11 Appendix 6 – Stormwater assessment

PROJECT

STORMWATER ASSESSMENT & MANAGEMENT PLAN PACIFIC PINES ESTATE MONTWOOD DRIVE & HUTLEY DRIVE LENNOX HEAD NEW SOUTH WALES

PREPARED FOR

LEND LEASE

DATE

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GILBERT SUTHERLAND

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SYNOPSIS This report describes assessments of the proposed stormwater management measures required to ensure that the stormwater runoff from the proposed development meets NSW Department of Planning & Infrastructure and Ballina Shire Council's conditions of approval and water quality objectives.

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SUMMARY

Lend Lease on behalf of Petrac Lennox Head (Receivers and Managers appointed) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Stormwater Assessment and Management Plan (SWMP) for the balance of the proposed residential development known as 'Pacific Pines Estate' located off Montwood Road and Hutley Road, Lennox Head, New South Wales. This SWMP provides detailed assessments of the stormwater management measures required to meet NSW Department of Planning & Infrastructure and Ballina Shire Council's (BSC) conditions of approval, stormwater runoff quality objectives and the peak flow management objectives.

G&S used the MUSIC computer model to assess the quality of the stormwater runoff resulting from the proposed development over the site. An analysis of the estimated water quality after completion of the development was also carried out. This analysis indicated that, provided the recommended water quality management measures are properly installed and maintained, the water quality of runoff from the proposed development will achieve BSC's adopted water quality objectives.

The assessments described within this report demonstrate that provided the stormwater management measures proposed are appropriately designed, installed and maintained, Council's stormwater quality and quantity objectives would be achieved and the conditions of approval would be satisfied.

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GLOSSARY

TERM	MEANING
Australian Height Datum (AHD)	National reference for relative height measurement in Australia.
Average Recurrence Interval (ARI)	The average or expected length of time between exceedances of a given variable, such as rainfall.
Bund	An embankment constructed around an area to prevent the inflow or outflow of liquids. Also called Bunding.
Catchment	The area above a given point which contributes to the runoff.
Clay	Very fine-grained sediment or soil (often defined as having a particle size less than 0.002 mm, or 2 microns, in diameter).
Ephemeral	A stream that flows briefly only in direct response to precipitation in the immediate locality and the channel of which is at all times above the watertable.
Erosion	The process by which material (such as rock or soil) is worn away or removed (as by wind or water).
Groundwater	The water contained in interconnected pores located below the watertable in an unconfined aquifer or located in a confined aquifer.
Intermittent	A stream in which the flow is seasonal, usually in response to rainfall in the immediate area (see ephemeral).
Loam	Medium-textured soil composed of approximately 10% to 25% clay, 25% to 50% silt and less than 50% sand.
pH	The degree of acidity or alkalinity measured on a scale of 1 to 14 with 7 as neutral. From 0 to 7 is acidic; from 7 to 14 is alkaline.
Sand	Sediment composed of particles within the size range 63 microns to 2 millimetres.
Scouring	The action of removing sediment from stream banks, particle by particle. This is a more destructive process than collapse when viewed over time due to incremental effects.

TERM	MEANING
Sediment	Unconsolidated, fine-grained material (typically derived from the weathering of rocks), that is transported by water and settles on the floor of seas, rivers streams and other bodies of water.
Silt	Sediment having particles finer than sand and coarser than clay (i.e. 2 to 63 microns).
Sub-catchment	A smaller area within a catchment drained by one or more tributaries of the main water body.
Suspended Solids (SS)	The concentration of filterable particles in water (retained on a 1.2µm filter) and reported by volume (mg/L).
Total Nitrogen (TN)	Total nitrogen is the sum of the nitrogen present in all nitrogen-containing components in the water column. The nutrients, nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth.
Total Phosphorus (TP)	Total phosphorus is the sum of the phosphorus present in all phosphorus-containing components in the water column. The nutrients, nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth.
Turbidity	A measure of the cloudiness of water which is determined by the amount of light scattered by suspended particles.

1 Introduction

Lend Lease Pty Ltd (LL) on behalf of Petrac Lennox Head Pty Ltd (Receivers and Managers Appointed) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Stormwater Management Plan (SWMP) in support of a development application to Ballina Shire Council (BSC) for a Construction Certificate approval for Stage 1a of the proposed 'Pacific Pines Estate' development off Montwood Drive and Hutley Drive, Lennox Head, New South Wales. The site is formally described as Lot 234 on DP1104071.

This estate has been under construction since the late 1990's. The first four stages and associated infrastructure were completed under existing approvals from BSC. Some works required as part of the proposed development are yet to be completed. These additional works are to be completed under the existing approvals.

In 2007 the undeveloped portion of the project (Lot 234 on DP1104071, or 'the site', for the purposes of this report) was acquired by Petrac Lennox Head Pty Ltd (Petrac). Petrac reviewed the development layout and product mix of the site and submitted Part 3a applications to the NSW Department of Planning and Infrastructure (NSW DoP) for Major Project Concept and Project approvals. In 2008 Petrac was placed in receivership. The Receivers have subsequently appointed Lend Lease to act as development and project managers to proceed with the development of the balance of the project.

