Shoalhaven City Council

TABOURIE LAKE ENTRANCE MANAGEMENT POLICY and REVIEW of ENVIRONMENTAL FACTORS

FINAL DRAFT

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PART A
Tabourie Lake Entrance Management Policy

1. PURPOSE

This Entrance Management Policy describes

- the procedures to be followed by Shoalhaven City Council for artificial openings of Tabourie Lake entrance
- the conditions that should be satisfied prior to an artificial opening
- the responses that may be requested of state agencies in response to artificial or natural opening events and
- a course of actions to approach more natural entrance behaviour.

2. POLICY CONTEXT

There are a number of State Government policies and guidelines supporting the management of estuarine lakes in a manner that promotes the maintenance of natural processes. These include the NSW State Rivers and Estuaries Policy, NSW Estuary Management Policy, Aquatic Habitat Management and Fish Conservation Policy and Guidelines, and the Water Quality and River Flow Interim Environmental Objectives for the Clyde River and Jervis Bay catchments.

The objective of the NSW State Rivers and Estuaries Policy is to manage the rivers and estuaries of NSW in ways which:

- slow, halt or reverse the overall rate of degradation in their systems,
- ensure the long-term sustainability of their essential biophysical functions, and
- maintain the beneficial use of these resources.

The NSW Estuary Management Policy (1992) is a component policy of the NSW State Rivers and Estuaries Policy (1992) it advocates the sustainable use and management of estuaries through the production and implementation of Estuary Management Plans. The Tabourie Lake Estuary Management Task Force (TLTF), the equivalent of an Estuary Management Committee, was established by Shoalhaven City Council (SCC) in 1996 to develop and implement an Estuary Management Plan for Tabourie Lake. The Tabourie Lake Estuary Management Plan was adopted by Shoalhaven City Council in 1997. The Task Force role has been broadened and its name changed to the Far Shoalhaven Natural Resources & Floodplain Management Committee.

In order to achieve the objective of protection of estuarine habitats, ecosystems and amenity, together with the sustainable use of estuarine resources there are a number of basic principles for Estuary Management Committees to apply in planning and management decision making. These principles are detailed in the Estuary Management Manual (1992) and include:

- developments and activities near intermittently opening coastal lagoons should be strictly controlled with the objective of maintaining a level of water quality suitable for fish and other aquatic life;
- whenever possible, estuarine foreshores, wetlands and aquatic habitats should be preserved in their natural state;
- estuarine habitats should be protected by appropriate zoning and development controls; this applies particularly to saltmarshes, mangroves, seagrass beds, islands and other areas of importance to nature conservation;

- developments or activities should not be allowed to restrict tidal exchange, tidal inundation of low-lying lands, or fish passage; and
- areas zoned for development should be separated by 'buffer zones' of adequate width from ecologically sensitive areas, especially wetlands.

NSW Fisheries through their publication, Aquatic Habitat Management and Fish Conservation Policy and Guidelines (1998), support minimum interference of estuarine lagoon barriers and natural processes being allowed to operate to the greatest extent possible. Further, they do not support the artificial opening of a lagoon where there is little threat to public health or safety from flooding or water quality deterioration.

The Water Quality and River Flow Interim Environmental Objectives (EPA, 1999) for the Clyde River and Jervis Bay catchments, which includes Tabourie Lake, indicates that the second biggest issue highlighted by the community was the connection between inundation from rivers and estuaries and the viability of adjoining wetlands. As such community support was expressed for objectives such as the protection of important rises in water levels and the maintenance of wetland and floodplain inundation.

One of the issues of concern to the community highlighted during the preparation of the Tabourie Lake Estuary Management Plan is the management of the entrance to Tabourie Lake. The lake's entrance has been artificially breached at least 24 times since 1987. The lake has breached naturally twice within the same period. The reason for artificially opening the lake has been to alleviate the flooding of low-lying assets including residential development. The effects upon the lake's ecology of continual artificial openings below the lake's natural breakout range have not been quantified and the repercussions of such actions are of concern to various stakeholders in the area. The preparation of an Entrance Management Policy and Review of Environmental Factors (REF) were identified as a high priority action in the Tabourie Lake Estuary Management Plan.

The Healthy Rivers Commission's Independent Inquiry into Coastal Lakes (*HRC 2002*) lists Tabourie Lake under the ***Significant Protection*** classification for management orientation. The main implication for this lake opening policy is the recommended action to implement a program to progressively minimise intervention in natural entrance behaviour (with a view to full reinstatement over a period as long as 50 years). The program would include progressive removal or modification of selected assets, as opportunities and resources are realised, that are prone to water damage, create significant inconvenience, or exacerbate public health problems when lake levels are high. Further, any new assets should be designed to not be affected by future lake opening levels.

3. AIMS AND OBJECTIVES

The aim of this Policy is to provide Shoalhaven City Council, State Government and the community with a detailed procedure for the short and long-term management of the entrance to Tabourie Lake. This policy has been prepared as part of the implementation of the Tabourie Lake Estuary Management Plan (*March, 1997*). Just as the Estuary Management Plan will be regularly reviewed and updated to incorporate new information and address the community's changing needs, so will this Entrance Management Policy.

The specific objectives of the Policy are to:

- implement a management regime which is consistent with the principles of ecologically sustainable development;
- ensure that entrance opening follows as natural a regime as possible within the constraints of property inundation and flooding;
- gain broad based community understanding and support for management of the lake entrance;
- deter unauthorised opening of the lake;
- streamline the decision-making and approval process in relation to artificial opening events;
- provide a mechanism for review and update of this policy;
- ensure the appropriate level of environmental assessment and consultation are undertaken before the lake is artificially opened;
- clarify responsibilities and accountabilities in relation to artificially opening the lake;
- clarify when, where and how the lake is artificially opened; and
- detail the procedure for monitoring the lake entrance after it has opened.

Accompanying this policy is a Review of Environmental Factors (REF), prepared in accordance with the requirements of Part 5 of the Environmental Planning and Assessment Act, 1979, for the artificial opening of Tabourie Lake. The objective of the REF is to detail the environmental impacts of artificially opening the lake, particularly on aquatic and fringing terrestrial habitats and associated animal and birdlife.

4. BACKGROUND

Tabourie Lake is a small brackish coastal lake that is intermittently connected to the sea. The village of Lake Tabourie is located east of the Princes Highway on the shores of the lake and its tributary, Saltwater Creek.

Tabourie Lake is typical of many south coast lagoons:

- **it is small and shallow** covering an area of 1.4 km^2 with depths typically less than 1m. The lake volume at Mean High Water Level is 350 ML (**M**ega or million **L**itres). As a result of the lake's small size relative to the catchment (43 km^2), water levels are responsive to rainfall.
- **urban development is limited** (~2% of the catchment area) and mostly confined to low-lying areas on the southern side of the lake entrance;
- **it is an intermittently opening lagoon which is periodically closed to the sea by a sand bar.** Since water level records were continuously recorded in 1990, the lake has been open for about 47% of the time.
- **the condition of the lake's entrance will play a part in the character of the estuarine ecosystem** including the composition of plant and animal species, water quality, tidal and flooding characteristics;
- **it is a popular tourist and recreation area**, with the permanent residential population of 620 swelling five fold during peak holiday periods overloading septic sewerage systems; and
- **the entrance is opened more often artificially using mechanical equipment for the purpose of flood mitigation than by natural rainfall events**. From 1987 to 2005, the lake was mechanically opened 24 times. In the same period the entrance has also opened naturally twice.

This lake is unusual in that:

- The shape of the lake system is mostly linear and extends in a north-south direction over 4 kilometres. The long shallow entrance channel has the potential to limit the lake discharge as it has limited flow capacity.
- Residential areas on the lake fringe are very low and flood prone.
- When the lake is open to the sea, tidal inflows are insufficient to penetrate far into the lake basin. As a result it is mostly brackish and never totally flushed by seawater. When full after a rain event, salinity as low as 1 parts per thousand (ppt) has been recorded in the lake basin.

Some low lying areas around the lake are subject to flooding when the lake level is elevated. A flood level of 2.8 metres AHD (including freeboard) is understood to apply to residential development in Lake Tabourie village.

The long-term average lake level is calculated from Manly Hydraulics Laboratory data as 0.48 m AHD***** (see note). Historically Council has maintained a policy of artificially opening the lake entrance when the water level rises to **1.17 m AHD** recorded by manual measurement at the Princes Highway bridge. Some localised flooding is experienced at or near this level. Artificial opening of the lake by Council has been in response to the lake's often rapid water level rise during rainfall events and the impact of this upon low-lying urban development.

**** Note*** *Expressing heights in metres above (or below) AHD is a surveying practice, which allows a standard comparison of levels across Australia. AHD stands for Australian Height Datum, with 0.0 m AHD being very close to mean sea level. Therefore 1.17 metres AHD is 1.17 metres higher than the average level of an ocean tide. All levels in this policy refer to AHD.*

5. DESCRIPTION OF EXISTING ENVIRONMENT

5.1 General Characteristics

The Tabourie entrance is situated at the southern end of Wairo Beach adjacent to Crampton Island. The entrance area is characterised by an expanse of unvegetated sand between the vegetated dunes to the north and south and the vegetated and unvegetated rocky outcrop of Crampton Island.

Historically the lake has established an entrance channel on the northern side of Crampton Island.

The substrate in the entrance area is completely dominated by unconsolidated and unsorted sand with varying amounts of broken shell and drying algae, such as kelp, which has been washed ashore. Sediments in this area are very mobile due to the influence of waves and the frequency of lake openings.

5.2 General Estuary Behaviour

The level, frequency and duration of entrance opening is an important determinant of the hydraulic character of the lake (that is, the frequency and magnitude of water level fluctuations and quality changes). When the entrance is open, water levels vary across the tidal range (usually attenuated) on an approximately twelve-hour cycle. When the entrance is closed, water levels tend to be stable on a daily basis (unless there is rainfall, in which case water levels will be rising).

Water levels vary to a much greater extent over a time scale of months in response to the combined impacts of rainfall, catchment runoff and evaporation. The water level could potentially rise up to 2.5 metres above mean sea level during major floods, or fall below sea level during drought conditions as a result of evaporation exceeding inflow.

Natural lake opening behaviour can be estimated by assessment of the range of heights of the entrance beach berm. This area is very active, responding both to lake openings which scour it out, and to ocean swells which can deposit large volumes of sand in short time periods. The natural maximum lake level without intervention is defined in practice by the height of the beach berm at the entrance. Information on beach berm levels has been made available to support this study (**Table 1**).

Table 1: Range of beach berm levels at Tabourie Lake entrance that would control natural lake opening levels.

Date	Beach Berm Level (m AHD)	Comment	Time Since Entrance Closure (months)
1978	2.0	Maximum berm level reported in *EMS 1994*	Not known
21 April 1986	1.6	Aerial photogrammetry DIPNR	Not known
14 May 1993	1.4	Aerial photogrammetry DIPNR	Closed for 2 months
1 February 2005	1.5	Aerial photogrammetry DIPNR	Closed for 2 months
June 2005	1.7 to 1.8	Survey by SCC	Closed for 6 months

The limited data of **Table 1** suggests that the maximum level that the lake would attain prior to commencement of natural breakout would very rarely exceed 2.0m AHD. The lake would periodically open naturally at levels as low as 1.4m AHD or even lower, dependent on the sand deposition over the period since its last closure. This opening range is lower than many South Coast estuaries, possibly for two reasons:

- The lake is open relatively frequently so opportunities for sand build-up are limited, and

- the northern entrance area is partially protected from dominant southerly ocean waves by Crampton Island and the sand tombolo, resulting in less onshore-directed forces that tend to build up entrance berm height in more exposed locations.

Table 1 suggests a trend that the longer the lake has been closed, the higher the beach berm. This is plausible to some extent, but the berm height will ultimately be limited by other factors such as wave energy and sand supply.

5.3 Acid Sulphate Soils

In NSW, acid sulphate soils have been mapped in every estuary and embayment along the coastline. Acid sulfate soils are those that have been formed in low energy, depositional environments over the last 6,000 years. As the entrance to Tabourie Lake is a highly dynamic area, consisting predominantly of recently deposited marine sands, acid sulfate soils are not expected to occur in the area where the entrance opening is proposed to be carried out.

5.4 Water Quality

Salinity

Shoalhaven City Council's quarterly water quality database indicates that during those times when the entrance channel is open, the salinity of the water in the lake and tidal tributaries is commonly around that of seawater (that is, 35 to 36 parts per thousand - ppt). After heavy rain, even when the lake is open, salinity in the whole lake can temporarily drop to levels of 10 to 15 ppt. The lowest salinity level recorded in the main lake basin on one occasion was 1 ppt (11 February 1992), when the lake received 230 mm of rain in the two days prior to sampling. Other than this one event, salinity levels in the main lake basin have more routinely fallen to 10 to 12 ppt on a number of occasions following rainfall of up to 160mm. Normally the lake would open shortly after these rainfall events.

Nutrients

The Estuary Management Study (EMS) reports low levels of nutrients (both nitrogen and phosphorus) in the main lake basin and Tabourie Creek on one occasion after detailed sampling when the lake was open and flushing was maximised. However a more detailed examination of Council data which focuses on the lower estuary creeks indicates on average high total phosphorus levels, regardless of the condition of the entrance. Nitrate levels are also elevated. Guideline values for both phosphorus and nitrogen were routinely exceeded in Saltwater Creek and Tabourie Creek.

Monthly sampling of nutrient concentrations was carried out in Tabourie Lake, by the then Tabourie Lake Estuary Management Task Force. Sampling encompassed the period from April 1998 to March 1999. Sampling was carried out at eight sites within the lake and its tributaries. Results indicated that for much of the year nutrient concentrations were below the (old) guideline values set by ANZECC (1992) for the protection of aquatic ecosystems (*Coastcare et al., 1999*). These values are 0.1 mg/L for total phosphorous and 0.75 mg/L for total nitrogen. The only sites where the guideline values for total nitrogen were exceeded on more than one occasion were Munno Creek and one site in the main lake basin. New guideline values set by ANZECC (2000) are more stringent than the 1992 guidelines, and much of the lake exceeds these values regularly. However the new guidelines are difficult to apply to ICOLLs as they are designed for open estuary systems.

Chlorophyll a

Chlorophyll a is used as an indicator of microscopic algal biomass (such as phytoplankton) and can indicate if algal blooms are occurring. Chlorophyll a concentrations recorded by Council have exceeded ANZECC (2000) trigger values (0.004 mg/L) in the two sites monitored on 8 occasions

since this indicator was first measured in 1994. Both sample sites are in the lower estuary and readings were highest as expected when the lake was closed. All episodes of high biomass occurred during the months November to March, indicating the role that higher temperatures can play in increasing biomass production, if sufficient nutrients are available. This will be an issue for intermittently open, shallow estuaries such as Tabourie Lake.

Dissolved Oxygen

Dissolved oxygen is a fundamental component of a healthy functioning aquatic system. Typically DO concentrations will vary through the day and night, with higher values during daylight hours. No night recordings of DO are available. Daytime readings by Council indicate most DO concentrations are at healthy levels. A few records indicate some concern in warmer months with low DO (< 6 mg/L) noted throughout the lake when closed in February 1991 and again in February 1995. Wind blowing across shallow estuaries such as Tabourie can mask otherwise low DO recordings.

Faecal coliforms

Faecal coliform monitoring has been carried out quarterly since 1989, by Shoalhaven City Council. Monitoring has been at fifteen sites within the lake and its tributaries. The median value of this pooled data is 8 cfu/100mL (colony forming units per 100 millilitres). The guideline value set by ANZECC (1992) for primary contact recreation (for example, swimming and direct contact water sports) is a median value of 150 cfu/100ml calculated over the bathing season. The 90th percentile value of the pooled data is 150 cfu/100ml, as such for 90% of the time faecal coliform levels in Tabourie Lake are better than the guideline level.

