

**Shaping the Future** 

# Brisbane Water Estuary Management Study

Dredging Options CLAMs Summary Report

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### 1 Introduction

This report provides a summary of a series of Coastal Lake Assessment and Management (CLAM) models that have been developed for Gosford City Council (GCC) to investigate a range of dredging options within the Brisbane Water estuary. The CLAM model system is a Bayesian decision support tool developed by the Australian National University (ANU). The system was originally designed as a tool to assist in the management of small coastal lakes and lagoons by using a Bayesian (i.e. probabilistic) approach to investigating potential outcomes from specified management scenarios.

The CLAM tools have been prepared as part of the *Brisbane Water Estuary Management Study* (Cardno, 2009) and will inform the development of the Brisbane Water Estuary Management Plan (Cardno, forthcoming). The CLAM tools aim to assist Council in considering a range of different scenarios for implementing the dredging options identified in the Management Study and also by providing additional information to support the implementation of any specific dredging actions as part of the Estuary Management Plan.

A key issue in the Brisbane Water estuary system, as identified via community consultation, is navigation in the narrow, shallow channels of the various estuarine branches. These CLAM tools seek to analyse various options for dredging, incorporating environmental, social and financial considerations.

### 1.1 Project Background

Brisbane Water estuary has a relatively shallow waterway which, in combination with the popular usage of the waterway for recreational boating and fishing, has resulted in a range of issues relating to safe navigation for a number of channels within the estuary. Concerns over the need for maintenance dredging of these navigation channels have been raised with Council by a number of waterway user groups. GCC has recognised that dredging in Brisbane Water estuary for navigation purposes is a critical management issue in the short to medium term.

### 1.2 Coastal Lake Assessment and Management (CLAM) Tool

The CLAM tool has been developed by the ANU with the support of the Department of Environment, Climate Change and Water (DECCW) to assist in the management of coastal lagoons and estuaries. The CLAM tool is intended for use by local council and state government representatives to assist in applying a holistic approach to planning and decision making in the management of these systems in particular. CLAMs have been developed, or are under development, for 27 coastal lake catchments in NSW, with an increasing demand for the development of specific applications for the management of localised estuarine areas within a larger estuary.

The CLAM tool integrates existing knowledge on the ecological, social and economic functions of estuaries using a range of methods in such a way as to incorporate uncertainty (i.e. where knowledge gaps exist because of the complexity of physical and ecological processes within estuarine systems). When assessing a range of management options for estuaries (such as options for dredging), the CLAM tool identifies the likely trade-offs between ecological, social and economic values associated with the implementation of

those management options. In this way, the CLAM tool explicitly incorporates a triplebottom line approach.

For the purposes of this study, the Dredging Options CLAM Tool comparatively assesses the social, economic and environmental impacts of the various dredging options for the Brisbane Water estuary within an objective framework. Further information on the CLAM tool and its applications can be found at the following websites:

http://icam.anu.edu.au/html/clam.html http://www.dnr.nsw.gov.au/estuaries/factsheets/modellingtools/CLAM.shtml http://www.dnr.nsw.gov.au/estuaries/factsheets/modellingtools/pdfs/Ticehurst\_MODSIM05.pdf

### 1.3 Study Outline

Cardno Lawson Treloar has been commissioned by GCC to develop a series of Dredging CLAMs for seven separate locations within Brisbane Water. The purpose of these tools is to investigate dredging options as identified through the community and stakeholder consultation process (refer to Section 2.3 of Cardno, 2009). **Figure 1.1** shows the location of the estuary waterways, otherwise referred to as 'CLAM regions', proposed for dredging.

This study follows on from the application of the CLAM tool at two locations that were previously proposed for dredging (Cardno, 2008b). The previous CLAM tool was designed as a case study to investigate the suitability of the CLAM system for the future management of Brisbane Water estuary. Those two study sites considered in that CLAM tool, Gosford City and Entrance areas, were selected because they represent the upstream and downstream extents of the Brisbane Water estuary system and were therefore useful in determining the suitability of the CLAM tool for application to the whole of the Brisbane Water estuary. The case study proved the usefulness of these CLAM tools in assessing management options and Council subsequently commissioned the development of other CLAM tools (i.e. the current report) as part of the *Brisbane Water Estuary Management Study* (Cardno, 2009).



Figure 1.1: Estuary Waterways Proposed for Assessment with the Dredging CLAMs

### 2 Stakeholder and Community Consultation

### 2.1 Community Consultation

An extensive community consultation exercise was undertaken as part of the Brisbane Water Estuary Management Study to obtain community and stakeholder input into the navigation issues currently affecting the waterway and to identify dredging options for consideration as part of the Dredging Options CLAMs. Full details of the consultation program and outcomes are described in the *Estuary Management Study* (Section 2 of Cardno, 2009), of which this report is an appendix.

A full description of the consultation program and the outcomes of that process are provided in Cardno (2009).

General dredging related issues raised included:

- Overall concerns that the rate of siltation is increasing within Brisbane Water;
- Community representatives, DECCW and DII Fisheries indicated that storage of dredge spoil and management of acid sulphate soils are important issues for any dredging proposal; and
- The potential impacts dredging may have on the hydrodynamics of the Brisbane Water estuary system. With specific reference to the entrance channel, Cardno (2007b) found that dredging in this location would have a negligible impact on the hydrodynamics of the system.

### 2.2 Stakeholder Consultation

In addition to consulting with the community, ongoing liaison with the relevant agency stakeholders has been undertaken.

As part of the development of the initial Dredging CLAM case studies, a stakeholder consultation activity was undertaken on 29 May 2007. Invited participants included government agencies, community representatives, boat users and local surfers. Details of this consultation have been described in Cardno (2009).

#### 2.3 Consultation with the Committee

The Dredging CLAMs framework described in this report was presented to Council's Coastal and Estuary Management Committee on 4 August 2009. This presentation included a demonstration of the CLAM tool's function and discussion of its application.

### **3 Dredging Options**

The Dredging CLAMs have been developed to investigate potential impacts associated with implementation of the dredging options identified in the Brisbane Water Estuary Management Study (Cardno, 2009).

This section of the report provides a brief outline for each of the dredging options proposed for the various waterways or CLAM regions mapped in **Figure 1.1**. Details are provided on the various dredging options proposed for each of the regions identified in **Figure 1.1**, including consideration of:

- The perceived site specific issues supporting the case for dredging;
- The exact location proposed for dredging;
- Estimates of the volume of material that would need to be dredged based on desired depth and configuration;
- The need for maintenance dredging;
- Whether the option would be a short (1-2 years), medium (3-5 years) or long term (5 years +) solution to the issue (i.e. is the option likely to be sustainable?); and
- Identification of any sensitive aquatic habitats in the vicinity of the proposed dredged area.

Following advice from NSW Maritime, it is suggested that internal navigable waterways of Brisbane Water estuary be maintained at 2m below ISLW. Therefore, all the dredging options that seek to improve navigability have adopted this design depth. Where a dredging option seeks to serve some other purpose (e.g. improved flushing), an alternative design depth has been considered.

Further details on the inputs to the Dredging CLAMs for each of these dredging options have been provided in **Section 4**.

The full details of these dredging options are included in the CLAM tool interfaces.

### 3.1 Northern Broadwater Dredging Options

**Figure 3.1** shows the location of those dredging options identified in the Management Study (Cardno, 2009) that are located within the Northern Broadwater CLAM region, including:

- Gosford Boat Harbour (Option W115);
- Correa Bay Royal Volunteer Coastal Patrol (Option W25);
- Victory Parade, Tascott (Option W36); and
- Green Point Boat Ramp (Options W25 & W116).



Figure 3.1: Dredging Options and Seagrass Distribution - Northern Broadwater Dredging CLAM

### 3.1.1 Gosford Boat Harbour (Option W115)

Over the last 20 years a number of proposals have been considered to re-develop the foreshore of Brisbane Water adjacent to the Gosford Central Business District (CBD). One such proposal was the SuperShuttle Boat Harbour and Marina development, for which an Environmental Impact Statement (EIS) was prepared in 1999 (Patterson Britton and Partners, 1999). This proposal proposed the re-development of the Gosford foreshore to provide harbour facilities for a high-speed ferry between Sydney and Gosford. Included in the proposal was the development of a 150-berth marina. Full details of the development are presented in Paterson Britton and Partners (1999). The proposal required the dredging of 90,000m<sup>3</sup> of predominantly muddy sediment to provide the necessary depth for the ferry and other craft using the marina.

