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323 Charlestown Road Charlestown NSW 2290 PO Box 180 Charlestown NSW 2290
T (02) 4943 1777 F (02) 4943 1577 E newcastle@northrop.com.au
www.northrop.com.au ABN 81 094 433 100

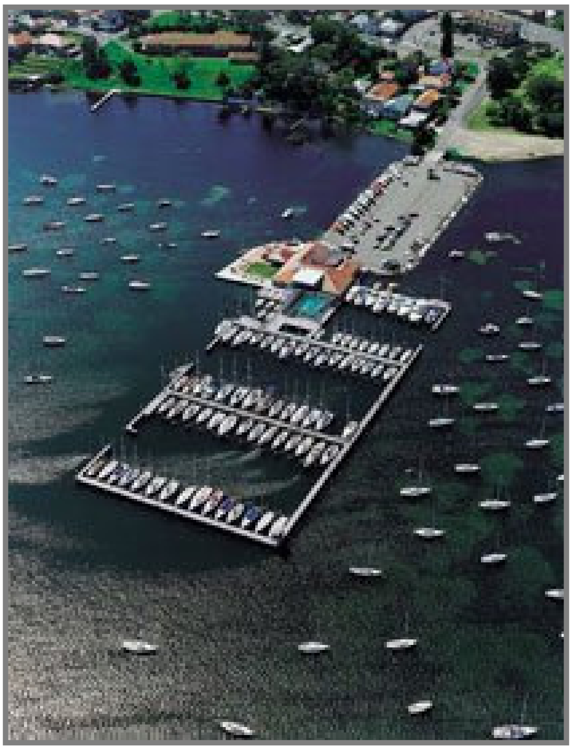
Engineering Report

for

Part 3A Assessment

for

Lake Macquarie Yacht Club
Alterations and Additions



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Executive Summary

This report provides an assessment of the engineering issues associated with the proposed redevelopment of Lake Macquarie Yacht Club. Lake Macquarie Yacht Club is located at the end of Ada Street, in Belmont NSW, on the eastern shore of Lake Macquarie. The Club's facilities currently comprise an aging two-storey clubhouse, an 84 wet berth marina, 12 swing moorings, and a bitumen carpark with a hardstand area for boat storage. The existing carpark, clubhouse and marina extend from the foreshore out over Lake Macquarie, into an area known as Belmont Bay. On the foreshore adjacent to the Club, a gravelled area caters for overflow parking in busy periods.

A proposal to expand the marina's wet berth facilities, construct a new two-storey clubhouse in place of the existing building, expand the existing bitumen carpark, and undertake foreshore improvements (landscaping works and carpark formalisation) has been developed by Lake Macquarie Yacht Club, EJE Architecture and de Witt Consulting. The redevelopment proposal is to be assessed by the NSW Department of Planning (DOP) as a Major Project under Part 3A of the EP&A Act. The Director General's Environmental Assessment Requirements (DGR's) for the project have been issued, and the project allocated an Application Number (08_0045) by the DOP.

Northrop Consulting Engineers (Northrop) were engaged by Lake Macquarie Yacht Club to prepare a report responding to the engineering related issues outlined in the DGR's. This report addresses the following DGR items:

DGR No.	Outline of DGR Item	Section of this Report
4.1	Assess capacity and requirements of infrastructure	2
6.1	Assess impact on groundwater hydrology and quality	3.2
6.2	Provide details of stormwater management system	3.1, 3.5
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13.2	Address movement & accumulation of sea-grass wrack	7
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This report presents a detailed response to each of the listed DGR items. A brief summary of these is provided below. The reponses presented in this report are heavily dependant upon the information and direction provided to us by Lake Macquarie Yacht Club, EJE Architecture, de Witt Consulting, Ecotone Ecological Consultants and Econalysis. Information received through liasion with Lake Macquarie City Council (Council), NSW Government departments including the Department of Environment, Climate Change and Water NSW (DECCW) and local infrastructure providers also influences the findings of this report.

Infrastructure Provision (DGR 4.1)

Investigation into the capacity of existing services (sewerage, water supply, electricity, waste disposal, telecommunications and gas) indicates them to be adequate for the current development. Discussions with service authorities indicate the existing service infrastructure is likely adequate to cater for the proposed redevelopment.

The proposed redevelopment of the clubhouse will be similar in size and operational nature to the existing clubhouse, and therefore a significant increase in demand for services is not expected. The proposed marina extension will require only minor extensions of electricity and water services.

Water Cycle Management (DGR 6.1, 6.2, 6.3)

Stormwater runoff from the existing clubhouse, marina, carpark, and foreshore area currently drains unmitigated and untreated into Lake Macquarie. The proposed redevelopment works include provision to improve stormwater management for the site.

Proposed stormwater inlet pits with filter inserts will be installed to capture sediment, hydrocarbons, oils and greases from the existing and proposed sealed carpark areas. This will improve the quality of surface water entering the lake.

Works proposed for the foreshore area include revegetation, permeable paving (reinforced 'turf cells') and a rock surfaced infiltration trench. These measures will capture and filter stormwater runoff from the foreshore carpark area to remove sediment and nutrients, improving the quality of surface water entering both the lake and the ground water table. The works will also serve to reduce potential shoreline erosion due to stormwater runoff, and mitigate sediment deposition into the lake during rainfall events.

The existing clubhouse, marina, and bitumen carpark have negligible impact on groundwater hydrology and quality, as they are situated over the lake, rather than on land. The proposed redevelopment will not alter this scenario, and will similarly not have an impact on groundwater quality.

Chemical storage, boat maintenance and cleaning does not currently take place on site, and are not proposed as part of the redevelopment. These practices will therefore not impact on surface or ground water quality.

The proposed stormwater treatment devices will require routine maintenance to function properly over time. An appropriate monitoring and maintenance schedule for the devices could be readily incorporated into the grounds maintenance routine for the Club.

Ada Street Causeway (DGR 6.4)

A concrete causeway currently provides a bridge from the Club to Ada Street. The hydrodynamics report prepared by Econalysis for this project (included as Appendix A to this report) recommends a maintenance program of regular dredging within the causeway channel, to alleviate problems of sediment and sea-grass accumulation and odour issues.

Hazard Management and Mitigation: Coastal Processes (DGR 7.1)

The proposed redevelopment concept has been developed in consideration of coastal processes, and the guidance provided by the NSW Government's 'Coastline Management Manual'.

The proposed foreshore landscaping and carpark formalisation works will stabilise the existing gravel foreshore and shoreline, and serve to reduce the potential for erosion of these areas due to stormwater runoff and wave actions.

Econalysis' hydrodynamic modelling of the relevant coastal processes for the Club's location indicates the impact of wave and wind actions will continue to be within acceptable criteria for the marina structure and clubhouse post redevelopment. The Econalysis' hydrodynamic modelling considered potential impacts on the proposed redevelopment due to sea (lake) level rise and the incidence of more frequent and intense storms due to climate change. The Econalysis report indicates significant wave heights in extreme events will only increase marginally under modelled climate change scenarios, and impacts of wave and wind action can be appropriately managed during and post construction of the works.

Econalysis' modelling indicates there will be no significant change to hydrodynamic processes within Belmont Bay due to the proposed development.

The detailed design phase for the redevelopment works will further consider impacts of sea (lake) level rise and increased storm events due to climate change, as well as existing lake processes, wind and wave actions and the corrosive nature of coastal environs.

Hazard Management and Mitigation: Flooding (DGR 7.5, 7.6)

The existing clubhouse ground floor level is approximately 1.2m Australian Height Datum (AHD). The existing clubhouse has been exposed to several extreme storm events, most recently in June 2007; however, the clubhouse has never been inundated. The existing decking and marina structure are situated at 1.1m AHD, approximately 1m above the Lake mean water level[1].

Following consideration of the site specific nature of the development, the existing relationship of the facilities to the Lake mean water level, Council flood planning levels, wave action, storm surge and sea (lake) level rise due to climate change; an adaptable ground floor structure has been proposed for the new clubhouse. The ground floor areas of the clubhouse will be designed to allow provision for the finished floor level to be raised in future if required, given the uncertainty in the area of climate change science and sea

[1] Lake Macquarie City Council, Fact Sheet 12 – Environmental Facts and Issues, 01/09/2006.
Average lake surface level is 0.15m AHD. AHD 0.0m is the average sea level around Australia.

(lake) level rise predictions. An initial ground floor level of 1.98m AHD is proposed for the new clubhouse, an increase of 0.78m from the existing level. The proposed marina extension will be constructed at the level of the existing decking.

Detailed design of the proposed redevelopment works will include consideration of hydrostatic pressure, to ensure structural integrity is maintained in the unlikely event of inundation. In the improbable event of the proposed clubhouse becoming inundated, flood refuge will be available on the first floor of the building, however, timely evacuation of club patrons to higher ground via Ada Street would be readily achievable and a more likely course of action. An evacuation plan demonstrating opportunities for egress from the site in an extreme flood event is included in Appendix D to this report.

Noise and Air Quality Impacts (DGR 11.2)

Construction activities proposed are very typical of domestic and marina construction. Appropriate methods of construction will be adopted to minimise both noise pollution and dust creation, in accordance with the recommendations outlined in the Noise Impact Assessment prepared by Reverb Acoustics for this project, and the project's preliminary Construction Management Plan prepared by Northrop.

Riparian / Foreshore Protection (DGR 12.1, 12.2)

The proposed redevelopment works will enhance and improve the foreshore ecology and stability. The proposed works will boost endemic plant species, and greatly reduce the potential for erosion of the shoreline and foreshore area.

The reports prepared by Econalysis and Ecotone Ecological Consultants indicate works associated with the redevelopment of the clubhouse will have no significant impact on the foreshore or lakebed, and no significant impact on existing vegetation or the local hydraulic regimes. The reports indicate works associated with the expansion of the marina structure will not impact on the foreshore, and will have a minimal impact on the lakebed, existing sea-grass and hydraulic regime. The reports indicate the completed redevelopment works are likely to have an overall positive environmental impact, and potential adverse environmental impacts during the construction phase can be effectively mitigated and managed within acceptable limits.

Marina Impacts (DGR 13.1, 13.2, 13.3, 13.4, 13.5)

Hydrodynamic modelling undertaken by Econalysis indicates the proposed marina extension will have no significant impact on existing hydrodynamic processes within Belmont Bay or the wider lake, including on sea-grass wrack movement and accumulation.

The proposed decking material for the marina extension will be appropriately selected to minimise shading of the sea-grass below. A 'wave skirt' similar in nature to the existing skirt will be installed along the marina extension to attenuate wave energy and minimise excess turbulence within the marina. Reports prepared by Econalysis and Ecotone Ecological Consultants indicate the marina extension may result in improved seagrass cover in the marina extension area.

Conclusion & Recommendation

In our opinion the proposed redevelopment of the clubhouse and marina and foreshore works, will not adversely water quantity, quality, ecology or amenity of the site. The construction process can be appropriately managed to ensure the works are undertaken without causing significant environmental impacts. The proposed redevelopment is an opportunity to enhance local environmental outcomes and the overall amenity of the site, and should therefore be supported.

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A	**Econalysis Hydrodynamic Processes Report**
B	**Infrastructure Authority Correspondence**
C	**Engineering Plans**
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1 Introduction

Lake Macquarie Yacht Club is located at the end of Ada Street, in Belmont NSW, on the eastern shore of Lake Macquarie. The Club's facilities currently comprise an aging two-storey clubhouse, an 84 wet berth marina, 12 swing moorings, and a bitumen carpark with a hardstand area for boat storage. The existing carpark, clubhouse and marina extend from the foreshore out over Lake Macquarie, into an area known as Belmont Bay. On the foreshore adjacent to the Club, a gravelled area between Cullen Park and the shoreline caters for overflow parking in busy periods. An aerial photograph of the existing facilities and the locality is provided as Figure 1 below.

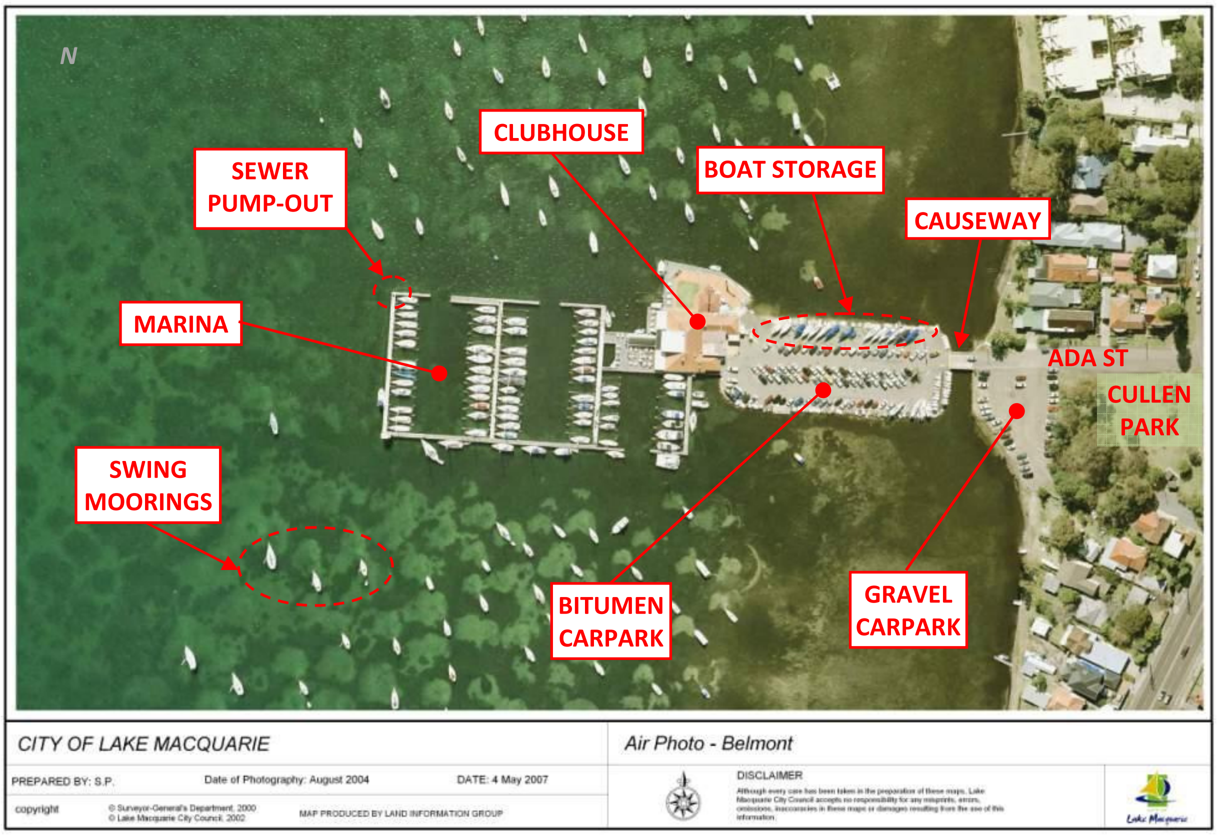

Figure 1 – Aerial Photograph of Existing Lake Macquarie Yacht Club and Surrounds

As evident in Figure 1, a number of privately owned swing moorings in addition to those controlled by the Club are located to the north and south of the existing marina. The approximate extents of the existing seagrass beds in the vicinity of the Club are indicated in Figure 1 by the darker areas visible within the Lake. From the Figure, it can be seen that area's of the lakebed around the swing moorings are typically denuded of seagrass, whilst the seagrass beds within the existing marina structure are comparably intact.

A redevelopment proposal for the Club has been developed by Lake Macquarie Yacht Club, EJE Architecture and de Witt Consulting. The proposed works include expansion of the marina's wet berth facilities to the west, construction of a new two-storey clubhouse in place of the existing building, expansion of the existing bitumen carpark to the north and south, and foreshore improvements (landscaping works and carpark formalisation). A comparison of the existing and proposed facilities is provided in Table 1 below.

Table 1 - Facility Schedule

ACCOMMODATION	EXISTING	PROPOSED ADDITIONAL	TOTAL AFTER COMPLETION
MARINA WET BERTHS	84	56	140
HARDSTAND BERTHS	19	0	19
SWING MOORINGS	12	- 4	8
CAR PARKING SPACES	94	57	151
CLUB GROUND FLOOR (GFA)	658m^2	440.0m^2	1,098.0m^2
CLUB LEVEL 1 FLOOR (GFA)	80m^2	574.8m^2	654.8m^2
CLUB TOTAL (GFA)	738m^2	1014.8m^2	1,752.8m^2

Source: EJE ARCHITECTURE, June 2009 Drawing DA A00 Revision B, Project No. 4000

The proposed redevelopment works will almost double the wet berth capacity of the existing marina, however will reduce the Club's swing moorings by one third. Formal carparking facilities will be increased by 60% and the clubhouse gross floor area (GFA) will approximately double. The extent of the proposed works is depicted in Figure 2 below.

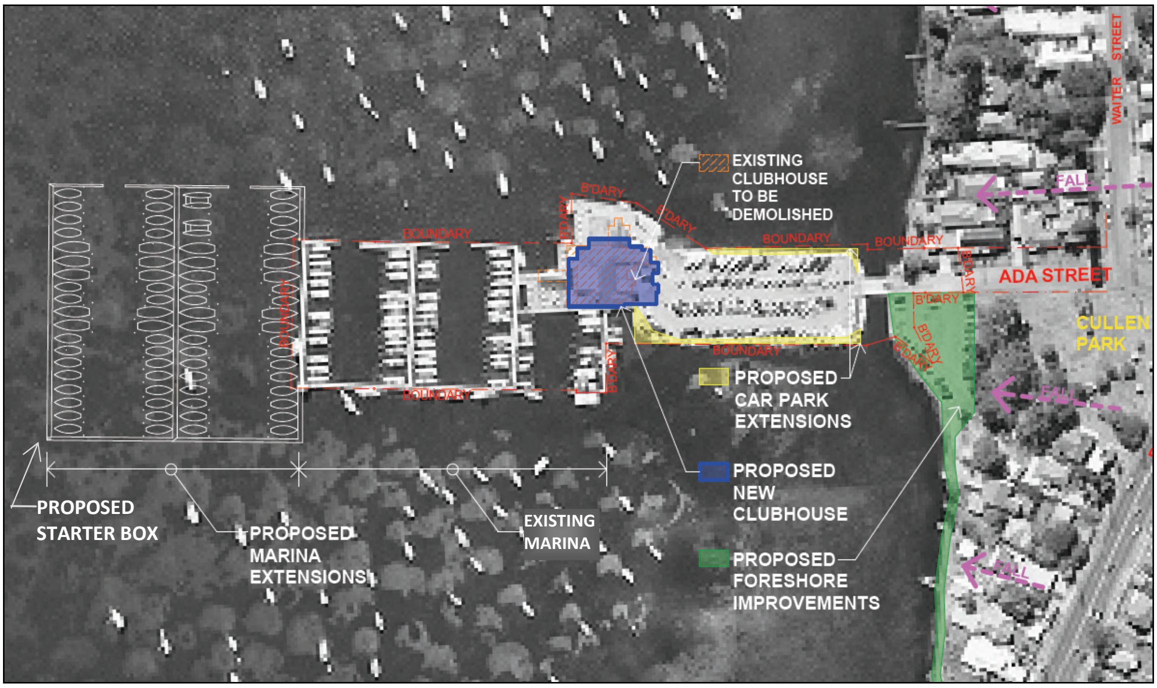

Figure 2 – Montage of Proposed Redevelopment Works and Existing Facilities

The proposed carpark expansion (extents shown in yellow in Figure 2) will be achieved using a suspended concrete slab structure, supported on an edge beam and piles driven or screwed into the lake bed. Figure 3 below indicates this concept.

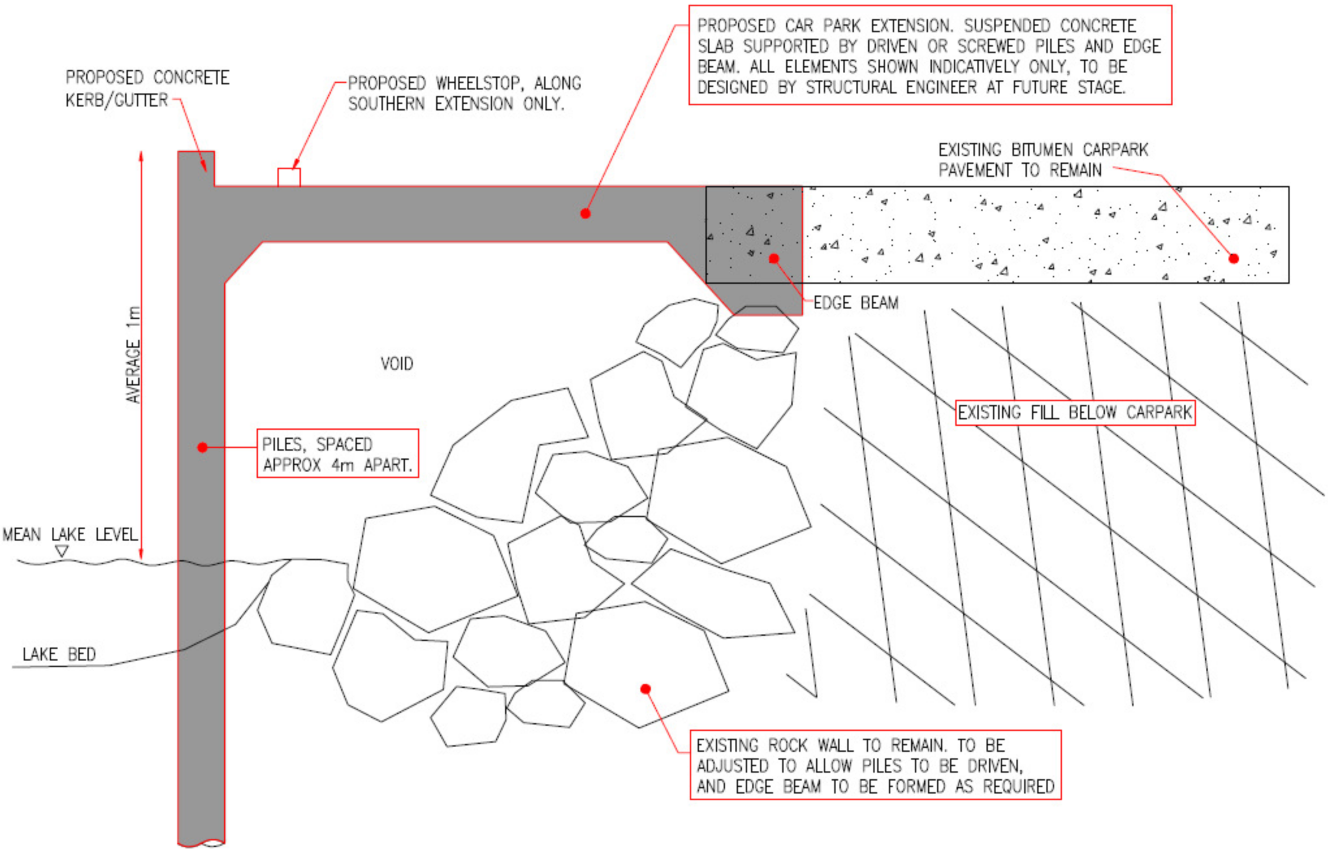

Figure 3 – Proposed Typical Edge Detail, Carpark Expansion

As shown in Figure 3, a sloping rock wall extends out from the existing bitumen carpark into the lake, to dissipate wave energy. The proposed slab structure will effectively cantilever out over the existing rock wall, which will remain in place so as to continue to dissipate wave action. Piles will be designed to have minimal surface area (diameter) and maximum spacing, to minimise wave reflection. The existing bitumen carpark surface will be regraded as required, to permit adequate drainage following the expansion.

The proposed formalisation of the foreshore carparking area and the extent of the proposed foreshore landscaping works are depicted in Figure 4 overleaf.

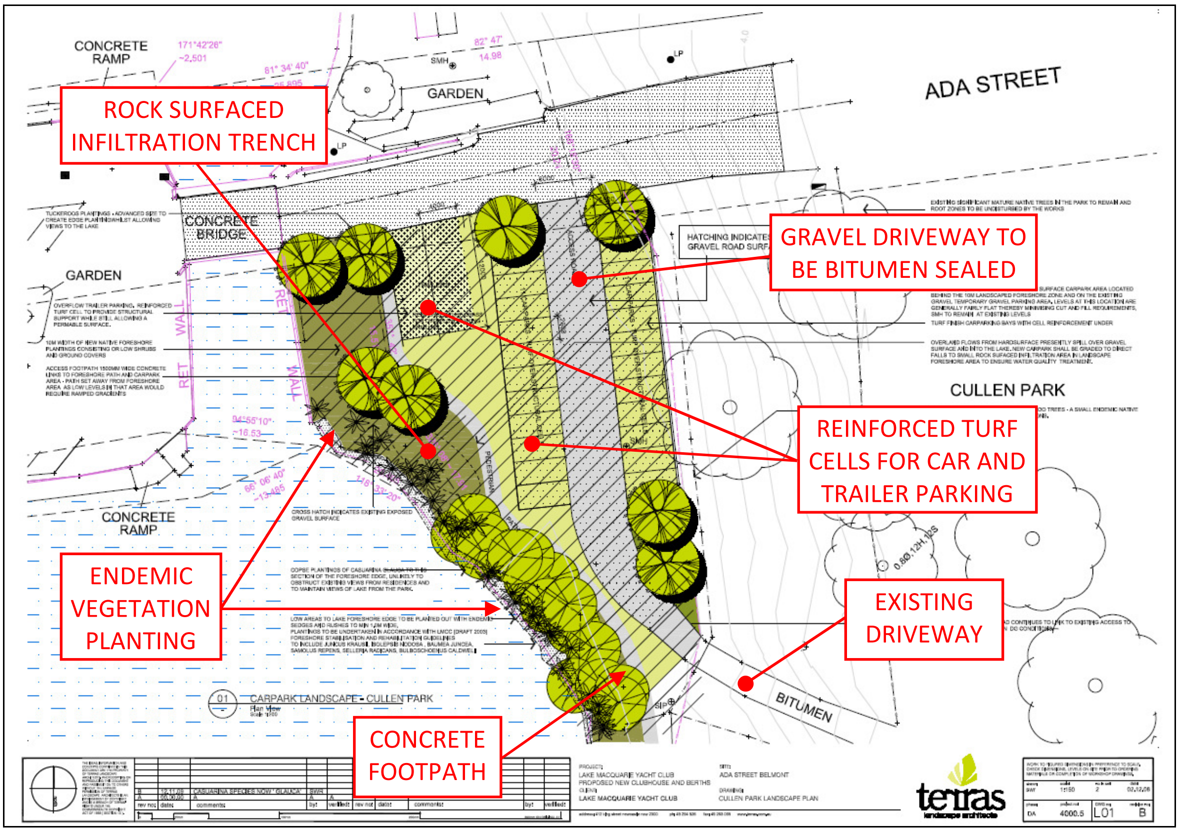

Figure 4 – Proposed Foreshore Works

It is proposed to regrade the gravel foreshore area between Cullen Park and the shoreline to fall toward an infiltration trench. Minor filling may be required to achieve appropriate grades for the foreshore carparking area and proposed footpath.

The redevelopment proposal is to be assessed by the NSW Department of Planning (DOP) as a Major Project under Part 3A of the EP&A Act. The Director General's Environmental Assessment Requirements (DGR's) for the project have been issued, and the project allocated an Application Number (08_0045) by the DOP. This report addresses the engineering related DGR's for the proposed redevelopment of Lake Macquarie Yacht Club. To this end, the proposed works depicted in Figures 2 and 4 are discussed in further detail within the ensuing sections of this report, with respect to the relevant DGR items.

The Flora and Fauna Impact Assessment Report for the proposed redevelopment works prepared by Ecotone Ecological Consultants in January 2010 is heavily referenced within this report. Ecotone Ecological Consultants' Seagrass Management Plan (January 2010) for the proposed redevelopment works is also referenced within this report. Hydrodynamic modelling of the proposed redevelopment works has been undertaken by Econalysis as background for this report, and the results are included in Appendix A.

2 Infrastructure Provision

DGR 4.1 "Address existing capacity and requirements of the development for sewerage, water (including scope for recycled water), electricity, waste disposal, telecommunications and gas in consultation with relevant agencies. Identify and describe staging, if any, of infrastructure works."

Utility services currently used by the existing facilities are typically located within Ada Street along the site frontage. These services include mains water, sewer, electricity, telecommunications and gas. A waste collection service is currently provided to club. A plan indicating the location of existing services is provided in Appendix C to this report as drawing 'C05 DA'.

At this stage of enquiry, service authorities have indicated existing services are adequate for the existing facility, and will be adequate to support the proposed redevelopment if demands are not significantly increased. Correspondence with service authorities is included as Appendix B to this report. Formal application and assessment based on the final detailed design and associated service demands for the site will be needed to confirm if any upgrades to services are ultimately required, as with any development.

The proposed new clubhouse will be similar in operational nature to the existing facility, and no significant increase in services demand is expected following the redevelopment. Works to the existing carpark will have no significant impact on service demand or supply. The proposed marina expansion will require minor extension of water and electricity services. A discussion of the likely implications to each as a result of the proposed redevelopment works is discussed in more detail in the following sections.

2.1 Marina & Clubhouse Infrastructure

2.1.1 Marina & Clubhouse Potable Water & Electricity

Potable water and electricity usage within the existing marina structure is currently limited to lighting, intermittent temporary 240 volt power supply outlets for docked boats, power to the sewage pump-out system, and intermittent tap fixtures for filling of water bottles and hosing of saltwater from boat decks. It is proposed to extend the potable water supply along the new marina to provide tap fixtures at intervals similar in nature to the services currently supplied at the existing marina. It is proposed to extend electricity services for lighting and temporary 240 volt power supply for docked boats, similar in nature to the services currently supplied. Electricity will also be provided to the proposed new starter box for lighting and 240 volt power supply as required.

It is proposed the new clubhouse adopt energy and water efficient measures and appliances throughout, to minimise demand on these services. A rainwater storage tank is proposed for collection and reuse of stormwater runoff from a portion of the proposed clubhouse roof. The tank water will be used for garden irrigation and for boat washdown, reducing demand on mains water for these activities. Reuse of collected roofwater is not proposed internally for toilet flushing, as it is likely to have a high salt content due to the lake environment, and a subsequent high potential to corrode fittings and fixtures over time.

Correspondence received from Hunter Water Corporation (Appendix B) indicates recycled water is not proposed for this area, and therefore installation of a dual main is not proposed as part of the redevelopment works.

With energy and water efficient measures and appliances to be incorporated within the new clubhouse, and only minor additional demands on potable water and electricity expected from the new marina, it is likely the demand on these services following the redevelopment will be similar to the current demand from the site.

2.1.2 Marina & Clubhouse Sewer

The proposed marina extension will not require extension of the sewer network. It is proposed to maintain the single sewage pump-out point currently servicing the existing marina. The increase in wet berths is likely to result in only a minor increase in sewage waste from the marina, if any, as many of the wet berths will be occupied by boats that already use the marina's sewage pump-out system. Should it be required in the future, the pump-out system could be upgraded or replaced to cater for additional sewage loads.

The new clubhouse will be similar in operational nature to the existing facility, and no significant increase to sewage waste volumes is expected. Water efficient appliances, including taps and toilets, are proposed within the new clubhouse, which could result in some reduction in sewage waste generation from the building.

