gbaCOASTAL Pty Ltd

Consulting Engineers

D'ALBORA MARINA, THE SPIT, MOSMAN

Environmental Assessment for Proposed Alterations and Additions, Coastal and Maritime Engineering Aspects

Prepared by gbaCOASTAL Pty Ltd

for

Ardent Leisure

May 2010

D'ALBORA MARINA, THE SPIT, MOSMAN

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Coastal and Maritime Engineering Aspects

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May 2010

Document Amendment Record

Issue	Amendment	Date of Amendment
1	Draft	9 April, 2008
2	Final	25 May, 2010

Document Reference: J07-4/R73

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EXECUTIVE SUMMARY

The marina, on the western side of The Spit at Mosman, and its immediate shoreline precinct, has a long history. The seawall at Pearl Bay was built around the 1920s. The marina itself has existed, in more or less its present form, since the 1960s. Up until 2000, the marina was privately owned and operated by d'Albora Marinas. The group was then sold to Macquarie Leisure Operations Limited, although the d'Albora name has been retained.

An upgrade is currently proposed at d'Albora Marina, The Spit *(Spit Marina)*. The upgrade involves alterations and additions to achieve berthing for an additional 35 vessels on the marina, upgraded buildings, a new hardstand and boat lift, and a new fuel berth and pump out facilities. The additional 35 new permanent berths would take the total permanent berth numbers at Spit Marina from the existing 165, to 200. The proposal has been developed by Ardent Leisure *(d'Albora Marinas)* in association with Corben Architects. **Appendix D** shows the current concept for proposed alterations and additions to Spit Marina *(Master Plan, Corben Architects DA01/O, latest revision 24/4/10)*.

Gary Blumberg & Associates Pty Ltd *(GBA)*, Specialist Coastal and Maritime Engineers, were retained by Macquarie Leisure *(trading as d'Albora Marinas)* to undertake the environmental assessment for selected hydrological and water transport issues. Hamptons Development Group Pty Ltd is coordinating the preparation of the assessment on behalf of d'Albora Marinas. GBA was renamed gbaCOASTAL Pty Ltd *(GBAC)* in November 2008.

GBAC has collated and reviewed relevant background information. This has included the full suite of current DA drawings for the marina upgrade prepared by Corben Architects, the current hydrographic survey covering the full marina precinct *(Harvey Hydrographic Surveys, November 2007)*, and the current NSW Maritime Mooring Plan for Pearl Bay. In addition to marina industry guidelines, GBAC has referenced AUS bathymetric charts for Middle Harbour, NSW Maritime's Engineering Standards and Guidelines for Maritime Structures, and other relevant coastal and maritime engineering design manuals and texts. A search was also made of Mosman Council's development files and its public library for relevant documents relevant to Spit Marina and the scope of GBA's assessment. Australian Standard 3962, *Guidelines for Design of Marinas*, has served as the principal text for guiding the assessment.

Four site inspections were made by GBAC. The initial inspection was undertaken in December 2007. This was followed by further inspections with the Planning Focus Group *(31 January 2008)*, an inspection of spring tidal currents *(7 February 2008)*, and an inspection of the opening of Spit Bridge *(17 February 2008)*.

GBAC has assessed the environmental impact of the proposal associated with estuarine morphology and evolution, water depths and sediments, water levels, waves and wave loading, currents and current loading and the sediment transport regime. As a contribution to the overall assessment of marina functionality and safety, GBAC has also reviewed water transport in and about the marina. This has considered the proximity and type of passing boat traffic, mooring and channel arrangements and vessel motions at berth.

This assessment has found that the proposed concept to be sustainable in respect of coastal and maritime engineering. The environmental impacts associated with the proposal are generally small and acceptable. Where impacts are found to be unacceptable, remedial measures have been recommended and adopted as part of the final proposal (**Appendix D** Master Plan).

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1 INTRODUCTION

1.1 BACKGROUND

The marina on the western side of The Spit at Mosman, and its immediate shoreline precinct, has a long history. The seawall at Pearl Bay was built around the 1920s, while the marina itself has existed, in more or less its present form, since the 1960s. Up until 2000, the marina was privately owned and operated by d'Albora Marinas, with the group then sold to Macquarie Leisure Operations Limited. The d'Albora name has been retained. On 31 August 2009, Macquarie Leisure was renamed Ardent Leisure Group.

An upgrade is currently proposed at d'Albora Marina, The Spit *(Spit Marina)*. The upgrade involves alterations and additions to achieve berthing for an additional 35 vessels on the marina, upgraded buildings, a new hardstand and boat lift, and a new fuel berth and pump out facilities.

Pre-Development Application *(DA)* discussions took place with Mosman Council in May 2007. The Department of Planning *(DoP)* subsequently designated the proposal a Significant Development under SEPP *(Major Projects)* 2005, for which the Minister of Planning would act as the approval authority. We understand that the DA is to comprise a single package of works to be covered by a unified Environmental Assessment.

Gary Blumberg & Associates Pty Ltd *(GBA)*, Specialist Coastal and Maritime Engineers, renamed gbaCOASTAL *(GBAC)* Pty Ltd in November 2008, have been retained by Macquarie Leisure *(trading as d'Albora Marinas)* to undertake the environmental assessment for selected hydrological and water transport issues. Hamptons Development Group Pty Ltd is coordinating the preparation of the assessment on behalf of d'Albora Marinas.

A Preliminary Environmental Assessment prepared by Hamptons Development Group was lodged with DoP in November 2007. A Planning Focus Meeting was undertaken in late January 2008.

1.2 STUDY AREA

The study area includes Middle Harbour immediately upstream of Spit Bridge at Mosman, NSW. The study area is shown in **Figure 1**.

1.3 CONSULTANCY SCOPE OF WORK

The scoping requirements for the Environmental Assessment were developed by Hamptons Development Group having regard to typical marina assessment requirements. Formal requirements were provided by DoP following the Planning Focus Meeting. The agreed Scope of Work for GBAC's specialist assessment comprised the following:

- Collation and Review of Background Information

- Site Inspection
- Assessment of Selected Hydrological Issues
- Assessment of Water Transport Issues
- Meetings
- Reporting

The agreed Scope of Work is based on matters discussed between GBAC and HP. It has regard to relevant material covered in the following industry guidelines:

(i) EIS Guideline: Marinas and Related Facilities *(DUAP, 1996)*
(ii) Environmental Action for Marinas Boatsheds and Slipways *(DECC, 2007)*
(iii) Guidelines for Design of Marinas *(Standards Australia, 2001)*

It was agreed that the site inspection be made early in the consultancy to gauge layout of the facility relative to neighbouring shorelines, structures, navigation channels and swing moorings. Consultation took place with the marina manager to discuss relevant matters, and photos were taken for inclusion in the report.

GBAC attended project meetings and the planning focus meeting. At the request of Hamptons Development Group, GBAC prepared stand alone Environmental Assessment documentation to support a Part 3A application under the Environmental Planning and Assessment Act 1979.

1.4 DATUM

Reference to Relative Level *(RL)* in this report is in metres above Zero on the Fort Denison Tide Gauge *(ZFDTG)* which is approximately Lowest Astronomical Tide *(LAT)*. RL 0 is understood to be 0.925 m below Australian Height Datum *(AHD)*, where AHD is approximately Mean Tide Level.

1.5 ACKNOWLEDGEMENTS

In preparing this report, GBAC acknowledges the assistance provided by the following individuals:

D'Albora Marina, The Spit

Bill Loader	Project Manager
Clemens Overdjik	Marina Manager

Hamptons Planning

Kristy Lee	Director - Planning, Sydney

2 DESCRIPTION OF PROPOSAL

The Spit Marina upgrade proposal involves works to achieve berthing for a total additional 35 vessels. This is to comprise 31 additional vessels on A, B, C and N-Arms, building works, and new hardstand and boat lift, and works at D-arm including an additional four berths plus two reorganized temporary berths for fuelling and sewage pumpout facilities. The upgrade proposal has been developed by d'Albora Marinas, in association with Corben Architects.

The additional 35 new permanent berths would take the total permanent berth numbers at Spit Marina from the existing 165 to 200.

We understand that preliminary discussions between d'Albora Marinas and NSW Maritime have established that the upgrade proposal is compliant with the current waterway zoning, and that the required revisions to the leasing arrangements are modest and achievable. A minor extension is required at the southern end, but within the correct zoning.

At the time of preparing Issue 1 of this report *(April 2008)*, **Figure 2** reproduced the latest concept for proposed alterations and additions to d'Albora Marinas at The Spit. The most recent discussions regarding refinements to the proposal concerned refinements to berth sizes and fairway widths, and an improved configuration for the hardstand and boat lift on the north side of the marina, primarily to avoid impacts to existing seagrass beds and facilitate ready vessel manoeuvring in to, and out from, the boat lift bay, aligned parallel to predominant ambient *(tidal)* currents. The proposed upgrade arrangement shown in **Figure 2** was adopted for the purposes of this environmental assessment.

Appendix D shows the Master Plan in its final form ready for DA submission to NSW Maritime *(Corben Architects, DA01/O, latest amendment 24/4/10)*. GBAC has checked that the layout in **Appendix D** accords with that adopted for the Environmental Assessment shown in **Figure 2**. No changes that could affect GBAC's assessment could be discerned.

The upgraded facility incorporates the same width walkway pontoons as the existing facility at A, B and C-Arms. It is proposed that these pontoons would comprise concrete encased polystyrene, equivalent to the Bellingham system. Standard 400 mm pontoon drafts are assumed for DA assessment purposes.

d'Albora Marinas has advised that design development for the marina upgrade assumes a nominal planning period of 50 years. This notwithstanding, d'Albora Marinas believes a reasonable life for a floating marina at about 15 years after which connections and corners start to fail and major repairs or replacement is required. d'Albora Marinas is exploring recent advances with precast concrete to apply at its facilities in order to extend the life of its water-based assets.

3 COLLATION AND REVIEW OF BACKGROUND INFORMATION

3.1 GENERAL

GBAC has collated and reviewed relevant background information. This has included:

(i) full suite of current DA drawings for the marina upgrade prepared by Corben Architects *(latest supplied 6/2/08 and 27/3/08).* GBAC is advised that no prior design reports have been commissioned to support the design development of the proposal;

(ii) current hydrographic survey covering the full marina precinct *(including new berths and approach channels)* prepared by Harvey Hydrographic Surveys, dated November 2007;

(iii) current NSW Maritime Mooring Plan for Pearl Bay *(supplied 14/1/08)*.

In addition to the industry guidelines listed in **Section 1.3**, GBAC has referenced AUS bathymetric charts for Middle Harbour, NSW Maritime's Engineering Standards and Guidelines for Maritime Structures *(March 2005)*, and other relevant coastal and maritime engineering design manuals and texts.

3.2 INFORMATION FROM MOSMAN COUNCIL

A search was made of Mosman Council development files and its public library for relevant documents relevant to Spit Marina and the scope of GBAC's assessment.

3.2.1 Mosman Council Development Files

The following Council development files were retrieved and inspected by GBAC:

- DA 50/92
- DA 92/265
- DA 8.1998.615.1
- DA 8.1999.176.1
- 8.2001.378.1

A précis of the material is set out below.

DA 50/92

This DA covered the provision of a public sewage pumpout facility at the marina and the construction of floating pontoons to accommodate four pumpout berths. The estimated cost of this project was $234,000, funded under the NSW Waterways Infrastructure Development Program. Public Works (1992) presents the Statement of Environmental Effects *(SEE)*. A copy of this document was retrieved and referenced for this investigation.

DA 92/265

A contentious application for signage replacement which took over 12 months to resolve with Mosman Council (mainly visual and land ownership issues). While not relevant to this assessment, the file makes reference to a total of 130 leased moorings on the marina in April 1993.

DA 8.1998.615.1

The DA dated 18/4/98 covered the enlarging of an existing walkway for boat owners and guests to gather/sit, and providing space for garbage storage and recycling. The estimated cost of this project was $10,000. Arthur Gartell Architects assisted d'Albora Marina, and the proposal was approved in November 1998.

DA 8.1999.176.1

The DA dated January 1999 sought the use of the west side of the existing outer arm *(C-Arm)* for berthing of four vessels up to 32 m in length. This pre-Sydney 2000 Olympics project was associated with no physical change to the marina, although six existing swing moorings within Pearl Bay operated by d'Albora Marinas were relinquished as part of the proposal.

While this project was initially conceived as a temporary measure, the Waterways Authority advised in April 1999 that "mooring of vessels on the seaward side of outer arm C on a continuing basis would be acceptable in principle". Furthermore, the Authority advised that proposed berthing arrangements would:

> "….. not obstruct general navigation although there may be some impact on access to *(the Marina's)* own commercial moorings. These are matters for your application to Mosman Council to address in the context of the surrender of some moorings and consolidation of the remainder. Particular attention should be paid to the potential for obstruction arising from the current location of the emergency and Royal Volunteer Coastal Patrol *(RVCP)* moorings."

