

Murray Mouth Sand Pumping: Keeping the Tides Flowing

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With a basin over 1,000,000 square kilometres in area within four States and a Territory, the Murray-Darling Basin is the largest and most important river system in Australia. Flows originate within several catchments from Queensland south to Victoria and flow into South Australia ending in the Lower Lakes and Coorong. From the Coorong, the water flows out of the Murray Mouth to the sea. With the construction of the major storage dams, the Locks along the River and the Barrages at the Murray Mouth, the system has become highly regulated. As a result of increasing levels of water extractions, compounded by the current seven year drought, flows in the lower river have reduced dramatically in recent years and flow to the Murray Mouth has ceased for long periods, with no flow through the Barrages since October 2006. Without mechanical intervention the Murray Mouth would almost certainly have closed, resulting in potentially catastrophic environmental impacts within the internationally recognised and Ramsar listed wetlands of the Lower Lakes and Coorong, impacting on the traditional owners, local industry and the public. In October 2002, a six month dredging program commenced to create two channels from the Southern Ocean into the Coorong, one from the Murray Mouth into the Goolwa side, and the other from the Mouth to the Tauwitchere side of the Coorong. After five years of dredging, the program continues, having moved in excess of 5,000,000 cubic metres of sand at a cost of \$33m. It has successfully drawn together the traditional owners of the area, seven State and Federal Government departments and agencies, and several private sector contractors and suppliers to ensure that the mouth of the largest river system in Australia remains open.

The Lower Lakes and Coorong

The waters of the River Murray flow from three main catchments within Queensland, New South Wales and Victoria – the Darling River catchment, the Murrumbidgee and Lachlan Rivers catchment and the Murray River catchment. By the time the waters have arrived at the South Australian border, the three catchments have merged into a single river that flows west and then south to the Lower Lakes and Coorong and out to sea (Fig. 1).

The Lower Lakes consist of two main bodies of water, Lake Alexandrina and Lake Albert, which were formed as two fresh water lakes when the Murray Mouth Barrages were built in between 1935 and 1940. Fresh water from Lake Alexandrina flows through any of the five Barrages, into the Coorong and out the Murray Mouth to the sea. The total area of Lower Lakes and Coorong is approximately 140,000 hectares¹ and provides an area of high cultural, ecological,

¹ The Living Murray, 'Lower Lakes, Coorong and Murray Mouth', Murray Darling Basin Commission, updated: 25 Sep 2007, viewed: 10 Aug 2008, http://www.thelivingmurray.mdbc.gov.au/iconsites/lower_lakes

commercial and social importance. It has been recognised by the State and Commonwealth as one of the six iconic sites along the River Murray.

