SGD1
C/- Tattersal Lander Pty Ltd

martens consulting engineers

Concept Integrated Water Cycle Management Strategy (Revised) Riverside, Tea Gardens, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1404136JR04V01
October 2015

Limitations Statement

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to provide a concept integrated water cycle management strategy for the Riverside development site in accordance with the scope of services set out in the contract / quotation between Martens & Associates Pty Ltd and SGD1 Pty Ltd c/- Tattersall Lander Pty Ltd (hereafter known as the Client). That scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources which may include for example site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Martens & Associates Pty Ltd may have relied upon and presumed accurate certain information (or absence thereof) relative to the site. Except as otherwise stated in the report, Martens & Associates Pty Ltd has not attempted to verify the accuracy of completeness of any such information (including for example survey data supplied by others).

The findings, observations and conclusions expressed by Martens & Associates Pty Ltd in this report are not, and should not be considered an opinion concerning the completeness and accuracy of information supplied by others. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings and conclusions are based solely upon site conditions, information and drawings supplied by the Client *etc*. in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Martens & Associates Pty Ltd and the Client. Martens & Associates Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

Head Office
Suite 201, 20 George Street
Hornsby, NSW 2077, Australia
ACN 070 240 890 ABN 85 070 240 890
Phone: +61-2-9476-9999
Fax: +61-2-9476-8767
Email: mail@martens.com.au
Web: www.martens.com.au

Document and Distribution Status

Author(s)	Reviewer(s)	Project Manager	Signature
D Galia, B Rose	D. Martens G. Taylor	D. Martens	

Revision No.	Description	Status	Release Date	Document Location			
				File Copy	Tattersall Lander P/L	SGD1	-
1	DA application	Final	08.10.2015	1E, 1P, 1H	1H	1P	

Distribution Types: F = Fax, H = hard copy, P = PDF document, E = Other electronic format. Digits indicate number of document copies.

All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Overview

This report has been prepared to support a Development Application for the proposed Riverside Development at Tea Gardens, NSW. It presents an updated approach to the management of ground and surface waters in response to a long history of consultation with State and Local Government agencies.

This report has been updated to address changes to the concept drainage layout design and flood assessment by Tattersall Lander P/L and the Martens and Associates previous Concept Integrated Water Cycle Management Plan (revised) dated January 2013 (report reference P0902346JR08V02) which was approved by the Department of Planning.

Site Hydrology – Drainage and Flood Management

A drainage and flood study (Tattersall Lander P/L, 2015) for the proposed development application lot layout was completed to investigate impacts of the proposed development, adjacent properties and downstream receiving environments. Detailed flood modelling concludes:

- Provision of storage and low flow discharge structures ensure environmental flows into the wetland buffer are maintained.
- Proposed level spreader ensures the development will not increase flow velocities during rare events.
- Existing flood levels remain unaffected.
- All lots remain flood free to the design 100yr event as a result of provision of floodways and site filling.
- The safety of future residents is catered for in the peak PMF event.

Water Quality

Detailed water quality modelling has been undertaken in accordance with BMT WBM Sydney Metro CMA *'Draft NSW MUSIC Modelling Guidelines'* (2010) to determine treatment measures required to achieve a Neutral or Beneficial Effect (NorBE) for post development water quality conditions, as well as satisfying Great Lakes Council DCP (2014) Chapter 11 (previously DCP 54) requirements.

Treatment measures include a combination of 'at source' (bioretention swales, rainwater tanks) and end of line (constructed wetlands) structures (where needed) to achieve these objectives. Water quality modelling concludes:

- NorBE test is satisfied.
- WSUD, including distributed and 'at-source' management measures will be effective in mitigating against any water quality impacts on receiving wetlands, river and groundwater system.

Groundwater

The groundwater assessment quantifies existing groundwater conditions and potential hydrologic and water quality impacts on adjacent SEPP 14 wetlands. A conceptual groundwater management plan has been prepared to outline potential risks resulting from the development on the aquifer and risk management methodology.

Outcomes from the groundwater assessment conclude that the proposed development will result in:

- No discernible impact from the proposed development on SEPP 14 wetland groundwater levels and water budgets
- No discernible impact on water quality and levels in existing brackish lake (J Lake)
- NorBE on groundwater resources for the site and surrounding areas.
- Largely unchanged groundwater regime from existing conditions. This is due to the distributed WSUD approach to water quality management and recharge where possible in the catchment.

Contents

Tables

1 Introduction

1.1 Background

This concept integrated water cycle management strategy (IWCMS or the 'strategy') has been prepared by Martens & Associates to support a Development Application (DA) for the proposed Riverside Development at Tea Gardens NSW. The report addresses the management of ground water and surface waters on the site in response to a long history of consultation with State and Local Government agencies.

The principle objective is to ensure Neutral or Beneficial Effect (NorBE) from the development on receiving groundwater and surface water systems to protect receiving waters and critical ecosystems including groundwater dependant ecosystems (GDEs). Overall management focuses on the use of 'at source' (i.e. 'distributed') stormwater treatment measures allowing preservation (to the extent possible) of existing ground water recharge mechanisms and surface water hydrology, such that there would be no significant impact on receiving waters and adjoining GDEs.

1.2 Site Description

The Riverside at Tea Gardens site is bounded by Myall River to the east and Myall Road to the west (Attachment 1A). 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 east. The site ranges in height from approximately 0.6m Australian Height Datum (AHD) (along the foreshore of the Myall River) to 20m AHD (at the northern end of the site adjacent to 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. The current land use on the site is cattle grazing.

1.3 Project Description

The Riverside at Tea Gardens site is already zoned 2(f) – Mixed Residential – Commercial for urban development. 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 commercial area located in the SW 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.

We understand that development approval is sought for the following key elements:

- Site subdivision into 767 small to medium residential lots, carried out in 16 stages.
- Site cutting and filling to achieve final levels of between 2.4 m and 5 m above Australian Height Datum (AHD).
- Construction of internal road and buried services networks.
- Creation of areas dedicated to open space, public recreation and stormwater management corridors.
- Creation of a future commercial area.

Refer to the staging plan prepared by Tattersall Lander (TL) (Attachment 1A) for further details.

1.4 Previous Investigations

A number of studies have been previously undertaken at the site in respect of water cycle management. These have been broadly summarised by Cardno in the IWMM report (2011) and Martens and Associates (MA) Concept Integrated Water Cycle Management Strategy (Revised) dated January 2013 (report reference: P0902346JR08V02).

1.5 Department of Planning Approved Martens and Associates Water Cycle Management Strategy (2013)

Martens & Associates prepared a "Concept Integrated *Water Management Strategy (Revised), Riverside, Tea Gardens, NSW*" in January 2013. The report was prepared to support a Concept Proposal Application under Part 3a of the EP&A Act (1979) for the Riverside Development at Tea Gardens, NSW. It presented a revised approach to the management of ground and surface waters in response to a long history of consultation with State and Local Government agencies.

Specifically, the assessment addressed concerns expressed by the NSW Department of Planning and Infrastructure (DoPI), NSW Office of Water (NOW) and Great Lakes Council over the previously prepared strategy by Cardno (2012). The report was approved by the DoPI.

The report included:

- A drainage and flood study (Tattersall Lander, 2012) to investigate impacts of the proposed development, adjacent properties and downstream receiving environments.

- A detailed water quality modelling in accordance with BMT WMB (2010) to determine treatment measures required to achieve a Neutral or Beneficial Effect (NorBE) for post development water quality conditions, as well as satisfying Great Lakes Council DCP (2014) Chapter 11 (previously DCP 54) requirements.

- A conceptual groundwater management plan was prepared to outline potential risks resulting from the development on the aquifer and risk management methodology.

1.6 Strategy Elements

Following receipt of the Tattersall Lander updated proposed development (2015) and associated lot layout the previous Martens and Associates WCMS (2013) was updated. Elements forming part of the updated integrated strategy include:

i) Site hydrology – drainage and flood management

An updated stormwater drainage concept plan and supporting hydrological model including flood assessment has been developed by Tattersall Lander Pty Ltd.

The concept drainage plan was developed in coordination with the water quality and groundwater management strategies. Key to this was the preservation of surface water hydrology on receiving environments including the adjacent SEPP 14 Wetlands.

As part of the works, Tattersall Lander prepared a detailed post-development site terrain or 'surface' which was used for water quality and groundwater modelling.

ii) Surface water quality

A revised stormwater management system has been formulated by Martens & Associates using current best practice WSUD philosophies for water quality tailored to the site. This includes compliance with:

- Great Lakes Council DCP (2014) Chapter 11 requirements.
- DoPI's and BMT WBM previous concerns and comments.
- NOW feedback.
- Draft NSW MUSIC Modelling Guidelines (BMT WBM, 2010).

The revised water quality management concept relies on "at-source" treatment structures and is integrated with groundwater and surface water management strategies for the development.

iii) Groundwater

An updated groundwater model and groundwater management strategy has been formulated by Martens & Associates. The revised model utilises additional groundwater data, including increased data coverage, and addresses concerns raised by various assessment agencies.

The groundwater management strategy integrates closely with the stormwater management strategy utilising 'at source' recharge mechanisms to ensure NorBE impacts on groundwater patterns and conditions particularly in relation to impact on critical receiving waters and GDEs.

2 Site Hydrology – Drainage and Flood Management

2.1 Overview

Tattersall Lander (2015) have completed a concept drainage layout design and flood assessment (Attachment 7) to investigate the impacts of flooding on the proposed development, adjacent properties and downstream receiving environments. It has been completed in accordance with Great Lakes Council requirements and the Floodplain Management Manual (NSW Government, 2005).

2.2 Site Hydrology Objectives

The objectives of the flood study were to:

1. Determine appropriate floodway designs, and the required fill levels within the proposed development.

2. Design a drainage system to mitigate any potential post development impacts on receiving downstream environments.

3. Assess the impact of the proposed development on adjacent development and environmental lands.

2.3 Conclusions

The Tattersall Lander study demonstrates that the proposed development will not have an adverse impact on flood behaviour on or around the site. Specifically it concludes:

1 The combination of provided storage and low flow discharge structures ensure environmental flows into the wetland buffer area are maintained once the site is developed.

2 The proposed level spreader designed for high flow discharge ensures the development will not result in an increase in flow velocities during rare events that would otherwise cause damage to downstream environments.

3 Existing flood levels remain unaffected by the proposal.

4 Proposed filling works plus floodway capacities ensure all lots remain flood free to the design 100yr event.

5 The proposed development design caters for the safety of future residents in the peak PMF event.

3 Water Quality Management

3.1 Overview

This water quality assessment determines treatment measures required to achieve adopted water quality objectives thereby protecting downstream receiving environments.

This assessment allows for a general specification of water quality structures, and will require refinement at detailed design stage.

3.2 Water Quality Objectives

Chapter 11 of Great Lakes Council's Development Control Plan (DCP) 2014 requires the following water quality performance targets be achieved for development of greenfields sites within their LGA:

- 90% reduction of gross pollutants (GPs) relative to pollution generation from development without treatment.
- Neutral or Beneficial Effect of total suspended solids (TSS).
- Neutral or Beneficial Effect of total phosphorus (TP).
- Neutral or Beneficial Effect of total nitrogen (TN).

The DCP (2014) defines 'Neutral or Beneficial Effect' (NorBE) as *'loads of pollutants from future development must be equivalent to or less than land use prior to development'*.

The DCP (2014) also requires stormwater management to incorporate the principles of Water Sensitive Urban Design (WSUD) whereby treatment structures form a 'treatment train' rather than single 'end of line' structures.

3.3 Reference Documents

Table 1 provides a summary of relevant past documentation and how these have been utilised in preparation of this assessment.

Table 1: Reference documentation summary

Document	Comment
BMT WBM (2010) *'Draft NSW MUSIC Modelling Guidelines'* prepared for Sydney Metropolitan CMA	These guidelines were recommended by BMT WBM (2012) to be used for water quality modelling for the proposed development.
BMT WBM (June, 2012) '*Review of Water Quality Management for the Proposed Riverside at Tea Gardens Development – Final Report*'	Review of previous surface water management assessment undertaken on behalf of NSW Department of Planning for the proposed development
Martens and Associates (2012) *'Concept Outline of Revised Water Management Strategy; Riverside, Tea Gardens, NSW'*	Prepared to provide a review of correspondence relating to previous surface water management proposals for the development and to provide recommendations for an amended water management strategy.
BMT WBM (July, 2012) '*Riverside at Tea Gardens Residential Subdivision Revised Concept Plan*'	A review of Martens and Associates (2012) concept outline for water management at the site. Provides additional recommendations to BMT WBM (June, 2012).
Martens and Associates (2013) *'Concept Integrated Water Cycle Management Strategy (Revised); Riverside, Tea Gardens, NSW'*	A review of Martens and Associates (2013) concept outline for water management at the site detailing the drainage, flood, water quality and groundwater study results approved by the NSW Department of Planning

3.4 Modelling Aims

For the purposes of water quality modelling, 4 receiving environments were noted as being potentially affected by development at the site:

1. Myall Creek
2. SEPP 14 wetlands
3. Existing 'J' Lake
4. Site groundwater system and groundwater dependant ecosystems (GDEs)

The groundwater element is considered in Section 6. Given the existing site has a number of drainage outlets into the wetlands, the wetlands were further spilt into 3 separate receiving 'nodes' ('Wetland 1', 'Wetland 2' and 'Wetland 3')to ensure water quality compliance along its entire length.

The aim of this assessment is therefore to achieve the water quality objectives for each of the 5 identified downstream surface water receiving environments.