It is likely sewage waste volumes for the redevelopment will be very similar to the current volumes from the site. Given the increase in wet berths within the marina, a small overall increase may occur, although this will likely not be significant enough to warrant any changes to the existing mains. The existing sewer services will require some relocation to suit the proposed new clubhouse layout.

2.1.3 Marina & Clubhouse Telecommunications

The new clubhouse will be similar in operational nature to the existing facility, and no change to the existing telecommunications services is proposed, other than relocation as required to suit the proposed new clubhouse layout.

Telecommunications services are not currently part of the marina structure and are not proposed for the extension, therefore there will be no increase in demand for these services from the marina. Telecommunications services are available for extension to the proposed new starter box, if required.

2.1.4 Marina & Clubhouse Gas

The new clubhouse will be similar in operational nature to the existing facility, and as such a significant increase in demand for gas is unlikely. Should upgrade to gas supply services be required, Jemena have advised this could likely be achieved in consultation with the Club's gas retailer (Appendix B). Relocation of gas services is likely to be required to suit the proposed new clubhouse layout.

Gas supply is not currently provided to the marina structure and is not proposed for the extension.

2.1.5 Marina & Clubhouse Waste Disposal

Waste bins are likely to be provided at intervals along the proposed marina structure. Many of the proposed wet berths will be immediately filled by boats currently using the swing moorings adjacent to the club, and these boats are likely to already dispose of their waste at the Club. While there may ultimately be some increase in boat numbers using the facility, the amount of waste generated on board is likely to be minimal, and it is unlikely garbage collection services will need to be increased as a result of the marina extension.

The new clubhouse will be similar operational nature to the existing facility, and as such no upgrade to the existing garbage collection operations should be required. The proposed redevelopment includes identification of a waste collection area for bin storage and collection.

Should garbage collection services be found to need augmenting post redevelopment, it is considered this will be readily acheivable through consultation with the collection provider.

2.2 Foreshore Services

Landscaping and carpark formalisation works are proposed for the area of the foreshore adjacent to the clubhouse. The area is currently gravel and used as temporary overflow carparking for the club.

2.2.1 Foreshore Electricity

Existing street-lighting for Ada Street, the adjacent existing Cullen Park and the existing clubhouse carpark currently provide spill-over night lighting for this area. Additional lighting will be provided for this area if it is deemed required following detailed assessment. The foreshore works will have a minimal impact on existing electrical services, if any.

2.2.2 Foreshore Potable Water, Sewer, Telecommunications & Gas

The proposed foreshore works will not impact existing water, sewer, gas or telecommunications services.

2.2.3 Foreshore Waste Disposal

Garbage collection services are already provided for the adjacent Cullen Park, therefore if additional waste bins were to be incorporated in the foreshore works this would result in only a minor increase in duties for local garbage collectors, which could be readily acheived.

3 Water Cycle Management

A site specific, holistic Water Cycle Management Strategy (WCMS) will be implemented for the proposed redevelopment, based on the principles of Water Sensitive Urban Design (WSUD), and in accordance with Lake Macquarie City Council's guidelines. Key elements of the proposed stormwater management strategy for the works are discussed in detail within Sub-Sections 3.1 to 3.4 inclusive. A Stormwater Concept Plan for the redevelopment works is included in Appendix C as drawing 'C03 DA'.

3.1 Proposed Stormwater Management Concept

DGR 6.2 "Provide details regarding the design and maintenance of stormwater drainage, water reuse, assess the impacts of tidal flushing and installation and maintenance of gross pollutant traps".

3.1.1 Clubhouse Stormwater Management

Currently, roofwater runoff from the existing clubhouse drains unmitigated directly into the lake. Stormwater detention is not required for the clubhouse, as the building is immediately on the edge of the receiving water of Lake Macquarie. However, as previously noted in Sub-Section 2.1.1, the clubhouse redevelopment works will include a rainwater storage tank to collect stormwater runoff from a portion of the new roof, for reuse for garden irrigation and boat washdown.

3.1.2 Marina Stormwater Management

Runoff from the existing marina decking currently drains unmitigated into the lake. We believe this is an acceptable solution for the structure, and it is proposed to continue this regime for the marina extension. The decking is a pedestrian only thoroughfare, with no vegetation and no upstream catchment, and therefore is subject to negligible pollutant loads that do not warrant the use of water quality treatment devices. Further, the existing and proposed decking materials are highly permeable, making collection of runoff impractical.

3.1.3 Foreshore Stormwater Management

Currently, stormwater runoff from the foreshore area, including from the gravel area often utilised as overflow carparking, runs unmitigated into the lake. The proposed redevelopment provides opportunities for water quality treatment of stormwater runoff from the foreshore area, and for slowing and dispersing runoff to reduce erosion potential of the shoreline.

It is proposed to provide an aggregate filled rock surfaced infiltration / dispersion between the shoreline and proposed footpath (Figure 4) to collect and treat stormwater runoff. The trench will be designed to effectively filter nutrients and fine sediments, and trap hydrocarbons and oils, improving the quality of stormwater running into the lake. The proposed landscaped and reinforced turf areas will provide additional polishing of stormwater runoff, aiding water quality improvement.

The proposed works will serve to stabilise and seal foreshore area, reducing the potential for erosion due to wind and rain.

3.1.4 Bitumen Carpark Stormwater Management

Currently, stormwater runoff from the existing bitumen carpark area runs unmitigated into the lake. The proposed redevelopment provides opportunity to capture and treat stormwater runoff from the carpark, to improve the quality of water entering the lake. During the proposed resurfacing and extension works, the carpark will be regraded to fall toward its northern and southern edges. New upright kerbs will be constructed along the northern and southern edges, to direct stormwater runoff into a series of proposed stormwater inlet pits. It is proposed to fit the new inlet pits with appropriate pollutant traps and filters to treat stormwater runoff from the carpark area, prior to it discharging into the lake. The proposed traps and filters will be proprietary items, which will be easily maintainable.

3.2 Groundwater & Surface Hydrology

DGR 6.1 "Assess impacts on surface and groundwater hydrology and quality during construction and occupation of the site. Provide details of any works likely to affect groundwater sources or potentially result in pollution and any protective measures for groundwater dependent ecosystems".

As detailed in Section 3.1, implementation of the proposed stormwater management concept for the redevelopment will improve surface water quality and conveyance from the site.

The existing clubhouse, marina, and bitumen carpark extend out across the permanent water of Lake Macquarie, and as such, have negligible impact on groundwater hydrology and quality. The proposed redevelopment will not alter this scenario.

The proposed foreshore landscaping works, infiltration trench, and reinforced turf areas will likely increase the amount of water discharging to the ground water table, compared to the existing compacted gravel surface. The works will filter and treat stormwater prior to it entering the ground water table, improving existing conditions.

A site specific Sediment and Erosion Control Plan is included in Appendix C as drawing 'C01 DA', outlining appropriate protective and preventative measures to be adopted for the duration of the redevelopment works. Construction works will be carried out in accordance with the Sediment and Erosion Control Plan and the preliminary Construction Management Plan for the project, to minimise deposition of sediment and other materials into the lake.

3.3 Water Quality

DGR 6.3 "Assess the impacts on water quality (during construction and operation) including stormwater management systems, surface water controls, management of slipways, hardstand areas and vessels, management of sewerage waste from vessels, fuel and chemical storage and spill management".

As detailed in previous sections within this report, the proposed redevelopment works will improve overall water quality outcomes for the site. The current stormwater regime for the site does not include quality treatment measures for stormwater runoff.

As part of the proposed redevelopment, stormwater runoff from the proposed new clubhouse, carpark and foreshore will be variously collected and treated prior to discharging into the lake. The proposed stormwater management system will greatly improve the quality of water discharging from the site during future operation, compared to existing operational conditions.

Construction works will be carried out in accordance with the project's Sediment and Erosion Control Plan and preliminary Construction Management Plan, to mitigate adverse impacts on water quality. Site specific protective and preventative measures including sediment fencing, floating bunds and silt curtaining, and the adoption of appropriate construction methods will minimise risks to water quality during construction.

It is proposed to maintain the sewage pump-out system currently servicing the marina, and no operational changes to the management of sewerage waste from vessels are proposed.

Fuel and chemical storage, does not currently take place on site, and are not proposed as part of the redevelopment. These practices will therefore not impact on surface or ground water quality.

A slipway for boat maintenance and cleaning is not currently located at the site, and is not proposed as part of the redevelopment. Slipway management practices will therefore not impact on surface or ground water quality.

3.4 Ada Street Causeway

DGR 6.4 "Improve the maintenance and water flows through the causeway linking Ada Street to the Club's car park to alleviate ongoing problems of odour and seagrass accumulation".

An existing concrete causeway extends between the bitumen carpark and Ada Street, and forms the main access for the club. In the past, problems have been reported regarding seagrass accumulation and an unpleasant odour at the causeway.

There is a large diameter stormwater drainage pipe on the northen side of the causeway, which is a Council asset and drains a large catchment directly into the lake. Discharge from the stormwater pipe appears to have minimal if any upstream water quality treatment, as there is a build up of sediments and gross pollutants in front of the outlet. This may contribute to the reported past problems at the causeway.

Investigations into options for alleviating seagrass accumulation and unpleasant odours at the causeway have been undertaken. Potential solutions identified included changing the geometric configuration of the causeway to promote better self-flushing, installation of water quality treatment measures for the nearby stormwater pipe, and improvement of manual maintenance programs.

Hydrodynamic modelling undertaken by Econalysis for multiple geometric configurations of the causeway indicates negligible change to water flow velocities or volumes can be achieved under any practical scenario. Without increased flow velocities or volumes, improved self-flushing of the area under wave action is not likely to occur. This option has therefore been dismissed as a solution. Econalysis' modelling is presented in Appendix A.

Installation of a gross-pollutant and sediment trap immediately upstream of the existing stormwater pipe discharging at the causeway could provide improvement in conditions at the pipe outlet, which may contribute to alleviating odours. This option would need to be adopted by Lake Macquarie City Council, as they are the asset owners of the pipe and associated stormwater network. Council would need to implement a regular manual maintenance program for emptying debris from any trap installed in order for this solution to be viable.

The Econalysis report states that *"given that the sedimentation from the stormwater outlet is a major contributor to the maintenance problem, it is recommended that Lake Macquarie Yacht Club negotiate a permanent maintenance arrangement to dredge the causeway channel with Lake Macquarie City Council".*

It is similarly our opinion that a regular maintenance program for removal of excess seagrass wrack from under the causeway could alleviate the reported problems of seagrass accumulation and odour, if it is combined with a regular Council maintenance program for removal of the sediments and gross pollutants discharging from the nearby stormwater pipe.

3.5 Maintenance

DGR 6.2 "Provide details regarding the design and maintenance of stormwater drainage, water reuse, assess the impacts of tidal flushing and installation and maintenance of gross pollutant traps".

The proposed stormwater management strategy for the redevelopment works includes a number of stormwater treatment devices which require routine maintenance to function properly over time. An appropriate monitoring and maintenance schedule for the devices could be readily incorporated into the grounds maintenance routine for the Club. Maintenance requirements for proposed stormwater treatment devices will be dependent on local weather patterns and pollutant loading.

3.5.1 Turf Cell Maintenance

The proposed turf cells will filter stormwater runoff from the proposed driveway pavement, capturing fine sediments and petrol based hydrocarbons, oils and greases (from vehicles). Sediment loading is expected to be low and limited to windblown particles, as the catchment upstream of the turf cells and driveway is vegetated / sealed. Hydrocarbon, oil and grease loadings are expected to be low and limited to occasional localised incidences for individual vehicles needing repair.

Routine mowing and weeding of turf cell areas will provide opportunity to observe and remove any built-up areas of sediment, oils or grease. No additional maintenance should be required. Installation of the turf cells in accordance with industry best practice, including protection of the turf cells from sediment input during construction, should provide a design life is similar to conventional pavements (~25yrs).

3.5.2 Infiltration Trench Maintenance

The proposed infiltration trench will primarily perform as a dispersion device to slow and disperse stormwater flow, reducing the erosion potential of the foreshore during rainfall events. The trench is to be located downstream of the proposed turf cells, and sediment loading is expected therefore to be low and limited to windblown particles.

The trench should be designed to minimise clogging from surrounding soils, and to overflow during major storms. Installation should follow industry best practice and ensure sediment does not enter the trench during construction. An appropriately selected geo-textile fabric should surround the trench (such as Bidim A24), and the trench should be filled with ~40mm washed no-fines aggregate. A slotted observation well with a removable cap or grate should be installed from ground level to the base of the trench.

Following installation of the trench in accordance with industry best practice, maintenance requirements will be limited to annual visual inspections of the area around the trench and of the observation well, to ensure the trench is free-draining. Visual inspections should also be undertaken 3-5 days after major rainfall events.

3.5.3 Stormwater Pit Maintenance

The proposed stormwater pits within the carpark shall be fitted with filter inserts to collect sediment, litter, hydrocarbons oils and greases. The filter inserts will serve to reduce the pollutant load entering the lake to Lake Macquarie City Council standards or above. Filter inserts appropriate for this application include the 'Enviropod Catchpit Filter' and the 'Ecosol RSF 100', and will be fully specific at Construction Certificate stage.

It is recommended that the proposed stormwater pits and filters be regularly monitored for the first 12 months of installation, to determine an appropriate cleaning regime for the site. Typically, inspection and cleaning should be undertaken monthly, and also after large rainfall events. Filter inserts are likely to require replacement after 5 years, however this is dependent on the insert selected, the pollutant loading, local weather patterns and the cleaning regime. The proposed pits are intended to be located such that they will be readily accessible for monitoring of the filters, and for cleaning out either manually or via an eductor truck.

4 Hazard Management & Mitigation

4.1 Coastal Processes

DGR 7.1 "Address coastal hazards and the provisions of the Coastline Management Manual. In particular, consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms".

The NSW Government's 'Coastline Management Manual' provides guidance on identification and management of coastal hazards to development, and guidance on protection and enhancement of coastal ecological and recreational amenity.

Assessment of existing site conditions and the proposed redevelopment with consideration to the Coastline Management Manual has been undertaken. The concept designs for the redevelopment works have been developed with consideration of coastal processes, and the guidance provided by the NSW Government's 'Coastline Management Manual'.

Potential hazards due to coastal processes are identified in Section 4.1.1 below, together with proposed strategies to manage and minimise their impact. Potential opportunities to protect and enhance the ecological and recreational amenity of the site are explored in Section 4.1.2.

4.1.1 Coastal Hazards & Management

Identified coastal hazards due to the location of the existing and proposed redevelopment works include:

- Wave action (including increases due to climate change)
- Wind action (including increases due to climate change)
- Lake level rise (due to sea level rise due to climate change)
- Flooding
- Coastline erosion
- Corrosion

Management strategies to mitigate impacts from the identified hazards can be readily implemented for the proposed redevelopment, and will include:

- Provision of hydrodynamically modelled 'wave skirts' along the marina structure in accordance with AS3962:2001, similar to those currently in place along the existing marina structure, to attenuate and control wave heights within the marina. Hydrodynamic modelling undertaken for the project by Econalysis indicates wave actions (including increases due to climate change) will be within acceptable criteria for the proposed marina structure and clubhouse.

- Design of the marina, clubhouse and carpark extension to appropriate wind loading for coastal areas under Australian Standards.

- The proposed clubhouse finished ground floor level will be set above estimated peak 1 in 100 year flood levels for the lake (discussed in Section 4.2), with allowance for revision to flood levels due to sea (lake) level rise and other climate change impacts through the design of an adaptable floor structure.

- The proposed foreshore works will improve the stability of the existing shoreline, and provide improved protection against coastline erosion.

- The existing bitumen carpark is not currently subject to erosion, and the proposed extension to the carpark will be designed to ensure this integrity is maintained. The construction of a concrete edge beam and suspended slab structure supported by driven piles over the existing sloping rock wall improve the stability of the carpark edges without detracting from the wave dissipating role of the existing rock wall.

- Appropriate construction materials for coastal environments will be specified for the proposed works, in accordance with relevant Australian Standards and building codes to reduce the risk of corrosion.

4.1.2 Coastal Ecology & Recreational Amenity

Hydrodynamic modelling undertaken by Econalysis indicates there will be minimal change to hydrodynamic processes within Belmont Bay following the proposed redevelopment, resulting in no significant impact to sea-grass or other local marine life / habitat. The Flora and Fauna Impact Assessment undertaken by Ecotone Ecological Consultants for this project concludes that the proposed redevelopment will not have an adverse effect on the terrestrial or aquatic habitats at the site.

Potential adverse ecological impacts during construction can be adequately managed and mitigated, as outlined below:

- Demolition of the existing clubhouse will be undertaken using best practise methods. A Demolition Management Plan will be developed to reduce the risk of building materials entering the lake during demolition.

- Material stockpiles will be minimised and covered to reduce the risk of foreign material entering the lake.

- The marina structure will be constructed using best practise construction methods. Pilons will be driven or screwed to minimise disturbance to the lake bed.

- Sediment and erosion control measures including sediment fences, floating bunds and silt curtains and dust suppression will be implemented for the duration of works to minimise the risk of sediment entering the lake.

- Existing vegetation on the foreshore will be protected during construction.

Recreational amenity and the aesthetics of the area will be improved following the redevelopment works. The proposed foreshore works will transform the existing gravel area into a grassy parking area with a sealed driveway, with appropriate endemic landscaping and a new footpath to improve access and along the foreshore.

4.2 Flooding

DGR 7.5 "Provide an assessment of any flood risk on the site, taking into consideration any relevant Council requirements and the NSW Floodplain Development Manual (2005). This should include: determining flood hazard, the impact of flooding on the proposed development, the impact of the development on existing flood behaviour and the impact of flooding on the safety of people/users of the development".

The NSW Floodplain Development Manual provides guidance on the use, occupation and development of flood prone land. The intent of the NSW Government's Flood Prone Land Policy (on which the manual is based) is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land.

4.2.1 Flood Hazard & Risk

Flood hazard categorisation is based on a number of factors, including local flow hydraulics (particularly velocity / depth interactions), size of flood, effective warning time, flood readiness, rate of rise of flood waters, duration of flooding, evacuation problems, effective flood access, and type of development.

The proposed development, extending out over Lake Macquarie, has the potential to be flood affected. The existing clubhouse has been exposed to several extreme storm events which have resulted in flooding of some Lake Macquarie foreshore areas, (most recently June 2007), however, we understand the clubhouse has never been inundated.

The normal still water level for the lake has been adopted by Lake Macquarie City Council as 0.15m to the Australian Height Datum (AHD)[2]. The existing clubhouse ground floor is at a level of approximately 1.2m AHD. A ground floor level of 1.98m AHD has been proposed for the new clubhouse, following close consultation with Council and DECCW, and consideration of Council flood planning levels, wave action, storm surge and of the site specific nature of the development and its' need to relate to the lake water level. The proposed first floor level for the new clubhouse is 5.78m AHD. In the unlikely event of the ground floor level being inundated, flood refuge will be available on the first floor.

[2] Lake Macquarie City Council, Fact Sheet 12 – Environmental Facts and Issues, 01/09/2006.
Average lake surface level is 0.15m AHD. AHD 0.0m is the average sea level around Australia.

The existing bitumen carpark currently has surface levels in the order of 0.8m AHD to 1.2m AHD. The redevelopment proposal will maintain the carpark at similar levels to existing. Time to peak flood level for extreme flooding events within the lake is likely to be in the order of 48 hours[3], providing sufficient time for evacuation of the clubhouse and surrounds to higher ground. The carpark will support ample egress, for both pedestrians and vehicles, from the Club to Ada St and higher ground on the foreshore. A Flood Evacuation Plan for the proposed redevelopment is presented in Appendix D, indicating available egress routes and refuge areas.

Given that flood levels in extreme events are likely to rise slowly and peak with some 2-days notice, and considering the available egress to higher ground on the foreshore and the refuge available on the proposed clubhouse first floor, we believe the flood hazard category for the development is 'low', despite it's location on the edge of Lake Macquarie. In our opinion, the proposed redevelopment will not pose significant risk to users in the event of flooding, provided a formalised Flood Emergency Response Plan is administered by the Club. A preliminary Flood Emergency Response Plan for the site is provided in Appendix D.

4.2.2 Sea (Lake) Level Rise due to Climate Change

As noted, the proposed ground floor level for the new clubhouse is 1.98m AHD (denoted 'Proposed GFL' in Table 2 overleaf). This level is derived from the currently accepted 1 in 100yr ARI regional Lake Macquarie flood level, plus a 200mm freeboard for hydraulic modelling uncertainty[4], plus a 400mm allowance for wave action at the club (on advice from Econalysis). The determination of this floor level is the result of discussions with Lake Macquarie City Council Engineering and Planning staff and the Lake Macquarie Yacht Club Building Committee; and considers anecdotal observed flood heights during the 1974 and 2007 floods (where we understand, no flooding to the club occurred). Table 2 overleaf indicates the hydrologic and hydraulic factors considered relevant for determining the appropriate finished ground floor level for the new clubhouse.

[3] Data from the February 1990 Flood within Lake Macquarie, presented by Webb, McKeown & Associates in the Lake Macquarie Floodplain Management Study, October 2000.

[4] Lake Macquarie Flood Study Part 2 – Foreshore Flooding, Manly Hydraulics Laboratory, 1998

Table 2 – Finished Ground Floor Level (GFL) Considerations

Item	Description	Current Clubhouse GFL	Previous Policy 100yr Design Life	Current Policy 50yr Design Life	Current Policy 100yr Design Life	Proposed GFL
1	100yr Flood Level (as defined by the 1998 Lake Macquarie Flood Study)	-	1.38m	1.38	1.38	1.38
2	Freeboard (model uncertainty)	-	0.2m	0.2m	0.2m	0.2m
3	Freeboard (climate change uncertainty)	-	0.2m	0.2m	0.2m	-
4	Freeboard (wave action)	-	0.1m	0.1m	0.1m	-
5	Temporal increase in Rainfall Intensity (DECC estimates 30% increase by 2100)	-	-	0.10m	0.18m	-
6	Sea Level Rise (IPCC and CSIRO reports)	-	-	0.49m	0.99m	-
7	Discount for climate change uncertainty already included in Item 3 above.	-	-	-0.2m	-0.2m	-
8	Wave Action at Clubhouse	-	-	-	-	0.4m
	Minimum Habitable GFL (AHD)	**1.2m (approx)**	**1.88m**	**2.27m**	**2.85m**	**1.98m**

Notes:

a. The total magnitude of '**Wave action at Clubhouse**' is taken from advice provided by Econalysis for peak wave action at the clubhouse when considering wave attenuation from the marina

The existing and proposed clubhouses are intimately related to the lake surface level, given the activities and access required between the two. For this reason, an initial ground floor level which is lower than Council's current 50 year design life flood planning level is desired and proposed for the new clubhouse. However, to provide security against future sea (lake) level rise, given the current uncertainty in this area of science, and to ensure the intent of Council's current habitable floor level policy is still met, it is proposed the new clubhouse be designed and constructed with an adaptable ground floor, able to be raised in the future should lake levels rise over time due to climate change.

The proposed ground floor level of 1.98m AHD implicitly considers potential sea (lake) level rise due to climate change will be catered for by construction of an adaptable building, insofar as the clubhouse ground floor level, services, access and facilities will be designed to be incrementally raised over time to reflect rising lake levels, as required. Figure 5 below diagramatically presents the proposed adaptability of the ground floor level.

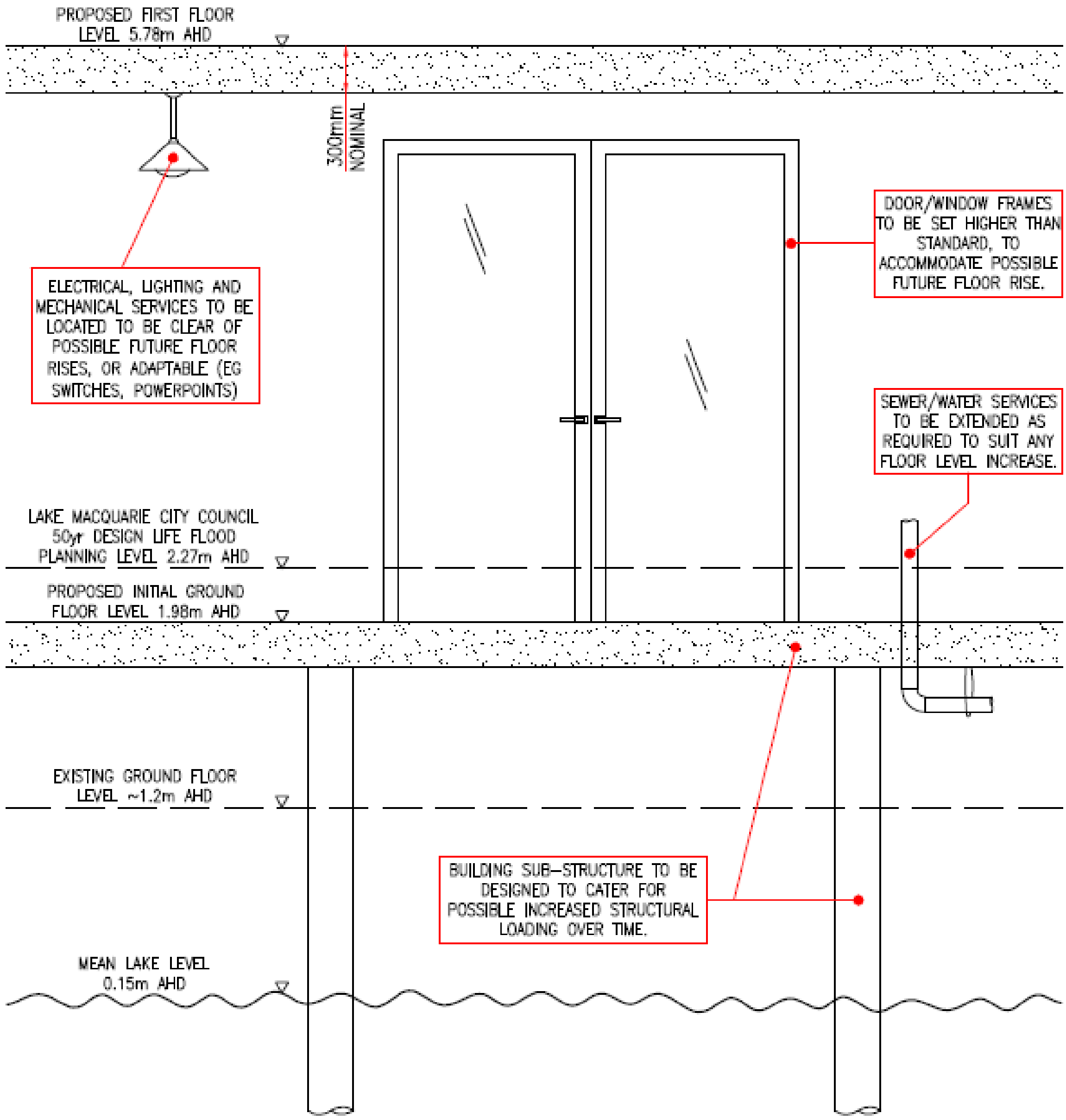

Figure 5 – Ground Floor Level Adaptability

Detailed design of the proposed new clubhouse and marina will include consideration of hydrostatic and dynamic pressures to ensure the integrity of the structures in the unlikely event of inundation. In the unlikely event of the proposed clubhouse becoming inundated, flood refuge will be available on the first floor of the building, however, timely evacuation of club patrons via Ada Street to higher ground would be readily achievable and a more likely course of action.

4.2.3 Impact on Existing Flood Behaviour

The proposed redevelopment is expected to have no significant impact on existing flood behaviour within the lake. This is discussed further in Section 4.3 below.

4.3 Filling

DGR 7.6 "Consider the potential impacts of any filling on the flood regime of the site and adjacent lands".

The proposed redevelopment works involve minor filling of up to 300mm in depth within the foreshore and bitumen carpark areas, potentially resulting in a minor loss of temporary floodplain storage in extreme flooding events. The Lake Macquarie Floodplain Management Study prepared by Webb, McKeown & Associates in October 2000 suggests that for land surrounding Lake Macquarie, the effect of a loss of temporary floodplain storage due to filling can be effectively ignored, as it represents such a small percentage of the total storage available. The Webb, McKeown & Associates study suggests the most significant impact of filling of land surrounding Lake Macquarie is likely to be the redirection of local runoff (say) onto adjoining properties. In the case of the Lake Macquarie Yacht Club, minor filling of the existing bitumen carpark will not alter the existing runoff regime as surface water will continue to be directed into the Lake. The foreshore works will be graded to fall toward the lake as per the existing regime. It is therefore considered that the minor filling associated with the proposed redevelopment will have no significant impact on existing flood behaviour within the Lake.

5 Noise & Air Quality Impacts

Construction activities proposed are very typical of domestic and marina construction and should not result in any significant noise or air quality impacts. Appropriate methods of construction will be adopted to minimise both noise pollution and dust creation.

5.1 Air Pollution

DGR 11.2 "Assess the impacts on air quality, including dust generation during construction activities and on-going boat maintenance and repairs".

Boat maintenance and repairs are not currently undertaken at the marina, and are not proposed as part of on-going operations following the redevelopment.

The site specific Sediment and Erosion Control Plan (Appendix C, drawing 'C01 DA'), and the project Construction Management Plan details appropriate strategies for management of dust during the construction phase. Dust suppression measures including stockpile covers and hand sprinklers will be employed as required, and exposed areas along the foreshore will be sealed and revegetated as soon as practical.

When complete, the proposed foreshore works will reduce the current potential for airborne dust, as the unsealed gravel carpark will be replaced with a sealed surface and landscaping.

Construction methods and machinery will be selected to minimise potential air pollution. Machinery will be monitored to ensure good working order is maintained, reducing the potential for air pollution due to oil / petrol or exhaust fumes.

5.2 Noise Pollution

Construction noise will be managed in accordance with Council requirements and Australian Standard AS2436 'Guide to Noise Control on Construction, Maintenance and Demolition Sites' to minimise impacts on the amenity of the location. Noise from construction works will be monitored in accordance with the recommendations of the Noise Impact Assessment report prepared for the project by Reverb Acoustics.

A noise and vibration strategy detailing measures to be adopted to minimise the impact of the construction phase on the amenity of the locality will be developed in accordance with Council requirements and Australian Standard AS2436 'Guide to noise and vibration control on construction, demolition and maintenance site'. The strategy will consider:

- Statutory requirements
- Identification of potential noise & vibration sources
- Effect of noise on persons on site, including PPE requirements
- Potential for noise from the site to be a neighbourhood nuisance
- Survey and monitoring of noise and vibration levels before and during construction
- Identification and implementation of appropriate controls and mitigation measures, including at source controls, acoustic screens and enclosures
- Appropriate project supervision
- Timing of works
- Appropriate means of community relations and complaints resolution

Operation of the Club and marina facilities post redevelopment will be similar in nature to current operations. Noise generation from the site following the redevelopment is not expected to alter significantly from current levels.

6 Riparian / Foreshore Protection

DGR 12.1 "Provide details of all construction, clearing, draining, excavation and filling and consider likely impacts on the foreshore resulting from any works in terms of existing vegetation, sediment movement, water quality, hydraulic regime and stability of the seabed and bank".

DGR 12.2 "Provide details of design features and measures that can be incorporated to provide a riparian buffer and protect against long-term environmental impacts".