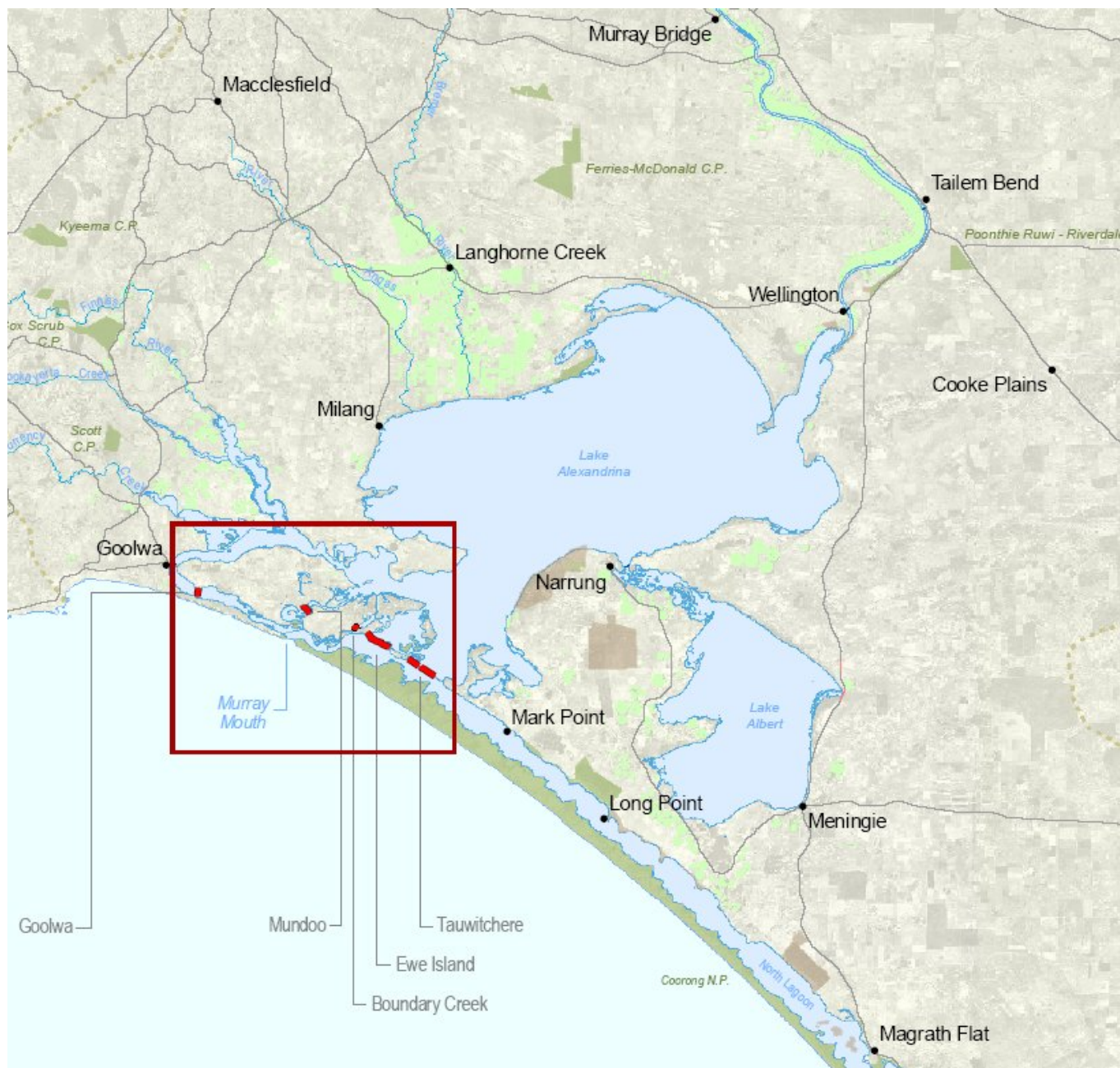


Fig 1. Lower Lakes and Coorong (Source: DWLBC)

The Coorong and Murray Mouth

The Coorong is a 140 kilometer long estuarine area that runs parallel to the Southern Ocean behind sand dunes 3 to 5 kilometres wide and is a Ramsar protected area because of its high biodiversity value. A small section of the sand dune system extends north-west from the Mouth and is known as the Sir Richard Peninsula, whilst the section of land extending to the south-west is known as the Younghusband Peninsula².

² AWE (2004). *Environmental Benefits from dredging the Murray Mouth*, a report prepared for the Department of Water, Land and Biodiversity Conservation, Australian Water Environments, Adelaide.

Cultural significance

The Lower Lakes and Coorong region is of high cultural, economic, spiritual and social value to the traditional owners, the Ngarrindjeri. This area forms part of a Native Title Claim that extends from the Coorong across to Cape Jervis and up to Murray Bridge.

Studies have shown that this area is rich in beliefs, cultural heritage, dreaming stories and anthropological evidence³. For the Ngarrindjeri, the Lower Lakes and Coorong provides an area where traditional activities can occur such as fishing, hunting, gathering eggs, collecting reed and making traditional wares. A significant change in the area can have a significant impact on these activities and hence upon Ngarrindjeri culture.

Ecological significance

Ecologically, the Coorong and Lower Lakes are an extremely important site. It is habitat to over 85 species of birds and as such, is one of the top six sites within Australia for bird diversity and abundance⁴. It is an internationally important foraging ground for waders (Table 1) and is subject to migratory bird agreements with Japan and China (JAMBA and CAMBA).

Breed In	Scientific Name	Common Name
Siberia	<i>Calidris ruficollis</i>	Red Necked Stint
	<i>Calidris ferruginea</i>	Curlew Sand Piper
	<i>Calidris acuminata</i>	Sharp-tailed Sand Piper
	<i>Tringa nebularia</i>	Common Greenshank
Australia	<i>Cladorhynchus leucocephalus</i>	Banded Stilt
	<i>Himantopus himantopus</i>	Black-winged Stilt
	<i>Recurvirostra novaehollandiae</i>	Red Necked Avocet
	<i>Charadrius ruficapillus</i>	Red Capped Plover
	<i>Vanellus miles</i>	Masked Lapwing

Table 1. Waders found within the Coorong⁵

In addition to the importance of the area to birdlife, it is equally important for fish. The area is home to over 78 species of fish, supports several commercial fisheries, as well as playing a key role within the life cycle of many fish, both freshwater and marine⁶.

