



# SWAN LAKE ENTRANCE MANAGEMENT POLICY

*Policy Number: POL05/41*

*Adopted: 25/5/04*

*Minute Number: MIN04.575*

*File: 12404-03*

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*Review Date: 1/09/2008*

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# Swan Lake Entrance Management Policy

## 1. POLICY PREAMBLE

This Entrance Management Policy is an action arising from the Swan Lake and Berrara Creek Natural Resources Management Strategy. It describes

- the procedures to be followed by Shoalhaven City Council for artificial openings of Swan Lake entrance, should this course of action be necessary
- 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 totally natural entrance behaviour.

## 2. POLICY CONTEXT

This policy investigates the sustainability of managing the entrance to Swan Lake. Since records commenced in 1983, the lake's entrance has been (naturally or artificially) breached on average once every year. Records show that the entrance has been artificially opened under the direction of Shoalhaven City Council only twice in this period. The reason for artificially opening the lake is to alleviate flooding of low-lying assets.

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.

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 Swan / Berrara Estuary Management Task Force (SBEMTF) was established by Shoalhaven City Council (SCC) in 1996, to formulate long term management strategies to ensure waterway uses are ecologically sustainable.

There are a number of basic principles for Estuary Management Committees to apply to management decision making. These principles are detailed in the NSW Government Estuary Management Manual 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.
- 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. NSW Fisheries

support natural processes being allowed to operate to the greatest extent possible. Further, Fisheries do not support the artificial opening of a lagoon unless there is a threat to public health or safety from flooding or water quality deterioration.

The Healthy Rivers Commission's inquiry into Coastal Lakes lists Swan Lake under the *Significant Protection* classification for management orientation. The main implication for this lake opening policy is 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 should include progressive removal or modification of selected assets as resources are realised. Further, any new assets should be designed to not be affected by future lake opening levels.

### **3. AIM 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 Swan Lake entrance.

This Entrance Management Policy and Review of Environmental Factors will be regularly reviewed and updated to incorporate new information and address the community and government's changing needs.

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 of infrastructure
- 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, when required
- 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
- 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 the Environmental Planning and Assessment Act, 1979, for the artificial opening of Swan 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 fauna.

## 4. BACKGROUND

### 4.1 General Description

Swan Lake is a large brackish coastal lake that is intermittently connected to the sea. The village of Swanhaven is located on the north-eastern shore of the lake, and Cudmirrah is located further south on the coast beside the lake inlet.

Swan Lake is typical of many intermittently opening south coast lagoons:

- It is often closed to the sea by a sand bar. Lake openings tend to only last a few weeks or months. Sand is deposited in the entrance area by wave and long shore drift action.
- 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, and tidal and flooding characteristics.
- It is a popular tourist and recreation area; with tourist visitation adding markedly to the permanent residential population during peak holiday periods.

Swan Lake is however unusual in that:

- The lake is large compared to its relatively small catchment. This means there are insufficient freshwater flows to maintain an open entrance. Records collected by the local community confirm that the lake is closed on average about 85% of the time.
- The entrance is opened more often by natural rainfall events than artificially by council using mechanical equipment. Often it is opened by public intervention, but at levels quite close to a natural breakout level.
- It has a long shallow meandering channel, which normally passes over a reef when first open to the ocean. As a result, Swan Lake discharges slowly to the ocean when opened.
- The average lake level over almost 2½ years of daily records (February 2000 to June 2002) was 1.39 metres AHD.
- When the lake is open to the sea, tidal inflows are insufficient to penetrate far into the estuary. As a result it is mostly brackish and never totally flushed by seawater. When full after a rain event, salinities as low as 6 parts per thousand (ppt) have been recorded (seawater is 35 or 36 ppt).

Some low lying areas around the lake are subject to flooding when the lake level is elevated. A flood level of 3.0 metres AHD (including freeboard) is understood to apply to redevelopment in the Swan Lake Tourist Village.

SCC previously had a policy of artificially opening the lake entrance at no lower than 1.25 metres AHD \* (see note). When the lake is at this level, no direct flood risk is imminent. Further, this designated level is well below the level to which the lake has been allowed to fill in recent years. Water levels of 2.47 m AHD have been recorded at the August 1998 opening, although some localised flooding is experienced at this level.

*\* 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 2.47 metres AHD is about 2.47 metres higher than the average level of an ocean tide. All levels in this policy refer to AHD.*

## 4.2 Lake Dimensions

The DIPNR web site [www.dlwc.nsw.gov.au/care/water/estuaries/Inventory/swan.html](http://www.dlwc.nsw.gov.au/care/water/estuaries/Inventory/swan.html) suggests that Swan Lake has a catchment area of 34 km<sup>2</sup> (3,400 hectares) and a waterway area of 4.5 km<sup>2</sup> (450 hectares).

The then Department of Public Works and Services in June 2000 surveyed Swan Lake, producing a detailed map of the lake's bathymetry and some foreshore topography (Plan Cat 54042). To support this study, the Department has produced detailed estimates of lake area and volume utilising this data, shown below in **Table 1**. Note that the accuracy of all volume calculations is influenced by the vertical and horizontal limits of the digital terrain model.

Further, in places along the shoreline, the survey did not extend beyond 0.3m AHD. Contours were supplemented by aerial photography to estimate those unmapped areas. However, the volume and surface area estimates for lake levels 0.4m and 0.5m AHD in the following data are approximate and should be used with caution.

**Table 1: Relationship between Swan Lake height, surface area and volume (DPWS)**

Lake Height (m AHD)	Lake Surface Area (km <sup>2</sup> )	Lake Volume (million m <sup>3</sup> )
Zero	4.08	8.4
0.1	4.25	8.8
0.2	4.38	9.2
0.3	4.49	9.7
0.4**	4.55	10.1
0.5**	4.60	10.6

\*\* These statistics are known to be imprecise and should be used with care

## 5. ISSUES

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

### 5.1 Flooding

Council has as part of this study commissioned surveyors Watkinson Apperley Pty Limited to survey low-lying assets at risk from elevated lake levels. This report is referenced in Section 12.

#### Asset Levels

**Table 2** presents the lake levels (in metres AHD) at which inundation of low-lying assets around Swan Lake occurs.

Inundation of accesses to private property around the lake is generally not an issue. The one exception is 'The Springs' Lakeside Cabins at Swan Haven. Access to the cabins is across a creek on the foreshore Public Reserve. The lowest point of this access is at elevation 2.03m AHD (Table 2). Discussions concerning the on-going use of this access are continuing and may result in closure of the access or elevation of the bridge height. This matter may not be resolved ahead of adoption of this plan.

**Table 2: Relationship between Swan Lake water levels and inundation of surrounding assets at Swan Haven and Cudmirrah**

Asset	Lake Level (m AHD)
<b>A. Swan Haven</b>	
'The Springs' Lakeside Cabins access track low point	2.03
'The Springs' sewage holding tank cover	2.7
Pumping Station 13 access track low point	2.93
'The Springs' lowest cabin (No 4) floor level	3.37
Public toilets floor level	3.46
Slab at Pumping Station No. 13 (Lake Drive Reserve)	3.62
<b>B. Cudmirrah</b>	
Collier Drive – lowest point south of bridge	2.47
Swan Lake Tourist Park lowest ground level	2.47
The Springs Road north of Collier Drive Bridge	2.60
Collier Drive at bridge deck	3.17
Swan Lake Tourist Park office floor level	3.25
Switchgear building Pumping Station No. 1 Goonawarra Drive	3.41
Public toilets floor level	3.60

'The Springs' cabins are located in a low area, which necessitates pumping to council's sewer from a holding tank. **Table 2** shows its top at 2.7m AHD. This area has complex watertable interactions with the lake. It is impossible to predict the impact of sustained lake levels above say 2.2m AHD on the sewage holding tank. If it were found that elevated lake levels were having an impact, there should be further investigation into causes and possible solutions, including the possibility of an amendment to the policy's opening levels if appropriate.

