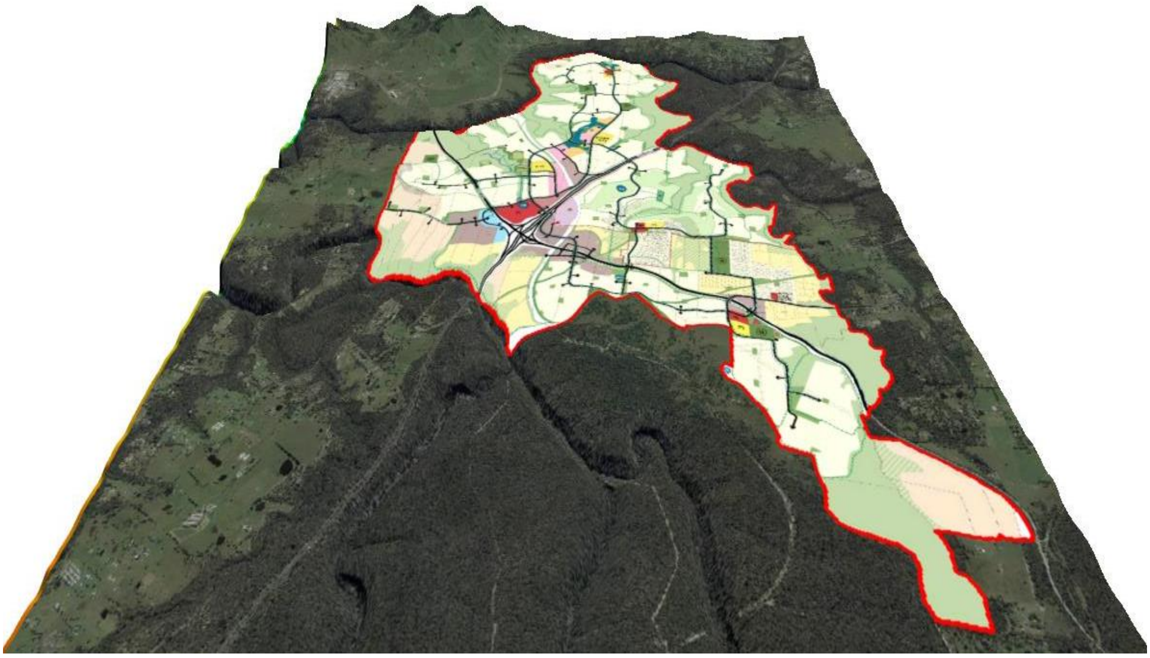
WILTON JUNCTION

Water Cycle Management Strategy



Wilton Junction Landowner's Group

June, 2014

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

WILTON JUNCTION

Water Cycle Management Strategy
- DOCUMENT CONTROL SHEET -

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1 EXECUTIVE SUMMARY

The ~~Integrated~~ Water Cycle Management Strategy for Wilton Junction has been prepared to inform the planning process and support the rezoning of the site. The ~~integrated~~ water cycle management strategy was developed by a project team consisting of J. Wyndham Prince Pty Ltd (stormwater quantity & quality management and flood risk assessment) and VKL Consulting (recycled water management). VKL Consulting has coordinated closely with J. Wyndham Prince to devise a strategy that conforms with statutory requirements and industry best practice for an ~~integrated~~ water cycle management strategy for this project.

Wilton Junction represents ~~2612~~ 2741 ha of land, ~~1649~~ 1541.7 ha of which is suitable for urban development, with the remaining set aside for conservation. The area is bounded by the two (2) major river systems of Allens Creek, forming the eastern site boundary and Nepean River on portions of the southern, western and northern boundaries of the site. Rural properties form the remaining boundary limits to the west and south of the site. The site is located at the intersection of the Hume Highway and Picton Road, near Wilton.

The planning for Wilton Junction will deliver between 11,000 to 13,000 dwellings, employment lands, a Town Centre, two (2) local shopping villages, five (5) schools and 64 ha of open space for some 36,000 residents.

The objective of this investigation is to identify the stormwater, recycled water and flood management issues to be considered in the future development of the Wilton Junction Project, to identify flood risks, evaluate and propose appropriate solutions and locations for the control of the quantity and quality of stormwater leaving the site, assess all watercourses which are proposed as part of the urban development; and to identify the land areas required to implement the recommended stormwater management options. Much of the ~~Integrated~~ Water Cycle Management infrastructure identified by these investigations will be incorporated into the Section 94 Contributions Plan for the site.

A copy of the VKL Consulting Report outlining the investigations undertaken and strategy developed for management of the ~~sites~~site's recycled water, is provided in Appendix A of this report.

The ~~Integrated~~ Water Cycle Management Strategy proposed for the site consists of a treatment train including on lot treatment, street level treatment and subdivision / development treatment measures. The structural elements proposed for the development consist of:

- Proprietary GPT units at each stormwater discharge point.
- Approximately seventy six (76) proposed bio-retention raingardens of total area 149,900 m².
- Gravel soakaway/ level spreaders to distribute flows to the bushland perimeter.
- One (1) proposed regional detention basin on-line within Allens Creek (approximate total volume 35,000 m^3).
- A Recycled Water Management System consisting of;
  - A cascading raingarden system (total 3000 m^2).
  - Two (2) treatment / evaporation lakes (10.9 Ha total).
  - Irrigation of 52 ha of Active open space and road verges
  - Recycled water returned to employment lands for toilet flushing, irrigation, washdown and other suitable uses.
  - Distribution pipe and control infrastructure and polishing raingardens.

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The Water Cycle Management Strategy developed for the site will ensure that the post development stormwater and recycled water discharges will meet the Department of Planning and Environment Director General's, Wollondilly Shire Council's and the NSW Government Agency water cycle and flood risk management objectives for the project. The provision of WSUD elements within the site will also assist in minimising the impact of urbanisation on the waterway stability of the Nepean River. A schematic representing the water cycle scheme is presented in Figure 1 of this report.

A summary that outlines how the proposal addresses each of the specific water management and flood risk issues specified in the Final Director General's Requirements (dated 2nd May 2013) is provided in the following table.

DIRECTOR GENERALS REQUIREMENTS	STRATEGY RESPONSES
Water and Air Quality Identify watercourses, riparian land and wetlands that may be potentially affected by the proposed Masterplan. Assess the potential impacts on water quality and quantity in order to demonstrate that key River Flow and Water Quality Objectives are achieved to protect environmental values including waterways, riparian land, wetlands and down slope vegetation.	The development is located directly adjacent to a portion of the Nepean River with Allens Creek as a major tributary. Consequently, appropriate development controls are essential to protect the ecological values of this sensitive waterway. The watercourses and riparian lands within the site have been mapped and categorised and these are presented in Figure 4 herein. A visual stream assessment has confirmed that all of the minor watercourses within the site likely to be directly affected by the planning proposal are not "rivers" as defined under the Water Management Act 2000 and could be removed or replaced by urban drainage infrastructure. Further details on the riparian corridor assessment is presented in Section 9.7 herein. The Hawkesbury Nepean River Statement of Joint Intention (Health River Commission, 2000) has set maximum discharges concentrations for both Total Nitrogen (0.7 mg/l) and Total Phosphorus (0.035 mg/l). The proposed Water Cycle Management Strategy has been configured to ensure that both stormwater and recycled water to the Nepean system achieve the relevant concentration levels for stormwater alone. Consequently, the integrated system achieves all of the NSW agency requirements for this project. VKL Consulting have prepared a SEPP Study Report outlining the recycled water disposal infrastructure for the project area outside the Bingara Gorge Development. A copy of the VKL Consulting report is provided in Appendix E.
Address potential impacts on water quality of surface and groundwater and provide Integrated Water Cycle Management Plans based upon Water Sensitive Urban Design principles, including consideration of climate change scenarios in accordance with relevant Government policies.	The strategy proposes a treatment train of Water Sensitive Urban Design (WSUD) elements to manage Water Quality including on lot controls, gross pollutant traps, raingardens and absorption trenches / level spreaders. This system has been modelled using MUSIC to confirm system performance. Details of the proposed Water Cycle Management system are provided in Figure 1 of this report
Flooding Address the potential flood risk that may occur on site, in accordance with the NSW Floodplain Development Manual (2005) and Section 117 Direction, noting proposed mitigation measures.	Suitable hydrological and hydraulic calculations were undertaken to confirm that, due to the incised nature of the Nepean River adjacent the site, 1 % AEP flows within the Nepean River will not impact the portions of the site proposed for development. The Catchments within the site itself are generally characterised as small (<40 ha) and consequently flood risks will be managed by providing a conventional major /minor street drainage system. Details of the assessment undertaken are provided in Sections 10 and 11 of this report.

Infrastructure, Servicing, Staging and Housing Delivery	
The Infrastructure Strategy and Implementation Plan will detail the infrastructure in a staged manner as well as required to service the ultimate development including: Stormwater detention and treatment for water quality (including infrastructure maintenance for future Council assets).	An assessment of Stage 1 works in Wilton Junction has been completed in Section 11. Recommendations are made on both the interim and final measures, which are required to attain designated Water Quality and Water Quantity objectives.

The Water Cycle Management Strategy presented in this report for Wilton Junction is functional, delivers the required technical performance, lessens environmental degradation and pressure on downstream ecosystems and infrastructure, and provides for a 'soft' sustainable solution for stormwater & recycled water management within the release area.

Wilton Junction includes a large number of 1^{st} and 2^{nd} order watercourses as defined by the NSW Office of Water guidelines for Riparian Corridors (NOW, 2012) which are proposed for removal and / or to be replaced by urban drainage infrastructure. Those watercourses which are proposed for development have been assessed with a description (and photographs) provided as to whether a defined stream banks exists and made recommendations on whether the watercourse is a "river" under the Water Management Act.

The proposed Water Cycle Management Strategy for the Precinct provides a basis for the detailed design and development of the site to ensure that the environmental, urban amenity, engineering and economic objectives for water cycle management and site discharge are achieved.

2 INTRODUCTION

2.1 Project Background and Context

In November 2011, the NSW Government initiated the Potential Housing Opportunities Program and invited landowners with suitably located substantial landholdings to nominate sites which might be able to deliver additional housing to address Sydney's housing supply shortfall. Walker Corporation, Governors Hill, Bradcorp and Lend Lease responded to the Program and nominated landholdings of more than 100ha in Wollondilly Shire, surrounding the Hume Highway-Picton Road intersection for consideration. This area has subsequently become known as Wilton Junction, and is the subject of this application.

Following a Wollondilly Shire Council resolution in May 2012, the four major landowners (collectively known as the Wilton Junction Landowners' Group) signed an agreement to work cooperatively with Council to prepare a high level Master Plan for Wilton Junction to deliver high quality new housing, jobs close to homes, supporting social and utilities infrastructure and services, and a range of complementary land uses.

A high level Master Plan and a Preliminary Infrastructure Requirements Report were considered by the Council on 17 December 2012, with Council resolving to give in-principle support to the proposal. Council also resolved to request that the rezoning be a state-driven process.

Subsequently, the NSW Government decided to coordinate the statutory planning process, led by the Department of Planning and Infrastructure (now the Department of Planning and Environment, DP&E). The Minister for Planning and Infrastructure (now the Minister for Planning and Environment) proposed to prepare a State Environmental Planning Policy (SEPP), as per Section 24 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), which identifies that a SEPP is an Environmental Planning Instrument, and Section 37 of the EP&A Act, which relates to the making of a SEPP for State or regional significant development. This was done with a view to rezone the land through an amendment to the Wollondilly Local Environmental Plan 2011 (LEP) to facilitate the early delivery of housing and infrastructure, linked to an agreed Infrastructure, Servicing and Staging Plan.

The Department of Planning and Environment issued Key Study Requirements (KSRs) to the Proponents (Walker Corporation, Bradcorp and Governors Hill) to guide the planning investigations for a new town at Wilton Junction. The KSRs set the criteria for carrying out environmental investigations across the Study Area (excluding both Bingara Gorge and the existing Wilton village which will not be affected by any proposed amendments to their current zoning and planning provisions). The investigations examine the potential for the Wilton Junction Study Area to be rezoned under a SEPP.

The modelling presented in this report is basis on the proposed Masterplan dated 2nd August 2013. However, the masterplan is ever evolving and there will be a for further detailed assessment as part of any future Development Application for the site.

2.2 Study Area

Wilton Junction is located within Wollondilly Shire Council and is approximately 80km from Sydney Central Business District, and 30km west of Wollongong. The study area includes the existing village of Wilton and the recently approved suburb of Bingara Gorge.

The area is strategically located around the Hume Highway-Picton Road interchange, and represents the next potential major town along this transport corridor south of Campbelltown–Macarthur. Moreover, Wilton Junction has the distinct advantage of a consolidated land ownership of more than 2,700ha in the control of recognised developers, with the resources and capability to expedite housing delivery, roll out enabling infrastructure, deliver social services and provide local employment.

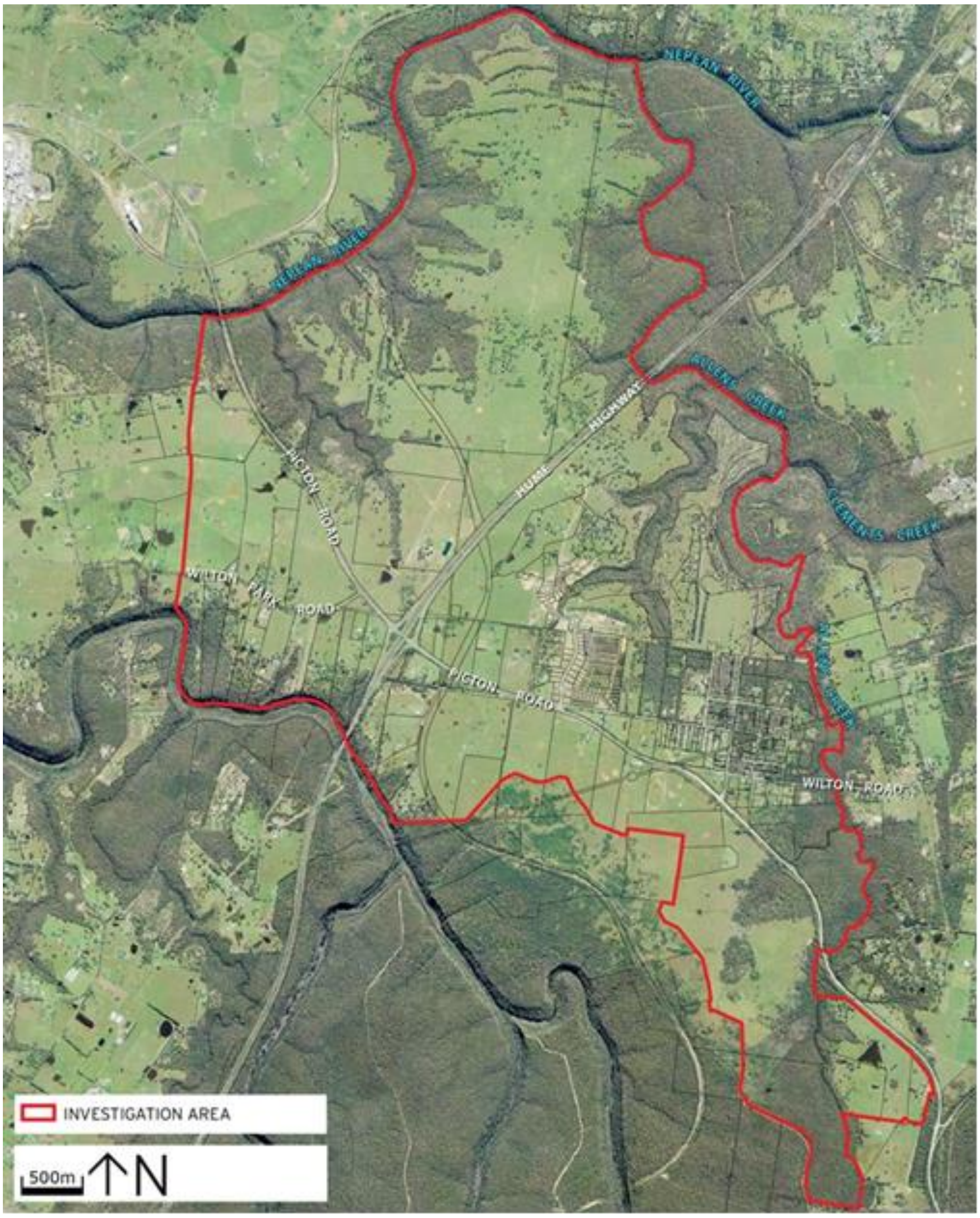


PLATE 2.1 - STUDY AREA

2.3 Landownership

There are four major landowners within the Investigation Study Area:

- Bradcorp Pty Ltd (land at Wilton West)
- Walker Corporation (lands south of Picton Road and east of the Hume Highway)
- Governors Hill (land including the Wilton Aerodrome and lands on both sides of Picton Road west of the Hume Highway)
- Lend Lease (land to the north-west of the Hume Highway-Picton Road intersection; but is excluded from the study requirements)

The Investigation Study Area also includes land by other private owners (excluding land in Bingara Gorge and Wilton village) as outlined in the table below; with a plan of the extent of ownership being provided below.

Landowner	Gross area (ha)	Net developable area (ha)
Lend Lease	455	240
Bradcorp	872.4	458.7
Governors Hill	175.3	123.5
Walker Corporation	405.2	230.3
Other landowners**	572.3	489.2
Totals	2480.2	1541.7

** This comprises 113 other private landowners, excluding the new Bingara Gorge estate and the existing Wilton village which will not be affected by any proposed amendments to the existing Wollondilly Shire Council planning provisions.

For the purposes of this rezoning application, the Proponents include Walker Corporation, Governors Hill and Bradcorp. Lend Lease will continue with the planning and delivery of its Bingara Gorge community in Wilton, which is already zoned for residential development. Lend Lease is working with the Proponents of this rezoning application to plan and deliver the new town at Wilton Junction and its associated infrastructure.

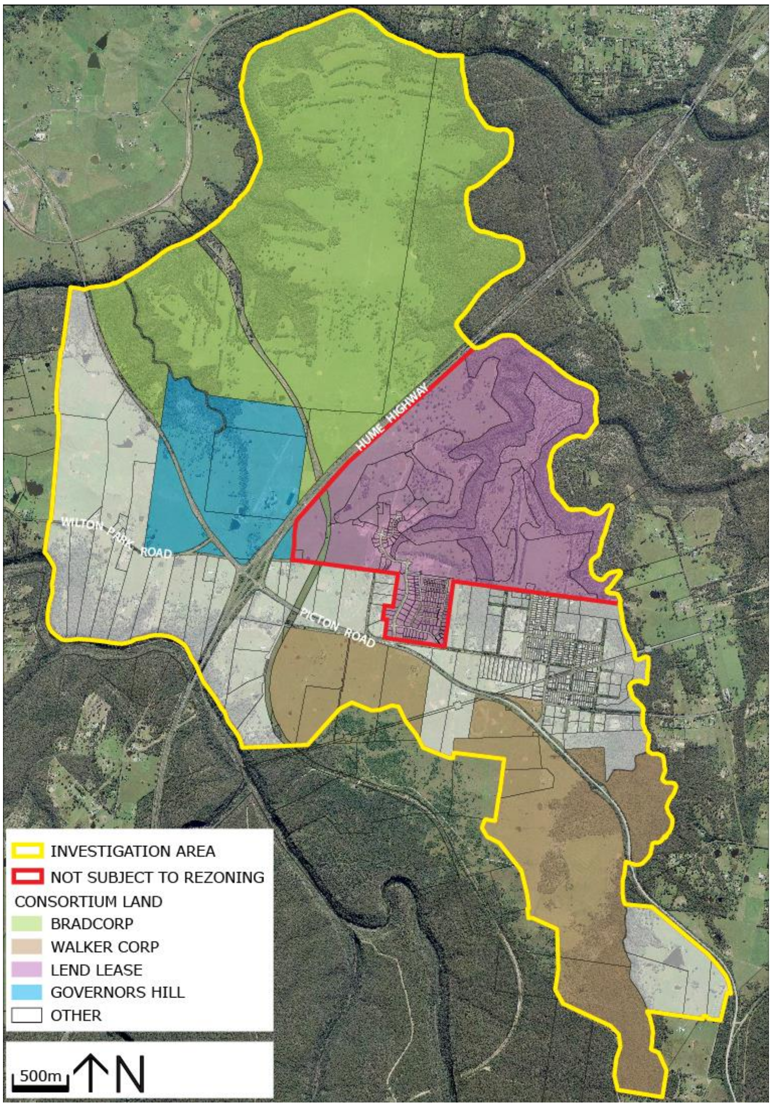


PLATE 2.2 - LAND OWNERSHIP (CORRECT AS AT 30TH MAY 2014)

2.1 Vision for Wilton Junction

The Proponents have a vision for the proposed rezoning of land at Wilton Junction, which is:

> Wilton Junction is a new community cradled in a unique landscape characterised by bushland, rivers, creeks, lakes and ridges set against the backdrop of the Razorback Range. By design, the place and the lives of its people are intertwined with the bush.
>
> The community respects the location's rich bushland setting, engages with surrounding water features and embraces sustainability.
>
> Inclusive and welcoming of diversity, it's a place to nurture relationships, grow a family - to put down roots.
>
> ***Founded on a 21st century interpretation of timeless "Garden City" principles, Wilton Junction combines the best features of our most loved country towns with the facilities, services and technologies found in Australia's most successful, edgy, and vibrant town centres.***
>
> ***A safe place to visit – a healthy place to live – a great place to learn - a rewarding place to work – the local community takes pride in the strength of its cultural and civic life and the role of their town in Wollondilly Shire and the region.***

2.2 Delivering the Vision and Project Description

This vision will be delivered through the creation of a new town with between 11,000 and 13,000 new homes and 11,000 jobs. Residential neighbourhoods will be created around green spaces providing a range of housing choice and facilitating healthy lifestyles options for all new residents. A new town, comprising of approximately 17ha, will be established within the north-west quadrant of the study area and will be surrounded by employment generating uses for business, bulky goods and light industry, comprising of approximately 120 - 130ha of land. Smaller neighbourhood centres will be created within the residential neighbourhoods to cater for convenient daily shopping choices. Community facilities and physical infrastructure will be provided facilitating the creation of a self-sustaining community. Existing significant environmental features and heritage items will be preserved commemorating the natural and historical setting of the study area.

