10.0 Lake and Sea Interactions Action Plan

10.1 Scope

This Action Plan focuses on the interaction of the management of the Tuggerah Lakes estuary system with the management of the coastline. WSC is implementing the Tuggerah Lakes Estuary Management Plan (2006). This Action Plan is intended to support a consistent approach between coastline management actions and estuary management actions. The key to a consistent and sustainable approach is the management of the entrance channel.

The Lake and Sea Interactions Action Plan also complements the Coastal Erosion Action Plan (**Section 9.3**) and the Coastal Inundation Action Plan (**Section 9.4**).

10.1.1 Sediment dynamics – beach and estuary

Tuggerah Lakes are an example of an estuary system known as 'Intermittently Closed and Open Lakes and Lagoons' (ICOLLs). More than half the estuaries along the NSW coast are of this general type. They are shallow, wave dominated lakes, with variable catchment rainfall and runoff. The entrances to these lakes are usually at the southern end of long sandy beaches where long shore drift driven by prevailing wave direction (which varies seasonally and over periods of about 7 to 10 years) affects the distribution of beach sand.

The entrance of an ICOLL is often closed naturally. In periods of low rainfall, and with shoaling waves directing sand southwards along the beach, sand is driven into the entrance of the lake system by tidal currents and gradually builds up shoals known as a tidal delta. If these conditions continue, a sandy spit and then berm builds up across the entrance, eventually cutting off tidal exchange.

Figure 10.1 illustrates the accumulation of sand in the entrance as the tidal delta. This area is indicative of the area of significant tidal influence on the lake system.

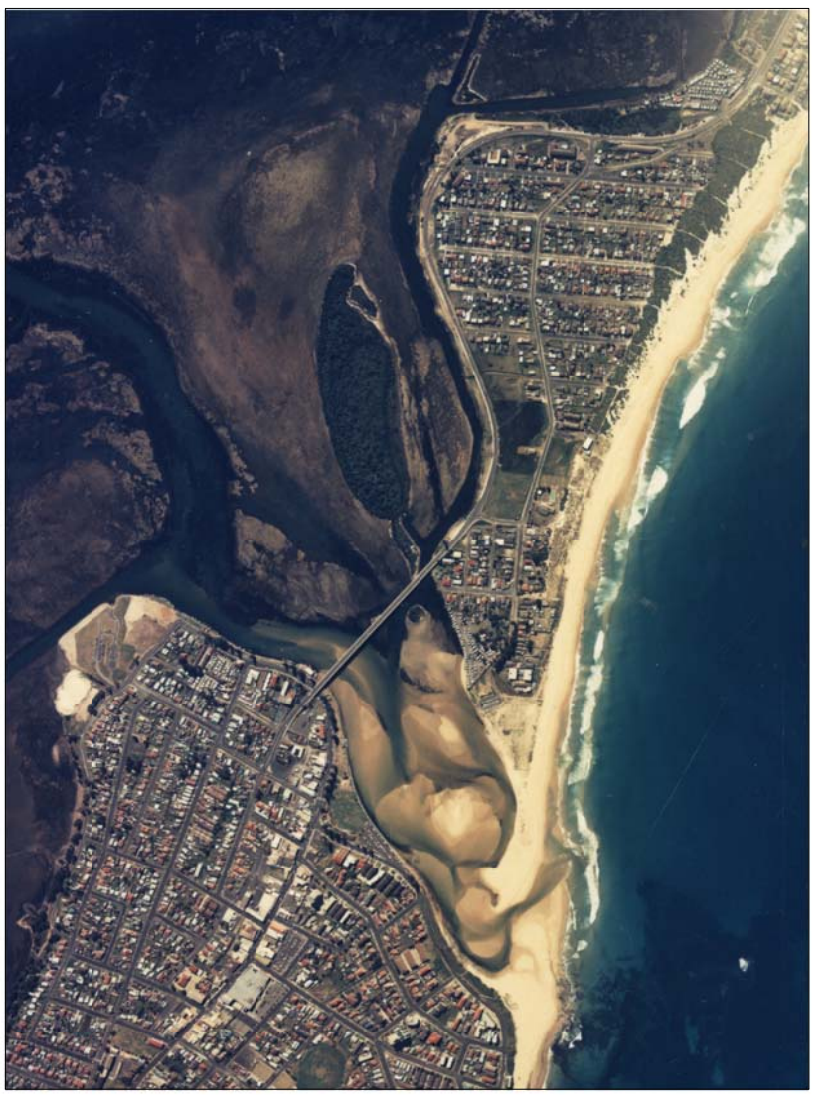
There is a second, relic tidal delta in Budgewoi Lake, showing that at times in the last few thousand years, this lake also opened intermittently to the sea. The berm at Lakes Beach has been closed for hundreds of years at least and the ecology of Budgewoi Lake has adapted to extremely low tidal circulation conditions.