The proposed redevelopment works provide opportunity to enhance and improve water quality and foreshore ecology and stability. The completed works will result in an improved riparian buffer, and improved protection against long-term environmental impacts. As discussed in previous sections of this report, the proposed foreshore works include:

- Revegetation of the foreshore with endemic plants, and installation of reinforced turf areas to reduce the current erosion potential and improve water quality runoff;

- Construction of an aggregate filled infiltration trench to filter and treat stormwater runoff to improve the quality of both surface water runoff and water soaking into the ground water table. The trench will also provide for a dispersed release of stormwater runoff, further reducing the erosion potential of the shoreline;

- Reinforced turf cells and bitumen paving of the existing gravel parking area, to reduce sediment deposition into the lake;

- Construction of a new pedestrian footpath along the foreshore, reducing the potential for damage to revegetated areas and the shoreline.

The Flora and Fauna Impact Assessment prepared for this project by Ecotone Ecological Consultants concludes the proposed works *"will not have an adverse effect on the terrestrial or aquatic habitats at this site".*

Minor excavation and filling associated with the proposed foreshore carpark will be managed to minimise transportation of sediments during construction. As discussed in previous sections, best practise sediment and erosion control measures will be implemented during all phases of construction. Also as discussed in previous sections, the proposed foreshore works will improve water quality runoff into the lake. Reports prepared by Econalysis and Ecotone Ecological Consultants indicate the proposed foreshore works will not significantly impact the lakebed or hydrodynamic processes within the lake.

Works associated with the redevelopment of the clubhouse will have no significant impact on the foreshore or lakebed, and will have no significant impact on existing vegetation or the current hydraulic regime. The Hydrodynamic modelling undertaken by Econalysis and the Flora and Fauna Impact Assessment prepared by Ecotone Ecological Consultants for the project indicate works associated with the expansion of the marina structure will not impact the foreshore, and assert they will have no significant impact on either the lakebed, existing seagrass or hydraulic regime.

7 Marina Impacts

DGR 13.1 "Assess the impact of the marina extension, foreshore works and any proposed filling on the Lake's ecosystem and hydrodynamic processes, in particular Belmont Bay".

DGR 13.2 "Address the movement and accumulation of sea-grass wrack and other marine life/habitat and demonstrate minimal impact".

DGR 13.3 "Provide details of how the design of the marina structures/building will minimise shading of seagrass, transfer wave energy and creation of excess turbulence".

DGR 13.4 "Undertake an analysis of the impacts of marina operations, and resultant increase in vessel numbers and operations, on water quality, aquatic ecology and recreational amenity".

DGR 13.5 "Address potential environmental impacts from any extractive or dredging activity associated with the construction and on-going operation of the marina".

The proposed marina extension will be constructed to be similar in nature to the existing structure. The marina will be designed and constructed in accordance with Australian Standards including AS3962:2001 'Guidelines for design of marinas' and with consideration of DECC's 2007 publication 'Environmental Action for Marinas, Boatsheds and Slipways'.

Hydrodynamic modelling undertaken by Econalysis indicates the proposed marina extension will have no significant impact on existing hydrodynamic processes within Belmont Bay or the wider lake, including on seagrass wrack movement and accumulation.

Piles for the marina structure will be driven or screwed, to minimise disruption to the lakebed and minimise mobilisation of sediments. An appropriate sediment control plan will be implemented for the marina works, including floating bunds and submerged silt curtaining as required.

The Ecotone Ecological Consultants Seagrass Management Plan recommends seagrass situated in the locations of the proposed marina piles be transplanted to nearby appropriate locations, such as the denuded areas where the existing swing moorings are to be decommissioned. Ecotone Ecological Consultants Flora and Fauna Impact Assessment notes that the construction of the marina extension may improve water quality within the proposed marina bays to the point that seagrass percentage cover increases.

The proposed decking material for the marina extension will be appropriately selected to minimise shading of the seagrass below. Decking material shall be equivlant to the Fibregrate 'Rigidex II' which has been recently used on Lake Macquarie and has been approved by DECCW and LMCC. A 'wave skirt' similar in nature to the existing skirt will be installed along the marina extension to attenuate wave energy and minimise excess turbulence. Hydrodynamic modelling and assessment undertaken by Econalysis indicates the proposed wave skirt will not significantly impact on the lakebed or seagrass, whilst providing appropriate wave attenuation within the marina.

Marina operations following the redevelopment will be similar in nature to current marina operations. Whilst the marina extension will increase the number of 'wet berths' at the club, boats that currently use the swing moorings adjacent to the club will immediately fill many of these. This may result in a reduction of swing moorings in excess of the four proposed to be decommissioned as part of the redevelopment works, and provide an overall improvement in conditions for seagrass growth in the swing mooring locales. The Ecotone Ecological Consultants Flora and Fauna Impact Assessment for the project suggests that the construction of the proposed marina extension has the potential to result in an order of magnitude net increase in seagrass population, due to expected improvements in water quality / reduced turbidity.

No dredging of the lakebed is proposed in association with the proposed redevelopment. As discussed in Section 3.4 of this report, it is recommended a maintenance regime be established in partnership between Lake Macquarie Yacht Club and Lake Macquarie City Council, to remove seagrass wrack and sediment deposition at the Ada Street causeway. The adopted maintenance regime may result in minor dredging in this area, as recommended by the Econalysis hydrodynamic report. The Econalysis report indicates minor dredging beneath and adjacent to the existing causeway would improve self-flushing, and provide re-aeration of water deoxygenated by decomposing seagrass wrack.

As noted in Section 6, the Flora and Fauna Impact Assessment prepared for this project by Ecotone Ecological Consultants concludes the proposed works *"will not have an adverse effect on the terrestrial or aquatic habitats at this site"*.

8 Conclusions & Recommendations

As discussed in detail within this report, the engineering related requirements of the Director General for the proposed redevelopment of Lake Macquarie Yacht Club can be appropriately addressed, by adopting site appropriate construction methods and considered design of the proposed new elements to suit the local environs.

Based on our engineering assessment of the proposed redevelopment works, and on review of the modelling and assessment undertaken by the projects environmental consultants, we conclude that the proposed redevelopment of the foreshore, clubhouse and marina will not adversely impact water quality, ecology or amenity of the site, and should therefore be supported.

9 References

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APPENDIX A

Econalysis Hydrodynamic Processes Report

Investigation of hydrodynamic impacts of proposed extension to Lake Macquarie Yacht Club

Dr Brian Williams

Econalysis P/L
6 Paris Crescent,
Valentine, 2280.

Table of Contents

Executive Summary

This summary addresses five requirements of the Director-General of the Department of Planning, NSW for the Environmental assessment of MP 08-0045, 'P*roposed marina expansion at Lake Macquarie Yacht Club, 9 Ada St, Belmont*'.

The specific requirements addressed and their resolutions are summarised:

DGR *6.4* "I*mprove the maintenance and water flows through the causeway linking Ada Street to the Club's car park to alleviate ongoing problems of odour and seagrass accumulation.*"

Current system accumulates sediment at northern end due to stormwater outfall deposition. Present depth is approximately 0.5*m* at the centre rising to 0.1*m* at the edges, with a waterway area of approximately 3.0m^2. LMYC and Lake Macquarie City Council should negotiate a permanent maintenance dredging program to maintain a waterway area of 5m^2 (average depth of 0.5*m*).

DGR *7.1* "…. In particular consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms."

As demonstrated in Sections 3, 4 and 5, impacts of the proposal are not significant with respect to the adjacent coastline and passage of floating materials. Sea level rise will cause a small increase in lake mean and peak tidal levels above the new MSL. An approximate simulation indicates that for the 'average' tide, peaks will be 82.5*mm* higher due to increased range in the lake and tidal pumping. This will be additional to sea-level rise. Significant wave heights in extreme events will only increase marginally. Estimates of 1 in 50 year winds have been adjusted to allow for climate change.

DGR *13.1* "*Assess the impact of the marina extension, foreshore works and any proposed filling on the Lake's ecosystem and hydrodynamic processes, in particular Belmont Bay.*"

Hydrodynamic impacts are insignificant as demonstrated by dye patch advection and dispersion in Section 3. Reduced wave climate within the marina will reduce bottom stresses,

DGR *13.2* "*Address the movement and accumulation of sea-grass wrack and other marine life/habitat and demonstrate minimal impact.*"

Sea grass wrack movement will not change greatly because of the very similar advection, dispersion and shoreline wave climates demonstrated in Sections 3 and 4.

DGR *13.3* "*Provide details of how the marina structures/building will minimise shading of seagrass, transfer of wave energy and creation of excess turbulence*."

The changes in transfer of wave energy are clearly indicated in simulation outputs in Section 4. Aside from the immediate surrounds of the proposed marina, where reduction and diffraction of the wave field is evident, wave climate changes are small and generally supportive of biota requiring more sheltered environments.

Turbulence will be low within the new marina and wakes from local effects such as piles, will dissipate quickly in the low velocity fields.

1 Purpose and approach of investigation

This study was undertaken to determine the impacts of the proposed extension of the marina attached to the Lake Macquarie Yacht Club (LMYC). The investigation focussed on issues noted for address by the Director –General, but also includes other analyses thought by the author to be relevant to the environmental impact of the proposal.

The Director General's requirements will be referred to as DGR *section number*, e.g. DGR *7.1* etc. Superscripted numerals in the report indicate reference numbers in Section 6.

The particular requirements addressed here are:
DGR *6.4* "Improve the maintenance and water flows through the causeway linking Ada Street to the Club's car park to alleviate ongoing problems of odour and seagrass accumulation."
DGR *7.1* "…. In particular consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms."
DGR *13.1* "Assess the impact of the marina extension, foreshore works and any proposed filling on the Lake's ecosystem and hydrodynamic processes, in particular Belmont Bay."
DGR *13.2* "Address the movement and accumulation of sea-grass wrack and other marine life/habitat and demonstrate minimal impact."
DGR *13.3* "Provide details of how the marina structures/building will minimise shading of seagrass, transfer of wave energy and creation of excess turbulence."

DGR *6.4* is addressed with analysis and discussion in Section 2; a recommendation is made.

To support responses to the other requirements, extensive use was made of two computer models. Firstly, a hydrodynamic model, FVCOM [2-5] was used to simulate water motion, three-dimensional velocities and turbulence (mixing processes), under the driving forces of wind and tide, both for present depths and those under a nominal sea level rise. Simulation of spread of a tracer, which might be a pollutant, nutrients or a patch of seagrass wrack, demonstrated the effects of both time-averaged velocities and turbulent mixing processes. Secondly, a wave generation and propagation model, SWAN[1, 8, 9] was used to simulate the impact of the proposed marina extension on the propagation of waves near and to the shoreline in Belmont Bay. The modelling is discussed at length in Sections 4 and 5.

DGR 7.1 is discussed in Section 3. Mean lake level established under a 910*mm* increase in mean sea level (MSL) is estimated by modelling the increased channel fluxes arising from greater depths there. Significant wave heights are generated for the existing marina and the proposed marina and presented graphically to demonstrate the marginal effect of the proposed extension. Wave climates are also shown under increased water levels in the lake due to climate change, with the wind magnitudes increased by 7.5% in accordance with the high range estimate from CSIRO. Changes to coastal erosion would be negligibly small.

DGR *13.1* is discussed in Section 4. Foreshore works are not proposed to extend below the shoreline and so will not impact on hydrodynamic processes. Impacts on the ecosystem of foreshore works and proposed filling are discussed by others as part of the Environmental Assessment for this project.
The tracer movement before and after the proposed extension together with a consideration of wave motion to the shoreline was used to assess likely impacts on wrack and other marine life/habitat movement and accumulation to meet DGR *13.2*.

The issues of DGR *13.3* , namely transfer of wave energy and ‘creation of excess turbulence’ are addressed in Section 3 along with the wave climate simulations undertaken using SWAN described in Section 5.

2 Ada St Causeway

DGR *6.4 "Improve the maintenance and water flows through the causeway linking Ada Street to the Club's car park to alleviate ongoing problems of odour and seagrass accumulation."*

The causeway at present is approximately trapezoidal in section, measuring 500*mm* at its deepest and roughly 100*mm* at the edges. It is 20*m* wide and approximately 40*m* long. Flow through the causeway is strongly influenced by wind, so an order of magnitude calculation is presented here under a light NW wind. It must be appreciated that flows under tidal influence alone are an order of magnitude smaller and in lengthy non-windy periods, near-stagnant water is inevitable, regardless of any modifications to the causeway.

FVCOM simulations (Figure 2), show that under a NW wind at 4*m/s,* velocities of around 0.04*m/s* are sustained from the northern end of the causeway around the car park fill to the southern end of the causeway, a distance of around 350*m*. If we assume a steady flow, Manning roughness of 0.1, average depth of around 2*m*, we can use the Manning equation to estimate the head difference from one end of the causeway to the other (as modelled with no flow through it).

The result is :

$$h = (\frac{v \times n \times L^{0.5}}{R^{2/3}})^2 = (\frac{0.04 \times 0.1 \times 350^{0.5}}{2^{2/3}})^2 = 2.2mm$$

If we now use this head difference in the Manning equation along the length of the causeway channel, we can get a rough estimate of discharge through the channel.

$$Q = A\frac{1}{n}R^{2/3}S^{1/2} = 6\frac{1}{.1}2^{2/3}(\frac{0.0022}{40})^{1/2} = 0.707\, m^3/s.$$

This value needs to be seen in the context of the wider flow field, where if one took a width of 40*m* (arbitrary), depth of 2*m* and velocity of 0.04*m/s*, we arrive at a flow of 3.2m^3/s. In this situation, the contribution of the causeway to a 40*m* square box at the southern end of the causeway, would be about 20%. If one takes a slightly larger box, the percentage decreases; or with a smaller box, the percentage increases. The causeway ensures some flushing will occur in the dead corner where the car-park would otherwise abut the shoreline. The reduced velocities in the corner are easily seen in any of the velocity plots.

The effect of the causeway is useful, but it would be difficult to argue that it would be worthwhile to expand it. In my opinion, accumulation of sea-grass wrack on the shore-line is unlikely to be greatly reduced by changes to the causeway. On the other hand, the causeway could be easily maintained to provide a significantly greater flow by regular dredging, thereby improving odour issues in otherwise nearly stagnant water.

The causeway channel's northern end is at present subject to sedimentation from a stormwater outlet, which is substantially reducing flow area. Within the length of the causeway itself, there is also a considerable depth of sediment. The causeway cross-section area could be nearly doubled by dredging the centre to 0.8*m* below MSL and the edges to 200*mm*. A geotechnical assessment may allow even further deepening. In any case, an assessment confirming good foundation condition should be made prior to commencement of dredging. Dredging would increase flow slightly more than proportionally to the area, i.e. almost doubling the effective flushing with the suggested dimensions, which should provide useful dilution and re-aeration of water de-oxygenated by decomposition of wrack.

Recommendation:

Given that sedimentation from the stormwater outlet is a major contributor to the maintenance problem, it is recommended that LMYC negotiate a permanent maintenance arrangement to dredge the causeway channelwith Lake Macquarie City Council.

3 Impacts of wind and wave action, coastal erosion and climate change

DGR *7.1* "*…. In particular consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms.*"

DGR *13.3* "*Provide details of how the marina structures/building will minimise shading of seagrass, transfer of wave energy and creation of excess turbulence.*"

An extensive series of simulations was undertaken to determine the impacts of the proposed extension on hydrodynamics and wave action. Simulations were carried out in both typical moderate wind situations and also for the 1 in 50 year wind, with sea level rise. An adjustment of 7% was made to estimates of the west and north-west winds in accordance with the estimates of CSIRO and BOM (http://www.climatechangeinaustralia.gov.au/technical_report.php Chapter 5) of likely increases in extreme winds. The 1 in 50 year wind, with sea level rise is the design condition for the marina and results in significant wave heights approaching the marina of 1.1*m* and within the marina of about 0.55*m* or less.

Sea level rise will also cause an increase in the lake's tidal prism and peak tidal elevations. Tidal pumping will increase the mean water level in the lake by about 40*mm* and increase in the tidal range will add a further 42*mm* to peak tidal elevations in 'average' conditions. This additional 82*mm* will be additional to sea level rise itself. Details of these calculations and simulations are presented in Section 4.3.

Sea level rise and the associated increase in depths in the lake appear to have only a small impact on the wave climate. There are only small increases in significant wave height evident in the comparative simulations. The reader should note that the over-riding proviso is that this investigation did not seek to determine run-up or other impacts beyond the existing shoreline and the focus was on the differential impact in the water due to the proposed marina. Shoreline run-up has not been modelled and clearly there will be major impacts on low-lying shorelines, not so much because of any increase in the height of the waves, but rather because of increased mean levels.

The wave field is distorted at the marina by the wave skirt's attenuating capacity, and causes reflection and diffraction around the corners of the marina, but at the shoreline, where potentially erosion may occur or seagrass wrack accumulate, there is no measurable difference in the wave climate, when compared with simulations of the existing system.

The wave climate within the proposed marina, limited to 0.6*m* will reduce resuspension of sediments and this would improve light transmission in that area under windy conditions. Bottom stresses due to wave action would also generally be reduced, increasing potential for the establishment of seagrasses within the bounds of the proposed marina and as is evident in the existing marina.

The design of the wave skirt, in particular the substantial gap beneath the skirts, will allow reasonably free flow through the system with minimal turbulence derived from the skirt itself, apart from the immediate small scale wakes imposed by the gaps in the skirt. These are well above the benthic system and will not cause bottom disturbance. Turbulent wakes shed from piles are inevitable, but at the generally very low velocities are also unlikely to cause scouring beyond the immediate vicinity (1 metre) of the pile.

Details of the proposal for the wave attenuation skirt and examples of the wave climate simulations are presented in Section 5.

4 Hydrodynamic simulations – changes in currents and mixing processes

4.1 Introduction

This section addresses the following DGR's:

DGR *13.1* "Assess the impact of the marina extension, foreshore works and any proposed filling on the Lake's ecosystem and hydrodynamic processes, in particular Belmont Bay."

DGR *13.2* "Address the movement and accumulation of sea-grass wrack and other marine life/habitat and demonstrate minimal impact."

The simulations described in this section demonstrate that there will be negligibly small impacts on advection and dispersion of buoyant materials and solutes contained in wind and tide driven flows. There will be some resistance to flows into and within the marina but this has been minimised by focussing wave attenuation on the western side of the marina, which is parallel to the major flow directions which are north-south, parallel to the shore as is evident in the flow velocity plots in Figure 2 - Figure 7.

Simulations of 'computational dye' advection and dispersion capture both differences in velocities and turbulent mixing processes and Figure 9 - Figure 19 clearly demonstrate the negligibly small differences in hydrodynamic process brought about by the proposed marina. These simulations provide clear predictions of unchanged movement of sea-grass wrack and together with the unchanged shoreline wave-climate suggest that changes in sea-grass wrack would not be measurable.

The remainder of Section 3 describes the computer model in Section 4.2, its calibration and sea-level rise effects on tidal movement in Section 4.3 and the analysis of resistance of the wave skirt and piles in Section 4.4. Section 4.5 and Section 4.6 present extensive results of simulations.

4.2 The FVCOM model

A state-of-the-art unstructured grid, finite volume model called FVCOM was used for the hydrodynamic simulations [2-5]. Eighteen papers describing FVCOM and its use in oceanic and estuarine applications were published in high ranking journals in the period 2006-2008. Finite volume models guarantee conservation of mass and momentum, unlike finite element models, which cannot do so.

Unstructured grids allow complete flexibility in modelling topographic features. The triangulated grid used for the Lake Macquarie model is shown superimposed on the bathymetry in Figure 1.

FVCOM has the capacity to use either 'z' or σ-coordinates (bottom-following) in the vertical, but in this case σ -coordinates were used for the vertical dimension and five layers were used assuming no density stratification. The model is explicit and consequently constrained by the Courant stability condition and was run with a time step of 1.5 seconds for the external mode (surface wave) and 6 seconds for the internal mode (horizontal velocity distribution through a vertical section).

4.3 Marmong Point tidal range and estimates with sea level rise

A spin-up period of eight days was used with an M2 ('average') tide, resulting in tidal pumping raising the lake mean elevation about 50*mm* above mean Sea Level (MSL) which is typical of measured values. The tidal range at Marmong Point after eight days was 71mm. For the M2 component, the peak level is thus 85.5*mm* above current mean sea level. This is a similar order of magnitude to that determined in the Lake Macquarie Process Study, but because of subsequent dredging of the channel, no direct calibration is now possible without further substantial measurement of flows in the channel. The range is similar to current recordings of levels at Marmong Point.

In order to address DGR 7.1, the model was run with all depths increased by 910*mm* to simulate sea level rise. The expectation is that deeper water in Swansea Channel should allow larger volumes of water to exchange intertidally, increasing the range of tidal motion in the lake. In this case a tidal range of 116*mm* is reached after 10 days, with a mean level 110*mm* above mean (new) sea level. This results in an increased peak due to the M2 component of 168*mm* so that with the addition of the 910*mm* of sea level rise used here, tidal maximum level is raised by 910+168-85.5 = 992.5*mm*. It must be stressed that these are quite hypothetical numbers because a), the model is not properly calibrated, b), the model does not account for increases in waterway area and volumes due to flooding of formerly dry land and c), the sea level rise must still be considered quite speculative.

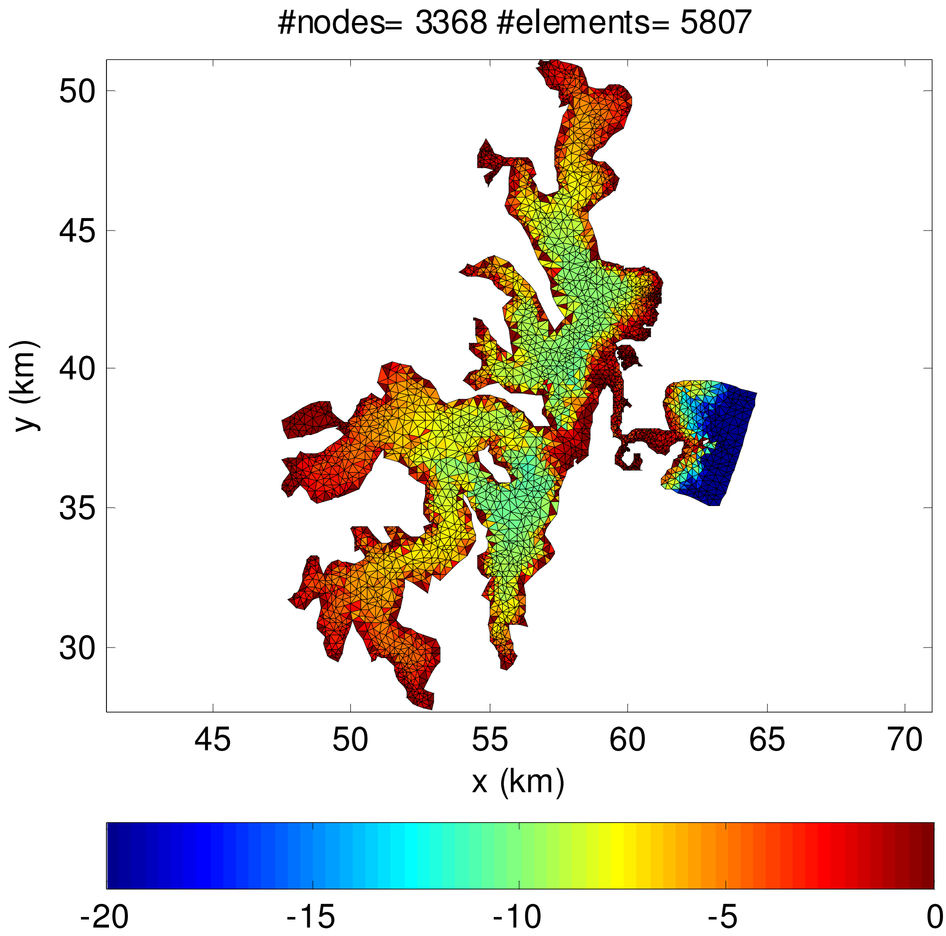

Figure 1 Finite volume mesh and bathymetry used in FVCOM simulations

4.4 Impact of wave attenuation skirt and piles on hydrodynamics.

During simulations, velocities in the piled area of LMYC are used to determine drag forces of both piles and wave skirt. These drag forces are then immediately distributed across the surface of the elements in the marina area as an equivalent opposing surface stress. This has been done for the existing conditions and also the proposed marina extension. Computational dye was added to a node upstream of the marina and its passage is shown in Figure 9 - Figure 19. Note that in all plots below, the grid is shown as the last 5 digits of AMG coordinates.

In all simulations, flows are essentially north-south as currents are driven largely parallel to the shoreline. In terms of change to flow patterns, the focus is on the impact of the skirts perpendicular to these currents, i.e. the northern and southern sides. In the next section, we see that wave action is principally perpendicular to the shoreline and wave attenuation is heavily concentrated in the western skirt.

The existing wave skirt consists of 200*mm* boards separated by 85*mm* gaps giving a 'porosity' of 85/2085 = 0.3. The boards extend 1200mm below the surface, in water which is about 3.3m deep. A drag force was computed by a momentum balance assuming that 40% of the water above the bottom of the skirt passed though it with unchanged velocity and the remainder passed underneath like a sluice gate. (Some acceleration would clearly take place in the gaps.) The analysis is very similar to that of a sluice gate and resulted in a force per unit width on the skirt of $0.7v^2$ *kN/m,* where, *v* is the water velocity. This acts on about 250*m* of skirt (both sides of the marina, i.e. entering and leaving marina), when approached from the south. There are around 430 piles of approximately 330*mm* diameter in typically 3.3*m* of water in the existing marina club-house system. The total drag force associated with these piles (assuming a drag coefficient of 1.0) is approximately $430 \times 1.0 \times 3.3 \times 0.33\ v^2 = 470\ v^2$ *kN.*

The total load was distributed over the entire marina area as a surface stress opposing flow. The pile forces should ideally be distributed through the depth, but the skirt forces are largely in the upper third of the depth. The load will be evenly distributed over about 9800m^2. Hence the opposing stress is about:

$((250*0.7+470)/9800)v^2 kPa$, i.e. $0.0735v^2$ kPa.

For wind-speeds (W) < 11*m/s*, a drag coefficient of 1.2E-3 is used in FVCOM
So that the stress is determined as $0.00144W^2$ Pa.

A similar analysis and simulation apply for the NW direction.

'Ball park' figures of wind velocity of 5*m/s* and water velocities of 0.01*m/s* give a wind stress of 0.036*Pa* and 0.00735*Pa* for the resistance, so that the resistance might effectively reduce the wind stress by about 25%. Where water velocities are up to .05m/s, opposing stresses are around 0.2*Pa*, equivalent to an opposing wind of around 12*m/s*. In tidal flows, the velocities are around half this value which leads to an opposing stress of around 0.002*Pa*, which is equivalent to that applied for a wind of around 1*m/s*. With these numbers, one would not expect large effects on advection and dispersion of material such as sea-grass wrack within the flow, and this is evident in the dye dispersion simulations presented in Section 4.6.

There will be approximately 350 new piles in the proposed marina extension and its 2-sided skirt length is about 216*m*. The area of the proposed marina extension is 13300m^2. The north and south sides of the proposed marina will have a skirt depth of 1.8m and 200mm boards spaced at 60mm centres. Using this data and the same analysis as above, the stress is determined to be $0.0543v^2$ *kPa*.

These coefficients were added to the model code, using actual water velocities generated in the model to simulate the resistance to flow of the existing and proposed pile and skirt systems.

Because the structure reduces currents and wave action, there will be reduced turbulence within it. Immediately adjacent to all flow obstacles, there will be turbulent wakes which under the very low velocities, will dissipate within a few metres.

The greatest fetch for the yacht club is from the south-west and there is also a significant fetch from the north-west. From Williamtown wind records winds of 4*m/s* from the north-west often persist for 12 hours, much less frequently from the south-west. These conditions drive currents into the LMYC which might reasonably demonstrate the effect of the proposed marina extension on dispersion of a tracer through the area and have been used in the simulations in Section 4.5 and 4.6.

4.5 Simulations of currents near the marina and proposed extension

It is easy to see the minor damping effect on currents which the proposed marina extension would produce. Figure 2 shows surface currents near the marina (marina and piled area shown in green) in the existing situation when a 4*m/s* NW wind has been blowing for 3 hours. Figure 3, shows surface currents near the marina in the same circumstances when the proposed marina, shown in magenta, is in place. Reduced water velocities within the extension are evident, but beyond the marina, distances of 1-200*m*, the velocity patterns are largely unchanged.

Figure 4 and Figure 5 show simulation outcomes for SW winds at 4*m/s*, with a similar scale of minor current damping effects in the area of the proposed marina extension. Figure 6 and Figure 7 show depth-averaged currents for the SW wind and it can be seen that the wind driven flows operate through the depth, not just at the surface in this case.