5.5 Flora

The lake supports six natural vegetation communities:

- sandy entrance barrier and Crampton Island tombolo. This is a highly dynamic habitat which is essentially unvegetated consisting of unconsolidated sands with variable amounts of shell and beached seaweed. This can be an important shorebird resting and nesting area. The area is several hundred metres across and is flanked by higher dunes supporting a range of common dune species such as coastal wattle *Acacia longifolia var sophorae,* coastal teatree *Leptospermum laevigatum,* spiny matt rush *Lomandra longifolia* and coastal banksia *Banksia integrifolia*. *Spinifex sericeus* and *Cakile spp*. may also be present.
- lake waters, sand banks and unconsolidated sediments of the lake bed. These support *Zostera capricorni* and *Z. muelleri* on the sandier sediments of the entrance channel, and *Ruppia sp.* and filamentous algae over the black organic muds of the main basin.
- fringing *Casuarina glauca* and *Eucalyptus botryoides* swamp forest,
- *Melaleuca ericifolia* shrublands,
- *Juncus krausii* reedlands,
- saltmarsh dominated by *Sarcocornia quinqueflora, Selliera radicans, Mimulus repens* and *Sporobolus virginicus.*

ENDANGERED ECOLOGICAL COMMUNITIES declared under Part 3 of Schedule 1 of the Threatened Species Conservation (TSC) Act (1995) exist along the lake foreshore. Saltmarshes in the region are listed under **Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions.** Saltmarshes are globally threatened, with threatening processes including infilling, modified tidal flow, weed invasion, damage by domestic and feral animals, human disturbance, altered fire regimes and climate change.

Landward of the saltmarsh community is a second endangered ecological community dominated by *Casuarina glauca* - **Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions**. This community occupies low-lying fringes of estuaries; habitats where flooding is periodic and soils show some influence of saline ground water.

Impacts on these endangered ecological communities is considered in the Review of Environmental Factors.

No threatened flora species are known from Tabourie Lake or the shoreline (*Craven, October 1998, written communication*). There exists suitable habitat for the species, Sand Spurge *Chamaesyce psammogeton,* which grows in loose sand on frontal dunes and is distributed along the south coast of NSW into Victoria. This species is listed as Endangered in the TSC Act. However is not known in the Tabourie Lake area and is unlikely to be found in the entrance area due to the dynamic nature of sand deposits.

5.6 Fauna

The faunal groups considered in this policy are fish, waterbirds, frogs and mammals..

Fish

West and Jones (2001) carried out a three-year study on shallow water fish communities in 24 NSW south coast estuaries. Tabourie Lake was included in the sampling program and was sampled at a low intensity. The objective of the sampling was to provide very basic information on a large number of estuaries where no previous data had been collected on fish communities. Shallow water fish communities were sampled at Lake Tabourie during the summer and winter periods in 1999. A total of 96 fish were caught from 22 species. A total of 10 of those species are considered of commercial importance (**Table 2**).

Table 2: Total number of fish caught by each species, from Tabourie Lake during February and July 1999 (from West and Jones, 2001).

Species **(common name)**	**Number caught**
*Hyporhamphus australis** (sea garfish)	1
Urocampus carinirostris (pipefish)	2
Vanacampus poecilolaemus (pipefish)	1
Centropgon australis (fortescue)	8
Pelates quadrilineatus (trumpeter)	12
*Pomatomus saltator** (tailor)	1
*Acanthopagrus australis** (yellow-finned bream)	2
*Rhabdosargus sarba** (tarwhine)	2
*Chrysophyrs auratus** (snapper)	1
*Gerres subfasciatus** (silver biddies)	10
*Girella tricuspidata** (blackfish)	15
*Mugil cephalus** (sea mullet)	1
*Achoerodus viridis** (groper)	4
Philypnodon grandiceps (flat-headed gudgeon)	2
Favonigobius lateralis	10
Favonigobius exquisites	7
Bathygobius kreffti	1
Afurcagobius tamarensis (tamar river goby)	4
Pseudogobius olorum (blue-spotted goby)	1
Gobiopterus semivestitus	5
*Meuschenia trachylepsis** (yellow tailed leatherjacket)	4

Meuschenia species (leatherjacket)	2
TOTAL (nos. species=22)	**96**

** Commercially caught species*

Certain fish species, such as mullet and bream, and also prawns, can grow to large sizes in closed lakes. This can enhance their chances of surviving and reproducing when the lake subsequently opens and they make their way into coastal waters.

No fish species classified as threatened are known or expected to occur in the lake.

It is noted that Tabourie Lake was declared a Recreational Fishing Haven in May 2002, and is under a complete closure to commercial fishing operations. Previous to that date, commercial fishing operations comprised meshing upstream of the bridge between June and September. A summary of the commercial catches from the lake from 1984/85 to 1998/99 is given in **Table 3**. The average annual catch for the years with returns lodged over this period was 2,450 kg of finfish.

Table 3: Summary of commercial fish catch statistics for Tabourie Lake (figures represent the total catch in kilograms)

	84/5	**85/6**	**86/7**	**87/8**	**88/9**	**89/90**	**90/1**	**91/2**	**92/3**	**93/4**
Finfish catch (kg)	0	0	0	0	980	0	283	210	2008	5237

	94/5	**95/6**	**96/7**	**97/8**	**98/9**	**Total**
Finfish	611	2872	4258	5781	2250	**24,490 kg**

Note: Zero figures may indicate an absence of catch returns for that year rather than an absence of fish catch.

Recreational fishing also takes place but there is no data available regarding the extent of recreational fishing or the magnitude and nature of the catch. It is known to be a popular prawning area during the summer months. Recreational fishing is mainly restricted to the entrance area due to the shallowness of the main lake and the common abundance of *Ruppia sp.* and algal growth.

Birds

Bird species which commonly use the entrance area include seabirds and migratory waders. Silver Gulls and Common Terns frequently rest on the bare sand. Little Terns also could potentially nest in these areas although none have been recorded from the Tabourie sandspit since the 1950s (*Craven NPWS, October 1998, written communication*).

Other species such as Red-capped Plover and Hooded Plover can feed across the sand or around the shoreline. Migratory wader species such as godwits, knots and curlews feed around the shallow sandflats although in general, species from this group tend to prefer strongly tidal habitats dominated by muddy rather than sandy substrates.

Craven (*October 1998, written communication*) notes 81 species of birds that occur in the habitats within or adjoining the lake. Sixty-six of these could be loosely termed waterbirds. The species which dominate include Black Swan, Chestnut Teal, Little Pied Cormorant, Little Black Cormorant, Great Cormorant, Great Egret, Silver Gull and Masked Lapwing. Species classified as 'Endangered' or 'Vulnerable' under the Threatened Species Conservation Act (TSC Act) have been recorded from on or near the lake or its entrance area as detailed in **Table 4**.

Table 4: Bird species listed under TSC Act known at Tabourie Lake

Common Name	Scientific Name	Status (TSC Act)
Little Tern	*Sterna albifrons*	Endangered
Osprey	*Pandion haliaetus*	Vulnerable
Sooty Oystercatcher	*Haematopus fuliginosus*	Vulnerable
Pied Oystercatcher	*Haematopus longirostris*	Vulnerable
Hooded Plover	*Thinornis rubricollis*	Endangered

A list of Migratory, Marine and Resident threatened bird species whose range coincides with Tabourie Lake provided by Craven (*October 1998, written communication*), is shown in **Table 5**.

Table 5: Migratory, marine and resident threatened bird species whose range coincides with Tabourie Lake

(Craven, October 1998, written communication).

	Habitat / Occurrence
Migratory Shorebirds	
Sanderling	Potentially rare visitor. Could possibly benefit from artificial opening in the short term due to exposure of intertidal flats for feeding.
Great Knot	"
Greater Sand Plover	"
Lesser Sand Plover	"
Broad-billed Sandpiper	"
Black-tailed Godwit	Potentially common visitor. Could possibly benefit from artificial opening in the short term due to exposure of intertidal flats for feeding.
Grey Ternlet	Potentially use the sand spit for resting.
White Tern	"
Terek Sandpiper	Potentially rare visitor. Could possibly benefit from artificial opening in the short term due to exposure of intertidal flats for feeding.
Marine Pelagic Birds	
Osprey	Recorded from site. Would feed in the area. Not likely to be significantly affected.
Black-bowed Albatross	Oceanic species. Not likely to be affected.
Shy Albatross	"
Providence Petrel	"
Gould's Petrel	"
Little Shearwater	"
Fleshy-footed Shearwater	"
Black-winged Petrel	"
Resident Waterbirds	
Australasian Bittern	No known records but possibly occurs in the reedbeds. Possible impacts in long term related to contraction of reedbed habitat. Not likely to be significant.
Black Bittern	No known records. Unlikely to occur.
Blue-billed Duck	Predominantly inland species. No known records and not likely to be impacted.
Freckled Duck	"
Migratory Waterbirds	
Painted Snipe	Predominantly inland species with a preference for freshwater habitats. No known records and not likely to be impacted.

Frogs

The upper reaches of Tabourie Lake's tributary creeks and fringes provide potential habitat for amphibian species as listed in **Table 6**.

Table 6: Frog species listed under TSC Act possibly occurring at Tabourie Lake

Common Name	Scientific Name	Status (TSC Act)
Green and Golden Bell Frog	*Litorea aurea*	Endangered
Giant Burrowing Frog	*Heleioporus australiacus*	Vulnerable

The Green and Golden Bell Frog *Litoria aurea* is the possible exception to the above, based on sightings in other south coast estuaries such as Meroo Lake at times of low salinity. Although not known in the immediate lake area, *L. aurea* could extend into areas of sedgeland where the water level is shallow (i.e. less than 300 mm). The species is known to utilise sedgeland communities for refuge and dispersal (*Daly et al. 1998*). The habitat of *Litoria aurea* and its successful breeding relies on areas of fresh and or lightly brackish (less than 8 parts per thousand) water in wetlands around the lake. The fringes of Tabourie Lake where creeks enter the lake is potentially able to offer these combinations of habitat at times of extremely high rainfall only. This would require frogs to relocate temporarily from permanently suitable habitat in nearby freshwater such as those at SEPP Wetland No. 275 at the Munno Creek entrance to the lake.

Mammals

One threatened mammal (**Table 7**) has been recorded within SEPP 14 wetland No 275 on the western fringe of the lake (*Biosphere Environmental Consultants 2000*):

Table 7: Threatened mammals recorded in Tabourie Lake wetlands

Common Name	Scientific Name	Status (TSC Act)
Large-footed Myotis (Fishing Bat)	*Myotis adversus*	Vulnerable

The Large-footed Myotis or Fishing Bat forages over fresh and semi-saline water, often along creeks, for insects and occasionally fish. They have been found roosting in caves, mines or tunnels under buildings and bridges, in dense foliage and tree hollows adjacent to water. At Wetland 275, two small freshwater creeks run parallel to the estuary on both sides of Munno Creek before it enters the lake. This provides ideal habitat for Fishing Bat.

5.7 Landscape Qualities

The entrance area itself, being simply a large expanse of bare sand, does not in general have strongly attractive landscape qualities when the entrance channel is closed. The adjoining ocean beach, Crampton Island and the lake's waters tend to provide a more notable visual feature under these circumstances. When the entrance is open, visual qualities tend to be more diverse, being characterised by a tidal channel passing between the ocean and the entrance lagoon.

5.8 Recreational Uses

Tabourie Lake supports a range of recreational uses including swimming, boating and fishing. The entrance area is not used for any specific purpose apart from beach activities including bathing,

surfing and fishing, and nature observation. A walking access track provides pedestrian access to the entrance area. Lower parts of this track are inundated by elevated lake levels.

5.9 Archaeology

Craven (*October 1998, written communication*) notes the existence of five sites along the shoreline of the lake. Four of these are middens and one is a shelter deposit. A large midden eroding out of the foredune face is located on the south side of the lake entrance. There are unlikely to be any adverse impacts, either direct or indirect, upon these sites as the northerly-directed lake opening would not scour sediments so as to destabilise these areas.

The extremely dynamic nature of the entrance area means that no archaeological sites exist directly within the entrance where artificial opening excavations are proposed.

6. ISSUES

The issues that need to be considered if the entrance is to be artificially opened include flooding, water quality, water based recreation and lake ecology.

6.1 Flooding

The impacts of flooding of Lake Tabourie village is a key issue to come to terms with, as the area under development is quite low in elevation. While NSW policy strives to raise the intervention level and this report investigates future actions to achieve this, flooding of residential areas remains the major constraint to this course of action.

The annual catchment runoff to Tabourie Lake is of the order of 15,500 ML (*Estuary Management Plan*). The lake's maximum storage volume (at a water level of 1.9 m AHD) is 2,204 ML, so the frequency that lake waters will rise to elevated levels would be expected to be high.

A conventional half to one day duration rainfall event of about 100 mm could raise a closed lake by up to 0.5 meters. If the lake water level were at its average level of 0.48 m AHD (when the entrance was closed), it would require about 150 mm of rainfall for the lake to attain its current opening level..

Property and Development Levels

A survey of house floor levels around the village was carries out in April 1999. This information is supplemented by a contour plan for sewerage system design made available by the Department of Commerce. Low points around the village derived from these seta of data that could be impacted by elevated lake levels are detailed in **Table 8**:

Table 8: Summary of survey data for low points around Tabourie Lake village

Location	Survey Height (m AHD)
Residential Development	
Blocks on Princes Hwy at northern end of village	1.0 to 1.2
Blocks at northern end of Oak Avenue (low backyards)	1.7
Floor level – garages and sheds at low houses on Oak Avenue and Princes Hwy (estimated)	1.3 to 1.6
Floor level - lowest houses on Oak Avenue	1.84, 1.98, 1.99
Blocks on Princes Hwy (south of stormwater drain)	1.9
Floor level - lowest houses on Princes Hwy	1.92, 1.98, 1.99
Floor level - lowest house on Centre Street	1.99
Blocks on Princes Hwy south of lowest area	1.9 to 2.3
Blocks along length of Oak Ave on Saltwater Creek	2.0 to 2.1
Blocks on Centre Street on Lake	1.9 to 2.2
Blocks at end of Paterson Close on Saltwater Creek	2.5
Blocks on Weymouth Street south	2.8 to 2.9
Other Development	
Lake Tabourie Tourist Park - lake frontage camp sites	1.6
Road Levels	
Oak Avenue (north of bridge)	2.0 to 2.1
Intersection of Oak Avenue / Centre Street	2.2
Intersection of Weymouth Rd / Portland Way	2.2
Corner Torquay Drive / Portland Way	2.2

Location	Survey Height (m AHD)
Corner Portland Way / Ludsworth Cres south	2.3
Corner Portland Way / Ludsworth Cres north	2.4
Corner Beach Street / Dermal Street	2.5
Princes Hwy at northern end of village	2.5 to 2.6
Centre Street at Saltwater Creek Bridge	3.1

It can be seen that a small number of highway-frontage blocks at the northern end of the village would be the first to suffer inconvenience when the lake reaches a level of 1.0 to 1.1 meters AHD. Low-level inundation reaching underneath houses and in backyards has occurred for a short time in past lake openings. Note that house floor levels are not reached until a level of 1.92 in this area.

It is assumed in developing this policy that inundation of residential yards for a short time is only acceptable provided an opening is imminent. At present if the lake level is close to the opening level (1.17 m AHD), it is foreseeable that levels could continue to rise to inundate the yards of these lowest blocks before plant arrives on site to open the entrance and the lake level drops. Issues related to the sustainability of private property at levels as low as 1.0 to 1.2 meters AHD would therefore need to be addressed before the intervention level for lake opening could be significantly raised.

The next trigger that would require intervention is possibly at 1.6 to 1.7 m AHD, affecting camping areas at the Caravan Park and one backyard in Oaks Avenue. The floor level of the lowest house on Oak Avenue at 1.84 m AHD is a major constraint. Garages attached to houses along Oaks Avenue in particular are estimated at a floor level of 1.5 to 1.6 m AHD (note that these levels are estimated as garages were not included in house floor level surveys). Delays in opening the lake, if levels around 1.4 m AHD were attained could subject Council to damages claims if flooding of garages and houses were to eventuate.

This suggests that the next highest intervention level (once house yards on the Princes Highway were addressed) could be as low as 1.3 m AHD to allow a freeboard to the house or garage level. A better hydrological understanding of the timing of the lake's rise in response to rainfall is required in order to better judge the magnitude of risk associated with a freeboard allowance.

A detailed Flood Study and subsequent Floodplain Management Plan have not been undertaken for Tabourie Lake. A flood study for the village is understood to be proposed to commence shortly. That process will aid the understanding of issues such as the sustainability of and potential costs of damages to low houses and garages, the timing of the lake's flood response and capacity of the entrance channel to discharge floodwaters. Implementation of a Floodplain Management Plan would be a necessary precursor to raising lake opening intervention levels beyond the current level of 1.17 m AHD.

