trinity point

LAKE MACQUARIE

CONCEPT PLAN MODIFICATION: STORMWATER AND FLOODING MANAGEMENT PLAN

April 2015

Document Control Sheet

Issue No.	Amendment	Date	Prepared by	Checked by
A	DRAFT Issue	29 September 2014	MK	LG
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C	Revised - DPE Comments	9 February 2015	MK	SH
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Executive Summary

Johnson Property Group (JPG) are seeking to modify an approved Concept Plan (MP06-0309) to carry out development of a marina and mixed use development for the Trinity Point site near Bluff Point, Morisset Park.

The proposed modifications reduce the extent of paved surfaces and allows for more landscaping opportunities compared to the approved concept. The reduced extent of impervious surface area (in combination with the deletion of vessel hardstand and repair facilities as per Modification 2) reduces potential sources of waterway pollutants. With regard to the proposed modifications ADW Johnson was engaged to review the stormwater management strategy and flooding impacts for the site, and provide come comparative analysis between the approved and proposed concept.

The review found:

- *Stormwater Management*. Broadly, the proposed stormwater management strategy and general principles and objectives of stormwater management identified in the approved concept plan is appropriate, and the identified water quality targets in the approved concept is appropriate. Specific comparison between the proposed concept and the approved concept yielded the following:

    - No new sources of potential pollutants that would impact water quality are identified between the approved and modified concept.

    - Given the magnitude of construction and consistent with the approved concept, appropriate erosion and sediment control practices during construction will be implemented for the modified concept. This requirement is identified in approved and modified Principle 11, and reinforced by Condition C23 of the concept approval.

    - The modified concept has a reduced roof area, reduced path and roads areas and significant increase in pervious area by calculated comparison with the approved concept plan.

    - In order to achieve the broader stormwater management strategy and water quality targets from the approved concept plan and enable a more efficient treatment of stormwater management for the modified plan, minor amendments are proposed to source controls and updates provided to the required capacity of various source controls.

      This includes the retention of rainwater tanks (but with reduced volume to reflect the modified concept and updated water balance assessment), retention of bio-retention swales (but with reduced area to reflect the modified concept and water quality modelling requirements), exclusion of permeable paving and roof top gardens, and the addition of gross pollutant traps.

    - Water quality modelling of the approved and modified concept and treatment trains has been undertaken. The modelling demonstrates that the revised concept treatment train can meet the same identified water quality targets as the approved concept.

- The required volume of rainwater tanks and area of bio-retention swales, along with concept reticulation and overland flow paths, have been conceptually overlaid onto the modified concept to demonstrate they are capable of being provided to required capacities and integrated into the modified concept.

- *Flooding.* All building floor levels are proposed to be located above flood levels, consistent with intent of the approved concept plan. It is noted that Lake Macquarie City Council (LMCC) has initiated a Waterway Flood Study and Flood Plain Risk Management Plan which supersedes the proposed flood planning levels identified in the approved concept plan. The more recent LMCC flood planning levels have been incorporated into the modified concept.

Although some amendments to the stormwater strategy and flood planning levels are proposed, the general principles and objectives of stormwater management and flooding can be met under the proposed modification and remain generally the same as approved concept.

This report was submitted to the NSW Department of Planning and Environment in November of 2014 to support the Concept Plan modification. The department responded in January 2015 (attached at **Appendix C**) requesting additional details. These details have been added to the report and summarised at **Table 1.**

Table of Contents

APPENDICES

1.0 Introduction

1.1 Background

Johnson Property Group (JPG) are seeking to carry out the development of a marina and mixed use development for the Trinity Point site near Bluff Point, Morisset Park (refer Figure 1 for site locality). The site is located approximately 6km from Morisset, which has been identified in the *Lower Hunter Regional Strategy* as an emerging regional centre. The site is within the Lake Macquarie City Council Local Government Area (LGA). The original concept plan was assessed under Part 3A of the EP&A Act as a 'major project', and as such was referred to the NSW Department of Planning (NSW DoP) for assessment and approval.

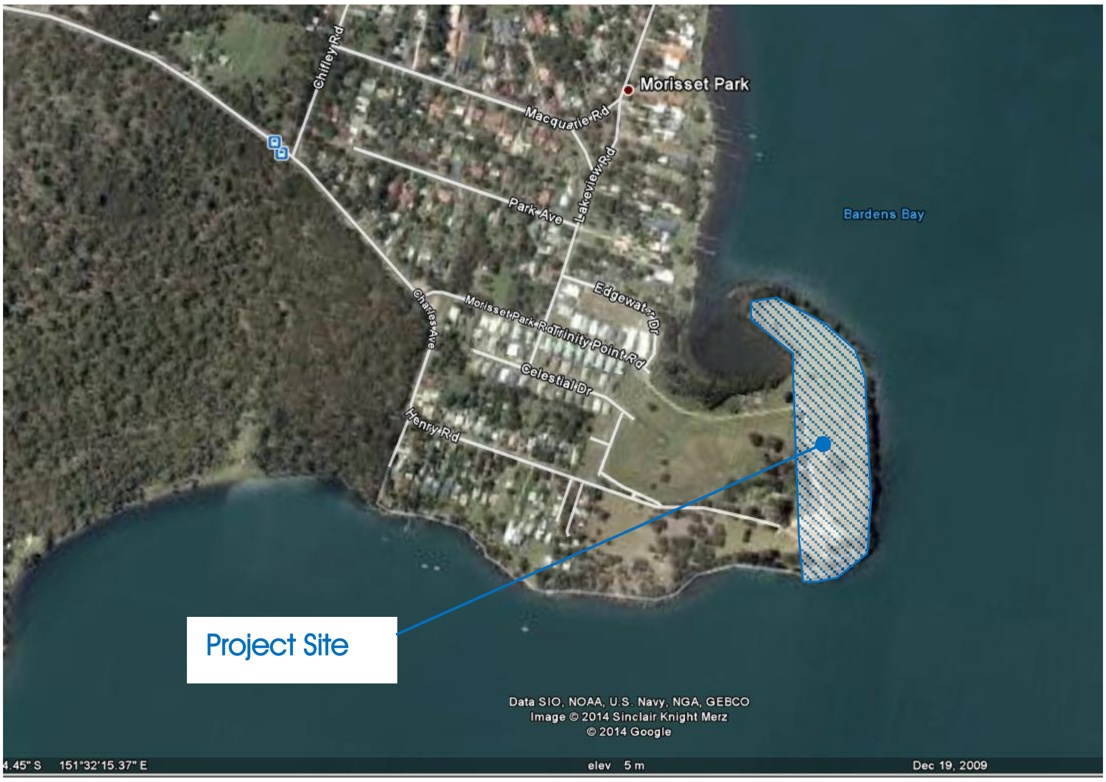

Figure 1: Locality Plan.

The Concept Plan was approved by the NSW DoP in 2009, which included a stormwater and flood management report in support of an earlier version of the concept. Attached to the concept plan was a Preferred Project Report, in which the objectives and principles of stormwater management and flooding were established for the site (being Principals 11 and 12). Conditions C19 and C20 also relate to stormwater management and flooding, and Condition 23 regarding sediment and erosion control.

The developer, Johnson Property Group, are seeking approval to modify the concept plan, whilst progressing with Development Applications for parts of the site.

This report addresses the stormwater, flooding and water quality management issues as they apply to the modifications proposed to the concept plan.

This report is intended to accompany the Concept Plan Modification Application (75W) and should be read in conjunction with the drawings attached at **Appendix A.**

1.2 Report Objectives

The objectives of this report are as follows:

- To summarise the proposed amendments to the previously approved concept plan from a stormwater and flooding perspective;
- To summarise how the new proposal meets the intent of the concept plan;
- To detail how the new proposal meets the relevant principles and objectives as referenced in the Preferred Project Report and relevant approval conditions; and
- To provide some comparative analysis between the approved and modified concept.

1.3 Previous Reports

A previous report *"Trinity Point Marina Development - Stormwater Management Plan"* Patterson Britton – October 2008 accompanied the Concept Plan Environmental Assessment Reports. This report was prepared for a larger and different scheme than what was ultimately approved.

"Lake Macquarie Waterway Flood Study" and "Lake Macquarie Waterway Flood Risk Management Study and Plan" WMA Water 2012 has been prepared following concept plan approval and adopted by Lake Macquarie City Council to inform flood planning levels around Lake Macquarie.

"Mixed Use Development (Tourism and Hospitality) Development Application: Stormwater and Flood Risk Management Plan" has been prepared by ADW Johnson to accompany the Development Application of the combined restaurant/function centre and a marina/hotel accommodation facility.

"Trinity Point Stormwater and Flood Risk Management Plan" – Royal Haskoning DHV – September 2014 accompanied the Development Application for the Stage 1 marina site only.

1.4 NSW Department of Planning and Environment Comments

This report was submitted to the NSW Department of Planning and Environment in November of 2014 to support the Concept Plan modification. The department responded in January 2015 (attached at Appendix C) requesting additional details. These details have been added to the report and for ease of reference the location where the additional details can be found is shown in Table 1.

Table 1. NSW DPE Comments and Reference

NSW DPE Comment	Reference
The RTS should include a revised stormwater and flooding management plan which considers the flooding impacts associated with the revised building envelopes and provides a comparisons between approved and modified concept.	Section 5
Details regarding the source controls, average monthly demands, water balance, water quality, proposed catchment sizes, indicative water quality control design parameters, proposed water quality sampling program, location of overland flow paths and demonstration that the bio retention basins proposed have sufficient capacity are to be provided.	Source controls – Section 3.4 Average Monthly Demands and Water balance – Section 3.4.1 Water Quality – Section 3.4, Section 3.4.4 and Section 3.5 Proposed Catchment sizes - Section 3.4.1.2 Indicative water quality control design parameters – Section 3.3 Proposed water quality sampling program – Section 3.6.1 location of overland flow paths - Section 4.2 and Appendix A Bio retention basins Section 3.4.3 and 3.4.4
The flood plan provided to support the approved Concept Plan should be updated to reflect the revised application.	Appendix A
Any revisions required to the approved flood mitigation measures should also be provided.	Section 5.3 and Appendix A

2.0 Project Description

2.1 Approved Concept Plan Proposal

The approved Concept Plan included 188 marina berths, workshop maintenance and club facilities with residential and tourist accommodation and a café, restaurant and function centre and other uses. Following the approval several modifications have been lodged with NSW Department of Planning as follows:

- Modification 2, which is currently undergoing assessment, seeks a range of modifications to marina related matters, notably including the removal of the workshop and maintenance facilities;
- Modification 3 sought to include a Helipad, which is water based and to be subject to separate environmental assessment; and
- Modification 4 sought to extend the lapse date, and has been approved.

This report accompanies Modification 5 which incorporates land based changes.

2.2 Proposed Modifications

Architectural drawings of the approved Concept Plan and proposed modification are shown on Figures 2a and 2c on the following pages. The proposed modifications reduces the extent of paved surfaces and allows for more landscaping opportunities. The reduced impervious surfaces reduce the impact upon the catchment hydrology and reduces potential sources of waterway pollutants.

It is noted that the concept plan varied from that originally submitted in the 2008 Stormwater Management report submitted by Patterson and Britton to that approved in 2009 (these changes did not arise as a result of water cycle management issues, and where relevant to water cycle management, they include a change of built form style from U-shaped apartment buildings to small integrated housing on an internal grid driveway system for the central and southern part of the site). The plan included in the 2008 Stormwater Management Report is shown on Figure 2b on the following pages.

The original 2008 stormwater management report was not updated to reflect the approved concept and there is no stormwater management plan, analysis or reporting available for the approved concept. However, in its response to this proposed concept plan modification, the NSW Department of Planning has requested that a direct comparison be undertaken. To form a basis of comparison, an analysis of the approved concept plan has been undertaken by adopting similar principles as outlined in the 2008 Stormwater Management report. The results of this analysis have been compared to the current proposed concept plan as outlined in Section 3.

Figure 2a: 2009 Approved Concept Plan.

Figure 2b: Concept Plan as reported in the 2008 Stormwater Management Plan.

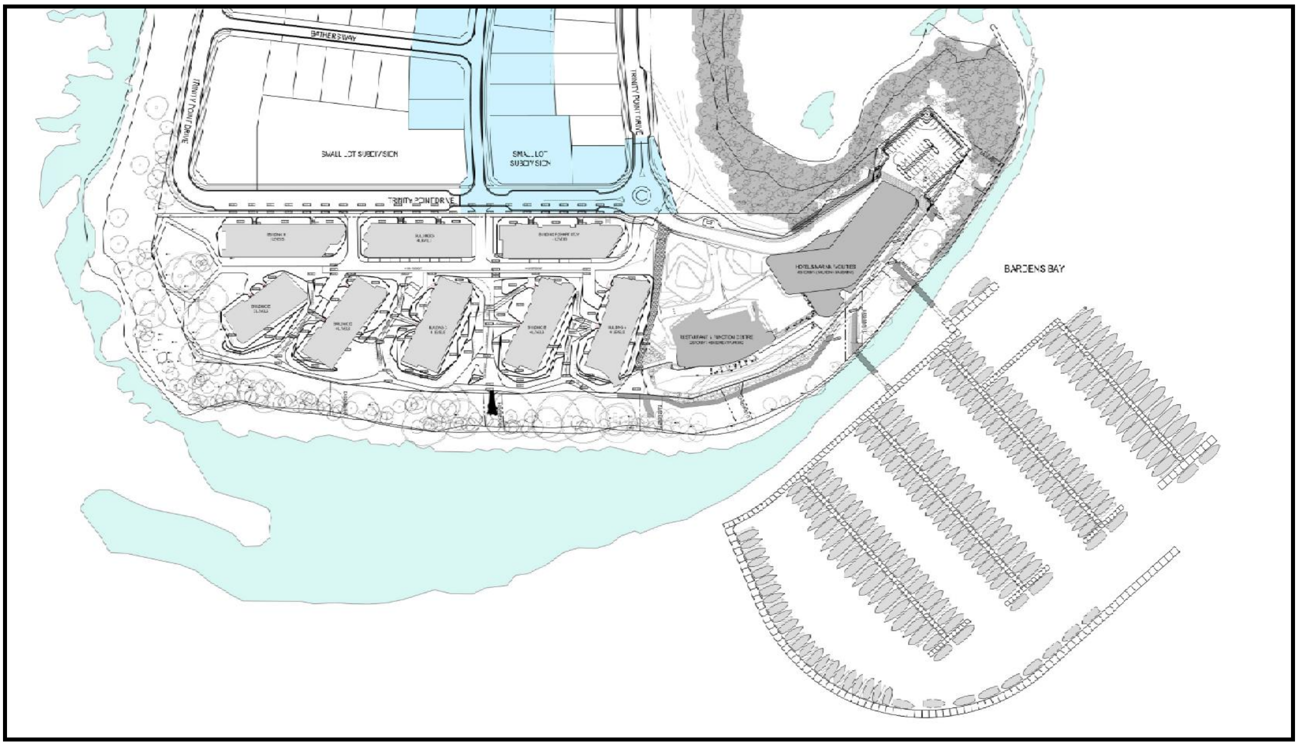

Figure 2c: Proposed Concept Plan modification – Squillace Architects.

3.0 Water Quality Impacts

3.1 Stormwater Management Principles in Concept Plan

The principles established in the approved preferred project report (Principle 11) include:

Objective

To provide preventative measures to ensure no impact on aquatic environment and lake water quality and to provide for water harvesting and re-use opportunity.

Guidelines

- *Stormwater Management Plans are to be provided with Project Applications, incorporating the following measures:*
- *Adopt a best practice water sensitive urban design approach, focusing on preventative and source controls where possible.*
- *Provide rainwater harvesting, permeable pavements and bio-filtration swales as part of overall stormwater strategy (where deemed appropriate). Residential dwellings to achieve water efficiency targets as required by BASIX.*
- *Incorporate and adopt a range of preventative, containment and treatment measures for stormwater management from the marina workshop and hardstand area. To include a first flush tank and treatment of captures stormwater for reuse/ trade waste discharge, and segregations of hardstand surface area into three areas to facilitate waste collection and treatment.*
- *Provide oily waste recycling tank for wastes from workshop and from oily bilge water from the pump out facility on the marina.*
- *Fuel storage tanks to be designed according to authority requirements including double skinned tanks.*
- *Implement a water quality monitoring program during construction and for three years of marina operation.*
- *Design and install sediment and erosion control structures during construction according to an erosion and sediment control plan.*
- *Incorporate overland flow paths as necessary.*

In addition:

- *Consider acid sulphate soils management, in line with a management plan, in design and construction methodologies.*
- *Consider groundwater implications in design and construction methodologies.*

These matters are to be considered in further detail with Development Applications where relevant, and Section 3.8 of this report considers these against the proposed modification.

3.2 Stormwater Management Principles in Concept Plan

The proposed modifications to the concept plan have been considered in reviewing the stormwater treatment strategy for the entire site.

Broadly, as discussed in Section 2.2, the proposed amendment to the concept plan can be summarised as:

- A net decrease in impervious roof area within the accommodation precinct;
- A net decrease in road and paved areas; and
- A net increase in landscaped area.

Based on the above it is proposed to undertake a number of changes to the stormwater treatment train to optimise performance within the new site conditions and modified concept.