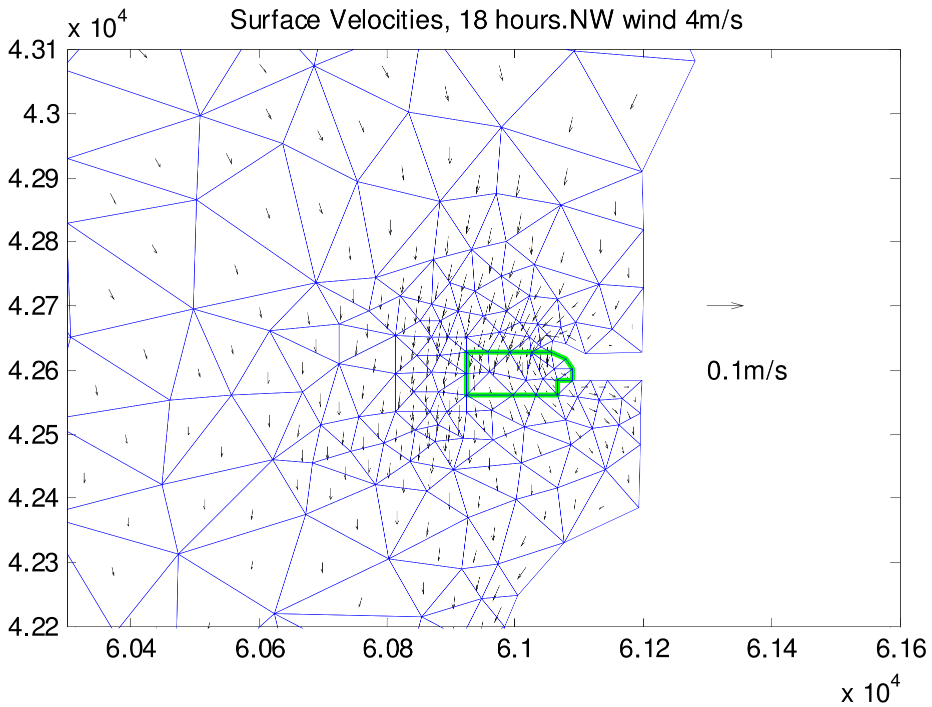

Figure 2 Velocity vectors under 4m/s NW wind near existing marina

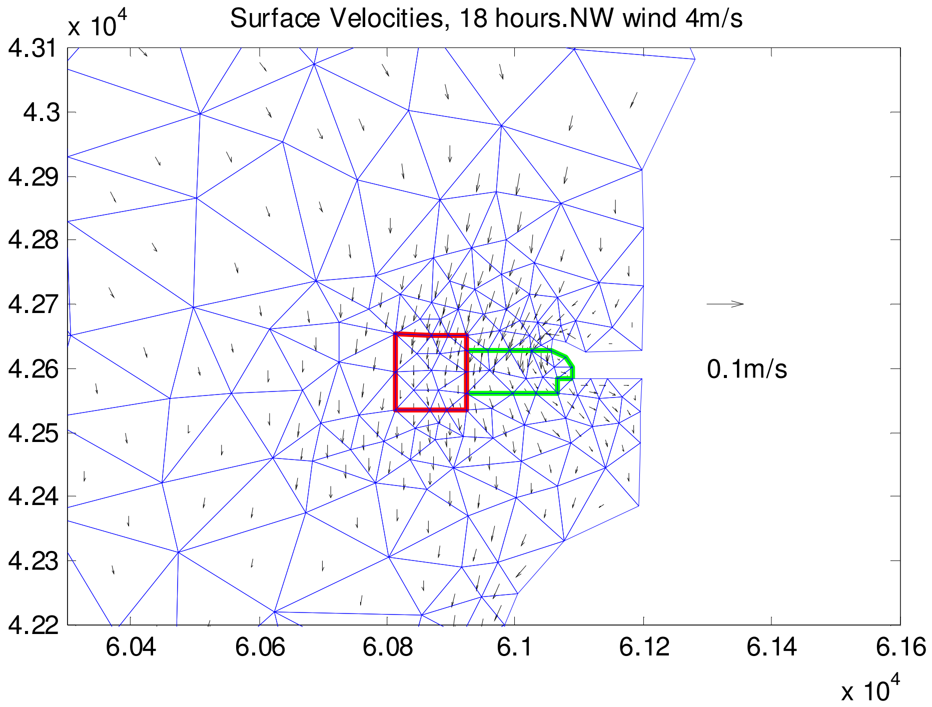

Figure 3 Velocity vectors in proposed marina area under a NW wind at 4m/s

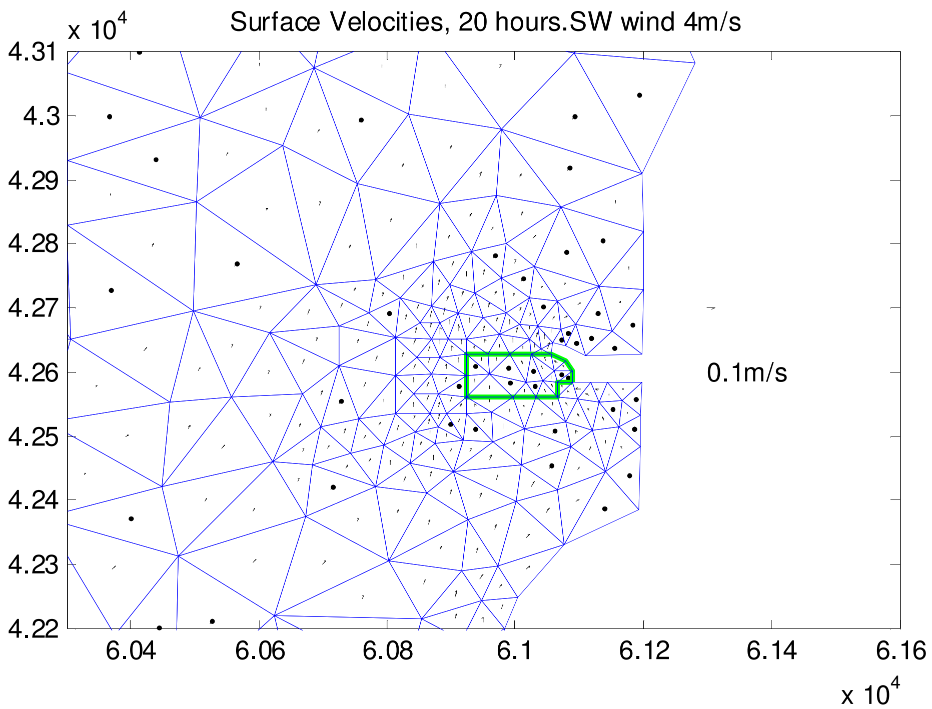

Figure 4 Velocity vectors through existing marina system - 4m/s SW wind.

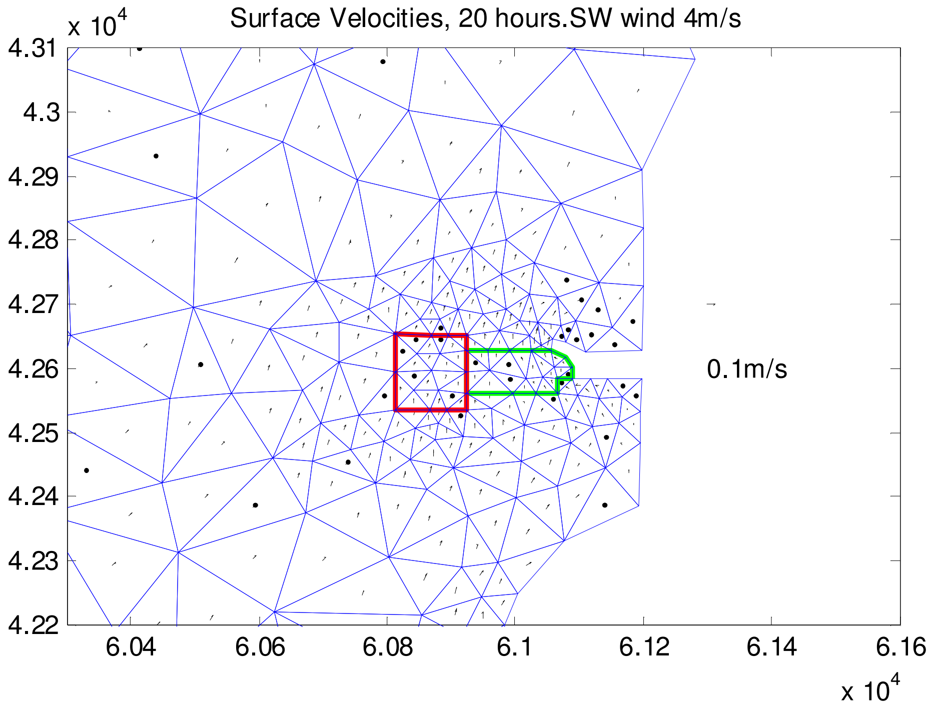

Figure 5 Surface velocities through proposed marina under 4m/s SW wind.

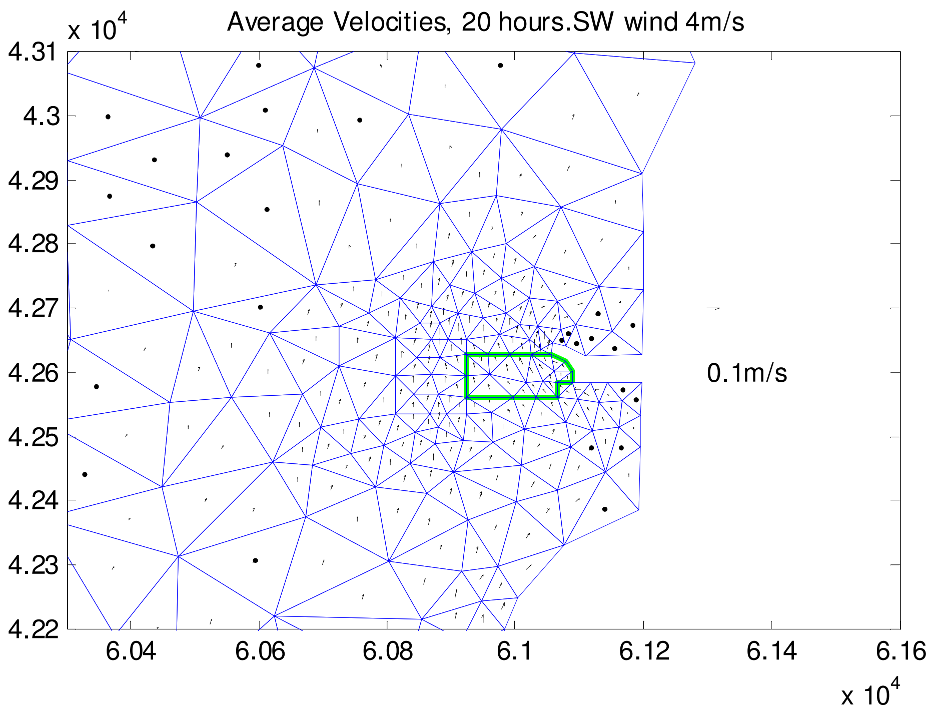

Figure 6 Depth averaged velocities in existing system, 4m/s SW wind

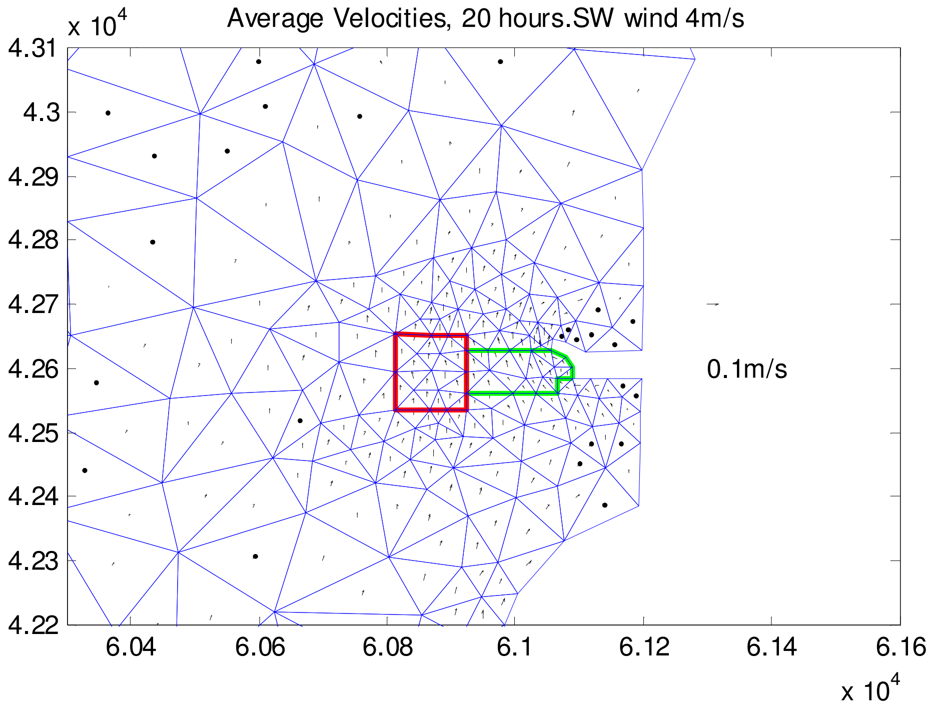

Figure 7 Depth-averaged velocities through proposed marina extension under 4m/s SW wind.

4.6 Plume advection and dispersion

The following simulations show the movement of neutrally suspended and dissolved materials by the water.

The existing car park and filled area is indicated with the heavy black line, the existing piled and wave protected area is indicated with the magenta line and the proposed marina extension is indicated by the red line.

Currents in Lake Macquarie are very small under tidal influence alone and most significant motion is wind driven. Figure 8 shows wind frequencies from an analysis of one-hour duration averages in the period 1989-2009. The NW wind is clearly dominant and for Belmont Bay has good fetch. The longest fetch into Belmont Bay is from the south-west, although winds from this direction are infrequent. These two directions have been chosen for simulations of advection and dispersion.

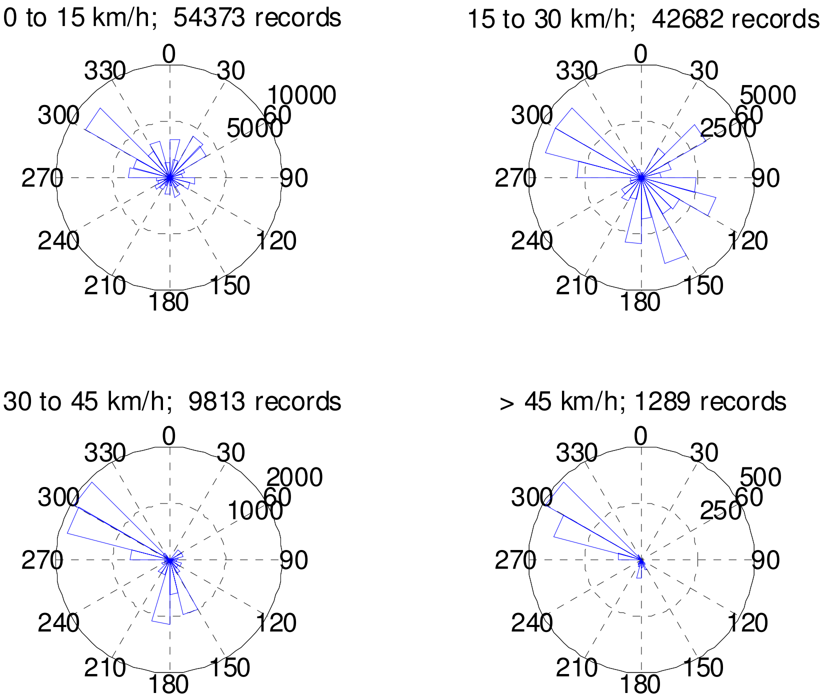

Figure 8: Wind roses for 1 hour integrated velocities at Williamtown, 1989-2009.

These simulations provide a good indication of the way seagrass wrack might move in these situations although wrack masses are cohesive and would not be expected to spread apart as much as the plumes shown here. Nevertheless, the very small general differences would certainly be maintained in wrack movement, and the simulations amply demonstrate that there will be little change in wrack movement in the hydrodynamic regime which would maintain under the proposal.

The first sequence (Figure 9 - Figure 13) is for two dye releases (just before time 18 hours in these simulations) south west of the marina in a typical 4*m/s* south westerly wind. Close inspection of the dye contours shows only very small differences, as one might expect from the velocity plots above. Mixing (turbulence) in the marina basins is reduced by the lowered velocities there, but the difference is difficult to detect in the plume contours.

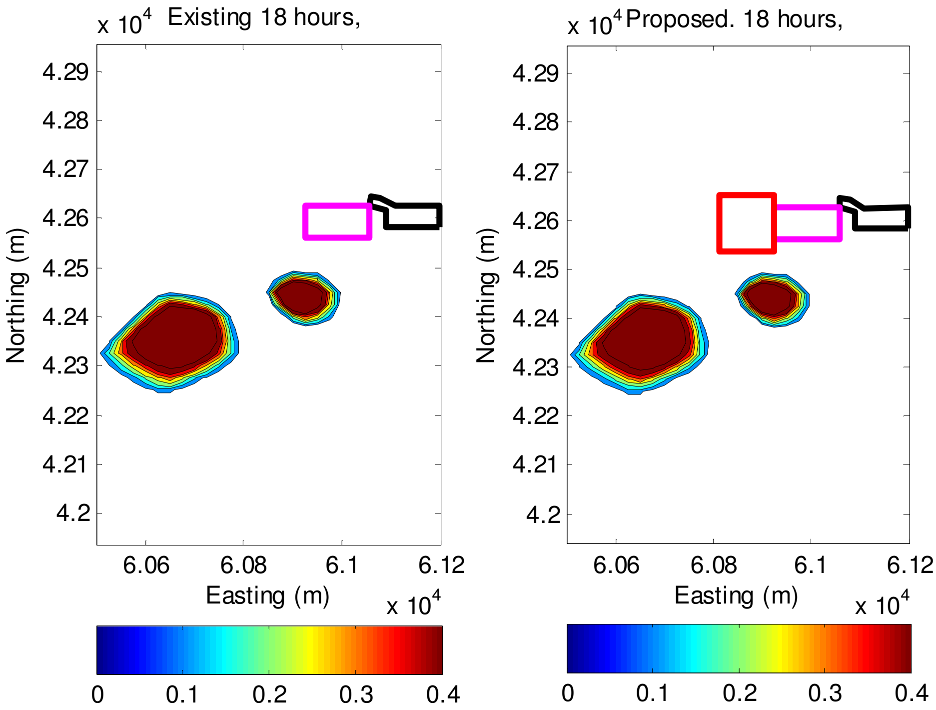

Figure 9 'Dye' plume shortly after release in 4m/s south-westerly wind.

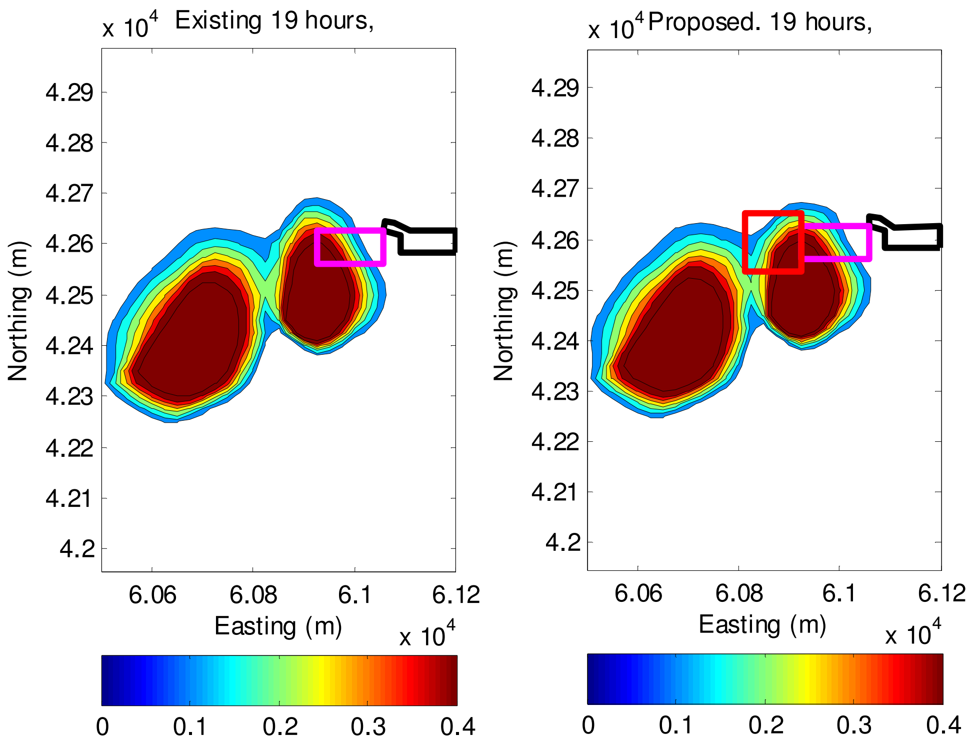

Figure 10 Plumes about 1 hour after initial release of the dye

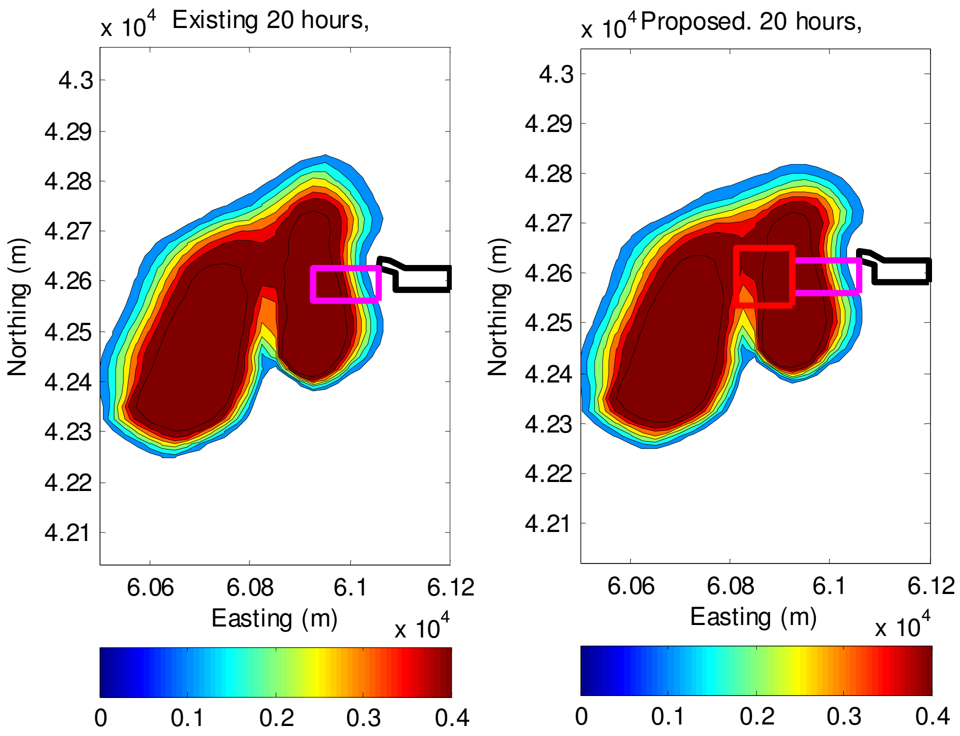

Figure 11 Dye plumes two hours after initiation in a 4m/s SW wind.

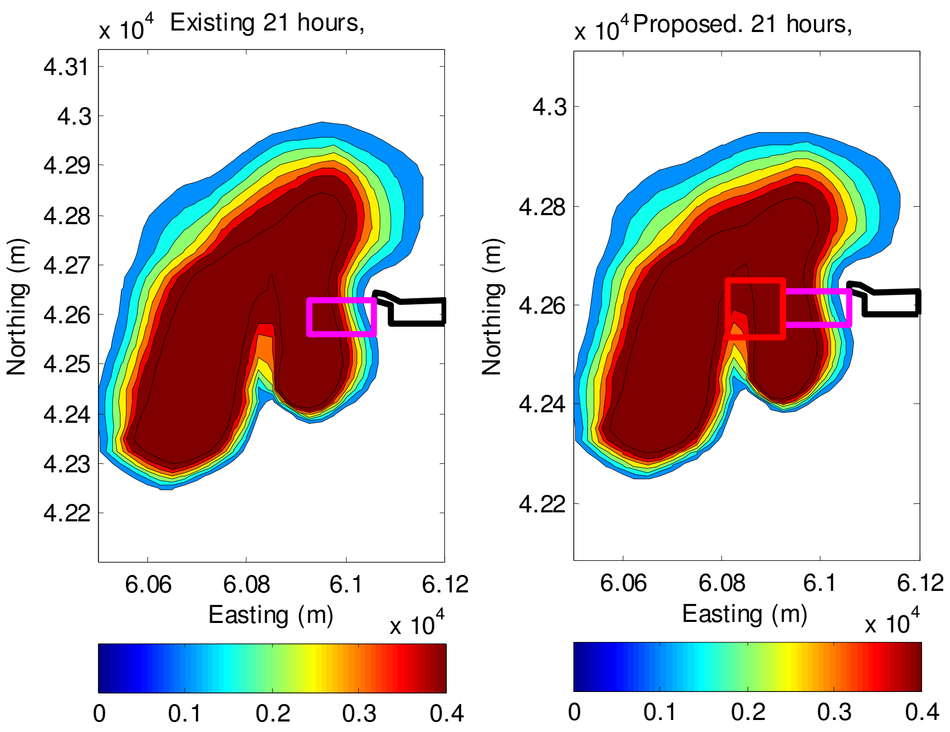

Figure 12 Plumes after 3 hours in a 4m/s SW wind.

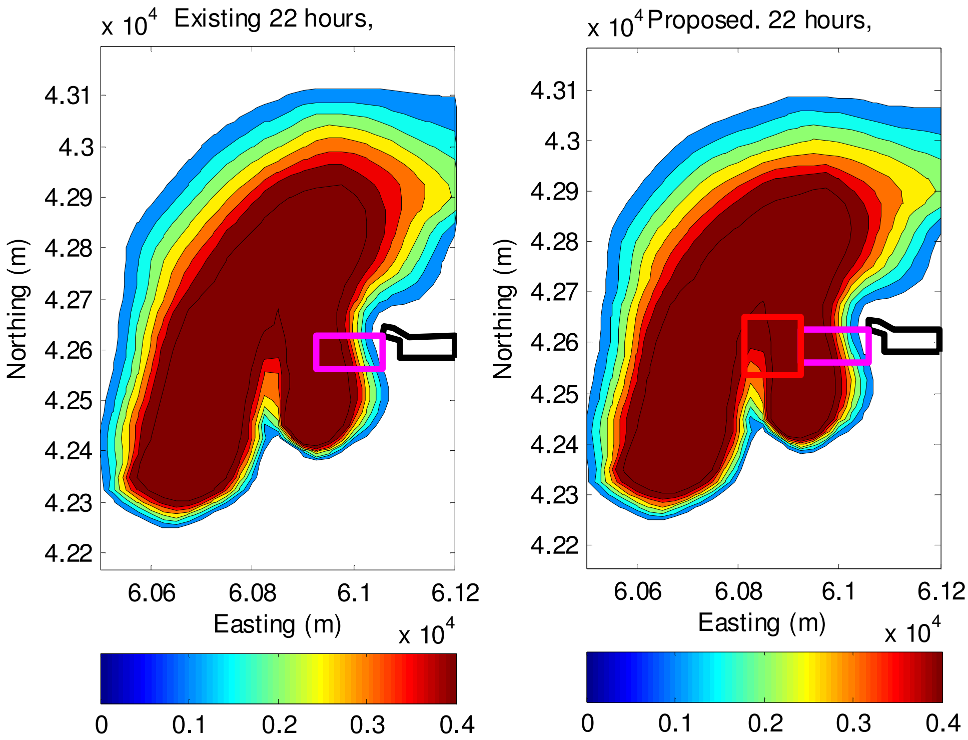

Figure 13 Plumes after 4 hours under SW wind 4m/s

In the next sequence, a NW wind at 4*m/s* drives currents around the north end of Belmont Bay and into the marina almost directly from the north as shown in Figure 14.

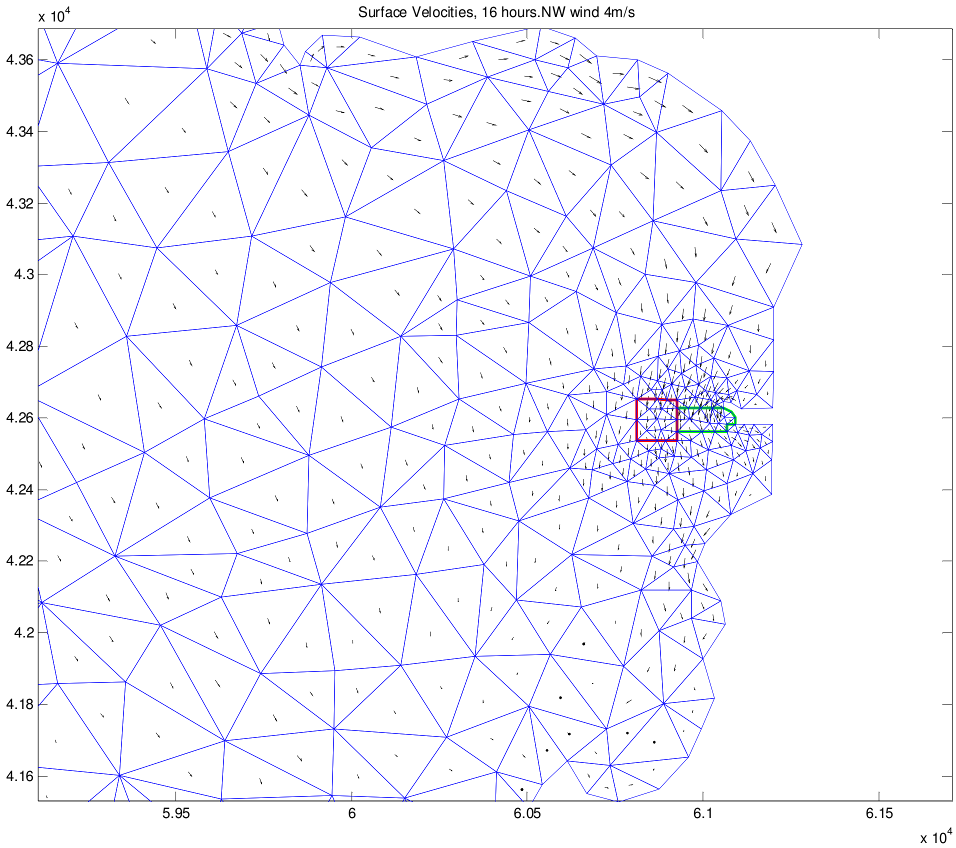

Figure 14 Belmont Bay velocities under a 4m/s NW wind

Once again it requires very careful observation to detect the differences in the dye fields. The impact of the new marina on mixing and flow is negligible and can be expected to have no discernible impact on wrack movement in the area, excepting situations where wrack is prevented from motion by the wave skirt itself. Indications at the existing skirt are that trapped wrack eventually simply falls to the bottom beneath the skirt where it decomposes.

In Section 5, SWAN simulations of wave regimes are undertaken. Wave action at the shoreline will ultimately have some impact on the deposition of wrack, though it is not currently possible to model this process accurately. The SWAN simulations will be seen to demonstrate, however, in much the same way as we have seen for the advection, dispersion simulations, that the proposed marina will have very little impact on waves outside the immediate area of the marina.