Ongoing planning is currently underway regarding the future of the Gosford foreshore and this may provide for the implementation of some of the components of the Boat Harbour development. A second Boat Harbour development is included in the CLAM which is based on the *Gosford Waterfront Strategy* (Taylor Cullity Lethlean, 2006). The dredging volume requirement with the second Boat Harbour development is estimated at approximately 120,000m<sup>3</sup>. Maintenance dredging requirements are estimated at 10,000m<sup>3</sup> to 15,000m<sup>3</sup> per year.

The existing boat harbour area has also been identified as being in need of maintenance dredging. The current sea-bed levels are said to restrict yacht access to the harbour facilities. Option W115 proposes dredging down to -2mISLW in this area would require approximately 350m<sup>3</sup> of sediment to be removed.

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#### 3.1.2 Coastal Patrol Maintenance Dredging (Option W25)

The Royal Volunteer Coastal Patrol (RVCP) site at Point Clare is the base for water craft used by the RVCP, DII - Fisheries and NSW Maritime. The site features a fixed jetty and a channel which connects to the Brisbane Water.

The nearshore area in this region has been subject to ongoing siltation and the access channel has been dredged twice over the last 25 years. The last dredging of the channel occurred in 2000. The RVCP have identified the need for maintenance dredging to occur in the near future. Estimates of siltation depths which have developed since the last dredging campaign are up to 1m. It is estimated that 3,000 to 4,000m<sup>3</sup> of sediment would need to be removed to ensure accessibility for water craft.

Adjacent to the site DII - Fisheries have mapped significant aquatic habitat including *Posidonia australis* seagrass beds (**Figure 3.1**).

#### 3.1.3 Victory Parade, Tascott (Option W36)

The community has identified that significant sediment build up has occurred at this location (**Figure 3.1**), which has resulted in restrictions to navigation. The community also considers that sedimentation at this location has encouraged the collection of garbage and weeds, and that this impacts on the amenity of the area by producing unpleasant odours. Dredging to a depth of -2mISLW has been suggested, which would require approximately 3,500m<sup>3</sup> of material to be dredged.

There are significant seagrass beds covering the majority of the potential dredge footprint.

#### 3.1.4 Green Point Boat Ramp (Option W26 & W116)

Ongoing siltation has been identified in the vicinity of the Green Point boat ramp. This has restricted boat access and utilisation of the facility. Dredging down to a level of -2mISLW has been proposed, which would require 1,600m<sup>3</sup> of sediments to be removed. Seagrass beds are located in the vicinity of the boat ramp.

#### 3.2 Southern Broadwater CLAM

**Figure 3.2** shows the location of those dredging options identified in the Management Study (Cardno, 2009) that are located within the Southern Broadwater CLAM region, including:

- Paddy's Channel (Option W18 & W25);
- Saratoga Boat Ramp (Option W25);
- Saratoga Channel (Option W25); and
- Woy Woy Channel (Option W117).



Figure 3.2: Dredging Options and Seagrass Distribution within the Southern Broadwater CLAM

### 3.2.1 Paddy's Navigation Channel (Option W18 & W25)

Over many years sediment build up and apparent reduction in current speed has been reported for Paddy's Channel by the community. This has restricted the provision of safe boating navigation. This area is thought critical as it is the only access in and out of the Brisbane Water Broadwater area. The maintenance of a 50m wide navigation channel would rectify this problem. Dredging to a depth of -2mISLW has been assumed, which would require approximately 18,000m<sup>3</sup> of sediment to be removed. No seagrass beds are present within the channel alignment.

### 3.2.2 Saratoga Boat Ramp (Option W25)

Continuing siltation has been identified in the vicinity of the Saratoga boat ramp. This has restricted boat access and utilisation of the facility. Dredging down to a level of -2mISLW would require 1,500m<sup>3</sup> of sediments to be removed. Seagrass beds are located in the vicinity of the boat ramp.

#### 3.2.3 Saratoga Channel (Option W25)

Currently the Saratoga Channel is heavily affected by siltation and is unsafe for navigation. A reduction in currents though the area has also been reported. Dredging down to a level of -2mISLW would require 16,000m<sup>3</sup> of sediments to be removed. No seagrass beds are located along the channel alignment.

#### 3.2.4 Woy Woy Channel (Option W117)

Continuing siltation has been identified along the Woy Woy Channel. The community now considers that navigation is hazardous through this area. This has restricted boat access and easy passage to the Woy Woy area. Dredging down to a level of -2mISLW would require 12,000m<sup>3</sup> of sediments to be removed. Seagrass beds are located in the vicinity of the channel, but are unlikely to be directly disturbed by dredging of the channel.

#### 3.3 St Hubert's Island/Davistown/Empire Bay

**Figure 3.3** shows the location of those dredging options identified in the Management Study (Cardno, 2009) that are located within the St Hubert's/Davistown/Empire Bay CLAM region, including:

- Western Cockle Channel (Option W116);
- Lintern Channel (Option W18);
- Cockle Channel (Option W18 & W116);
- Davistown Boat Ramp (Option W25 & W116); and
- St Hubert's Island (Option W19).



Figure 3.3: Dredging Options and Seagrass Distribution within the St Hubert's/Davistown/Empire Bay CLAM Area

#### 3.3.1 Western Cockle Channel (Option W116)

Cockle Channel is the only waterway access passage to Kincumber Broadwater and Cockle Bay. Bar migration across the western end of Cockle Channel has been identified as resulting in a navigational hazard. Dredging of this area would require 8,500m<sup>3</sup> of sediment removal to achieve design depth.

#### 3.3.2 Lintern Channel (Option W18)

The Lintern Channel is a narrow stretch of waterway separating Rileys Island from the Davistown/Saratoga area. It is utilised by boats travelling to and from the Davistown, Empire Bay and Kincumber areas.

#### 3.3.3 Cockle Channel (Option W18 & W116)

As discussed above the Cockle Channel is a critical waterway in providing access to Kincumber Broadwater and Cockle Bay. Community consultation identified that medium sized craft (1m draft) cannot pass through the eastern end below half tide. Dredging of this area would be required to re-establish full time long-term navigability of the channel. Approximately 6,000m<sup>3</sup> of dredging would be required to establish a 30m wide channel.

#### 3.3.4 Davistown Boat Ramp (Option W25 & W116)

Continuing siltation has been identified in the vicinity of the Davistown boat ramp. This has restricted boat access and utilisation of the facility. Dredging down to a level of -2mISLW would require 1,000m<sup>3</sup> of sediments to be removed. Seagrass beds are located within the proposed dredging footprint.

#### 3.3.5 St Hubert's Island (Option W19)

The residents of St Hubert's Island have seen the slow infill of the canal system over the years and have campaigned to have the canals dredged to their original design depths. This would improve navigation through the system, providing ease of access to the foreshore properties. Some seagrass beds have colonised these canals and would be directly disturbed by dredging of these areas.

### 3.4 Woy Woy

**Figure 3.4** shows the location of those dredging options identified in the Management Study (Cardno, 2009) that are located within the Woy Woy CLAM region, including:

#### Boat Access. Horsefield Bay (Option W118);

#### 3.4.1 Horsefield Bay Boat Access (Option W118)

Local residents and boat users have identified siltation as a cause of restricted access to shoreline areas of Horsefield Bay. Small dredging campaigns may improve this access and would require approximately 3,000m<sup>3</sup> of sediments to be removed to achieve reasonable depths.



Figure 3.4: Dredging Options and Seagrass Distribution within the Woy Woy CLAM Area

### 3.5 Ettalong/The Rip

**Figure 3.6** shows the location of those dredging options identified in the Management Study (Cardno, 2009) that are located within the St Hubert's/Davistown/Empire Bay CLAM region, including:

- Navigational Channel, Ettalong Shoals (Option W18);
- Navigational Channel, East Ettalong (Option W119); and
- Mulhall St, Wagstaffe (Option W119).



Figure 3.6: Dredging Options and Seagrass Distribution within the Ettalong/The Rip CLAM Area

#### 3.5.1 Navigational Channel, Ettalong Shoals (Option W18)

Navigation through the Ettalong area is impeded by the highly mobile shoal system that extends from Brisbane Water entrance at Half-Tide Rocks up to Booker Bay in the north. Maintenance of navigation channels through this area has been highlighted as a community priority to improve safety and encourage boat usage of the estuary. Dredging of a channel 50m wide down to a level of -2mISLW would require 11,000m<sup>3</sup> of sediments to be removed. No seagrass beds would be expected to be located in such a dynamic shoal area.

