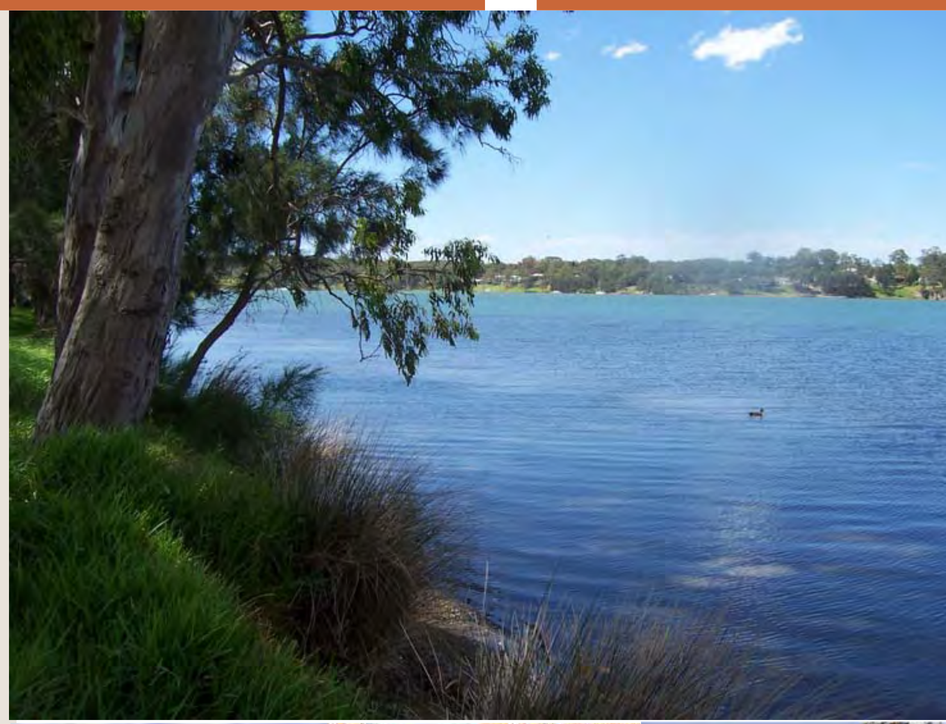
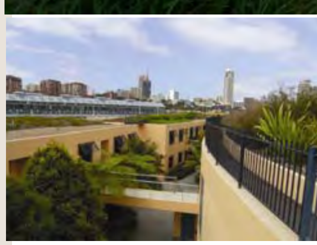
Trinity Point Marina Development

Stormwater/Flooding Management Plan





Johnson Property Group

Issued: November 2008

Patterson Britton
& Partners Pty Ltd
consulting engineers

Trinity Point Marina Development

Issue	Description of Amendment	Prepared by (date)	Verified by (date)	Approved by (date)
1	Draft for client review	Chris Kuczera 4/12/07	Ben Patterson 4/12/07	B&P 4/12/07
2	Final	Chris Kuczera 14/12/07	Ben Patterson 17/12/07	B&P 17/12/07
3	Revised Draft for client review	Chris Kuczera 19.06.08	Ben Patterson 19.06.08	
4	Final for Submission	Chris Kuczera 23.06.08	Ben Patterson 23.06.08	
5	Revised Final for Submission	Chris Kuczera 14.11.08	Dan Messiter 14.11.08	

Issue No. 5

Note:

This document is preliminary unless it is approved by principal of Patterson Britton & Partners.

Document Reference: 6759.12 Trinity Point SWMP (ck) 28.10.08 (Final for Submission)V7.doc

Time and date printed: 14/11/2008 4:22 PM

Sydney Office

Level 4, 104 Mount Street
North Sydney 2060

PO Box 515
North Sydney 2059
Australia

telephone 02 9957 1619
facsimile 02 9957 1291
reception@patbrit.com.au

ABN 89 003 220 228

Newcastle Office

8 Telford Street
Newcastle East 2300

PO Box 668
Newcastle 2300
Australia

telephone 02 4928 7777
facsimile 02 4926 2111
mail@newcastle.patbrit.com.au

Patterson Britton & Partners Pty Ltd
consulting engineers

Table of Contents

Table of Contents

Table of Contents

LIST OF TABLES

1 INTRODUCTION

1.1 BACKGROUND

Johnson Property Group *(JPG)* propose a marina tourism development for the Trinity Point site near Bluff Point, Morisset Park located on in southern Lake Macquarie *(refer* **Figure 1** *for site locality)*. Lake Macquarie is one of Australia's largest coastal saltwater lakes, located approximately 20km south of Newcastle and approximately 125km north of Sydney.

The site is within the Lake Macquarie City Council Local Government Area *(LGA)*, however the proposal is to be assessed under *Part 3A* of the *EP&A Act* as a 'major project', and as such will be referred to the Department of Planning *(DoP)* for concept plan approval. The overall tourism project is currently in the conceptual development phase, and will been submitted as a 'concept plan' application under the Part 3A process. This report addresses the stormwater, flooding and water quality management issues for the proposed development in support of the 'concept plan' *Environmental Assessment Report* (*EAR*).

1.2 STUDY OBJECTIVES

This study is to address the stormwater management and flooding issues for the proposed Trinity Point Marina development. The primary objectives are outlined as follows:

- to formulate a stormwater management plan (*SWMP*) for the development proposal;
- establish stormwater and waste control measures required for the proposed marina, village centre, residential/tourism area and the marina workshop area; and
- define flood levels in Lake Macquarie for a full range of Average Recurrence Intervals (*ARI*), including consideration of potential sea level rise and increases in rainfall intensity as a result of climate change.

This report will form part of the Environmental Assessment (EA) for the proposed development.

1.3 SITE DESCRIPTION

The Trinity Point site is located on the south-western shore of Lake Macquarie (*refer* ***Figure 1***). Currently, the site is sparsely vegetated with remnant signs of cattle grazing. The site generally grades towards the lake, with no established drainage paths. A seagrass community exists immediately to the east of the site, (*indicated as the darker area adjacent to the development site in* ***Figure 2***)**.**

1.4 PROPOSED DEVELOPMENT

The proposed Marina Village development consists of a breakwater and marina, associated boat maintenance facilities (*travel lift, hardstand and workshop*) as well as other related infrastructure such as a café, restaurant and function facilities. The Marina Village also incorporates three six storey accommodation buildings (for *both apartment and hotel style accommodation*) and associated car parking, footpaths and boardwalk/decking areas.

The remainder of the tourism development consist of apartment / hotel style accommodation, in 2 – 5 storey buildings, associated car parking (*under croft parking*), access roadways, footpaths, boardwalks and landscaping. The proposed development Masterplan is presented in **Figure 2**.

1.5 RELEVANT GUIDELINES AND LEGISLATION

The scope of this study falls under the umbrella of many government and industry guidelines and legislation. The key legislation and guidelines considered in this study are outlined below.

Stormwater Industry Guidelines

Australian Rainfall and Runoff[10]

Australian Rainfall and Runoff (*AR&R*) is a document published in 1987 by the *Institution of Engineers, Australia* (*IEAust).* This document has been prepared to provide designers with the best available information on design flood estimation and is widely accepted as a design guideline for all flood and stormwater related design in Australia.

Australian Runoff Quality[13]

Australian Runoff Quality (*ARQ*) is a document published in 2005 by *IEAust* which provides design guidelines for all aspect of *Water Sensitive Urban Design* (*WSUD*), including preventative measures, source controls, conveyance controls and end of line controls. Additionally, it provides guidance for water quality modelling as well as stormwater harvesting and re-use.

National Guidelines

Australian Guidelines for Water Quality Monitoring and Reporting – ANZECC, 2000[22]

These guidelines are the benchmark document of the National Water Quality Management Strategy (*NWQMS)* which is used for comparison of water quality monitoring data throughout Australia.

State Government Guidelines

Best Management Practice for Marinas and Boat Repair Facilities, EPA 1999[1]

This guideline applies to all new marina and boat repair facility proposals, outlining best management practice for marina design and operation. The primary objectives of the document are to provide guidance on relevant environmental issues, recommend mitigation measures, outline statutory environmental protection requirements and encourage waste minimisation and recycling.

Managing Urban Stormwater Series, EPA

This series of documents issued by the EPA provide guidance on a wide range of stormwater management issues. Relevant guidelines to this study are:

- EPA (1998) *Managing Urban Stormwater: Council Handbook* [4];
- EPA (1998) *Managing Urban Stormwater: Source Control* [5];
- EPA (1998) *Managing Urban Stormwater: Treatment Techniques* [6];

- EPA (2007) Managing Urban Stormwater: Environmental Targets (*Consultation Draft*) [7]
- EPA (2006) *Managing Urban Stormwater: Harvesting and Reuse* [8]; and
- EPA (1998) *Managing Urban Stormwater: Soils and Construction* [9].

Water Management Act 2000 [18]

The *Water Management Act 2000 (WMA)* is administered by the *Department of Water and Energy* (*DWE*). The act provides guidelines regarding development constraints and riparian setback for any controlled activity occurring within 40 metres from a river, lake or estuary.

The purpose of a *WMA* is to control activities that have the potential to cause adverse impacts such as:

- Increased erosion or siltation of watercourses or lakes;
- Bed lowering and bank collapse;
- Diverting the course of a watercourse;
- Obstructing or detrimentally affecting stream flow; and
- Ecological deterioration, leading to long term watercourse stability problems.

As the Trinity Point Marina project is assessed under the Part 3A permit, the development proposal is not legally bound to meet the requirements of the WMA. However, the WMA is considered best practise and has been applied in principle to the development proposal.

Floodplain Development Manual[11]

The *Floodplain Development Manual* is a document published by the *New South Wales State Government* in 2005. The document details *Flood Prone Land Policy* which has the primary objective of reducing 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 from occupation and development of flood prone land[11].

Practical Consideration of Climate Change, Floodplain Risk Management Guideline Note, NSW Government – Department of Environment and Climate Change, Final November 2007[23]

This document is a Floodplain Risk Management Guideline issued to assist Councils with the preparation and implementation of their Floodplain Risk Management Plans. The guideline outlines typical ocean level rise and peak rainfall and storm volume increases that should be considered in any climate change sensitivity analyses for flood risk assessment.

State Environmental Planning Policy (*Building Sustainability Index: BASIX*) 2004 [15]

The Building Sustainability Index (*BASIX*) assesses the performance of new homes against a range of sustainability indices, viz Landscape, Stormwater, Water, Thermal Comfort and Energy. *BASIX* primary objective to reduce the environmental impact on these indices through the implementation water and energy efficiency targets for all future developments.

Lake Macquarie City Council Guidelines

LMCC DCP No.1 [14]

Section 2.5 of Lake Macquarie City Councils DCP No.1 "*relates to the provision of stormwater management and infrastructure that is necessary to all parts of development*"[14]. This document outlines stormwater management guidelines suitable for Lake Macquarie catchments. Of particular relevance is:

- Performance criteria P 2.5 – water quality protection measures such as bunding and first flush must be provided for potentially polluting areas; and
- Performance criteria P 2.6 - stormwater management for properties adjacent to the lake should focus on source controls.

Engineering Guidelines Part 1: Stormwater Drainage Design [17]

This document is primarily a detailed design guideline, hence it has minimal relevance at the conceptual level. None the less, future detailed design of the stormwater system will adhere to this guideline, so it has been considered where relevant.

Marina Guidelines

Australian Standard 'Guidelines for Design of Marinas', AS 3962-2001 [16]

This Standard provides designers, manufacturers and operators of marina and berthing facilities with a set of guidelines for recreational marinas and small commercial vessels up to 50 m in length. Guidance is also given for onshore facilities such as dry boat storage, boatlifts, boat ramps and associated parking facilities.

The Standard has been utilised to assist in the concept design of the proposed marina facilities.

1.6 PREVIOUS STUDIES

The only formal stormwater management study undertaken specifically for the site was conducted by Northrop Engineers in June 2003, titled *Investigation for Stormwater Management* [20]. This investigation was for a predominantly residential land use and therefore it has limited application to the current development proposal.

1.7 AVAILABLE DATA

The following data was used for this study:

- A topographical survey of the existing landform;
- Recent aerial photographs; and
- The flood assessment results published in the *Lake Macquarie Flood Study*[2]

2 STUDY OBJECTIVES

2.1 DISCUSSION

Given the high sensitivity of aquatic ecosystems in the immediate receiving water, management of stormwater quality is an essential element of the environmental objectives for the proposed development. Of particular importance are the local seagrass populations, some of which are located in the shallow waters immediately adjacent to the proposed development site. Seagrass communities are typically highly sensitive to increased levels of suspended sediment and nutrients, which are commonly observed in elevated levels in stormwater runoff from urbanised catchments. Accordingly, a range of stormwater control measures are proposed to achieve water quality control beyond current best practice, to mitigate any degradation of the water quality in Lake Macquarie resulting from the proposed development.

Historically, marina workshop and vessel repair areas have been a source of a range of heavy metals and other potentially toxic pollutants. Generally, these pollutants are produced as an unintended by-product of vessel hull repair and maintenance operations occurring over a hardstand area within or adjacent to the tidal zone of the receiving water. A range of preventative, containment and treatment measures would be adopted to manage stormwater runoff quality from the marina workshop/hardstand area.

2.2 STORMWATER MANAGEMENT OBJECTIVES

The following stormwater management objectives have been established for the Trinity Point site:

- ❒ Establish preventive measures to minimise the generation of pollutants throughout the development;
- ❒ Identify opportunities for stormwater harvesting and provide a conceptual design for a stormwater harvesting system;
- ❒ Provide water quality control measures to mitigate any adverse impacts on the water quality in the receiving waters;
- ❒ Provide preventative measures to minimise the risk of spillage of hazardous materials from the marina and associated infrastructure;
- ❒ Isolate potentially contaminated areas such as boat workshops and provide stormwater controls inline with best practice guidelines; and
- ❒ Address the operational and maintenance aspects of the stormwater management plan.

3 STORMWATER MANAGEMENT PLAN

3.1 DISCUSSION

A water sensitive urban design (*WSUD*) would be adopted to achieve the stormwater management objectives for the Trinity Point site. Given the close proximity of the development site to Lake Macquarie, and considering that there are no major established catchments, stormwater management for the site would focus on preventative measures and source controls rather than conveyance and downstream controls. Collectively, these control measures would provide a high level of water quality management for all runoff generated on-site. Additionally, opportunities exist to implement a stormwater harvesting scheme, which would reduce the volume of runoff as well as mains water demands for the proposed development.

Section 3.2 outlines the proposed stormwater management philosophy. The proposed stormwater configuration is presented in **Section 3.3.**

3.2 STORMWATER MANAGEMENT PHILOSOPHY

For stormwater management purposes, the proposed development will be segregated into three management areas:

- Development Area: - Incorporates all development areas other than the marina hardstand area. Landuse areas would include: multistorey dwellings, landscaped gardens, boardwalk areas as well as roads and pathways;

- Marina Hardstand Area:- Marina hardstand areas will facilitate vessel maintenance operations, which are potentially polluting activities. Hence, this area will have a separate stormwater management strategy; and

- Revegetation Area:- A minimum 20 metre riparian vegetation buffer between the developed area and the lake is proposed. This area would be revegetated with native vegetation, hence no stormwater treatment is required.