This report forms part of the studies required to be undertaken to meet the Director Generals' Key Study Requirements outlined by the Department of Planning and Environment as part of the investigations for the release and rezoning of land at the junction of the Hume Highway and Picton Road through a SEPP. The study outcomes and report has also informed the development and preparation of a Master Plan for Wilton Junction.

The proposed Master Plan will also be informed by the following key principles:

- **Employment and commercial drivers**. The delivery of approximately 11,000 jobs focused around a new town centre and in close proximity to the Hume Highway and Picton Road.
- **Housing**. Providing between 11,000 and 13,000 new dwellings across the precinct, inclusive of the 1,165 already approved at Bingara Gorge and the existing Wilton village.
- **Community facilities**. Provide a diverse range of high quality community facilities including a schools, library, community centre in a town centre and three neighbourhood centres across the precinct.
- **Environment**. Conserving ecological features and biodiversity and establishing a Trust to rehabilitate and manage approximately 614.5ha of bushland.

- **Place making.** Delivering high quality and connected network of streets, spaces and squares throughout the development.
- **Activity centres**. Focus on the delivery of a new town centre and three smaller neighbourhood centres with a diverse mix of retail, commerce, business and light industry.
- **Traffic and transport.** Providing strategic motorway and bus access to surrounding areas, legible movement throughout the development.
- **Infrastructure**. Integrated water, waste water and stormwater management systems and access to all other utilities including gas and NBN.

3 PREVIOUS REPORTS

A series of reports were reviewed to inform this assessment. Provided below are details of the relevant documents.

3.1 Wilton Junction New Town – High level infrastructure Business Case

In February 2013, Elton Consulting (EC, 2013) on behalf of the 'Landowners Group' (Bradcorp, Lend Lease, Governor Hills and Walker Corporation), prepared a High Level Infrastructure Business Case for presentation to the NSW Department of Planning and Environment to address the guidelines set out by the NSW Treasury. This document provides details of infrastructure costs and funding proposals over the next 20 years and shows that in the short term, a cost effective development can be undertaken within the Wilton Junction development area.

Supporting the High Level Infrastructure Business Case were a number of technical studies. Some of these studies have informed the development of this assessment and details of the relevant studies are provided below:

3.1.1 *Wilton New Town – Sewerage Overview*

An investigation into the available options for sewage treatment and discharge has been undertaken by CH2M HILL Australia Pty Ltd (CH2M HILL, 2012). The CH2M HILL report recommended that a central treatment facility(s) is to be adopted with:

"latest technology processes to produce a high quality effluent with significantly reduced nutrients suitable both for re-use purposes as a resource in accordance with National Guidelines for Water Recycling and the NSW Environmental Guidelines for Effluent Irrigation, and also for environmental flows.

The intent for disposal will focus on beneficial reuse using the treated effluent for water features, lakes, irrigation of parks and road verges, possibly reticulation within the employment areas for non-potable uses, together with environmental flows to the creeks and Rivers where justified".

The CH2M HILL report (CH2M HILL, 2012) *assumed that the treatment standard to be achieved by the plant for discharges to the environment would be similar to Picton, with concentration levels to be achieved of (all 50th %-ile figures):*

- *BOD_5, 7 mg/L*
- *TSS, 6 mg/L*
- *Total N, 6 mg/L*
- *NH3, 0.5 mg/L*
- *Total P, 0.2 mg/L*

The CH2M HILL Report is discussed further in Section 13.

3.1.2 *Proposed Wilton New Town Development*

Cardno Ecology Lab (Cardno, 2012) prepared a high-level review of the issues, including a broad scale assessment of potential ecological impacts of the Wilton development. Cardno subsequently identified that *the treatment and disposal of wastewater will require several components:*

- *High level treatment plant, likely to use MBR technology*
- *An effective and appropriate re-use scheme*

- *A storage reservoir integrated in the natural environment of the site which further treats sewage effluent*
- *A route along which the treated water would pass once it is released from the storage reservoir*
- *A suitable point of discharge for the treated water into the Nepean River*

Cardno Ecology Lab (Cardno, 2012) then made recommendation that *MUSIC* modelling be undertaken to assess the *"nutrient concentrations and size (s) of reservoir"*

The current assessment has subsequently taken into consideration those investigations by Cardno Ecology Lab. A *MUSIC* assessment of the Integrated System is modelled with details presented in Section 12, whilst MWH Global and VKL Consulting have since undertaken additional investigations on the MBR plant and the effluent discharge system.

3.2 Bingara Gorge – Stormwater Master Plan

A Stormwater Master Plan (JWP, 2002) was previously developed for the Bingara Gorge Project by J. Wyndham Prince in close consultation with Wollondilly Shire Council to assist the LEP process for the Project (Wilton Park Release Area). The Plan was formulated to conform to statutory requirements and industry best practice for stormwater management within the Wilton Park catchment. J. Wyndham Prince then later updated and refined this Plan (JWP, 2005) to match the relevant Wilton Park Release Area Structure Plan and to develop a stormwater strategy specific to Stage 1 of the Bingara Gorge development, which also included the construction of part of the proposed golf course.

A component of the Stormwater Master Plan was to introduce a Stormwater Retention and Reuse Scheme that can fulfil most of the irrigation needs of the proposed golf course, while ensuring that nutrient and sediment loads are retained on site and that environmental flows to downstream ecosystems are maintained.

As part of the Stormwater Master Plan investigations (JWP, 2002 and 2005), MUSIC Modelling was undertaken to support the findings. The modelling catchments being defined as both "Urban" and "Golf" course Source Nodes whilst the Water Quality treatment objectives were achieved via the introduction of gross pollutant traps and a combination of both underground reuse tanks and reuse ponds at the golf course.

In more recent years, J. Wyndham Prince has also performed a number of refinements to the strategy associated with Stormwater Harvesting at the golf course as well as a letter in support of the Development Application (DA) for the Highlands Precinct located within Bingara Gorge (JWP, 2012).

3.3 Upper Nepean River Flood Study

In September 1995, the *Upper Nepean River Flood Study* was undertaken by the Department of Land and Water Conservation on behalf of Wollondilly, Campbelltown, Camden, Liverpool and Penrith LGAs (DLWC, 1995). The study investigated the 52.2 km reach of the Upper Nepean River from Menangle Bridge to the Warragamba River junction.

Flood behaviour was defined using the computer based model (RORB) with initial calibration against recorded rainfall and streamflow data. Hydrographs were then generated within the study area at critical locations and adopted within hydraulic modelling for a range of Average Recurrence Intervals (ARI).

Several key locations were assessed within the report (DLWC, 1995) with the location closest to Wilton Junction being positioned at “Maldon Weir”. Results of the RORB assessment indicate that the peak 100 year ARI event occurs in the 48 Hour design storm and is summarised in the following Table 3.1, while the hydrograph is shown in Plate 3.1.

TABLE 3.1 – PEAK DISCHARGES FROM RORB MODEL

ARI (years)	Maldon Weir	
	Peak Flow (m^3/s)	Time to Peak (hour)
100	6500	22

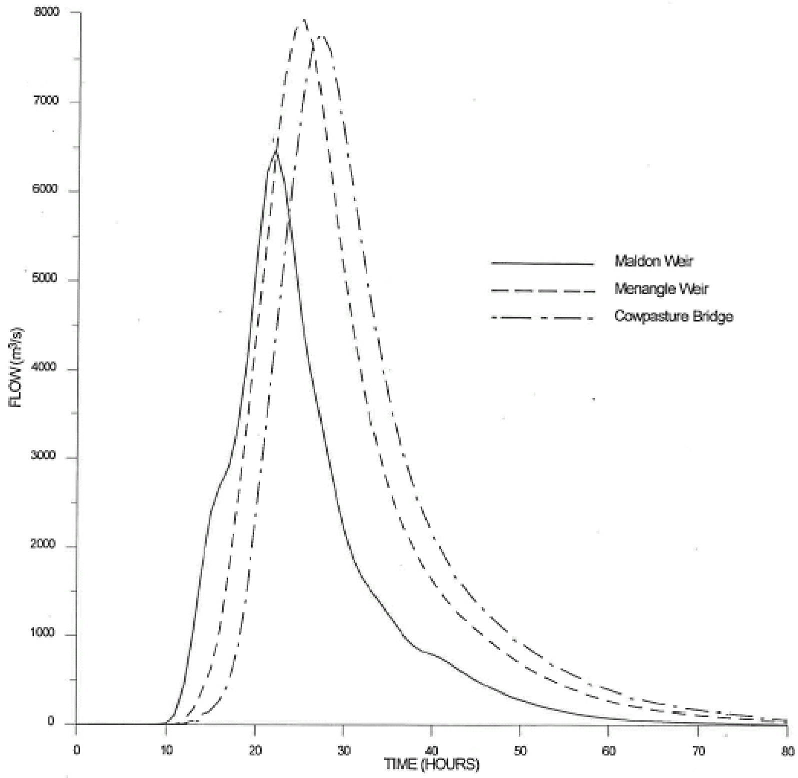


PLATE 3.1 – RORB HYDROGRAPH AT MALDON WEIR

4 THE EXISTING ENVIRONMENT

4.1 The Site

The Wilton Junction development is located within the Wollondilly Shire Council LGA in the suburb of Wilton. The gross site area is approximately 2600 Ha and is bound by two (2) major tributaries. Nepean River forms the Western and Northern boundaries, whilst Allens Creek forms the Eastern boundary.

A portion of Wilton Junction has previously been approved by Wollondilly Shire Council and is currently under development by Lend Lease - known as “Bingara Gorge” (approximately 456 Ha), which includes an approved 1165 lots and a championship golf course. . Three (3) Major Landowners are responsible for 1,457 Ha (approximately 56 %).

The existing terrain generally consists of undulating open pastures with steep gorges surrounding the perimeter of the site. The overall boundary extent of Wilton Junction is shown on Plate 4.1 whilst details of the ownership and major drainage elements are included in Plate 2.2 and Figures 2 and 3 in Appendix A respectively.

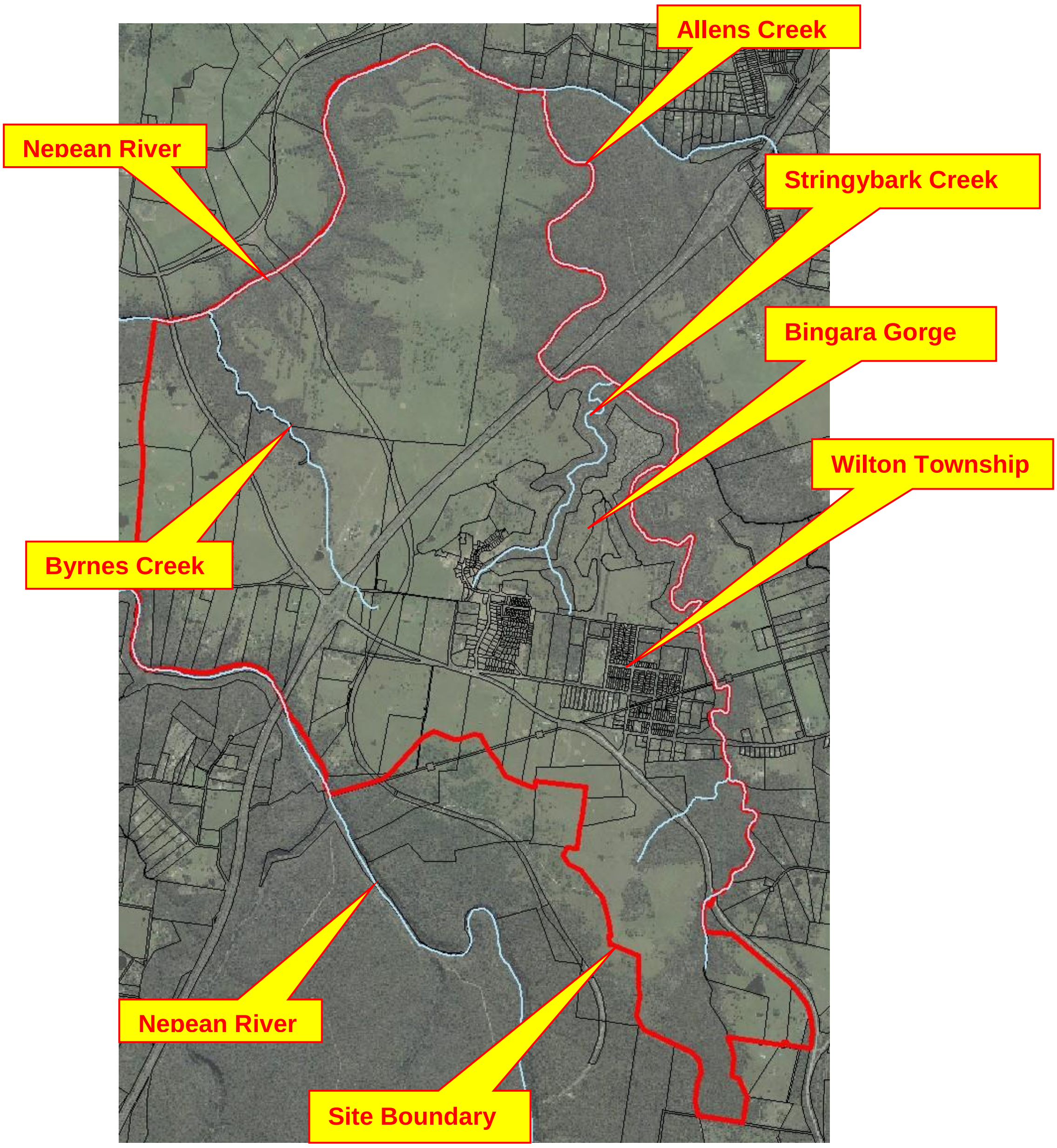


PLATE 4.1- SITE BOUNDARY

5 THE PROPOSED DEVELOPMENT

The overall Wilton Junction development will provide between 11,000-13,000 homes, (10,735 for the purposes of this assessment), employ 11,000 people, includes a town centre, social infrastructure and provides essential services for the surrounding townships of Wilton, Appin and Picton.

The development will include provision of essential services (water, wastewater and electricity), with targeted investigation being undertaken by a series of technical specialists collaborating on the rezoning process.

Details of the proposed Masterplan for Wilton Junction is provided in Plate 5.1 A detail land use breakdown is also provided in Table 5.1 below.

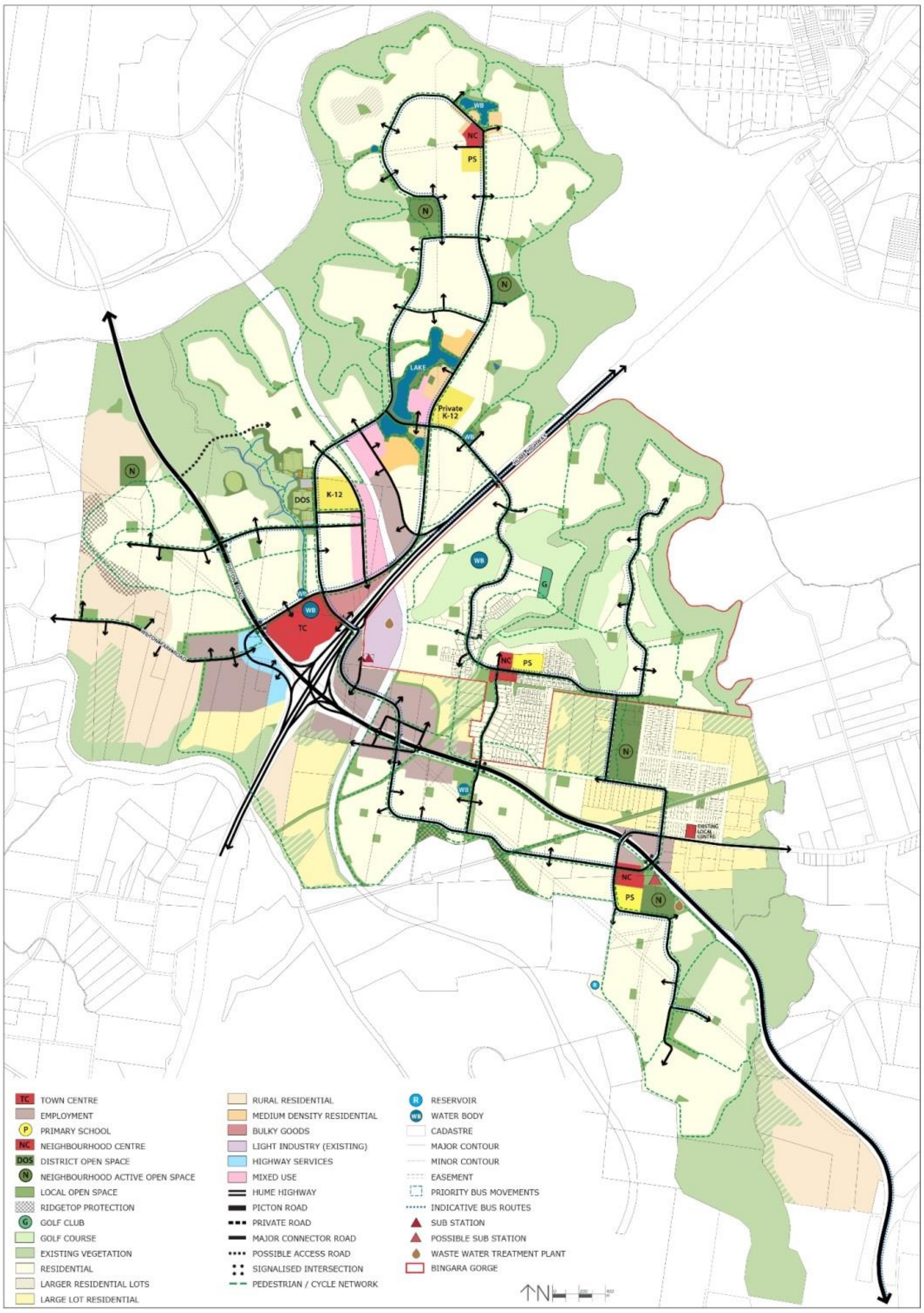


PLATE 5.1 - MASTERPLAN

TABLE 5.1- LANDUSES IN WILTON JUNCTION

LANDUSE	AREA (Ha)	Total Area (Ha)
1. Open Space	155	**155**
2. Bushland	674	**674**
3. Retail		
a. Town Centres		
b. Other Centres	9	
c. Bulky Goods	7	**34**
4. Employment		
a. Highway Services		
b. Employment	97	
c. Light Industry	13	**120**
5. Mixed Use	27	**27**
6. School	26	**26**
7. Residential		
a. Residential		
b. Existing Residential	58	
c. Medium Density	18	
d. Rural Living	207	
e. Large lot Residential	174	**1450**

6 DIRECTOR GENERALS REQUIREMENTS

Final Director General Requirements (DGR's) were issued by the NSW Department of Planning and Environment on the 2nd May 2013. The requirements that relate to the Wilton Junction Development are detailed below, with responses provided on how they are addressed.