Receiving environments ('nodes') are shown in Attachment 3A (Figure 1 and 2) and Attachment 3C.

3.5 Modelling Methodology

3.5.1 Overview

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*, Version 6.1) developed by the CRC for Catchment Hydrology was utilised to evaluate pre and post development pollutant loads from the site.

The following modelling scenarios were considered:

1. Pre Development – the existing site was modelled to determine baseline pollutant generation rates for TSS, TN and TP.

2. Post Development (untreated) – the developed site was modelled without water quality structures to determine baseline gross pollutant generation rates.

3. Post Development (treated) – the developed site was modelled with water quality structures included to achieve adopted objectives for nutrients and gross pollutants.

Pre and post development (with treatment nodes) MUSIC model layouts are provided in Attachment 3A.

3.5.2 Climate Data

Base rainfall data was sourced from Williamtown RAAF from 1997 – 2006. In accordance with BMT WBM (June, 2012) the rainfall data file was adjusted using Hawks Nest data to make an allowance for the increased rainfall experienced at the site. The conversion factor between the annual averages for the 2 stations was calculated to be 1.2 (i.e. Hawks Nest rainfall data approximately 120% higher than Williamtown RAAF at the time of analysis).

Average monthly areal potential evapotranspiration (PET) was sourced from '*Climatic Atlas of Australia – Evapotranspiration*' (Bureau of Meteorology, 2001). Inputs are summarised in Table 2.

Table 2: PET inputs – Hawks Nest (BOM, 2001).

Month	PET (mm)
January	180
February	135
March	135
April	90
May	70
June	50
July	50
August	70
September	95
October	135
November	150
December	175

A 6 minute timestep was adopted for the water quality analysis.

3.5.3 Model Input Parameters

Input parameters for pre and post development MUSIC modelling are in accordance with BMT WBM (2010) and based on development design by Tattersall Lander (August 2015).

A summary of input parameters and their source is provided in Attachment 3B.

3.5.4 Catchment Areas

3.5.4.1 Pre Development

Pre development catchment areas were identified based on the following process:

- Upslope catchments affecting the site were provided by Tattersall Lander.
- SEPP14 wetland buffer area was calculated based on aerial photography interpretation and site investigations.

- The site was split into 5 catchments based on site hydrology, recent site aerial and 0.1m contours. The 5 catchments were directed into 5 separate receiving environments ("receiving nodes"):

    - J Lake
    - Wetland 3 (southern extent of SEPP 14 wetland)
    - Wetland 2 (middle of SEPP 14 wetland)
    - Wetland 1 (northern extent of SEPP 14 wetland)
    - Myall Creek

- Catchments land use was defined as 'forest' or 'agricultural' source nodes based on aerial interpretation and detailed site investigations (inspections, walkovers and geotechnical testing).

- Each catchment was split into subcatchments based on soil type(s) within upper 0.5m of the ground surface (Attachment 3C) to dictate pervious input parameters (Attachment 3D). Soil types were based on the findings of intrusive geotechnical testing (49 boreholes) undertaken by Coffey (2008) and Martens and Associates (2009 and 2012). Site testing plan is provided in Attachment 3H.

- Across the site seven soil landscape were identified :

    - Sandy clay
    - Clayey sand
    - Clayey sand overlying sandy clay
    - Sand overlying sandy clay
    - Loamy sand
    - Loamy sand overlying sand
    - Sandy clay overlying clay

  Borelogs are provided in Attachment 3I.

- Soil landscape for upslope catchments was taken to be sandy clay loam based on the Port Stephens Soil Landscapes 1:100 000 sheet (Department of Land and Water Conservation, 1995).

- Soil landscape for wetland buffer areas was assumed to be clayey sand.

3.5.4.2 Post Development

Post development catchment areas were defined based on the following process:

- Upslope areas affecting the site and wetland buffer areas remained consistent with the pre development model.

- The site was split into 5 catchments to be consistent with the pre development model and to allow assessment of water quality impacts at discrete receiving environments. However, due to proposed site drainage, sub catchment areas differed somewhat from the pre development model. Total modelled site catchment area is consistent with pre development (Attachment 3D).

- Proposed residential/development areas within each catchment were split into smaller subcatchments by Tattersall Lander according to proposed site drainage.

- Individual sub-catchments were further split into roof, road, bioretention swale and residential areas ('nodes') by Tattersall Lander (Attachment 3D). 'Residential' nodes included driveway, footpath and pervious lot areas (such as landscaping and lawns).

- Proposed floodway areas were calculated based on proposed development layout provided by Tattersall Lander. These areas were assigned the 'urban' node.

- The 'Myall Creek' catchment floodway includes re-forested corridor 20m wide and 330m long leading down to the proposed wetland (Section 3.6.2) and the discharge point into Myall Creek.

- Re-forestation areas were calculated based on proposed development layout provided by Tattersall Lander. Re-forestation areas include both areas to be planted out (i.e. actively revegetated) and areas to remain undeveloped that are assumed will regenerate naturally once agricultural practices cease. These areas were assigned the 'forest' node.

- Based on advice from the Client, we understand the majority of the site is to be filled by varying amounts to achieve flood levels. We understand soil type for the post developed site is 100mm loamy sand topsoil overlying sand. This soil type was utilised for pervious input parameters for all post development source nodes within the development footprint (Attachment 3D).

- o Upslope areas, wetland buffers and onsite retained forest areas had soil landscapes properties consistent with the pre development model.

3.6 Treatment Train Philosophy

The preferred stormwater treatment strategy for the site is based on the principles of WSUD. It utilises 'at source' controls and some end of line structures (where required) to provide a treatment train that ensures treatment objectives are satisfied and the integrity of downstream receiving environments are maintained. Individual stormwater quality improvement devices (SQIDs) are outlined in the following sub sections. A conceptual layout of the proposed treatment train is provided in Attachment 3E.

3.6.1 Bioretention Swales

Road side bioretention swales ('bioswales') are proposed to provide 'at source' treatment of developed areas. Approximately 2% in standard residential streets and up to 4-5% in areas of open space will be utilised for bioswales to achieve water quality outcomes.

Bioswales provide treatment through media filtration, biological uptake of nutrients, evapotranspiration and detention. Although infiltration is also a feature of these structures that provides treatment, this feature has been set to 0mm/hr to ensure sufficient water quality treatment is provided prior to infiltration in an effort to protect downslope receiving environments that are reliant on groundwater quality (Section 3.7).

On advice from BMT WBM (October 3, 2012) the highflow bypass was set to 100m^3/s (i.e. all flow is directed to the bioswales) to allow the bioswales to also act as gross pollutant traps (GPTs). Maintenance of the bioswales will therefore require regular removal of gross pollutants captured.

Bioswale input parameters are provided in Attachment 3B. Proposed bioswale design is provided in Attachment 3F.

3.6.2 Rainwater Tanks

Rainwater tanks are required to capture roof water from individual residential lots with the following parameters used:

- A 5 kL rainwater tank shall be used for individual lots within the 'Myall Creek' catchment with 2 kL rainwater tanks per lots being used for all other catchments.
- A nominal amount of 0.24 kL/day/lot for internal reuse was modelled to account for likely reuse of toilet flushing and laundry.
- A nominal amount of 112 kL/year/lot was used for external reuse.
- Volume of rainwater tanks were modelled at 80% of total capacity.

3.6.3 Wetland

A wetland is required within the 'Myall Creek' catchment (the proposed northern precinct) to reduce nitrogen and phosphorus levels prior to discharge into Myall Creek. Modelling indicates the following preliminary specifications are required to achieve water quality objectives:

- Surface area of 1,300 m^2
- Batter slopes of 1(V):3(H)
- Extended detention depth of 0.35 m
- Total depth of 0.75 m
- Permanent pool volume of 562 m^3
- 0 mm/hr exfiltration (i.e. the wetland will be lined)
- Outlet pipe diameter of 61 mm and overflow weir width of 3.0m (preliminary design factors)

The wetland shall be located offline to the east of the main northern precinct development footprint (Attachment 3A). A highflow bypass channel shall be located within the northern precinct floodway to carry flows exceeding 0.7 m^3/s (the peak Q_{3mth} inflow into the floodway as provided by Tattersall Lander) through the floodway and directly to Myall Creek.

3.7 MUSIC Model Run Types ('Modes')

The post development model was run in two 'modes'

Mode 1: Infiltration capacity of bioswales was 'switched off' by setting exfiltration to 0mm/hr. This mode was used for water quality assessment.

Mode 2: infiltration capacity of bioswales was 'switched on' by setting exfiltration rate to a suitable value. This mode was used to determine site water balances.

3.8 MUSIC Results

3.8.1 Suspended Solids and Nutrient Loads

Modelling results achieved are summarised in Table 3. These demonstrate that the WSUD approach results in the NorBE test being satisfied.

Table 3: MUSIC results - NorBE assessment.

Receiving Environment	Parameter	Pre Development (kg/y)	Post Development (kg/y)	Achieved Reduction (%)	Complies (Y/N)
Myall Creek	TSS	5520	3170	42	Y
	TP	21.8	21.7	0	Y
	TN	231	189	18	Y
Wetland 1	TSS	2630	1040	60	Y
	TP	8.39	3.51	58	Y
	TN	74.9	36.6	51	Y
Wetland 2	TSS	52500	20000	62	Y
	TP	204	98.2	52	Y
	TN	1310	729	44	Y
Wetland 3	TSS	10700	5140	52	Y
	TP	41.2	32.6	21	Y
	TN	286	265	7	Y
J Lake	TSS	3230	1440	55	Y
	TP	14	10.5	25	Y

	TN	91.2	80	12	Y
Total	TSS	73800	31000	58	Y
	TP	290	166	44	Y
	TN	2000	1310	35	Y

3.8.2 Gross Pollutant Loads

Table 4 provides an assessment of the treatment train effectiveness for gross pollutant loads generated from the site. This demonstrates that pollutant load reductions are met.

Table 4: MUSIC results - treatment train effectiveness – gross pollutants.

Receiving Environment	Untreated (kg/yr)	Treated (kg/yr)	Achieved Reduction (%)	Complies (Y/N)
Myall Creek	2440	57	98	Y
Wetland 1	0	0	100	Y
Wetland 2	6910	0	100	Y
Wetland 3	3210	0	100	Y
J Lake	1720	0	100	Y
Total	14280	57	100	Y

3.8.3 Nutrient Concentrations in Treated Stormwater

Table 5 provides median concentrations of nutrients in stormwater following treatment. These are used for comparison to existing groundwater quality data at the site.

Table 5: Nutrient concentrations.

Receiving Environment	TSS (mg/L)	TP (mg/L)	TN (mg/L)
Myall Creek	5.68	0.043	0.477
Wetland 1	2.910	0.015	0.146
Wetland 2	3.130	0.086	0.534

Wetland 3	3.920	0.085	0.544
J Lake	4.520	0.101	0.657

3.8.4 Conclusion

The proposed treatment train achieves site water quality objectives outlined in Section 3.2 and will have a beneficial impact on stormwater quality discharging to downstream sensitive receiving environments.

Treatment devices assumed no infiltration (despite this occurring in reality) to ensure water quality targets were being achieved prior to any infiltration into the groundwater table. The proposed treatment train therefore also protects the integrity of the groundwater quality, which downstream SEPP 14 wetland environments rely on.

3.9 Groundwater Recharge Assessment

Using the MUSIC node water balance feature, the following factors were extracted:

1. Total rainfall inflow
2. Evapotranspiration loss
3. Baseflow losses for source nodes
4. Infiltration loss for treatment nodes
5. Total storm outflow

In order to estimate the volume of water which could conceivably *reach* the groundwater system, the following method was used to estimate areal 'net infiltration' rates:

Net infiltration rate = (Source node baseflow + treatment node infiltration)/(total source and treatment node area)

Whilst the above method may result in some overestimation of infiltration, it provides a convenient means of comparing infiltration rates between different parts of the study area. We note that MUSIC is not a distributed groundwater model and not capable of the same level of modelling sophistication as MODFLOW.

The above approach therefore provides a means of scaling MUSIC model outcomes to the calibrated MODFLOW recharge rates for existing conditions. The same scaling factor can then be used to estimate

MODFLOW recharge rates under developed conditions using MUSIC model water balance results data for developed conditions.

Section 6 covers the above in more detail.

3.10 Compliance with BMT WBM Recommendations

This updated WCMS is compliant with BMT WBM requirements as per Table 6 of Martens and Associates previous WCMS report (January 2013).

3.11 Conclusions and Recommendations

The revised stormwater management system and MUSIC model is consistent with both the NSW MUSIC modelling guidelines (BMT WBM 2010) and the BMT WBM reviews (June and July, 2012). Results of MUSIC modelling indicate that water quality objectives will be met by the proposed stormwater treatment train.

The proposed management system is consistent with the principles of Water Sensitive Urban Design (WSUD) as the proposed treatment strategy utilises 'at source' controls and a 'treatment train' rather than relying solely on large end of line structures. This approach is considered the most appropriate for the site and will provide the best outcome for receiving environments

We note that further refinement of the model at the detailed design stage may alter the sizes of proposed treatment structures.

4 Erosion and Sediment Control Plan

4.1 Overview

Temporary erosion and sediment controls (ESC) are to be constructed prior to the commencement of any work to eliminate the discharge of sediment from the site. The controls are to be installed in accordance with the ESC plan and details provided in Attachment 7A and the requirements of Landcom's "Managing Urban Stormwater: Soils and Construction", Volume 1, 4th edition, March 2004.