The absolute lowest point at the Swan Lake Tourist Park at Cudmirrah is on the Collier Drive frontage at 2.47m AHD. Flooding of this park would occur by rising water in the wetland adjacent to the lake surcharging through drainage pipes under Collier Drive. This park has six caravan / annex sites located marginally below 2.5m AHD, with the annex floor levels generally 0.1m higher. All roads are

above 2.5m AHD in the park. A further 24 caravan and ten tent sites would be affected if the lake were to rise to 3.0m AHD.

The public assets that first limit lake opening levels all relate to access roads. Collier Drive, the main road into Cudmirrah, is at its lowest to the north and the south of the Collier Drive Bridge. Inundation would first occur to the south at a level of 2.47m AHD. The low point on The Springs Road to the north of the bridge is just above 2.5m AHD. In total, a length of 40 metres of road is marginally below 2.5 m AHD at the road centreline. Some 80 metres of road would be affected along the road verge if the lake were to reach 2.5m AHD. No visible road surface damage is evident as a result of pavement wetting during high lake levels, however pavement strength testing would be necessary to provide a true assessment.

It is suggested that the inconvenience of inundation to a level of 2.5m AHD could be tolerated for a very short time, in an unexpected flooding event. Vehicles can drive through this depth of water safely, albeit in brackish water. Warning signs and safety lights should be installed in accordance with normal traffic safety practice to manage any driver hazard. Note that once opened, the lake level would be expected to fall 0.1 metres in 3 or 4 hours, so any inconvenience would be short-lived.

## **Asset Raising / Floodproofing**

In order to ensure that lake levels of 2.5m AHD will have no unexpected impact on caravan annexes in the Swan Lake Tourist Park, it is recommended that tide flaps be installed on drainage pipes under Collier Drive that can surcharge into the low area of the park.

At lake levels beyond 2.5m AHD, there would be an expectation that natural breaching of the berm would be imminent, with a very small likelihood of council intervention being required. For instance, a survey of the beach berm on 26 May 2003 shows the berm level controlling entrance breaching to be 1.9m AHD. Natural beach berm levels, inferred from past opening data, have rarely exceeded about 2.6m AHD and would not be expected to often (if ever) exceed 3.0m AHD at this location, due to the sheltering effect of offshore and nearshore reefs.

Nonetheless, this policy investigates ways to progressively raise the intervention level beyond 2.5m AHD. It may be possible (subject to funding availability) to increase the intervention level by raising those critical items of infrastructure that are most prone to flooding.

In the case of Cudmirrah, the lowest sections of Collier Drive and The Springs Road on both sides of the bridge could be raised up to 2.8m to 3.0m AHD to provide a freeboard to the 2.5m intervention level. Also, part of the Swan Lake Tourist Park and a number of caravan annexes would be prone to flooding at lake levels above 2.5m AHD, unless lake waters were excluded from the park by engineering works. One short-term option is the installation of tide flaps on drainage lines under Collier Road as discussed above. The installation of tide flaps, while not a foolproof measure, would assist to manage unexpected times of high water level for a short period.

The raising of the road to act as a low levee bank is a further longer-term possibility. This raising of road levels and installation of levees would require detailed engineering investigation to ensure the caravan park could drain freely and to ensure road pavement damage did not result from elevated lake levels.

The next critical asset level at 3.17m AHD, the level of the Collier Drive bridge deck, would be exceedingly expensive to augment. This is a logical limit to any long-term upgrading of the intervention level.

## **Response to Historical Rainfall Events**

Swan Lake has a relatively large lake area for its catchment size. This means that its water level will respond slowly to small rainfall events. Only extreme rainfall events are likely to cause emergency flooding situations, except when water levels prior to the rain are already high.

The rate of rise of the lake will rely on

- the intensity of the rainfall event
- the condition of the catchment (wet or dry) prior to rain

- the lake level - as wetlands fill, the rate of rise will decrease.

Swan Lake was manually opened on 15<sup>th</sup> April 2002. This opening was preceded by rain in September 2001 and again in February 2002 (see Table 3). These storms progressively elevated the lake to about 1.84 metres above AHD without it opening. A total of 88 mm further rain on 14<sup>th</sup> / 15<sup>th</sup> April 2002 was then sufficient for lake waters to breach the entrance, with minor assistance from the public. The lake had reached a level of 2.12 metres AHD when it was opened.

The Department of Infrastructure, Planning and Natural Resources (DIPNR) 'Hydromace 2000' data logger has recorded hourly water levels since February 2000. This data is valuable in depicting detailed lake levels and responses to rainfall events.

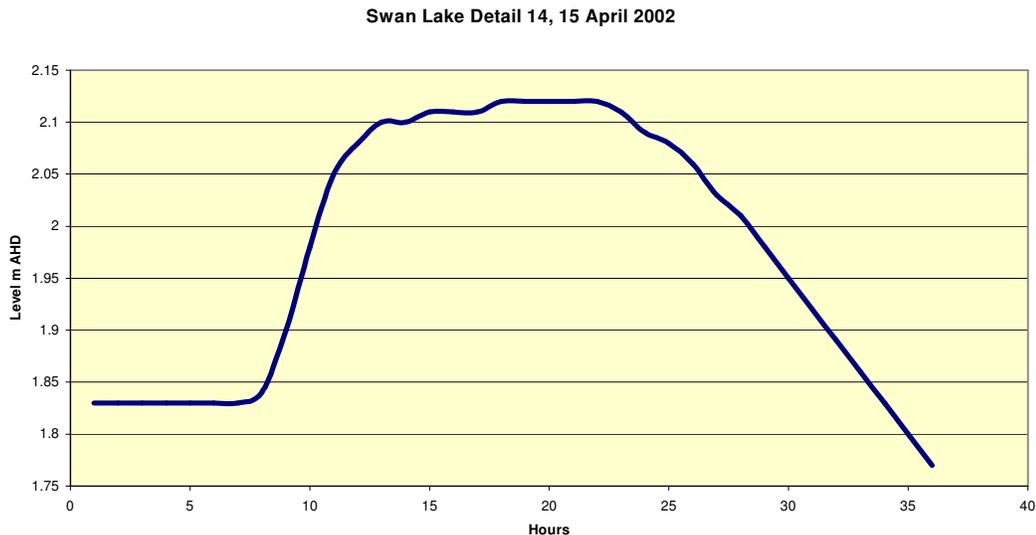
Table 3 shows a range of lake responses due to rainfall recorded by the DIPNR data logger. Varying rates of rise in response to rainfall can be noted. The 0.29 metre rise in the lake after 104mm of rain on 4<sup>th</sup> and 5<sup>th</sup> February 2002 equates to 0.2 metres per day. This would be considered a moderate rate of water level increase, and more intense rainfall would produce a more rapid catchment response. Table 3 suggests that every 100mm of rain will increase the lake level by about 0.3 metres.

**Table 3 : Swan Lake Responses to Rainfall 2001 and 2002**

Dates	Rainfall (mm)	Initial Lake Level (m AHD)	Final Lake Level (m AHD)	Rise (m)	Time (hours)	Averaged Rate of Rise (m / hour)	Lake Rise (m) per 100mm rain
12.9.01 to 13.9.01	75.6	1.42	1.59	0.17	18	0.009	0.23
4.2.02.to 5.2.02	104	1.33	1.62	0.29	36	0.008	0.28
14.4.02 to 15.4.02	88	1.83	2.12	0.29	11	0.026	0.33

Hourly rates of rise of 0.06 up to 0.08 metres have been recorded by the logger over short durations that, if sustained would give a rate of rise of 1.4 to 1.9 metres per day. These may be considered cautious estimates of Swan Lake's response to an extreme sustained rainfall event. Historic data suggests the lake will more often open a day after a heavy rainfall event.