The NSW DoP granted Concept and Project approvals in respect of the revised layout, subject to conditions. A number of refinements to these approvals have subsequently been granted, with the latest having been approved on 8 September 2011.

G&S was commissioned to address a number of the conditions of approval regarding stormwater management, imposed by NSW DoP in respect of the development application to BSC for a Construction Certificate for Stage 1a. For ease of reference, relevant conditions from the approvals are reproduced below in italic text. Each item is then followed (in Roman text) by further details or a reference to the location within this report where required details have been provided.

Concept Plan Approval 07_0026 Mod3

> *B6 Stormwater Management Plan*
>
> *The proponent is to prepare a stormwater management plan for the entire site, prepared by a suitable qualified person(s) that includes detailed modelling for both water quality and quantity. The plan shall demonstrate:*
>
> *1) That the project does not concentrate or lead to an increase in the volume or rate of flow of stormwater discharged from the site over and above pre-development flow conditions; and*
>
> *2) That the project does not increase the average annual load of key stormwater pollutants in stormwater discharged from the site over and above pre-development conditions.*
>
> *The plan is to be prepared in accordance with the Water Sensitive Urban Design requirements of Ballina Shire Combined Development Control Plan Chapter 13 – Stormwater Management.*
>
> *The stormwater plan is to be submitted to and approved by Council prior to the issue of a Construction Certificate for Stage 1A.*

This document constitutes the required stormwater management plan. Assessments of the stormwater treatment train are provided in Sections 4 and 6 demonstrating that these requirements have been fulfilled.

> *B19 No development is to be undertaken until the water quality control pond is operating in accordance with DA 2002/333. The water quality control pond is to operate in accordance with DA 2002/333 for the life of the project.*

A detailed Works-as-Executed survey has been undertaken by Kennedy Surveys. The details of the constructed works have been compared with the approved Construction Certificate drawings in

DA 2002/333 and a letter report detailing departures from the approved design and remedial measures to be undertaken has been provided to Council under separate cover.

C12 Stormwater Management

All future applications for development on the site are to include a detailed stormwater management plan for the proposal. These management plans shall be consistent with the Stormwater Management Plan required by condition B6 of this approval.

The future application for the development of the tavern (super lot 2) is to include consideration of the relocation of the sediment basin and how the proposed system will integrate with existing water quality control pond.

This report contains conceptual details for the entire site as required by condition B6 and includes detailed assessments for Stage 1a in Sections 4, 6 and 8.

Project Approval 07_0026 Mod3

B3 Stormwater Management Plan

The stormwater management plan required by condition B6 of the concept plan approval is to be approved by Council prior to the issue of the Construction Certificate for Stage 1a.

This document constitutes the required stormwater management plan.

B4 Water Quality Control Pond

The proponent shall submit the Works–as-Executed drawings for the water quality control pond in accordance with DA2002/333 for Council's approval prior to the issue of a Construction Certificate for Stage 1a.

The required Works-as-Executed drawings have been submitted to Council under separate cover.

E4 Stormwater Implementation Strategy

The proponent shall develop a Stormwater Implementation Strategy detailing the implementation of the Stormwater Management Plan (required by condition B6 of the concept plan approval). A detailed report shall be submitted to and approved by Council prior to the issue of a Construction Certificate.

Note: Weldmesh pedestrian fencing to 1.6m high is required around the perimeter of stormwater assets where:
1) The depth of water is greater than 600mm;
2) The velocity depth product is greater than 0.6; or
3) The internal side slopes are steeper than 1.3.

E5 Stormwater Works Process Strategy

The proponent shall develop a Stormwater Works Process Strategy to maintain the performance of the stormwater system during the construction phase. This strategy shall include, but not be limited to the following:
1) The water quality performance targets to be achieved;
2) The proposed treatment system for each stage of the project
3) The proposed water quality testing regime and frequency of site inspections; and
4) The reporting requirements to Council.

Details are to be approved by Council prior to issue of a Construction Certificate.

E6 Stormwater Treatment Assets

Stormwater treatment assets shall be designed and constructed to the approval of Council's engineers and make due provision for all weather access and vehicle turning facilities. Detailed design plans are to be approved by Council prior to issue of a Construction Certificate.

E7 Stormwater

The proponent shall make due provision for the diversion of the existing stormwater quantities that discharge onto the site via adjacent properties. The project shall be required to provide a suitable drainage system and demonstrate that the pre-development performance of the existing stormwater and overland drainage system is maintained. Details are to be included in the stormwater

designs and approved by Council prior to issue of a Construction Certificate.

These details have been prepared by SMEC Urban and will be submitted to BSC as part of the application for Construction Certificate approval for Stage 1a.

1.1 Report structure

This report is divided into sections dealing with the proposal for the entire site as well as detail for Stage 1a. It includes a description of the physical characteristics of the site, an assessment of the likely stormwater runoff quality and management of the potential stormwater impacts during the construction and operational phases. These latter management sections form the SWMP that is included as Attachment 1.

This report, prepared by qualified Gilbert & Sutherland staff, is based on MUSIC Version 4 computer modelling of likely changes to annual stormwater sediment and nutrient loads due to the proposed development.