TABLE 6.1- DGR RESPONSES

DIRECTOR GENERAL REQUIREMENT	STRATEGY REPONSE
Water and Air Quality Identify watercourses, riparian land and wetlands that may be potentially affected by the proposed Masterplan. Assess the potential impacts on water quality and quantity in order to demonstrate that key River Flow and Water Quality Objectives are achieved to protect environmental values including waterways, riparian land, wetlands and down slope vegetation.	The development is located directly adjacent to a portion of the Nepean River with Allens Creek as a major tributary. Consequently, appropriate development controls are essential to protect the ecological values of this sensitive waterway. The watercourses and riparian lands within the site have been mapped and categorised and these are presented in Figure 4 herein. A visual Stream assessment has confirmed that all of the minor watercourses with in the site likely to be directly affected by the planning proposal are not "rivers" as defined under the Water Management Act 2000 and could be removed or replaced by urban drainage infrastructure. Further details on the riparian corridor assessment is presented in Section 9.7 herein. The Hawkesbury Nepean River Statement of Joint Intention (Health River Commission, 2000) has set maximum discharges concentrations for both Total Nitrogen (0.7 mg/l) and Total Phosphorus (0.035 mg/l). The proposed Water Cycle Management Strategy has been configured to ensure that both stormwater and recycled water to the Nepean system achieve the relevant concentration levels for stormwater alone. Consequently, the integrated system achieves all of the NSW agency requirements for this project. VKL Consulting have prepared a SEPP Study Report outlining the recycled water disposal infrastructure for the project area outside the Bingara Gorge Development. A copy of the VKL Consulting report is provided in Appendix E.
Address potential impacts on water quality of surface and groundwater and provide Integrated Water Cycle Management Plans based upon Water Sensitive Urban Design principles, including consideration of climate change scenarios in accordance with relevant Government policies.	The strategy proposes a treatment train of WSUD elements to manage Water Quality including on lot controls, gross pollutant traps, raingardens and absorption trenches / level spreaders. This system has been modelled using MUSIC to confirm system performance. Details of the proposed Water Cycle Management system are provided in Figure 1 of this report
Flooding Address the potential flood risk that may occur on site, in accordance with the NSW Floodplain Development Manual (2005) and Section 117 Direction, noting proposed mitigation measures.	Suitable hydrological and hydraulic calculations were undertaken to confirm that, due to the incised nature of the Nepean River adjacent the site, 1 % AEP flows within the Nepean River will not impact the portions of the site proposed for development. The Catchments within the site itself are generally characterised as small (<40 ha) and consequently flood risks will be managed by providing a conventional major /minor street drainage system. Details of the assessment undertaken are provided in Sections 10 and 11 of this report.
Infrastructure, Servicing, Staging and Housing Delivery The Infrastructure Strategy and Implementation Plan will detail the infrastructure in a staged manner as well as required to service the ultimate development including: Stormwater detention and treatment for water quality (including infrastructure maintenance for future Council assets).	An assessment of Stage 1 works in Wilton Junction has been completed in Section 11. Recommendations are made on both the interim and final measures, which are required to attain designated Water Quality and Water Quantity objectives.

7 DEVELOPMENT GUIDELINES, OPPORTUNITIES & CONSTRAINTS

Several guidelines were considered in the development of the Water Cycle Management Strategy. These are summarised in Sections 7.1 to 7.10 below.

7.1 Wollondilly Shire Council Development Control Plan (DCP) 2011

We understand that a future DCP will be created as part of the SEPP. At this stage however, Wollondilly Shire Council's DCP guidelines have been adopted to inform these investigations.

The requirements of Wollondilly Shire Council's DCP 2011 related to stormwater management are set out below.

7.1.1 Volume 1 – General

Wollondilly Shire Council's DCP sets out a series of guidelines for the management of riparian corridors. J. Wyndham Prince notes however that the NSW Office of Water have recently released new industry guidelines for Riparian Corridors (NOW, 2012) which would form the bases of any future application for works adjacent to any defined watercourse. The latest NOW guidelines are subsequently considered the most appropriate guidelines for this assessment.

7.2 Wollondilly Design Specifications – Subdivision and Engineering Standards

Section D5 of Wollondilly Shire Council's *Subdivision and Engineering Standards (2008)* is applicable to the management of stormwater and water quality for the proposed site. The modelling parameters considered in this assessment are discussed below.

7.2.1 XP-RAFTS Hydrologic Modelling

Where hydrologic modelling is carried out using *XP-RAFTS*, Section D5.07 of Council guideline provides the following parameters that shall be used in this type of modelling:

- Initial Loss
  - Impervious = 10 mm
  - Pervious = 0 mm
- Continuing Loss
  - Impervious = 0 mm/hr
  - *Pervious = 2.5 mm/hr*

There appears to be an error with Councils DCP as it unlikely that an initial loss of 10mm for impervious areas (i.e. Concrete) is possible and a pervious loss of 0mm. It would appear that these parameters for both initial and continuing loss have been incorrectly listed in the DCP and we have modelled the catchment with a more traditional loss arrangement. Please see Section 10 for further details.

Details of percentage impervious for various land uses are given in Table D5.1 of the Wollondilly Shire Council's *Subdivision and Engineering Standards (2008)* and should be used where actual information is not available. This table was reproduced in Table 7.1 below.

TABLE 7.1– LANDUSE

Landuse	% Impervious
Residential (10 lots / hectare)	40%
Medium density (15 lots / hectare)	60%
Rural Residential	30%
Industrial / Commercial	90%
Road Reserve	70%
Public Recreation Area	10%

7.2.2 Water Quality

Wollondilly Shire Council's DCP sets out a series of objectives for the management of Stormwater pollutants. Some of the key elements of Section D5.33 are listed below.

- It is essential to treat the "first flush" of stormwater as these initial flows from urban areas have relatively high pollutant loads. Such heavy pollution results from significant areas of impervious surfaces, which do not assimilate pollutants such as dust, fertilisers, pesticides, detergents, etc. to the same extent as occurs in environments that are more rural. This will be managed by GPT's throughout the site.
- Council's DCP indicates that in the absence of site-specific data, the designer shall refer to Australian Standard *'Australian Runoff Quality – a Guide to Water Sensitive Urban Design'* (EA, 2007) for pollutant loads and design of the treatment system.

  It is noted however that we have adopted the more recent guidelines for the pollutant loading rates in this Study as defined by the *Draft MUSIC Guidelines* (SCA, 2010).
- Gross pollutants and course sediment shall be treated to a flow rate of 60 L/s/ha.
- Stormwater detention and treatment systems shall be constructed off-line of any watercourse, regardless of the order of the stream. Note this position is superseded by NSW Office of Water Guidelines.
- Unless otherwise required in the development consent, the treatment objectives in the table below, shall be met by provision of stormwater treatment measures:

TABLE 7.2 – HEALTHY RIVERS COMMISSION TARGETS

Pollutant	Description	Treatment Objective
Gross Pollutant	Trash, litter and vegetation larger than 5mm	70% of the load
Coarse Sediment	Contaminant particles between 0.1mm and 5mm	90% of the load
Fine Sediment	Contaminant particles 0.1mm or less	50% of the load
Nutrients	Total Phosphorus and Nitrogen	To meet water quality objectives set by the Healthy Rivers Commission Inquiries at all points in the catchment
Hydrocarbons, motor oils, oils and grease		Whichever is greater: 1. 90% of the load; or 2. Total discharge from site of Total Petroleum Hydrocarbons (TPH) <10 mg/L at all times.

It is important to note that Council's policy currently specifies a different treatment objective percentage for coarse and fine sediments. There is currently no modelling software available on the market that can differentiate treatment between coarse and fine sediments. "MUSIC" is the industry-accepted program used for such analysis and performs assessments upon "Total Suspended Solids" (TSS). Most coarse sediment will be captured in the GPT's that will from part of the development. The modelling demonstrates that the finer TSS particles will be managed to the required levels and ,by default, the course sediment will be also managed to a much higher standard than the Council target of 70% of the load. Refer to the MUSIC assessment in Section 12.

Healthy Rivers Commission Targets

As specified in Table 7.2 above, the required pollution reduction targets are those targets set out in Table 2 of the Healthy Rivers Commission (HRC, 2000). Details of the required targets are provided below in Table 7.3. Wilton Junction is located within the "Mixed use rural areas and sandstone plateau" classification.

TABLE 7.3 – HRC TARGETS

Water Quality Indicator (all values µg/l)	Forested areas and drinking water catchment	Mixed use rural areas and sandstone plateau	Urban areas - main streams	Urban areas - tributarry stream	Estuaries areas
Total Phosphorus					
NWQMS range	10-100	10-100	10-100	10-100	n/a
HRC recommendation	**50** (b)	**35**	**30**	**~50**	**30**
Measured range (a)	7.-50	10-740	10-100	50-360	15-30
Total Nitrogen					
NWQMS range	100-750	100-750	100-750	100-750	n/a
HRC recommendation	**700** (b)	**700**	**500**	**~1000**	**400**
Measured range (a)	100-800	200-3200	400-2200	500-15000	200-500

7.3 Lower Hawkesbury Nepean Nutrient Strategy

The strategy was development by the Department of Environment, Climate Change and Water NSW in September 2012 (DECCW, 2010). The strategy sets out the current pressures that exist within the Hawkesbury- Nepean River. The strategy has been developed to provide clear direction and an overarching framework with an aim to reduce the current nutrient that enter the water courses.

The strategy looks at ways to reduce a range of different pollutant sources including urban and agricultural runoff and point sources from sewage treatment plants. The strategy makes a series of recommendations including education and water quality monitoring to improve the nutrient levels with this river system.

7.4 ANZECC Guideline 2000

The ANZECC guideline provides the framework for assessing water quality objectives throughout Australia. The guideline is not intended to be applied directly as regulatory criteria but provides guidance in the setting of appropriate water quality objectives.

Since the release of the ANZECC guidelines in 2000, a number of other documents have been issued that set guidelines and/ or performance standards on the quality of water as it relates to public health management. The "Australian Guidelines for Water Recycling: Managing Health & Environmental" (NRMMC, EPHC & AHMC 206) provide guidance on recycled water quality and hazard assessments required to support the development of a recycled water scheme. A risk management approach is recommended.

The recommended risk management assessment will be undertaken for the STP at the next stage of the planning approvals process for Wilton Junction. For the purposes of the current rezoning stage assessment, the ANZECC trigger values for Secondary Contact have been adopted as interim targets for the quality of effluent discharges from the sewerage treatment plant.

7.5 NSW Office of Water (NOW) Guidelines

The NSW Office of Water (NOW) has recently amended the NSW riparian corridor guidelines across the industry. Revisions to the guidelines now permit the following features, which are likely to benefit development areas within the Wilton Junction development. These include:

- Detention basins are now permitted to be "on-line" within watercourses up to 2nd order;
- Buffer zones are no longer required. Instead, the width of the "Vegetated Riparian Corridor" (VRZ) is simplified and reduced. The VRZ requires the following offset from top of bank:
  - 1st order watercourse is 10m either side from top of bank.
  - 2nd order watercourses require 20m either side from top of bank.
  - 3rd order watercourses require 30m either side from top of bank; and
  - 4th order watercourses require 40m either side from top of bank.
- 1st order watercourses can be realigned;
- Encroachments are permitted up to 50 % of the VRZ width on both sides, as long as there is equivalent offset areas dedicated as riparian corridor elsewhere within the development; and

Such encroachments which are permitted into the VRZ include water quality devices (i.e. raingardens), offline or online detention basins, playing fields and associated carparks, circulation roads or even developable lots.

Further discussion on riparian corridors at Wilton Junction is provided in Section 9.7 of this report.

7.6 Soils / Salinity

A separate Land Capability assessment has been undertaken by Douglas Partners for the study area (DP, 2013). The conclusions drawn from this assessment in short, are summarised below:

- *No evidence of hillside/slope instability was observed within the proposed net developable area.*
- *The presence of erosive soils on site should not present significant constraints to development provided they are well managed during earthworks and site preparation stages.*
- *No significant evidence of saline soil was identified within the site. Although further salinity testing is considered necessary, at this stage salinity levels are sufficiently low for this site to be deemed free of no significant salinity constraints.*
- *Although mild aggressivity to concrete is regularly encountered across the site, aggressivity levels are considered to be manageable, subject to appropriate design and construction consideration.*
- *Highly sodic and sodic soils appear widespread and will require management to reduce dispersion, erosion and to improve drainage.*
- *The results of the land capability assessment have not identified any issue that would preclude the rezoning of the Wilton Junction site for urban development*.

7.7 Office of Environment and Heritage – Flood Impacts Assessment

As part of the Final DGR's for the project provided on the 2 May 2013, a number of supporting documents from various government agencies were provided. One of these support documents was from the Office of Environment and Heritage (OEH) which provided details as to the level of flood assessment that OEH see necessary for the Wilton Junction project.

OEH has stated that flood risk may occur on the site and that an assessment in accordance with the NSW Floodplain Management Manual and Section 117 direction is required. The advice goes on the state that no recent flood studies have been undertaken and that a hydrological and hydraulic assessment is required for all water courses including Nepean River, Allens Creek, Stringybark creek and Byrnes Creek.

OEH have suggested any investigations is to assess the full range of floods events up to the Probable Maximum Flood (PMF) for both existing and proposed developed conditions. As series element that will need to be address in any study have been listed in the OEH advice these include:

- Floodway determination;
- Hazard categorisation;
- Peak flow management;
- Impacts of any fill within the development fill impacts and
- Climate change assessments.

Details as to how these issues have been addressed within this assessment are provided in Sections 10 and 11 of the report.

7.8 NSW EPA Comments

A letter from the NSW EPA (dated 3 December 2012) was considered by NSW Department of Planning & Environment in their development of the final DGR's for Wilton Junction. This letter contained a range of objectives for the management of stormwater and treated effluent for the project.

The Wilton Junction project team met with NSW EPA on 24 May 2013 to present the proposed Water Cycle Management strategy for the project. The strategy was generally well received.

A subsequent meeting was held with the NSW EPA on 25 June 2013 where the project team presented updates for both the Sewerage Treatment Plant design and the Water Cycle Management strategy. The email of 25 July 2013 issued following this meeting confirmed the NSW EPA's new position that the "*HRC target numbers are dated and difficult to apply and it will confirm the appropriate targets."* The NSW EPA subsequently confirmed via email that they believe that the targets most suitable for this development are the values for 'Mixed use rural areas and sandstone plateau' (see Table 7.3 above for details).

A further meeting was held with the NSW EPA on the 25th October 2013 where the project team presented the final updates to the Sewerage Treatment Plant design and Water Cycle management strategy. At this meeting, EPA officers confirmed that the level of modelling undertaken is support of the proposal is suitable for rezoning assessment.

Details are presented in Section 12 and 13 of this report on how the best practice water cycle strategy developed for Wilton Junction achieves the 'TP and TN targets specified by the 'Mixed use rural areas and sandstone plateau' landuse.

7.9 Sydney Regional Environmental Plan No. 20

The Sydney Regional Environmental Plan No. 20 – Hawkesbury Nepean River (SREP 20) (Ref. 12) provides a number of specific planning policies and recommended strategies for new developments within the Hawkesbury Nepean River system. Those related to stormwater for the Wilton Junction Area are:

Water Quality

Policy: Future development must not prejudice the achievement of the goals of use of the river for primary contact recreation and aquatic ecosystem protection in the river system. If the quality of the receiving waters does not currently allow these uses, the current water quality must be maintained, or improved, so as not to jeopardise the achievement of the goals in the future

Strategies:

- Quantify, and assess the likely impact of, any predicted increase in pollutant loads on receiving waters.
- Consider the need to ensure that water quality goals for primary contact recreation and aquatic ecosystem protection are achieved and monitored.
- Consider the need for an Erosion and Sediment Control Plan (to be implemented at the commencement of development) where the development involves the disturbance of soil.
- Minimise or eliminate point source and diffuse source pollution by the use of best management practices
- Site and orientate development appropriately to ensure bank stability. Plant appropriate native vegetation along banks of the river and tributaries of the river, but not so as to prevent or inhibit the growth of aquatic plants in the river, and consider the need for a buffer of native vegetation.
- Protect the habitat of native aquatic plants.

Water Quantity

Policy: Aquatic ecosystems must not be adversely affected by development which changes the flow characteristics of surface or groundwater in the catchment.

Strategies:

- Ensure the amount of stormwater run-off from a site and the rate at which it leaves the site does not significantly increase as a result of development. Encourage on-site stormwater retention, infiltration and (if appropriate) reuse.
- Consider the impact of development on the level and quality of the water table

The water cycle management system proposed for the Wilton Junction project addresses the SREP 20 policy intent as it relates to the management of the water on the site.

8 WATER CYCLE MANAGEMENT OPTIONS

The Water Cycle Management Strategy proposed for the Wilton Junction development has been prepared with consideration of the statutory requirements and guidelines listed in Section 7 of this report. The strategy focuses on mitigating the impacts of the development on the total water cycle and maximising the environmental, social and economic benefits achievable by utilising responsible and sustainable stormwater management practices.

A range of stormwater management techniques and options considered for the management of nutrients and suspended solids discharging from the site are summarised.

Each of these management techniques were evaluated and compared with consideration of a range of environmental, social/amenity, economic, maintenance and engineering criteria.

8.1 Vegetated Swales and Buffers

Swales are formed, vegetated depressions that are used for the conveyance of stormwater runoff from impervious areas. They provide a number of functions including:

- Removing sediments by filtration through the vegetated surface.
- Reducing runoff volumes (by promoting some infiltration to the sub-soils).
- Delaying runoff peaks by reducing flow velocities.

Swales are typically linear, shallow, wide, vegetation lined channels. They are often used as an alternative to kerb and gutter along roadways but can also be used to convey stormwater flows in recreation areas and car parks.

Comment: The grade of the land within certain portions of Wilton Junction is suitable for swales and buffers (< 3%), in particular the land in the Northern peninsular. However, swales and buffers within urban residential streets are not recommended due to the large number of culvert crossings required for driveways, safety concerns, increased number of GPT's required and significant maintenance requirements.

8.2 Sand Filters

Sand filters typically include a bed of filter media through which stormwater is passed prior to discharging to the downstream stormwater system. The filter media is usually sand, but can also contain gravel and peat/organic mixtures. Sand filters provide a number of functions including:

- Removing fine to coarse sediments and attached pollutants by infiltration through a sand media layer.
- Delaying runoff peaks by providing retention capacity and reducing flow velocities.

Sand filters can be constructed as either small or large scale devices. Small scale units are usually located in below ground concrete pits (at residential/lot level) comprising of a preliminary sediment trap chamber with a secondary filtration chamber. Larger scale units may comprise of a preliminary sedimentation basin with a downstream sand filter basin-type arrangement.

Comment: Sand filters are generally suited to smaller catchments. They are inefficient when compared to bio-retention systems and require frequent maintenance. Sand filters are therefore not included as part of the Proposed Stormwater Management Strategy for Wilton Junction.

8.3 Permeable Pavement

Permeable pavements, which are an alternative to typical impermeable pavements, allow runoff to percolate through hard surfaces to an underlying granular sub-base reservoir for temporary storage until the water either infiltrates into the ground or discharges to a stormwater outlet. They provide a number of functions including:

- Removing some sediments and attached pollutants by infiltration through an underlying sand/gravel media layer.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing retention/detention storage capacity and reducing flow velocities.

Commercially available permeable pavements include pervious/open-graded asphalt, no fines concrete, modular concrete blocks and modular flexible block pavements.

There are two (2) main functional types of permeable pavements:

- Infiltration (or retention) systems – temporarily holding surface water for a sufficient period to allow percolation into the underlying soils.
- Detention systems – temporarily holding surface water for short periods to reduce peak flows and later releasing into the stormwater system.

Comment: Permeable pavements are generally a more 'at source' solution and best suited as an 'on lot' approach or for small roadway catchments. Permeable pavers may possibly be considered at the development application stage for on lot treatment or for areas draining small catchment areas with low sediment loads and low vehicle weights. These systems are also prone to clogging and are not suitable in saline soils similar to those located close to the site and therefore not recommended in the Stormwater Management Strategy for Wilton Junction.

8.4 Infiltration Trenches and Basins

Infiltration trenches temporarily hold stormwater runoff in a sub-surface trench prior to infiltrating into the surrounding soils. Infiltration trenches provide the following main functions:

- Removing sediments and attached pollutants by infiltration through the sub-soils.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing detention storage capacity and reducing flow velocities.

Infiltration trenches typically comprise of a shallow, excavated trench filled with reservoir storage aggregate. The aggregate is typically gravel or cobbles but can also comprise modular plastic cells (similar to a milk crate). Runoff entering the system is stored in the void space of the aggregate material or modular cells prior to percolating into the surrounding soils. Overflow from the trench is usually to downstream drainage system. Infiltration trenches are similar in concept to infiltration basins; however, trenches store runoff water below ground in a pit and tank system, whereas basins utilise above ground storage.

Comment: Infiltration trenches and basins are not appropriate for clay soils or where there is potential for salinity issues. Infiltration trenches and basins are therefore, not recommended for Wilton Junction.

