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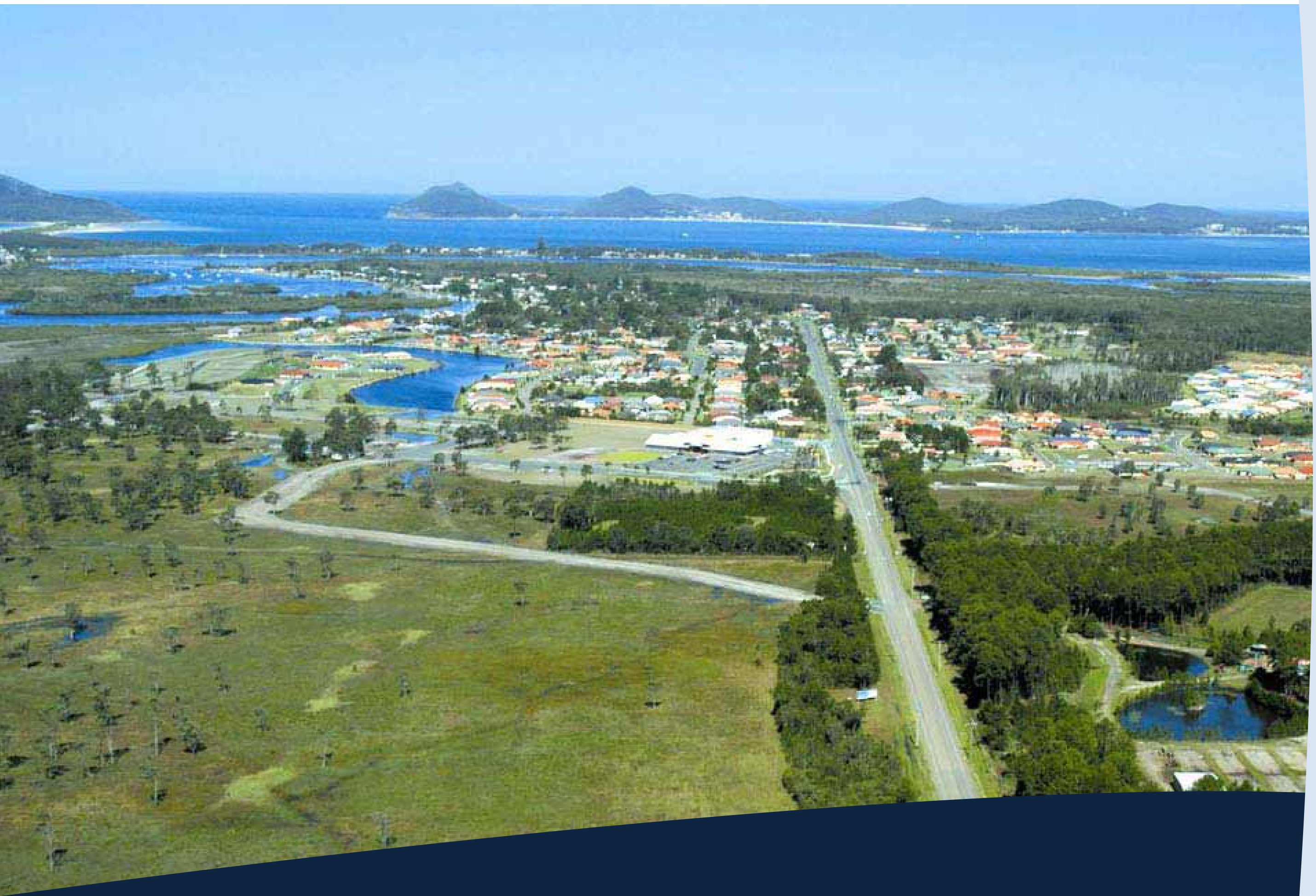

Riverside at Tea Gardens

Integrated Water Management

Main Report

Job Number W4332-7

Prepared for Crighton Properties

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As of 1 July 2009 Cardno Willing (NSW) Pty Ltd merged into Cardno (NSW/ACT) Pty Ltd. Any reference to Cardno Willing is to be read as a reference to Cardno.

Cover Image: Oblique aerial view of the Riverside at Tea Gardens site looking southeast.

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Executive Summary

Background

The Riverside at Tea Gardens Estate is currently being developed and comprises a range of residential, retail/commercial, recreation and tourist development. The part of the site remaining to be developed and covered by the concept plan comprises Lot 34 and Lot 10 DP 270100.

Following the introduction of Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and State Environmental Planning Policy (Major Development) 2005, the Minister for Planning confirmed by letter dated 16 September 2008 that the project was a matter to which Part 3A of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) applies, and that an application may be lodged with the Director General.

The proposed development is considered to be a major project under Clause 6 of the Major Projects State Environmental Planning Policy as advised on 16 September 2010.

An Environmental Assessment Report for a concept plan and project application was prepared in accordance with the Director-General's Environmental Assessment Requirements (DGRs) issued on 16 September 2008. The Environmental Assessment Report was placed on public exhibition for a period of 30 days from 19 February 2009 to 20 March 2009.

The Department of Planning (DoP) appointed an Independent Hearing and Assessment Panel (IHAP), which was subsequently modified to a Planning and Assessment Commission (PAC), to undertake an expert review of the proposed development. The terms of reference of the PAC were focused on the review on two main areas: the ecological constraints of the site and the hydrological issues associated with groundwater, the SEPP14 wetland and flooding. The PAC undertook a site inspection on 6 April 2009 and held a Preliminary Public Hearing on 7 April 2009.

The PAC could not reach a unanimous view on recommendations concerning the ecological constraints of the site, and subsequently issued two reports, one being a majority report, the other a minority report. The PAC submitted its reports to the DoP in July 2009.

Prior to the Minister for Planning making a determination on the concept plan and project application Crighton Properties withdrew the application. The application was withdrawn to enable additional information and studies to be undertaken to address issues raised by the PAC, DoP and other government agencies. These additional investigations resulted in modifications to the development footprint.

In response to the issues of concern Cardno, Martens and Associates and Worley Parsons have formulated an amended IWCM strategy based on water Sensitive Urban Design (WSUD) principles for the Riverside at Tea Gardens site. The strategy has been based upon:

- Intensive analysis of existing site conditions;
- A significant assembly of base data regarding performance of the existing surface and groundwater systems and in particular the existing lake;
- Detailed computer modelling and assessment of a range of development options against performance criteria and legislative requirements;
- Refinement of the selected management strategy;
- Modelling of likely future performance and impacts of the selected management strategy; and
- Consultation with the DoP, MidCoast Water and Council.

Site Conditions

The Riverside at Tea Gardens site is bounded by Myall River to the east and Myall Road to the west. The Shearwater Residential Estate lies to the north of the site and residential development of Tea Gardens is to the south. The site has approximately a one kilometre frontage to Myall Road and two kilometre frontage to the Myall River. State Environmental Planning Policy No. 14 – Coastal Wetlands (SEPP 14) applies to wetlands within a portion of the eastern boundary of the site adjacent to the Myall River. These wetlands have been clearly identified along with a buffer to the wetlands and zoned accordingly when the site was rezoned in 2000. The remainder of the site is available for urban development and zoned accordingly.

The site is flat with generally sandy soils. There is a slight fall to the south. The site ranges in height from 0.6m Australian Height Datum (AHD) (along the foreshore of the Myall River) to 20m AHD (at the northern end of the side adjacent to the Shearwater Estate). However most of the site varies in height from between 1.6m AHD to 5.0m AHD.

The majority of the site was previously used for a pine plantation and has been substantially cleared of native vegetation. Some scattered isolated occurrences of both pines and natives currently exist on the site.

Project Description

The current proposal differs from that previously lodged with the DoP in several key respects. Changes have been made to address concerns raised by the PAC and DoP. Key changes include the following:

(i) residential development of the site which will include the potential to create approximately 920 dwellings comprising 855 residential (variety of lots), 50 lodges and 15 houses in a Tourist Precinct;

(ii) residential lots have been moved from the north west portion and northern corridor. The overall number of dwellings proposed has been reduced from approximately 1040 to 920;

(iii) the proposed 4 hectare expansion of the existing commercial area has been removed from the Concept Plan;

(iv) Precinct 1 which included 71 lots previously located in the south east portion of the site has been deleted and will now become part of the conservation area;

(v) a biodiversity offsetting package is proposed which will consist of both on-site and yet to be identified off-site offsets;

(vi) lined water management devices (not in contact with the groundwater table) are proposed and the number of detention ponds has been reduced. There will be no link between the saltwater and freshwater lakes and the single existing drain outlet to the Myall River will not be upgraded or duplicated;

(vii) a new Integrated Water Cycle Management Strategy has been prepared which has the support of MidCoast Water; and

(viii) additional vegetation mapping and a new ecological assessment for the project has been undertaken by newly appointed ecological consultants.

The amended development concept plan is provided in **Figure S1** while the diagrammatic stormwater concept plan is given in **Figure S2**.

Legislative Requirements

The Director-General's Environmental Assessment Requirements for water cycle management issued on 13 October 2010 are in part as follows:

> " Address potential impacts on the water quality of surface and groundwater during both construction and occupation, having regard to the relevant State Groundwater, Rivers, Wetlands and Estuary Policies. Consideration must be made for water impacts to the River and identified SEPP 14 and RAMSAR Wetlands. Particular regard must be given to how the proposal will minimise altered salinity, pH, litter, weeds, exotic fauna, gross disturbance of these wetlands, nutrient intake to receiving water bodies, and any other issues raised by the PAC relating to groundwater and groundwater ecosystems.
>
> …. Stormwater management should be designed to ensure ongoing protection of the groundwater aquifer in accordance with the principles of ANZECC & ARMCANZ: Guidelines for Groundwater Protection in Australia, National Water Quality Management Strategy, Commonwealth of Australia, 1995. Ensure there is no impact on the existing groundwater aquifer and existing groundwater quality resulting from the proposal. Suitably justify the stormwater treatment measures to be used in the proposal."

Mitigating the Impacts of the Development

When formulating the current proposal (which is a modified version of the "preliminary scheme without rainwater tanks" which was amended in response to comments from the DoP, the PAC and other authorities) consideration was given to the two following stormwater quality objectives:

- Nil or Beneficial Effect ie, no increase in the overall TSS, TP and TN exports to the Myall River (based on the performance targets identified in the Great Lakes Council Draft Water Sensitive Design DCP (Version 1.1, May 2010); and
- Mean TP and TN concentrations in discharges to window lakes/ponds to not exceed limits identified by Martens & Associates in November 2009, namely TN < 1.0 mg/L and TP < 0.2 mg/L ie. background groundwater quality

These objectives are compatible with the Director-General's Environmental Assessment Requirements for water cycle management.

Mitigating Surface Water and Groundwater Impacts

Flooding and Drainage

The planned development will increase the rate of local runoff and peak flows. A number of basins have been sized to ensure that the post development peak flows in the 100yr ARI event is no greater than under existing conditions ie. pre and post development runoff conditions have been matched.

Previously, the approach to drainage design in Tea Gardens was to maintain drainage structure outlet levels at or above Mean High Water, at approximately RL 0.5m AHD. This is reflected in the levels of drainage structures throughout the existing Tea Gardens township, including all existing stages of the Myall Quays estate.

In order to account for the possible impacts of climate change, modifications have had to be made to the previously proposed drainage regime in the Riverside Estate proposal. In order to maintain the existing approach, the most significant change has been to lift the entire drainage system for the site, to ensure that the minimum invert of all new drainage structures in the proposed Riverside Estate are now at or above the predicted worst post climate change Mean High Water of 1.4 m AHD. This would ensure that the drainage system would remain unaffected by tidal waters. In discussions with Great Lakes Council's engineering department, this has been supported as an appropriate response.

The other possible effect of climate change has been to increase flooding levels due to potential increases in tailwater and rainfall intensities. Revised flood levels across the site have then been accounted for in determining landform levels. A direct result of this raising of the drainage network is the raising of the surface levels across the site to provide cover to the pipes. Consequently the majority of the site is already raised above the revised flood levels. Additional lot filling is proposed in any remaining low-lying areas to ensure that all lots remain flood free above the modelled 100 yr flood levels, with climate change. It should be noted that finished floor levels will be a minimum of a further 0.3m above this lot fill level which will provide further freeboard.

Groundwater

To assess the potential impacts of proposed development on groundwater levels a series of preliminary steady state groundwater models of the study area were developed by Martens and Associates. Modelling works extended a concept model previously prepared by Coffey, 2007b which was modified by Martens and Associates. Three steady-state conditions were assessed including current conditions; post-development conditions and post-development conditions under possible climate change.

Results indicate that groundwater levels are likely to be drawdown by up to approximately 0.05 m to 0.1 m over the adjacent SEPP14 wetlands due to reductions to recharge in the area of the site. However this drawdown, which would occur incrementally during the long term development programme for the project, would be balanced by approximately 10 years of sea level rise during the long term development programme. The impact on groundwater levels are therefore expected to be negligible. Changes to groundwater flow direction at the site boundaries and within adjoining wetlands are negligible.

Simulation results also indicate that sea level rise will lead to inundation of the majority of the SEPP14 wetland area adjacent to the site. Groundwater levels in the area of the site where development is proposed are modelled to increase by a maximum of 0.4 m.

There was a concern previously expressed regarding the potential re-use applications for recycled water from the sewerage treatment plant for irrigation and whether this would affect the health of the aquifer that lies below Riverside at Tea Gardens.

However, Martens 2011 concludes that the demand for nutrients in garden areas alone far outstrips that which can be supplied by recycled water ie. irrigation of recycled water is not expected to threaten groundwater quality.

Water Quality

The planned development will also increase the average annual export of pollutants from the site. Catchment water quality assessments of the planned development demonstrate that the preferred final water management scheme meets the stormwater quality objectives under current conditions and under possible climate change conditions.

The treatment train for stormwater discharging through the existing saline lake to the Myall River includes (refer **Figure 4**):

- GPTs if appropriate on outfalls from the commercial centre;
- Two lined wetlands (not in contact with the groundwater table) with a total surface area of around 1.4 ha;
- Additional point source subsurface biofiltration pits;
- Freshwater (window) recharge lakes with a combined surface area of around 3.5 ha.
- A 550 m long swale connecting the eastern arm of the freshwater lakes to the existing saline lake; and the
- Existing saline lake with a surface area of around 6 ha. There is no direct link between the saltwater and freshwater lakes and the single existing drain outlet from the saline lake to the Myall River will not be upgraded or duplicated.

The treatment train for stormwater discharging to the Conservation zone includes

- A lined wetland (not in contact with the groundwater table) with a surface area of around 0.25 ha;
- Additional point source subsurface biofiltration pits;
- A 4400 m long swale to distribute runoff along the edge of the conservation zone

The treatment train for stormwater discharging to the Myall River includes (refer **Figure 4**):

- A lined wetland (not in contact with the groundwater table) with a surface area of around 0.56 ha located within a detention basin.

The performance of the treatment train is summarised in **Table S1**.

It was concluded from lake modelling that under developed conditions that in the near term the existing saline lake will become less brackish due to the requirement that the existing outlet remain unchanged ie. additional freshwater runoff will reduce the salinity of the lake water.

In the longer term sea level rise and increasing tidal inflows will increase the salinity of the lake. In the event that a sea level rise of 0.9 m or greater occurs then the lake will become part of the Myall River and salinity levels would be expected to match the salinity of the Myall River. The installation of ancillary local ponds or lined wetlands as proposed is necessary to manage the water quality discharging into the proposed unlined freshwater lakes to protect groundwater quality.

Practical Consideration of Climate Change

The impact of possible climate change on flooding, stormwater quality and groundwater levels have all been assessed. Key levels for stormwater infrastructure have been adjusted to accommodate possible future climate change. All site and floor levels are based on the 100 yr ARI flood levels under climate change as discussed in **Section 2.3**.

Potable Water, Recycled Water and Sewerage Servicing

In 2010 Worley Parsons assessed the potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens. The investigation considered the Riverside at Tea Gardens development together with the entire catchment to be serviced by the Hawks Nest Sewage Treatment Plant. In particular, the three new developments Riverside at Tea Gardens, Myall River Downs and North Shearwater were considered. This assessment was carried out in full consultation with MidCoast water and in accordance with its requirements.

The full assessment of assessed the potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens is attached in **Appendix G** and are outlined in **Section 5**. Based on its review of the assessment MidCoast Water has confirmed that the Riverside project (subject to approval) will be serviced by sewer, water and recycled water for toilet flushing, laundry and outdoor uses.

Management, Maintenance and Monitoring

The management responsibilities of various stakeholders including the landowner, contractors/builders Riverside Community Association (Residents), Great Lakes Council, the Department of Environment, Climate Change and Water and MidCoast Water are identified.

In view of the potential presence of acid sulphate soils a generic plan has been prepared for management of ASS in future earthworks that occur within the Riverside Estate that include the laying of sewer and drainage lines and the excavation of stormwater treatment basins.

Table S1
Estimated Pollutant Exports under Developed Conditions – Final Scheme

Average Annual Pollutant Exports to Myall River under Final Scheme

Average Annual Pollutant Exports to Myall River from Riverside Catchment	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Comment
Current Conditions - Existing Catchment + Drains + Existing Lake	**127,330**	**271**	**2088**	
Development no Controls (Overall)	210,280	445	3414	
Development with Controls (without RWTs)	26,900	164	2000	Swale seepage = 0 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	
	25,800	153	1890	Swale seepage = 5 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	
Development with Controls (without RWTs) under Climate Change	52,500	187	2050	Swale seepage = 0 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	
	51600	179	1950	Swale seepage = 5 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	

Discharge to Window Lakes/Ponds under Final Scheme

		TP (ug/L)	TN (mg/L)	Comment
Water Quality Objectives		< 200	<1.0	
Development with Controls (without RWTs)				
From N10 Wet		46.2	0.73	Meets objective
From E8 Wetland		27.1	0.44	Meets objective
From EE5 Pond		54.3	0.69	Meets objective
From EE6 Pond		61.4	0.84	Meets objective
Development with Controls (without RWTs) under Climate Change				
From N10 Wet		41.6	0.65	Meets objective
From E8 Wetland		22.8	0.36	Meets objective
From EE5 Pond		49.3	0.61	Meets objective
From EE6 Pond		52.9	0.72	Meets objective

A concise version of this plan will be provided as a reference to all lot purchasers and contractors required to work on any home within the site.

This plan has been formatted in a way to assist individual land owners obtaining DA approvals by outlining methods to control and manage ASS during the development of each lot. The plan will also guide the management of any future excavation to extend the detention lake.

Maintenance activities for constructed ponds and wetlands and the extended detention lake are outlined. The management of aquatic weeds in constructed pond and wetland systems and the extended detention lake will be based on the practices already implemented for existing ponds and wetlands located within developed areas of Riverside Estate and the Myall River Downs estate and for the existing detention lake.

A monitoring program is proposed for the SEPP 14 wetlands, constructed ponds and wetlands and the extended detention lake. The management actions proposed to rectify any failures to meet the water quality objectives are also identified.

Architectural and Landscape Treatment

In addition to the environmental performance of the proposed system, a number of opportunities are presented with regard to visual and physical interaction with the system that intelligent architectural and landscape design can capitalise upon, such as foreshore parks, walkways, cycleways, placement of public buildings etc.

The internalisation of the water management system and the unfettered public access which is proposed to be provided to all new water bodies and detention basins and drainage corridors will ensure ongoing adoption of maintenance regimes due to the surveillance and public amenity that the system provides.

This maintenance discipline has been proven to date, even though the existing lake does not enjoy the same level of public visibility (due to site layout) as the design currently proposed.

Ongoing Performance

Demonstrated Performance

Detailed water quality data collected since 1996 has demonstrated the effective performance of the existing water management system, which is similar to that proposed for the planned development. It gives confidence of the likely future success of the proposal – it is rare to have this level of technical support.

Community Ownership and Maintenance

The Community Title ownership of the existing lake (and all proposed future stormwater management measures) ensures a body exists in perpetuity as well as providing a funding mechanism to ensure the ongoing maintenance and monitoring of the water management system.

Conclusions

The integrated water management system proposed for the Riverside site is based on a strategy which collects, detains and treats stormwater runoff in an integrated train of local, neighbourhood and regional facilities and integrates the detailed consideration of potable water, rainwater, wastewater and recycled water.

It is concluded that management of surface water using a number of lined ponds, lined wetlands, swales, basins, freshwater lakes and the existing saline lake will meet the water quality, and quantity objectives for the site set down by the various relevant authorities.

It is also our opinion, that this scheme is the most likely to succeed in the long term and, if properly managed in accordance with the plan provided in this report is likely to continue to perform at or near the already demonstrated performance levels.

The proposed scheme also offers an opportunity to increase the extent, complexity and quality of near-shore habitats for fish, invertebrates and birds that is rarely available in new developments.

Item	Description
1	Extent of concept plan area 'Riverside' at Tea Gardens.
2	Existing 7(a) wetland zone.
3	Existing 7(b) buffer zone.
4	Wildlife movement corridor.
5	Water management & open space corridors.
6	Community parks incorporating walking/cycle ways, BBQs, children's play area equipment.
7	Community pocket parks.
8	Not Applicable
9	Not Applicable
10	Existing detention and water quality lake.
11	New fresh water, water quality management & detention ponds.
12	Existing residential development.
13	Precinct community facilities.
14	Future precinct community facilities.
15	Site area currently owned by Great Lakes Council.
16	Separate medium density/commercial precint (not part of this application-current waver is-sued by DoP.)
17	Tourist lodgings precinct.
18	Additional land proposed for conservation
19	Proposed residential lot development to be developed under community title.
20	Future development site.
21	Existing house.
22	DCP buffer.
23	Location of known midden & buffer.
24	Existing drain outlet to Myall River.
25	Existing drainage swale
26	Existing shopping centre/medium density approvals
27	Future connecting road

Land Use Legend

Total Site	Ha	%
Open Space		
- Wetlands (zoned 7a)	28.6	12.9
- Buffer Zones (zoned 7b)	21.0	9.4
- Additional Conservation Buffer	17.8	8.0
- Wildlife Corridors	41.9	18.8
- Drainage Corridors, Ponds & Large Parks	23.1	10.4
- Pocket Parks	2.6	1.2
- Existing detention & water quality lake	6.7	3.0
Total	141.7 Ha	63.7%
Built Upon Area		
- Residential (including roads & community facilities)	67.1	30.2
- Tourist/Residential (Lodgings)	8.1	3.6
Total	75.2 Ha	33.8%
Future Development Site		
Total	5.6 Ha	2.5%
Total	222.5 Ha	100%

Figure S1 Riverside at Tea Gardens Concept Development Plan – Final Scheme

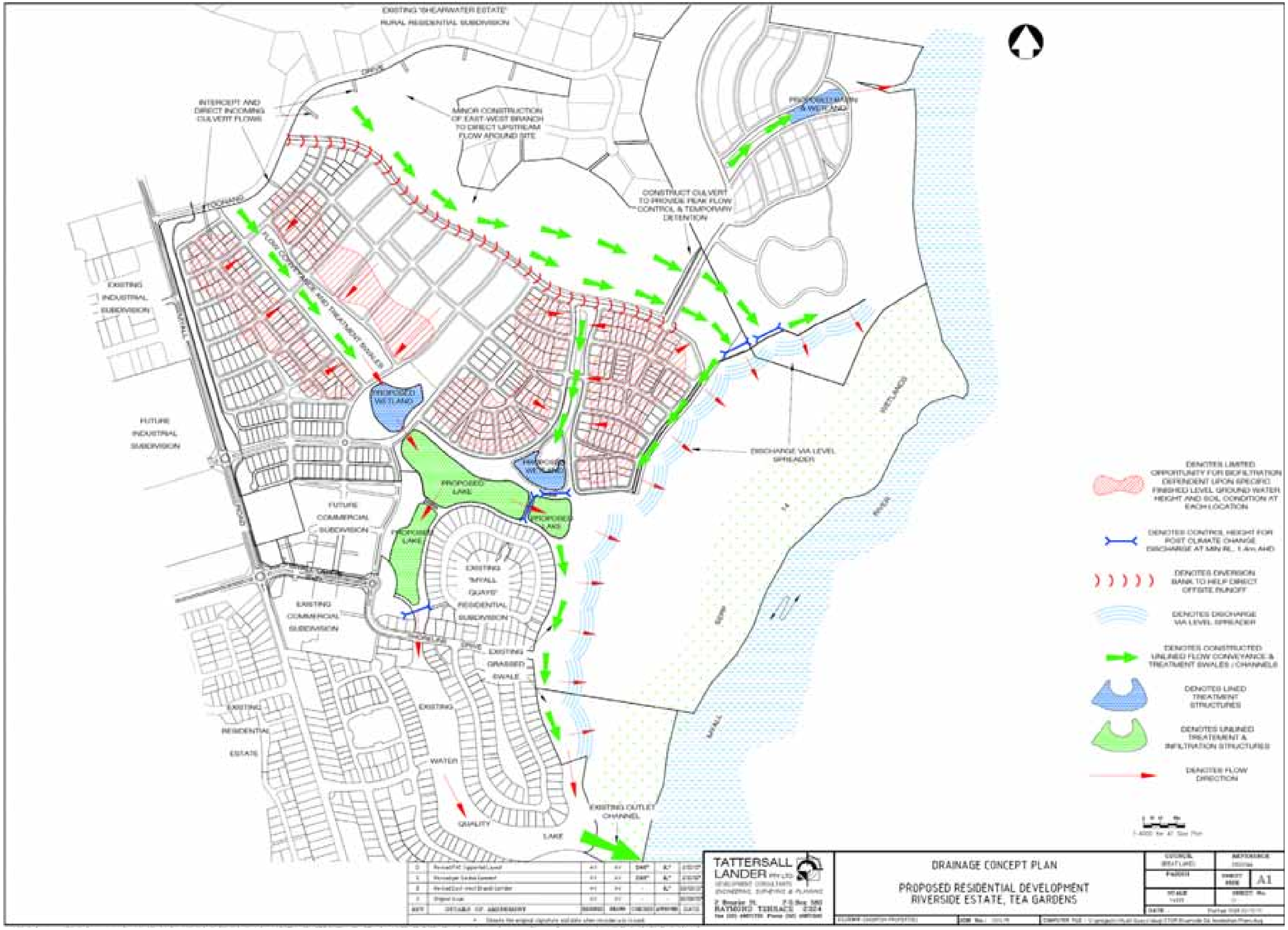

Figure S2 Diagrammatic Stormwater Concept Development Plan – Final Scheme

1 Introduction

In 1991 Crighton Properties bought the 230 hectare site currently known as 'Riverside at Tea Gardens' (formerly 'Myall Quays') which lies immediately to the west of the Myall River and to the east of Myall Road (the main road linking Tea Gardens / Hawks Nest with the Pacific Highway). The location of the Riverside at Tea Gardens site is shown as **Figure 1**.