Stormwater management philosophies for both the general development area and hardstand area are outlined below.

3.2.1 General Development Area – Stormwater Management Philosophies

Proposed stormwater control measures for both the marina, village centre and the residential tourism developments are outlined as follows:-

- **Preventative Measures –** The following preventative measures would be adopted as development controls to reduce the generation of pollutants under normal conditions as well as providing contingency in the event of an accidental spill of potentially polluting substances: -

  - Minimising areas of impervious surfaces - by reduced road widths and increased landscaping around dwellings;

  - Implement drought tolerant native plant species into the landscape, which would reduce the need for irrigation and fertiliser application;

- Establishment of a fertiliser management plan which would ensure fertiliser application is undertaken in a controlled manner using best practice methods;

- Provision of industry best practice arrangements for the dispensing of fuel (*e.g. integral secondary containment tanks and delivery lines, provision of drip trays, provision of oil/fuel boom and oil absorbent material*);

- Provide adequate rubbish bins and waste disposal services to encourage responsible disposal of waste and rubbish;

- Establish measures to reduce pet droppings in the development area; and

- Establish a public education system, which informs residents and guests of the stormwater management issues and encourages environmentally responsible behaviour.

❒ **Source Controls -** The following source control measures have been considered for the Trinity Point Development: -

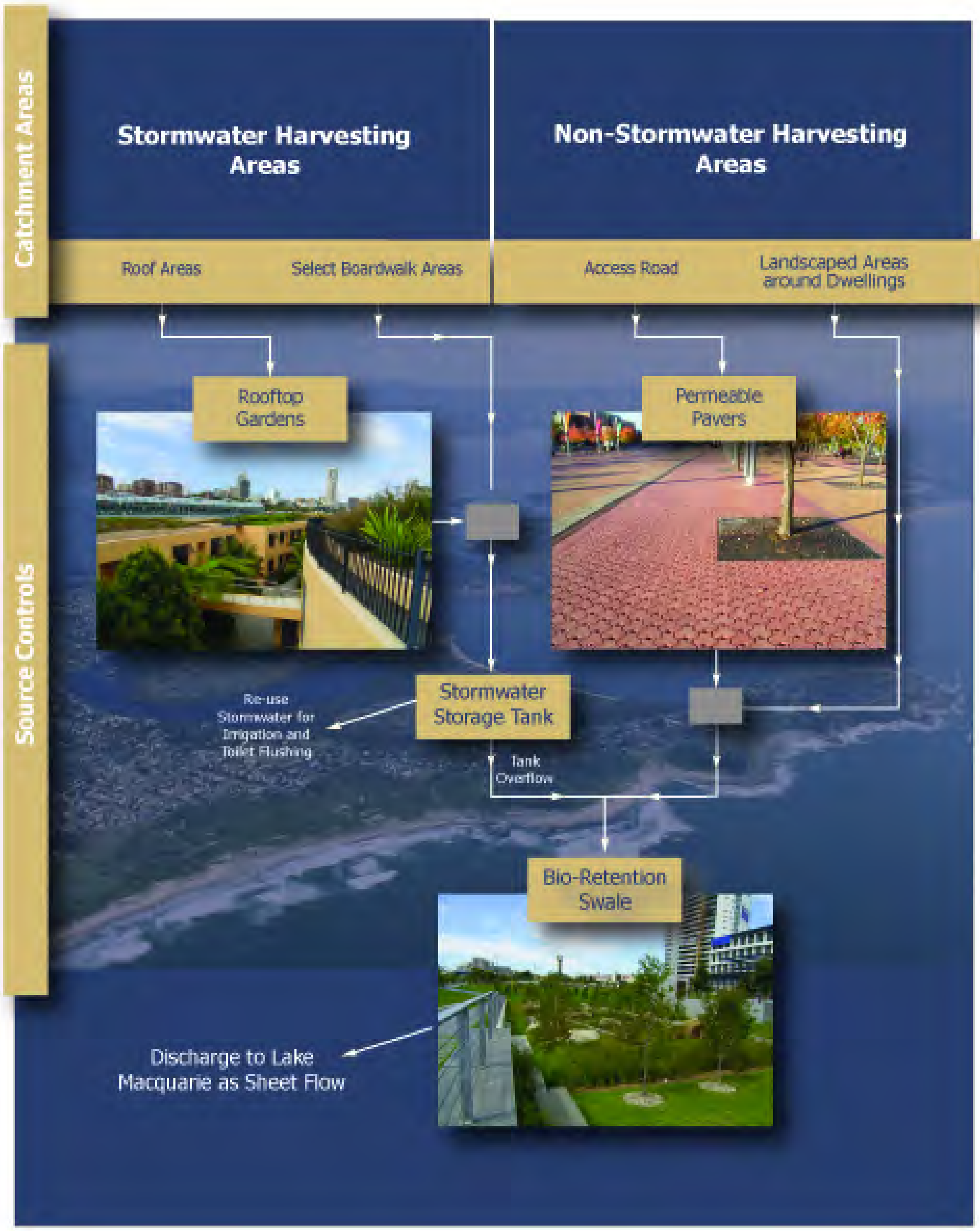
- Rooftop Gardens – rooftop gardens could be implemented to achieve a reduction in runoff volume and treatment of runoff by infiltration into the soil media, hence limiting impacts on groundwater and the receiving waters. Should green roofs be implemented, they would be predominantly vegetated with drought tolerant, non-fertilised gardens, which would provide water quality, thermal efficiency and aesthetic benefits. An alternative to green roofs would be to harvest rainwater directly from the impervious roof surface, and to increase the area of downstream bio-retention area to compensate for the loss of potential green roof areas;

- Rainwater Harvesting - would capture roof and boardwalk runoff for reuse within the establishment for non-potable purposes. This would allow for a reduction in mains water demand as well as reduce the runoff volume from the site, hence limiting effects on groundwater and the receiving waters;

- Permeable Pavement - can be implemented into any un-covered walkways or parking bays. The pavement would allow stormwater to infiltrate into the sub-base, where stormwater retention and treatment is provided. As permeable pavement can be integrated into the landscape, there is generally have no net land take. Note, in order to limit the effects of potentially contaminated runoff from permeable pavements from affecting site groundwater, permeable pavements would be lined to prevent infiltration to the underlying strata. Subsoil drainage from the permeable pavements will be directed to downstream bio-retention systems; and

- Bio-Filtration Swales – All site runoff is to be treated by bio-retention areas which are to be integrated into the lakeside walkway. Bio-filtration areas would consist of vegetated areas with an enhanced filtration media. Stormwater attenuation is provided within the filter media as well as ponding within the swale. Runoff is slowly infiltrated through the enhanced filter media, where physical and bio-chemical processes provide removal of suspended sediments and nutrients. Filtered stormwater would be collected in an underlying subsurface drainage system and discharged into the lake in a “low impact” distribution system. At this point, stormwater runoff will have been treated to a level that is suitable for discharge to the environment. While direct infiltration to groundwater will not be encouraged, some infiltration will occur along the development edge, adjacent to the vegetation buffer proposed along the eastern and northern edges of the site.

The proposed treatment train philosophy is demonstrated in the following schematic.



3.2.2 Marina Hardstand Area – Stormwater Management Philosophies

The marina workshop/hardstand area is a potential source of pollutants toxic to marine life. Hence, strict stormwater controls will be required, these are outlined as follows:-

- **Preventative Measures –** The following preventative measures would be adopted to minimise generation of pollutants from the vessel repair operations:-
  - Mist shrouds would be used in the wash down bay to minimise the migration of any wash down waters outside the hardstand area;
  - Abrasive blasting would be undertaken within tarp enclosures and would be closely monitored on windy days to prevent drifting dust;
  - Where practical, vacuum sanders would be used to remove paint from hulls and collect paint dust;
  - Sacrificial anodes would be removed or covered before water blasting;
  - The majority of solid contaminants (*e.g. paint shavings, marine growths, etc*) which can accumulate on the hardstand would be regularly swept up in the dry (*rather than wash down*) and stored in solid waste bins for collection by a commercial waste contractor;
  - Tributyltin (*an antifouling paint which is highly toxic to marine life)* would not be used onsite; and
  - The hardstand area would be set above the 5 year ARI Lake Macquarie still flood level to prevent frequent inundation.
- **Containment and Treatment Controls –** A first flush tank would be provided to capture the initial 15mm of runoff from the hardstand\workshop area (*as well as any water used for vessel wash down*). Captured stormwater would be treated using a proprietary treatment package and reused for vessel repair/wash down purposes. Excess water would be discharged to the sewer under a trade waste agreement.

The following section details the proposed stormwater configuration, indicating adopted catchment areas and preliminary location of treatment controls.

3.3 WATER QUALITY MONITORING

A surface and ground water quality monitoring programme would be implemented to observe key water quality parameters during the pre-construction, construction and operation stages of the proposed development. Monitoring would allow for the developments influence on water quality to be established. In order to accurately define any variations in water quality, existing water quality parameters must be established. This would be achieved by collection of samples prior to the initial construction of the development and a review of the large array of existing water quality data for Lake Macquarie. Water quality monitoring would be undertaken during both the construction stage and the initial three years of marina operation. The resulting observation would be compared to the existing water quality parameters and an assessment would be made to establish if any degradation in water quality has occurred as a result of the development. If monitoring indicates the development is detrimentally affecting water quality, the stormwater management strategy would be revised accordingly.

The water quality monitoring programme is further discussed in **Section 7.1.**

3.4 PROPOSED STORMWATER CONFIGURATION

Figure 4 outlines the proposed stormwater management plan for the site, including stormwater management areas (*sub catchments*) and proposed stormwater control measures. The proposed stormwater and waste management plans for the marina and workshop/hardstand area are discussed in detail in **Section 4**. **Section 5** discusses the proposed stormwater harvesting scheme while **Section 6** details the water quality modeling undertaken for the stormwater management plan.

4 MARINA AND BOAT REPAIR FACILITY

Historically, standard marina operations have allowed for contaminated by-products associated with vessel repair and maintenance activities to freely fall into flood or tidal zones. Hence, marinas are commonly a source of both surface water and sediment contamination. This section outlines the proposed mitigation measures to be adopted at the Trinity Point Marina with close consideration to the EPA guideline *Best Management Practice for Marinas and Boat Repair Facilities* (*EPA, 1999*).

4.1 DESCRIPTION OF MARINA

This section summarises the proposed marina and associated facilities and outlines the proposed operational requirements. A more thorough description of the marina facilities is available in the EA document.

4.1.1 Vessel Repair Facilities

Proposed repair and maintenance facilities would comprise of the travel-lift, hardstand area and workshop, and would be located on the northern end of the site. **Figure 3** provides a plan view of the proposed facilities.

4.1.1.1 Boat Travel-lift

The boat travel-lift facility would be situated at the north-eastern corner of the hardstand area and will extend into water of depth great enough to ensure no dredging requirement. The capacity of the travel-lift would be in the range of 70 to 75 tonnes and would be capable of lifting a vessel up to about 25m in length and about 8m beam.

The travel-lift support structure would comprise two runway beams 20 to 25 m in length, consisting of precast or insitu reinforced concrete supported on tubular steel piles installed to rock. At least one of the runway beams would have sufficient width to allow pedestrian access alongside the travel-lift device.

4.1.1.2 Hardstand Area

A hardstand area of approximately 2000 m^2 would be 55 to 60m long and have a width of between 30 and 35m. An additional 20m by 15m runway area will be provided for the boat travel-lift. Between 7 to 9 vessels (*depending on vessel size*) will be able to be accommodated on the hardstand area at any one time. Activities undertaken on the hardstand would include washing and scraping down, abrasive blasting, sanding, painting, mechanical/electrical repairs and fit outs as well as fibreglass, timber and metal work.

Diesel and unleaded petrol tanks with integral secondary containment (*i.e. "double skinned" to prevent fuel leakage*) would be located in the northern corner of the hardstand area.

The hardstand surface area would be segmented into three separate zones to facilitate waste collection and treatment. This is further discussed in **Section 4.3**.

The proposed minimum level of the hardstand is 1.3 m above Australian Height Datum (*1.3 m AHD*). The hardstand would be fenced using an appropriate security fence.

4.1.1.3 Workshop

A workshop servicing the marina would be incorporated in to the northern edge of the marina village adjacent to the hardstand area. A two storey building is proposed, containing the following uses:

- on the ground floor, workshops to suit boat maintenance operations such as shipwright, rigger, trimmer, inboard and outboard mechanical services, engineering, painter and electrician, and a plant room and amenities; and
- on the first floor, offices associated with the workshops or other marine related activities, and amenities.

4.2 POTENTIAL SOURCES OF POLLUTION

The following sources of pollution are typically generated by marina workshop facilities [(1)]:

- Elevated levels of copper and other heavy metals resulting from leaching of copper based paints from vessel hulls;
- paint flakes or soluble paint in the water;
- spillage of fuel, oil, sewage or other potentially polluting liquid wastes;
- Runoff from hardstand/workshop areas which can include:
  - by-product from sand or grit blasting operations;
  - discharges of emulsified oils (*incorporating degreasers*); and
  - chemicals from the overspray from painting.

Of particular concern are contaminants such as heavy metals, organic toxicants and solvents which can be toxic to most forms of aquatic life at very low concentrations. Mitigation measures are proposed to minimise the risk of contamination of both the receiving water and lakebed sediments, these are outlined in subsequent sections.

4.3 PROPOSED MITIGATION MEASURES

Proposed mitigation measures can be broadly separated into the following categories:

- Mitigation of pollution arising from vessel repair activities undertaken on the hardstand area; and
- Mitigation of pollution arising from maintenance and operational activities occurring while vessels are berthed at the marina.

Proposed mitigation measures include both design features and management / operational requirements. These are discussed in detail in subsequent sections. Additionally, the proposed mitigation measures are detailed in **Figure 5**.

4.3.1 Repair and Maintenance Facilities

As discussed in **Section 4.1**, the proposed repair facility would incorporate a boat travel lift, a hardstand area and a covered workshop. All repair activities would occur on the hardstand area, for which the pollution mitigation measures are outlined below.

The hardstand area would be divided into three drainage areas. An area of 180 m^2, immediately adjacent to the boat travel-lift facility, would be dedicated as a wash down area. High pressure hoses would be used in this area to clean all vessels prior to further maintenance work. The remainder of the hardstand would be graded into two sections, one in front of the workshops and the other adjacent to the wash down area.

The purpose of segmentation of the work areas is to contain any solid wastes generated within the respective maintenance areas and therefore facilitates efficient housekeeping. The guiding policy is to minimise the production of liquid trade waste by regular clean-up of solid wastes in the dry. Provision of a reinforced concrete or asphaltic concrete surface will ensure that any contamination cannot infiltrate into the underlying soil, and will protect groundwater from contamination.