As part of the stakeholder agency referral process for this application, the Waterways Planning and Development Advisory Committee comprising representatives from the NSW Department of Transport, the Department of Urban Affairs and Planning, and Mosman Council, supported in principle the permanent proposed use of C-Arm, and recommended deferred commencement approval subject to confirmation of the structural adequacy of that arm for the proposed purpose.

Records indicate that Mosman Rowing Club, located along the shoreline to the south of the marina, supported the DA on the basis that the removal of the six swing moorings would enable the Waterways Authority to reinstate the rowing fairway in Pearl Bay. The Club indicated that rowing access to its facilities had become a safety issue over past years. The Authority, in response, acknowledged the access issue and advised that it was independently pursuing clearance on the waterway by attrition and mooring management.

DA 8.1999.176.1 was approved by Mosman Council in June 1999.

Matters in relation to navigation access, associated with the present proposal, are considered in **Sections 6.2** and **6.3**.

8.2001.378.1

This DA sought a reconfiguration of the existing sewage pumpout, a relocation of services from an existing dock to a reconfigured sewage pumpout dock, the use of the existing services dock as a boat berth, and removal of up to five swing moorings. The reconfigured facility was located between the marina buildings and the Spit Bridge inshore of the RL-6 bed contour. The estimated cost of the work was $40,000. Land Owners Consent was obtained from the Waterways Authority in October 2001, and Council approved the project in March 2002.

3.2.2 Mosman Council Library Search

GBAC undertook a search of Mosman Council Library for reports relevant to the physical processes operating at the site, the marina facility and its operation, and the use generally of the waterway in, and about, the marina and in Pearl Bay.

Two reports were retrieved and reviewed:

(i) Land Use Management Plan for The Spit *(GHD, 1990)*
(ii) SEE/REF for Proposed Widening of Spit Bridge *(RTA, 2003)*

Our citations relate to matters of interest and relevance to this investigation.

Land Use Management Plan for The Spit

Spit Marina in 1990 included 124 berths in the 8 to 40 m range, located on three arms. The floating breakwater was in place on C-Arm, as were the present slipway and commercial outlets.

GHD (1990) investigated the most suitable location for expanded berthing facilities at The Spit. GHD considered offshore marine aspects *(water depth, exposure, sediment movement, passing boat traffic)* and land area requirements. Comparing four potential sites at the southern end of Pearl Bay *(Site 1)*, NE Spit near current Fergusons Boatshed *(Site 2)*, SE Spit between Middle Harbour Yacht and Amateur Sailing Clubs *(Site 3)* and north of d'Albora Marinas *(Site 4)*, GHD reported that "there is scope for extending d'Albora Marinas northwards towards Spit Bridge. Water depths and exposure are suitable for expansion in a northwards direction although care would need to be taken to retain adequate separation from passing *(boating)* traffic."

GHD determined that Site 1 presented the most favorable opportunities for expanded berthing facilities *(9 points in their scoring system)*, followed by Sites 3 and 4 *(7 points)* and Site 2 *(6 points).*

Today Site 1 is no longer compatible with marina activities under Sydney Harbour Catchment REP 1995, and Site 3 is remote from existing commercial marina operations.

In respect of the advantages with Site 4, GHD noted that the 2 m contour encroached to within 25 m from the shoreline *(reasonably close)* and 50 year recurrence wave exposure did not exceed 0.9 m *(and thus would be manageable, although a wave screen may be necessary)*. While sediment movement had not been studied, available water depths and the presence of the seawall suggested little or no sediment movement *(important for maintenance of berthing depth)*, and the existing land based facilities and its surrounding *(albeit contained)* land area should support expanded facilities.

However, GHD also found that the area available for expansion into Site 4 would be restricted by requirements for navigating the Spit Bridge channel and the area required for waiting for the bridge to open.

SEE/REF for Proposed Widening of Spit Bridge

The information in this document of direct relevance to GBAC's assessment is limited to the results of a geotechnical investigation, and reference to bridge opening times for passage of masted boats.

A geotechnical investigation was undertaken by the Geotechnical and Scientific Services arm of the RTA, reported November 2002 and appended to RTA (2003). Eight boreholes were drilled from a barge, 5 m to the west of the existing bridge piers and abutments and spread along the length of the bridge. This investigation found deep alluvial sediments overlying sands. At the southern end of the bridge closest to the marina, 1.5 m of silty sand grades to fine to medium sand which is at least 6 m thick.

As at March 2003, the lift span of the Spit Bridge was opened seven times a weekday in winter and eight times a weekday in summer. The first opening was at 10.15 am, and the last at 7.30 pm. On Saturdays and Sundays, the bridge opened 11 times a day approximately hourly between 8.30 am and 9.30 pm.

3.3 OTHER REPORTS

GBAC has sourced and reviewed two other relevant reports:

- SEE for public sewage pumpout facilities at the Spit *(PWD, 1992)*
- REF for Reduced Weekend and Public Holiday Openings of Spit Bridge *(SKM, 2006)*

PWD (1992) provides information on the environment of the site upstream of Spit Bridge including bathymetry, geotechnical conditions, wave climate, waterway usage and tidal currents. The report canvases environmental issues including navigation. SKM (2006) addresses boating movements past Spit Bridge. We also refer to both of these reports in developing our assessment.

4 SITE INSPECTIONS

Four site inspections were made by GBAC:

- Initial inspection
- Inspection with Planning Focus group
- Inspection of tidal currents
- Inspection of opening of Spit Bridge

4.1 INITIAL INSPECTION

A walk-over inspection of the marina was made by Mr Gary Blumberg between 2.00 and 3.00 pm on 6 December 2007. Weather during the inspection was fine and winds were light. The predicted tide was low at RL -0.4. Mr Blumberg was accompanied at the inspection by Mr Bill Loader from d'Albora Marinas. The walk-over inspection covered all existing floating arms and the waterside facilities on the north side of the marina.

Five vessels up to approximately 30 m in length were observed berthed up along the outer face of C-Arm. The relative exposure of the outer berths to the predominant westerly fetch was noted (**Section 5.4.1**), as were the sprung moored craft on the leeward side of C-Arm. A 22 m long vessel was berthed at the southern end of B-Arm.

The fairway widths between the arms appeared approximately one and a half times the length of the larger berthed craft. Mr Loader pointed out that while this arrangement may appear constrained, bow thrusters which today are frequently used on the larger-sized vessels readily facilitate their manoeuvring within the marina fairways. Channel arrangements inside the marina are addressed in **Section 6.3**.

At 2.45 pm we observed the charter vessel Majestic 2 travelling upstream under the northern span of Spit Bridge, and two other vessels waiting for the bridge lift.

It appeared that sand levels may have lowered close to the shoreline in the vicinity of the marina buildings. Concrete encasement of the marina piles under the buildings, apparently cast to bed level, were observed to be elevated some 300 mm above the bed. Existing sediment transport behaviour in and about the marina is addressed in **Section 5.6**.

4.2 INSPECTION WITH PLANNING FOCUS GROUP

Mr Gary Blumberg attended the Planning Focus Meeting at the marina on 31 January 2008, commencing at 9.30 am. Later that morning and as part of the meeting, the group inspected the marina facility.

4.3 INSPECTION OF TIDAL CURRENTS

Mr Gary Blumberg inspected peak ebb spring surface tidal currents between 12.20 pm and 1.40 pm on 7 February 2008. Weather was overcast with rain periods, and wind was light to moderate from the south and strengthening. There had been moderate rainfall within the catchment in the week preceding the investigation.

The predicted ebb tidal range on the day was 1.48 m which compares to a mean spring range of 1.3 m (**Section 5.3.1**). Our measurements were made about midway through the ebb tide.

We measured surface current speeds between 0.06 m/s and 0.31 /s. The maximum speeds were encountered along the base of Spit Reserve seawall, immediately south of the suspended south-west corner of the marina buildings. The currents were all directed towards Spit Bridge. It is possible that minor freshwater flooding was contributing to the measured currents.

Selected photographs taken during this inspection are attached in **Appendix A**.

4.4 INSPECTION OF OPENING OF SPIT BRIDGE

Mr Gary Blumberg inspected the 11.30 am bridge opening on Sunday 17 February 2008. Weather was fine, skies partly cloudy with moderate winds from the SE. The prospects for boating on the day were good. The opening was observed from the RTA operator's booth.

We counted 19 vessels headed downstream through the lift span, all yachts. Our estimate of size distribution for the observed passing is summarised in **Table 4.1**.

TABLE 4.1 VESSEL MOVEMENTS DOWNSTREAM DURING 11.30 AM BRIDGE OPENING, SUNDAY 17 FEBRUARY 2008

Estimated Vessel Sizes	Number of Vessels
< 8 m	1
8 m – 10 m	10
10 m – 12 m	2
12 m – 14 m	5
>14 m	1
Total	**19**

During our observation a Captain Cook cruise vessel made a downstream pass at 11.28 am, two minutes before the bridge opened (**Photo B45**). She navigated the northern side of the channel passing under a northern span of the bridge. She sounded her horn at 11.26 am to warn mustering vessels that she was making her approach. We understand from the RTA Bridge Operator that on such occasions when a charter cruiser passes The Spit at the time of a bridge opening, the mustering vessels clear a path, shifting to the southern side of the channel closer to Spit Marina. It was apparent therefore that our observation on the day represented a congested situation for assessing the interaction between the marina and the muster fleet. Selected photos taken during the 11.30 am bridge opening on Sunday 17 February 2008 are included in **Appendix B**, and our observations summarised below:

- mustering commenced 10 minutes before the bridge opened, although within 5 minutes of the opening no more than 50% of the total that passed had assembled on the bridge side of say C-Arm. The remainder wither either still approaching from further upstream or drifting / holding position on the western side of the marina and into Pearl Bay;

- vessels encroached to with approximately 15 m of bridge while mustering (**Photo B43**);

- there was encroachment towards Spit Marina during the mustering and this was probably greater due to the downstream movement of Captain Cook, two minutes before the bridge opening.

We understand from the RTA Operator that weekend sailors allow more time to pass through an opening, compared to the regular sailors. The Operator also expressed his view that he would not anticipate a congestion impact associated with the marina upgrade, between berthed vessels on the marina and mustering craft headed downstream, so long as the rearranged berthed vessels did not encroach across a line extending from the southern shoreline at the bridge opening, at right angles away from the bridge. This is depicted in **Figure 3**.

Reference to the RTA Bridge Operator's current log book provided data on the number of downstream vessel passings over recent weekends and Public Holidays. For the peak 11.30 am downstream weekend passing, the RTA records showed that between 6 and 38 vessels had navigated the opening during this time slot. As would be expected the number of passing vessels was highly dependent on weather (**Table 4.2**).

The RTA Operator advised that boat numbers are substantially lower during week days and over the winter months. In the four years that he had worked the bridge, he recalled going up to two days without an opening of the bridge.

TABLE 4.2 VESSEL MOVEMENTS DOWNSTREAM DURING JANUARY 2008 AT 11.30 AM, SPIT BRIDGE LIFT SPAN

January 2008 Weekends	Details	Weather Record	Number of Vessel Movements
Tues 1	New Years Day		31
Sat 5		Rain	6
Sun 6		Overcast	14
Sat 12			17
Sun 13			31
Sat 19		Rain	10 (approx)
Sun 20		Rain	10 (approx)
Sat 26	Australia Day	Fine	38
Sun 27			19
Mon 28	Australia Day public holiday		34

Source RTA Log Book, Spit Bridge

5 ENVIRONMENTAL ASSESSMENT OF SELECTED HYDROLOGICAL ISSUES

This section presents our assessment of selected hydrological issues, namely:

- Estuarine morphology and evolution
- Water depths and sediments
- Water levels
- Waves and wave loading
- Currents and current loading
- Existing sediment transport regime and perturbations

The existing environment is described. Impacts, mitigation and management associated with the marina upgrade proposal are then addressed.

5.1 ESTUARINE MORPHOLOGY AND EVOLUTION

5.1.1 Existing Environment

Sydney Harbour is a “drowned river valley” formed within the last 10,000 years *(Chapman et al, 1982)*. Middle Harbour forms a tributary estuary with common morphological features to Sydney Harbour.

Dendritic valley patterns and rocky shorelines characterise such drowned valley systems. At Middle Harbour there is a relatively shallow tidal delta *(depths 4 to 8 m between Hunters Bay and Chinamans Beach),* a deep mud basin *(up to 30 m deep upstream of Beauty Point)*, and an estuarine channel. Apart from the tidal delta, marine deposits also occur in nearshore and barrier beach environments, with tidal flats exhibited in shallow tributary valleys. Pearl Bay upstream of The Spit is a typical side bay, located in the transition zone between the tidal delta *(downstream)* and mud basin *(upstream)*. Intertidal sediment deposits are not notable in Peal Bay.

Sydney Harbour exhibits a relatively wide and exposed entrance to the ocean. Ocean swell penetration usually influences morphology and sediment distribution for some distance from the entrance of drowned valleys *(typically up to 5 km).* While we would expect ocean swell penetration in severe storms to extend into Middle Harbour beyond Grotto Point *(say 3 km from the ocean)* and probably as far as Clontarf Point *(4 km)*, because of protruding headlands and the meandering channel, swell wave penetration upstream of The Spit *(5 km)* does not occur.