#### 3.5.2 Navigational Channel, East Ettalong (Option W119)

As discussed above, the maintenance of safe navigation is seen as an important management objective to promote the use of Brisbane Water Estuary. Dredging of a channel 50m wide down to a level of -2mISLW would require 20,500m<sup>3</sup> of sediments to be removed. No seagrass beds would be expected to be located in such a dynamic shoal area and none have been mapped in this location by DII - Fisheries.

#### 3.5.3 Mulhall St, Wagstaffe (Option W119)

Local residents have noted hazardous navigation conditions in the vicinity of Mulhall St, Wagstaffe. A small dredging campaign may improve navigability and therefore safety in this area. Preliminary investigations suggest a small amount of dredging, in the order of 4,000m<sup>3</sup>, would provide adequate depth and improve safety. No seagrass beds have been identified along the Wagstaffe shoreline.

### 3.6 Hardy's Bay Dredging Options

**Figure 3.8** shows the location of those dredging options identified in the Management Study (Cardno, 2009) that are located within the Hardy's Bay CLAM region, including:

- Hardy's Bay Entrance (Option 25);
- RSL Creek Entrance (Option 25);
- Mudflat Creek Entrance (Option 25);
- Entrance to Riley's Bay (Option 121); and
- Killcare Marina (Option 120).



Figure 3.8: Dredging Options and Seagrass Distribution - Hardy's Bay Dredging CLAM Area

#### 3.6.1 Hardy's Bay Entrance (Option 25)

The entrance to Hardy's Bay is defined as the connection between the main Brisbane Water Channel and the embayments of Hardy's and Riley's Bay. The area is dominated by large sand shoals that are shaped and formed by the flood and ebb tides. Local residents have raised concerns in regard to a reported deterioration in Hardy's Bay water quality in recent years.

The dredging described by this scenario is designed to improve the flushing and water quality of Hardy's Bay. This option proposes to dredge the estuary bed to -2mISLW to improve the conveyance of tidal waters through the entrance. The dredging volume required to establish this design depth is 25,000m<sup>3</sup> based on available bathymetric information. Ongoing regular maintenance dredging would be required to maintain these design depths.

Sandy sediment occurs in this location and there are no known seagrass beds present.

#### 3.6.2 RSL Creek Entrance (Option 25)

The entrance of RSL Creek into Hardy's Bay is dominated by a large mudflat area predominantly formed by fluvial sediments. Local residents have raised concerns in regard to a reported deterioration in Hardy's Bay and creek water quality and the increase in the extent of mangrove trees; the latter reportedly arising from increasing siltation rates and inter-tidal flat progradation.

The dredging described by this scenario is designed to provide medium term improvement to the flushing and water quality of RSL Creek. To address this issue, a 10m wide channel dredged to -1mISLW has been put forward as a management option. A channel of this depth will provide constant tidal flushing of lower RSL creek over the full tidal cycle. The dredging volume required to establish such a channel is 4,450m<sup>3</sup>. Ongoing maintenance dredging would be required.

The dredged channel would pass through an area of *P. australis* seagrass beds at its eastern end.

#### 3.6.3 Mudflat Creek Entrance (Option 25)

The entrance to Mudflat Creek into Hardy's Bay is dominated by a large mudflat area predominantly formed from fluvial sediments. Review of available historical aerial photography shows that the course of Mudflat Creek through the mudflat shoal has changed over time and that the extent of bay siltation has developed further westward by about 30m to 40m over the period 1976 to 2004. Local residents have raised concerns in regard to a reported deterioration in the water quality of Mudflat Creek. In addition, there has also been reported an increase in the extent of mangrove trees, thought to be due to increasing siltation rates and intertidal flat progradation. Although there is anecdotal evidence from local residents that GCC has undertaken maintenance dredging to provide navigational access (or at least relocated sediments by side-casting), GCC were not able to locate any records of such activities.

The dredging proposed under Option 25 is designed to provide a medium term improvement to the flushing and water quality of Mudflat Creek. In order to achieve these

objectives, a 20m wide channel dredged to -1mISLW is proposed. A channel of this depth will provide tidal flushing of lower Mudflat Creek over the full tidal cycle. The dredging volume required to establish such a channel is 7,400m<sup>3</sup>. Ongoing maintenance dredging would be required.

The dredged channel would pass through an area of *P. australis* seagrass beds at its western extent.

#### 3.6.4 Entrance to Rileys Bay (Option 121)

The entrance to Rileys Bay is a 500m long and 70m wide channel that provides navigable access from Hardy's Bay. The channel is separated from the main Brisbane Water estuary waterbody by a large sand spit formation over an area of disused oyster leases. Public consultation has identified that blockage of this channel is occurring due to siltation, and this is starting to restrict navigable access to and from Rileys Bay.

The dredging proposed under Option 121 has been designed to provide medium term improvement to the navigability of the channel. Following advice from NSW Maritime it is suggested that the internal navigable waterways of Brisbane Water be maintained at 2m below ISLW. Therefore, assessment of this dredging option has considered dredging to this depth. The dredging volume required to establish a 30m wide channel to a design depth of -2mISLW is 21,000m<sup>3</sup>. Ongoing maintenance dredging would be required, although this would likely be infrequent.

The channel is lined by seagrass beds composed principally of *P. australis*.

#### 3.6.5 Killcare Marina (Option 120)

The Killcare Marina is located on the southern shore of Hardy's Bay. This facility offers a range of services including mechanical and structural repairs (slipway services), boat hire and a free sewage pump-out, and also has berthing facilities for 23 boats. It is a heavily utilised facility for local boat owners, especially for the sewage pump-out station. Recently it has been noted that access to the marina is limited for larger vessels due to siltation and decreasing water depths. For this reason, Killcare Marina has been identified as an area by the community as being in need of dredging.

Option 120 has been designed to provide medium term improvement in terms of both access and boating safety for the marina. It also includes dredging works for the public wharf located immediately adjacent to the marina. The dredging volume required to establish design depths of -2mISLW at these sites is 3,900m<sup>3</sup>. Ongoing maintenance dredging would be required, although likely infrequent (e.g. every 5-10 years).

The facilities are surrounded by seagrass beds, primarily *P. australis* and *Z. capricorni*, although there is limited occurrence of seagrasses within the proposed dredging profile.

### 3.7 Entrance Dredging Options

The Entrance Dredging CLAM has been developed to investigate the effects of potential dredging between the Entrance region and Wagstaffe Point. Currently the entrance navigation channel is located adjacent to the south-east shoreline between Half Tide Rocks and Little Box Head. The channel is not subject to regular maintenance dredging; however, infilling of the channel has been an issue periodically. In 2007 rapid infilling of the channel

occurred near Lobster Beach as a result of natural propagation of bedform feature across the shoal.

The Entrance Dredging CLAM considers three management scenarios for maintaining suitable navigation conditions in the entrance region; namely:

- Permanent Outer Channel Maintaining the existing outer channel with specified minimum depths (i.e. 2.5m depth along the whole channel),
- Secondary Inner Channel Establishing a secondary inner channel which can be used to separate recreational and commercial vessels, and
- SEPP35 Maintenance Dredging Undertaking SEPP35 maintenance dredging on an ad hoc basis as critical navigation hazards arise.

Figure 3.9 presents the identified dredging options within the Entrance CLAM study area.



Figure 3.2: Dredging Options - Entrance Dredging CLAM Area

#### 3.7.1 Permanent Outer Channel

The Outer Channel (current marked channel) has a nominal design depth of 2.5m at low water (ISLW); however, significant sections of the channel have low water depths closer to 2m.

This scenario involves formally establishing a 30m wide channel between Little Box Head and Half Tide Rocks with options for design depths of 2.5m or 3m at low water. The deeper depths would allow larger vessels to enter Brisbane Water estuary. The dredging volumes required to establish the Permanent Outer Channel are:

-2.5m (ISLW) – 24,000m<sup>3</sup>; and

■ -3m (ISLW) – 40,000m<sup>3</sup>.

Ongoing maintenance dredging would be required, principally near Lobster Beach.

The Outer Channel is surrounded by *H. australis* (80,000m<sup>2</sup>) seagrass beds, with a small area of *Z. capricorni* (12,000m<sup>2</sup>).

#### 3.7.2 Secondary Inner Channel

The Inner Channel refers to a secondary navigation route which has been utilised historically and follows a path directly north-west from Lobster Beach. The channel passes directly over the active sand shoal and navigation is variable due to the mobile sand shoals. NSW Maritime has indicated that the current Outer Channel is a preferred navigation route due to its protection from breaking swell waves. In the event that the Outer Channel option is implemented, the Inner Channel could be maintained as an 'unlit' secondary channel that could be utilised by experienced boat users. Ferry operators view the Inner Channel as an effective way of separating commercial and recreational boat users and an option for improving general boating safety within Brisbane Water estuary. They would prefer to use the Inner Channel when conditions are suitable.