3.3 Water Quality Strategy - General Development Area

Stormwater runoff treatment targets for commonly occurring urban pollutants were discussed in the concept plan report based on a review of relevant guidelines, specifically, those included in the "*Managing Urban Stormwater: Environmental Targets*"*.* The suggested rainwater quality treatment targets are as follows:

- *Total Suspended Solids (TSS) – 85% mean annual retention;*
- *Total Phosphorus (TP) 65% mean annual retention; and*
- *Total Nitrogen (TN) 45% mean annual retention.*

These targets are compared to best practice targets suggested in Australian Rainfall Quality, and Lake Macquarie City Council Guidelines. No stormwater treatment measures were proposed to manage peak flow, as such treatments would be ineffective when discharging to Lake Macquarie.

The original stormwater report (2008) identified a water quality treatment train to achieve the stormwater management objectives for the Trinity Point site. Specific stormwater quality improvement devices included:

- ***Rooftop Gardens.*** To reduce the impact of impervious rooftop surfaces;
- ***Rainwater Harvesting***. To reduce runoff volume and decrease demand on potable water supplies;
- ***Permeable Pavement***. To reduce the runoff from impervious road surfaces and provide some infiltration; and
- ***Bio-Filtration swales.*** To provide high levels of pollutant removal before discharging off site.

To augment the proposed source control measures, a number of preventative measures were proposed including minimising impervious areas, drought tolerant plantings, fertiliser management regimes, public education on environmentally responsible behaviours and provision of rubbish bins.

Noting above, it is considered that rooftop gardens were unlikely to form part of the treatment train for the approved concept given it changed to pitched roof structures and increased small lot housing built form.

3.4 Proposed Water Quality Strategy – Source Controls

The stormwater management system incorporates Water Sensitive Urban Design elements to retain pollutants as described above. Specific source control measures are outlined in Table 2 below.

Table 2. Approved Concept plan source controls compared to proposed controls.

Approved Concept Plan Source Control	Proposed Modified Concept Plan Source Control	Comment/ Justification
Rooftop Gardens	N/A	Rooftop Gardens were unlikely to form part of the treatment rain for the approved concept plan based on built forms (inclusive of a pitched roof) and they are not proposed in this revised stormwater strategy. Further, rooftop gardens are difficult to maintain, often require potable water during time of drought and can lead to poor visual amenity if not properly cared for. The approved concept plan notes that an alternative to green roofs would be to increase rainwater harvesting directly from the roof source, which is what is currently proposed.
Rainwater Harvesting	Rainwater Harvesting	Rainwater is proposed to be harvested by the placement of rainwater tanks that capture roof runoff during storm events. Harvested rainwater is intended to provide a supply of non-potable water for toilet flushing and irrigation.
Permeable pavement	N/A	Permeable Pavement is not proposed in the revised overall stormwater strategy. Given the significant decrease in road paving this is not considered to be required.
N/A	Gross pollutant Traps	It is proposed to include Gross Pollutant Traps that will treat any overflow from rainwater tanks and runoff collected from paved areas.
Bio-filtration basins	Bio-filtration basins	Bio-filtration swales are proposed at discharge points along the perimeter of the site, similar to what was proposed in the concept plan.
Passive measures	Passive measures	Preventative measures are proposed including drought tolerant plantings, fertiliser management regimes, public education on environmentally responsible behaviours and provision of rubbish bins.

Details on each proposed source control are outlined in the following sections.

3.4.1 Rainwater Tanks

3.4.1.1 Demand Analysis

Given the change in proposed roof areas, the size, requirements and nature of roof water tanks has been recalibrated to provide an optimal water balance between tanks size and reliability.

It is noted that the development is connected to a potable water source, and hence it is not proposed to use captured rainwater for drinking water and household use, which is consistent with the approach recommended in Chapter 6.3 of *Australian Rainfall Quality* – Engineers Australia 2006.

As per the concept plan, proposed demands are limited to irrigation and toilet flushing. Demands have been calculated as follows:

Toilet Flushing

- *Restaurant and Function Centre and Marina.* Employees have been conservatively estimated at 14 equivalent full time staff. Average toilet use has been estimated as 3 times per day, at 5L per use. This totals 210 l/day.

  It has been assumed that on average, there will be 300 users of the facilities each day, half of which will use the facilities. The total visitor demand is therefore approximately 750l/day (300x 0.5usesx 5L = 750L/day).

- *Accommodation.* 35l/day has been allowed for toilet flushing per person, which has been sourced from *Water by Design - MUSIC Modelling Guidelines.*

  Occupancy rates have been sourced from *Water by Design Guidelines-MUSIC Modelling Guidelines* for short stay accommodation demands and have bene adjusted seasonally, consistent with the approved concept plan.

- *Residential.* 30l/day has been adopted as per Water by Design -MUSIC Modelling Guidelines.

Irrigation Demand

- 530mm/year/m2 for 4,000m^2 of irrigated lawns and garden beds. It is noted that not all garden beds are intended to be irrigated, as many will be planted out with drought tolerant species. Seasonal Irrigation demand patterns have been allowed for. This approach reflects a more advanced landscape design than what was available during the previous concept plan development.

  The demands for irrigation are approximately 24mm per week during the summer and growing months down to 8mm per week during winter periods. These figures have been derived form industry best practice and in consultation with the landscape architect, Terras Landscaping.

Total average demands are tabulated in Table 5. A comparison to the approved concept is not available, however these demands are less than those reported for the 2008 Stormwater Management report concept.

3.4.1.2 Catchment Analysis

The total catchment area of the proposed modification is tabulated in Table 3 below. It is intended to harvest stormwater from roof catchments only. For means of comparison the approved Concept Plan and the plan associated with the 2008 Stormwater Management Report are also shown (area have typically been scaled off drawings where more detailed information is not available, and hence should be considered approximate).

Table 3: Catchment Analysis

Catchment	Total Area (Ha)	Roof Area (Ha)	Other Impervious areas paths and board walks)	Pervious area (lawns and gardens)
1:	0.42	0.1	0.21	0.11
2:	0.4	0.14	0.16	0.1
3 (Marina access road):	0.26	0	0.17	0.09
4:	1.0	0.41	0.24	0.35
5:	1.2	0.39	0.18	0.63
6 (Marina and Carpark[1]):	0.33	0.06	0.22	0.05
Overall	**3.61**	**1.1**	**1.18**	**1.33**
2008 Stormwater Management Report[2]	3.61	0.9	1.5	1.21
Approved Concept Plan[3]	3.61	1.4	1.31	0.9

Notes on Table 3:

1. Based on "Trinity Point Stormwater and Flood Risk management Plan" – Royal Haskoning DHV – September 2014
2. Based on approximate measure of drawings in the 2008 report.
3. Based on approximate measure from drawings in the approved concept plan.

3.4.1.3 Water Balance

Water balance modelling was undertaken using a series of spread sheets developed by ADW Johnson. The spreadsheets utilise daily rainfall data over a period from 1999-2008 at Wyee, Bureau of Meteorology station 061-082. This period was chosen to be consistent with Lake Macquarie City Council's MUSIC Link data, as to be consistent with the water quality modelling. Demand and catchment parameters were obtained from Sections 3.3.1.1 and 3.3.1.2 above.

The water balance spreadsheets calculate the total reduction in potable water which is supplied by the tanks and the tanks efficiency (that is the percentage of runoff captured from the tank divided by the total runoff to the tank). An objective of minimum 60% reliability (that is the tank is empty less than 40% of days) and an 50% efficiency was considered appropriate.

Several simulations were run to determine the most appropriate methodology for rainwater tank provision:

- Irrigation demand only; and
- Irrigation and toilet flushing demands.

Storage sizes from 50KL to 300KL were modelled. The results are tabulated in Table 4. Detailed calculations are included at **Appendix D.**

Table 4: Water balance results

Tank Size	Total Rainfall to Tank (kl/year)	Rainwater Tank efficiency (%)	Reliability (% of days where rainwater meets demand)	Reduction in potable main use (kl/year)
100KL	9,180	41%	55	3,781
150KL	9,180	47%	61	4,304
200KL	9,180	52%	66	4,695
250KL	9,180	55%	69	5,003
300KL	9,180	57%	72	5,254

3.4.1.4 Water Balance Discussion

Based on the above preliminary water balance modelling undertaken above the following conclusions can be drawn:

- That the incremental improvements in tank efficiency of the rainwater tanks begin to drop significantly for tank sizes above 200KL. This is suggesting that the tanks are capturing only fractionally more rain water than the smaller tanks though not using substantially more.
- Incremental improvements in the reduction of potable water mains use decreases for tank sizes above 250KL.

Based on the above it would appear that an overall tank storage volume of approximately 200KL achieves an appropriate nexus between reliability, efficiency and reduction in potable water demand, whilst not imposing unnecessary capital investment.

For the purposes of future modelling it is proposed that 200KL storage capacity be adopted for water quality modelling, supplying landscape and toilet flushing demands. It is proposed that as design progresses, that this volume is refined based on individual catchment parameters and a cost benefit to optimise the tank configuration.

It is noted that this tank volume is less than that proposed 250KLl in the 2008 Concept Report and that may have also applied to the approved concept. This is due to the following factors:

- The catchment parameters have changed, and hence the supply and demand for rainwater have been altered. In particular the harvestable roof area has increased in comparison to the 2008 report;

- The demand for irrigation has been reduced. Notwithstanding an increase in pervious area proposed for the modified concept (by comparison to the 2008 concept and approved concept), not all gardens beds are proposed to included irrigation, as they will be planted with drought tolerant species; and

- The roof area has increased by comparison to the 2008 concept, meaning that rainwater yields have increased, improving reliability of a smaller tank. It could be considered that as the approved concept plan included greater roof areas than the 2008 concept, it would have been likely that the final tank sizes would have been reduced to account for the greater roof area should development had progressed in line with the approved concept.

Overall the proposed tank configuration saves approximately 4,671KL of potable water per year, compared to 3,000KL as reported in the 2008 Stormwater Management Report and approved concept plan.

3.4.1.5 Operational Maintenance

As the proposed system collects run off from roof sources only, it will not require tertiary water quality treatment. However water quality can be improved through ongoing management, including cleaning the tanks, regular maintenance of the roofs and gutters, and installing a first flush system that diverts initial runoff that transports the majority of roof sediments away from the tanks and installing tanks with filter to prevent gross pollutants entering the tanks.

Table 5: Demand Analysis

Demand Type (KL/Day)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Garden Irrigation	Seasonal Variation (%)	100	100	80	65	50	30	30	40	50	50	80	100
Demand (KL/ Day)		12	12	9.6	7.8	6	3.6	3.6	4.8	6	6	9.6	12
Toilet Flushing – Commercial	Seasonal Variation (%)	100	100	100	100	100	100	100	100	100	100	100	100
Demand (KL/ Day)		1	1	1	1	1	1	1	1	1	1	1	1
Toilet Flushing – Short Stay Accommodation	Seasonal Variation (%)	90	90	80	60	50	50	50	50	60	80	80	90
Demand (KL/ Day)		7.56	7.56	6.72	5.04	4.2	4.2	4.2	4.2	5.04	6.72	6.72	7.56
Toilet Flushing – Residential	Seasonal Variation (%)	100	100	100	100	100	100	100	100	100	100	100	100
Demand (KL/ Day)		7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Total (KL/Day)		**27.76**	**27.76**	**24.52**	**21.04**	**18.4**	**16**	**16**	**17.2**	**19.24**	**20.92**	**24.52**	**27.76**

3.4.2 Gross Pollutant Traps

Gross Pollutant Traps were not proposed in the original approved Concept Plan, however have been added to the treatment train in the proposed Concept Plan modification, as they provide a space efficient and practical means of primary stormwater treatment. Further, Gross Pollutant Traps will capture minor rubbish and debris and prevent the debris from being deposited within the bio filtration basins.

Gross Pollutant Traps have been based on 'Rocla CDS' units for the purposes of water quality modelling. Rocla CDS units provide a capture efficiency of approximately 70% of Suspended Solids, 30% Nitrogen and 98% Gross Pollutants.

The units have been designed with a high flow bypass of 54l/s which simulates the impact during intense storm events where the treatment capacity of the Gross Pollutant Trap is exceeded (refer Section 4.0 for details on the minor and major stormwater network).

3.4.3 Bio Retention Basins

Bio retention basins are proposed to provide tertiary treatment of fine suspended solids and capture of nitrogen and phosphorus. This strategy is similar to what was proposed in the approved Concept Plan.

Bio filtration swales have been designed with 200mm extended detention storage and media filtration depth of 500mm, with a hydraulic conductivity rate of 100mm/hour, which is consistent with the FAWB (Facility for Advancing Water Biofiltration – Monash University) guidelines. It is proposed to provide for sub soil drainage that will convey treated stormwater flows to the proposed discharge point. The basins will be planted with native plants (refer Landscape Architects drawings) to enhance nutrient removal.

Basins will be provided with a high flow stormwater outlet where runoff exceeds the infiltration rates of the filter media to convey stormwater flows.

The area of Bio Retention basins has been modelled to meet the treatment targets as set out in Section 3.3. The areas were modified to provide the optimal performance given the site catchment conditions and modified concept. In total it is proposed to provide approximately 400m^2 of filter area. This is broken down into catchment areas in Table 6. By comparison to the approved concept, this represents an approximate reduction of 150m^2.

3.4.4 MUSIC Modelling

A MUSIC Model was prepared to model the performance of the revised strategy. MUSIC has been developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH) to simulate the treatment of stormwater runoff in Urban Catchments, and is widely accepted as an appropriate conceptual model. It should be noted that the model interprets a complex environment over a period of 10 years, and provides a long terms average of treatment performance. Treatment train performance for specific storm events would vary over time.

The model was used to determine the minimum size of the Bio retention basins and to confirm the effectiveness of the proposed treatment train described in the preceding sections.

Meteorological data including rainfall and evapotranspiration data was obtained from Lake Macquarie Council's *MUSIC Link* files.

The MUSIC Model was setup in five sub catchments. That is, the dual use short stay and permeant residential precinct, the short stay precinct (with upper levels also for permeant residential) and two catchments in the tourism and hospitality precincts, and the marina (refer to Appendix A for a Catchment Plan). Pollutant generation rates were obtained from Chapter 3 of the Australian Rainfall Quality Manual – Engineer Australia 2006.

For the purposes of making a direct comparison of the approved Concept Plan and the current proposal, a model of the approved Concept Plan has been prepared, by adopting the principles set out in the 2008 Stormwater Management Plan.

Results are presented in Table 6 on the following page.

Catchment	Catchment Breakdown			Treatment Train				Treatment Train Targets (%)			Treatment Train Results (%)		
	Impervious		Pervious										
	Roof	Paths and Roads	Gardens and Lawns	Rainwater Tank	Gross Pollutant Trap	Bio-filtration	Permeable Pavement	TSS	TP	TN	TSS	TP	TN
Proposed Concept Plan Modification													
1	0.1	0.1	0.11	20KL (2x10KL)	Yes	45m2	N/A	85	65	45	92.9	66.0	58.7
2	0.14	0.16	0.1	20KL (2x10KL)	Yes	30m2	N/A	85	65	45	86.7	65.6	54.7
3	0.26	0.17	0.09	N/A	No	N/A	N/A	85	65	45	93.8	76.0	46.3
4	0.41	0.24	0.35	70KL	Yes	160m2	N/A	85	65	45	95	68.4	67.4
5	0.39	0.18	0.63	70KL	Yes	140m2	N/A	85	65	45	95.7	69.1	68.9
6 (Marina and Carpark1)	0.06	0.22	0.05	20KL	No	30m2	N/A	85	65	45	92	73	54
Proposed Concept Plan Modification	1.14	1.14	1.33	200KL	Yes	405m2	N/A	85	65	45	92.8	67.8	61.6
2008 Stormwater Management Report	0.9	1.5	1.21	250KL	No	$200m^2$	1000m2	85	65	45	89	71	46
Approved Concept Plan- Achieved Reductions[3]	1.9	1.01	0.7	250KL	No	550m2	1000m2	8 5	65	45	88	70	46

Table 6: Water Quality Modelling Results and Comparison

3.5 Results and Comparison

It can be seen from Table 3 above that water quality targets are achieved for the entire site, as well as each catchment. Results compare similarly to the 2008 concept report for removal of Suspended Solids and Phosphorus, whilst providing a significant improvement in the removal of Nitrogen.

Detailed MUSIC outputs are included in Appendix E.

The results illustrate the following differences in the strategies:

- The proposed concept plan *includes* a Gross Pollutant Trap within the treatment train. The strategy outlined in the 2008 Stormwater management report, and hence the approved Concept Plan, would not have included a Gross Pollutant Trap. The reasons for this approach are outlined in Section 3.4.2;

- The proposed concept plan includes *more* bio filtration area than the 2008 Stormwater Management Report. This is primarily due to the removal of green roofs from the strategy. The approved Concept Plan did not feature green roofs, and hence the proposed area of infiltration basins is *less* than what would have been required under the approved Concept Plan to achieve water quality objectives;

- The proposed concept *does not* include Permeable Pavement. The proposed concept plan has significantly increased the extent of pervious surfaces which more than compensates for the small allowance of permeable paving in the 2008 Stormwater Management Report and the approved Concept Plan; and

- The proposed concept plan proposes fractionally smaller rainwater harvesting tanks than the 2008 Stormwater Management Report and the approved Concept Plan. However, for reasons outlined in Section 3.4.1.4, the harvested water remains similar to the concept plan.

3.6 Water Quality Monitoring

3.6.1 Monitoring Strategy

Water quality monitoring will be established to ensure treatment targets are being met and to establish the existing water quality conditions.