In periods of high catchment runoff, water levels in the lake set up above ocean levels and eventually break through the sandy berm at the entrance. In these flood flow conditions, sand is scoured from the shoals in the entrance channel and from the spit and berm and is returned to the open beach. From there it can be carried along the shoreline by long shore currents, or blown into the incipient foredune and frontal dune system, or it returns to the lake entrance as the cycle begins again. Historical records show that the entrance to Tuggerah Lakes has been fully closed at least 13 times over the last 100 years, sometimes for as much as three years at a time. A large volume of sand of marine origin is stored within the tidal delta of the lake entrance. Some parts of this tidal delta have been stabilised by aquatic vegetation and provide both habitat for estuarine species and a natural buffer protecting the lake system from storm surge.

ICOLLs have low natural tidal exchange and circulation beyond the entrance channel area. The large shallow lake area absorbs the energy of tidal flows quickly. In Tuggerah Lakes, tidal influences extend only about one kilometre from the entrance – affecting only a small part of the lake. Tidal exchange of the volume of Tuggerah Lakes takes about 100 days.

1941

1961



1980

2002

FIGURE 10.1

Marine Sand in The Entrance Channel

Note: The tidal delta in the Entrance Channel of Tuggerah Lakes incorporates an extensive area of low activity lakeward of The Entrance bridge (where sediment movement is now principally restricted to dredged channels); and a small dynamic area east of the bridge. The wave trimming lake margin of the old tidal delta is trimmed by waves. Until the late 1960s, blowouts from North Entrance beach conveyed sand back into the lake. The mobile dune is now stabilised by residential development

10.1.2 The Entrance and North Entrance Beach

North Entrance Beach is situated immediately to the north of The Entrance channel of Tuggerah Lakes.

North Entrance Beach is at the southern end of the Tuggerah Beach embayment, which extends from The Entrance, approximately 7 kilometres to Pelican Point. The Holocene barrier widens northwards, and complex transgressive dunes developed on the central to northern part of the barrier in the mid to late Holocene. Pleistocene cliff top dunes at the northern end of this embayment also provide evidence of a general northward drift of sediment in this embayment, driven by exposure to south-east swell and winds. In the long term, the marine sedimentary processes in this embayment have favoured accumulation at the northern end, with sand loss from the southern end. At North Entrance Beach, only a single frontal dune exists with low relief back barrier flats immediately landward. Substantial reserves of aeolian sand exist at the northern end of the Tuggerah embayment, some of which were exploited for construction sand in the 1960s. Much of the dune field is now protected within Wyrrabalong National Park. The remainder of the dune field is stabilised and developed (e.g. at Magenta Shores).

Preliminary assessment of sedimentary processes at the Entrance (Patterson Britton & Partners Pty Ltd 1991; 1994; Worley Parsons 2008) identify what they describe as a 'null point' on North Entrance Beach. The location of this point varies seasonally and with longer term weather patterns, but conceptually, Worley Parsons suggest that south of the 'null point', i.e. towards The Entrance, littoral drift is to the south and into the shoals at the lake entrance. North of the 'null point', littoral drift is to the north, along the Tuggerah Beach compartment. Other factors affecting the patterns of sediment movement along the beach include the period of time since the lake entrance was fully open (i.e. since a major entrance scouring event), and the status of beach rotation which accompanies *el nino/la nina* cycles. The significance of these factors in terms of the success of potential beach nourishment is not currently known.