The lake's opening in response to the small April 2002 rainfall event (in the circumstances of a prior high lake level) is depicted in Figure 1.



**Figure 1 : Swan Lake levels - response to opening April 2002.**

**Figure 1** also shows hourly detail of the lake’s rise and subsequent fall over 14<sup>th</sup> and 15<sup>th</sup> April. Over the five-hour period of peak inflow from this 88mm storm, the lake rose at an average hourly rate of 0.06 metres per hour. This would equate to 1.4 metres per day if an equivalent intensity of heavy rain were sustained.

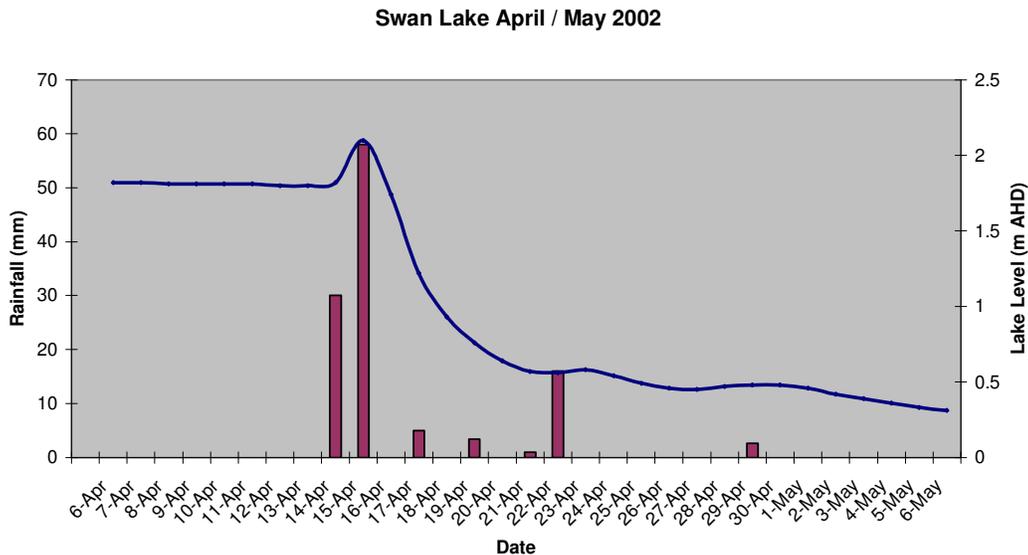
## Lake Response to Opening

**Figure 2** overleaf shows the lake level and daily rainfall for the period 6<sup>th</sup> April to 6<sup>th</sup> May 2002.

Once opened, the lake falls generally at a slower rate than the peak rate of rise that may be possible during extreme rain. The overall rate of fall in 2002 recorded by DIPNR averaged 0.014 metres per hour or about 0.35 metres per day. In this event the lake required 105 hours (almost 4½ days) to drop a total of 1.46 metres to mean high water mark. An initial rapid drop of 0.25 metres over 10 hours equates to 0.025 metres per hour, about equal to the average rate of rise.

The rate of fall will be determined by the hydraulic configuration of the entrance channel. This is affected by three factors, all of which limit the lake’s outflow rate. These factors are:

- The breakout point is naturally close to or over the rocky reef which limits scour across the beach. This in turn limits both the rate of outflow and eventual tidal inflow.
- The entrance channel meanders across deposits of sand that have naturally formed from tidal inflow and possibly from erosion of the dunes on the sweeping channel bend. This configuration of channel reduces its capacity to carry flow.
- The delta at the designated swimming area further reduces the lake’s flushing capability.



**Figure 2 : Swan Lake response to opening - 6<sup>th</sup> April 2002 to 6<sup>th</sup> May 2002**

This slow rate of water level drop is a natural feature of Swan Lake that an opening policy should strive to maintain. One opening by council to the north of the natural location has been reported to have scoured deeply across the beach and dropped the lake level rapidly, with reported damage to dunes. The resultant low lake level caused odour complaints.

## 5.2 Opening Duration

The local community has recorded the opening status of Swan Lake since 1983. This data is presented in **Table 4**. This data shows that the lake has been open on four occasions for long periods of 13 to 21 weeks. Examination of rainfall records for these four periods confirms that heavy rain over

the time the lake was open would have re-scoured the entrance, essentially reopening what may well have been near to closure. The more typical lake behaviour is to remain open on average for about 4 to 8 weeks.

Conceptually, higher water levels in the lake prior to opening will generally result in a longer opening duration. This phenomenon has been recorded for similar estuaries. The reason this normally occurs is that a higher lake level will scour a deeper and more stable connecting channel to the ocean.

However, the rock shelf at the entrance to Swan Lake will limit the depth of scour, potentially more so if the lake opens across the reef in a southern direction. Subsequently as the lake drops and operates tidally, the shallow entrance channel will reduce effective tidal influx of ocean waters. The conclusion for Swan Lake is that most entrance openings will not provide effective flushing of the estuary. This is a natural process for this estuary and it should be emulated if possible by any artificial openings.

**Table 4 : Opening statistics for Swan Lake 1983 – 2002 (combined from all sources)**

Date of Opening	Water level (m AHD)	Cause of opening*	Duration of opening (weeks)
Nov 83		F	17
Apr 84			1
Jul 84		F	3
Oct 85		F	21
Oct 87		C	6
Apr 89		P	9
Jun 89			6
Feb 90		P	13
Aug 90		F	4
Sep 90			4
Jun 91			4
Feb 92		F	6
May 93	1.48	C	3
Nov 95	Approx 2.0	P	13
Jul 97	Approx 2.5	P	4
Aug 98	2.47	F	9
Oct 99		P	
Apr 02	2.12	P	9?

\* Cause of Opening: Flood (F) Public (P) Council (C)

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However the rock shelf at the entrance to Swan Lake will limit the depth of scour, potentially more so if the lake opens across the reef in a southern direction. Subsequently as the lake drops and operates tidally, the shallow entrance channel will reduce effective tidal influx of ocean waters. The conclusion for Swan Lake is that most entrance openings will not provide effective flushing of the estuary. This is a natural process for this estuary and it should be emulated if possible by man-made openings.

There is insufficient information to examine the relationship between water levels immediately prior to entrance opening and opening duration. The water level of the lake prior to opening has been recorded on too few occasions to draw firm conclusions.

The factor that initiates the closure of Swan Lake is ocean swell conditions. Even a moderate swell sustained over a period of a few days can result in a spit formation across the entrance. If the spit forms quickly in response to larger storm swells, closure can result overnight.

A central principle underlying a lake opening policy is to reproduce as far as possible natural lake behaviour. In turn, this entails a policy that will encourage a longer lasting lake opening, maximising a natural water exchange between the ocean and the lake waters. However, the natural behaviour of Swan Lake is for poor water exchange with the ocean when open. This places even more importance on best practice soil and nutrient management in the catchment.

### 5.3 Opening Location

Council has collated data on the location of opening of Swan Lake as gathered from local residents. The data is presented in **Table 5** in combination with the recorded cause of each opening event.

**Table 5 : Location of Lake Openings for Swan Lake**

Date of Opening	Location of Opening *	Cause of Opening
Nov 83	B1	F
Apr 84		
Jul 84	B1	F
Oct 85	B1	F
Oct 87	B2	C
Apr 89		P
Jun 89		
Feb 90	B1	P
Aug 90	B1	F
Sep 90		
Jun 91	A	
Feb 92	A or B1	F
May 93	B2	C
Nov 95	A or B1	P
Jul 97	A	P
Aug 98	B1	F
Oct 99	B2	P
Apr 02	A	P

\* **Locations of Opening: A** South across reef  
**B1** Across sand spit immediately north of reef  
**B2** Further north near sand dunes  
**C** 'The Gap' (no recorded openings)

The initial location of the opening does not appear to affect how long the lake remains open. A natural flood-related opening event most frequently breaches the berm at location B1, although some of the reported locations of the more recent openings are a little conflicting.