It is intended to undertake water quality monitoring in three phases:

- *Pre-Construction*. Establish existing water quality. This will include testing of baseline levels of TSS, TP, TN and trace heavy metals. This requirement is reiterated in Condition C11 of the concept approval for the marina. Baseline water quality has been established and documented in the Development Application 1503/2014 and no further baseline water quality monitoring is required beyond that.

- *During Construction (land based)*. During this time, water quality is impacted by the unestablished nature of the catchment as existing vegetation is stripped, leading to the sediment laden water potentially leaving the catchment. Testing of water quality will therefore be focused on inspection and maintenance of erosion control measures and sampling Total Suspended Solids (TSS) following storm events. This will typically be undertaken concurrently with marina based sampling of water based construction, and will also occur throughout land based construction processes should there be no other water quality monitoring otherwise occurring.

Development Applications will require erosions and sediment control plans for each stage, and the contractor will be required to establish a comprehensive sediment and erosion control plan in accordance with "*Managing Urban Stormwater – Soils and Construction*". These plans will identify on site erosion controls such as sedimentation basin, silt fencing and filters to prevent sediment laden runoff leaving the site. These controls will be visually assessed before anticipated rain and following storm events to confirm suitability.

- ***During Construction (water based)***. The water based construction of the marina requires special consideration in relation to pollution control. Specific activities that could impact upon the water quality would include:

    - Piling, including pile launching activities;
    - Operation of vessels and other water-based plant; and,
    - Land based site preparation, earthworks and construction.

  The proposed water quality monitoring program (documented in DA1503/2014) during water based construction would comprise the following elements:

    - Daily visual inspections undertaken from shore and working barges for potential visual surface plumes or oily sheens;
    - Weekly measurements of physical and chemical parameters using hand-held instrumentation;
    - Collection of water samples for laboratory analysis of various contaminants, undertaken on a fortnightly basis for at least the first six weeks of water-based construction, then monthly provided it can be demonstrated that initial monitoring results are consistent with baseline levels; and
    - Reactive water sampling.

- ***Operational Stage (marina).*** Post construction water quality monitoring is required by Condition C13 for one (1) year from commencement of the marina. The proposed water quality monitoring program is documented in DA 1503/2014 and comprises 10 monitoring events over a 12 month period with collection of samples, laboratory analysis of key parameters (similar to the predevelopment baseline) and measurements of other physio-chemical parameters undertaken adjacent to the marina and a baseline location.

- ***Operational Stage (non-marina).*** An additional monitoring regime would include water sampling of TSS, TP and TN at the stormwater outlets (one at the marina and the other at the function centre for a period two years following construction of the marina, consistent with Condition C19 of the concept approval. This will ensure that the stormwater management plan operates as intended. Also, regular testing of the harvested rainwater will be undertaken to ensure the water is suitable for irrigation. Bassline measurement will also be taken away from the outlets to determine surrounding water quality. Proposed locations are shown on **Figure 3** below.

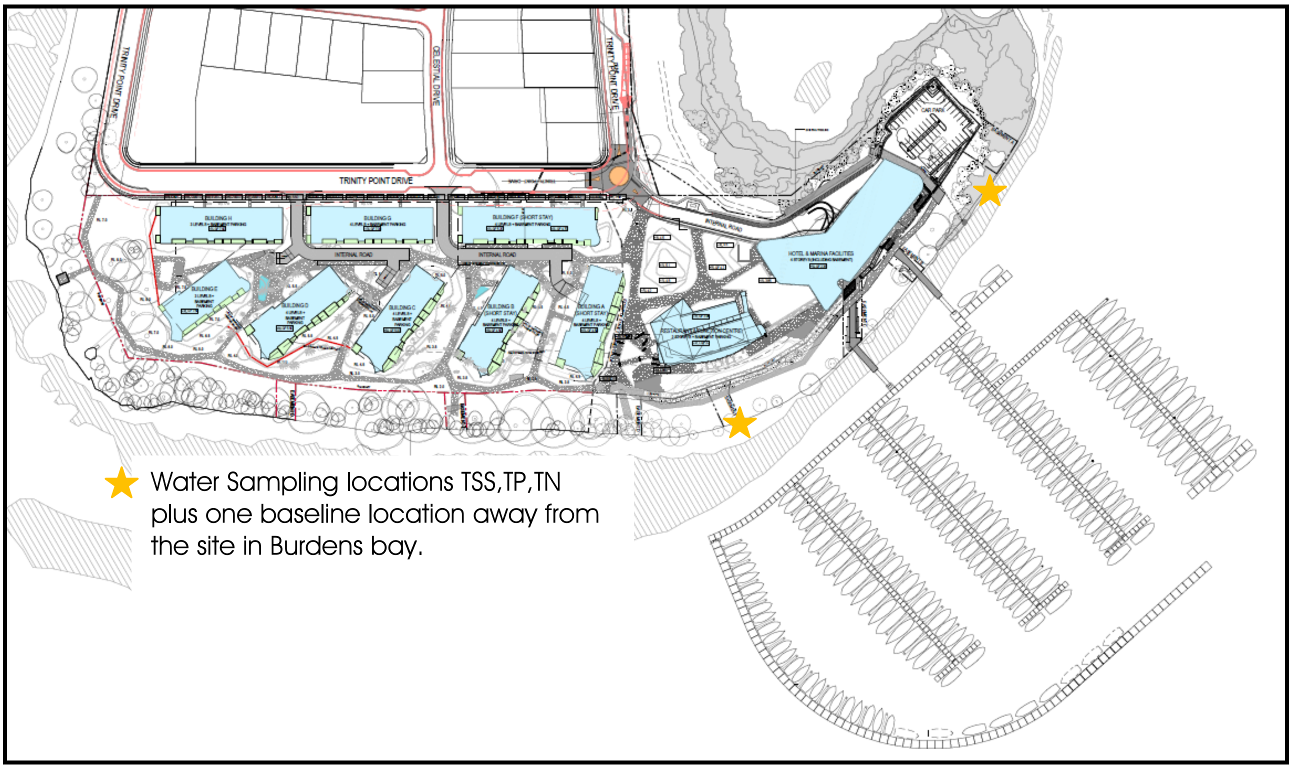

Figure 3: Additional Non-marina proposed water quality monitoring locations (for marina water quality program refer DA1503/2014).

The proposed sampling regime is outlined in Table 7.

Table 7: Proposed water sampling regime.

Sample Type	Construction	Operational
Land based		
Water Way Pollutants TSS,TP,TN	Downstream of Sediment basins following storm events (TSS only)	6 Samples per year for two years with at least two following wet weather.
Marina		
Heavy Metals	As per DA1503/2014: Daily visual inspection inspections Weekly handheld tests Fortnightly then Monthly samples Reactive sampling if required	10 Samples over a 12 month period including at least one following wet weather
Water Way Pollutants TSS,TP,TN	Daily visual inspection inspections Weekly handheld tests Fortnightly then Monthly samples Reactive sampling if required	

3.6.2 Comparison with Approved Concept Plan

The proposed water sampling regime is similar to that proposed in the in the 2008 report and approved concept plan. Amendments include:

- As the marina hardstand and workshop are no longer proposed specialised sampling at the workshop is no longer required. Sampling is still proposed with the marina itself and is document in Stage 1 marina EIS (DA1503/2014).

- The extent of Predevelopment baseline sampling has been revised from the 2008 report to include the marina only, which is consistent with Condition 11 of the approved concept plan.

- The duration of operational water quality monitoring has been revised from the 2008 report from 3 to 2 years, though this is consistent with Condition 19 of the approved concept plan.

- Harvested stormwater is proposed to be sampled twice a year instead of 6 time per year as outlined in the 2008 report. This is considered a more reasonable frequency as harvested water is obtained from roof water only and not roof and ground sources as described in the 2008 report, meaning contamination is far less likely. Further, harvesting rainwater for use in gardens and toilet flushing is a common established practice on both commercial and residential sites, most of which have not monitoring regime.

- Testing locations have been amended to suit outlet locations under the modified concept.

3.7 Water Quality Strategy - Marina

The Marina includes refuelling and sewerage disposal. These services are unique and require a different approach when compared with managing stormwater runoff from typical urban catchments, and have been specifically addressed within DA 1503/2014 (Stage 1 Marina DA).

The approved concept plan included a number of preventative measures to minimise the discharge of pollutants. Concept Plan Modification 2 (currently under assessment by the Department of Planning), seeks to remove the maintenance facility, vessel hardstand and travel lift which has removed the requirement for the previously proposed first flush treatment systems proposed at the vessel hardstand. The modification also seeks to remove the Oily bilge pump out management facility as a result of the removal of the maintenance facility.

This concept plan modification does not propose any further modifications to the stormwater strategy relating to the marina beyond those described in the Concept Plan modification 2 or in detail in DA 1503/2014.

3.8 Performance against Water Management Principles

The performance against the principles noted in the approved preferred project report are as follows:

Table 8: Performance against principles (Principle 11) in the preferred project report.

Principle	Comment
Stormwater Management Plans are to be provided with Project Applications	No proposed changes. A SWMP has been prepared for current development applications and will be prepared for future submissions.
Adopt a best practice water sensitive urban design approach, focusing on preventative and source controls where possible.	Source controls include rainwater tanks, Gross pollutant Traps and bio-filtration basins and meet best practice water quality treatment targets. Preventative measures are consistent with the approved concept plan. Further detail will accompany subsequent project application.
Provide rainwater harvesting, permeable pavements and bio-filtration swales as part of overall stormwater strategy (where deemed appropriate).	Rainwater harvesting and bio filtration basins are provided. Permeable paving is not considered appropriate due to the reduction in impervious area and the inclusion of gross pollutant traps.
Incorporate and adopt a range of preventative, containment and treatment measures for stormwater management from the marina workshop and hardstand area. To include a first flush tank and treatment of captures stormwater for reuse/ trade waste discharge, and segregations of hardstand surface area into three areas to facilitate waste collection and treatment.	Spill containment measures and treatment measures are still proposed as per the original concept plan and where relevant. The removal of the workshop in concept modification 2 negates the need for a first flush system.
Provide oily waste recycling tank for wastes from workshop and from oily bilge water from the pump out facility on the marina.	No longer required due to the proposed removal of the marina workshop in Concept Modification 2 and alternative management proposed.
Fuel storage tanks to be designed according to authority requirements including double skinned tanks.	Fuels tanks will comply with this requirement in the course of detailed design.
Implement a water quality monitoring program during construction and for three years of marina operation.	A water quality monitoring program relating to the site is proposed above.
Design and install sediment and erosion control structures during construction according to an erosion and sediment control plan.	Sediment and erosion control strategies have been provided in development applications and with future applications.
Consider acid sulphate soils management	An acid sulphate soil management plan have been provided in development applications and with future applications.

Principle	Comment
Incorporate overland flow paths	Concept Overland flow paths have been shown on the SWMP attached Appendix A and form part of SWMP provided in development applications.
Consider groundwater implications in design and construction methodologies.	Management of groundwater will be considered and reported against in Geotechnical reports accompanying Development Applications.

4.0 Stormwater Reticulation

4.1 General

A concept layout of the stormwater network and overland flow paths is shown in **Appendix A.** It is proposed that the stormwater network is designed in accordance with the minor/major network as described in the *Australian Rainfall and Runoff Manual* – Engineers Australia 1987 (AR&R1987).

4.2 Pipe Network and Overland Flow Paths

The site is to be held in private ownership, and therefore future reticulation will be designed to *AS3500 – Plumbing and Drainage*. AS3500 requires that commercial facilities should be free from nuisance flooding in the 10%AEP (Annual Exceedance Probability) and hence the minor network has been design to accommodate the runoff from the 10%AEP.

Flows up to the 1%AEP (or the 100 year ARI storm) are diverted via the grading of access paths and open space between the buildings adjacent to pathways. Whilst the specific grading of overland flow paths will be undertaken during subsequent design phases, the following design approach is recommended:

- Overland flow path will be directed away from buildings to mitigate flood damage in all storm events up to the 100 year ARI + 500mm freeboard;

- For public safety, the velocity depth ratios will be maintained below 0.4m2/s. This is consistent with the requirements of AR&R 1987 and Council guidelines; and

- The velocity of overland flow paths will be kept below scouring potential (typically under 2m/s for grassed surfaces).

5.0 Lake Macquarie Flood Impacts

5.1 Flooding Principals in Concept Plan

Principles established in the approved preferred project report (Principal 12) include:

Ensure that the proposed buildings consider and design for the effects of flooding.

Objective
Locate building above flood level, with flood level to be determined with regard to sea level rise through climate change.

Guidelines
Flood planning levels have been devised taking into account frequency, still water level, wave action, potential climate change impact and design life of various components of the site.

The proposed minimum flood planning levels are:

- *Habitable Floor Levels – 2.85m AHD.*
- *Hardstand Area and workshop – 1.1m AHD (with electrical wiring above 2.42m AHD).*
- *Road level and foreshore regrading to protect marina village undercroft parking spaces – 1.60m AHD.*
- *Marina Structures – 1.60m AHD.*

- *Where necessary, Project Applications relating to the village piazza (including undercroft parking area) and marina utility components of the project are to document broad sea level rise adaption measures and strategies available and how they have been, or can be, incorporated. These are to integrate with other principles of this Concept Plan.*
- *Appropriate evacuation strategies and draft evacuation plans are to be prepared and submitted with relevant project applications for village piazza undercroft parking area, village piazza and marina utility buildings and areas.*

Adaptive Management in response to Climate Change

- *Habitable floor levels for buildings are to be designed based on the 100 year design life above the 100 year ARI flood level plus 100 year sea level rise allowance.*
- *Evacuation routes to be defined above the anticipated PMF level in 00 years.*
- *Adoption of shorter design life for structures with adaptive capability and higher acceptable flood risk such as marina piles, breakwater, boat lift facility, marina access walkways. Piles can be extended to accommodate rising sea levels and therefore flood levels over time.*
- *Marina hardstand and workshop area – practicalities of purpose dictate lower levels and wet flood proofing is possible. Retrofitting to changes in levels in the future is possible for these land uses.*

In 2012, Lake Macquarie City Council (LMCC) initiated a Waterway Flood Study and Flood Risk Management Plan which included a detailed study into the flood behaviour of Lake Macquarie. This study has refined the anticipated flood levels in Lake Macquarie under present and climate change conditions. LMCC refers to this document when establishing flood planning levels for developments within the flood impacted foreshore of Lake Macquarie. A copy of the flood inundation certificate is attached at **Appendix B.**

5.2 Proposed Flood Planning Levels

The estimated flood levels in Lake Macquarie are listed in the Lake Macquarie's Flood Risk Management Plan illustrated in Table 9 below.

Table 9: Estimated flood levels form Lake Macquarie Council's Flood Risk Management plan.

Flood Level	Current	Projected – Year 2050	Projected – Year 2100
Still Water Level	0.10 AHD	0.50 AHD	1.00 AHD
1 in 20 year ARI probable flood level	1.23 AHD	1.61 AHD	2.10 AHD
1 in 100 year ARI probable flood level	1.50 AHD	1.86 AHD	2.32 AHD
Probable Maximum Flood	2.45 AHD	2.81 AHD	3.27 AHD

Based on the above, LMCC have provided minimum flood levels based on the development type and anticipated design life. Interpretation of the appropriate levels was discussed with representatives of ADW Johnson and LMCC in the preparation of this report. A summary of the flood planning levels and development notes are summarised in Table 10.

Table 10: Flood planning levels depending on Development type.

Development type	Flood Planning Levels	Notes and Justification
Commercial development Retail and Basement Car parking	2.36m AHD at entry	Hotel foyer, retail and undercroft car parking is set at RL 2.36, which is equivalent to the year 2050 flood level with 500mm freeboard. One exception is the outdoor marina car park (not basement) that is set a 1.23 AHD, which is equivalent to a 1 in 20 year ARI flood event under current conditions. This car park is rated as a High flood hazard rating. To manage this flood risk it is proposed to prepare a flood evacuation strategy. It is noted that flood water within Lake Macquarie would rise relatively slowly, allowing time for egress via the primary access road that rises above the flood hazard level.

Development type	Flood Planning Levels	Notes and Justification
Mixed use Development and Medium Density and High rise Basement Car parking	2.82m AHD at entry	Vehicular entries to Basement car parking for mixed use and residential car parking will be set at minimum levels of 2.82m AHD A single corridor from the main foyer entry at 2.36m AHD is proposed to provide pedestrian connectivity between the basement car parking and the retail precinct. To prevent flooding from the retail precinct into the basement car park, it is proposed to install a flood gate which will provide flood immunity to a level of 2.82m AHD. All internal floor heights for residential and hotel room are above the 2.82m AHD level.

5.3 Impact of Flooding Strategy on Revised Building Envelopes

5.3.1 Flood Planning and Evacuation

It is anticipated that during the Probable Maximum Flood (PMF), flood levels could potentially reach a level of 3.27m AHD in year 2100.

The proposed levels of the internal loop road within the residential and short stay accommodation precinct is at minimum level of 3.8m AHD, which is higher than the PMF level, including allowance for sea level rise and hence an evacuation plan is not applicable.