There is a relationship between entrance processes and sand supply on North Entrance Beach. When sand is held inside the entrance in the tidal delta, there is slightly less sand available on North Entrance Beach. When sand is scoured out of the entrance, there is a slight increase in the amount of sand available on North Entrance Beach. Details of sand volumes and sedimentary process dynamics are currently being investigated.

10.1.3 Measured changes to shoals and channels at The Entrance

Council has collated historical aerial photos of The Entrance area, spanning the period from 1941 to the present. Comparison of these photos shows significant changes to the morphology of the flats, shoals and channels around The Entrance over the last 60 years. These changes reflect a combination of:

- foreshore reclamation and construction of fixed foreshores;
- regular dredging of sand in tidal shoals in the outer part of The Entrance;
- channel straightening and potentially channel deepening, particularly upstream of the bridge. More formal dredged channels have isolated some former active lobes of the tidal delta;
- stabilisation of shoals and islands within the inner part of the tidal delta with saltmarsh, mangrove and sea grass; and

- stabilisation of the mobile dune which traversed the barrier at North Entrance until the late 1960s. This dune contributed sand from the beach to the lake shore; the sand was reworked across the tidal delta by waves and tidal currents.

These changes have decoupled large volumes of sand from active sedimentary processes.

10.2 Dredging operations

WSC conducts dredging operations at The Entrance using a mobile dredge. The dredge is moored in the Wyong River when not in use. Dredging of the active tidal delta shoals has been conducted since about 1990, to maintain tidal flushing of the entrance area. The dredging has secondary benefits such as restoring eroded foreshore and improving recreational amenity.

When a dredging campaign is undertaken, the dredge moves in stages from upstream to downstream. Council has a licence to dredge up to 100,000 cubic metres of clean sand from the entrance channel annually. The actual amount dredged varies with short and medium term weather patterns and sediment dynamics, and therefore the amount of sand which needs to be removed to maintain a slightly open entrance form and maintain tidal flushing. The outer channel (i.e. seaward of The Entrance Bridge) is dredged more frequently than the area upstream of the bridge, along the Terilbah channel, other channels and sumps. Details of dredging locations are reviewed in Worley Parsons (2008).

Most of the dredged sand (the long term average volume of dredged sand is approximately 50,000 cubic metres per year) is placed on North Entrance Beach, south of the inferred null point, with other sand placed on the Karagi Park foreshore near the entrance or over the rock base of South Entrance Beach. Approximately 30,000 cubic metres of sand was placed on South Entrance Beach in 2004. **Figure 10.2** (from Worley Parsons 2008) shows the current dredging footprint and sand placement areas. Sand is placed on North Entrance Beach in front of properties at the southern end of Hutton Road, in the vicinity of Hargraves Street. Following placement of the sand slurry, the material is shaped into a 'natural' accreted beach profile by bulldozer and is left unvegetated as mobile beach sand. Council aims to match the crest level of the emplaced material with the existing dune crest level and to achieve a stable slope on the seaward side of the foredune and berm.

The volume of sand currently dredged is a small fraction of the volume of sand which may be scoured from the entrance in occasional major floods, when the entrance can widen to 500 metres (Worley Parsons 2008) with channel depths of up to 3 metres (Worley Parsons 2008). These maximum channel dimensions, likely to be a very rare occurrence, would give a maximum sediment volume in the outer part of the tidal delta (assuming 500 metre distance downstream of the bridge) of around 750,000 cubic metres. Sand scoured from The Entrance is delivered to near shore shoals and to both South Entrance and North Entrance Beach. However, because major floods occur rarely, for most of the time a significant volume of sand is naturally stored in the tidal delta and is not available to bolster beach and dune volume. The tidal delta processes help to maintain the tidal range and other hydrodynamic processes which underpin the estuarine ecology of the lake system.

