determine water levels to AHD. The installation of two staffs is suggested, one near the Eden Tourist Park and the other near Emblem Street. This would allow the manager of the tourist park, members of the EFC and local residents to report water levels to Council.

The current entrance breakout procedures should be documented as set out below and further refined once further investigations and a Review of Environmental Factors are completed. To alleviate community concerns, a summary of the following information could be disseminated to residents, so they are aware of the steps taken to address potential property flooding.

Artificial opening of the lake is undertaken primarily in response to the threat of flooding to low-lying areas around the foreshore of the lake. Other possible reasons are:

- deterioration of water quality in the lake over a period of time; and
- as a response to an emergency spill within the catchment.

In some circumstances estuaries are opened in an attempt to aid recruitment of fish and prawns. However, NSW Fisheries has concluded *that without a detailed sampling and analysis of offshore and coastal larval populations, it is virtually impossible to artificially manipulate entrance opening with any certainty of enhancing fish or prawn recruitment and subsequent production. Further, artificial opening of coastal lagoons to promote production of one species or group of species may in fact disadvantage other species, with the final outcome being no net benefit* (ESC 2000).

The following procedures relate to artificial break-out for the purposes of flood mitigation.

Responsibility for Opening Lake Curalo

(a list of contact names and numbers to be included and updated as required)

- During rainfall events, Quality Assurance Inspector (QAI) – South to monitor lake water level by comparison with existing post at the end of the Aslings Beach carpark or proposed new staffs. When appropriate, a local contact is to advise the Quality Assurance Inspector of high water levels.

- Once the lake water level has reached the adopted opening level, Quality Assurance Inspector – South to seek verbal approval to open the lake from:
  - NSW Fisheries - Merimbula Office and Habitat Management Officer at NSW Fisheries Nowra office
  - Bega Valley Shire Council – Manager – Administration and Design.
- Quality Assurance Inspector to contact earthmoving contractor to undertake the mechanical breakout.

Procedure

- pilot channel to be excavated the width of a bucket and of a similar depth to the water depth on the lakeside edge of the beach berm
- excavation to start from the lakeside edge of the beach berm, as close as possible to the rock boundary on the northern side of the entrance area (length of excavation is usually 50 m)
- breakout to be timed to coincide with the highest tide of the day (pilot channel excavation usually takes two to three hours)
- Aslings Beach Life Guards to be informed of the breakout operation (when patrols are operating)
- temporary signs to be installed and/or Quality Assurance Inspector – South/Life Guards to advise spectators and body boarders to keep away from the area due to hazards associated with operating plant, pilot channel bank collapse and high velocity flows once the lake is open
- temporary signs may also need to be placed on the beach warning that the water is unsuitable for swimming as a result of the discharge of lake waters to the ocean (ie water quality may not meet ANZECC guidelines for primary contact recreation).

Entrance Monitoring

A log sheet is to be developed and completed by the Quality Assurance Inspector – South. A copy is to be provided to the Manager – Administration and Design so that data are readily available for use in further investigations.

The following data is to be recorded on a log sheet for artificial breakouts and natural breakouts (where data are applicable):

- time, date and water level for monitoring period prior to lake water level reaching the adopted opening level
- time and date when water level reached the adopted opening level
- approvals obtained – time, date, name of approvals officers
- time of high tide
- time pilot channel excavation commenced
- location and length of excavation
- preceding rainfall conditions
- maximum beach berm height across entrance channel
- ocean wave conditions (wave height and direction)
- lake level immediately prior to breakout
- time of breakout

- comments and photographs, ie:
  - to record approximate width and depth of channel and flow velocity at breakout; and
  - periodically, at least until the lake has dropped to ocean tidal levels
- water quality samples taken in lake before breakout and faecal coliform levels in ocean after breakout (as part of monitoring program described in **Section 6.1.1**, including locations/lab used/ results)
- date of closure and cause (ie lack of flow through entrance channel, build-up of beach berm, mechanical closure).

When lake opening is proposed as a result of deteriorating water quality, consultation with a wider group of State Government authorities is required, including DLWC and EPA. This is likely to occur over a period of two to three weeks before a decision is made on whether to open the lake.