Reliable reports of the opening in April 2002 are backed up by the photographs shown in **Figures 3 and 4**. Note the data stamp on these photographs is behind by one day. These show the entrance channel, initially excavated towards location 'A' (with some minor hand digging) having relocated naturally towards location B1 (Figure 3). By the next day (Figure 4), the channel was redirected southwards to 'A' by sand deposited on the beach assisted by a slight swell. This channel apparently opened up overnight (termed a 'breakout') to form a wide delta over the rock shelf. This overnight migration may well explain the conflicting data of entrance location (A or B1) reported by local sources.

Openings by Council at location B2 have raised opposition from local residents. The October 1987 opening on the northern side caused damage to a steep dune and reportedly its vegetation. The May

1993 opening scoured a deep channel, and the lake reportedly flushed out to a lower level than when it opened over the reef. Complaints of subsequent odours have been recorded. Location B2 should be avoided for these reasons.

It is clear from the above discussion that the natural locality of the opening will move slightly from one year to the next, but will be centred on the reef area. The exact locality will be governed by prior beach behaviour, with prevailing winds and swells reshaping the beach berm around the reef over time. The recommended location for a manual opening by council, should this be required, would be to emulate where nature would have opened the lake at that time i.e. at the point where the beach berm is lowest. This will not always be the shortest distance to the ocean, and will be either at locations A or B1. Locality B2 near the sand dunes should be avoided due to the possibility of dune damage from scour.



Figure 3 : Manual opening of Swan Lake on 15<sup>th</sup> April 2002 at Location A



Figure 4 : April 2002 opening on the day following an overnight breakout

## 5.4 Flushing Times

Swan Lake opens to the ocean on average about once per year. It has opened 17 times since 1983 (20 years) twice in summer, 6 times in spring, 3 times in Autumn and 6 times in Winter. 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. 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.

The ability to replace an estuary's waters with seawater is measured by its flushing time. Flushing time varies with such aspects as the entrance channel effectiveness, lake shape and volume. Other estuaries which, when open to the ocean have a very strong tidal inflow, have flushing times supported by observation of about 24 days. The flushing time for Swan Lake would be much longer, with available data suggesting that the lake would possibly never open for long enough to reach full ocean salinity.

This notional behaviour of Swan Lake is borne out by past records of lake salinity. A well-flushed lake will increase its salinity during the period it is open, typically from 20 parts per thousand (ppt) to 34 ppt in the case of Coila Lake. (Ocean water has a salinity of 35 to 36 ppt.) Recordings in Swan Lake over 1984 to 1988 by Pollard (referenced in the NRMS) indicate a low salinity range of 10 ppt reducing to 6 ppt after rainfall inflow. This is consistent, based on dilution calculations, with a lake level rise due to rainfall from 0.5 metres to about 2 metres AHD.

The lake's subsequent response to opening recorded by Pollard was to increase salinity from 6 ppt to about 16 ppt, well short of ocean salinity. This is calculated to be consistent with flushing by an inflow of seawater equal to about 30% of the lake's volume. That is, it would take an opening duration at least three times as long to have completely flushed the lake on this occasion.

More recent data, collected by Manly Hydraulics Laboratory, shows similar trends. It is apparent that for effective flushing of Swan Lake to take place, a prolonged opening is required; estimated well in excess of three to four months of tidal exchange. **Table 4** highlights a typical average duration of opening for Swan Lake of 4 to 8 weeks. Clearly, Swan Lake will be rarely (if ever) totally flushed by an opening event.

## 5.5 Water Quality

Water quality is influenced by lake entrance conditions, which in turn affects the functioning of the lake's ecology. When catchment discharges into coastal lakes do not breach the entrance, any constituent sourced from the catchment will be retained in the lake. Repeated instances of low rainfall followed by evaporation can lead to an accumulation of pollutants within the system. Typically, organic matter inputs will be either buried or recycled back into the water column; phosphorus is particularly prone to accumulating in fine silty sediments. Chlorophyll *a* concentrations in the water column of coastal systems are useful indicators of algal biomass, and provide insight into the overall health of aquatic systems.

### Nutrients & Chlorophyll *a*

Shoalhaven City Council and Manly Hydraulics Laboratory have undertaken water sampling for nutrient analysis in Swan Lake. The guideline value of < 0.05 mg/L was used for total phosphorus (TP), and < 0.5 mg/L used for total nitrogen TN (ANZECC, 2000). During the sampling program undertaken by council (Nov 1994 – Oct 2002), the total phosphorus concentrations were regularly below designated guideline values, only exceeding them on 3 occasions (**Table 6**). However, total nitrogen concentrations were often above 0.5 mg/L (i.e. 72 % of sampling occasions) (**Table 6**).

Manly Hydraulics Laboratory sampled Swan Lake's central basin during 1999 (April - July). This dataset shows a similar trend to the Council's inlet sampling, phosphorus was below guidelines values most of the time and nitrogen concentrations were above the guidelines most of the time (**Table 7**). Evidence from other south coast lakes with intermittently open entrances would indicate that nitrogen guideline values may in fact be difficult to achieve for lakes of this type which act as natural sinks for nutrients due to their irregular opening characteristics. In particular the upper areas of Swan Lake will be vulnerable to elevated TN & TP water column concentrations.

**Table 6: Summary statistics for total nitrogen, total phosphorus, and chlorophyll *a* concentrations in the water column of Swan Lake inlet, n = 40 (May 1992 to January 2003).**

	TN (mg/L)	TP (mg/L)	Chlorophyll a (mg/m <sup>3</sup> )
10 <sup>th</sup> percentile	0.27	0.05	0.5
Median	0.60	0.05	0.9
90 <sup>th</sup> percentile	0.83	0.1	1.2

**Table 7: Summary statistics for total nitrogen and phosphorus, nitrate, and chlorophyll a concentrations in the water column of Swan Lake’s central basin, n = 17 (April 1999 to July 1999).**

	TN (mg/L)	TP (mg/L)	Chlorophyll a (mg/m <sup>3</sup> )
10 <sup>th</sup> percentile	0.46	0.005	0.2
Median	0.61	0.01	1.2
90 <sup>th</sup> percentile	0.87	0.05	3.4

The concentrations of chlorophyll *a* in Swan Lake’s water column are low, and they are considered indicative of a system that is functioning well. The median concentrations of both the inlet sampling (**Table 6**) and the central basin of Swan Lake (**Table 7**) are below 2 mg/m<sup>3</sup> which is considered oligotrophic \* by international standards.

\* *Oligotrophic* = a system that is not nutrient rich, and has few algal problems

## Faecal Matter

Shoalhaven City Council has monitored faecal coliform concentrations (cfu/100ml or colony forming units per 100 mL), at three sites within Swan Lake since May 1992. The summary statistics from these sites are presented in **Table 8**. The criteria set by ANZECC (1992) for monitoring primary contact recreational water quality (water quality suitable for swimming etc.), is that, ‘the median bacterial content taken over the bathing season should not exceed 150 cfu/100mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 cfu/100mL)’.

Whilst the design of the sampling program has not met the frequency of sampling as recommended by ANZECC (1992), **Table 8** illustrates that the median faecal coliform values within Swan Lake are extremely low. Only one sample from site 36 during May 1998 exceeded the upper level of 600 cfu/100ml, but over the sampling period, a median of zero cfu/100ml was calculated.