The Access Driveway from Trinity Point Drive down to the Marina is below the PMF, to facilitate ease of access to the waterfront. The lowest level is at the marina carpark at level approximately 1.23m AHD. The Access Driveway is graded to a level of 4.0m approximately 100m from the carpark, towards Trinity Point Drive and hence forms an evacuation when leaving the site. It is noted that flood water within Lake Macquarie would rise relatively slowly (2-4 Day peak according to the Flood Plain Risk Management Plan), allowing ample time leave the site. A concept flood immunity and evacuation plan is included in **Appendix A.**

5.3.2 Comparison with Approved Concept Plan

The proposed modification proposes changes to building envelopes and as a result internal roads have been modified to suit, though are broadly in similar locations to the approved Concept Plan (though the layout differs from the concept plan as reported in 2008 Stormwater Management Plan, which proposed access to the residential precinct via short stubs as opposed to an internal loop road). Although detailed grading of the approved concept plan is not available, given the similar location of the roads it would be anticipated that the roads would be designed to suit the topography and as such offer similar flood immunity.

The other differences are largely driven by the revised flood levels as per the 2012 Flood

Risk Management Plan.

5.4 Performance against Flood Management Principles

The performance against the principles noted in the approved preferred project report are as follows:

Table 11: Performance against principles in the preferred management report.

Principle	Comment
Locate buildings above flood level, with flood level determined with regard to sea level with climate change	Buildings have been located above flood levels as per LMCC Flood Inundation Certificate. This includes allowance for anticipated sea level rise in the years 2050 (0.4m rise) and 2100 (0.9m rise) where relevant.
Flood Planning levels take into account still water level, wave action, climate change and design life.	Flood planning levels include still water level, climate change and design life. Although no specific allowance for wave action has been allowed for all levels include 500mm freeboard.
Minimum Flood Levels: • *Habitable Floor Levels – 2.85 AHD* • *Hardstand area and Workshop – 2.42 AHD* • *Marina Structures – 1.6 AHD*	Levels have been revised in accordance LMCC's Flood Inundation Certificate. Levels are indicated in Table 5 above. The Marina Hardstand area is no longer proposed, however the adjacent carpark is located at level 1.23 AHD, which is above the 20 year ARI storm event.
Project applications relating to the village piazza and marina are to document broad sea levels rise adaption measures.	Where relevant appropriate design to flood planning levels will be incorporated.
Evacuation routes are to be defined for the Probable Maximum flood (PMF) in 100 years.	This will be provided for in future applications, however broadly the evaluation strategy will include leaving the site via the main access road that rises to a level above the project PMF (3.27 AHD) at Trinity Point Drive.
Adoption of shorter design life for structures with adaptive capacity and higher acceptable flood risk such as marina piles, breakwater and boat lift.	This will be accounted for in future submissions relating to the marina design.
Marina Hardstand and workshop area – practicalities of purpose dictate lower levels and wet proofing is possible. Retrofitting changes in levels in the future is possible for these land uses.	The Marina Hardstand area is no longer proposed, however the adjacent carpark is located at level 1.23 AHD, which is above the 20 year ARI storm event.

6.0 Conclusion

A review of the stormwater management strategy and flooding impacts was undertaken in light of the proposed Concept Plan modification. A summary of specific consequences of the proposed modifications on stormwater management and flooding is outlined below:

- *Stormwater Management*. Broadly, the proposed stormwater management strategy is similar to the approved concept plan. Minor amendments include removing the proposed green roofs (whether this component actually applied or not the approved concept) and permeable paving, and optimising the rainwater harvesting and the area of bio filtration basins to the revised catchment parameters. It is further proposed to add Gross Pollutant Traps to the treatment train.

  The revised approach is considered more effective in treating stormwater runoff under the proposed modifications and meets the treatment targets as set in the approved concept plan and is considered best practice.

- *Flooding.* All buildings are proposed to be located above flood planning levels, consistent with the approved concept plan. It is noted that Lake Macquarie has undertaken a Waterway Flood Study and Flood Plain Risk Management Plan that supersedes the proposed levels in the approved concept plan.

Although, some amendments to the stormwater strategy and flood planning levels are proposed, the general principles and objectives of stormwater management and flooding have been met.

Appendix A

Concept Stormwater Management Plan

Plan of:	OVERALL CONCEPT STORMWATER MASTERPLAN	Location:	TRINITY POINT DRIVE MORISSET PARK	Datum:	AHD	Date:	8th SEPTEMBER 2014	Version:	C (17th OCTOBER 2014)
				Origin:	PM 58712	Sheet:	4 OF 8	Client:	JOHNSON PROPERTY GROUP
				Projection:	MGA ZONE 56	Plan By:	AM	Survey:	
				Origin:	DCDB	Project Manager:	MK	AutoCAD:	S:\237429(2)E\237429(2)E_SK_004
				North Direction:	GRID	Office:	COAST	Our Ref:	237429
		Council:	LAKE MACQUARIE	Contour Interval:		Plan Purpose:	ENGINEERING DESIGN		

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LEGEND

- PROPOSED STORMWATER
- BIO RETENTION BASIN
- GRATED INLET PITS
- PROPOSED GPT
- OVERLAND FLOW PATH
- RAINWATER TANK
- EDGE OF BASEMENT CARPARK
- IMPERVIOUS PAVED SURFACE
- LANDSCAPED AREAS POTENTIAL FOR IRRIGATION

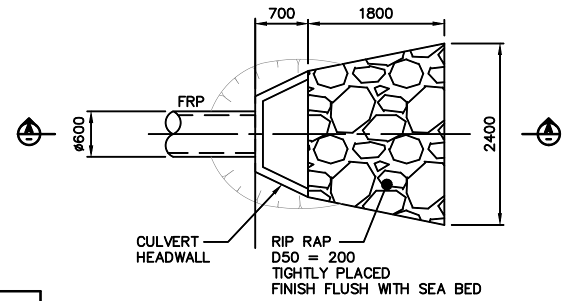
NOTES :

1. BASED ON SQUILLACE BASE PLANS DATED JANUARY 30TH 2015.
2. STORMWATER TARGETS BASED ON APPROVED CONCEPT PLAN. TARGETS AS FOLLOWS:

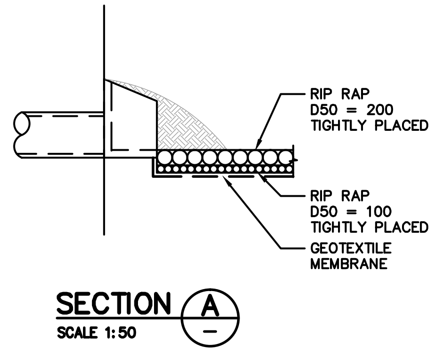
POLLUTANT	TARGET REDUCTION	ACHIEVED %
TSS	85%	91.9%
TP	65%	66.1%
TN	50%	63.1%

3. CATCHMENT DETAILS

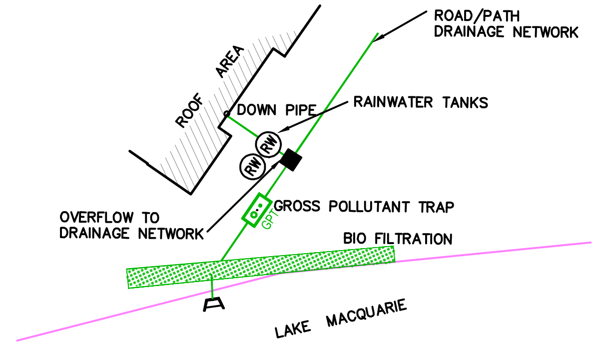
CATCHMENT	AREA(Ha)	% IMPERVIOUS	TREATMENT TRAIN.
1	0.42	75%	RAIN WATER TANK, GPT AND BIO FILTRATION.
2	0.40	75%	RAINWATER TANK, BIO FILTRATION.
3	0.26	67%	SWALE, BIO FILTRATION.
4	1.00	65%	RAINWATER TANK, GPT AND BIO FILTRATION.
5	1.20	48%	RAINWATER TANK, GPT AND BIO FILTRATION.
6	0.33	85%	RAINWATER TANK, GPT AND BIO FILTRATION.



OUTLET DETAIL
SCALE 1:50



SECTION A
SCALE 1:50

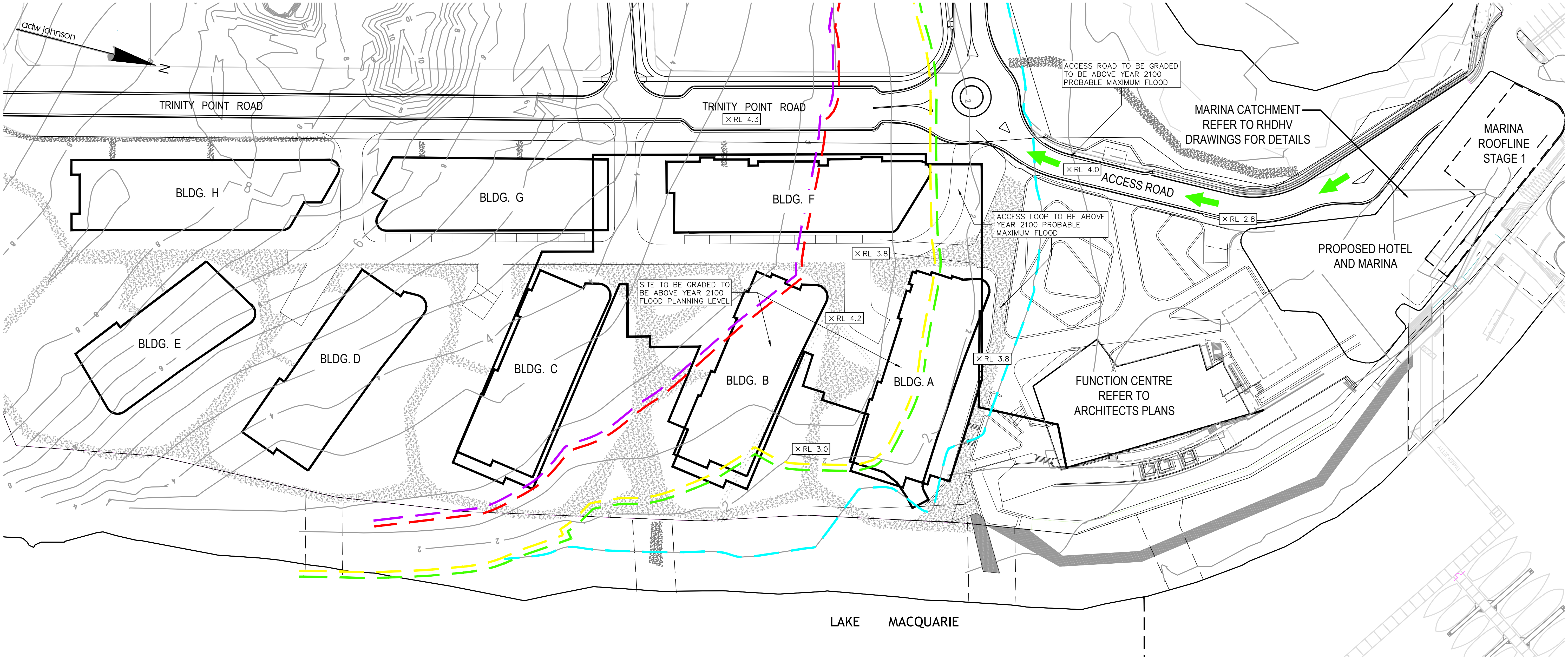


DETAIL 1
SCHEMATIC OF TREATMENT TRAIN
N.T.S.

OVERALL CONCEPT PLAN
SCALE N.T.S.

Ver.	Date	Comment
D	10/04/2015	ADD CATCHMENT 6
C	17/10/2014	LAYOUT & NOTES UPDATED
B	15/09/2014	GENERAL REVISION
A	8/09/2014	PRELIMINARY ISSUE

Plan of:	OVERALL CONCEPT STORMWATER MASTERPLAN	Location:	TRINITY POINT DRIVE MORISSET PARK	Datum:	AHD	Date:	8th SEPTEMBER 2014	Version:	C (17th OCTOBER 2014)
				Origin:	PM 58712	Sheet:	4 OF 8	Client:	JOHNSON PROPERTY GROUP
				Projection:	MGA ZONE 56	Plan By:	AM	Survey:	
				Origin:	DCDB	Project Manager:	MK	AutoCAD:	S:\237429(2)E\237429(2)E_SK_004
				North Direction:	GRID	Office:	COAST	Our Ref:	237429
		Council:	LAKE MACQUARIE	Contour Interval:		Plan Purpose:	ENGINEERING DESIGN		



LEGEND

(green arrow)	EMERGENCY EVACUATION ROUTE
(cyan dashed)	CURRENT 1:100 YEAR FLOOD (1.5 AHD)
(purple dashed)	CONCEPT PLAN YEAR 2100 FLOOD PLANNING LEVEL (2.82 AHD)
(yellow dashed)	YEAR 2100 PREDICTED 1:100 YEAR FLOOD EVENT (2.32 AHD)
(red dashed)	2100 FLOOD PLANNING LEVEL MIXED USE (2.82 AHD)
(green dashed)	2100 FLOOD PLANNING LEVEL COMMERCIAL (2.36 AHD)
— 2 —	EXISTING CONTOUR
× RL 3.0	PROPOSED DESIGN LEVEL (APPROXIMATE)

Ver.	Date	Comment
D	25/02/2015	LAYOUT & NOTES UPDATED
C	17/10/2014	LAYOUT & NOTES UPDATED
B	15/09/2014	GENERAL REVISION
A	8/09/2014	PRELIMINARY ISSUE

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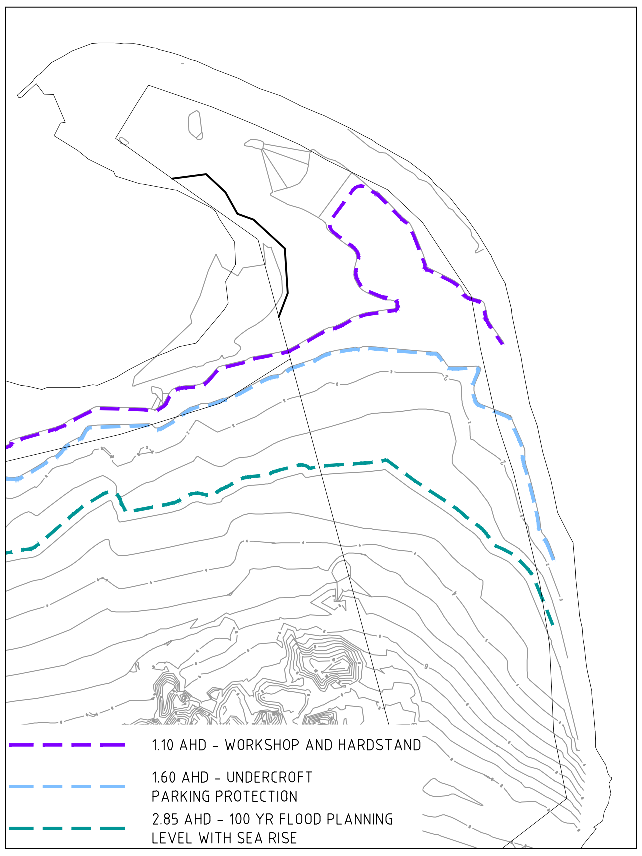
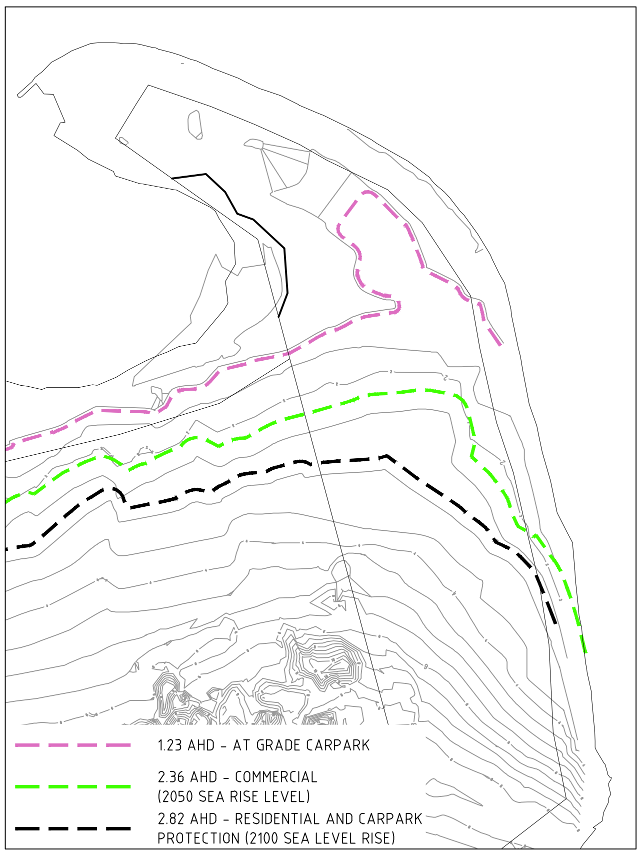
FLOOD STUDY COMPARISON PLAN