Sewerage Issues

During April 1999 Council surveyed all septic tanks and floor heights in the village below 3 m AHD (**Table 9**). This data has been adjusted to reflect current conditions, with some low septic systems having been replaced.

There is one septic tank below the 1.75 m AHD level, the lowest a pump-out tank at 1.7 m AHD. There are an additional 13 properties with septic tank levels between 1.75 and 2 m AHD. Disposal systems are a mix of pump-out and septic trenches. Areas of the foreshore with low septic absorption trenches are on the Princes Highway, Oaks Avenue and the northern side of Centre Street.

Table 9: Survey of septic tanks at Tabourie Lake (April 1999).

Survey Height (m AHD)	Number of properties with septic tanks below this level
1.25	0
1.50	0
1.75	1
2.00	13

While the opening policy to date has considered flooding of septic tanks to be the limiting criterion, inundation of absorption trenches would render them ineffective in terms of treatment of nutrients. These trenches are generally 0.5 to 0.6m deep, are located in areas as low as 1.4 m AHD, and so would be compromised with lake levels above about 0.9 m AHD. Many trenches would be sited well within an acceptable buffer distance to the lake. It is concluded that even at low lake levels, effluent seepage to the lake would probably impact locally on water quality. Adjustment of the intervention level would therefore not be warranted to attempt to alleviate nutrient impacts from flooded trenches.

It is expected that the village of Tabourie Lake will be connected to a reticulated sewage system by the end of 2006. This will alleviate much of the concern about water quality impacts from septic systems on the estuary. We would recommend no raising of the intervention level until these low lake frontage houses are all connected to the scheme. A new intervention level would then be dependent on implementation of a Floodplain Management Plan as discussed earlier in this section.

Small Rainfall Events

Lake openings in response to rainfall events have not been formally recorded. Based on Council records, automatic water level records from 1992 and aerial photographs, an entrance opening history has been established for Tabourie Lake from 1987 to the present (**Table 10**).

Table 10: Opening history of Tabourie Lake, 1987 to present.

Date of Opening	Type of Opening	Opening Level (m AHD)*	Closure Date	Period Open (weeks)	Period Closed (weeks)
17/8/87	Council	(1.19)	Prior to 12/11/87	<12	-
29/7/88	Council	(1.33)	Prior to 14/12/88	<20	>38
29/7/89	Council	(1.15)	Prior to 6/12/89	<18	>32
15/12/89	Council	Unknown	Unknown	Unknown	>1
4/2/90	Council	(1.16)	Prior to 5/4/90	<9	-
5/4/90	Council	(1.27)	Prior to 25/12/90	<38	-
9/6/91	***Natural***	Unknown	22/10/92	70	>23
5/12/92	Council	1.03	19/3/93	15	6
13/4/94	Council	1.2	9/8/94	17	56
16/6/95	Council	1.09	18/6/95	0	45
7/12/95 ??	Council	(1.27)	6/2/96	8	25
1/9/96	Council	1.53	21/11/96	12	29
6/3/97	Council	1.12	10/5/97	9	14
27/6/97	Council	1.17	1/7/97	0.5	7
7/7/97	***Natural***	0.83	Prior to 3/9/97	<8	1
9/10/97	Council	1.16	1/5/98	29	>5
16/6/98	Council	1.09	7/2/99	32.5	6.5
14/7/99	Council	(1.21)	14/7/99	0	22

Date of Opening	Type of Opening	Opening Level (m AHD)*	Closure Date	Period Open (weeks)	Period Closed (weeks)
15/7/99	Council	(1.32)	15/7/99	0	-
16/7/99	Council	(1.35)	24/10/99	14	-
25/10/99	Unknown	1.16	11/12/99	7	-
14/11/00	Council	1.08	12/3/01	17	48
30/8/01	Unknown	Unknown	31/1/03	70	15
16/5/03	Council	1.21	16/8/03	13	61.5
22/10/04	Council	1.21	29/12/04	10	27
9/7/05	Council	1.29	16/8/05	6	-

** Unbracketed water levels are from logger data from Manly Hydraulics Laboratory, levels in brackets are estimated by Council. Note that due to an unexplained discrepancy, Council estimates possibly over-estimate the lake level by about 0.1 meters.*

The longest recorded opening period is 70 weeks after a flood in June 1991 and again over the whole of 2002. Follow-up rainfall of 90mm in May 1992 would have helped to re-flush a partially closed channel. On average over the period since 1990 the lake has been open for 47% of the time for an average duration of about 5 months. It has been closed for 53% of the time with an average duration of closure of about 6 ½ months.

Over this period of record, there have been a number of occasions when the berm reached a height to partially block complete tidal flow, yet allowed high tide peaks to flow into and out of the lake over part of the tidal cycle. It would be expected therefore that full tidal flushing of the main lake body would only occur for a proportion of the calculated opening durations shown above.

There is no evident relationship between opening level and opening duration for this dataset. The reasons are likely that the variation in opening levels is only slight, and the variable factors such as ocean swells (to close the entrance) and follow-up rainfall (to flush out the entrance) would dominate entrance behaviour in a random pattern.

Following a lake opening, lake levels drop in response to the scouring of the entrance channel. Once breakout is achieved, lake levels from available data drop at rates of 0.2 to 0.3 metres per hour. The maximum recorded fall is 0.34 m per hour (from 1.00 m AHD to 0.66 m AHD) after an opening at 1.03 m AHD on 5th December 1992. The lake has recorded overall falls of 0.88 meters over about 4 hours in the May 1994 opening and 0.79 meters over 4 hours in the March 1997 opening.

Eventually after an entrance opening, the lake closes due to sand filling the entrance channel from ocean swells. The relatively sheltered location of the entrance in the lee of dominant southerly swells assists to maintain the entrance in an open or near open state, compared to many other South Coast estuaries which would close more rapidly and stay closed for longer periods. Local description of lake closure suggests the entrance will often meander southwards to eventually coincide with shallow water at the sand spit. Closure will normally follow shortly afterwards as more sand is available to be transported to the entrance by tidal currents at this locality.

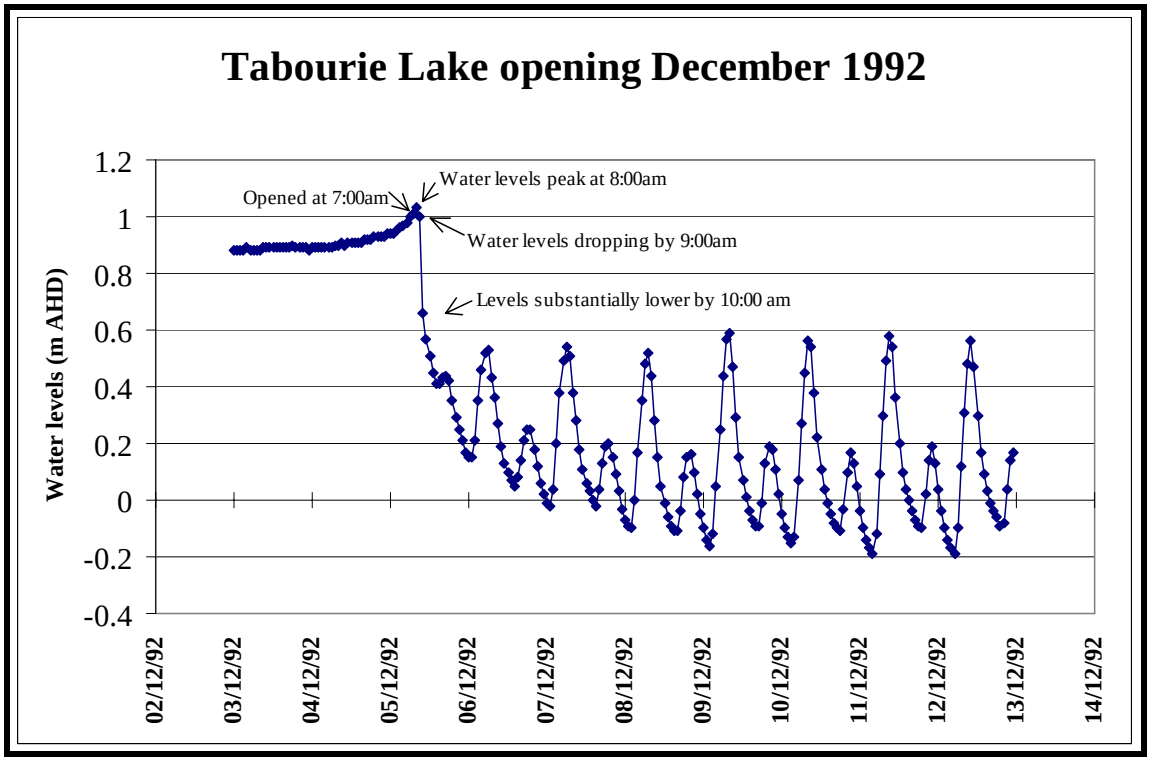
When the entrance is closed and the lake level rises slowly in response to moderate rainfall, artificially opening the entrance to the sea can prevent flood damage of low-lying assets. Historically, the lake opening level was set at 1.17 m AHD to allow for a further rise of 0.7 m before the floor of the lowest house is inundated. After comparing water level records and the recorded times of lake opening, no evidence could be found to suggest water levels continued to rise markedly after the lake was opened. On the contrary, for those openings where water level records existed, the water levels almost immediately began to drop (**Figure 1**). It is more likely that the cause of lake

levels increasing (once a decision to open the lake were made) would be due to unavoidable delays in opening the entrance caused by

- stormy seas and elevated tides, or
- time taken (4 to 6 hours) in excavating a large volume of sand and
- time for establishing a strong breakout flow that would exceed inflows.

Records were searched to determine the maximum rate of rise of lake level. Level increases over a single hour of up to 0.32 meters per hour have been recorded on 7th August 1998. Rainfall in Ulladulla of only 82mm over two days preceded this event, and as the lake was open a rising tide accounts for some proportion of the rise.

Figure 1: Water level and rainfall record for December 1992.



Over the period of record most heavy rain events have occurred while the lake has been either open to the ocean, or nearly open so that the lake response is reduced by flushing out from a partial opening. As such, it is difficult to predict the lake's response to rainfall from recorded lake behaviour.

Large Flooding Events

In a severe flood with a probability of occurring once in 100 years (that is, a 1% Annual Exceedance Probability or AEP) flows at the highway bridge are 513 m^3/s and at the lake entrance 603 m^3/s. However, the flow capacity of the entrance channel is only about 100 m^3/s, much less than the flows experienced during a major flood. There is likely, therefore, to be considerable overbank flows during major floods. It is concluded that **manually breaching the entrance bar earlier than would occur naturally, is unlikely to significantly reduce peak flood levels during major events.**

The highest known lake level is reportedly 2.5 m AHD recorded during a major flood in February 1971. Depending on ocean levels and the flow rate able to escape through the entrance and inlet

channel, the peak lake level during a major flood event could be expected to reach 3 m to 3.5 m AHD (*Estuary Management Plan*). Flood levels through the developed area along the downstream reach of the inlet channel would be somewhat lower than the main lake basin.

6.2 Water Quality

Water quality is influenced by entrance conditions which in turn affects the functioning of the lake's ecology and also recreational opportunities such as swimming. When rainfall events do not breach the entrance, any pollutant sourced from the catchment will be retained in the lake. Identifying and controlling the source of pollutants and understanding their impact on the lake's ecology is important to the protection of the aquatic ecosystem in the lake.

Because of the shallow nature of the lake, water movement would be expected to be dominated by winds when the lake is closed. This may result in increased turbidity when water levels in the lake are low.

When open to the ocean, an estuary will progressively become flushed with ocean water. In reality there is usually an incomplete mixing of ocean water with estuarine water, and some of the water that does flush to the ocean during the ebb tide returns on the following flood tide.

When Tabourie Lake is first opened to the ocean, tidal penetration into the first 250 meters of the main lake basin occurs (*Estuary Management Study, July 1994*). That is, mixing by tidal inflow will be quite limited and wind mixing would be expected to dominate when the lake is open. If all the ocean water entering the lake were to mix evenly with the lake water, a simple volumetric calculation suggests that the lake would effectively be flushed in a few days. This is not the case however as in a linear system such as Tabourie. Studies on Wagonga Inlet and Lake Illawarra have given estimates of the efficiency of entrance exchange of 20% and 30% respectively, that is, between 20 and 30% of tidal inflow remains in the lakes while 70 to 80% is unmixed and flows back out to sea on the ebb tide. Regardless of the theoretical flushing time for this lake, past reports conclude that water quality within the lake basin under tidal conditions is expected to be extremely good.

Insufficient data exists to provide accurate estimates of flushing times. In any case these estimates are not necessary for this study as manipulation of the entrance to manage water quality would involve openings at low and unsustainable levels and is not an option.

Assimilative Capacity

For Tabourie Lake, 100 mm of rain in the catchment would produce some 1,200 ML of runoff, over twice the typical volume of the lake. The lake's volume at a typical water level of 0.15 m AHD is 550 ML. The lake therefore has very limited capacity to dilute pollutants, and water quality within the lake will quickly reflect the poorer quality catchment runoff. The lake when closed does periodically exhibit conditions that suggest it can be under stress.

Balancing this tendency to concentrate pollutants, the lake has a very low trapping efficiency, as large rainfall events will result in entrance breaching. During such events all dissolved pollutants transported to the lake by catchment inflow, and some pollutants bound in lake sediments, would be expected to discharge from the lake to the ocean.

Public Health

From the water quality monitoring undertaken by Council it is evident that bacterial levels in the lake increase following rainfall. However, it is unknown whether the source of the contamination is bacteria derived from urban runoff (e.g. dogs), agricultural or forestry runoff (e.g. stock or native animals) or seepage from septic absorption trenches. It is likely that septic absorption trenches are being inundated by rising groundwater, reducing their efficiency.

The entrance of Tabourie Lake is not opened for the purposes of water quality improvement. This is not seen as a practical option for the future as the lake is most vulnerable to poor water quality at low levels (since there is less dilution at low lake volumes), yet at low levels an opening would not provide effective flushing.

6.3 Water Based Recreation

When the lake entrance is open water levels are lowered, affecting the potential for recreational activities. Conversely, when lake levels are elevated, access to shallow flats in the lake by motorised vessels is possible. Concerns over the safety of these vessels in shallow areas and the compatibility of motorised vessels with other recreational activities and their environmental impact have been raised. Nonetheless, management of lake levels for recreational purposes is not foreseen under this policy.

6.4 Lake Ecology

Flooding is an important component of the ecological processes operating in coastal lagoons. It is likely to be especially important in maintaining the character and extent of fringing wetland vegetation communities. Regular and repeated initiation of an early breakout prior to water levels filling wetlands may degrade both the wetlands and riparian vegetation. This can reduce fisheries production over the long term, and contribute to a decline in regional biodiversity.

Ecological considerations have historically not influenced decisions about when the entrance is opened. However, there are issues of bird and frog breeding that can be allowed for in planning entrance openings, within the limitations of flood mitigation.

Fauna

The distribution and abundance of fish and prawns in the lake is primarily determined by past entrance openings (that is, the season of occurrence, duration of opening and time since last opening), which allowed exchange with ocean waters. The entrance of Tabourie Lake is closed or has limited channel depth for a large proportion of the time, and it follows that the type and abundance of species found in the lake would reflect conditions within the lake, independent of the ocean and tidal cycles. The ability of larvae to enter the lake is dependent on the entrance opening randomly coinciding with recruitment seasons. This is reflected in a large variation in the historical commercial fish catch from year to year.

Bird species protected under the Threatened Species Conservation Act and international treaties are known to use the lake and entrance area. The timing of artificially opening the lake needs to take into account the breeding season of birds that may be using the entrance.

Wetland surveys in 2000 by Biosphere Environmental Consultants Pty Ltd (see following section) have detected frog and mammals in wetlands on the lake and within the catchment. Notably, the threatened species Large-footed Myotis or Fishing Bat (*Myotis adversus)* was detected in one wetland

on the western side of the lake. Although not detected in the other wetlands fringing the lake at the time of survey, it would be a likely visitor when foraging across the lake surface for insects.

The wetlands surveys detected three species of common frogs. Notably no Green and Golden Bell Frog were detected during these surveys. However there is suitable habitat for this endangered species in freshwater wetlands on the lake fringe (particularly SEPP Wetland 275 – see below).

A full list of frog and mammal species detected during these surveys is reproduced in **Table 11** in the following section.