2 Site description and proposal

2.1 Site location

This site is located off Montwood Drive and Hutley Drive at Lennox Head, New South Wales and is within the Shire of Ballina. Drawing No 10734.1.1 shows the site location whilst details of the entire proposed development are shown on Drawing No. 10734.1.2.

Stage 1a has an area of approximately 5.2ha, contains 54 residential allotments and may be described as part of Lot 234 on DP1104071.

2.2 Receiving environment

The site lies to the west of North Creek Road (which generally follows a ridge line) and is situated in the bowl of a natural amphitheatre formed by spurs in the north, east and south that follow Stoneyhurst Drive, North Creek Road and Montwood Drive, respectively. It ranges in elevation from below RL 1.0m Australian Height Datum (AHD) to RL 51.0m AHD.

Runoff flows towards the lower lying central portion of the site, then in a generally westerly direction through the Ballina Nature Reserve before discharging to the tidal zone of North Creek. Stage 1a lies in the southern portion of the site and falls in a generally northerly direction.

No water quality monitoring has been carried out by Gilbert & Sutherland to establish background water quality levels on the site. However, care should be taken to ensure that there is no worsening of the water quality in the receiving waters resulting from this development, during the construction or operational phase.

2.3 Existing development

The bulk of the site has been cleared and used for grazing purposes, however small patches remain of vegetation and scattered isolated trees. There are no buildings on the site.

A number of agricultural drains have been excavated through the lower portions of the site, to facilitate grazing.

A large water quality control pond (WQCP) or constructed wetland has been excavated in the lower central western portion of the site. The WQCP has not been completed as some works required under DA 2002/333 have not been finalised to BSC's satisfaction and the landscaping within and around the pond has not commenced.

Stage 1a adjoins and is an extension of the existing approved development on the southern boundary of the site.

2.4 Proposed development

The proposed development comprises the construction and/or installation of the following:

- site earthworks and landscaping
- roads / trafficable areas
- stormwater drains
- sewer reticulation mains
- water reticulation mains
- underground electricity distribution cables
- telecommunications cables
- other ancillary services
- construction/building works.

Once the development has been completed, all disturbed portions of the site will be rehabilitated or covered by some form of improvement protecting the soils from erosion, hence minimising the transport of suspended solids from the site. The improvements will include structures, paved areas, lawns and landscaping.

3 Stormwater quality assessment method

To assess the likely impacts of the proposed development on water quality, the CRC for Catchment Hydrology Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 4 computer model was used.

MUSIC is a water resources package with components for generating surface and subsurface runoff, non-point source pollutant export and pollutant transporting and routing.

MUSIC is specifically designed for the analysis of the effects of planned land use changes and for the evaluation of best management practice stormwater quality improvement devices.

The MUSIC model input data requirements are described below.

3.1 Model input data

Rainfall data (in the form of 6 minute time-step pluviometer records) and evapotranspiration data are required for the model.

Suitable 6 minute time-step pluviometer records were available from Bureau of Meteorology for the weather station 58131 at Alstonville from 1963 to 2008. From this we extracted a continuous 6 minute time-step dataset from 01/01/1988 to 31/12/1992. This period was selected because it has an average annual rainfall of 1,873mm, which is similar to the weather station 58198 at Ballina Airport (being a location closer to the site and hence more representative).

It should be noted that the Ballina Airport rainfall data set does not supply the 6 minute time-step rainfall data required for MUSIC modelling, but does record daily timesteps (which were used as part of the hydrological modelling detailed in Section 7).

An analysis of the daily time-step rainfall data set for Ballina Airport for the period from 1992 to the present provided the following annual rainfall data:

- Driest Year • 1,134mm
- 10th percentile year • 1,411mm
- Average year • 1,860mm
- Median year • 1,726mm
- 90th percentile year • 2,335mm
- Wettest year • 2,908mm

It should be noted that in the above analysis the results are statistical annual totals and may not necessarily refer to an actual historical year. A continuous model run using the MUSIC dataset from 1988 to 1992 would therefore be expected to yield representative results. This is because the average rainfall (1,873mm) of the model dataset is close to the long term average (1,860mm).

The Bureau of Meteorology web site lists average monthly potential areal evapotranspiration values and these are presented in Table 3.1.1.

Table 3.1.1 Evapotranspiration data

Month	Evapotranspiration (mm)
Jan	199
Feb	168
Mar	156
Apr	107
May	71
Jun	52
Jul	55
Aug	69
Sep	102
Oct	152
Nov	177
Dec	207

3.1.1 Runoff parameters

Relevant runoff parameters for the land uses were sourced from Water by Design ‘Music Modelling Guidelines’, Version 1.0 2010 (WbD, 2010) Table 3.7 and are presented in Table 3.1.2.