2006

The Entrance area east of the bridge has been dredged annually since about 1990. The channels upstream from the bridge are dredged less frequently. The straight dredged channels tend to confine tidal flows close to the northern and southern shoreline lakeward of the bridge

FIGURE 10.2

Recent Dredging Footprint and Sand Placement Location

10.3 Sediment budget issues at The Entrance

SMEC (2010) has shown that most of Wyong's beaches have been relatively stable in sand volume over the last three to four decades. For most beaches, measured recession since the 1970s is less than three metres (note however, that this would still lead to recession of approximately 10 metres over 100 years, if the same average rate continued). Some beaches have accreted slightly, as the coast recovers from the impacts of a series of major storms such as those of 1974 and 1978.

SMEC (2010) identified two clear exceptions to this apparently stable situation. Parts of North Entrance Beach have receded by 3 to 15 metres over the last three decades and Lakes Beach has also receded by approximately 15 metres. At North Entrance Beach, the largest measured recession (averaging 0.5 metre per year) is immediately to the north of the section which has been nourished with sand dredged from The Entrance. In the next section north (including Curtis Parade) average recession since the 1970s is 0.2 metre per year. Some long term recession (averaging 0.1 metre per year) has also been measured in the nourished section.

The current management of this southern part of Tuggerah Beach is therefore not preventing ongoing recession. Sand nourishment with material dredged from The Entrance does not balance the amount of sand lost from the beach and dunes – back to The Entrance, over the dune field, to deep water offshore or along shore to the north. It should be noted that a single major storm has the potential to temporarily remove 250 m^3/m of sand off the southern section of North Entrance Beach. So for the 2.5 kilometre section of beach extending from the southern end of Hutton Road, past Curtis Parade, a single major storm bite would cut approximately 625,000 cubic metres of sand from the beach and dune.

The management of sand build up in The Entrance is part of the story of managing the stability of North Entrance Beach. Issues to be considered in the interaction of the lake entrance area and the beach include:

- How does major scouring of the Entrance channel in flood conditions affect sand supply on North Entrance Beach?

- If Council continues dredging, how much sand could be available from the entrance channel without destabilising the channel or lake ecology? The dredging to date has been designed to keep sand in the southern part of the beach compartment – either in the entrance channel or on the North Entrance beach and frontal dune. The sand is placed on the beach close enough to the entrance so that when/if removed by erosion it ultimately returns to the channel. If sand is placed outside the area of influence of the entrance then it would result in a decrease in the volume within the entrance. A long term, significant reduction of sand in the lake entrance is likely to have undesirable implications for the health of the estuary (e.g. in terms of tidal range).

- If sand dredged from the entrance channel is used on the ocean beaches, where should it be placed for maximum benefit e.g. to provide enough sand to withstand a storm, to protect recreational amenity, or to maintain a particular alignment.

- What would happen if Council stopped dredging? Would the berm eventually build up and sand would accumulate on the beaches (rather than being caught for years in the entrance channel)? Without climate change, the best evidence of what would happen to the beach if council stopped dredging is the pre dredging configuration of the entrance. Pre 1990, the entrance closed for long periods, but the exact distribution of sand volumes across the spit/berm, in the tidal delta and on the beach/dunes is not known.

- How will sea level rise affect the sediment dynamics in the entrance channel? Would the volumes of sand moving into The Entrance channel change? Would the locations of sand deposition change? Would rates of sediment transport in and out of the entrance change, and affect the viability of dredging? It has been assumed that with a long term stable sea level, there is no net supply of sand to The Entrance either from the ocean or the lake side. A rising sea level would, in theory, drive the tidal delta further into the lake entrance area. A further question is whether recession associated with rising sea level would remove the narrow frontal dune system at North Entrance, creating the potential for a wide or relocated entrance channel.

- At a few locations, oceanic inundation may exacerbate lake flooding. Lake flood risk is increased by the throttling effect of the narrow shallow channel, which slows discharge of lake waters during flood events.

Additional information about these issues is included in **Appendix 7**.