7.2 Reserves/Turf Management

The following policies/practices are recommended to minimise the input of nutrients to the lake and to minimise weed invasion of bushland. These should be incorporated in plans of management for reserves and sportsfields, where appropriate, and in the proposed management plans for the Eden golf course and Eden Tourist Park.

- rehabilitation of native bushland to be undertaken, eg weed control, removal of non-indigenous species, bush regeneration, supplementary planting with species indigenous to the area – as per **Section 6.3.2** a list of suitable indigenous plant species to be developed with consideration given to species of habitat value to native animals
- landscaping/re-establishment of vegetated corridors to utilise plants grown from local seed stock to preserve genetic variability
- native vegetation to be retained and a buffer strip maintained between mown lawn and vegetated foreshores and creek/drainage lines – planting of species such as the swordgrass *Lomandra longifolia* can be used for this purpose to form an identifiable planting strip
- native grasses to be used in passive recreational areas
- control burning to be in mosaic form and have regard to fire regimes (eg frequency, intensity and season of burn) which encourage regeneration of native plants
- organic waste, such as lawn clippings not to be placed near or in Lake Curalo, tributary creeks or drains or adjacent to native bushland
- exotic vegetative material containing seed heads or capable of resprouting to be removed from site and not used for mulch
- only herbicide which is suitable for use near waterways to be used (ie herbicide with surfactant of low toxicity to fish and frogs)
- soil nutrient analysis to be undertaken to determine if fertiliser is required and if so, type, application rate, timing and application method
- only fertilisers with slow release characteristics to be used, no manure, as this is likely to be high in nitrogen

- water quality in golf course dams to be monitored for nutrients and algae – the vegetable dye, *Caribbean*, can be used in ponds to limit algal growth (ie reduce light penetration and hence photosynthesis)
- golf course ponds water levels to be kept low to prevent overflow into drainage and creeklines during storm events (suggest storage to contain up to the 1 in 5 year event, if possible)
- any stockpiled materials to be kept clear of drainage channels and creeklines
- disturbed creeklines to be managed, rehabilitated, planted out to prevent erosion
- for earthworks, slopes to drainage channels to ideally be a maximum of 1:4 and planted out where access is not required/desirable.

8 Additions/Changes to DCPs and Management Plans

Due to the large number of existing development control plans, Council's planners favour the incorporation of additional information relating to the management of Lake Curalo in Development Control Plan No.38 Eden Urban Area.

This approach is consistent with current planning practice where broad objectives and general provisions relating to development control are contained in the overall LEP with specific aims, guidelines and development controls contained in DCPs for particular localities within a local government area (LGA). The guidelines and controls are based on conserving and enhancing the desirable characteristics of an area.

Providing detailed area specific information also enables applicants to consult one document, rather than a number of policies and DCPs when preparing development applications.

8.1 Water Sensitive Urban Design

DCP No.38 identified the potential for 220 new dwellings within the catchment of Lake Curalo (see Section 2.3, **Appendix A**), ie multi-unit housing and infill developments (including industrial lots) and future releases of the Eden Cove Subdivision on the northern side of Lake Curalo.

It is recommended that DCP No.38 include references to Water Sensitive Urban Design (WSUD) and encourage applicants for urban release, infill and redevelopment to incorporate the principles of WSUD in development proposals.

The general aims of WSUD are to:

- prevent flood damage in developed areas;
- reduce stormwater runoff volumes and peaks, and the velocity of discharges;
- prevent excessive erosion of waterways, slopes and banks;
- minimise water-borne sediment loadings;
- enhance in-stream water quality;
- minimise transport from stormwater to surface or ground waters;
- improve efficiency in the use of water, and reduce demand for imported mains water;
- reduce sewer overflows in wet weather;
- protect riparian ecosystems, including restoration of degraded ecosystems; and
- promote scenic, landscape and recreational values of stream corridors (Lower Hunter and Central Coast Regional Environmental Management Strategy 1999).