Aquatic plants found within the area also play an important role in the ecology. Several form a part of the diet of migratory waders; whilst others are important habitats for invertebrates, biofilms and juvenile fish.

The Coorong and Lower Lakes have been declared a Ramsar site, one of 64 within Australia. The classification of the area as a Ramsar wetlands means that management plans must be produced to satisfy six objectives - integrated management and monitoring; increased involvement of Ngarrindjeri people; increased community awareness of wetland values;

³ NRWG (1998). *Ngarrindjeri Perspective on Ramsar Issues*, a paper prepared by the Ngarrindjeri /Ramsar Working Group for the Ramsar Planning Team, for inclusion into the draft *Coorong, and Lakes Alexandrina and Albert Ramsar Management Plan*.

⁴ DWLBC (2008). *Murray Mouth Sand Pumping Program – Progress Report 2002 to 2008*. South Australia. Department of Water, Land and Biodiversity Conservation, June 2008, p. 1-14.

⁵ DWLBC, p. 1-14.

⁶ PIRSA (2005). *Paper number 44: Management Plan for the South Australian Lakes and Coorong Fishery*, Fisheries Section, Primary Industries and Resources, South Australia, p. 65.

protection and restoration of wetland habitats; improved water resource management; and funds and resources made available to implement the plan.

Recreation importance

From a recreation perspective, the Coorong and Lower Lakes has significant value. It provides a range of fresh and estuarine semi protected waters for boating (power and sailing), fishing and camping. The Coorong is serviced by two main public boat launching facilities as well as several smaller boat ramps while the Lower Lakes has several marinas and additional launching facilities. Access from the Lakes to the Coorong is via boat locks within the Goolwa and Tauwichee Barrages.

Industry importance

The Coorong area is important for two main industries. The first is that of commercial fishing which contributes approximately \$5.5 million to the economy per annum⁷. Species target include Coorong Mullet, Mulloway/Jewfish and Cockles, using a variety of methods including netting⁸. There are also fresh water fisheries in the Lower Lakes.

The second industry within the area is that of Ecotourism. This is supported by both land and water based tours, and local and intrastate operators. The traditional owners also operate education programs offering tours within the area.

Changes in flow – natural change

Historically the Murray Mouth and Coorong was a very dynamic tidal inlet and estuary, characterised by highly variable flows in the River Murray and a very active coastal system. Large and rapid changes in the size and location of the mouth were brought about by the boom or bust nature of flows in the River Murray, together with the wide variation in the amount and direction of the longshore drift, storms and tides^{9,10}.

Changes in flow - human influence

In 1922, the construction of a series of Locks and Weirs began along the length of the River Murray¹¹. In 1935, five barrages were built near the Murray Mouth, changing the Lower Lakes from estuarine conditions to freshwater lakes by creating a physical barrier between the Lakes and the Coorong¹². The Locks and Weirs were originally built to provide navigable waters for steamers and barges but the focus changed to provide stable water pools for consumptive use (human consumption, irrigated horticulture and recreation). The Barrages were built to ensure a fresh water pool in the 260 kilometre section below Lock 1 for consumptive and recreation use.

⁷ Hera-Singh (2002). Fishing Industry, in *The Murray Mouth: Exploring the implications of closure or restricted flow*, a report prepared for the Murray-Darling Basin Commission, Department of Water, Land and Biodiversity Conservation, Adelaide, pp. 13-20.

⁸ PIRSA (2005)

⁹ DWLBC, p. 1-3,5

¹⁰ DWLBC, p. 1-7.

¹¹ The Living Murray, 'Locks and Weirs', Murray Darling Basin Commission, updated: 29 Oct 2006, viewed: 10 Aug 2008, http://www.mdbc.gov.au/rmw/river_murray_system/locks_and_weirs

¹² The Living Murray, 'The Barrages', Murray Darling Basin Commission, updated: 29 Oct 2006, viewed: 10 Aug 2008, http://www.mdbc.gov.au/rmw/river_murray_system/barrages

The combination of river regulation and the increasing level of diversions have had a significant effect on the condition of the Murray Mouth. An open mouth depends on the occurrence of sufficient river flows to prevent sand deposition inside the mouth and to flush accumulated sand out of the mouth.