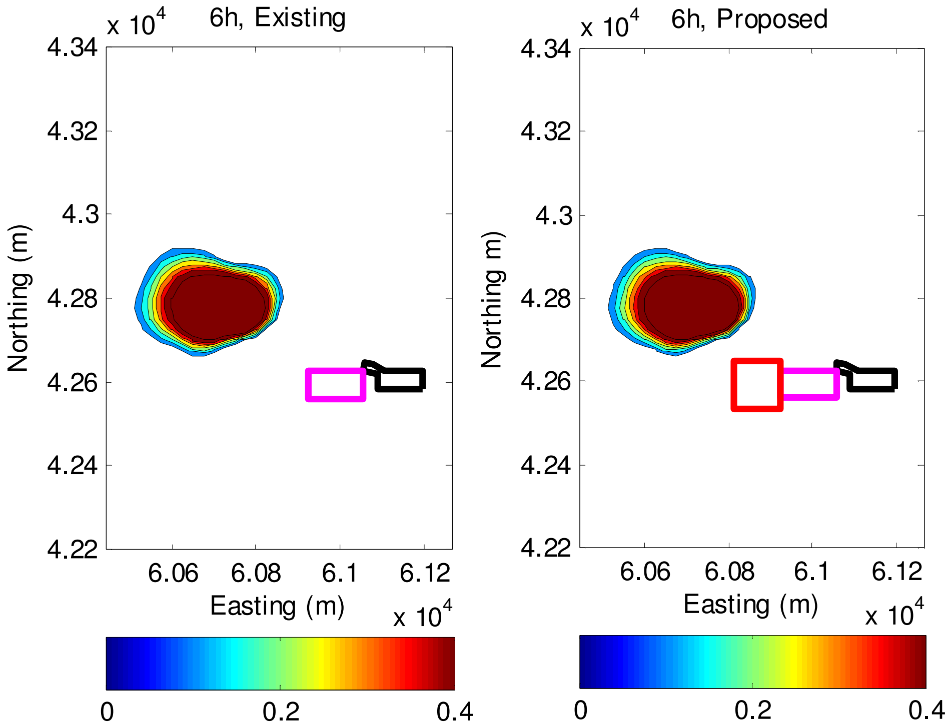

Figure 15 NW wind at 4m/s, surface dye concentration shortly after release at 6 hours

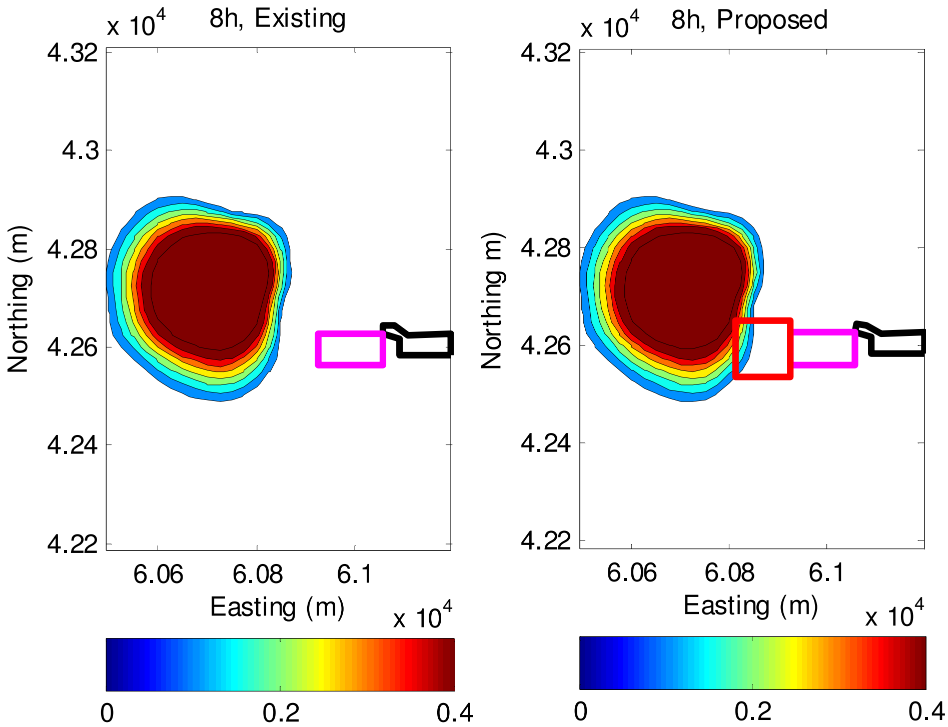

Figure 16 Plume under NW 4m/s wind, 8 hours (2 hours after release).

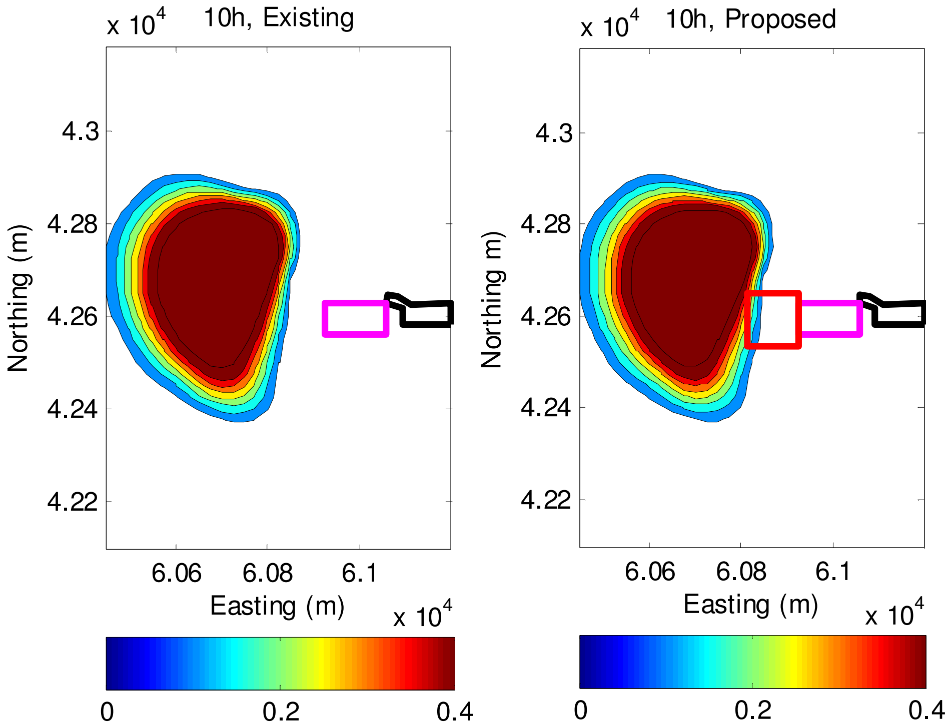

Figure 17 Plume under NW wind at 4m/s, 10 hours (4 hours after release)

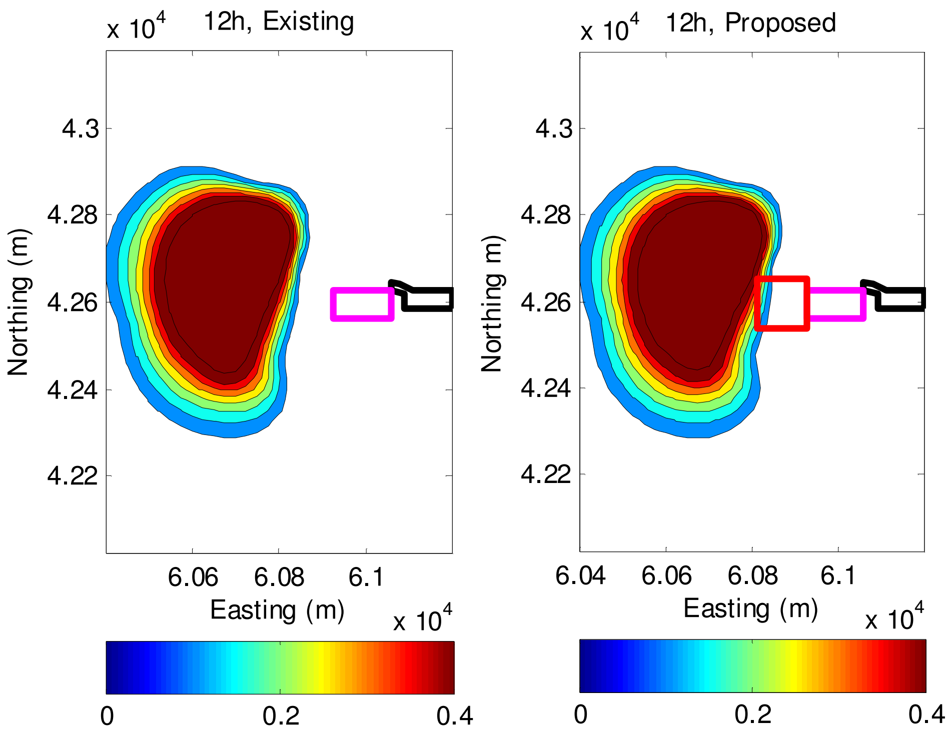

Figure 18 Dye plume under 4m/s NW wind 6 hours after release

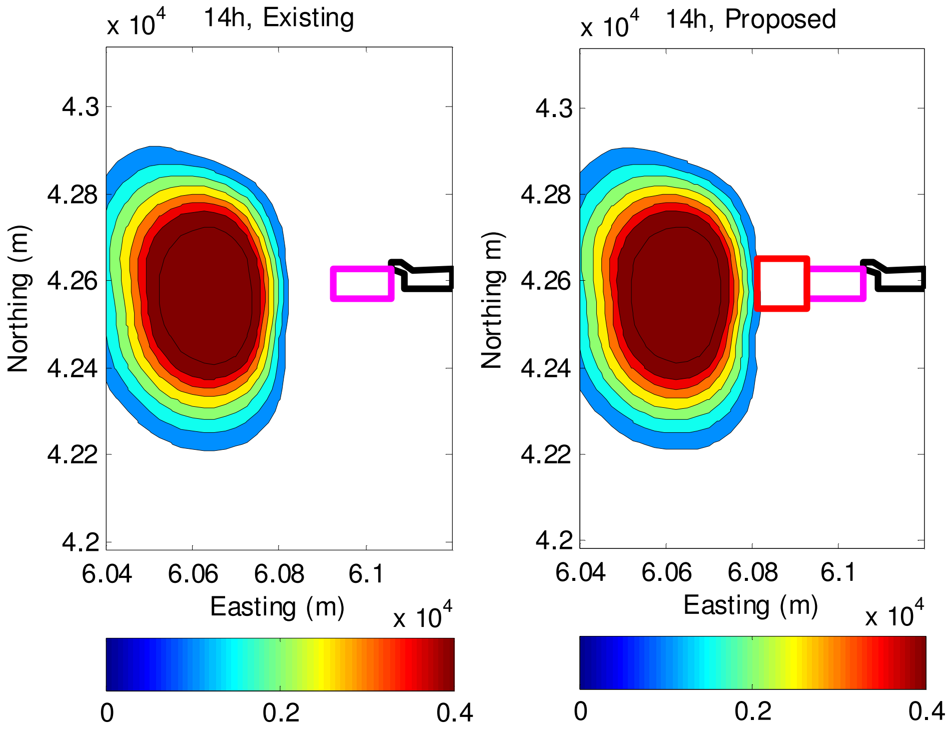

Figure 19 Dye plume under 4m/s NW wind 8 hours after release

5 Wave climate modelling – SWAN

SWAN[1, 8, 9] is probably the most widely used wave climate simulation model in the world. It is used as the basis for a number of commercial models and has been under development and continual use for more than 10 years. The model and its application are discussed in 28 references, mostly in high quality journals, listed on the SWAN website, www.swan.tudelft.nl.

In Section 5.1 the attenuation due to the wave skirts of the existing and the proposed marina are discussed.

In Section 5.2 impacts of the new marina on the general wave climate under moderate winds from the north-west and south west are shown to be negligible at the shore line and only significant immediately adjacent to and inside the marina. Simulations are shown in this section of significant wave heights, (H_s) generated in the existing marina system and its surrounds and then the effect of the proposal is shown for comparative purposes. Wave energy is proportional to the square of significant wave height, so that the latter can and has been used as a surrogate for energy.

In Section 5.3, design 1 in 50 year average recurrence interval (ARI) winds are applied to the lake with all depths increased by 910*mm* to address the impact of climate change.

5.1 Wave attenuation of the wave skirt

There is only a limited literature on analysis and experiments on breakwaters constructed as slotted vertical members and only the most recent deals with walls which do not penetrate to full depth. Gardner and Townsend [6] describe theoretical and experimental studies for full height screens and provide several formulae for wave transmission coefficients (ratio of wave height leaving barrier to the incoming wave height). The simplest formula is 1.25 times the ‘porosity’ of the wall, which is the width of the space between vertical slats divided by the sum of slat width and space width. In the present case with a slat width of 200*mm* and space of 85*mm*, the porosity is 0.3. and the transmission coefficient on this basis would be 0.37, which seems far too low. The other formulae seem equally unlikely to provide useful estimates.

Kriebel[7] described a design method for vertical slat walls with penetration of half the full depth or more. In fact his data suggest that penetration depths of 40% can provide similar outcomes. He provided charts which depend on the depth to wave length ratio, *d/L* and the porosity (the ratio of area of voids to total area) . If for the existing marina we assume a depth of 3.5*m* and wave length of 12*m*, the transmission coefficient computed using Kriebel’s deep draft chart for a porosity of 0.25 (allowing for piles and cross-members) is about 0.7.
The author observed waves of about 0.6*m* being attenuated to around 0.35*m* at the LMYC marina in a westerly in February. Given the rough agreement between this observation and the preceding estimate, for the purposes of this report a transmission factor of 0.7 is used for the existing marina.

The western skirt of the proposed marina is the most important in reducing wave action in the marina because most of the waves approach the marina from the west because of the bathymetry. Using Kriebel’s design chart, a skirt of 2.4*m* with porosity of 0.08, (200mm boards with 18mm gaps), at depth 5*m*, wave length 14*m*, gives a transmission coefficient of 0.5. This will reduce approaching waves of height 1.2m to the acceptable level of 0.6m within the basin.

The northern and southern skirts are not subject to such high direct wave impingement with waves approaching them at acute angles which significantly reduces transmission. No experimental results or analyses have been reported in the literature for partial depth, slotted wave skirts impacted by waves on a non-perpendicular approach. It is proposed that these skirts should be 1.8*m* deep with 200*mm* boards spaced with 60*mm* gaps. This is 600*mm* deeper than the existing skirts and the gaps between boards are 25*mm* less, giving a porosity of less than 0.22 when horizontal members and piles are taken into account. In these conditions waves perpendicular to the skirt would transmit about 72% of the wave height. The porosity can be seen to be effectively reduced by the projection of the 20*mm* board thickness for approaches at lesser angles; a 60 degree approach gives a porosity in this sense of 0.18 with which a transmission of 67% is associated and for a 40 degree approach, the projected porosity drops to 0.133 with transmission coefficient of 62%.
A transmission coefficient of 0.7 has been used in simulations with SWAN.

5.2 Moderate winds – comparison with existing and proposed structure

A large number of simulations were undertaken and representative ones are shown in this report. The directions of most interest (longest fetch and highest winds) were from the SW and NW and a velocity of 15m/s was used to represent moderate winds. The analysis of Sydney Airport data in the appendix shows that there is about a 70% chance in any one year of this velocity being exceeded by wind from the South West and a 60% chance from the North-West.

In the first two plots, Figure 20 and Figure 21, a SW wind at 15 m/s operates on the longest fetch and produces wave-heights in Belmont Bay in excess of 0.7*m*. The outer edge of the fill (car park) area is shown in a heavy black line, the existing piled and protected area is in magenta and the proposed extension is shown in red in the following plots.

It should be noted that the plots are interpolations of contours onto a 50m finite difference grid used in SWAN and there will be minor errors at scales less than 50m. In particular the wave attenuation at the western face of the new marina will occur over a distance of less than one metre as the wave passes through the skirt and the interpolation will be seen to occur over a much larger distance inside the marina. This effect is more evident with extreme wind conditions.

At the outer edge of the existing marina wave heights are between 0.5 and 0.6*m*, attenuated inside to about 0.4*m* and on the downwind side of the marina, there is also substantial reduction in wave height to about 0.4*m*.

The proposed extension would penetrate a zone of waves in excess of 0.6m and attenuate this, but perhaps more noticeably on the downwind side a much larger protected area is created reducing wave heights further north of the existing marina, in addition to the reductions now occurring behind (north of) the proposed marina. Despite these noticeable changes in moderately deep water, there is little if any evidence of change occurring at the shoreline, where the filled car-park area has the dominant effect along with bottom frictional effects in the much shallower water.

Figure 22 and Figure 23 show the wave climates for north-westerly winds with similar indications of insignificant impacts at the shoreline and reduced wave-heights within and immediately adjacent to the marina. All other simulations undertaken during the investigation show similar outcomes for moderate winds.

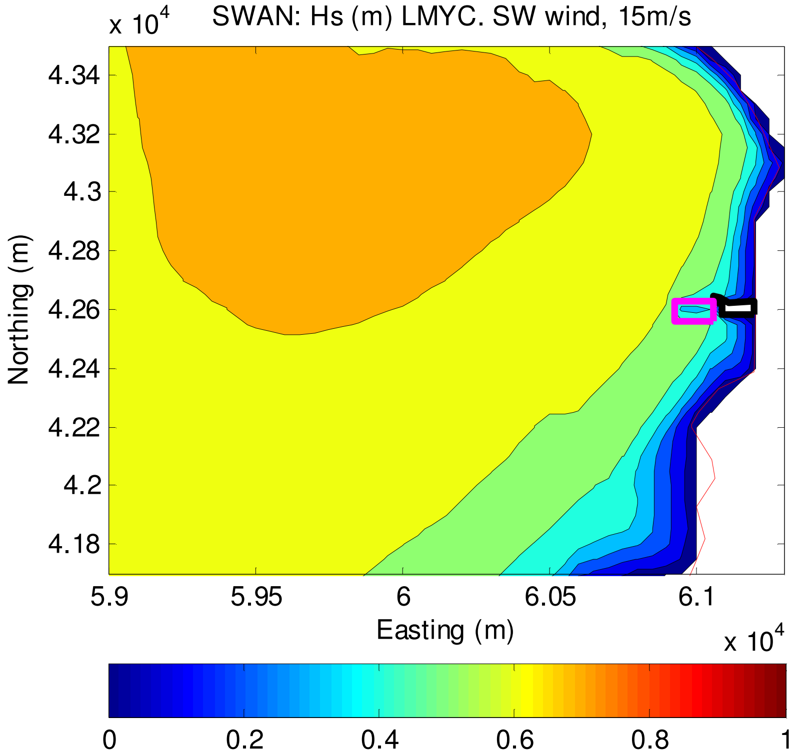

Figure 20 SWAN simulation of significant wave heights (H_s) for existing marina under 15*m/s* SW wind

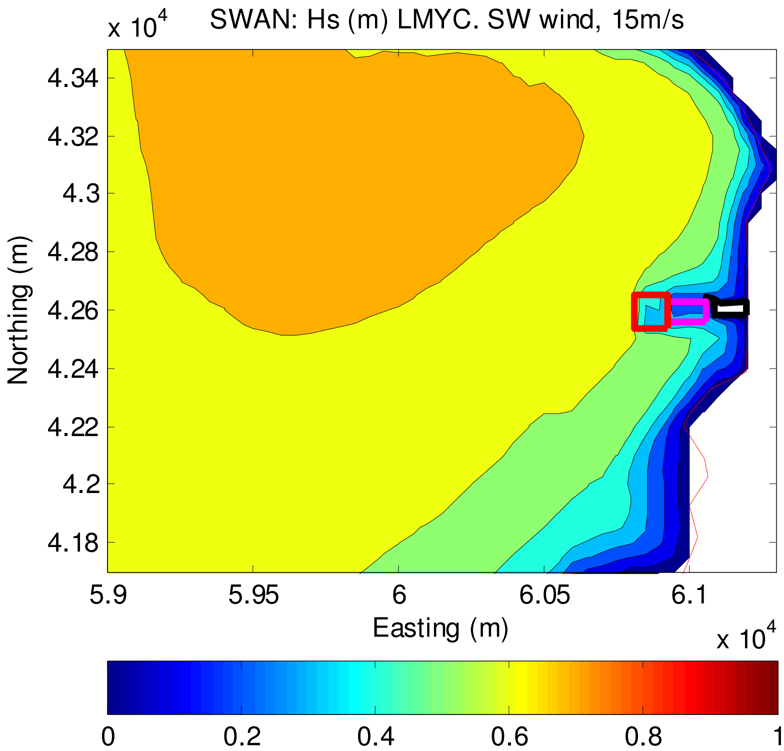

Figure 21 SWAN simulation of H_s for proposed marina extension under 15*m/s* SW wind

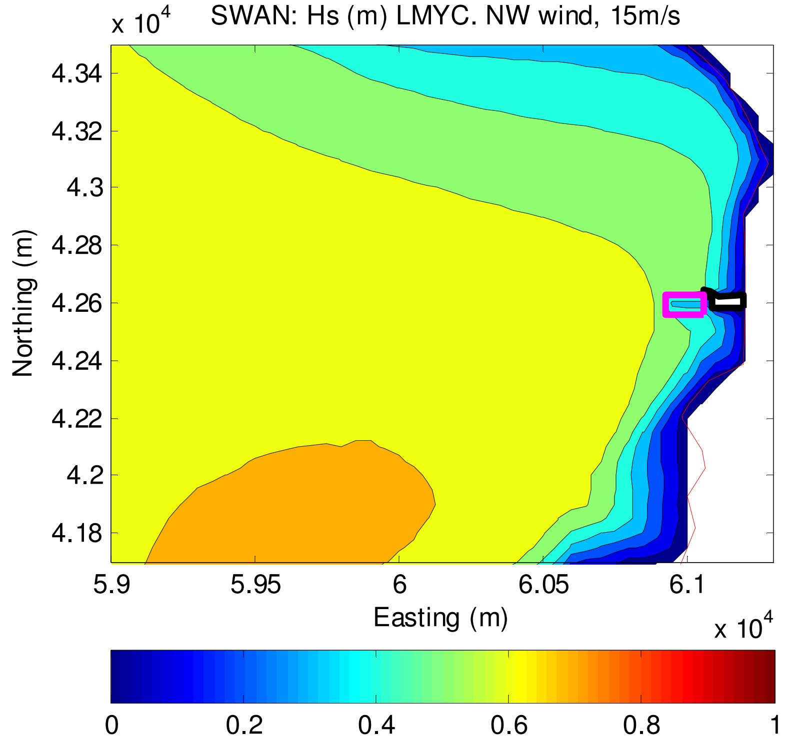

Figure 22: SWAN simulation of H_s for existing marina with 15*m/s* north-westerly wind

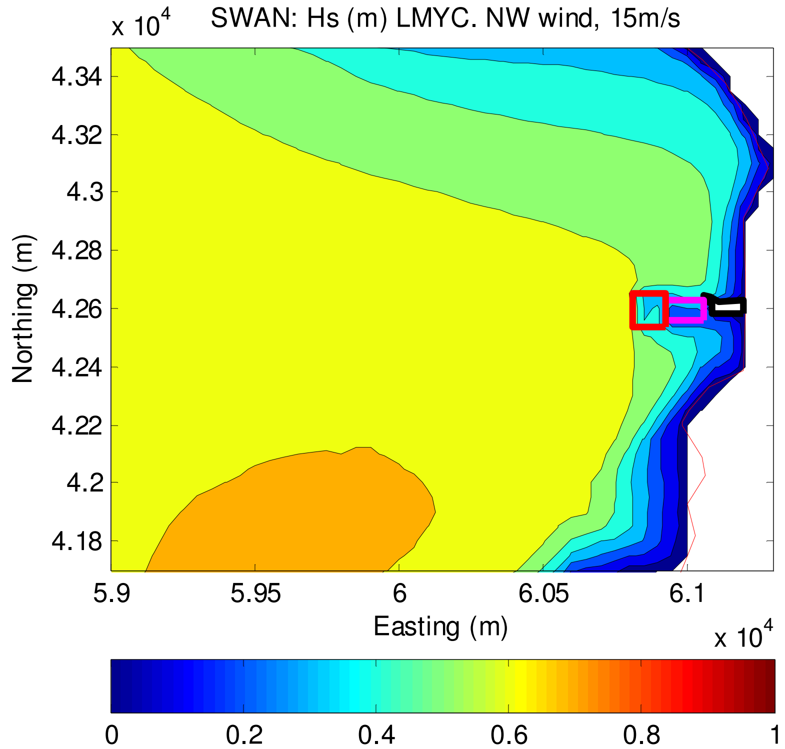

Figure 23 SWAN simulation of H_s for proposed marina extension with 15*m/s* north-westerly wind

5.3 Design 1 in 50 year winds with raised sea level

Climate change scenarios have been modelled by increasing the depth of all current wet points in the models by 0.91m. No adjustments have been made to the shoreline, so that the models do not show newly drowned areas. No adjustment was made to the transmission coefficient for the wave skirt, though it might be expected to increase marginally as its fraction of penetration increases and the solid beams supporting the decking are reached by waves. Given the wave heights at the outer edge of the proposed marina, there may also be some minor overtopping, which has not been modelled.

Wave climates under 1 in 50 year winds from the south, south-west, west and north-west are shown in Figure 24 - Figure 28 for the proposed marina using bathymetry increased by 910*mm* to simulate sea level rise. For comparison purposes, Figure 25 shows the impact of a 50 year ARI NW wind at present (2008) sea level. The outcomes show once again the additional sheltering effect of the proposed marina, but even in these extreme wind conditions, the effects do not impact significantly on shoreline conditions.

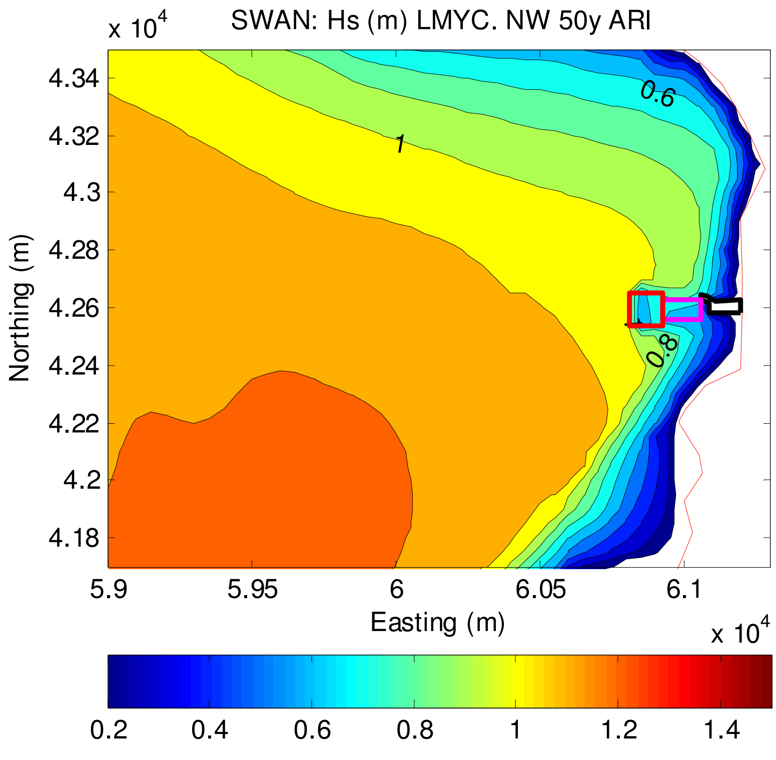

Figure 24: ARI 50 year NW wind with Sea Level Rise of 0.91m

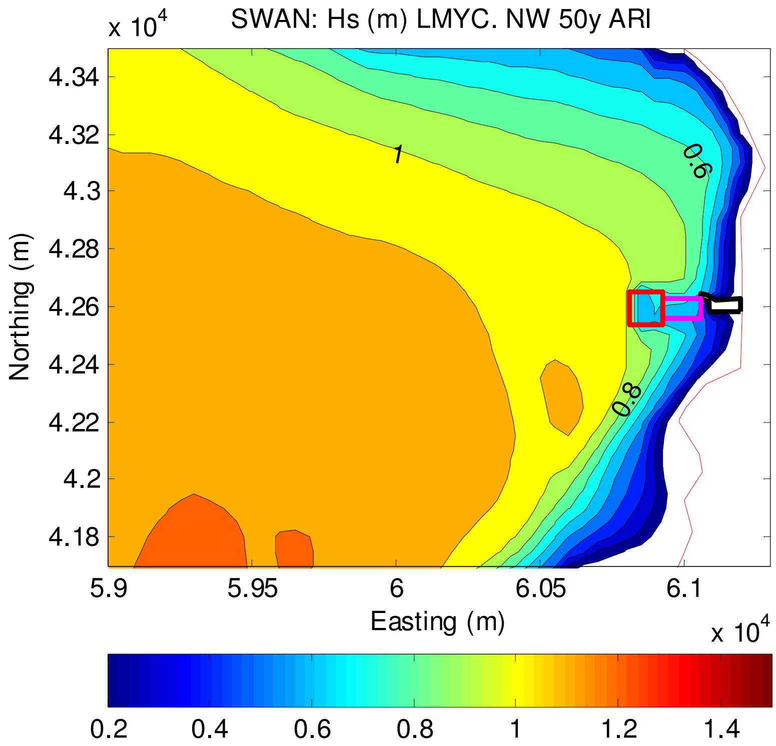

Figure 25 Design 50 Year ARI NW wind using present day bathymetry.

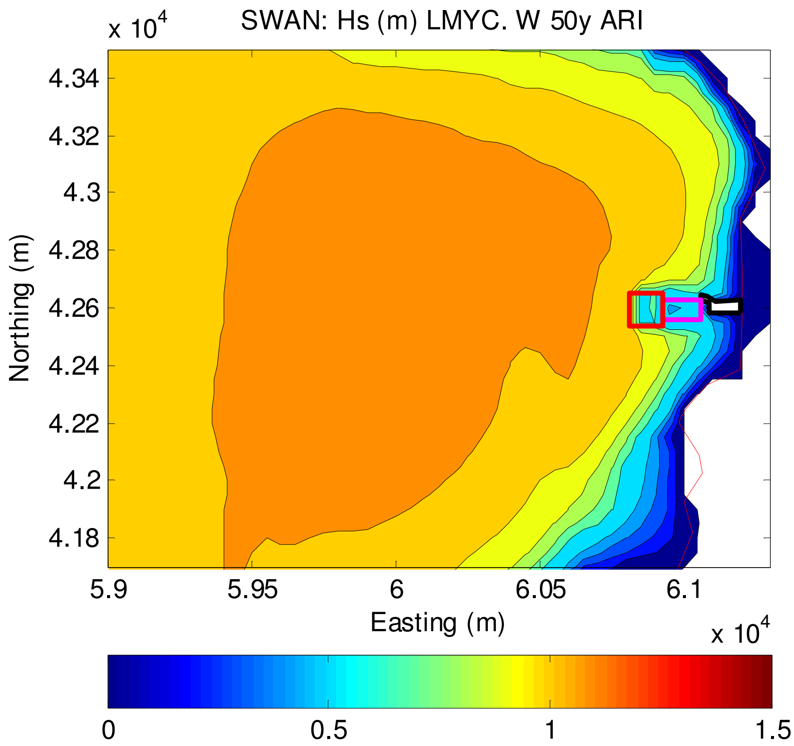

Figure 26: ARI 50 year W wind with Sea Level Rise of 0.91m

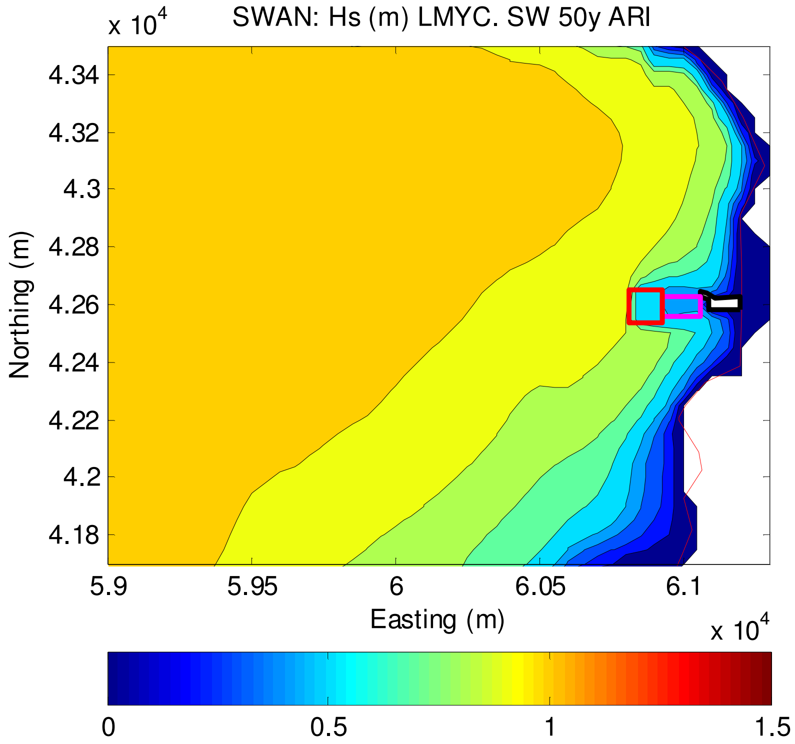

Figure 27 ARI 50 year SW wind with Sea Level Rise of 0.91m.