WSUD comprises:

- **source controls**, eg vegetated filter strips, minimisation/design of hard surfaces to maximise infiltration, stormwater retention trenches/basins, rainwater tanks, stormwater/greywater re-use, collection, containment, treatment and appropriate disposal of contaminants in runoff (eg oil and grit)
- **conveyance controls**, eg grassed swales and open grass lined channels, natural drainage systems, water sensitive road design, landscaping.
- **discharge controls**, eg gross pollutant traps, detention basins, vegetated filter strips, constructed wetlands.

- **natural systems planning**, eg rehabilitated or natural streams, receiving waters (Lower Hunter and Central Coast Regional Environmental Management Strategy 1999)

Water Sensitive Urban Development – Implementation issues for the Lower Hunter & Central Coast (Lower Hunter and Central Coast Regional Environmental Management Strategy 1999) provides a number of specifications for source, conveyance and discharge controls, design principles and reference documents which could be used to formulate development controls.

Better Drainage (Land Systems EBC 1993) also provides information on design principles, technical issues and examples of the multiple use of drainage systems (eg nature conservation, restoration/reinstatement of creeklines, habitat enhancement, water quality improvements, recreation, education, pedestrian and bicycle access).

The *Stormwater Pollution Control Code for Local Government* (SCC 1992) provides specifications for site controls applicable to different businesses and land uses and could be used to provide advice to applicants and as a reference in formulating conditions of consent/development controls.

8.2 Specific Guidelines for Development Around Lake Curalo

As noted in Section 1.3, **Appendix A**, land at Eden is zoned 2(e) (Urban Zone), under the *Bega Valley Local Environmental Plan 1987*. Institutions, junk yards, mines and offensive or hazardous industries are prohibited within this zone and all other development (other than exempt development as defined in Council's DCP No.98) requires consent from Council.

Under DCP No.38, Lake Curalo and foreshore reserves are zoned Open Space. The open space zoning provides for active and passive recreation, conservation of vegetation and scenery, and facilities and amenities associated with sports and recreation.

The general aims and objectives of DCP No.38 include to:

- *protect the amenity of residential sectors;*
- *conserve natural resources and heritage values;*
- *allow varied uses within the township to stimulate the local economy without reducing the amenity or changing the character of a locality; and*
- *identifying existing items of environmental heritage.*

It is not considered necessary to introduce additional zones, ie an Environment Protection Zone, in view of the above controls and because more specific aims and development controls can be incorporated in the existing DCP. It is more appropriate for a review of land use zonings to be undertaken on a shire-wide basis as part of any revision of the *Bega Valley Local Environmental Plan 1987.*

It is beyond the scope of the Estuary Management Plan to specify development controls and in many cases further information is needed to formulate development standards. Development proposals are assessed on a merits basis under the *Environmental Planning and Assessment Act 1979* and overly prescriptive development controls do not necessarily result in the best outcome as they may, by their nature, prevent innovation and implementation of future best practice.

To assist in implementing the goals and objectives of the Estuary Management Plan it is recommended that specific aims and development guidelines/controls be developed and included in DCP No.38. The following principles and guidelines provide a basis for the revision of DCP No.38.

Flooding

Structures/works to:

- have no adverse impact on upstream and downstream flood levels
- not increase flood hazard or potential flood damage to other properties
- minimise loss of flood storage/channel capacity
- be able to withstand the forces of flooding
- be built from flood compatible materials below the Flood Planning Level (FPL)*

* until a flood study is completed individual property investigations will need to be carried out to determine flood levels. It is usual to adopt the 100 year average recurrence interval (ARI) flood event plus a free board of 0.5 m as the FPL

- services to be located/designed/flood-proofed so they are unaffected by the 100 year ARI flood
- where an existing dwelling floor level is below the FPL, additions/alterations, where practicable to be at FPL
- in flood affected areas pier/pile footings to be used in lieu of filling and enclosed foundations
- fences and retaining walls not to block overland flow paths

Council's Stormwater Drainage System and Natural Watercourses

- new developments to be designed so that they do not adversely impact on existing stormwater drainage systems or natural watercourses
- development adjacent to stormwater drains and natural watercourses to be sited and designed so that it is not subject to flooding for all storm events up to and including the 100 year ARI flood event