5.1.2 Impacts, Mitigation and Management

The proposal would have no impact on the morphological behaviour of Middle Harbour. There would be no influence whatsoever on gross tidal and freshwater flows (**Section 5.5**), and also sediment supply and sediment movement patterns (**Section 5.6**). All new waterside structures would be designed to accommodate the water depths, water flows and bed materials *(see below)*.

5.2 WATER DEPTHS AND SEDIMENTS

5.2.1 Existing Environment

Middle Harbour upstream of The Spit is relatively deep. Aus Chart No 200 shows depths to 15 m in the channel immediately upstream of Spit Bridge. Similar depths are encountered along C-Arm, reducing inshore.

Harvey Hydrographic Surveys undertook a survey of the marina in November 2007. Covering the full facility and extending northwards to the southern abutment of Spit Bridge, the survey shows A and B-Arms coinciding approximately with the RL -5 and RL -10 bed contours, respectively.

Sediments comprising The Spit are primarily sands of marine origin (**Section 5.1.1**). These have reworked upstream from the main tidal delta off Chinamans Beach, mainly under the influence of flood tidal currents and SE wind waves. Terrestrial muds also have accumulated along the eastern shore of Pearl Bay before the seawall was constructed at Spit Reserve, and these finer sediments could be expected to have remobilised and settled over the deeper areas within Spit Marina.

5.2.2 Impacts, Mitigation and Management

The proposal will have no influence on existing water depths, be these within the channel, within the marina precinct, or elsewhere. The reconfigured berths are to be restrained by piles. These would comprise the existing piles, and any new piles to be determined as part of the detailed design. The piling design would have regard to existing water depths and bed materials.

The suitability of the existing water depths for the proposed berthing arrangements is considered in **Section 6.2**.

5.3 WATER LEVELS

5.3.1 Existing Environment

Water levels at the site are influenced by tide and coastal weather systems. Sea Level Rise *(SLR)* due to the Greenhouse Effect should also be considered.

Tides

Water levels in Sydney Harbour are largely governed by tide. Predicted tidal planes are available for Fort Dennison, Sydney Harbour. These tidal planes, presented in **Table 5.1**, would be applicable at The Spit. At RL 1.5 m AHD, the seawall crest level at Spit Reserve is approximately 0.8 m above Mean High Water Springs.

TABLE 5.1 PREDICTED TIDAL PLANES FOR THE SPIT, MIDDLE HARBOUR

Tidal Plane		RL (m ZFDTG)
Mean High Water Springs	MHWS	1.56
Mean High Water	MHW	1.44
Mean High Water Neaps	MHWN	1.32
Mean Sea Level	MSL	0.89
Mean Low Water Neaps	MLWN	0.49
Mean Low Water	MLW	0.37
Mean Low Water Springs	MLWS	0.24
Indian Spring Low Water	ISLW	0.00

Source Public Works (1990)

Influence of Coastal Weather

Actual water levels vary from predicted tide levels for a combination of reasons. Extreme elevated *(actual)* water levels are of interest at the site. They would be influenced by oceanic surges during storms *(due to barometric setup and possibly wind setup on the Sydney coastline)*. Local wind and wave setup at the Peal Bay shoreline may also occur. Freshwater flooding may influence still water levels in the upper parts of Middle Harbour, however its contribution at The Spit would be expected to be small.

Our assessment of extreme elevated still water levels at The Spit is summarised in **Table 5.2**.

TABLE 5.2 EXTREME ELEVATED STILL WATER LEVELS AT THE SPIT

Recurrence		RL (m ZFDTG)
Average Recurrence Interval (ARI)	**Annual Exceedence Probability (AEP) (1)**	
100 years	1% AEP	2.4
50 years	2% AEP	2.3
1 year	100 % AEP	2.1

Notes (1) An x % AEP *(Annual Exceedence Probability)* has an x % chance of being exceeded in any one year

Thus, an actual still water level of RL 2.4 would have a 1% chance of occurring on a single occasion in any one year, whereas a still water level of RL 2.1 would have a 100% chance of occurring on a single occasion in any one year. It is of interest to note that a 2% AEP event, equivalent to a 50 year ARI which might reasonably constitute a design planning period for a marina facility, has a 64% chance of occurring in a 50 year period. Note that wave runup will exceed the still water level (**Section 5.4**).

Actual still water levels can also be lower than predicted tide levels. We understand that a water level up to 0.2 m below ZFDTG datum occurs once every 20 years or so in Sydney Harbour.

Sea Level Rise (SLR)

The Intergovernmental Panel on Climate Change has recently reported its SLR scenarios to the years 2090/2099 *(IPCC, 2007)*. IPCC's current predictions are considered by DECC to be the best information available to assess the likely impact of climate change on sea levels. For coastline hazard assessments in NSW, it has been common practice to consider the average of the SLR scenarios which, for the current IPCC revision, translates to a conservative postulated rise of 0.49 m over the 100 years to 2090/2099. This is based on:

(i) 0.34 m as the combined average of the model ranges *(Table SPM-3, IPCC 2007)*;

(ii) plus 0.15 m to account for uncertainties in carbon feedback and changes in ice sheet flow *(p14, 3rd bullet, IPCC 2007).*

Since SLR predictions exhibit larger increases over the second half of the 21st century compared to the first half, it follows that adopting 50% of 0.49 m over 50 years is a prudent position, and we consider reasonable for the purposes of this assessment.

Our recommended 50 year SLR for The Spit is thus 0.25 m.

5.3.2 Impacts, Mitigation and Management

In relation to extreme high water levels, the impact on the floating berths of tide, weather influence on water level and SLR would be fully accounted for on the condition that:

(i) pile cut off levels are suitably elevated, and that the bending capacity of the piles can accommodate the increased bending moments due to larger lever arms. Pile lengths should cater for a 1% AEP SWL of RL 2.4 (**Table 5.2**), plus a nominal wave amplitude of say 400 mm; and

(ii) ramps are operable for a SWL range between RL -0.3 and RL 2.8.

The selection of building floor level must have regard to the water level contributions reported in **Section 5.3.1** and wave action in **Section 5.4.1**. The likelihood and consequences of minor flooding should be weighed against visual and building function considerations, to be addressed by others. It would be reasonable to expect, and tolerate from time to time, minor inundation of the hardstand and suspended over-water maritime structures. We recommend that new fixed power outlets throughout the facility be set no lower than RL 2.8.

5.4 WAVES AND WAVE LOADING

5.4.1 Existing Environment

The wave environment at the site is a result of wind waves from the west, and boat generated waves. Due to the relatively large water depths, wind wave climate at the site is independent of tide. Also, deep water wave processes are applicable and wave shoaling may be disregarded.

Wind Waves

Wind waves are generated when the wind blows across a body of water. The size and period of the waves depends on the wind speed and duration over which this is measured, the distance over which the wind blows, and the water depth.

GBAC has developed a wind wave hindcast model for the site based long-term directional wind statistics available for Sydney, and wave hindcasting procedures set out in CERC (1984). The predicted wind wave climate for Spit Marina is summarised in **Table 5.3**.

The largest wind waves are incident from the west. Making fair allowance for upfetch topographic shielding, we estimate 1.85 km and 1.25 km fetch lengths applicable to the southern and northern areas of the marina respectively. Significant wind waves up to 0.3 m in height are predicted to occur once a week on average, increasing to 0.9 m once every 50 years. No other wind fetch directions of any significance occur.

TABLE 5.3 INCIDENT WIND WAVE CLIMATE AT SPIT MARINA

Direction	**West**			
Location within Marina	**Southern Areas (C-Arm)**		**Northern Areas (D and N-Arms)**	
Fetch Length	1.85 km		1.25 km	
Average Depth	15 m		15 m	
Average Recurrence Interval (ARI)	**Hs (m)** [(1)]	**T (s)**	**Hs (m)** [(1)]	**T (s)**
1 week	0.28	1.8	0.24	1.6
1 year	0.58	2.3	0.48	2.0
50 years	0.89	2.6	0.75	2.3

Notes (1) Significant wave height Hs is the average of the highest 1/3 of waves in a wave train. At this site, H max ~ 1.8 Hs

Boat Waves

Boat generated waves are governed by submerged hull shape, boat speed and water depth. Boat waves exhibit a diverging component which emanates at the bow, and a transverse component that follows at the stern. Boat speed relative to water depth can affect the nature of the waves. Boat waves attenuate with distance from the sailing line.

Based on GBAC's experience with boat wave climate in Sydney Harbour and observations of vessel types and movements in and about the marina site, we estimate a design incident boat wave climate as summarised in **Table 5.4**. These waves could occur on a daily basis.

Combined Wind and Boat Waves

It is possible for wind and boat waves to coexist for frequent wind wave events, but not for extreme events when boating traffic is absent. For Spit Marina, while some boat wave action may occur during severe weather, GBAC would not expect design boat waves (**Table 5.4**) to occur at the same time as wind waves with recurrence of 1 year or more (**Table 5.3**).

TABLE 5.4 DESIGN INCIDENT BOAT WAVE CLIMATE AT SPIT MARINA [1]

Vessel Type	Recurrence	Hmax (m)	T (s)
Outer Berths at C-Arm, N-Arm and D-Arm			
- Recreational Power Craft	Weekly	0.5	2.5
- Charter Vessels	Weekly	0.35	2.0

Notes (1) Wave conditions have regard to wash restrictions within the marina and adjoining navigation channel, as well as the likelihood that these would be breached from time to time

Source GBAC database and site observations

Wave Loads

Wave loads may be considered at the floating marina and at the seawall.

Our estimate of 50 year ARI maximum horizontal wave load at C-Arm, assuming no vessels are berthed at C-Arm, is 5 kN/m. Attributed to 0.9 m 2.6 s significant waves incident from the west, this load estimate is derived from physical model testing of various breakwater configurations reported by Blumberg and Cox (1988). With berthed vessels included, wave loads on C-Arm would increase.

If these waves passed through the marina and impacted directly on the seawall at Spit Reserve, disregarding any attenuation from the marina or its boats, we estimate maximum horizontal wave loads on the seawall between 5 and 40 kN/m, for the cases of unbroken and breaking waves respectively. The larger loads would generally occur at higher tides. At lower tides, wave breaking may be instigated seaward of the wall and wave loading on the wall would be reduced.

5.4.2 Impacts, Mitigation and Management

Waves will impinge on the marina resulting in the movement of vessels at their berths and imparting loads on the marina itself.

The impact assessment set out below assumes the upgraded facility to incorporate the same width walkway pontoons as the existing facility, 5 m wide at C-Arm and 2.5 m wide elsewhere. Fingers are 1.1 m wide throughout. Standard 400 mm pontoon drafts are adopted, provided by concrete encased polystyrene pontoon units (**Section 2**).

Movement of Vessels

AS 3962 recommends criteria for “excellent”, “good” and “moderate” wave climates in small craft harbours, adapted from Mercer et al (1982). These criteria account for wave direction relative to berthing alignment *(head, beam and oblique seas)*, wave period *(less than 2 s and greater than 2 s)*, and wave recurrence *(1 and 50 year ARI)*. NSW Maritime accepts a “moderate” wave climate for marina design in NSW.

We note that AS 3962 does not include weekly wave climate criteria, the recurrence attributed to boat waves (**Table 5.3**). We understand that the code subcommittee considered that a weekly recurrence may be too onerous for marina design, and that boat waves should be accepted if they satisfy the once a year criterion *(Mr Chris Abraham, AS 3962 subcommittee, 20/9/01 pers comm).*

Permanent Berths

Our assessment of design incident wave action and wave climate criteria for all proposed permanent berths within Spit Marina is summarised in **Table 5.5** and described below.

- **C-Arm**

Proposed outer berths on C-Arm are 25 m long and inner berths 15 m long. Design waves are confined to head seas. AS 3962 “moderate” wave climate criteria for 1 yr and 50 yr ARI waves are 0.38 m and 0.75 m respectively.

For the outer berths, these criteria may be compared with predicted design incident wave heights up to 0.58 m *(1 yr)* and 0.89 m *(50 yrs)*. Thus direct compliance is not achieved for both the 1 yr *(0.58 > 0.38)* and 50 yr conditions *(0.89 > 0.75)*. However, compliance is effectively satisfied having regard to the proposed 25 m boat lengths compared to the 6 to 12 m boat lengths used to develop the criteria in AS 3962. Our assessment of wave climate compliance having regard to boat length is presented in **Appendix C**.

For the inner berths, these criteria may be compared with predicted design incident wave heights of up to 0.29 m *(1 yr)* and 0.61 m *(50 yrs)*. The wave heights allow for 50 and 68% transmission under the pontoons comprising C-Arm for 1 for 1 r and 50 yr ARI waves respectively. Here direct compliance is achieved for both 1 yr *(0.29 < 0.38)* and 50 yr conditions *(0.61 < 0.75)*.