Wetland Issues

State Environmental Planning Policy 14 (SEPP 14) wetlands are associated directly with Tabourie Lake and its catchment. The SEPP 14 wetlands fringing the lake are wetlands number 272, 273, 274, 275 and 276. Wetlands number 277 and 278 occur higher in the catchment on the tributaries draining to the lake and, being effectively landlocked, are unaffected by lake inundation. A list of frog and mammal species detected during these surveys is reproduced in **Table 11** below.

Table 11: List of species detected in 2000 in surveys of SEPP 14 wetlands fringing Tabourie Lake..

Common Name	Scientific Name
Mammals:	
European Fox	*Vulpes vulpes*
Eastern Bush Rat	*Rattus fuscipes*
Swamp Rat	*Rattus lutreolus*
Long-nosed Bandicoot	*Perameles nasuta*
Sugar Glider	*Petaurus breviceps*
Dusky Antechinus	*Antechinus stuartii*
Brush-tail Possum	*Trichosurus vulpecula*
Swamp Wallaby	*Wallabia bicolor*
Ring-tail Possum	*Pseudecheirus peregrinus*
Bats:	
Little Forest Bat	*Verspadelus vulturnis*
Southern Forest Bat	*Verspadelus regulus*
Large Forest Bat	*Verspadelus darlingtoni*
Gould's Wattle Bat	*Chalinolobus gouldii*
Chocolate Wattle Bat	*Chalinolobus morio*
Eastern Broad-nosed Bat	*Scotorepans orion*
Fishing Bat **1	***Myotis adversus***
Frogs:	
Common Eastern Froglet	*Crinia signifera*
Striped Marsh Frog	*Limnodynastes peronii*
Eastern Banjo Frog	*Limnodynastes dumerilii*

NOTES *****1*** *indicates a listed threatened species under TSC Act (1995)*
Reference - Biosphere Environmental Consultants P/L 2000

Wetland 272 covers about 5 ha adjoining Tabourie Creek. It consists of a narrow fringing band of *Casuarina glauca* forest adjoining the lake landward to a *Juncus kraussii* rushland with occasional *Phragmites australis*.

Wetland 273 covers about 22 ha on the western side of Tabourie Lake. A narrow band (about 2 m wide) of *J. kraussii* sedgeland (with *P. australis*) adjoins the lake water landward to a band of *Melaleuca ericifolia* closed shrubland (about 5 m wide) thence landward to a swamp forest of *Eucalyptus botyroides* with a *Gahnia sp.* understorey.

Wetland 274 is a long and narrow wetland of about 20 ha between the lake's eastern shore and the Princes Highway. Adjoining the lake is a fringing sedgeland of *J. kraussii* with *C. glauca* and *M. ericifolia* to the east in distinct zones. Low woodland trees link through to the highway.

Wetland 275 borders the western arm of the lake and the Munno Creek delta. The lower lying portions of the wetland are dominated by sedges. Freshwater areas run parallel to Munno Creek on both sides of the creek before it enters the lake. A small saltmarsh of *Sarcocornia quinqueflora*, *Selliera radicans*, *Mimulus repens* and *Sporobolus virginicus* adjoins the creek. Frog and mammal surveys in this wetland (*Biosphere Environmental Consultants Pty Ltd 2000*) detected the threatened mammal Fishing Bat (*Myotis adversus).* The survey noted an abundance of forest and water birds present in and on the fringes of this wetland.

Wetland 276 is centred around the delta of Lucy Kings Creek. It consists of an extensive band of *J. kraussii* and large patches of *Phragmites australis*, backed by a narrow fringe of *M. ericifolia with E. botryoides* and *Gahnia sp.* behind.

These wetlands are an integral part of the estuarine ecosystem due to the role they play in nutrient cycling, contributing organic material to the estuary and in providing habitat to various types of fauna. Less frequent inundation of these wetlands may be occurring as a result of manually opening the lake. It is unknown whether the wetlands are contracting or the composition and distribution of flora and fauna species are changing as a result of past opening policies. An entrance opening policy should aim to retain regular wetting of these wetlands, requiring information on critical levels for inundation.

Council has surveyed the fringes of **Wetland 274** in order to determine the onset of inundation as lake levels rise. The survey shows that for lake levels in the range 0.7 to 0.8 meters AHD penetrate from 150 to 300 meters into this wetland. Site inspection confirms that this level of inundation provides inundation of wetland species including Swamp Oaks in Wetland 274. Similar level information is not available for the other fringing wetlands.

Wetland 274 is situated between the lake and the Princes Highway, and lake levels above 1.4 m AHD approach the toe of the highway's western fill batter over a length of about 1 kilometre. The highway is not flooded at these levels.

7. TABOURIE LAKE ESTUARY MANAGEMENT PLAN

The Tabourie Lake Estuary Management Plan was completed in March 1997. The plan was the outcome of a lengthy investigation and consultation process initiated by Shoalhaven City Council (SCC) in accordance with the NSW Government's Estuary Management Policy. The plan was developed with close participation by members of the then Tabourie Lake Task Force, the local community, SCC Councillors and officers, and State Government Departments. The plan incorporates comments raised during public exhibition of the plan during July 1996. Each of the previously mentioned parties is involved in plan implementation.

Issues raised during development of the plan were grouped into six management areas:

1. Water Quality
2. Erosion and Sedimentation
3. Flooding
4. Visual Quality
5. Lake Ecology
6. Recreation and Tourism.

Management objectives were developed for these six management areas which ensured that the lake's key values were maintained or improved and which addressed the issues identified by the community. For each management area, a large number of alternative strategies were developed and then considered at a workshop held with the community and representatives from Council and State Government Departments.

Strategies developed to implement the plan were prioritised. Development of an Entrance Management Policy for Tabourie Lake was given Priority 1 status, and involves strategies from three of the management areas:

Water Quality Strategy 15 Develop an opening regime that will, as one of its objectives, achieve and maintain water quality within the lake consistent with ANZECC Water Quality Guidelines and that recognises social and ecological needs.

Action	**Status**	**Responsibility (Timeframe)**
Monitor water quality in major tributaries during wet weather and in the lake during and after wet weather and during open and closed lake entrance conditions to establish water quality variability	SCC monitoring ongoing. Community monitoring of nutrients began April '98	SCC (Ongoing)
Develop community based system of recording algal surface scums and algal blooms	Community monitoring began April '98	SCC/DIPNR Complete
Use results of monitoring program as input to Tabourie Lake Entrance Management Policy	Ongoing	SCC/DIPNR

Lake Ecology Strategy 5 Monitor the effect of lake opening on the ecology of the lake.

Action	**Status**	**Responsibility (Timeframe)**
Develop a monitoring program which complements monitoring of entrance conditions for feedback to entrance opening policy.	As per outlined in Entrance Management Policy	SCC (ongoing)
Monitoring to include distribution and	Fish sampling completed	NSW Fisheries

abundance of fish associated with sandy substrates and seagrass, benthos, and epiphytes on seagrass before, during and after entrance opened.	by University of Wollongong	

Flood Strategy 2 Amend existing Interim Flood Policy that ensures future developments and land use are compatible with flooding characteristics of the area.

Action	**Status**	**Responsibility (Timeframe)**
Undertake a detailed flood study to accurately establish water levels throughout the village under a range of entrance opening scenarios	Survey of all assets below 3 m AHD completed. No formal flood study produced as yet.	SCC, DIPNR (unknown)

As these strategies are implemented and the results of the monitoring and studies recommended become available, the Entrance Management Policy will be reviewed.

8. STATUTORY CONTEXT

8.1 Approvals

The following acts are to be considered as part of development of this policy:

- Environmental Planning and Assessment Act 1979
- Crown Lands Act 1989
- Threatened Species Conservation Act 1995
- Environment Protection and Biodiversity Conservation Act 1999
- Fisheries Management Act 1994 and Fisheries Management Amendment Act 1997
- National Parks and Wildlife Act 1974

Environmental Planning and Assessment Act 1979

Clause 35 of the Environmental Planning and Assessment (EP&A) Act Model Provisions has been adopted under Shoalhaven City Council's Local Environment Plan. This allows council to assess the impact of flood mitigation works under Part 5 of the EP&A Act. The obligation under Part 5 of the EP&A Act is to consider the likely environmental impacts of the activity and to consider the appropriate level of environmental assessment that is required

A determining authority *(* see below*), in this case Shoalhaven City Council, must satisfy the provisions of Section 111 of the Act in determining whether the proposed activity is likely to have a significant effect on the environment. This is generally referred to as a Review of Environmental Factors (REF), and its conclusions may take the following form:

- The proposal is not likely to have a significant effect on the environment and the determining authority can then give approval (if other requirements under other legislation and policy is satisfied).
- The proposal is likely to have a significant effect on the environment and therefore
  - the preparation of an Environmental Impact Statement (EIS) should be undertaken to enable a more detailed assessment before a decision is made, or
  - modifications to reduce any likely significant effect are in order; or
  - a decision not to proceed is made.

Either assessment should consider the impacts associated with repeat openings over a long period and under a range of conditions, rather than a single opening, so that it does not have to be reproduced each time an opening is necessary. Although this assessment is by its strategic nature a generic one, it must take into consideration specific conditions likely to be present at the time of any proposed opening. The Review of Environmental Factors (REF) that forms part of this policy serves this purpose.

> **NOTE *** *A determining authority means the public authority (for example, Council) by or on whose behalf the activity is to be carried out, or any Minister or public authority whose approval is required to enable the activity to be carried out. Therefore, SCC is a determining authority. The Department of Lands is also a determining authority by virtue of the requirement for a licence under Division 4 of the Crown Lands Act (see below). NSW Fisheries would only be a determining authority if marine vegetation is to be directly affected. National Parks would be a determining authority if there were any impacts upon threatened species or Aboriginal archaeological sites and a licence to harm or destroy was required.*

Crown Lands Act 1989

Whilst, SCC has care and control of the entrance area above mean high water mark, excavation will be below this level and will therefore affect Crown Land. Local Councils proposing maintenance dredging on Crown land are required to obtain a licence from Department of Lands under Part 4, Division 4 of the Crown Lands Act. As such, Department of Lands will be requested to issue a licence to SCC to carry out excavation across the beach at Tabourie Lake entrance in accordance with the conditions outlined in the Policy.

A land assessment prepared in accordance with the Crown Lands Act, which identifies the proposal as a preferred use, will generally be required before approval is granted. A land assessment may be waived where it is in the public interest to do so and due regard has been given to the principles of Crown land management.

In this instance the policy and REF are considered to provide valid reasons for the granting of a waiver. The licence requested will be for a period of five years (which is the period up to and including the first review of these documents), and the conditions for work to be carried out under that licence would be as outlined in this Policy.

Threatened Species Conservation Act 1995

This Act requires an assessment of whether threatened species, populations or ecological communities are likely to be affected by the activity. The Section 5a assessment is in the form of an Eight Part Test of significance. If a significant effect on threatened species is likely, a Species Impact Statement (SIS) must be completed and a licence obtained.

The policy outlines threatened species issues and responds to them in terms of entrance management objectives. The REF accompanying this policy provides detail on the threatened species that may be present in the Tabourie Lake area and provides detailed assessments of likely impacts.

Schedule 3of the Act lists Key Threatening Processes to be considered. As of December 2004 there are three threatening processes relevant to the issue of entrance management at Tabourie Lake. These are listed and assessed in the REF.

Fisheries Management Act 1994

This Act requires an assessment of whether threatened species of fish and marine vegetation, populations or ecological communities are likely to be affected by the activity. If a significant effect on threatened species is likely, a species impact statement must be completed and concurrence of or consultation with NSW Fisheries is required.

Sections 198 and 200 of the Fisheries Management Act require a local council proposing to undertake dredging works to obtain a permit. These sections do not apply if the dredging is authorised under the Crown Lands Act 1989 or by another relevant authority (other than a local government). Sections 204 and 205 (damage to marine vegetation) could apply if seagrasses were to be damaged.

The works proposed under this policy are likely to be authorised under the Crown Lands Act and will be confined to the unvegetated entrance area. There are no threatened fish species issues identified from species found at Tabourie Lake. As such, approvals under the Fisheries Management Act will not be required.

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is Commonwealth legislation that protects matters of national environmental significance. It acts in parallel with the TSC Act and requires separate tests of significance, should listed species or processes be potentially impacted by the works.

Under Part 9 of the EPBC Act (1999) an action that has, may have or is likely to have a significant impact on a matter of national environmental significance may only be taken with approval of the Commonwealth Minister for the Environment.

The EPBC Act lists migratory species protected under international agreements (JAMBA and CAMBA). For Tabourie Lake, this act is relevant to Green and Golden Bell Frog, classed as Vulnerable under the list of nationally threatened species in the EPBC Act.

National Parks and Wildlife Act 1974

It is an offence under this Act to knowingly destroy an Aboriginal site, relic or artefact. No Aboriginal site, relic or artefact has been recorded from the area where works will be carried out, and as entrance barriers are extremely dynamic environments it is unlikely that any would be present in this environment.

A licence is also required if the lake opening will impact on protected wildlife (other than threatened species). Potential impacts upon wildlife are addressed in the accompanying REF. None are identified that impact on protected wildlife.

There are no Conservation Agreements prepared under this Act for the area. There are no Plans of Management under the Act that are relevant.

State Environmental Planning Policy 35 - Maintenance Dredging of Tidal Waterways

The maintenance dredging of a tidal waterway to enable it to function as a tidal waterway, or to resume its function as a tidal waterway, may be carried out in accordance with 'State Environmental Planning Policy No. 35 – Maintenance Dredging of Tidal Waterways' (SEPP 35).

In the case of Tabourie Lake, which is intermittently open to the ocean, the purpose of maintenance dredging is to alleviate problems associated with flooding around the lake. In this case, SEPP 35 has been determined to <u>not</u> apply to the activity. Rather, Council's LEP is the relevant planning instrument. However, the requirements of Schedule 2 of SEPP 35 are considered to provide guidance to council on appropriate consultation processes with government agencies.

The State Government will ultimately replace the use of SEPP 35 for artificial openings of estuaries with the use of the licensing and approvals system (as a 'controlled activity' approval) under the Water Management Act 2000. This will replace Part 3A of the Rivers and Foreshores Improvement Act 1948, which will be repealed when the new approvals system commences. The new requirements may apply to entrance openings of Tabourie Lake.

Controlled activity approvals may be issued for up to 3 years under the Water Management Act 2000. However powers could be delegated to the council or approvals exempted for certain activities where council has adequately addressed necessary considerations. In so doing, the Department of Lands

and/or Department of Natural Resources (DNR) would have to be satisfied that the objects and principles of the act were being achieved.

The changes to the 'controlled activity' provisions of the Water Management Act 2000 are scheduled to be finalised shortly. It is envisaged that some minor amendments to this policy may be required when the Water Act requirements apply. However, the major environmental considerations of this policy or its Review of Environmental Factors would not be expected to change under the new act. Council will need to review the policy to ensure that it complies with the revisions, once they are released.

State Environmental Planning Policy 14 – Coastal Wetlands

If SEPP 14 wetlands were to be affected by direct excavation for lake opening, then the consent of Council and concurrence of the Director-General of Planning would be required. Under the SEPP, a number of matters must be taken into consideration when a development proposal is considered.

These matters include but are not limited to:

- the environmental effects of the proposed development, including effects on plant and wildlife communities;
- safeguards and rehabilitation measures which have been, or will be made; and
- whether any feasible alternative exists or has been considered.

As previously stated a number of SEPP14 wetlands exist around Tabourie Lake. As no excavation within SEPP 14 wetlands is proposed, the concurrence requirements of this SEPP are not triggered.

SEPP 71 Coastal Protection

This policy aims for improved state, regional and local planning and encourages management decisions to better protect the coast. It gives the Minister for Planning the consent authority role for specified developments or State significant developments. Proposals for development in sensitive coastal locations fall under SEPP 71.

SEPP 71 has no direct impact on the proposed lake opening activity.

8.2 Penalties

Local Government Act 1993
Under the Local Government Act 1993, Council has the authority to enforce penalties on anyone acting contrary to a notice erected on public land or in a bathing place under Section 632 (1). Signage prohibiting unauthorised openings must be adhered to.

Rivers and Foreshores Improvement Act 1948
The Department of Natural Resources has the authority to prosecute anyone who opens lagoon entrances without proper authorisation under Section 22h (2) of the Rivers and Foreshores Improvement Act 1948.