Mist shrouds would be used in the wash down bay to minimise the spread of any wash down waters. Abrasive blasting would be undertaken within an enclosure and would be closely monitored on windy days to prevent drifting dust. Where practical, use would be made of vacuum sanders to remove paint from hulls and collect paint dust. Sacrificial anodes would be removed or covered before water blasting.

The majority of solid contaminants (*e.g. paint shavings, marine growth, etc*) which can accumulate on the hardstand would be regularly swept up and stored in solid waste bins for collection by a commercial waste contractor.

To ensure that the remaining contaminants which may be picked up by surface runoff are not discharged to the lake, a first flush stormwater collection system would be installed to contain and treat first flush from a rainfall event. The system would also capture wash waters resulting from the hose down of vessels on the hardstand. The system would be designed in accordance with the relevant EPA guidelines for the design of first flush systems. The first 15 mm of rainfall would be treated as this runoff contains the majority of pollutants.

Each of the three hardstand drainage areas would be graded away from the waterway and adjacent edges to a central grated drainage pits. A dry basket silt arrester would be provided in each pit in order to capture larger solids. The water would then pass via an intermediate diversion pit to a first flush collection tank. Once the first flush collection tank becomes full, all subsequent stormwater runoff would be directed to the lake via a flow diversion arrangement in the intermediate pit designed to retain oil and other floating matter.

The first flush collection tank would be pumped out using a pump with low emulsifying characteristics to a water reclamation plant located in a plant room within the workshop building. The treated effluent (*reclaimed water*) would be directed to a reclaimed water holding tank for re-use for vessel wash down or other maintenance tasks. There are a number of proprietary trade waste treatment / water reclamation systems on the market that can be used in this application and the available treatment plants have a number of common features including:

- fine screening to remove barnacles and other large particles, grit, shavings, etc;

- ❒ oil / water coalescing plate interceptor which removes oil and settleable materials from waste waters (*an alternative would be to use dissolved air floatation to remove floatables and a settling tank to remove smaller particles*);
- ❒ pH adjustment and precipitation of heavy metals;
- ❒ filtering to remove residual metals (*typically sand filters and activated carbon*);
- ❒ collection of particulate matter in solid waste bins and oily waste in 200 L drums for disposal by a commercial waste contractor. Sludges can be tankered off site in liquid form or dried in filter bags; and
- ❒ disinfection to meet *NSW Department of Health* requirements.

Once the reclaimed water tank is full then effluent would be directed to the sewer under a trade waste agreement. A rainfall measurement device such as “Rain Sentry”, or similar, would be linked to the pumps to prevent their operation for at least one hour after 10 mm of rain has been registered in order to prevent loading the sewer excessively with stormwater. Hunter Water would require access to a separate trade waste sampling point and flow metre for this waste water stream. These facilities would be provided adjacent to the package pumping station.

4.3.2 Oily Waste Recycling

An oily waste recycling tank would be provided within the repair and maintenance area. Oily wastes generated from maintenance facilities would be discharged to the tank manually via a covered slops hopper. Oily bilge water from vessels using the pump-out berth (discussed further below) would be transferred into the tank by a pumped main.

Signs would be installed at appropriate locations indicating the position of the slops hopper and specifying use for oily waste recycling. The tank would be emptied by a commercial oil recycling contractor.

4.3.3 Solid Wastes and Recycling

Solid waste and recycling bins would be provided within the repair and maintenance area for collection of solid wastes and recyclable materials. A separate bin storage area would be provided for domestic solid wastes.

Signs would be installed at appropriate locations indicating the position of bins and specifying use for solid waste disposal or recycling. The bins would be emptied by commercial contractors.

4.3.4 Maintenance Activities & Marina Operation

4.3.4.1 Copper Leaching

An assessment of the extent and nature of potential leachate from antifouling paints on vessels moored within the marina has recently been undertaken to determine the potential effect on aquatic ecosystems. Sampling for dissolved and total copper and total suspended solids was undertaken within and outside of a number of marinas in Lake Macquarie and at the proposed Trinity Point marina site to establish background levels within the lake and assess typical levels within marinas generally.

ANZECC (*2000*) [22] establishes default trigger values for copper for the protection of aquatic ecosystems, these are reproduced in **Table 4-1**.

Table 4-1 – Copper Trigger values for the protection of aquatic ecosystems

% aquatic species protected	99%	95%	90%	80%
Trigger value (ug/L):	0.3	1.3	3.0	8.0

Samples were taken in the lake over a period of six months since November 2007 and resulted in the following findings:

- Outside of the marinas sampled, the total copper concentrations range from 1.8 to 3.9 µg/L and dissolved copper ranges from 1.2 to 2.5 µg/L, generally in the 90 to 95 % species protected range; and
- Copper levels inside the marinas sampled are on average 1.6 times higher than outside, with some dissolved values above the 90% species protected level.
- When sampled, the proportion of dissolved copper within the marinas observed to be bioavailable (labile copper) was on average 76% (ranging from 58% to 95%). It should be noted that this testing was only undertaken on one occasion.

All sampling results are attached in **Appendix C**.

Copper sampling observed moderate to high background copper levels in Lake Macquarie with 90% and 95% trigger values defined in ANZECC (2000) being exceeded depending on the location. The Trinity Point sampling site was typical of these observations. As such, because of the existing background levels it is expected that the marine biota will already be relatively copper tolerant. Trinity Point marina is expected to have similar flushing, copper levels and colonisation by marine organisms as the other marinas studied. The layout design of the Trinity Point marina will assist in maximizing dilution and dispersion. The design of the associated breakwater design with a partial depth wave screen and open section at the foreshore will assist in minimising restrictions to flushing. Thus the concentrations of copper within the Trinity Point Marina, if built, should not be extraordinary in comparison to existing marinas in Lake Macquarie, or impact on biota such that the 90% to 95% species protected range is not preserved.

Monitoring of dissolved and labile (bioavailable) copper gives a superior description of the biological effect of copper in the lake, as opposed to total copper by itself, and should be continued for the remainder of the monitoring program.

4.3.4.2 Fuelling Facilities

A fuelling berth would be provided on the breakwater as indicated on **Figure 3**. A dual bowser located on the wharf deck would dispense diesel and unleaded petrol (*ULP*).

Location of the fuelling and pump-out facilities on the floating berths, in preference to onshore, is desirable from a safety perspective, a matter referred to in AS 3962-2001. AS 3962-2001 also notes the need for particular precautions when supplying fuel over water, such as use of lined containment delivery lines. All of these precautions would be adopted in the design and installation of fuel facilities.

Fuel storage would be provided in two steel tanks located above ground in a sealed area adjacent to the hardstand area. A 20,000 - 25,000 L capacity tank would be used for diesel storage, and a 10,000 - 15,000 L tank would be used for ULP.

The fuel bowser would be installed in accordance with the requirements of relevant authorities. In particular, the following requirements would be met:

- not less than two fire extinguishers would be provided, selected from the following type and minimum size;
- 9 kg dry chemical type;
- 9 kg halogenated hydrocarbon type;
- 9 litre foam type;
- drip trays would be provided under and around the bowser. Trays would be of sufficient size to hold any jerry cans being filled;
- a holding tank would be provided on site to collect and retain the wastes from the drip trays;
- provision would be made for regular emptying and disposal of the holding tank to an approved system or site;
- an oil/fuel boom would be provided to contain any accidental fuel spillage; and
- oil absorbent material would be provided to absorb petroleum products spilt on the water surface.

4.3.5 Sewage Pump-out and Oily Bilge Pump-out Facilities

A sewage pump-out facility would be provided at the same berth as the fuel facilities. All craft from time to time must take on fuel and the installation of the sewage pump-out facilities at the same berth encourages use of the pump-out. Hench, such an arrangement provides for improved environmental management, functional efficiency and cost efficiency.

The sewage pump-out facility would consist of a pump-out unit to empty holding tanks on craft and a waste slops hopper for manual collection of chemical toilet waste.

There are various proprietary pump-out systems available offering a choice of pump size. The pump would typically be a diaphragm type with a waterproof motor. A suction hose would be connected between the craft's holding tank and the pump and the effluent would be discharged to the site sewage pumping station for disposal to the sewer. A drip bucket for storage of the end of the pump-out hose when not in use would be provided for storage of the end of the pump out hose when not in use. The pump and motor housing, hose stand and electrical controls would be enclosed within a cabinet.

The chemical toilet waste slops hopper is a convenient disposal and storage cabinet which contains a hose for rinsing chemical toilets. The chemical toilet waste slops hopper would be located adjacent to the sewage pump-out unit or be incorporated with the sewage pump-out unit in a single overall unit. A pump would be provided to deliver the contents of the chemical toilet waste storage hopper to the sewerage system.

The sewage pump-out system would not have holding tanks to cause an odour problem. The facility incorporates a water supply for rinsing the slops hopper and drip bucket. With regular rinsing of these items and the suction hose there would be no odour problems associated with the pump-out facility.

The sewage pump-out facilities would be for use of all craft at the marina although craft would require an on-board holding tank to make use of the sewage pump-out. The NSW Government has announced a policy requiring sewage holding tanks in all recreational craft fitted with a toilet. In the medium term, the majority of craft longer than 8 metres can be expected to be fitted with holding tanks.

In addition to the above, a Marina Occupation Licence to be finalised by the marina operator would require that flushing heads (*toilets*) on craft not be used while craft are at berths. Fines would be imposed for non-compliance with this measure. The ultimate action would be eviction from the berth if the owner does not comply. Adequate land-based toilet, shower and laundry facilities are proposed within the development for use by marina patrons.

A bilge water pump-out system would be provided adjacent to the sewage pump-out facilities. It would consist of a separate pump, hose and delivery lines. The pump would typically be a diaphragm type and would be located at the pump-out berth. A long flexible suction hose would be provided to extend to boat bilges. As for the sewage pump-out system, a drip bucket would be provided for storage of the end of the suction hose when not in use.

The bilge water would be pumped to the oily waste storage tank for recycling by a commercial contractor.

In addition to the above precautions for disposal of bilge water, the Marina Occupation Licence to be finalised by the marina operator would ban the direct discharge of bilge water within the berthing area. Specifically, the Marina Operations Rules & Regulations would require that automatic bilge pumps in vessels must be fitted with an isolation switch and that these must be left in the “off” position while the vessel is at berth. This is contrary to normal use but is considered a reasonable safeguard for which owners should be expected to bear the small inconvenience. As in the case of flushing heads, fines would be imposed for non compliance with the above measure and the ultimate penalty for non compliance would be eviction of the craft.

A floating boom would be maintained at the site to contain any surface pollutants in the event of an accidental leakage of bilge water. Oil absorbent material would also be maintained at the site to absorb any petroleum contained within the boom.

4.3.6 Potable Water Substitution

In addition to use of AAA-rated water saving devices the use of potable water on the site would be minimised by two potable water substitution facilities, namely:

- collection of roof water from the Marina Village Buildings in a below ground tank for use in toilet flushing and garden irrigation; and

- treatment of marina hardstand area first flush / wash down waters to reclaimed water standard for use as the primary source of vessel wash down water. This approach also minimises the discharge of pollutants to the sewer.

4.4 WASTE DISPOSAL

4.4.1 General

The proposed means of water and waste management in the proposed redevelopment can be conveniently described under the following headings:

- Sewage;
- trade waste (*workshop and hardstand*);
- potable water substitution;
- oily waste recycling; and
- solid waste and recycling.

These facilities are discussed below.

4.4.2 Domestic Sewage

Domestic sewage would be generated by the office and marina amenities located in the Marina Village buildings (*including wastewater from toilets, basins, showers and laundry*). This wastewater would drain by gravity to a new site wastewater pumping station, which would in-turn pump to the Morisset Park 4 Wastewater Pump Station (WWPS), to be located north of Trinity Point Drive, on the lake side of the intersection of Trinity Point Drive and Mirraby Drive. This WWPS will be owned and operated by Hunter Water Corporation.

The Morisset Park 4 WWPS would be provided with a duty and stand by pumps rated 30L/s and automatic level controls. The pumping station would transfer a wastewater flow via a 150mm diametre rising main to the discharge access chamber constructed in the park area north-east of intersection of Lakeview Road and Macquarie Road. From the rising main discharge chamber, the wastewater would be transferred via a new DN225 gravity main and discharged into new access chamber constructed in the existing DN300 sewer line N17758 located behind the properties fronting Chifley Road.

Refer to *Trinity Point Waste Water Servicing Strategy* [(21)] for more information on the proposed wastewater transfer system.

4.4.3 Trade Waste

The trade waste generated by the site comprises four streams, namely:

- wastewater from the marina village centre kitchens/café/restaurant;
- sewage pump-out and chemical toilet waste from the dedicated vessel pump-out berth;
- drainage from the proposed workshop; and

- effluent from the hardstand area first flush / wash down water treatment / water reclamation facility.

Generally, dry cleanup techniques would be sufficient in the workshops, with direct collection of oil and grease from engine maintenance. Cleaning of mechanical parts would be undertaken within purpose designed parts-cleaning basins. The workshop floor areas will be graded to individual sumps that will be provided to retain any accidental spillage of liquids within the workshops. In the event of a spillage, these sumps would be manually cleaned out using absorbent materials. These sumps are not connected to the trade waste system that may discharge to the sewer.

4.4.4 Kitchen Wastes

Hunter Water requires pre-treatment of waste waters generated in kitchens prior to discharge to the sewer as trade waste. Typical requirements for the marina village centre would include:

- provision of grease traps on the sewer draining from the any kitchens;
- dry basket arrestor on floor wastes in the food preparation and handling areas. Floor wastes to drain to the grease trap serving the kitchen; and
- dry basket arrestors in sinks.

The grease trap would be located adjacent to the car park to allow tanker access for regular clean-out. The grease trap would be serviced by a commercial waste contractor.

4.4.5 Sewage Pump-out and Chemical Toilet Wastes from Vessels

A small private WWPS would be required to service a proposed boat pump-out facility. This WWPS would be owned and operated by the Marina under a trade waste agreement with Hunter Water.

The trade waste from the marina pump out facility would be transported via a DN50 rising main to the connection point on the Trinity Point gravity sewer (*access chamber J3595*). The Trinity Point sewer will drain by gravity to the Morisset Park 4 WWPS.

It was noted that a proposed private pumping station servicing the pump out facility at the marina will occasionally discharge into the Morisset Park 4 WWPS system. As a result there is a potential for an odour impact from this private pumping station transporting a septic sewage into the system. Design of this pumping station should include odour control and a designated time for pumping into the common sewage system (preferably in the morning to avoid NE winds to transport the odours).

4.4.6 Oily Waste Recycling

As discussed in **Section 4.3.2**, an oily waste recycling tank would be provided within the repair and maintenance area.