On-site Stormwater Detention

Requirements for on-site detention should be investigated as part of a floodplain management study. General principles follow:

- new developments not to increase flooding or stormwater flows in downstream areas
- the re-use or recycling of stormwater to be encouraged

Soil and Water Management

- Soil and Water Management Plans for urban release, multi-unit development and infill redevelopments to be prepared in accordance with Department of Housing (1998) *Managing Urban Stormwater: Soils and Construction.*
- other development to be managed in accordance with Council's Erosion and Sediment Control Policy (currently in preparation)

Acid Sulfate Soils

It is recommended that the *Bega Valley Local Environmental Plan 1987* adopt the Model LEP to trigger development consent for works that may affect acid sulfate soils.

- Acid Sulfate Soils Management Plan to be prepared for all development/works likely to disturb acid sulfate soils as mapped by DLWC, unless a preliminary site assessment identifies that potential acid sulfate soils are not present

- assessment and management of acid sulfate soils to be in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee 1998)

Landfill/Earthworks

- landfill/earthworks not to create siltation of waterways or drainage lines, mar the landscape or landforms, degrade or destroy areas of ecological significance, nor degrade or destroy neighbouring bushland or wetlands
- landfill/earthwork areas to be appropriately rehabilitated/revegetated

Dredging

- any dredging of Lake Curalo to be confined to that which falls under the provisions of SEPP No.35 – Maintenance Dredging of Tidal Waterways

Built Form

This encompasses a number of matters which are outside the scope of the Estuary Management Plan, eg spatial separation of buildings, solar access etc. Only matters relevant to the management of Lake Curalo and aspects covered in the Visual Amenity Report (see **Appendix D**) are addressed below.

- height, form and bulk of buildings to ensure minimal visual impact on Lake Curalo and its setting
- buildings not to protrude above the existing tree line (where applicable) - two storeys is a reasonable maximum for areas in the vicinity of Lake Curalo
- view sharing to be achieved by maintaining established de facto building lines, minimising excessive height of structures, and/or designing and locating buildings to be sympathetic to the topography of the site and view lines from other properties
- roof lines of proposed developments to preferably match the slope of the land - gabled and hipped roof forms preferred to skillions
- muted building tones and materials with low reflectivity to be encouraged (appropriate colours include green-grey, olive greens, light brown)

Setbacks/Buffer Zones

In accordance with DCP No.24:

- animal boarding, breeding and training establishments, pig farming or poultry farming not to be located within 150 m of permanent surface waters (eg Lake Curalo, creeks and drainage lines) – this has implications for how the agricultural plot at Eden Technology High School is managed
- development involving on-site disposal of sewage (eg septic tanks), not to be located within 150 m of permanent surface waters

Also:

- 100 m buffer zones to be maintained between permanent surface waters and land application of treated effluent (eg surface spray irrigation, surface drip and trickle irrigation, subsurface irrigation and absorption systems)
- on-site sewage management to be in accordance with DCP No.99
- 100 m vegetated buffer zones to permanent surface waters to be encouraged to provide stormwater filter strips and wildlife habitat corridors

Landscaping

- native ridgeline, creekline and foreshore vegetation to be protected and maintained
- existing mature trees to be retained where possible
- landscaping of new development to enhance and complement the natural environment and surrounding landscape character, reinstate elements of the natural environment, reduce the visual bulk and scale of development, and complement the design of the proposed development - use of indigenous species is encouraged
- landscaped buffer area to be established between developed areas and the foreshore open space to soften visual impact (eg exposed fences at Lake Curalo Reserve)
- construction of new fences fronting Lake Curalo and foreshore reserves to preferably be from open, see-though, dark coloured materials