4.2 Control Devices

The preferred ESC strategy for the site is based on the principles outlined in Landcom's "Managing Urban Stormwater: Soils and Construction", Volume 1, 4th edition, March 2004. It utilises end of line structures (where required) to ensure the integrity of downstream receiving environments are maintained. An ESC plan should be prepared for each stage(s) of development prior to works commencing. Individual ESC devices are outlined in the following sub sections.

4.2.1 Level Spreader

Level spreaders shall be provided at stage 1a and 1b prior to discharging flows to the SEPP wetlands. The devices shall be used in conjunction with the energy dissipater to minimise erosion and flow velocities leaving the site.

4.2.2 Energy Dissipater

The energy dissipaters are to be provided at the outlet of each major storm water outlet system to reduce total energy of flowing water and minimise erosion of soils.

4.2.3 Sediment Fences/Alternative Fence

Sediment fences are to be provided downslope of the development at each stage to trap sediments from escaping the site, fences shall be provided at the lowest points of each stage where feasible.

4.2.4 Stabilised Site Access

Access to the site and the staged development shall be provided to reduce the likelihood of vehicles tracking soil materials onto public roads and ensure all-weather entry/exit. These devices shall be located at the entrance of each of the staged works.

4.2.5 Straw Bales

Straw bales shall be used over hay bales to eliminate the potential for nuisance seeds washing into the SEPP 14 wetlands promoting weed growth. They are to be provided downslope of the development at each stage to reduce large flows of water and filter sediments.

4.3 Control Measures

Before works commence on site the following ESC measures are required to be provided.

- All runoff and ESCs are to be installed before any works are carried out at the site.
- Entry and exit points to the site are to be established to minimise the disturbance of soils.
- All contaminated surface waters and debris from the site must be screened, collected and pollutants captured within the site.
- Contamination of surface waters on downslope lands must be mitigated by installing sediment control devices downslope of the disturbed areas to capture sediment and debris escaping from the site.
- During windy weather, large, disturbed, unprotected areas shall be kept moist (not wet) by sprinkling with water to keep dust under control.

ESC measures must be maintained in good working order, and be repaired or replaced throughout the course of works on site. This may include, but is not limited to, removing sediment trapped in sediment fences, topping up the gravel on the stabilised access, repairing any erosion of drainage channels and repairing damage to sediment fences.

5 Monitoring and Adaptive Management Plan

5.1 Overview

Upon completion of works it is necessary to monitor the established treatment systems to quantify the impact on the downstream receiving environment. The monitoring and adaptive management plan shall focus on nutrient concentrations entering/leaving a treatment system and provides a database which enables the analysis of treatment system trajectory.

5.2 Management Plan Objectives

The objectives of the monitoring and adaptive management plan are to:

- Maintain the long term viability of treatment systems.
- Ensure water quality control devices meet NorBe requirements and can be maintained realistically.
- Keep maintenance costs to a minimum through early detection.

5.3 Monitoring requirements

To ensure monitoring is done effectively it is important to record data (service reports, water quality samples, etc) accurately and maintained in a reliable database. Field data collected should be recorded on appropriate data sheets and kept electronically. Refer to Attachment 8 for sample table to be used.

An annual report is to be completed by suitably qualified person/s to document and evaluate monitoring results for the previous 12 month period. All service reports, fault sheets (including follow-up action documentation) to be attached. Recommendations for any necessary changes to the operation of the system, or any required system improvements are to be made.

It is anticipated that following 12 months of the monitoring and maintenance program, positive results should allow for reduction of the monitoring sampling frequency.

A detailed stormwater monitoring plan should be prepared during the detailed design phase of the development and correspond to the staged development.

5.4 Maintenance requirements

To ensure the long-term viability of the treatment systems implemented regular maintenance will be necessary and in accordance with manufacturers recommendations. These include, but are not limited to, mechanical components, structural components, embankments, batters, banks, sediment removal and disposal, water body, water levels and other data, water levels, water quality sampling and analysis, macrophytes, weeds, algae and mosquitoes. A detailed maintenance schedule shall be provided at the detailed design stage outlining the actions to be taken and frequency of the components mentioned above.

6 Groundwater Assessment

6.1 Overview

As part of the revision of the integrated water cycle management strategy, the previous groundwater assessment (MA, 2013) has been updated to reflect the new development lot layout and associated Development Application.

The revised groundwater assessment (MA, 2013) had included:

1. Review of site previous hydrogeological investigations and collation of key data.

2. Collection of additional site groundwater data including:

   - Groundwater level measurement at existing site bores and at newly installed bores in areas lacking data coverage.

   - Groundwater quality sampling.

   - Soil permeability testing.

3. Revision of numerical groundwater models for the existing and developed site conditions incorporating:

   - Additional collected groundwater data.

   - Revised strategy of 'at source' recharge for the developed site model.

6.2 Groundwater Objectives

The principle objectives of the MA (2013) strategy with regard to groundwater were:

1. Preserve Water Quality
   Existing groundwater quality to be preserved or improved.

2. Preserve Groundwater Levels
   Ensure groundwater levels critical for GDEs (i.e. SEPP 14 wetland) are not disturbed.

3. Preserve Flow Patterns and Water Balance
   Maintain existing groundwater flow patterns and flow budgets to critical ecosystems (SEPP 14 wetlands and the existing saltwater (J) lake).

6.3 Existing Groundwater Conditions

6.3.1 Conceptualisation of Aquifer System

Groundwater is confined within a shallow to medium depth marine sand deposit (with some areas of clay deposit) that sits at or above sea level and adjoins a bed rock controlled hill in the north and north west of the site. The aquifer is bounded by Myall River to the east and Port Stephens associated bays and creeks to the south/west.

Water table depths are frequently shallow and typically less than 1-2m below existing ground level. Groundwater depth variation is minimal spatially across the majority of the site in response to minimum site grades. Water levels within the aquifer are significantly dependant on incident rainfall and sea level rather than other catchment processes such as run-on.

A number of existing small incised man-made channels drain surface water and intermittent shallow groundwater to the lower lying heath and wetland areas to the site's east.

6.3.2 Available Data

6.3.2.1 Previous investigations

This assessment draws from a number of previous groundwater investigations conducted on the site. More specifically, groundwater level data, water quality results and geotechnical information has been utilised from:

- Coffey Partners International (February, 1996), Myall Quays Development Groundwater and Surface Water Study.

- Coffey Geotechnics (October, 2007), Groundwater Assessment Riverside Development, Tea Gardens.

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

- Martens & Associates (January, 2013), Concept Integrated Water Cycle Management Strategy (Revised), Riverside, Tea Gardens, NSW.

6.3.2.2 Site Groundwater Monitoring Bores (GMBs)

A total of 19 GMBs exist across the site including three recently constructed bores (GMB201, GMB202 and GMB203) and 16 remaining bores from previous investigations. Bore locations are indicated on Figure 3 (Attachment 6A).

6.3.2.3 *Geotechnical*

Aquifer material generally comprises fine to medium grained sands with some cemented layers (coffee rock). However, variations in soil landscape (Section 3.5.4) do exist across the site resulting in variations in hydraulic conductivity and recharge capacity.

6.3.2.4 *Hydraulic Conductivity*

In-situ Hydraulic conductivity (K) testing (Table 6) was undertaken in September 2012 utilising single bore slug tests (Hvorslev method, 1981) on all existing site bores. Calculation sheets are provided in Attachment 6D. The site was categorised into zones of equivalent hydraulic conductivity for groundwater modelling purposes (Figure 16, Attachment 6A).

Table 6: Measured in-situ hydraulic conductivity.

GMB	K (m/d)	K Zone (Figure 16)	Adopted K (m/d)
GMB1Aa	6.5	1	4.5
GMB3	11.7	2	10
GMB4	13.1	2	10
GMB5	18.4	5	16
GMB6	17.0	5	16
GMB7	4.4	1	4.5
GMB8	3.5	1	4.5
GMB9	4.5	1	4.5
GMB10	16.6	5	16
GMB11	3.1	1	4.5

GMB12	4.8	1	4.5
GMB21	9.8	2	10
GMB22	6.7	2	10
GMB23	8.6	2	10
GMB24	8.9	2	10
GMB25	3.6	7	3.5
GMB201	4.8	1	4.5
GMB202	16.3	5	16
GMB203	4.0	1	4.5

6.3.2.5 Specific Yield

Specific Yield (S_Y) is likely to be of the order of 0.1 to 0.15 based on review of Coffey (February, 1996) and our experience with similar aquifers.

6.3.2.6 Water Level Data

Historical groundwater level measurements at established GMBs are collated in Attachment 6B. The data includes a long history of instantaneous dipped levels and also some periods of continuous monitoring with data loggers. It is considered that the data set is satisfactory for the purposes of steady state groundwater modelling for the proposed development.

Continuous monitoring undertaken in July 2009 is presented in Figure 4 (Attachment 6A) to illustrate response to tidal and rainfall variation.

The following comments are made based on review of site groundwater level data:

1. Groundwater levels are generally shallow.

2. Groundwater resurfaced at times at GMBs 7 and 23 during the Martens and Associates (July, 2009) continuous data logging period.

3. Short-term groundwater level fluctuations are typically <1m and can occur within hours of heavy rainfall.

4. Lake levels are consistently lower than groundwater levels suggesting that groundwater discharges to the lake in the vicinity of the existing GMBs. Discharge of groundwater to the lake is expected to occur

around the majority of the lake based on likely groundwater gradients.

5. Groundwater response to rainfall is shown to be rapid, occurring within 1-2 days of incident rainfall. Groundwater responses appear more substantial at higher ground elevations.

6.3.2.7 Groundwater Quality

Historical groundwater quality data at established GMBs are collated in Attachment 6C and summarised in Table 7 with site data grouped and compared against lake data.

Table 7: Summarised groundwater quality data.

Analyte	Site GMB Median [1]	Site GMB Mean [1]	Lake Median [1,2]
pH	5.6	5.6	6.1
TDS (mg/L)	200	1653	5565
Chloride (mg/L)	65	847	2919
Sulphate (mg/L)	16	125	431
Magnesium (mg/L)	6.1	60.2	181.5
Calcium (mg/L)	3.6	19.7	59.0
EC (us/cm)	264	2151	7091
TN (mg/L)	2.5	46.6	0.7
TP (mg/L)	0.41	4.35	0.07

Notes:

[1]. Laboratory detection limit used where result below detection limit. [2] Median and Mean results equal as based on 2 data points

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). Results are summarised in Table 8 and plotted in Figure 5 (Attachment 6A). Results indicate saline/brackish lake water does not migrate from lake to local groundwater system. This is expected given the groundwater gradient is towards the lake.

Table 8: Summary of continuous groundwater EC (µS/cm) monitoring.

GMB	1A [1]	2A [1]	25 [1]	26 (lake) [1]
Mean	255	155	229	10285
Minimum	240	140	180	7830
Maximum	260	150	380	13150
Range	20	10	200	5320

Notes:

1. Martens and Associates (July, 2009) continuous data logging (04/06/2009 to 06/07/2009) at 0.5 hr logging frequency.

The following comments are made based on review of site groundwater quality data:

1. Groundwater quality is not of sufficient standard to satisfy potable use requirements in accordance with 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, April, 2009).

2. The most significant beneficial uses for groundwater in some locations of the site are for irrigation and ecosystem maintenance (Coffey, October, 2007).

3. Median EC and TDS concentrations within the lake are higher than in GMBs and are indicative of saline water. This is expected as the lake's drain invert level is approximately 0.66 mAHD (Coffey, October, 2007). Based on review of Fort Denison tidal data such an elevation can be expected to be breached by tides approximately 25 days per year.

4. Median EC and TDS concentrations within GMBs are indicative of fresh water.

5. Monitoring data indicates that lake nutrient concentrations are lower than those observed in nearby GMBs.

6.3.2.8 Summary

GMB coverage and the extensive historical levels data record are considered well suited for the purposes of groundwater modelling for proposed development assessment.

6.4 Groundwater Modelling

6.4.1 Previous Groundwater Modelling

6.4.1.1 Overview

A series of preliminary steady state groundwater models were developed as part of the Concept Integrated Water Cycle Management Strategy (MA, 2013) which was prepared to support the now approved Concept Proposal Application under Part 3a of the EP&A Act (1979) for the Concept Riverside Development.

Modelling works extended a concept model previously prepared by Coffey (October, 2007 and August, 2009) and Martens & Associates (December, 2011) and incorporated 'mean' and 'wet' year scenarios, sea level rise scenarios, additional calibration locations and data, additional parameter zones and recharge zones/rates which were derived ultimately from water quantity/quality (MUSIC) modelling.

The following models were previously developed.

M0: Calibration model - Existing terrain and conditions
Using available site geotechnical data and GMB level data, a calibrated single layer steady state model was developed.

M1a: Existing terrain, mean rainfall conditions
Recharge zone values derived in M0 factored to account for difference between average rainfall experienced during groundwater level data collection and mean rainfall conditions experienced on site.

M1b: Existing terrain, wet rainfall conditions
As per M1a with recharge values factored for wet conditions.

M1c: Existing terrain, mean rainfall conditions, sea level rise
As per M1a with boundary conditions changed to reflect potential climate change induced sea level rise of 0.9m (increased from 0.045m AHD to 0.9m AHD).

M1d: Existing terrain, wet rainfall conditions, sea level rise
As per M1b with sea level rise boundary conditions.

M2a: Developed terrain, mean rainfall conditions
M1a terrain replaced with developed site terrain including proposed drainage systems. Recharge zone values adjusted with "MUSIC to MODFLOW" conversion factor.

M2b: Developed terrain, wet rainfall conditions
As per M2a with adjustment of recharge values for wet conditions.