Environmental Planning and Assessment Act 1979
To artificially open the entrance without assessing the environmental impacts, obtaining the relevant approvals required, or complying with the requirements of State Environmental Planning Policies (as

outlined above) constitutes a breach of the EP&A Act. Possible penalties imposed may include rehabilitation or restoration orders and/or monetary penalties.

Threatened Species Conservation Act 1995
This act incorporates penalties for significant impacts on listed protected species without the consent of NPWS.

Fisheries Management Act 1994
Penalties apply under this act for harming marine vegetation, and for dredging and / or reclamation in a waterway, unless a permit from DPI has been applied for and granted.

9. CONSULTATION

This Entrance Management Policy, whilst not eliminating the need for consultation as guided by SEPP 35 or the need to obtain relevant approvals, will significantly streamline the process of entrance opening.

Schedule 2 of SEPP 35 establishes requirements for consultation with a range of bodies that may be affected or that have an interest in a proposed dredging operation. Although SEPP 35 does not apply to this activity, the consultation process is appropriate for this policy. The consultation period specified in SEPP 35 is 28 days. However, the unpredictable nature of rainfall often results in Council having to take urgent action within a matter of days or sometimes overnight to prevent flooding.

The purpose of this Policy is to document in advance the conditions under which the entrance is opened and gain the agreement of all affected parties to those pre-conditions for opening. When emergencies do arise, quick reference to affected parties can be made whilst still complying with the relevant legislation. It should be noted, however, if any determining authority considers that any opening activity is likely to significantly affect the environment then an EIS is required.

Should application of this policy determine that breaching of the entrance bar is likely, SCC shall give notice to the bodies listed below. It is likely that this notice would be issued when the lake attains a level above about 1.0 m AHD and rain is continuing, in order to allow advanced notice to be given.

This notice shall be in writing by e-mail or facsimile marked urgent, specifying that the lake is approaching the policy level, the reasons for opening and the proposed timing of opening.

Department of Natural Resources
Estuaries Manager
Sydney/South Coast Region
Tel. (02) 4224 9639
Fax (02) 4224 9651

Department of Primary Industry (NSW Fisheries)
Senior Conservation Manager
Huskisson
Tel. (02) 4441 8969
Fax (02) 4441 8961

Department of Environment & Conservation (National Parks & Wildlife Service)
Regional Manager, Ulladulla
Tel. (02) 4454 9515
Fax (02)

Department of Lands
Tel. (02) 4428 6900
Fax (02) 4428 6988

The Coordinator
Far South Shoalhaven Natural Resource & Floodplain Management Committee

Tel. (02) 4429 3300

Any matters concerning the opening that are raised by the above agencies shall be satisfactorily addressed by SCC prior to the commencement of entrance opening works if this is practical. For Tabourie Lake, assets are so low that emergency situations are common (when water levels have rapidly risen to or above policy levels and urgent opening for flood relief is necessary). Therefore this policy proposes that notification to the above bodies is required, but a three-day consultation period would not be relevant. This policy is subject to council satisfying itself that the accompanying REF is a suitable level of environmental assessment for each particular opening event.

The above contact details and position titles may well be amended in time. Accordingly, this list should be reviewed by council and updated from time to time. Amendment of these details does not constitute a policy amendment.

An E-mail based contact list may prove most convenient but, as this would identify individual officers and may change regularly, details are not listed within the policy. Council officers maintain a current list of relevant email contacts.

10. LAKE OPENING DECISION MAKING

10.1 Prior Entrance Breaching Conditions

Sheet 1 (attached to this policy) outlines the decision making process to be followed before an immediate entrance opening is contemplated. The logic behind this policy is the serious threat of flooding to low-lying urban areas around the lake foreshore.

The policy addresses the following flooding issues in particular:

- The rear yards and below-floor areas of at least four houses along the Princes Highway are inundated by lake levels as low as 1.0 m AHD. Although not resulting in direct damage as such, saturated soil conditions cause malodour from rotting vegetation and limit access to outbuildings if sustained for lengthy periods.
- Garages and outbuildings such as laundries and sheds in this location can flood if the lake reaches a level estimated at 1.3 to 1.4 metres AHD.
- The lowest house floor level is 1.83 m AHD.

There is a need to address extended elevated lake levels due to the impact over time on flooded yards. The policy addresses this issue by considering a lake opening if lake water levels have been at an elevated level (assessed as being above **1.0 m AHD**) for a continuous period of two months. The requisite is that after two months, lake opening can take place only in a non-breeding season for threatened shorebirds or if clearance from NPWS for the excavation has been obtained.

The following summarises conditions under which the lake entrance can be breached.

1. Conditions that are essential before mechanical lake opening occurs are:

    a) Lake water level at or exceeding 1.17 m AHD initiates an immediate entrance opening (see **Sheet 1**)

    OR

    b) Lake water level stabilises after rainfall at a level between 1.00 m and 1.17 m AHD and a period of over two months has elapsed since attaining that level;

    AND

    c) Non-breeding season for threatened shorebirds, or clearance from NPWS has been obtained.

2. The following conditions are desirable to enable a successful opening but are not essential:
    a) Continuing moderate to heavy rainfall
    b) Relatively large ocean tidal range (greater than 1.0 m) with opening to coincide with a falling tide
    c) Relatively low wave action at opening location north of tombolo.

If the above essential condition 1(a) is not met for an immediate entrance opening, a 28 day consultation period will apply after the lake attains a level at or above 1.0m AHD.

SCC shall give notice in writing by email or facsimile marked urgent, specifying that opening of the lake may be required in the near future, and the reason for and proposed timing of opening, to the bodies listed in the section above.

NOTES:
Note the gauge at the Caravan Park is currently the most reliable indicator of lake water level related to Australian Height Datum (AHD). However it is recognised that it is more convenient for both outdoor Council staff and residents if lake height information were made available closer to the village. It is therefore to be recommended that gauge plates be installed at the Princes Highway bridge and at the Saltwater Creek bridge, both sites relating lake level to AHD for consistency.

The lake level can be viewed by Council staff from the Manly Hydraulics Laboratory website. Note that a password and user number are necessary to access MHL data.

10.2 Prediction of Lake Level Response to Rainfall

Prediction of Tabourie Lake's response to rainfall is complicated by the large catchment area and the variable nature of rainfall losses. The Ulladulla daily rainfall records and lake level data display a marked variation in response to moderate rainfall events, possibly as the Ulladulla rainfall is not always representative of rainfall in the Tabourie catchment. Another reason is the variable nature of rainfall losses which over a large catchment such as this will have a major effect on resultant runoff to the lake.

As a theoretical approximation, the lake can rise about 500mm in height as a result of daily rainfall of 100mm over the whole catchment.

11. LAKE OPENING PROCEDURE

11.1 Responsibility for Opening

- The Council officer responsible for carrying out specific on site assessment in accordance with the REF, consultation and any subsequent decision to open the lake (*as per Sheet 1*) is the Manager Natural Resources Unit. In his absence, decision making responsibility will fall to the Coastal Estuaries Officer, the Director of City Services or the regional Maintenance Engineer, in that order.

- The Council officer responsible for plant management and onsite control is the Regional Maintenance Engineer, or in his absence the Maintenance Supervisor. The procedures and assessments outlined in this document will be made available to the Regional Maintenance Engineer to ensure the opening is made in the location specified.

11.2 Procedures

The procedure is to be planned so that where possible the actual opening of the lake occurs shortly after the tide turns from high to low. Ideally the initial breaching would occur 30 minutes after the published high tide time - adjusted for daylight saving time when appropriate. This timing will normally require commencement of excavation just after the low tide, as a total of 4 to 6 hours excavation across the beach would commonly be necessary.

The location of the opening is to be to the north of Crampton Island as shown in **Figure 1**. This is the most frequently occurring entrance location determined from aerial photographs and past experience.

The opening should be sufficient for scour flow to develop. The preferred size is 2 m wide with the bed graded to the ocean. An excavator will cut the channel, pushing the excavated sand as far as is feasible from the cut face. Normally excavation will commence at the ocean, working back to the lake. This procedure could be reversed, leaving a 'plug' of sand at the lake edge, should high seas hamper excavation at the ocean. The sand to be excavated will be retained on the beach and will be washed into the channel as it expands laterally. Excavated sand will not be removed from the beach area.

The possibility of possible contamination of adjacent surf beaches should be considered while the lake is emptying, for at least the first 7 days.

Appropriate action should be taken to protect public health and safety at the site while excavation equipment is operating. Under OH&S legislation, the activity of excavating a channel between the lake and the ocean requires a clear Safe Work Method statement. Given the nature of the "work" and identified hazards, a clear description of operation would address issues such as induction of operators, the use of public access barriers, temporary signage and hazards management.

Figure 2: Location of Tabourie Lake entrance channel (broken lines indicate area for excavation of entrance channel).

Aerial photography dated 25th November, 1991 (Land Information Centre).

12. ENTRANCE MONITORING

12.1 Artificial Openings

When artificial openings have been carried out, monitoring of the entrance should be undertaken (**Sheet 2**). Council's Natural Resources and Floodplain Manager and the Coastal Estuaries Officer will be responsible for coordination of this monitoring function. Monitoring is to be carried out by Council with assistance from the Natural Resources and Floodplain Management Committee members.

For each opening attempt, the following data will be recorded :

- level of lake prior to opening
- date and time of opening
- location and length of excavation
- approximate width and depth of channel
- ocean swell conditions (wave height and direction)
- preceding rainfall
- date of closure and cause if evident
- digital photographs of opening and breakout development

12.2 Natural Openings

Monitoring will also include natural entrance breakouts, recording the prior lake level, time and date of natural opening, the date of lake closure, and any other relevant comments. Monitoring is to be carried out by Council with assistance from Management Committee members.

The information is to be recorded on a standard monitoring sheet (**Sheet 2**), which is to be completed for every entrance opening, whether artificial or natural.

13. RECOMMENDATIONS

The following actions arising from this policy and a regular review of the policy are the responsibility of Shoalhaven City Council.

13.1 Policy Review and Update

Subject to funding and other constraints it is anticipated that a Floodplain Risk Management Plan for Tabourie Lake will developed, with the Flood Study commencing over the next few years. It is recommended that the assumptions of this Policy and accompanying REF be reviewed following adoption of the Floodplain Risk Management Plan. If a Floodplain Risk Management Plan is not finalised within the next five years this Policy will next be reviewed in 2010.

Following the above review, the Policy and REF should be reviewed every five years or in response to relevant legislation changes.

13.2 Recommendations for Raising the Intervention Level

This policy recommends the current lake opening level of 1.17 m AHD be retained until a Floodplain Risk Management Plan for Tabourie Lake has been developed. Urban flooding (garages and house floors) dominates considerations for entrance level intervention. A better understanding of lake response to rainfall and timing of that response will come about from a Floodplain Risk Management Plan. The Plan would consider potential flood damages and relative risk. It would develop strategies to deal with risk of flooding in low developed areas, including consideration of planning, social and economic issues.

There has been conjecture that, following the connection of lakefront houses to the proposed sewerage system, the lake intervention level should be raised. This policy finds that, despite obvious benefits to water quality from the sewerage system, this improvement will not provide opportunity for raising of lake opening levels due to the dominant urban flooding issue.

13.3 Recommendations for Threatened Species Impact Management

Implementation of this policy should be conditional upon the implementation of the following mitigation strategies:

- **Breeding activity by threatened resident and migratory shorebirds (particularly Hooded Plover, Pied Oystercatcher and Little Tern) should be checked with the National Parks and Wildlife Service prior to artificial lake opening. No excavation work across Wairo Beach is to be undertaken without consent from NPWS if birds, nests or fledglings are known to be present. Presence or absence of threatened bird species should be confirmed by NPWS upon request from council. The likely breeding period collectively extends from late August to March in any year.**

13.4 Recommendations for Water Quality Management

The design of the Tabourie Sewerage Scheme will better manage the risk of pollutants entering the waterway from septic systems and effluent holding tanks. Connection of lake-frontage houses should be made a priority. Manipulation of the lake entrance for water quality improvement in the meantime is not a feasible management option.

13.5 Recommendation for Water Level Measurement

It is recommended that a set of gauge plates over the full lake height range be installed at the Princes Highway bridge and at the Saltwater Creek bridge, both sites relating lake level to AHD for consistency. Lake height measurement shall relate to gauge readings rather than the current practice of measurement from the Princes Highway bridge kerb.

SHEET 1: IMMEDIATE ENTRANCE OPENING CHECKLIST

Is water level approaching **1.17 m AHD** at the Caravan Park gauge or proposed gauges, with rainfall continuing or forecast?

YES

Is there evidence of breeding activity by threatened shorebirds, particularly Little Tern and Hooded Plover.

NO

Proceed with artificially opening the lake entrance when gauge level of **1.17 m AHD** reached. Carry out subsequent monitoring as detailed in the Policy.

YES

Objections to proceeding with entrance opening dealt with to the satisfaction of all parties concerned.

NO

Council to modify proposal to satisfy objections.

YES

Undertake consultation as per Entrance Management Policy. Are there any objections raised to proceeding?

NO

Do not proceed with artificial entrance opening.

SHEET 2 - TABOURIE LAKE - ENTRANCE MONITORING DATA SHEET

Page ..…. of ….....

Opening Date	**Natural (N) or Artificial (A)**	**Height (m) of Beach Berm**	**Location of Breach**	Time & Date	**Lake Level** (m AHD)	**Channel Details**		
						Alignment	**Width (m)**	**Depth (m)**
				Initial Breach **(** indicates photo taken)**				
Wave Height	**Wave Direction**	**Rainfall**	**Wind Direction**	**Ongoing Channel Development**				
				Full Breakout Final Dimensions				
Closure Date -								

Initial wave height/direction ..... Preceding rainfall .....……

Initial wind strength/direction ..... Further rainfall ……

Cause of closure …….

PART B
Review of Environmental Factors for the Artificial Opening of Tabourie Lake

14. REVIEW OF ENVIRONMENTAL FACTORS OVERVIEW

Breaching of the entrance barrier to Tabourie Lake is periodically undertaken by Shoalhaven City Council (SCC) to relieve existing flooding problems, or as a flood prevention strategy where it is expected that heavy rainfall will cause water levels, which may already be high, to rise rapidly.

Shoalhaven City Council intends to assess and carry out the activity as specified in the Tabourie Lake Entrance Management Policy by utilizing the provisions of the Shoalhaven LEP and Clause 35 of the EP&A Act (1979) Model Provisions. This allows council to undertake and assess impacts of the activity under Part 5 of the act i.e. without requiring formal development consent.

This Review of Environmental Factors (REF) reviews and documents the magnitude and nature of the potential environmental impacts of artificially opening Tabourie Lake according to the procedure given in the Tabourie Lake Entrance Management Policy. It is intended to be the environmental assessment required under Part 5 of the Environmental Planning and Assessment Act. This REF is written without the benefit of knowing what exact circumstances (prior precipitation rate) will prompt SCC to open the lake, because it is impossible to undertake the environmental assessment procedures immediately prior to when the need arises.

This REF and preceding Entrance Management Policy have been prepared and considered by all relevant State Government agencies, Shoalhaven City Council and the Far South Shoalhaven Natural Resources & Floodplain Management Committee. The Policy outlines the circumstances (where, when and how) under which the entrance barrier at Tabourie Lake can be breached.

15. BACKGROUND

Under natural conditions, the frequency and duration of closure of the Tabourie Lake entrance is influenced primarily by prevailing climatic conditions. Timing and duration of closure cannot be predicted. However based on records since 1992, the lake has been open over 48% of the time and closed for 52% of the time.

With a closed entrance, and freshwater inflows from the catchment, water levels in the lake can rise to a height considerably above peak tidal levels. The highest known lake level is 2.5 m AHD recorded in a major flood in February 1971. Water levels sometimes rise rapidly (that is, within hours) following heavy rainfall. Frequently however, levels rise slowly over a period of months. Urban and rural development has taken place on, or close to, the fringes of the lake, and high water levels can cause disruption or damage to human activities and properties by inundating septic tanks and absorption trenches, the yards of residential properties, garages and residences. To manage the possible cost and inconvenience of this disruption, Council has historically adopted a policy of opening the lake whenever water levels reach 1.17 m AHD.