Natural and Cultural Environments

- flora and fauna habitats, including wetland areas, to be protected in a manner that is consistent with their conservation value, while also recognising the need for and appropriate nature of other uses of the foreshores and the lake
- indigenous trees, shrubs and ground cover to be retained, regenerated and planted wherever possible to increase the canopy cover, habitat values and to improve the natural landscape character of the area
- water quality in Lake Curalo to be maintained and improved to provide a healthy habitat for aquatic and birdlife and for water-based recreational pursuits, through the application of appropriate development controls
- environmental heritage, including the archaeological resources of the foreshores and littoral zones, to be protected and interpreted

Public Access

- as opportunities arise, additional foreshore open space to be reserved
- access to the lake from foreshore reserves to be provided and used to promote the area's scenic and educational resources
- recreational activities and development to be encouraged which are in keeping with the natural character of the lake and which do not adversely affect the amenity of the lake and its foreshore residents
- priority to be given to public recreational activities which require, or are enhanced by a foreshore location
- pedestrian and bicycle links through the area and to the lake to be reinforced
- encroachment of residential uses into public reserves to be eliminated
- vehicle access and storage of canoes and dinghies etc not to be permitted on public reserves.

Where applicable aims and development controls based on the above principles and guidelines should also be included in Draft Development Control Plan No.89 - North Eden Small Holdings.

8.3 Management Plans

The policies and practices outlined in **Section 7.2**, where appropriate, should be incorporated in the Eden Local Urban Reserves Plan of Management, Eden Sportsground Reserves Plan of Management and the proposed plans of management for the golf course and Eden Tourist Park. The Eden Local Urban Reserves Plan of Management should be expanded to include Lake Curalo itself and open space on the northern side of the lake, fronting the Eden Cove Estate. Planning and management of this reserve should aim to conserve the bulk of the area as passive open space under native vegetation. Input from NPWS, DLWC and the Eden LALC should be sought on management objectives and actions.

Development within these reserves would be subject to DCP No.38 and appropriate aims developed for DCP No.38 should be incorporated in these plans of management.

For Lake Curalo Reserve and the reserve fronting the Eden Cove Subdivision, wetlands, areas of indigenous vegetation and foreshore areas adjacent to waterbird roosting or feeding habitats should be designated and preserved for conservation. Activities such as picnics, walking dogs, launching watercraft etc should be restricted to existing cleared and grassed areas. Community consultation would be required on appropriate areas for off-leash dog exercise.

Figure 5.1 provides the basis for development of these recreational activity/conservation 'zones'. More information is required to refine these areas based on information, such as:

- vegetation surveys including compilation of species lists and extent of weed invasion;
- identification of waterbird habitats on a seasonal basis;
- community consultation to identify appropriate areas for off-leash dog exercise; and
- investigation of recreational needs to assist in planning for additional recreational facilities/park furniture (the results of the community survey in **Appendix C** provide relevant information).

9 Assessment of Actions

The following techniques are suggested as means of monitoring the effectiveness of actions set out in **Section 5** which require evaluation.

- Assessment of trial openings of Lake Curalo at a higher level, ie mapping of flood extents and comparison of entrance log sheets (eg change in longevity of entrance openings under similar conditions, compared to records for opening at 1.2 m AHD).
- Analysis of water quality data to identify trends as well as compliance with water quality guidelines.
- Use and analysis of data bases on reports/incidents relating to water pollution, illegal tree clearing, dumping of garden refuse in foreshore reserves, harm to wildlife from fishing nets etc.
- Records of numbers of participant hours/participants in Landcare and bush regeneration group activities.
- Vegetation surveys to map increases in vegetated areas/success of planting programs and weed control programs.
- Community attitudes survey to gauge success of environmental education material, to record observations of improvements to lake water quality/ecology and utilisation of walking tracks and other reserve facilities
- Follow-up industrial area surveys to gauge implementation of appropriate environmental management practices.
- Implementation of all high priority actions by 2007.

10 References and Bibliography

Acid Sulfate Soil Management Advisory Committee (ASSMAC 1998), *Acid Sulfate Soil Manual.*

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ draft 1999), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Overview.*

Beaver D (2000), *Lake Curalo Estuary Processes Study and Management Plan Visual Amenity Study.*

Bega Valley Shire Council (BVSC), Natural Heritage Trust – Coast and Clean Seas (2000), *Twofold Bay and Hinterlands Co-ordination Strategy Issues Paper*.