Separate to the issues at The Entrance and North Entrance, are long term concerns about overtopping or breaching of the barrier at Budgewoi Lake. For the 2100 planning period, with sea level rise, there is potential that the low sandy barrier in the vicinity of Hargraves Beach/Lakes Beach could be breached by coastal recession and severe storm waves. If this did occur, there are major consequences for the habitats on Budgewoi Lake, but also the other Tuggerah Lakes.

The Lake and Coast Interactions Action Plan explains how Council proposes to address these questions, including actions that are proposed now and how the results of ongoing studies will help to refine management.

10.4 Council's priorities

Over the next 10 years, Council will manage the sediment budget of The Entrance channel and adjacent beaches to balance the values of lake ecology, recreation and tourism in The Entrance and the stability of beaches and coastal dunes.

Council will continue to dredge some tidal delta sand from The Entrance and use this sand for beach and dune nourishment. Council does not regard the volume of sand available in the active tidal delta as sufficient to mitigate against long term coastal recession at North Entrance Beach. However, Council will continue to refine the dredging process (timing, sediment volumes and placement options) to get the best benefits for a sustainable alignment of North Entrance Beach and frontal dune system.

Council will implement a monitoring system to provide accurate information about how the beach responds to sand nourishment and how sand is redistributed after nourishment.

Council will invest in new technical and modelling studies to clarify how the entrance of Tuggerah Lakes will respond to sea level rise and other aspects of climate change (see **Appendix 7** for current progress on these studies). Council will review its management of The Entrance channel based on the results of these studies.

Based on currently available information, Council has no evidence that constructing training wall(s) at The Entrance would be beneficial for either the lake system or for the sediment budget on North Entrance Beach. It should be noted that the rock foreshore on the southern shore of The Entrance channel already functions as a natural training wall and has done so for thousands of years.

Recent analysis (Worley Parsons 2011, DECCW 2010 and SMEC 2011) consistently indicates that major interventions at The Entrance, including training wall on the northern side of the entrance berm or major dredging to force the entrance into a wide open condition, would have significant detrimental effects on sediment budgets and local morphology.

10.5 Who is responsible for making a difference?

The actions in this Action Plan are principally the responsibility of Wyong Council. Council will work closely with OEH in relation to technical issues about lake entrance dynamics and with DPI (relevant sections for former L&PMA) and DTIRIS (Primary Industry, Fisheries) in relation to land tenure and approval matters for actions such as dredging and sand placement.

Council will consult with relevant landholders, businesses (e.g. tourism operators) and the Chamber of Commerce where proposed actions have the potential to affect their interests and values. Council will continue to present information about the interactions between lake management and coastline management at the meetings of the Tuggerah Lakes Estuary Management Committee.

10.6 How these actions contribute to coastal management objectives and targets

Table 10.1 sets out Council's objectives and targets relevant to the interactions of management of the Tuggerah Lakes and the Wyong coastline. These overarching objectives lead to an operational objective to maintain the separation of the Tuggerah Lakes system and the open ocean, other than at the existing lake entrance at The Entrance.

Table 10.1 – Achieving objectives and targets relevant to lake interactions

Objectives and performance targets	Action summary (see Table 10.2 for details)
O7 To enhance the awareness of residents, landholders, and land users of coastal processes, climate change, impacts and adaptation measures**.** **Target** • By 2012, there is a measurable increase in the awareness of coastal residents and landholders of the variability of coastal processes (and the impacts of climate change and how that can adapt to these changes)	See actions in **Sections 7.0**, **9.0** and **13.0**
O2 To inform and facilitate adaptation to climate change impacts along the Wyong coast **Target** • By 2011, Council provides competent and comprehensive advice to residents and ratepayers about the impact of climate change on Council operations (planning, assets, infrastructure and emergency response) in the coastal zone and how council will manage these risks.	See actions in **Section 7.0** and **Section 13.0**