When the lake entrance closes, tidal flushing is eliminated. Continuing inputs of water carrying nutrients and pollutants from the catchment, combined with evaporative concentration, could lead to a gradual deterioration in water quality. Eutrophication resulting from nutrient enrichment can lead to blooms of algae and aquatic plants which in turn can cause low dissolved oxygen levels with associated impacts upon aquatic fauna. Rising water levels may flood septic tanks causing leakage of potentially harmful bacteria into the lake. High levels of faecal coliform bacteria may indicate that the lake is unsuitable for recreational pursuits that require contact with the water (for example, swimming).

16. DESCRIPTION OF PROPOSED WORKS

A channel will be excavated through the unvegetated sand barrier and adjacent shallow shoals to the north of Crampton Island in the location shown in Figure 1 using mechanical equipment - most likely an hydraulic excavator. The machine will access the site as much as possible via established roads and tracks and unvegetated areas. Particular care will be taken to avoid damage to or disturbance of vegetated areas of sand dunes.

As outlined in the Policy the excavation will only be undertaken if:

(a) Lake water level is at or exceeding 1.17 m AHD, using the existing gauge at the Caravan Park or recommended gauges in the village for height measurement, and
(b) There is no evidence of threatened shorebirds such as Little Tern and Hooded Plover undertaking breeding activities in the entrance area.

The excavated sand will be placed to one or both sides of the excavated channel and will not be removed from site. The channel dimensions cannot be specified, but the initial excavated channel will be about 2 m wide with the bed at 0.0 m AHD. Excavation will cease once a strong outward flow of water has been established. The total excavation time will typically be of 3 to 6 hours duration.

The flowing water will scour sand from the excavated channel causing the channel to enlarge and migrate, normally southwards. The degree of enlargement/migration cannot be predicted but experience at this site and at other lakes has shown that if excavation is in the area of the natural entrance channel the artificial channel will rarely exceed the dimensions, or move from the locations, that are attained by natural breakouts.

While there is no intention to establish a permanent opening, a reasonably long lasting opening is preferred to maximise the possibility of full water exchange and obviate the need for repeated intervention after a short period of time (that is, a few days or weeks). To assist with the establishment of a large and deep channel which will be slow to infill, completion of the excavated channel will generally be undertaken during the falling stage of the tidal cycle to ensure that an adequate head difference between the water in the lagoon and the ocean is maintained for the first few hours of outflow. Preference will also by given to undertaking the works during a spring tide but since these only occur for a few days every fortnight this is not always possible.

17. PURPOSE OF WORKS

The purpose of the works is to re-establish a temporary tidal connection between the lake and the ocean to allow accumulated water to flush to the ocean and thereby lower water levels below those which causes flooding problems on adjacent property.

The intention is not to establish a permanent opening. It is recognised that the entrance channel could well close again within a matter of days, although it would generally be expected that the channel would remain open for a period of weeks or months to minimise the need for further openings. The average opening duration from records is about 20 weeks.

18. ALTERNATIVES

In the short term there are no viable alternatives to artificial opening of the lake. High water levels and poor water quality conditions could remain for many months. Not interfering and allowing nature to take its course so that water levels rise until a natural breakout takes place, could result in flood damage and associated trauma to local residents and possibly even result in adverse health effects.

Rather than adopting a fixed level, a variable level could be used. This would have more ecological benefits. However the current intervention level of 1.17 m AHD represents a ceiling which it is difficult to go above. Variation could only be introduced by opening at lower levels (that is, 1.1 m or 1.0 m), which would not be ecologically beneficial. Also in reality a certain degree of variability is introduced simply because it is impossible to achieve a breakout at the precise moment of the water level reaching 1.17 m AHD. If rainfall is continuing it is most likely that the lake level would exceed this value, and levels as high as 1.53 m AHD have been experienced over the past 10 years.

In the longer term it may be possible to increase the intervention level above 1.17 m AHD by selectively flood proofing, removing or relocating those items of infrastructure which are most prone to flooding. This process is best examined incorporating social ane economic issues within the framework of a forthcoming Floodplain Risk Management Plan. The Policy recommends that this Plan is a necessary precursor to raising the intervention level.

More significant gains will become progressively more difficult to achieve as the extent of flood prone infrastructure progressively increases at higher water levels. For instance, there are seven houses in the village with floor levels located between 1.84 and 2.00 m AHD.

In the absence of a comprehensive Flood Study and Floodplain Risk Management Plan there have been no viable alternatives proposed. In the longer term the opening threshold level may be able to be increased, as the lake's hydrology is better understood and closer examination of flood mitigation options is undertaken.

It would be preferable if no intervention was required but it is not known whether this will ever be a practical alternative considering the current configuration of many building lots in the village. The Policy notes that natural breakouts would occur at lake levels nominally in the range 0.83 m to 2.0 m AHD based on a combination of known lake behaviour and inferred behaviour from historical beach berm level information.

19. RELEVANT LEGISLATION, REGULATIONS AND PERMIT REQUIREMENTS

19.1 Acts

The requirements of the following Acts as discussed in the Policy are relevant to this REF:

- Environmental Planning and Assessment Act 1979,
- National Parks and Wildlife Act 1974,
- Threatened Species Conservation Act 1995,
- Environment Protection and Biodiversity Conservation Act 1999
- Fisheries Management Act 1994 and Fisheries Management Amendment Act 1997

All considerations under these headings are listed in the accompanying Entrance Management Policy. Comments related to this REF are provided below.

Environmental Planning and Assessment Act
A determining authority (in this case Shoalhaven City Council) must satisfy the provisions of Section 111 of the Act in determining whether the proposed activity is likely to have a significant effect on the environment. This is generally referred to as a Review of Environmental Factors (REF). This document satisfies these requirements.

National Parks and Wildlife Act 1974
No Aboriginal place, relic or artefact are known to exist or are likely to exist within the entrance barrier. It is concluded that this Act will not have effect.

Threatened Species Conservation Act 1995
This Act requires an assessment of whether threatened species, populations or ecological communities are likely to be affected by the activity. This Section 5a assessment is in the form of an Eight part test of significance appended to this REF.

Fisheries Management Act 1994 and Fisheries Management Amendment Act 1997
No species listed as 'threatened' on the schedules associated with the Fisheries Management Amendment Act occur within Tabourie Lake. Therefore no Eight part test or Species Impact Statement for any fish species is required.

19.2 State Environmental Planning Policies

State Environmental Planning Policy No 14 Coastal Wetlands
A total of five State Environmental Planning Policy 14 (SEPP 14) wetlands are associated directly with Tabourie Lake. Two additional wetlands are within the lake's catchment but are on tributaries and unaffected by lake levels.

Certain activities under SEPP 14 are listed as designated development and as such require an EIS and concurrence of the Director of DIPNR. Breaching the lake entrance would normally cause fringing wetlands to become exposed. In this instance the effect is temporary and part of a natural water level fluctuation and therefore is not significant under SEPP 14.

SEPP 26 Littoral Rainforest
This SEPP is not relevant in this instance since no areas are mapped in the Tabourie Lake area.

SEPP 35 Maintenance Dredging of Tidal Waterways
The maintenance dredging of a waterway to enable it to resume its function as a tidal waterway may be carried out in accordance with 'State Environmental Planning Policy No. 35.

In the case of Tabourie Lake, the purpose of maintenance dredging is to alleviate problems associated with flooding or prolonged inundation around the lake. In this case, SEPP 35 has been determined to not apply to the activity. Rather, Council's LEP is the relevant planning instrument. However, the requirements of Schedule 2 of SEPP 35 are considered to provide guidance to council on appropriate consultation processes with State Agencies. These are adopted in the Policy.

SEPP 71 Coastal Protection
This policy aims for improved state, regional and local planning and encourages management decisions to better protect the coast. It gives the Minister for Planning the consent authority role for specified developments or State significant developments. Proposals for development in sensitive coastal locations fall under SEPP 71.

SEPP 71 has no direct impact on the proposed lake opening activity.

19.3 Local Environmental Plans
The LEP shows the entrance area to Tabourie Lake as uncoloured land. The beach on either side of the entrance channel is zoned as 6(a) - Open Space Existing.

19.4 Draft Environmental Planning Instruments on Exhibition
There are no Draft Environmental Planning Instruments on Exhibition.

19.5 Draft State Environmental Planning Policies submitted to the Minister
No draft SEPPs are of relevance.

19.6 Development Control Plans
No DCPs are relevant.

20. POTENTIAL ENVIRONMENTAL IMPACTS

20.1 General Direct and Indirect Effects

The activity can potentially affect the environment of the lake both directly and indirectly. Direct effects are likely to be localised and restricted to the sand spit and associated with the excavation of the entrance channel by machinery. They are also relatively easy to predict and mainly relate to impacts upon seabirds nesting on the sand spit. These will largely be dependent upon the season of occurrence. For example, if opening is undertaken in spring, summer or autumn there could be disruption to Little Tern nesting. Opening in winter is unlikely to cause such problems since it is outside the breeding season. The approach to entrance management recognises the possibility of these impacts within the breeding season. Lake opening works in the breeding season would follow consultation with NPWS.

Indirect impacts by contrast will affect the whole lake and adjacent ecosystems mainly by altering the hydrology. The hydrology of the lake, in particular the water level and the frequency and extent of its fluctuations, is one of the main determinants of the flora communities occupying the bed and banks of the lake.

The complex inter-relationships between the water cycle, plants and animals at the terrestrial-estuary interface makes it difficult to predict the significance of environmental impact of an artificial opening. It is possible to predict the types of impacts but very difficult to predict the ecosystem responses at the species level. The rate of change of ecosystem response may be too small to detect or directly attribute to a single artificial opening. Ecosystem and species response may only be detectable over the long term.

20.2 Water Level Impacts

Clarifying the nature and extent of potential indirect environmental impacts associated with this activity is difficult. This is due to the fact that the activity is not one that is wholly "unnatural" but simply the early facilitation of a natural process. The nature and extent of the environmental impacts will therefore depend upon the extent to which the activity departs from the natural process which is not itself able to be precisely defined due to a lack of historical data. Therefore to gain an insight into the nature and extent of the environmental impacts it is necessary to understand the natural hydrologic processes that would have operated.

It is likely that under natural conditions, entrance breaching would occur over a wide range of water levels depending upon prevailing sea and weather conditions. This is termed the 'natural breakout range' (see **Line 1 Figure 3**). Note that this is a conceptual graph. It is not intended to imply that the levels are definitive for Tabourie Lake, however available data suggests that Line 1 might be a reasonable interpretation.

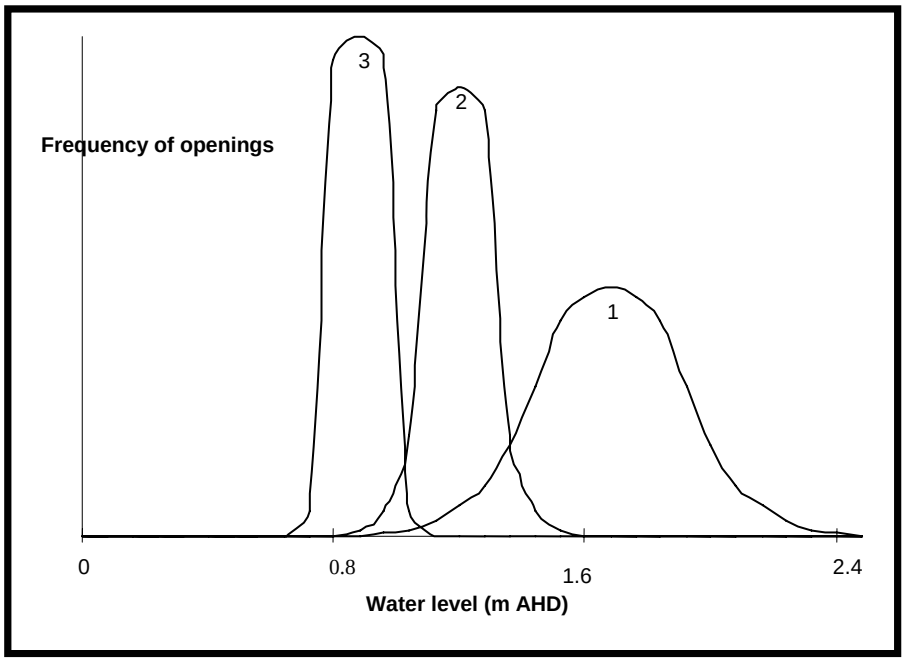
A single artificial opening within this range is not likely to have a significant environmental impact since it falls within the expected natural variation. However over the longer term, continued opening at a low level within the natural range, is likely to have an environmental impact since the frequency distribution will be significantly altered (for example, **Line 2** which may reflect the case at Tabourie Lake). A single artificial opening below the natural breakout range will also have a significant environmental impact as this would be outside the natural expected variation. However the worst scenario in terms of environmental impact is likely to be

provided by the extreme circumstances depicted by **Line 3** whereby continued opening below the natural breakout range is practised.

Records show the lake has opened naturally at a level as low as 0.83 m AHD in 1997, a little over a month after it closed. In the relatively sheltered location behind Crampton Island, coastal sand accumulation will be generally slower than many other south coast lake entrances. Beach berm levels ranging from 1.4 to 2.0m AHD have been recorded. These berm levels define by inference a range of lake levels prior to natural entrance breaching.

Nevertheless, a lake opening at the current policy level of 1.17m AHD is quite low in comparison to many other lakes in the region and the lake is not usually able to break out unassisted at this level. It is concluded that this level (1.17 m AHD) is towards the lower end of the natural breakout range.

Figure 3: Conceptual frequency distribution curves for natural breakout and artificial breakouts of a typical intermittently opening lagoon.



Line 1 *– Approximated Natural breakout frequency curve. Upper and lower limits define expected natural breakout range for Tabourie Lake inferred from historical beach berm levels.*
Line 2 *- Artificial breakout frequency curve for a level set within the natural breakout range (in this case 1.2 m AHD).*
Line 3 *- Artificial breakout frequency curve for a level set below the natural breakout range (in this case 0.85 m AHD).*

Therefore for the purposes of this REF and in the absence of any substantive evidence to the contrary it will be assumed that the intervention level adopted by the Entrance Management Policy lies in the lower quartile of the natural breakout range (Line 2). It is therefore assumed that a single opening will have minimal impact but continued opening at or close to this level will

represent a significant departure from the natural hydrologic condition over the long term. This assumption is the basis for the analysis and judgements made in the following sections.

There will be indirect impacts upon the ecosystems associated with the lake including the seagrass communities, riparian vegetation communities including endangered ecological communities under the TSC Act (1995)and fringing wetlands. In general, species occupying the area between about 0.0 m AHD and 2.4 m AHD have to contend with widely fluctuating ecological conditions. For example, they can be subject to prolonged flooding for many months with either saline or brackish water, or they can be subject to prolonged periods of drying. Those communities below 0.0 m AHD while remaining permanently wet, have to cope with salinity levels varying from almost fresh to hypersaline.

The nature of the indirect and cumulative environmental impacts can be inferred but it is extremely difficult to quantify their extent. They will likely include:

- a gradual migration of plant communities to lower levels, due to the reduced frequency and duration of flooding at higher levels,
- contraction in the areal extent of fringing wetlands due to invasion of the higher fringes by dryland adapted species,
- possible invasion of species adapted to less widely fluctuating (or more predictable) ecological conditions due to the elimination (or at least truncation) of one of the environmental extremes (i.e. flooding),
- a gradual replacement of *Ruppia* seagrass (which is adapted to brackish conditions) with *Zostera* (which is better adapted to more saline conditions) especially towards the entrance,
- accelerated shoaling of the entrance area due to reduced scouring capacity.

It is also worth noting that Tabourie Lake has been subject to entrance manipulations for many decades, and there has probably already been a degree of ecosystem shift in response to the changed hydrology. Much of the potential change may have already occurred over the last 4 decades and it is possible the system has reached a new equilibrium.

20.3 Water Quality Impacts

Water quality within the lake when it is closed is generally characterised by higher levels of nutrients and bacteria than exist in adjacent oceanic waters. Creating an artificial opening allows a certain degree of water exchange or flushing, and water quality within the lake will more closely resemble that of oceanic water especially in those areas close to the entrance. In the extremities of the lake well removed from the entrance channel, limited flushing may take place.

The lake's water quality will also be dependent upon the nature and extent of inflows from the catchment. During dry periods with little if any catchment runoff, oceanic inputs may dominate, and the lake's water quality may be similar to seawater. By contrast, during prolonged wet periods, the lake's water quality may closely reflect the quality of surface runoff.