This scenario involves formally establishing a secondary channel with a design depth of 2.5m at low water. The establishment of a permanent Inner Channel would require significant ongoing maintenance dredging. The Inner Channel is predominantly located on a mobile sand shoal and there is little to no aquatic habitat on the seabed there.

### 3.7.3 SEPP35 Maintenance Dredging

In 2007 rapid siltation of the navigation channel near Lobster Beach occurred. A large scale sand wave (height 1 to 2m, wavelength  $\approx$  150m) propagating to the south-east deposited up to 1,700m<sup>3</sup> of sand per month over several months into the navigation channel. This constricted the navigation channel to only permit one-way vessel movements near Lobster Beach. This area is exposed to peak ebb tide currents in excess of 1.5m/s and it is dangerous for large vessels to idle in this area whilst waiting for other boats to pass in the opposite direction. The Land and Property Management Authority, together with GCC, is proposing to dredge up to 20,000m<sup>3</sup> of sand from the entrance channel and surrounding sand shoal under SEPP35. This dredging is designed to provide a short to medium term improvement in the usability and safety of the navigation channel. Historically, SEPP35 dredging has also occurred near Half Tide Rocks. Future SEPP35 maintenance dredging activities could be added to this scenario in the CLAM.

### 4 CLAM Framework and Data Population

All the Dredging CLAMs apply a common framework, such that the same range of impacts can be considered for the different dredging options at all locations. The models incorporate the following impact categories:

- Water and sediment quality;
- Sediment quality;
- Aquatic flora and fauna;
- Local revenue;
- Recreational amenity; and
- Cost of implementation (incorporating both capital and ongoing/maintenance costs).

### 4.1 Conceptual Framework

**Figure 4.1** presents the conceptual framework for the Dredging CLAMs, incorporating those impact categories described above.



Figure 4.1: Dredging CLAMs Conceptual Framework

Each of the boxes represents a node in the CLAM framework. Details on each of the nodes are presented in **Appendix 1**. The solid connectors shown in the conceptual model (**Figure 4.1**) identify interactions which are explicitly represented in the CLAM. The dashed connectors identify interactions which have been considered in the development of the CLAM, but have not been specified in the model because of their relatively weak or indirect

interaction. In assessing the potential impact of the option on aquatic flora and fauna due to dredging, for example, indirect impacts (such as water quality impacts) have been included. However, generally speaking, the magnitude of potential water quality impacts has been assessed to be relatively small and would have minimal impacts on the wider ecosystem. Therefore the link was not explicitly represented in the CLAM model – see Section 4.4.

Wherever possible, each of the nodes shown in the conceptual model (**Figure 4.1**) is populated with data to inform the CLAM assessment.

#### 4.2 Water and Sediment Quality Impact Assessment

The GCC Water Quality Database, which contains data from sampling sites in Brisbane Water estuary, has been used to make an assessment of the ambient water quality for the various CLAM regions. Total phosphorus (TP) concentrations are generally below ANZECC guidelines for estuarine waters (ANZECC/ARMCANZ, 2000) throughout the estuary. Total nitrogen (TN) concentrations in many areas of Brisbane Water estuary generally exceed ANZECC guidelines (ANZECC/ARMCANZ, 2000). However, adverse water quality outcomes are not commonly observed, for example, fish kills.

However, there is potential for sediment-bound nutrients stored within the seabed sediments to be released into the water column during dredging. Patterson Britton and Partners (1998) reported sediment samples from the Gosford Boat Harbour area had very high nutrient concentrations.

The calibrated Brisbane Water estuary Delft3D computer model developed for the *Estuary Processes Study* (Cardno, 2008a) has been used to investigate the transport and dispersion of nutrients released into the water column during dredging. **Figure 4.2** presents the peak tracer plume (i.e. the largest plume extent) from dredging within the Cockle Channel (Option W116).

Similar simulations have been undertaken for each dredging option in the Dredging CLAMs. The results from the Delft3D model have been used to estimate the changes for each dredging option in dissolved TN and TP likely to occur during dredging works. This data is incorporated into the CLAM tools as a percentage increase in average nutrient concentrations (TN and TP) during dredging works.

The Delft3D computer model was also used to investigate potential suspended sediment plumes that might occur during dredging. The Delft3D dredge plume modelling provided an indication of the increase in average near-bed suspended sediment concentrations during dredging works. **Figure 4.3** presents modelling results of peak near-bed suspended sediment concentrations for dredging at the Saratoga boat ramp site (Option W25). These can be considered representative of a 'worst case' scenario as they neglect the application of silt curtains and other systems that are applied for 'best practice' dredging operations. However, in general, these increases would be confined to a relatively small spatial area and would quickly disperse following the completion of suspended solids are not anticipated.

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Figure 4.2: Peak Tracer Plume - Cockle Channel (Option W116)



Figure 4.3: Peak Suspended Sediment Concentrations for (near bed) Dredging Plumes - Saratoga Boat Ramp (Option W25)

Heavy metal contamination is also an issue at some locations as noted in Cardno (2008a). Any dredging in such areas would need to minimise the potential for heavy metal mobilisation. These points are highlighted within each CLAM tool.

It is noted that, for the purposes of this assessment, it has been assumed that the dredge contractor will implement best practice environmental management and mitigation measures during the dredging works phase. Therefore, these water quality impacts are likely to be short in duration.

#### 4.3 Aquatic Flora and Fauna Impact Assessment

Any potential impact on the wider ecology of the Brisbane Water estuary associated with the dredging options described in the CLAM will primarily be related to the loss of habitat, especially where this relates to the loss of seagrass beds. Therefore, the impact assessment for aquatic flora and fauna focussed primarily on impacts on seagrass beds.

It has been assumed that indirect impacts on flora and fauna will be captured through assessment of water and sediment quality impacts.

As part of the *Brisbane Water Estuary Processes Study* (Cardno, 2008a), GCC supplied Cardno Lawson Treloar with GIS data that included aquatic vegetation mapping (NSW Fisheries, 2003). **Figures 3.1-3.9** display the various dredging options and also incorporate the seagrass mapping from NSW Fisheries. The dominant seagrass species within Brisbane Water estuary are *Z. capricorni* and *P. australis. P. australis* seagrasses have been identified as being in decline in NSW estuaries and have therefore been considered as being more significant for the purposes of this assessment.

Depending on the particular footprint associated with a dredging option, the dredging option will either have a direct negative impact (i.e. loss of actual seagrass area though physical removal during dredging operations) or negative indirect impact on seagrass areas (e.g. due to water quality impacts during dredging operations).

The area of seagrass beds suffering direct impacts relative to the total area of seagrass beds in the surrounding areas was calculated for all dredging options. Consider, for example, the option for dredging of the RVCP area (Option W114) in the Northern Broadwater CLAM region. Implementation of this option would result in the loss of around 0.5% of the seagrasses present in the Northern Broadwater CLAM region. There are sizable seagrass beds located throughout the Broadwater area. It is assumed, therefore, that mobile fauna may migrate to seek refuge in nearby undisturbed seagrass beds. However, the loss of any *P. australis* seagrasses has been considered as being more significant (comparative to other seagrass species) due to the limited re-colonisation capacity of this species.

In summary, the wider ecological impact has been represented in the Dredging CLAM in terms of the impact on aquatic fauna biomass due to reductions in seagrass habitat extent. The relative loss of aquatic fauna biomass has been assumed to be directly proportional to the relative loss of seagrass habitat in the area.

Full details for each of the various regions are provided in the CLAM tool interfaces.

### 4.4 Social Impact Assessment

A range of social impacts have been incorporated in the CLAM, including:

- Impacts on recreational activities other than boating;
- Net impacts on boating safety, and
- Impacts on the number of boat moorings or berths in Brisbane Water.

These impacts were based on subjective assessments of the likely outcomes of each dredging activity.

The implementation of a particular dredging option may be deemed to result in either positive or negative impacts on other recreational users of Brisbane Water. For example, where dredging is considered likely to increase boat traffic to a certain part of the estuary, this will result in a positive impact for a small number of boating people, but at the expense of a larger number of recreational users (e.g. swimmers, paddlers). In this case, a net negative impact on recreational usage would be allocated. In contrast, a net positive impact may result where implementation of the option provides more broad benefits for a large number of user groups.

Similar impact assessments were undertaken for boating safety.