BVSC (2000), Coastal Zone Management Project – Action Plans.

BVSC (1999a), *1998/1999 Supplementary State of the Environment Report.*

BVSC (1999b), Building & Planning Services Ordinary Report, 26 October 1999, DA No.99.1322: Government Road, Eden (JW) – Proposed Eden Cove Subdivision (Timms Estate).

BVSC (1997a), *Eden Sportsground Reserves Plan of Management.*

BVSC (1997b), *Eden Local Urban Reserves Plan of Management*.

BVSC (1995), *Eden Urban Overview Report 1994-2016.*

BVSC (1994), *State of Environment Report 1993.*

Bell FC & Edwards AR (1980), *An environmental Inventory of estuaries and coastal lagoons in New South Wales*, Total Environment Centre, Sydney.

Clark (2000), *Bega Valley Shire Urban Stormwater Management Plan.*

DUAP (1997), *Lower South Coast Regional Settlement Strategy.*

Environment Australia (EA 2001), *A Directory of Important Wetlands*, 3rd Edition.

EPA (2000), *Water Quality and River Flow Interim Environmental Objectives for Towamba and Genoa River*.

EPA (1999), *Environmental Guidelines: Assessment, Classification & Management of Liquid & Non-liquid Wastes.*

EPA (1997), *Managing Urban Stormwater: Council Handbook.*

ERM Mitchell McCotter (1997), *Sapphire Coast Tourism Strategy.*

ESE, Coastal and Marine Geosciences, Nelson Consulting and The Ecology Lab (2001), *Lake Curalo Estuary Processes Study*.

Eurobodalla Shire Council (ESC 2000), *Coila Lake Entrance Management Policy and Review of Environmental Factors.*

Land Systems EBC (1993), *Better Drainage – Guidelines for the Multiple Use of Drainage Systems*, prepared for NSW Department of Planning.

Lawson & Treloar (2001), *Careel Creek Floodplain Management Plan*, for Pittwater Council.

Lower Hunter and Central Coast Regional Environmental Management Strategy (1999), *Water Sensitive Urban Development – Implementation issues for the Lower Hunter & Central Coast,* published by Lake Macquarie City Council.

Nelson Consulting (2000), *Lake Curalo Estuary Management Study Questionnaire Results.*

NPWS (1996), Ben Boyd National Park Visitors Guide (pamphlet).

NPWS (undated) *Walking Track Construction Guidelines*.

NPWS (1985), *Ben Boyd National Park Plan of Management.*

NRMA (1999), *Tourist Parks Guide*, Edition 1: May 1999-May 2000.

Pittwater Council (1995), *Development Control Plan No.14 – Development Control Plan/Policy for the Pittwater Waterways.*

Pittwater Council (1994), Development Control Plan No.11 Landfill/Earthworks.

Public Works (1992), *Estuary Inventory of New South Wales.*

Robert Paton Archaeological Studies Pty Ltd (1994), *The Archaeological Sensitivity of Four Urban Investigation Areas Near Eden, Far South Coast, New South Wales.*

Sapphire Coast Tourism (1999), Current Status of Tourism on the Sapphire Coast (two page update on Tourism Strategy).

Sinclair Knight & Partners (1988), *Proposed Dredging of Lake Curalo, Eden*, *Environmental Impact Statement*.

Smith P (1991), *The biology and management of Waders (Suborder Charadrii) in NSW*, NSW National Parks and Wildlife Service.

State Forests (2000a), *Managing our forests sustainably: Forest Management Zones in NSW State Forests.*

State Forests (2000b), *Ecologically Sustainable Forest Management ESFM Plan.*

Sydney Coastal Councils (SCC 1992), *Stormwater Pollution Control Code for Local Government.*

SCC (undated), *Water Pollution it's Your Choice*, brochure.

The Ecology Lab (1999), *Lake Curalo Estuary Processes Study – Aquatic Ecology Issues.*

Warringah Council (undated), *Brookvale Industrial Education Package – Environmental Information.*