Table 3.1.2 Runoff Parameters

Parameter	Rural Land use	Urban Land use
Impervious Area Properties		
Rainfall threshold (mm)	1	1
Pervious Area Properties		
Soil storage capacity (mm)	98	500
Initial storage (%)	10	10
Field capacity (mm)	80	200
Infiltration coefficient	84	211
Infiltration exponent	3.3	5.0
Groundwater Properties		
Initial depth (mm)	50	50
Daily recharge rate (%)	100	28
Daily baseflow rate (%)	22	27
Daily deep seepage rate (%)	0	0

3.1.2 Water quality parameters

The water quality parameters modelled were:

- Suspended Sediment
- Total Nitrogen
- Total Phosphorus

The sediment and nutrient export characteristics were adopted from Water by Design 'Music Modelling Guidelines', Version 1.0 2010 (WbD, 2010) Table 3.8 and are presented in Table 3.1.3.

It should be noted that the rainfall to runoff model and the pollutant export expressions have not been calibrated for local catchments. This means the modelling results can not be expected to produce accurate assessments of the amount of pollutants likely to be exported from the proposed development. However, the results do provide useful assessments which enable comparisons of the effectiveness of various stormwater management strategies.

An assessment of the pervious and impervious proportions for the urban areas in each catchment was carried out to provide input for the model using the recommendations in Section 3.3.3 of WbD 2010.

3.2 Modelling undertaken

The MUSIC model was used to form models to assess the performance of the stormwater treatment system by comparing the Base Case (i.e. the site in its undeveloped state) with the Treated Developed Case during the operational phase (after completion of the construction phase). This process enabled verification that the water quality objective of 'no net increase' in annual pollutant loads would be satisfied by the proposed treatment devices.

The modelled scenarios were as follows:

- Base Case, undeveloped site
- Developed Case WITH treatment measures.

Details of the stormwater treatment methods recommended and the results of the MUSIC modelling are provided in Section 4.

Table 3.1..3 Pollutant Export Parameters (Log_{10}mg/L)

Land use	Parameter	Suspended Solids		Total Nitrogen		Total Phosphorus	
		Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow
Forest	Mean	0.51	1.90	-0.59	-0.075	-1.79	-1.10
	Std Deviation	0.28	0.20	0.22	0.24	0.28	0.22
Rural	Mean	0.53	2.26	-0.52	0.32	-1.54	-0.56
	Std Deviation	0.24	0.51	0.39	0.30	0.38	0.28
Urban Road	Mean	1.00	2.43	0.20	0.26	-0.97	-0.30
	Std Deviation	0.34	0.39	0.20	0.23	0.31	0.31
Urban Roof	Mean	1.00	1.30	0.20	0.26	-0.97	-0.89
	Std Deviation	0.34	0.39	0.20	0.23	0.31	0.31
Urban Balance	Mean	1.00	2.18	0.20	0.26	-0.97	-0.47
	Std Deviation	0.34	0.39	0.20	0.23	0.31	0.31

3.3 Catchment description

This assessment is based on the approved concept plan of development. Detailed design parameters are provided for the treatment measures required for the whole of the proposed development including Stage 1a together with details of their performance in mitigating the impacts of stormwater runoff.

The physical catchment characteristics were described in Section 2 of this report. The developed catchment boundaries are shown on Drawing No. 10734.1.3. These catchments were appropriately dissected into sub-catchments to represent the proposed land uses when the development has been completed. These details are provided in Appendix 3.

Generally the 'urban' land use areas have been dissected to represent the roads, roofs and the balance areas of the building envelopes and surrounds. The estimated impervious areas and impervious fractions for the urban catchments have been calculated in accordance with the WBD 2009 guidelines.

The rural land use has been used to represent the designated open space and undeveloped areas.

3.4 Water Quality Objectives

The Water Quality Objectives (WQO's) for site runoff during the operational phase have been adopted from Ballina Shire Council's Combined Development Control Plan – Chapter 13 – Stormwater Management 2006 which requires *"there shall be no net increase in the average annual loads of key stormwater pollutants and peak discharge flow rates, above that occurring under existing conditions"*.

4 Stormwater quality assessment results

MUSIC model and catchment details have been provided in sections 3.4 and 3.5 respectively.

4.1 Base Case

The results of the undeveloped or Base Case modelling, demonstrating the runoff and pollutant loads that are estimated to emanate from the site in its present state are shown in Table 4.2.1.

Table 4.2.1 Base Case average annual loads

	Pollutant loads (kg/year)		
Runoff (ML/yr)	Suspended Solids	Total Nitrogen	Total Phosphorus
1070	378,000	2790	360

4.2 Developed Treated Case

The same areas as above were modelled under the same rainfall conditions in a developed state with treatment measures included.

Considerable work has previously been completed in respect of the selection, siting and design of the proposed stormwater treatment train. This has been illustrated in drawings C7 and P4 which have been approved by NSW DoP.

A constructed wetland or water quality control pond (WQCP) was previously designed to serve the whole estate. This WQCP was approved by BSC under Construction Certificate 2002/333 and has been excavated. This WQCP has not been fully completed in that some works required under DA 2002/333 have not been finalised to BSC's satisfaction and the landscaping within and around the pond has not been commenced.

In response to concerns about maintaining the hydrological regime in the freshwater wetland EEC, the performance of the WQCP has been reassessed to account for the changes in development extent, layout and density. An assessment of the hydrological regime within the freshwater wetland EEC has been presented in Sections 7 and 8. The hydrological assessment assumes that rainwater storage tanks would be installed at each dwelling to meet the BASIX requirements and indicates that bioretention devices and infiltration systems should be installed in appropriate locations to minimise the impacts of the proposed development.