M2c: Developed terrain, mean rainfall conditions, sea level rise
As per M2a with boundary conditions changed to reflect potential climate change induced sea level rise of 0.9m (increased from 0.045m AHD to 0.9m AHD).

M2d: Developed terrain, wet rainfall conditions, sea level rise
As per M2b with sea level rise boundary conditions.

6.4.1.2 Results and Conclusion

Based on groundwater modelling results, it was concluded that the proposed development would likely result in no discernible impact on groundwater levels within or adjacent to the critical ecosystems (i.e. SEPP 14 wetland and J lake) of the site. The proposed development's impact on groundwater would be limited to the higher western portions of the site and the Monkey Jacket area with the zone of impact being relatively confined and not extending to downslope critical ecosystems.

6.4.2 Supplementary Groundwater Modelling

6.4.2.1 Overview

All proposed development groundwater models (i.e. M2a through to M2d) documented in MA (2013) (and outlined in Section 6.4.1.1) were re-run to take into account revisions to the proposed development. Prior to model re-running, the following changes were made to all models to reflect the revised proposed development:

- Site recharge rates were changed to reflect the results of supplementary MUSIC modelling, and to reflect the relinquishment of the former proposed eco-tourism precinct south of Monkey Jacket.
- The level of the drain boundary condition applied over the 'west branch' floodway was lowered 0.15 m in accordance with proposed design levels.

Model cell top elevations were not changed to reflect revised proposed development surface levels as TIN to TIN analysis within terrain software indicated that design levels were generally similar to the DTM which was used to develop the MA (2013) groundwater models.

Aside from the 'west branch' drain boundary condition, the coverages and depths of drain boundaries used to represent drainage features in the MA (2013) groundwater models were not changed. This is justified as whilst the MA (2013) drainage features are somewhat different in coverage to those currently proposed, on balance, the MA (2013) drainage features adequately represent the current proposed development, especially given groundwater model resolution and cell size.

6.4.2.2 Model Setup

Modelling was undertaken with Visual Modflow Version 4.6.0.161 utilising single layer, steady state modelling and with background (constant) properties as summarised in Table 9.

Table 9: Summary of groundwater model properties.

Property	Value/Detail	Comment
Grid cell size	25m x 25m	-
Existing Terrain	DTM from Tattersall Lander	06.11.2012
Developed Terrain	DTM from Tattersall Lander	14.11.2012
Cell Base	DTM produced from rock level contours	Coffey (2007)
Head observation wells	Mean GMB observations from data record for 19 GMBs	Attachment 6B
Boundary Conditions	Constant Head: Myall River = 0.045m AHD J Lake = 0.7m AHD Monkey Jacket upper slopes = 4.45-4.6m	-
Boundary Conditions – Sea Level Rise	Constant Head: Myall River = 0.9m AHD J Lake = 0.9m AHD Monkey Jacket Upper slopes = 4.45-4.6m	Myall River and J Lake constant head heights increased to 0.9m (DECCW, 2009, benchmark for sea level rise planning = 0.9 by 2100).
Water Balance Zones	Refer to Figure 15 (Attachment 6A)	Assigned to existing condition and developed condition models to allow comparison of water movement between zones and total zone budgets between models.
Hydraulic Conductivity – K	Refer to Figure 16 (Attachment 6A)	Site divided into K zones based on field K testing results.

6.4.3 Existing Conditions Modelling

6.4.3.1 Calibration Model

The calibration model (M0) was developed to establish base recharge values for existing site conditions and involved:

- o Definition of hydraulic conductivity (K) zones across the site based on field testing results (Figure 16, Attachment 6A; Attachment 6D).
- o Definition of recharge zones across the site based on site landform, vegetation type and drainage conditions (Figure 17, Attachment 6A).
- o Calibration of head equipotentials against observed heads (at GMBs) by iterative adjustment of recharge zone values whilst keeping K values constant. Calibrated recharge values are summarised in Table 10.

Calibration results are depicted in Figure 6 (Attachment 6A) showing a normalised RMS of 4.27%, comparing favourably with the typical industry accepted upper threshold of 10%. A calibrated residual mean of -0.066m indicates suitable prediction of mean groundwater head.

6.4.3.2 *Mean and Wet Year*

'Mean' and 'wet' year versions (M1a and M1b respectively) of the existing conditions groundwater model were developed as follows:

- Assessment of average monthly rainfall experienced during site observations (R_{obs}). Average monthly rainfall was used rather than average annual rainfall due to the lack of complete annual groundwater monitoring records.
- Assessment of 'mean' (R_{mean}) and 'wet' (R_{wet}) (90th percentile) average monthly rainfall for the site based on rainfall records (Nelson Bay BOM Station Number 61054).
- Calculation of recharge adjustment factors by the following method:

  'Mean' = R_{mean} / R_{obs}

  'Wet' = R_{wet} / R_{obs}
- Calculation of 'mean' and 'wet' year recharge values (Table 11) for use in the model scenarios by multiplying calibrated recharge values by the adjustment factors (Table 10).

Table 10: 'Mean' and 'Wet' year recharge adjustment factors.

	R_{obs}	R_{mean}	R_{wet}
Rainfall mm/month	104.2	112.4	158.1
Recharge Adjustment Factor	1	1.08	1.52

Table 11: Summary of adopted recharge values (existing site conditions).

	Recharge rate (mm/year)		
Zone	**Calibrated Model**	**Mean Year**	**Wet Year**
Industrial	40	43	61
Residential	100	108	152
Quarry	40	43	61
Coastal saltmarsh/mangrove	40	43	61
Dense heath/wetland	80	86	121
Forested slopes	70	75	106
Cleared clay soils	30	32	46
Cleared poorly drained	150	162	228
Cleared sandy soils	250	270	379

6.4.4 Developed Conditions Model

6.4.4.1 Terrain file and Drains

The concept design surface DTM (from Tattersalls Lander) associated with the MA (2013) groundwater models was utilised in the developed conditions modelling. The DTM incorporated drain invert levels including the invert of proposed roadside biofilters. This is an important consideration as it allowed evaluation of groundwater levels against drainage structures function to ensure structures are not "drowned out" and that stormwater treatment within biofilters is undertaken prior to interception of groundwater. To supplement assessment of modelling results, groundwater model levels were also viewed in the context of the current proposed DTM within terrain modelling software.

As outlined in Section 6.4.2.1, in accordance with the current proposed development DTM, the 'west branch' drain levels were lowered by 0.15 m.

Drain layout is depicted in Figure 15, Attachment 6A.

6.4.4.2 *Recharge Adjustment and Zonation*

Recharge rates derived in calibrating the existing conditions model were compared against infiltration rates derived from water quality (MUSIC) modelling (Section 3.9).

Developed condition groundwater recharge rates were developed based on the outcomes of MUSIC modelling. MUSIC water balance results provided values for 'infiltration losses'. These were compared to the calibrated recharge rates for the 'mean' groundwater level model. A direct adoption of MUSIC infiltration rates could not be used as the 2 models use different algorithms to model groundwater (MODFLOW is a distributed model).

MUSIC to MODFLOW recharge conversion factors were then calculated by dividing the MODFLOW recharge rate for a particular recharge zone by the MUSIC derived infiltration rates for the equivalent site location. Conversion factors were determined for all recharge zones.

As the majority of the site shall be filled with loamy sands overlying sand loams (Section 3.5.4), the recharge factor determined for the pre development area comprising similar soil conditions of loamy sand over sandy loam profile was deemed appropriate to utilise across the total developable site footprint. This factor was calculated to be 0.5 (e.g. MODFLOW recharge rate of 250mm/yr divided by MUSIC infiltration rate of approximately 500mm/yr).

Similar results were achieved for the proposed revegetated slope and revegetated low lying areas of the site, thus a conversion factor of 0.5 was applied uniformly across the total area of the site to be developed or rehabilitated. Conversion rates were not applied to areas of the site remaining unchanged as a result of the development such as the dense heath/wetland area, coastal saltmarsh and forested slopes west of the site.

The conversion factor was applied to post development MUSIC water balance figures to derive relative recharge values for the MODFLOW developed model (Table 12). Recharge zones were also redefined into four new zones to reflect developed conditions including residential areas, revegetated low lying area and revegetated slopes (Figure 17, Attachment 6A).

Table 12: MUSIC to MODFLOW Recharge conversion for developed conditions.

Area	Description	MUSIC Infiltration (mm/yr)	Conversion Factor	MODFLOW Recharge (mm/yr)
A	Residential (Main)	385	0.5	193
B	Residential (Monkey Jacket)	334	0.5	167
C	Revegetated Low Lying	480	0.5	240
D	Revegetated Slopes	304	0.5	152

6.4.5 Modelling Results

6.4.5.1 Head Equipotential Plots

Head equipotential plots are presented in Figures 7-10 (Attachment 6A). These represent groundwater contours at a 0.1m contour interval.

6.4.5.2 Drawdown Comparisons

Drawdown comparisons (Attachment 6A, Figures 11-14) present the difference in groundwater levels between model scenarios as drawdown contours (0.05m interval).

<u>Effect of development – no sea level rise</u>
Figure 11 demonstrates that under mean rainfall conditions, proposed development will have insignificant effects on groundwater across the majority of the site, including within and adjacent to all wetland areas (GDEs) south of the Monkey Jacket area. However, groundwater levels primarily in the more undulating areas in the site's west will be reduced. This is as a result of design surface interception with groundwater particularly west of GMB9 and GMB201 (Monkey Jacket area) and at the upper ends of the main drainage line near GMB7 and GMB11.

<u>Effect of development – with sea level rise</u>
Figure 13 demonstrates very similar results to Figure 11, demonstrating that sea level rise has no discernible impact on the relationship between the developed site groundwater levels and the existing site's groundwater levels.

<u>Effect of 'wet' year</u>
Figure 12 demonstrates minor water table rises within the upper areas of the site under 'wet' conditions compared to 'mean' conditions for the developed site without sea level rise. There is no discernible difference in the eastern (GDE) areas of the site.

Effect of sea level rise

Attachment 6A, figure 14 demonstrates that sea level has an effect on groundwater levels in the eastern (GDE) parts of the site but no significant effect in the higher areas in the site's west.

6.4.5.3 Water Balance to Receiving Environments

A water balance assessment was conducted for:

1 Myall Creek catchment area

2 Rehabilitation and SEPP 14 wetland area

3 J lake

Total in-flow to these areas (sum of groundwater and drain contributions) was determined for existing and developed conditions without sea level rise (Table 13) and with sea level rise (Table 14). Results indicate:

- Water balances to the rehabilitation area and SEPP 14 wetland are maintained.
- Discharges to Myall Creek will increase. This is primarily due to increased drain flows which shall be discharged directly to the Myall River (following proposed water quality wetland treatment) and will not impact on GDEs.

Table 13: Water balance summary (no sea level rise).

	Existing Conditions			Developed Conditions			Difference	
	Flow In	Upslope Drains	Total flow In	Flow In	Upslope Drains	Total flow In	Total flow in	
Receiving Node	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	m^3/day	%
Myall Creek	110.4	0.0	110.4	130.0	242.2	372.2	261.8	237%
Rehab Area & SEPP 14 Wetland	1059.8	202.5	1262.3	836.8	438.4	1275.2	12.9	1%
J Lake	613.8	0.0	613.8	600.3	0.0	600.3	-13.5	-2%

Table 14: Water balance summary (with sea level rise).

	Existing Conditions			Developed Conditions			Difference	
	Flow In	Upslope Drains	Total flow In	Flow In	Upslope Drains	Total flow In	Total flow in	
Receiving Node	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)	m^3/day	%
Myall Creek	97.0	0.0	97.0	87.6	300.4	388.1	291.1	300%
Rehab Area & SEPP 14 Wetland	484.2	614.8	1099.0	333.7	858.8	1192.4	93.4	9%
J Lake	491.7	0.0	491.7	484.1	0.0	484.1	-7.6	-2%

6.4.5.4 Groundwater Interception Plot

A comparison of the proposed design surface DTM and the M2a surface is presented in Attachment 6A, figure 18. This indicates design surface areas (developed site contours) that intercept the modelled groundwater level (M2a) under mean rainfall conditions. Peach and brown coloured areas indicate groundwater being intercepted. <u>We note that the design surface DTM is based on drain invert levels including the invert of proposed roadside biofilters as opposed to finished ground surface levels in these areas.</u>

The main areas where interception is modelled to occur are within the Western Branch and Monkey Jacket drainage corridors. Other areas of likely interception include the higher western slopes of the Monkey Jacket area.

Results indicate interception over the majority of depicted interception areas is typically less than 0.05m.

More significant interception occurs within the Monkey Jacket higher slope areas where approximately 1.0m interception is indicated. This would result in local lowering of the groundwater within this immediate area through subsurface road drainage. The drawdown plots suggest the spatial influence of the drawdown is relatively focused and does not extend to influence downslope wetland areas. This area of the site is not flanked by GDE's. In reality, a very minor area of the development site (approximately 1%) is affected by this. We would recommend that design levels within this area could be re-evaluated at a more detailed design stage in the project, with further consideration to water table levels, supported with additional data.

Modelling results demonstrate that the extent of groundwater interception likely as a result of the proposed design levels will have negligible impact on GDE's. We therefore recommend that the current grading is acceptable and suitable for approval. If grading levels change at CC stage then they will need to be reassessed accordingly.

6.4.6 Transient Groundwater Levels

The modelling undertaken has provided a range of groundwater level scenarios. We make the following specific comments in relation to transient or 'day to day' groundwater level variations.