4.4.7 Solid Wastes and Recycling

Solid waste and recycling is outlined in **Section 4.3.3.**

5 RAINWATER HARVESTING

5.1 POTENTIAL FOR STORMWATER HARVESTING

Given the considerable roof and deck area in the proposed Trinity Point Marina development, there is an opportunity to implement a centralised rainwater harvesting system. As the proposed development is connected to mains water supply, reduction in average mains demand is the design objective rather than drought security. Water balance modelling was undertaken to assess the potential for rainwater harvesting. In addition, limitation of runoff volume from the introduced impervious areas on the site are seen to be an advantage in terms of limiting impacts on groundwater at the site.

5.2 DEMAND ANALYSIS

It is proposed to use harvested rainwater for the following non-potable uses:

- Garden irrigation; and
- Toilet flushing;

A demand analysis was conducted to estimate the seasonal demands for non-potable water for the Trinity Point development. The results from this analysis were used for water balance modelling which assesses the effectiveness of a rainwater harvesting system in reducing the mains water demand for the development.

5.2.1 Demand Calculation

An assessment of the irrigation and toilet flushing water demand for the development was undertaken. Methodologies adopted for the demand calculations are outlined below:

- **Toilet Flushing**: A toilet flushing demand of 20 l per person per day was adopted for demand calculations, this assumes that dual flush toilets would be installed. Marinas typically experience seasonal variation in patronage, with the summer months generally being more busy than the winter period. Hence, average monthly patronage was estimated in order to calculate the toilet flushing demand; and
- **Irrigation Demand**: It is estimated that proposed courtyard areas as well as planter boxes on the boardwalk would require irrigation, with the combined area estimated to be 8000 m^2. A maximum application rate (*i.e in the summer months*) of 18mm / per week was adopted, this was seasonally adjusted to account for lower irrigation demand during winter months. The simulation also tracks rainfall, and only applies irrigation 4 or more days after significant rain, with significant rain being defined as a daily rainfall depth greater than 15mm.

Adopted average monthly demands are presented in **Table 5-1**. Detailed calculations are provided in **Appendix A**.

Table 5-1 – Average Monthly Demands

Demand	Peak Demand (KL/day)^		Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
Garden Irrigation^^	20.6	Seasonal Adjustment (%)	100	100	80	65	50	30	30	40	50	50	80	100
		Adjusted average monthly Demand (KL/day)	20.6	20.6	16.5	13.4	10.3	6.2	6.2	8.2	10.3	10.3	16.5	20.6
Toilet Flushing Residential	5.4	Seasonal Adjustment (%)	100	100	100	100	100	100	100	100	100	100	100	100
		Adjusted average monthly Demand (KL/day)	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Toilet Flushing Tourism Accommodation	6.2	Seasonal Adjustment (%)	90	90	70	65	50	50	50	50	65	70	80	90
		Adjusted average monthly Demand (KL/day)	5.6	5.6	4.3	4.0	3.1	3.1	3.1	3.1	4.0	4.3	5.0	5.6
Toilet Flushing Village Centre	10	Seasonal Adjustment (%)	90	90	70	65	50	50	50	50	65	70	80	90
		Adjusted average monthly Demand (KL/day)	9	9	7	6.5	5	5	5	5	6.5	7	8	9
Total	**42.2**	Average Daily Demand (KL/day)	**40.6**	**40.6**	**33.2**	**29.3**	**23.8**	**19.7**	**19.7**	**21.7**	**26.2**	**27.0**	**34.8**	**40.6**

^Refer to **Appendix A** for detailed calculations of peak demands
^^ Note: irrigation demand is only applied on days in which there has been no significant rainfall for four proceeding days. This is calculated in the water balance and has not been accounted for in the average daily demands reported in **Table 5-1**.

5.3 POTENTIAL CATCHMENTS

The following land uses have been identified as a potential catchment for the rainwater harvesting scheme:

- Roofs of Dwellings – The proposed development would incorporate approximately 8000m^2 of roof area, namely on multistorey apartment buildings. Up to 100% garden coverage could be implemented on these buildings. The gardens would incorporate drought tolerant plants which would require no fertiliser application. Provision of 'green roofs' would reduce runoff volume. The upper soil media would consist of an upper sandy loam layer (3*00-400mm thick*), with an underlying gravel drainage layer to collect filtered rainwater. The filtration provided would benefit the harvested water quality; and

- Selected Boardwalk Areas – It is proposed to harvest water from approximately 3000m^2 of the boardwalk area. In such areas, the boardwalk would consist of a an impervious surface (*i.e. a concrete slab*). A series of pits would collect runoff and direct it towards a rainwater storage tank. Litter baskets and a first flush diversion will be required to improve captured water quality.

Proposed rainwater harvesting areas are indicated in **Figure 6.**

5.4 WATER BALANCE MODELLING

Water balance modelling was undertaken using the predicted non-potable water demand estimations detailed in **Section 5.2.** The water balance uses historic rainfall data to assess the relationship between roof area (*which governs the available water supply*), tank size and non-potable water demand. The model was used to comprehensively assess the effectiveness of a range of system configurations, allowing for the most efficient system configuration to be adopted.

5.4.1 Water Balance Methodology

Water balance modeling was undertaken using in-house water balance software that has been developed by Patterson Britton specifically for rainfall driven water balances. The water balance is a continuous simulation model which is used to assess a range of rainwater harvesting configurations. For this application, the model was run for 100 years on a daily time step. Estimated runoff from observed daily rainfall data was concurrently applied with the estimated seasonally varied non-potable water demands defined in **Section 5.2**, to comprehensively assess the relationship between the variable nature of rainfall and the estimated demand profile. A range of storage sizes were assessed allowing for an optimum rainwater storage size to be selected based on a statistical analysis of the water balance results.

Daily rainfall data recorded at Wyee Post office rain gauge (*BoM Station 061082*) between 1900 and 1999 was used for the water balance simulation. Wyee Post office is approximately 8km to the south-west of the site and is the closest weather station with a comprehensive data set.

The SIMHYD Rainfall-Runoff model was adopted for assessment of runoff from the rooftop garden areas. SIMHYD is a lumped conceptual rainfall-runoff model which calculates daily runoff (*both surface flows and base flows*) using daily precipitation and potential evapotranspiration values (*PET*) as forcing data. SIMHYD was chosen as it tracks soil moisture storage, allowing for a more accurate runoff yield estimation than a fixed runoff coefficient model, which is important when analysing the proposed roof-top gardens. SIMHYD parameters adopted for the model are defined in **Appendix A.** As the boardwalk area is 100% impervious, a 5mm per day initial loss was applied, to account for loss on the impervious surface and first flush diversion.

Runoff from both the rooftop areas and the boardwalk areas is to be directed into an underground storage. Overflow from the storage node discharges into the downstream bio-retention swale and is lost from the model. As the proposed storages are underground, evaporation losses would be negligible and were not considered. The calculated daily demand is extracted from the storage node, with any shortfall *(in the storage volume*) being sourced from mains supply.

The model was run in numerous configurations, including a range of storage sizes, allowing for an array of solutions to be assessed. These are discussed in the following section.

5.4.2 Water Balance Results

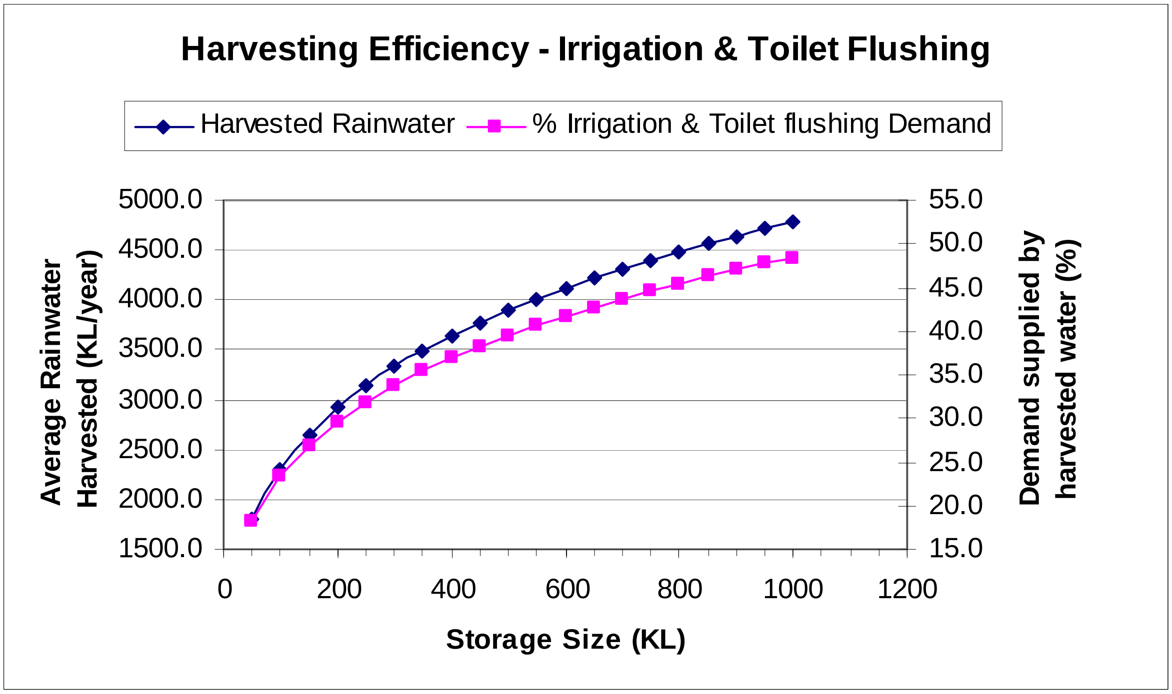
As the proposed development is connected to mains water supply, reduction in average mains demand is the design objective rather than drought security. Hence, water balance output data is processed to present the results in a statistical manner, reporting the average performance of the rainwater harvesting system over the 100 years of simulation.

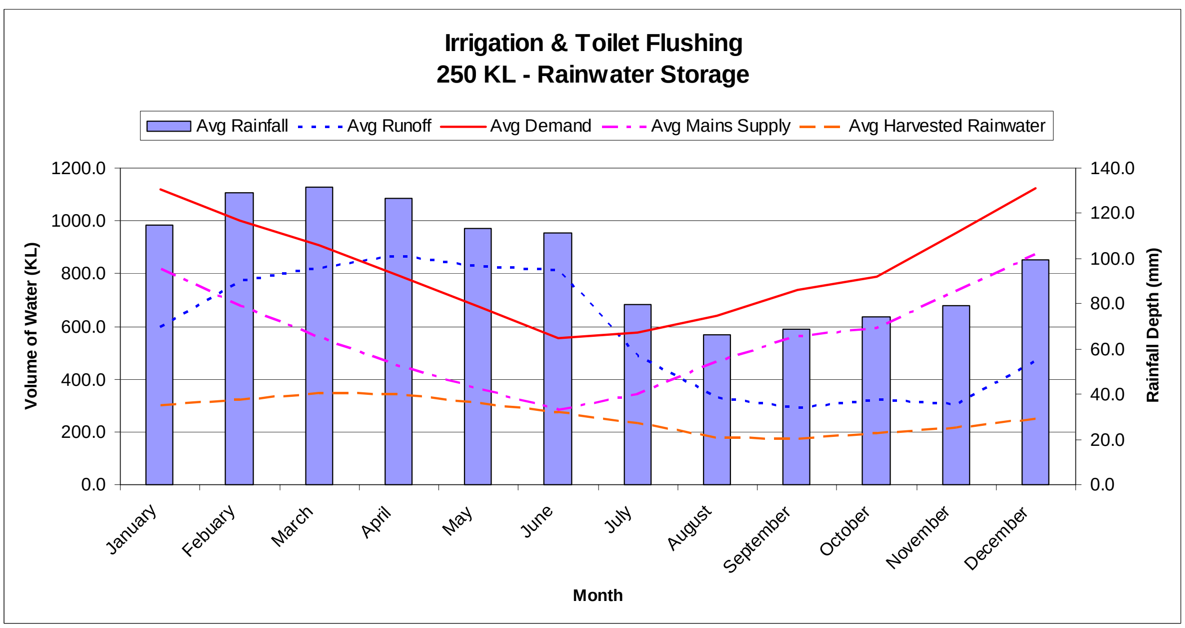
The following two demand scenarios were assessed:

- ❒ Harvested rainwater re-used for both irrigation and toilet flushing demands; and
- ❒ Harvested rainwater re-used for irrigation only.

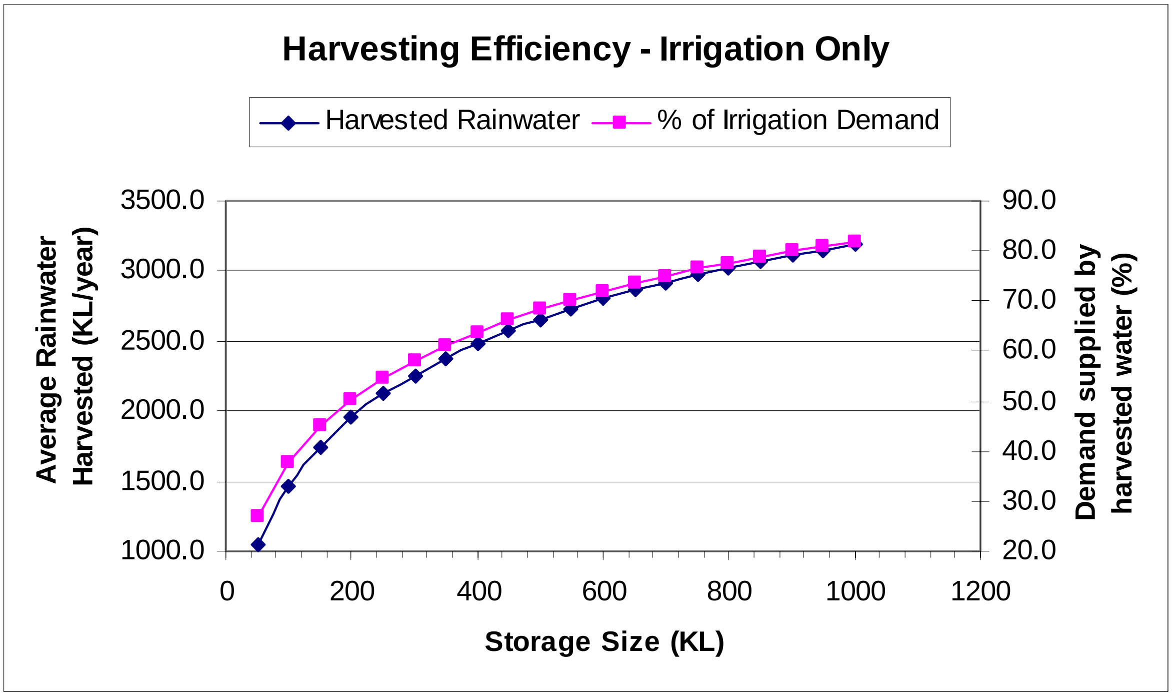
For both scenarios a range of storage sizes between 50 KL and 1000KL (*incrementing at 50 KL intervals*) was assessed. The results from the above simulation are graphically provided in the following 'Harvesting Efficiency' graphs, which plot the average annual harvested rainwater yield as well as the percentage of the modeled demand (*demand is the demand considered in the model, not the total development demand*) met using harvested rainwater. Additionally, a time series graph presents the key average monthly water balance results (*including: average demand, mains top-up required, harvested rainwater, monthly runoff and rainfall totals*) for the 250 KL storage size for both demand simulation scenarios. These time-series graphs demonstrate the relationship between demand, storage and the variable catchment yield. A tabulated summary of the results of all simulations are provided in **Appendix A**.