The proposed permanent treatment measures included in the modelling are shown on Drawing No 10734.1.4 and include:

- water quality control pond
- bioretention basins
- infiltration systems
- rainwater tanks.

These treatment measures are described in further detail below.

4.2.1 Water quality control pond (WQCP)

G&S previously assisted with the design of the WQCP and provided a report titled '*Wetland Assessment of Water Quality Control Pond for Proposed Residential Subdivision, Pacific Pines Estate, Lennox Heads'* dated May 2004.

The report, based on water quality modeling using AQUALM-XP software, indicated that the WQCP could achieve BSC's water quality objectives of 'no net increase' for the estate. Since that time, more refined stormwater modelling software has been released and this reassessment has been undertaken using the MUSIC version 4 software.

Details of the WQCP are shown on Drawing No 10734.1.5 and the characteristics used in the modelling are shown in Table 4.2.1.1 (next page). SMEC civil drawings have been provided within Appendix 2 for further WQCP details.

4.2.2 Bioretention basins

The bioretention basins would be designed generally in accordance with QUDM and the Healthy Waterways Technical Design Guidelines. It is envisaged that the basins would be used to manage water quality alone and would generally be dry. However during (and for a short period after) wet weather, the basin may contain water to a depth of up to 300mm.

Table 4.2.1.1 WQCP details

Basin No.	2
Inlet Properties	
Low Flow Bypass (m^3/s)	0.0
High Flow Bypass (m^3/s)	100
Inlet pond volume (m^3)	800.0
Storage Properties	
Surface Area (m^2)	22,500
Extended Detention Depth (m)	0.5
Permanent pool volume (m^3)	24,400
Vegetation cover (% of surface area)	50.0
Exfiltration rate (mm/hr)	0.00
Evaporative loss as % of PET	125.00
Outlet properties	
Equivalent pipe diameter (mm)	200.0
Overflow weir width (m)	10.0
Notional detention time (hrs)	47.4

Where possible, a high flow bypass for flows in excess of $Q_{3months}$ would be installed. Otherwise, a combination of weir and pipe outlets would be provided.

The filter surface should be level while the floor of the basin should have a minimum grade of 0.5% towards a low point that would be additionally drained by a system of subsurface perforated drains at 1.5m maximum spacings.

The subsurface drainage pipes are to be 100mm diameter class 400 perforated corrugated PVC pipe Type 1 with 6 rows of perforations 1.25mm wide by 7.4mm long. A non-perforated riser with a sealed removable screw cap is to be provided at the end of each perforated pipe for maintenance flushing.

Filter media
The bioretention filter's upper layer provides the majority of the pollutant removal function and is intended to support healthy vegetation growth to enhance the treatment process. It is to consist of at least 400mm depth of sandy loam with a nominal particle size of 0.45 to 0.50mm and a saturated hydraulic conductivity of 145 to 220 mm/hour.

The organic content (measured in accordance with AS 1289.4.1.1-1997) should be 5% to 10%. The filter media must meet the requirements of FAWB 2009.[1]

Sieve size	%passing
3.4mm	100%
2.0mm	97 – 100%
1.0mm	89 – 92%
0.25mm	30 – 50%
0.15mm	10 – 30%
0.05mm	0 – 3%

Transition layer
The transition layer underlies the filter medium and is intended to prevent the filter medium flowing into the drainage layer and the pipe drains. This layer is be 150mm thick and is to consist of coarse sand having a particle size distribution as shown below.

Sieve size	%passing
1.4mm	100%
1.0mm	80%
0.7mm	44%
0.5mm	8.4%

Drainage layer
The lowest layer in the system is to consist of 150mm depth of granular backfill (2mm to 5mm gravel) bedding medium surrounding the perforated pipes. It provides for the free flow of filtered water to the pipe drainage system.

A graphical representation of the bioretention basins are shown on the attached Drawing No. 10734.1.6. Further details are presented within SMEC civil drawings (Appendix 2).

The basin characteristics for basin 1 & 2 are the same, however slightly differ for basins 3 and 4.

[1] Facility for Advancing Water Biofiltration, 2009, *Guidelines for Soil Filter Media in Bioretention Systems* (v3.01) June 2009.

Table 4.2.1 present their corresponding characteristics adopted in the modelling. Basin 3 & 4 treat minor flows from catchments 8B & 8A respectively, while the proposed GPT (discharging between these basins) will treat flows from the remainder of the site (catchment 8C) and part of the existing development to the south of Stage 1a.