8.5 Ponds

Ponds are usually deep (>1.5 m) artificial bodies of open water. Many ponds have a small range of water level fluctuation because they are formed by a simple dam wall with a weir outlet structure. Newer systems may have riser-style outlets allowing for extended detention and temporary storage of inflows. Emergent aquatic macrophytes are normally restricted to the pond surrounds because of water depth, although submerged plants may occur in the open water zone.

Water quality improvement in ponds are promoted by a complex array of physical, chemical and biological actions. Whilst not as effective in the removal of pollutants as wetlands, they do still provide benefit an effective means of intercepting pollutants from stored sediments.

Comment: Ponds and Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. At Wilton Junction, there appear to be several existing ponds which may remain in the ultimate development. It is unclear at this stage whether they will be converted to a full wetland for the purposes of water quality treatment – however, there is opportunity to do so.

A large lake system is also proposed to be included in the development and will receive recycled water from the Sewage Treatment Plant (STP). The recycled water flows exiting the STP will resulting in a high level of treatment (0.1 mg/L Total Phosphorus and 6 mg/L Total Nitrogen) prior to discharge to the lake. The combination of lake system, local evaporation and final treated by raingardens will reduce concentration levels to below HRC mean concentration levels prior to discharge to the nearby tributaries.

8.6 Bio-retention Systems

Bio-retention systems consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 100-300 mm deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed (raingarden) or a linear swale (bio-swale) and are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. The surface of the bio-retention system can be grassed or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.5 to 0.6 metres deep.

Comment: Bio-retention systems are an effective and efficient means of treating pollutants from urban development when part of an overall treatment train. Bio-retention systems do however require a reasonable amount of maintenance during the vegetation establishment phase. At Wilton Junction, there is opportunities for many of these raingarden devices to be located within the Asset Protection Zone (adjacent to woodland areas), which minimises landtake and provides easy access for maintenance (i.e. if located adjacent to a perimeter road).

Bio-retention "raingardens" are therefore included within the overall Stormwater Management Strategy for Wilton Junction where they will provide "end of line" treatment prior to discharge from site and minimise land take.

8.7 Cartridge Filtration Systems

Cartridge filtration systems are underground pollution control devices that treat first flush flows. The unit consists of a vault containing a number of cartridges each loaded with media that targets specific pollutants. Each cartridge has a maximum treatable flowrate of approximately 1 - 1.5 litres per second, and the unit can accommodate up to 24 cartridges providing a maximum treatable flowrate of 24-36 litres per second.

Comment: Cartridge filtration systems are an efficient means of treating pollutants from urban development, as they are typically located underground and therefore do not require additional landtake. As cartridge systems have a low treatable flow rate, additional 'buffer' storage is usually provided to keep the capital costs down. Cartridge filtration systems also need to be supplemented with additional treatment devices to achieve pollutant reduction targets. This requires significant height differences between the inlet to the filtration system and the discharge point from the supplementary system. It also generally results in expensive capital and ongoing maintenance costs.

Cartridge Filter systems are therefore not currently included as part of the Proposed Stormwater Management Strategy for Wilton Junction.

8.8 Rainwater Tanks

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs.

Rainwater tanks provide the following main functions:

- Allow the reuse of collected rainwater as a substitute for mains water supply, for use for toilet flushing, laundry, or garden watering.
- When designed with additional storage capacity above the overflow, provide some on-site detention, thus reducing peak flows and reducing downstream velocities.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing) or outdoors (garden watering). Rainwater tanks can be either above ground or underground. Above ground tanks can be placed on stands to prevent the need of installing a pump to distribute the water. Such systems are referred to as gravity systems. Pressure systems require a pump and can be either above or below ground tanks.

Tanks can be constructed of various materials such as Colorbond™, galvanised iron, polymer or concrete.

Comment: Rainwater tanks are effective in removing suspended solids and a small amount of nutrient pollutants. They are also effective in reducing overall runoff volumes. The effectiveness of rainwater tanks is also increased when plumbed in for internal use. Rainwater Tanks are therefore included within the overall Stormwater Management Strategy for Wilton Junction.

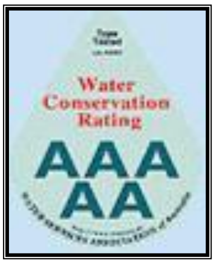
9 PROPOSED WATER CYCLE MANAGEMENT STRATEGY

A critical consideration for the Water Cycle Management strategy for the Precinct is the ecological sustainability of the Nepean River and its riparian corridors. To maintain stormwater quality at the required levels, a 'treatment train' approach is proposed where various types of pollutants are removed and flow volumes and discharge rates are managed by a number of devices acting in series. The stormwater management treatment train will consist of the following elements.

9.1 Water Efficiency

9.1.1 On Lot Treatment

- Implementation of water efficient fittings and appliances in all dwellings (dual flush toilet, AAA shower heads, water efficient taps and plumbing).
- Minimisation of impervious areas through acceptable development controls.
- The provision of rainwater tanks on each allotment, along with implementation of the above water efficient devices, will satisfy the requirements of BASIX. The connection of water tank to service internal uses will ensure any requirements are met and additional benefits are realised.



9.2 Water Quality Measures

9.2.1 Street Level Treatments

Inlet Pit Filter Inserts and Gross Pollutant Traps (GPTs)

GPT devices are typically provided at the outlet to stormwater pipes. These systems operate as a primary treatment to remove litter, vegetative matter, free oils and grease and coarse sediments prior to discharge to downstream (Secondary and Tertiary) treatment devices. They can take the form of trash screens or litter control pits, pit filter inserts and wet sump gross pollutant traps.

In theory, inlet pit filter inserts have several advantages over end of pipe GPT's, such as providing a dry, at source collection of litter, vegetative matter and sediment as well as allowing for staged construction works without having to provide additional / temporary GPT units. Pit filter inserts will provide an at source mechanism for treatment of gross pollutants as development proceeds throughout the site. However it should be noted that pit inserts have been subject to discussions with Wollondilly Shire Council for use in the Bingara Gorge Development and it is our understanding that "end of pipe" GPT solutions are now being considered for this development.

For the purpose of this assessment, we have assumed that pit inserts are not part of the treatment train and Vortex style GPT's as shown in plate 9.1 are to form part of the Wilton Junction development.

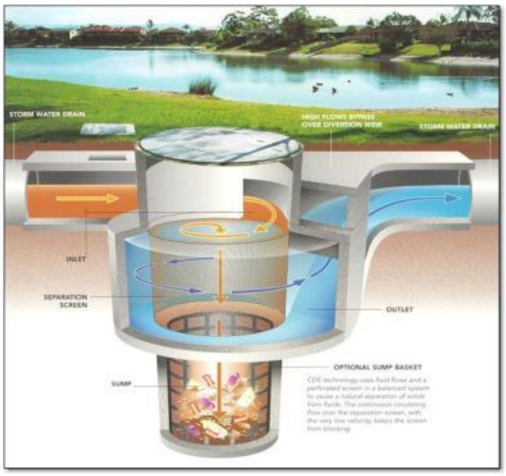


PLATE 9.1 – VORTEX STYLE GPT

9.2.2 Subdivision / Development Treatment

Raingardens

A series of 'rain-gardens' are proposed within the development. Rain-gardens are large scale, non-linear bio-retention systems. The rain-gardens will be appropriately sized to achieve the nutrient reduction targets for the development site. These targets are consistent with *Managing Urban Stormwater Guidelines - Harvesting and Reuse* (DEC, 2006). The rain-gardens will also attenuate first flush flows to reduce the risk of stream erosion on both the Nepean and Allens creek catchments

PLATE 9.2 – TYPICAL RAIN-GARDEN AFTER PLANT ESTABLISHMENT

The strategy for Wilton Junction does not preclude the use of additional or alternate WSUD elements within the streetscape or landscape. These elements, such as swales or bio-retention systems in the medians of dual carriageways, can be considered at the development application and detailed design stages. The use of such elements would require consideration of issues such as practicality in the urban environment, safety, maintenance and performance.

9.3 Water Quantity (Flood Control) Measures

9.3.1 Subdivision / Development Treatment

Detention Basins

Storage in the upper portions of Allens Creek are the most efficient and effective means of managing peak flows on the Wilton Junction project.

The optimal solution has been identified to include the construction of a 35,000 m³ Detention Storage on-line to Allens Creek upstream of Picton Road. This would retain existing landform on the watercourse but would construct an elevated earth bank across the watercourse and provide a “slotted weir” type basin outlet. A concept sketch of the basin and location is included on Figures 5 and 6 in Appendix A.

Modelling indicates that the Basin is only needed to be constructed near the end of Stage 2 (post 2025), as peak discharge levels throughout Allens Creek are not increased after completion of Stage 1, and are marginally increased at the completion of Stage 2.

As the development of Wilton Junction progresses there may be opportunities to augment the water quantity strategy proposed under this strategy with additional localised detentions basins. These basins may be utilised to limit downstream infrastructure costs. The benefits of this approach would be assessed at the time of future DA’s for development on the site.

Stream Erosion Index

The stream erosion index is defined by the Office of Environment and Heritage (OEH) as the post development duration of flows greater than the ‘*stream forming flow’* divided by the natural duration of flows greater than the ‘*stream forming flow’*. OEH guidelines recommend a stream erosion index of between 3.5 – 5.0,

Even though a Stream Erosion Index (SEI) assessment has not been completed for this project, the treatment train proposed for the site is expected to deliver an SEI within acceptable limits.

9.4 Construction Stage

Erosion and sediment control measures are to be implemented during the construction phase in accordance with the requirements of Wollondilly Shire Council and the guidelines set out by Urban Growth NSW (formerly Landcom) (the “Blue Book” 2004).

As the operation of “bio-retention” (rain-garden) type water quality treatment systems are sensitive to the impact of sedimentation, construction phase controls should generally be maintained until the majority of site building works are complete. Alternatively, a very high level of at source control on individual allotments during the building and site landscaping works, which is regularly inspected by Council officers, would be required.

9.5 Interim Treatment Measures

The rain-garden media bed should be protected throughout the civil and housing construction phases of the development. The floor of the rain-garden should be lined with either a layer of turf or a sacrificial upper media bed layer and planting that would need to be replaced upon 80% completion of housing construction.

Upon 80% completion of housing construction within the catchment, the turf or sacrificial layer can be removed, replaced and the final planting completed.

9.6 Long Term Management

Regular maintenance of the stormwater quality treatment devices is required to control weeds, remove rubbish, and monitor plant establishment and health. Some sediment build-up may occur on the surface of the rain-gardens and may require removal to maintain the high standard of stormwater treatment.

Proper management and maintenance of the water quality control systems will ensure long-term, functional stormwater treatment. It is strongly recommended that a site-specific Operation and Maintenance (O & M) Manual is prepared for the system. The cost of preparing this manual should be a component of the Section 94 scheme. The O & M manual will provide information on the Best Management Practices (BMP's) for the long-term operation of the treatment devices. The manual will provide site-specific management procedures for:

- Maintenance of the GPT structures including rubbish and sediment removal.
- Management of the rain-garden including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal).

9.7 Riparian / Bushland Interface

In accordance with the NSW Office of Water (NOW) Guidelines, all existing watercourses have been identified under the "Strahler" system (refer to Figure 4 in Appendix A). Results of this assessment indicate that there are a number of 1st order watercourses which bisect Wilton Junction. Whilst the majority of higher watercourses (i.e. 2nd, 3rd and 4th order) are generally located within the existing bushland and will be retained.

The watercourses on the site that are proposed to be retained and those earmarked for removal are shown on Figures 4 and 13 in Appendix A and G respectively. Detailed site investigations of each of the watercourses which are proposed to be removed have been undertaken by J. Wyndham Prince with discussion provided in Section 9.7.1.

To manage stormwater discharges from the proposed development into the adjacent water courses and perimeter bushland it is proposed to construct a series of absorption trench / level spreaders. These devices will be formed using a gravel trench with timber edge strip to ensure point discharges to bushland areas are avoided. A general arrangement indicating details of the devices proposed is provided on Figure 7. As discussed in Section 12, water quality devices are provided upstream of the discharge points to ensure that discharge water quality is consistent with the Healthy Rivers Targets. These devices will ensure that regular base flow discharges do not have a detrimental impact upon the existing bushland and watercourses.

In instances where there is no protected bushland, discharge will occur via an appropriately sized rock outlet with scour protection. This outlet is to extend to a gully location to ensure the ecosystem is not adversely impacted. Specific locations of the devices are to be confirmed at the DA stage.

As shown on Figure 13, no Riparian Corridor Offsets are currently required at Wilton Junction. It is noted however that if offsets are identified in future detailed assessments (e.g. if water quality devices are located within the outer 50 % of the Vegetated Riparian Zone), then these offsets could be easily accommodated alongside the many Riparian Corridors which surround Wilton Junction without the need to modify the current development footprint.

9.7.1 Detailed Assessment

Mr Jeremy Morice from the NSW Office of Water was contacted (phone conversation dated 6th February 2014) to discuss the information which is required to support the proposed removal of watercourse / drainage lines throughout Wilton Junction. The NSW Office of Water indicated that: the adopted criteria shall include:

- A report and description of each proposed watercourse to be removed;
- Photographs both up and down stream for each reach;
- Justification that the watercourse is not waterfront land; or
- Proposal for suitable offsetting where the watercourse is determined to be Waterfront land (if required).

Details of this assessment are included in Section 9.7.2 below and Appendix G.

9.7.2 Description of Watercourses to be Removed

A site inspection of all watercourses which are proposed for removal at Wilton Junction was undertaken on the 6th and 7th May 2014. A review of the Bureau of Meteorology rainfall data (at nearby Menangle Bridge) indicates that it was three (3) days since greater than 1 mm had fallen on the catchment.

TABLE 9.1 – RECENT RAINFALL DATA

Date	29-Apr	30-Apr	1-May	2-May	3-May	4-May	5-May	6-May	7-May
Daily rainfall (mm)	0	2	0	0	3	1	0	0	0

* Recorded Data from BOM website (Station 68216 - Menangle Bridge)

Wilton Junction predominately features cropped pastures which have been heavily modified by past and / or modern farming activities. The terrain is undulating with each watercourse generally discharging to the surrounding protected bushland areas. Site investigations indicate that the majority of watercourses across Wilton Junction generally exhibit:

- no defined channel,
- no overland flow (only a dry gully); and
- only pasture grass.

Farm dams are scattered across Wilton Junction with no flowing water or observed connectivity to the flowpath downstream. All dams appear to be man-made with a raised embankment on the downstream side and exposed soil and erosion due to livestock. In isolated locations, occasional ponding was noted in depressions just upstream of dams.

Watercourses across Wilton Junction are considered to be "Ephemeral", since they only appear to flow for hours or days following a rainfall event. In most instances a defined channel was not observed and instead includes a very wide natural depression / flowpath. Where defined channels were observed, it is noted that in most instances the channel was typically eroded (due to livestock) and appears to have little ecological significance.

Watercourses located within the bushland areas which surround Wilton Junction generally exhibit traits of riparian corridors (refer photos 10, 14A, 21A, 33A and 83) and will be retained as fully functional riparian corridors.

Wilton Junction however includes a large number of 1st and 2nd order watercourses which are not considered to be "rivers" under the Water Management Act 2000 and are proposed for removal and / or to be replaced by urban drainage infrastructure. Refer to Figure 4 for the locations where removal is proposed.

To support the proposal to remove these watercourses, a compilation of photographs at the upstream and downstream ends of each watercourse have been provided in Appendix G with locations of each photograph shown on Figure 13

Assessment has been undertaken for each of the watercourses which are proposed for removal and provided a description as to whether a defined stream banks exists. Based on this assessment, we have made recommendations on whether the watercourse is a "river" under the act. Refer to the assessment Summary Table in Appendix G.

It is noted that there are a few watercourses which have currently been "undetermined" due to limited site access in some areas. We expect that these watercourses could also be removed, but will need to be confirmed during future development approval phases.

9.7.3 *Water Holding Structures*

The total area of the six (6) water holding structures at Wilton Junction is approximately 17.7 Ha (which includes 10.9 Ha for the two (2) treatment lakes that form part of the treated effluent system). Refer to Figure 11 for locations.

It is important to note that the two (2) treatment / evaporation lakes are perched and do not receive flows from the upstream stormwater catchments but instead treated effluent from the Sewage Treatment Plant will be directed to the water bodies to maintain their water level and aesthetic appearance. As these devices are "offline" to the stormwater catchment and will not "harvest" any stormwater they have been excluded from the Harvestable Rights assessment.

The Maximum Harvestable Rights Dam Capacity for Wilton Junction has been determined from the Office of Water's *"Maximum Harvestable Right Dam Capacity Calculator"*. The overall Maximum Harvestable Rights Dam Capacity for Wilton Junction has been determined at 233.665 ML which equates to 233,665 m^3. Refer to Appendix G for calculation sheet.

The Water Holding Structures at Wilton Junction that can be considered as Harvestable Right Dams have been conservatively assumed to have an average depth of 2.5 m which results in a total retained volume of 170,000 m^3. This indicates that the total volume of Water Holding Structures at Wilton Junction is less than the permitted Maximum Harvestable Rights Dam Capacity. Therefore the need for purchasing of additional licences is not required.

10 HYDROLOGIC ANALYSIS

The hydrologic analyses for this study were undertaken using the rainfall - runoff flood routing model *XP-RAFTS* (Runoff and Flow Training Simulation with XP Graphical Interface) (Willing, 1996 & 1994). The hydrologic analysis for Wilton Junction was undertaken to determine the need for and size of any detention basins needed to restrict peak post development flows to pre development levels and also to generate peak flow rate hydrographs for input to the hydraulic assessment.

10.1 Sub catchment Delineation

CatchmentSIM was used as the tool to break the catchment upstream from the confluence of the Upper Nepean River and the Cataract River into smaller sub-catchments of approximately 1000 ha. Figures 8 and 9 in Appendix A shows the initial catchment breakup.

CatchmentSIM automatically calculates link lag times based on estimated time of concentration calculation between sub-catchments for use in *XP-RAFTS* modelling.

Lag times have a significant influence on resulting peak flow, so checks on each sub catchment has been undertaken and lag times were manually adjusted where appropriate.

10.2 XP-RAFTS Parameters

As discussed in Section 7.2.1, it would appear that Council's initial loss values for both the pervious and impervious percentage of the catchment are incorrect. Therefore, we have adopted the following parameters in the assessment.

TABLE 10.1 - ADOPTED INITIAL AND CONTINUING LOSSES

	Initial Loss	Continuing Loss
Impervious	2.5 mm	0 mm/hr
Pervious	15 mm	2.5 mm/hr
Bingara Gorge Impervious	11.5 mm	2.5 mm/hr

The impervious initial loss rate for those catchments with the Bingara Gorge Development area were increased to 11.5 mm (2.5 mm standard + 9 mm stormwater capture) to reflect the Bingara Strategy of capturing and re-using first flush stormwater runoff prior to discharging into the downstream environment.

10.2.1 Roughness Coefficients "n"

As the regional catchment is dominated by natural bushland, a Manning's roughness coefficient of 0.05 was generally adopted, however, parts of the contributing catchments are influenced by some development. Adjustments are made in accordance with the amount of development within each catchment and are consistent with the values provided below in Table 10.2:

TABLE 10.2 - ADOPTED MANNING'S 'N' ROUGHNESS COEFFICIENT

Catchment Condition	Adopted Pern Value
Urban Impervious	0.015
Urban Pervious	0.025
Open Space Pervious	0.035
Rural Pervious	0.045
Bush Pervious	0.05

Catchments that involved varying land-use types adopted 0.015 for the impervious sub-catchment portion. The roughness coefficient for the pervious sub-catchment of the development catchments varied, and a single value representing the pervious portion of the site was determined by area weighting in accordance with the land-uses within the catchment.

10.2.2 Rainfall Data

In accordance with Wollondilly Shire Council's Design Specification (pg. D5-6), the following parameters were used in the *XP-RAFTS* IFD curve to provide the rainfall data for the hydrological assessment.

TABLE 10.3 - WOLLONDILLY SHIRE COUNCIL IFD DATA

2 Year ARI				50 Year ARI			
1 Hour	12 Hour	72 Hour	F2	1 Hour	12 Hour	72 Hour	F50
33.5	7.8	2.5	4.29	67	16	5.4	15.75
Geographical Skewness		0					

These values were increased by a further 15% when undertaking the sensitivity assessment in determining the expected increase in discharges due to climate change.

10.3 XP-RAFTS Existing Condition Modelling

10.3.1 Bingara Gorge

For modelling purposes, it was assumed that the approved portion of the Bingara Gorge development has been fully implemented and this assumption was applied to the existing case modelling for this portion of the catchment.