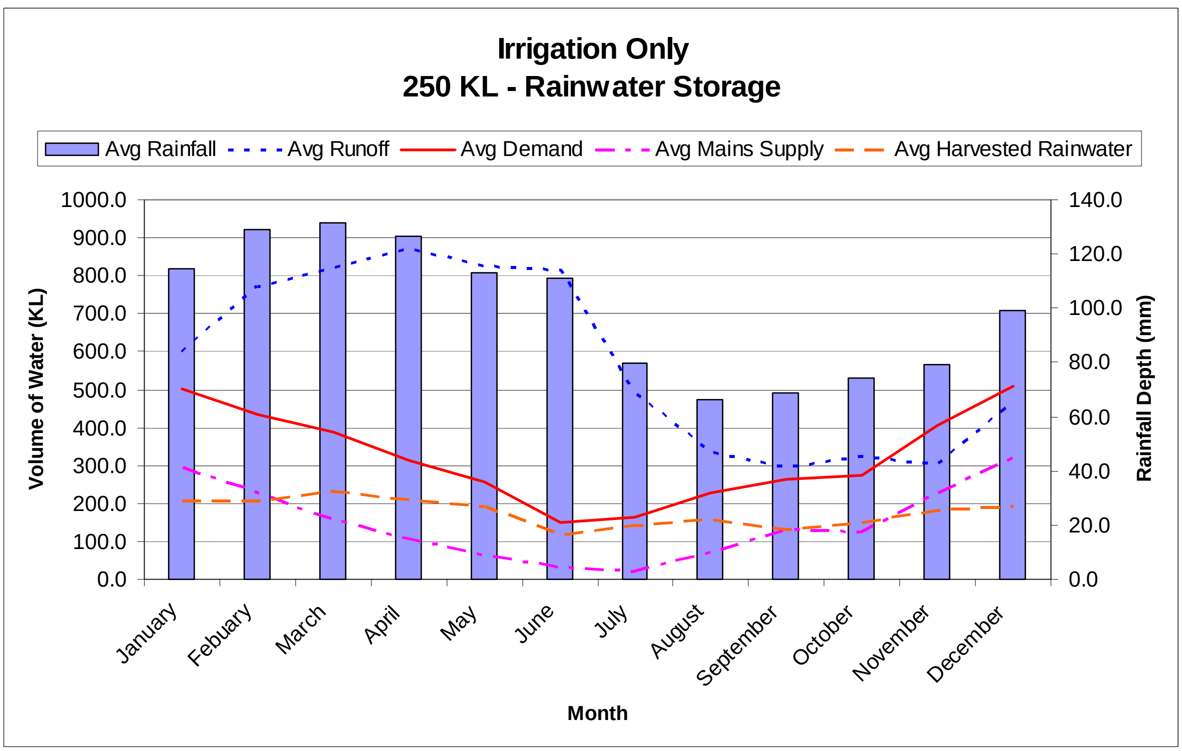
Harvested rainwater re-used for both toilet flushing and garden irrigation





Harvested rainwater re-used for garden irrigation only





The results presented in the above graphs indicate the following trends:

- Preliminary modeling indicates that the provision of 250KL of rainwater storage would facilitate a 2500 to 3000 KL per annum average mains water savings;
- The highest harvesting volume can be achieved if harvested rainwater is used for both toilet flushing and irrigation. However, if only garden irrigation is implemented, the harvesting yield would be approximately 80% of that achieved from both garden irrigation and toilet flushing;
- The benefit (*average volume of rainwater harvested*) for each incremental increase in tank sizes reduces as the tank size increases; and
- The combined demand of toilet flushing and irrigation is greater than the estimated average runoff yield during the summer months. Hence, the rainwater harvesting scheme can at best only partially meet the non-potable demand.

While a cost benefit study has not been undertaken, the above results indicate that only a marginal (20%) increase in harvested rainwater would be achieved if toilet flushing is included in the rainwater harvesting scheme. Considering a third pipe reticulation system would be required, it is likely that the 'irrigation only' scenario (*which would require a much simpler reticulation network*) would provide superior benefit for the capital costs in the residential areas (*subcatchments A, B and C*). The greater area of boardwalk (*which is 100% impervious*) and the reduced garden area in subcatchment D could result in harvested rainwater being used for both garden irrigation and toilet flushing. At this stage, a net rainwater storage of 250KL is considered an appropriate balance between harvesting efficiency and capital costs (*indicative tank sizes are indicated in **Figure 4***). This would facilitate an average 2500KL to 3000KL annual savings in mains water, which is approximately 10 to 12% of the estimated total demand (*based on these calculations*) for the development (*excluding water supply for moored vessels*). A further more detailed assessment, including a cost verses benefit analysis, would be undertaken at a later design stage to finalise the optimal rainwater harvesting configuration.

5.5 WATER QUALITY CONSIDERATIONS

Water quality requirements for non-potable uses are a topic of continuing debate. Harvesting of roof water for non-potable uses is widely encouraged through legislation such as BASIX. Water quality of roof runoff can be maximised by implementation of the following management and design measures:

- regular cleaning of accumulated debris in gutters and on roofs;
- Provision of a first flush bypass system;
- Provision of a gross pollutant trap (*GPT*) upstream of the storage tank, to remove both organic and inert suspended solids; and
- Cleaning of rainwater storage tanks as required.

As the proposed system is to exclusively harvest roof water for non-potable uses, the implementation of the above design and management water quality control measures would achieve a higher level of water quality observed in the average household rainwater tank (*in which there is no guarantee that maintenance would take place*). Hence, no formal treatment systems such as disinfection would be required to meet acceptable non-potable water quality standards. When the site is operational, water quality monitoring would be undertaken to confirm acceptable water quality levels are being achieved.

5.6 SUMMARY OF PROPOSED RAINWATER HARVESTING SCHEME

A preliminary assessment of a rainwater harvesting scheme has been undertaken based on the demand analysis and water balance modelling conducted in the above sections. As discussed in **Section 3**, it is proposed to provide an independent rainwater harvesting system in each stormwater management area (*refer to **Figure 4** for definition of stormwater management areas*). Each harvesting system would incorporate a catchment area (*namely roof areas and select boardwalk areas*), an underground storage tank and a reticulation network. Preliminary tanks sizes and locations are indicated in **Figure 4.**

As discussed in **Section 5.4.2**, the rainwater system would only partially meet the non-potable water demand, with an estimated average annual saving of between 2500KL and 3000KL. It is estimated this would result in an average 10 to 12% reduction in overall mains water demand. Hence, mains water top-up will be required to guarantee supply. Appropriate backflow prevention measures will be required to meet *Department of Health Requirements*. Further mains water savings would be made by using water efficient appliances throughout the development (*e.g. AAA rated shower heads, toilet and laundry facilities*).

The conceptual rainwater harvesting arrangement is demonstrated in **Figure 7**.

5.7 OPERATIONAL REQUIREMENTS

The proposed Trinity Point Marina development is to be run under a community title. Hence, all maintenance of the rainwater harvesting system would be the responsibility of the Trinity Point Marina management. Routine maintenance tasks required to maintain an acceptable level of water quality would include:

- Cleaning debris from roof and gutter areas as required;
- Removing captured debris from the GPTs as required; and
- Cleaning storage tanks as required.

6 WATER QUALITY ASSESSMENT

6.1 DISCUSSION

Stormwater quality control is an imperative aspect of the SWMP. The preservation of acceptable stormwater quality is essential in order to maintain the environmental, recreational and aesthetic qualities of Bardens Bay and the greater Lake Macquarie. In this regard, it is proposed to maintain post development pollutant export to pre-development levels.

The philosophies adopted in the SWMP are discussed in **Section 3**. This section discusses the nature of the existing water quality at the site using information derived from previous studies conducted by others and initial results from water quality sampling undertaken as part of the Trinity Point Marina EA. Additionally, this section provides a quantitative analysis of the proposed stormwater management measures using MUSIC, a water quality modelling software package.

6.2 EXISTING WATER QUALITY

6.2.1 Surface Water

Substantial studies of the water quality of Lake Macquarie have been undertaken by others. A summary of these studies is outlined in the *Lake Macquarie Estuary Process Study* (*AWACS, 1995*), which indicates that the lake waters have varying levels of contaminants. As part of the Trinity Point Marina EA, surface and groundwater quality sampling and analysis programmes have been initiated. Additionally, a geochemical analysis of on-shore and marine sediments has been undertaken. The surface water quality monitoring programme is discussed in detail in **Section 7.1**. Refer to *Report on Geochemical Assessment (Douglas Partners*) [24] for a detailed description of the groundwater and geochemical investigations undertaken by Douglas Partners.

To date only initial test results from the surface and groundwater monitoring sampling programmes are available. These laboratory test results are attached in **Appendix D**. Surface water sample locations are shown in **Figure 9**.

It is noted that while the results to date should be considered indicative only (*as there have only been two rounds of sampling and testing undertaken as part of the proposed overall monitoring strateg*y), the initial results outlined below have been compared to long term trends provided by others, in order to gain an appreciation of the existing environment.

Dissolved Oxygen

Investigations conducted by others observed that dissolved oxygen in Lake Macquarie ranged from 71% to 139% in the surface waters and between 0.9% and 147% for bottom water (*AWACS, 1995*). ANZECC (*2000*) guidelines stipulate values for the protection of aquatic ecosystems of between 80-90% saturation. Initial monitoring results as part of this study, measured dissolved oxygen values in surface water at the Trinity Point site ranging between 8.3 and 9.9 mg/L (*refer to **Appendix D***). Assuming a water temperature of 20 degrees Celsius, this converts to a dissolved oxygen level of between 91 to 109 % saturation, which is within ANZECC (*2000*) guidelines.

Nutrients

The *Lake Macquarie Estuary Process Study* (*AWACS, 1995*) reports annual mean concentrations of surface and bottom nutrients (*Ammonia, Oxidised Nitrogen, and Orthophosphate*) that generally exceeded ANZECC (*2000*) guidelines, except for Oxidised Nitrogen, which generally complied with the guidelines.

Nutrient concentrations in the lake are likely to vary considerably, depending on inputs from uncontrolled stormwater runoff, sewer overflows, septic system overflows, and wastewater treatment plant discharge. Other variables include release of nutrients from lakebed sediments due to bottom stirring (*wind / wave action*) particularly following periods of low dissolved oxygen.

Initial monitoring results (*refer to* ***Appendix D***) indicate that total phosphorus levels exceed those for a slightly disturbed estuarine or marine ecosystems conditions, and that for total nitrogen levels exceed those expected for slightly disturbed marine ecosystems, but are typical of those expected in slightly disturbed estuarine conditions.

Suspended Sediment and Turbidity

The *Lake Macquarie Estuary Process Study* (*AWACS, 1995*) reports annual mean concentrations of suspended sediment between 3.1 to 7.9 mg/l, with the highest value being recorded at 123.6 mg/l. Inflow from the lakes tributaries is generally higher, with average values between 5 to 40 mg/L. Observations as high as 300 mg/l have been recorded in Cockle Creek, which inflows into the northern portion of the lake. Initial monitoring of TSS undertaken at the subject site (*refer to* ***Appendix D***) observed concentrations generally with in the annual mean concentration range listed above.

There are no Total Suspended Sediment values for comparison in the ANZECC (*2000*) guidelines, however, for Estuaries, ANZECC (*2000*) guidelines recommend turbidity values of between 0.5 – 10 NTU, and for shallow lakes as high as 20 NTU. Water quality testing undertaken for the Trinity Point site (*refer to* ***Appendix D***) indicated turbidity readings of between 3.1 to 87.7 NTU, with a mean value of approximately 16 NTU (*Note: only 2 of the 15 turbidity measurements observed values in excess of 20 NTU*), indicating that the turbidity at the proposed marina site generally complies with ANZECC (*2000*) guidelines for a shallow lake.

Heavy Metals

Limited data is available on lake water quality in terms of metals contaminants. *The Lake Macquarie Estuary Process Study* (*AWACS, 1995*) reports high levels of cadmium, lead and selenium, particularly for the northern areas of the Lake, around Cockle Creek, adjacent to the Sulphide Corporation discharge. A summary of the results is outlined below:

- the most significant heavy metal input to the Lake is that via Cockle Creek from the lead smelter;
- heavy metal concentrations in samples from the sewerage treatment works at Toronto, Edgeworth and Marmong Point were quite variable and appeared to contribute only zinc which is the least toxic of the metals studied;
- lead, zinc and cadmium concentrations varied significantly from very high readings in the north, to the lowest readings in the south, away from the old Lead smelter at Cockle Creek;

- copper concentrations were found to be high near Wangi and Pulbah Island and these were attributed to an atmospheric input, possibly fly ash from the nearby power stations; and

- testing of Lake Sediments confirmed significant contamination of the Cockle Creek sediments for lead, zinc, copper and cadmium. The distribution of contaminants in the surface sediments show clear trends southward with decreasing concentrations. As well as this major trend, localised problem areas including:
  - Water pollution around larger jetties, and boat launching ramps;
  - Sediment influx at heads of bays containing wetlands, and in areas of bays secluded from wind and wave action; and
  - Pollution associated with the discharge of fly ash – particularly for copper, zinc and lead. Concentrations of copper in lake bed sediments reached as high as 150 mg/kg, with typical values likely to be encountered at the Trinity Point site reported in the range 5 - 50 mg/kg in bottom sediments.

Initial sampling results observed concentrations of Copper, Cobalt, Chromium and Tin above the 95% trigger values defined in ANZECC (*2000*). Refer to **Table D-2** in **Appendix D** for laboratory results.

6.2.2 Groundwater Quality

Refer to *Report on Geochemical Assessment (Douglas Partners*) [24] for a detailed description of the groundwater investigation currently undertaken by Douglas Partners. Initial results from the investigation are attached in **Appendix D**.

Initial testing indicated that groundwater levels generally varied across the site, depending on topography. Those areas closest to the lake level in elevation (*i.e. the lower lying areas*) observed groundwater levels closest to mean lake level (*i.e. range 0 to 0.3m AHD*), while those in higher areas of the site observed generally slightly more elevated groundwater levels (*0.4 to 1.0 m AHD*). Groundwater level fluctuation measured over the period 5/10/07 to 15/05/08 indicated changes in groundwater level of up to 0.3m. Refer to **Table D- 3** in **Appendix D** for field observations. Note that these variations were measured at different times over the period mentioned above, and do not constitute a true measure of potential groundwater level fluctuations. It is possible that groundwater level fluctuations are greater than those recorded over the period mentioned above, particularly during lake flood events.