Trinity Point

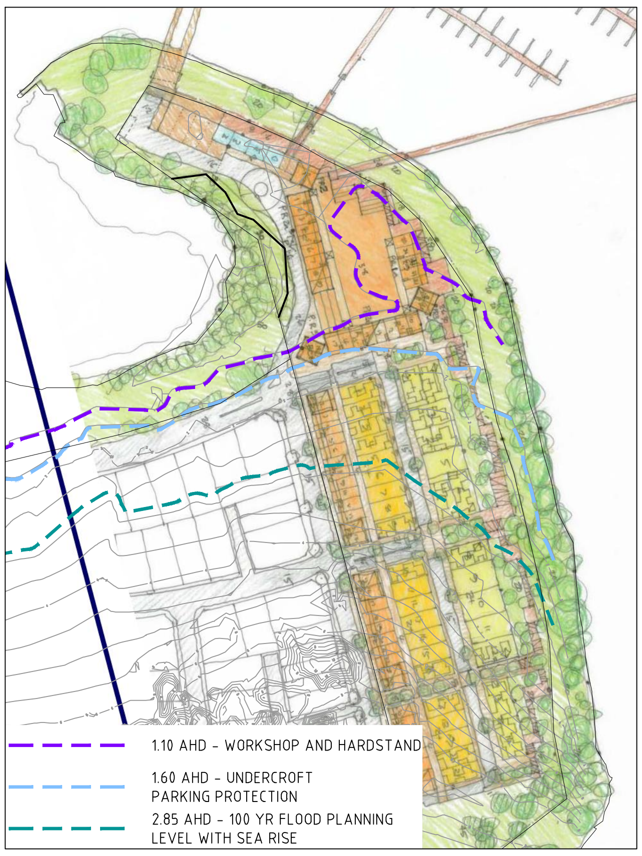


1. CONCEPT FLOOD PLANNING LEVELS
(FROM PRICIPLE 12 CONCEPT APPROVAL)



2. PROPOSED FLOOD PLANNING LEVELS

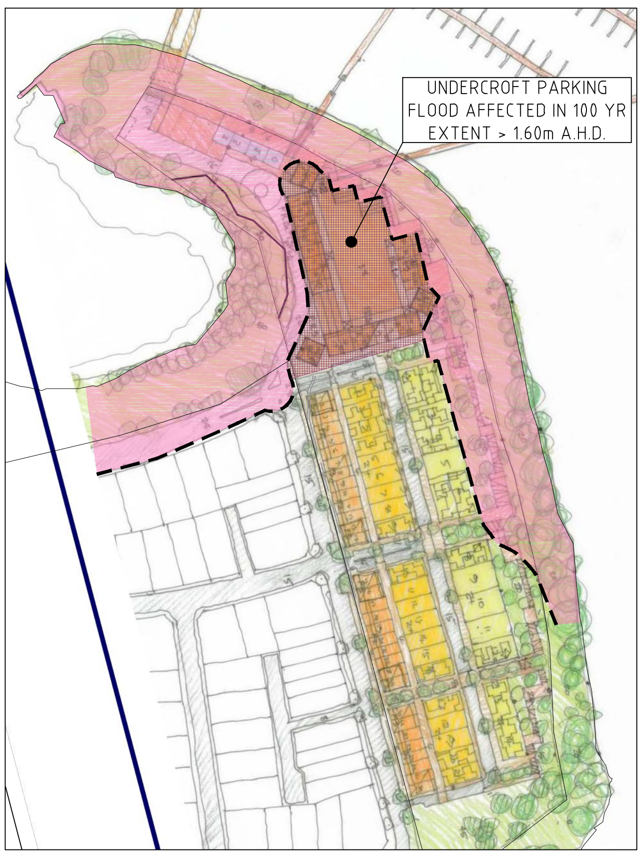
COMPARISON OF APPROVED CONCEPT FLOOD PLANNING LEVELS AND PROPOSED FLOOD PLANNING LEVELS (IN ACCORDANCE WITH LMCC SEA LEVEL RISE POLICY)



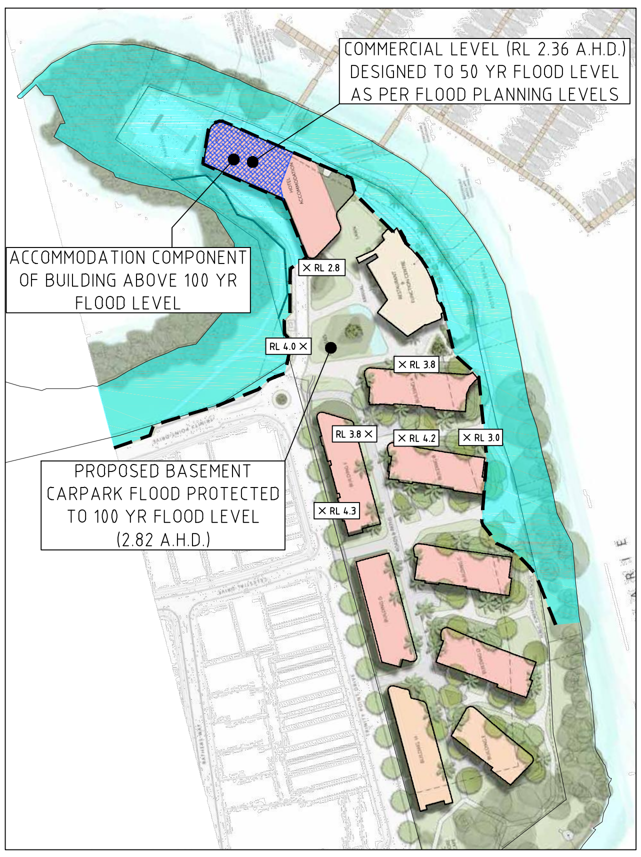
3. CONCEPT LAYOUT WITH FLOOD PLANNING LEVELS

4. PROPOSED LAYOUT WITH FLOOD PLANNING LEVELS

COMPARISON OF EXTENT OF WORKS BELOW APPROVED CONCEPT FLOOD PLANNING LEVELS AND PROPOSED FLOOD PLANNING LEVELS



5. POST DEVELOPMENT CONCEPT FLOOD EXTENT (LMCC FLOOD POLICY 100 YRS WITH SEA LEVEL RISE)



6. POST DEVELOPMENT PROPOSED FLOOD EXTENT (LMCC FLOOD POLICY 100 YRS WITH SEA LEVEL RISE)

COMPARISON OF EXTENT OF 100 YR FLOOD FLOOD PLANNING LEVEL WITH SEA LEVEL RISE FOR APPROVED CONCEPT AND PROPOSED.

Ver.	Date	Comment	Drafter
A	04/03/2015	PRELIMINARY ISSUE	JN

PLAN PURPOSE: INFORMATION

PROPERTY DESCRIPTION: LOT 31 D.P.1117408 TRINITY POINT DRIVE, MORISSET PARK

COUNCIL: Lake Macquarie

DWG REF: 37429(3)-FSCP-001(A) PM: LG

CLIENT: JOHNSON PROPERTY GROUP

adw johnson
central coast office ph: (02) 4305 4300
hunter office ph: (02) 4978 5100
www.adwjohnson.com.au

project management • civil engineering • infrastructure • superintendency • economic analysis • social impact • town planning • surveying • development feasibility • visualisation • urban planning

Plotted By: jaysonn Plot Date: 04/03/15 - 15:50 Cad File: N:\37429\37429(3)\Third Party\Flood Levels\37429(3)_FSCP_001(A).DWG

Appendix B

LMCC Flood Inundation Certificate

Lake Macquarie City Council

Lake Macquarie
City Council

20 June 2014

RECEIVED
23 JUN 2014
BY: ....

Johnson Property Group
c/- ADW Johnson Pty Ltd
7/335 Hillsborough Rd
WARNERS BAY NSW 2282

Our Ref: 987
Your Ref:
ABN 81 065 027 868

FLOOD / TIDAL INUNDATION CERTIFICATE

Land fronting or located adjacent to Lake Macquarie Waterway

Fee Paid: 104.55

Receipt No:

DESCRIPTION OF LAND

Address:	71 Trinity Point Drive, MORISSET PARK NSW 2264
Lot Details:	Lot 31 DP 1117408
County:	Northumberland
Owner:	THE TRUSTEE OF THE HOSPITALLER BROTHERS OF ST JOHN

G D Jones
Senior Sustainability Officer (Natural Disaster Management)

For: BRIAN BELL
GENERAL MANAGER

The following information is provided from the records of the Council pursuant to the Local Government Act 1993, in response to your request for details of the possible effects on the above land from flooding, tidal inundation, and predicted sea level rises.

Levels shown are in metres on Australian Height Datum (AHD). Refer to Flood Information Sheet attached for information on the AHD.

The likelihood of the land and buildings thereon being flooded can be assessed from the following information:

1. **Highest observed flood over or adjacent to the land:**

   1.20m AHD (1949 Lake flood)

NOTE: Applicants are advised that where highest observed flood levels are stated, this data may not have been observed by Council, but may be the result of local information and, therefore applicants may consider it advisable to carry out their own investigations.

2. **Information derived from Flood Studies and Floodplain Risk Management Studies/Plans:**

   A *Lake Macquarie Waterway Flood Study* and *Lake Macquarie Waterway Flood Risk Management Study and Plan (June 2012)* were undertaken in 2011 and approved by Council at its meeting held on 25 June 2012.

   The endorsed *Lake Macquarie Waterway Flood Risk Management Study and Plan* has indicated the following results, which are extracted from Table 7 of the report:

Current Year	▪ Lake mean still water level	0.10m AHD
(using Year 1990 as baseline)	▪ 1 in 20 year probable flood level	1.23m AHD
	▪ 1 in 100 year probable flood level	1.50m AHD
	▪ Probable Maximum Flood level	2.45m AHD

Year 2050	▪ Predicted Lake mean still water level	0.50m AHD
(projected sea level rise 0.4 metres)	▪ 1 in 20 year probable flood level	1.61m AHD
	▪ 1 in 100 year probable flood level	1.86m AHD
	▪ Probable Maximum Flood Level	2.81m AHD

Year 2100	▪ Predicted Lake mean still water level	1.00m AHD
(projected sea level rise 0.9 metres)	▪ 1 in 20 year probable flood level	2.10m AHD
	▪ 1 in 100 year probable flood level	2.32m AHD
	▪ Probable Maximum Flood level	3.27m AHD

The final inundation levels at the foreshore will depend on the combination of:

- the lake still water level (to include normal and rainfall event conditions)
- the wind wave climate
- the local bathymetry and foreshore structures, and
- the impacts of climate change, including sea level rise

3. **Existing ground levels at site:**

See copy of Detail Survey Plan No 1320 by SurDevel Surveyors dated 28-10-2013, on page 9 below.

4. **Existing Dwelling floor level** ... Not available / applicable

5. **Existing Garage floor level** ... Not available / applicable

The nature and extent of flooding of any land or buildings will be affected by the fill (if any) upon the land and the floor heights of the buildings.

6. Flood Planning Levels:

To reduce the risk from flooding, including predicted sea level rises, over the life of assets, the following flood planning levels have been adopted for new development:

Development Type (including extensions)	Minimum Height Requirements	
Dwellings		
Habitable rooms	1 in 100 year probable flood level for Year 2050 + 500mm freeboard (post and beam rather than slab on ground preferred)	2.36m AHD
Non-habitable rooms and garages	1 in 20 year probable flood level for Year 2050	1.61m AHD
Carports, boat sheds, garden sheds, and other ancillary structures (excluding garages)	No requirement	-
Unsealed electrical installations	1 in 100 year probable flood level for Year 2050 + 500mm freeboard	2.36m AHD
Medium and high density residential development		
Habitable rooms	1 in 100 year probable flood level for Year 2100 + 500mm freeboard	2.82m AHD
Non-habitable rooms and garages	1 in 20 year probable flood level for Year 2100	2.10m AHD
Carports, boat sheds, garden sheds, and other ancillary structures (excluding garages)	No requirement	-
Basement car parking	Constructed to preclude entry of floodwater at levels up to the 1 in 100 year probable flood level for Year 2100 + 500mm freeboard. Basement levels to have a failsafe means of evacuation, and a pump-out.	2.82m AHD at entry
Unsealed electrical installations	1 in 100 year probable flood level for Year 2100 + 500mm freeboard	2.82mAHD

Development Type (including extensions)	Minimum Height Requirements	
Commercial and retail*		
* NOTE: Flood Planning Levels for "Commercial and Retail" also apply to places of public worship, restaurants, clubs, entertainment facilities, warehouses and bulky goods showrooms.		
Internal floor height	1 in 100 year probable flood level for Year 2050 + 500mm freeboard	2.36m AHD
Basement car parking	Constructed to preclude entry of floodwater at levels up to the 1 in 100 year probable flood level for Year 2050 + 500mm freeboard. Additional requirement for basement levels to implement a failsafe means of evacuation, and a pump-out system to remove flood waters.	2.36m AHD at entry
Unsealed electrical installations	1 in 100 year probable flood level for Year 2050 + 500mm freeboard	2.36m AHD
Mixed use development		
Internal floor height	1 in 100 year probable flood level for Year 2100 + 500mm freeboard	2.82m AHD
Basement car parking	Constructed to preclude entry of floodwater at levels up to the 1 in 100 year probable flood level for Year 2100 + 500mm freeboard. Additional requirement for basement levels to implement a failsafe means of evacuation, and a pump-out system to remove flood waters.	2.82m AHD at entry
Unsealed electrical installations	1 in 100 year probable flood level for Year 2100 + 500mm freeboard	2.82m AHD
Industrial		
Internal floor height	1 in 100 year probable flood level for Year 2050	1.86m AHD
Unsealed electrical installations	1 in 100 year probable flood level for Year 2050 + 500mm freeboard	2.36m AHD
Sensitive uses (Residential care facilities, hospitals, etc)		
Internal floor height	Probable Max Flood level Year 2100	3.27m AHD
Unsealed electrical installations	Probable Max Flood level Year 2100	3.27m AHD

7. Applications for approval of/consent to major additions or relocation of existing buildings will be required to observe the relevant floor height (flood planning level) adopted by Council at the time the development proposal is considered by Council. Applications for approval of/consent to minor additions of existing buildings will be considered on the merits of the application.

Additional conditions may apply to applications involving subdivisions (see below).

8. **Implications of climate change and sea level rise:**

Council at its meeting held on 23 July 2012, adopted a *Lake Macquarie Waterway Flooding and Tidal Inundation Policy* for properties located at or adjacent to the lake waterway. This policy accords with expert advice from the NSW Government on sea level rise benchmarks of a rise in the ocean from the Baseline Year 1990 levels, of 0.4 metres by Year 2050 and 0.9 metres by Year 2100. It requires new developments on affected land to apply the Flood Planning Levels (floor levels) recommended by the *Lake Macquarie Waterway Flood Study* and *Lake Macquarie Waterway Flood Risk Management Study and Plan, June 2012.*

The *Lake Macquarie Waterway Flooding and Tidal Inundation Policy* adopts the recommendations from Section 5.3 Flood Hazard Classification of the *Lake Macquarie Waterway Flood Risk Management Study and Plan, June 2012.* Based on the survey information (Sections 3 to 5 above) some or all of the subject property is classified as indicated below.

The hazard category applies to the susceptibility of the land to flooding and inundation, and guides planning and development decisions.

It is not an indication of the risk to buildings, which depends on other factors such as floor height, construction methods, and construction materials.

[X] LOW flood hazard = properties in the flood fringe area between the 1 in 100 year ARI flood for Year 2011 (1.50m AHD) and the limit of the flood planning area (3.0m AHD).

Conditions may apply to new developments to reduce the risk from flooding.

[X] HIGH flood hazard = properties at or below the 1 in 100 year ARI flood level for Year 2011 (1.50m AHD)

Development conditions similar to LOW flood hazard, but additional conditions may apply to new developments to further manage the risk from flooding.

[X] HIGH permanent inundation hazard = properties at or below the Lake mean still water level for Year 2100 (1.00m AHD)

Development conditions similar to HIGH flood hazard, but additional conditions may apply to new developments to further manage the risk from future tidal inundation.

9. Filling

Filling the subject land would require Council's consent.

Filling of flood affected land may have an impact on the nature and extent of flooding downstream or on neighbouring land and generally is not favoured as a planning response on flood prone land.

10. Exempt and complying development in the Flood Planning Area

Development on a flood control lot would need to comply with conditions as defined in SEPP (Exempt and Complying Development) 2008.

11. Other development conditions and approvals

Development approval/consent for this property is dependent on a range of issues, including compliance with all relevant provisions of Lake Macquarie Local Environmental Plan 2004 (LM LEP 2004) and Development Control Plan (DCP) No. 1, including Part 2.1.7 Flood Management and these should be used in conjunction with DCP 2013 (to come into effect when draft LMLEP 2014 comes into effect likely mid 2014).

Copies of these documents and further information in regard to development on this property can be obtained from Council's website. Compliance with these requirements does not guarantee Council will approve a development on this property.