Modelling of natural versus regulated conditions has shown a significant reduction in the volumes and frequencies of flows at the Mouth, which can be summarised as follows¹³:-

- Years with annual volumes of less than 5,000 gigalitres (GL) – natural: 7% vs regulated: 66%;
- Medium sized flood event (20,000 to 80,000 GL/day) – threefold reduction in frequency and duration;
- Murray Mouth now ceases to flow – natural: 1 in 20 years vs regulated: 1 in 2 years;
- The median outflow is now 27% of natural flow.

The result of this has been a steady accumulation of sand inside of the Murray Mouth. A report from the Department of Water, Land and Biodiversity Conservation¹⁴ suggests that:

‘...it is probable that the construction of the barrages in 1940 affected the long term stability of the mouth and increased the propensity for sand accumulation and risk of closure’.

Impact of the current drought conditions

In accordance with the water sharing provisions of the Murray Darling Basin Agreement, South Australia receives an annual entitlement of water. However due to the drought, water storages in the Murray-Darling Basin are at historic lows resulting in South Australia receiving significantly less water than entitlement. This means that the extraction and evaporation from the Lower Lakes are greater than inflows, causing lake levels to drop with little or no water being released through the Barrages and out of the Mouth.

There have been no significant flows out of the Mouth since 2001 as the drought conditions persisted and inflows into Lake Alexandrina have been low. Discharge from the barrages ceased completely in 2006 and Lake Alexandrina currently experiences reverse head conditions (Coorong water levels higher than Lake water levels) 100% of the time.

It is forecast that for lake levels to return to normal, several years of above average rainfall are needed throughout the Murray-Darling Basin.

The Mouth has only closed once in recorded history, in 1981 but by mid 2002 the Mouth was becoming severely restricted and it was very likely that it would close without some form of intervention.

Consequences of the Mouth closing

If the mouth closed, several risks were apparent, including;-

- Increased salinity within the Coorong waters;
- No tidal variation;
- Increased water levels;

¹³ DWLBC, p. 1-6

¹⁴ DWLBC, p. 1-18

- Increased water temperatures; and
- De-oxygenation of water.

The consequences of a closure are:-

- Reduction in the biodiversity of the Coorong;
- Flooding of habitat for both endemic and migratory bird species;
- Cultural trauma for the Ngarrindjeri;
- Reduction or loss of fish and the fishing industry;
- Reduction or loss of recreation areas impacting on tourism; and
- Impacts on Regional business.

Expert advice was that a rise in water temperature of only a few degrees would be catastrophic to the ecology of the Coorong.

Maintaining a mouth

Approval was received by the Murray-Darling Basin Ministerial Council in September 2002 to commence dredging of the Murray Mouth. The objectives of the project were to:-

- Lower the elevated water levels in the Coorong;
- Re-establish a tidal variation; and
- Provide stable channels.

This led to the development of three ecological objectives which continue to be used today:

- An open Murray Mouth – to ensure that there is connectivity between the Coorong and the sea;
- More frequent estuarine fish spawning and recruitment – preserving existing species and numbers for both economical and ecological reasons;
- Enhanced migratory bird habitats/tidal response – ensuring that tidal fluctuations (providing cool oxygenated water) are preserved to protect the mudflats within the Coorong.

The Sand Pumping Technical Committee (SPTC) was formed to oversee the project. The SPTC consists of:

- The Murray-Darling Basin Commission
 - Project Sponsor;
- Department of Water, Land and Biodiversity Conservation
 - Project Management, Policy and SA Ministerial liaison, publicity and public liaison;
- South Australian Water Corporation
 - Contract Management and operational support;
- Department of Environment and Heritage and National Parks and Wildlife Service
 - Provide monitoring and management of environmental impacts in the Coorong National Park.

In addition to the SPTC, external stakeholders involved within the project include:

- The Department of Transport Energy and Infrastructure
 - Boating assistance, support and enforcement;
- The traditional owners, the Ngarrindjeri
 - Cultural ranger monitoring service;

- Technical advice on cultural issues;
- Community
 - General public who use the area;
 - Boat and marina operators;
 - Tourism operators;
 - Commercial fishermen.