EC values measured by *Douglas Partners* (*refer **Table D-4** in **Appendix D***) for groundwater indicate that the source of the groundwater is non – saline (*i.e. EC readings in the range typically 0.6 to 6.8 mS/cm, with an outlier at 21.1 mS/cm, probably caused by contamination from drilling mud.* Typical readings from freshwater are in the range < 0.3 to 5 ms/cm, while saline lake waters would typically be in the range 40-45 mS/cm. Again, it is noted that during periods of elevated lake water levels *(flooding)*, groundwater salinity could possibly increase above the observed fresh water levels.

pH readings of groundwater undertaken by Douglas Partners in their Acid Sulphate Soil Assessment [25] varied considerably, with readings ranging from 4.1 to 4.2 in BH 104 to 7.2 to 7.7 in BH 101A, indicating the presence of acid generating soils in some parts of the site.

Chemical analysis of ground water samples was undertaken as part of the investigation. Sampling results are attached in **Table D-5** in **Appendix D**. Initial sampling observed concentrations of some metals, and nutrients above the 90% and 95% trigger values defined in

ANZECC (*2000*) water quality guidelines. The source of these elevated metals and nutrients could possibly be previous on-site activities including the boarding school, and in particular the effluent storage dams. These results indicate that the site is not a pristine greenfields site, and that groundwater is already somewhat contaminated.

Refer to *Report on Geochemical Assessment (Douglas Partners*) [(24)] for further analysis of the groundwater assessment.

6.3 WATER QUALITY TREATMENT TARGETS

An accurate estimate of the existing water quality of the site is difficult to determine without long and detailed water quality monitoring records. Furthermore, it is possible that parts of the site in its current condition could have higher pollutant export loads than a stabilised developed catchment. As such, a more reasonable approach is to adopt long term water quality treatment targets recommended in current best management guidelines. Currently, the most stringent water quality treatment targets for urban development in industry best-practice literature are those listed in the *Managing Urban Stormwater: Environmental Targets* [(7)] (which is *currently in the consultation draft stage*), from which the key water quality treatment targets are outlined below:-

- ❒ Suspended Solids (TSS) 85% retention of the developed average annual load
- ❒ Total Phosphorous (TP) 65% retention of the developed average annual load
- ❒ Total Nitrogen (TN) 45% retention of the developed average annual load

As the development area discharges directly to Lake Macquarie, water quantity controls are not required. However, it is noted that the proposed water quality prevention measures (such as limiting the areas of impervious areas), and treatment controls would provide a reasonable level of attenuation of peak flow runoff during high return period rainfall events.

A water quality model (*MUSIC*) was used to estimate the likely pollutant loads and assess the water quality treatment provided by proposed water quality controls. The model was used to define the minimum design parameters (*i.e. areas and volumes etc*.) required for water quality control devices to meet the above targets. The following sections describe the modelling methodologies and report the estimated performance and minimum design parameters for the proposed water quality controls.

6.4 MUSIC WATER QUALITY MODEL

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. MUSIC is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

To undertake the water quality assessment, a MUSIC model was established for the proposed Trinity Point Development.

6.4.1 Meteorological Data

In order to establish a MUSIC model, rainfall and evaporation records in the vicinity of Trinity Point were sought.

Rainfall

In order to develop a model that could comprehensively assess the performance of the proposed SWMP, the use of 6 minute pluviograph data was considered necessary. The nearest Bureau of Meteorology (*BoM*) weather station with pluviograph data was Bolton Point (*station 061139*). A review of the historical data found that the annual average rainfall depth at Bolton Point Bay is approximately 1200mm. A selected 12 month period generating a rainfall depth of 1200mm was adopted for the purposes of comparative modelling of existing and proposed conditions.

Evaporation

Monthly areal potential evapotranspiration (*PET*) rates for the site were estimated from PET data provided by the BoM. The monthly average PET adopted for the MUSIC model are shown in **Table 6-1**.

Table 6-1 – Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	180
February	135
March	128
April	85
May	58
June	43
July	43
August	58
September	88
October	127
November	152
December	163

6.5 MODEL SETUP

As indicated in **Figure 4**, the proposed development area is divided into 5 separate stormwater management areas, referred to as catchments A thru to E. These catchment areas, and proposed treatment measures (*as indicated in **Figure 4***) , were incorporated into the MUSIC model. It is noted, that proposed rehabilitation areas have not been included in the MUSIC model as they are to be naturally vegetated, hence no stormwater controls will be required. Additionally, subcatchment E (*the hardstand area*) has unique stormwater management strategy which is also not assessed in MUSIC.

Table 6-2 presents adopted subcatchment areas, providing estimated harvesting and non-harvesting areas.

Table 6-2 – Adopted Catchment Areas

Catchments	Total Area	Harvesting Area		Non-Harvesting Area
		Building Area	Deck Area	Gardens, pathways etc
Units	ha	ha	ha	ha
Catchment A	0.61	0.12	0	0.50
Catchment B	0.84	0.20	0.04	0.60
Catchment C	0.89	0.20	0.05	0.63
Catchment D	1.08	0.26	0.22	0.60
Catchment E	0.2	N/A	N/A	0.2
Total	3.62	0.78	0.31	2.53

Catchment Parameters

MUSIC simulates the generation, mobilisation and removal of the following pollutants:-

- Total Suspended Solids (*TSS*);
- Total Phosphorus (*TP*); and
- Total Nitrogen (*TN*).

The pollutant loadings for each catchment were assigned based on the landuse areas indicated in **Table 6-2.** Event mean concentrations (*EMC*) for each of the above land uses were derived from mean loads presented in *Chapter 3* of the '*Australian Runoff Quality*' (*Engineers Australia, 2006*)[13]. Adopted EMCs for each land use are detailed in **Appendix B**. It is noted that proposed preventative measures such as fertiliser management, would most likely result in pollutant loadings below the mean values, hence the adoption of mean values EMCs is considered conservative.

Water Quality Control Measures

Both the proposed rainwater harvesting tanks and the bio-retention swales were included in the MUSIC model. Rooftop gardens were accounted for by setting the roof area catchment to 100% pervious. **Appendix B** contains all model parameters adopted for the subcatchments and water quality control nodes.

6.6 MODEL RESULTS

The results from the *MUSIC* water quality assessment are summarised in **Table 6-3**. Indicative design parameters for the rainwater storage tanks and the bio-retention swales are tabulated in **Table 6-4** and graphically illustrated in **Figure 4**.

Table 6-3 – MUSIC Results

Catchment	Pollutant	Source (untreated) (kg/yr)	Residual Load (after treatment) (kg/yr)	Removal Efficiency (%)
Catchment A	TSS	452	42	91
	TP	1.0	0.3	74
	TN	8.5	4.6	46
Catchment B	TSS	562	59	90
	TP	1.3	0.4	72
	TN	11.4	6.2	46
Catchment C	TSS	599	68	89
	TP	1.4	0.4	71
	TN	12.3	6.8	45
Catchment D	TSS	638	84	87
	TP	1.7	0.5	69
	TN	15.9	8.5	47
Total	TSS	2250	252	89
	TP	5.4	1.6	71
	TN	48.1	26.0	46

Table 6-4 – Indicative Water Quality Control Design Parameters

Catchment	Rainwater Storage Tank	Bio-Retention Swale	
	Tank Volume (KL)	Filter Area (m^2)	Retention Storage (m^3)
A	30	40	35
B	50	50	40
C	50	50	40
D	120	60	50
Total	250	200	165

As shown in **Table 6-3**, modelling indicates the water quality control measures specified in **Table 6-4** would achieve the water quality targets defined in **Section 6.2**, with removal efficiencies estimated to be 89% for TSS, 71% for TP and 46% for TN.

It is noted that MUSIC simplifies a complex environment where many physical and bio-chemical processes can potentially influence the water quality. As MUSIC algorithms are based on observed average water quality performances (*which are highly variable*) it does not consistently accurately represent a modelled scenario. All efforts have been made in this study to realistically represent the water quality scenario, however MUSIC results should be only be considered as estimates of average conditions only. As with any statistical representation, results could potentially be above or below average conditions. Hence, some degree of variability should be expected in the performance of the proposed SWMP. Water quality monitoring would be undertaken to verify the effectiveness of the SWMP, this is further discussed in **Section 7.1**.

7 DESIGN AND OPERATIONAL CONSIDERATIONS

7.1 WATER QUALITY MONITORING

Water quality monitoring will be undertaken to provide an assessment of the existing surface water quality conditions and observe water quality parameters during both construction and operational stages of the proposed development. A groundwater quality monitoring programme is concurrently being undertaken by Douglas Partners, refer to *Report on Geochemical Assessment (Douglas Partners*) [(24)] for a description of the groundwater monitoring programme.

Water quality observations would be used to assess the impact of the development on water quality and would provide a framework for ongoing assessment of the effectiveness of the water quality management plan proposed for the site, allowing for remedial action to be taken if required. The key objectives of the water quality monitoring programme are as follows:

- Establish existing water quality parameters;
- Monitor water quality during both construction and operational periods of the development, allowing for any adverse impact on water quality to be observed;
- Monitor water quality of harvested rainwater as well as treated hardstand area runoff to assess if water quality is acceptable for exposure to employees, residence and guests of the development; and
- Create a water quality data base which would benefit future environmental management decision making for the development site.

The proposed water quality monitoring programme would be segregated into the following three phases:

- **Pre-Development Monitoring**: would be undertaken to define existing water quality parameters. Monitoring would include a range of contaminates including TSS, TN, TP and dissolved and total copper;
- **Construction Stage Monitoring**: sampling of TSS concentrations would be undertaken during the construction stage to determine the effectiveness of the soil and water management plan (*to be formulated at a later design stage*) in controlling TSS levels in site runoff; and
- **Operational Stage Monitoring**: would monitor the quality of stormwater runoff from development areas as well as the quality of the surface water of Lake Macquarie adjacent to the development site. Monitoring would include a range of contaminants including TSS, TN, TP and dissolved and total copper. Contaminant levels in sediments near the proposed stormwater outlet from the hardstand area would also be assessed. Additionally, testing of harvested stormwater and treated hardstand runoff would be undertaken from a public health point view (*e.g. an assessment of Faecal Coliforms and Turbidity*). It is proposed to provide monitoring for the initial three years of operation, where by the post development water the quality trends would be established. At this time, future monitoring requirements can be negotiated with authorities.

The proposed sampling plan for the three phases of the monitoring programme is outlined in **Table 7-1**. **Figure 9** locates indicative sampling locations. A detailed water quality monitoring programme would be established at a later design stage.

Table 7-1 – Proposed Water Quality Sampling Programme

Sample	Test Analytes	Pre-Development Samples			Construction Stage			Operational Stage		
		Wet Weather Sample Methodology	Dry Weather Sample Methodology	Sample Freq	Wet Weather Sample Methodology	Dry Weather Sample Methodology	Sample Freq	Wet Weather Sample Methodology	Dry Weather Sample Methodology	Sample Frequency
Lake Surface Water – Common Stormwater Pollutants	**TN, TP & TSS^**	Take surface water samples at two locations indicated in **Figure 9**	Obtain dry weather sample if no wet weather sample opportunity occurs	6 samples per year	Take surface water samples at two locations indicated in **Figure 9**.	Obtain dry weather sample if no wet weather sample opportunity occurs	Monthly	Take surface water samples at two locations indicated in **Figure 9**	Obtain dry weather sample if no wet weather sample opportunity occurs	6 samples per year for the first 3 years
Lake Surface Water - Leached Copper	**Total & Dissolved Copper^^**	NA	Take samples at three locations indicated in **Figure 9**	2 samples per year	NA	NA	NA	NA	Take samples at three locations indicated in **Figure 9**	2 samples per year for the first three years
Bio-Retention Runoff	**TN, TP & TSS**	NA	NA	NA	NA	NA	NA	Randomly sample 2 subsurface discharge locations	NA	6 samples per year for the first 3 years
Harvested Stormwater	**Turbidity & Fecal Coliforms**	NA	NA	NA	NA	NA	NA	Test harvested water from each tank for FC (two tests per tank) and turbidity. Take samples shortly after rainfall.	NA	6 samples per year. Continuous
Hardstand Area	**Heavy Metals & TOC**	All ready undertaken as part of the sediment contamination analysis			NA	NA	NA	3 sediment samples at 5 metre intervals from the hardstand overflow outlet	NA	Annually for the first three years
Hardstand Area runoff	**Heavy Metals & TOC**	NA	NA	NA	NA	NA	NA	Extract 1 sample from first flush tank overflow	NA	2 samples per year for the first three years
Treated Hardstand Runoff (for re-use)	Sampling requirements to be defined in consultation with the manufacturer of the treatment unit when a unit is chosen at a later design stage									

^ Only TSS samples required for sampling during the construction stage
^^use results from bio-availability tests to determine total/dissolved copper to bio available copper ratios

7.2 CONSTRUCTION PHASE

During construction, sediment and erosion control structures would be designed and installed in accordance with the NSW Department of Housing "*Managing Urban Stormwater – Soils and Construction*" (*Blue Book*) and Lake Macquarie City Council guidelines (*namely Councils DCP 1*). These controls will ensure that there are no significant adverse impacts on receiving water quality during the construction stage. An erosion and sediment control plan would accompany a Construction Certificate application for the development. Special attention should be given to the protection of bio-retention swales until the development is fully stabilised.

7.3 PROVISION OF OVERLAND FLOW PATHS

Overland flow paths must be provided to safely convey a 1 in 100 year ARI storm in compliance with ARR 1987 and Councils DCP 1. This would be addressed at a later design stage, however, consideration of overland flow path routes has been undertaken in the preliminary civil design.

8 LAKE MACQUARIE FLOOD ASSESSMENT

Flooding in Lake Macquarie is governed by runoff volume, resulting from direct precipitation over the lake and runoff from contributing catchments. Tailwater effects (*nominally the water level in the Pacific Ocean*) also influences lake flood levels. Hydrodynamic models can be used to concurrently simulate all the drivers to flooding in Lake Macquarie, resulting in estimated 'still water levels' for a range of Average Exceedance Probabilities (*AEP*). Additionally, a site specific allowance has to be adopted to account for wave action. Furthermore, *DECC* have requested that additional allowances be made to account for potential sea level rise resulting from climate change.

The following sections address these issues and recommend flood planning levels for various flood sensitive land uses in the proposed Trinity Point Marina development. The assessment refers to the *Lake Macquarie Flood Study: Part 1 – Design Lake Water* Levels[(2)] and Wave Climate and Part 2 – *Foreshore Flooding*[(3)] produced by Manly Hydraulics laboratory (*MHL*) in 1998. This flood assessment is currently adopted by Council to define flood planning levels on properties around Lake Macquarie.

8.1 ELEVATED STILL WATER LEVELS

Elevated still water levels within Lake Macquarie are caused by a combination of the following potential factors:

- astronomical tide;
- storm surge (*barometric setup*[1] *and oceanic and local wind setup*[2]);
- ocean wave setup (*caused by breaking waves*[3]); and
- catchment runoff, which is dependant on rainfall and catchment characteristics.