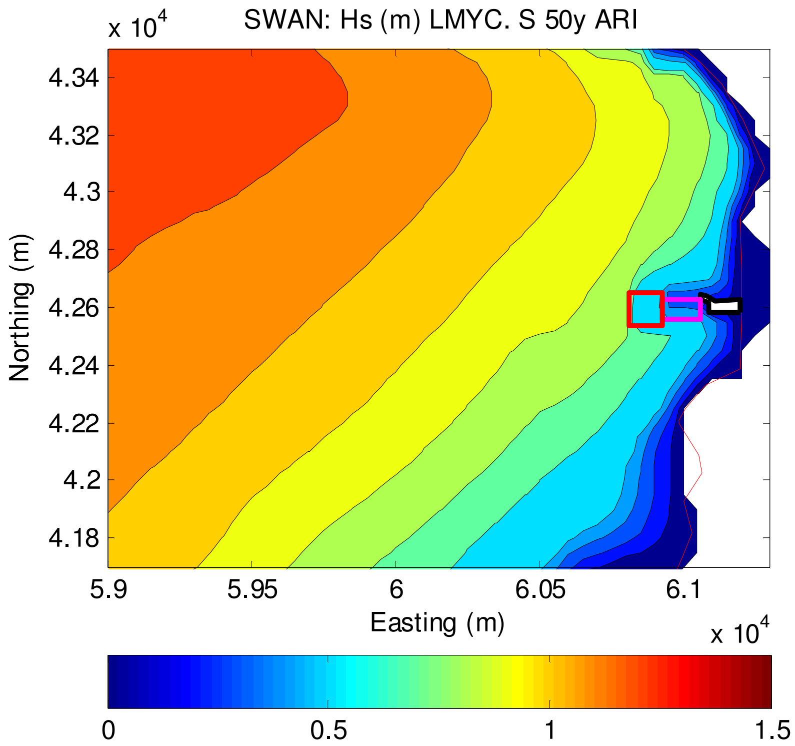

Figure 28: ARI 50 year S wind with Sea Level Rise of 0.91m

6 Conclusions

The five requirements of the Director-General of the Department of Planning, NSW for the Environmental assessment of MP 08-0045, 'P*roposed marina expansion at Lake Macquarie Yacht Club, 9 Ada St, Belmont*' in relation to hydrodynamics and storm and wave climate have been addressed.

The specific requirements addressed and their resolutions are summarised:

DGR *6.4* "I*mprove the maintenance and water flows through the causeway linking Ada Street to the Club's car park to alleviate ongoing problems of odour and seagrass accumulation.*"

Current system accumulates sediment at northern end due to stormwater outfall deposition. Present depth is approximately 0.5*m* at the centre rising to 0.1*m* at the edges, with a waterway area of approximately $3.0m^2$. LMYC and Lake Macquarie City Council should negotiate a permanent maintenance dredging program to maintain a waterway area of $5m^2$ (average depth of 0.5*m*).

DGR *7.1* "…. In particular consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms."

As demonstrated in Sections 3, 4 and 5, impacts of the proposal are not significant with respect to the adjacent coastline and passage of floating materials. Sea level rise will cause a small increase in lake mean and peak tidal levels above the new MSL. An approximate simulation indicates that for the 'average' tide, peaks will be 82.5*mm* higher due to increased range in the lake and tidal pumping. This will be additional to sea-level rise. Significant wave heights in extreme events will only increase marginally. Estimates of 1 in 50 year winds have been adjusted to allow for climate change.

DGR *13.1* "*Assess the impact of the marina extension, foreshore works and any proposed filling on the Lake's ecosystem and hydrodynamic processes, in particular Belmont Bay.*"

Hydrodynamic impacts are insignificant as demonstrated by dye patch advection and dispersion in Section 3. Reduced wave climate within the marina will reduce bottom stresses,

DGR *13.2* "*Address the movement and accumulation of sea-grass wrack and other marine life/habitat and demonstrate minimal impact.*"

Sea grass wrack movement will not change greatly because of the very similar advection, dispersion and shoreline wave climates demonstrated in Sections 3 and 4.

DGR *13.3* "*Provide details of how the marina structures/building will minimise shading of seagrass, transfer of wave energy and creation of excess turbulence*."

The changes in transfer of wave energy are clearly indicated in simulation outputs in Section 4. Aside from the immediate surrounds of the proposed marina, where reduction and diffraction of the wave field is evident, wave climate changes are small and generally supportive of biota requiring more sheltered environments.
Turbulence will be low within the new marina and wakes from local effects such as piles, will dissipate quickly in the low velocity fields.

7 References

1. Booij, N., R.C. Ris, and L.H. Holthuijsen. 1999. A third-generation wave model for coastal regions, Part 1. Model description and validation. *Journal of Geophysical Research (Oceans)* **104**(C4): p 7649-7666.
2. Chen, C., R.C. Beardsley, and G. Cowles. 2006. An unstructured grid, finite-volume coastal ocean model (FVCOM) system. *Oceanography* **19**(1): p 78-89.
3. Chen, C., H. Huang, R.C. Beardsley, H. Liu, Q. Xu, and G. Cowles. 2007. A finite volume numerical approach for coastal ocean circulation studies: comparisons with finite difference models. *Journal of Geophysical Research (Oceans)* **112, C03018**, doi:10.1029/2006JC003485.
4. Chen, C., H. Liu, and R.C. Beardsley. 2003. An unstructured grid, finite-volume, three-dimensional, primitive equations ocean model: application to coastal ocean and estuaries. *Journal of Atmospheric & Oceanic Technology* **20**(1): p 159-186.
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6. Gardner, J.D. and I.H. Townend. 1988. Slotted vertical screen breakwaters. In *Design of breakwaters*, Thomas Telford: London.
7. Kriebel, D.L. 2004. A design method for timber wave screens. In Conference Proceedings: *29th International Conference 'Coastal Engineering 2004'*. J.M. Smith (Ed). 2004 World Scientific, p 3891-3903.
8. Ris, R.C., L.H. Holthuijsen, and N. Booij. 1999. A third-generation wave model for coastal regions, Part 2. Verification. *Journal of Geophysical Research (Oceans)* **104**(C4): p 7667-7681.
9. Rogers, W.E., P.A. Hwang, and D.W. Wang. 2003. Investigation of wave growth and decay in the SWAN model: three regional-scale applications. *Journal of Physical Oceanography* **33**(2): p 366-389.

Appendix A – Wind Analysis

One hourly wind data was purchased from the Bureau of Meteorology (BOM) for Sydney Airport and Williamtown. An analysis of the data was undertaken which firstly involved removing approximately twenty records which clearly contained faulty data. (Typically winds in excess of 150*km/h* occurring in a series of records of around 20*km/h*.)

The Williamtown record is only 20 years long and far too short for reliable estimates of 1 in 50 year winds. Figure 29 shows cumulative probability plots of both sets of data for winds from the Western octants which are the critical ones for LMYC. The westerly and north-westerly plots suggest that the Sydney Airport data is a reasonable surrogate and has been used for estimates of the 1 in 50 year winds.

CSIRO and BOM (http://www.climatechangeinaustralia.gov.au/technical_report.php Chapter 5) suggest that under climate change, extreme wind may increase by as much as 7.5% and that increase has been used for wave height estimates of the 1 in 50 year events from both the west and north-west.

Data for winds from the south and south-west are clearly impacted at Sydney airport by the large (~7*km*) fetch of Botany Bay. Once again the data is insufficient at Williamtown, so much so that the preferred 'binning' methods for skewed statistics cannot be used for this data. More effective binning methods for skewed data were used for the Sydney plots alone, below.

Since high winds from the south and south-west are apparently 20% or more higher at Sydney Airport than Williamtown, it seems that a conservative compromise may be to simply use the Sydney Airport data for the south and south-westerly octants, but without the 7% increase due to climate change. It is of interest to note that the differences are much smaller at lower wind speeds and that the mean southerly (south-westerly) wind at Sydney Airport is 6.44*m/s* (4.89m/s) and at Williamtown 5.97*m/s* (4.68*m/s*) which are 7.5% and 4% different.

Accordingly, the wind speeds used were as follows:

North-westerly	24 x 1.075 = 25.8m/s
Westerly	22 x 1.075 = 23.65 m/s
South-westerly	22m/s
Southerly	25m/s

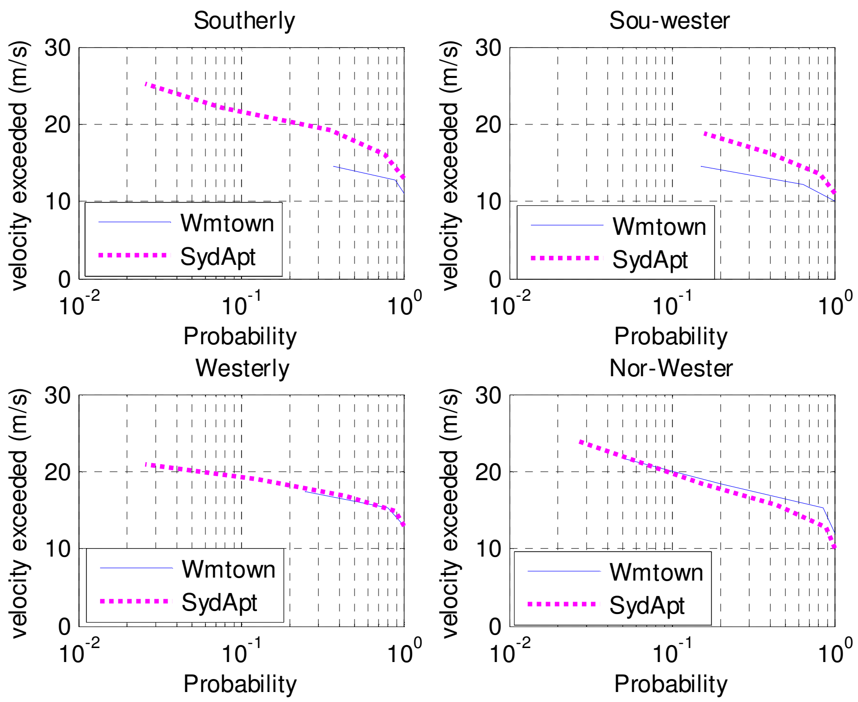


Figure 29 Cumulative probability plots for western half winds for Sydney Airport and Williamtown data

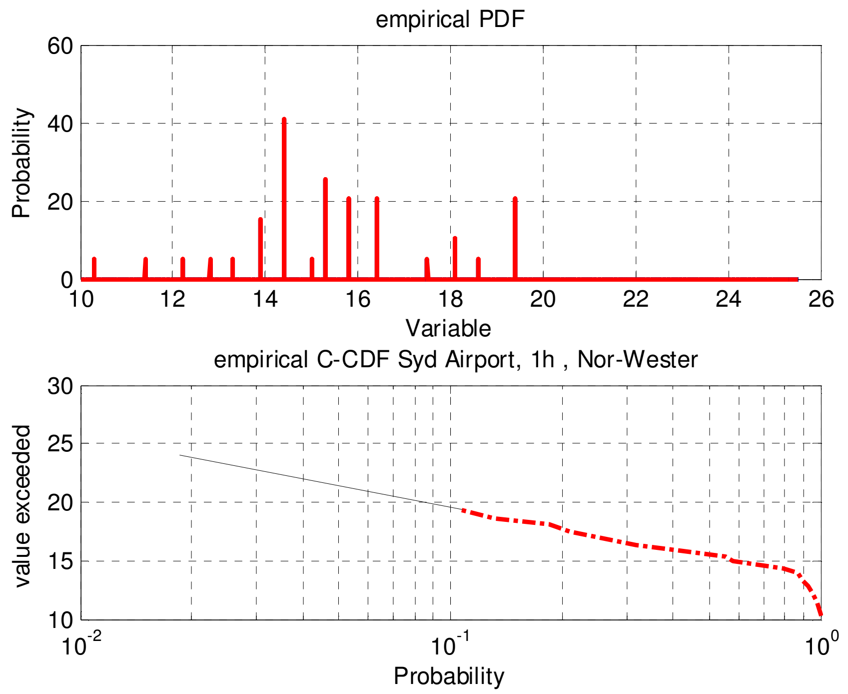


Figure 30 Cumulative probability plot of 1 hourly annual maximum wind velocities in the North-westerly octant, recorded at Sydney Airport. Extrapolation to 1 in 50 year probability is shown in black.

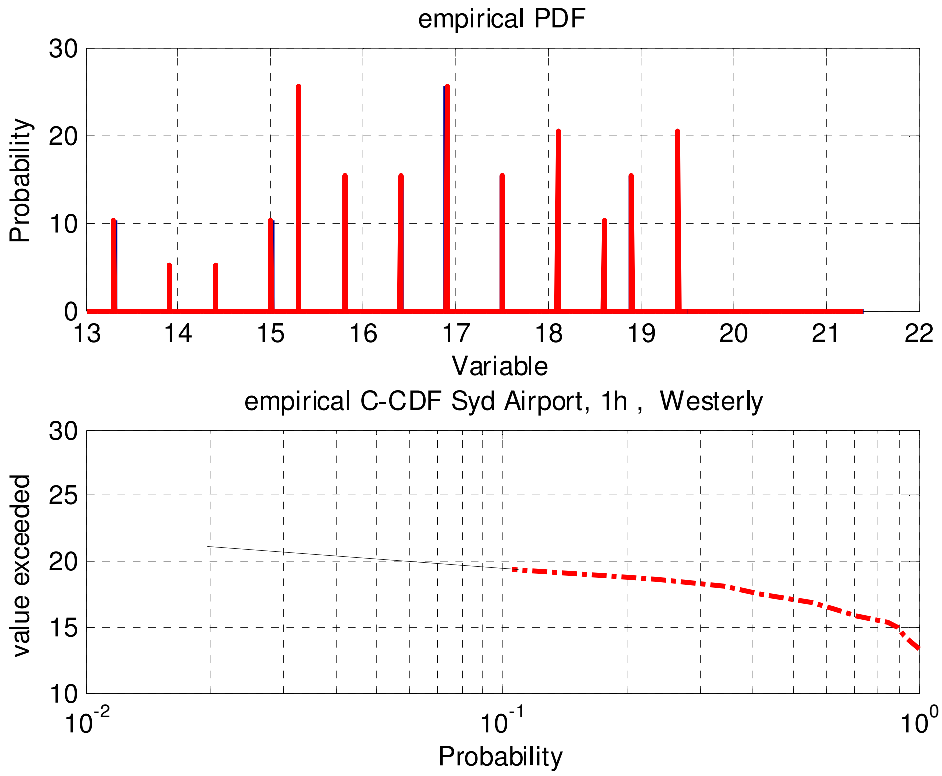


Figure 31 Cumulative probability plot of 1 hourly annual maximum wind velocities (m/s) in the westerly octant, recorded at Sydney Airport. Extrapolation to 1 in 50 year probability is shown in black.

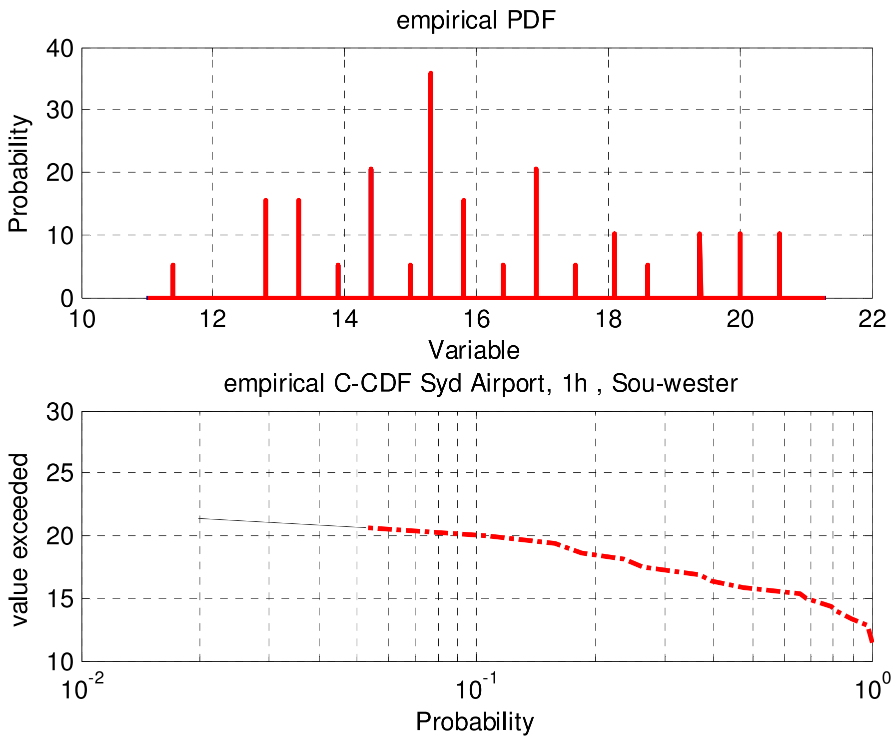


Figure 32 Cumulative probability plot of 1 hourly annual maximum wind velocities (m/s) in the south-westerly octant, recorded at Sydney Airport. Extrapolation to 1 in 50 year probability is shown in black.

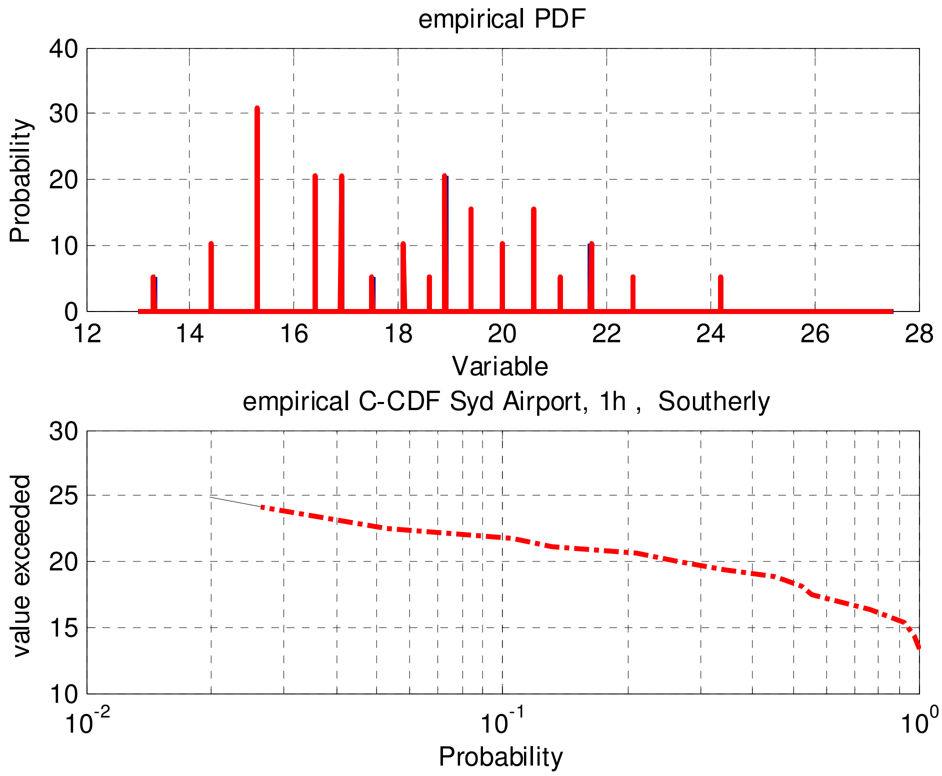


Figure 33 Cumulative probability plot of 1 hourly annual maximum wind velocities (m/s) in the southerly octant, recorded at Sydney Airport. Extrapolation to 1 in 50 year probability is shown in black.

APPENDIX B

Infrastructure Authority Correspondance

HUNTER WATER

HUNTER WATER CORPORATION . PO BOX 5171 HRMC NSW 2310 . TEL 1300 657 657
36 HONEYSUCKLE DRIVE NEWCASTLE . ABN 46 228 513 446 . HUNTERWATER.COM.AU

RECEIVED
20 MAY 2009
NORTHROP ENGINEERS
Job No. NL080037

18 May 2009

Ref:2009-438

Lake Macquarie Yacht Club
C/- Northrop Consulting Engineers
P O Box 180
Charlestown NSW 2290

Dear Sir/Madam

RE INDICATIVE REQUIREMENTS FOR PROPOSED DEVELOPMENT

Hunter Water's Indicative Requirements for the provision of water and sewerage facilities to the replacement of existing Yacht Club (13 WC's, 1105m2), Restaurant (90 seats, 192m2) & extension of Marina (141 berths) at Lots 973, 974 & 975 DP 755233, 9 Ada Street , Belmont are as follows:

As the development is subject to approval by Local Council, any information at this point is indicative only and maybe subject to significant change prior to your development proceeding.

These indicative requirements are not commitments by Hunter Water. Once approval has been granted and the decision is made to proceed with the development application you will need to lodge an Application under Section 49 with Hunter Water.

On receipt of the Section 49 Application Hunter Water will forward a **Notice of Formal Requirements**. You will need to comply with each of the requirements for the issue of a Section 50 compliance certificate.

Hunter Water's Indicative Requirements provide general information on water and sewer issues relevant to the proposed development. The information provided is based on Hunter Water's knowledge of its system performance and other potential development in the area at the present time. As you will appreciate there could be significant change by the time the development proceeds to the lodging of a Development Application and therefore these indicative requirements maybe different to the Notice of Formal Requirements provided in the future.

Hunter Water's requirements have been based on the understanding that the proposed development replaces an existing club facility (no additional loadings) however increases the number of "Wet Berths" to 141 from the existing 77. Please advise should this not be the case.

Hunter Water's Indicative Requirements for the provision of water and sewerage facilities to the replacement of existing Yacht Club (13 WC's, 1105m2), Restaurant (90 seats, 192m2) & extension of Marina (141 berths) at Lots 973, 974 & 975 DP 755233, 9 Ada Street , Belmont are as follows:

1. Your proposed development has been identified as having the potential to discharge trade waste into Hunter Water's sewerage system. You are therefore required to **contact Hunter Water's Hydraulic Consultant on 4979 9713** make the necessary

application for a Trade Waste Permit and pay the prescribed fees. The discharge of trade waste to the sewer will not be permitted without a permit authorising that discharge; and

2. You will be required to submit an application for a hydraulic design assessment of internal water and sewerage services for this development, including rainwater tanks and any greywater systems. If you are unsure please **contact Hunter Water's Hydraulic Consultant on 49799713**. (Refer to the attached guide).

3. Water and sewer facilities are adequate for the existing development.

4. As the proposed development will connect to Corporation sewermains by way of a pump system, Hunter Water cannot comment on the adequacy of the existing water and sewer services for the development until receipt of the abovementioned "Hydraulics Application" with details of pump flow rates etc for the 64 additional "wet births".

5. Recycled water is not proposed for this area

6. Hunter Water will require a copy of your Council approval & DA conditions.

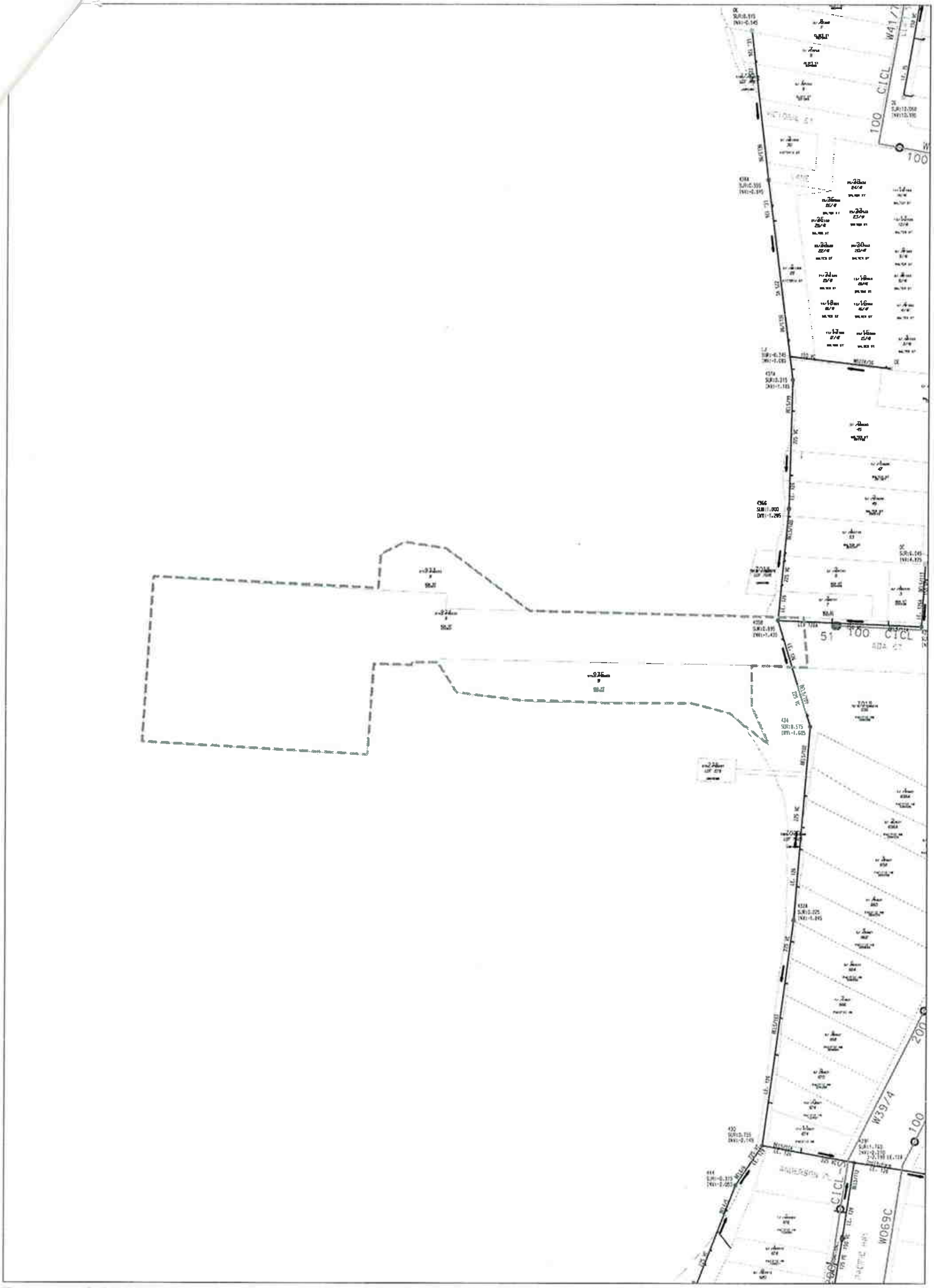
These indicative requirements are not commitments by Hunter Water and maybe subject to significant change prior to this development proceeding.

Yours faithfully

Brett Lewis
Manager Sales and Business Development

Enquiries: Peter Hull
Tel: 1300 657 657
Fax: (02) 4979-9711
Your Ref: NL080037

2009-438.



Date: 4/05/2009 **Scale:** 1 : 2000

Notes: LOT 973,974 & 975 DP 755233 - 9 ADA STREET BELMONT

HWC DOES NOT GUARANTEE THE ACCURACY OF THIS PLAN

Telstra

19 May 2009

Network and Technology
Forecasting and Area Planning

6/317 Hunter Street, NEWCASTLE, 2300
LOCKED BAG 16, HAMILTON DC, 2303

Telephone (02) 49858420
Facsimile (02) 49249212

Bruce.v.batten@team.telstra.com

Angus Brien
323 Charlestown Rd, Charlestown, NSW, 2290
P.O. Box 180 Charlestown, NSW, 2290
Phone : 02 49431777

Re: Development of Lake Macquarie Yatch Club

Dear Angus,

Based on the provided information relating to the proposed development at Lake Maccquarie Yatch Club, a review was undertaken of the area and nearby telecommunications infrastructure.

Telstra maintains existing network throughout the land marked for development. The existing plant is adequate for present requirements but may require upgrade or relocation depending on new service requirements. Telstra has no objection to the change of use of this land.

The technology and services provided would be determined closer to the time of development commencement, depending on Telstra deployment policy and any negotiations based on a commercial agreement.

Telstra will require the protection or relocation of its telecommunications infrastructure that may be impacted by activities on this site. To minimise risk of liability due to any damage, the Telstra 1100 Inquiry number should be contacted to obtain location of Telstra plant before commencement of construction work.

Further discussions regarding details for network expansion are strongly encouraged once detailed planning for the development is in progress. To inform Telstra of likely commencement of this development, you are requested to register this development on the Telstra Smart Community website: http://www.telstrasmartcommunity.com

Please note that Telstra reserves the right to change its decision in relation to network deployment within the development without prior notice.

Yours faithfully,

Bruce Batten
Area Planner

From: Percival, Thomas [mailto:Thomas.Percival@jemena.com.au]
Sent: Friday, 1 May 2009 12:22 PM
To: Angus Brien
Subject: FW: Gas Supply to Lake Macquarie Yacht Club.

Angus

These statements are valid providing the gas load for the new club does not exceed the capacity of the existing gas service or metering arrangements currently in place. Your hydraulic consultants can determine the future load and should any changes to the service size or metering be required you should consult with the clubs retailer.

Regards Tom

Tom Percival
Field Manager
Jemena
36 Mitchell Rd Cardiff NSW 2285
| M: 0402 059 739 | F:(02) 4956 9834
E: thomas.percival@jemena.com.au **| W:**www.jemena.com.au

From: Angus Brien [mailto:abrien@northrop.com.au]
Sent: Tuesday, 28 April 2009 1:57 PM
To: Endean, Tracey
Cc: Shelley Wilson
Subject: Gas Supply to Lake Macquarie Yacht Club.

Hi Tracey,

RE: Development of Lake Macquarie Yacht Club, Belmont

I write to confirm the outcomes of our discussions earlier today. As discussed, the existing clubhouse is to be demolished and replaced with a clubhouse very similar in operational nature. It is envisaged that little change in gas consumption will eventuate. For our discussion, I understand that;

- A 210 kPa 50mm gas service exists in Ada St, with a 32mm branch extending to the yacht club.
- This existing infrastructure will be ample to supply the new development.
- No upgrades of Jemena infrastructure are necessary as a result of the new development.

Please confirm the validity of these statements. Thank you for your assistance.