Table 4.2.1 Bioretention basin details

Basin No.	1 & 2	3	4
Inlet Properties			
Low Flow Bypass (m^3/s)	0.0	0.0	0.0
High Flow Bypass (m^3/s)	100	100	100
Storage Properties			
Extended Detention Depth (m)	0.3	0.3	0.3
Surface Area (m^2)	500	270	90
Seepage loss (mm/hr)	0.0	0.0	0.0
Infiltration Properties			
Filter area (m^2)	400	200	90
Filter depth (m)	0.5	0.6	0.6
Filter particle effective diameter (mm)	0.45	0.45	0.45
Saturated hydraulic conductivity (mm/hr)	180	180	180
Outlet properties			
Overflow weir width (m)	5.0	5.0	5.0

It is intended that the bioretention basins would be landscaped and planted out as a 'rain garden', rather than simply topsoiled and turfed. Species used would be selected from the list of approved species included in Appendix A of the Healthy Waterways Technical Design Guidelines.

Details of the plant species selection, size and spacing would be provided by the landscape architects in a landscape plan to be submitted as part of an application for approval to operational works (landscaping).

Bioretention basins are to be constructed in stages to prevent damage to the filter media. The construction sequence is to be in accordance with Section 2.1 of the Stormwater Management Plan included as Attachment 1.

4.2.3 Rainwater Tanks

We have assumed that one or more rainwater storage tanks would be installed by the land owners or builders on each proposed lot to capture runoff from the roof areas in accordance with the State Government's and Council's requirements.

Whilst there may be rainwater tanks in the existing development, their number and size is not known. Therefore any stormwater quality benefit these may provide has not been included in this modelling. The tank sizes adopted for the MUSIC modelling are shown in Table 4.2.2.1.

Table 4.2.2.1 Rainwater storage tank capacity to be provided

Development	Tank capacity required
Detached dwellings on lots > $600m^2$	5,000L
Detached dwellings on lots < $600m^2$	3,000L
Attached dwellings & units	3,000L

It is expected that the tanks would be connected to the reticulated drinking water supply system for top-up purposes and that the water would be used for flushing toilets, laundry cold water, outdoor uses and swimming pool top-up. A first flush diversion device or filtration unit should be installed in accordance with Council's policy.

Each tank's performance has been assessed using a model that calculates the amount of rainfall captured from the roof area, the amount of runoff, and the amount of water to be drawn from the mains water supply.

Average values were calculated using 30 years of daily time step rainfall data for the period from 1961 to 1990 at Ballina. This period is considered to be representative of current climatic conditions as the average annual rainfall for the period is 1858mm, which compares with the long-term average of 1860mm.

For the purposes of the tank modelling, it has been assumed that:

- the tank storage volume would be at least 5,000L per detached dwelling
- the roof area contributing to the tank would be 150m^2 (note: the total roof area may be larger)
- the average daily water usage would be 150L/day
- the area of garden/lawn to be watered would be 150m^2.

These estimates indicate that the tank would supply ~ 50% of the volume required from it, which would be in excess of 105KL per year.

Runoff from the roof area would be reduced by ~ 42%. The impact of the tank on the volume of runoff and pollutant loads has been assessed using the MUSIC model. A conservative estimate of 75KL average annual usage from the tank has been used in the MUSIC model to account for the possibility that some tanks on the smaller lots would be smaller than 5,000L.

The properties of the rainwater tanks used in the modelling are provided in Appendix 4.

Additional Parameters
It should be noted that the final choice of management measures used, their location and size will be subject to detailed survey and design.

The retention of suspended sediment and nutrients is generally calculated by MUSIC using the default parameters of the exponential decay functions for each pollutant.

4.3 Modelling results

Modelling results for the Developed Treated Case are shown in Table 4.3.1.

Table 4.3.1 Developed Treated Case average annual loads

	Pollutant loads (kg/year)		
Runoff (ML/yr)	Suspended Solids	Total Nitrogen	Total Phosphorus
1,280	188,000	2,380	325

A copy of the model is provided on the enclosed CD. A comparison of the pre- and post-development average annual loads is provided in Table 4.3.2.

Table 4.3.2 Comparison of average annual pollutant loads

	Load reduction (%)		
	Suspended Solids	Total Nitrogen	Total Phosphorus
Existing	378,000	2,790	360
Developed	188,000	2,380	325
Change%	-48.2%	-13.1%	-6.9%

Based on the assessment and modelling described above, the Council's operational phase performance criteria can be met. The results are within the limits of accuracy of the model and the assumptions made in creating it and are therefore considered to be acceptable.

4.4 Water quality management

Stormwater management measures should be installed as described in Section 4.3. Provided these are properly designed, installed and maintained, the estimates detailed in Section 4.3 indicate that the quality of the stormwater runoff from the site during the operational phase will be acceptable.

Careful management will be required to ensure that the projected quality levels are achieved and maintained particularly during the construction phase. These details are considered in the stormwater management plan, which is included in this report as Attachment 1.

5 Stormwater quantity assessment method

5.1 WBNM modelling

A hydrological assessment was undertaken to assess the extent of flow attenuation measures required under a range of rainfall events using the Watershed Bounded Network Model (WBNM) computer modelling software.

5.1.1 Local intensity frequency

Rainfall intensities for the simulation of design rainfall events were calculated in accordance with the procedures provided in Australian Rainfall & Runoff 1998 (AR&R) using the parameters for this site obtained from the Bureau of Meteorology web site, which are summarised in Table 5.1.1.