12. Further information

Procedure - Assessing Development Proposals on Land Affected by Sea Level Rise – Version 7, 1 August 2013

Acceptable Solutions for Residential Development - New Subdivisions

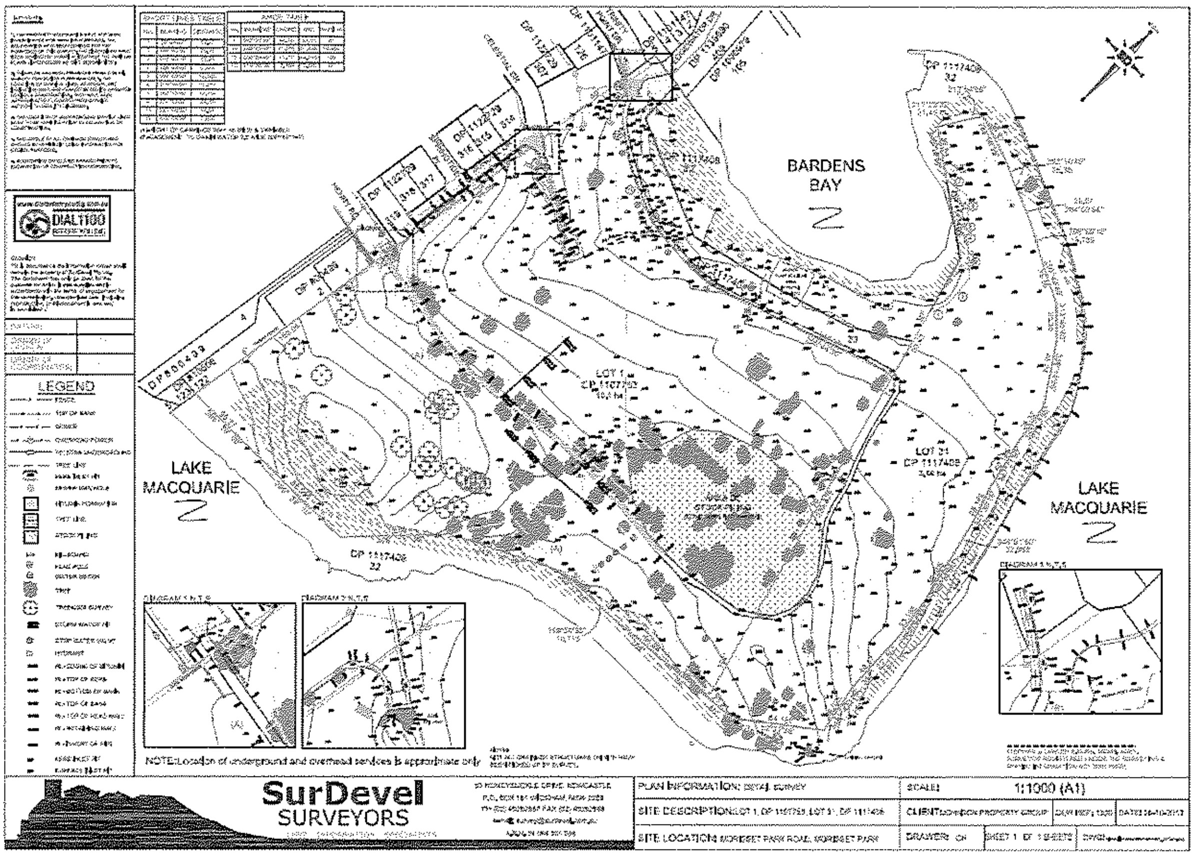
New residential subdivisions in 'greenfield' or new urban area should provide all new roads, other above-ground infrastructure and building envelopes above 3.0m AHD.

Subdivisions in established urban areas with a 2(1) Residential zoning may be considered where each lot has a building area with a minimum area of 250 square metres located at a minimum height of 2.0 metres AHD, and it can be demonstrated that there is adequate flood free access to the site including the impact of sea level rise.

Subdivisions in established urban areas with a 2(2) Residential zoning should be located on land above 3.0 metres AHD, unless it is a subdivision of an approved and constructed development.

Filling sites to achieve these minimum levels will not be supported due to potential impacts on adjoining development, drainage, access, foreshore function, ecological values and visual amenity.

13. This certificate considers the relevant flood and flood planning levels for the specific property. There may be other issues to do with flooding, sea level rise, filling, and emergency access and egress that are not addressed in this document.


BARDENS BAY
LAKE MACQUARIE
LAKE MACQUARIE
LEGEND
NOTE: Location of underground and overhead services is approximate only
SurDevel
SURVEYORS
PLAN INFORMATION:
SITE DESCRIPTION:
SITE LOCATION:
SCALE:
1:1000 (A1)
DRAWER:

Attachment to Certificate
Flood Explanation Sheet

1 in 100 year Probable Flood Level

The 1 in 100 year flood is one that has a 1% chance of occurring in any year, or has the chance of occurring once every 100 years. The term "100-year flood" is really a statistical probability designation stating there is a 1-in-100 chance that a flood this size will happen during any year. Another interpretation could be the "1-in-100 chance flood". The I in 100 year flood does not mean that if a location floods one year, it will definitely not flood for the next 99 years. Nor, if it has not flooded for 99 years, will it necessarily flood this year. Some parts of Australia have received more than one 1 in 100 year flood in one decade. Lake Macquarie waterway (the Lake) has not experienced a 1 in 100 year flood since written records began 150 years ago. The 1 in 100 year flood is a serious but infrequent event, and is used widely as the risk threshold for flood planning.

1 in 20 year Probable Flood Level

The 1 in 20 year flood is one that has a 5% chance of occurring in any year, or has the chance of occurring once every 20 years. This is a statistical probability, and does not mean that if a location floods one year, it will definitely not flood for the next 19 years. .

The 1 in 20 year flood is less serious but more frequent than the 1 in 100 year flood.

Flood Planning Level (FPL)

The Flood Planning Level is the risk threshold set for new buildings in flood-affected areas, and is usually applied as a minimum floor level. It is commonly based on the 1% (1-in-100 year) flood level plus 'freeboard' (see below).

Freeboard

Freeboard is included in the Flood Planning Level to allow a safety margin for unpredictable factors such as waves, localised hydraulic effects, blockages, flood debris, and uncertainties in the computer flood modelling. A freeboard of 500mm is typically applied to the 1-in-100 year probable flood level for residential / commercial developments (see page 3).

Probable Maximum Flood (PMF)

The Probable Maximum Flood is the largest flood that could feasibly occur. However, it is an extremely rare event. Despite this, some floods in Australia have approached the PMF. Council provides the PMF level on this Flood Certificate, if it is available, to indicate the full extent of risk, even if the chance is very small.

Some essential services (such as hospitals) and retirement housing, are required to locate above the PMF to avoid any risk from flooding.

Australian Height Datum (AHD)

Australian Height Datum refers to the elevation relative to a reference point. In Australia this reference point approximates mean sea level, which is taken as 0.00metres AHD. Flood levels, ground levels, floor levels, and flood planning levels are shown in metres on AHD.

Appendix C

NSW DPE Response

NSW GOVERNMENT | Planning & Environment

Contact: Kate Masters
Phone: 02 9228 6321
Email: kate.masters@planning.nsw.gov.au

Mr Bryan Garland
Development Director
Johnson Property Group Pty Ltd
PO Box A1308
Sydney South NSW 1235

Dear Mr Garland

Trinity Point Mixed Used Development - Request for Response to Submissions (MP06_0309) MOD 5

The exhibition for the above mentioned modification application ended on Friday 19 December 2014. The Department has reviewed the application and has concerns with the following aspects for your application:

- urban design;
- stormwater and flooding;
- noise;
- air quality;
- acid sulphate soils;
- visual; and
- traffic.

These concerns are outlined in full in Attachment 1.

In accordance with section 75H of the Environmental Planning and Assessment Act 1979, the Secretary requires Johnson Property Group (JPG) to respond to the issues raised by the Department.

I have arranged for Ms Kate Masters, at the Department to assist you should you have any enquiries. She can be contacted on (02) 9228 6321 or via email at kate.masters@planning.nsw.gov.au

Yours sincerely

Kate MacDonald
Team Leader
Industry Assessments

Department of Planning & Environment
23-33 Bridge Street Sydney NSW 2000 | GPO Box 39 Sydney NSW 2001 | T 02 9228 6111 | F 02 9228 6455 | www.planning.nsw.gov.au

ATTACHMENT 1

1. Urban Design

Gross Floor Area

The Response to Submissions (RTS) should include a table outlining the approved and proposed gross floor area (GFA) for each component of the development (hotel, gym, pool, cafØ, shops, function centre, restaurant, office commercial, service area, tourist units and residential units etc.). This table should also specify the percentage change in GFA for each land use. Any changes from the approved Concept Plan must be fully justified.

Built Form

The RTS should demonstrate whether the building envelopes comply with the requirements of State Environmental Planning Policy - Design Quality of Residential Flat Development No. 65, the Residential Flat Design Code (RFDC), and the Draft Apartment Design Guide ¡ Tools for improving the design of residential flat development.

You should also detail any changes to the location of the pool facility and any consequential impacts arising from these changes.

Open Space

The RTS should quantify the total amount of open space approved under the Concept Plan and any changes to the total amount and distribution of open space across the site. Any changes to the total amount and distribution of open space need to be fully justified.

Provide details of how all open space will be activated (public and semi-public spaces).

Please detail whether the application will result in a reduction in public access within the site and along the public foreshore, and how any loss will be compensated.

Shadowing

The RTS should include an assessment of the shadow impacts, inclusive of shadow diagrams for the proposed building envelopes.

2. Stormwater and Flooding

The RTS should include a revised stormwater and flooding management plan which considers the flooding impacts associated with the revised building envelopes. The level of detail provided should be similar to the Stormwater/Flooding Management Plan, prepared by Patterson Britton and Partners, November 2008 to enable a direct comparison of the impacts of the approved and proposed development concept.

Details regarding the source controls, average monthly demands, water balance, water quality, proposed catchment sizes, indicative water quality control design parameters, proposed water quality sampling program, location of overland flow paths and demonstration that the bio retention basins proposed have sufficient capacity are to be provided.

The flood plan provided to support the approved Concept Plan should be updated to reflect the revised application.

Any revisions required to the approved flood mitigation measures should also be provided.

3. Noise

A revised assessment of the construction and traffic noise is to be provided. The revised assessment should contain a similar level of detail to that provided in the Acoustic Assessment Report prepared by Arup, November 2008. The revised report also should be based of the most recent guidelines and policies.
Please provide the anticipated construction duration for each stage including any proposed respite schedule. The proposed construction hours and the percentage of time the equipment operates should also be identified.
The construction noise impacts must be predicted. A revised noise impact assessment should be provided in accordance with the Interim Construction Noise Guideline. The parameters (i.e. noise sources such as machinery and equipment) for predicting noise impacts need to be clearly identified for noise impacts to be predicted adequately.
Predicted traffic noise must be provided. Traffic noise should be assessed via the methodology outlined by the NSW Road Noise Policy.
All relevant mitigation measures should be provided for construction, traffic and operation noise.
Cumulative noise impacts including the residential subdivision west of the site should be assessed.
A comparison between the predicted noise impacts in the Concept Plan and the predicted noise impacts from the proposed application should be provided and assessed against the relevant noise criteria.

4. Air Quality

A revised air quality assessment must be provided. The revised assessment should provide a similar level of detail as the Air Quality Assessment prepared by Arup, May 2008 having regard to the most recent guidelines or policies. The assessment should also quantify whether the proposed modification will result in any additional impacts beyond those predicted for the approved Concept Plan.

5. Acid Sulphate Soils

It is noted that the function centre may be located in an area subject to acid sulphate soils (ASS), please confirm whether the location of the function centre will result in greater ASS disturbance in comparison to the approved Concept Plan, and any proposed management measures.

6. Visual

The Visual Impact Assessment should be updated to provide a comparison between the visual impacts of the approved Concept Plan and the impacts associated with the proposed modification.
Please ensure all photomontages are clearly labelled to identity the location of each vantage point.

Appendix D

Water Balance Results

	This spreadsheet allows the user to estimate the best size for a rainwater tank for a development. Number of residents, roof area,% of water use from mains or tank etc. are the variables used.			
	Tank Design			
	Roof catchment area (m²)	11,000.0		
	Catchment area efficiency	80%		
	Actual roof catchment area (m²)	**8,800.0**		
	Storage capacity excluding detention (litres)	100,000		
	Initial storage capacity	100%		
	Initial storage capacity (litres)	**100,000**		
		SUMMER	WINTER	
	Daily roof water demand (litres)	**25,540**	**17,980**	
	Daily mains water demand (litres)	**0**	**0**	
	Total Demand (litres)	**25,540**	**17,980**	
	First flush loss (mm/m²)	1		
	First flush loss per rainfall (litres)	**11,000.0**		
	Irrigation Threshold (mm)	100.0		
	mm to fill storage from empty	9		
	Days overflowing (%)	10%		
	Days empty (%)	45%		
	Longest period empty (days)	30		
	Average rainfall to roof per annum (litres)	13,031,659		
	Average rainfall to tank per annum (litres)	9,180,146	9180.146	
	Average roof water consumed per annum (litres)	3,781,039	3781.039	
	Average roof water overflowing per annum (litres)	5,405,732	5405.732	
	Rainwater Tank Efficiency	**41.2%**		
	Average volume available in tank (litres)	**75,170**		
	Average volume available in tank (%)	**75.2%**		
	Maximum rainwater used per annum (%)	**29.0%**		

	This spreadsheet allows the user to estimate the best size for a rainwater tank for a development. Number of residents, roof area,% of water use from mains or tank etc. are the variables used.			
	Tank Design			
	Roof catchment area (m²)	11,000.0		
	Catchment area efficiency	80%		
	Actual roof catchment area (m²)	**8,800.0**		
	Storage capacity excluding detention (litres)	150,000		
	Initial storage capacity	100%		
	Initial storage capacity (litres)	**150,000**		
		SUMMER	WINTER	
	Daily roof water demand (litres)	**25,540**	**17,980**	
	Daily mains water demand (litres)	**0**	**0**	
	Total Demand (litres)	**25,540**	**17,980**	
	First flush loss (mm/m²)	1		
	First flush loss per rainfall (litres)	**11,000.0**		
	Irrigation Threshold (mm)	100.0		
	mm to fill storage from empty	14		
	Days overflowing (%)	8%		
	Days empty (%)	39%		
	Longest period empty (days)	30		
	Average rainfall to roof per annum (litres)	13,031,659		
	Average rainfall to tank per annum (litres)	9,180,146	9180.146	
	Average roof water consumed per annum (litres)	4,304,049	4304.049	
	Average roof water overflowing per annum (litres)	4,886,035	4886.035	
	Rainwater Tank Efficiency	**46.9%**		
	Average volume available in tank (litres)	**107,992**		
	Average volume available in tank (%)	**72.0%**		
	Maximum rainwater used per annum (%)	**33.0%**		

	This spreadsheet allows the user to estimate the best size for a rainwater tank for a development. Number of residents, roof area,% of water use from mains or tank etc. are the variables used.			
	Tank Design			
	Roof catchment area (m²)	11,000.0		
	Catchment area efficiency	80%		
	Actual roof catchment area (m²)	**8,800.0**		
	Storage capacity excluding detention (litres)	200,000		
	Initial storage capacity	100%		
	Initial storage capacity (litres)	**200,000**		
		SUMMER	WINTER	
	Daily roof water demand (litres)	**25,540**	**17,980**	
	Daily mains water demand (litres)	**0**	**0**	
	Total Demand (litres)	**25,540**	**17,980**	
	First flush loss (mm/m²)	1		
	First flush loss per rainfall (litres)	**11,000.0**		
	Irrigation Threshold (mm)	100.0		
	mm to fill storage from empty	18		
	Days overflowing (%)	8%		
	Days empty (%)	34%		
	Longest period empty (days)	30		
	Average rainfall to roof per annum (litres)	13,031,659		
	Average rainfall to tank per annum (litres)	9,180,146	9180.146	
	Average roof water consumed per annum (litres)	4,695,432	4695.432	
	Average roof water overflowing per annum (litres)	4,494,866	4494.866	
	Rainwater Tank Efficiency	**51.1%**		
	Average volume available in tank (litres)	**139,088**		
	Average volume available in tank (%)	**69.5%**		
	Maximum rainwater used per annum (%)	**36.0%**		

	This spreadsheet allows the user to estimate the best size for a rainwater tank for a development. Number of residents, roof area,% of water use from mains or tank etc. are the variables used.			
	Tank Design			
	Roof catchment area (m²)	11,000.0		
	Catchment area efficiency	80%		
	Actual roof catchment area (m²)	**8,800.0**		
	Storage capacity excluding detention (litres)	250,000		
	Initial storage capacity	100%		
	Initial storage capacity (litres)	**250,000**		
		SUMMER	WINTER	
	Daily roof water demand (litres)	**25,540**	**17,980**	
	Daily mains water demand (litres)	**0**	**0**	
	Total Demand (litres)	**25,540**	**17,980**	
	First flush loss (mm/m²)	1		
	First flush loss per rainfall (litres)	**11,000.0**		
	Irrigation Threshold (mm)	100.0		
	mm to fill storage from empty	23		
	Days overflowing (%)	7%		
	Days empty (%)	31%		
	Longest period empty (days)	30		
	Average rainfall to roof per annum (litres)	13,031,659		
	Average rainfall to tank per annum (litres)	9,180,146	9180.146	
	Average roof water consumed per annum (litres)	5,003,022	5003.022	
	Average roof water overflowing per annum (litres)	4,187,276	4187.276	
	Rainwater Tank Efficiency	**54.5%**		
	Average volume available in tank (litres)	**168,517**		
	Average volume available in tank (%)	**67.4%**		
	Maximum rainwater used per annum (%)	**38.4%**		