1. On a daily basis, groundwater levels may fluctuate considerably across the site in response to incident rainfall. During periods of heavy rainfall, for example, groundwater can locally rise within a few hours in the order of 0.1-0.5 m (depending on location). This groundwater response is generally short lived due to the sandy permeable nature of the aquifer.

2. In some locations within the development site, surface drains and inverts of some road side swales may capture a small proportion of these intermittently high groundwater levels.

3. We note that the site already maintains a number of drainage channels which achieve the same effect as that described above (i.e. they remove the higher groundwater levels to surface drains). However, these are generally at a lower level than that to be constructed for the developed site.

4. It is our view that whilst drain interception of intermittently elevated groundwater levels is not ideal, that the placement of fill at the site and broadly higher elevation of the proposed site drainage system compared with the existing conditions, will not result in any significant change to the capture of higher groundwater levels at the critical ecosystem boundaries than is presently the case.

6.4.7 Model Classification and Limitations

In accordance with Australian groundwater modelling guidelines (June, 2012), the model is considered to generally represent a 'Class 2' model confidence-level classification.

A 'Class 2' classification is justified on the basis of the following:

- Geotechnical and groundwater data coverage are high for the entire model domain.

- The conceptual model is relatively simple and therefore inherently exhibits a relatively lower degree of uncertainty compared to other more complex hydrogeological systems.

- Digital elevation models (DEM) for terrain surfaces are high quality.

- Model is a steady state and single layer.

Model limitations:

- Temporal head data coverage is considered reasonable but insufficient to permit transient calibration verification. We do not consider this a significant limitation as discussed in Section 6.4.1.

- Dry-cells developed in the model within the higher slopes of the northern site area (west of GMB201). This is considered to be an effect of relatively sharp ground steepening area and was offset by assigning constant head boundary conditions in this area. Lack of variation in head equipotentials in the area for the various model scenarios is a consequence. We do not consider this a significant limitation as:

  1) GMB data in this area allows confidence in the assigning of constant head values in this area.

  2) This area is not adjacent to critical receiving waters or GDEs.

In spite of these limitations the model's target confidence level is deemed fit for purposes of concept stage assessment.

6.5 Effects of Development on Groundwater

6.5.1 Groundwater Levels

From groundwater modelling results it is concluded that the proposed development would result in no discernible impact on groundwater levels within or adjacent to the critical ecosystems (i.e. SEPP 14 wetland and J lake) of the site. The development's impact on groundwater would be limited to the higher western portions of the site and the Monkey Jacket area with the zone of impact being relatively confined and not extending to downslope critical ecosystems.

6.5.2 Water Balance to Wetland

The water balance analysis demonstrates that existing groundwater flow patterns and water budgets to critical ecosystems (SEPP 14 wetlands and J lake) are maintained for the proposed development.

6.5.3 Groundwater Quality

Water quality modelling results (Section 3.7) demonstrates that proposed surface water treatment strategy will produce concentrations of key pollutants (TP and TN) that are considerably below existing groundwater concentrations found on site (Table 15). Hence, a NorBE groundwater quality result is achieved.

Table 15: Comparison of water quality modelling results with existing groundwater quality.

Pollutant	Stormwater Pollutant Concentration[1]	Existing Groundwater[1]
TP mg/L	0.063	0.41
TN mg/L	0.489	2.5

Notes:

1. Median values (see Table 7).

6.6 Groundwater Management Plan

6.6.1 Overview

This groundwater management plan provides advice on the following:

1. Existing aquifer characteristics
2. Potential aquifer risks
3. Risk management objectives
4. Risk management methods
5. Further investigation requirements

6.6.2 General Aquifer Characteristics

Based on preliminary investigations and modelling of the aquifer, the following characteristics define the Riverside site aquifer:

1. The aquifer is sand-dominated, of a relatively low gradient and highly permeable.
2. The groundwater system is coupled with the Port Stephens estuary/Myall River and is responsive to tidal fluctuations.
3. The aquifer is highly responsive to recharge events. Reasonably rapid groundwater level fluctuations of the order of 500 mm to 1000 mm can occur in response to rainfall.
4. Aquifer recharge is local and is predominantly controlled by incident rainfall.
5. Based on available groundwater quality data, groundwater is likely to be of a low-value resource due to TDS, pH, chloride, sodium and ammonia concentrations which exceed Australian Drinking Water Guidelines (NHRMC, 2004).

6.6.3 Primary Risk Identification

The following broad scale potential risks are identified in association with the release of urban land.

1. Untreated stormwater discharge to groundwater resulting in groundwater contamination.
2. Changes to groundwater level which come about through modifications to surface infiltration and recharge properties at the site.

3. Changes to groundwater flow direction which come about through modifications to surface infiltration and recharge properties at the site.

4. Significant modifications to groundwater flow budgets to GDEs and receiving waters.

5. Locally increasing groundwater levels though excessive recharge resulting in surface water losses from the groundwater system.

6.6.4 Risk Management Objectives

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

1. Development is to be undertaken in such a way so as to ensure that groundwater table drawdown is minimised.

2. Development should not result in a degradation of the existing aquifer water quality.

3. Development should not significantly alter the flow directions of ground water at the site.

4. Development water and groundwater management strategies should be integrate and ensure surface water and groundwater systems are managed such that the integrity of GDEs is preserved or enhanced.

6.6.5 Risk Management Methods

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

1. All stormwater management systems treat stormwater to a level equal to or better than existing groundwater quality prior to discharge to any groundwater body.

2. No direct permanent connection to groundwater.

3. Minimised (as far as practical) exposure of groundwater to surface water systems.

4. Recharge treated stormwater throughout the site in such a way so as to enable distributed recharge rather than single point recharge. This ensures that groundwater flow gradients, levels and directions are maintained at/close to pre-development

levels. It is noted that that current proposal features a recharge swale that buffers the SEPP 14 wetland.

6.6.6 Groundwater pH Management

Existing groundwater pH levels at the site are variable and may typically range between say 5.0 and 6.5 depending on specific location, local soil and geology, and antecedent rainfall conditions. Samples from GMB returned the lowest pH value of 3.99.

Rainfall pH levels for coastal NSW are generally acidic due to the disassociation of CO_2 to form carbonic acid and may range between say 5.5 and 7.0. Lower levels [to say pH of 4.5] can be experienced in coastal areas near larger urban centres or closer to industrial centres (such as Newcastle in the case of this site) (Bridgman, 1989).

Contrasting the depressed pH of rainfall, urban runoff, notably from concrete and other pavement surfaces, has the potential to maintain a slightly elevated pH of say 6.5 – 7.5. In the case of this development, we do not expect any changes to background groundwater pH levels at the fringing wetlands for the following reasons:

1. 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.

2. 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.

3. 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).

6.6.7 Beneficial Use of Site Groundwater Resource

The proposed development, together with the integrated water management strategy in place will have NorBE on the potential for beneficial use of the site's groundwater resource given the findings of NorBE on surface water and groundwater assessments determined in this study.

It is noted from Section 6.3.2 that existing groundwater quality is not suited for potable use.

Use of groundwater for GDE maintenance represents the most suitable potential use of the site's groundwater resource.

6.7 Groundwater Monitoring Plan

6.7.1 Monitoring Elements

Key surface/groundwater elements to be monitored include:

1. Groundwater quality and levels at the adjacent SEPP 14 wetlands.
2. Groundwater quality and levels at the nearby J lake.

6.7.2 Monitoring Locations

To monitor water quality and levels at the J lake, location 'Lake 26' (or suitable alternative if this location cannot be found) is to be monitored.

To monitor groundwater quality and levels at the adjacent SEPP 14 wetlands, GMB3 and GMB6 are to be monitored.

6.7.3 Monitoring Frequency

Groundwater level should be monitored at monthly intervals, or preferably continuously via data logger at Lake 26, GMB3 and GMB6.

Groundwater quality should be sampled quarterly at Lake 26, GMB3 and GMB6.

6.7.4 Water Quality Analysis

Samples should be analysed for the following:

- Total Nitrogen
- Total Phosphorus
- pH
- EC

6.7.5 Bore-field Maintenance

As part of routine monitoring events, Lake 26, GMB3 and GMB6 are to be maintained to ensure that collected surface/groundwater samples are representative. Maintenance shall include at a minimum visual inspection and purging the bore until such time as water quality being pumped is uniform.

Bores found to be damaged, lost or vandalised are to be replaced.

Bores with excessive algae matt build up are to be remediated with chlorine flushing and pumping, or if this is ineffective, replaced.

Where possible, we recommend all site GMBs are kept in-tact until construction processes require their removal. In the event that routine monitoring locations are required to be expanded beyond Lake 26, GMB3 and GMB6, this will broaden the selection pool of potential GMBs.

6.7.6 Interim Trigger Values

Interim trigger values are provided for surface/groundwater levels and quality in Table 16 and Table 17 respectively. Trigger values were generally derived based on mean background data and a reduction of two standard deviations (groundwater levels), or addition (subtraction for pH) of two standard deviations (groundwater quality). For the Lake 26 level trigger value, the value was derived from the minimum level monitored by data logger between 04.06.2009 and 06.07.2009.

Trigger values should be confirmed prior to commencement of construction works if any additional site surface/groundwater monitoring data not available at the time of preparing this report is acquired.

We note that nominated trigger values are based on minimal sampling events, and are quantitatively statistically based. The trigger values are not considered to necessarily reflect unprecedented background values. Therefore, whilst exceedance of trigger values should incite some form of assessment, it is possible that certain trigger values will be exceeded as a result of natural variability. This is especially the case for TP at GMB3 and GMB6, where every background value was below the laboratory practical quantification limit (PQL) of 0.05 mg/L. As site data increases, it is envisaged that the interim trigger values may need to be modified, particularly the GMB3 and GMB6 TP trigger value.

Table 16: Interim surface/groundwater level trigger values.

Interim Surface/Groundwater Level Trigger Values (mAHD)	
Lake 26	**GMB3 and GMB6**
0.63 [1]	0.19 [2]

Notes:

1. Trigger value represents minimum level monitored by data logger between 04.06.2009 and 06.07.2009.
2. Calculated based on mean of GMB3 and GMB6 values in Attachment 6B less 2 standard deviation values.

Table 17: Interim surface/groundwater quality trigger values.

Location	Interim Surface/Groundwater Quality Trigger Value [1]			
	pH	EC µS/cm	TN mg/L	TP mg/L

GMB3 and GMB6 (wetland) [1]	5.4	30,445	2.79	0.05
'Lake 26' (J lake) [2]	5.0	27,288	1.04	0.09

Notes:

1. Calculated based on mean value in Attachment 6C for GMB3 and GMB6 plus (minus for pH) two standard deviation values.

2. Calculated based on mean value in Attachment 6C for 'Lake 26' and 'Lake' plus (minus for pH) two standard deviation values.

6.7.7 Action Requirements

Action will be required if trigger values are exceeded, or in case of pH and groundwater levels, fall below. Action will involve the following:

- Engage a suitably qualified professional to provide advice.
- Review the data in light of environmental/climate conditions.
- Determine if further investigation is warranted.
- Spatially identify key areas requiring action.
- Determine appropriate action based on circumstances in consultation with Council and NSW DECCW.
- Undertake action.

6.7.8 Reporting

All monitoring data is to be presented in an annual report that will be forwarded to Council. Council and NSW DECCW are to be notified if results above trigger values are found.

The need to continue the groundwater monitoring is to be assessed at the time of annual reporting. At a minimum, it is envisaged that monitoring will be required until at least 2 years following the completion of all proposed development stages.

A detailed groundwater monitoring plan should be prepared during the detailed design phase of the development and correspond to the staged development.

6.8 Compliance with Previous Review Feedback

This updated groundwater assessment is compliant with previous assessors as per Table 16 of Martens and Associates previous Water Cycle Management Strategy (January, 2013).

7 Conclusions and Recommendations

This report has been prepared to support a Concept Proposal Application under Part 3a of the EP&A Act (1979).

The revised strategy has been carefully formulated from a long history of consultation with State and Local Government agencies and specifically addresses concerns expressed by the NSW Department of Planning and Infrastructure (DoPI), NSW Office of Water (NOW) and Great Lakes Council over the previously prepared strategy by Cardno (2012).

The revised strategy has been formulated with the principle objective of ensuring Neutral or Beneficial Effect (NorBE) from the development on receiving groundwater and surface water systems to protect receiving waters and critical ecosystems including groundwater dependant ecosystems (GDEs). The strategy focuses on the use of 'at source' (i.e. 'distributed') stormwater treatment measures allowing preservation (to the extent possible) of existing ground water recharge mechanisms and surface water hydrology, such that there would be no significant impact on receiving waters and adjoining GDEs.

7.1 General Conclusions

Concluding remarks for three main elements that form part of the integrated strategy are summarised as follows:

i) Site hydrology – drainage and flood management

Undertaken by Tattersall Lander, the updated stormwater drainage concept plan and supporting hydrological model including flood assessment was developed in coordination with the water quality and groundwater management strategies.

The assessment demonstrates that the proposed development will not have an adverse impact on flood behaviour on or around the site. Specifically it concludes:

- The combination of provided storage and low flow discharge structures ensure environmental flows into the wetland buffer area are maintained once the site is developed.
- The proposed level spreader designed for high flow discharge ensures the development will not result in an increase in flow velocities during rare events that would otherwise cause damage to downstream environments.
- Existing flood levels remain unaffected by the proposal.

- Proposed filling works plus floodway capacities ensure all lots remain flood free to the design 100yr event.