MHL modelled the flood scenarios as part of the *Lake Macquarie Flood Study*[(2)]. A numerical hydrologic model was developed for the various Lake Macquarie catchment areas to estimate the runoff resulting from rainfall on the catchment. This model was calibrated using historical rainfall and flood records. A range of design flood hydrographs were estimated for different storm duration rainfalls to allow a combination of events to be tested to determine the critical case.

A hydraulic numerical model was developed using RMA-2 (*2-D hydraulic modelling software*) to simulate the flooding behaviour of Lake Macquarie under various combinations of local wind, astronomical tide; storm surge; ocean wave setup; and catchment runoff. Table 8-1 summarises

---

[1] Barometric setup is a localised vertical rise in the still water level due to a reduction in atmospheric pressure. The increase in water level is approximately 0.1m for each 10 hectopascal drop below normal barometric pressure of 1013 hPa (MHL, 1992). Note that hectopascals are approximately equivalent to millibars.
[2] Wind setup is the vertical rise in the still water level on the leeward side of a body of water caused by wind stresses on the surface of the water.
[3] Wave setup is defined as the superelevation of the mean water level caused by wave action alone. The phenomenon is related to the conversion of the kinetic energy of wave motion to quasi-steady potential energy. It is manifested as a decrease in water level prior to breaking, with a maximum set down at the break point; from the break point the mean water surface slopes upward to the point of intersection with the shore (Coastal Engineering Research Center, 1984).

the resulting still water levels determined from the modelling for various annual exceedance probabilities (*AEP's*). The results have been given to two decimal places for comparative purposes though the accuracy of the model would only justify one decimal place.

Table 8-1 – Lake Macquarie Design Still Water Levels (m AHD)

Extreme	1% AEP	2% AEP	5% AEP	20% AEP	100% AEP
2.63	1.38	1.24	0.97	0.70^	0.40

^ interpolated between 5%AEP and 100 %AEP

The still water levels presented in Table 8-1 are from the simulation of a 144 hour design storm, which was the reported critical storm duration(2). Given the long storm duration, a 3 to 4 day time to peak would be expected, allowing sufficient time to implement flood preparation measures (*such as moving vehicles or evacuating people*).

8.2 WAVE CLIMATE

The incident wave climate at the Trinity Point site is a direct consequence of the local wind climate as no ocean wave penetration occurs through the Swansea Channel into the Lake.

A detailed numerical wave model of the south west portion of Lake Macquarie was developed to investigate the wave climate and associated coastal processes at the Trinity Point proposed marina site. PatBrit (*2007*)(19) describes this modelling investigation and reports the predicted wave climate at the site. The estimated wave climate description is reproduced in the **Table 8-2** and **Table 8-3** which defines predicted operational conditions and design event parameters respectively.

Table 8-2 – Inshore Wave Parameter Exceedance

Probability of Exceedance (%)	Breakwater Location		Eastern Foreshore		Northern Foreshore		Associated Wave Period (Tp) (s)
	H_s (m)	Predominant Direction	H_s (m)	Predominant Direction	H_s (m)	Predominant Direction	
0.001	0.82	SE	0.75	SE	0.55	NE-SE	3.5
0.01	0.42	NW, E-SE	0.40	NW, E-SE	0.25	NE-SE	3.5
1	0.21	NW, E-S	0.21	NW, E-S	0.13	NE-SE	3.0
5	0.15	NW, E-S	0.15	NW, E-S	0.09	NW, NE-SE	3.0
50	0.07	All	<0.05	All	<0.05	All	3.0
75	<0.05	All	<0.05	All	<0.05	All	3.0

Table 8-3 – Design Event Wave Parameters

Design Wind Direction	1yr ARI		50yr ARI		200yr ARI	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
NW	0.25	3.1	0.40	3.2	0.41	3.2
N	0.21	3.1	0.38	3.2	0.40	3.2
NE	0.23	3.1	0.40	3.2	0.42	3.2
E	0.36	3.3	0.63	3.7	0.65	3.7
SE	0.43	3.3	0.95	3.6	0.95	3.6
SSE	0.41	3.6	0.85	4.0	0.86	4.0
S	0.33	3.3	0.70	3.7	0.72	3.8

PatBrit (*2007*) [19] also discusses the effect of nearshore seagrass beds on the attenuation of wave heights before reaching the shoreline. The attenuation factor varies with differing mean water level events as described in **Table 8-4** below.

Table 8-4 – Seagrass Wave Attenuation

Water Level (m above MSL)	Water Level ARI (yr)	K_w	
		North Eastern Foreshore	Eastern Foreshore
0	-	0.71	0.18
0.5	2.5	0.90	0.59
1.0	20	0.96	0.82
1.5	>100	0.99	0.94

PatBrit (*2007*) [19] reports that similar breakwater structures to the proposed breakwater design at the Trinity Point marina site has been shown to achieve a wave attenuation effectiveness in the order of 0.2 - 0.3 of existing wave heights.

8.3 IMPACT OF CLIMATE CHANGE

The potential impact of climate change at the Trinity Point site has been assessed with reference to the DECC floodplain risk management guideline titled '*Practical Consideration of Climate Change'* [23], which was published in October 2007. This document provides guidance on the potential impacts of climate change on flood prone land and provides recommended mitigation measures to minimise the risk of climate change on infrastructure.

8.3.1 Potential Sea Level Rise

The *International Panel for Climate Change* (*IPCC*) has predicted that average global sea-level rise due to climate change will range from 0.18m to 0.79m by between 2090 and 2100 (*DECC, 2007*). The upper limit of sea level rise incorporates an allowance for ice flow melt. Additional modelling undertaken by the CSIRO indicate that sea level along the NSW coast is expected to rise by more that the global average (*by up to an additional 0.12m*). Therefore, the predicted range of sea level rise along the NSW coast is in the range of 0.18m to 0.91m by between 2090 and 2100 (*DECC, 2007*).

Accordingly, for floodplain risk management applications, DECC recommends that sensitivity analyses be undertaken for the following three cases of sea level rise by 2090 to 2100:

- 0.18m increase (*low level impact*)
- 0.55m increase (*mid-range impact*)
- 0.91m increase (*high level impact*)

According to the Lake Macquarie Floodplain Management Study (*LMCC, 2000*), the standing water level in Lake Macquarie is typically at 0.1 mAHD. The ocean tide has a ± 0.5m variation, but this has minimal impact on the water level in the lake (± 0.05m). This suggests that the lake is relatively insensitive to short term fluctuations in ocean level.

However, as Lake Macquarie is hydraulically connected to the ocean, any sea level rise would result in the equivalent rise in the standing water level in Lake Macquarie. Hence, the sea level rise allowances listed above can be directly added to the current flood level predictions to account for sea level rise. DECC have requested that both the 50 year and 100 year sea level rise scenarios be reported for all flood level calculations. It was conservatively assumed that rate of sea level rise would be constant (*i.e a linear relationship*), hence, the 50 year predicted rise was assumed to be half of the predicted 100 year sea level rise. **Table 8-5** presents the 50 and 100 year low, mid-range and high level ocean impacts as reported in the *'Practical consideration of Climate Change'* [(23)] guideline.

Table 8-5 – Predicted 50 year and 100 year sea-level rise

	LOW LEVEL IMPACT	MID-RANGE IMPACT	HIGH LEVEL IMPACT
Existing Standing Water Level in Lake Macquarie (mAHD)	0.1	0.1	0.1
50 Year Predicted Sea Level Rise (m)	0.09	0.28	0.45
Standing Water Level by 2040 to 2050 (mAHD)	0.19	0.38	0.55
100 Year Predicted Sea Level Rise (m)	0.18	0.55	0.91
Standing Water Level by 2090 to 2100 (mAHD)	0.3	0.7	1.0

It is recommended that a mid-range sea-level rise prediction be adopted for this project, resulting in a mean still water level in Lake Macquarie of 0.38 m AHD by 2050 and 0.70 m AHD in 2100.

8.3.2 Potential Increase in Rainfall

An assessment of rainfall increase has been undertaken, primarily based on information extracted from the *Lake Macquarie Flood Study* (DPWS, 1998)[(2)]. The DECC guideline (*Reference 23)* recommends that analysis of the increase in rainfall should consider a sensitivity analysis of three scenarios: 10%, 20% or 30% peak rainfall increases and storm volume increases.

For a large catchment such as Lake Macquarie which is governed by storm volume, it was assumed that an increase in rainfall intensity directly correlates to an increase in runoff volume.

A basic volumetric analysis for the 100 year recurrence flood has been used as a base from which to test scenarios of increased rainfall volume. This method has shown that a 10% increase in rainfall will result in an increase in lake flood level of some 0.06m. A 20% increase in rainfall will result in a flood level increase of approximately 0.12m in the lake. A 30% rainfall increase will result in a lake level increase of about 0.18m. This prediction is similar to the sensitivity analysis undertaken as part of the *Lake Macquarie Flood Study*[(2)], which estimated a 20% increase in runoff volume would result in an increase in peak flood level of 0.12m[(2)]. A detailed discussion on the impact of climate change, including calculations supporting the above assumptions, is attached in **Appendix E**.

It is recommended that a mid-range increase be adopted for this project, meaning that a 20% rainfall increase is likely to result in a lake level rise of about 0.12m. Based on a conservative assumption of linear increase over the 100 years, the predicted 50 year increase in lake level resulting from increased rainfall would be 0.06m.

8.3.3 Combined Impact

Table 8-6 presents the estimated still water 100 year ARI flood levels accounting for the combined impact of seal-level rise and increased rainfall intensity and volumes. Estimated still water levels are presented for the low, mid-range and high level climate change impacts for both the 50 year and 100 year timeframes.

Table 8-6 – Estimated Combined Impact of Climate Change

	LOW LEVEL IMPACT	MID-RANGE IMPACT	HIGH LEVEL IMPACT
Existing 100 Year Recurrence Flood Level (mAHD)	1.38	1.38	1.38
50 Year Sea Level Rise (m)	0.09	0.28	0.46
Increase in Flood Level due to Increase in Rainfall Volume (m)	0.03	0.06	0.09
50 Year Recurrence Flood Level by 2040 to 2050 (mAHD)	1.5	1.7	1.9
100 Year Sea Level Rise (m)	0.18	0.55	0.91
Increase in Flood Level due to Increase in Rainfall Volume (m)	0.06	0.12	0.18
100 Year Recurrence Flood Level by 2090 to 2100 (mAHD)	1.6	2.1	2.5

The potential impacts of climate change can vary significantly with location (*DECC, 2007*). DECC recommends that a range of factors be considered when managing the impacts of climate change at a particular location. These include any potential changes in flood behaviour, frequency, hazard and damages that may occur due to climate change and whether these impacts can be managed now or in the future as the impacts of climate change manifest.

The development of a marina facility at Trinity Point can be considered to have reduced sensitivity to the impacts of climate change, based on the following local factors:

- Due to its location at the edge of Lake Macquarie, it is not expected that any new floodways will be developed in the vicinity of the marina as a result of increased lake water levels. As a result, it is not likely that increased flood levels would translate to other changes in flood behaviour, such as increased flow velocity.

- The increase in flood hazard associated with increased water levels could be effectively managed by implementing flood evacuation procedures that adapt to any long term changes in water level. Due its lakeside location, the flood evacuation route from the marina is not expected to be cut-off as a result of increased lake water levels (*i.e. a continuously rising evacuation route away from the lakes' edge will be provided*).
- Any increase in flood damages resulting from increased frequency of flooding would be limited to structures and infrastructure that is privately-owned by the marina. Community infrastructure is not likely to become more susceptible to climate change impacts due to the marina development.

Based on the above factors, it is recommended that a combined mid-range impact of climate change be considered for design of the Trinity Point Marina. This involves the adoption of a mid-range impact on lake water level due to sea level rise combined with a mid-range impact due to increased rainfall intensity/volume (*refer **Table 8-6***).

Accordingly, the combined effect of potential increases in rainfall and sea level that have been adopted for this study translates to a total increase in lake water level of approximately **0.7** metres (*refer **Table 8-6***).

It is recognised that the science associated with current climate change predictions has potential uncertainties in the order of the magnitude of the predictions. As a result, it is recommended that all habitable floor levels in the Trinity Point development be constructed above the flood planning level where possible to accommodate this uncertainty.

Further discussion on the potential impact of climate change in Lake Macquarie is attached in **Appendix E**.

8.4 ESTABLISHMENT OF FLOOD PLANNING LEVELS

Design flood planning levels have been established based on the design 'still water' levels reported in the *Lake Macquarie Flood Study* [(2)] and factoring in allowances for localised wave action, potential sea level rise and increased rainfall due to climate change. As the resulting design flood levels are derived from a combination of wave action and elevated still levels, the estimation of an Annual Exceedance Probabilities (*AEP*) flood levels is a joint probability problem. To account for this, the *Lake Macquarie Flood Study* [(2)] recommends that a major/minor approach be adopted. This is achieved by assessing both a wave dominated and 'still water' level dominated flood level event for a given AEP and adopting the greater of the two as the design flood level. Wave and 'still water' level dominated events are calculated by adding the major flood level for the dominant event with a minor flood level for the non-dominant event. For example, the 1% AEP 'still water' level dominated event would be the sum of the predicted 1% AEP 'still water' level and the 100% AEP wave height. In all cases the 'still water' level was found to be the dominant flood mechanism for the Trinity Point site. Hence, a 100% AEP wave height allowance was adopted for all design flood level calculations. In areas protected by either the marina breakwater or wave attenuation barriers, a reduced wave height allowance of 0.05m was adopted.

Estimated design flood levels are used to define flood planning levels for the site. Adopted flood planning levels vary depending on the design flood frequency, the provision of wave attenuation measures as well as the design life of the subject infrastructure (*which would define which sea level rise scenario is adopted*). In some cases, the subject infrastructure can be easily modified if sea level rise is realised (*for example: marina piles can be extended*). In which case, no sea level rise allowance is necessary. **Table 8-7** details the minimum flood planning levels and outlines the methodologies adopted in the assessment of a range of flood liable infrastructure proposed for the development. **Figure 8** details the proposed flood mitigation measures in a spatial sense.

Additionally, a 0.5 metre freeboard is applied to infrastructure which is likely to be significantly damaged if inundated during a flood. This freeboard was conservatively applied in addition to the wave allowance to provide a buffer against uncertainties in flood level predictions, wave heights and potential effects of climate change.