	This spreadsheet allows the user to estimate the best size for a rainwater tank for a development. Number of residents, roof area,% of water use from mains or tank etc. are the variables used.			
	Tank Design			
	Roof catchment area (m²)	11,000.0		
	Catchment area efficiency	80%		
	Actual roof catchment area (m²)	**8,800.0**		
	Storage capacity excluding detention (litres)	300,000		
	Initial storage capacity	100%		
	Initial storage capacity (litres)	**300,000**		
		SUMMER	WINTER	
	Daily roof water demand (litres)	**25,540**	**17,980**	
	Daily mains water demand (litres)	**0**	**0**	
	Total Demand (litres)	**25,540**	**17,980**	
	First flush loss (mm/m²)	1		
	First flush loss per rainfall (litres)	**11,000.0**		
	Irrigation Threshold (mm)	100.0		
	mm to fill storage from empty	27		
	Days overflowing (%)	7%		
	Days empty (%)	28%		
	Longest period empty (days)	30		
	Average rainfall to roof per annum (litres)	13,031,659		
	Average rainfall to tank per annum (litres)	9,180,146	9180.146	
	Average roof water consumed per annum (litres)	5,254,456	5254.456	
	Average roof water overflowing per annum (litres)	3,935,842	3935.842	
	Rainwater Tank Efficiency	**57.2%**		
	Average volume available in tank (litres)	**196,201**		
	Average volume available in tank (%)	**65.4%**		
	Maximum rainwater used per annum (%)	**40.3%**		

Appendix E

MUSIC Results

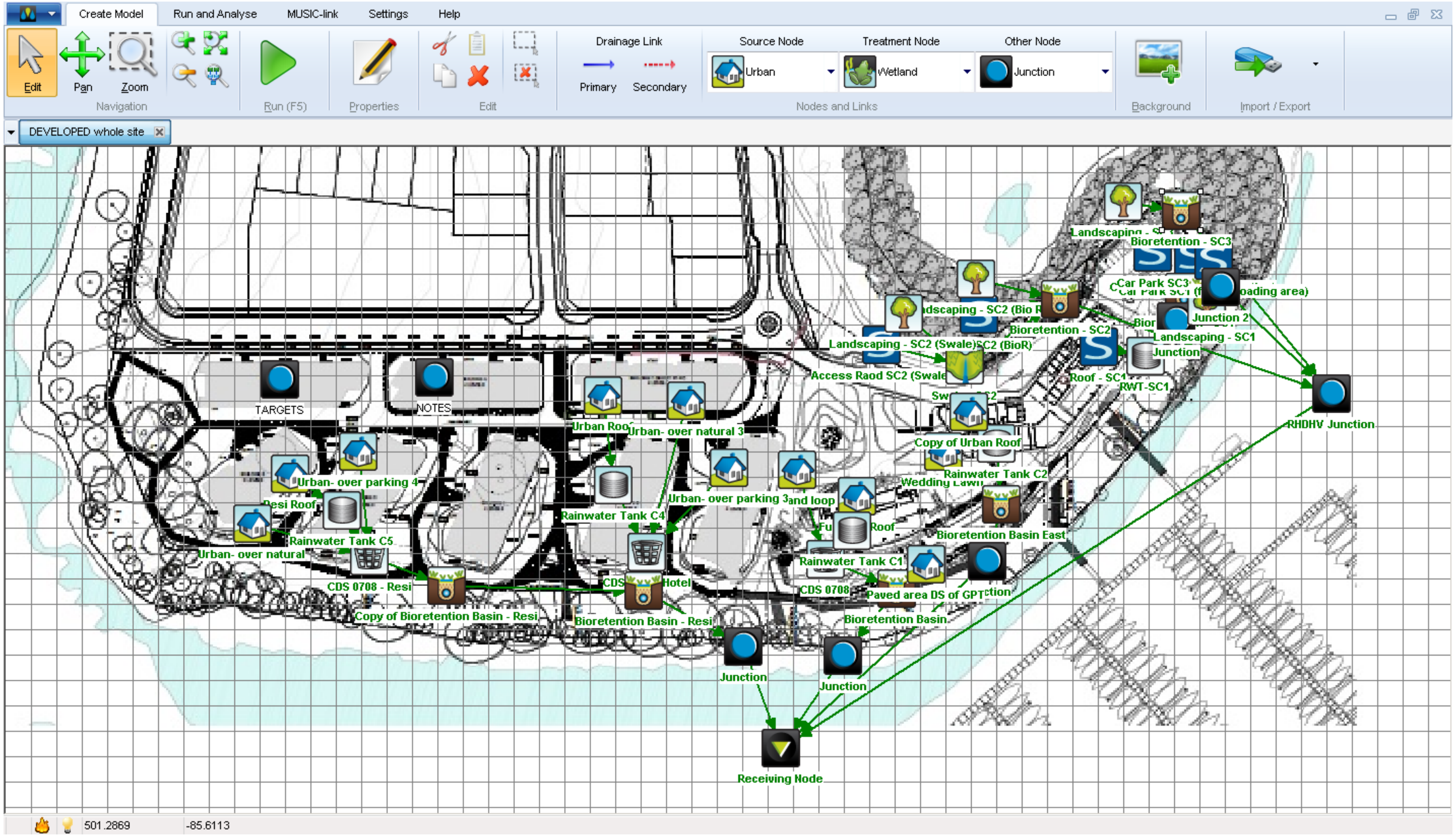


Figure A: MUSIC Network Schematic

Source nodes

Location	Forecourt and loop road	Function Roof	Wedding Lawn	Paved area DS of GPT	Roof - SC1	Car Park SC1 (to bioretention)	Car Park SC2 (BioR)	Access Raod SC2 (Swale)	Landscaping - SC2 (Bio R)	Landscaping - SC2 (Swale)	Landscaping - SC1	Car Park SC1 (fuel unloading area)	Car Park SC3	Landscaping - SC3	Urban Roof	Resi Roof	Urban- over parking	Urban- over natural	Urban- over parking	Urban- over natural	Copy of Urban Roof
ID	1	2	4	9	12	14	17	18	19	21	22	23	25	26	34	35	37	38	39	41	46
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UserDefinedSourceNode	UserDefinedSourceNode	UserDefinedSourceNode	UserDefinedSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	UserDefinedSourceNode	UserDefinedSourceNode	ForestSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	0.238	0.091	0.1	0.01	0.1	0.055	0.032	0.162	0.006	0.044	0.012	0.007	0.05	0.006	0.388	0.39	0.362	0.448	0.29	0.29	0.1
Area Impervious (ha)	0.157630505	0.091	0.033820857	0.01	0.1	0.055	0.032	0.162	0	0	0	0.007	0.05	0	0.388	0.39	0.120972836	0.122698507	0.09581903	0.092540299	0.1
Area Pervious (ha)	0.080369495	0	0.066179143	0	0	0	0	0	0.006	0.044	0.012	0	0	0.006	0	0	0.241027164	0.325301493	0.19418097	0.197459701	0
Field Capacity (mm)	94	94	94	70	60	60	60	60	115	115	115	60	60	115	70	70	70	70	70	70	70
Pervious Area Infiltration Capacity coefficient - a	180	180	180	210	150	150	150	150	150	150	150	150	150	150	210	210	210	210	210	210	210
Pervious Area Infiltration Capacity exponent - b	3	3	3	4.7	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Impervious Area Rainfall Threshold (mm/day)	1	0.3	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	142	142	142	170	81	81	81	81	135	135	135	81	81	135	170	170	170	170	170	170	170
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	50	25	25	25	25	25	25	25	25	25	25	50	50	50	50	50	50	50
Groundwater Daily Baseflow Rate (%)	25	25	25	5	10	10	10	10	10	10	10	10	10	10	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.15	1.3	2.15	2.15	1.55	2.43	2.43	2.43	2.15	2.15	2.15	2.43	2.43	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
Stormflow Total Suspended Solids Standard Deviation (log mg/L	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.2	0.2	0.2	0.32	0.32	0.2	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.6	-0.89	-0.6	-0.6	-0.89	-0.3	-0.3	-0.3	-0.6	-0.6	-0.6	-0.3	-0.3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.22	0.22	0.25	0.25	0.22	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.3	0.3	0.3	0.3	0.3	0.34	0.34	0.34	0.3	0.3	0.3	0.34	0.34	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.19	0.19	0.24	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.2	1.2	1.2	1.2	0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0	0.17	0.17	0.17	0.13	0.13	0.13	0.17	0.17	0.13	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.85	-0.85	-0.85	-0.85	0	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85	-0.85
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0	0.19	0.19	0.19	0.13	0.13	0.13	0.19	0.19	0.13	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.11	0.11	0.11	0.11	0	0.11	0.11	0.11	0.115	0.115	0.115	0.11	0.11	0.115	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0	0.12	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flow based constituent generation - enabled	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Flow based constituent generation - flow file																					
Flow based constituent generation - base flow column																					
Flow based constituent generation - pervious flow column																					
Flow based constituent generation - impervious flow column																					
Flow based constituent generation - unit																					
OUT - Mean Annual Flow (ML/yr)	1.59	0.892	0.441	9.12E-02	0.872	0.48	0.279	1.41	1.22E-02	8.95E-02	2.44E-02	6.10E-02	0.436	1.22E-02	3.54	3.56	1.81	2.08	1.45	1.43	0.912
OUT - TSS Mean Annual Load (kg/yr)	279	23	70.5	16.9	30.9	129	75.1	380	1.69	12.4	3.39	16.4	117	1.69	645	659	264	285	207	199	171
OUT - TP Mean Annual Load (kg/yr)	0.456	0.134	0.121	2.69E-02	0.112	0.24	0.14	0.708	3.04E-03	2.23E-02	6.08E-03	3.06E-02	0.219	3.04E-03	1.04	1.06	0.472	0.529	0.382	0.372	0.271
OUT - TN Mean Annual Load (kg/yr)	3.46	1.97	0.912	0.199	1.74	1.05	0.61	3.09	2.42E-02	0.177	4.84E-02	0.134	0.954	2.42E-02	7.71	7.82	3.56	4.06	2.85	2.79	2.02
OUT - Gross Pollutant Mean Annual Load (kg/yr)	45.7	23.6	13	2.36	22.1	12.2	7.08	35.9	0	0	0	1.55	11.1	0	91.5	92	45.9	49.3	36.8	36	23.6
Rain In (ML/yr)	2.41511	0.92342	1.01475	0.101475	1.01475	0.558112	0.324719	1.64389	0.0608851	0.446488	0.12177	0.0710323	0.507375	0.0608851	3.93723	3.95752	3.6734	4.54606	2.94277	2.94277	1.01475
ET Loss (ML/yr)	0.819623	0.0311037	0.571484	0.0103081	0.142741	0.0785063	0.0456766	0.231238	0.0485133	0.355764	0.0970266	0.0099918	0.0713703	0.0485133	0.399953	0.402016	1.85282	2.457	1.4843	1.502	0.103079
Deep Seepage Loss (ML/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Out (ML/yr)	0.0705751	0	0.0575624	0	0	0	0	0	0.000238	0.0017457	0.0004761	0	0	0.000238	0	0	0.450798	0.607854	0.361137	0.366527	0
Imp. Stormflow Out (ML/yr)	1.43205	0.89232	0.309967	0.0911671	0.87201	0.479605	0.279043	1.41266	0	0	0	0.0610407	0.436005	0	3.53728	3.55551	1.08908	1.10276	0.872467	0.846029	0.91167
Perv. Stormflow Out (ML/yr)	0.0905169	0	0.0738275	0	0	0	0	0	0.0119653	0.0877453	0.0239305	0	0	0.0119653	0	0	0.272856	0.367918	0.218587	0.221849	0
Total Stormflow Out (ML/yr)	1.52257	0.89232	0.383795	0.0911671	0.87201	0.479605	0.279043	1.41266	0.0119653	0.0877453	0.0239305	0.0610407	0.436005	0.0119653	3.53728	3.55551	1.36194	1.47067	1.09105	1.06788	0.91167
Total Outflow (ML/yr)	1.59314	0.89232	0.441357	0.0911671	0.87201	0.479605	0.279043	1.41266	0.0122033	0.089491	0.0244066	0.0610407	0.436005	0.0122033	3.53728	3.55551	1.81274	2.07853	1.45219	1.43441	0.91167
Change in Soil Storage (ML/yr)	0.0023401	0	0.0019086	0	0	0	0	0	0.0001685	0.0012354	0.0003369	0	0	0.0001685	0	0	0.0078376	0.0105683	0.0062788	0.0063725	0
TSS Baseflow Out (kg/yr)	1.20754	0	0.984309	0	0	0	0	0	0.0037728	0.0276674	0.0075457	0	0	0.0037728	0	0	7.70199	10.3988	6.18341	6.27037	0
TSS Total Stormflow Out (kg/yr)	277.646	23.0035	69.5191	16.9084	30.9401	129.087	75.1054	380.222	1.69014	12.3944	3.38028	16.4293	117.352	1.69014	644.671	658.608	256.266	274.372	200.803	192.96	170.841
TSS Total Outflow (kg/yr)	278.854	23.0035	70.5034	16.9084	30.9401	129.087	75.1054	380.222	1.69391	12.422	3.38783	16.4293	117.352	1.69391	644.671	658.608	263.968	284.771	206.986	199.23	170.841
TP Baseflow Out (kg/yr)	0.0109791	0	0.0089529	0	0	0	0	0	3.36E-05	0.0002466	6.73E-05	0	0	3.36E-05	0	0	0.0700992	0.0944825	0.0561473	0.0569821	0
TP Total Stormflow Out (kg/yr)	0.445156	0.134153	0.112055	0.026875	0.112337	0.240372	0.139853	0.708005	0.0030055	0.0220406	0.0060111	0.0305928	0.21852	0.0030055	1.03996	1.05645	0.401483	0.434719	0.326165	0.314654	0.270682
TP Total Outflow (kg/yr)	0.456135	0.134153	0.121008	0.026875	0.112337	0.240372	0.139853	0.708005	0.0030391	0.0222872	0.0060784	0.0305928	0.21852	0.0030391	1.03996	1.05645	0.471583	0.529201	0.382312	0.371636	0.270682
TN Baseflow Out (kg/yr)	0.0944992	0	0.0770673	0	0	0	0	0	0.0003102	0.0022749	0.0006204	0	0	0.0003102	0	0	0.603243	0.813945	0.482738	0.490238	0
TN Total Stormflow Out (kg/yr)	3.36331	1.97096	0.835228	0.199043	1.73989	1.04926	0.61048	3.09056	0.0238739	0.175075	0.0477477	0.133543	0.953875	0.0238739	7.7144	7.82227	2.96128	3.24223	2.36576	2.30418	2.0153
TN Total Outflow (kg/yr)	3.45781	1.97096	0.912295	0.199043	1.73989	1.04926	0.61048	3.09056	0.0241841	0.17735	0.0483681	0.133543	0.953875	0.0241841	7.7144	7.82227	3.56452	4.05618	2.8485	2.79442	2.0153
GP Total Outflow (kg/yr)	45.7891	23.5593	13.065	2.35949	22.1384	12.1761	7.08428	35.8642	0	0	0	1.54968	11.0692	0	91.5481	92.0203	46.3872	49.9282	37.161	36.412	23.5949

No Imported Data Source nodes

USTM treatment nodes

Location	Bioretention Basin	Bioretention Basin East	RWT-SC1	Bioretention - SC1	Swale - SC2	Bioretention - SC3	Bioretention - SC2	Bioretention Basin - Resi	Rainwater Tank C4	Copy of Bioretention Basin - Resi	Rainwater Tank C5	Rainwater Tank C1	Rainwater Tank C2
ID	3	5	13	15	20	27	28	32	36	42	43	44	45
Node Type	BioRetentionNodeV4	BioRetentionNodeV4	RainWaterTankNode	BioRetentionNodeV4	SwaleNode	BioRetentionNodeV4	BioRetentionNodeV4	BioRetentionNodeV4	RainWaterTankNode	BioRetentionNodeV4	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode
Lo-flow bypass rate (cum/sec)	0	0	0	0	0	0	0	0	0	0	0	0	0
Hi-flow bypass rate (cum/sec)	1	1	100	100		100	100	1	0.1	1	0.1	0.1	0.1
Inlet pond volume			0						0		0	0	0
Area (sqm)	45	20	5	23		12	30	160	8	242	8	3	3
Initial Volume (m^3)			5						10		10	10	10
Extended detention depth (m)	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2
Number of Rainwater tanks			1						1		1	1	1
Permanent Pool Volume (cubic metres)			20						70		70	20	20
Proportion vegetated			0						0		0	0	0
Equivalent Pipe Diameter (mm)			200						450		450	450	450
Overflow weir width (m)	2	2	10	2		2	2	2	10	2	10	10	10
Notional Detention Time (hrs)			6.66E-03						2.11E-03		2.11E-03	7.90E-04	7.90E-04
Orifice Discharge Coefficient			0.6						0.6		0.6	0.6	0.6
Weir Coefficient	1.7	1.7	1.7	1.7		1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Number of CSTR Cells	3	3	2	3	10	3	3	3	2	3	2	2	2
Total Suspended Solids - k (m/yr)	8000	8000	400	8000	8000	8000	8000	8000	400	8000	400	400	400
Total Suspended Solids - C* (mg/L)	20	20	12	20	20	20	20	20	12	20	12	12	12
Total Suspended Solids - C** (mg/L)			12		14				12		12	12	12
Total Phosphorus - k (m/yr)	6000	6000	300	6000	6000	6000	6000	6000	300	6000	300	300	300
Total Phosphorus - C* (mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total Phosphorus - C** (mg/L)			0.13		0.13				0.13		0.13	0.13	0.13
Total Nitrogen - k (m/yr)	500	500	40	500	500	500	500	500	40	500	40	40	40
Total Nitrogen - C* (mg/L)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Total Nitrogen - C** (mg/L)			1.4		1.4				1.4		1.4	1.4	1.4
Threshold Hydraulic Loading for C** (m/yr)			3500		3500				3500		3500	3500	3500
Horizontal Flow Coefficient	3	3		3		3	3	3		3			
Reuse Enabled	Off	Off	On	Off	Off	Off	Off	Off	On	Off	On	On	On
Max drawdown height (m)			4						8.75		8.75	6.666666667	6.666666667
Annual Demand Enabled	Off	Off	Off	Off	Off	Off	Off	Off	On	Off	On	On	On
Annual Demand Value (ML/year)									0.072		0.087	0.03	0.018
Annual Demand Distribution									Monthly		Monthly	Monthly	Monthly
Annual Demand Monthly Distribution: Jan									10.97		10.97	10.97	10.97
Annual Demand Monthly Distribution: Feb									10.97		10.97	10.97	10.97
Annual Demand Monthly Distribution: Mar									9.46		9.46	9.46	9.46
Annual Demand Monthly Distribution: Apr									7.96		7.96	7.96	7.96