Crighton Properties originally lodged a rezoning request with Great Lakes Council for a multi-stage residential/resort type development on the site. The Council resolved to prepare a draft Local Environmental Plan (LEP) subject to the findings of a formal local environmental study (LES). The LES was prepared in 1991 and the site was finally rezoned to 2(f) mixed commercial residential in 2000.

The following overviews of the history of the Riverside at Tea Gardens site and project description are drawn from ERM, 2010.

1.1 Site History

The Riverside at Tea Gardens Estate is currently being developed and comprises a range of residential, retail/commercial, recreation and tourist development. The part of the site remaining to be developed and covered by the concept plan comprises Lot 34 and Lot 10 DP 270100.

In 1989, Crighton Properties predecessor in title lodged a rezoning request with Great Lakes Council for a multi-stage residential/resort type development on the site. The Council resolved to prepare a draft Local Environmental Plan (LEP) subject to the findings of a formal local environmental study (LES). The LES was prepared in 1991 and the site was finally rezoned to 2(f) mixed commercial residential in 2000.

In 2002 Crighton Properties began the process of seeking approval to develop a substantial portion of this site for residential purposes and for a nine hole golf course and tourist facilities. Following the introduction of State Environmental Planning Policy No 71 – Coastal Protection (SEPP 71) in November 2002, a master plan was required to be adopted by the Minister for Planning before any further residential subdivisions could be approved.

A Planning Focus Meeting was held on site on 28 December 2003 to discuss the master plan and the various development proposals. The Director- General's requirements for the EIS were subsequently issued by the Department of Infrastructure, Planning and Natural Resources in January 2004 (Ref: N91/00721) for the artificial water detention body and the residential/tourist/recreational components. The Department also provided requirements regarding the preparation of a master plan for the development under SEPP 71 (Ref: S03/03010).

Following the introduction of Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and State Environmental Planning Policy (Major Development) 2005, the Minister for Planning confirmed by letter dated 16 September 2008 (REF: 904 1553) that the project was a matter to which Part 3A of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) applies, and that an application may be lodged with the Director General.

The proposed development is considered to be a major project under Clause 6 of the Major Projects State Environmental Planning Policy as advised on 16 September 2010.

An Environmental Assessment Report for a concept plan and project application was subsequently prepared in accordance with the Director-General's Environmental Assessment Requirements (DGR's) issued on 16 September 2008. The Environmental Assessment Report was placed on public exhibition for a period of 30 days from 19 February 2009 to 20 March 2009.

The Department of Planning (DoP) appointed an Independent Hearing and Assessment Panel (IHAP), which was subsequently modified to a Planning and Assessment Commission (PAC), to undertake an expert review of the proposed development. The terms of reference of the PAC were focused on the review on two main areas: the ecological constraints of the site and the hydrological issues associated with groundwater, the SEPP14 wetland and flooding. The PAC undertook a site inspection on 6 April 2009 and held a Preliminary Public Hearing on 7 April 2009.

The PAC could not reach a unanimous view on recommendations concerning the ecological constraints of the site, and subsequently issued two reports, one being a majority report, the other a minority report. The PAC submitted its reports to the DoP in July 2009.

In a letter dated 22 October 2009, the DoP raised the following concerns regarding the concept plan and project application:

- (i) The size of the commercial area is considered excessive and not required for the likely future population;
- (ii) The traffic impact assessment inadequately considers traffic generation and other aspects of the proposal;
- (iii) The subdivision layout does not adequately address the constraints plan and site analysis plan;
- (iv) The proposal exceeds the capacity allocated for the development within the current servicing strategies of MidCoast Water and an Integrated Water Cycle Management Plan should be required;
- (v) There are drafting issues which need to be addressed in the Community Management Statements;
- (vi) The Voluntary Planning Agreement (VPA) needs to be amended in several areas;
- (vii) Avoidance of Acid Sulphate Soils does not appear to have been considered in the project; and
- (viii) The proponent has not adequately established that the surface and groundwater flows to the adjoining SEPP 14 Wetland would remain unaltered.

Prior to the Minister for Planning making a determination on the concept plan and project application Crighton Properties withdrew the application. The application was withdrawn to enable additional information and studies to be undertaken to address issues raised by the PAC, DoP and other government agencies. These additional investigations resulted in modifications to the development footprint.

1.2 Site Description

The Riverside at Tea Gardens site is bounded by Myall River to the east and Myall Road to the west. The Shearwater Residential Estate lies to the north of the site and residential development of Tea Gardens is to the south. The site has approximately a one kilometre frontage to Myall Road and two kilometre frontage to the Myall River. State Environmental Planning Policy No. 14 – Coastal Wetlands (SEPP 14) applies to wetlands within a portion of the eastern boundary of the site adjacent to the Myall River. These wetlands have been clearly identified along with a buffer to the wetlands and zoned accordingly when the site was rezoned in 2000. The remainder of the site is available for urban development and zoned accordingly.

The site is flat with generally sandy soils. There is a slight fall to the south. The site ranges in height from 0.6m Australian Height Datum (AHD) (along the foreshore of the Myall River) to 20m AHD (at the northern end of the side adjacent to the Shearwater Estate). However most of the site varies in height from between 1.6m AHD to 5.0m AHD.

The majority of the site was previously used for a pine plantation and has been substantially cleared of native vegetation. Some scattered isolated occurrences of both pines and natives currently exist on the site.

1.3 Project Description

The Riverside at Tea Gardens site is already zoned 2(f) – Mixed Residential – Commercial for urban development (refer **Figure 2**). The concept plan for the development of the Riverside at Tea Gardens site consists of a residential / mixed use precinct proposed for the majority of the site and a tourist and larger lot component located in the NE corner of the site. Substantial areas of the 2(f) zoned land are proposed to be protected and enhanced as open space / wildlife movement corridors, over and above those already protected within the 7(a) and 7(b) zones.

The current proposal differs from that previously lodged with the DoP in several key respects. Changes have been made to address concerns raised by the PAC and DoP. Key changes include the following:

(i) residential development of the site which will include the potential to create approximately 920 dwellings comprising 855 residential (variety of lots), 50 lodges and 15 houses in a Tourist Precinct;

(ii) residential lots have been moved from the north west portion and northern corridor. The overall number of dwellings proposed has been reduced from approximately 1040 to 920;

(iii) the proposed 4 hectare expansion of the existing commercial area has been removed from the Concept Plan;

(iv) Precinct 1 which included 71 lots previously located in the south east portion of the site has been deleted and will now become part of the conservation area;

(v) a biodiversity offsetting package is proposed which will consist of both on-site and yet to be identified off-site offsets;

(vi) lined water management devices (not in contact with the groundwater table) are proposed and the number of detention ponds has been reduced. There will be no link between the saltwater and freshwater lakes and the single existing drain outlet to the Myall River will not be upgraded or duplicated;

(vii) a new Integrated Water Cycle Management Strategy has been prepared which has the support of MidCoast Water; and

(viii) additional vegetation mapping and a new ecological assessment for the project has been undertaken by newly appointed ecological consultants.

The amended development concept plan is provided in **Figure** 3 while the diagrammatic stormwater concept plan is given in **Figure 4**.

1.4 Planning Context

ERM, 2010 discuss in detail the planning provisions that apply to the site and whether the project is permitted under the prevailing instruments, plans, policies and strategies.

It was concluded that the proposed development is consistent with the following instruments/plans/policies/strategies.

- SEPP (Major Projects) 2005
- SEPP (Infrastructure) 2007
- SEPP 14 – Coastal Wetlands
- SEPP 44 – Koala Habitat Protection
- SEPP 50 – Canal Estate Development
- SEPP 71 – Coastal Protection
- NSW Coastal Policy 1997
- Coastal Design Guidelines for NSW
- Mid North Coast Regional Strategy
- Great Lakes LEP 1996
- DCP 22 – Myall Quays Estate
- DCP 30 – Residential Urban Areas
- DCP 31 – Subdivision
- Car Parking Policy
- Draft DCP 34 – Acid Sulphate Soils
- Tea Gardens Hawks Nest Conservation & Development Strategy
- Draft Tea Gardens Hawks Nest Housing Strategy (2nd Draft)
- Urban Design and Density Review Forster Tuncurry and Tea Gardens Hawks Nest
- Recovery Plan for the Hawks Nest & Tea Gardens Endangered Koala Population

The proposed development is partly consistent with DCP 22 – Myall Quays Estate. As discussed by ERM (2010) DCP 22 is outdated as it was prepared prior to recent environmental studies and investigations into the capabilities and suitability of the site. While many of the management principles actions outlined in the DCP remain relevant, some of the specific controls are no longer appropriate as they are based on a previous master plan that has little resemblance to the current (and proposed) development of the site, nor in any event, can this masterplan be realised, given the current planning legislation. It is anticipated that the DCP will be repealed and replaced by a concept plan for the Riverside at Tea Gardens Estate.

1.5 Consultation

As outlined by ERM (2011), Crighton Properties and its consultants began the process of seeking approval to develop a substantial portion of the Riverside at Tea Gardens site in 2002. Crighton Properties has consulted with the DoP, other government agencies and the community over many years with regard to the form of the proposal, the planning framework / process and outcomes of the environmental assessment related to the project.

Consultation and development of the previous project proposal culminated in the lodgement and exhibition of a concept and project plan in February 2009, public exhibition from 19 February to 20 March 2009 and PAC review and public hearing on 7 April 2009. The previous application was subsequently withdrawn by Crighton Properties due to unresolved concerns raised by DoP, the PAC and other government agencies.

Since the withdrawal of the previous application, Crighton Properties was briefed directly by the PAC with regard to the assessment and subsequently has consulted with the DoP and the former Department of Environment Climate Change and Water (DECCW) on a number of occasions to discuss additional assessments being undertaken to resolve the concerns of DoP and the PAC, and the form of a revised concept plan and future application.

Additionally, Crighton Properties has directly consulted with a number of government agencies to resolve outstanding concerns, including:

- ongoing liaison with the former DECCW in respect to ecological impacts, in particular revised vegetation mapping and ecological impact assessment which have been recently completed;
- liaison with NSW Office of Water (NOW) in respect to the amended water management strategy for the site;
- consultation with MidCoast Water during the development of the Integrated Water Cycle Management Plan; and
- consultation with Council re VPA inclusions.

1.6 Previous Studies

A number of studies of surface water and groundwater issues for the Riverside at Tea Gardens site have been undertaken previously. These studies are overviewed in chronological order as follows:

Coffey Partners International Pty Ltd (1996a) *"Myall Quays Development - Groundwater and Surface Water Study", Report No. G39811-AJ*, prepared for Paterson Britton & Partners, February.

This study reported on existing site groundwater conditions. The report included:

- A review of existing conditions,
- An assessment of the need for further field studies,
- Additional field testing,
- Modelling of groundwater and surface flows, and
- An assessment of the effects of proposed development.

Field monitoring of 10 bores was also undertaken in the Myall Quays area during 1994 - 1995 including high rainfall events in May and June 1995. In most cases the peak groundwater level associated with a rainfall event followed within about a week of the rainfall. It was reported that a high level of groundwater response occurred under existing conditions, suggesting that little rainfall runs off and most reports to the groundwater system.

Water quality tests were performed on the bore water by Hunter Water Laboratories and the results are reported in CPI, 1996a. Bores close to the Myall River showed concentrations similar to seawater, while other bores were less saline. Lead levels exceeded guidelines for human consumption in many of the samples. It was considered that the lower salinity groundwater could be used for golf course irrigation provided that sodium levels were monitored.

Coffey Partners International Pty Ltd (1996b) "Myall Quays Development - Groundwater and Surface Water Study, Estuarine Lake Option*", Report No. G39811-AS*, prepared for Paterson Britton & Partners, June.

This study examined the groundwater and freshwater impacts of an Estuarine Lake option.

Cardno Willing (2003a) "Myall Quays Drainage and Water Quality Management Plan", *Draft Report*, prepared for Crighton Properties, April.

This report was prepared to provide background information on water quality solutions to address the potential impacts of proposed future stages of the Myall Quays development at Tea Gardens, NSW.

It was concluded that the existing detention lake on the site would need to be enlarged in order to maintain the existing water quality and its ancillary role as a fish habitat. Preliminary calculations and computer modelling showed that an increase in size to about 18 hectares may be needed in order to prevent more rapid and extreme changes in salinity and dissolved oxygen (DO), levels which would adversely affect the aquatic habitat. An increase in tidal flushing would be also necessary in order to maintain the mean salinity at the present value of about 12,000 ppm. Draft ecological principles for the extension of the existing detention lake were also formulated.

Cardno Willing (2003b) "Myall Quays Precincts 7 and 8, Water Management Plan", *Final Report*, prepared for Crighton Properties, September.

A Water Management Plan for Precincts 7 and 8 (that is now constructed) was prepared to address Great Lakes Council Deferred Commencement Conditions No. 2 and No. 4 as detailed in the Minutes of the Planning & Development Committee of the Great Lakes Council held on 25th March 2003.

The Plan identifies the water quality performance criteria to be achieved within the water quality treatment system for the site and the procedures for ensuring that the specified water quality performance criteria are met.

The Plan also outlines a monitoring program to ensure the long term viability of the water quality treatment system, including details of the monitoring procedure for ensuring the performance of the pollutant control function, with regard to nutrient stripping.

The Plan identifies the persons responsible for the monitoring and maintenance, including responsibility for costs for maintaining scenic and water quality of the water treatment system, and further identifies those persons responsible for any remediation actions or costs required to Improve scenic, recreation and water quality of the water quality treatment system.

Cardno Willing (2003c) “Myall Quays Development”, *Options Paper*, prepared for Crighton Properties, July.

This paper discusses water management options to protect the aquatic environment that has been already established in the first stage of the detention lake by maintaining existing water quality under the ultimate developed condition.

Based on an assessment of water quality impacts and the advantages and disadvantages of each option it was concluded that the option that is best able to protect the aquatic environment that has been already established in the existing detention lake is to extend the lake to an 18 ha detention lake in combination with existing practices of implementing OSR on lots draining directly to the lake and construction of mini ponds and wetlands in strategic locations within the future developed areas.

Cardno Willing (2003d) “Myall Quays Water Quality Detention Lake, Applicability of SEPP50”, Position paper, prepared for Crighton Properties, July.

As part of the planned development of the Myall Quays site it was proposed to extend the detention lake to mitigate the impacts of the development of the remaining area of the southern catchment while maintaining the aquatic environment that has been already established in the first stage of the detention lake. This paper reviewed the proposed detention lake extension in the context of State Environmental Planning Policy 50 – Canal Estate Development.

It was concluded that the lake extension was the minimum reasonable size and capacity to meet statutory requirements and the management objectives of the LEP and DCP and would be in accordance with the provisions of SEPP50.

Cardno (2004) “Myall Quays Development, Tea Gardens, Assessment of Water Management Options”, Final Report, prepared for Crighton Properties, September.

This report provides background information on the proposed Myall Quays development at Tea Gardens, NSW. It overviews the LEP, DCP gazetted in 2000, zoning constraints, environmental constraints, development constraints and community constraints.

A detailed assessment of existing and future catchment runoff and pollutant exports and water management options to maintain as far as possible to maintain the existing lake water quality and its ancillary role as a fish habitat is outlined.

A Do Nothing option and six schemes to mitigate the impact of planned future development on lake water quality were assessed. These schemes were:

0. Existing conditions ie. a 6 ha lake;
1. Do nothing – keep the current water body as it is without increasing the size (but with BASIX implemented).
2. Existing lake (6 ha) with increased tidal flushing (x4);
3. Extended lake (13.5 ha) with increased tidal flushing (x2);
4. Existing lake with increased tidal flushing (x1.6) and a new freshwater lake (12 ha);
5. Partially extended lake (8 ha) with increased tidal flushing (x1.8) and new freshwater lake (6.5 ha);
6. Existing lake (6 ha) with increased tidal flushing (x1.6) and new wetlands (16 ha); and
7. Existing lake (6 ha) and dry swales.

Possible stormwater quantity (retardation) management strategies were also assessed and outlined. Retardation modelling was undertaken for Schemes 2 – 6.

The modelling of the various Schemes has been conducted to maintain, as close as possible, the existing (estimated) 100 year outflow to Myall River. The total volume of retardation required and other possible engineering interventions were considered for each of the Schemes and are outlined.

A multi-criteria assessment of water quality performance, environmental impacts and viability was undertaken. The assessment criteria included:

- Water Quality
  - Salinity
  - Dissolved Oxygen
  - Algae
  - Total Nitrogen
  - Total Phosphorous
- Environmental Impacts
  - Impact on existing water body
  - Impact on SEPP 14 wetlands
  - Impact on Myall River
  - Impact on Groundwater
- Viability
  - Loss of potential lots
  - Aesthetic/Health
  - Landtake for Basins
  - Landtake for Ponds / Wetlands
  - Filling

The three highest ranked schemes in order of performance and benefit were:

Rank	Scheme
1	Scheme 3
2	Scheme 5
3	Scheme 4

Cardno (2004) “Myall Quays Development EIS”, partially prepared for Crighton Properties.

An EIS report was partially completed in response to the previous Director General requirements. This partially completed report is unpublished.

Coffey Geosciences Pty Ltd (2004) *"Groundwater Assessment, Myall Quays Development, Tea Gardens",* Report No. E12752/3-AF, prepared for Crighton Properties, December.

This report presents the results of a groundwater study and modelling program undertaken to assess the impact of a proposed development in Tea Gardens on local groundwater movements. The purpose of the assessment was to provide information to address specific issues raised by the Department of Infrastructure, Planning and Natural Resources (DIPNR) (Ref: N91/00721, 5 January 2004) for the Myall Quays development, in particular:

- Analysis of groundwater quality of the site;
- Interception and use of groundwater;
- Potential for groundwater contamination associated with the detention basin and resulting from the residential development and the proposed open space recreational areas;
- Beneficial uses of groundwater; and
- Contingency and remediation plans for the detention basin and aquifer in the event of detention basin pollution and/or eutrophication.

Coffey Geotechnics (2007a) "Proposed Subdivision – Riverside Estate Stage 9, Tea Gardens*", Report No. GEOTSGTE20248AA-AC*, prepared for Tattersalls Surveyors Pty Ltd, May.

The purpose of the assessment was to provide comments and recommendations on acid sulfate soils within the proposed development area. A generic Acid Sulfate Soils (ASS) Management Plan has been provided for Riverside Estate Stage 9 and subsequent stages.

The assessment also provides preliminary geotechnical information for the design and construction of road pavements and residential footings. On site soils have been assessed and preliminary site classifications in accordance with AS2870-1996 are provided.

Coffey Geotechnics (2007b) "Groundwater Assessment*", Draft Report No. GEOTLCOV23225AA-AC*, prepared for Crighton Properties, May.

This report presents the results of a groundwater study and modelling program undertaken to assess the Scheme 3 concept layout for the proposed Riverside development at Tea Gardens on local groundwater movements. The purpose of the study was to address the issues noted in the amended Director-General's Environmental Assessment Requirements (Ref.: MP 06_0010, dated 29 December 2006) for the site, in particular:

- Analysis of groundwater quality of the site;
- Interception and use of groundwater;
- Potential for impact on existing groundwater with respect to the latest concept layout for the development;
- Beneficial uses of groundwater; and
- The potential impact of reuse of reclaimed water and the quality required to minimise impact on
- groundwater.

Coffey Geotechnics (2007c) "Myall Quays Detention Lake Sediment Sampling and Analysis*", Letter Report*, prepared for Crighton Properties, 24 October.

The objectives of this investigation were to assess the lake sediments with regards to the potential for the lake to become a ‘pollutant sink’ resulting in the build up of nutrients and persistent chemical pollutants. The scope of work included:

- Fieldwork including sediment sampling at selected locations on the lake floor;
- Laboratory analysis of a selected number of samples for heavy metals (Sb, As, Cd, Cr, Cu, Pb, Ni, Ag, Sn, Zn, Hg), total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX), Polynuclear aromatic hydrocarbons (PAH), organochlorine pesticides (OCP), polychlorinated biphenyls (PCB), total phosphorous, total oxidised nitrogen (NOx) and total Kjeldahl nitrogen (TKN);
- Data assessment and reporting.

The assessment concluded that:

- The sediment samples analysed from Myall Quay’s Detention Lake show low heavy metals (Cr, Cu, Pb, Hg, Ni and Zn) concentrations which are below the adopted warning levels and may possibly be at background levels.
- OCP and PCB were not detected above the laboratory reporting limits. PAH were detected in sample D1 (duplicate of S1) at concentrations below the warning levels for this investigation.
- Nutrient concentrations (total nitrogen and total phosphorous) indicate they have not accumulated to levels typical of urban ponds and lakes.

Coffey Geotechnics (2007d) "Geotechnical and Acid Sulphate Assessment for Riverside Estate Project Application and Master Plan Area, Tea Gardens*", Report GEOTSGTE20248AA-AE*, prepared for Crighton Properties, 24 October.

This report presents the results of geotechnical and acid sulphate assessments of the Riverside Estate Master Plan area. The scope of work for the geotechnical assessment included providing recommendations on:

- Site preparation;
- Excavation conditions;
- The suitability of the site soils for use as fill and on fill construction procedures;
- Acid sulfate soil conditions and requirements for an acid sulfate soils management plan;
- Preliminary site classification to AS2870–1996;
- Preliminary pavement design and construction;
- Special requirements for construction procedures and or site drainage.

A generic plan for management of ASS in future earthworks that occur within the Riverside Estate was also prepared. It is understood that the plan will be provided as a reference to all lot purchasers and contractors required to work on the site. It has been formatted in a way that will be useable to individual land owners to assist in obtaining DA approvals and in controlling and managing ASS during the development of each lot.

Coffey Geotechnics (2007e) "Groundwater Assessment*", Report No. GEOTLCOV23225AA-AD*, prepared for Crighton Properties, 26 October.

This report presents the results of a groundwater study and modelling program undertaken to assess the Scheme 5 concept layout for the proposed Riverside development at Tea Gardens on local groundwater movements. The purpose of the study was to address the issues noted in the amended Director-General's Environmental Assessment Requirements (Ref.: MP 06_0010, dated 29 December 2006) for the site, in particular:

- Analysis of groundwater quality of the site;
- Interception and use of groundwater;
- Potential for impact on existing groundwater with respect to the latest concept layout for the development;
- Beneficial uses of groundwater; and
- The potential impact of reuse of reclaimed water and the quality required to minimise impact on
- groundwater.

Harris Research (2007) Fish Community Survey of the Riverside Lake, Summary Report, prepared for Crighton Properties, May, 5 pp + Apps.

The fish community of the Riverside lake (previously Myall Quays) was surveyed in April 2007 as part of a series of biological studies to record the aquatic ecological development of the lake.

Seine netting and gill netting captured numbers of both individual fish and fish species that were well in excess of previous surveys. Substantially larger-bodied fish and some fisheries species were caught including yellow-fin bream, striped mullet, sand mullet and silver biddies. The distribution patterns and occurrence of aquatic plants in the lake were similar to those recorded in 2002.