- The proposed development design caters for the safety of future residents in the peak PMF event.

ii) Surface water quality

The revised stormwater management system, formulated by Martens & Associates, uses current best practice WSUD philosophies for water quality tailored to the site. The revised surface water quality management concept relies on "at-source" treatment structures and elimination of proposed "window lakes" and is integrated with groundwater and surface water management strategies for the development.

Detailed water quality modelling has been undertaken in accordance with BMT WBM (2010) to determine treatment measures required to achieve a Neutral or Beneficial Effect (NorBE) for post development water quality conditions, as well as satisfying Great Lakes Council DCP (2014) Chapter 11 (previously DCP 54) requirements.

Treatment measures include a combination of 'at source' (bioretention swales, rainwater tanks) and end of line (constructed wetlands) structures (where needed) to achieve these objectives. Water quality modelling concludes:

- NorBE test is satisfied.

- WSUD, including distributed and 'at-source' management measures will be effective in mitigating against any water quality impacts on receiving wetlands, river and groundwater system.

iii) Groundwater

The revised groundwater model and groundwater management strategy, formulated by Martens & Associates, utilises additional groundwater data, including increased data coverage, and address' concerns raised by various assessment agencies.

The groundwater management strategy integrates closely with the stormwater management strategy utilising 'at source' recharge mechanisms to ensure NorBE impacts on groundwater patterns and conditions particularly in relation to impact on critical receiving waters and GDEs.

Groundwater assessment outcomes conclude:

- Modelling shows minor areas of groundwater interception within the development footprint. However, no discernible impact from the proposed development is likely on SEPP 14 wetland groundwater levels and water budgets.

- No discernible impact on water quality and levels in existing brackish lake (J Lake).

- NorBE on groundwater resources for the site and surrounding areas.

- Largely unchanged groundwater regime from existing conditions. This is due to the distributed WSUD approach to water quality management and recharge where possible in the catchment.

7.2 Recommended Commitments

The following recommendations are made for developer commitments in progression of the project.

Detailed design for the development shall be consistent with the integrated approach to water cycle management as outlined in this strategy. Additionally, it shall include provision for ongoing monitoring and reporting to ensure water cycle management objectives are being met.

Recommended commitments include:

i) Site hydrology – drainage and flood management

- Proposed drainage storages, low flow discharge structures and level spreaders shall be designed and constructed to ensure environmental flows into the wetland buffer area are maintained to predevelopment conditions and will not result in a significant increase in flow velocities during rare events that would otherwise cause damage to downstream environments.

- The proposed development including filling works will ensure all lots remain flood free to the design 100yr event and that existing flood levels (including for neighbouring areas) remain unaffected by the development.

- The proposed development design will cater for the safety of future residents in all reasonably considered flooding scenarios including the peak PMF event.

ii) **Surface water quality**

- The proposed stormwater treatment train shall be implemented at the site to ensure that water quality objectives are met.

- Proposed treatment train is to combine 'at source' and end of line controls in accordance with principles of Water Sensitive Urban Design and to avoid reliance on large end of line structures.

- The development shall have a neutral or beneficial effect on water quality in order to protect receiving environments, including SEPP14 wetlands, existing brackish lake, Myall Creek and the groundwater table.

- Regular monitoring of treatment systems and implementation of an associated treatment system management plan.

i) **Groundwater**

- Proposed 'at source' water quality treatment mechanisms incorporate groundwater recharge mechanisms are to ensure distributed recharge and NorBE impacts on groundwater patterns and conditions across the development site.

- Proposed development is to have no significant impact on SEPP 14 wetland groundwater levels and water budgets.

- Proposed development to have no significant impact on water quality and levels in existing brackish lake (J Lake).

- Proposed development to be designed so that minimal groundwater interception will occur. Any areas of interception are to be approved in consultation and subject to approval of NOW (and any other relevant Government agencies).

8 References

ANZECC (2000), National Water Quality Management Strategy. *Australian Guidelines for Urban Stormwater Management.*

BMT WBM (2012), *Review of Water Quality Management for the Proposed Riverside at Tea Gardens Development; Final Report*.

Bureau of Meteorology (2001), *Climatic Atlas of Australia – Evapotranspiration*.

Cardno (2011), *Riverside at Tea Gardens, Integrated Water Cycle Management Strategy and Sewerage Servicing*, *Final, November*.

Coffey Partners International (February, 1996), *Myall Quays Development Groundwater and Surface Water Study.*

Coffey Geotechnics (October, 2007), *Groundwater Assessment Riverside Development, Tea Gardens.*

ERM (November, 2012), Riverside at Tea Gardens Preferred Project Report.

Great Lakes Council (2014), *Development Control Plan*

Landcom (2004), *Soils and Construction 'Managing Urban Stormwater'*.

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

Martens & Associates (January, 2013), *Concept Integrated Water Cycle Management Strategy (Revised) Riverside, Tea Gardens, NSW.*

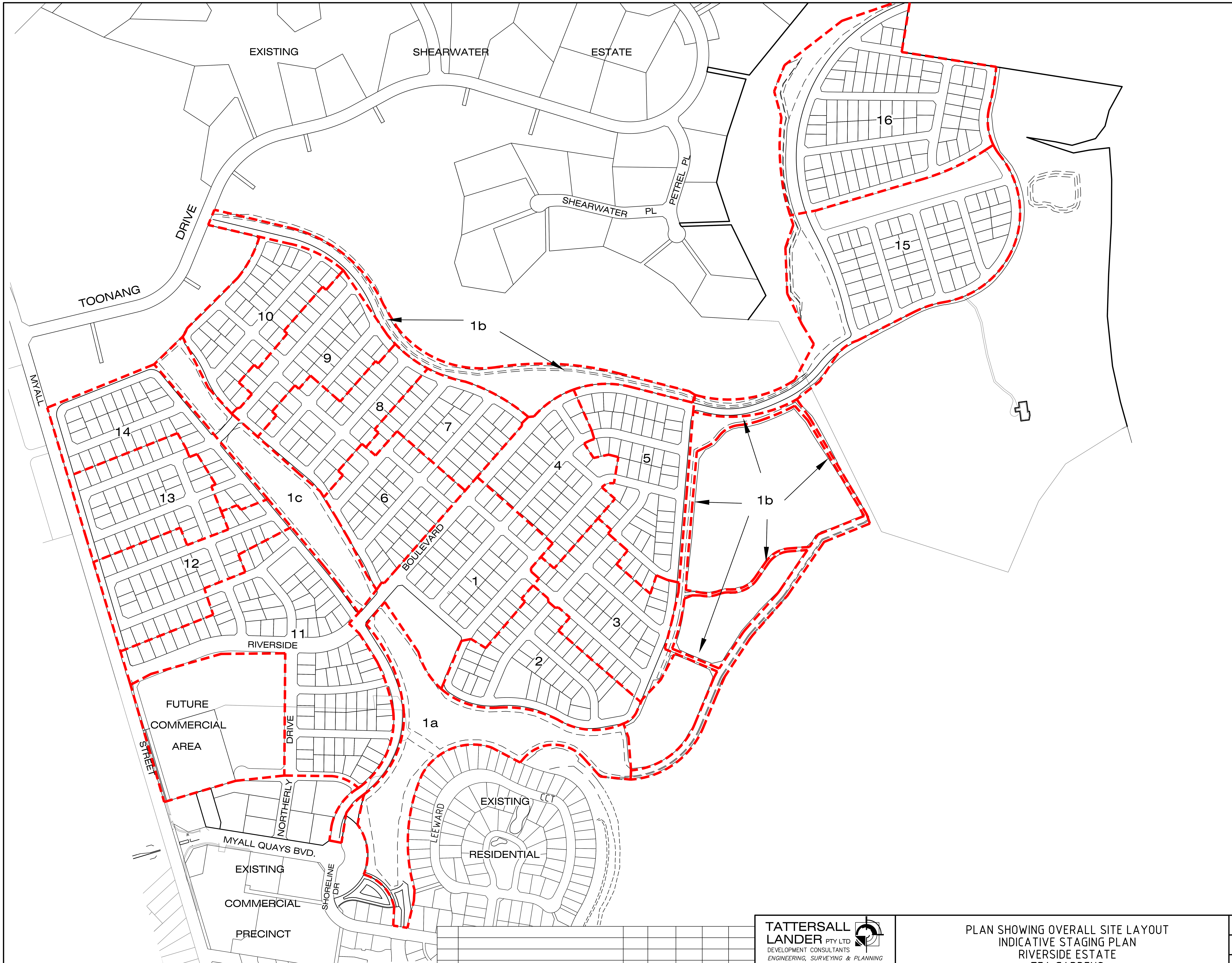
Murphy, C. L. (1995), *Soil Landscapes of the Port Stephens 1:100 000 Sheet*, Soil Conservation Service of NSW.

NHMRC (2004), *Australian Drinking Water Guidelines.*

NSW DECCW (2009), *Sea Level Rise Policy Statement.*

Sydney Metropolitan Catchment Management Authority (SMCMA) (2010), *Draft NSW MUSIC Modelling Guidelines.*

9 Attachment 1A – Preliminary Drainage Details Plan



STAGE	LOTS
1	45
2	41
3	47
4	42
5	52
6	39
7	36
8	32
9	38
10	40
11	89
12	44
13	43
14	37
15	58
16	84
TOTAL	767

0 30 60m
(1: 3000for A1 Size Plot)

A	Original Issue	AV	AV			
REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE

* Denote the original signature and date when revision was issued.

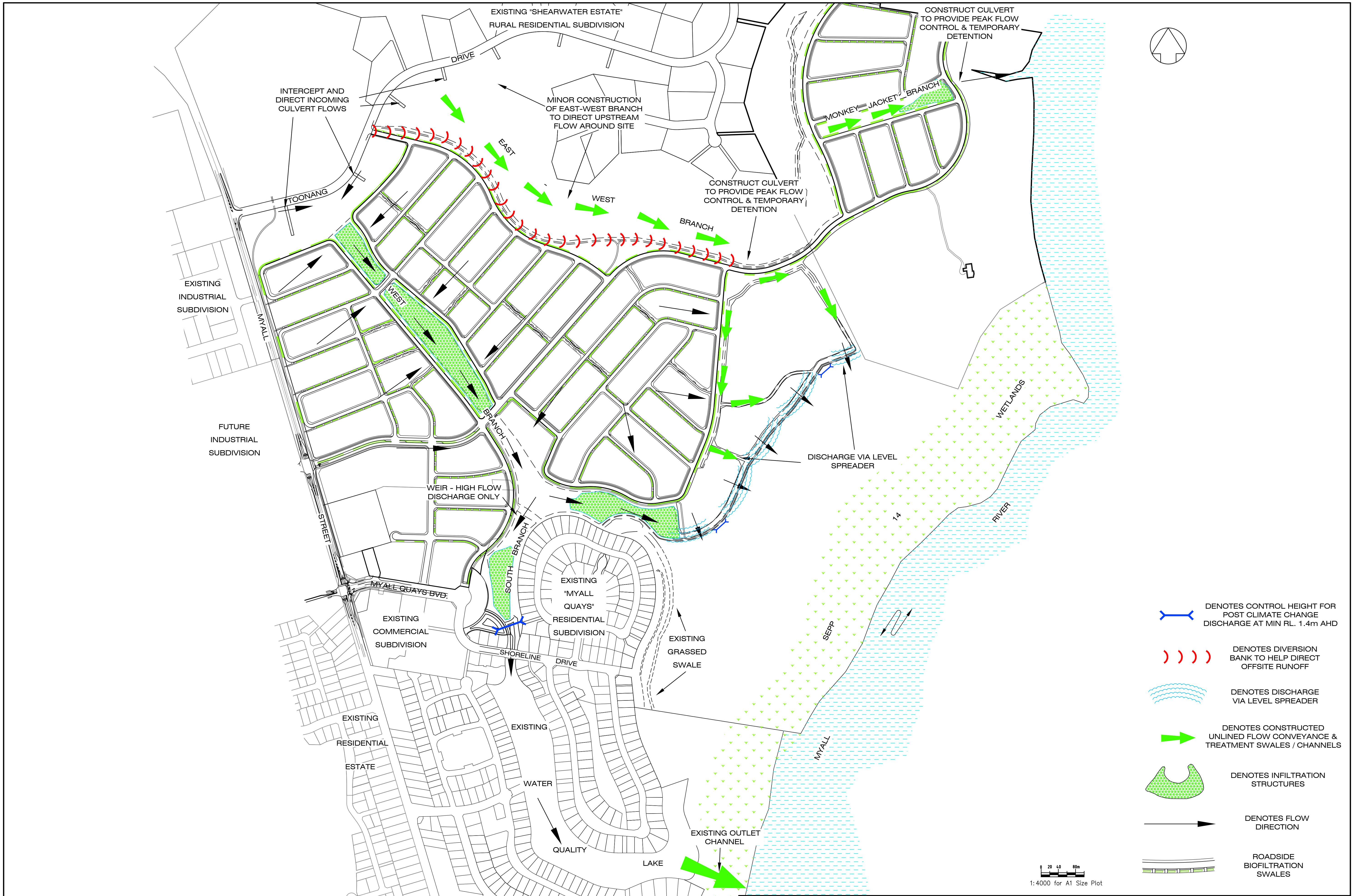
TATTERSALL LANDER PTY LTD
DEVELOPMENT CONSULTANTS
ENGINEERING, SURVEYING & PLANNING
2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Fax (02) 49871733 Phone (02) 49871500

PLAN SHOWING OVERALL SITE LAYOUT
INDICATIVE STAGING PLAN
RIVERSIDE ESTATE
TEA GARDENS

COUNCIL: GREAT LAKES	REFERENCE: ########
PARISH: COWEAMBAH	SHEET SIZE: A1
SCALE: 1:3000 on A1	SHEET No.: 1
DATE :	Plotted 17:38 30/07/15