Irrespective of any dredging activities, projected population increases in Gosford and Woy Woy will likely result in a gradual increase in the number of boat users in Brisbane Water estuary. Any dredging activity could result in an increase in the number of boats that are moored or berthed in a particular region of the estuary.

#### 4.5 Economic Impact Assessment

The economic impact assessment component incorporates the assessment of impacts on local revenue, as well as the cost of implementing the dredging option.

#### 4.5.1 Cost of Implementation

Dredging costs have been based on a feasibility study prepared for dredging sediments at Lake Macquarie, which included costing for the setup of equipment, together with removal and treatment of organic sediments from nearshore areas of Lake Macquarie (WBM, 2004).

The initial setup cost outlined in WBM (2004) was estimated at \$30,000 for a campaign of approximately 15,000m<sup>3</sup>, which represents a cost of \$2/m<sup>3</sup>. Dredging and treatment requirements (including treatment of acid sulfate soils) were costed at \$20.1 per m<sup>3</sup> (WBM, 2004). However, this included additional treatment requirements (i.e. for organic material) and, therefore, this value was re-adjusted to an assumed cost of treating acid sulfate soils (ASS) of \$10/m<sup>3</sup>. The cost of treating ASS is incorporated into the overall cost of implementation based on the likelihood of ASS occurrence.

For each dredging option, the cost of implementation has been estimated based on the cost of both capital and maintenance dredging works.

#### 4.5.2 Impacts on Local Revenue

The economic benefits resulting from implementation of a dredging option may result in a change to the number of moorings located in the estuary. Due to the fact that dredging

works will facilitate improved access to many parts of the estuary, it is assumed that there would be a net increase in moorings for many of the dredging options.

The economic impact of establishing additional boat moorings in Brisbane Water estuary has been estimated based on tourism revenue for the Central Coast region. The NSW Regional Tourism Forum – 2002 estimated that there are approximately 4.6 million overnight and day visitors to the Central Coast per year, which generates \$620 million of revenue for the local economy. Additional boat berths in Brisbane Water have been assumed to provide 4 additional tourists to the region. Each person (tourist) has been assumed to visit the region for 12 days per year. Based on these assumptions, the revenue benefit per tourist has been assumed at \$135 per day.

#### 4.5.3 Net Present Value

Implementation costs and local revenue impacts have then been included in a calculation of Net Present Value. This provides an indication of the economic benefit associated with any of the dredging options assuming a 30 year period of implementation. A discount rate of 6.35% was applied based on treasury recommendations. It assumes maintenance dredging would be undertaken every 5 years and includes the annual return from an increase in tourism revenue.

#### 4.6 Discussion

The reader is directed to each of the individual Dredging CLAM tools for a review of the CLAMs themselves.

The CLAM tools do not identify a definitive 'result' as such. Rather, they permit a comparison of the relative impacts of different implementation scenarios in relation to each of the impact categories identified in **Sections 4.2-4.5**. Considering, for example, the case of Hardy's Bay, GCC may choose to investigate a range of different scenarios, such as:

- Implementing only Option W121;
- Implementing all three options relating to Option W25; or
- Implementing all five options (W25 (3), W120 and W121).

The CLAM tool allows Council to assess the relative impacts associated with each of these scenarios. For example, implementation of all five options may provide the greatest economic and recreational benefits relative to the other two scenarios, but come at the highest relative cost in terms of impacts on flora and fauna. In such a case as this, Council may wish to consider what the desired outcome is for this location: Is it a priority to improve water quality (i.e. via implementation of Option W25)? Or is improved boating amenity more important at this location (i.e. via implementation of Option W120)?

Resource limitations may also be a factor, in which case the CLAM tool can be used by Council to assess which Option (or combination thereof) provides the greatest net benefit for the least expenditure.

The Dredging CLAM tool may also be used to run scenarios incorporating more than one option (e.g. implementing all five options for Hardy's Bay), which may be considered in some regards to be a cumulative impact assessment.

In this fashion, the CLAM tool functions as a decision support tool.

The CLAM tools are currently being reviewed by Council and ANU. Discussion of the results will be expanded once these reviews are complete and the CLAM tools finalised.

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### **5** Conclusions

The Brisbane Water Dredging CLAMs have been developed as a decision support tool to assist Council in:

- Presenting the dredging options to the community and stakeholders in a user-friendly format;
- Explicitly incorporating a triple-bottom line assessment into the consideration of the different dredging options;
- Prioritising the various dredging options identified in the Management Study (Cardno, 2009) for implementation; and
- Identifying a preferred method of implementation through more detailed consideration of the likely impacts associated with each option.

Due to the complex nature of estuarine processes operating within Brisbane Water, separate CLAMs have been developed for seven CLAM regions within the estuary. Each of the dredging CLAM models uses a common Bayesian framework to facilitate comparison of different dredging options between the separate CLAM models. The CLAM tools have been developed as part of the *Brisbane Water Estuary Management Study* (Cardno, 2009). Much of the input data for the CLAM models was derived from the *Brisbane Water Estuary Process Study* (Cardno, 2008a).

The CLAM models have been shown to be useful in quantifying impacts and benefits of dredging options and also comparing the outcomes of different management options. The spatial complexity of Brisbane Water means there is very limited capability to use the CLAM system to investigate management options in a whole-of-estuary manner. However, the common framework applied has allowed the comparison of dredging options between the various regions.

### 6 Qualifications

The following qualifications and assumptions apply to this report:

- The dredging issues (and the causes to which they have been attributed) identified in this report and assessed in the Dredging CLAM have in most cases been identified by members of the community. Unless expressly indicated otherwise, these issues do not represent the professional opinion of the study team or of Council.
- The currency of data used to populate the CLAM tool is detailed in the summary sheets within the CLAM.
- The CLAM tool may only be updated, re-populated with data or re-configured by a qualified CLAM developer under the review of ANU.

<sup>19</sup> October 2009

### 7 References

ANZECC and ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, pp. 317.

Cardno Lawson Treloar (2007b) *Brisbane Water Entrance Proposed SEPP35 Dredging – Coastal Processes Investigations.* Report Prepared for Gosford City Council and Department of Lands (NSW).

Cardno (2008a) *Brisbane Water Estuary Processes Study.* Prepared for Gosford City Council and Department of Environment and Climate Change.

Cardno Lawson Treloar (2008b) *Brisbane Water Dredging Option CLAMs – Summary Report.* Report Prepared for Gosford City Council and Department of Environment and Climate Change.

Cardno (2009) *Brisbane Water Estuary Management Study* (Draft). Prepared for Gosford City Council.

Patterson Britton & Partners (1999) Environmental Impact Statement. Gosford CBD – Circular Quay Super Shuttle Ferry Service and Gosford Boat Harbour Marina & Tourist Development.

Taylor Cullity Lethlean (2006) *Gosford Waterfront Strategy.* Prepared for the NSW Department of Planning and Gosford City Council.

WBM (2004) *Lake Macquarie Organic Sediments: Feasibility Study on Sediment Removal –Final.* Prepared for Office of Lake Macquarie Catchment.

Appendix 1

**CLAM Node Descriptions** 

## TP

### **INTRODUCTION**

### Node:

TP Concentration (local water)

### **Descriptions and Units:**

TP concentration (mg/L) during to dredging operations. Considers existing TP conditions and additional phosphorous delivered to the water column during dredging. Within the CLAM, only water quality outcomes not water quality inputs are considered.

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- <0.01 mg/L ,
- 0.01-0.04.mg/L,
- >0.04mg/L ,

### **INITIAL RESULTS:**

*Method(s)* Data interpretation (existing WQ)

Sample: Brisbane Water Water Quality Database Location: Booker Bay Collection regime: Results from Laxton (2000) Source: Laxton (2000), Summarised in WBM (2003) Analysis description: TP samples at Booker Bay between 1996 and 1999 (closest site to Hardy's Bay). Sample size = 82. Max = 0.09mg/L, Min = 0.005mg/L, Mean = 0.03mg/L, Median = 0.02mg/L. Nutrient concentrations within Hardy's Bay are expected to be similar to Booker Bay. The measured phosphorous concentrations are generally below ANZECC guidelines and adverse water quality outcomes are not commonly observed. Completed by: Sean Garber Date of completion: 24<sup>th</sup> July, 2009

*Method*(*s*) Data interpretation (dredging WQ)

Sample: Nutrient release from Dredged Sediments Location: Proposed Gosford Boat Harbour (Broadwater) Collection regime: Elutriate testing of sediment samples from Patterson Britton and Partners (1999)
Source: Patterson Britton and Partners (1999)
Analysis description: Elutriate testing of 3 sediment samples from the Gosford seabed indicated that the sediments in that area had the potential to release similar concentrations of soluble phosphorous and nitrogen compared to the undisturbed concentration in the water column (i.e. 0.05mg/L)
Completed by: Sean Garber Date of completion: 24<sup>th</sup> July, 2009

*Method*(*s*) Data interpretation (Change in TP due to dredging)

Sample: Dispersion assessment near the dredging site Location: Dredging Option Areas within Hardy's Bay Collection regime: Based on results from a calibrated Delft3D transport dispersion model of Brisbane Water of nutrient release during dredging

Source: Estuary Management Study (ongoing) & Cardno Lawson Treloar (2007) Analysis description: Transport / dispersion modeling indicated that dredging could lead to the following increases in average nutrient concentrations (TP) during dredging:

- Hardy's Bay Marinas 15%
- Riley's Bay Entrance 10%
- Mudflat Creek Entrance 15%
- RSL Creek 13%

• Hardy's Bay Entrance - 5% *Completed by:* Sean Garber *Date of completion:* 27<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

#### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

Key assumptions:

\* Measured TP at Booker Bay is similar to conditions within Hardy's Bay.