An appropriate percentage imperviousness has been assigned to represent built and approved development extents within the Bingara Gorge Site, where the relevant catchments have been assigned two sub-catchments (pervious portion and impervious portion, in accordance with recommendations for XP-RAFTS.

10.3.2 Existing Wilton Township

The existing Wilton township (56.3 ha) has been assigned 40 % imperviousness to reflect the current densities and is in accordance with Wollondilly Shire Council's guidelines. The remainder of catchment (22 ha) has been assigned 10% imperviousness to account for large areas of undeveloped land and rural residential lots.

As adopted for Bingara Gorge, catchments were assigned two sub-catchments (pervious portion and impervious portion), in accordance with recommendations for XP-RAFTS.

10.4 Preliminary Modelling Results

A high level *XP-RAFTS* model was prepared in the early stages of this investigation to assess the impact of the Wilton Junction development on the Nepean River catchment. This assessment delineated the 106,000 ha of upstream catchment into 1000 ha sub-catchments for the purposes of the assessment. Refer to Figure 8 for catchment delineation.

The model assumed that the undeveloped portion of the catchment has a percentage imperviousness of 2 %. Other townships that contribute flows to the Nepean River upstream of Wilton Junction have been assessed by interrogating aerial photography and assigning appropriate percentage imperviousness to each catchment. A detailed breakdown of the adopted catchment areas, the percentage imperviousness and adopted catchment slopes for each detailed scenario are provided in Appendix B.

The high level assessment concluded that for those catchments that drain directly into Nepean River, the development will result in insignificant increases (less than 0.05%) in peak flows within the Nepean River. However, the development portion that drains to Allens Creek (see Figure 8 for details of the Allens Creek catchment) result in flow increases within Allens Creek itself that are noticeably higher than existing conditions (by up to 4 %). It should be noted that at the confluence of Allens Creek and the Nepean River flow peak at levels are less than existing conditions.

These preliminary results were presented to Manager of Planning, Mr Dick Webb from Wollondilly Shire Council in May 2013, where he confirmed that if additional, more detailed modelling concluded that increases within the Nepean River are negligible, then detention will not be required. However, within the Allens Creek catchment, where increases in post development flow has been identified, detention will be required.

With this advice J. Wyndham Prince have undertaken a more detailed assessment as described in the following sections.

10.5 Detailed XP-RAFTS modelling for Developed Conditions

A 'developed' condition *XP- RAFTS* model has been based on the latest Wilton Junction Masterplan. Development densities and resulting percentage imperviousness have been assigned in accordance with Table 10.4 below, which is derived from Wollondilly Shire Council guidelines.

TABLE 10.4 - PERCENTAGE IMPERVIOUS

Landuse	% Impervious
Residential (10 lots / hectare)	40%
Medium density (15 lots / hectare)	60%
Rural Residential	30%
Industrial / Commercial	90%
Road Reserve	70%
Public Recreation Area	10%

10.5.1 Calibration

It is normal practice for flood routing models such as *XP-RAFTS* to be calibrated with historical rainfall and streamflow data for the catchment being investigated in order to produce the most reliable flow results. Standard practice is that the "BX" factor is adjusted so that modelled result adequately reproduces observed hydrographs. As no streamflow records were provided for this location, comparisons are made against the Probabilistic Rational Method (PRM) and an updated procedure called the Australian Regional Flood Frequency Model (ARFF), developed as part of the current Australian Rainfall and Runoff (ARR) update project.

Whilst the PRM as outlined in Australian Rainfall and Runoff (ARR, 1987) has long been used in rural stormwater drainage design as a reliable estimate of peak flow rates, the more recent ARFF is still currently under development and it is suggested that results derived from using this method are not to be adopted in practice at this time.

During the development of the hydrological model, Wollondilly Shire Council provided a copy of the previous flood study for the Upper Nepean River (DLWC,1995) which used *RORB* calibrated to Flood Frequency Studies (FFS) to assess flows within the river .

A summary of the peak discharges at Maldon Weir was presented in the Upper Nepean River Report (DLWC, 1995) and we have undertaken an assessment a similar location for comparison purposes for this assessment with the results presented below in Table 10.5.

TABLE 10.5 – SUMMARY OF PEAK 100 YEAR FLOWS AT MALDON WEIR USING DIFFERENT ESTIMATION METHODS

Peak Discharges at Maldon Weir	Peak Discharge (m^3/s)	Storm Duration (hrs)
Upper Nepean River Study (DLWC 1995)		
Flood Frequency Studies (FFS)	6800	48
RORB	6500	48
J. Wyndham Prince's Current Assessments		
Probabilistic Rational Method (PRM)	4030	NA
Australian Regional Flood Frequency Model (ARFF)	2900	NA
XP-RAFTS (Bx = 1.0, Losses as per Table 10.1)	5800	36
XP-RAFTS (Bx=0.2, IL 60.0mm, CL 0.5mm/hr)	6400	48
XP-RAFTS (Bx=0.2, IL 60.0mm, CL 0.5mm/hr)	6700	36
XP-RAFTS (Unadjusted Post Climate Change)	6700	36

Adopted in Sections 10.6 - 10.8 (Basin Assessment)

Adopted in Sections 11 (Hydraulic Analysis)

The PRM and ARFF estimates are included in Table 10.5 for comparison purposes and are noted to be significantly lower than those flowrates which were determined at Maldon Weir in the Upper Nepean River Study (DLWC, 1995).

Notwithstanding, a calibration of the *XP-RAFTS* Model was undertaken to match the 6500 m^3/s flowrate at Maldon Weir (DLWC, 2005), by modifying both the Bx multiplier and loss parameters. Other catchment parameters such as 'pern' values and catchment areas were also reviewed.

Results of the calibration indicate that by adopting a Bx of 0.2, Initial Loss of 60 mm, Continuing Loss of 0.5 mm then similar results will be achieved at Maldon Weir. It is noted however that the need to reduce the Bx factor to 0.2 to match the DLWC study flow rates is considered to exceed standard calibration practices.

Since the model is primarily used to provide an indication on the impact of local flows throughout Wilton Junction, the *XP-RAFTS* model used in the Basin Assessment (Sections 10.6 - 10.8) has therefore adopted a default Bx factor of 1.0 in order to accurately reflect local conditions.

The Hydraulic Analysis in Section 11 has however adopted the 6500 m^3/s flowrate which was determined by the *Upper Nepean River Flood Study* (DLWC, 1995) as the upstream flows to Wilton Junction (at Maldon Weir). Refer to further discussion in Sections 10.9 and 11.

It is noted that the 6500 m^3/s flow determined by the *Upper Nepean River Flood Study* (DLWC, 1995) was not utilised within the Basin Assessment since the published hydrograph was only available for the 48 hour duration (see Plate 3.1 of this report). It is considered important that the basin assessment needs to consider the full range of durations (including the local peak 2 hour event).

10.6 Discharge Estimates

Discharge estimates were derived for the existing and developed catchments for 2 and 100 years ARI's. A range of storm durations from 30 minutes to 48 hours were analysed to determine the critical storm duration for each catchment. A 15% increase to all rainfall intensities have been applied to both the existing and developed case so as to provide a conservation assessment of flood impacts associated with Climate Change.

XP-RAFTS modelling was undertaken to determine the estimated peak discharges from the catchment for the following conditions:

- Undeveloped Site under existing rural conditions;
- Site developed without detention;
- Site developed with selected detention systems provided;
- Part site developed (Stage 1) without detention; and
- Part site developed (Stage 2) without detention.

The 2 and 100 year ARI peak discharges from the catchment are presented in Appendix B. The location of the comparison points are shown in Plate 10.1, in more detail in Figure 8, and the discharge values at these locations are listed in Table 10.6.

XP-RAFTS outputs for the basin under site fully developed conditions is provided in Table 10.7.

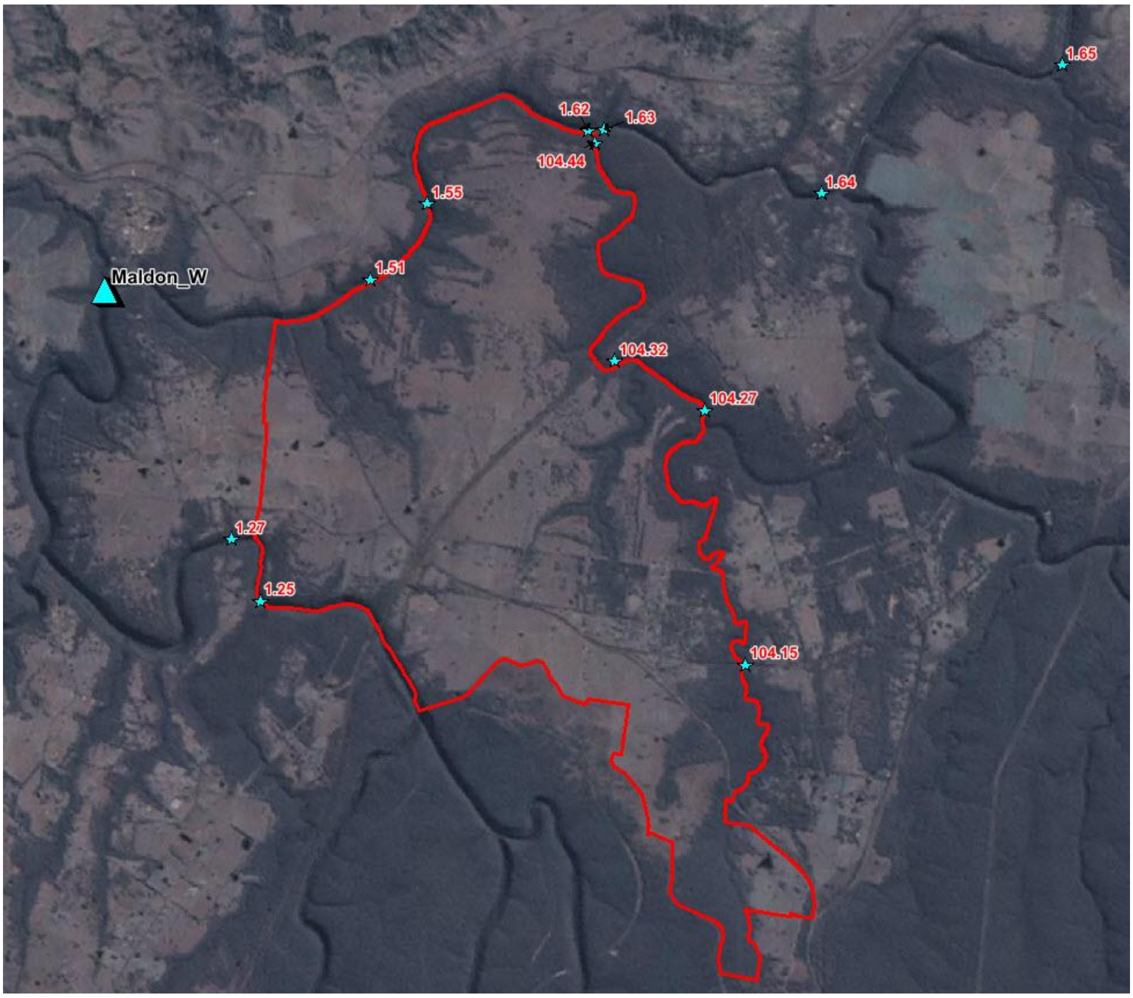


PLATE 10.1 – FLOW COMPARISON POINT LOCATIONS

TABLE 10.6 – SUMMARY OF PEAK FLOWS – 2 AND 100 YEAR ARI

Node	Peak Flows (m³/s)				Flow Change Ratio	
	Existing Conditions		Developed Conditions		Developed / Existing	
	2 yr ARI	100 yr ARI	2 yr ARI	100 yr ARI	2 yr ARI	100 yr ARI
104.15	50.9	140	47.4	133	-6.7%	-5.4%
104.27	96.0	256	93.1	247	-3.0%	-3.7%
104.32	120	315	119	303	-1.3%	-3.6%
104.44	130	343	129	332	-0.9%	-3.3%
1.25	1796	5077	1796	5076	0.0%	0.0%
1.32	1811	5087	1812	5087	0.1%	0.0%
1.51	2126	5791	2126	5791	0.0%	0.0%
1.55	2129	5800	2128	5799	0.0%	0.0%
1.62	2132	5815	2132	5814	0.0%	0.0%
1.63	2172	5938	2174	5939	0.1%	0.0%
1.64	2179	5965	2180	5966	0.1%	0.0%
1.65	2617	7166	2620	7168	0.1%	0.0%

Note: Developed Condition Flows include detention on Allen's Creek

10.7 Basin Performance

Storage in upper portions of Allens Creek are the most efficient and effective means of managing peak flows on Allens Creek. The optimal solution was identified as the construction of a single 35,000 m³ Detention Storage on-line to Allens Creek, upstream of Picton Road. This device would retain existing landform on the watercourse but would construct an elevated earth bank across the watercourse and provide a "slotted weir" type basin outlet.

The Detention Basin in Allens Creek does not assist in lowering peak discharges in the Nepean River, in fact, there are further minor increases in these flows as a result of the basin being in place. The results of the hydrological assessments indicate timings of peak flow discharges from the site are such that there is no practical means of compensating for these tiny increases in the much larger and substantially delayed peak flows on the Nepean River.

The proposed basin is to consist of a 5 m high embankment formed across Allens Creek approximately 200 m upstream of Picton Road, with the natural watercourse profile providing the storage behind the embankment. A detailed layout of the basin is provided in Figure 6.

The performance of the basin for the 2 and 100 year ARI storm events are detailed in Table 10.7 below.

TABLE 10.7 – BASIN PERFORMANCE – ON-LINE BASIN AT NODE 104.09

ARI Years	Peak Inflows (m³/s)	Storm Duration (min)	Peak Outflows (m³/s)	Storm Duration (min)	Flow Reduction (%)	Storage Volume Used (m³)	Stage Used RL (m)
2	22.9	540	21.6	540	94%	18400	227.4
100	64.6	120	63.5	120	98%	33760	228.9

10.8 Discussion of Results

The assessment indicates that there is some minimal increases in the Nepean River (less than 0.1 % during the peak 2 year ARI storm event and less than 0.025% during the peak 100 year ARI storm event) as a result of the development of Wilton Junction. These increases are insignificant and are within acceptable limits of the modelling accuracy for this (high level) rezoning assessment.

The introduction of the detention basin on Allens Creek upstream of Picton Road appears to have negligible influence on discharges within the Nepean River downstream of the confluence with Allens Creek.

Results of the assessments of the Stage 1 development indicate that the basin is not required for Stage 1, as discharges within Allens Creek are not increased as a result of the Stage 1 development of Wilton Junction. Further discussion on the results of the development under Stage 1 is provided in Section 14.

In addition, it was determined that discharges within Allens Creek are increased marginally over existing conditions as a result of the Stage 2 development. The construction of the basin will be required towards the end of the Stage 2 development phase depending on development sequencing.

10.9 Mainstream Flooding based on DLWC 1995 Modelling

As discussed in Section 10.5.1, the Hydraulic Analysis of Mainstream flooding considers the peak flowrate determined by the *Upper Nepean River Flood Study* (DLWC, 1995) as the upstream flows to Wilton Junction.

The *Upper Nepean River Flood Study* (DLWC, 1995) defined the flood behaviour in the Nepean River with a peak hydrograph for the 100 year ARI event at "Maldon Weir" as being 6500 m^3/s (refer to Plate 3.1). *XP-RAFTS* Modelling therefore includes:

- The peak hydrograph (6500 m^3/s at 48 hour duration) being applied at Node 1.46 (Maldon Weir);
- All catchments upstream from Maldon Weir nodes removed;
- The catchments which are (a) positioned downstream from Maldon Weir; and (b) draining to Allens Creek, have been maintained within the model;
- Bx multiplier = 1.0 applied.

For the purposes of Hydraulic Analysis, the revised 100 year ARI peak discharges which are aligned to the previous study (DLWC, 1995) are summarised in Table 10.8 with comparison points shown in Plate 10.1. Conservatively, those comparison locations which are positioned upstream of Maldon Weir (Nodes 1.25 and 1.27) are assumed at 6500 m^3/s.

It is noted that the peak hydrograph estimated by the *Upper Nepean River Flood Study* (DLWC, 1995) had a critical duration of 48 hours and therefore, the results listed in Table 10.8 are also for the 48 hour duration event only.

By adopting this revised approach, calibration is not required for the upstream catchment given the hydrograph is directly applied as an input to the *XP-RAFTS* model.

TABLE 10.8 – SUMMARY OF PEAK FLOWS – 100 YEAR ARI (ALIGNED WITH DLWC 1995 MODELLING)

Node	100 year ARI Peak Flows (m^3/s)		
	Existing	Developed	Flow Change Ratio
	100 yr ARI	100 yr ARI	100 yr ARI
104.15	140	133	-5.4%
104.27	256	247	-3.7%
104.32	315	303	-3.6%
104.44	343	332	-3.3%
1.25^	6500	6500	0.0%
1.32^	6500	6500	0.0%
1.51*	6521	6521	0.0%
1.55*	6529	6529	0.0%
1.62*	6545	6545	0.0%
1.63*	6644	6648	0.1%
1.64*	6668	6672	0.1%
1.65*	7964	7961	0.0%

^ Assumed conservative peak flow rate from Maldon Weir Hydrograph

*Calculated from model at 48hr duration with Maldon Weir Hydrograph

The results indicate that by adopting the *Upper Nepean River Flood Study* (DLWC, 1995) peak hydrograph, there continues to be only marginal increases in pre-post flows at Nepean River (less than 0.1 % during the 100 year ARI event). Whilst the revised 100 year ARI flows which are conveyed along Nepean River are generally 12.5 % higher than those shown in Table 10.6. Therefore the flowrates adopted in the hydraulic assessment is conservative.

11 HYDRAULIC ASSESSMENT

Due to the nature of the site providing numerous short, steep-sided watercourses draining catchments directly to major the watercourses (Nepean River and Allan's Creek) surrounding the project area, it was considered that detailed hydraulic flood assessment is not necessary to establish flood risks.

We have assessed the 92 catchment areas across the site and have determined that prior to discharge, most of the catchment areas are less than 40 ha. However, there are a four (4) of the catchments south of Picton road that are up to 20% greater than 40 ha and careful consideration will be needed in the master planning and detailed design of the road layouts and associated street drainage infrastructure so that these catchments are limited to 40 ha wherever possible. This will ensure that a traditional road and street drainage system will deliver the safe passage of flood flows to the sites major watercourses. This approach will also ensure that acceptable size and cost of pipe infrastructure can be delivered and that trunk drainage reserves are avoided.

A catchment plan has been prepared for the overall Wilton Junction site based on the existing terrain (refer to Figure 8 in Appendix A). The sub-catchment plan has confirmed that Wilton Junction generally grades from a ridgeline in the centre of the development area to the nearest major tributary (Nepean River, Allens Creek and Stringybark Creek). There are generally no upstream sub-catchment areas which drain through the proposed development areas which would necessitate formalised Trunk Drainage Channels.

Site discharges are expected to quickly drain from the site and are unlikely to be influenced by backwater from the Nepean River or Allens Creek. Results of the hydraulic assessments indicate that the tailwater levels are greater than 10 metres below the lowest development levels. To ensure that discharges within the Nepean River or Allens Creek do not impact the development extents, simple (and conservative) Manning's Calculations have been carried out to assess the expected hydraulic capacity of the major watercourses.

The hydraulic assessment of Wilton Junction was undertaken to:

a) Determine indicative flood heights for the 100 year ARI within the nominated cross section of the watercourses;

b) Determine whether the development is clear from the floodplain of the overall Hawkesbury / Nepean River catchment; and (c) consider both regional / local flood evacuation issues.

11.1 Catchment Roughness

A component that has a major influence on flow levels within a watercourse is the application of varying roughness factors. If a low roughness coefficient is adopted, the surface is smooth and flows travel more quickly with a lower flooding level. In order to conservatively assess the watercourse capacity, a high roughness coefficient has been adopted, artificially setting flood levels as high as possible, to determine whether the development has sufficient freeboard to regional flooding levels.

For the Wilton Junction hydraulic assessment, the adopted conservative roughness assumptions are summarised in Table 11.1.

TABLE 11.1 - ADOPTED MANNINGS ROUGHNESS COEFFICIENTS

	Adopted Manning's 'n'	
Description	**100 year ARI**	**Channel Capacity**
Watercourse Invert	0.07	0.07
Overbank Areas	0.20	0.10

11.2 Hydraulic Gradient

The longitudinal grade of the Nepean River and Allens Creek inverts are approximately 0.25% and 1.0%, respectively. An assumed top water hydraulic gradient is generally in accordance with the channel invert slope under normal flow conditions, however, a flatter gradient would provide a higher flood level.

In order to provide a conservative assessment, to ensure that the proposed development has sufficient freeboard to the regional flooding levels within the watercourses, a hydraulic gradient of 0.1% has been adopted for the Manning's Assessments for all profiles of both the Nepean River and Allens Creek.