Increased biological diversity and abundance of the fish community show that the Riverside lake is continuing its development towards the ecological condition of the surrounding Myall River estuary and supports casual observations of recreational fishing in the lake. Habitat conditions, water quality and the food web are continuing to develop, supporting fish recruitment and productivity. Fish recruitment and growth in the lake are contributing to biological values in the estuary as a whole and this should increase as ecological processes mature further.

It is recommended that previous recommendations for enhancing the amount and quality of aquatic habitats remain relevant and should be pursued in the design of any extension of the existing lake system, particularly with respect to increasing the extent, complexity and quality of near-shore habitats for fish, invertebrates and birds.

Cardno (2008b) "Riverside at Tea Gardens Integrated Water Management", Final Report, prepared for Crighton Properties, November.

After September 2004 the development concept evolved considerably including the removal of the nine hole golf course, an increase in the number of dwellings upon the site and wholesale changes to the site planning and layout in keeping with planning best practice.

Despite these substantial changes to the proposed layout over the period from September 2004, it was concluded that the principal conclusions of the comparative assessment presented in the Cardno, 2004 report remained valid and supported the adoption of either of the two highest ranked water management options (Scheme 3 or Scheme 5). Both these schemes were further developed.

The aims of the 2008 study were to update the previous hydrological, hydraulic, groundwater and water quality assessments of the two highest ranked water management schemes (Scheme 3 and Scheme 5) to reflect the 2008 concept development and to refine and develop each scheme and any other measures that may be required to mitigate the impacts of the planned development.

Martens and Associates (2011) "Preliminary Hydrogeological Study and Concept Groundwater Management Plan, Riverside, Tea Gardens, NSW", Final, December.

This report outlines preliminary groundwater investigations and the development of a Concept Groundwater Management Plan (CGMP) to inform the proposed residential development of 'Riverside' at Tea Gardens, NSW.

This report seeks to collate and extend the previous groundwater investigation works undertaken at the site dating back to 1996 and to assess groundwater related impacts in light of the current proposed development concept plan. The investigation also responds to Planning Assessment Commission (PAC) and NSW Department of Planning (DoP) comments which were made in relation to a previous Part 3a Application which was withdrawn in February 2010.

This report is attached in **Appendix F**.

Worley Parsons (2010) "Riverside at Tea Gardens, Integrated Water Cycle Management Strategy and Sewerage Servicing", Final, November.

This report was prepared in response to a request from MidCoast Water to address aspects of sewerage servicing for the Riverside at Tea Gardens development.

The report details the options available for servicing the Riverside development and informs the requirements for sewerage infrastructure moving forward. The study considered stormwater, water and effluent in an integrated manner and illustrated that:

- The use of rainwater tanks need not affect the sewerage/recycled water servicing strategy;
- The Hawks Nest Waste Water Treatment Plant would need to be augmented to meet the needs of future developments; and
- A recycled water system would offset effluent generation at Hawks Nest STP and ensure the ultimate development yield within the STP catchment would not exceed the ultimate effluent disposal capacity at the STP.

This report is attached in **Appendix G**.

1.7 This Study

As discussed above, a detailed assessment of existing and future catchment runoff and pollutant exports and water management options to maintain as far as possible the existing lake water quality and its ancillary role as a fish habitat was reported in 2004 (Cardno, 2004).

Despite substantial changes to the proposed layout over from September 2004 to 2008, it was concluded in 2008 that the principal conclusions of the comparative assessment presented in the Cardno, 2004 report remained valid and supported the adoption of either of the two highest ranked water management options.

The aims of the current study were to update the previous hydrological, hydraulic, groundwater and water quality assessments reported in 2008 to reflect the current concept development that evolved in response to comments received from DoP, the PAC and other authorities.

The latest assessments of hydrology, hydraulics, stormwater quality and lake water quality are described in **Appendices B, C, D** and **E**.

2 Flooding and Drainage

2.1 Hydrology

The aims of hydrological analyses were to

- Assemble an **xprafts** rainfall/runoff model of the Riverside at Tea Gardens catchment;
- Estimate catchment runoff under existing catchment conditions as a benchmark for comparison with proposed development conditions for the 5 yr ARI, 20 yr ARI and 100 yr ARI events;
- Estimate catchment runoff under proposed development conditions; and
- If needed, size detention structure(s) to reduce the 100y ARI peak flow downstream of the proposed development areas to no greater than the 100 yr ARI peak flow under existing conditions.
- Generate 5 yr ARI, 20 yr ARI, 100 yr ARI and PMP hydrographs for input into the hydraulic model.

Estimates of runoff from the Riverside at Tea Gardens catchment during design storms were obtained using the **xprafts** rainfall/runoff model.

The hydrological analyses of the Riverside at Tea Gardens catchment are described in **Appendix B**.

2.1.1 Existing Conditions

The catchment of Riverside at Tea Gardens is bounded to the north by the ridge line of the ridge outcrop, and to the south-west by Myall Road. Riverside at Teagardens represents a major portion of the catchment. With the exception of the portion at the south of the site that has already been developed, there is little natural development of surface drainage features and as the surface soils are generally sandy such that a high level of rainfall infiltration to the groundwater system takes place. As a result, significant surface runoff is unlikely except during periods of high rainfall.

The site contains several low natural sand ridges which tend to channel runoff in the western half of the site from north to south. However a number of shallow drains have been previously constructed to convey runoff from the western areas of the site to the east to join with runoff from the eastern area of the site that flows east towards the SEPP 14 wetlands and the Myall River.

During wet periods, water ponds in low lying areas in the western and northern areas of the site.

The estimated peak 5 yr ARI, 20 yr ARI and 100 yr ARI outflows from the Riverside at Tea Gardens site are summarised in **Table 1**.

Table 1
Estimated Peak Flows (m^3/s) at Key Locations in Riverside at Tea Gardens under Existing Conditions

5 yr ARI	20 yr ARI	100 yr ARI	Comment
5.3 *(9)*	9.8 *(9)*	17.1 *(2)*	Total inflow to the existing detention lake
3.3 *(9)*	8.6 *(9)*	14.7 *(2)*	Outflow from the existing detention lake
6.9 *(9)*	8.7 *(9)*	10.9 *(9)*	Aggregated flow to the Conservation Zones
0.58 *(9)*	0.88 *(9)*	1.25 *(9)*	Outflow to an existing drainage line that discharges directly into the Myall River

Note: The Critical Storm Burst Duration (hrs) is reported in brackets

2.1.2 Developed Conditions

Previously, the approach to drainage design in Tea Gardens was to maintain drainage structure outlet levels at or above Mean High Water, at approximately RL 0.5m AHD. This is reflected in the levels of drainage structures throughout the existing Tea Gardens township, including all existing stages of the Myall Quays estate.

In order to account for the possible impacts of climate change, modifications have had to be made to the previously proposed drainage regime in the Riverside Estate proposal. In order to maintain the existing approach, the most significant change has been to lift the entire drainage system for the site, to ensure that the minimum invert of all new drainage structures in the proposed Riverside Estate are now at or above the predicted worst post climate change Mean High Water of 1.4m AHD. This would ensure that the drainage system would remain unaffected by tidal waters. In discussions with Great Lakes Council's engineering department, this has been supported as an appropriate response.

The other possible effect of climate change has been to increase flooding levels due to potential increases in tailwater and rainfall intensities. Revised flood levels across the site have then been accounted for in determining landform levels. A direct result of this raising of the drainage network is the raising of the surface levels across the site to provide cover to the pipes. Consequently the majority of the site is already raised above the revised flood levels. Additional lot filling is proposed in any remaining low-lying areas to ensure that all lots remain flood free above the modelled 100yr flood levels, with climate change. It should be noted that finished floor levels will be a minimum of a further 0.3m above this lot fill level providing further freeboard.

It is proposed to direct runoff in events up to the 100 yr ARI event from the upper catchment areas east along the proposed open space corridor located on the northern boundary to a major retarding basin (Basin EW) with outflows from the basin discharging south east to a swale located on the eastern boundary of the site. This swale is intended to distribute runoff along the western boundary of the buffer zone to reduce the concentration of runoff into the buffer zone and the SEPP14 wetland. Two local basins (Basins N42 and N43) are proposed to manage runoff from the Tourist Precinct.

The planned development located south of the open space corridor will drain southwards towards a number of ponds, wetlands and freshwater lakes that will discharge via swales into the existing saline lake (refer **Figure 4**).

Basins

Preliminary concept basin sizes and outlet configuration were sized iteratively. In the case of Basin EW the aim was to either:

(i) limit the 100 yr ARI peak discharge to the Conservation Zone under developed conditions to no greater than the existing peak 100 yr ARI discharge to the Conservation Zone, or to

(ii) limit basin outflows to around 6 m^3/s based on the feasibility of constructing a waterway through rising ground to the east of the concept basin wall.

It was found that the latter aim controlled the basin size.

In the case of Basins N42 and N43 the aim of the basins was to limit 100 yr ARI peak flows to no greater than the 100 yr ARI peak flow under existing conditions.

The adopted basin properties are detailed in **Appendix B.4.2.**

The estimated peak basin water levels for 20 yr ARI, 50 yr ARI and 100 yr ARI events are summarised in **Table 2**.

The 5 yr ARI, 20 yr ARI, 100 yr ARI and PMP hydrographs under developed conditions were estimated and input into the hydraulic model of the final proposed developed conditions to estimate peak outflows to the conservation zone and SEPP 14 wetlands as well as the 5 yr ARI, 20 yr ARI 100 yr ARI and local PMF flood levels.

Table 2 Estimated Peak Basin Water Depths

Basin	5 yr ARI	20 yr ARI	100 yr ARI
EW	0.97	1.22	1.58
N42	0.55	0.79	0.92
N43	0.53	0.78	0.87

2.2 Hydraulics

The aims of the hydraulic analyses were to:

- Assemble an **xpswmm** hydraulic model of the main drainage lines under proposed developed conditions with concept water management measures in place; and
- Estimate peak flows and peak flood levels under developed conditions for the 5 yr ARI, 20 yr ARI, 100 yr ARI and PMF events.

2.2.1 Concept Sizing of Waterways

Prior to assembling an hydraulic model of the main drainage lines, the concept grading and concept sizing of each of the main drainage lines was undertaken. Four main drainage lines were identified. The East Branch, West Branch, North Branch and EastWest Branch drainage lines are identified in **Figure C.1**.

Hydraulic assessments of the sensitivity of maximum channel depth, channel top width and maximum flow velocity were undertaken using spreadsheet models of a single trapezoidal channel.

The adopted properties of the single trapezoidal channel are given in **Figure C.2**.

Each section was subdivided into 22 subsections. The top width, area, wetted perimeter, conveyance, discharge and velocity of flow were calculated for each subsection. The channel capacity was calculated as the sum of the flows in each subsection. The overall channel top width was calculated as the sum of the top widths of each subsection. The overall maximum velocity was the maximum of the velocities calculated for all subsections.

The assumed bed slopes for each reach were guided by the concept grading bed.

The assumed Manning roughness value was an average of 0.065 across all sections ie. some sections of a channel may be lightly vegetated while other sections of the channel may be more heavily vegetated.

Waterways were assessed for the 100 yr ARI event with basins in place.

2.2.2 Preliminary Developed Conditions Hydraulic Model

An **xpswmm** hydraulic model was assembled for preliminary Developed Conditions.

The concept layout of waterways, ponds and lakes for preliminary Developed Conditions is given in **Figure C.2.**

2.2.3 Flood Levels under Final Developed Conditions

The final Developed Conditions layout evolved from the preliminary layout in response to comments from the DoP, the PAC and other authorities. The preliminary model was adjusted to reflect changes in the planned extent of development and removal of a proposed reach of freshwater lake and its associated land bridge, the removal of the North Branch and the retention of an existing swale. It was found that four ponds proposed in the preliminary scheme could be removed in the upper arms of drainage lines while still meeting the stormwater quality objectives. Two remaining major ponds (N10Pond and E8Pond) were converted into shallow lined wetlands.

The **xpswmm** model of final Developed Conditions was run to estimate the 5 yr ARI, 20 yr ARI and 100 yr ARI peak flows and basin water levels. Based on the outcomes of the hydrological analysis the **xpswmm** model was run for both the 1.5 hour and 9 hour storm durations.

The estimated peak outflows from the swale and the existing saline lake in the 5 yr ARI, 20 yr ARI and 100 yr ARI events are summarised in **Table 3.**

Table 3
Estimated Peak Outflows from the Swale and Existing Saline Lake under the Final Scheme

5 yr ARI		**20 yr ARI**		**100 yr ARI**	
1.5 hr	9 hr	1.5 hr	9 hr	1.5 hr	9 hr
2.4	5.0	4.7	8.6	9.3	13.3

The estimated 100 yr ARI peak flows, flood levels and flood depths within the hydraulic study area for storm bursts of 1.5 hours and 9 hours are presented in **Figures 5** and **6** respectively. The extent of inundation in a 100 yr ARI local event is plotted in **Figure 7**.

The estimated 5 yr ARI and 20 yr ARI flood levels under 1.5 hour and 9 hour storm bursts are presented spatially in **Figures C.6** to **C.9**.

2.2.3 PMF Results

Riverside at Tea Gardens is subject to flooding from both the Myall River and from runoff from the local catchment. An assessment of the PMF levels under river and local flooding (without climate change) was undertaken at the request of the NSW Department of Planning and was reported in November 2008 (refer **Appendix H**).

The estimated PMF levels in the Myall River in the vicinity of Riverside are summarised as follows:

Event	Description	Estimated Flood Level (m AHD)
PMF	The PMF level under existing conditions with a 100 yr ARI downstream boundary level in the lower reach of the Myall River of RL 1.89 m.	2.82 – 2.89 m
PMF	The PMF level under existing conditions with an extreme downstream boundary level in the lower reach of the Myall River of RL 2.0 m	2.86 – 2.93 m

The hydraulic model used for the assessments of local flooding and drainage up to 100 yr ARI events was used to also estimate PMF levels due to local runoff.

It was noted that in almost all locations the 1 hour PMP storm gave the highest flood level except for the upper reach of the West Branch where the 30 minute PMP storm gave the highest estimated flood levels.

It was also noted that the local PMF levels are based on floodwaters confined to the drainage corridors and as such these are conservative estimates. During a PMF event local runoff would spill from the drainage corridors into the residential areas which would result in slightly lower PMF levels.

The local PMF levels under the Final Scheme were also estimated for the 30 minute and 1 hour PMP storms and are presented spatially in **Figures 8** and **9.**

2.3 Practical Consideration of Climate Change

The planned development is subject to flooding from both the Myall River and from runoff from the local catchment. In 2008 sensitivity assessments of climate change were undertaken for the scenarios given in the 2007 DECC Guideline titled “Practical Consideration of Climate Change”. These scenarios include +0.18m, +0.55 m and +0.91 rises in sea level as well as 10%, 20% and 30% increase in rainfall intensities. This assessment is in Cardno, 2008a**.**

In 2008 it was concluded from the results of the sensitivity runs for the Myall River that:

- The current adopted 100 yr ARI level of 2.1 m AHD could accommodate up to a 30% increase in rainfall under conditions where there is no increase in sea level;
- The increase in 100 yr ARI levels in the Myall River in the vicinity of Riverside due to increases in rainfall reduce as the sea level rise increases ie. a 30% increase in rainfall increases 100 yr ARI levels in the Myall River by
  - 0.06 m to 0.07 m under a sea level rise of 0.18 m
  - 0.04 m to 0.06 m under a sea level rise of 0.55 m
  - 0.03 m to 0.04 m under a sea level rise of 0.91 m

An assessment of 100 yr ARI flood levels for the final scheme resulting from local runoff under a possible climate change scenario including a 30% increase in rainfall intensities was undertaken.

The estimated local 100 yr ARI flood levels for the final scheme under 1.5 hour and 9 hour storm bursts with possible climate change conditions (based on a 30% increase in rainfall intensities) are presented spatially in **Figures 10** and **11**.

The extent of inundation in a 100 yr ARI local event under climate change is plotted in **Figure 9** while the extent of .inundation in a 100 yr ARI under climate change from local and regional flooding combined is plotted in **Figures 12** and **13**.

These Figures demonstrate that all residential lots within the proposed development remain free of inundation during a 100 yr ARI event under current conditions and under future conditions with climate change. In a 100 yr ARI event inundation within the site is generally confined to opens pace areas and drainage corridors. It should be noted that while local inundation of some local roads is expected under climate change the level of inundation would be safe for wading and that all residential would be able to evacuate to higher ground via the proposed public roads.

3 Groundwater

The following assessment of groundwater issues is drawn directly from the groundwater assessment undertaken by Coffey Geotechnics in October 2007 and Martens Associates in November 2011. A copy of the 2011 assessment is attached in **Appendix F**.

3.1 Topography and Geology

Within the study area the ground surface generally slopes gently south-east towards the Myall River with ground levels below 3 m AHD. A series of sand ridges trending roughly north-south are present across the site. An elevated bedrock outcrop, rising to about 25 m AHD, is present at the northern end of the site. Elevated bedrock levels are also present at the north-western limit of the site.

Soils in low lying areas are generally silty sand and topsoil overlying fine to medium grained sand containing cemented layers (coffee rock) and peaty bands. Basement rock occurs at a depth of 10 m to 20 m over much of the site, rising steeply at the northern end of the site forming an outcrop. A surface clay layer of 1m to 2.5 m thickness exists at the north-west of the site accompanied by an underlying layer of peat.

The sand aquifer is underlain by basement sandstone at a depth of up to approximately 20 m. Sand thickness varies from 0m in the elevated areas in the north of the site to about 20 m at the southern limit of the proposed development.

3.2 Groundwater Conditions

The subsurface sands form an aquifer characterised by moderate to high transmissivity, previously estimated at 200m^2/day, which is present over much of the development site and over the SEPP 14 wetland area. Previous groundwater levels indicated shallow water tables are present over the site generally within 1 m of the surface and at the western limit of the SEPP 14 wetlands and Myall River, groundwater levels are within 0.5m of the ground surface. Groundwater flow is south-east toward the Myall River and groundwater is relatively fresh in the main body of the sand aquifer. There is a secure town water supply well to the north of the area and currently groundwater is not used except for minor home irrigation.

The shallow rock levels to the north of the site provide a barrier to groundwater inflow from that direction. The sand aquifer is expected to extend to the south and west of the site and be in hydraulic contact with the waters of the Myall River to the south, Wobbegong Bay and Pindimar Bay (Port Stephens) to the south-west and Kore Kore Creek to the west.

During periods of low rainfall, losses from the groundwater system will occur due to seepage to the Myall River and evapotranspiration from areas of shallow water table. Evapotranspiration losses from the water table reduce with increasing depth of the water table in a non-linear fashion (CPI, 1996).

Rainfall infiltration forms the main groundwater recharge mechanism. Previous monitoring results from the bores over the site show marked groundwater level response to rainfall events.

The aquifer is in contact with saline water in the Myall River and also in contact with the brackish water in the lake in the south of the site. This results in the development of an interface between high quality fresh groundwater and saline water. The depth of the fresh/salt water interface is a function of the density difference between fresh and salt water and the height of the groundwater surface.

The final scheme involves the retention of the existing lake and three freshwater lakes. Evaporation from these lake extensions would be greater than evapotranspiration losses from the water table over a similar area. These increased evaporative losses are expected to be balanced in part by the reduced evapotranspiration losses that would accompany covering part of the ground surface for residential development.

3.3 Existing Groundwater Levels

A network of twelve groundwater monitoring bores (GMBs) (GMB1 to GMB12) was installed by DJ Douglas & Partners in 1994 and four monitoring bores (GMB21 to GMB24) were installed by Coffey in 2006. Four of the bores (GMB1, GM 2, GMB3 and GMB7) have been destroyed or lost between the March 2007 and previous monitoring rounds in April and May 2004. The remaining available bores formed a network for Coffey's 2007 monitoring program.

One round of groundwater level monitoring was undertaken from the existing monitoring network using a dip meter. Table 1 in Coffey Geotechnics, 2007b presents a summary of groundwater monitoring data from the previous monitoring rounds. Additional monitoring undertaken by Martens in 2009 is summarised in **Appendix F**.

Martens & Associates, 2011 conclude that:

- Groundwater levels are generally shallow (typically <1 m BGL).
- Groundwater reached the surfaces at times at GMBs 7 and 23 during the Martens and Associates (July, 2009) continuous data logging period.
- Short-term groundwater level fluctuation is likely to typically be <1 m.
- Lake levels are consistently lower than groundwater levels and therefore suggest that groundwater discharges to the existing lake.
- Groundwater response to rainfall appears to be relatively rapid and occurs within 1-2 days of incident rainfall. Groundwater responses appear more substantial at higher ground elevations.

3.4 Acid Sulphate Soils

An assessment of potential acid sulfate soils was undertaken at the site (Coffey Geotechnics, 2007d). The laboratory results indicated elevated levels of total potential sulfidic acidity and peroxide oxidisable sulfur were present in the samples tested. It was considered that the potential acid sulfate soils were likely to be present in the area.

Groundwater modelling reported by Martens, 2011 (refer **Appendix F**) concludes that the proposed development is likely to reduce groundwater levels in the area of the proposed unlined lakes by up to approximately 0.5 m due to interception of groundwater.

Results also indicate that groundwater levels are likely to be drawdown by approximately 0.05 to 0.1 m over the adjacent SEPP14 wetlands due to reductions to recharge in the area of the site which would be balanced by approximately 10 years of sea level rise. Changes to groundwater flow direction at the site boundaries and within adjoining wetlands are negligible.

To date there is no indication of the potential for sulfate production in the area but a number of bores were drilled within close proximity of the proposed development. Several test holes were drilled and the soils tested for the potential to produce acid sulfate soils. BH37 is located in the area where the maximum drawdown has been predicted and the results of SPOCAS analysis indicate that from 2 m below surface, samples tested exceed the Acid Sulfate Soil Management Advisory Committee (ASSMAC) action criteria. The potential to produce acid soils increased with depth with the interval 2.0 – 2.5 m just exceeding the criteria.

Groundwater levels in this area are approximately 1.5 m below surface and a 0.5 m groundwater level decline will lower groundwater levels to around this zone however it is anticipated that the area that may be impacted is small.

A comparison of pH from previous investigations conducted in April 2004 with recent results collected in March 2007 indicates that there has been no discernable change in groundwater pH. This suggests that even with the groundwater level reductions assessed to be affected by lower than average rainfalls in the last few years, there has been no additional increase in acid production resulting from the drying of acid producing soils.

In view of the potential presence of acid sulphate soils, a generic plan has been prepared for management of ASS in future earthworks that occur associated with the laying of sewer and drainage lines and the excavation of stormwater treatment basins within the Riverside Estate. A concise version of this plan will be provided as a reference to all lot purchasers and contractors required to work on any home within the site. This plan has been formatted in a way to assist individual land owners obtaining DA approvals by outlining methods to control and manage ASS during the development of each lot. The plan will also guide the management of any future excavation to extend the detention lake.

3.5 Groundwater Quality

In 2007 Coffey Geotechnics concluded that laboratory results from the groundwater bores selected for analysis indicated that groundwater quality has not changed significantly since the last monitoring round in 2004. The 2004 report indicated that groundwater chemistry had not changed significantly since the groundwater quality monitoring undertaken in 1994/1995 (Coffey Geotechnics, 2007b).

Continuous monitoring of groundwater and lake EC concentrations was undertaken concurrently with groundwater level monitoring by Martens and Associates (July, 2009) for GMB 1A, 2A, 25 and 26 (lake). A summary of results is provided in Table 5 with a continuous groundwater EC plot provided in Figure 4 in Martens, 2011 (refer **Appendix F**). Results indicated that saline/brackish groundwater was not intruding from the lake to the local groundwater system.

Martens, 2011 concluded that:

- Groundwater quality is not to a standard to meet a potable quality in accordance with the Australian Drinking Water Guidelines (NHMRC, 2004), primarily on the basis of acid levels, variable salinity and elevated concentrations of a range of analytes (Martens and Associates, 2009).
- The most significant beneficial uses for groundwater in some locations of the site are for irrigation and ecosystem maintenance (Coffey, 2007).
- The median EC and TDS concentration within the lake is higher than in GMBs and is indicative of saline water. This is expected as the invert level of the lake's drain is reported to be at an approximate elevation of 0.66 m AHD (Coffey, 2007).
- The median EC and TDS concentration within GMBs is indicative of fresh water.
- Monitoring data indicates that lake nutrient concentrations are lower than those observed in nearby GMBs.

3.6 Potential Impacts of Development on Groundwater Levels

To assess the potential impacts of proposed development on groundwater levels a series of preliminary steady state groundwater models of the study area were developed by Martens & Associates using Visual MODFLOW 2009.1 Pro. Modelling works extended a concept model previously prepared by Coffey (October, 2007) which was modified by Martens and Associates to include the following:

- Site GMB calibration data;
- Additional GMB's (more calibration locations)
- A slightly larger active domain area;
- Slightly modified layer terrain in the north of the model to reduce the potential for dry cells due to abrupt changes in elevation; and
- Changes to aquifer/boundary condition properties;

Three steady-state conditions were assessed as follows:

- Current conditions
- Post-development Conditions
- Post-development conditions under possible climate change

3.6.1 Existing Conditions - Model 1 (M1)

Simulation results are provided in Figure 6 in **Appendix F** which indicate that groundwater flows from the north west to the south east in the area of the site and discharges to the Myall River.