The SPTC considered a range of alternative options for keeping the Mouth open. Twelve options were evaluated including dredging, sand bypass, pumping, jetting, breakwaters, transferring water from Upper South East, constructing a new mouth and piping the Mouth. It became apparent that conventional dredging was the cheapest option with the lowest level of risk.

Channel Design, Modelling and Specification

In 2002, two companies were approached to produce computer-based hydro-dynamic sediment transport models of the Murray Mouth. These models were used to simulate various management options to maintain the openness of the Murray Mouth.

The models were used to develop channel profiles that would provide sufficient connectivity between the ocean and the Coorong to ensure that the objectives of the project would be met. Once the channel profiles were agreed, a scope of work was developed, tenders called and a dredging contractor engaged.

The design called for a channel 80 metres wide and 3 metres deep to be dredged from the Mouth to the Tauwichee Channel and a 40 metre wide by 3 metre deep channel connecting to the Goolwa side of the Coorong. This channel configuration is reviewed on a regular basis to ensure that the project objectives continue to be met (Fig 2).



Fig 2. Engineered channels (Source: BMT WBM)

Dredging program 2002 to 2008

Dredging work commenced in October 2002 using a cutter suction dredge to create the two channels. The initial program was envisaged to remove 375,000 cubic metres of sand from the Murray Mouth and only last for several months (Fig 3). Sand was to be deposited on the ocean beaches on Sir Richard and Younghusband Peninsulas.

As conditions continued to remain dry through 2003, it became apparent that additional sand removal capacity was required to enable the project objectives to be met. In June 2003 the Murray-Darling Basin Commission approved the introduction of a second dredge to ensure the Mouth remained open. In December 2004, the contract was re-let to the same contractor after an open tender call.

A significant milestone was reached in May 2006 when the design channel cross sections were achieved for the first time since dredging commenced in 2002. In June 2006, one of the dredges was stood down and placed on standby as the channels and Mouth were sustaining themselves, reducing dredging costs by about 30% (Fig 4).



Fig 3. Murray Mouth at commencement of dredging program (Source: NPWS SA)



Fig 4. Murray Mouth 2007 (Source: DWLBC)

The dredging contract was recalled in mid 2007 and a new contractor engaged.

Dredging equipment continues to operate 24 hours a day, seven days a week, with the only shut downs being over Christmas and Easter.

Dredge type and support vessels

While each contractor will operate slightly different setups and methods, the type of dredge used on the Murray Mouth Dredging project is a cutter suction dredge (Fig. 3). These operate by using a rotating cutter head to loosen material at the dredge cut face. The material is then sucked up through the dredge's pump and discharged through the rear of the vessel via a floating pipeline. The pipeline feeds to a booster, providing additional pressure to move the material to the discharge areas.



**Fig 3. Cutter Suction Dredge currently operating at Murray Mouth
(Source: DWLBC)**

The dredge/booster combination operating on the project is able to move a minimum of 2,000 cubic metres of material in a 24-hour period, in pipelines up to 2km in length.

As well as operating a minimum of one dredge at any one time, the program also funds a wide array of support vessels and equipment. There are slight differences between contractors, but in general each operates similar machinery (Table 2).

Type	Equipment	Use
Land Based	Excavator	Disposal area management
	Front end loader	Disposal area management
	Cranes	Maintenance
Water based	Floating excavator	Disposal area management and pipe manoeuvring
	Fuel barge	Fuel transport (up to 16,000L)
	Work boats	Act as a tug, dredge reposition
	Run around	Crew movement
	Lifting equipment	Pipe movement, anchor positioning

Table 2. Equipment operated

Exclusion zone

The Lower Lakes and Coorong are very popular recreational boating destinations. Prior to the dredging commencing, boat access past the Mouth was restricted because of the shoaling.

When the project was being established it was agreed with the local community all boating would be excluded from the Mouth because of safety concerns. It was also agreed that there would be no vehicle access to the Mouth along the Goolwa beach because vehicles would have to drive through the sand discharge area.

While this was acceptable when it was thought that the project was going to be of limited duration, it became a major issue in the community when it became apparent dredging would be required for a number of years. As the project continued and the dredged channels were established, boat navigation has been made available during the peak boating season of October to April by minimizing the size of the exclusion zone. Beach access was also restored as soon as it became safe to bypass the discharge area via a designated track. In addition, the project has worked with Alexandrina Council to upgrade existing boat ramps to improve access to the Coorong.