CLIENT: SHEARGOLD GROUP
JOB No.: 213366
COMPUTER FILE : S:\projects\Riverside\dwg\Riverside Layout Plan.dwg

Xref: Shearwater Boundaries xref (Shearwater Boundaries xref.dwg) Xref: port4scon (port4scon.dwg) Xref: Riverside (Riverside.dwg) Xref: Commercial Site (Commercial Site.dwg) Xref: Future Industrial (Future Industrial.dwg) Xref: Myall Quays Bdys (Myall Quays Bdys.dwg) Xref: Shearwater Bdys (Shearwater Bdys.dwg) Xref: Myall River Downs Bdys (Myall River Downs Bdys.dwg)



A	Original Issue	AV	AV			
REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE

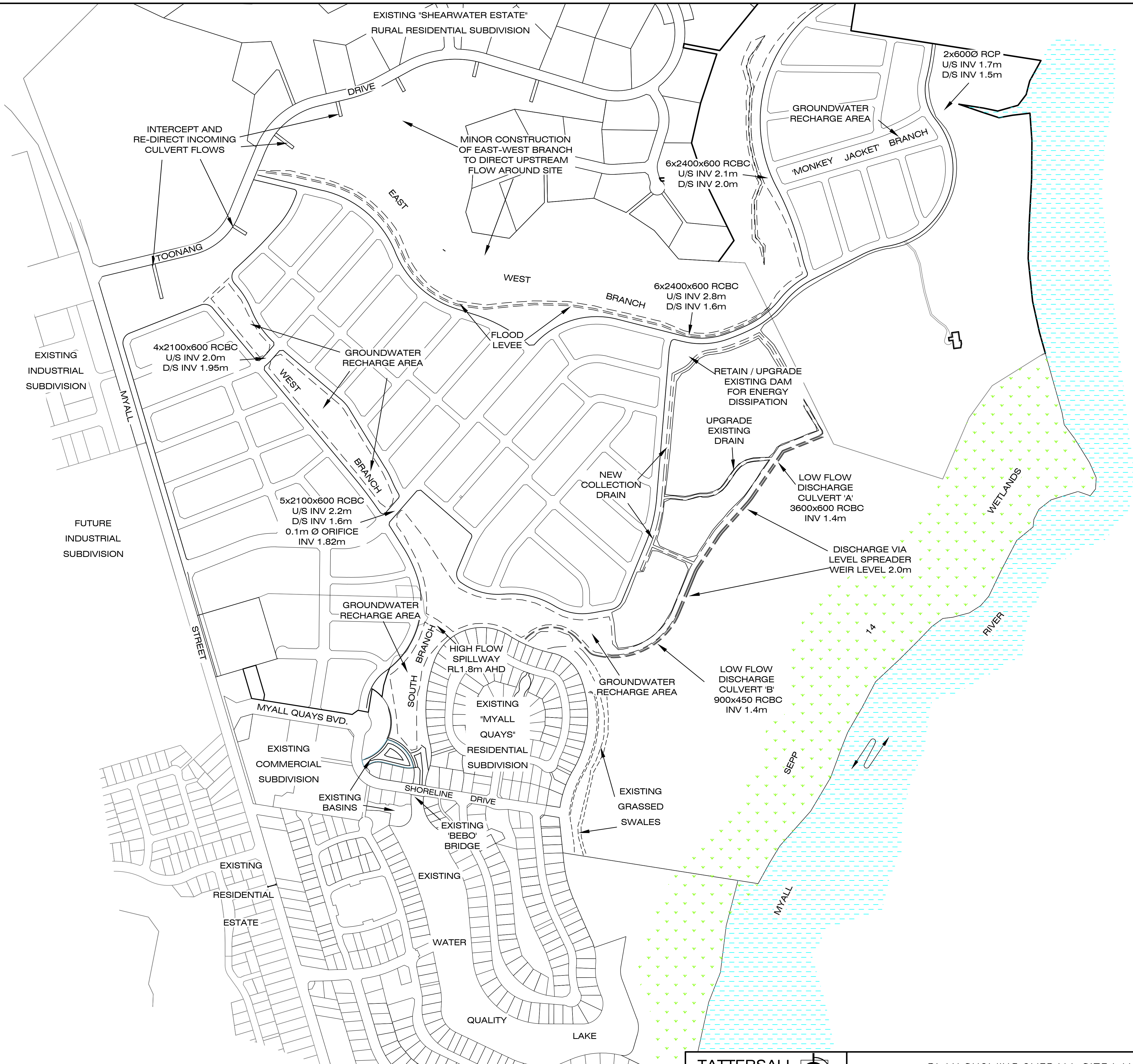
* Denote the original signature and date when revision was issued.

TATTERSALL LANDER PTY LTD
DEVELOPMENT CONSULTANTS
ENGINEERING, SURVEYING & PLANNING
2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Fax (02) 49871733 Phone (02) 49871500

PLAN SHOWING OVERALL SITE LAYOUT
DRAINAGE CONCEPT PLAN
RIVERSIDE ESTATE
TEA GARDENS

COUNCIL: GREAT LAKES	REFERENCE: ########
PARISH: COWEAMBAH	SHEET SIZE: A1
SCALE: 1:4000 on A1	SHEET No.: 1
DATE : Plotted 15:31 04/08/15	

CLIENT: SHEARGOLD GROUP | JOB No.: 213366 | COMPUTER FILE : S:\projects\Riverside\dwg\Riverside Layout Plan.dwg



REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
A	Original Issue	AV	AV			

* Denote the original signature and date when revision was issued.

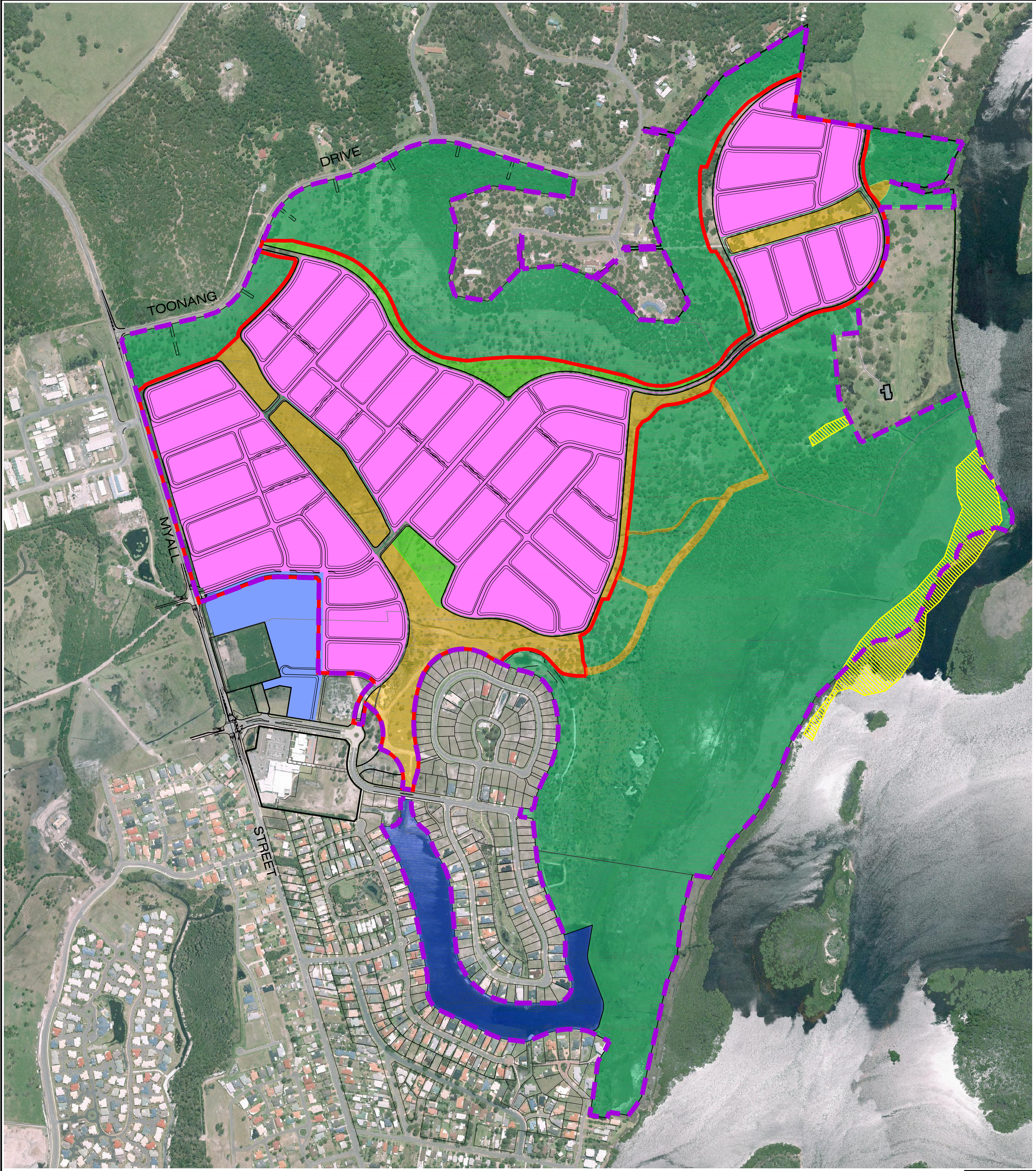
TATTERSALL LANDER PTY LTD
DEVELOPMENT CONSULTANTS
ENGINEERING, SURVEYING & PLANNING
2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Fax (02) 49871733 Phone (02) 49871500

PLAN SHOWING OVERALL SITE LAYOUT
PRELIMINARY DRAINAGE DESIGN DETAILS
RIVERSIDE ESTATE
TEA GARDENS

COUNCIL: GREAT LAKES	REFERENCE: ########
PARISH: COWEAMBAH	SHEET SIZE: A1
SCALE: 1:4000 on A1	SHEET No.: 1
DATE :	Plotted 15:33 04/08/15

CLIENT: SHEARGOLD GROUP | JOB No.: 213366 | COMPUTER FILE : S:\projects\Riverside\dwg\Riverside Layout Plan.dwg

10 Attachment 1B – Amended Concept Development Plan



ITEM	DESCRIPTION	Ha	%	APPROX YIELD
	Extent of Site - 'Riverside' concept plan	212.5Ha		
	Development Footprint	88.9Ha	41.8%	
	Conservation	113.9Ha	53.6%	
	Existing Lakes	6.9Ha	3.2%	
	Open Space / Water Management	13.6Ha	6.4%	
	Active Recreation Area	3.8Ha	1.8%	
	Low Density Residential	66.2Ha	31.2%	935 Dw = 14.1/Ha
	Future Commercial	4.9Ha		
	Location of Known Midden			
	Existing House			

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
B	Riverbank Reserve & Commercial Area Excluded	AV	AV			
A	Original Issue	AV	AV			

* Denote the original signature and date when revision was issued.

TATTERSALL LANDER PTY LTD
DEVELOPMENT CONSULTANTS
ENGINEERING, SURVEYING & PLANNING
2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Fax (02) 49871733 Phone (02) 49871500

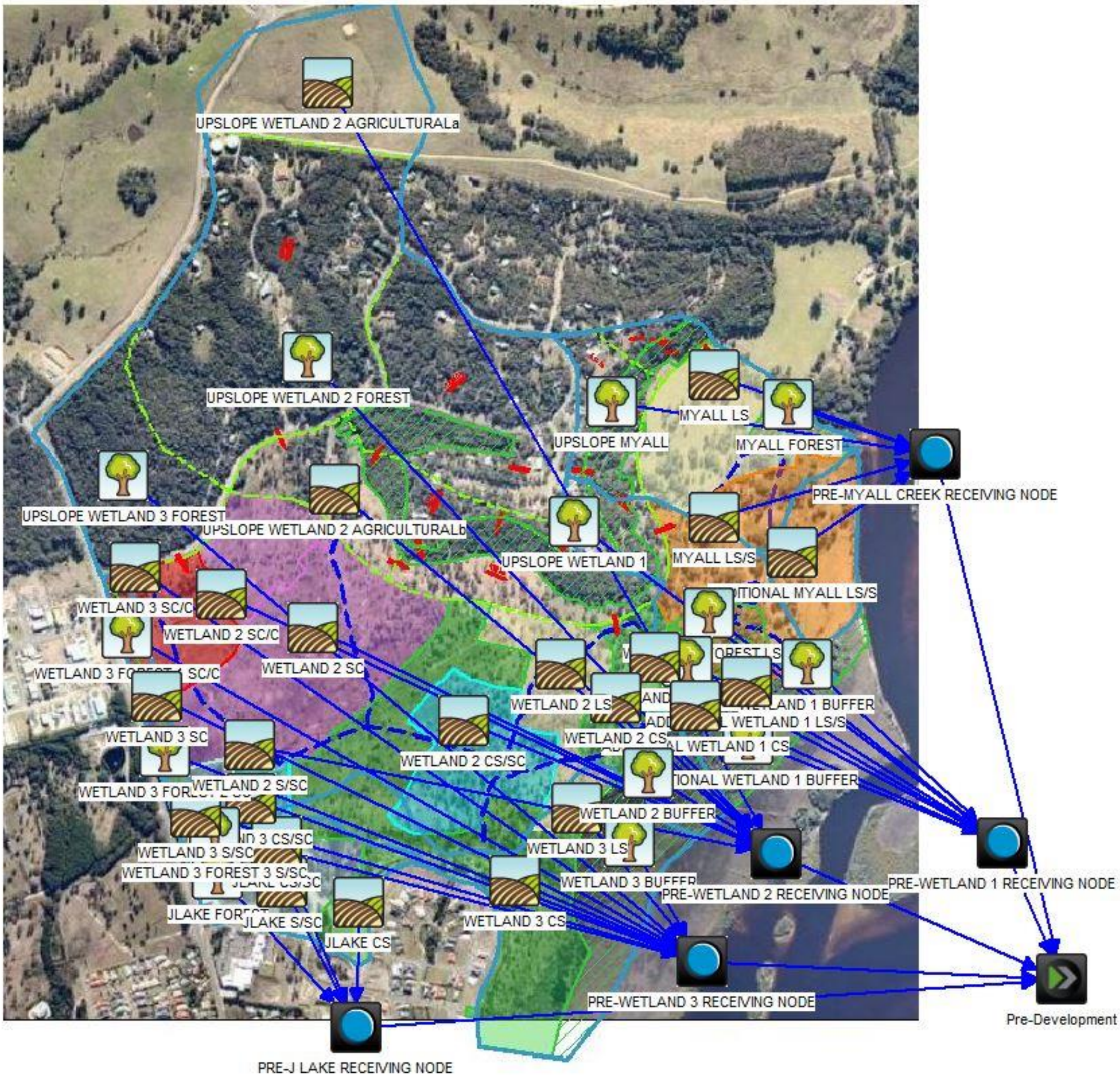
R.C.03 CONCEPT PLAN

RIVERSIDE TEA GARDENS

COUNCIL: GREAT LAKES
REFERENCE: 21500155
PARISH:
SHEET SIZE: A1
SCALE: 1:5000 on A1
SHEET No.: 3
DATE : Plotted 12:49 17/05/16