3.6.2 Developed Conditions - Model 2 (M2)

Simulation results outlining groundwater head and drawdown (using M1 output for initial head) are provided in Figures 7 and 8 respectively in **Appendix F**. Results indicate that the proposed development is likely to reduce groundwater levels in the area of the proposed unlined lakes by up to approximately 0.5 m due to interception of groundwater.

Results also indicate that groundwater levels are likely to be drawdown by approximately 0.05 to 0.1 m over the adjacent SEPP14 wetlands due to reductions to recharge in the area of the site which would be balanced by approximately 10 years of sea level rise. Changes to groundwater flow direction at the site boundaries and within adjoining wetlands are negligible.

3.6.3 Developed Conditions with Sea Level Rise - Model 3 (M3)

Simulation results outlining groundwater head and drawdown (using M2 output for initial head) are provided in Figure 9 and Figure 10 respectively in **Appendix F**. Results indicate that sea level rise will lead to inundation of the majority of the SEPP14 wetland area adjacent to the site. Groundwater levels in the area of the site where development is proposed are modelled to increase by a maximum of 0.4 m.

3.7 Potential for Groundwater Contamination resulting from the Development

3.7.1 Potential Impact of Runoff on Groundwater

The planned development has the potential to impact on groundwater quality through the discharge of urban runoff into window lakes/ponds. Consequently the following stormwater quality objectives were adopted to avoid adverse impacts of runoff on groundwater quality:

- Nil or Beneficial Effect ie, no increase in the overall TSS, TP and TN exports to the Myall River (based on the performance targets identified in the Great Lakes Council Draft Water Sensitive Design DCP (Version 1.1, May 2010); and
- Mean TP and TN concentrations in discharges to window lakes/ponds to not exceed limits identified by Martens & Associates in November 2009, namely TN < 1.0 mg/L and TP < 0.2 mg/L ie. background groundwater quality

The treatment train for stormwater discharging through the existing saline lake to the Myall River includes (refer **Figure 4**):

- GPTs if appropriate on outfalls from the commercial centre;
- Two lined wetlands (not in contact with the groundwater table) with a total surface area of around 1.4 ha;
- Additional point source subsurface biofiltration pits;
- Freshwater (window) recharge lakes with a combined surface area of around 3.5 ha.
- A 550 m long swale connecting the eastern arm of the freshwater lakes to the existing saline lake; and the
- Existing saline lake with a surface area of around 6 ha. There is no direct link between the saltwater and freshwater lakes and the single existing drain outlet from the saline lake to the Myall River will not be upgraded or duplicated.

It was concluded from the water quality assessments that the proposed treatment train meets the stormwater quality objectives thereby protecting the quality of groundwater.

3.7.2 Potential Impact on Adjacent Ecosystems

Groundwater quality results are generally below the key criteria for protection of species in marine water (90% protection) presented in the ANZECC (2000) guidelines, with the exception of some metal concentrations. Groundwater quality modelling indicates that the salt water interface would not be significantly affected by the development and groundwater level modelling indicates that there will be little impact within the wetland area.

Groundwater level changes resulting from the proposed development are assessed to be and 0.05 m to 0.1 m within the wetland area. Changes of this magnitude would be within the existing groundwater level variability and are therefore considered unlikely to adversely affect adjacent ecosystems.

3.7.3 Impact on Potential Future Use of Groundwater as a Potable Water Source

Groundwater quality is not considered to be potable due to concentrations of a range of analytes exceeding the drinking water guidelines (ANZECC 2000). Groundwater in all bores and the surface water in the lake are acidic to slightly acidic and below the criteria for drinking water of pH 6.5. Groundwater near the Myall River (including GMBs 21, 22, 24) has elevated levels of EC, anions and cations (due to the interaction of groundwater with seawater in this area) above the criteria for drinking water. Groundwater in GMBs 9, 21, 22 and 24 are not potable due to the concentration of ammonia exceeding the ANZECC (2000) guidelines.

The groundwater results indicate that it is generally select parameters, namely pH, ammonia and salinity (or TDS) that are limiting the potential use of the groundwater rather than a wide range of parameters. Consequently, some treatment of groundwater with respect to these parameters is likely to increase the potential uses of the groundwater across the site.

It is also noted that groundwater away from the Myall River tends to have greater potential usability, primarily due to lower salinity (or TDS) and lower concentrations of sodium and chloride.

Groundwater quality is such that treatment would be required to allow potable use given the limited extent of the aquifer and the constraints on usage rates which would need to be imposed to avoid saltwater intrusion and the impacts on wetland areas. Consequently, Coffey consider the groundwater resource unsuitable for development as a significant potable supply.

3.7.4 Irrigation of Recycled Water

There was a concern previously expressed regarding the potential re-use applications for recycled water from the sewerage treatment plant for irrigation and whether this would affect the health of the aquifer that lies below Riverside at Tea Gardens.

However, Martens 2010 (refer **Appendix F**) concludes that the demand for nutrients in garden areas alone far outstrips that which can be supplied by recycled water ie. the irrigation of recycled water is not expected to threaten groundwater quality.

4 Water Quality

4.1 Existing Lake Water Quality

A water quality monitoring programme for the existing detention lake was established in 1996 firstly by the developer, and more recently taken over by the Myall Quays Community Association. Hunter Water Laboratories collects and analyses samples at 5 lake locations approximately every 3 months. Sampling locations are shown on **Figure A.1**.

Initial testing involved the following parameters:

- pH
- Salinity
- Turbidity
- Suspended solids
- Kjeldahl nitrogen
- Oxidised nitrogen
- Ammonia#
- Nitrates#
- Nitrites#
- Phosphate
- Chlorophyll#
- Dissolved oxygen
- Faecal coliforms

(# denotes testing commenced in November 1997)

The results are reported in Hunter Water Laboratories, 2002 and summarised together with subsequent sampling results for Sites 1 to 5 in **Tables A.5** to **A.9.**

4.1.1 Salinity

The sampling indicates that the lake water is brackish having a 50th percentile value of salinity of 12.9 g/L, which is approximately one third of the salinity of seawater. There is variability in the salinity concentration due to both catchment (freshwater) runoff as well as the influence of tides and varying salinity in the Myall River. The observed salinity varied from 4.4 g/L to 25.9 g/L (between the 10th percentile and 90th percentile values).

4.1.2 Dissolved Oxygen

The 50th percentile of all Dissolved Oxygen (DO) values (120 readings) in the lake for the sampling period is 6.7 mg/L, with a 10th percentile level of 4.9 mg/L. The 4.9 mg/L level is just below the recommended ANZECC trigger value of 5.0 mg/L for freshwater fish. A comparison of the DO levels measured within the existing lake and the Myall River disclosed that the ANZECC guidelines for DO are not currently met at all times, in either the lake or river (at Copeland Ave Wharf). As indicated in **Figure 14**, DO levels in the existing lake are often better than in the Myall River.

4.1.3 Suspended Solids

The sampling indicates that the 50th percentile value of suspended solids for the lake is 24.5 mg/L. In comparison the 50th percentile value of suspended solids for the Myall River (at Site 5) was 44 mg/L. As indicated in **Figure 15**, the TSS levels in the existing lake are often better than in the Myall River.

4.1.4 Nutrients

The adopted ANZECC, 2000 trigger value for Phosphorus (TP) is 0.03 mg/L for estuarine systems. Most of the samples have been below the recommended value with a 50th percentile (120 readings) of 0.005 mg/L. Higher P levels occurred soon after the lake was constructed, possibly due residual P released from exposed soil. The TP levels in the existing lake are compared with the TP levels in the Myall River in **Figure 16.**

The ANZECC, 2000 trigger value for Nitrogen (TN) is 0.3 mg/L, NO_x is 0.015 mg/L and Ammonia is 0.015 mg/L for estuarine systems. TN values could not be calculated from the available data. The 50th percentile of all NO_x values (44 readings) in the lake for the sampling period was 0.0105 mg/L. The 50th percentile of all Ammonia values (104 readings) in the lake for the sampling period is 0.03 mg/L. The Ammonia levels in the existing lake are compared with the Ammonia levels in the Myall River in **Figure 17.**

The nutrient levels measured in the lake have generally been low, contributing to the overall good water quality in the existing lake. The nutrient levels in the existing lake are often better than in the Myall River.

4.2 Water Quality Objectives

4.2.1 Water Quality Objective identified in the Environmental Assessment Requirements

The Director-General's Environmental Assessment Requirements for water cycle management issued on 13 October 2010 are in part as follows:

> " Address potential impacts on the water quality of surface and groundwater during both construction and occupation, having regard to the relevant State Groundwater, Rivers, Wetlands and Estuary Policies. Consideration must be made for water impacts to the River and identified SEPP 14 and RAMSAR Wetlands. Particular regard must be given to how the proposal will minimise altered salinity, pH, litter, weeds, exotic fauna, gross disturbance of these wetlands, nutrient intake to receiving water bodies, and any other issues raised by the PAC relating to groundwater and groundwater ecosystems.
>
> …. Stormwater management should be designed to ensure ongoing protection of the groundwater aquifer in accordance with the principles of ANZECC & ARMCANZ: Guidelines for Groundwater Protection in Australia, National Water Quality Management Strategy, Commonwealth of Australia, 1995. Ensure there is no impact on the existing groundwater aquifer and existing groundwater quality resulting from the proposal. Suitably justify the stormwater treatment measures to be used in the proposal."

4.2.2 Stormwater Quality Objectives

When formulating the final scheme (which is a modified version of the preliminary scheme without rainwater tanks that was amended in response to comments from the DoP, the PAC and other authorities) consideration was given to the two following stormwater quality objectives:

- Nil or Beneficial Effect ie, no increase in the overall TSS, TP and TN exports to the Myall River (based on the performance targets identified in the Great Lakes Council Draft Water Sensitive Design DCP (Version 1.1, May 2010); and
- Median TP and TN concentrations in discharges to window lakes/ponds to not exceed limits identified by Martens & Associates in November 2009, namely TN < 1.0 mg/L and TP < 0.2 mg/L.

These objectives are compatible with the Director-General's Environmental Assessment Requirements for water cycle management.

4.3 Catchment Water Quality

The aims of the catchment based water quality modelling were to (refer **Appendix D**):

- Create MUSIC models of the Pre-existing and Existing conditions based on the approaches adopted in 2004 catchment based water quality (**xpaqualm**) assessments;
- "Calibrate" the MUSIC model parameters against the unit area results previously calculated using the **xpaqualm** model(s);
- Estimate catchment exports under the Pre-existing and Existing conditions for input into models of the Pre-existing detention lake and Existing detention lake;
- Create MUSIC models of the proposed preliminary and final concept development with and/or without rainwater tanks and run the generate for inputs into the lake model; and
- Create a MUSIC model of a possible change scenario and assess the performance of the final concept development.

4.3.1 Catchment Water Quality Models

MUSIC water quality models were assembled previously for the Existing and preliminary Developed Conditions. Amended models of final Developed Conditions without and with climate change were also assembled.

The approach to MUSIC modelling, various assumptions and model parameters that were adopted for the water quality modelling are is described in **Appendix D**.

The adopted period of modelling was 1/01/1982 – 31/05/2004 in which 22 calendar years (1/01/1982 – 31/12/2003) were selected for generating statistics.

4.3.2 Pre-Existing and Existing Conditions

The Pre-existing Condition was defined as the conditions that existing in the early 1990s with a lake area of around 5 ha, subcatchments R1 & R2 were fully developed and there were a limited number of dwellings in subcatchments L1L, L2R, WQB1 and Nat3 (refer **Figure D.1** for location).

The Existing Condition was defined as the conditions at around 2004 with the lake area extended to 6 ha, and more dwellings constructed in subcatchments L1L, L2R, WQB1, and Nat3.

The layout of the model of Pre-existing and Existing Conditions is shown in **Figure D.1**.

The estimated average annual runoff and TSS, TN and TP exports to the Myall River, Conservation Zone and SEPP14 wetlands are summarised in **Table 4**.

The average annual runoff and TSS, TN and TP exports that would be estimated if the existing diversion drains were not in place were also estimated and are summarised in **Table 4**.

4.3.3 Developed Conditions

Two MUSIC models of preliminary Developed Conditions with and without rainwater tanks were created. The layout of the preliminary Developed Conditions model with rainwater tanks is shown in **Figure D.2.**

The final Developed Conditions layout evolved from the preliminary layout in response to comments from the DoP, the PAC and other authorities. The preliminary model was adjusted to reflect changes in the planned extent of development and removal of a proposed reach of freshwater lake, the removal of the North Branch and the retention of an existing swale. It was found that four ponds proposed in the preliminary scheme could be removed in the upper arms of drainage lines while still meeting the stormwater quality objectives. Two remaining major ponds (N10Pond and E8Pond) were converted into shallow lined wetlands (refer **Figure 4**)

Two MUSIC models of final Developed Conditions were also created based on:

- the final concept development (without rainwater tanks);
- a possible climate change scenario which was applied to the final concept development.

The layouts of the final Developed Conditions model (without rainwater tanks) under current conditions and under climate change are shown in **Figure D.3** and **D.4** respectively.

The estimated average annual TSS, TN and TP exports to the Myall River and the median concentrations of inflows to the window lakes are summarised in **Table 5**. The adopted properties of the lakes, ponds, wetlands and swales are summarised in **Table D.13**.

Table 4
Estimated Runoff and Pollutant Exports under Existing Conditions

ID	Area (ha)	Rainfall (ML/yr)	Runoff and Pollutant Loads				Remark
			Runoff (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	
Existing Catchment + Drains + Existing Lake (Current Conditions)							
N42	15.8	220	28	4330	9	68	Discharges direct to Myall River
N43	13.5	189	20	2810	6	47	Discharge to Conservation Zone
Myall-2	206.0	2882	684	116000	234	1710	Discharge to Conservation Zone
	219.5	3071	704	118810	240	1757	Total Discharge to Conservation Zone
Lake Inflow	74.4	1040	318	28700	55	459	
Lake Outflow			229	4190	22	263	
				85%	*59%*	*43%*	*Reduction*
			933	123000	262	2020	Discharge to Wetland Zone
Existing Catchment + No Drains + Existing Lake (Theoretical Condition)							
N42	15.8	220	28	4330	9	68	Discharges direct to Myall River
N43	13.5	189	20	2810	6	47	Discharges to Conservation Zone
Myall-2	70.7	988	128	20600	41	322	Discharges to Conservation Zone
	84.1	1177	148	23410	47	369	Total Discharge to Conservation Zone
Lake Inflow	209.7	2934	874	124000	247	1850	
Lake Outflow			785	21190	92	1131	
				83%	*63%*	*39%*	*Reduction*
			933	44600	139	1500	Discharge to Wetland Zone

Subcatchment N42 discharges direct to the Myall River
Total Discharge to Conservation Zone = Myall-2 + N43
Discharge to Wetland Zone = Lake Outflow + Myall-2 + N43

Table 5
Estimated Pollutant Exports under Developed Conditions – Final Scheme

Average Annual Pollutant Exports to Myall River under Final Scheme

Average Annual Pollutant Exports to Myall River from Riverside Catchment	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Comment
Current Conditions - Existing Catchment + Drains + Existing Lake	**127,330**	**271**	**2088**	
Development no Controls (Overall)	210,280	445	3414	
Development with Controls (without RWTs)	26,900	164	2000	Swale seepage = 0 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	
	25,800	153	1890	Swale seepage = 5 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	
Development with Controls (without RWTs) under Climate Change	52,500	187	2050	Swale seepage = 0 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	
	51600	179	1950	Swale seepage = 5 mm/h
Nil or Beneficial Effect (NoBE)	Y	Y	Y	

Discharge to Window Lakes/Ponds under Final Scheme

		TP (ug/L)	TN (mg/L)	Comment
Water Quality Objectives		< 200	<1.0	
Development with Controls (without RWTs)				
From N10 Wet		46.2	0.73	Meets objective
From E8 Wetland		27.1	0.44	Meets objective
From EE5 Pond		54.3	0.69	Meets objective
From EE6 Pond		61.4	0.84	Meets objective
Development with Controls (without RWTs) under Climate Change				
From N10 Wet		41.6	0.65	Meets objective
From E8 Wetland		22.8	0.36	Meets objective
From EE5 Pond		49.3	0.61	Meets objective
From EE6 Pond		52.9	0.72	Meets objective

Final Scheme under Climate Change

A MUSIC model of the final scheme under a possible change scenario was also created.

The rainfall sequence and PET were adjusted as described in **Section D.2.2**. To represent changes in the river levels and tidal extent the saline Lake and the existing swale around the "island" were removed. The volume of remaining ponds and lakes were increased by the equivalent of 0.6 m to reflect likely changes in groundwater levels.

The estimated average annual TSS, TN and TP exports to the Myall River and the median concentrations of inflows to the window lakes are summarised in **Table D.12**.

The adopted properties of the lakes, ponds, wetlands and swales are summarised in **Table D.14**.

4.4 Lake Water Quality

The aims of the lake modelling were to

- Assemble and run eWater Pond models of the Pre-Existing and Existing detention lakes using catchment inputs calculated using the MUSIC model;
- Assess water quality in lakes included in the preliminary and final Developed Conditions Pond models.

The approach to lake modelling and the various assumptions and 2004 model calibration of the lake water quality model are described in **Appendix E**.

4.4.1 Pre-Existing and Existing Conditions

The Pond models of the Pre-Existing detention lake and the Existing detention lake were run using inputs calculated using the MUSIC model and were compared with the results previously reported in 2004. The results are compared in **Table 6**.

It was concluded that the calculated lake water quality using inputs generated by MUSIC are very similar to the lake water quality previously calculated using inputs generated by **xpaqualm**.

4.4.2 Developed Conditions

The preliminary scheme comprised a partial extended saline lake (8 ha) with increased tidal flushing and new freshwater lakes (6.5 ha in total); supported by additional ponds or wetlands as needed (total area of ponds draining to the lakes is 4.7 ha). The preliminary Developed Conditions Pond models of the freshwater lakes and a separate linked model of the partially extended saline lake were run with inputs calculated using the MUSIC model.

The final concept scheme is a modified version of the preliminary scheme without rainwater tanks (WSUD2) which was amended in response to comments from the DoP, the PAC and other authorities.

Table 6
Comparison of Lake Water Quality under Pre-existing and Existing Conditions

Percentile	Pre-existing Condition		Existing Condition	
	2004 Study	This Study	2004 Study	This Study
DO Bottom				
5%	1.0	0.7	1.5	1.6
20%	4.5	4.3	4.6	4.4
50%	5.9	5.8	5.9	5.8
80%	7.2	7.1	7.2	7.1
95%	8.2	8.1	8.1	8.1
DO % Saturation				
5%	12%	8%	21%	20%
20%	59%	57%	61%	59%
50%	78%	76%	78%	77%
80%	88%	88%	89%	88%
95%	95%	94%	95%	95%
TP				
5%	0.0014	0.0014	0.0011	0.0010
20%	0.0028	0.0026	0.0019	0.0019
50%	0.0055	0.0055	0.0040	0.0040
80%	0.0124	0.0135	0.0094	0.0106
95%	0.0283	0.0371	0.0221	0.0278
TN				
5%	0.29	0.27	0.31	0.29
20%	0.34	0.31	0.36	0.33
50%	0.41	0.39	0.42	0.40
80%	0.50	0.51	0.50	0.51
95%	0.68	0.77	0.64	0.72
Algal Biomass				
50%	0.0010	0.0010	0.0010	0.0010
70%	0.0011	0.0011	0.0010	0.0010
90%	0.0016	0.0021	0.0012	0.0014
95%	0.0034	0.0048	0.0022	0.0026
100%	0.0374	0.0323	0.0268	0.0265

The final scheme was adjusted to reflect changes in the planned extent of development and removal of a reach of freshwater lake and retention of the existing swale. It was found that four ponds proposed in the preliminary scheme could be removed in the upper arms of drainage lines while still meeting the stormwater quality objectives. Two remaining major ponds (N10Pond and E8Pond) were converted into shallow lined wetlands.

The final Developed Conditions Pond models of the freshwater lakes and a separate linked model of the existing saline lake were run with inputs calculated using the MUSIC model.

The results of the assessment of the final scheme are compared with the results reported for Existing Conditions in **Table 7**.

Table 7
Estimated Lake Water Quality under Final Developed Conditions

	Existing	Final Scheme	ANZECC, 2000 Trigger Value / Ranges
Percentile			
Salinity			
5%	5.1	0.9	
20%	8.3	2.8	
50%	14.0	6.3	3-20 g/L
80%	20.2	11.2	
95%	24.3	16.0	
DO Bottom			
5%	1.6	4.02	
20%	4.4	6.0	
50%	5.8	7.2	
80%	7.1	8.3	
95%	8.1	9.0	
DO % Saturation			
5%	20%	45.3%	
20%	59%	74%	
50%	77%	84%	80%-100%
80%	88%	92%	
95%	95%	96%	
Total Phosphorus			
5%	0.0010	0.0013	
20%	0.0019	0.0030	
50%	0.0040	0.0078	0.03 mg/L
80%	0.0106	0.0211	
95%	0.0278	0.0495	
Total Nitrogen			
5%	0.29	0.32	
20%	0.33	0.38	
50%	0.40	0.47	0.3 mg/L
80%	0.51	0.65	
95%	0.72	0.99	
Algal Biomass			
50%	0.0010	0.0010	0.004 mg/L
70%	0.0010	0.0012	
90%	0.0014	0.0017	
95%	0.0026	0.0022	
100%	0.0265	0.0330	

A comparison of the saline lake under the final scheme with the saline lake under existing conditions concluded that:

(i) In the near term the lake will become less brackish due to the requirement that the existing outlet remain unchanged. In the longer term sea level rise and increasing tidal inflows will increase the salinity of the lake. In the event that a sea level rise of 0.9 m or greater occurs then the lake will become part of the Myall River and salinity levels would be expected to match the salinity of the Myall River;
(ii) The DO levels in bottom waters and DO saturation would improve slightly;
(iii) TP and TN concentrations would increase slightly;
(iv) Algal concentrations are comparable to existing conditions;
(v) Salinity and DO saturation remain within the ANZECC, 2000 range; and
(vi) TP, TN and algal concentrations remain under ANZECC, 2000 trigger values.

It was also noted that the freshwater lakes may experience algal blooms occasionally. the monitoring the water quality in the freshwater lakes would be undertaken in accordance with the monitoring program given in **Section 6.3.6** and management actions to overcome any failures to meet the water quality objectives would be as described in **Section 6.8**.

5 Potable Water, Recycled Water and Sewerage Servicing

In 2010 Worley Parsons assessed the potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens. The investigation considered the Riverside at Tea Gardens development together with the entire catchment to be serviced by the Hawks Nest Sewage Treatment Plant. In particular, the three new developments Riverside at Tea Gardens, Myall River Downs and North Shearwater were considered.

The projected population for these areas is an ultimate 2,570 ET with an estimated total ultimate winter EP of 4,626 and a total ultimate summer EP of 6,939.

The full assessment of assessed the potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens is attached in **Appendix G**. This assessment is summarised as follows.

5.1 Potable Water

5.1.1 Existing Services

The traditional water supply for the Tea Gardens scheme is from the Tea Gardens aquifer, 6 km north of Tea Gardens. Groundwater is pumped from the aquifer, treated and transferred to reservoirs prior to distribution.

The existing capacity of the borefield is 8.6 ML/d. The Water Supply Scheme identifies that augmentation of the borefield to 12.4 ML/day in 2016 and 16.2 ML/day in 2031 will be required to meet future demands.

5.1.2 Potable Water Servicing Concept

The water management objectives adopted in developing a potable water supply concept for the site include the following:

- Minimise the potable water demand from the site by using water saving devices on fixtures and water efficient appliances;
- Installation of rainwater tanks and connection to toilet flushing and hot water systems;
- Use of alternative water supply sources, where possible;
- Retention of native vegetation and minimal use of turf to reduce irrigation requirements; and
- Infrastructure to be designed with long term sustainability in mind.

The Hawks Nest WWTP may be upgraded to include a facility to provide recycled water to new developments (including Riverside at Tea Gardens). The provision of recycled water to Riverside at Tea Gardens would reduce potable water consumption through the development.

5.1.3 Minimising Potable Water Demand

Potable water demand could be minimised through a combination of the following measures:

- Maintaining natural vegetation outside designated development envelopes on each lot;
- Where required, landscaping lots and road verges with natural vegetation and plant species that require no irrigation;
- Using water conservation measures throughout households, such as water efficient taps, dual flush toilets, shower roses or flow restricting devices, washing machines and dishwashers.
- Installing rainwater tanks to reuse runoff for toilet flushing, washing machines and irrigation. Alternatively, utilising treated effluent from the future Hawks Nest WWTP recycling plant for reuse in toilets, washing machines and irrigation. The reuse application would depend on the level of treatment applied to the effluent;

5.1.4 Potable Water Demand

Mid-Coast Water (MCW) have advised that a typical design water demand per ET for their area of operation is 205 kL/ET/year, which is equivalent to 312 L/EP/day (assuming 1.8 EP/ET). This figure is seasonally variable, in that:

- 30% of total annual demand occurs in summer months
- 25% of total annual demand occurs in spring and autumn months
- 20% of total annual demand occurs in winter months

These seasonal variation assumptions account for the assumed peaking factor of 1.5 for summer to winter population. The potable water demands assumed in the Water Supply Strategy are shown in **Table 8**, along with a comparison of the expected demands of the proposed development.