Objectives and performance targets	Action summary (see Table 10.2 for details)
O10 To identify priorities for WSC investment in capacity building and on ground works **Target** • By 2012, WSC has adopted and is implementing priority activities to improve the resilience and sustainability of the parts of the coastline in its direct care.	A28: Review the entrance management strategy and dredging management plan for The Entrance channel to maximise sustainable beach nourishment now and as sea level rises. The first review will focus on maximising the benefits of sand placement for dune stability. After the research described in A13/A68 is conducted, Council will review and revise the dredging program over time, as necessary. A68: Council will commission further studies of sediment dynamics in The Entrance channel, with sea level rise. This is likely to include a hydrodynamic model to test sediment budget changes in the Entrance channel as sea level rises. Further research is also necessary to clarify the relationship between lake flood levels, coastal recession and oceanic inundation hazards at Lakes Beach area. A66: Council will review the structural integrity of The Entrance sea wall and schedule structural upgrades as necessary to balance risk and cost. A44: Use beach nourishment or beach scraping to reinforce dunes and to maintain dune crest height above 7 metres at affected locations (potentially 8 metres at North Entrance) A9: Council will continue to dredge sand from the active tidal delta at The Entrance and place the sand on North Entrance Beach. Some sand may also be placed on The Entrance Beach to maintain beach amenity. A28: Review the entrance management strategy and dredging management plan for The Entrance channel to maximise sustainable beach nourishment now and as sea level rises. The first review will focus on maximising the benefits of sand placement for dune stability. After the research described in A13/A68 is conducted, Council will review and revise the dredging program over time, as necessary.
O8 Efficient and effective strategies for minimising risk in the coastal context **O6** Maintain visual, social and heritage values of significant coastal cultural landscapes	A28: Review the entrance management strategy and dredging management plan for The Entrance channel to maximise sustainable beach nourishment now and as sea level rises. The first review will focus on maximising the benefits of sand placement for dune stability. After the research described in A13/A68 is conducted, Council will review and revise the dredging program over time, as necessary.

10.7 Implementation of management responses

Table 10.2 identifies management actions to address issues associated with the interaction between the Tuggerah Lakes and the open ocean coastline.

Table 10.2 – Management actions at The Entrance

Step 2: Take action to reduce risk or to increase opportunities

A9: Council will continue to dredge sand from the active tidal delta at The Entrance and place the sand on North Entrance Beach. Some sand may also be placed on The Entrance Beach to maintain beach amenity.

A28: Review the entrance management strategy and dredging management plan for The Entrance channel to maximise sustainable beach nourishment now and as sea level rises. The first review will focus on maximising the benefits of sand placement for dune stability. After the research described in A13/A68 is conducted, Council will review and revise the dredging program over time, as necessary.

Intent and logic

Although the purpose of entrance dredging is to maintain some tidal flushing of the lake entrance area, the placement of dredged sand is how Council currently manages the sediment balance between the tidal delta and the open ocean beaches. Dredging gradually moves sand from the tidal delta to the beach at times when it would normally accumulate in the estuary entrance. In the short term this provides a greater sand buffer on the beach and dunes of the open coast. The volume and rate of dredging is adapted to current sea level and rainfall/flood conditions See also **Table 9.1**.

Responsibility and key partners	When - Priority	Where – locations for investment	Indicative cost and source of funding
See **Table 9.2**	See **Table 9.2**	See **Table 9.2**	See **Table 9.2**

Step 2: Take action to reduce risk or increase opportunities

A66: Council will review the structural integrity of The Entrance sea wall and schedule structural upgrades as necessary to balance risk and cost.

There is already a sea wall on the southern side of The Entrance, which provides a formal promenade and separates the shoreline from road and other infrastructure. It is an important tourism asset. See also **Table 9.1**.

Council does not propose to construct a training wall on the northern side of The Entrance channel.

Intent and logic

This action relates only to the sea wall at The Entrance. The wall is part of a major tourism area and protects community infrastructure, including the road, car parking and pedestrian promenade. This action will ensure that the sea wall remains structurally sound in the long term.

Responsibility and key partners	When - Priority	Where – locations for investment	Indicative cost and source of funding
Council Asset Manager, with OEH and DPI (relevant sections of the former L&PMA).	Confirm structural integrity and design requirements for the sea wall within 2 years.	The Entrance sea wall	Allow $20,000 for assessment and design requirements. Any structural changes to the wall would be costed separately. Significant sea wall reconstruction could cost more than $1 million.