- **A and B-Arms**

Proposed berths on A and B-Arms range between 8 and 12 m long. Design waves are confined to head seas. AS 3962 “moderate” wave climate criteria for 1 yr and 50 yr ARI waves are 0.38 m and 0.75 m respectively.

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TABLE 5.5 SUMMARY OF WAVE CLIMATE COMPLIANCE ASSESSMENT AT PERMANENT BERTHS

Location		Proposed Berth Lengths (1) (m)	Alignment to Incident Waves	AS 3962 "Moderate" Criteria		Design Incident Wave Climate				Direct Compliance with AS 3962		Effective Compliance having regard to Boat Length (2)	
				1 yr	50 yrs	1 yr		50 yrs					
				Hs (m)	Hs (m)	Hs (m)	T (s)	Hs (m)	T (s)	1 yr	50 yrs	1 yr	50 yrs
C-Arm	Outer	25	Head	0.38	0.75	0.58	2.3	0.89	2.6	×	×	✓	✓
	Inner	15	Head	0.38	0.75	0.29	2.3	0.61	2.6	✓	✓		
A and B-Arms	All	8 to 12	Head	0.38	0.75	≤0.29	2.3	≤0.61	2.6	✓	✓		
N-Arm	Outer	11 and 21	Head	0.38	0.75	0.18	2.0	0.38	2.3	✓	✓		
	(E-W aligned)		Oblique	0.38	-	0.35	2.5	-	-	✓			
	Inner	25 and 30	Head	0.38	-	0.5	2.5	-	-	×		✓	
	(N-S aligned)		Beam	0.19	0.31	0.10	2.0	0.25	2.3	✓	✓		
D-Arm	E-W aligned	12	Head	0.38	0.75	≤0.18	2.0	≤0.38	2.3	✓	✓		
			Oblique	0.38	-	0.35	2.5	-	-	✓			

Notes
(1) Derived from Corben Architects drawings and confirmed by d'Albora Marinas
(2) GBAC assessment (**Appendix C**)

For both the outer and inner berths on these arms, the criteria may be compared with predicted design incident wave heights not exceeding 0.29 m *(1 yr)* and not exceeding 0.61 m. Thus direct compliance is achieved for both the 1 yr *(0.29 < 0.38)* and 50 yr conditions *(0.61 < 0.75)*.

- **N-Arm**

Outer Berths (E-W Aligned)

Proposed outer berths *(E-W aligned)* on N-Arm are 14 m long, plus a single 21 m berth. Design waves comprise head seas due to winds *(1 yr and 50 yr ARI)*, and oblique boat waves *(1 yr ARI)*. AS 3962 “moderate” wave climate criteria for 1 yr and 50 yr ARI head seas are 0.38 m and 0.75 m respectively, and for 1 yr ARI oblique waves are 0.38 m.

For the head seas, these criteria may be compared with predicted design incident wave heights of 0.18 m *(1 yr)* and 0.38 m *(50 yrs)*. The wave heights allow for 38% *(1 yr)* and 50% transmission *(50 yrs)* under the pontoons comprising the northern end of C-Arm. Thus direct compliance is achieved for both 1 yr *(0.18 < 0.38)* and 50 yr conditions *(0.38 < 0.75)*.

For the oblique waves, the criterion may be compared with a predicted design incident wave height of 0.35 m *(1 yr)*. This wave height allows for 70% transmission under the pontoons comprising the L-head and fingers at N-Arm. Thus direct compliance is achieved for the 1 yr condition *(0.35 < 0.38)*.

Inner Berths (N-S Aligned)

Proposed N-S berths on N-Arm are between 25 and 30 m long. Design waves may comprise head seas due to boats *(1 yr ARI)*, and beam seas due to winds *(1 yr and 50 yr ARI).*
AS 3962 “moderate” wave climate criteria for 1 yr ARI head seas is 0.38 m, and for 1 yr and 50 yr ARI beam seas are 0.19 m and 0.31 m respectively.

For the head seas, the criterion may be compared with the predicted design incident wave height of 0.5 m *(1 yr)*. The wave height neglects any transmission losses. Thus direct compliance is not achieved for the 1 yr condition *(0.5 > 0.38)*. However, compliance is effectively satisfied having regard to the proposed 25 to 30 m boat lengths compared to the 6 to 12 m boat lengths used to develop the criteria in AS 3962 (**Appendix C**).

For the beam seas, the criteria may be compared with predicted design incident wave heights of 0.10 m *(1 yr)* and 0.25 m *(50 yrs)*. For the 1 yr condition, these wave heights allow for a total 21% transmission under the pontoons comprising the northern end of C-Arm *(38%)* and the western leg of N-Arm *(54%)*. For the 50 yr condition, these wave heights allow for a total 33% transmission under the pontoons comprising the northern end of C-Arm *(50%)* and the western leg of N-Arm *(65%)*. Thus direct compliance is achieved for both the 1 yr *(0.10 < 0.19)* and 50 yr conditions *(0.25 < 0.31)*.

- **D-Arm**

Proposed E-W berths on D-Arm are 12 m long except for the southern most berth D193 which is 8 m long. Design waves comprise head seas due to winds *(1 yr and 50 yr ARI),* and oblique boat waves *(1 yr ARI)*. AS 3962 “moderate” wave climate criteria for 1 yr and 50 yr ARI head seas are 0.38 m and 0.75 m respectively, and for 1 yr ARI oblique waves are 0.38 m.

For the head seas, these criteria may be compared with predicted design incident wave heights not exceeding 0.18 m *(1 yr)* and 0.38 m *(50 yrs)*. The wave heights would not exceed those encountered at the N-Arm Outer berths *(see above)*. Thus direct compliance is achieved for both 1 yr *(0.18 < 0.38)* and 50 yr conditions *(0.36 < 0.75).*

For the oblique waves, the criterion may be compared with a predicted design incident wave height of 0.35 m *(1 yr)*, the same as that encountered at the N-Arm outer berths *(see above)*. Thus direct compliance is achieved for the 1 yr condition *(0.35 < 0.38)*.

<u>Temporary Berths</u>

- **Services Berth**

The proposed services berth on the northern end of D-Arm *(fuel / pumpout)* would cater for all lengths of craft berthed at the marina. Being a temporary berth, it would only be used when the wind wave climate was conducive. This, GBAC would expect, for over 99% of the time *(average winds ≤ 45 km/hr, BoM 1979)*. Boat waves to 0.5 m would be expected to occur at the services berth on a regular basis. At its nearest, the centre of the main channel is located 85 m away from the proposed services berth.

The boat wave climate at the proposed services berth would, for all intents and purposes, be the same as that encountered at the existing services berth, 90 m away at the northern end of B-Arm. We note that the existing services berth, with its fuel and pumpout facility, has been in operation at the marina for over 6 years without a wave climate serviceability issue. On this basis alone, it would be reasonable to expect that wave climate compliance would be achieved at the proposed services berth.

- **Boat Lift Bay**

The proposed boat lift is located behind D-Arm, immediately adjacent to the services berth. The boat lift would cater for all lengths of craft up to the capacity of the lift facility, provisionally selected as 15 m.

It would be reasonable to expect wave conditions conducive to operation of the adjacent services berth, as being acceptable for operation of the boat lift. Furthermore, the boat lift would be operated less often than the services berth, and at greater discretion.

D’Albora Marinas has duly weighed its operational experience in choosing the location and orientation of the boat lift (**Section 6.2.2**).

Wave Loads on Marina

Conventional concrete encased floating marina systems with its piling restraint would readily withstand the current loads on the marina, to be accounted for in the detailed design.

5.5 CURRENTS AND CURRENT LOADING

5.5.1 Existing Environment

Currents within the waterway at Spit Marina are primarily due to tidal flows and wind induced water movements. Localised currents could occur at stormwater outlets. Wave induced water particle movements are more a wave than current related process, suitably accounted for in **Section 5.4**.

Tidal Currents

Tidal currents in Sydney Harbour would rarely exceed 1.5 knots *(0.75 m/s)* as shown on Aus Chart No 200. In Middle Harbour between Clontarf Point and Wy-ar-gine Point, maximum currents are called up as 1.0 knot *(0.5 m/s)*. Higher velocities could be expected under Spit Bridge.

GBAC inspected peak surface currents during a large ebb spring tide on 7 February 2008 (**Section 4.3**). Midway through the 1.48 m ebb tide, current speeds were measured between 0.06 m/s and 0.31 /s. Maximum speeds were encountered along the base of Spit Reserve seawall, immediately south of the suspended south-west corner of the marina buildings. Currents were all directed towards the Spit Bridge.

Fresh Water Flows

Freshwater flows in Middle Harbour could contribute to increase ebb tidal velocities within the marina, however the affect is likely to be modest. Assuming 100 mm of rain over the catchment is discharged through Middle Harbour over a single tidal cycle *(6 hrs)*, certainly a substantial rainfall event and conservative drainage scenario, we estimate that depth-averaged velocities within the marina could be increased by up to 0.1 m/s. It is possible that a minor freshwater flooding component was contributing to the measured peak ebb spring tidal currents described above.

Wind Generated Currents

Wind generated flows are generally taken as 2 to 3% of the wind speed, up a maximum wind speed of about 7 m/s after which the shear mechanism becomes oscillatory rather than unidirectional *(wave generation takes over)*. Hence maximum wind induced currents would be approximately 0.2 m/s *(3% x 7).*

Currents at Stormwater Outlets

Flows at stormwater outlets could be as high as 2 to 3 m/s during periods of heavy rainfall, however for smaller sized outlets *(dia < say 300 mm)* such as those which might be used at a marina, these currents would be localised and rapidly attenuate.

Propeller Wash

Propeller wash from vessels *(or screw race)* is also a source of water flow. The magnitude of this flow essentially depends on the installed engine power and propeller diameter. Propeller wash is larger for vessels applying engine power from rest than when underway. While propeller wash velocities can be as high as 10 m/s or more immediately behind the submerged propeller, these velocities are confined to a small diameter jet. They immediately entrain ambient water and dissipate rapidly. Estimated maximum propeller wash velocities at the bed within Spit Marina for typical marina craft and water depths are summarised below in **Table 5.5**

The estimated propeller velocities at the bed are varied, depending on boat type and rudder configuration. A 14 m power boat starting from rest in a water depth of 5 m is expected to generate a localised current at the bed up to between 0.3 and 0.9 m/s. These peak velocities would more than halve for a 25 m vessel in 15 m of water.

Current Loads on Marina

Current loads are significantly smaller than wave loads. For sustained currents of say 1 m/s, current loads on the existing floating marina would not exceed 0.5 kN/m, an order of magnitude less than the design wave loads (**Section 5.4.1**). With berthed vessels included, larger current loads would be applied, but not exceeding the design wave loads.

5.5.2 Impacts, Mitigation and Management

Conventional concrete encased floating marina systems with its piling restraint would readily withstand the current loads on the marina, to be accounted for in the detailed design.

TABLE 5.5 ESTIMATED PROPELLER WASH VELOCITIES (1)

Vessel	*Assumptions* Installed Engine Power (1) (kW)	*Assumptions* Propeller Diameter (m)	Water Depth (m)	Maximum Velocities at Bed (m/s) (2)
14 m Power boat	*340*	*0.5*	5	0.3 – 0.9
			10	0.1 – 0.4
25 m Power boat	*600*	*0.75*	5	0.4 – 1.1
			10	0.2 – 0.6
			15	0.1 – 0.4

Notes (1) Installed engine power per drive
(2) Vessels starting from rest

Source Methodology from PIANC (1987)

5.6 EXISTING SEDIMENT TRANSPORT REGIME AND PERTURBATIONS

5.6.1 Existing Environment

Sediments at the site are expected to comprise sands and sandy muds. Mobile flood tide sand shoals do not occur. These are located further downstream. Regional transport processes would be dominated by suspended muds at times of wet weather.

Water velocities greater than approximately 0.3 m/s would be sufficient to mobilise the bed sediments in the marina. Such velocities are likely to occur on a daily basis due to tide. Existing propeller wash may also contribute, particularly in shallower areas with larger craft. Regional freshwater flows *(<0.1 m/s)* and wind induced currents *(<0.2 /s)* would be insufficient to mobilise sediments.

We note that there are no existing issues at Spit Marina with accumulation of sediments at the berths, and there is no history of dredging.

We understand from d'Albora Marinas that wave protection provided by the existing wave attenuator at C-Arm may assist to retain sand along the beach immediately south of the marina buildings. While this may be the case, GBAC would expect that the existing berthed craft on A, B and C-Arms would themselves act as floating breakwaters, providing significant additional protection to this shoreline.

5.6.2 Impacts, Mitigation and Management

The upgrade proposal would have no influence on existing sediment distribution or movement patterns. As the upgraded facility comprises both floating and suspended structures, no changes would occur to existing tidal and fluvial circulation patterns.

Except for the fairway inshore of A-Arm, Spit Marina enjoys good water depths. There is no history of dredging at the marina, and since sedimentation patterns would not be affected, there is no suggestion of a requirement for future dredging.