Table 8
Potable Water Demands

	Potable water Reduction (%)	Potable water average daily demand (m3/d)	Potable water peak daily demand (m3/d)
MCW Water Supply Strategy (1,085 ETs)		996	2,496
Potable water consumption with WSD plus recycled water used for toilet	40%	597	1,497
Potable water consumption if alternative supply for both toilet and washing machine	45%	548	1,373
Potable water if alternative supply for washing machine, toilet and outdoor	66%	339	848

The potable water reductions in **Table 8** have been calculated based on BASIX household water consumption calculations.

MCW have advised that their design water demand of 205 kL/ET/day has taken into account some uptake of water efficient devices in existing dwellings. For the purpose of this study and the estimation of recycled water demand, the following assumptions on water demand reduction compared to the MCW benchmark were adopted:

- 20% reduction for water saving shower heads (2 star rated)
- 35% reduction for dual flush toilets
- 15% reduction for water efficient washing machines (2 star rated)
- 20% reduction for water efficient kitchen taps (2 star rated)

The reduced demand represents a 15% decrease in total water demand, which is consistent with MCW's objective of offsetting effluent generation and potable water supply. It is also significantly less than the statutory BASIX requirement for a 40% reduction in potable water use for all new development. As such, it is a very conservative allowance.

The incorporation of 2-star flow restrictors in the kitchen and bathroom, 2-star shower heads, 3-star dual flush toilets and 2-star dishwashers is estimated to directly reduce total potable water usage by approximately 24%.

The values for potable daily consumption (generated from consumption rates published in the MCW Water Supply Strategy, 2004) were reviewed and compared to the BASIX traditional water consumption of 247.5 L/person/day. The comparison shows that the values generated from the MCW demands are very high compared to demands generated from BASIX.

Based on the MCW value of 335 m^3/ET/y, the average daily demand for Riverside at Tea Gardens, with 920 lots, is 844 m^3/day.

The peak summer population at Riverside at Tea Gardens is predicted to be 2,484 (based on 920 lots with 1.8 EP/ET and a summer peaking factor of 1.5 per the MCW Briefing Paper to the Project Assessment Committee, 7/4/09). Based on potable water consumption of 247.5L/person.day (BASIX traditional consumption), through the development, potable water demand is equal to 615 m^3/day, this is significantly less than 844 m^3/ET/day, which also includes non-domestic and un-accounted for water. A dwelling which is compliant with BASIX would consume 148.5 L/person.day, or the development demand of 369 m^3/day for the summer peak population.

5.2 Rainwater

The re-use of rainwater from rainwater tanks has the potential to make considerable reductions in potable water consumption. However, rainwater can compete with recycled water as they are both used for non-potable applications. Hence the use of rainwater and recycled water needs to be considered in an integrated manner.

It was concluded from the Cardno, 2008 study that the decision on implementation of rainwater tanks would not impact on the ability of the development to meet stormwater quality objectives, provided additional treatment is provided.

It has been previously proposed to reuse harvested rainwater for toilet flushing, washing machines and irrigation/outdoor use with a mains water supply top-up system. However, full substitution could not be guaranteed due to the variability of rainfall. Infrastructure would need to be sized to deliver potable demand, assuming the rainwater tanks are empty due to extended periods of dry weather.

The optimum size of the rainwater tank would need to be confirmed by detailed design, but is expected to be about 3-4 kL in size.

5.3 Water Balance

The Worley Parsons in-house water balance model was used to estimate the likely recycled water irrigation demand and assess recycled water storage volumes for Myall River Downs, Riverside and North Shearwater. The model utilises local catchment data, historical rainfall and evaporation records to estimate the irrigation demand within a soil profile. The model comprises a daily time step balance that can assess combinations of recycled water supply, recycled water demand and reservoir storage volumes. Detailed water balance model input data is included in **Appendix G.**

The results of the water balance model are summarised as follows.

- Average daily irrigation: 52 L/EP/day
- Average annual irrigation: 91 ML (3 ML/ha/year)

The average daily irrigation calculated in the water balance represents approximately 60% of the MCW design ET outdoor usage (84.2 L/EP/day including garden irrigation, car washing, pools and spas).

A number of reservoir volumes were input into the water balance model to determine the number of days the recycled water reservoir would overtop and an average overtopping volume, refer to **Table 9**. These results indicate the extent of upgrade required for the effluent disposal system at Hawks Nest STP with a recycled water system due to periods of rainfall when there is no recycled water irrigation demand.

Table 9
Recycled Water Reservoir and Overtopping Volumes

Reservoir volume (ML)	Number of days reservoir overtops (days per year)	Average Overtopping volume (ML/day)	Maximum overtopping volume (ML/day)
0	365	0.74	0.894
1.0	280	0.42	0.894
2.5	267	0.40	0.894
5.0	263	0.39	0.894

Table 9 indicates that increasing the reservoir volume does not greatly reduce overtopping. Therefore a reservoir would be sized purely to cater for the likely recycled water demand within the development areas.

It is noted that in utilising a lower irrigation demand the water balance is conservative in assessing the reservoir volumes and sizing effluent disposal infrastructure as there is a higher volume of excess recycled water.

5.4 Wastewater

5.4.1 Existing Services

The existing settlements at Tea Gardens and Hawks Nest are serviced by the existing Hawks Nest WWTP. However, due to limited treated effluent disposal capacity at the plant, the extent of augmentation to service further development is limited.

5.4.2 Wastewater Servicing Concept

The water management objectives adopted in developing a servicing concept for the site include the following:

- Minimise impacts on existing infrastructure by reducing the sewage loads where possible;
- Minimise impacts on receiving waters by designing optimal effluent management practices and minimising effluent discharge;
- Reuse of treated effluent where possible and appropriate; and
- Infrastructure to be designed with long term sustainability in mind. This will involve location of sewerage systems with adequate buffer zones and flexibility for future expansion to meet potential augmentation requirements.

It is proposed to service the development using a vacuum sewerage system. This will deliver sewage from the development site to the existing sewage treatment plant. A vacuum sewerage system is considered to be the most appropriate technology due to the topography of the site.

The Sewerage Servicing Strategy identified that the exfiltration basins (existing and proposed) had sufficient capacity to cater for all of the predicted development loads.

5.4.3 Loading Projections

The future population numbers were extracted from the MCW briefing paper, including both summer and winter estimates**.** No population estimates were available for the proposed Myall Way development and as such this has been excluded from our analysis. Even if MCW were to supply approximate numbers, this is unlikely to change the principal outcomes and would only change the numbers by a relative proportion.

Data from the NSW Department of Planning, including in the report titled Single Dwelling Outcomes 05-08 BASIX Ongoing Monitoring Program, was reviewed and yielded the following information:

- BASIX achieved an overall reduction in potable water use of 41%.
- Non-potable water uses account for 50-70% of total demand and hence recycled water could achieve even greater reductions than BASIX.
- Usage data for single dwellings indicates that effluent production is generally in the order of 75% of the water used.
- Water saving devices alone may achieve a 35% reduction in potable water consumption. More typical uptake of these devices would yield at least a 20% reduction for water saving devices alone.

The original sewage generation volume adopted by Mid Coast Water was 240 L per person per day, however it is expected this volume would now be lower for both existing and new developments due to:

- Uptake of water saving devices in existing dwellings,
- Water restrictions and heightened awareness,
- Current building codes, and
- BASIX requirements for new dwellings.

As a minimum, it is considered that in line with a reduction in potable water consumption the sewage production of new areas would be reduced by at least 20% due to the implementation of water saving devices including regulated minimum requirements. Hence, a rate of 192 L per person per day would apply for new dwellings.

If the use of rainwater tanks were limited to hot water systems, hot water usage would not be expected to change. Hence there would be no impact on the sewage loads.

5.4.4 Ultimate Loadings at Hawks Nest STP

The ultimate loadings based on current development projections and information provided by MCW is included in **Appendix G**.

5.5 Recycled Water

The opportunity may exist to recycle treated effluent from the existing Hawks Nest WWTP.

It is assumed that the existing areas of Tea Gardens and Hawks Nest would not be serviced with recycled water and that only new developments would be included.

5.5.1 Recycled Water Supply Concept

The water management objectives adopted in developing a supply concept for the site include the following:

- Minimise the discharge of treated effluent to the environment by maximising the reuse of recycled water;
- Minimise impacts of recycled water reuse on the surrounding environment by designing optimal management practices (minimise runoff, effective irrigation practices etc.);
- To achieve unrestricted reuse status, the recycled water will most likely require tertiary filtration and disinfection at the Hawks Nest STP before distribution; and

- Infrastructure to be designed with long term sustainability in mind. This will involve location of additional treatment trains, recycled water management systems with adequate buffer zones and flexibility for future expansion to meet potential future reuse opportunities.

Additional treatment will most likely be required to achieve an effluent standard that allows unrestricted reuse. This is necessary to allow use of the recycled water in potentially primary contact situations. The most likely technology that would be used to achieve this would be tertiary filters and disinfection. The tertiary filters and disinfection treatment trains could be staged to allow for future upgrade of the plant and accommodate possible future reuse opportunities.

The recycled water supply to the development site would require a pumping station at the sewage treatment plant and a transfer main (nominally DN150mm) to deliver recycled water to a small recycled water reservoir. Recycled water would be distributed from the reservoir, through the development.

5.5.2 Recycled Water Demand

There was a concern previously expressed regarding the potential re-use applications for recycled water from the sewerage treatment plant for irrigation and whether this would affect the health of the aquifer that lies below Riverside at Tea Gardens. However, Martens 2011 (refer **Appendix F**) concludes that the demand for nutrients in garden areas alone far outstrips that which can be supplied by recycled water ie. irrigation of recycled water is not expected to threaten groundwater quality.

The potential demand for recycled water use in future development areas would be based on the reduced water demand (including the MCW outdoor demand) and sewage generation including provision for water demand reduction.

It is assumed that recycled water would be used for external and internal use, including:

- Outdoor irrigation (27% of total water demand)
- Toilet flushing (12% of total water demand)
- Washing machines (22% of total water demand)

Based on these assumptions, recycled water demand could comprise as much as 61% of total household water demand. For the purposes of this study and for sizing the trunk recycled water infrastructure, it was conservatively assumed that recycled water demand would include laundry use and the MCW design outdoor demand.

Based on the benchmark water demand, adopted water demand reduction and recycled water usage assumptions, the design flows that have been adopted for sewage generation, potable water demand and recycled water demand are included in **Table 10**.

Table 10
Design Flows for Future Development Areas

Area of Usage	Adopted Demand (L/EP/day)	Wastewater to sewer (L/EP/day)	Potable Water Demand (L/EP/day)	Recycled Water Demand (L/EP/day)
Outdoor	84.2	0	0	84.2
Toilet	24.3	24.3	0	24.3
Laundry	58.3	58.3	0	58.3
Bathroom	72.4	72.4	72.4	0
Kitchen	12.5	12.5	12.5	0
Other	15.6	15.6	7.8	7.8
TOTAL	**267.3**	**183.1**	**92.7**	**160.9**

It is noted that based on the MCW design water demand and the potable water demand the reduction in potable water demand as a result of BASIX demand reduction measures and a recycled water system could be up 75%.

MCW has prepared an Effluent Management Scheme concept design for recycled water use at Hawks Nest Golf Course (MCW, 2008). It is estimated that the scheme would supply up to 1.5 ML/day and could reuse an average of 101 ML/year (274 kL/day), which is equivalent to approximately 35% of the existing annual effluent load from Hawks Nest STP. This potential reuse is not included in the potential recycled water demand assessed in this study.

5.5.3 Future Supply Scenarios

Three potential scenarios for future water supply to new developments within the Hawks Nest STP catchment are:

- Scenario 1: Internal and external recycled water supply (including laundry)
- Scenario 2: Internal and external recycled water supply (excluding laundry)
- Scenario 3: No recycled water supply

Under Scenario 1, the ultimate excess effluent of 3.1 ML/day is within the ultimate capacity of Hawks Nest STP (3.6 ML/day). Under Scenario 2, the excess effluent would increase to 3.5 ML/day, which would still be within the ultimate STP capacity. Under Scenario 3, the ultimate STP capacity would be insufficient to service the total projected development.

The total ultimate sewage generation (4.4 ML/day) is greater than the future planned STP capacity, meaning the STP would need to be upgraded to cater for the projected development. These upgrades would be dependent on the timing and staging of future developments. It is envisaged that timing and staging of upgrades to the STP would be considered in further detail in subsequent studies. The size of any future upgrades of the STP would be dependent on the projected recycled water demand and any changes to future development projections.

Due to the limited ultimate capacity of the effluent disposal system (3.6 ML/day), some form of offset of effluent disposal would be required to ensure the proposed development precincts can be adequately serviced. A recycled water system could offset effluent disposal at the STP and ensure the STP has adequate effluent disposal capacity to cater for the sewage generated by Riverside at Tea Gardens, Myall River Downs and North Shearwater.

5.5.4 Recycled Water Infrastructure

The recycled water strategy to service the development precincts would consist of constructing trunk infrastructure to transfer recycled water from Hawks Nest STP to the development. The trunk infrastructure would include the following components:

- A recycled water treatment facility at Hawks Nest STP, to produce recycled water of a standard suitable for unrestricted public access and internal reuse.
- A recycled water pumping station at the STP site.
- A recycled water reservoir adjacent to existing MidCoast Water potable water reservoirs.
- A rising main from the treatment facility at Hawks Nest STP to the proposed recycled water reservoir.
- Distribution mains from the reservoir to the site.

6 Integrated Water Management Plan

The concept plan for the development of the Riverside at Tea Gardens site consists of a residential / mixed use precinct proposed for the majority of the site and a tourist precinct located in the NE corner of the site. Substantial areas of the land are proposed to be protected and enhanced as open space / wildlife movement corridors, over and above those already protected in the Conservation Zone and the Wetland Zone.

The current proposal differs from that previously lodged with the DoP to address concerns raised by the PAC and DoP.

The preferred development concept plan is provided in **Figure 3** while the diagrammatic stormwater concept plan is given in **Figure 4**.

6.1 Flooding & Drainage

It is proposed to direct runoff in events up to the 100 yr ARI event from the upper catchment areas east along the proposed open space corridor located on the northern boundary to a major retarding basin (Basin EW) with outflows from the basin discharging south east to a swale located on the eastern boundary of the site. This swale is intended to distribute runoff along the western boundary of the buffer zone to reduce the concentration of runoff into the buffer zone and the SEPP14 wetland. Two local basins (Basins N42 and N43) are proposed to manage runoff from the Tourist Precinct.

The planned development located south of the open space corridor will drain southwards towards a number of ponds, wetlands and freshwater lakes that will discharge via swales into the existing saline lake.

Under the final scheme with additional lined wetlands and ponds and three freshwater lakes will create additional active storage in combination with the existing saline lake will mitigate the increases in peak runoff up to the 100 yr ARI event due to the planned development.

The impact of possible climate change (based on a 30% increase in rainfall intensities) on 100 yr ARI flood levels was also assessed and has been recognised in the planning on new development.

Previously, the approach to drainage design in Tea Gardens was to maintain drainage structure outlet levels at or above Mean High Water, at approximately RL 0.5m AHD. This is reflected in the levels of drainage structures throughout the existing Tea Gardens township including all existing stages of the Myall Quays estate.

In order to account for the possible impacts of climate change, modifications have had to be made to the previously proposed drainage regime in the Riverside Estate proposal. In order to maintain the existing approach, the most significant change has been to lift the entire site, to ensure that the minimum invert of all new drainage structures in the proposed Riverside Estate are now at or above the predicted worst post climate change Mean High Water of 1.4m AHD. This would ensure that the drainage system would remain unaffected by tidal waters.

In discussions with Great Lakes Council's engineering department, this has been supported as an appropriate response.

The other possible effect of climate change has been to increase flooding levels due to potential increases in tailwater and rainfall intensities. Revised flood levels across the site have then been accounted for in determining landform levels. A direct result of this raising of the drainage network is the raising of the surface levels across the site to provide cover to the pipes. Consequently the majority of the site is already elevated above the revised flood levels. Additional lot filling is proposed in any remaining low-lying areas to ensure that all lots remain flood free above the modelled 100yr flood levels, with climate change. It should be noted that finished floor levels will be a minimum of a further 0.3m above this lot fill level.

6.2 Groundwater

Martens, 2011 prepared a concept groundwater management plan based on consideration of the existing aquifer characteristics, potential risks to the aquifer and identification of management objectives and methods (refer **Appendix F**). This plan is overviewed as follows:

The following broad scale risks of development on groundwater were identified:

(i) Untreated stormwater discharge to groundwater resulting in groundwater contamination.
(ii) Changes to groundwater level which come about through modifications to surface infiltration and recharge properties at the site.
(iii) Changes to groundwater flow direction which come about through modifications to surface infiltration and recharge properties at the site.
(iv) Significant modifications to groundwater flow budgets to groundwater dependent ecosystems and the receiving waters.
(v) Locally increasing groundwater levels though excessive recharge resulting in surface water losses from the groundwater system.

On the basis of identified risks, the following risk management objectives are provided:

(i) Development is to be undertaken in such a way so as to ensure that groundwater table drawdown is minimised;
(ii) Development should not result in a degradation of the existing aquifer water quality;
(iii) Development should not significantly alter the flow directions of ground water at the site; and
(iv) The surface and groundwater system should be maintained such that the integrity of groundwater dependent ecosystems is preserved or enhanced.

6.2.1 Risk Management Methods

The following methods are recommended in order that the risk management objectives can be met:

(i) Ensure all stormwater management systems treat stormwater to a level equal to or better than existing groundwater quality prior to discharge to any groundwater body;

(ii) Minimise [but do not necessary preclude] the exposure of groundwater to surface water systems;
(iii) Ensure that where groundwater recharge has been locally reduced, that recharge is increased in other areas of the site to compensate for any potential water budget short falls;
(iv) Recharge treated stormwater throughout the site in such a way so as to enable distributed recharge rather than single point recharge to ensure as far as possible that groundwater flow gradients, levels and directions are maintained at pre-development levels.

6.2.2 Groundwater pH Management

Martens, 2011 concludes that this development is not expected to give rise to any changes to background groundwater pH levels at the fringing wetlands for the following reasons:

(i) There will be minimal concrete pavements / surfaces within the development relative to other surfaces (ie. pervious surfaces and roofs) and therefore limited potential for significant production of alkaline urban runoff;
(ii) Rainwater will remain the primary source of acidity within urban runoff and there will continue to be significant opportunity within the development footprint and within the proposed surface drainage system for contact between rainwater and in-situ soil prior to percolation to the groundwater system.
(iii) Local soils within and adjoining the fringing wetlands have a significant capacity to maintain stable pH levels given the high levels of organic matter and buffering capacity of local soils (Murphy, 1995).

6.2.3 Irrigation of Recycled Water

There was a concern previously expressed regarding the potential re-use applications for recycled water from the sewerage treatment plant for irrigation and whether this would affect the health of the aquifer that lies below Riverside at Tea Gardens. However, Martens 2011 (refer **Appendix F**) has concluded that the demand for nutrients in garden areas alone far outstrips that which can be supplied by recycled water ie. irrigation of recycled water is not expected to threaten groundwater quality.

6.3 Water Quality

6.3.1 Temporary Controls

Sediment and erosion control measures will be implemented in the construction phases in accordance with the requirements of the current edition of the Managing Urban Stormwater – Soils and Construction (Blue Book) released by the former NSW Department of Housing.

6.3.2 Permanent Controls

The stormwater treatment objectives and lake water quality objectives will be met by:

(i) Retaining the existing saline lake and it current outlet;
(ii) Constructing three freshwater ponds upstream of the saline lake that discharge into swales that conveys runoff to the existing saline lake;
(iii) Constructing two large lined wetlands and several ancillary small ponds to pre-treat runoff discharged to the freshwater ponds;
(iv) Constructing local wetlands to treat runoff from residential development discharging to the Myall River (subcatchment N42) or to the Conservation Zone (subcatchment N43), as well as
(v) Constructing a 440m swale along the eastern edge of the development (to distribute flow to the Conservation Zone).

It should be noted that experience to date in Tea Gardens has shown that there is little need to install GPTs as even sediment is highly controlled from the individual lots as part of a comprehensive Community Title arrangement that imposes strict controls on individual builders during construction.

6.3.3 Maintenance Activities

Pond and Wetland Maintenance

The maintenance activities for the pond and wetland systems will be based on the practices already implemented for existing ponds and wetlands located within developed areas of Riverside at Tea Gardens and the Myall River Downs estate. The following maintenance activities are expected to be undertaken but may not be required at all times:

- Routine inspection of inlet and outlet points to identify any area of scour, litter build up and blockages;
- Inspection and removal of accumulated litter and debris from inlet and outlet structures (every 3 months);
- Periodic draining and desilting of the ponds (every 5 -10 years);
- Inspection and removal of noxious and invasive weeds from within the macrophyte zone (every 1-3 months during establishment phase);
- Replacement of plants that have died with plants of equivalent size and species (as needed);
- A macrophyte zone will need to be ‘reset’ every 20 to 50 years depending on the pollutant loading rate on the system.

Design attributes that will facilitate maintenance activities include:

- Inlet zone for the removal of coarse particulates;
- Provision of an access and entry point to the macrophyte zone for the periodic removal of accumulated material; and
- Access to outlet structure for routine inspections.

Lake Maintenance

The existing lake and new freshwater ponds will be maintained by contractors experienced in this type of work acting under instructions from the Community Association Manager. The maintenance activities generally include:

Maintenance activities for the lakes would involve:

- Inspection and removal of accumulated debris and litter from inlets and outlet structures;
- Inspection and removal of noxious weeds from within the water body;
- Inspection and removal of any vegetation that may invade the outlet channel to maintain the outlet capacity;
- Inspection and removal of accumulated sediment from inlet zones as needed.

Design attributes that will facilitate maintenance activities include:

- Provision of access to inlets and to the perimeter of the existing lake; and
- Provision of access to the outlet channel for routine inspections and removal of accumulated debris and/or invasive vegetation.

6.3.4 Management of Aquatic Weeds

The management of aquatic weeds in constructed pond and wetland systems will be based on the practices already implemented for existing ponds and wetlands located within developed areas of Riverside at Tea Gardens and the Myall River Downs estate and for the existing lake. Aquatic plants are inspected periodically to control pest species and to promote the desired mix of plants for conservation and landscape purposes.

The constructed Wetlands Manual defines an aquatic weed as a plant ‘out of place’ or a plant that interfere with the objectives of the wetland or its desired function.

Weed management in constructed wetlands is important to ensure that weeds do not out-compete the species planted for the particular design requirements. This may also include some native species like Phragmites that naturally can appear in constructed wetlands and out-compete other more important planted species.

It is possible to minimise and control weeds by incorporating the following:

- Buying seed that is either known to be free of weeds or certified free of weed seeds, preventing weeds from being introduced;
- Timing activities to minimise weed germination;
- Applying pre-emergent herbicides;
- Manual removal; and
- Competition with a dense, health crop to crowd out potential weeds.

6.3.5 Management of Aquatic Species and Birdlife

Wetlands and lakes usually provide a sanctuary for waterbirds and other animals.

During the early stages of wetland establishment, water birds can be a major nuisance due to their habit of pulling out recently planted species. Interlocking planting systems (i.e. where the maintenance activities for the pond and wetland systems will be based on the practices already implemented for existing ponds and wetlands located within developed areas of Riverside at Tea Gardens and the Myall River Downs estate several plants are grown together in a single container such as 'floral edges') can be used, as water birds find it difficult to lift the interlocking plants out of the substrate unlike single plants grown in tubes.

Harris Research, 2007 also recommend that the 2002 recommendations for enhancing the amount and quality of aquatic habitats remain relevant and should be pursued, particularly with respect to increasing the extent, complexity and quality of near-shore habitats for fish, invertebrates and birds. These recommendations for optimising the quality of aquatic habitats, which are incorporated in current proposals to extend the lake area, include:

- Influencing the water-quality regime to increase habitat diversity and stability.
- Continuing effective management of the series of runoff-treatment ponds.
- Increasing variability of depth profiles by introducing physical structures such as submerged logs, rockwork or other artificial reefs
- Experimentally introducing indigenous submerged and emergent aquatic plants and planting littoral trees, shrubs and grasses and
- Introducing shoreline complexity in newly created waterway areas.

6.3.6 Monitoring Program

The proposed monitoring program is based on the monitoring program previously adopted in late 2003 for Precincts 7 and 8 of Riverside at Tea Gardens as follows.