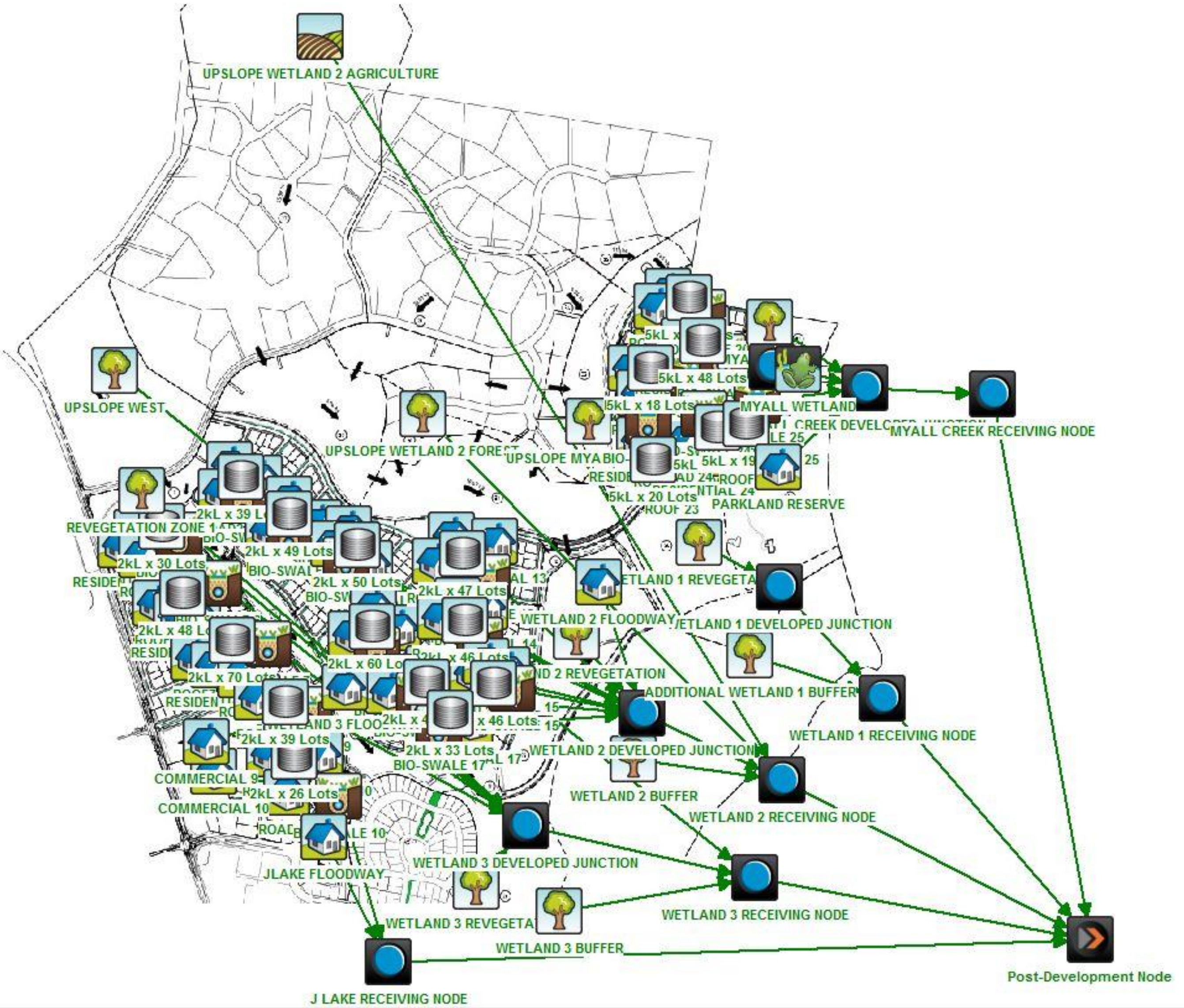
CLIENT: SHEARGOLD GROUP
JOB No.: 213366
COMPUTER FILE : S:\projects\Riverside\dwg\Project Plans\Project Plans - RC03 Concept Plan.dwg

11 Attachment 3A – Pre and Post Development MUSIC layouts



martens

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	DG	Pre Development MUSIC model layout Riverside development at Tea Gardens	Figure 1
Approved:	DM		
Date:	17.09.15		
Scale:	NA		Job No: P1404136



Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	DG	**Post Development MUSIC model layout Riverside development at Tea Gardens**	**Figure 2**
Approved:	DM		
Date:	17.09.15		
Scale:	NA		Job No: P1404136

martens

12 Attachment 3B – MUSIC Input Parameters

Attachment 3B: MUSIC modelling input parameter values and source.

Element	Factor	Input	Source
Setup	Climate File	Rainfall: Hawks Nest adjusted Williamtown RAAF 6min pluvio 1/1/1997 - 31/12/2006 PET: Monthly averages as per BOM 'Climatic Atlas of Australia'	WBM (2012a) requires Williamtown to be used with a 6min timestep. WBM (2010) MUSIC guidelines suggests 1/1/2002 - 31/12/2006 is used for this climate file in Table 3-1. Discussion with T. Weber (Sept 4, 2012) confirmed the climate file should also include 5 years prior to 2002 (i.e. 1/1/1997 - 31/12/2006). PET as per advice from T Weber on Oct 3, 2012.
Source Nodes	Node Type	The existing site will be a mixture of agricultual and forested nodes, depending on location across the site. Proposed will be a mixture of roof, road and residential nodes plus forest for reforestation areas and agricultural for pre=post areas.	As recommended in WBM (2012a)
	Roof Area	Roof area assumed to be 40% of total lot area in accordance with Great Lakes requirement for floor space ratio.	Area supplied by Tattersall Lander.
	Road Area	Based on proposed lot layout.	Area supplied by Tattersall Lander.
	Residential - Impervious area	Includes effective impervious area (EIA) only in accordance with WBM (2010). EIA for site (excluding roads and roofs which are modelled separately) are footpaths and the driveway area from road to front boundary.	EIA as per WBM (2010). Footpath and driveway area provided by Tattersall Lander
	Residential - Pervious area	Total lot area minus total roof. Includes driveway area on each lot as not considered EIA.	Area supplied by Tattersall Lander.
	Rainfall Threshold	Based on land use type or surface type	As recommended in WBM (2010) Table 3-6
	Pervious Area Parameters	Existing site - based on soils within the top 0.5m of existing soil profile Catchment 1: SCC, FC and rainfall-runoff parameters based on WBM (2010) for sandy clay soils. Catchment 16: SSC, FC and rainfall runoff parameters based on a weighted average of values in WBM (2010) based on clayey sand (0.3m) overlying sand (0.2m).	Average soil properties based on WBM (2010) Table 3-7 and 3-8 and site geotechnical testing by Coffey (2008) and Martens (2009) of 49 boreholes.
		Proposed site - the site will be filled with sand and then 100mm of loamy sand growing media to achieve FFL's consistent with flood requirements. SCC, FC and rainfall-runoff parameters based on a weighted average of values in WBM (2010) for top 0.5m - where 0.4m is sand and 0.1m is loamy sand.	
	EMC's	As per WBM (2010)	WBM (2012b) requires that the proponent should use site calibrated parameters or the MUSIC guidelines. In the absense of site specific data we are using the EMCs specified within the WBM (2010) guidelines which are taken from Fletcher *et al* 2004.
	Estimation Method	Stochastically generated	As per WBM (2010) MUSIC modelling guidelines
Rainwater Tank	Low Flow Bypass	$0 m^3/s$	As recommended in WBM (2010)
	High Flow Bypass	varies	As recommended in WBM (2010) $0.005 m^3/s$ per dwelling
	Volume below overflow	Assumed 2 kL and 5kL (Modelled at 80% capacity)	As recommended in WBM (2010)
	Depth above overflow	0.2 m	Tank design
	Surface Area	N/A	Cumulative surface area for tanks based on number of lots
	Overflow pipe diameter	90mm per tank	Tank design
	Reuse	0.24KL/day/dwelling for internal reuse in toilet flushing and laundry for 2 b/r house	Tank design
		112KL/yr/dwelling for external reuse for irrigation (scaled by PET)	
Bioswale	Low Flow By-Pass	0 m3/s	As per WBM (2010) MUSIC modelling guidelines
	High Flow Bypass	100 m3/s	As per advice from T Weber (October 3, 2012)
	Extended Detention depth	0.25m	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Surface area	Surface area (combined surface area for subcatchment) at half the detention depth	As per WBM (2010) MUSIC modelling guidelines. Area provided by Tattersall Lander.
	Filter area	By design. Total area within subcatchment.	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	As per WBM (2010) MUSIC modelling guidelines
	Saturated Hydraulic Conductivity	180 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductibity of 360 mm/hr be used for sands. 50% of this value has been used in modelling as a conservative estimate of realistic long-term hydraulic conductivity of system
	Filter Depth	0.4m	Design of proposed swales. Design provided by Tattersall Lander (attached).
	TN content of filter media	500 mg/kg	As per direction from T. Weber c/o Stuart Withington in correspondance dated September 7, 2012.
	Orthophosphate content of filter media	50 mg/kg	
	Exfiltration rate	0mm/hr	Although some exfiltration is expected, the system is being designed such that treatment occurs prior to surface water being lost to the system. A second model
	Is based lined?	Yes	Although system will not be lined, system has been modelled to not allow water to be lost from the system prior to treatment.
	Vegetation Properties	With effective nutrient removal plants	Landscaping of Bioswales will include deep rooted vegetation.
	Oveflow weir width	Driveway is weir for each swale (3.5m). Total weir is used in modelling (i.e. 3.5 x number of swales).	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Underdrain present	Yes	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Submerged zone with carbon present	No	Design of proposed swales. Design provided by Tattersall Lander (attached).
Wetland	Low Flow By-Pass	0 m3/s	As per WBM (2010) MUSIC modelling guidelines
	High Flow Bypass	50% of 1 year ARI based on total subcatchment area and AR&R results for Nelson Bay	As per WBM (2010) MUSIC modelling guidelines
	Inlet pond Volume	0 m3	Bioswales provide pre treatment include gross pollutant capture and so an inlet pond is not required as per WBM (2010) MUSIC modelling guidelines
	Surface area	Surface area (1300 m2)	By design and as per WBM (2010) MUSIC modelling guidelines
	Extended Detention depth	0.35m	By design
	Permanent pool volume	562 m3	Based on a surface area of 1300m2 at 0.4m depth (permanent pool depth). Typical 1:3 side batters
	Exfiltration rate	0mm/hr	Wetland shall be lined
	Equivalent pipe diameter	61 mm	adjusted to achieve detention time of 40 hrs as per WBM (June, 2012)

NB:

WBM (2010) ***'Sydney Metro CMA: Draft NSW MUSIC Modelling Guidelines'***

WBM (2012a) ***'Review of Water Quality Management for the Porposed Riverside at Tea Gardens Development: Final Report'***

WBM (2012b) ***'Riverside at Tea Gardens Residential Subdivision Revised Concept Plan'***

13 Attachment 3C – Soil Landscapes Mapping

NOTE
AERIAL SOURCE: TATTERSALL LANDER P/L (2012)

PAGE BAR SCALE
0 120 240 360 480 600
UNITS - METRES
SCALE - 1:6000 @ A1 1:12000 @ A3

N
W E
S

Martens & Associates Pty Ltd ABN 85 070 240 890

Environment | Water | Wastewater | Geotechnical | Civil | Management

Drawn:	KT
Approved:	DM
Date:	17.09.2015
Scale @ A1:	1:6000

SOIL LANDSCAPES - EXISTING SITE
RIVERSIDE DEVELOPMENT AT TEA GARDENS, NSW

Drawing No./ID: D100

6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

Project:	File:	Revision:
P1404136	JD05V01	A