Step 2: Take action to reduce risks

A44: Use beach nourishment or beach scraping to reinforce dunes and to maintain dune crest height above 7 metres at affected locations (potentially 8 metres at North Entrance)

This applies to parts of North Entrance Beach (e.g. Curtis Parade area), and to the Hargraves and Lakes Beach area, where low barrier height increases the long term hazard of breaching from the coast through into Budgewoi Lake.

Intent and logic

Council currently uses bulldozers to shape parts of North Entrance Beach during sand nourishment activities. This action continues that process and also provides for beach scraping to move sand from the beach face onto the incipient dune and frontal dune area at other times.

This action will help to maintain the dune height at Lakes Beach/Budgewoi, to reduce the risk of oceanic inundation/wave overtopping of the barrier. Beach scraping is a short term option, which can be used as sand begins to move back onto the beach after major storms. Sand sources for beach nourishment are currently limited, and are discussed in **Section 10.0**.

Responsibility and key partners	When - Priority	Where – locations for investment	Indicative cost and source of funding
See **Table 9.1** and **Section 10.0**	See **Table 9.2** and **Section 10.0**	See **Table 9.2** and **Section 10.0**	See **Table 9.2** and **Section 10.0**

Step 3: Enhance knowledge and monitor achievements

A67: Establish a detailed monitoring program to clarify how sand placed on North Entrance Beach is redistributed and (sediment budget) and to support amendments that would provide more effective sand retention to buffer against major storm bite.

This action is part of a suite of monitoring and review tasks that are designed to refine understanding of the effectiveness of management actions and therefore to improve management of sediment budgets in changing conditions. See also A1, A73, A68.

Intent and logic

Council does not currently have detailed information about how and when sand moves on North Entrance Beach and how sand loss can be minimised. Long shore sediment transport can be modelled using wave data. Monitoring using a combination of remote sensing and ground survey will calibrate the models and help clarify opportunities for improved management. The results of this monitoring will also help landholders to understand how the sediment budget can be managed to provide the best possible protection to property.

Responsibility and key partners	When - Priority	Where – locations for investment	Indicative cost and source of funding
WSC will lead this action, with assistance from OEH.	The monitoring program should be developed and implemented as soon as possible and should also revisit as necessary, information from beach nourishment and storms over the last several decades.	The focus is on North Entrance Beach from The Entrance spit, to north of Curtis Parade, a distance of some 2.5 km	Indicative cost is $10,000 per year. Options include council funds, landholder contributions (if approved through the amendments to the *Coastal Protection Act 1979*) and OEH programs.

Step 3: Enhance knowledge and monitor achievements

A68: Council will commission further studies of sediment dynamics in The Entrance channel, with sea level rise. This is likely to include a hydrodynamic model to test sediment budget changes in the Entrance channel as sea level rises. Further research is also necessary to clarify the relationship between lake flood levels, coastal recession and oceanic inundation hazards at Lakes Beach area.

The timing of trigger points for increased risk is important for this location. See also **Table 9.4**. **Appendix 7** provides information about some additional studies.

Intent and logic

Lake frontage properties and low lying coastal land in Wyong Shire have been identified as significant risk areas as sea level rises to 40 centimetres and 90 centimetres above 1990 levels over the next century. The extent to which lake processes and marine processes will interact and the cumulative effects of lake flooding, coastal recession and oceanic inundation are not well understood. These studies will help Council and land owners to better understand the extent of risks that need to be managed.

Responsibility and key partners	When - Priority	Where – locations for investment	Indicative cost and source of funding
Council's Environment and Natural Resources Unit will work with OEH in relation to scoping and funding these studies	See **Tables 9.1** and **9.4**	Entrance of Tuggerah Lake, North Entrance peninsula (first priority) and Budgewoi/Lakes Beach area are key locations. Studies involve modelling sediment transport consequences of changes to hydrodynamics as sea level rises, and testing a range of management options using the model.	See **Table 9.1** and **9.4**. Allow up to $50,000 as Council's contribution (assuming 50% contribution from NSW Government).