11.3 Floodway Profiles

The hydraulic assessment was undertaken at a number of locations along the Nepean River and Allens Creek, immediately adjacent the site. The assessed profile locations are indicated on Figure 10 and in Plate 11.1 below and have been selected within areas of visibly narrow and steep-sided sections along the respective reaches. This is to ensure that the smallest sections of minimal flow area are assessed to determine the likely restrictive choke points along the watercourses. Again, these points have been assessed to provide the most conservative indication of the highest likely flooding level along the watercourses adjacent the lowest likely proposed development levels of the site within the area.

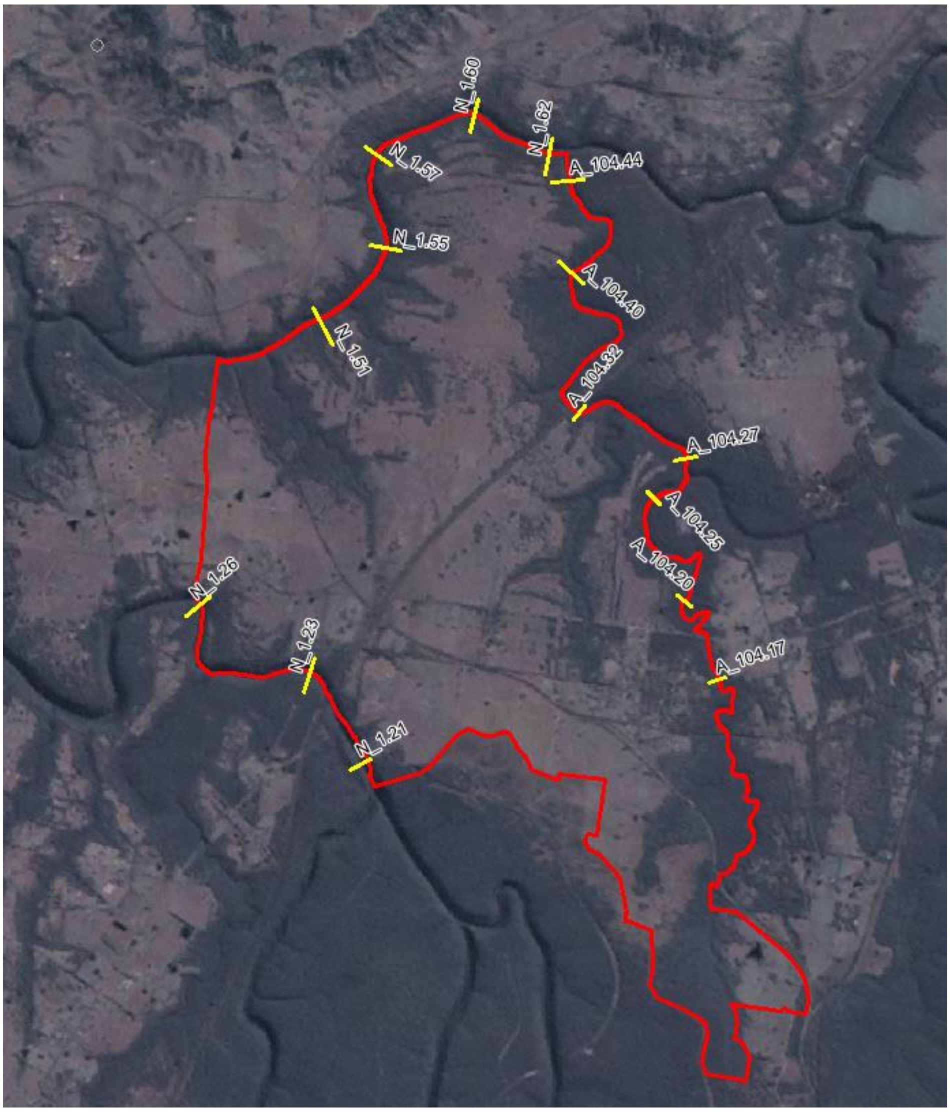


PLATE 11.1 – HYDRAULIC ASSESSMENT PROFILE LOCATIONS

The existing contour information for the Wollondilly Shire area have been sourced from LPMA and was utilised to assist in determining the section locations and provide the levels in the adopted profiles. The profiles adopted in the hydraulic assessment are provided along with the assumptions and results in Appendix C.

11.4 Adopted Discharges

As discussed in Section 10.5.1 and 10.9, the Hydraulic Analysis of Mainstream flooding considers the peak flowrate determined by the *Upper Nepean River Flood Study* (DLWC, 1995) as the upstream flows to Wilton Junction.

The peak 100 year ARI flows within the Nepean River and Allens Creek estimated by the *XP-RAFTS* model are summarised in Table 10.8. The Manning's calculations performed for the profiles within the Nepean River and Allens Creek have adopted these high flow rates in order to determine the maximum likely extent of flooding for the purposes of comparing against the proposed development footprint.

11.5 Modelling Results

The assessment results indicate that the Nepean River and Allens Creek watercourses adjacent the site are generally well defined with steep banks, providing adequate capacity to drain the regional 100 year ARI discharges around the site without inundating the future development area.

The profiles used in the Manning's Calculations show that the top width of the Nepean River is generally between 150 to 200 m, and Allens Creek ranging from about 70 - 100 m in the upper reaches to 100 – 150 m for the lower part of the reach with no flooding in developable areas.

The results of the hydraulic assessment is provided in Appendix C and a summary is presented below in Table 11.2

TABLE 11.2 – HYDRAULIC ASSESSMENT RESULTS

Node	100 year ARI Discharge (m^3/s)	Flow Velocity (m/s)	Flow Depth (m)	Top Water Level (m AHD)	Minimum Development RL (m AHD)	Minimum Freeboard to Development (m)
Allens Creek						
A_104.17	137	0.7	7.9	183.9	198	14.1
A_104.20	151	0.7	8.4	174.4	186	11.6
A_104.25	157	0.7	10.3	138.3	166	27.7
A_104.27	256	0.8	12.1	122.1	160	37.9
A_104.32	315	0.9	13.3	117.3	150	32.7
A_104.40	326	1.1	8.0	98.0	128	30.0
A_104.44	343	1.2	11.7	85.7	122	36.3
Nepean River						
N_1.20^	6500	1.6	45.5	175.5	214	38.5
N_1.23^	6500	1.9	57.4	181.4	188	6.6
N_1.26^	6500	2.6	29.5	149.5	176	26.5
N_1.51*	6521	1.8	45.2	117.7	132	14.3
N_1.55*	6529	1.6	44.7	112.7	130	17.3
N_1.57*	6533	2.0	42.3	110.3	122	11.7
N_1.60*	6544	2.1	41.3	101.1	120	18.9
N_1.62*	6545	1.7	41.9	105.8	120	14.2

^ Assumed conservative peak flow rate from Maldon Weir Hydrograph

*Calculated from model at 48hr duration with Maldon Weir Hydrograph

The results indicate that by conservatively adopting the larger upstream flowrate there continues to be sufficient freeboard from the proposed development land to the 100 year ARI flood level. The minimum freeboard is over 6.6 m which is well clear of the proposed Wilton Junction development footprint.

It is noted that those sections which are located upstream of Maldon Weir (N_1.21, N_1.23 and N_1.26) are considered to be extremely conservative since 6500 m^3/s has been applied, whilst it is more likely to be closer to 4800 m^3/s (from the J. Wyndham Prince assessment). Thus it is likely that a greater freeboard then is presented in Table 11.2 will be achieved.

Based on this assessment it is considered that more detailed Flood Modelling is not required to support the proposed Wilton Junction development.

11.6 PMF and Flood Evacuation

The majority of catchment areas across Wilton Junction are less than 40 Ha which minimises the need for trunk corridor elements (such as drainage channels, etc) and assists in controlling the flood impacts on the development layout. Flows from localised catchments will be conveyed via a traditional road and street drainage (minor / major) system safely to the nearest watercourse. It is recommended that a detailed assessment is undertaken at the detailed design stages of the development to ensure that the 100 year ARI event is safely conveyed in the road reserve and deliver a "low hazard" classification which is safe for vehicles and pedestrians. If necessary, provision will be made to upsize the pipe system capacity to ensure that there are no "hot spots" (i.e isolate high hazard areas in the final design).

It is noted that whilst the proposed Wilton Junction development is located within the overall Hawkesbury / Nepean River catchment, it is positioned well clear from the associated floodplain.

It is recommended that there should be no evacuation during a PMF event but rather a "shelter in place" approach. The type of event that would likely cause significant flooding within Wilton Junction will be a short duration high intensity storm (i.e a 2 hour storm duration which has reaches its peak in approximately 30 minutes). There is limited opportunities to activate any flood evacuation strategy given the timeframes in which a hazard will occur.

It is also our opinion that the nearby roads would be likely be inundated during extreme flood events and a flood evacuation may well send residents into hazardous flood waters which is considered to be unnecessary risk to life. Whilst flooding is unlikely to be higher than floor levels.

11.6.1 PMF Assessment – Regional

Manning's Calculations have been undertaken to demonstrate that the PMF event along the Nepean River does not extend to unacceptable levels within the proposed development areas of Wilton Junction. The adopted modelling approach includes (a) determine the hydraulic capacity of the floodway (to the development edge); and then (b) make comparison against the estimated flowrate for the PMF event. If the hydraulic capacity exceeds the estimated PMF flowrate, then the development is clear from the associated PMF extent.

A hydraulic assessment for Sections N_1.21, N_1.51 and N_1.62 are included in Appendix F. Refer to Table 11.3 for results.

TABLE 11.3 - PMF HYDRAULIC ANALYSIS RESULTS

Node	Floodway Capacity (m^3/s)	PMF Flow (m^3/s)	100 year ARI Flow (m^3/s)	Flow Ratio vs 100 yr (factor)
Upper Nepean River Flood Study				
Maldon Weir	-	13700	6500	2.1
Hydraulic Assessment				
N_1.21	45000*	-	6500	6.9
N_1.51	23500*	-	6521	3.6
N_1.62	20800*	-	6545	3.2

* Capacity of Section to development edge

The *Upper Nepean River Flood Study (DLWC, 1995)* estimated the PMF flow at Maldon Weir at 13700 m^3/s, which is **2.1 times** the 100 year ARI flow. The hydraulic analysis undertaken demonstrates that the capacity of the watercourse up to the development areas of Wilton Junction has the ability to convey up to **3.2 – 6.9 times** the 100 year ARI flow. Results therefore indicate that the capacity of the watercourse comfortably exceeds the PMF flow estimates which were determined by the *Upper Nepean River Flood Study (DLWC, 1995)* and subsequently would suggest that the proposed development at Wilton Junction is not impacted by the regional PMF event. Therefore large scale regional flood evacuation is unnecessary.

11.6.2 PMF Assessment – Local Catchments

It is anticipated that nearby roadways will be inundated during extreme events and impose a flood hazard if large scale regional flood evacuation was adopted as the strategy for Wilton Junction. Additional calculations have been undertaken to determine the possible depth of flood at a typical local road arrangement during the PMF event.

As noted in Section 11, sub-catchments at Wilton Junction are generally less than 40 Ha with the exception of four (4) isolated catchments south of Picton Rd that are up to 20 % greater than 40 Ha and will need to considered in the master planning stage and detailed design of the road layouts.

The 100 year ARI flowrate from a 40 Ha catchment has been derived from *XP-RAFTS* at 18.6 m^3/s, whilst the corresponding PMF flow would be in the order of 93 m^3/s (based on the general industry practice of adopting 5 times the 100 year ARI flow). Refer to Summary Table and in Appendix F.

The typical minor / major road system will convey 5 year ARI flows in the piped system, with the remaining 100 year ARI flows being conveyed overland. In "hot spots" the piped system will be increased to ensure that the roadway safely conveys flows in the 100 year ARI event with velocity - depth of less than 0.4 m^2/s.

For the purposes of this assessment, a typical roadway 20 m wide roadway was assessed. Refer to the typical road sketch in Appendix F. Assessment has allowed for the minor pipe system to be upsized so that it contains the peak 5 year ARI plus some additional capacity to ensure that overland flows are safely conveyed with a velocity-depth < 0.4 in the 100 year ARI event.

Results indicate that by applying a PMF flow to the standard 20 m road cross section, the flood depths are increased to 0.89 m and would be classified "high hazard". The "Shelter in Place" approach is therefore recommended.

11.7 In Stream Basin

The proposed regional basin at Allens Creek is for the purposes of detention only and is not intended to provide water quality treatment. The arrangement includes a single embankment and slotted weir across the watercourse. It is anticipated that Wollondilly Shire Council would be the asset owner.

The impact upon native vegetation imposed by the in-stream basin within the corridor is not anticipated to be significant given the proposed works will be limited to a single embankment and weir. It is anticipated that a Statement of Environmental Effects (SEE) would be undertaken to assess the potential impacts upon native vegetation in the proximity of the embankment as part of any future Controlled Activity Approvals for the works. Undertaking the assessment at the time these works are designed will provide a better understanding of the final configuration of this device.

12 WATER QUALITY ANALYSIS

The stormwater quality analysis for this study was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology, which is based at Monash University and was first released in July 2002. Version 5.10 (Build 16) was released in 2012 and was adopted for this study.

The model provides a number of features which are relevant to the Wilton Junction project:

- Determines the source pollutant loads which are generated from a variety of land uses (i.e. commercial, roads, residential, rural residential, etc)
- Ability to model the potential nutrient reduction benefits associated with Water Quality devices such as gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems and ponds. *MUSIC* includes mechanisms which enable stormwater re-use to be used as a treatment technique;
- Provides a mechanism to evaluate the attainment of both (a) Wollondilly Council's Water Quality objectives; and (b) Healthy Rivers Commission targets.

The proposed stormwater strategy for Wilton Junction includes a "treatment train" of Water Quality Control devices to treat runoff from both residential, commercial, rural residential and public domain areas prior to discharge to the downstream system. This "treatment train" includes rainwater tanks, bio-retention raingardens and water quality treatment ponds.

A *MUSIC* model has subsequently been created to demonstrate that the stormwater strategy will reduce the overall pollutant loads and concentrations being discharged from the proposed development to comply with target objectives. Refer to Section 7.2.2 for a summary of the Water Quality target objectives for the study.

12.1 Liaison with EPA and Healthy River Commission (HRC) Targets

A supporting letter from the EPA (dated 3rd December 2012) was considered by NSW Department of Planning & Environment in their development of the final Director General Requirement's (DGR's) for Wilton Junction. This letter contained a range of objectives for the management of stormwater and treated effluent for the project.

The Wilton Junction project team met with NSW EPA on the 24th May 2013 to present the proposed Water Cycle Management strategy for Wilton Junction. The proposed strategy was generally well received.

A subsequent meeting was held with the NSW EPA on the 25th June 2013 where the project team presented updates for both the Sewerage Treatment Plant design and the Water Cycle Management strategy. At this meeting EPA officers commented on the water quality targets adopted for these investigations. An email issued after this meeting confirmed the NSW EPA's position that the *"HRC target numbers are dated and difficult to apply and it will confirm the appropriate targets."* The NSW EPA subsequently confirmed (email correspondence dated 25th July 2013) that they believe that the targets most suitable for this development are the values for *'Mixed use rural areas and sandstone plateau'*. (Refer to Table 12.1 below)

TABLE 12.1 – HEALTHY RIVERS COMMISSION TARGETS

Water Quality Indicator (all values µg/l)	Forested areas and drinking water catchment	Mixed use rural areas and sandstone plateau	Urban areas - main streams	Urban areas - tributarry stream	Estuaries areas
Total Phosphorus					
NWQMS range	10-100	10-100	10-100	10-100	n/a
HRC recommendation	**50** (b)	**35**	**30**	**~50**	**30**
Measured range (a)	7.-50	10-740	10-100	50-360	15-30
Total Nitrogen					
NWQMS range	100-750	100-750	100-750	100-750	n/a
HRC recommendation	**700** (b)	**700**	**500**	**~1000**	**400**
Measured range (a)	100-800	200-3200	400-2200	500-15000	200-500

Consequently the nutrient concentration targets of **0.035 mg/L Total Phosphorus** and **0.07 mg/L Total Nitrogen** apply for the Wilton Junction project..

The information provided by the NSW EPA (email correspondence dated 25th July 2013) also included details of pollutant generation / loading rates which the agency consider applicable to various land uses in NSW(refer to Table D.8 within Appendix D).

A further meeting was held with the NSW EPA on the 25th October 2013 where the project team presented the final updates to the Sewerage Treatment Plant design and Water Cycle management strategy. At this meeting, EPA officers confirmed that the level of modelling undertaken in support of the proposal is suitable for rezoning assessment. Refer to sections 12.2 – 12.9 for further discussion on the modelling undertaken and for the result of the assessment.

12.2 Catchment Area Treatment Layout

The overall area of Wilton Junction is approximately 2612 Ha which includes the existing Wilton township, major roads and railways, protected forested areas and developable land from four (4) key stakeholders and other private land holdings. The overall area is broken up as follows:

- **Bingara Gorge (332 Ha)** is currently being developed by Lend Lease and has previously been approved for development by Wollondilly Shire Council for the construction of approximately 1165 lots and golf course.
- **Wilton Junction Development Areas (1457 Ha)** includes all developable land from the remaining key stakeholders (Bradcorp, Walker Corporation and Governors Hill) and numerous other private landowners. These development areas naturally grade to various natural depressions before discharging to Nepean River, Allens Creek and Stringybark Creek.
- **Wilton Township (53 Ha)** is located directly adjacent to Bingara Gorge and discharges to Allens Creek to the North-East. The proposed Wilton Junction development works do not currently include modifying land uses at the Township.
- **Remaining Areas (100 Ha)** comprises all major roadways & railways and protected forested areas which are outside of the development footprint.
- **Forested Areas (670 Ha)** includes all protected forested areas across the study area.

The overall catchment adopted in the Water Quality Assessment has an area of 2180 Ha and includes those contributing developed areas from Wilton Junction Development Areas and the Wilton Township and forested areas. For the purposes of this technical study, the "Remaining Areas" have conservatively been excluded from calculations as there are not planned to be developed. "Bingara Gorge" is also excluded from calculations since it has previously been approved. Refer to Section 12.2 for further discussion.

The following items have been considered in the development of the *MUSIC* model:

The overall catchment area was split into 12 sub-catchments based on the existing natural terrain and measured digitally within GIS software. The proposed road network, Masterplan layout, natural discharge positions and key stakeholder boundaries were also considered. Refer to Figure 9 in Appendix A and Plate 12-1;

The six (6) Water Bodies across Wilton Junction have a total area of 17.7 Ha (which includes 10.9 Ha for the two (2) treatment / evaporation lakes in Catchment M3). It is important to note that the two (2) treatment / evaporation lakes do not receive flows from the upstream stormwater catchments but instead treated effluent from the Sewage Treatment Plant will be directed to the water bodies to maintain their water level and aesthetic appearance. The areas of all Water Bodies have subsequently been excluded from the overall catchment area (i.e. decreases from 1512 Ha to 1494 Ha). Refer to Section 13 for discussion on treated effluent Management.

Details of percentage impervious for various land uses are listed in Table D5.1 of the *Wollondilly Shire Council's Subdivision and Engineering Standards (2008)* and are shown in Table 7.1.

In accordance with the *Draft NSW MUSIC Modelling Guidelines* (CMA, 2010), the sub-catchments were further defined based on landuses including "Commercial", "Rural Residential", "Roofs" and "Roads" with each assigned to a suitable source node. Base and Storm Flow Concentration Parameters for each type of source node are summarised in Appendix D.

"General Urban Impervious" and "General Urban Pervious" components were also derived for the remaining areas upon residential lots in order to suit the overall fraction impervious specified in Table 7.1, whilst "Parks" are assigned for all new residential urban parks. These areas were then also assigned to a suitable source node.

"Forest" nodes have been assigned for all bushland and riparian corridors within the study area – clear of development footprint.

Table 12.2 shows the percentage fraction impervious which has been adopted for each Source Node in *MUSIC*, whilst a full summary table of areas are included in Appendix D.

TABLE 12.2 – MUSIC SOURCE NODES

Source Node	% Impervious
Roof	100%
Roads	70%
General Urban Impervious	100%
General Urban Pervious	0%
Rural Residential	10%**
Park	0%
Commercial	90%

** We note that Council's default fraction impervious for "rural residential" areas is 30 %. J. Wyndham Prince consider this percentage to be relatively high given a typical 'rural residential" lot is expected to be in the order of 5,000 m^2, which would equate to 1,500 m^2 of impervious area per lot. Based on experience, we consider 10 % to be representative of a rural catchment, and has subsequently been adopted in this study. Similarly those lots marked as "large lot residential" and "larger residential" in the Masterplan have also been adopted at 10 %.