Table 5.1.1 Table of rainfall maps for use in (Ballina Shire Council)

Factor		Parameter Value
Duration (hours)	ARI (yrs)	Design Rainfall Isopleths
1	2	48.53
12	2	9.51
72	2	3.35
1	50	86.66
12	50	19.08
72	50	6.72
Average regional skewness		0.01
Geographical factor F2		4.41
Geographical factor F50		16.98

The Watershed Bounded Network Model (WBNM) is an event-based hydrologic model that calculates flood hydrographs from storm rainfall hyetographs. It can be used for modelling natural, partially developed and fully developed catchments.

For developed catchments, it calculates runoff from pervious and impervious surfaces and routes it through the major system of open watercourses.

WBNM does not model the details of piped drainage systems. It can be used to generate hydrographs from an actual storm event and or a design storm utilising Intensity – Frequency – Duration data together with dimensionless storm temporal patterns.

The WBNM model is flexible in its data requirements and is able to produce satisfactory results with the following data input:

- local intensity frequency duration data
- design temporal patterns
- sub-catchment areas
- impervious areas.

Because no rainfall to runoff data is available for the site, the model is not calibrated. The model results have been compared with results produced by WBM in its April 2004 report titled '*Hydrologic and Hydraulic Assessment of Stormwater for Pacific Pines Estate at Lennox Head*'.

5.1.2 Storm data

The rainfall intensities for the simulation of the design rainfall events were calculated in accordance with Book 2 of Australian Rainfall and Runoff 1998 (AR&R). Rainfall intensity-frequency-duration data for Lennox Head was produced in AUSIFD Version 2, using the inputs described in Table 5.1.1 to provide a reliable estimate of rainfall intensities for the site. The temporal patterns used were those for Zone 3 provided in AR&R Volume 2 September 2007, Table 3.2.

Losses were determined in conjunction with the recommendations contained in Australian Rainfall and Runoff 1998, Book 2, Design Rainfall Considerations, Section 3.4. The losses adopted for this catchment are shown in Table 5.2.1 (following page).

Table 5.2.1 Model losses

Storm ARI (yrs)	Pervious Initial Loss (mm)	Pervious Continuing Loss (mm)	Impervious Initial Loss (mm)	Impervious Continuing Loss (mm)
1	15.0	2.5	0.5	0.0
2	15.0	2.5	0.5	0.0
5	12.0	2.5	0.5	0.0
10	10.0	2.5	0.5	0.0
20	6.0	2.5	0.5	0.0
50	2.5	2.5	0.5	0.0
100	0.0	2.5	0.5	0.0

It should be noted that the actual estimates of the impervious areas for the proposed development have been used in the modelling as this approach would provide more realistic estimates of the likely changes resulting from the development. These estimates were the same as those used by WBM in its report titled '*Hydrologic and Hydraulic Assessment of Stormwater for Pacific Pines Estate at Lennox Head'* dated April 2004. Assumptions for the impervious areas are detailed in Section 6.

5.1.3 Peak flow site characteristics

The physical characteristics of the catchment were described in Section 2 of this report. In its current state, the catchment may be described as rural.

It is proposed to attenuate peak flows within the development site using detention basins. Rainwater storage tanks would be installed to collect runoff from roof areas, however it is assumed that the tanks may be full at the start of the critical storm and have not been included as part of the detention storage. Details of the detention basins are provided in Section 6.

6 Stormwater quantity assessment results

6.1 WBNM modelling results

6.1.1 Pre-development case

The catchment areas and percent (%) impervious adopted to determine the peak flow rates discharging from the site in its present condition are listed in Table 6.1.1.1.

Drawing 10734.1.7 shows the pre-developed catchment boundaries. It should be noted that in estimating the runoff from the undeveloped site, the existing dams and other structures have been ignored so that the results represent a rural area.

Table 6.1.1.1 Pre-development model assumptions

Catchment	Area (ha)	Impervious%
A	7.70	30.0
B	11.80	0.0
C	15.00	2.5
D	19.20	0.0
E	25.40	12.5
F	6.90	0.0
G	13.50	0.0
H	6.50	0.0
I	6.53	0.0
J	7.50	0.0

Table 6.1.1.2 shows the resultant peak flow rate at the legal point of discharge for an ARI of 100 years. A Lag parameter (C) value of 1.7 has been adopted for the modelling. Peak flow rates determined by WBM have also been provided for comparison.

Table 6.1.1.2 100 year ARI pre-development peak flow

G&S modelled (WBNM) Q (m^3/s)	WBM reported Q (m^3/s)
23.7	38.0

6.1.2 Developed Case

The catchment areas and % impervious adopted to determine the peak flow rates discharging from the site in its developed condition are provided in Table 6.1.2.1. Drawing 10734.1.8 shows the post-developed catchment boundaries.

Table 6.1.2.1 Post-development model assumptions

Catchment	Area (ha)	Impervious%
1	7.72	30.0
2	12.91	50.0
3	9.08	50.0
4	1.71	50.0
5	8.77	50.0
6	3.89	0.0
7a	0.86	0.0
7b	1.52	15.5
7c	2.10	0.0
7d	1.10	10.0
8	12.18	50.0
9	4.14	50.0
10	5.22	50.0
11	6.09	37.2
12	8.27	44.0
13	5.42	0.0
14	3.83	33.6
15	14.76	46.0
16	6.53	38.1
17	7.50	0.0

Table 6.1.2.2 shows the resultant peak flow rates at the legal point of discharge over the standard ARI events. A Lag parameter (C) value of 1.7 has been adopted for the modelling. Peak flow rates determined by WBM have also been provided for comparison.