This appraisal is consistent with a finding reported in GHD (1990). As part of their landuse management plan for The Spit, GHD identified the waterway immediately to the north of Spit Marina *(in the vicinity of existing D and N-Arms)* as suitable for expansion of boating facilities with a cited attribute being "little or no sediment movement" (**Section 3.2.2**).

Accordingly, the general arrangement of boats and pontoons comprising the facility is to remain unchanged. The wave energy which is presently delivered to the shoreline along Spit Reserve, immediately south of the marina buildings, would not be expected to change in any significant way. GBAC is of the opinion that beach condition in, and about, Spit Marina would be unaffected by the proposal.

6 ENVIRONMENTAL ASSESSMENT OF WATER TRANSPORT ISSUES

As a contribution to the overall assessment of marina functionality and safety, GBAC has reviewed water transport in, and about, the marina. The following aspects have been considered:

- Proximity and type of passing boat traffic
- Mooring arrangements
- Channel arrangements
- Vessel motions at berth

6.1 PROXIMITY AND TYPE OF PASSING BOAT TRAFFIC

6.1.1 Existing Environment

Boat traffic navigates the channel under Spit Bridge, passing to the northern side of the marina. This comprises private craft, charter vessels and occasional work boats. Rowing also takes place in and about Pearl Bay.

Vessels berthed within the marina also navigate to and from their berths (**Section 6.2**).

Private Boat Traffic

Many hundreds of commercial and private moorings and berths, and NSW Maritime swing moorings, are located within Middle Harbour. There are also various public boat ramps. Private craft would mainly use the waterway upstream of The Spit for sailing, cruising and fishing. From time to time vessels venture down harbour, past the marina and Spit Bridge. Craft size and type would vary from runabouts *(L~3 m)* to large cruisers and yachts *(L to 30 m)*, and occasional charter vessels *(L to 40 m)*.

Charter Vessels

Captain Cook Cruises and Magistic Cruises currently operate sightseeing and coffee cruises into Middle Harbour, passing upstream of Spit Bridge. MV Captain Cook III operates once a day from Circular Quay (**Photo A**). She measures 37 m in length and draws 400 tonnes. Magistic 2 is a luxury catamaran 35 m long, 9 m in the beam and 14 m high. She displaces 105 tonnes. Magistic 2 operates twice daily from Circular Quay (**Photo B**). Both vessels can pass under Spit Bridge without it lifting. These vessels are the largest that presently pass the marina.

Until recently Sydney Ferries operated its Lady Class vessels on a daily cruise into Middle Harbour passing the Spit. This service, which required the bridge to open, was curtailed in 2007, at about the same time that the bridge opening times were reviewed *(see below)*.

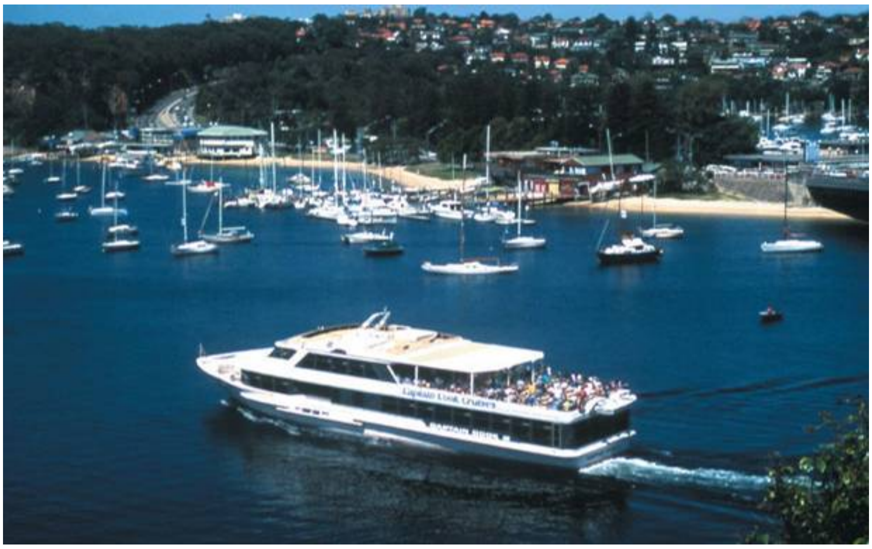

Photo A – MV Captain Cook III passes the marina once a day.

Photo B – Magistic 2 passes the marina twice a day (Source: SKM 2006)

Rowing

The Mosman Rowing Club is based in Pearl Bay. The Club serves as a rowing centre for some 450 rowers, including elite, seniors, juniors, masters, recreational and school rowers. The boatshed houses over 100 rowing craft.

A 50 m wide fairway aligned WNW links the boatshed to the main waterways of Middle Harbour. The designated rowing course from the boatshed passes along this fairway. The fairway is free of swing moorings. The northern edge of the fairway *(or potential northern limit of the rowing course)* is 170 m from the south-west corner of the marina. The rowing course and fairway through Pearl Bay in relation to Spit Marina is shown in **Figure 4**.

Rowing takes place year round. During the week, rowing mainly occurs in the early morning *(before say 9.00 am)* and later in the afternoons *(after 4.00 pm)*. Training may commence before light, however no rowing is permitted from the Mosman shed without correct lighting *(a white light on the bow visible at least 270 degrees and a white light on the stern)*.

In 1999 Mosman Rowing Club supported the proposal by Spit Marina to berth four 32 m vessels alongside the outer edge of C-Arm. The proposal included relinquishing six of the marina's commercial swing moorings in Pearl Bay, enabling the then Waterways Authority to reinstate the rowing fairway which had been a safety concern for the Club (**Section 3.2.1**).

Mosman Rowing Club is progressively upgrading its facilities in Pearl Bay. A new boatshed was completed in March 2009 and installation of the Club's second pontoon was completed in October 2009. Refurbishment of the existing boatshed remains an important objective for the Club, but would need to be staged to match availability of funds. The immediate need is an upgrade of the boat racking system in the old boatshed *(2009 Annual Report MRC)*.

Spit Bridge Opening and Navigation

Spit Bridge is a constraint on navigation of yachts and on very few occasions, also large cruisers. These vessels are required to time their passage to coincide with scheduled openings of the bridge. Boating charts indicate that the Spit Bridge lift span clears 5.1 m when closed. The fixed span immediately to the north clears 6.4 m, and it is this span that is used for passage of charter vessels *(see above)*.

The RTA has recently amended the opening times for Spit Bridge. The current schedule is given in **Table 6.1**

TABLE 6.1 SPIT BRIDGE OPENING TIMES

Monday to Friday	Weekend and Public Holidays
10.15 am	8.30 am
11.15 am	10.00 am
	11.30 am
1.15 pm	2.30 pm
2.15 pm	4.30 pm
8.15 pm	6.30 pm
9.15 pm (daylight saving only)	8.30 pm
	9.30 pm

Source RTA web site *(12/5/10)*

Mustering of boats occurs immediately prior to bridge opening. We understand from the RTA Bridge Operator that the largest assembly of craft headed downstream currently occurs at the 11.30 am opening on Sundays when, during a typical summers day, between 15 and 25 vessels congregate and make passage. These vessels do not cut engines, but muster under power, usually within 100 to 200 m of the bridge. Vessels at the head of the queue may encroach as close to 10 m or less from the bridge. Mustering vessels are observed to pass even closer to the swing moorings on the northern side of the channel.

Mr Gary Blumberg inspected the 11.30 am bridge opening on Sunday 17 February 2008. Details of this inspection and data for the same time slot over weekends and public holidays for January 2008, are provided in **Section 4.4**.

Peak usage days occur on New Years Eve and Australia Day when as many as 40 vessels may assemble for an opening; however the RTA Bridge Operator has stressed that these are “one off” occasions. Outside of the boating season and during the weeks, vessel passings at bridge opening times are substantially lower. We understand that there have been even successive days during winter when no scheduled bridge openings have needed to take place because no vessels have been waiting.

The bridge opening protocol is to permit those craft headed downstream to pass through the open span first, followed by the craft headed upstream. This is done because there seems to be less congestion on the downstream side of the bridge and the mustering craft here tend to be better organised *(Mr Roger Lagoas, Spit Bridge Operator RTA, 15/2/08 pers comm)*.

As part of the REF prepared to develop the current bridge opening schedule, SKM (2006) undertook a survey of vessel movements over three weekends in May 2006 *(8.00 am to 8.00 pm)*. Key findings documented in the REF were:

- peak demand for using bridge openings occurs both at 11.30 am and 4.00 pm, with an average of 10 to 14 boats using the crossing over the weekend at these times;
- on average, Sunday volumes were 50% higher than on Saturdays;
- approximately 90% of vessels observed on each day were able to pass under the bridge without the lift-section open;
- log-books identified the busiest 4-week period as occurring in February / March, with volumes in this period approximately 50% higher than the surveyed period *(May)*;
- on public holidays, boat traffic was 40% higher than on a typical weekend day;
- approximately 91% of vessels requiring the bridge opening are observed to be tall-masted yachts.

At times when the bridge is not open, boat traffic mostly passes the marina on the northern side of the main channel. This is done to access the northern span of Spit Bridge with its greater height clearance. Having regard to the channel position and desirable navigation lines, GBAC would expect through traffic using the northern span to pass no less than 80 m from the existing NW corner of the marina *(C-Arm)*. For most cruisers that can navigate the lift span when not open, and yachts that can only pass when it is open, their predominant navigation lines may be slightly closer, probably not less than 70 m.

Small boats *(10 m typical)* accessing the swing moorings in Pearl Bay would need to skirt the marina, passing closer by. Based on discussions with the Marina Operations Manager, we understand that such vessels may encroach to within about 30 m of the NW corner. Sailing craft tend to keep a greater distance-off than power craft *(Mr Clemens Overdjik, D'Albora Marinas, 20/12/07 pers comm)*.

The waterway between Beauty Point and Spit Bridge is a No Wash Zone. Here boats are required to travel at speeds which create minimal wash. A speed limit does not apply.

The existing operational arrangements for vessel passings on the northern side of Spit Marina are summarised in **Figure 5**.

6.1.2 Impacts, Mitigation and Management

Charter and Private Boat Traffic

Charter cruisers are the largest vessels to pass the marina. These navigate the channel, maintaining at least 75 m from the marina berths. The minimum passing distance occurs off the NW corner of C-Arm. Other craft would pass closer to this corner, particularly those accessing the swing moorings in Pearl Bay as well as vessels transiting to and from Spit Marina.

The NW corner of the marina is to be extended 9 m to the north. A new 30 m berth is located on the northern side of the T-head (**Figure 2**). From our observations, berthing of large vessels *(say 20 to 30 m)* currently takes place on the northern side of the pontoon L-head at the NW corner of C-Arm (**Photo A29**). Thus, the change in position of berthed craft at this location would be limited to the 9 m extension *(the width of the existing and proposed vessels assumed unchanged).* The existing channel width between the northern-most vessel on C-Arm and the closest swing mooring directly across the channel at Seaforth is measured at 130 m. The proposal has this distance reducing to 120 m, a reduction of 7%.

From the NW berthing pile at the existing double 30 m berth on N-Arm, the proposed floating L-head at the NW corner of N-Arm Outer would be located 32 m further to the north. The proposal incorporates a 21 m berth on the outside of the L-head. Accounting for the existing and proposed berthed vessels, we measure their effective northward extension associated with the proposal as 25 m. The existing channel width between existing berthed vessels at N-Arm and the closest swing mooring directly across the channel at Seaforth is measured at 160 m. The proposal has this distance reducing to 130 m, a reduction of 19%.

The proposed reconfiguration of D-Arm has the existing critical berthed vessel which is located on the existing L-head, relocated to the temporary berth on the outside of the proposed fuel / pumpout pontoon. The existing channel width between the critical berthed vessel on the L-head and the closest swing mooring directly across the channel at Seaforth is measured at 160 m. The proposal has this distance reducing to 140 m, a reduction of 13%.

In respect of impacts on through navigation, GBAC would consider these to be modest and manageable, for the following reasons:

(i) **Vessels which navigate the main channel** upstream of Spit Bridge would not need to deviate from their present tracks, currently located 70 to 80 m from the NW corner of C-Arm.

(ii) **Vessels which skirt the NW corner of C-Arm**, to access swing moorings in Pearl Bay or circumnavigate the marina to enter the fairways on its southern side, would obviously need to pass some 9 m to the north of where they presently pass. Downstream of this point, these vessels would track directly to or from the channel and bridge and no further influence would be expected from the reconfigured berths at N and D-Arms.

The direct sailing line has these vessels passing the proposed extended berths at N and D-Arms by no less than 40 m. This is 10 m in excess of the safe minimum passing distance for persons, objects or moored craft, reported by NSW Maritime for passing speeds of 10 knots or more *(NSW Maritime, 2008).*

(iii) **Mustering of vessels headed downstream during bridge openings** would be expected to accommodate the reconfigured berths without due difficulty. While there may, at present, be congestion once or twice a week during the summer months and during public holidays, the changed configuration on the northern side of Spit Marina should be manageable and we do not believe would significantly impact on navigation hazard within the mustering period or bridge opening times.