The degree to which 'pollutants' will be flushed from the lake cannot be predicted in advance. It depends on the magnitude of the entrance channel that develops and its longevity. However, the lake's flushing time is likely to favour an improvement in water quality, even

when the period to a subsequent entrance closure is relatively short. Of course improvements in water quality conditions will not be permanent, and deterioration may occur after the entrance closes. The Entrance Management Policy, while maximising the potential for natural behaviour, will have little long-term impact on water quality.

20.4 Geomorphological Impacts

Natural breakout of Tabourie Lake would tend to occur during or soon after a significant rainfall event. Rainfall is a necessary precursor in order to raise the lake level to a level greater than the beach berm level.

The ability of the lake water to erode a deep and wide entrance channel is directly related to the head difference that exists between the lake and the ocean at the time of breakout. A higher lake level and therefore larger head difference will result in a deeper channel than would a small head difference, all other factors being equal.

Intervention in the breakout process takes place before maximum lake water levels have been reached, causing a less-than-maximal head difference and resulting in a lessened capacity to erode sediments from the entrance area. This is a temporary impact as sand volumes in this area fluctuate in response to many other factors including swell direction, swell height and duration, tide height and wind.

20.5 Impacts on Habitat and Species

Descriptions and environmental attributes of Tabourie Lake including its fringing estuarine wetlands and the beach entrance area can be found in the Entrance Management Policy.

Fish

No fish species classified as threatened are known or expected to occur in the lake.

Vegetation Communities

Vegetation communities and habitats around the lake and the lake entrance are typical of those associated with coastal areas for a large section of the south coast. They are relatively common and widespread and reasonably well represented in conservation reserves or by virtue of public ownership or planning instruments (for example, SEPP 14).

Substantially modified communities now exist within and adjacent to the urban area. Impacts upon these would not represent a significant environmental impact.

ENDANGERED ECOLOGICAL COMMUNITIES declared under Part 3 of Schedule 1 of the Threatened Species Conservation (TSC) Act (1995) exist along the lake foreshore. Threatening processes to the Tabourie saltmarsh community (**Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions)** include modified tidal flow, weed invasion and climate change.

Landward of the saltmarsh community is a second endangered ecological community dominated by *Casuarina glauca* - **Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions**. This community occupies low-lying fringes of estuaries; habitats where flooding is periodic and soils show some influence of saline ground water. Threats to the local community would include weed invasion and reduction in

salinity impacts, should lake opening practices not mimic natural regimes. These issues are discussed further in the eight-part test appended to this REF (see **Appendix 1**).

No threatened flora species are known from Tabourie Lake or the shoreline (*Craven, October 1998, written communication*). The entrance area is unvegetated and would not be expected to develop vegetation due to the frequency of disturbance to this area.

Threatened Species Impacts

Bird species classified as 'Endangered' or 'Vulnerable' under the Threatened Species Conservation (TSC) Act 1995 recorded from the region in areas of similar habitat to that provided by Tabourie Lake are Hooded Plover, Little Tern, Pied Oystercatcher, Sooty Oystercatcher and Osprey. The Green and Golden Bell Frog, listed as Endangered in the TSC Act and as Vulnerable in the Commonwealth Environment Protection and Biodiversity Conservation Act, and could potentially be present in suitable wetland habitat fringing the lake, although it has not been recorded locally. The Large-footed Myotis (Fishing Bat) is listed as Vulnerable in the TSC Act and has been recorded in wetlands at Tabourie Lake.

A list of all known threatened species whose range coincides with Tabourie Lake has been provided by Craven (*October 1998, written communication*) - these are listed in **Table 12**. The likelihood of each of these species occurring in the habitats at Tabourie Lake and the possibility that they will be impacted by implementation of the Entrance Management Policy is considered in **Table 12**.

Table 12: Threatened species whose range coincides with Tabourie Lake *(Craven, October 1998, written communication).*

	Habitat / Occurrence	Eight part Test
Resident Shorebirds		
Hooded Plover	Feed and nest around the open beaches, rock platforms and estuarine flats. Nesting activity in the entrance area could be directly impacted by machinery and associated disturbance.	Yes
Pied Oystercatcher	Nest on beaches. Could possibly benefit from artificial opening in the short term due to exposure of intertidal flats. Nesting activity in the entrance area could be directly impacted by machinery and associated disturbance	Yes
Sooty Oystercatcher	Forage on exposed rocky shorelines. Breed on offshore islands. Potentially indirectly impacted by opening works.	Yes
Migratory Shorebirds		
Little Tern	Little Terns could breed in bare sand at the entrance area. Nesting activity in the entrance area could be directly impacted by machinery and associated disturbance. Disruption of breeding activity would be a significant impact.	Yes
Sanderling	Potential visitor to the Shoalhaven coast. Could possibly benefit from artificial opening in the short term due to exposure of intertidal flats for feeding.	
Great Knot	"	
Greater Sand Plover	"	
Lesser Sand Plover	"	
Broad-billed Sandpiper	"	
Black-tailed Godwit	"	
Terek Sandpiper	"	
Grey Ternlet	Potentially use the sand spit for resting.	

	Habitat / Occurrence	Eight part Test
White Tern	"	
Marine Pelagic Birds		
Osprey	Recorded from site. Would feed in the area, fishing in clear open water. Nests in trees close to the sea. Disruption of feeding behaviour possible.	Yes
Black-bowed Albatross	Oceanic species. Not likely to be affected.	
Shy Albatross	"	
Providence Petrel	"	
Gould's Petrel	"	
Little Shearwater	"	
Fleshy-footed Shearwater	"	
Black-winged Petrel	"	
Resident Waterbirds		
Australasian Bittern	No known records. Possibly occurs in mainly freshwater reedbeds adjacent to the estuary. Feed on frogs, fish and insects in still shallow water near vegetation. Impact unlikely.	
Black Bittern	No known records. Possibly inhabits wetlands or creeks with dense vegetation particularly Swamp she-oak. Impact unlikely..	
Blue-billed Duck	Predominantly inland species. No known records and not likely to be impacted.	
Freckled Duck	"	
Migratory Waterbirds		
Painted Snipe	Predominantly inland species with a preference for freshwater habitats. No known records and not likely to be impacted.	
Amphibians		
Green and Golden Bell Frog	Preference for freshwater habitats. No known records of the species from the lake. Suitable habitat exists.	Yes
Giant Burrowing Frog	Preferred habitat open forest, woodland and heath. No known records from around the lake.	
Mammals		
White-footed Dunnart	Terrestrial species favouring open understorey in drier vegetation, notably ridges and mid-slopes. Impact unlikely.	
Large footed Myotis (Fishing Bat)	Recorded in wetlands at Tabourie Lake. Fishing bat requires creeks and lakes for foraging. Impacts related to roosting or food sources are possible but unlikely.	Yes

Based on the findings of **Table 12**, The Eight-part test is applied in **Appendix 1** to the Hooded Plover, Pied Oystercatcher, Sooty Oystercatcher, Little Tern, Osprey, Green and Golden Bell Frog, and the Large-footed Myotis (Fishing Bat) as these species based on recorded presence, or habitat, foraging and breeding preferences are judged as likely to experience impacts.

Impacts on Migratory Birds under EPBC Act

Several species that are known to forage in similar habitats in the Shoalhaven are subject to international migratory bird agreements with Japan and China as listed in the JAMBA and CAMBA Treaties. These birds are protected under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999. These species are listed in **Table 13**.

It is noted that these species would not nest in the entrance area. Impacts on these foraging migratory birds, should they be present while the lake was artificially opened, would be confined to indirect issues such as local noise disturbance for a matter of hours while machinery was operating. This does not constitute a serious disruption to the bird's life cycle.

Table 13: Regionally significant migratory bird species listed under EPBC Act possibly foraging at Lake Tabourie entrance area.

Species	Common Name	EPBC Listing
Ardea alba	Great Egret	Migratory species (JAMBA & CAMBA) listing
Haliaeetus leucogaster	White-bellied Sea Eagle	Migratory species (CAMBA) listing
Charadrius ruficapillus	Red-capped Plover	Listed Migratory species
Charadrius bicinctus	Double-banded Plover	Listed Migratory species

With consideration of the EPRB Act guidelines, the adoption of the policy would not have a significant impact on a listed migratory species. Specifically, the proposal will not:

- Substantially modify, destroy or isolate an area of important habitat of the migratory species, or
- Result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species, or
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species.

Impacts on Key Threatening Processes

Key threatening processes are listed under Schedule 3of the TSC Act. As of September 2005, there are three threatening processes that are considered relevant to the issue of entrance management at Tabourie Lake:

i) Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands,

Wetlands and floodplains around the lake verge would drain as a result of opening the lake under this policy. It is concluded that changes instigated by the policy are not permanent and for wetlands in particular maximise opportunity for inundation as far as possible.

ii) Predation by *Gambusia holbrooki*. (Plague Minnow or Mosquito Fish)

Although West et al (2001) did not detect Plague Minnow *(Gambusi holbrooki)* in Tabourie Lake, this species could conceivably colonise the lake. *Gambusia holbrooki* is a fish which is found in brackish waters. Opening the lake to discharge brackish waters and allow exchange with marine waters increases salinity levels. Conditions after a lake opening would therefore not favour an increase in population of this fish species.

iii) Infection of frogs by amphibian *chytrid* causing the disease *chytridiomycosis*

All frog species that are listed under the schedules of the Act may be affected by this disease. *Chytridiomycosis* has been reported from Green and Golden Bell Frog (*Litoria aurea*), which although not known in the Lake catchment, could be present based on habitat preference. However, the actions proposed under the policy are not known to impact on the spread of this disease or Green and Golden Bell's susceptibility.

20.6 Visual Qualities

The landscape's visual qualities are unlikely to be altered to any great extent by the construction of a channel. The lake entrance will change temporarily, but these changes will be within natural bounds. There may be some temporary creation of an unnatural appearance due to excavated sand being piled alongside the channel, but this is also likely to be short-lived as wind and water action will erode it away and reduce it to the general level of the surrounding sand spit.

20.7 Cultural Heritage

There are unlikely to be any adverse impacts, either direct or indirect, upon archaeological sites as the proposed lake opening would not scour sediments so as to destabilise these known areas. The extremely dynamic nature of the entrance area means that no archaeological sites exist directly within the entrance where artificial opening excavations are proposed.

21. CHECKLIST - MATTERS FOR CONSIDERATION

Clause 82 of the Environmental Planning and Assessment Act Regulation lists the factors to be taken into account when considering the likely impact of an activity on the environment under Part 5 of the EP&A Act. The following section deals in turn with each of the matters considered to be relevant to the artificial opening of Tabourie Lake in accordance with the Policy.

a) Any environmental impact upon a community

The community most likely to be affected will be the residents of the township of Tabourie Lake. There will be no significant adverse impact upon this community. In fact not undertaking the activity is likely to have a significant social and economic impact upon some residents.

b) any transformation of a locality

The locality will not be permanently transformed in any manner. The lake entrance and lake fringes will change temporarily, but these changes will be within natural bounds.

c) any environmental impact on the ecosystems of the locality

The possible impacts have been discussed above under Section 20.

d) any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality

There is not likely to be any reduction in the aesthetic quality or value of the locality as a result of implementing the Policy.

The recreational value could be modified as a result of implementing the Policy. Early breakout will reduce water levels across the lake reducing its capacity to support activities such as boating which are currently constrained by shallow water. This reduction may effectively range from only a few hours (that is, the lake was rising rapidly and would have broken out naturally anyway) to many months (that is, the lake was rising slowly and water levels would have stabilised at a level below that required to initiate a natural breakout).

The impact upon fish and prawn populations could have a bearing upon the recreational value of the lake. If an artificial breakout were to allow a large population of prawns to escape to sea there would be a significant loss of recreational opportunity especially if this occurred just prior to the Christmas New Year holiday period. Such a scenario would most likely occur if the breakout was initiated less than twelve months since the previous opening. However, an artificial opening could enhance recreational prawning opportunities in the following twelve months if the opening coincided with a high abundance of prawn larvae in nearshore coastal waters and there was a large influx of prawn larvae into the lake. Such conditions are impossible to predict. On balance and over the long term, the impacts are likely to be slightly negative.

Intervention in the natural breakout process diminishes the scientific value of the system since an element of ‘naturalness’ has been lost. However many ecological processes will continue to operate and the locality could still be suitably used for a wide range of scientific purposes.

e) any effect on a locality, place or building having aesthetic, anthropological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations

The only possible impact under this consideration relates to potential effects upon Aboriginal archaeological sites. As discussed above, there are no known sites within the entrance area apart from a midden in the southern sand dune - this should not be impacted to any greater degree than what might occur from a natural opening.

f) any impact on the habitat of protected or endangered fauna

The focus of this section is on those species which are rare, threatened or otherwise restricted in distribution and which could be adversely affected by opening the lake entrance.

As noted above, there are species of birds, one frog and one bat which have been recorded or potentially use the lake's habitats and entrance area that are classified as vulnerable or endangered. A detailed assessment of the potential impact of implementing the policy on these species is considered in the respective Eight-part tests included as an Appendix to this REF.

In general an artificial opening could have a significant adverse impact upon ground nesting species such as Little Tern or Hooded Plover by disrupting breeding activity (for example, pair formation, nesting, fledging). This issue is however largely theoretical, since threatened species of shorebirds haven't bred at this site for many years. Nevertheless, breeding activity for these species could feasibly take place in any year based on habitat suitability. Any loss of a breeding colony would be considered significant.

The area needs to be regularly monitored so that the existence of any shorebird breeding activity is detected. Only then will the proponent be in a position to identify and implement mitigating measures.

The lowering of the level of the lake during the breeding season of the Green and Golden Bell Frog may impact on breeding success if tadpoles were to dehydrate or were exposed to increased predation / mortality. This is considered unlikely as suitable habitat exists for Green and Golden Bell Frog on the lake's fringing wetlands, isolated from the body of the lake.

With regard to Fishing Bat, which is known in wetlands fringing the lake basin, the lowering of water levels would not impact on the species' ability to forage. A likely improvement in water clarity in the main lake basin may marginally assist the species' ability to forage in shallow water.

g) any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air

With the possible exception of the bird species classified as endangered there will be no endangering of any species of animal, plant or other life form. The special cases for the bird species are considered in Appendix 1.

h) any long term effects on the environment

The possible long term effects have been discussed above under Section 20. Cumulative effects of regular intervention in Tabourie Lake openings are identified in this document, and have possibly already been experienced over past decades.

i) any degradation of the quality of the environment

The quality of the lake environment will be degraded by virtue of the fact that a major natural process is being interfered with. In effect the lake is losing a major element of 'naturalness'. Naturalness is a significant environmental attribute. It is often a criteria used to determine environmental or conservation value.

However this happened initially many years ago, that is, it will not be a direct result of implementing the Policy, but the Policy continues to perpetuate the problem.

j) any risk to the safety of the environment

It is unlikely that the environment will be any less 'safe' as a result of implementing the Policy. The robustness or ability of the environment to withstand environmental fluctuations should not be compromised.

k) any reduction in the range of beneficial uses of the environment

There will be no reduction in the range of beneficial uses of the environment apart from those discussed under point d) above.

l) any pollution of the environment

Pollution of the environment (noise, minor diesel fumes) may be experienced for a matter of hours while construction equipment excavates a channel across the sand at the lake entrance.

m) any environmental problems associated with the disposal of waste

Nil. Sand excavated from the channel will be spread across the beach and would probably be incorporated into the channel as it expands. Alternatively, it will spread later by natural causes (wind, waves) and will not be lost to the system.

n) any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply

None are relevant.

o) any cumulative environmental effect with other existing or future activities

Other activities are likely to be based in the catchment or on the foreshore. Although it is difficult to predict other future activities that may take place, it is unlikely that implementation of the Policy would have a cumulative effect with these other activities.

22. CONCLUSIONS

The proposed activity - implementation of the Tabourie Lake Entrance Management Policy - could potentially have a significant adverse impact upon threatened shorebird species by disrupting breeding colonies or disturbing or destroying nests. This scenario could result from direct disturbance by the machinery at the time of opening or later on, due to migration of the entrance channel. Given no recent history of breeding activity for many years, this possibility is very slight. Nevertheless to guard against it, the proponent should ensure that the entrance area is regularly monitored during the spring, summer and autumn to detect breeding activity. If breeding activity is taking place, and an artificial opening is planned, the proponent must notify the National Parks and Wildlife Service to determine appropriate responses.