Annual Demand Monthly Distribution: May									7.2		7.2	7.2	7.2
Annual Demand Monthly Distribution: Jun									7.2		7.2	7.2	7.2
Annual Demand Monthly Distribution: Jul									5.83		5.83	5.83	5.83
Annual Demand Monthly Distribution: Aug									5.94		5.94	5.94	5.94
Annual Demand Monthly Distribution: Sep									7.92		7.92	7.92	7.92
Annual Demand Monthly Distribution: Oct									7.8		7.8	7.8	7.8
Annual Demand Monthly Distribution: Nov									9.22		9.22	9.22	9.22
Annual Demand Monthly Distribution: Dec									9.53		9.53	9.53	9.53
Daily Demand Enabled	Off	Off	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Daily Demand Value (ML/day)			0.000163										
Custom Demand Enabled	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Custom Demand Time Series File													
Custom Demand Time Series Units													
Filter area (sqm)	45	20		15		8	8	160		140			
Filter perimeter (m)	54	54		80		80	80	40		54			
Filter depth (m)	0.5	0.5		0.4		0.4	0.4	0.5		0.5			
Filter Median Particle Diameter (mm)													
Saturated Hydraulic Conductivity (mm/hr)	180	180		100		100	100	180		180			
Infiltration Media Porosity	0.35	0.35		0.35		0.35	0.35	0.35		0.35			
Length (m)					130								
Bed slope					0.01								
Base Width (m)					0.4								
Top width (m)					1.8								
Vegetation height (m)					0.25								
Vegetation Type	Vegetated with Effective Nutrient Removal Plants	Vegetated with Effective Nutrient Removal Plants		Vegetated with Effective Nutrient Removal Plants		Vegetated with Effective Nutrient Removal Plants	Vegetated with Effective Nutrient Removal Plants	Vegetated with Effective Nutrient Removal Plants		Vegetated with Effective Nutrient Removal Plants			
Total Nitrogen Content in Filter (mg/kg)	800	800		800		800	800	800		800			
Orthophosphate Content in Filter (mg/kg)	43	43		50		50	50	50		50			
Is Base Lined?	No	No		No		No	No	No		No			
Is Underdrain Present?	Yes	Yes		Yes		Yes	Yes	Yes		Yes			
Is Submerged Zone Present?	No	No		No		No	No	No		No			
Submerged Zone Depth (m)													
B for Media Soil Texture	13	13	-9999	13	-9999	13	13	13	-9999	13	-9999	-9999	-9999
Proportion of upstream impervious area treated													
Exfiltration Rate (mm/hr)	3.6	3.6	0	2	2	2	2	3.6	0	3.6	0	0	0
Evaporative Loss as % of PET			0						0		0	0	0
Depth in metres below the drain pipe										0			
TSS A Coefficient													
TSS B Coefficient													
TP A Coefficient													
TP B Coefficient													
TN A Coefficient													
TN B Coefficient													
Sfc	0.37	0.37		0.37		0.37	0.37	0.37		0.37			
S*	0.22	0.22		0.22		0.22	0.22	0.22		0.22			
Sw	0.11	0.11		0.11		0.11	0.11	0.11		0.11			
Sh	0.05	0.05		0.05		0.05	0.05	0.05		0.05			
Emax (m/day)	0.008	0.008		0.008		0.008	0.008	0.008		0.008			
Ew (m/day)	0.001	0.001		0.001		0.001	0.001	0.001		0.001			
IN - Mean Annual Flow (ML/yr)	2.55	1.33	0.872	1.32	1.5	0.448	1.68	12.1	3.54	7.35	3.56	0.892	0.912
IN - TSS Mean Annual Load (kg/yr)	107	180	30.9	153	393	119	99.8	350	645	369	659	23	171
IN - TP Mean Annual Load (kg/yr)	0.434	0.336	0.112	0.351	0.73	0.222	0.332	1.8	1.04	1.36	1.06	0.134	0.271
IN - TN Mean Annual Load (kg/yr)	5.49	2.81	1.74	2.65	3.27	0.978	2.99	17.8	7.71	15	7.82	1.97	2.02
IN - Gross Pollutant Mean Annual Load (kg/yr)	3.34	13	22.1	12.2	35.9	11.1	7.08	3.28	91.5	4.93	92	23.6	23.6
OUT - Mean Annual Flow (ML/yr)	2.23	1.18	0.811	1.23	1.39	0.4	1.58	10.7	3.46	5.77	3.46	0.861	0.893
OUT - TSS Mean Annual Load (kg/yr)	22.5	32.1	21	33.3	23	13	29.1	113	444	52.2	455	17.7	110
OUT - TP Mean Annual Load (kg/yr)	0.21	0.135	0.105	0.179	0.189	6.37E-02	0.209	1.22	0.859	0.637	0.871	0.124	0.215
OUT - TN Mean Annual Load (kg/yr)	2.32	1.33	1.55	1.63	2.36	0.474	2.1	9.4	7.35	4.8	7.42	1.83	1.9
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0.145	0	0.148	0	0
Flow In (ML/yr)	2.54459	1.33366	0.872008	1.31472	1.50191	0.448163	1.67913	12.0985	3.53729	7.34625	3.55535	0.89234	0.91167
ET Loss (ML/yr)	0.106034	0.04638	0	0.0321415	0	0.0174659	0.0177671	0.409721	0	0.372016	0	0	0
Infiltration Loss (ML/yr)	0.212691	0.109922	0	0.0537584	0.118131	0.0306579	0.0845713	1.02342	0	1.21649	0	0	0
Low Flow Bypass Out (ML/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
High Flow Bypass Out (ML/yr)	0	0	0	0	0	0	0	0	0.0091716	0	0.009423	0	0
Orifice / Filter Out (ML/yr)	1.62493	0.790108	0.810977	0.61794	1.38381	0.262017	0.650954	8.31264	3.45025	4.94012	3.45326	0.861345	0.892718
Weir Out (ML/yr)	0.601502	0.38727	2.77E-05	0.611304	0.0042502	0.138065	0.92602	2.36358	0	0.827385	0	0	0
Transfer Function Out (ML/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Reuse Supplied (ML/yr)	0	0	0.0595311	0	0	0	0	0	0.0718404	0	0.0871695	0.0300688	0.0179601
Reuse Requested (ML/yr)	0	0	0.0595311	0	0	0	0	0	0.0718404	0	0.0871695	0.0300688	0.0179601
% Reuse Demand Met	0	0	100	0	0	0	0	0	100	0	100	100	100
% Load Reduction	12.5033	11.7182	6.99573	6.50144	7.58033	10.7285	6.08378	11.7556	2.20136	21.4905	2.60641	3.47345	2.07882
TSS Flow In (kg/yr)	107.186	180.017	30.9401	153.454	392.643	119.035	99.7555	349.851	644.671	368.123	658.608	23.0035	170.841
TSS ET Loss (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TSS Infiltration Loss (kg/yr)	0.668816	0.657273	0	0.772109	1.95178	0.655157	1.44408	2.43785	0	3.65754	0	0	0
TSS Low Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TSS High Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	1.07231	0	1.87657	0	0
TSS Orifice / Filter Out (kg/yr)	3.97215	1.92892	20.9842	1.74529	21.8771	0.742135	1.76259	18.4108	443.084	10.7068	453.214	17.6804	109.615
TSS Weir Out (kg/yr)	18.5081	30.1291	0.000805727	31.5375	1.08457	12.2961	27.3639	94.6074	0	41.459	0	0	0
TSS Transfer Function Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TSS Reuse Supplied (kg/yr)	0	0	0.920707	0	0	0	0	0	4.66058	0	5.64226	0.461119	0.979521
TSS Reuse Requested (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TSS % Reuse Demand Met	0	0	0	0	0	0	0	0	0	0	0	0	0
TSS % Load Reduction	79.0268	82.1917	32.1754	78.3109	94.152	89.0467	70.8021	67.6953	31.1034	85.8293	30.9011	23.1404	35.838
TP Flow In (kg/yr)	0.433638	0.335707	0.112337	0.351232	0.730291	0.221526	0.331664	1.79662	1.03996	1.35741	1.05645	0.134152	0.270682
TP ET Loss (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TP Infiltration Loss (kg/yr)	0.0157786	0.0086392	0	0.0067317	0.0161034	0.0042868	0.0107671	0.101627	0	0.120353	0	0	0
TP Low Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TP High Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0.00271412	0	0.00354559	0	0
TP Orifice / Filter Out (kg/yr)	0.118723	0.057694	0.104832	0.0669687	0.186787	0.0284184	0.0694837	0.831412	0.856456	0.490869	0.867234	0.123597	0.214853
TP Weir Out (kg/yr)	0.0908572	0.0770125	3.57E-06	0.111754	0.00201406	0.0352748	0.139846	0.38561	0	0.145817	0	0	0
TP Transfer Function Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TP Reuse Supplied (kg/yr)	0	0	0.00772771	0	0	0	0	0	0.013715	0	0.0166653	0.00408614	0.00322389
TP Reuse Requested (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TP % Reuse Demand Met	0	0	0	0	0	0	0	0	0	0	0	0	0
TP % Load Reduction	51.6692	59.8738	6.67761	49.1153	74.1471	71.248	36.8851	32.2603	17.3843	53.0955	17.5749	7.86794	20.6253
TN Flow In (kg/yr)	5.4868	2.80928	1.73989	2.64874	3.26789	0.977956	2.99398	17.7762	7.7144	15.0214	7.82226	1.97096	2.01531
TN ET Loss (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TN Infiltration Loss (kg/yr)	0.144784	0.081362	0	0.0621788	0.186665	0.038277	0.112495	0.631341	0	0.802703	0	0	0
TN Low Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TN High Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0.0155874	0	0.0276377	0	0
TN Orifice / Filter Out (kg/yr)	1.05087	0.513306	1.55153	0.440339	2.35035	0.189523	0.44215	5.13565	7.33437	3.05282	7.38867	1.83252	1.89825
TN Weir Out (kg/yr)	1.27304	0.812061	5.42E-05	1.18536	0.00920904	0.284125	1.65418	4.26754	0	1.74735	0	0	0
TN Transfer Function Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TN Reuse Supplied (kg/yr)	0	0	0.104981	0	0	0	0	0	0.145387	0	0.177034	0.0598903	0.0361154
TN Reuse Requested (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
TN % Reuse Demand Met	0	0	0	0	0	0	0	0	0	0	0	0	0
TN % Load Reduction	57.6455	52.8219	10.8229	38.6238	27.7956	51.5676	29.9818	47.1023	4.72419	68.0446	5.18971	7.02399	5.80854
GP Flow In (kg/yr)	3.33926	12.9765	22.1384	12.1762	35.8642	11.0692	7.08424	3.27726	91.5483	4.92871	92.0202	23.5593	23.5949
GP ET Loss (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP Infiltration Loss (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP Low Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP High Flow Bypass Out (kg/yr)	0	0	0	0	0	0	0	0	0.144629	0	0.148176	0	0
GP Orifice / Filter Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP Weir Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0

GP Transfer Function Out (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP Reuse Supplied (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP Reuse Requested (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
GP % Reuse Demand Met	0	0	0	0	0	0	0	0	0	0	0	0	0
GP % Load Reduction	100	100	100	100	100	100	100	100	99.842	100	99.839	100	100

Other nodes

Location	Junction	Junction	Receiving Node	TARGETS	Junction	Junction 2	NOTES	Junction	RHDHV Junction
ID	6	7	8	11	16	24	29	33	40
Node Type	JunctionNode	JunctionNode	ReceivingNode	JunctionNode	JunctionNode	JunctionNode	JunctionNode	JunctionNode	JunctionNode
IN - Mean Annual Flow (ML/yr)	1.18	2.23	17.3	0	0.835	1.29	0	10.7	3.27
IN - TSS Mean Annual Load (kg/yr)	32.1	22.5	259	0	24.4	49.7	0	113	91.9
IN - TP Mean Annual Load (kg/yr)	0.135	0.21	2.04	0	0.111	0.209	0	1.22	0.482
IN - TN Mean Annual Load (kg/yr)	1.33	2.32	17.4	0	1.6	1.76	0	9.4	4.33
IN - Gross Pollutant Mean Annual Load (kg/yr)	0	0	1.55	0	0	1.55	0	0	1.55
OUT - Mean Annual Flow (ML/yr)	1.18	2.23	0	0	0.835	1.29	0	10.7	3.27
OUT - TSS Mean Annual Load (kg/yr)	32.1	22.5	0	0	24.4	49.7	0	113	91.9
OUT - TP Mean Annual Load (kg/yr)	0.135	0.21	0	0	0.111	0.209	0	1.22	0.482
OUT - TN Mean Annual Load (kg/yr)	1.33	2.32	0	0	1.6	1.76	0	9.4	4.33
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	1.55	0	0	1.55
% Load Reduction	13	13.6	19.2	0	6.81	10.2	0	23	11.2
TSS % Load Reduction	86.7	92.9	92.8	0	29	72.4	0	95	88
TN % Load Reduction	54.7	58.7	61.6	0	10.5	40.8	0	67.4	44.9
TP % Load Reduction	65.6	66	67.8	0	6.33	46.2	0	68.4	67.5
GP % Load Reduction	100	100	99.7	0	100	95.7	0	100	98.3

Links

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	4	5	3	7	6	9	1	10	26	25	23	17	19	20	18	21	22	13	16	15	12
Target node ID	5	6	7	8	8	3	10	3	27	27	24	28	28	28	20	20	16	16	15	24	13
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K																					
Muskingum theta																					
IN - Mean Annual Flow (ML/yr)	0.441	1.18	2.23	2.23	1.18	9.12E-02	1.59	2.45	1.22E-02	0.436	6.10E-02	0.279	1.22E-02	1.39	1.41	8.95E-02	2.44E-02	0.811	0.835	1.23	0.872
IN - TSS Mean Annual Load (kg/yr)	70.5	32.1	22.5	22.5	32.1	16.9	279	90.3	1.69	117	16.4	75.1	1.69	23	380	12.4	3.39	21	24.4	33.3	30.9
IN - TP Mean Annual Load (kg/yr)	0.121	0.135	0.21	0.21	0.135	2.69E-02	0.456	0.407	3.04E-03	0.219	3.06E-02	0.14	3.04E-03	0.189	0.708	2.23E-02	6.08E-03	0.105	0.111	0.179	0.112
IN - TN Mean Annual Load (kg/yr)	0.912	1.33	2.32	2.32	1.33	0.199	3.46	5.29	2.42E-02	0.954	0.134	0.61	2.42E-02	2.36	3.09	0.177	4.84E-02	1.55	1.6	1.63	1.74
IN - Gross Pollutant Mean Annual Load (kg/yr)	13	0	0	0	0	2.36	45.7	0.98	0	11.1	1.55	7.08	0	0	35.9	0	0	0	0	0	22.1
OUT - Mean Annual Flow (ML/yr)	0.441	1.18	2.23	2.23	1.18	9.12E-02	1.59	2.45	1.22E-02	0.436	6.10E-02	0.279	1.22E-02	1.39	1.41	8.95E-02	2.44E-02	0.811	0.835	1.23	0.872
OUT - TSS Mean Annual Load (kg/yr)	70.5	32.1	22.5	22.5	32.1	16.9	279	90.3	1.69	117	16.4	75.1	1.69	23	380	12.4	3.39	21	24.4	33.3	30.9
OUT - TP Mean Annual Load (kg/yr)	0.121	0.135	0.21	0.21	0.135	2.69E-02	0.456	0.407	3.04E-03	0.219	3.06E-02	0.14	3.04E-03	0.189	0.708	2.23E-02	6.08E-03	0.105	0.111	0.179	0.112
OUT - TN Mean Annual Load (kg/yr)	0.912	1.33	2.32	2.32	1.33	0.199	3.46	5.29	2.42E-02	0.954	0.134	0.61	2.42E-02	2.36	3.09	0.177	4.84E-02	1.55	1.6	1.63	1.74
OUT - Gross Pollutant Mean Annual Load (kg/yr)	13	0	0	0	0	2.36	45.7	0.98	0	11.1	1.55	7.08	0	0	35.9	0	0	0	0	0	22.1

Catchment Details

Catchment Name	DEVELOPED whole site
Timestep	6 Minutes
Start Date	1/01/1999
End Date	31/12/2008 23:54
Rainfall Station	
ET Station	User-defined monthly PET
Mean Annual Rainfall (mm)	1015
Mean Annual ET (mm)	1425
MUSIC-link Area	South Region
MUSIC-link Scenario	South Region