\* Nutrient release from disturbed sediment estimated from only 3 elutriate samples

#### Strengths, Weaknesses and methods for improvement:

\*The current modeling approach does consider the ecological response to changes in TP.

\*For elutriate testing the water volume relative to the disturbed sediment area is much smaller than for a real dredging scenario. Therefore the nutrient release during dredging on a mass basis may be overestimated.

### REFERENCES

Cardno Lawson Treloar (2007) Brisbane Water Estuary Processes Study – Hydraulic Processes. Prepared for Gosford Council and DECC

Paterson Britton and Partners (1999) EIS for SuperShuttle Ferry Service and Gosford Boat Harbour Marina and Tourist Development. Prepared for Supershuttle.

WBM (2003). Gosford City Council - Historical Water Quality Data Review and Analysis. Prepared for Gosford Council.

\*\*\*\*\*\*\*

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date of completion:* 6<sup>th</sup> October, 2009

### TN

### **INTRODUCTION**

Node:

TN Concentration (local water)

#### **Descriptions and Units:**

TN concentration (mg/L) during to dredging operations. Considers existing TN conditions and additional nitrogen released into the water column during dredging. Within the CLAM, only water quality outcomes not water quality inputs are considered.

• Scenario Dredging Options

### **Output states:**

- <0.16 mg/L ,
- 0.16-0.66.mg/L ,
- >0.66mg/L ,

### **INITIAL RESULTS:**

*Method*(*s*) Data interpretation (existing WQ)

Sample: Brisbane Water Quality Database Location: Brisbane Water Entrance Collection regime: Results from Laxton (2000) and Cheng (2002) Source: Laxton (2000), Cheng (2002), Summarised in WBM (2003) Analysis description: TN samples at Booker Bay between 1996 and 2002 (closest site to Hardy's Bay). Sample size = 113. Max = 2.6mg/L, Min = 0.04mg/L, Mean = 0.45mg/L, Median = 0.30mg/L. Nutrient concentrations within Hardy's Bay are expected to be similar to Booker Bay. The measured nitrogen concentrations are generally above ANZECC guidelines however adverse water quality outcomes are not commonly observed. Completed by: Sean Garber

Date of completion: 24th July, 2009

*Method*(*s*) Data interpretation (dredging WQ)

Sample: Nutrient release from Dredged Sediments
Location: Proposed Gosford Boat Harbour (Broadwater)
Collection regime: Elutriate testing of sediment samples from Patterson Britton and Partners (1999)
Source: Patterson Britton and Partners (1999)
Analysis description: Elutriate testing of 3 sediment samples from the Gosford seabed indicated that the sediments in that area had the potential to release similar concentrations of soluble phosphorous and nitrogen compared to the undisturbed concentration in the water column (i.e. 1.96mg/L)
Completed by: Sean Garber
Date of completion: 24<sup>th</sup> July, 2009

*Method*(*s*) Data interpretation (Change in TP due to dredging)

Sample: Dispersion assessment near the dredging site Location: Dredging Option Areas within Hardy's Bay Collection regime: Based on results from a calibrated Delft3D transport dispersion

model of Brisbane Water of nutrient release during dredging Source: Estuary Management Study (ongoing) & Cardno Lawson Treloar (2007) Analysis description: Transport / dispersion modeling indicated that dredging could lead to the following increases in average nutrient concentrations (TN) during dredging:

- Hardy's Bay Marinas 30%
- Riley's Bay Entrance 20%
- Mudflat Creek Entrance 30%
- RSL Creek 25%
- Hardy's Bay Entrance 10%

Completed by: Sean Garber

Date of completion: 27th July, 2009

### **REVIEW OF RESULTS**

#### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

*Key assumptions*:

\* Measured TN at data is over 5-years old.

\* Nutrient release from disturbed sediment estimated from only 3 samples of organic content.

Strengths, Weaknesses and methods for improvement: \*The current modeling approach does consider the ecological response to changes in TN.

### REFERENCES

Cardno Lawson Treloar (2007a). "Brisbane Water Entrance Proposed SEPP35 Dredging – Coastal Processes Investigations". Prepared for Gosford Coucil and Department of Lands, Draft Report September 2007. LJ2658/R2406.

Cardno Lawson Treloar (2007b) Brisbane Water Estuary Processes Study – Hydraulic Processes. Prepared for Gosford Council and DECC

Cheng (2002) "Water Quality Monitoring of Brisbane Water and Gosford Lagoons – Summary of Data August 1999 – June 2002. Prepared for Gosford Council.

WBM (2003). Gosford City Council - Historical Water Quality Data Review and Analysis. Prepared for Gosford Council.

\*\*\*\*\*

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date of completion:* 6<sup>th</sup> October, 2009

TSS

### **INTRODUCTION**

### Node:

Total Suspended Solids (local water)

### **Descriptions and Units:**

Total Suspended Solids concentration (mg/L) during to dredging operations. Considers existing TSS conditions and additional solids suspended into the water column during dredging.

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- <2 mg/L ,
- 2-11 mg/L ,
- >11 mg/L ,

### **INITIAL RESULTS:**

*Method(s)* Data interpretation (existing WQ)

Sample: Brisbane Water Quality Database
Location: Woy Woy and Cockle Bays
Collection regime: Results from Cheng (2002)
Source: Cheng (2002), Summarised in WBM (2003)
Analysis description: TSS samples at Woy Woy and Cockle Bays (considered similarly sheltered locations with Creek inflows) between 1993 and 1994. Sample size = 22. Max = 4.6NTU, Min = 0.6 NTU, Mean = 1.69 NTU, Median = 1.40 NTU. The suspended solids and light penetration in this area of Brisbane Water is generally above ANZECC guidelines and adverse water quality outcomes are not commonly observed. A ratio of 1NTU = 1.4mg/L has been adopted to convert from mass units to NTU (see below).
Completed by: Sean Garber Date of completion: 25<sup>th</sup> July, 2009

*Method(s)* Data interpretation (dredging WQ)

Sample: NTU – mg/L relationship (Brisbane Water)
Location: Brisbane Water
Collection regime: Unknown
Source: GHD (1998)
Analysis description: It is reported that 3.6-4.5 NTU corresponds to total suspended solids of 5-6 mg/L.
Completed by: David Taylor
Date of completion: 14<sup>th</sup> June, 2007

*Method*(*s*) Data interpretation (Change in TSS due to dredging)

Sample: TSS assessment near the dredging sites Location: Dredging Option Areas within Hardy's Bay Collection regime: Based on results from a calibrated Delft3D model of Brisbane Water of dredge plume during dredging

*Source:* Estuary Management Study (ongoing) & Cardno Lawson Treloar (2007) *Analysis description:* Transport / dispersion modeling indicated that dredging could lead to the following increases in average near-bed suspended sediment concentrations (TSS) during dredging:

- Hardy's Bay Marinas 15-20mg/L
- Riley's Bay Entrance 10-15mg/L
- Mudflat Creek Entrance 15-20mg/L
- RSL Creek 10-15mg/L
- Hardy's Bay Entrance 5mg/L

A 10% near-bed re-suspension rate has been assumed. This value is typical of modern cutter-suction or auger type dredging.

Completed by: Sean Garber

Date of completion: 25th July, 2009

### **REVIEW OF RESULTS**

**INPUT LINK(S):** 

In Progress

### **REVIEW OF PROCESS:**

*Key assumptions*:

\* Background TSS concentrations assumed to be similar to sites of similar exposure and creek flows within Brisbane Water. Measured TSS from Woy Woy Bay and Cockle Bay used in the assessment.