**Table 8: Summary statistics for faecal coliform monitoring in Swan Lake (May 1992 to January 2003).**

	SITES					
	35	36	37	38	334	334
No. of samples	34	39	40	42	40	38
10 <sup>th</sup> percentile (cfu/100mL)	0	0	0	0	0	0
Median (cfu/100mL)	10	0	12	0	4	0
90 <sup>th</sup> percentile (cfu/100mL)	75.7	156	179	74	108	85

## Water Column Oxygen

Dissolved oxygen concentrations in the water column of Swan Lake’s inlet and central basin are very stable (**Table 9**). Dissolved oxygen is of critical importance to the cycling of nutrients in coastal lakes. Stable dissolved oxygen concentrations enable efficient cycling of nutrients and reduce the likelihood of large increases and fluctuation in ‘biologically available’ nutrient concentrations

**Table 9: Summary statistic for dissolved oxygen concentration (mg/L) in the water column of Swan Lake, Inlet n = 40 (Shoalhaven City Council, May 1992 to January 2003), and Central Basin n = 17 (Manly Hydraulics Laboratory, April 1999 to July 1999).**

	Inlet	Central Basin
10 <sup>th</sup> percentile	6.1	8.7
Median	8.2	10.6
90 <sup>th</sup> percentile	10.6	12.3

During the monitoring programs in Swan Lake there were no recorded dissolved oxygen concentrations below 2 mg/L, which indicates anoxic respiration is limited and Swan Lake is relatively healthy.

### Salinity

Swan Lake has a median salinity of 12 ‰, which indicates that freshwater inflow dominates the water column (i.e. open sea 35 ‰ and freshwater = 0 ‰). Furthermore, it appears that the salinity in Swan Lake is relatively stable with small inter-annual changes (**Table 10**). This provides a stable habitat for biotic organisms and reduces the chance of mass fatalities from salinity changes.

**Table 10: Summary statistic for Salinity (‰) in the water column of Swan Lake, Inlet n = 40 (Shoalhaven City Council, May 1992 to January 2003)**

	Inlet	Central Basin
10 <sup>th</sup> percentile	10	10
Median	12	12
90 <sup>th</sup> percentile	16.7	15.4

### Assimilative Capacity

Swan Lake has a relatively small ratio of catchment runoff to estuary volume, due to the small, well-forested catchment compared to the large lake.

This small ratio results in the system having a large dilution capacity. This means the change in concentrations of key water quality parameters in the lake from catchment runoff could be expected to be less than in many other lakes. The capacity of the lake to assimilate pollutants such as nutrients or organic material from single rainfall events should therefore be sufficient to protect water quality. Analysis of water quality data tends to support this conclusion.

However, the lake also has a very high trapping efficiency, whereby large rainfall events may not result in entrance breaching. During such events all pollutants transported to the lake by catchment inflow will be retained in the lake, to be assimilated by the aquatic flora and fauna. Subsequent evaporation may lower lake water levels so that even further large rainfall events or a succession of smaller ones may still not breach the entrance. There is a balance required between the lake's ability to assimilate pollutants and its ability to trap them. Swan Lake is on the one hand a robust system, but with the potential to crash if catchment inputs were not well managed.

### Lake Processes and Public Health

The entrance to Swan Lake has not historically been opened for the purposes of recreational water quality improvement, and based on the current water quality analysis there is no reason to suggest that this situation should change. The limited entrance capacity for tidal exchange, and short opening durations, provide little opportunity for tidal mixing. Furthermore, as there is often little algal biomass within the water column, there is little need for flushing to reduce nutrient accumulations.

The catchment that exports organic and inorganic matter to Swan Lake is relatively pristine, and as such, is likely to deliver highly refractory \* material and low inorganic nutrient loads. This is supported by the stability of the salinity and dissolved oxygen concentrations in the water column of Swan Lake.

\* *Refractory material* = not easily broken down by biological or chemical means, e.g. gum leaves have a waxy coating and high lignin content, which allows them to stay intact for months in the lake's bottom sediments, whereas grass/algae is broken down very rapidly).

Stable salinity and low biological oxygen demands (indicated by high DO conc.) are indicative of a highly secure system that is functioning effectively with little need for intervention for water quality.

## **Sewerage Issues**

The Task Force has mentioned the possibility of sewage spills to the estuary as having a potential impact on water quality.

There are three pumping stations around the edges of Swan Lake, located at:

- the western end of Hoffman Drive – this pumping station is elevated well above the lake
- the reserve at the southern end of Yaroma Ave / Lake Drive (pumping Station 13)
- the reserve at the eastern end of Goonawarra Dr. (Pumping Station 1)

Survey information suggests that these wet wells are at minimal risk of flooding until the lake attains a level of 3.5 metres AHD. Under normal circumstances, the entrance would be naturally opened well before this level was reached. It would be prudent to check the levels of overflow pipes, and the lowest manholes in these latter two lakefront systems to ensure these would not allow inadvertent influx of water at lake levels up to say 3.0m AHD.

Shoalhaven City Council sewerage staff advise that to control the location of surcharge of sewage, overflow points are located at sewage pumping stations. To minimise the possibility of overflows, the system has a number of safeguards:

- Each catchment has 4 hours of average dry weather flow (ADWF) storage capacity located at the pumping station.
- A standby pump in the pumping station is switched on automatically if the water level in the station reaches a predetermined high point.
- A telemetry alarm system provides 24 hour per day surveillance of each sewage pumping station. This system monitors operations and high-level alarm conditions. If there is a problem, a standby operator is automatically called to attend.
- If necessary, a portable generator can be brought in to provide power.
- Pump-out tankers can be utilised in an emergency.

There have been two minor discharges of sewage into Swan Lake since the commissioning of the sewerage scheme in 1990. Council confirms that one was a result of a thrust block moving shortly after commissioning the new scheme. The other was an overflow from a manhole, also occurring in the early nineties.

We note, in relation to storage volumes provided at these pump stations, that current Environment Protection Authority requirements for new schemes are 8 hours detention storage at ADWF. Newer sewerage schemes are required to provide in-ground detention storage particularly in locations adjacent to sensitive waterways. While there is no statutory requirement for council to upgrade storage at these three locations, the sensitive nature of the estuary suggests that the feasibility of these works should be investigated.

## **5.6 Lake Ecology**

Swan Lake's catchment supports a great variety of habitats. The area is known for its biodiversity, with nearly 500 plant species, 150 bird species and at least 23 native mammal species known to occur in the area (*Draft Swan Lake and Berrara Creek Natural Resources Management Strategy - NRMS*). Much of the catchment area lies within the Conjola National Park.

Flooding is an important component of the ecological processes operating in coastal lagoons such as Swan Lake. It is likely to be especially important in maintaining the character, extent and biodiversity of fringing wetland vegetation communities.

## Fauna

### Aquatic Species

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). The ability of juvenile fish or prawn larvae to enter the lake is dependent on the entrance opening coinciding with recruitment seasons.

The latest evidence on fish recruitment into estuaries such as Swan Lake suggests that this is much less seasonal and more random than first thought (West and Jones 2001). Similarly, the timing of prawn recruitment on the south coast is driven by many variables, including ocean currents and the timing of major floods on the state's big north coast estuaries. NSW Fisheries concludes that it is virtually impossible to artificially manipulate entrance opening with any certainty of enhancing fish or prawn recruitment and subsequent production.

Fish species recorded in Swan Lake by West and Jones at the entrance of Swan Lake during February and July 1998 are listed below (West and Jones, 2001). Two commercial species, sea garfish and Yellowfin bream were caught. Additional commercial species recorded in Swan Lake are listed in section 5.7. The flat-headed gudgeon and the small mouth hardyhead dominated the seagrass fish fauna at that time. The lake was continuously closed over these periods of sampling.