The proposed activity is unlikely to have a significant environmental impact upon the ecosystems of the lake in the short term. This assessment is based on the assumption that the intervention level (**1.17 m AHD**) is within, albeit at the lower end of, the natural breakout range. To mitigate against any possibility of impacts, it would be necessary to raise the intervention level. This is consistent with the precautionary principle.
Raising the intervention level while avoiding the risk of urban flooding would require better knowledge of the lake's response to rainfall than we currently possess. This possibility should be further explored once a Floodplain Risk Management Plan is adopted for Lake Tabourie.

Over the long term the proposed activity will probably have a cumulative environmental impact by causing a hydrologic and ecological shift from the natural condition. The impact will be mainly related to shifts in plant community structure and distribution, which will in turn, cause impacts upon the faunal communities. Part of this impact has probably already occurred since the Policy formalises the intervention level which has been adopted for at least four decades. It is impossible to predict the magnitude or extent of the indirect impacts without knowing more about the natural breakout range.

The impact would be considered 'significant' if the habitats and/or species affected were uncommon, rare or threatened. This is not the situation since all the habitats/species which are known or are likely to exist in the area that would be affected by artificial entrance opening are common and widespread. Nevertheless the environmental impacts are undesirable since they remove the element of 'naturalness' which is an important environmental value. There may also be impacts which remain unforeseen. Again the precautionary principle suggests it will be necessary to raise the intervention level if possible within urban flooding constraints.

There are no viable alternatives to the activity in the short term which do not have the potential to cause undue hardship and disruption to members of the local community. In the longer term it should be possible to reduce the extent of impacts by taking active measures to manage the flood risk to infrastructure that currently constrain the opening level. Management of these issues through the Floodplain Management process may allow the intervention level to be raised, thereby taking it more towards the natural range and reducing the potential for adverse environmental impacts.

In conclusion, the Policy can be implemented in the short term recognising that there are likely to be cumulative environmental impacts over the long term but there are no viable alternatives presently available. Implementation should be conditional upon the following mitigation strategies:

- Breeding activity by threatened birds particularly Little Tern and Hooded Plover, should be regularly monitored. No excavation work is to be undertaken without clearance from the National Parks and Wildlife Service if birds, nests or fledglings are known to be present in the entrance area.
- Shoalhaven City Council investigate and implement a Floodplain Risk Management Plan for Lake Tabourie village, including a better understanding of the timing of lake response to flood-producing rainfall. The Floodplain Risk Management Plan would allow examination of how the intervention level can be raised within acceptable levels of risk to residents.

23. DECLARATION

This Review of Environmental factors provides a true and fair review of the proposed activity - implementation of the Tabourie Lake Entrance Management Policy - in relation to its potential effects on the environment.

Having considered this document, and the factors listed in Clause 82 of the Environmental Planning & Assessment Regulations, Shoalhaven City Council is of the view that the proposed activity - the implementation of the Tabourie Lake Entrance Management Policy - **will not** have a significant adverse environmental impact.

…….. ……

Signed ***Date***

For Shoalhaven City Council

24. ACKNOWLEDGEMENTS

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Appendix 1 - Eight part test

The eight-part test will be applied to the listed threatened species **Green and Golden Bell Frog, Little Tern, Pied Oystercatcher, Sooty Oystercatcher, Hooded Plover, Osprey and Large-footed Myotis,** as these species were either detected in the area, or based on habitat preference are likely to utilise the beach at the entrance, the waters of the lake or wetlands on the lake fringe on occasions.

Two endangered ecological communities on the lake foreshore - **Swamp Oak Floodplain Forest and Coastal Saltmarsh** - are also assessed under this eight-part test.

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

Green and Golden Bell Frog breed in a wide variety of habitats that include man made ponds and dams. They also utilise intermittently closed or open (to the sea) lakes and lagoons (ICOLLs) if salinity levels are suitable. In a recent study at Meroo Lake, adult frogs were observed calling from on top of submerged aquatic plants (Sea Tassel *Ruppia polycarpa*) (Gaia Research, 2003). Subsequently tadpoles were found in the lake. Although the concentration of the lake at this time was a very low 3 ppt, tadpoles of Green and Golden Bell Frog can tolerate concentrations up to 7-8 ppt (Pyke and White, 2002).

The lowest salinity level recorded in the main Tabourie Lake basin on one occasion was 1 ppt (11 February 1992), when the lake received 230 mm of rain in the two days prior to sampling. Other than this one event, salinity levels in the main lake basin have more routinely fallen to 10 to 12 ppt on a number of occasions following rainfall events of up to 160 mm. Salinity levels suitable for frog breeding or tadpole survival would be extremely infrequent.

Freshwater habitat is available adjacent to the lake waters which did not reveal GGBF during frog and mammal surveys (Biosphere Environmental Consultants, 2000). A fuller assessment of the potential impact of opening the lake should be adequately assessed, if the presence of GGBF were to be determined. Breeding would on probability not be impacted.

The Little Tern is migratory and leaves eastern Australia outside the summer breeding season and moves north into Asia (Higgins and Davies, 1996). The species is found in Australia from September to March.

The Little Tern inhabits sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand spits (Higgins and Davies, 1996). The species nest on raised sandy areas within 150 m of the tideline, most within 5 m of the high tide mark in areas with sparse (5 %) vegetation cover (Higgins and Davies 1996). They forage in shallow waters of estuaries, coastal lagoons and lakes, usually over channels next to spits and banks, often close to the breeding colonies (Higgins and Davies, 1996).

Smith (1995) states that the Little Tern historically nested at nine sites in the area, from Shellharbour to Meroo Lake. Oven the last 40 odd years there has been a dramatic decline in the records of nests in the region. The only sites where the species regularly nests in the Shoalhaven are Comerong Island, Lake Conjola and Lake Wollumboola (Smith 1996). There are no recent records of breeding attempts by Little Terns at Tabourie Lake although a colony of 20 is known from 1950. Therefore the potential to cause disruption to this species is remote.

The opening of Tabourie Lake would have a minor impact on the foraging habitat for the Little Tern. Should artificial lake opening become necessary under this Plan during the breeding season, contact prior to channel excavations should be made with National Parks officers at Ulladulla to determine whether this species is present in the entrance area and if mitigating actions are available.

The Pied Oystercatcher occurs on the coast especially in intertidal mudflats, sandbanks and open beaches (Marchant and Higgins, 1993). They forage on exposed sand, mud, rock or coral for molluscs, worms, crabs and small fish (Marchant and Higgins, 1993).

They nest on areas of sand immediately above the high-water mark of beaches, sand bars and margins of estuaries and lagoons (Marchant and Higgins, 1993). Usually two eggs are laid in an unlined scrape between September and December in southern Australia (Marchant and Higgins 1993).

The opening of Tabourie Lake would have a minor impact on the foraging habitat for the Pied Oystercatcher. Should artificial lake opening become necessary under this Plan during the breeding season, contact prior to channel excavations should be made with National Parks officers at Ulladulla to determine whether this species is present in the entrance area and if mitigating actions are available.

The Sooty Oystercatcher is strictly a marine coastal species, which usually occurs within 50 m of the shore (Marchant and Higgins 1993). It prefers rocky intertidal shorelines where it forages for molluscs, crustaceans, polychaetes, echinoderms and small fish (Marchant and Higgins, 1993).

Adult Sooty Oystercatchers are territorial and often breed on offshore islands. Sooty Oystercatcher will nest from August to March, but nesting locations would be well removed from the entrance area. The opening of Tabourie Lake would have a minor impact on the foraging habitat for the Sooty Oystercatcher.

In south-east Australia the Hooded Plover prefers sandy ocean beaches, especially those that are broad and flat, strewn with beach cast seaweed with a wide wave-wash zone for feeding (Marchant and Higgins, 1993). Usually between 2-3 eggs are laid between August and March in depressions in the sand (Marchant and Higgins, 1993). It feeds during the day and at night in the sand at all levels in the zone of wave wash during low and mid-tide for polychaetes, molluscs, crustaceans, insects, turions and seed (Marchant and Higgins, 1993).

The opening of Tabourie Lake would have a minor impact on the foraging habitat for the Hooded Plover. Should artificial lake opening become necessary under this Plan during the breeding season, contact must be made with National Parks officers at Ulladulla prior to channel excavations, to determine whether this species is present in the entrance area and if mitigating actions are required.

The Osprey has littoral habits but also occurs in terrestrial wetlands in tropical and temperate Australia and offshore islands (Marchant and Higgins, 1993). They feed mostly on fish but also take small terrestrial vertebrates, seabirds and crustaceans (Marchant and Higgins, 1993). They require extensive areas of clear open water for fishing (Marchant and Higgins, 1993).

Ospreys are mostly sedentary but forage over a large area. They show a high fidelity to nest sites (Marchant and Higgins, 1993). They breed mostly on coasts and islands and the nest is positioned in a prominent position on rocky headlands, stacks, cliffs in dead trees or artificial platforms near the ocean or large waterbodies (Marchant and Higgins 1993). The opening of Tabourie Lake would have a minor impact on the foraging habitat for the Osprey.

The Large-footed Myotis forages over fresh and semi-saline water often along creeks for insects and occasionally fish (Robson, 1984). They have been found roosting in caves, mines or tunnels under buildings and bridges, in dense foliage (Dwyer, 1970) and tree hollows adjacent to water. The opening of Tabourie Lake would have a minor impact on the foraging habitat for the Large-footed Myotis. There is no impact on vegetation around the lake edge such that this species' habitat would be impacted.

2. In the case of an endangered population, whether the life cycle of the population that constituted the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,

No populations currently listed under Part 2 Endangered populations of Schedule 1 occur in the area. No assessment is required.

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

The NSW NPWS defines the region as the Sydney Basin, which roughly extends from Batemans Bay north to Newcastle and west to Lithgow and Muswellbrook. Habitat of the Green and Golden Bell Frog, Pied Oystercatcher, Sooty Oystercatcher, Hooded Plover, Little Tern, Osprey and Large-footed Myotis has now been included in the reserve system as a consequence of the Regional Forest Agreement.

Some of the additional areas now within the reservation system that contain potential or realised habitat utilised by the above species include Conjola NP, Meroo Lake NP (3641 hectares), Barnunj SRA (164 hectares) and Murmuring NP.

As salinity ranges are unsuitable for Green and Golden Bell Frog to breed in Tabourie Lake, the opening of the lake will not modify a significant area of known habitat. While Large-footed Myotis could forage in the lake waters, opening the lake would cause no negative impact on this activity. In fact as water clarity improves subsequent to lake openings, foraging activity could be improved.

With regard to the subject endangered ecological communities on the lake foreshore, removal is not proposed under the policy. Further, these communities are expected to have stabilised to some extent in response to the last four decades or more of lake opening at similar levels to those proposed. Further modification of these communities is not expected as a result of adopting the policy.

4. Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,

The opening of the lake will not isolate interconnected habitat of Threatened species or endangered ecological communities.

5. Whether critical habitat will be affected,

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. No critical habitat has been listed for these species.

6. Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,

The NSW NPWS defines the region as the Sydney Basin, which roughly extends from Batemans Bay north to Newcastle and west to Lithgow and Muswellbrook.

Habitat of the Pied Oystercatcher, Sooty Oystercatcher, Hooded Plover, Little Tern, Osprey and Large-footed Myotis is conserved in several conservation reserves in the region.

For the subject Threatened species, the adequacy of the number within the reservation system is complicated by the large home ranges (Sooty Oystercatcher, Pied Oystercatcher, Osprey and Hooded Plover) and seasonal occurrence (Little Tern) of several species. Hence, conservation of these species requires the retention of habitat within and outside of the reservation system.

The Green and Golden Bell Frog are considered to not be well represented in conservation reserves (or other similar protected areas) in the region. GGBF is known from only about 40 sites in NSW (White & Pike, 1996.), the majority of which are outside the reserve system. GGBF has been detected in the last six years from Yuragir National Park (Clancy, 1996), Hat Head NP, Meroo Lake NP (Gaia Research, 2003) and Nadgee Nature Reserve (G Daly, pers. comm.).

With regard to the subject endangered ecological communities on the lake foreshore, these communities are considered to be well represented in conservation reserves (or other similar protected areas) in the region.

7. Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,

Schedule 3 of the TSC Act (1995) lists "the alteration of rivers and streams and their flood plains and wetlands" as a Key Threatening Process. The proposed development is considered a threatening process under this definition. **Section 8** of the Opening Policy and **Section 20** of this REF discuss relevant aspects of hydrology and water level impacts.

Three anthropogenic processes have predominantly altered flows in streams, rivers and their floodplains and wetlands in NSW. These are a) building of dams (including all dams and weirs and off-river storages); b) diversion of flows by structures or extraction and c) alteration of flows on floodplains with levees and structures (including those on wetlands to allow water storage). The issue as a Key Threatening Process has little relevance to the species addressed in this test.

Schedule 3 of the TSC Act (1995) lists 'Predation by *Gambusia holbrooki*. (Plague Minnow or Mosquito Fish)' as a Key Threatening Process. Although West et al (2001) did not detect Plague Minnow *(Gambusi holbrooki)* in Tabourie Lake, this species could conceivably colonise the lake. *Gambusia holbrooki* is a fish which is found in brackish waters. Opening the lake to discharge brackish waters and allow exchange with marine waters increases salinity levels. Conditions after a lake opening would therefore not favour an increase in population of this fish species.

Schedule 3 of the TSC Act (1995) lists 'infection of frogs by amphibian chytrid causing the disease *Chytridiomycosis'* as a Key Threatening Process. *Chytridiomycosis* is potentially fatal to all native species of amphibian. As such, all frog species that are listed under the schedules of the Act may be affected by the disease. *Chytridiomycosis* has been reported from Green and Golden Bell Frog (*Litoria aurea*), which although not known in the Tabourie Lake catchment is addressed under this test. However, the actions proposed under the policy are not known to impact on the spread of this disease or GGBF's susceptibility.

8. Whether any threatened species, population or ecological community is at the limit of its known distribution.

Historical the Green and Golden Bell Frog species' natural distribution ranged from Tyagarah Nature Reserve in the north (in ponds created from sand mining M. Fitzgerald pers. comm.) to east Gippsland (Gillespie, 1996). However, since the 1980's the species has had a rapid decline in distribution and abundance over much of its range (Mahony, 1996, Osborne *et al.*, 1996).

Green and Golden Bell Frog is currently known from only about 40 sites in NSW (White and Pike, 1996), the majority of which lie within one kilometre of salty water or water that contains contaminants such as copper and/or arsenic. The exceptions are a population on the southern tablelands, near Hoskinstown (Wassens and Mullins, 2001) and another in the Hunter Valley around sewerage treatment ponds near Lake Liddell (G. Daly pers. obs.).

In NSW populations have been detected within the last five years from Yuragir National Park (Clancy, 1996) and Hat Head in northern NSW south to Nadgee Nature Reserve. These populations are isolated and often small. A number of large (over 30 adults) populations of *L. aurea* occur in the Shoalhaven Local Government Area, however none are known to occur within the catchment of Tabourie Lake. The Green and Golden Bell Frog is not at the limit of its known distribution.

The Pied Oystercatcher is found in Australia, Irian Jaya and Papua New Guinea (Marchant and Higgins 1993). In Australia it occurs around the entire coast (see Simpson and Day 1998). The Pied Oystercatcher is not at the limit of its known distribution.

The Sooty Oystercatcher is endemic to Australia and occurs mostly along the east, south and western coasts (Marchant and Higgins 1993). The Sooty Oystercatcher is not at the limit of its known distribution.

The Hooded Plover is endemic to Australia and occurs from near Jervis Bay NSW to west Eyre Peninsula SA, Tasmania and Bass Strait Islands and south-west WA (Marchant and Higgins 1993). National Parks suggest that the Hooded Plover is near its limit of its known distribution further north at Swan Lake (L. Shields pers. comm.) and hence would not be near its limit of known distribution at Tabourie Lake.

The Osprey is found around much of coastal Australia with the exception of Victoria and Tasmania (Simpson and Day 1998). The Osprey is not at the limit of its known distribution.

The Large-footed Myotis occurs along the coastal strip of northern and eastern Australia, from northern Western Australia through to the Victorian South Australia border (Strahan 1995). The Large-footed Myotis at Tabourie Lake are not at the limit of their known distribution.

With regards to vegetation communities, neither of the endangered ecological communities found along the lake foreshore are at the limit of their known distribution.

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