From our discussions with the RTA Spit Bridge Operator and our observation of the bridge lift on 17 February 2008 (**Section 4.4**), it would appear that up to 13 vessels currently assemble downstream of the NW corner of C-Arm immediately prior to a bridge opening. If more vessels are needing to make the passage, these overflow upstream into the adjoining channel and side bays. Based on the available waterway area downstream on C-Arm and making allowances for observed clearances to structures, swings moorings and berthed craft, we calculate that typical yachts using the passage occupy a muster area of between 2,500 and 3,000 m^2 per vessel *(28 to 30 m effective clear radius)*. The reconfigured berths, including their berthed craft, are assessed to effectively occupy a total additional 3,000 m^2 from the waterway on the northern side of the marina. This 3,000 m^2 would otherwise be available to mustering craft. The impact therefore would be that instead of 13 vessels assembling downstream of C-Arm immediately prior to an opening as is presently the case, this would be expected reduce to 12 vessels.

The duration for 13 vessels to pass through the bridge from the time that the Operator signals green for the downstream headed fleet would typically be between 3 and 4 minutes, substantially in excess of the time for a boat to safely manoeuvre from the corner of C-Arm to the bridge. It follows that the bottleneck at the lift span would be controlled by the normal safe manoeuvring of vessels as they approach and pass through the opening, rather than the time taken to travel from C-Arm to the bridge.

The observation made by the RTA Bridge Operator and recent findings presented by the RTA should also be acknowledged.

The Bridge Operator has expressed his view that an impact on vessel mustering and navigation through the open bridge should not occur so long as the rearranged berthed vessels on the marina did not encroach across a line extending from the southern shoreline at the bridge opening, at right angles away from the bridge *(Warren, RTA Bridge Operator 17/2/08 pers comm.)*. This is achieved with the proposal as demonstrated in **Figure 3**.

In their assessment of the impact of reduced bridge opening times on navigation undertaken in support of the recent revised schedule implemented by the RTA, SKM (2006) reported as follows:

> "One of the concerns raised during the 2003 community consultation was that the space available for boats whilst waiting for passage is limited. There is a concern that an increase in the number of boats using each opening would reduce safety due to the lack of space for vessels waiting for passage. However, it is expected that the increase in number of boats waiting at the peak passage times would not increase to the extent to make navigation through the opening unsafe. There is likely to be a degree of excess capacity at these collecting points to accommodate any moderate increase in vessels. Also, the additional vessels are likely to be spread throughout the new opening times and generally use under utilised times.
>
> It should be noted that the bridge remains open until all vessels congregating for the passage have made the crossing. Therefore, contrary to some concerns raised, no vessel would be 'locked in' or 'locked out' of the harbour during each bridge opening."

Spit Marina has always operated under the constraint of the Spit Bridge and its opening times and this is set to continue for the foreseeable future. There is no suggestion that the upgraded marina facility would prompt any immediate or future change in the bridge opening arrangements.

Rowing

The proposed marina upgrade does not encroach at all on the rowing course and fairway. The existing minimum separation of 170 m is preserved. The berthed vessels that currently access the marina from the south would continue to do so as per the existing arrangements. At present there are over 50 swing moorings located between the marina and the rowing fairway. No change is proposed to this arrangement. The presence of the swing moorings serves as a major obstacle to any vessels entering or leaving the marina, and there is no benefit whatsoever for marina craft to choose to navigate through the swing moorings and congest the waters of the rowing fairway.

The upgrade proposal would have no influence on rowing operations within the rowing fairway or elsewhere in Pearl Bay.

6.2 MOORING ARRANGEMENTS

6.2.1 Existing Environment

Marina Berths

The existing marina comprises 165 wet berths. These are mainly permanent berths, with the berth customer billed on a three monthly basis. Approximately 40 of the 165 berthed craft are owned by business tenants located at the marina. These vessels are rarely moved. The remaining 125 vessels belong to retail customers. On an average summer weekend day, approximately 20 of the 125 craft may be moved or used. This number reduces to less than five during the week. In winter the general usage falls by more than 50%.

There are no visitor berths at the marina; however reciprocal berthing rights between the seven separate d'Albora operations permit occasional casual berthing by outside vessels, subject to availability. We understand that Spit Marina receives up to 10 boats from other d'Albora marinas in summer. In winter, space in the marina is at a premium with reciprocal berthing normally involving no more than a few vessels *(Mr Clemens Overdjik, d'Albora Marinas, 20/12/07 pers comm)*.

Because vessels are coming and going, the marina is never 100% occupied. Average occupancies range between 95% in winter and 98% in summer.

The existing fuel / sewage pumpout berth is a public facility, available to any vessel.

The berths at Spit Marina are almost totally occupied by motorised vessels, although yachts are not discouraged. d'Albora Marinas has advised existing berth lengths and numbers for the marina, listed in **Table 6.2**. The longest vessel currently on the marina is 35 m, located on the L-head at the south end of Arm-C.

GBAC has measured the existing berth widths from the November 2007 Harvey Hydrographic Survey, and compared these with minimum berth widths as required by AS 3962 (**Table 6.3**). Our assessment would be that the designated existing berth lengths shown in **Table 6.2** comply with the minimum berth widths as required by AS 3962 except for minor breaches at C-Arm Inner and A-Arm, Inner and Outer. We also note that the existing multiple berthing arrangement at A-Arm Inner is not endorsed under AS 3962. Our assessment of compliance of existing berth widths at Spit Marina is summarised below in **Table 6.3**.

TABLE 6.2 EXISTING BERTH LENGTHS AT SPIT MARINA

Location			Berth Length (m)	Number of Vessels
A-Arm	Inner		8	43
	Outer		10	28
	T-Head S		10	1
B-Arm	Inner		11	25
	T-Head S		11	1
	Outer		12	19
	T-Head S		12	1
C-Arm	Inner		15	28
	Outer	Alongside berthing	32	8
	L-Head (S)		35	1
	L-Head (N)		35	1
N-Arm			30	2
			20	3
D-Arm			15	4
			Total	**165**

Notes (1) According to AS 3962, berth length is taken to be the same as boat length

Existing berth depths at Spit Marina may be characterised in terms of bed level at the berths. The Harvey Hydrographic Survey shows bed levels at the berths ranging from approximately RL -2.2 to RL -18.0. The average bed level at the berths is assessed to be RL -9.3. Further information on water depth is given in **Section 5.2**.

Spit Marina's standard roping system requires between four and six ropes to tie each vessel into its berth. A bow line, springer line and two stern lines are always used. A heavy weather springer may be required depending on wind direction, and as is often the case for large vessels with a widely splayed bow, a stern-to-shoulder springer may be used to hold the boat's opposite gunwale. Roping is a documented OH&S procedure at Spit Marina, set up and checked three times per year *(Mr Clemens Overdjik, d'Albora Marinas, 20/12/07, pers comm).*

The type of boat mostly using the marina is changing, from flybridges to sports cruisers. The existing average length is 12 to 15 m which d'Albora Marinas believes should not change going forward.

TABLE 6.3 EXISTING BERTH WIDTHS AT SPIT MARINA

Location		Berth Lengths (m)	Single / Double Berths	Berth Widths		Full Compliance with AS 3962 ?
				Existing [1]	AS 3962 Minimum	
A-Arm	Inner	8	NA [2]	3.0	NA [2]	✗
			D	5.5 – 8.2	7.8	✗
	Outer	10	D	8.8 – 9.8	9.0	✗
B-Arm	Inner	11	D	10.1 – 10.3	9.6	✓
	Outer	12	D	10.5 – 13.7	9.8	✓
C-Arm	Inner	15	D	10.1 – 10.7	11.0	✗
	Outer	32	A [3]	42.6	38.0	✓
N-Arm	*20 m*	20	D	15.9	12.4	✓
	30 m	30	D	22.2	16.5	✓
D-Arm	*15 m*	15	D	11.2	11.0	✓

Notes
(1) Measurements from Harvey Hydrographic Survey November 2007.
(2) Unconventional multiple berths incorporating tie-off struts linking the vessel stern back to the floating walkway. This form of berthing is not endorsed by AS 3962.
(3) Alongside berths covered by AS 3962.

Sydney Boat Share *(SBS)* is a growing business operated at Spit Marina. Currently 12 investors with vessels in the 12 to 17 m range participate in the scheme. This involves boat drivers, provided by the marina, being used to get vessels in and out of berths. We understand that the berths available for SBS at the marina are very limited, and currently up to an additional four vessels could be accommodated. d'Albora Marinas believe that the operation of Sydney Boat Share with its experienced drivers reduces the risk of damage to vessels at the marina *(Messers Clemens Overdjik and Bill Loader, d'Albora Marinas, 20/12/07, pers comm).*

Swing Moorings

According to NSW Maritime's mooring plan for Pearl Bay, 54 swing moorings are located between the rowing fairway in front of Mosman Rowing Club, and Spit Marina. These moorings occupy an area which extends 200 m along the shoreline of Spit Reserve and 380 m into the waterway.

Of the 54 swing moorings, Spit Marina commercially operates 16. The marina operates a further 44 swing moorings in Quakers Hat Bay.

The marina operates a tender service to its moorings in Quakers Hat Bay and Pearl Bay. This runs 7 days a week between 8.30 am and 6.00 pm, except for Thursday to Sunday in summer when the service runs from 8.00 am to 8.00 pm. In winter the service stops at 5.00 pm.

6.2.2 Impacts, Mitigation and Management

The proposed reconfigured berthing arrangement for Spit Marina is presented in **Figure 2**. The spatial arrangements for the proposed berths are summarised below in **Table 6.4** and **Table 6.5**. We sum the total number of berths as shown on the current Corben architectural layout (**Figure 2**) as 200 permanent berths, plus the services berth and the boat lift bay.

While we note some non-compliances with the existing berth widths at Spit Marina (**Table 6.3**), regularisation with AS 3962 is fully achieved with the proposed arrangement (**Table 6.5**). This assessment covers berthing of both power boats and yachts.

The proposal involves the conversion of the existing 25 single "tie-off strut" 8 m berths on A-Arm Inner, to conventional double 8 m berths. This existing type of berthing is not endorsed by AS 3962, and the conversion of these to conventional double berths would be regarded as beneficial for berthing function and safety at Spit Marina.

The boat lift bay would be exposed to some wave action, addressed in **Section 5.4.2**. Westerly winds may cause difficulties at the boat lift; however GBAC agrees with d'Albora Marinas that operating sympathetically with the ambient tidal currents would be more important for this type of facility at this location. Spring ebb tidal currents are predicted to exceed 0.2 m/s some 4% of the time, whereas winds 17 knot or greater from the SW through W occur on average in Sydney approximately 3 % of the time. From the perspective of operational safety and feasibility, we note that Fergusons Boatshed, just downstream of Spit Bridge, successfully operates a boat lift *(35 t capacity)* and we see no reason why a comparable facility could not be successfully operated at Spit Marina as proposed.

TABLE 6.4 PROPOSED BERTH LENGTHS AT SPIT MARINA [1]

Location		Berth Length (m)	Number of Vessels
A-Arm	Inner	8	35
	Outer	10	32
	T-Head S	22	1
B-Arm	Inner	11	29
	Outer	12	28
	T-Head S	27	1
C-Arm	Inner	15	28
	Outer	25	22
	T-Head N	35	1
	T-Head S	35	1
N-Arm	Outer	11	8
	L-Head N	21	1
	Inner	30	2
		25	3
D-Arm		12	7
		8	1
Total Permanent Berths			**200**
D-Arm	Services berth	Up to 30	1

Notes (1) Derived from Corben Architects layout (**Figure 2**)
(2) According to AS 3962, berth length is taken to be the same as boat length

An assessment of water depths at the proposed berths is presented in **Table 6.6**. AS 3962 recommends a maximum bed level at each berth equal to the sum of the following, measured below Lowest Astronomical Tide *(RL 0 m ZFDTG)*:

(i) half the significant wave height for vessel movements resulting from wind generated waves and boat wake;

(ii) an appropriate allowance for siltation *(adopted as 300 mm in this environmental assessment)*; and

TABLE 6.5 PROPOSED BERTH WIDTHS AT SPIT MARINA

Location		Number of Vessels	Berth Length (m)	Single / Double Berth	Berth Widths		Compliance with AS 3962 ?
					Proposed [1]	AS 3962 Minimum	
A-Arm	Inner	1	8	S	>6.0	4.4	✓
		34	8	D	7.8	7.8	✓
	Outer	32	10	D	9.0	9.0	✓
	T-Head S	1	22	S	>7.4	7.4	✓
B-Arm	Inner	28	11	D	9.6	9.6	✓
		1	11	S	5.6 [2]	5.3	✓
	Outer	28	12	D	9.8	9.8	✓
	T-Head S	1	27	S	>8.5	8.5	✓
C-Arm	Inner	26	15	D	11.0	11.0	✓
		2	15	S	>5.4	6.0	✓
	Outer	22	25	D	14.5	14.5	✓
	T-Head N	1	35	S	>10.2	10.2	✓
	T-Head S	1	35	S	>10.2	10.2	✓
N-Arm	Inner	2	30	S	9.0	9.0	✓
		1	25	S	7.9	8.0	✓
		2	25	D	14.4	14.5	✓
	Outer	8	11	D	11.0	9.6	✓
	L-Head N	1	21	S	>7.3	7.3	✓
D-Arm		7	12	D	9.8	9.8	✓
		1	8	D [3]	9.8	9.8	✓
Total Permanent Berths		**200**					
D-Arm	Services	1	Up to 30	S	>9.0	9.0	✓

Notes
(1) Derived from Corben Architects layout (**Figure 2**)
(2) Splayed planform
(3) This double berth accommodates 1x8 m and 1x12 m vessels

(iii) a minimum under keel clearance of 300 mm or 10% of the vessel draft, whichever is the greater, where the bed consists of soft material *(as is the case at Spit Marina)*.