Family Species	Common Name	Number Caught
<b>Hemiramphidae</b>		
Hyporhamphus australis	Sea garfish	24
<b>Atherinidae</b>		
Atherinosoma microstoma	Small mouth hardyhead	431
<b>Pseudomugilidae</b>		
Pseudomugil signifer	Southern blue eye	67
<b>Sparidae</b>		
Acanthopagrus australis	Yellowfin bream	5
<b>Gobiidae</b>		
Philypnodon grandiceps	Flat-headed gudgeon	471
Pseudogobius olorum	Blue-spotted goby	6
Redigobius macrostoma	Large mouth goby	2
<b>TOTAL (nos. of species = 7)</b>		<b>1006</b>

### Birds

Bird species protected under the National Parks and Wildlife Act, the *Threatened Species Conservation Act 1995* and international treaties (JAMBA and CAMBA) are known to use the lake and estuary. Protection for migratory species listed under JAMBA and CAMBA is also offered under federal legislation, the Environmental Protection and Biodiversity Conservation Act 1999.

The following protected shorebird species have been recorded within 5 km of Swan Lake. The timing of artificially opening the lake needs to take into account the presence and breeding season of protected shorebirds if they are likely to utilise the entrance area for their nest scrapes.

In particular, lake opening could impact on the breeding of Hooded Plover and Pied Oystercatcher, both of which have been recorded nesting in the vicinity of the lake entrance. Cudmirrah beach is considered to be of high significance for Hooded Plovers on a statewide basis. The period from late August to March incorporates breeding months for the Hooded Plover and Pied Oystercatcher, and also the Little Tern, which although not known at Swan Lake could conceivably utilise the entrance area for nesting.

Common Name	Scientific Name	Status under TSCA 1995
Osprey	<i>Pandion haliaetus</i>	vulnerable
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>	vulnerable
Pied Oystercatcher	<i>Haematopus longirostris</i>	vulnerable
Hooded Plover	<i>Thinornis rubricollis</i>	endangered
Little Tern	<i>Sterna albifrons</i>	endangered

The Sooty Oystercatcher utilises rock outcrops and reefs for feeding and nests on offshore islands. Sooty Oystercatcher will nest from August to March, but nesting locations would be well removed from the entrance area. Osprey breed mostly on coasts and islands, and construct a stick nest in trees, on rocky outcrops or on the ground. Nests may be used for many years and can assume massive proportions. They would also not be expected to nest on sand in the entrance area.

In addition, NPWS advise that both Australasian Bittern (*Botaurus poiciloptilus*) and Black Bittern (*Ixobrychus flavicollis*) (both listed as vulnerable in TSC Act 1995) have been sighted around Swan Lake (L. Shields NPWS pers. comm. after advice from K. Mills). Australasian Bittern favours permanent freshwater wetlands with dense vegetation, and nests in dense wetlands on a platform of reeds. Black Bittern are found in dense riparian vegetation such as Swamp She-oaks. They breed in summer in leaf trees overhanging the water. These birds do not nest in the entrance area. Temporary but near-natural indirect impacts on feeding areas may result from lake opening.

The Coast and Wetlands Society, in its comments on the NRMS, point out that the lake is at times home to additional migratory species, some of which are protected under international treaty. These additional species are identified by the Society as:

- Spine-tailed Swift (or White-throated Needletail) (*Hirundapus caudacutus*), a listed Asian migratory species under the EPBC Act 1999, associated with coastal and mountain regions;
- Whiskered (Marsh) Tern (*Chlidonias hybrida*), an annual migrant or nomadic bird associated with lakes and estuaries;
- Little Egret (*Ardea garzetta*), a sedentary and nomadic bird found among intertidal mudflats and shallow wetlands;
- Intermediate Egret (*Ardea intermedia*), a partial migrant found in shallow wetlands and intertidal mudflats;
- Great Egret (*Ardea alba*), is listed under EPBC Act 1999 as a migratory species protected under international agreements. This species is found among floodwaters, rivers, shallow wetlands and intertidal mudflats.
- White Bellied Sea Eagle (*Haliaeetus leucogaster*) is listed under EPBC Act 1999 as a migratory species protected under international agreements. It inhabits large rivers, fresh and saline lakes, coastal seas and islands.

The above species would not nest in the entrance area. The lake is also home at times to large numbers of Black Swan (*Cygnus atratus*) and White-eyed Duck (*Aythya australis*).

In addition to shorebirds, the following threatened or vulnerable bird species have been recorded locally, and would inhabit or feed in the forests within the lake's catchment (Daly et al. 1998).

Common Name	Scientific Name
Glossy Black Cockatoo	<i>Calyptorhynchus lathami</i>
Powerful Owl	<i>Ninox strenua</i>
Masked Owl	<i>Tyto novaehollandiae</i>
Regent Honeyeater	<i>Xanthomyza phrygia</i>

The presence of top order consumers, such as large forest owls indicates that the habitat within the catchment is varied (several vegetation communities and large hollow bearing trees) and supports significant populations of prey species such as possums and native rodents (Daly et al 1998). However, the incidence of these species has no impact on entrance management considerations.

These matters are addressed more fully in the accompanying REF.

Amphibians

The upper reaches of Swan Lake and the lake tributary creeks and streams provide habitat for amphibian species. The protected Green and Golden Bell Frog *Litoria aurea* has been detected breeding in the Sussex Inlet STP overflow ponds (Gaia Research 2000 and 2002). The distribution of this population would in all probability extend further around the lake into areas of sedgeland where the water level is shallow (i.e. less than 300 mm).

The Green and Golden Bell Frog is listed as Endangered under the TSC Act 1995 and as Vulnerable under the EPBC Act 1999. The habitat of *Litoria aurea* and its successful breeding relies on areas of fresh and or lightly brackish (less than 8 parts per thousand ppt) water in wetlands around the lake. Swan Lake at times of high rainfall is potentially able to offer these combinations of habitat.

The timing of artificially opening the lake needs to take into account the breeding cycles of Green and Golden Bell Frog. This coincides with the spring / early summer breeding cycles of shorebirds and can be accommodated into the policy by allowing higher lake levels at this time if possible.

There is no confirmation that *L. aurea* is found in the lake. If they were present, an artificial lake opening event may trigger a significant impact the Commonwealth’s EPBC Act and certainly under the TSC Act. Consequently, there needs to be systematic targeted surveys in the catchment of Swan Lake to determine the size of the adult population and the location of breeding sites. Monitoring these sites will help to better understand possible impacts on their tadpoles, should they be present in the lake fringes during times of low salinity. This knowledge would assist to refine this policy, and should be prepared prior to the next policy review. Detailed recommendations are provided under Section 11.3.

Mammals

The following threatened mammals (listed overleaf) have been recorded within the catchment of the lake foreshore. Their presence highlights the biodiversity value of the native vegetation in the Swan Lake catchment. However, the incidence of these species has no impact on entrance management considerations. Large-footed Myotis, a species roosting in Swamp Oak on the lake foreshore, is further considered in the REF. There are no impacts on these species.

Common Name	Scientific Name
Yellow-bellied Glider	<i>Petaurus australis</i>
White-footed Dunnart	<i>Sminthopsis leucopus</i>
Grey-headed Flying Fox	<i>Pteropus poliocephalus</i>
Large-footed Myotis	<i>Myotis adversus</i>
Greater Broad-nosed Bat	<i>Scoteanax rueppellii</i>

**Wetlands**

Wetlands classified under State Environmental Planning Policy No. 14, are located to the north of Swan Lake and at the mouths of Mondayong and Teatree Creeks. Other wetlands to the west and south are also significant (NRMS). 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.

The critical level at which these wetlands are inundated is not known. From experience elsewhere it is assumed that by the time a lake level of 2.2m AHD is reached, these fringing wetlands would be inundated. This level should be checked prior to the first review of this policy.