Dredging program licences

The dredging program operates under two main licences. The first, the Environment Protection Agency (EPA) licence covers all dredging activity and ensures that the program of works and the contractor are operating in an environmentally 'safe' manner. This licence resides with the contractor and it is their responsibility to maintain. Under the licence, an independently audited water quality monitoring program must be established and undertaken.

The second, an Aquatic Activities Licence, places the control of the water in which the dredge operations are occurring into SA Water. This enables the project to close public access to particular areas due to the dredging activities. At the present the exclusion zone operates and is enforced under this licence.

Performance monitoring

The project utilises multiple monitoring processes within the dredging program for checking on the effectiveness of the activities. These methods are:

- Satellite imagery
 - For: spatial operations, visual monitoring, hydrographic and bathymetric overlay;
 - Time: occurs once per month dependent on conditions;
- Bathymetric surveys
 - For: monitoring of sand deposits and scour, dredging outcome analysis;
 - Time: local survey – monthly; large area survey – quarterly;
- Diurnal Tidal Ratios
 - For: tidal connectivity monitoring;
 - Time: recorded continuously daily, but reported monthly;
- Weekly dredge report
 - For: spatial dredge position, spud movement, general condition report, pumped volumes;
 - Time: weekly;
- Aerial flights
 - For: aerial visual and photographic survey;
 - Time: monthly;
- Water monitoring stations
 - For: water levels and salinity;
 - Time: telemetry updated to a website every hour;
- Bird surveys

- For: migratory bird monitoring;
- Time: twice per month during migratory season;
- Morphological monitoring
 - For: system response modelling, predictive behaviour for dredging and barrage releases;
 - Time: as required.

Project funding and review

Funding for a program of this size is substantial; project cost to date exceeds \$33m. Current funding comes from the Murray Darling Basin Commission (MDBC) with contributions from the Governments of South Australia, Victoria and NSW, as well as from the Federal Government.

A Cost Effectiveness and Efficiency review has recently been undertaken. As a project, the dredging program is performing to best practice standards and continues to make cost savings where possible.

Impacts and Outcomes

The project has been and continues to be successful in achieving the primary objectives of keeping the Murray Mouth open to maintain a tidal variation in the Coorong and to deliver cool oxygenated water into the Coorong, thus helping to maintain the ecological integrity of this internationally significant site.

Environmental observations within the Mouth show several positive impacts on the Coorong. These include the prevention of excessive build up of water temperatures, limiting salinity build up within the North Lagoon, maintenance of ecological habitats, improved water level conditions and improved flushing conditions.

There is a much bigger environmental issue in the Coorong because the reduction in freshwater flows has caused the system to change from an estuarine to a marine environment; however dredging continues to meet its objectives of keeping the Mouth open.

With respect to the general public, the program has been very well received with generally positive feedback from people visiting the area.

Recreational and commercial boating has generally been accommodated, with restricted access past the dredging plant being made available in the peak boating season. Unrestricted beach access to the Mouth has also been re-established.

Recreational and commercial fishing continues to occur within the system; however as parts of the Coorong increase in salinity, catch numbers are decreasing. Within the mouth there are still large numbers of recreational fishermen.

Traditional owners' interaction

The significance of the area to the Ngarrindjeri was recognized right from the start of the project and a program was established whereby two Cultural Heritage Rangers are employed 7 days a week to monitor the dredged material for cultural material. To date, only very limited material has been found and this has thought to have washed into the site, rather than being in situ. The provision still remains however for dredging to be stopped if any significant material is found.

In addition to the cultural heritage monitoring, the Cultural Rangers are also responsible for advising the boating public about the exclusion zone and for providing general advice about the dredging project and the significance of the Coorong to the Ngarrindjeri.

As the project has continued, the role of the Rangers has been expanded so they can assist in other project work in the area, thereby providing capacity building, training and employment opportunities.

Project Future

Substantial water is required to enter the Lower Lakes before consideration is given to release significant volumes from the Barrages (in the order of 800 GL). The current conditions found within the catchment, point toward the need for substantial and consistent rainfall before the Lower Lakes can refill.

For the foreseeable future, the dredging is expected to continue operation, maintaining an open Murray Mouth, connectivity and water conditions within the Coorong.