Bed depth regularisation with AS 3962 is achieved with the proposed berthing arrangement. While water depths limit the effective fairway width inshore of A-Arm, GBAC recommends that the proposed fairway arrangement here be accepted on the basis of restricted use, namely:

(i) that only power craft to 8 m in length be permitted to access the fairway; and

(ii) all berthing is stern-in to the A-Arm Inner berths.

According to AS 3962, the fairway width should not be less than 1.5 x the maximum boat length that would use the fairway. Also consideration must be given to the available water depth in the fairway. The required depth should be determined as for the berths *(refer above)*, except that allowance for waves and the rate of siltation may be lower. According to the code, it is preferable that all vessels berthed along A-Arm Inner can access the fairway at all states of the tide, however it is permissible for water depth to be reduced where “economics dictate”.

Our assessment of the fairway inshore of A-Arm shows that, over the 160 m length of this fairway, 75% of the minimum fairway area *(75% x 160 m x 12 m = 1,440 m^2)* exceeds the recommended minimum bed level of RL -1.23 m ZFDTG for power craft (**Table 6.6**). The inshore edge of the fairway is consistently shallowest, hence restricting the berthing to stern-in limits the opportunity for propellers to encroach into the shallower water thereby minimising potential stirring of bed sediments. Note that the location of A-Arm is not to be changed between the existing and proposed marina arrangements. Furthermore, Spit Marina has operated 8 m vessels to the A-Arm Inner berths for decades without incidents of vessel machinery damage or visible bed sediment plumes that have prompted complaints.

While the fairway depth may be relatively shallow inshore of A-Arm, the separation between the A-Arm Inner berths and the seawall ranges between 21 and 25 m, well in excess of the minimum 12 m required by the code.

As a final point, it should be acknowledged that the use of this or any fairway by marina vessels is discretionary. It would be reasonable for boat users to slightly delay berth departure or arrival, thereby avoiding vessel movements along the fairway at the bottom of very low tides.

To account for water depth, berth number 193 at the southern end of D-Arm should be restricted to power boats (**Table 6.6**).

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
Fairway between A – Arm and seawall			8	-0.2 to -4.0	0.9	1.5	0.07	0.2 (6)	0.3	-1.23	-1.83	×	×
A-Arm Inner (AI) berths	N end	AI1	8	-5.2	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI2	8	-4.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI3	8	-4.5	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI4	8	-4.5	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI5	8	-5.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI6	8	-5.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI7	8	-5.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI8	8	-5.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI9	8	-5.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI10	8	-4.5	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI11	8	-4.2	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI12	8	-4.1	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI13	8	-4.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI14	8	-3.8	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI15	8	-3.8	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI16	8	-3.9	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI17	8	-3.9	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI18	8	-3.5	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI19	8	-3.2	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI20	8	-2.9	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI21	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI22	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI23	8	-2.9	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI24	8	-2.9	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
		AI25	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI26	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI27	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI28	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI29	8	-2.8	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI30	8	-2.9	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI31	8	-3.0	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI32	8	-4.5	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI33	8	-4.5	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
		AI34	8	-4.4	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
	S end	AI35	8	-4.4	0.9	1.5	0.07	0.3	0.3	-1.57	-2.17	✓	✓
A-Arm T-head South (ATS) berth		ATS36	22	-5.0	1.7	2.9	0.20	0.3	0.3	-2.50	-3.70	✓	✓
A-Arm Outer (AO) berths	S end	AO37	10	-5.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO38	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO39	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO40	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO41	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO42	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO43	10	-5.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO44	10	-5.7	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO45	10	-5.7	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO46	10	-5.7	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO47	10	-5.7	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
		AO48	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO49	10	-5.8	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO50	10	-5.7	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO51	10	-5.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO52	10	-5.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO53	10	-5.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO54	10	-5.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO55	10	-5.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO56	10	-5.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO57	10	-5.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO58	10	-5.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO59	10	-5.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO60	10	-6.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO61	10	-6.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO62	10	-6.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO63	10	-6.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO64	10	-6.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO65	10	-6.3	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO66	10	-6.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO67	10	-6.6	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
		AO68	10	-6.5	1.0	1.8	0.10	0.3	0.3	-1.70	-2.50	✓	✓
Fairway between A and B Arms			11	-5.7 *(max)*	0.9	1.5	0.10	0.2	0.3	-1.26	-1.86	✓	✓
B-Arm Inner (BI) berths	N end	BI69	11	-9.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
		BI70	11	-10.0	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
		BI71	11	-10.2	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location	Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
				Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
	BI72	11	-10.3	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI73	11	-10.3	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI74	11	-10.1	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI75	11	-9.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI76	11	-10.2	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI77	11	-10.1	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI78	11	-10.2	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI79	11	-10.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI80	11	-10.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI81	11	-10.6	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI82	11	-10.6	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI83	11	-10.6	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI84	11	-10.6	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI85	11	-10.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI86	11	-10.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI87	11	-10.1	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI88	11	-10.0	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI89	11	-10.0	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI90	11	-10.0	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI91	11	-9.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI92	11	-9.5	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI93	11	-9.3	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI94	11	-10.0	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI95	11	-9.4	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
	BI96	11	-8.4	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓
S end	BI97	11	-8.4	1.0	1.9	0.10	0.3	0.3	-1.70	-2.60	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
B-Arm T-head South (BTS) berth		BTS98	27	-8.0	1.9	3.1	0.23	0.3	0.3	-2.74	-3.94	✓	✓
B-Arm Outer (BO) berths	S end	BO99	12	-11.5	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO100	12	-12.7	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO101	12	-12.8	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO102	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO103	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO104	12	-12.2	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO105	12	-12.2	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO106	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO107	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO108	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO109	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO110	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO111	12	-12.1	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO112	12	-12.1	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO113	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO114	12	-12.0	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO115	12	-11.6	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO116	12	-11.6	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO117	12	-11.5	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO118	12	-11.5	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO119	12	-11.7	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO120	12	-11.7	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO121	12	-11.1	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO122	12	-11.3	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
		BO123	12	-11.6	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO124	12	-11.5	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
		BO125	12	-11.4	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
	N end	BO126	12	-11.2	1.0	2.0	0.15	0.3	0.3	-1.75	-2.75	✓	✓
Fairway between B and C Arms			15	-11.6 *(max)*	1.0	1.9	0.15	0.2	0.3	-1.61	-2.91	✓	✓
C-Arm Inner (CI) berths	N end	CI127	12	-11.1	1.0	2.0	0.15	0.3	0.3	-1.75	-2.65	✓	✓
		CI128	15	-11.4	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI129	15	-11.8	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI130	15	-12.2	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI131	15	-12.3	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI132	15	-12.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI133	15	-12.6	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI134	15	-13.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI135	15	-13.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI136	15	-13.6	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI137	15	-14.0	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI138	15	-14.0	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI139	15	-14.1	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI140	15	-14.2	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI141	15	-14.4	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI142	15	-14.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI143	15	-14.8	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
		CI144	15	-15.0	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI145	15	-15.1	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI146	15	-15.1	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI147	15	-15.4	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI148	15	-15.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI149	15	-15.3	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI150	15	-15.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI151	15	-15.5	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI152	15	-15.8	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
		CI153	15	-16.0	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
	S end	CI154	15	-16.0	1.2	2.5	0.15	0.3	0.3	-1.95	-3.25	✓	✓
C-Arm T-head South (CTS) berth		CTS155	35	-16.2	1.7	2.9	0.29	0.3	0.3	-2.59	-3.79	✓	✓
C-Arm Outer (CO) berths	S end	CO156	25	-18.2	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO157	25	-17.9	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO158	25	-17.8	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO159	25	-17.5	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO160	25	-17.2	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO161	25	-16.8	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO162	25	-16.8	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO163	25	-16.0	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO164	25	-15.7	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) [1]	Design Draft (m) [2]		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) [5]		Complies with AS 3962 ?	
					Power	Yacht	Waves [3]	Siltation	Under Keel Clearance [4]	Power	Yacht	Power	Yacht
		CO165	25	-15.5	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO166	25	-15.0	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO167	25	-14.9	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO168	25	-14.2	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO169	25	-14.1	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO170	25	-13.9	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO171	25	-13.7	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO172	25	-13.2	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO173	25	-13.0	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO174	25	-12.8	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		CO175	25	-12.6	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
		COI76	25	-12.0	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
	N end	COI77	25	-11.7	1.8	3.0	0.29	0.3	0.3	-2.69	-3.89	✓	✓
C-Arm T-head North (CTN) berth		CTN178	30	-10.9	2.2	3.5	0.29	0.3	0.35	-3.14	-4.44	✓	✓
Fairway between N-Arm Outer and C-Arm			15	-10.1 *(max)*	1.2	2.5	0.20	0.2	0.3	-1.76	-3.06	✓	✓
N-Arm L-head North (NLN) berth		NO179	21	-9.5	1.6	2.9	0.25	0.3	0.3	-2.45	-3.75	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) [1]	Design Draft (m) [2]		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) [5]		Complies with AS 3962 ?	
					Power	Yacht	Waves [3]	Siltation	Under Keel Clearance [4]	Power	Yacht	Power	Yacht
N-Arm Outer (NO) berths	N end	NO180	11	-9.5	1.0	1.9	0.24	0.3	0.3	-1.84	-2.74	✓	✓
		NO181	11	-9.6	1.0	1.9	0.24	0.3	0.3	-1.84	-2.74	✓	✓
		NO182	11	-9.7	1.0	1.9	0.23	0.3	0.3	-1.83	-2.73	✓	✓
		NO183	11	-9.8	1.0	1.9	0.23	0.3	0.3	-1.83	-2.73	✓	✓
		NO184	11	-10.0	1.0	1.9	0.20	0.3	0.3	-1.80	-2.70	✓	✓
		NO185	11	-10.1	1.0	1.9	0.18	0.3	0.3	-1.78	-2.68	✓	✓
		NO186	11	-10.2	1.0	1.9	0.15	0.3	0.3	-1.75	-2.65	✓	✓
	S end	NO187	11	-10.1	1.0	1.9	0.13	0.3	0.3	-1.73	-2.63	✓	✓
N-Arm Inner (NI) berths		NI188	30	-9.2	2.2	3.5	0.18	0.3	0.35	-2.98	-4.28	✓	✓
		NI189	30	-8.3	2.2	3.5	0.20	0.3	0.35	-3.00	-4.30	✓	✓
		NI190	24	-7.4	1.8	3.0	0.20	0.3	0.3	-2.60	-3.80	✓	✓
		NI191	25	-4.7	1.8	3.0	0.18	0.3	0.3	-2.58	-3.78	✓	✓
		NI192	25	-4.7	1.8	3.0	0.18	0.3	0.3	-2.58	-3.78	✓	✓
Fairway /manoeuvring area between N-Arm Inner and D-Arm			30	-6.1 *(max)*	2.2	3.5	0.20	0.2	0.35	-2.81	-4.11	✓	✓
D-Arm (D) berths	S end	D193	8	-2.2	0.9	1.5	0.18	0.3	0.3	-1.68	-2.28	✓	✗
		D194	12	-2.8	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓
		D195	12	-5.0	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓
		D196	12	-5.2	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓

continued

TABLE 6.6 SUMMARY ASSESSMENT OF CHANNEL AND BERTH WATER DEPTHS AT PROPOSED MARINA (continued)

Location		Berth Code	Berth Length (m)	Existing Bed Level (m ZFDTG) (1)	Design Draft (m) (2)		Design Allowances (m)			AS 3962 Maximum Bed Level (m ZFDTG) (5)		Complies with AS 3962 ?	
					Power	Yacht	Waves (3)	Siltation	Under Keel Clearance (4)	Power	Yacht	Power	Yacht
		D197	12	-5.3	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓
		D198	12	-5.3	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓
		D199	12	-5.1	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓
	N end	D200	12	-5.2	1.0	2.0	0.18	0.3	0.3	-1.78	-2.78	✓	✓
Services Berth			Up to 30	-6.0	1.8	3.0	0.25	0.3	0.3	-2.65	-3.85	✓	✓
Boat Lift Cradle			18	-3.7	1.4	2.7	0.23	0.3	0.3	-2.23	-3.53	✓	✓

Notes

(1) Assessment of controlling bed level based on Harvey 2007 hydrographic survey.