Table 6.1.2.2 100 year ARI post-development peak flows

G&S modelled (WBNM) Q (m^3/s)	WBM reported Q (m^3/s)
38.5	42.0

Table 6.1.2.2 shows that the estimated developed case peak flows are comparable to those determined by WBM, indicating that our modelling is acceptable. The modelled pre-development peak flow rate is lower than that determined by WBM, hence design of the detention system to achieve these lower flows is conservative.

It should be noted that it is intended that runoff from the roof areas be directed towards rainwater storage tanks. In calculating the detention requirements for the development, the rainwater tanks have not been included. That is, it has been assumed that the tanks would be full at the commencement of the storm event. Details of the proposed detention stores are summarised below.

6.1.3 Final detention design

Flow attenuation for the developed portion of the subject site will be provided in the existing vegetation reserve, existing wetland and drainage channel. For ease of reference, this report refers to these features as 'basins'. Details of the operating conditions for the detention basins are given in Table 6.1.3.1. A plan showing the size and location of the devices is provided in Drawing No. 10734.1.9.

The WBNM model was run using storm durations ranging from 5 minutes to 12 hours to ensure the detention volume was able to provide effective attenuation for all expected events.

Full detention has been provided in the basins to ensure there is no increase in peak flow for all storms up to an ARI of 100 years. Results for these storms are presented in Appendix 6.

6.1.4 Attenuated post-development peak flow results

The model results for the post-development case including the attenuation effects of the proposed detention basins are shown in Table 6.1.4.1.

Table 6.1.4.1 100 year ARI WBNM modelled peak flows

Pre-Developed Q (m^3/s)	Attenuated Post-Developed Q (m^3/s)
23.7	23.7

Table 6.1.3.1 Detention basin operating conditions

Basin 1 (Water quality control pond and vegetation reserve)	
Stage-storage characteristics	
RL (mAHD)	Volume ($x10^3m^3$)
1.0	0
1.5	15.80
2.0	38.58
Outlet 1 (Pipe) Details	
Pipe diameter (mm)	375
Number of barrels	3
IL (mAHD)	1.0
Outlet 2 (Weir) Details	
Length (m)	22.0
IL (RL mAHD)	1.40
Estimated basin performance	
Maximum water surface elevation (mAHD)	1.979
Maximum volume stored ($x10^3m^3$)	37.61
Basin 2 (roadside drainage channel)	
Stage-storage characteristics	
RL (mAHD)	Volume ($x10^3m^3$)
1.50	0.00
2.00	0.91
2.50	2.50
3.00	4.89
Outlet 1 (Pipe) Details	
Pipe diameter (mm)	600
No. of barrels	1
IL (mAHD)	1.5
Estimated basin performance	
Maximum water surface elevation (mAHD)	2.82
Maximum volume stored ($x10^3m^3$)	4.04

A comparison of the attenuated post-development results above with the pre-development flows indicates that the proposed detention measures would have sufficient storage and appropriately sized outlet works to reduce the peak flows to rates comparable to the estimated pre-developed conditions.

6.1.5 Summary of hydrological modelling

A comparison of the estimated peak flow rates before and after completion of the proposed development subsequently including detention is shown Table 6.1.4.1.

This comparison confirms that the proposed stormwater management measures have the capacity to ensure that would be no increase in peak flows after completion of the proposed development for ARI 100 years.

It will be noted that the weir previously proposed and shown on Illustration C7 in the conservation zone has been eliminated to minimise the disturbance of this sensitive area.

7 Limitations of reporting

This report has been prepared by G&S specifically for Lend Lease acting on behalf of Petrac Lennox Head (Receivers and Managers appointed), to provide advice on stormwater quality management in relation to the Development Application for the Pacific Pines development, located off Montwood Drive and Hutley Drive, Lennox Head in New South Wales. As such its use is limited to this purpose and may not be applicable beyond this scope. Third parties should therefore seek advice from G&S on applicability for any other use.

In preparing this report, we have relied on information supplied by others including:

- Site survey and digital terrain models supplied by Kennedy Surveying Pty Ltd.
- Concept Plan provided by Lend Lease.
- Preliminary civil design carried out by SMEC Urban.

The accuracy of this report is limited to the accuracy of the information supplied.

While G&S's report accurately assesses average annual pollutant loads, the accuracy of these assessments is limited by the input parameters recommended in the Healthy Waterways 'MUSIC Modelling Guidelines' 2010, which has been adopted as a best management practice method. The models have not been calibrated. The predicted average annual loads may therefore differ from those measured on site.

Our analysis and overall approach have been specifically to cater for the particular requirements of Lend Lease and may not be applicable beyond this scope. For this reason any third parties are not authorised to utilise the report without further input and advice from G&S.