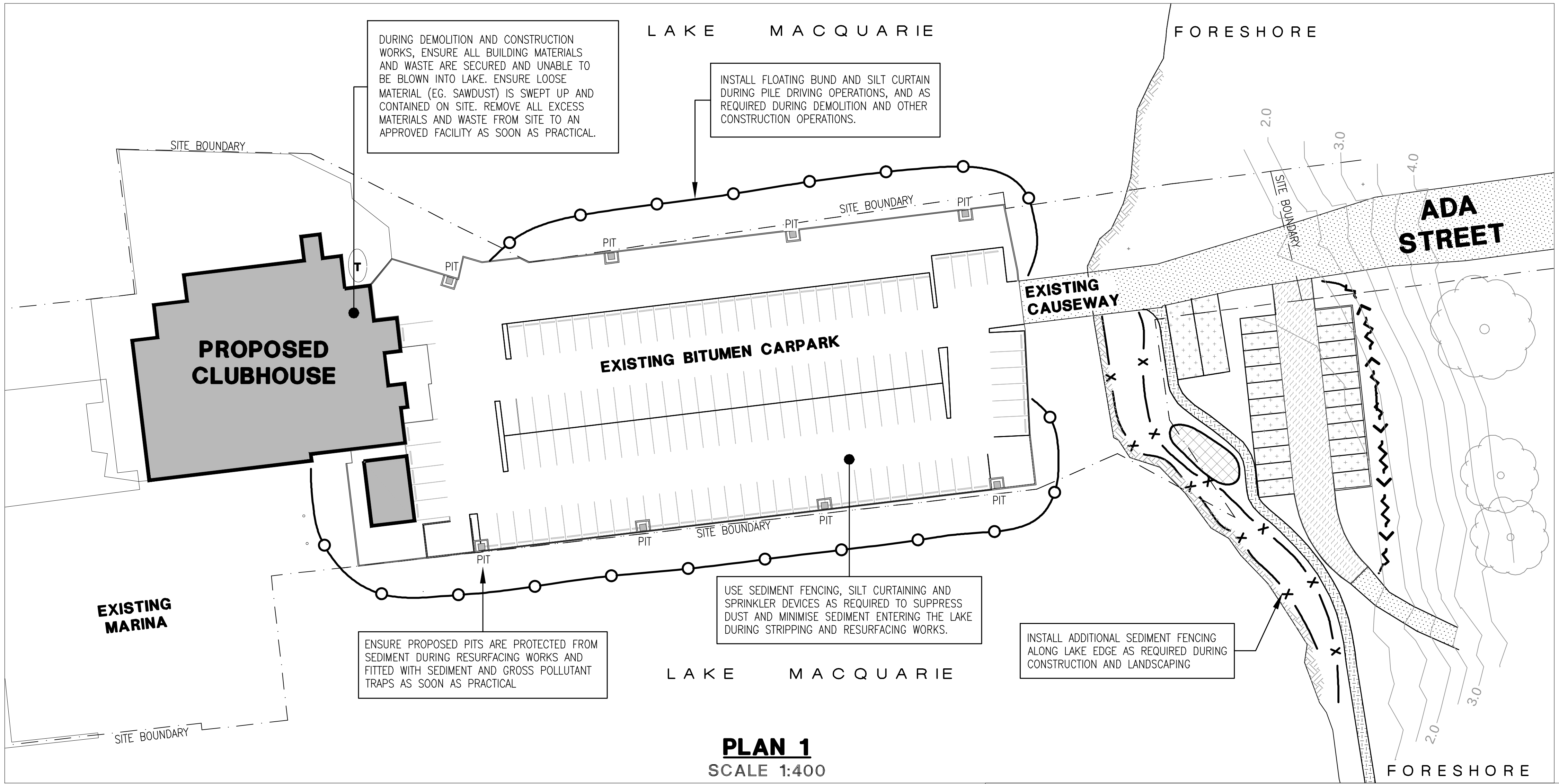
Kind regards,

NORTHROP
Angus Brien
Graduate Civil Engineer
Northrop Consulting Engineers Pty Ltd
T: 02 4943 1777
F: 02 4943 1577
M: 0413 358 531
323 Charlestown Road Charlestown NSW 2290
P.O. Box 180 Charlestown NSW 2290
www.northrop.com.au

APPENDIX C

Engineering Plans

- C01 DA – Sediment & Erosion Control Plan
- C02 DA – Stormwater Concept Plan
- C03 DA – Pavement Plan
- C04 DA – Earthworks Plan
- C05 DA – Existing Services Plan



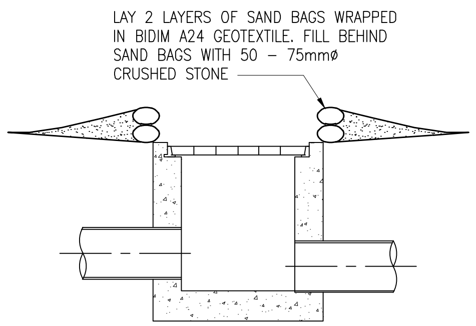
PLAN 1
SCALE 1:400

LEGEND

- DENOTES PROPOSED FLOATING BUND AND SILT CURTAIN
- DENOTES PROPOSED SEDIMENT FENCE
- PIT — DENOTES PROPOSED STORMWATER PIT & PIT PROTECTION
- DENOTES PROPOSED CUT-OFF SWALE
- DENOTES PROPOSED INFILTRATION TRENCH
- DENOTES PROPOSED TURF CELLS
- DENOTES PROPOSED SEALED ACCESS WAY
- DENOTES PROPOSED FOOTPATH
- DENOTES PROPOSED CARPARK EXTENSION
- DENOTES EXISTING PAVEMENT TO REMAIN
- DENOTES SHORELINE

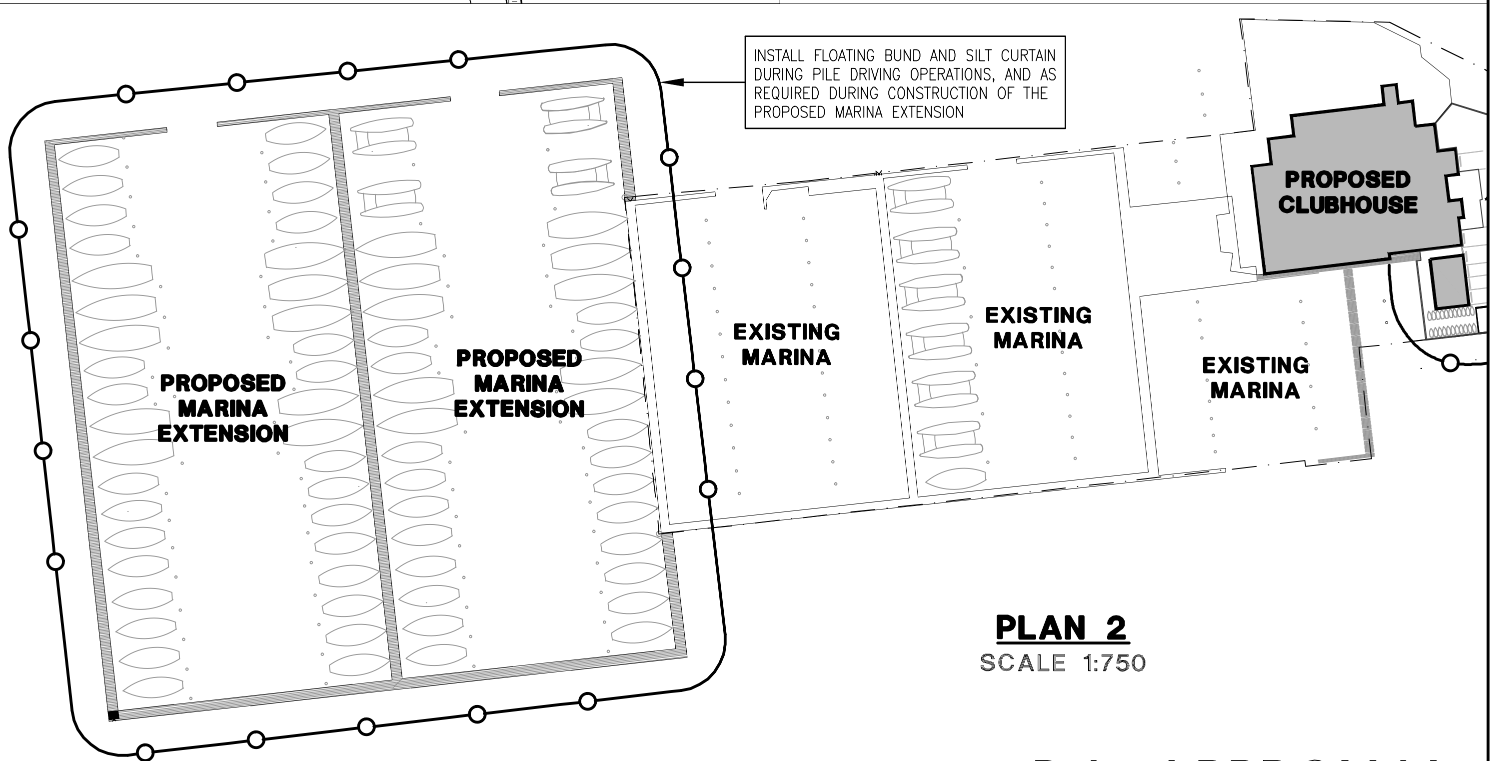
SEDIMENT AND EROSION CONTROL NOTES

1. ALL WORK SHALL BE CARRIED OUT IN ACCORDANCE WITH RELEVANT ORDINANCES AND REGULATIONS; NOTING IN PARTICULAR THE REQUIREMENTS OF LANDCOM'S MANAGING URBAN STORMWATER, SOILS AND CONSTRUCTION' (THE 'BLUE BOOK') AND THE REQUIREMENTS OF LAKE MACQUARIE CITY COUNCIL.
2. PRIOR TO CONSTRUCTION COMMENCING, SEDIMENT PROTECTION FILTERS SHALL BE INSTALLED ON ALL NEW AND EXISTING STORMWATER INLET PITS IN THE VICINITY OF THE WORKS IN ACCORDANCE WITH EITHER THE MESH AND GRAVEL INLET FILTER DETAIL SD6-11 OR THE GEOTEXTILE INLET FILTER DETAIL SD6-12 OF THE 'BLUE BOOK'.
3. PRIOR TO CONSTRUCTION COMMENCING, SEDIMENT FENCES SHALL BE ESTABLISHED AROUND INDIVIDUAL CONSTRUCTION ZONES, IN ACCORDANCE WITH DETAIL SD6-8 OF THE 'BLUE BOOK'. IN PARTICULAR, A SEDIMENT FENCE SHALL BE INSTALLED BETWEEN THE PROPOSED FORESHORE WORKS AND THE LAKE'S EDGE AS SHOWN ON THE PLAN.
4. A SILT CURTAIN AND FLOATING BUND SHALL BE ESTABLISHED AROUND THE SITE AS REQUIRED TO CAPTURE AND CONTAIN ANY LITTER OR SEDIMENTS LIKELY TO BE MOBILISED DURING CONSTRUCTION, IN PARTICULAR DURING THE DRIVING OF PILES.
5. ALL TRENCHES INCLUDING ALL SERVICE TRENCHES AND SWALE EXCAVATION SHALL BE SIDE-CAST TO THE HIGH SIDE AND CLOSED AT THE END OF EACH DAYS WORK.
6. ALL VEGETATION (TREE, SHRUB & GROUND COVER) WHICH IS TO BE RETAINED SHALL BE PROTECTED DURING THE DURATION OF CONSTRUCTION.
7. TOPSOIL SHALL ONLY BE STRIPPED IN AREAS DESIGNATED FOR STRIPPING, AND STOCKPILED FOR RE-USE AS REQUIRED. STRIPPED AND EXCAVATED AREAS SHALL BE RESURFACED AS SOON AS PRACTICAL AND STABILISED AT THE END OF EACH DAYS WORK.
8. ALL MATERIAL STOCKPILES SHALL BE CONSTRUCTED AND INSTALLED IN ACCORDANCE WITH DETAIL SD4-1 OF THE 'BLUE BOOK', AND SHALL NOT EXCEED 2.5M HIGH. WIND AND RAIN EROSION PROTECTION SHALL BE PROVIDED FOR ALL STOCKPILES IN ACCORDANCE WITH THE 'BLUE BOOK', INCLUDING CUT-OFF SWALES TO THE HIGH SIDE AND SEDIMENT FENCES TO THE LOW SIDE.
9. WATER TRUCKS OR HAND SPRINKLER DEVICES SHALL BE PROVIDED DURING CONSTRUCTION AS REQUIRED TO SUPPRESS DUST.
10. THE SITE SUPERINTENDENT SHALL BE RESPONSIBLE FOR KEEPING A DETAILED WRITTEN RECORD OF ALL EROSION & SEDIMENT CONTROLS ON-SITE DURING THE CONSTRUCTION PERIOD. THIS RECORD SHALL BE UPDATED ON A DAILY BASIS & SHALL CONTAIN DETAILS ON THE CONDITION OF CONTROLS, AND ANY/ ALL MAINTENANCE, CLEANING & BREACHES. THIS RECORD SHALL BE KEPT ON-SITE AT ALL TIMES AND SHALL BE MADE AVAILABLE FOR INSPECTION BY THE PRINCIPAL CERTIFYING AUTHORITY DURING NORMAL WORKING HOURS.



PIT PROTECTION DETAIL
(ALTERNATIVE DETAIL SD6-11 OR SD6-12 OF THE BLUE BOOK AS APPROPRIATE)

INSTALL PIT PROTECTION TO ALL NEW & EXISTING STORMWATER PITS.



PLAN 2
SCALE 1:750

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B	ISSUED FOR APPROVAL	SW	SW	08.03.10
C	ISSUED FOR APPROVAL - LEGEND AMENDED	SW	SW	10.06.10

CLIENT: **LAKE MACQUARIE YACHT CLUB**

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PLAN 2 1:750 0 7.5 15 22.5 30 37.5m
PLAN 1 1:400 0 4 8 12 16 20m

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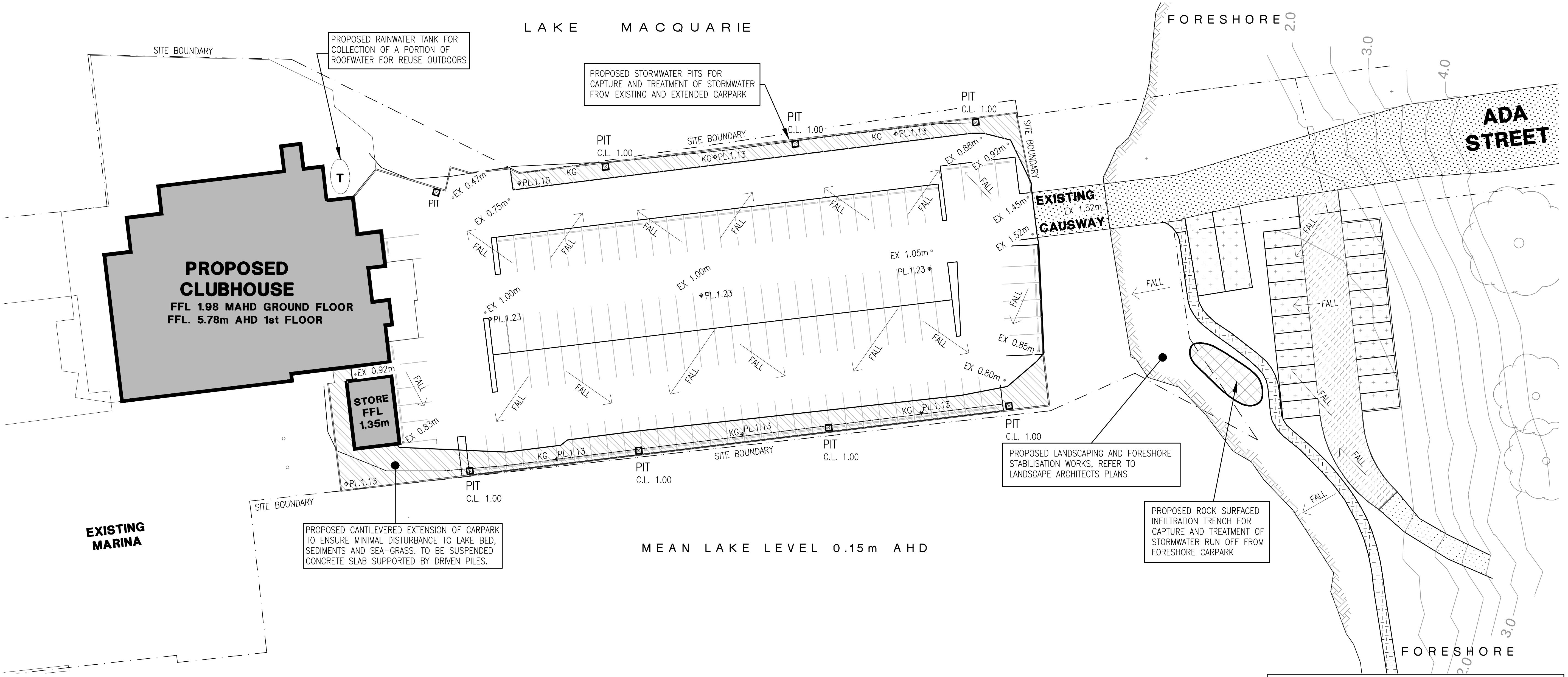
PROJECT: **PROPOSED RE-DEVELOPMENT OF LAKE MACQUARIE YACHT CLUB ADA STREET BELMONT, NSW**

DRAWING TITLE: **SEDIMENT & EROSION CONTROL PLAN**

JOB NUMBER: NL080037
DRAWING NUMBER: C01 DA
ISSUE: C
DRAWING SHEET SIZE = A1



STORMWATER MANAGEMENT CONCEPT

STORMWATER DETENTION IS NOT REQUIRED FOR THE YACHT CLUB, DUE TO IT'S IMMEDIATE PROXIMITY TO THE RECEIVING WATERS OF LAKE MACQUARIE. TREATMENT MEASURES TO IMPROVE THE QUALITY OF STORMWATER RUNOFF FROM THE SITE HAVE BEEN CONSIDERED AND ARE OUTLINED BELOW.

FORESHORE WORKS:

THE PROPOSED FORESHORE WORKS WILL INCLUDE STABILISATION OF THE EXISTING GRAVEL CARPARKING AREA, CONSTRUCTION OF A NEW FOOTPATH AND LANDSCAPING WORKS. THE PROPOSED WORKS WILL IMPROVE THE STABILITY OF THE FORESHORE AREA AND REDUCE THE POTENTIAL FOR EROSION. IT IS PROPOSED THAT STORMWATER RUNOFF FROM THE CARPARKING AREA BE DIRECTED TO AN UNDERGROUND INFILTRATION TRENCH, TO CAPTURE SEDIMENTS AND HYDROCARBONS. TREATED STORMWATER WOULD DISCHARGE FROM THE TRENCH IN A DISPERSED MANNER TO MINIMISE EROSION POTENTIAL, AND FLOW ACROSS THE LANDSCAPED AREA FOR SECONDARY POLISHING BEFORE ENTERING LAKE MACQUARIE. THE PROPOSED LANDSCAPING WORKS WILL ACT AS A NATURAL BUFFER STRIP FOR FILTERING FINE SEDIMENTS FROM STORMWATER. THE PROPOSED TURF CELLS WILL PROVIDE ADDITIONAL CAPACITY FOR STORMWATER INFILTRATION & POLLUTANT TREATMENT.

EXISTING AND EXTENDED CARPARK:

THE PROPOSED EXTENSION OF THE EXISTING BITUMEN CARPARK PROVIDES AN OPPORTUNITY TO CAPTURE AND TREAT STORMWATER RUNOFF FROM THIS AREA. IT IS PROPOSED THAT STORMWATER RUNOFF FROM THE CARPARK DRAIN TO NEW STORMWATER INLET PITS, TO BE CONSTRUCTED ALONG THE NORTHERN AND SOUTHERN EDGES OF THE CARPARK AREA. IT IS PROPOSED THE PITS BE FITTED WITH GROSS POLLUTANT AND SEDIMENT TRAPS AND HYDROCARBON FILTERS, TO TREAT STORMWATER RUNOFF PRIOR TO IT DISCHARGING INTO THE LAKE. THE STORMWATER WILL BE DIRECTED INTO THE PITS USING SURFACE GRADES AND KERB AND GUTTER WHERE APPROPRIATE.

CLUB HOUSE:

CURRENTLY, ROOF WATER RUNOFF FROM THE EXISTING CLUBHOUSE DRAINS UNMITIGATED DIRECTLY INTO THE LAKE. AS PART OF THE REDEVELOPMENT WORKS IT IS PROPOSED TO INSTALL A RAINWATER STORAGE TANK, FOR CAPTURE AND REUSE OF SOME ROOF WATER RUNOFF TO REDUCE MAINS WATER DEMAND. DUE TO THE HIGH SALT CONTENT LIKELY, IT IS PROPOSED THE STORED WATER ONLY BE USED FOR GARDEN IRRITATION AND BOAT WASH DOWN.

MARINA EXTENSION:

RUNOFF FROM THE EXISTING MARINA DECKING CURRENTLY DRAINS UNMITIGATED INTO THE LAKE. WE BELIEVE THIS IS AN ACCEPTABLE SOLUTION FOR THE STRUCTURE, AND IT IS PROPOSED TO CONTINUE THIS REGIME FOR THE MARINA EXTENSION. THE DECKING IS A PEDESTRIAN ONLY THOROUGHFARE, WITH NO VEGETATION AND NO UPSTREAM CATCHMENT, AND THEREFORE IS SUBJECT TO NEGLIGIBLE POLLUTANT LOADS THAT DO NOT WARRANT THE USE OF WATER QUALITY TREATMENT DEVICES. THE ACTUAL DECKING MATERIAL IS HIGHLY PERMEABLE WHICH WOULD MAKE COLLECTION OF RUNOFF IMPRACTICAL.

FOR RECOMMENDED STORMWATER TREATMENT DEVICE MAINTENANCE REQUIREMENTS REFER TO SECTION 3.5 OF THE ENGINEERING REPORT

LEGEND

EX 1.0m	DENOTES APPROXIMATE EXISTING SURFACE LEVEL
PL.1.23	DENOTES PROPOSED FINISHED SURFACE LEVEL
PIT C.L. 1.00	DENOTES PROPOSED STORMWATER INLET PIT WITH GROSS POLLUTANT & SEDIMENT TRAPS AND HYDROCARBON FILTERS, & COVER LEVEL
FFL	DENOTES PROPOSED FINISHED FLOOR LEVEL
	DENOTES PROPOSED TURF CELLS
	DENOTES PROPOSED BITUMEN SEALED ACCESS WAY
	DENOTES PROPOSED FOOTPATH
	DENOTES PROPOSED INFILTRATION TRENCH
	DENOTES PROPOSED CARPARK EXTENSION
T	DENOTES PROPOSED RAINWATER STORAGE TANK FOR REUSE OF ROOFWATER
	DENOTES SHORELINE
KG	DENOTES PROPOSED KERB & GUTTER
3.0	DENOTES EXISTING CONTOUR LEVEL

DA APPROVAL

DRAWN: K.BRADLEY DESIGNED: S.WILSON JOB MANAGER: A.BROWN VERIFIER: A.BROWN

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CLIENT: **LAKE MACQUARIE YACHT CLUB**

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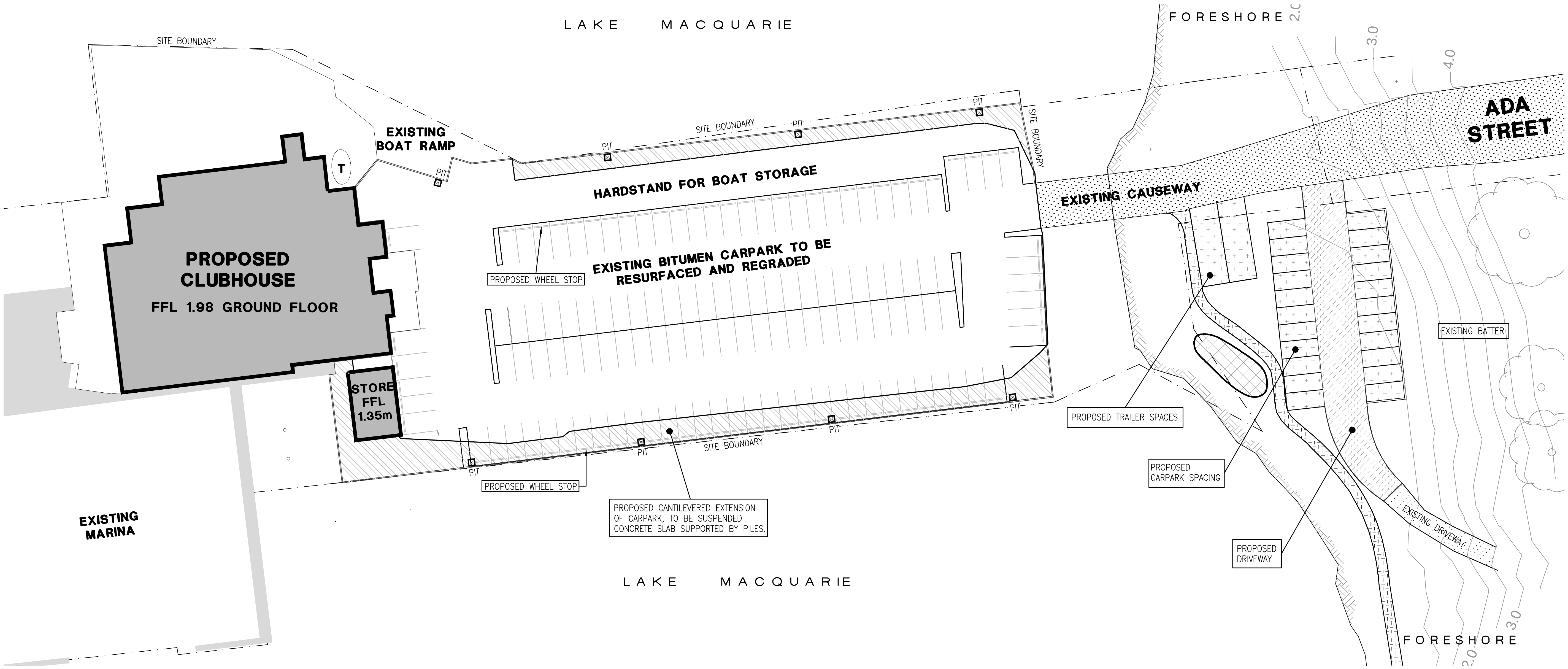
PROJECT: **PROPOSED RE-DEVELOPMENT OF LAKE MACQUARIE YACHT CLUB ADA STREET BELMONT, NSW**

DRAWING TITLE: **STORMWATER CONCEPT PLAN**

JOB NUMBER: NL080037
DRAWING NUMBER: C02 DA
ISSUE: C
DRAWING SHEET SIZE = A1



ACCESS AND CARPARKING NOTES

1. ALL THE EXISTING CLUBHOUSE IS CURRENTLY ACCESSED VIA A CONCRETE CAUSEWAY AT THE END OF ADA STREET. NO MODIFICATIONS TO THE CAUSEWAY STRUCTURE ARE PROPOSED. THE REDEVELOPED CLUB HOUSE WILL SIMILARLY BE ACCESSED BY THE EXISTING CAUSEWAY.

CARPARKING IS CURRENTLY PROVIDED BY ANGULAR PARKING IN THE EXISTING BITUMEN CARPARK, AND INFORMAL PARKING IN THE GRAVEL FORESHORE AREA OPPOSITE THE CLUB. THE REDEVELOPMENT WILL PROVIDE ADDITIONAL & IMPROVED CARPARKING FACILITIES FOR THE CLUB.

THE EXISTING CARPARK WILL BE EXTENDED TO THE NORTH AND SOUTH, AND CARPARKING RECONFIGURED TO 90° FOR MORE EFFICIENT UTILISATION OF THE AVAILABLE SPACE. REINFORCED TURF CELLS AND A SEALED BITUMEN DRIVEWAY WILL BE PROVIDED ON THE FORESHORE TO REPLACE THE GRAVEL SURFACE AND PROMOTE FOR FORMAL PARKING FACILITIES.

PEDESTRIAN ACCESS TO THE CLUB IS CURRENTLY AVAILABLE VIA THE ADA STREET CAUSWAY, AND WILL CONTINUE UNDER THE REDEVELOPMENT. A NEW FOOTPATH IS PROPOSED ALONG THE FORESHORE TO LINK ADA STREET TO ANDERSON PLACE. IMPROVING PEDESTRIAN ACCESS TO THE CLUB FROM SOUTH.

LEGEND

- DENOTES PROPOSED CARPARK EXTENSION
- DENOTES PROPOSED FOOTPATH
- DENOTES PROPOSED BUILDING ENVELOPE
- DENOTES PROPOSED INFILTRATION TRENCH
- DENOTES PROPOSED TURF CELLS
- DENOTES PROPOSED BITUMEN SEALED ACCESS WAY
- DENOTES EXISTING PAVEMENT TO REMAIN
- DENOTES SHORELINE
- PIT — DENOTES PROPOSED STORMWATER INLET PIT
- 3.0 — DENOTES EXISTING CONTOUR LEVEL

DRAWN: K.BRADLEY DESIGNED: S.WILSON JOB MANAGER: A.BROWN VERIFIER: A.BROWN

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C	ISSUED FOR APPROVAL - PITS LABELLED, LEGEND AMENDED	SW	SW	10.06.10

CLIENT: **LAKE MACQUARIE YACHT CLUB**

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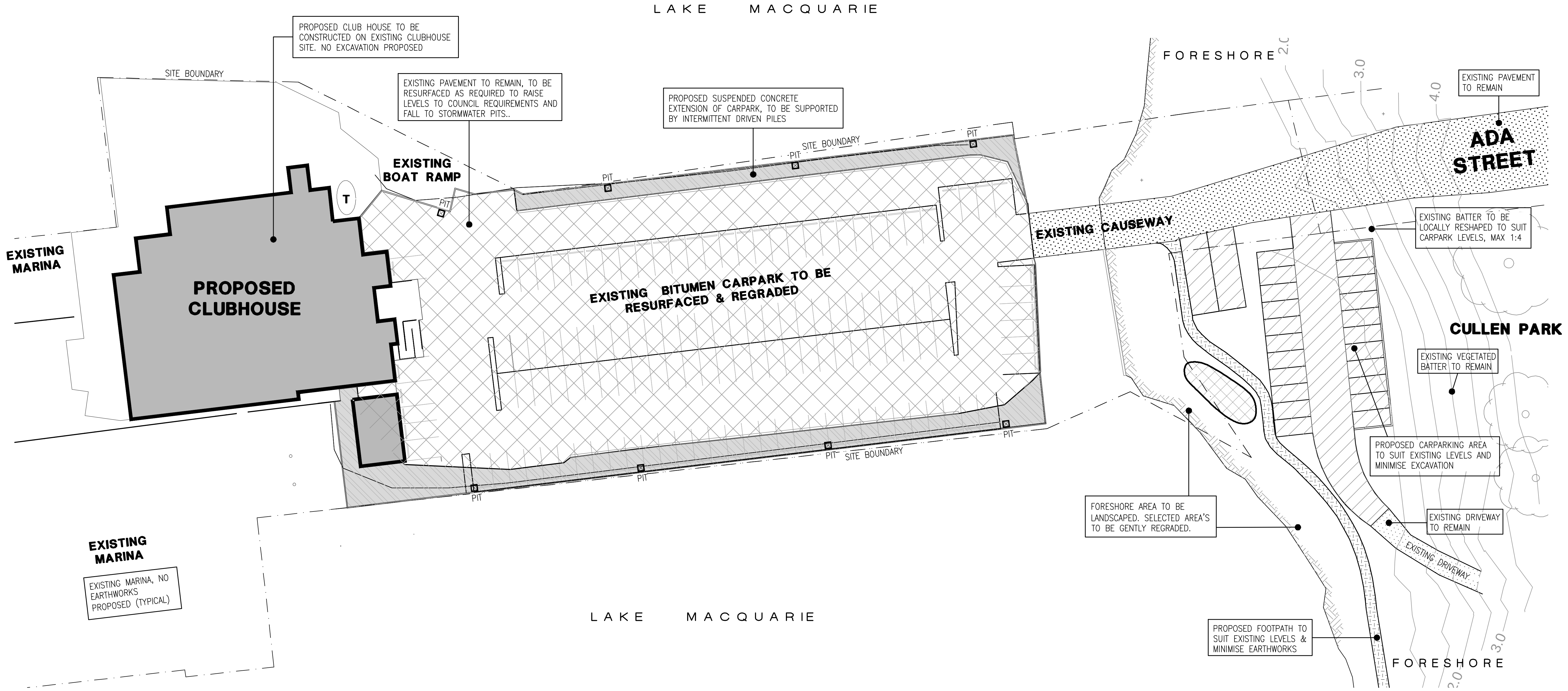
PROJECT: **PROPOSED RE-DEVELOPMENT OF LAKE MACQUARIE YACHT CLUB ADA STREET BELMONT, NSW**

DRAWING TITLE: **PAVEMENT PLAN**

JOB NUMBER: **NL080037**

DRAWING NUMBER: **C03 DA** ISSUE: **C**

DRAWING SHEET SIZE = A1



LEGEND

(shaded hatch)	DENOTES PROPOSED CARPARK EXTENSION, TO BE CONSTRUCTED AS SUSPENDED CONCRETE SLAB WITH INTERMITTENT DRIVEN CONCRETE PILES AS REQUIRED. NO EXCAVATION REQUIRED. SOME RELOCATION OF EXISTING ROCK BATTER MAY BE REQUIRED.
(cross hatch)	DENOTES EXISTING PAVEMENT. PAVEMENT TO BE RIPPED AND RESURFACED WITH BITUMEN AS REQUIRED TO SUIT PROPOSED FINISHED SURFACE LEVELS. AREA'S OF POOR PAVEMENT FINISH SHALL BE INVESTIGATED AND LOCALLY REPLACED AS REQUIRED. EXCAVATION SHALL BE LIMITED TO AREA'S OF PAVEMENT REQUIRING EXCAVATION FOR REPAIR PURPOSES
PIT	DENOTES PROPOSED STORMWATER INLET PIT
(diagonal hatch)	DENOTES PROPOSED FORESHORE CARPARKING AREA TO BE CONSTRUCTED. FINISHED CARPARK LEVELS SHALL BE CLOSE TO EXISTING SURFACE LEVELS. EXCAVATION REQUIRED DOWN TO SUBGRADE LEVEL, EXCAVATION DEPTH DEPENDANT ON PAVEMENT TYPE. TURF CELL/PERMEABLE PAVEMENT ~ 200mm BITUMEN PAVEMENT ~ 250mm
(heavy line)	DENOTES PROPOSED BUILDING ENVELOPE
(footpath hatch)	DENOTES PROPOSED CONCRETE FOOTPATH. EXCAVATION DEPTH APPROX. 100mm
(dotted)	DENOTES EXISTING PAVEMENT TO REMAIN
(line)	DENOTES SHORELINE
3.0	DENOTES EXISTING CONTOUR LEVEL
(oval)	DENOTES PROPOSED INFILTRATION TRENCH, EXCAVATION APPROX 1m DEEP.