Table 8-7 – Proposed Flood Planning Levels

Infrastructure	Design Flood Frequency Average Recurrence interval (ARI)	Design Still Water level (m AHD)	Design Wave Height Allowance (m)	Potential Climate Change Impact (sea level rise and inc. rainfall)		Design life	Free Board (m)	Adopted Minimum Flood Planning Level (m AHD)	Comments
				50 year (+0.34 m)	100 year (+0.67 m)				
Habitable Floor Levels	100 year	1.38	0.2	1.92	2.25	100 years	0.5	2.8	Habitable floor levels would be difficult to raise, hence a 100 year sea level rise allowance has been adopted
Hardstand Area, Workshop & Associated Parking Spaces	5 year	0.7	0.05	1.09	1.42	50 years	0	1.1	These areas would be protected by either the marina breakwater or engineered barriers, hence, a reduced wave allowance is adopted. All electrical wiring would be required to be above the habitable floor flood planning level (*for 50 year design life – i.e. 2.42m AHD*)
Barriers Protecting Marina Village Underroft Parking Spaces	5 year	0.7	0.2	1.24	1.57	100 years	0	1.6	The road to the west of the car park and the wave attenuation barrier to the east would provide flood barriers for the marina village undercroft car spaces (*refer **Figure 8***). Retrofitting would be difficult, so a 100 year sea level rise allowance has been adopted.
Marina Structures	100 year	1.38	0.2	NA	NA	25 years	0	1.6	Marina piles can be extended if sea-level rise is realised, hence no lake-level rise allowance is required

It is noted that following the undertaking of the flood assessment for the Trinity Point development site, Lake Macquarie City Council (LMCC) have more recently released a document which outlines flood planning level amendments in response to climate change (*ref 28)*. This document recommends adopting the high impact sea-level rise prediction of 0.91m for a 100 year timeframe. However, there is no allowance for increased rainfall or wave action. As such, the LMCC recommended a flood planning level of 2.79m AHD [(28)] for the 100 year timeframe which is similar to the 2.8m AHD presented in **Table 8-7.** Therefore, the flood planning levels recommended for habitable floor levels for the Trinity Point Site comply with that LMCC guideline.

Subsequently, following review of the flood assessment for the Trinity Point development site, LMCC revised the above guideline document to incorporate the impact of predicted increases in rainfall intensities. The resulting document is titled, "*Draft Guidelines for Development in Areas adjoining Lake Macquarie that are Vulnerable to the impacts of Sea Level Rise and Increased Rainfall*" (*ref 29)*.

This guideline recommends a flood planning level of 2.85m AHD for habitable floor levels. This is similar to the 2.8m AHD minimum flood planning level adopted for the site. The adoption of the 2.85m AHD level would have no impact on the proposed development design due to the recommendation that all habitable floor levels in the Trinity Point development be constructed above the flood planning level *(i.e. 2.8m AHD as derived above)* where possible to accommodate the uncertainty in climate change impacts *(discussed in **Section 8.3.3)***. Additionally, for commercial development, the flood planning level specified by the most recent LMCC guideline is 2.27m AHD which is over 0.5m less than the 2.8m AHD adopted for the Trinity Point site.

The latest LMCC guideline document specifies that basement car parks (*supporting medium density housing*) are to be constructed to preclude floodwater at levels up to 2.35m AHD. This is achievable at the Trinity Point site and would be ensured in detailed design.

A flood planning level of 1.97m AHD is specified for industrial buildings. However, the document states that "The flood floor levels of commercial/retail and industrial development may be varied if an alternative solution is proposed that complies with the floodplain development manual *(it would be necessary for electrical installations to be located above 2.27mAHD)*".

Table 8-7 presents alternative solutions for the different infrastructure types which comply with the floodplain development manual and the DECC guideline (*ref 23)* relating to climate change considerations. Consideration has been given to the level of risk for each infrastructure type in determining the relevant design flood frequency event.

The levels specified by LMCC for industrial development are above those presented in **Table 8-7** for similar development types. This is primarily because the LMCC levels are based on protection from the 100 year ARI flood. This level of protection has been adopted for development types that do not usually require such high level of protection due to low risk of damage and danger to personal safety. This methodology is considered overly conservative, given the long time to peak of any flood event at the Trinity Point site would allow for sufficient time for any cars to be removed, or evacuation procedures to be undertaken. The adopted minimum level necessary for electrical installations is 2.42m AHD which is 0.15m more than recommended in the LMCC guideline.

Similarly, a risk based approach has been applied to the adoption of a minimum flood planning level for the Marina Village undercroft parking spaces. Given the low risk of damage and danger to personal safety, a design flood frequency event with a lower ARI was chosen. Again, the long time to peak of any flood event at the Trinity Point site would allow for sufficient time for any cars to be removed, or evacuation procedures to be undertaken reducing risk. However, given the difficulty in retrofitting wave barriers and road levels protecting this area a design life *(and hence climate change impact)* of 100 years was chosen. This is similar to the approach outlined in the most recent LMCC guideline for non habitable floor levels.

8.5 FLOOD WARNING AND PREPARATION MEASURES

A flood warning and preparation guideline would be prepared. This document would outline flood preparation measures (*such as removing parked vehicles from car parking areas and closing the marina*) to be taken based on flood level and metrological forecasts. Given the long time to peak of flooding, there would be sufficient time to implement these measures. This offers a cost effective means to mitigate the risk of property damage during a Lake Macquarie flood event.

9 SUMMARY

An assessment of the stormwater and flood management requirements for the proposed Trinity Point Marina Development was undertaken. Given the close proximity of the development to Lake Macquarie, the stormwater management plan was primarily focused on managing water quality rather than flood mitigation. Accordingly, the following mechanisms were identified as potentially degrading to the water quality in Lake Macquarie:

- elevated pollutant levels (*particularly TSS, TN and TP*) in runoff from the residential, tourism and marina village centre components of the development;
- runoff from hardstand/workshop areas which can include:
  - by-product from sand or grit blasting operations;
  - discharges of emulsified oils (*incorporating degreasers*); and
  - chemicals from the overspray during painting operations.
- accidental spillage of fuel, waste water or other potentially polluting substances; and
- copper leaching (*copper based antifouling paints*) from moored vessel hulls.

A preliminary stormwater management plan was established for the proposed development site with a heavy emphasis on preventative measures and source controls. The key features of the stormwater management plan are summarised below:

- **Preventative Measures –** would include:
  - minimising impervious areas;
  - measures to minimise pet droppings; and
  - managing fertiliser application;
- **Source Controls –** would include
  - Consideration of providing up to 100% green garden roofs;
  - rainwater harvesting and storage;
  - permeable pavements on road and car-parking areas; and
  - bio-retention filter area with retention storage.

The marina and marina hardstand area would adopt a range of control measures to manage the potential adverse impact on the water quality in Lake Macquarie resulting from the marina operation, these are summarised below:

- **Control Measures –** would include
    - implement a range of preventative measures such as regular sweeping, the use of vacuum sanders and removal of sacrificial anodes (*prior to sand blasting*) to minimise the pollutant loading on the hardstand area;
    - confining the marina hardstand area and capturing the initial 15mm of runoff. Captured runoff would either be treated and re-used in the boat wash down or discharged to trade waste; and
    - provide double skinned fuel storage tanks and fuel and waste water transfer lines to reduce the change of an accidental puncture / spillage.

Water quality monitoring will be undertaken to provide an assessment of the existing water quality conditions and observe water quality parameters during both construction and operational stages of the proposed development. Water quality observations would be used to assess the impact of the development on water quality and would provide a framework for ongoing assessment of the effectiveness of the water quality management plan proposed for the site, allowing for remedial action to be taken if required.

An assessment of the flood constraints on the development site was also conducted. The assessment adopted the recommended flood planning levels in the *Lake Macquarie Flood Study*[(2)] and factored in allowanced for potential sea-level rise and increase in rainfall intensity over time. A range of flood mitigation measures are recommended including, recommended flood planning level and wave attenuation barriers.

The stormwater management assessment undertaken in this report indicates that the with appropriate mitigation measures, the impact of the proposed development on water quality can be effectively controlled.

10 REFERENCES

1) EPA (1999) Best management Practice for Marinas and Boat Repair Facilities;
2) Manly Hydraulics Laboratory (1998) Lake Macquarie Flood Study, Part 1 – Design Lake Water Levels and Wave Climate;
3) Manly Hydraulics Laboratory (1998) Lake Macquarie Flood Study, Part 2 – Foreshore Flooding;
4) EPA (1998) *Managing Urban Stormwater: Council Handbook*;
5) EPA (1998) *Managing Urban Stormwater: Source Control*
6) EPA (1998) *Managing Urban Stormwater: Treatment Techniques*
7) EPA (2007) Managing Urban Stormwater: Environmental Targets (Consultation Draft)
8) EPA (2006) *Managing Urban Stormwater: Harvesting and Reuse*
9) EPA (1998) *Managing Urban Stormwater: Soils and Construction*
10) Institution of Engineers (*1987*), *'Australian Rainfall and Runoff – A Guide to Flood Estimation'*; edited by DH Pilgrim.
11) New South Wales Government (*2005*), *'Floodplain Development Manual: the management of flood liable land'* ISBN 07313 0370 9
12) Bureau of Meteorology Website (*www.Bom.gov.au*)
13) Institution of Engineers, Australia (2006) '*Australian Runoff Quality*'
14) Lake Macquarie City Council, (2006) 'LMCC DCP No. 1 Part 2.5 Stormwater Management, Infrastructure and on-site Services
15) NSW Department of Planning, (2004), 'BASIX'
16) Australian Standard (2001) 'Guidelines for Design of Marinas', AS 3962-2001
17) Lake Macquarie City Council, (2003) Engineering Guidelines Part 1: Stormwater Drainage Design
18) NSW Department of Water and Energy, 2002, 'Water Management Act 2002'
19) Patterson Britton and Partners (2007) – 'Trinity Point Marina Proposal – Numerical Modelling Investigations'
20) Northrop Engineers (2003) – ' St. John of God Redevelopment – Investigation for Stormwater Management'
21) Patterson Britton and Partners (2007) – 'Trinity Point Wastewater Servicing Strategy'
22) ANZECC, (2000) - 'Australian Guidelines for Water Quality Monitoring and Reporting'

23) NSW Government – Department of Environment and Climate Change, Final November (2007) –'Practical Consideration of Climate Change, Floodplain Risk Management Guideline Note'

24) Douglas Partners, Report on Geochemical Assessment - 'Proposed Trinity Point Marina - Morisset Park Lake Macquarie, Prepared for Johnson Property Group Pty Ltd Project 39823B'

25) Douglas Partners, Acid Sulphate Soil Assessment and ASSMP - 'Proposed Trinity Point Marina - Morisset Park Lake Macquarie, Prepared for Johnson Property Group Pty Ltd, Project 39823B'

26) Douglas Partners (21 May 2008)- 'Additional Groundwater Sampling and Testing – Trinity Point Marina, Morisset Park'

27) Trinity Point Marina Development (2007)- 'Aquatic Ecological Investigations Final, November'

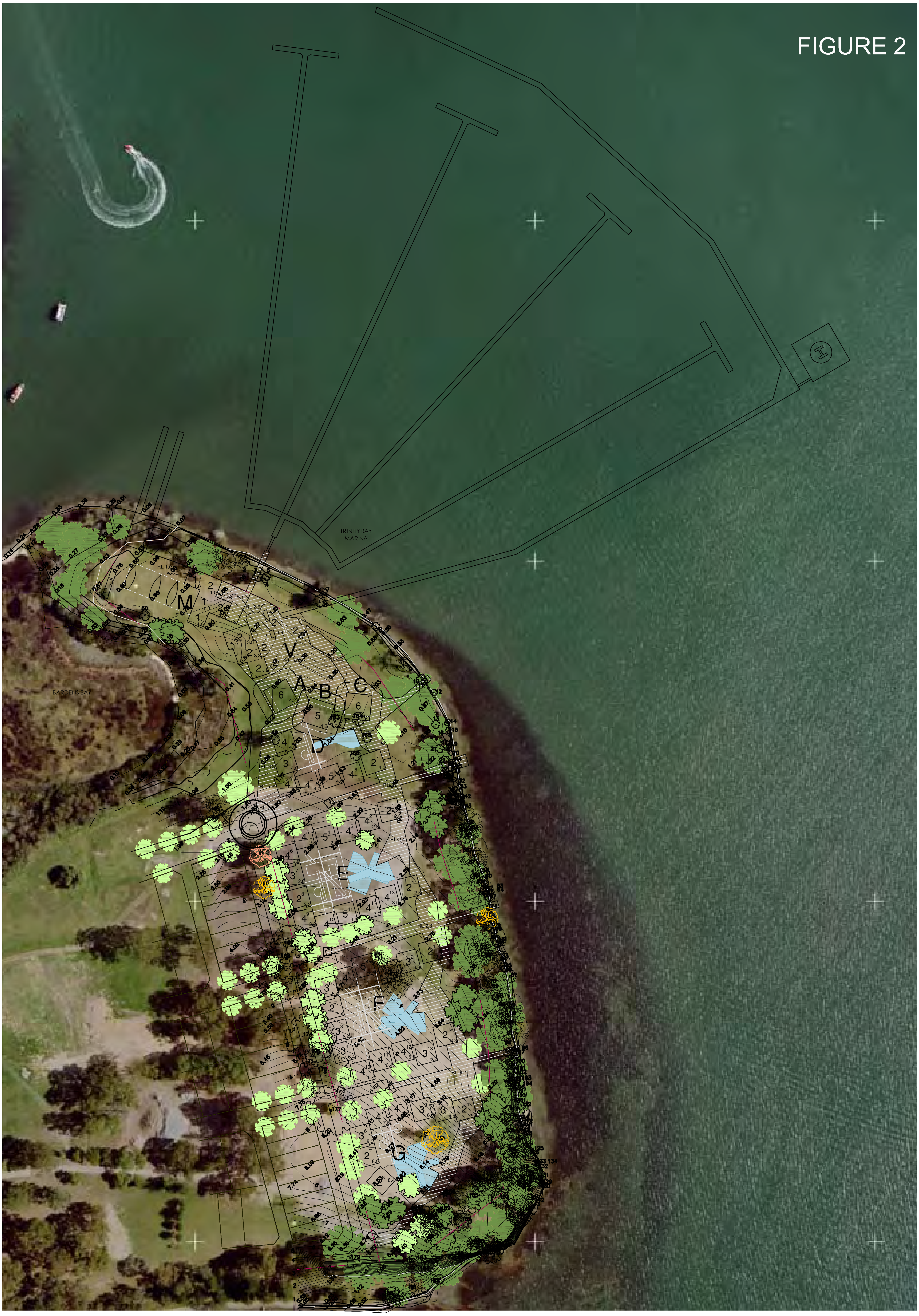
28) Lake Macquarie City Council (2008) – 'Planning levels and Other Adaptation Responses to Sea Level Rise and climate Change'

29) Lake Macquarie City Council (2008) – 'Draft Guidelines for Development in Area adjoining Lake Macquarie that are Vulnerable to the impacts of Sea Level Rise and Increased Rainfall'

FIGURES

FIGURE 1

SITE LOCATION PLAN



Johnson Property Group
Creating living communities

TRINITY POINT
LAKE MACQUARIE

HBO + EMTB

202669	02.11.2007	1:1000 @ A1 1:2000 @ A
SITE PLAN		SK00
		OPTION 01 revision