The occasional manual opening of Swan Lake would result in a slightly less frequent duration of inundation of these wetlands. Shoalhaven City Council records suggest the lake opens naturally by flooding or near-naturally by the public for 84% of openings. It can be assumed that openings by the public would only occur when a natural opening is imminent, and these openings would represent a near-natural event. Infrequent Council intervention in opening Swan Lake has occurred for the remainder of openings, on one occasion in 1993 recorded at a low level of 1.48 metres AHD. It is unknown whether the composition and distribution of flora and fauna species are changing because of

past opening policies, however it is unlikely that a major impact has occurred based on lake opening data.

Of note is the presence within the wetlands and other fringes of the lake at Cudmirrah of the protected (Threatened Species Conservation Act, 1995) saltmarsh species *Wilsonia rotundifolia* (Endangered) and *Wilsonia backhousei* (Vulnerable). In coastal New South Wales *Wilsonia rotundifolia* is known from four coastal populations at Lake Wollumboola and Swan Lake in the Shoalhaven, and Meringo Lagoon and Coila Lake further south in the Eurobodalla.

These protected species occur on the rocky shores of the lake (NRMS, 2002) and would occasionally be inundated by elevated lake levels. As this policy aims towards mimicking a natural lake opening regime, there will be no expected impacts on these species.

## **5.7 Commercial and Recreational Fishery**

The pattern in commercial fish catch statistics at Swan Lake (collected by NSW Fisheries) for the period 1984/85 to 1998/99 is highly variable. The average annual catch of combined species (fish, molluscs and crustacean) over this period is 9,939 tonnes with an average value of \$20,782.

A brief look into the catch figures suggests two possible reasons for the variability in catch:

- Openings are generally of short duration and the opportunities for fish recruitment are limited;
- With an opening on average once per year, the lake will often open too soon for fish stocks to mature;
- Swan Lake is remote compared to other traditional commercial estuaries such as St Georges Basin, and it historically has been fished infrequently (NSW Fisheries).

The catch effort operating commercially on Swan Lake has varied from less than six operators to a maximum of nine. With the declaration of the Recreational Fishing Haven on St Georges Basin and buyout of most commercial licences operating in the area, NSW Fisheries considers that the commercial catch effort for Swan Lake in future will decline even further.

The eight seine hauls taken in Swan Lake by West and Jones (2001) yielded 1006 individuals. This represented seven species of which only two commercial fish species were caught, Sea Garfish and Yellowfin Bream. The lake was continuously closed over these periods of sampling.

NSW Fisheries' Commercial Fish Catch returns confirm the regular commercial species in Swan Lake to be Yellowfin Bream, Luderick, Sand Whiting and Sea Mullet. At times, Tarwhine and Leatherjacket have been caught commercially but in small quantities.

Commercial catches of prawns have been sporadic, again due to the commercial fishers preferring other estuaries that are more easily accessed than Swan Lake. A commercial catch of 6 tonnes of eastern King Prawn in 1998/99 (after the lake opened in August 1998 and was closed for a long period until October 1999) is the best harvest recorded.

Recreational prawning is a popular tourist attraction in the area. There are no records of recreational prawn or fish catch for the estuary.

## **5.8 Cultural Heritage**

The Jerrinja people have close associations with Swan Lake. National Parks records numerous sites of Aboriginal cultural significance around the lake, including stone tool sites and axe grinding grooves.

Given the extremely dynamic nature of the entrance area, and the fact that this policy mimics natural lake openings, there are unlikely to be any direct impacts on Aboriginal objects or cultural sites caused by artificial entrance opening in the nominated location.

## **6. STATUTORY CONTEXT**

### **6.1 Statutory Requirements**

#### **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. For opening of a lake entrance, this may be in the form of a Review of Environmental Factors, but if the potential impacts were considered significant, an Environmental Impact Statement would be required. 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 at the time of any proposed opening. The Review of Environmental Factors (REF) that forms part of this policy serves this purpose.

#### **Crown Lands Act 1989**

Local Councils proposing maintenance dredging on Crown land are required to obtain a licence from the Department of Lands under Part 4, Division 4 of the Crown Lands Act. 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.

The State will generally require the payment of some royalty for material removed off site and on-sold. This arrangement will generally be undertaken under the authority of a licence agreement between Department of Lands and the relevant authority or the authority's contractor. Approval is also required where a contractor is undertaking maintenance dredging for public authorities and the material will be removed from the system, that is, taken, stockpiled or sold.

Whilst Shoalhaven City Council 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. As such, the department will be requested to issue a licence to Shoalhaven City Council to carry out maintenance dredging at Swan Lake in accordance with the conditions outlined in the Policy. In this instance 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). As no material is to be removed off site no royalty will be payable.

#### **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 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 must be completed and concurrence of or consultation with the Director-General of the National Parks and Wildlife Service is required.

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

## **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 Swan 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 Swan 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 entrance opening works will be carried out, and as entrance barriers are extremely dynamic environments it is unlikely that any would be present in this locality.

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.

## **Aboriginal Land Rights Act 1983**

This legislation would be relevant where an Aboriginal land claim has been made which affects submerged Crown Land or areas of Crown Land that may be proposed for processing, storage or use of dredged material. The Commonwealth Native Title Act (1993) and Native Title (New South Wales) Act (1994) may also be relevant in this regard.

## **State Environmental Planning Policy 35 and Water Management Act 2000**

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 Swan Lake, which is intermittently open to the ocean, 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 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 Swan 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 Infrastructure, Planning and Natural Resources (DIPNR) 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 in late 2003. 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.

A number of fresh and brackish wetlands exist around Swan Lake, two of which are listed under SEPP 14. However, as no excavation within SEPP 14 wetlands is proposed, the 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 impact on the proposed lake opening activity.

## **6.2 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 Infrastructure, Planning and 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. This act will in time be fully replaced with the Water Management Act 2000.

## **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 council's LEP and State Environmental Planning Policies (as outlined above)

would constitute 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.

## 7. AGENCY 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 an 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 required, SCC shall give notice to the bodies listed below. This notice shall be in writing by e-mail or facsimile marked urgent, specifying that opening of the lake is required in the near future, the reasons for opening and a proposed timing of opening.

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

NSW Fisheries  
Senior Conservation Manager  
Nowra  
Tel. (02) 4423 2200  
Fax (02) 4423 2007

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

Environment Protection Authority  
Regional Manager, South Coast  
Tel. (02) 4226 8100  
Fax (02) 4227 2348

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

Planning NSW  
Director, Illawarra/South Coast  
Tel. (02) 4224 9450  
Fax (02) 4224

The Coordinator  
Swan / Berrara Estuary Management Taskforce  
Tel. (02) 4429 3111  
Fax (02) 4422 1816

Any matters concerning the opening that have been raised by the above agencies within three days of the giving of notice shall be satisfactorily addressed by SCC prior to entrance opening works

commencing. For emergency situations, (such as when water levels have rapidly risen above 2.5m AHD and a natural breakout is unlikely to occur) notification to the above bodies is still required, but the three-day consultation period can be reduced at the discretion of SCC. This reduction is subject to council satisfying itself that the accompanying REF is a suitable level of environmental assessment.

Note that following the NSW State elections in March 2003, the Public Sector Employment and Management (General) Order 2003 amended the responsibilities of Planning NSW. That agency's representatives previously responsible for management of natural resources are relocated to DIPNR.

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.

## 8. LAKE OPENING DECISION MAKING

### 8.1 *Prior Conditions for Opening*

**Section 13 (Attachment 1)** outlines the decision making process to be followed before entrance opening is contemplated. The logic behind this policy is the ultimate threat to flooding of Collier Drive and a small area of the adjacent caravan park if the lake reaches a level of **2.5 metres AHD**. At levels between **2.2m and 2.5m AHD**, there is opportunity to plan an opening if a breeding season for migratory bird species is imminent. However there is a need to maintain a high water level in fringing wetlands to emulate natural patterns if possible. Therefore, to facilitate inundation of wetlands, water levels can be held at an elevated level (assessed in the absence of wetland survey as being above **2.2m AHD**) for three months, or until the 2.5m AHD level is attained.