The Wilton Junction development includes areas which are classified as both "rural residential", "residential" and "medium residential". The proposed Stormwater Strategy requires each lot to include a rainwater tank, which will form part of the "treatment train".

Prior to connection to the formal drainage network, 50 % of roof drainage on each lot will be connected to individual rainwater tanks for reuse on site (refer to Section 12.4.1 for further discussion). The following assumptions have been applied to determine roof areas:

For "residential" and "medium residential" areas, the overall fraction impervious was applied in accordance with Table 12.3. A 200 m^2 dwelling is assumed upon each lot, with those remaining impervious areas being assigned as "General Urban Impervious".

TABLE 12.3 – RESIDENTIAL / MEDIUM RESIDENTIAL BREAKUP

Residential	Medium Residential	Source Node
20%	30%	Roof
20%	30%	General Urban Impervious
60%	40%	General Urban Pervious

For "rural residential" areas, a 300 m^2 dwelling is assumed upon each lot, with remaining areas assigned as "Rural Residential"

TABLE 12.4 – RURAL RESIDENTIAL BREAKUP

Rural Residential	Source Node
300m^2 per lot	Roof
remaining area	Rural Residential

Residential and Rural Residential areas shown on the Masterplan include a number of additional categories. For the purposes of modelling, these have been assigned a suitable source node as shown in Table 12.5.

TABLE 12.5 – RESIDENTIAL AREA CLASSIFICATIONS

Landuse	Average Lot Size (m^2)	MUSIC Source Node
Residential	10 lots / hectare	Gen Urban Imp & Gen Urban Perv
Rural Residential	5,000	Rural Residential
Large lot Residential	4,000	Rural Residential
Larger Residential Lot	10,000	Rural Residential
Medium Residential	15 lots / hectare	Gen Urban Imp & Gen Urban Perv

The Wilton Junction Development encompasses a total of 10,735 dwellings (excluding Bingara Gorge).

Road areas are assumed at 20 % of the overall area within “commercial”, “residential” and “medium residential” areas. Similarly roads at all “rural residential” areas are assumed at 10 %. Refer to summary table in Appendix D;

Runoff from development areas will be connected to the formal drainage network before being treated by a Gross Pollutant Trap (GPT) prior to discharging to downstream raingardens;

Special consideration was given to the Treated Effluent discharge to the proposed lake in Catchment M3. Refer to Sections 12.1.1 and 12.1.2 for discussion.

The *MUSIC* model adopted the above mentioned items and has assessed the performance of the proposed treatment devices. The “treatment train effectiveness” and “concentration levels for each of the sub-catchments and at key locations where flows are purposed to be discharged to the environment have been assessed. Modelling parameters are discussed in Sections 12.4.1 to 12.4.3, while results are discussed in Section 12.5 and 12.6.

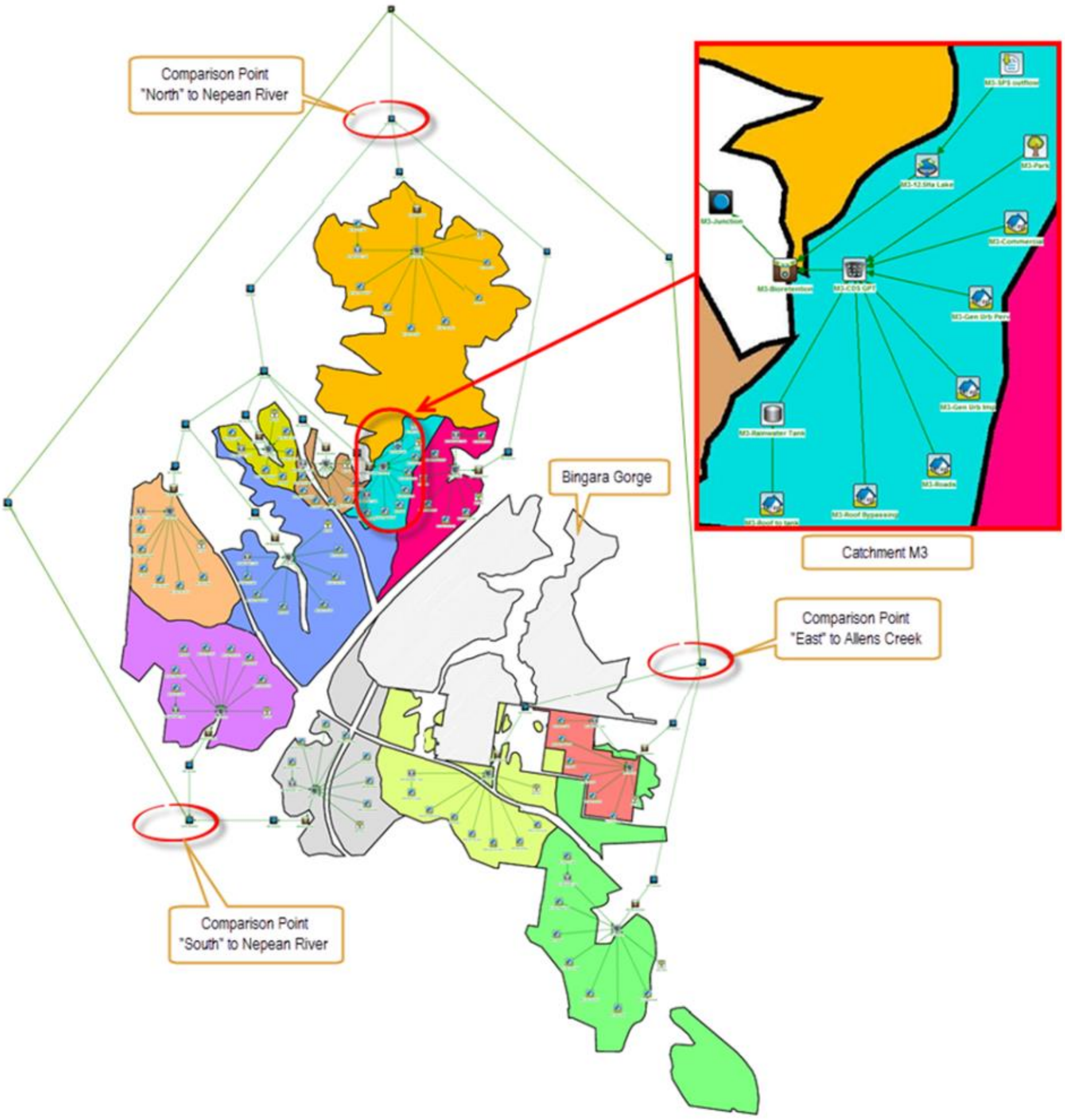


Plate 12.1: MUSIC model - Post Development
(9708MU5-Proposed Overall)

12.2.1 Rainfall Data

The *MUSIC* model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. In accordance with those recommendations from the *MUSIC* User Manual (CMA, 2010), a 6 minute rainfall data set has been selected for the subject site.

To select the appropriate dataset, rainfall records were obtained from the Bureau of Meteorology. The 6 minute data sets which are currently available for rainfall stations closest to Wilton were investigated. Results indicate that the data sets only have limited years available as well as extended periods of missing data.

The 6 minute data obtained for Liverpool between the years 1967 – 1973 was analysed and found to be a fair representation of the long term statistical data for the Wilton Area (Picton) and was therefore adopted in this study. The station used and the years of record selected are tabulated below.

TABLE 12.6 – RAINFALL DATA

Station No.	Location	Years of Record	Type of Data
67035	Liverpool (Whitlam Centre)	1967-1973	6 minute

A summary of the model rainfall data set (Liverpool 1967 – 1973) and that obtained from the Bureau of Meteorology for close the site (Picton 1880 - 2013) is shown below in Table 12.7.

TABLE 12.7 – SUMMARY OF RAINFALL DATA FOR THE SITE

Property	MUSIC Model Data Set (Liverpool) (1967-1973)	Bureau of Meteorology Data (Picton) (1880-2013)
Mean Yearly Rainfall (mm)	821.8	804.8
Highest Yearly rainfall (mm)	1159.5	1723.2
Lowest Yearly rainfall (mm)	503	303.2
Decile 1 rainfall (mm)	595.7	508.7
Decile 5 (median) rainfall (mm)	848.3	759.7
Decile 9 rainfall (mm)	998	1126.8
Mean No. Rain Days	115	97.1
Mean No. Rain Days > 1mm	80	71.3
Mean No. Rain Days > 10mm	23	21.4
Mean No. Rain Days > 25mm	7	7.1

The rainfall data summarised in Table 12.7 indicates that the data set used in the *MUSIC* modelling is a reasonable representation of long term statistical data. This is considered to be a conservative approach for the sizing of water quality devices since rainfall is typically higher for the adopted modelling dataset.

The rainfall and evapo-transpiration data for the period analysed is shown on the graph which is provided in Plate 12.2

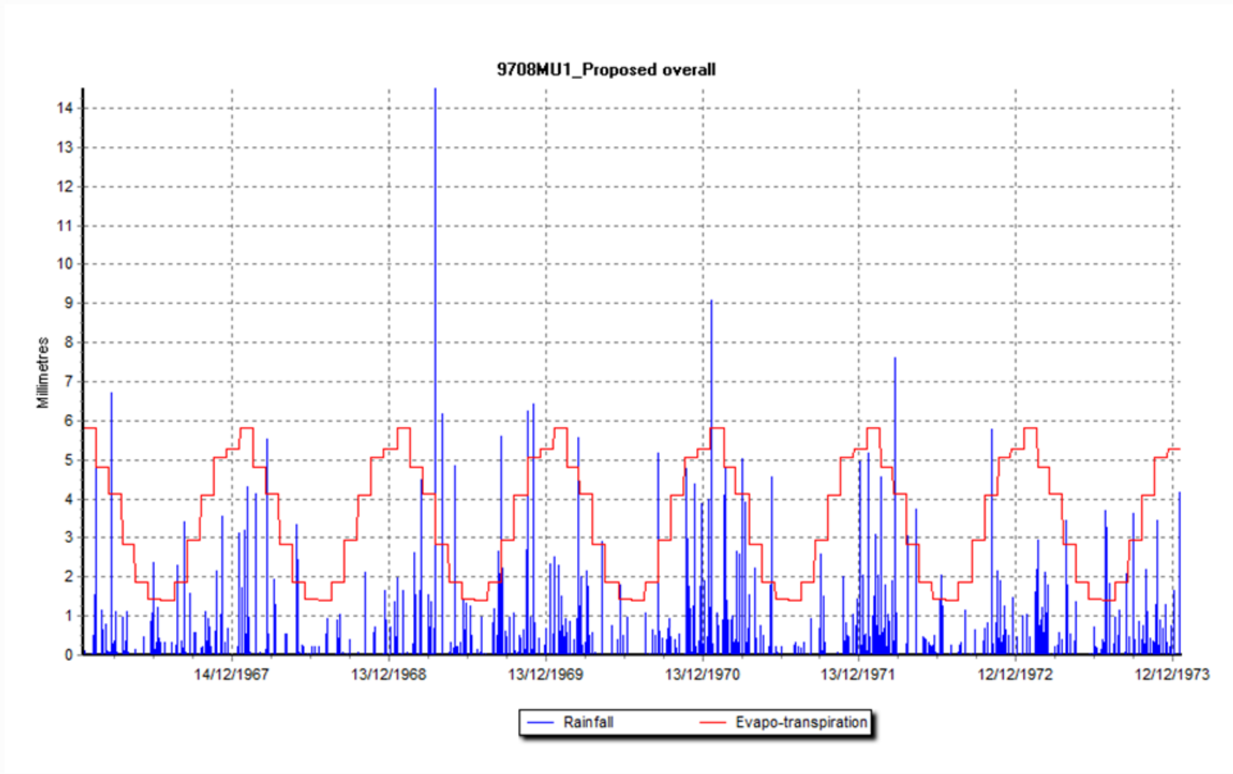


Plate 12.2 – Rainfall and Evapo-transpiration Data for Liverpool (1967-1973)

12.2.2 Soil / Groundwater Parameters and Pollutant Loading Rates

In the absence of site specific data, the soil / groundwater parameters and pollutant loading rates adopted for the urban catchments of Wilton Junction are based on the recommended parameters in the provided by the Department of Environment and Climate Change for areas within Western Sydney and the *Draft NSW MUSIC Modelling Guidelines* (CMA, 2010), respectively.

12.2.3 Treatment Device Performance

Each element of the treatment train, as represented in the *MUSIC* model, is described below.

Rainwater Tanks

As discussed in Section 12.1, rainwater tanks are to be incorporated for each lot which is located within the “rural residential”, “residential” and “medium residential” land use areas. At this stage, rainwater tanks have been conservatively excluded from “commercial lots. Refer to Appendix D for discussion and typical parameters adopted in modelling.

The impacts of the use of rainwater tanks provided on each residential lot were modelled using the “Rainwater Tank” nodes with the following design assumptions:

Minimum Connected Roof Area

It has been assumed that 50 % of all of the roofed areas will be directly connected to rainwater tanks. The remaining 50 % of the roof area is assumed to by-pass the rainwater tanks and discharge directly to the street drainage system.

Average Rainwater Tank Size

Nominal rainwater tank sizes were assumed to include:

3,000 L per tank per lot;

2,400 L of each rainwater tank is available for reuse (80 % capacity – assumed 20 % top-ups from potable water reticulation);

1.5 m high with 50 mm dia. overflow outlet per lot.

Average Reuse

The total number of lots was determined based on Table D5.1 of *Wollondilly Shire Council's Subdivision and Engineering Standards (2008).* As shown in Table 12.1, this includes:

10 lots per hectare for "residential",

15 lots per hectare for "medium residential"

Whilst the "rural residential" lots have varying sizes as shown in Table 12.6, Residential water demand is typically estimated based on the values presented in the Draft NSW MUSIC Modelling Guidelines by BMT WBM and CMA (2010). The external and internal usage for typical rural and urban residential households in indicated in Table D5 in Appendix D.

For Wilton Junction, rainwater tanks are assumed to store sufficient water for toilet and laundry (internal use). In today's water wise community we consider that the figures stated within Draft NSW MUSIC Modelling Guidelines significantly overestimate the external water use (i.e. gardens) and therefore we have conservatively excluded this reuse from our assessment.

The proposed Wilton Junction development will include a total of **2.93** occupants per dwelling. Based on Table D5 within Draft NSW MUSIC Modelling Guidelines, the water demand is therefore interpolated at **0.35 kL / day / dwelling.** Refer to Appendix D for further discussion.

TABLE 12.8 – SUMMARY OF AVERAGE TOTAL DAILY REUSE

Catchment	Dwellings (No.)	Daily Demand (kL/day)
M1	3317	1166.2
M2	804	282.8
M3	334	117.5
M4	221	77.6
M5	1121	394.0
M6	352	123.8
M7	674	237.1
M8	357	125.4
M9	517	181.9
M10	1112	391.1
M11	1602	563.2
M12 (Wilton Township)	324	113.8
Total	10735	

Litter and Sediment Control Structures

Gross Pollutant Traps (GPT) have been modelled in *MUSIC* to remove litter and coarse sediment prior to discharge into the bio-retention raingardens and then to nearby creeks.

GPTs are proposed to be installed on the pipe discharge outlets to each of the raingardens. In this high level assessment, each *MUSIC* catchment includes one (1) GPT and one (1) raingarden treatment node in order to represent all local devices. Further assessment would be required during future DA submissions to confirm exact sizes and locations of these devices.

The GPT treatment nodes adopted within *MUSIC* have been based on a proprietary GPT unit and has been applied with a 3 month high flow bypass.

Bio-retention Raingarden Systems

Bio-retention raingarden systems have generally been situated within each of the sub-catchments to ensure that stormwater runoff is captured and treated prior to discharging to the nearby creeks / protected forested areas. The position of all proposed raingarden devices are shown on Figure 5 in Appendix A with the following discussion:

- Each raingarden is typically located at the low point of the sub-catchment and clear of protected forested areas. Where possible, the raingardens will be positioned within the asset protection zone (APZ) or in instances where development is in close proximity to Riparian Corridors, within the outer 50 % of the Corridor as per the NSW Office of Water (NOW, 2012) guidelines in order to minimise landtake.
- The position of proposed raingardens will therefore generally be positioned within the Asset Protection Zone (APZ) as much as possible. In order to demonstrate the likely configuration of the bio-retention raingarden devices, a concept plan has been developed for a sample catchment (refer Figure 7 in Appendix A).
- This however is dependent on the width of the APZ (which varies between 10m and 60m) across the site. It is noted at those narrower APZ widths, landtake may be necessary in order to construct the raingarden device and associated outlet. These locations have been identified on Figure 5 in Appendix A and will need to be further investigated at DA stage.
- The size of each raingarden device has been limited to 4000 m^2 in order to optimise both it's constructability and its operations and maintenance efficiency. Additional raingardens are provided within those larger sub-catchment areas (where required).
- Several existing dams and Water Bodies are shown on the Masterplan. For the current modelling purposes, we have conservatively assumed that these water bodies do not provide any water quality treatment have been excluded from our assessment.
- It is noted that interim raingarden devices may also be required at Stage 1 in instances where the downstream raingarden is positioned in a future development area (i.e. Stage 2 or 3). Refer to Section 14 for discussion.
- Modelling parameters are discussed in Appendix D.

The size of raingarden devices were determined by iteration in *MUSIC*. Modelling results indicate that the required filter area of bio-retention raingarden devices is generally 1 % of the contributing catchment in order to achieve the target HRC concentration rates. Refer to the summary of raingardens adopted in *MUSIC* in Table 12.10.

TABLE 12.9 - SUMMARY OF RAINGARDEN SIZES

Catchment	Overall Area (Ha)	Percentage of catchment (%)	Raingarden Filter Area (m^2)	Raingarden Storage Area (m^2)
M1	319.7	1.0%	32000	32900
M2	74.8	1.0%	7500	8000
M3	35.9	1.0%	3600	3900
M4	24.1	1.0%	2500	2700
M5	179.0	1.0%	18000	18600
M6	32.3	1.0%	3300	3600
M7	101.1	1.0%	10200	10600
M8	154.6	1.0%	15500	16100
M9	127.8	1.0%	12800	13400
M10	153.5	1.0%	15400	16000
M11	236.8	1.0%	23700	24500
M12 (Wilton Township)	53.0	1.0%	5400	5700
	1493			

The raingarden treatment nodes adopted within *MUSIC* include an extended detention depth of 0.3m and a high flow bypass set at the 3 month ARI event.

12.3 Discussion on Healthy Rivers Commission Targets

The Healthy River Commission guidelines specify that the water quality objectives are *"indicative targets for management action in dry weather".* It is important to note that the MUSIC model assess "All Weather" continuous data sets at typically 6 min time steps (including both storm and dry weather conditions).

12.4 Modelling Scenarios

Five (5) scenarios have been modelled in MUSIC to assess the performance of the proposed Water Cycle Management scheme under a series of conditions. Details of the scenarios modelled are provided below:

Scenario 1 represents "existing" site conditions with all source nodes being defined as either "forest", "grazing" or "urban" in accordance with the EPA specified pollutant generation rates.

Scenario 2 builds upon the preliminary "post development" model developed as part of the Water Cycle Management scheme completed to date and includes the EPA's pollutant generation rates. It is noted that the nutrient rates specified by the EPA only include a single "Urban" node for residential development areas, whilst Wilton Junction is better represented by the full range of source nodes which occur in a residential area (i.e. roads, roofs, other urban area etc). The "Urban" node has been decompiled to reflect this arrangement. Detailed explanation as to our methodology in refinement of the pollutant generation rate to the more detailed landuse is provided in Appendix B.

Scenario 3 is identical to the "post development" assessment in Scenario 2 but includes the orthophosphate content of the filter media being adjusted in all raingardens from 40 mg/kg to 36.5 mg/kg. (refer to Section 12.5 for further details)

Scenario 4 is identical to Scenario 3 but considers the "driest" year only within the rainfall data set (1967-1973) used in the assessment. This scenario will assess the influence of drought conditions on discharge concentrations across Wilton Junction.

Scenario 5 builds upon Scenario 3 but splits the Water Cycle Management scheme so that treated effluent flows are assessed independently from stormwater runoff. Scenario 5 also allows for the proposed raingarden downstream from the two (2) treatment / evaporation lakes (10.9 Ha) to be optimised for treated effluent management only. The assessment has been developed to test a system that better fits within the current regulatory framework rather than the "Integrated" system proposed under Scenario 3

12.5 Orthophosphate Content of the Raingarden Filter Media

Bio-retention Raingardens consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 100-300 mm deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed (raingarden) or a linear swale (bio-swale) and are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. The surface of the bio-retention system can be grassed or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.5 to 0.6 metres deep.

Bio-retention Raingardens provide an effective means of removing nutrients from stormwater runoff and are proposed across Wilton Junction. An important component of their performance is associated with the *"Orthophosphate Content of the Media"* (which is measured in mg/kg). Based on experience, standard practice, the Orthophosphate content adopted for Scenario 2 as being 40 mg / kg (the MUSIC default).