\* The rate of sediment re-suspension is highly dependant on the dredging method and competency of dredge operator

Strengths, Weaknesses and methods for improvement: \*The current modeling approach does consider the ecological response to changes in TSS.

### REFERENCES

Cardno Lawson Treloar (2007) Brisbane Water Estuary Processes Study – Hydraulic Processes. Prepared for Gosford Council and DECC

Cheng (2002) "Water Quality Monitoring of Brisbane Water and Gosford Lagoons – Summary of Data August 1999 – June 2002. Prepared for Gosford Council.

WBM (2003). Gosford City Council - Historical Water Quality Data Review and Analysis. Prepared for Gosford Council.

GHD (1998) "Ettalong Beach to Sydney Fast Ferry Service – Environmental Impact Statement". Prepared by GHD for Fast Ships Pty Limited.

\*\*\*\*\*

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date of completion:* 6<sup>th</sup> October, 2009

## TSS

### **INTRODUCTION**

Node:

Acid Sulfate Soil

### **Descriptions and Units:**

Assessment of potential impacts from dredging potential acid sulfate soil material.

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- Little to none,
- Moderate,
- High,

### **INITIAL RESULTS:**

*Method(s)* Data interpretation (existing WQ)

Sample: Brisbane Water Estuary Processes Study – Acid Sulfate Soils Assessment Location: Hardy's Bay Collection regime: Data compilation and Collection (2003-2007) *Source:* GHD (2004) *Analysis description:* Three sediment samples were taken within Hardy's Bay which indicate the presence of potential acid sulfate soils. The Hardy's Bay area is therefore considered a high risk for impacts on the entrance water quality and ecology. *Completed by:* Sean Garber *Date of completion:* 20<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

#### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

Key assumptions:

\* Potential Impact of PASS based on plan area of dredging option and locality within Hardy's Bay,

\* PASS only becomes an issue when dredging occurs,

\* average of PASS probs taken for individual dredging scenarios when considering overall PASS,

\* Best practice dredging operations will be employed (as required by environmental permitting) therefore no risk to regional WQ is expected from dredging activities, \* Sediments to be dredged in Hardys Bay Entrance and Rileys Bay channel are more sandy and less likely to contain ASS.

Strengths, Weaknesses and methods for improvement: \*.

### REFERENCES

Cardno Lawson Treloar (2007) Brisbane Water Estuary Processes Study. Draft report. Prepared for Gosford Council and DECC

GHD (2004) Brisbane Water Estuary Processes Study – Acid Sulphate Soils Investigations. Prepared for Cardno Lawson Treloar.

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar 6<sup>th</sup> October, 2009

## **Seagrass Habitat Impacts**

### **INTRODUCTION**

### Node:

Seagrass Habitat Impacts

### **Descriptions and Units:**

Habitat loss due to dredging

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- $<1000 \text{ m}^2$ ,
- $1000 3000 \text{m}^2$ ,
- $3000 5000 \text{m}^2$ ,
- $>5000 \text{ m}^2$

### **INITIAL RESULTS:**

*Method(s)* Data interpretation

Sample: Aquatic Habitat Mapping Location: Brisbane Water Collection regime: Fisheries GIS layer Source: Fisheries (NSW), obtained from GCC 2004. Analysis description: Assessment made of the intersection between habitat areas and dredging footprints. The following impacts have been applied to each scenario:

- Hardy's Bay Marina: 1,100m<sup>2</sup> of Posidonia Australis habitat.
- Riley's Bay Entrance: 2,250m<sup>2</sup> of Posidonia Australis habitat.
- Mudflat Creek Entrance: 920m<sup>2</sup> of Posidonia Australis habitat.
- RSL Creek Entrance: 710m<sup>2</sup> of Posidonia Australis habitat.
- Hardy's Bay Entrance: No significant seagrass area.

*Completed by:* Sean Garber *Date of completion:* 20<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

**INPUT LINK(S):** 

In Progress

### **REVIEW OF PROCESS:**

Key assumptions:

Strengths, Weaknesses and methods for improvement: \*Based on the Fisheries (NSW) seagrass mapping which may not reflect the present condition.

\* Indirect impacts not assessed.

### REFERENCES

\*\*\*\*\*\*

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 20<sup>th</sup> July, 2009

## **Capital Dredging**

### **INTRODUCTION**

#### Node:

Capital Dredging Requirement

### **Descriptions and Units:**

Capital Dredging Requirement (one off)

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- 0
- $> 0-20,000 \text{m}^3$ ,
- 20,000-40,000m<sup>3</sup>,

- 40,000-60,000m<sup>3</sup>,
- $> 6000 \text{m}^3$ .

### **INITIAL RESULTS:**

*Method*(*s*) Data interpretation

Sample: Capital Dredge Volumes Location: Brisbane Water Collection regime: Bathymetric Data Source: Navigation Charts, NSW Maritime Seabed Data. Analysis description: Calculation of required dredge volume based on assumed dredged extent and desired depth of -2mISLW. Completed by: Sean Garber Date of completion: 29<sup>th</sup> September, 2009

*Method*(*s*) Data interpretation (dredging cost)

Sample: Dredging cost Location: Hardy's Bay Dredging Options Collection regime: Analysis of report on dredging similar material at Lake Macquarie Source: WBM (2004) Analysis description: The feasibility study prepared by WBM for dredging organic sediments at Lake Macquarie included costing for the setup of equipment, removal and treatment of organic sediments from nearshore areas of Lake Macquarie. The initial setup cost has been estimated at \$30,000 per campaign (for 15,000m<sup>3</sup> dredge, approx.). Dredging and treatment costs including treating acid sulfate soil is \$20.1 per m<sup>3</sup>. Dredging of clean sediments assumed to be \$10 per m<sup>3</sup>. Completed by: Sean Garber Date of completion: 29<sup>th</sup> September, 2009

### **REVIEW OF RESULTS**

#### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

*Key assumptions*:

• The cost may vary due to site specific factors

### REFERENCES

WBM (2004). "Lake Macquarie Organic Sediments: Feasibility Study on Sediment Removal – Final" Prepared for Office of Lake Macquarie Catchment.

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 29<sup>th</sup> September, 2009

## **Maintenance Dredging**

### **INTRODUCTION**

### Node:

Maintenance Dredging Requirement

### **Descriptions and Units:**

Maintenance Dredging Requirements (per year)

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- 0
- $>0-1000m^3$ ,
- 1000-2000m<sup>3</sup>,
- $> 2000 \text{m}^3$ .

### **INITIAL RESULTS:**

*Method*(*s*) Data interpretation (existing siltation from catchment)

 Sample: Modeling of Brisbane Water Catchment Area
 Location: Hardy's Bay – Mudflat Creek
 Collection regime: Based on results from MUSIC model and Delft3D transport dispersion model of Brisbane Water
 Source: Cardno Lawson Treloar (2007)
 Analysis description: Modelling of suspended sediment inflows from the Mudflat
 Creek catchment and estimation of siltation rates over the mudflat fan area. Siltation
 volumes from the catchment were assessed over three annual conditions (wet, average and dry rainfall conditions) resulting in siltation volumes of 266m3 (wet), 68m3 (avg) and 44m3 (dry). *Completed by:* Sean Garber *Date of completion:* 24<sup>th</sup> July, 2009

*Method(s)* Data interpretation (siltation post dredging)

Sample: Suspended Sediment assessment of Hardy's Bay dredging areas Location: Hardy's Bay
Collection regime: Based on results from Delft3D transport dispersion model of Brisbane Water
Source: Estuary Management Study (ongoing) & Cardno Lawson Treloar (2007)
Analysis description: Modeling of wave induced siltation rates within proposed dredged areas in Hardy's Bay. The following annual siltation rates were estimated from the modeling output: Hardy's Bay Marina – 1.5cm/yr
Riley's Bay Channel – 2cm/yr
Mudflat Creek Entrance – 1.5cm/yr
RSL Creek Entrance – 1cm/yr
Hardy's Bay Entrance - variable
Completed by: Sean Garber
Date of completion: 24<sup>th</sup> July, 2009

*Method*(*s*) Data interpretation (dredging cost)

Sample: Dredging cost Location: Hardy's Bay Dredging Options Collection regime: Analysis of report on dredging similar material at Lake Macquarie Source: WBM (2004) Analysis description: The feasibility study prepared by WBM for dredging organic sediments at Lake Macquarie included costing for the setup of equipment, removal and treatment of organic sediments from nearshore areas of Lake Macquarie. The initial setup cost has been estimated at \$30,000 per campaign (for 15,000m<sup>3</sup> dredge, approx.). Dredging and treatment costs including treating acid sulfate soil is \$20.1 per m<sup>3</sup>. Dredging of clean sediments assumed to be \$10 per m<sup>3</sup>. Costs are based on 5-year intervals between maintenance dredging campaigns. Completed by: Sean Garber Date of completion: 29<sup>th</sup> September, 2009

### **REVIEW OF RESULTS**

#### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

Key assumptions:

- The cost may vary due to site specific factors
- 5-years between maintenance dredging campaigns
- The base case (no dredging at any site) has been specified as having no maintenance dredging and hence no on-going cost.