The following summarises conditions under which the lake entrance can be breached. In all circumstances, notification shall be given to all state agencies listed in Section 7.

- If the level of the lake reaches 2.5 metres AHD, it shall be opened on the top of the first suitable high tide with minimal delay.
- If (after rainfall) the lake stabilises at a level between 2.2 metres and 2.5 metres AHD, a period of three months shall be allowed to elapse before an opening is initiated. The opening shall be planned for a period when tide and swell conditions are suitable. With the concurrence of NPWS, the above three-month period can be reduced if it is considered advantageous that the lake should be opened in the months May and June leading up to a shorebird breeding season.

**If the above conditions are not met, a 28 day consultation period will apply.**

A flowchart summarising the decision-making process is provided as Attachment 1.

Note that water level readings should be monitored by council utilising the water level recorder in Swan Lake maintained by Manly Hydraulics Laboratory. As a ground-truthing exercise, council should manually read the tide gauge plates at the Collier Drive Bridge. Gauge plates have the added advantage of providing public access to lake level information. It is necessary to extend these gauge plates to the lake's full operating range and to identify one, two and three metre marks on the plates for clarity.

### 8.2 *Close Lake Monitoring*

When the lake reaches a level of **2.2 metres AHD**, council staff shall enter into close lake monitoring mode. This involves a number of aspects listed below, to ensure as far as possible that sound environmental outcomes are achieved:

- Initiate Green and Golden Bell Frog survey during or within 24 hours of rainfall.
- Observe lake level on Collier Drive Bridge gauge to check against water level recorder.
- Observe beach berm at lake entrance to judge if lake can rise to 2.5m AHD or if it is likely to open naturally prior to this level being attained.
- Notify NPWS for its determination on the likelihood or confirmed presence of nesting shorebirds on the beach in the entrance area.
- Advise state agencies that opening could eventuate if rain was to continue and the lake was to rise to 2.5m AHD, and seek their input.
- Advise Council works staff responsible for the opening works that a lake opening could eventuate if rain was to continue and the lake was to rise to 2.5m AHD.

**Note that a prediction of lake response can be made knowing the daily rainfall:**

**Water level rise (mm)  $\approx$  0.3 metres per 100 mm rainfall**

## 9. RESPONSIBILITY & PROCEDURES FOR OPENING

### 9.1 Responsibilities

Shoalhaven City Council is responsible for lake opening, should intervention be necessary. The Council officer responsible for carrying out specific on-site assessment in accordance with the REF, consultation with other agencies and for making any subsequent decision to open the lake (as per **Attachment 1**) is the Natural Resources and Floodplain Manager. This Manager will also be responsible for the monitoring function detailed in **Section 10** and **Attachment 2**.

The Council officer responsible for plant management and on-site control is the Regional Maintenance Engineer. 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 and to the dimensions required.

### 9.2 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, for the lower tide of the day.

The location of the opening is to be within 10 metres of the reef at the lake entrance on Cudmirrah Beach, either across the sand spit on the northern side of the reef or across the reef to the south. Both of these locations appear from council data to be naturally occurring. The selection of location would be determined in nature by the relative height of the incipient dune at each location. This naturally random process should be allowed to continue, rather than force the lake to open at one side of the reef. The excavation shall be made in the area with the lowest incipient dune height as determined on site prior to works commencing.

The opening should be sufficient for scour flow to develop. The preferred size is 2 m wide with the bed graded to the ocean. Either an excavator or a dozer will cut the channel, pushing the excavated sand as far as is feasible from the cut face. Normally a sand plug will be left at the lake end of the entrance channel until the remainder of the channel is established.

The volume of sand to be excavated is expected to be small. This sand will be retained on the beach and may be washed into the channel as it expands laterally. Excavated sand is not to be removed from the beach area.

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.

## 10. ENTRANCE MONITORING

### 10.1 Artificial Openings

When artificial openings have been carried out, monitoring of the entrance should be undertaken (**Attachment 2**). Council's Natural Resources and Floodplain Manager will be responsible for this monitoring function.

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
- digital photographs

To aid this data recording, the gauge plates at the Collier Drive Bridge should be extended to cover the full range of the lake, and with metre marks clearly delineated.

### 10.2 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. Responsibility for monitoring is to be carried out by Council.

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

## 11. RECOMMENDATIONS

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

### 11.1 Policy Review and Update

It is recommended that this Policy and accompanying REF be reviewed in three years i.e. in 2006, following investigations carried out in accordance with Sections 11.2 to 11.4. Review of the policy will include analysis of all monitoring data collected over that period to ensure that predictions outlined in the current REF are correct.

In addition, this policy should be amended to refer to revisions to the Water Management Act 2000 scheduled in late 2003, and the relevant licence or approval under that act shall be gained if required.

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

### 11.2 Recommendations for Raising the Intervention Level

This policy recommends a lake opening level of 2.5m AHD. At or prior to this level the lake will, based on past behaviour, open naturally, and may require very occasional intervention by council when the beach berm is unusually high.

Should critical assets be raised to 3.0m AHD to provide a freeboard, the need for council intervention in lake opening would be extremely unlikely. Further, this would minimise potential impacts on migratory birds and the Green and Golden Bell Frog at breeding times. Therefore, in line with the state government's policy of moving towards more natural lake openings, the following recommendations arise from this policy.

- i. Investigations should be made into raising the road at both northern and southern approaches to the Collier Drive Bridge to attain a height of 3.0m AHD at the road centreline.
- ii. As a forerunner to raising Collier Drive, detailed investigations should take place to ensure that possible local flooding of the Swan Lake Tourist Park at about 2.5m AHD does not deteriorate due to the works. Management options may entail installation of drainage system tide flaps as a short-term solution, and/or utilising the road as a levee (if it were to be raised) in the longer term.
- iii. A detailed investigation should be carried out into Sewer Pumping Station overflow lines and receiving manholes at PS 1 and 13 to ensure there will be no ingress of lake waters if a lake level of 3.0m AHD were attained.
- iv. The impact of higher lake levels on operations of 'The Springs' Lakeside Cabins should be considered.

### 11.3 Recommendations for Threatened Species Impact Management

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

- v. 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 Cudmirrah 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.
- vi. Spring and summer breeding activity of Green and Golden Bell Frog *Litoria aurea* requires two levels of monitoring to check for the presence of frogs and tadpoles in the lake edges.
  - (a) Background surveys by council to determine if the species utilises the brackish edges of the lake for breeding. Survey sites should be investigated for appropriate microhabitat prior to the

survey effort. Surveys should be carried out by a suitably qualified person, during or within 24 hours of rain and when lake salinity is less than 8ppt.

(b) When the lake is at or near 2.2m AHD, a survey should be undertaken prior to lake opening. If Green and Golden Bell Frog were found breeding in the lake, this would trigger a significant impact under the TSC Act (1995). Further, Environment Australia should be contacted to confirm whether lake opening would trigger significance under the EPBC Act (1999). Detection of this species in the lake would require modification of the policy to cater for its presence.

- vii. Elevation surveys of the SEPP 14 wetlands should be finalised to determine critical inundation levels.

### ***11.4 Recommendations for Water Quality Management***

- viii. The feasibility of in-ground detention storage be investigated at Pumping Stations 1 and 13 to satisfy current Environment Protection Authority requirements for new schemes in sensitive locations i.e. 8 hours' detention storage at Average Dry Weather Flow.

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## SWAN LAKE ENTRANCE MANAGEMENT DECISION MAKING TOOL