SEPP 14 Wetland

The monitoring program for the SEPP 14 wetland is based on:

- The establishment of 3 transects in the vicinity of Precincts 7 and 8, perpendicular to the environmental gradient;
- Hand-auguring, small bore piezometers at intervals along the transects;
- Collecting further data on groundwater depth and salinity at each piezometer at regular intervals to supplement the data previously collected from Bores 3 and 6 (refer CPI, 1996a); and
- Undertake a quantitative plot based vegetation monitoring program to determine species composition, relative abundance and plant condition.

The timetable that was proposed was three monthly monitoring:

- immediately after construction (for 36 months),
- 5 years after the initial 3 years of monitoring (for 12 months), and
- 10 years after the initial 3 years of monitoring (for 12 months).

Comparison of post-construction data with the baseline dataset would generally be undertaken using non-parametric multivariate techniques, such as analysis of similarities (ANOSIM), which would provide a statistical assessment of whether changes had occurred.

Technical detail on methods would be provided in a methods statement in a baseline survey report to be submitted to Council within 3 months of the date of commencement. Reports on the groundwater observations and vegetation monitoring would be provided after every 12 month period of monitoring.

Constructed Freshwater Lakes, Ponds and Wetlands

The proposed monitoring program of both basin inflow and outflow is detailed in **Table 11**.

Table 11
Monitoring Program for Constructed Ponds and Wetlands (after HWR, 2001)

Parameter	Frequency	Test
Microbiological	Two (2) event monitoring periods per year with a minimum of 4 samples during each storm event. Storm event to be at least 15 mm with first flush to be targeted	Water samples for laboratory analysis
Nuisance organisms	Two (2) event monitoring periods per year with a minimum of 4 samples during each storm event. Storm event to be at least 15 mm with first flush to be targeted	Visual during storm events and water samples for laboratory analysis
Visual clarity & colour	Two (2) event monitoring periods per year. Storm event to be at least 15 mm with first flush to be targeted	In-situ analysis at time of sampling during storm events
pH	Two (2) event monitoring periods per year. Storm event to be at least 15 mm with first flush to be targeted	In-situ analysis at time of sampling during storm events
Toxic chemicals	In response to actual or potential toxic spills in Precincts 7 or 8.	Water samples for laboratory analysis
Surface films	Two (2) event monitoring periods per year. Storm event to be at least 15 mm with first flush to be targeted	Visual & smell at time of sampling during storm events
Phosphorus	Two (2) event monitoring periods per year with a minimum of 4 samples during each storm event. Storm event to be at least 15 mm with first flush to be targeted	Water samples for laboratory analysis
Nitrogen	Two (2) event monitoring periods per year with a minimum of 4 samples during each storm event. Storm event to be at least 15 mm with first flush to be targeted	Water samples for laboratory analysis

It is proposed that the key stakeholders including the landowner, the Myall Quays Community Association, Great Lakes Council and OEH officers meet to review the outcomes of the monitoring program after three (3) years and to agree on the scope of any ongoing monitoring program and the timing of any subsequent review.

The frequency of monitoring would be increased in the event of a potential pollution incident within a basin's catchment.

Existing Lake

It is proposed to continue the current monitoring program of the existing detention lake for at least a further three years. This current program comprises sampling and testing of lake water at five sites (refer **Figure A.1**) at three monthly intervals. The parameters that are monitored include:

- pH
- Salinity
- Dissolved oxygen,
- Turbidity, Suspended Solids
- Oxidised nitrogen, ammonia, nitrates, nitrites, phosphate
- Chlorophyll 'a'

It is proposed that the key stakeholders including the landowner, the Riverside Community Association, Great Lakes Council and OEH officers meet to review the outcomes of the monitoring of the detention lake after three (3) years and to agree on the scope of any ongoing lake monitoring program and the timing of any subsequent review.

It is further proposed to:

- undertake 6-monthly algae testing/analysis including one (1) summer assessment;
- Undertake additional sampling and testing of lake water if more than 50 mm of rain falls in a two day period or less. Council requires no more than two (2) such sampling events per year.

6.4 Potable Water

In 2010 Worley Parsons assessed the potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens. The investigation considered the Riverside at Tea Gardens development together with the entire catchment to be serviced by the Hawks Nest Sewage Treatment Plant. In particular, the three new developments Riverside at Tea Gardens, Myall River Downs and North Shearwater were considered.

The projected population for these areas is an ultimate 2,570 ET with an estimated total ultimate winter EP of 4,626 and a total ultimate summer EP of 6,939.

The full assessment of assessed the potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens is attached in **Appendix G**.

6.4.1 Potable Water Servicing Concept

The water management objectives adopted in developing a potable water supply concept for the site include the following:

- Minimise the potable water demand from the site by using water saving devices on fixtures and water efficient appliances;
- Installation of rainwater tanks and connection to toilet flushing and hot water systems;
- Use of alternative water supply sources, where possible;
- Retention of native vegetation and minimal use of turf to reduce irrigation requirements; and
- Infrastructure to be designed with long term sustainability in mind.

The Hawks Nest WWTP may be upgraded to include a facility to provide recycled water to new developments (including Riverside at Tea Gardens). The provision of recycled water to Riverside at Tea Gardens would reduce potable water consumption through the development.

6.4.2 Minimising Potable Water Demand

Potable water demand could be minimised through a combination of the following measures:

- Maintaining natural vegetation outside designated development envelopes on each lot;
- Where required, landscaping lots and road verges with natural vegetation and plant species that require no irrigation;
- Using water conservation measures throughout households, such as water efficient taps, dual flush toilets, shower roses or flow restricting devices, washing machines and dishwashers.
- • Installing rainwater tanks to reuse runoff for toilet flushing, washing machines and irrigation. Alternatively, utilising treated effluent from the future Hawks Nest WWTP recycling plant for reuse in toilets, washing machines and irrigation. The reuse application would depend on the level of treatment applied to the effluent.

6.5 Rainwater

The re-use of rainwater from rainwater tanks has the potential to make considerable reductions in potable water consumption. However, rainwater can compete with recycled water as they are both used for non-potable applications. Hence any decision to install rainwater tanks needs to take into account the proposed installation of infrastructure to deliver recycled water to properties for toilet flushing, laundry and outdoor uses.

The decision on implementation of any rainwater tanks will not impact on the ability of the development to meet stormwater quality objectives.

6.6 Wastewater

The existing settlements at Tea Gardens and Hawks Nest are serviced by the existing Hawks Nest WWTP. However, due to limited treated effluent disposal capacity at the plant, the extent of augmentation to service further development is limited.

6.6.1 Wastewater Servicing Concept

The water management objectives adopted in developing a servicing concept for the site include the following:

- Minimise impacts on existing infrastructure by reducing the sewage loads where possible;
- Minimise impacts on receiving waters by designing optimal effluent management practices and minimising effluent discharge;
- Reuse of treated effluent where possible and appropriate; and
- Infrastructure to be designed with long term sustainability in mind. This will involve location of sewerage systems with adequate buffer zones and flexibility for future expansion to meet potential augmentation requirements.

It is proposed to service the development using a vacuum sewerage system. This will deliver sewage from the development site to the existing sewage treatment plant. A vacuum sewerage system is considered to be the most appropriate technology due to the topography of the site.

The Sewerage Servicing Strategy identified that the exfiltration basins (existing and proposed) had sufficient capacity to cater for all of the predicted development loads.

6.7 Recycled Water

Based on its review of the assessment of potable water, recycled water and sewerage servicing options for Riverside at Tea Gardens, MidCoast Water has confirmed that the project (subject to approval) will be serviced by sewer, water and recycled water for toilet flushing, laundry and outdoor uses.

It is assumed that the existing areas of Tea Gardens and Hawks Nest would not be serviced with recycled water and that only new developments would be included.

6.7.1 Recycled Water Supply Concept

The water management objectives adopted in developing a supply concept for the site include the following:

- Minimise the discharge of treated effluent to the environment by maximising the reuse of recycled water;
- Minimise impacts of recycled water reuse on the surrounding environment by designing optimal management practices (minimise runoff, effective irrigation practices etc.);
- To achieve unrestricted reuse status, the recycled water will most likely require tertiary filtration and disinfection at the Hawks Nest STP before distribution; and
- Infrastructure to be designed with long term sustainability in mind. This will involve location of additional treatment trains, recycled water management systems with adequate buffer zones and flexibility for future expansion to meet potential future reuse opportunities.

Additional treatment will most likely be required to achieve an effluent standard that allows unrestricted reuse. This is necessary to allow use of the recycled water in potentially primary contact situations. The most likely technology that would be used to achieve this would be tertiary filters and disinfection. The tertiary filters and disinfection treatment trains could be staged to allow for future upgrade of the plant and accommodate possible future reuse opportunities.

The recycled water supply to the development site would require a pumping station at the sewage treatment plant and a transfer main (nominally DN150mm) to deliver recycled water to a small recycled water reservoir. Recycled water would be distributed from the reservoir, through the development.

6.7.2 Future Supply Scenarios

Three potential scenarios for future water supply to new developments within the Hawks Nest STP catchment are:

- Scenario 1: Internal and external recycled water supply (including laundry)
- Scenario 2: Internal and external recycled water supply (excluding laundry)
- Scenario 3: No recycled water supply

Under Scenario 1, the ultimate excess effluent of 3.1 ML/day is within the ultimate capacity of Hawks Nest STP (3.6 ML/day). Under Scenario 2, the excess effluent would increase to 3.5 ML/day, which would still be within the ultimate STP capacity. Under Scenario 3, the ultimate STP capacity would be insufficient to service the total projected development.

The total ultimate sewage generation (4.4 ML/day) is greater than the future planned STP capacity, meaning the STP would need to be upgraded to cater for the projected development. These upgrades would be dependent on the timing and staging of future developments. It is envisaged that timing and staging of upgrades to the STP would be considered in further detail in subsequent studies. The size of any future upgrades of the STP would be dependent on the projected recycled water demand and any changes to future development projections.

Due to the limited ultimate capacity of the effluent disposal system (3.6 ML/day), some form of offset of effluent disposal would be required to ensure the proposed development precincts can be adequately serviced. A recycled water system could offset effluent disposal at the STP and ensure the STP has adequate effluent disposal capacity to cater for the sewage generated by Riverside at Tea Gardens, Myall River Downs and North Shearwater.

6.7.3 Recycled Water Infrastructure

The recycled water strategy to service the development precincts would consist of constructing trunk infrastructure to transfer recycled water from Hawks Nest STP to the development. The trunk infrastructure would include the following components:

- A recycled water treatment facility at Hawks Nest STP, to produce recycled water of a standard suitable for unrestricted public access and internal reuse.
- A recycled water pumping station at the STP site.
- A recycled water reservoir adjacent to existing MidCoast Water potable water reservoirs.

- A rising main from the treatment facility at Hawks Nest STP to the proposed recycled water reservoir.
- Distribution mains from the reservoir to the site.

6.8 Management Responsibilities and Actions

The responsibilities of various stakeholders are summarised in **Table 12**.

As stated above it is proposed that the key stakeholders including the landowner, the Riverside Community Association, Great Lakes Council and DECCW officers meet to review the outcomes of the monitoring of the constructed ponds and wetlands and the freshwater lakes after three (3) years and to agree on the scope of any ongoing pond, wetland and/or lake monitoring programs and the timing of any subsequent review.

The management actions proposed to rectify any failures to meet the water quality objectives are set out in **Table 13**. These proposed actions have been adapted from HWR, 2001. In addition to these actions, if a potential pollution event (e.g. oil spill or chemical spill) occurs within the development, this event would trigger immediate sampling of the water bodies that may be affected for all water quality parameters, and the frequency of monitoring will be increased above that listed in **Table 13** until it is certain that any effect of the event has either been prevented from reaching the water body or has passed through the water body.

These measures should ensure that water discharged from the development does not impact upon the primary contact recreational condition of the Myall River.

Table 12
Responsibilities of Stakeholders

Parameter	Management Action
Landowner	Responsible for preparing and submitting management plans in accordance with Council requirements. Responsible for implementing the approved Soil and Water Management Plan and for maintaining the effectiveness of all measures during the construction and building phases. Responsible for undertaking remedial actions to reinstate the effective operation of measures during the construction/building phase as may be directed by the Superintendent, Great Lakes Council and/or OEH (NSW EPA).
Contractors/ Builders	Responsible for implementing the approved Soil and Water Management Plan and for maintaining the effectiveness of all measures during the construction and building phases. Responsible for undertaking remedial actions to reinstate the effective operation of measures during the construction/building phase as may be directed by the Superintendent, Great Lakes Council and/or OEH (NSW EPA).

Riverside Community Association (Residents)	Responsible for the operations and maintenance of permanent stormwater management measures and the detention lake and undertaking any remedial actions to reinstate the effective operation of measures as may be directed by Great Lakes Council and/or OEH (NSW EPA). Responsible for commissioning the SEPP 14 wetland monitoring program detailed above and submitting reports on the monitoring undertaken and the conclusions drawn at the end of each 12 month period. Responsible for commissioning a qualified agent to undertake post-construction monitoring of water bodies as detailed above. Reports are to be provided to Great Lakes Council at 3 monthly intervals. Each report is to provide details on the testing undertaken, including full results and will include an overview of water quality performance during the relevant period.
Great Lakes Council	Responsible for periodic review of soil and water management measures during the construction/building phase and the post-construction phase and issuing of directions to the appropriate stakeholder(s) to rectify any significant defects in the measures. Responsible for reviewing submitted reports on water quality and discussing any concerns regarding water quality trends with the Riverside Community Association and/or NSW EPA as appropriate.
OEH (NSW EPA).	Responsible for providing advice to Great Lakes Council on water quality issues that may be of concern to Council. Responsible for undertaking any site inspections that may be requested by Great Lakes Council in relation to water quality issues of concern.
MidCoast Water	Responsible for provision of potable water and wastewater services including nay augmentation works that may be required to service the future growth of Tea Gardens. MidCoast water would be also responsible for provision of any recycled water service that may be implemented in the future.

Table 13
Management Actions to Address Failure to Meet Water Quality Objectives
(after HWR, 2001)

Parameter	Management Action
Microbiological	Search for and rectify potential human sources of bacteria such as sewerage overflows. If source of bacteria is found to be non-human eg birds or animals then consult with Great Lakes Council and other stakeholders as appropriate regarding appropriate management actions.

Nuisance organisms	Check correlation between nuisance organisms and nutrient levels. If nutrient levels excessive, follow actions under 'Nutrients' below. If nutrient levels are not excessive, consider other actions that may include aeration and/or increased flushing.
Visual clarity & colour	Search for and rectify potential sources of turbidity and/or colour.
pH	Search for and rectify potential sources of acidity or basicity as appropriate.
Toxic chemicals	Implement measures to prevent future contamination from spill, etc.
Surface films	Search for and rectify potential sources of oils. Implement measures to prevent future contamination.
Phosphorus	Assess water body loadings by comparing input levels with output levels. If input levels are excessive, search for and rectify potential sources of phosphorus. If water body performance is unsatisfactory, enhance water body performance by redesign and/or other actions that may include aeration and/or increased flushing.
Nitrogen	Assess water body loading by comparing input levels with output levels. If input levels are excessive, search for and rectify potential sources of nitrogen. If water body performance is unsatisfactory, enhance water body performance by redesign and/or other actions that may include aeration and/or increased flushing.

7 Qualification

It is important to recognise that any modelling studies provide only an estimate of the predicted flood levels, flows, pollutant loads and/or treatment efficiencies. Although these estimates are based on the best data available at the time of writing, new data obtained in the future may lead to a revision of the estimates.

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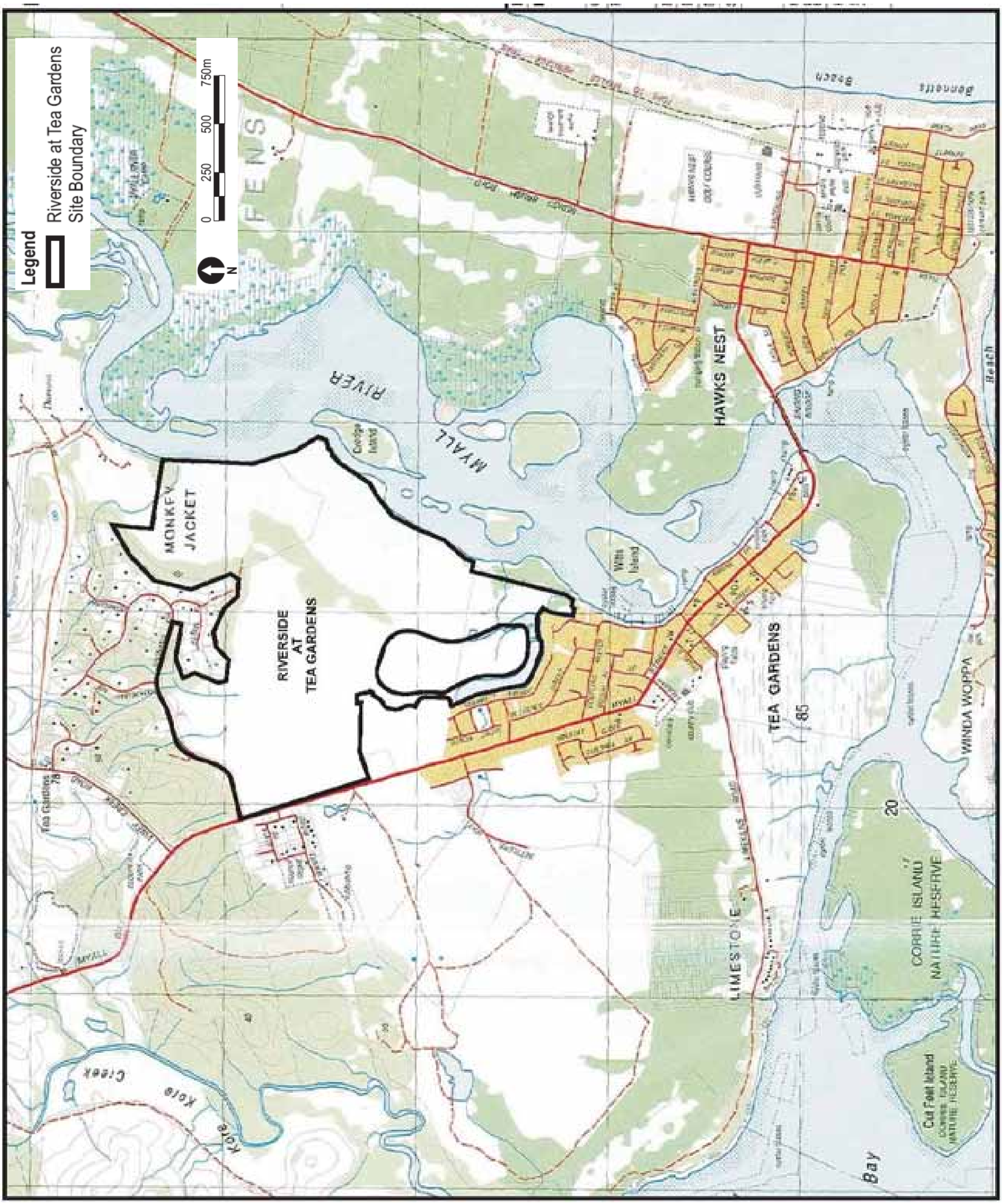

Figure 1
Riverside at Tea Gardens Site Plan (after ERM, 2011)

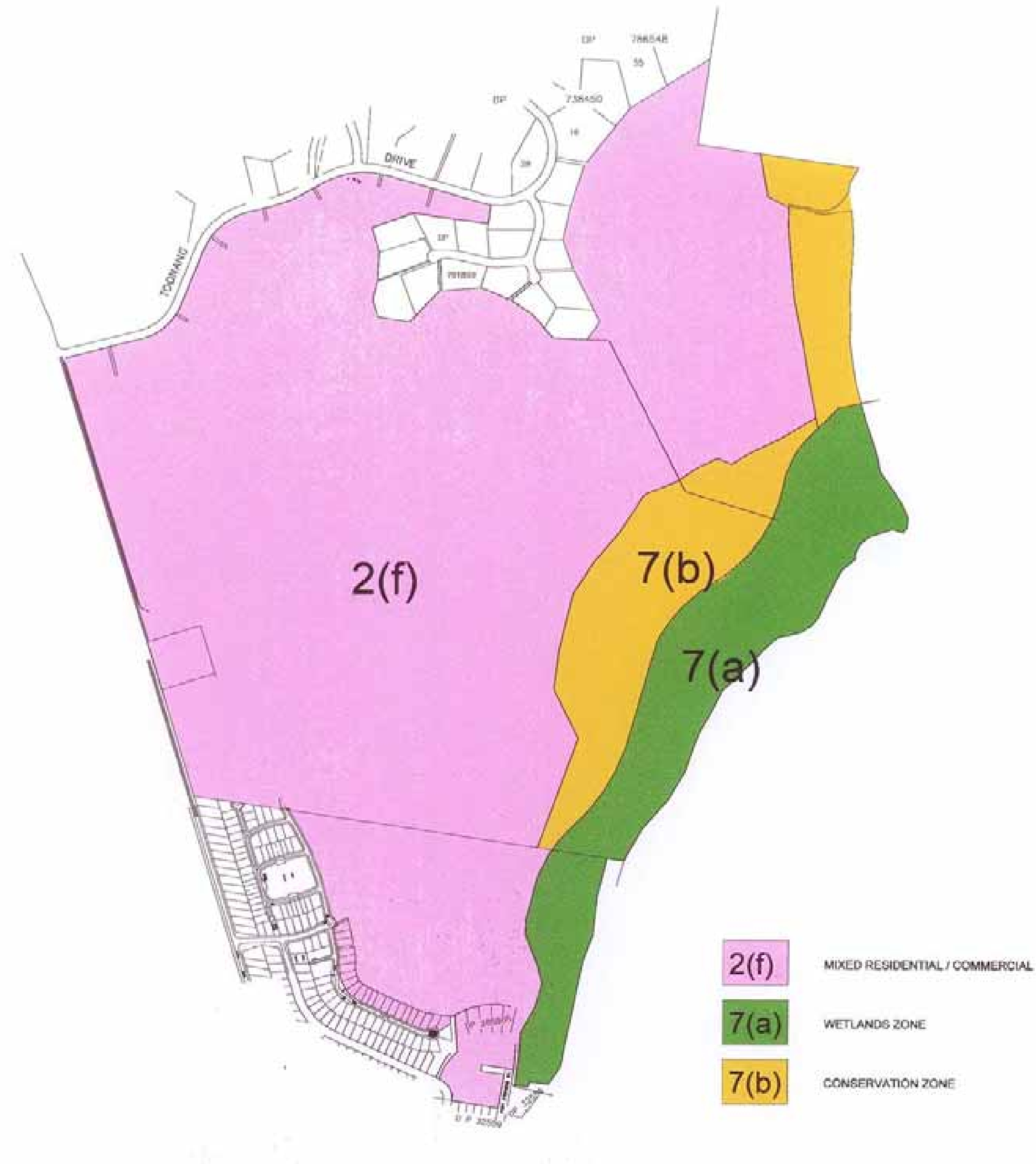

Figure 2
Riverside at Tea Gardens Zoning Plan

Item	Description
1	Extent of concept plan area 'Riverside' at Tea Gardens.
2	Existing 7(a) wetland zone.
3	Existing 7(b) buffer zone.
4	Wildlife movement corridor.
5	Water management & open space corridors.
6	Community parks incorporating walking/cycle ways, BBQs, children's play area equipment.
7	Community pocket parks.
8	Not Applicable
9	Not Applicable
10	Existing detention and water quality lake.
11	New fresh water, water quality management & detention ponds.
12	Existing residential development.
13	Precinct community facilities.
14	Future precinct community facilities.
15	Site area currently owned by Great Lakes Council.
16	Separate medium density/commercial precint (not part of this application-current waver issued by DoP.)
17	Tourist lodgings precinct.
18	Additional land proposed for conservation
19	Proposed residential lot development to be developed under community title.
20	Future development site.
21	Existing house.
22	DCP buffer.
23	Location of known midden & buffer.
24	Existing drain outlet to Myall River.
25	Existing drainage swale
26	Existing shopping centre/medium density approvals
27	Future connecting road

Land Use Legend

Total Site	Ha	%
Open Space		
- Wetlands (zoned 7a)	28.6	12.9
- Buffer Zones (zoned 7b)	21.0	9.4
- Additional Conservation Buffer	17.8	8.0
- Wildlife Corridors	41.9	18.8
- Drainage Corridors, Ponds & Large Parks	23.1	10.4
- Pocket Parks	2.6	1.2
- Existing detention & water quality lake	6.7	3.0
Total	141.7 Ha	63.7%
Built Upon Area		
- Residential (including roads & community facilities)	67.1	30.2
- Tourist/Residential (Lodgings)	8.1	3.6
Total	75.2 Ha	33.8%
Future Development Site		
Total	5.6 Ha	2.5%
Total	222.5 Ha	100%