### REFERENCES

WBM (2004). "Lake Macquarie Organic Sediments: Feasibility Study on Sediment Removal – Final" Prepared for Office of Lake Macquarie Catchment.

\*\*\*\*\*\*

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 29<sup>th</sup> September, 2009

## **Other Aquatic Recreation**

### **INTRODUCTION**

### Node:

Other Aquatic Recreation

### **Descriptions and Units:**

Impacts on other Aquatic Recreation

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- Negative,
- No Change,
- Positive,

### **INITIAL RESULTS:**

*Method(s)* Data interpretation (qualitative)

Sample: Estuary Management Study Consultation Location: Gosford City Council Collection regime: Community Consultation Source: Undertaken May, 2009

*Analysis description:* No specific aquatic recreational activity was identified within the consultation although it is assumed the maintenance on navigable depths would have a positive influence on aquatic recreation. Providing boat access to mudflat and RSL creeks may provide further recreational opportunity. Increased access and use of the Marinas could potentially have a negative influence on some activities (e.g. fishing).

*Completed by:* Sean Garber *Date of completion:* 29<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

**INPUT LINK(S):** 

In Progress

### **REVIEW OF PROCESS:**

*Key assumptions*: \* Maintenance of navigable depths has a positive influence on aquatic recreation.

*Strengths, Weaknesses and methods for improvement:* \* Arbitrary nature of the assessment.

### REFERENCES

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 29<sup>th</sup> July, 2009

## **Boating Safety**

### **INTRODUCTION**

Node:

**Boating Safety** 

### **Descriptions and Units:**

Impacts on Boating Safety in Brisbane Water

### **Input links:**

• Scenario Dredging Options

### **Output states:**

- Decreased Safety ,
- No Change,
- Increased Safety,

### **INITIAL RESULTS:**

*Method(s)* Qualitative assessment

Sample: Estuary Management Study Consultation Location: Gosford City Council Collection regime: Community Consultation Source: Undertaken May, 2009. Analysis description: Dredging options would control the sedimentation within Hardy's Bay and in doing so maintain design navigable depths thereby increasing boating safety. Dredging of the marina areas and the Riley's Bay entrance channel would have the most direct positive influence on boating safety. Completed by: Sean Garber Date of completion: 29<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

**INPUT LINK(S):** 

In Progress

### **REVIEW OF PROCESS:**

Key assumptions:

*Strengths, Weaknesses and methods for improvement:* \* Arbitrary nature of the assessment.

### REFERENCES

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 29<sup>th</sup> July, 2009

## **Boat Moorings and Berths**

### **INTRODUCTION**

#### Node:

Boat Moorings and Berths

#### **Descriptions and Units:**

Changes in number of boat moorings and berths

### **Input links:**

• Scenario Dredging Options

#### **Output states:**

- No Change,
- Increase < 50 berths,
- Increase > 50 berths,

### **INITIAL RESULTS:**

*Method*(*s*) Data interpretation (qualitative)

Sample: CLAM Consultation Location: Gosford City Council Collection regime: Stakeholder input Source: Undertaken May, 2007. Analysis description: Boat users and NSW Maritime indicated that improving navigation at within Brisbane Water would increase the attractiveness of Brisbane Water as a boating destination and potentially increase boat moorings in Brisbane Water. For this assessment boat moorings within Riley's Bay have also been included. Completed by: David Taylor Date of completion: 30<sup>th</sup> October, 2007

*Method*(*s*) Data interpretation (qualitative)

Sample: Economic Impacts Location: Central Coast Region Collection regime: Data analysis Source: NSW Regional Tourism Forum - 2002 Analysis description: Completed by: David Taylor Date of completion: 30<sup>th</sup> October, 2007

### **REVIEW OF RESULTS**

### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

Key assumptions:

*Strengths, Weaknesses and methods for improvement:* \* Arbitrary nature of the assessment.

### REFERENCES

Tourism Revenue Data - NSW Regional Tourism Forum - 2002

\*\*\*\*\*\*\*

*Input updated by:* David Taylor *Affiliation:* Cardno Lawson Treloar *Date:* 30<sup>th</sup> October, 2007

## **ANZECC Compliance**

### **INTRODUCTION**

### Node:

Change in ANZECC Compliance due to Dredging

### **Descriptions and Units:**

Assessment of change in ANZECC water quality guideline compliance.

### **Input links:**

- <u>TP</u>,
- <u>TN</u>.

### **Output states:**

- Increase,
- No Change,
- Decrease,

### **INITIAL RESULTS:**

*Method(s)* Data interpretation (existing WQ)

Sample: Brisbane Water Quality Database
Location: Booker Bay
Collection regime: Results from Cheng (2002) and Laxton (2000)
Source: Cheng (2002), Laxton (2000), Summarised in WBM (2003)
Analysis description: Comparing TN and TP to appropriate standards in ANZECC
2000 indicate that TN generally exceed guidelines. The median measured TP is
0.02mg/L (mean 0.03mg/L) compared to the ANZECC guideline of 0.03mg/L.
Median measured TN is 0.30mg/L (mean 0.43mg/L) compared to ANZECC guideline of 0.3mg/L. Adverse water quality outcomes are not generally observed.
Completed by: Sean Garber
Date of completion: 24<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

*Key assumptions:* \*

Strengths, Weaknesses and methods for improvement: \*.

### REFERENCES

Cheng (2002) "Water Quality Monitoring of Brisbane Water and Gosford Lagoons – Summary of Data August 1999 – June 2002. Prepared for Gosford Council.

WBM (2003). Gosford City Council - Historical Water Quality Data Review and Analysis. Prepared for Gosford Council.

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 5<sup>th</sup> October, 2009

## **Impact on Aquatic Fauna**

### **INTRODUCTION**

### Node:

Potential impact on Aquatic Fauna due to dredging

### **Descriptions and Units:**

Fauna impact has been based on the relative amount of seagrass area impacted by the dredging. The fauna impact is represented as a percentage estimate of biomass loss due to the dredging options. The potential impact on aquatic fauna due to changes in TSS, TN and TP caused by dredging have also been considered. However, the impacts caused by changes to these variables on the aquatic biomass is likely to be minimal compared to the impacts caused by the direct loss of aquatic habitat. Therefore the CLAM model only explicitly includes the loss of aquatic habitat in the fauna biomass loss estimate.

### **Input links:**

• <u>Seagrass Habitat Impacts</u>,

### **Output states:**

- <1% decrease
- 1-5% decrease
- 5-10 decrease
- >10% decrease

### **INITIAL RESULTS:**

*Method(s)* Data interpretation

Sample: Aquatic Habitat Mapping Location: Brisbane Water Collection regime: Fisheries GIS layer Source: Fisheries (NSW), obtained from GCC 2004. Analysis description: Assessment made of the intersection between habitat areas and dredging footprint.
 Completed by: Sean Garber
 Date of completion: 20<sup>th</sup> July, 2009

### **REVIEW OF RESULTS**

#### **INPUT LINK(S):**

In Progress

### **REVIEW OF PROCESS:**

*Key assumptions:* \*

Strengths, Weaknesses and methods for improvement: \*.

### REFERENCES

\*\*\*\*\*\*

*Input updated by:* Sean Garber *Affiliation:* Cardno Lawson Treloar *Date:* 20<sup>th</sup> July, 2009



**Shaping the Future** 

# Brisbane Water Estuary Management Study

**Processes CLAMs Summary Report** 

LJ2712/R2599 Prepared for Gosford City Council\* 16 October 2009



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Report No:\_\_\_\_\_

[Currently pending review by ANU and Council. To be included in the next version of the Brisbane Water Estuary Management Study.]

#### **Document Control**

Version	Status	Date	Author		Reviewer	
1	Draft	16 October 2009	Sean Garber	SJG		

\*Gosford City Council has prepared this document with financial assistance from the NSW Government through the Department of Environment, Climate Change and Water. This document does not necessarily represent the opinions of the NSW Government or the Department of Environment, Climate Change and Water.

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19 October 2009