NOTE:
NO EXCAVATION PROPOSED FOR MARINA EXTENSION WORKS.

PILES TO BE DRIVEN TO MINIMISE DISTURBANCE TO INSITU SOILS (TYPICAL)

DRAWN: K.BRADLEY DESIGNED: S.WILSON JOB MANAGER: A.BROWN VERIFIER: A.BROWN

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C	ISSUED FOR APPROVAL - PITS SHOWN, LEGEND AMENDED	SW	SW	10.06.10

CLIENT: LAKE MACQUARIE YACHT CLUB

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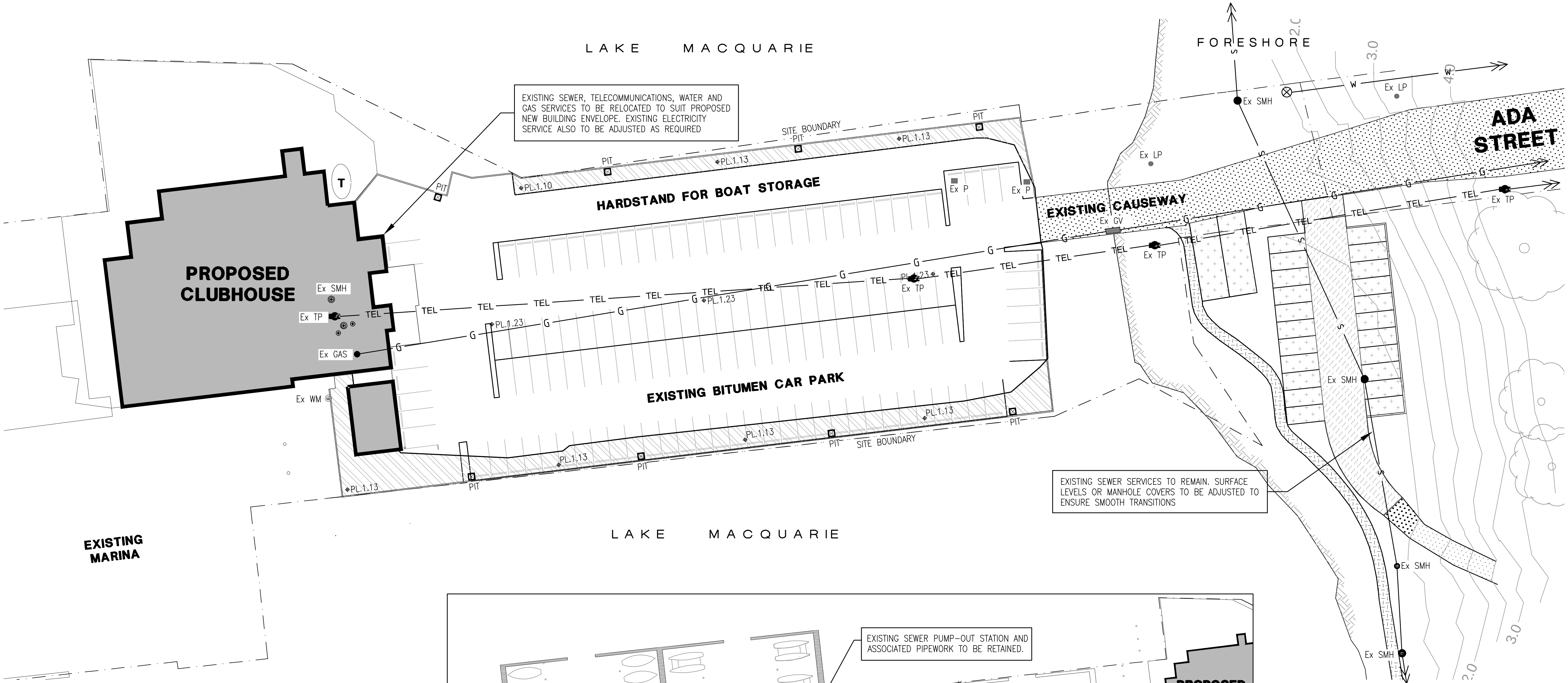
PROJECT: PROPOSED RE-DEVELOPMENT OF LAKE MACQUARIE YACHT CLUB ADA STREET BELMONT, NSW

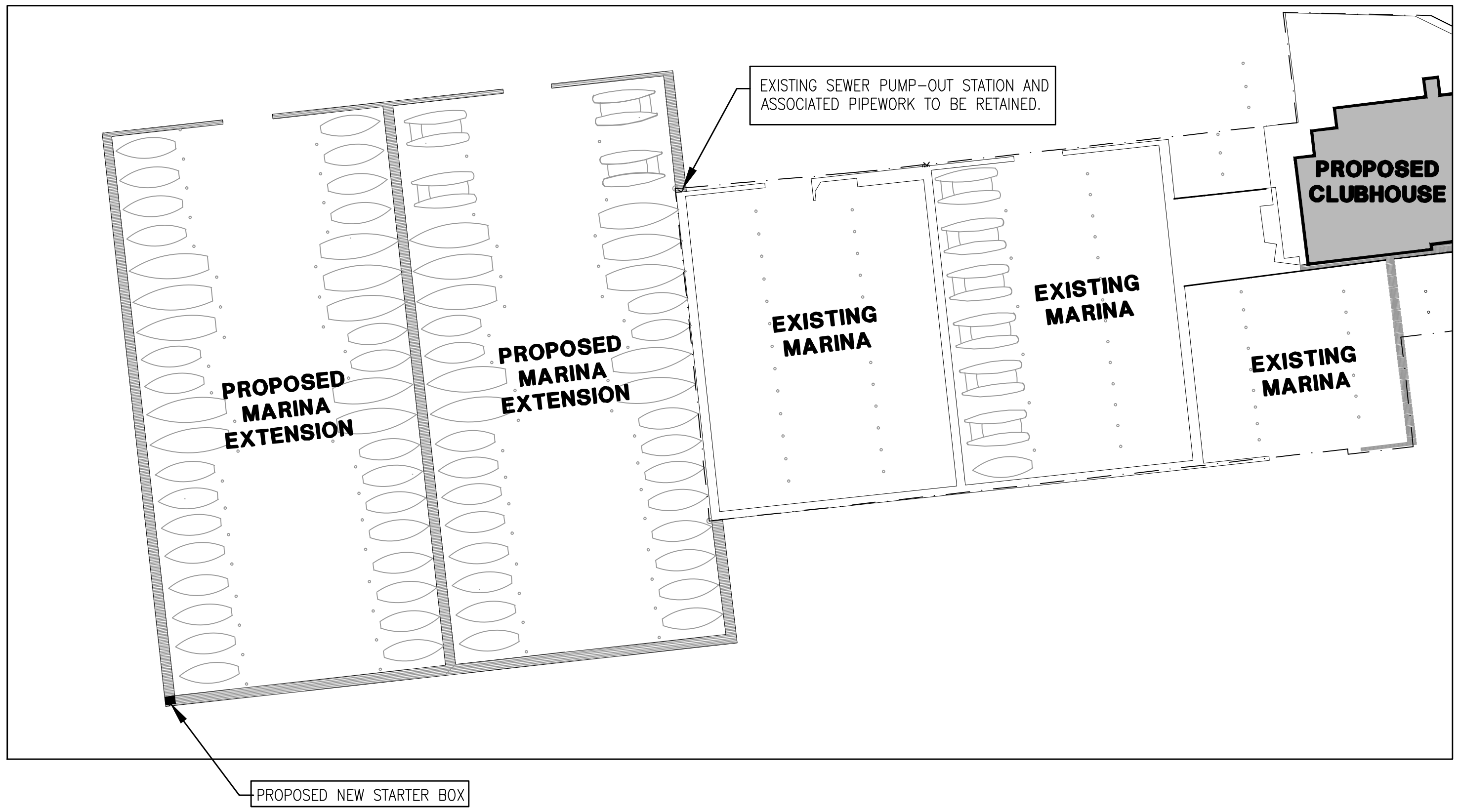
DRAWING TITLE: EARTHWORKS PLAN

JOB NUMBER: NL080037

DRAWING NUMBER: C04 DA ISSUE: C

DRAWING SHEET SIZE = A1





SERVICES NOTES

1. EXISTING MARINA SERVICES INCLUDE WATER AND ELECTRICITY. THESE SERVICES SHALL BE EXTENDED TO THE NEW MARINA AND NEW STARTER BOX AS REQUIRED.
2. SERVICE PROVIDERS HAVE INDICATED EXISTING SERVICES ARE ADEQUATE FOR THE SITE. ANY UPGRADES & EXTENSIONS/MODIFICATIONS REQUIRED TO SERVICES DUE TO THE PROPOSED REDEVELOPMENT WILL BE UNDERTAKEN AT THE CLUB'S EXPENSE. HOWEVER UPGRADES ARE UNLIKELY TO BE REQUIRED.
3. THE EXISTING SEWER PUMP-OUT POINT SHALL BE RETAINED IN ITS CURRENT LOCATION (FOR BOATS). REFER TO INSET PLAN.
4. LOCATION OF SERVICES SHOWN BASED ON INFORMATION SUPPLIED BY OTHERS. ALL SERVICES TO BE LOCATED AND CONFIRMED ON SITE PRIOR TO COMMENCEMENT OF WORKS.
5. SERVICES TO THE EXISTING CLUBHOUSE INCLUDE SEWER, POTABLE WATER, TELECOMMUNICATIONS, ELECTRICITY & GAY. THESE SERVICES WILL BE RETAINED AND RELOCATED AS REQUIRED TO SUIT THE PROPOSED NEW CLUBHOUSE. RECYCLED MAINS WATER IS NOT PROPOSED FOR THIS AREA.
6. A RAINWATER STORAGE TANK WILL BE PROVIDED FOR THE REDEVELOPMENT TO CAPTURE A PORTION OF ROOFWATER RUNOFF FOR REUSE FOR GARDEN IRRIGATION AND BOAT WASHDOWN. LOCATION OF TANK TO BE CONFIRMED AT DETAILED DESIGN STAGE, HOWEVER, IT WILL BE IN VICINITY OF EXISTING BOAT RAMP AND DRY DOCK ADJACENT TO CLUBHOUSE.

LEGEND

• Ex LP	DENOTES EXISTING LIGHTPOLE
—— TEL ——	DENOTES EXISTING TELSTRA LINE
	DENOTES EXISTING TELSTRA PIT
Ex GAS	DENOTES EXISTING GAS METER
Ex GV	DENOTES EXISTING GAS VALVE
—— G ——	DENOTES EXISTING GAS MAIN
■ Ex P	DENOTES EXISTING POWER (ELECTRICITY)
● Ex WM	DENOTES EXISTING WATER METER
⊙ Ex SMH	DENOTES EXISTING SEWER MANHOLE/INSPECTION PIT
—— S ——	DENOTES EXISTING SEWER MAIN
—— W ——	DENOTES EXISTING WATER MAIN
⊡ PIT	DENOTES PROPOSED STORMWATER INLET PIT

DA APPROVAL

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CLIENT: LAKE MACQUARIE YACHT CLUB

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PLANS 1:300 0 3 6 9 12 15m

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Email newcastle@northrop.com.au ABN 81 094 433 100

PROJECT: PROPOSED RE-DEVELOPMENT OF LAKE MACQUARIE YACHT CLUB ADA STREET BELMONT, NSW

DRAWING TITLE: EXISTING SERVICES PLAN

JOB NUMBER: NL080037

DRAWING NUMBER: C05 DA ISSUE: C

DRAWING SHEET SIZE = A1

APPENDIX D

Flood Planning

- Preliminary Flood Emergency Response Plan
- C06 DA – Flood Evacuation Plan

Preliminary Flood Emergency Response Plan

for

Lake Macquarie Yacht Club

9 Ada Street, Belmont NSW

February 2010

Issue B

Ref NL080037

Prepared By	SW	08.03.10
Checked By	AB	08.03.10

Contents

D1 Introduction

A site specific Flood Emergency Response (FER) Plan is an essential tool in the management of risks to life and property within a flood prone environment. Lake Macquarie Yacht Club extends out into Lake Macquarie, NSW in an area known as Belmont Bay. Lake Macquarie water levels have the potential to rise and create flooding of foreshore areas during extreme rainfall events.

This document is intended as a preliminary FER Plan for the proposed redevelopment of Lake Macquarie Yacht Club, and aims to provide guidance on flood risk, and appropriate education and evacuation procedures for the site. It will ultimately be the responsibility of the Lake Macquarie Yacht Club Management to update, maintain and implement a relevant and comprehensive FER Plan for the site.

This document aims to provide preliminary guidance on:

- Likely flood behaviour for the site;
- Appropriate flood warning systems;
- Education and awareness programs;
- Evacuation and evasion procedures;
- Evacuation routes and flood refuges including access constraints; and
- Flood preparedness and awareness procedures for Lake Macquarie Yacht Club employees and visitors;

such that Lake Macquarie Yacht Club Management will be equipped with a framework from which to develop a comprehensive FER Plan for the site.

D2 Likely Flood Behaviour

The existing clubhouse has been exposed to several extreme storm events, most recently in June 2007; however we understand the clubhouse has never been inundated.

The existing clubhouse ground floor level is approximately 1.2m Australian Height Datum (AHD), while the proposed ground floor level for the redeveloped club house is 1.98m AHD, and the proposed first floor level 5.78m AHD. The existing decking and marina structure are situated at 1.1m AHD, approximately 1m above the Lake mean water level[1]. The proposed marina extension will be constructed to match the existing marina levels. The existing bitumen carpark currently has surface levels in the order of 0.8m AHD to approximately 1.2m AHD. The redevelopment proposal will involve resurfacing and regrading of the existing carpark, however finished surface levels will generally be maintained at similar levels to existing.

The 1998 Lake Macquarie Flood Study (Part 2 – Foreshore Flooding) prepared by Manly Hydraulics Laboratory provides guidance on expected flood levels within the Belmont Bay area of Lake Macquarie. Table 1 below compares the estimated design flood levels noted in the report, compared to existing and proposed floor levels for the Lake Macquarie Yacht Club clubhouse.

Table 1 – Flood Levels & Lake Macquarie Yacht Club Floor Levels

Recommended Design Flood Level 1% AEP[2] (m AHD)	Recommended Design Flood Level 5% AEP[2] (m AHD)	Recommended Design Flood Level PMF[3] (m AHD)	Proposed Ground Floor Level (m AHD)	Proposed First Floor Level (m AHD)	Existing Ground Floor Level (m AHD)	Observed 1990 Flood Level[3] (m AHD)	Observed 1949 Flood Level[1] (m AHD)
1.6	1.3*	3.5	1.98	5.78	1.2	1.05	1.25

**Average of recommended design flood level for Belmont Bay North and Belmont Bay South*

[1] Lake Macquarie City Council, Fact Sheet 12 – Environmental Facts and Issues, 01/09/2006. Average lake surface level is 0.15m AHD. AHD 0.0m is the average sea level around Australia.

[2] Lake Macquarie Flood Study (Part 2 – Foreshore Flooding), Manly Hydraulics Laboratory, 1998

[3] 2.63m AHD per Lake Macquarie Floodplain Management Study, Webb, McKeown and Associates, 2000, plus 0.91m for Climate Change allowance, per Lake Macquarie City Council's Sea Level Rise Policy Fact Sheet, 2008

The historical and design flood levels in Table 1 suggest that the bitumen carpark and marina structure may be subject to inundation in the 1% and 5% AEP peak flooding events. The foreshore area adjacent to the clubhouse is similarly at risk of flooding during extreme rainfall events. Given the existing clubhouse has never been inundated, it is considered that raising the ground floor level by 780mm will provide further security against floodwaters entering the clubhouse in future extreme rainfall events.

The design flood levels listed in Table 1 do not take into account sea (lake) level rise under climate change. Due to the uncertainty surrounding this area of science, and the desire for the clubhouse to remain closely related to the lake water level under normal operations, it is currently proposed that the ground floor structure and services for the redeveloped clubhouse be designed to be adaptable, to permit them to be raised if and when required to accommodate a potential future increase in lake levels and an associated increase in flood levels due to climate change.

The 2000 Lake Macquarie Floodplain Management Study prepared by Webb, McKeown and Associates indicates the lake is expected to rise slowly during flood events, potentially, as in the case of the 1990 flood event, taking in the order of 48 hours to reach peak flood level. The study suggests people are therefore unlikely to be ‘caught completely unaware’ in the event of extreme flood events, and should have some time to prevent damage to easily moved items as well as to evacuate from areas likely to be subject to inundation.

D3 Flood Warning Systems

D3.1 Awareness

Lake Macquarie Yacht Club Management should set in place a procedure for monitoring of lake water levels during major rainfall events. The procedure should include an alert system for notifiying clubhouse and marina occupants of any potential need to evacuate, without creating a sense of alarm.

Users of the clubhouse and marina should be made aware of the potential for the marina, carpark and foreshore to be inundated during major rainfall events, and the estimated time for flood levels to reach their peak. Users of the clubhouse and marina should be aware of refuge and evacuation options available during flooding events.

In extreme rainfall events, local radio stations should be monitored for information on:

- Whether flooding is expected within the lake;
- Anticipated timing and height of peak flood levels; and
- When flood waters could be expected to recede.

D3.2 Communication Systems

The communications network for the proposed redevelopment should include an appropriate Emergency Warning and Intercommunication System (EWIS), designed to facilitate orderly evacuation from the site in the event of an emergency. For example, a loud speaker system able to be heard within the clubhouse, along the marina and within the carparking areas may be an appropriate EWIS for the site. Communication with the occupants of the site should be maintained during significant flooding events.

Contact with emergency authorities should be limited to emergency situations.

D4 Education Awareness Program

Education of all Lake Macquarie Yacht Club employees, members and visitors should be undertaken to make all individuals aware of the risk of flooding at the site. Clubhouse and marina occupants should be made aware of the emergencey alert and evacuation procedures established by the Lake Macquarie Yacht Club Management, and educated as to appropriate evacuation routes and refuges. Flood response drills should be undertaken and directed by the Lake Macquarie Yacht Club Management.

Appropriate signage similar to a fire evacuation plan should be provided to inform all clubhouse and marina occupants of their safest course of action in the event of a flood. An information sheet describing the procedure to be undertaken in the event of a flood should be on prominent and permanent display. A map indicating potential flood levels, evacuation routes and refuges should accompany the information sheet. An example of an appropriate information sheet and map for the site is included as Appendix I to this plan.

D5 Evacuation and Evasion: Procedure, Routes and Refuges

The procedures within the final FER Plan to be developed by the Lake Macquarie Yacht Club Management for the site should be aimed at self-directed evacuation and evasion to minimise draw on emergency services resources. An information sheet and map similar to the examples included as Appendix I to this document should be developed and used to assist this process. An evacuation meeting point should be established (for example, within Cullen Park), and a coordinated evacuation strategy developed for the site.

Lake Macquarie Yacht Club employees, members and visitors should be made aware of the available options for evacuation and refuge during flood events, and advised of potential flooding events with ample time to undertake orderly evacuation from the site or safe refuge on the first floor of the clubhouse.Club users should be made aware of the risks associated potential flooding of the marina structure, carpark and foreshore areas in extreme flooding events.

D6 Flood Preparedness and Awareness Procedures

It will be the responsibility of the Lake Macquarie Yacht Club Management to ensure the information and recommendations outlined in this document are integrated into a comprehensive FER Plan for the site. The Lake Macquarie Yacht Club Management will be responsible for updating and implementing the FER Plan.

It will be the Lake Macquarie Yacht Club Management's role to ensure employees, members and visitors are appropriately educated on flood risks and evacuation procedures, and to ensure appropriate signage is installed to inform people of their safest course of action in the event of a flood.

Appendix I – Example Information Sheet and Map

EXAMPLE FLOOD EMERGENCY RESPONSE – INFORMATION SHEET

1. **Flooding in the vicinity of this building is a rare and unlikely occurrence. It is estimated that in the event of an extreme flood, the ground floor of this building is unlikely to be inundated with water (i.e. a 1 in 100yr event). It is estimated that during the 1 in 100yr event the carpark in front of this building could become covered with water to a depth of approximately 0.4m, and the marina structure to a depth of approximately 0.6m. In the event of an extreme flood, the foreshore area could become covered with water to a depth of approximately 0.8m.**

2. **If flood waters are observed in the marina, carpark or foreshore areas, the best place to stay is in the clubhouse. Do not attempt to leave the clubhouse on foot. Do not attempt to remove your vehicle from the carparking areas.**

3. **Follow any instructions issued by Management for the Lake Macquarie Yacht Club. Only move to the Flood Evacuation Point if directed to do so by Management, otherwise remain in the clubhouse.**

4. **Monitor information bulletins on local radio stations, but avoid contacting emergency services unless there is a particular need to do so.**

5. **Lake Macquarie Yacht Club Management are to ensure a supply of candles and matches / lighter is handy and in a known location to provide light in the event of power failing. Lake Macquarie Yacht Club Management are to have a supply of batteries and a battery-powered torch and radio handy, in a known location, for such emergencies.**

6. **Advise Lake Macquarie Yacht Club Management of observation of any flood water within the vicinity of the site. Follow directions given by the Lake Macquarie Yacht Club Management with regard to safety.**

Example Map Only

Actual Map to be developed by Lake Macquarie Yacht Club Management.
Actual Flood Evacuation Point to be determined by Lake Macquarie Yacht Club Management.

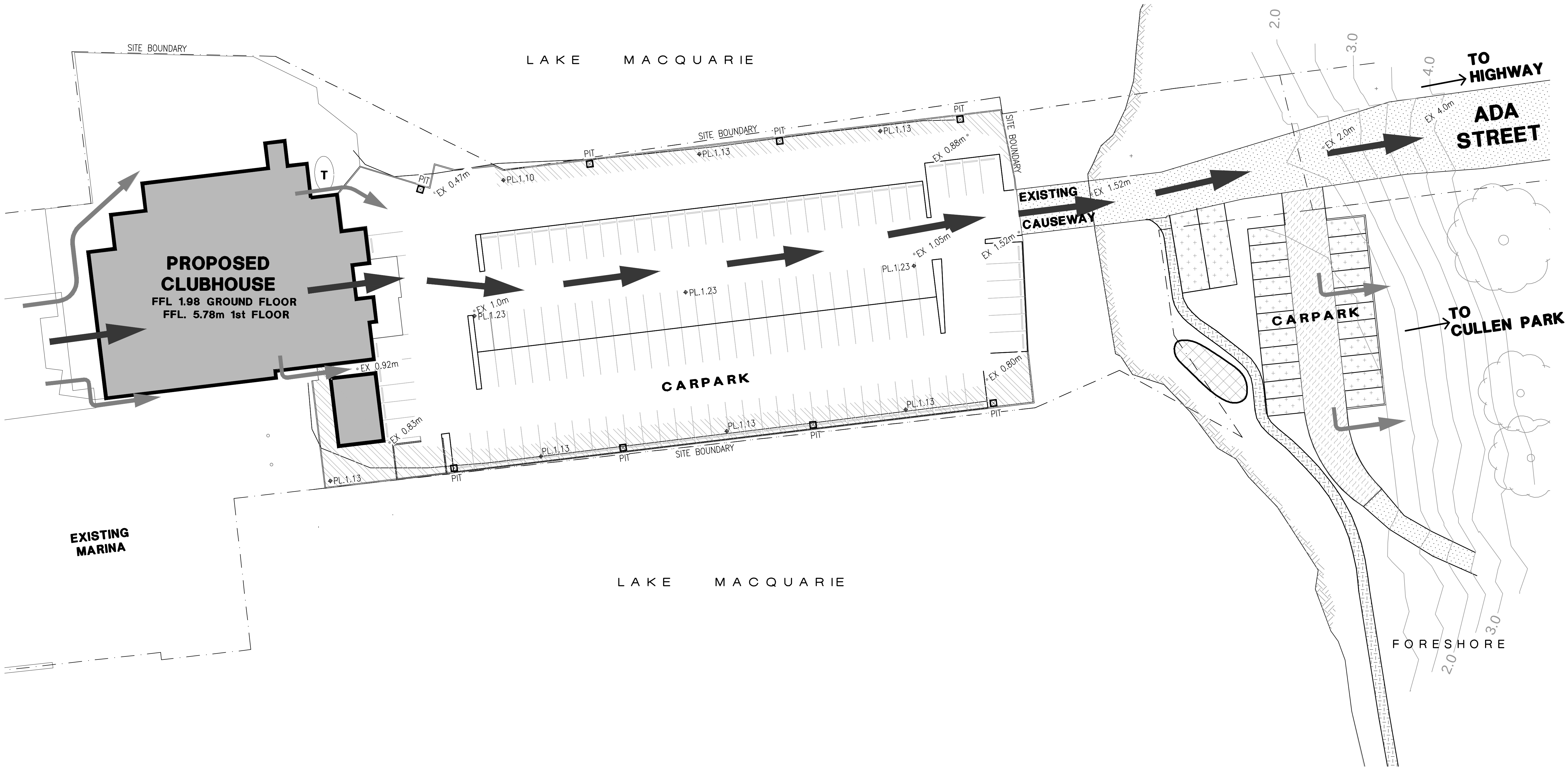
FLOOD EVACUATION ROUTES AND FLOOD REFUGE

EVACUATION OF CLUB PATRONS TO HIGHER GROUND VIA ADA STREET, OR CULLEN PARK, WOULD BE THE MOST LIKELY COURSE OF ACTION IN THE EVENT OF A FLOOD WARNING FOR LAKE MACQUARIE. TIMELY EVACUATION TO HIGHER GROUND WOULD BE READILY ACHIEVABLE, DUE TO THE NATURE OF THE LAKE HYDRAULICS. (IN THE ORDER OF 48 HOURS TO PEAK LEVEL IN EXTREME FLOOD EVENT IN 1990)

IN THE UNLIKELY EVENT OF THE PROPOSED CLUBHOUSE BECOMING INUNDATED, FLOOD REFUGE WILL BE AVAILABLE ON SITE ON THE FIRST FLOOR OF THE BUILDING AT 5.78M AHD. DETAILED DESIGN OF THE PROPOSED NEW CLUBHOUSE AND MARINA WILL INCLUDE CONSIDERATION OF HYDROSTATIC AND DYNAMIC PRESSURES TO ENSURE THE INTEGRITY OF THE STRUCTURES IN THE UNLIKELY EVENT OF INUNDATION.

LEGEND

- DENOTES PRIMARY EVACUATION PATH
- DENOTES SECONDARY EVACUATION PATH
- EX 0.88m · DENOTES EXISTING SURFACE LEVEL
- ◆PL.1.23 DENOTES PROPOSED FINISHED SURFACE LEVEL
- 3.0 DENOTES EXISTING CONTOUR LEVEL
- DENOTES SHORELINE
- DENOTES PROPOSED TURF CELLS
- DENOTES PROPOSED BITUMEN SEALED ACCESS WAY
- DENOTES PROPOSED FOOTPATH
- DENOTES PROPOSED CARPARK EXTENSION
- DENOTES EXISTING PAVEMENT TO REMAIN
- PIT DENOTES PROPOSED STORMWATER INLET PIT



DA APPROVAL

DRAWN: K.BRADLEY DESIGNED: S.WILSON JOB MANAGER: A.BROWN VERIFIER: A.BROWN

ISSUE	AMENDMENT	VERIFIED	APPROVED	DATE
A	ISSUED FOR APPROVAL	AB	AB	19.02.10
B	ISSUED FOR APPROVAL	SW	SW	08.03.10
C	ISSUED FOR APPROVAL - PITS SHOWN, LEGEND AMENDED	SW	SW	10.06.10

CLIENT: **LAKE MACQUARIE YACHT CLUB**

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT: EJE architecture

ALL DIMENSIONS TO BE VERIFIED ON SITE BEFORE MAKING ANY SHOP DRAWINGS OR COMMENCING ANY WORK.

PLANS 1:300 0 3 6 9 12 15m

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323 Charlestown Road, Charlestown, NSW 2290 Ph (02) 4943 1777 Fax (02) 4943 1577 P.O. Box 180 Charlestown, NSW 2290
Email newcastle@northrop.com.au ABN 81 094 433 100

PROJECT: **PROPOSED RE-DEVELOPMENT OF LAKE MACQUARIE YACHT CLUB ADA STREET BELMONT, NSW**

DRAWING TITLE: **FLOOD EVACUATION PLAN**

JOB NUMBER: NL080037

DRAWING NUMBER: C06 DA

ISSUE: C

DRAWING SHEET SIZE = A1