Figure 3 Riverside at Tea Gardens Concept Development Plan – Final Scheme

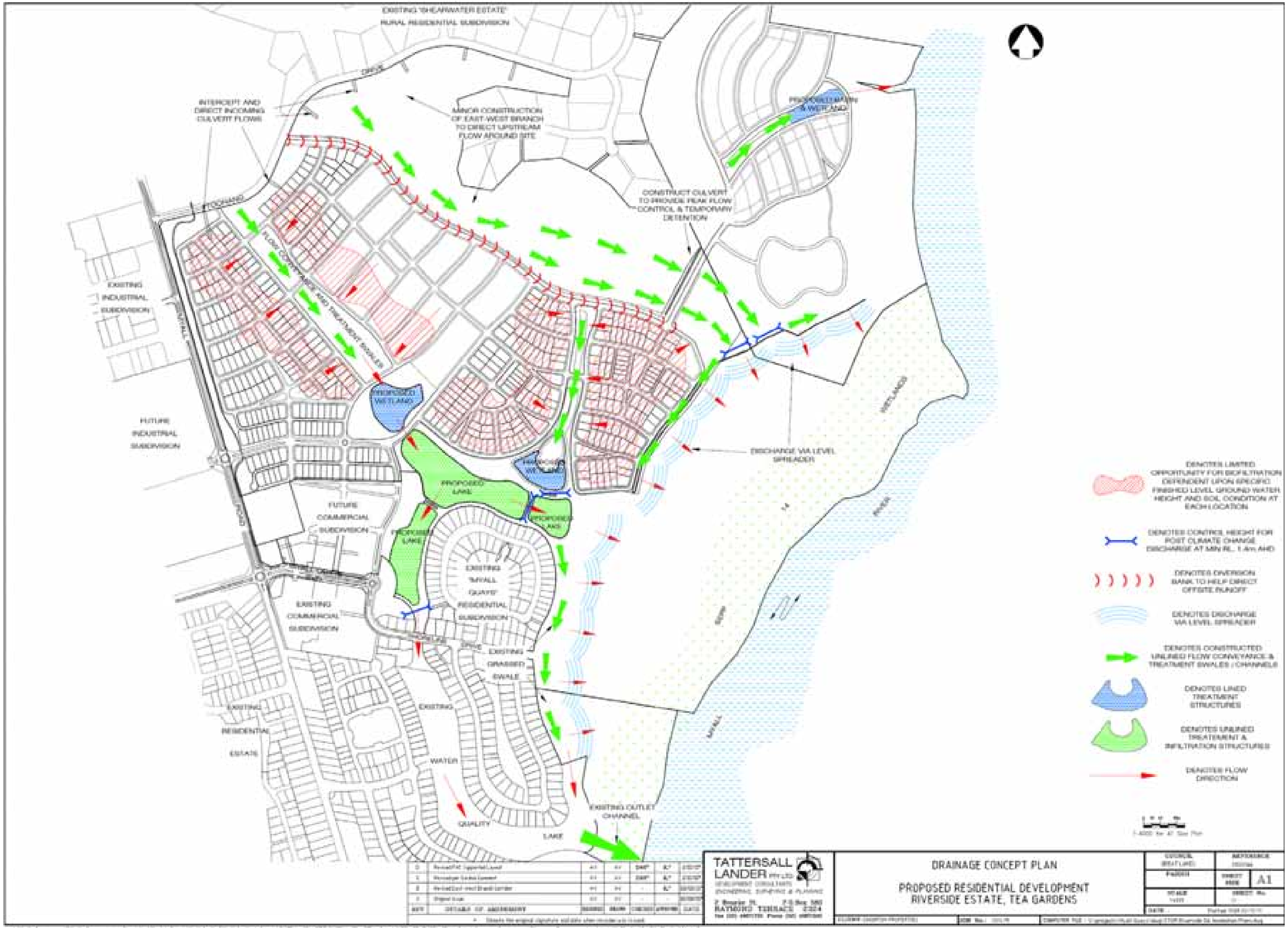

Figure 4 Diagrammatic Stormwater Concept Development Plan – Final Scheme

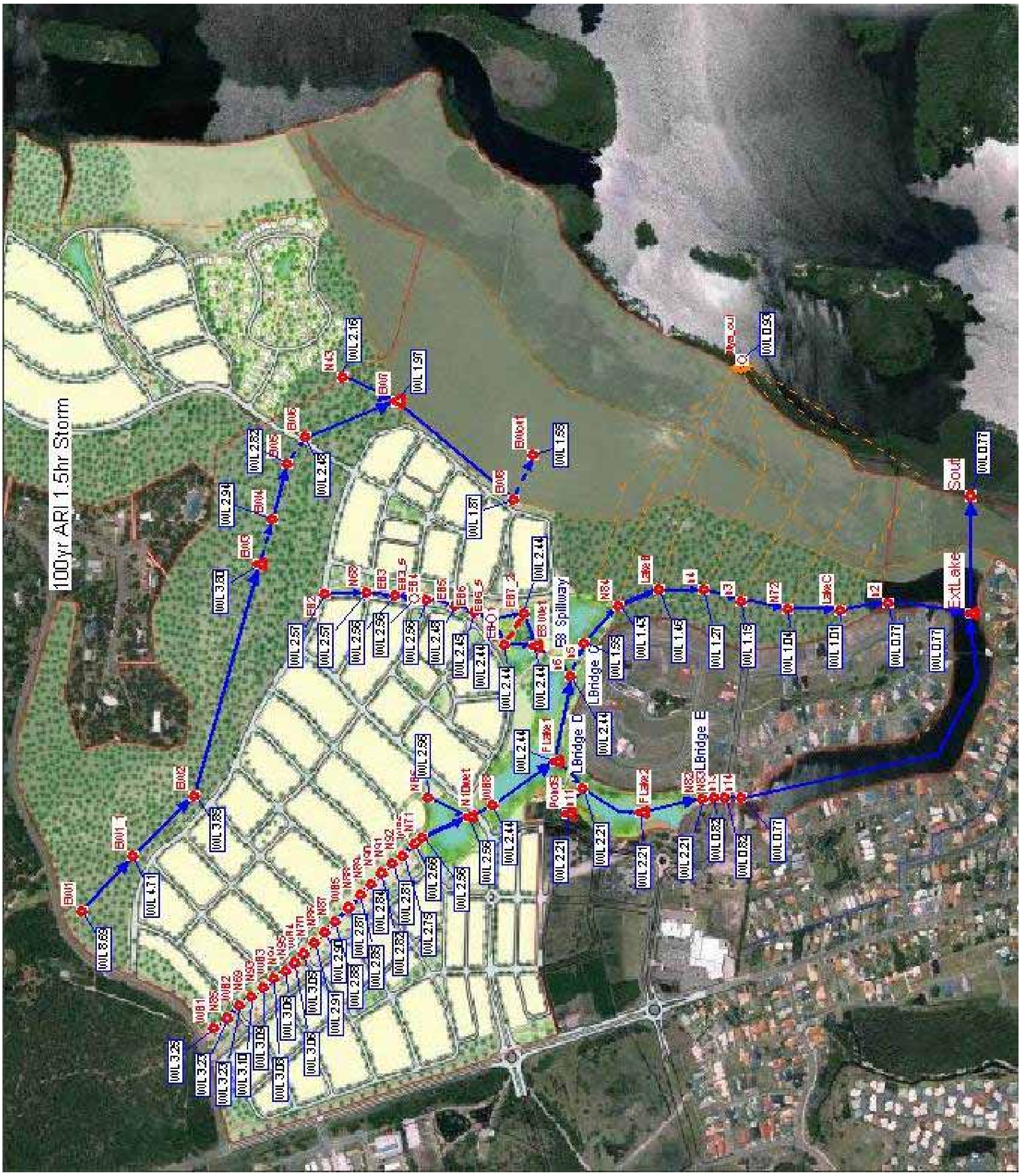

Figure 5
100 yr ARI Peak Flows and Flood Levels for 1.5 hour Storm Burst – Final Scheme

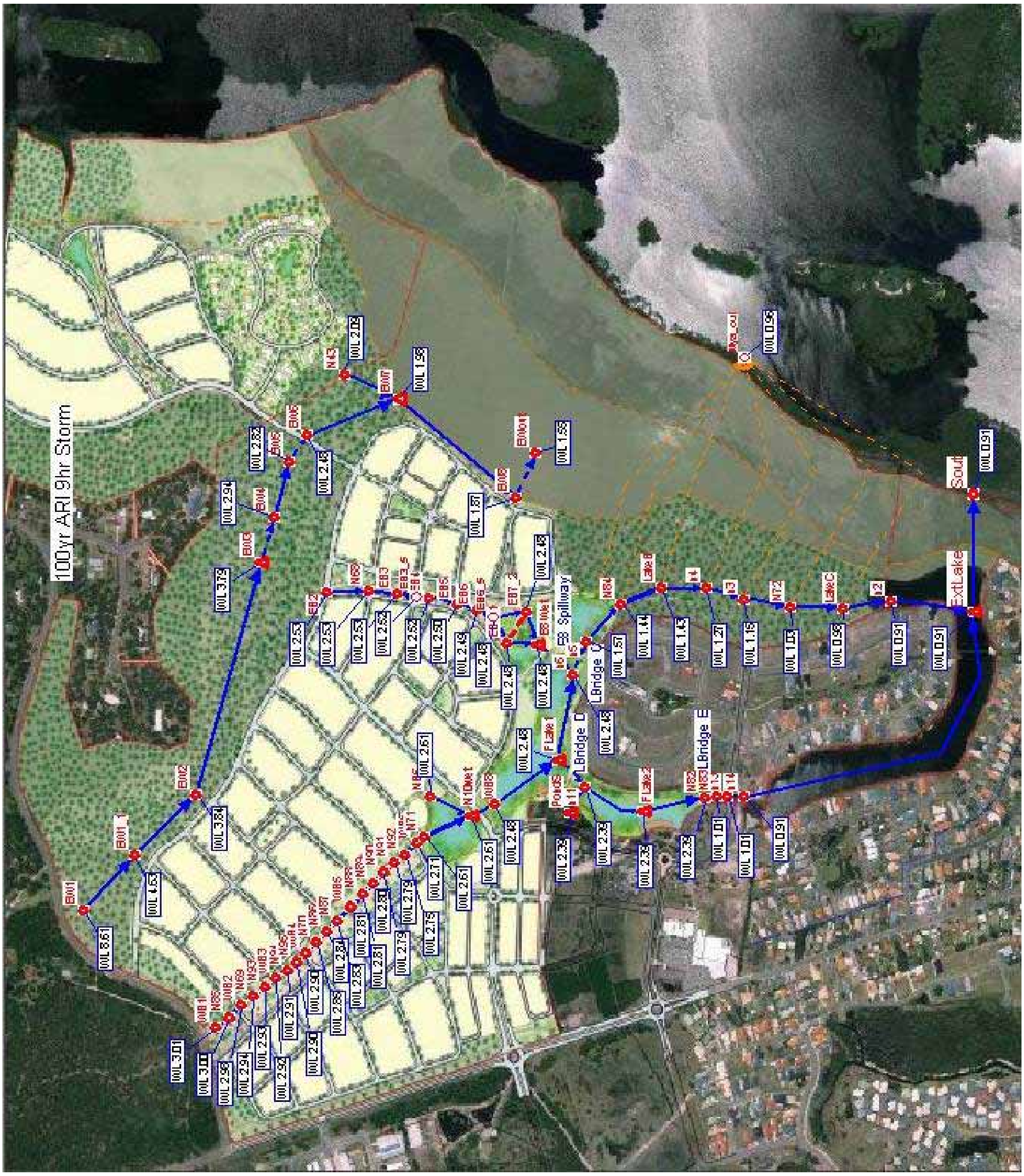

Figure 6

100 yr ARI Peak Flows and Flood Levels for 9 hour Storm Burst – Final Scheme

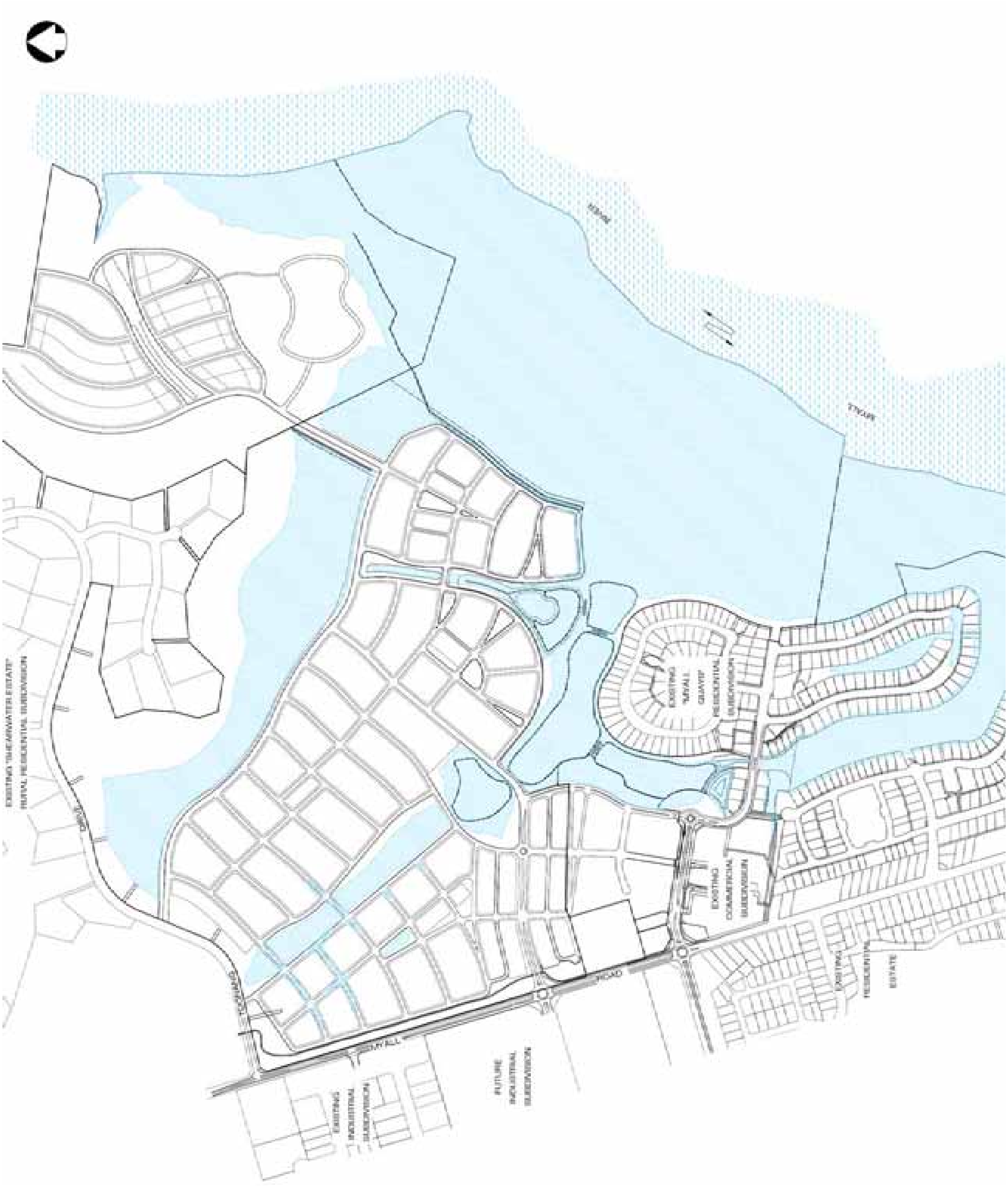

Figure 7
100 yr ARI Local Flood Inundation – Final Scheme

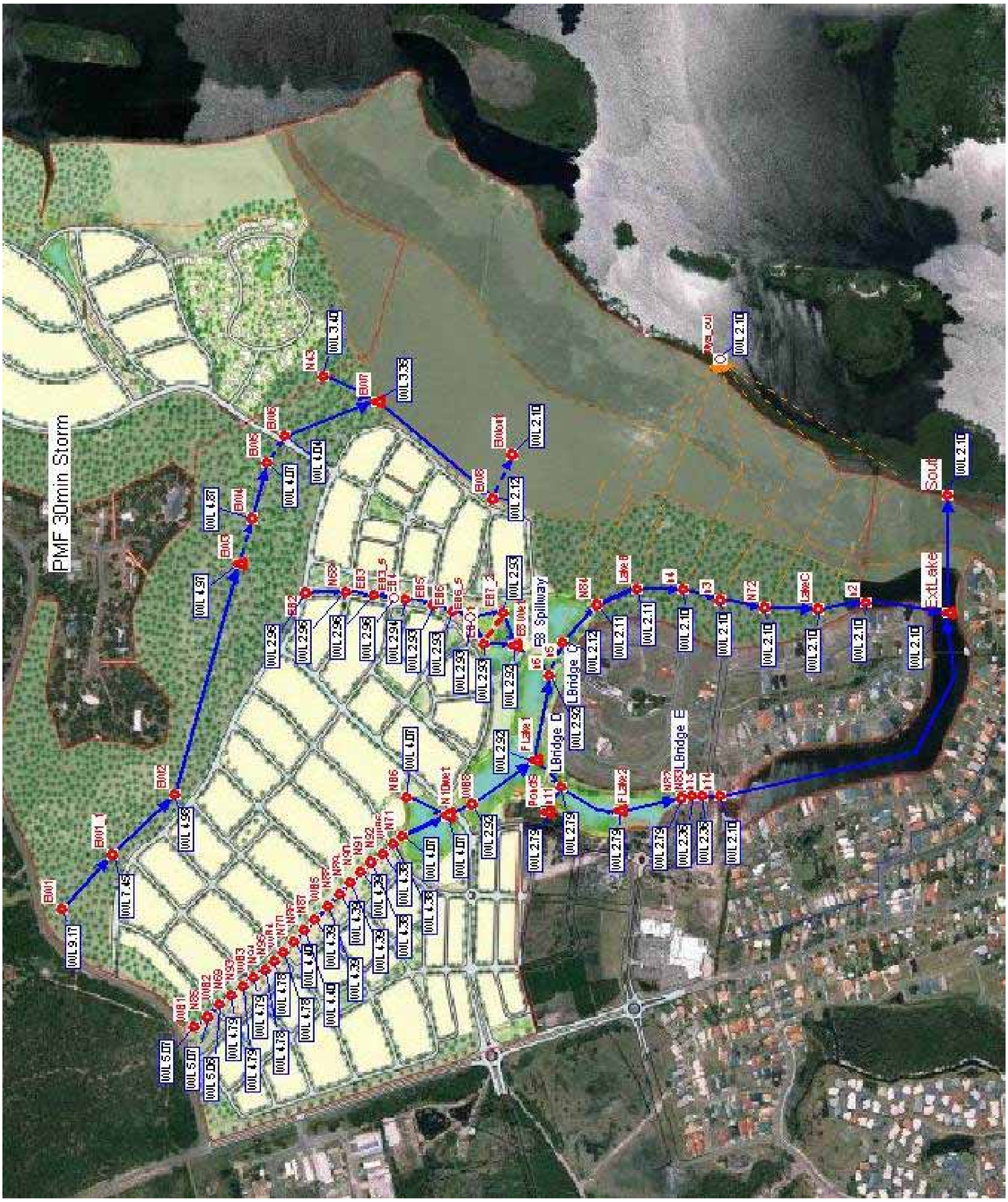

Figure 8
Local PMF Levels for 30 minute PMP Storm – Final Scheme

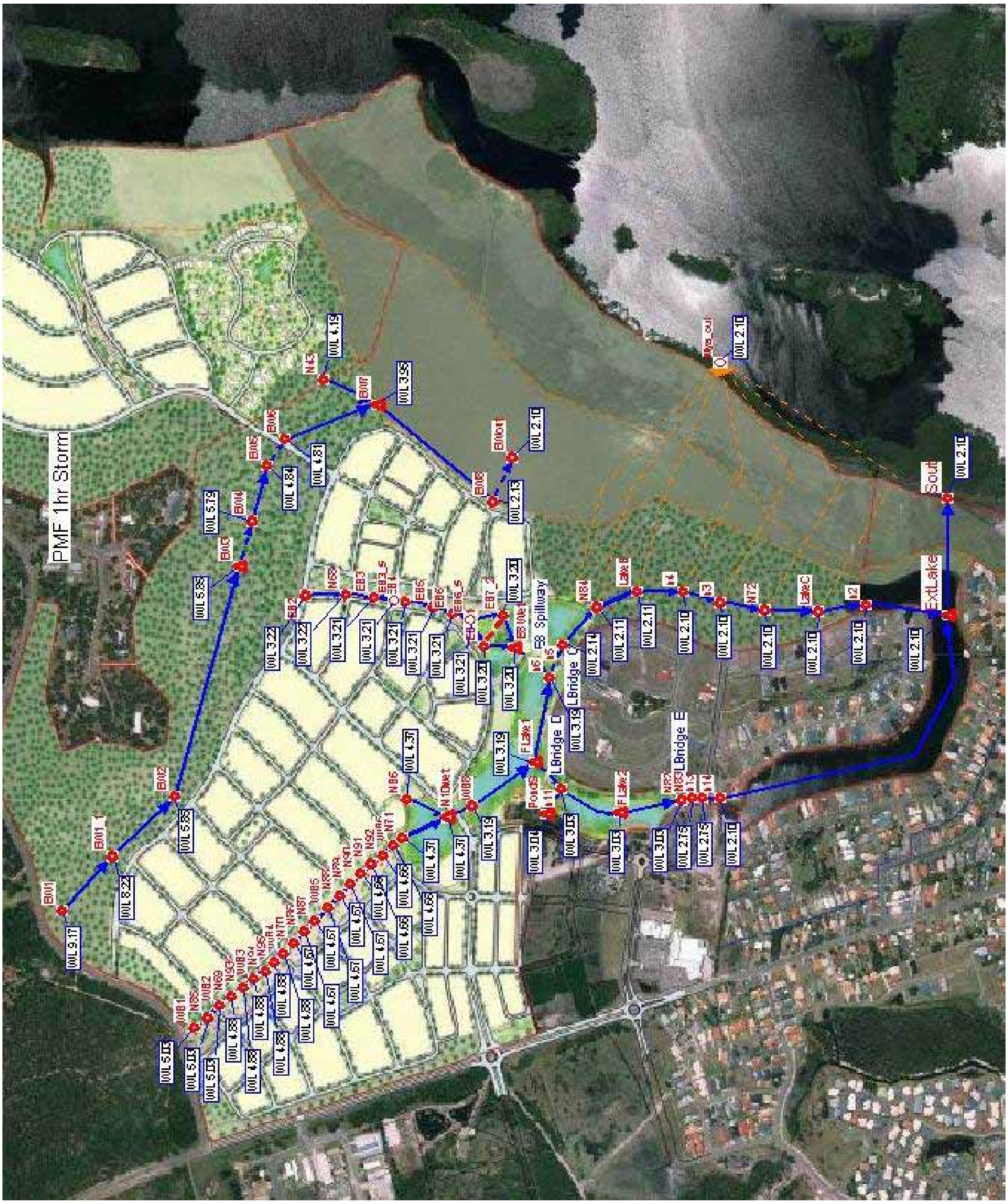

Figure 9
Local PMF Levels for 1 Hour PMP Storm – Final Scheme

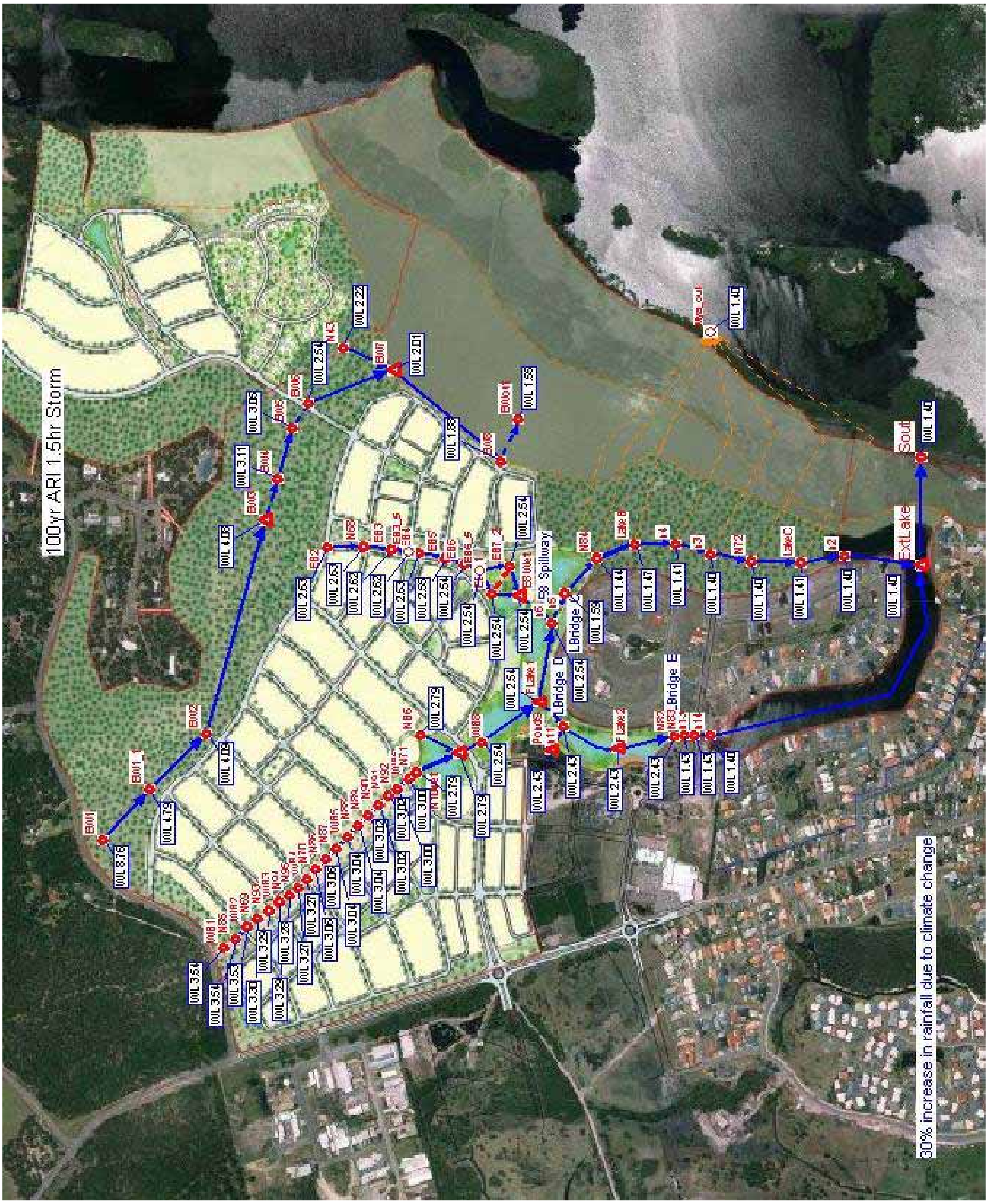

Figure 10
100 yr ARI Peak Flows and Flood Levels for 1.5 hour Storm Burst under Climate Change - – Final Scheme