(2) Design vessel draft from AS 3962-2001.

(3) Design wave amplitude allowed inside marina, having regard to assessment in **Section 5.4**. GBAC considers it reasonable to adopt 1 yr ARI wave condition given that water level and wave climate are independent parameters. Incident wave height has regard to combination of feasible boat waves and wind waves.

(4) As recommended in AS 3962 for a soft bed.

(5) Based on requirements set out in AS 3962 assuming Lowest Astronomical Tide (RL 0) in the berths and MLWS in the fairways and channels (RL 0.36). This recognises that boat owners have some control on when they enter or depart their berths.

(6) AS 3962 permits a lower allowance for siltation in interior channels and fairways.

6.3 CHANNEL ARRANGEMENTS

6.3.1 Existing Environment

Relevant navigation channels may be distinguished outside and inside the marina.

Channels Outside the Marina

The main navigation channel passing upstream of Spit Bridge into Middle Harbour is not marked. Waterway widths and depths are generous and channel markings are not required. As described in **Section 6.1.1**, the observed channel centerline passes some 75 to 80 m from the NW corner of the marina. Boating movements between Pearl Bay and waters downstream of The Spit may encroach to approximately 30 m of the NW corner of the existing marina.

The main marina fairways are accessed from the southern end of the facility. These internal fairways connect to an external “perimeter fairway”, no less than 40 m wide and clear of swing moorings. This serves as the main vessel access to and from Middle Harbour.

Channels Inside the Marina

Three main fairways are located inside the marina; between the seawall and A-Arm, between A and B-Arms, and between B and C-Arms. The existing fairway widths are summarised in **Table 6.7.**

TABLE 6.7 EXISTING FAIRWAY WIDTHS INSIDE SPIT MARINA

Location and Berth Lengths [(1)]	Fairway Widths (m)		Full Compliance with AS 3962 ?
	Existing	AS 3962 Minimum	
Between seawall and A-Arm *(8m)*	20 – 24	20	✓
Between A – Arm *(10 m)* and B-Arm *(11 m)*	15.4 – 16.0	16.5	×
Between B-Arm *(12 m)* and C-Arm *(15 m)*			
- south side of cross over walkway	23.2 – 23.3	22.5	✓
- north side of cross over walkway	28	22.5	✓

Notes (1) Largest berth length controls fairway width requirement.

Except for a minor *(5%)* shortfall between A and B-Arms, the existing fairway widths within the marina comply with the minima required under AS 3962.

6.3.2 Impacts, Mitigation and Management

Fairway widths associated with the reconfigured berthing arrangement at Spit Marina are summarised below in **Table 6.8**.

Subject to a power craft restriction *(no yachts)* and stern-in berthing at A-Arm Inner (**Section 6.2.2**), our assessment indicates that minimum recommended fairway widths as defined in AS 3962 are fully achieved within the proposed marina arrangement.

TABLE 6.8 PROPOSED FAIRWAY WIDTHS INSIDE SPIT MARINA

Location and Berth Lengths [1]	Fairway Widths (m)		Full Compliance with AS 3962 ?
	Proposed	AS 3962 Minimum	
Between seawall and A-Arm *(8 m)*	12 [2]	12	✓
Between A – Arm *(10 m)* and B-arm *(11 m)*	16.5	16.5	✓
Between B-Arm *(12 m)* and C-Arm *(15 m)*			
- south side of cross over walkway	22.75	22.5	✓
- north side of cross over walkway	22.75 min	22.5	✓

Notes (1) Largest berth length controls fairway width requirement.
(2) Subject to power craft restriction and stern-in berthing, as per discussion in **Section 6.2.2**

Vessels moored within NSW Maritime swing mooring areas are not required to be lit at night and it is the responsibility of the masters of other vessels to be aware of the location of such moorings. When navigating near, in or through a mooring area, masters are required to drive slowly and keep wash to a minimum, to keep a lookout for people in the water, small dinghies, and trailing ropes. When travelling at 10 knots or more, vessels must stay at least 30 m from any moored craft *(NSW Maritime, 2008)*.

6.4 VESSEL MOTIONS AT BERTH

Vessels motions at berth would be in response to incident wave action. The wave climate criteria recommended in AS 3962 and examined in **Section 5.4.2** are based on limiting vessel motions to an acceptable level.

The AS 3962 criteria were developed from a comprehensive study carried out by Northwest Hydraulics Consultants Ltd for the Small Craft Harbours Branch, Department of Fisheries and Oceans Canada (NHC, 1980), to review the, then, widely accepted practice for the design of wave protection in small craft harbours which required wave heights within the harbour not to exceed 0.3 m. It was felt that this rule-of thumb did not properly account for the many variables that affect the extent and nature of the distress experienced from waves.

Mercer et al (1982), which presents an overview of NHC (1980), is sourced by AS 3962 in its recommendations for wave climate criteria in small craft harbours.

The NHC (1980) study involved a number of tasks:

- Review of technical literature;
- Visits to marinas and small craft harbours across Canada with discussions with marina operators and engineers concerned with small craft harbours;
- Formal interviews on marina users by a team of environmental psychologists;
- Model tests of vessel response and field verification;
- Response predictions for four categories of hull shape using several simplified analytical methods.

At the onset of the investigations, it was thought that motion limits might involve accelerations and velocities as well as displacements. The affects of accelerations and velocities, however, were difficult to rationalise and NHC determined that most limiting conditions become a function of displacement. While the response of persons to motion do involve accelerations and velocities, NHC found that this response was relatively unimportant to wave distress. Displacements govern the relative position changes between the vessel and the pontoon as well as the elastic mooring rope forces (NHC, 1980).

All factors considered, it was determined that the need for wave restriction inside small craft harbours was a matter of boat response. A large number of variables affect the response of boats and it would be impractical to have the criteria reflect all of these variables. NHC (1980) identified the most important variables as:

- wave direction;
- wave period;
- recurrence of the wave event; and
- degree of protection required.

NHC (1980) and Mercer (1982) provisionally recommended “good” wave climate criteria for all vessels using a marina of nominal length 6 to 12 m, for head seas and beam seas with periods less than 2 s, 2 to 6 s, and greater than 6 s. The design wave events were identified as those exceeded once in fifty years, once a year and once a week. “Excellent” and “moderate” wave criteria were taken to equal the “good” criteria multiplied by factors of 0.75 and 1.25 respectively. This recommendation has been adapted by AS 3962.

Since wave climate compliance is achieved at all berths within the proposed Spit Marina, it follows that vessel motions at berth are acceptable.

7 CONCLUSION

The assessment has involved site inspections, and investigations covering selected hydrological issues and water transport Issues. Information has been collated and reviewed including architecturals, hydrographic surveys and mooring plans. NSW Maritime's engineering standards have been referenced as well as other relevant coastal and maritime engineering design manuals and texts.

Four site inspections were made. These included a joint inspection with the Planning Focus Group, and inspections of spring tidal currents, and boating movements associated with the opening of Spit Bridge. The investigation has covered estuarine morphology, water depths, bed sediments and sediment movement, water levels, waves, and wave and current loading.

The proposal would have no affect on the morphological behaviour of Middle Harbour. It would have no influence on existing water depths, be these within the channel, within the marina precinct, or elsewhere.

High water levels would be accommodated at the floating berths on the condition that pile bending capacities are adequate, and pile cut off levels are suitably elevated. These are standard requirements of NSW Maritime.

Waves impinge on a marina resulting in movement of vessels at their berths. For the proposed marina layout and pontoon configurations, wave climate compliance has been checked and demonstrated for all berths. Since the general arrangement of boats and pontoons comprising the proposed facility is to remain unchanged, the wave energy which is presently delivered to the shoreline along Spit Reserve, immediately south of the marina buildings, would remain low.

The boat lift would not be unduly affected by ambient wave conditions. It would operate sympathetically with the tidal currents. It is noted that Fergusons Boatshed, just downstream of Spit Bridge, successfully operates a 35 t boat lift. The similar facility proposed at Spit Marina should be equally serviceable.

As the upgraded facility comprises a mix of floating and suspended structures, no changes would occur to existing tidal and fluvial circulation patterns. The proposal would have no influence on sediment distribution or sediment movement.

Except for the fairway inshore of A-Arm, the marina enjoys good water depths. There is no history of dredging at the marina, and since sedimentation patterns would not be affected, there is no suggestion of any requirement for future dredging. Indeed, previous studies have found the Spit Marina site suitable for expansion of boating facilities because of the limited sediment movement.

Vessel movements inside and outside the marina have been assessed. Proximity and type of passing boat traffic, mooring arrangements, channel arrangements and vessel motions at berth have all been considered.

The impact on navigation past the marina is considered to be modest and manageable. Navigation within the main channel, passing close to corner of C-Arm, and vessel mustering during bridge openings, have each been addressed.

The proposal would have no influence on rowing operations. The proposed marina does not encroach on the rowing course or the fairway. Existing separation distances are preserved. The berthed vessels that currently access the marina from the south would continue to do so as per the existing arrangements.

The existing marina includes some non-complying berth widths. Regularisation to AS 3962 is fully achieved with the proposed arrangement. This covers berthing for both power boats and yachts.

The proposal involves the conversion of the existing 25 single “tie-off strut” 8 m berths on A-Arm Inner, to conventional double 8 m berths. The existing berth-type is not endorsed by AS 3962, and a conversion would be regarded as beneficial for berthing function and safety.

Bed depth regularisation is achieved with the proposed arrangement. While depth restrictions currently limit the effective fairway width inshore of A-Arm, GBAC recommends that the proposed arrangement here be accepted on the basis of restricted use, namely that only power craft to 8 m in length be permitted to access the fairway; and that all berthing is stern-in to the A-Arm Inner berths.

To account for low water depth, berth number 193 at the southern end of D-Arm would be restricted to power boats.

Since wave climate compliance is achieved at all proposed berths, it follows that vessel motions at berth are acceptable.

This environmental assessment has found that the proposed concept to be sustainable in respect of coastal and maritime engineering. The environmental impacts associated with the proposal are generally small and acceptable. Where impacts are found to be unacceptable, remedial measures have been recommended and adopted as part of the final proposal (**Appendix D** Master Plan).

8 REFERENCES

Bureau of Meteorology (1979)
Climatic Survey – Sydney
Region 5 (NSW)
April 1979

Blumberg GP and Cox RJ (1988)
Floating Breakwater Physical Model Testing for Marina Applications
PIANC Bulletin 1988.

Chapman d'Albora Marina, Geary M, Roy PS and Thom BG (1982)
Coastal Evolution and Coastal Erosion in NSW
Coastal Council of NSW

Department of Environment and Climate Change (2007)
Environmental Action for Marinas Boatsheds and Slipways
ISBN 978 1 74122 401 6, June 2007

Department of Urban Affairs and Planning (1996)
Marinas and Related Facilities, ENVIRONMENTAL ASSESSMENT Guideline
ISBN 0 7310 8936 7, October 1996

GHD (1990)
Land Use Management Plan, The Spit, Mosman
Prepared for Mosman Council, 12/4/90

IPCC (2007)
Climate Change 2007 – The Physical Science Basis
Summary for Policy Makers
Fourth assessment report of Intergovernmental Panel on Climate Change, February 2007

Mercer AG, Isaacson M and Mulcahy MW (1982)
Design Wave Climate in Small Craft Habours
18 th International Conference on Coastal Engineering, Cape Town

Northwest Hydraulic Consultants (1980)
Study to Determine Acceptable Wave Climate in Small Craft Harbours
DSS Contract 04SZ KF802-8-2112, Final Report
Prepared for Small Craft Harbours Branch, Fisheries and Oceans Canada
March 1980

NSW Department of Commerce (2005)
NSW Tide Charts
Manly Hydraulics Laboratory
ISSN 1039-1231

NSW Maritime (2008)
Safe Boating Handbook
http://www.waterways.nsw.gov.au/sbh.html, 15 February 2008

NSW Maritime (2005)
Engineering Standards and Guidelines for Maritime Structures
Current to March 2005

Patterson A, Blumberg G, Couriel E and Graskops M (1997)
Model and Prototype Behaviour of Effective Floating Breakwaters
Pacific Coasts and Ports '97, Christchurch, September 1997

Public Works (1992)
d'Albora Marinas, The Spit
Public Sewage Pumpout Facilities
Statement of Environmental Effects
NSW Waterways Infrastructure Development Program
Public Works Report No 92013, ISBN 0730594416, February 1992

Public Works (1990)
Design Guidelines for Wharves and Jetties
Report No 88062, August 1990

RTA (2003)
Proposed Widening of The Spit Bridge over Middle Harbour
SEE/REF
Two volumes, prepared by GHD, March 2003

SKM (2006)
Reduced Weekend and Public Holiday Openings of Spit Bridge, Mosman
Review of Environmental Factors
September 2006

Standards Australia (2001)
AS 3962 Guidelines for Design of Marinas
Prepared by Committee CE-030, Maritime Structures

FIGURES

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FIGURE 1

Gary Blumberg & Associates
J07-4/R73
Plot date: 9/4/08

STUDY AREA