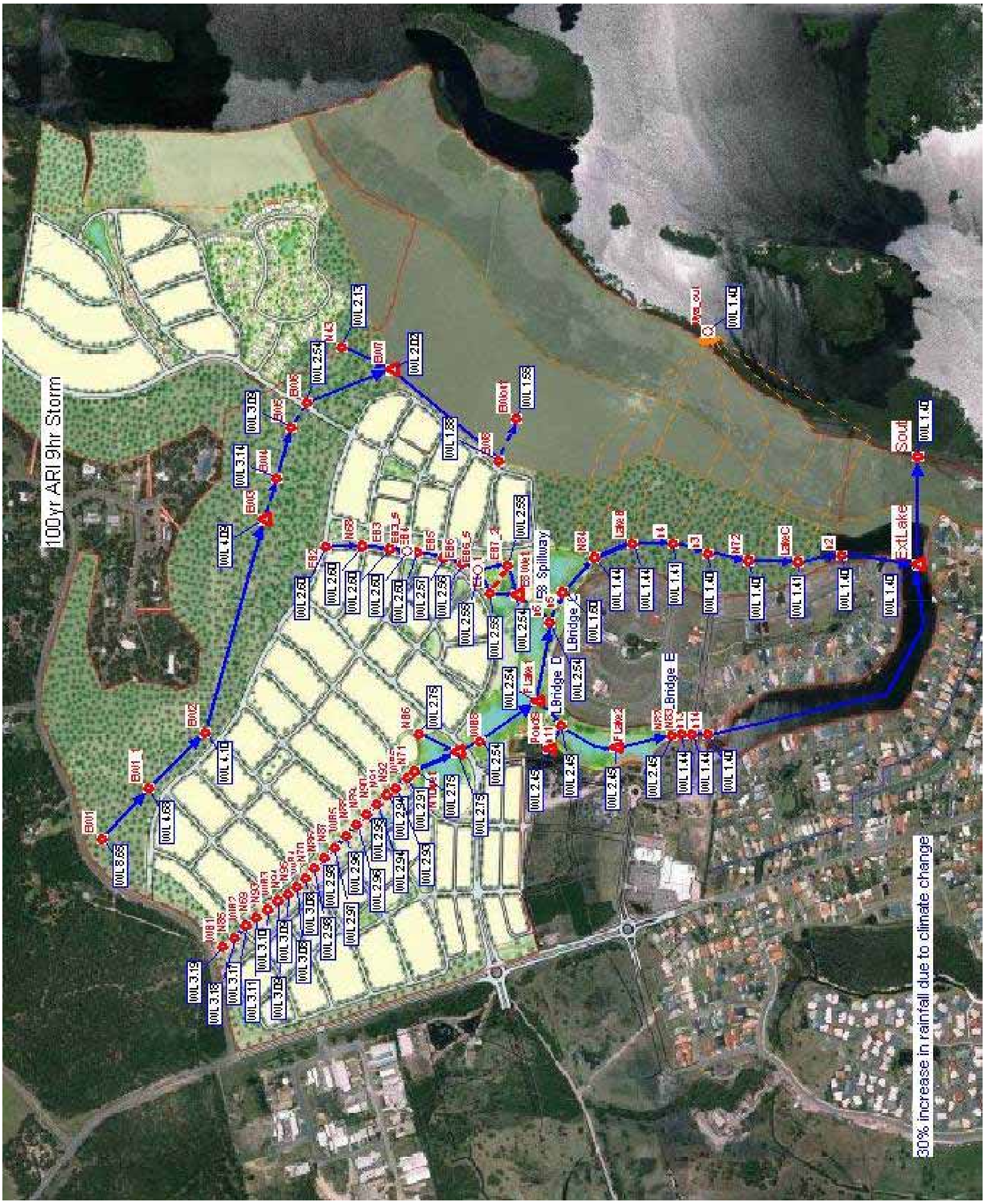

Figure 11

100 yr ARI Peak Flows and Flood Levels for 9 hour Storm Burst under Climate Change - Final Scheme

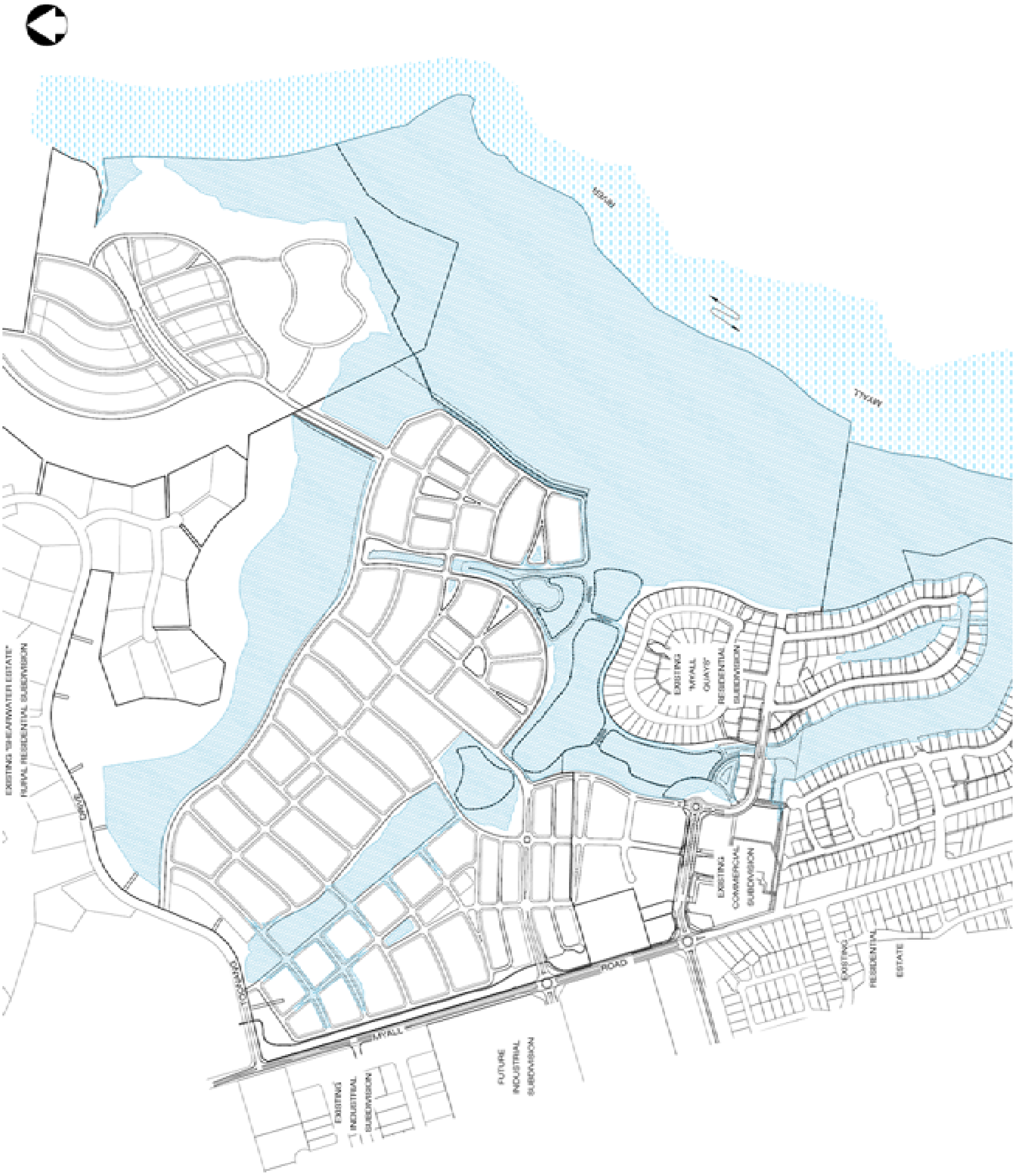

Figure 12
100 yr ARI Local Flood Inundation under Climate Change – Final Scheme

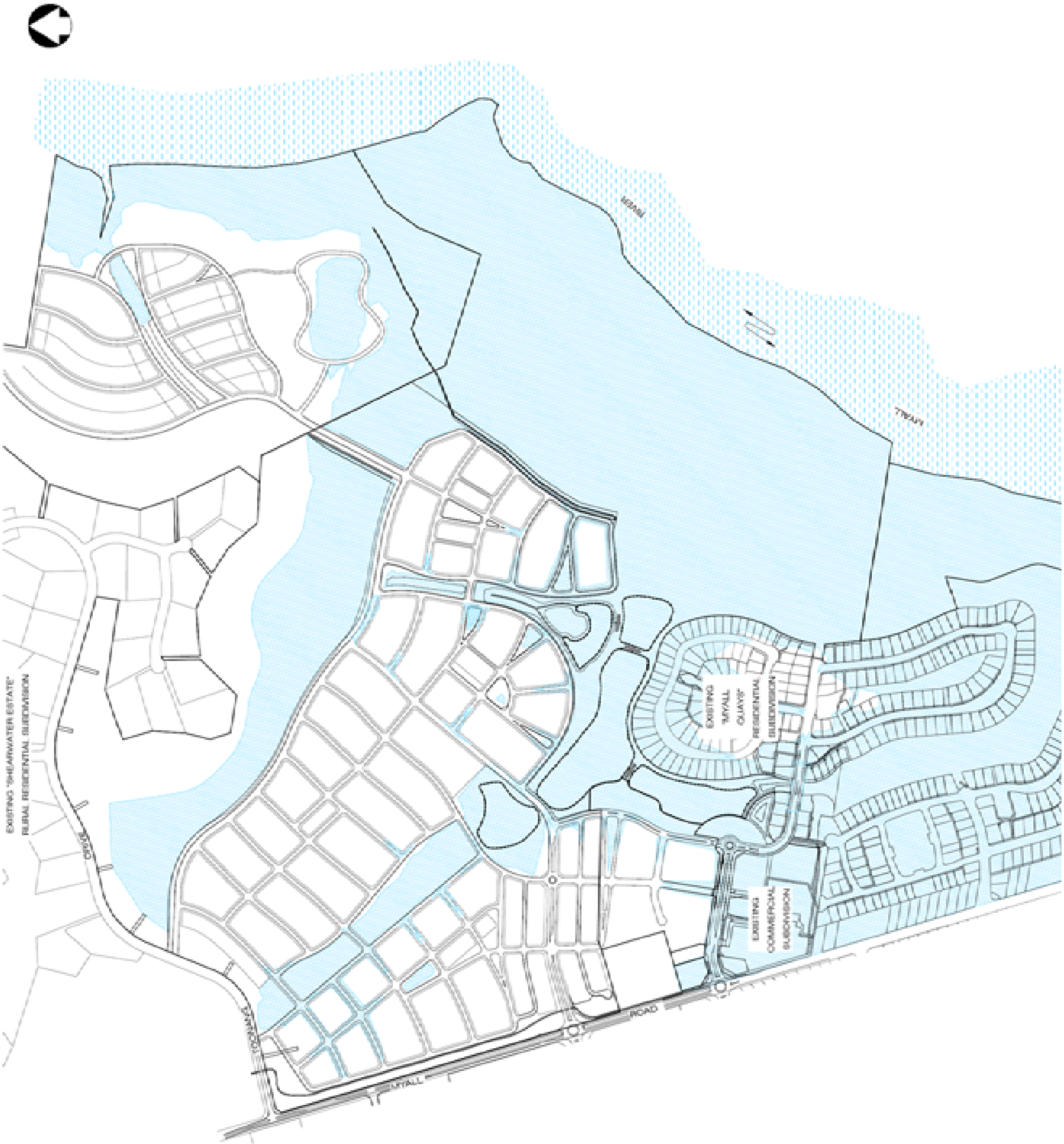

Figure 13
100 yr ARI Combined Flood Inundation under Climate Change – Final Scheme

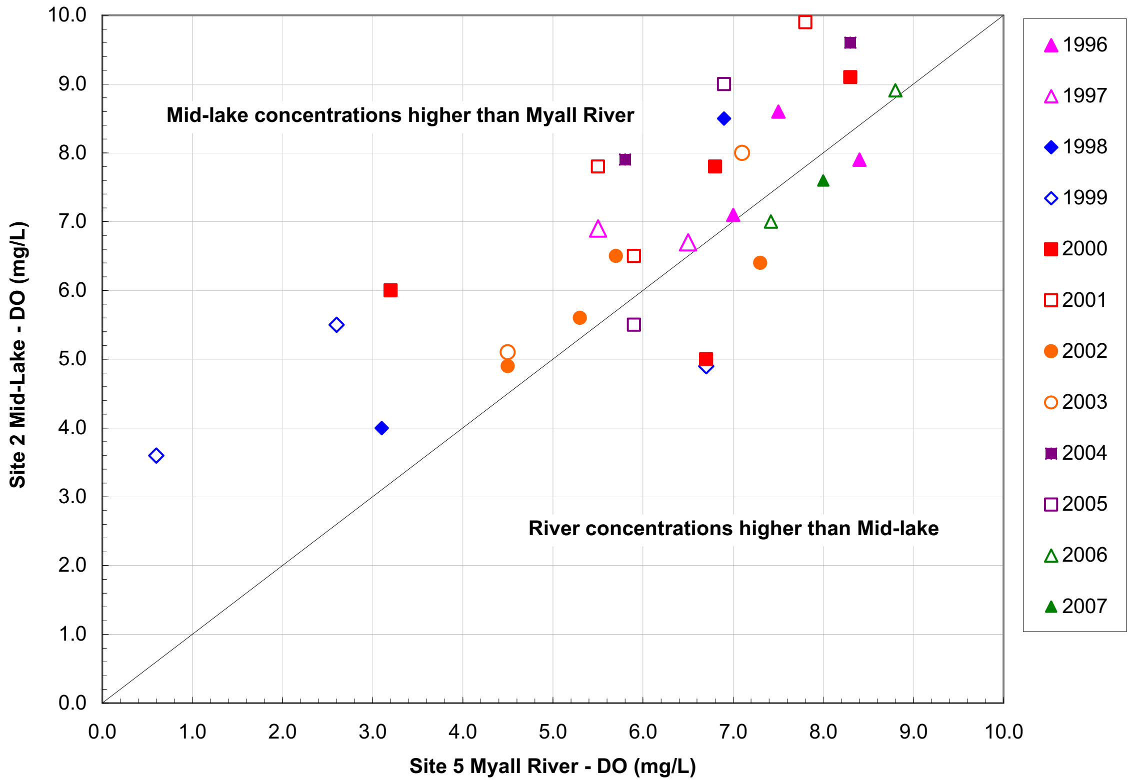

Figure 14
Comparison of DO Levels in the Existing Lake and the Myall River

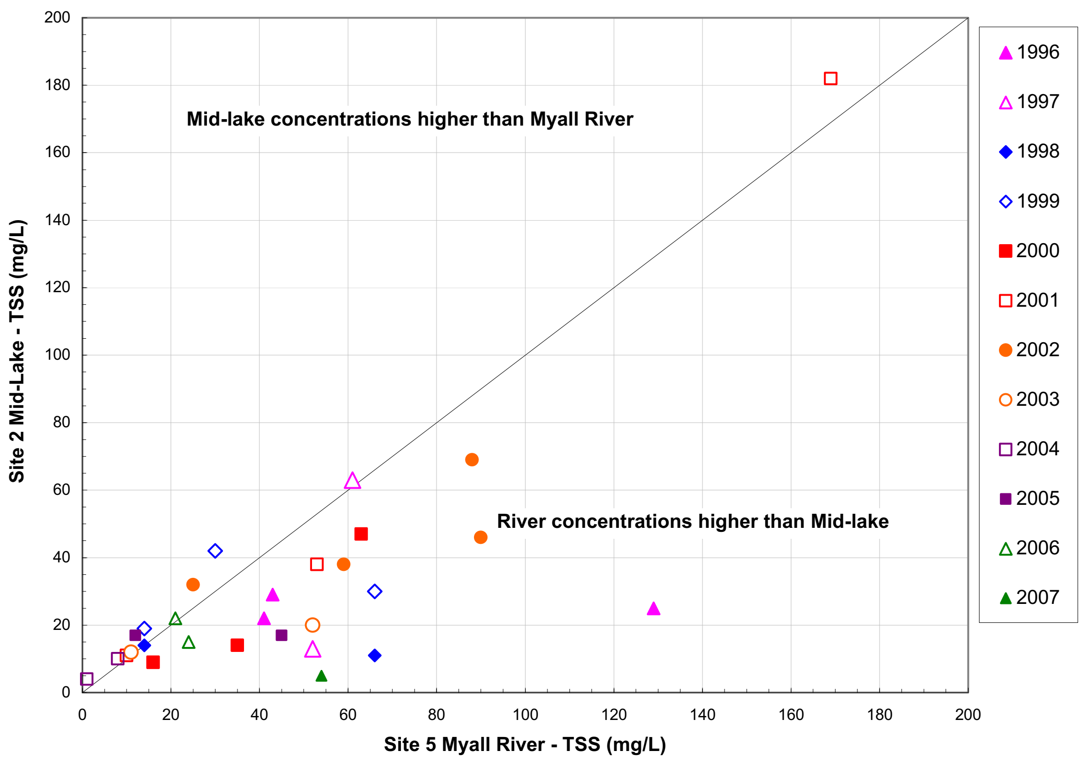

Figure 15
Comparison of TSS Levels in the Existing Lake and the Myall River

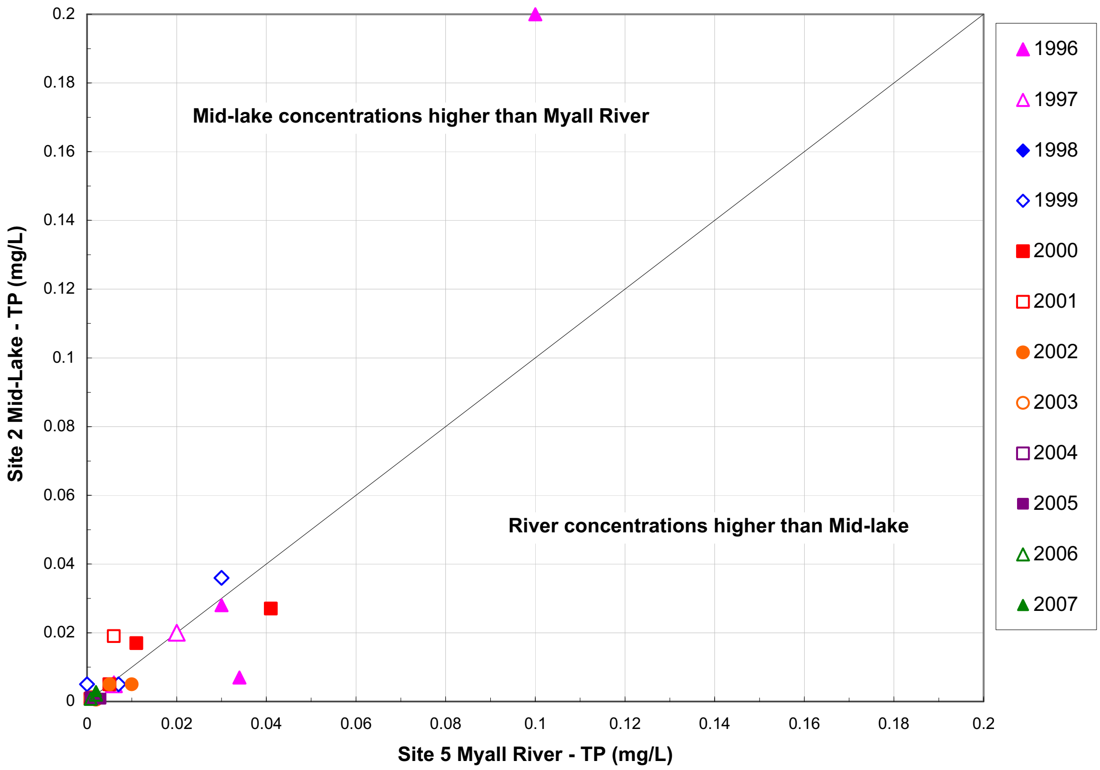

Figure 16
Comparison of TP Levels in the Existing Lake and the Myall River

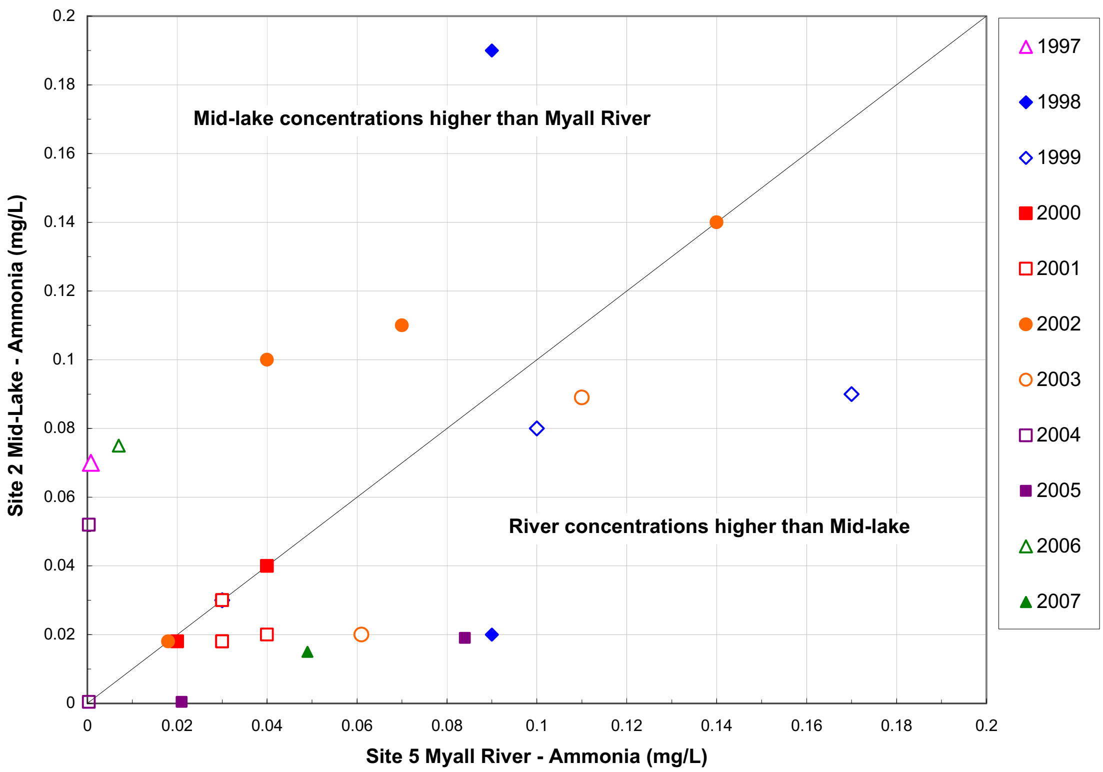

Figure 17
Comparison of Ammonia Levels in the Existing Lake and the Myall River