It is however noted that lower values of orthophosphate content can be achieved for particular filtration media. Recent test results of filter media provided by supplier's such as "Benedict Industries" demonstrate orthophosphate content for filter media as low as 9.3 mg/kg and 28.9 mg/kg (refer to test results in Appendix A).

Subsequent advice from the MUSIC software developers also indicates that the default rates in MUSIC (i.e. 40 mg/kg) are only a guide, the *"concentration can be adjusted and set to the value of the media supplied".*

Therefore, there is a significant opportunity to specify a filter media mix with a lower orthophosphate content across all raingardens in order to comply with the water quality targets. That is, improving the water quality treatment at raingardens in order to effectively remove TP from both stormwater and treated effluent prior to discharge to the environment.

This approach was assessed in Scenario 3.

12.6 Proprietary Devices

One of the preliminary outcomes of the water quality modelling suggested that Total Phosphorus concentration was the controlling parameter to achieve compliance with the water quality targets. A number of manufacturers across the industry include a range of proprietary devices that are specifically targeted at reducing pollutant concentration levels in particular Total Phosphorus. There is opportunity for these devices to be incorporated within the treatment train to further treat flows and potentially achieve the required concentration targets. However, the current Water Cycle Management scheme (for Scenario 3) delivers the water quality targets without the need for additional proprietary devices.

Notwithstanding this we have provided a description of the potential alternative approaches to the management of water quality for the Wilton Junction if these proprietary device were to be considered as part of any future detailed design process.

12.6.1 StormFilter Cartridges

Stormwater 360 market a product known as "StormFilters". These devices are a passive, flow-through stormwater filtration system consisting of a vault that houses rechargeable cartridges filled with a variety of filter media. The StormFilter works by passing stormwater through the media-filled cartridges, which trap particulates and adsorb pollutants such as dissolved metals, nutrients and hydrocarbons.

Stormwater 360 have recently extended their research to include an alternate filter media known as "PhosphoSorb". *PhosphoSorb filtration media was developed specifically to target both the particulate and soluble phosphorus fractions in order to meet the most stringent phosphorus removal criteria.*

The following extract is taken from Stormwater 360's research paper (Contech, 2010), which is attached in Appendix A.

Based on the results of initial field and laboratory testing, the StormFilter with PhosphoSorb media is expected to capture and retain a substantial portion of the total phosphorus load in stormwater runoff by targeting both particulate and soluble phosphorus. Initial field results suggest ***removal of greater than 65% of the total phosphorus*** *load can be expected when influent concentrations exceed 0.1 mg/l. In instances when low influent concentrations are experienced (Influence EMC <0.1mg/l), initial field results indicate that the StormFilter with PhosphoSorb media is capable of reducing effluent concentrations substantially with median effluent total phosphorus EMCs near the method detection limit.*

At Wilton Junction, there is an opportunity for these proprietary devices to be incorporated, in particular, as part of the treatment train downstream from the two (2) proposed treatment / evaporation lakes (10.9 Ha).

12.6.2 JellyFish Filter

Humes market a product known as "JellyFish" filters, which is a tertiary stormwater treatment system. The system features an up-flow membrane filtration in an underground structure which uses gravitational forces to remove coarse sediments, particulate-bound pollutants (nutrients, toxic metals, hydrocarbons), free oils and floatable trash and debris.

Flows generally pass through a drain down cartridge into a filtration zone. Each filter cartridge (which consists of multiple tentacles) then separates fine particles and allows filtered water into the centre drain tube of each tentacle, the water then flows upward into a backwash pool prior to discharging the treated flows.

Technical specifications from Humes indicates a **59% removal of Total Phosphorus** and 51% removal of Total Nitrogen (Humes 2012) are possible. Refer to Appendix A.

For the purposes of this report, the Jellyfish Filters have not been modelled in MUSIC but are discussed to demonstrate that there are options available within the industry.

12.7 Modelling Results

Results for each of the Scenarios tested under "All Weather" conditions are presented below in Table 12.10

TABLE 12.10 – WATER QUALITY OBJECTIVES AND POLLUTANT DISCHARGE CONCENTRATION

		Concentration (mg/L)			
		TSS	TP	TN	Flow (ML/yr)
RECOMMENDED DRY WEATHER INDICATIVE WATER QUALITY OBJECTIVES[1]					
Mixed Use Rural Areas & Sandstone Plateau WQO's (Dry Weather)		-	0.035	0.700	
AVERAGE POLLUTANT DISCHARGE CONCENTRATIONS - DERIVED FROM MUSIC (All weather Conditions)					
Scenario 1 - Existing Site[2]		10.50	0.023	0.343	3678
Scenario 2 - Site Developed as per EPA requirements (including Forest Nodes[2]		2.04	0.046	0.576	8010
Scenario 3 - Scenario 2 plus a Orthophoste Content amendement[3]		2.04	0.032	0.576	8010
Scenario 4 - Scenario 3 assessed under dry weather conditions[4]		1.77	0.033	0.594	4030
Scenario 5 - Scenario 3 with a Split Integrated Water Cycle Management scheme[5]	treated effluent	2.09	0.0347	0.657	1590
	urban	2.44	0.032	0.451	6420
	overall	2.56	0.0347	0.621	8010

Notes

1. Dry Weather Water Quality Objectives Specified by Healthy Rivers Commission for the Hawkesbury Nepean River System (1998)
2. Based on Nutrient Generation Rates for various land uses provided by the EPA 25/7/13
3. Orthophosphate Content of Filter Media across all raingardens reduced from 40mg/kg to 36.5mg/kg
4. Rainfall data run under the most dry year (1968) from the dataset
5. Integrated system is split in order to assess treatment of (a) urban catchment flows; and (b) treated effluent flows separately

We have also determined the pollutant reduction performance of the water quality treatment train for Scenario 3 with details presented in Table 12.11 below. The assessment demonstrates that the water quality scheme presented for the Wilton Junction project will also be compliant with the Upper Nepean River Stormwater Management Plan water quality targets.

TABLE 12.11 – WATER QUALITY OBJECTIVES AND POLLUTANT DISCHARGE CONCENTRATION

	Pollution Load Reductions		
Catchment	**TSS (%)**	**TP (%)**	**TN (%)**
Upper Nepean Stormwater Mangement Plans Targets	80	45	45
Scenario 3	82.0	54.2	73.6

12.8 Discussion

The MUSIC assessment demonstrates the following performance outcomes:

- **Scenario 1** – Both TP and TN concentrations are significantly lower than the Urban Tributary and Mixed Use Rural concentration targets levels presented in the HRC document. It would be expected that actual runoff concentrations under existing conditions would be higher than the model is reporting due to the unsewered nature of the existing Wilton Township, which has not been accounted for in this modelling.
- **Scenario 2** – The "developed conditions" model with the EPA pollutant generation rates has resulted in some increases in overall TP and TN concentration in comparison to Scenario 1

- **Scenario 3 –** Iterations were undertaken in MUSIC to determine the maximum Orthophosphate Content for filter media (36.5 mg/kg) to be adopted across the whole of Wilton Junction development in order to achieve the targets of TP < 0.035 mg/L and TN <0.07 mg/L. Results indicate that 36.5mg/kg will achieve the overall targets as well as other key comparison locations to the South, East and North of the model. It is noted that filter media with orthophosphate content of 36.5 mg/kg or better is readily available from media suppliers

- **Scenario 4** – The year 1968 was selected as the "driest" year within the 6 minute dataset used in Scenario 3. The total annual rainfall of 506.5 mm is well below the median rainfall of 822 mm. Refer to Table 12.12 for average yearly rainfall used in this assessment.

TABLE 12.12– RAINFALL STATISTICS (1967-1973 WHITLAM CENTRE, LIVERPOOL)

Rainfall Statistics (1967-1973)	
mean annual rainfall (mm)	822
Year	**annual rainfall (mm)**
1967	871.6
1968	**506.5**
1969	1165.3
1970	825.4
1971	658.1
1972	893.4
1973	873.4

The adjusted range of rainfall data was then incorporated within the MUSIC model. Results demonstrate that the dry weather HRC targets of TP < 0.035 mg/L and TN < 0.7 mg/L are still achieved. See Table 12.10 for details

- **Scenario 5** – The treated effluent system was separated from the stormwater treatment system in order to assess whether a separate treated effluent management scheme could also deliver the same performance targets stipulated in the HRC document. Refer to Plate 12.3 for details of the how the "split" scheme was modelled.

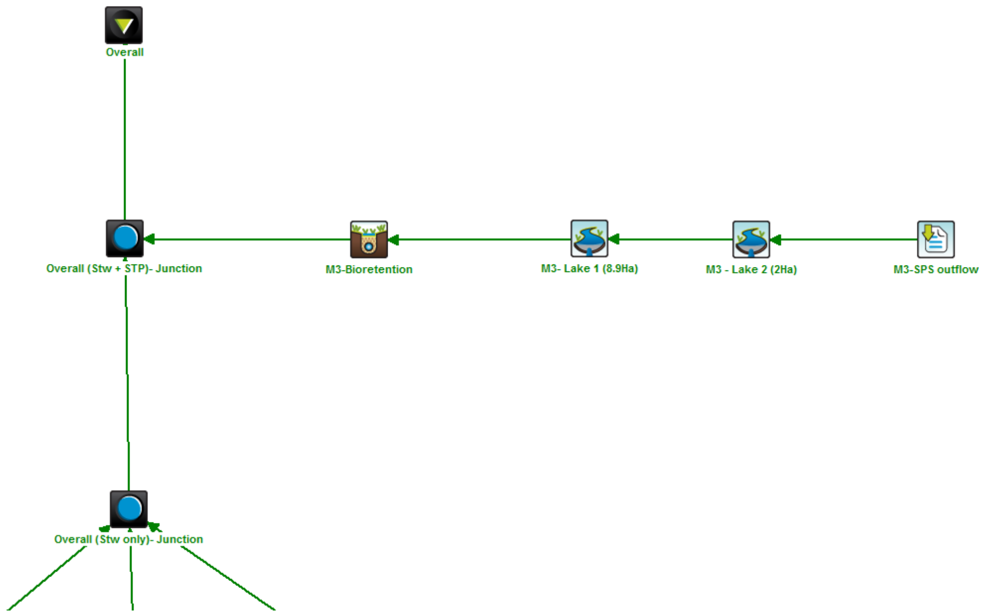


PLATE 12.3 – SCENARIO 5 MUSIC LAYOUT (FROM TREATED EFFLUENT MANAGEMENT)

Results indicate that a bio-retention raingarden (sized to 1075 m^2) located downstream from the two (2) treatment / evaporation lakes (10.9 Ha) will achieve the targets of TP < 0.035 mg/L and TN < 0.7 mg/L for treated effluent that surcharges from the lake. Similarly, results also indicate that stormwater runoff from the local catchment which was previously discharging to the same raingarden as the treated effluent, can, with a separate raingarden which manages only stormwater runoff, ensure compliance with the dry weather HRC water quality targets for TP and TN.

It is noted that the proposed raingarden downstream from the lakes is not a primary treatment device, but rather provides a final polishing on those low concentrations already being achieved by the sewerage treatment plant and other upstream treatment devices that form part of effluent management system.

It should also be noted that a number of raingarden configuration / management options are available that would allow the operation of the system in a manner that emulates the intermittent flows traditionally treated by raingardens (i.e. multiple devices that could operate on a day on day off arrangement). It would be appropriate to assess the need to adopt this approach during the design phases of the project.

12.9 Other Considerations

The following points should ne noted as part of the assessment related to Water Quality:

- There are no current statutory guidelines which require climate change to be considered with respect to Water Quality. It is noted however, that by taking Climate Change into consideration the overall average annual rainfall is expected to decrease (DECC, 2009) and therefore less pollutants being generated. We therefore anticipate that a Post Climate Change assessment would provide improved results. No software is currently available to undertake such an assessment.

- A comprehensive geotechnical investigation was undertaken by Douglas Partners and assess the impact on groundwater on the site. It is noted that infiltration to groundwater will be limited at Wilton Junction via conventional pipe system, impervious treatment devices and lined lakes.

- It is noted that modelling includes existing Wilton township with treatment being provided by a GPT and bio-retention raingarden. This is considered to be an important part of the overall strategy for the release area.

- The water quality targets that have been adopted are consistent with the recommendations setout in the Healthy Rivers Commission's Independent Inquiry into the Hawkesbury Nepean River System (HRC, 1998). This document requires an elevated level of water quality treatment which requires a consideration of pollutant concentration levels rather than standard urban development targets, which focus on a percentage reduction in pollutants discharging from the site.

  It is noted that the water quality targets nominated by the EPA and the Healthy Rivers Commission (for a "Mixed Use Rural & Sandstone Plateau") effectively assumes that all downstream areas are "sensitive" environments. Section 14 of this report also provides an assessment of the water quality treatment train against more traditional urban development requirements together with Council's adopted Stormwater Management Strategy. The results indicate that the proposed water quality treatment system would far exceed the Pollutant Load Reduction required in Council's DCP.

- In accordance with standard industry practice, provision will be made during the detailed design for maintenance access to all bio-retention raingardens. The placement of the raingardens on the outside of the perimeter road has been selected in order to receive flows and then discharge via an outlet to the nearby bushland.

It is noted that positioning the raingardens on the inside side of the perimeter road will impact on development potential and would still require the construction of a maintenance track as these devices are likely to be 1 – 2 m below road level to receive a pipe drainage outlet.

The current placement (on the outside of the perimeter road) is the optimal location given they are co-located in the asset protection zone and are consistent with industry practice at a number of recent residential estates. The final form and location of any water quality device will be subject to a separate DA application for Council's consideration.

- The MUSIC assessment has included proprietary CDS units as GPTs, however conservatively adopted zero pollutant removal for both Total Phosphorus and Total Nitrogen. A preliminary run has been undertaken in MUSIC to include a dry GPT with 10 % removal of Total Suspended Solids. Results indicate that there is minimal effect on the outcomes and the target objectives from Wollondilly Shire Council and the Healthy Rivers Commission are still achieved. J. Wyndham Prince therefore suggest that the type of GPT devices is selected at the DA stage.

12.10 WATER QUALITY SUMMARY

The *MUSIC* modelling demonstrates that the combination of rainwater tanks, gross pollutant traps, bio-retention raingardens with an orthophosphate content of 36.5 mg/kg and water quality control ponds will, when configured according to the "treatment train" proposed for Wilton Junction, reduce the priority pollutant loads to the required minimum concentration targets for a "Mixed Use Rural & Sandstone Plateau" as nominated by the EPA and the Healthy Rivers Commission.

In addition, a number of alternative proprietary stormwater treatment devices are also available to augment or vary the treatment train during the detailed design phases of the project. Modelling results demonstrate that these alternative approaches are not required.

It is important to note that the MUSIC results presented in the report are for "All Weather" conditions, yet still achieve the "dry weather" condition targets stipulated in the Healthy Rivers Commission documentation. Consequently, the Water Cycle Management scheme (Scenario 3) proposed for the Wilton Junction comfortably achieves the required water quality objectives specified in the Director General's Requirement's for the project and is recommended.

Results indicate that separating the treated effluent management scheme from the stormwater management scheme is viable and will still result in compliance with the water quality targets suggested by the EPA for the Wilton Junction project. This "split" system that was assessed under Scenario 5, aligns more closely with the current regulatory framework for licencing and operation of these systems and while it is a solution that is a little less "integrated" it is nevertheless a viable alternative to the recommended scheme.

The Wilton Junction Proponent will continue to work with authorities in order to develop a Voluntary Planning Agreement (VPA) that appropriately defines who will own and operate the water management infrastructure that is the subject of this assessment.

13 RECYCLED WATER DISPOSAL ASSESSMENT

13.1 Proposed Lake and Effluent Discharge (Sub-Catchment M3)

As discussed in Section 3.1.1, an investigation into the available options for sewage treatment and discharge has previously been undertaken by CH2M HILL Australia Pty Ltd (CH2M HILL, 2012). This report made recommendations that a central treatment facility(s) is to be adopted as part of the Integrated Scheme.

Assessment of the functionality and performance of the Integrated Scheme has since been undertaken by J. Wyndham Prince, MWH Global and VKL Consulting. The preliminary design of the Sewage Treatment Plant (STP) has been configured to deliver the agreed effluent quality criteria as listed in in Table 13.1 (MWH, 2013). These concentration levels have also been adopted within the *MUSIC* model using an "imported data" source node. It is noted that there may also be opportunity to even further optimise the Integrated STP / Recycled water design in the future.

TABLE 13.1 – POLLUTANT CONCENTRATIONS (RECYCLED WATER)

Pollutant	Concentration
Total Suspended Solids	6 mg/L
Total Nitrogen	6 mg/L
Total Phosphorus	0.1 mg/L
Sodium	<1200 ppm
Faecal Coliforms	<1000 cfu / 100mL
Enterococci	<230 cfu / 100mL

The effluent discharge from the proposed treatment facility is intended to be used for irrigation purposes on playing fields, parks and road verges whilst also discharging to the environment through the proposed two (2) treatment / evaporation lakes (10.9 Ha) within sub-catchment "M3". While there is a future opportunity to provide recycled water for employment lands, but these opportunities are conservatively ignored in this *MUSIC* assessment. Refer to the Water Cycle Schematic in Appendix A for further details.

The underlying soil sodium levels have been determined to be approximately 500 ppm. There may need to be some further refinement of this target value once a more specific geotechnical assessment have been undertaken which focuses on the treated effluent disposal areas. The ultimate level of sodium required from the STP will be dependent on both the underlying soil sodium levels and the selection of plants species. It is recommended that both geotechnical assessment and plant species selection would be determined at relevant Development Application stages for development at Wilton Junction.

In accordance with the MWH Report (MWHWWS, 2013) the estimate flow from the STP for Average Dry Weather Flow (ADWF) conditions will be 62 l/s or 5.35 ML/day. This flow has been used as input to MUSIC model. It is noted that evaporation from the two (2) treatment / evaporation lakes (10.9 Ha total) is performed within *MUSIC*.

13.2 Proposed Water Cycle Management Scheme

The Wilton Junction development proposes an "Integrated Scheme", which will include the integration and treatment of both Stormwater and Effluent before discharge to surrounding waterways.

We recognise that *MUSIC* modelling is typically adopted within the industry to assess pollutant removal rates of TSS, TP and TN from urban and / or rural sub-catchments. However as recommended by Cardno Ecology Lab (Cardno, 2012), the *MUSIC* assessment in this study is used to assess the performance of the *"Integrated System"* – which we understand from preliminary discussions with the EPA is one of the first of its kind.

In accordance with Wollondilly Shire Council's DCP, the *MUSIC* assessment is developed to demonstrate compliance with HRC standard targets with particular emphasis on Total Nitrogen and Total Phosphorus. Modelling includes those effluent discharges shown in Table 13.1 being adopted at a 'Source Node" which is directly connected to two (2) treatment / evaporation lakes (10.9 Ha total).

13.3 Recycled Water Disposal Study

VKL Consulting have undertaken investigations and have prepared a strategy for management of the sites recycled water titled: "Wilton Junction Precinct SEPP Study – Report on Treated Effluent Disposal System".

This particular report addresses the disposal of Treated Effluent produced by site based Sewerage Treatment Plant(s) and concluded that the Sewerage Treatment and associated Treated Effluent Disposal System is sufficiently flexible to accommodate development over a number of decades, occurring on a number of development fronts, at any one time because of diversity. The proposed treated effluent will be utilised partially as a resource and to provide improvement in overall amenity by creation of waterbodies, with water quality suitable for Secondary Contact activities.

A copy of the report is provided in Appendix E.

13.4 Discussion of Results

The assessment as detailed in Section 12, and the separate treated effluent assessment completed by VKL Consulting has concluded that the proposed Water Cycle Management Scheme for the Wilton Junction site will result in combined treated effluent and stormwater discharge concentrations that achieve the 'Urban Area – Tributary stream' concentration targets specified by the HRC for stormwater alone. Consequently, the assessment demonstrates that the Water Quality Objectives specified for the project are achieved.

14 STAGED DEVELOPMENT ASSESSMENT

The development of the Wilton Junction Project will be undertaken in stages, with construction phases extending well beyond the year 2031. The expected development timing has been identified (Connor Holmes (refer Plate 14.1) as follows:

- Current development areas (such as the existing Wilton Township and Bingara Gorge) are classified as "Existing".
- Stage 1 includes the construction of approximately 1700 new dwellings and is scattered across each of the three (3) Major Land Owners. Refer to Figure 3 in Appendix A.

The overall Stormwater Management Strategy is presented in Sections 8 to 13. In this Section however, a more in-depth assessment has also been undertaken for Stage 1. Discussion is also provided for those items which may require special attention during the detailed design of Stage 1.

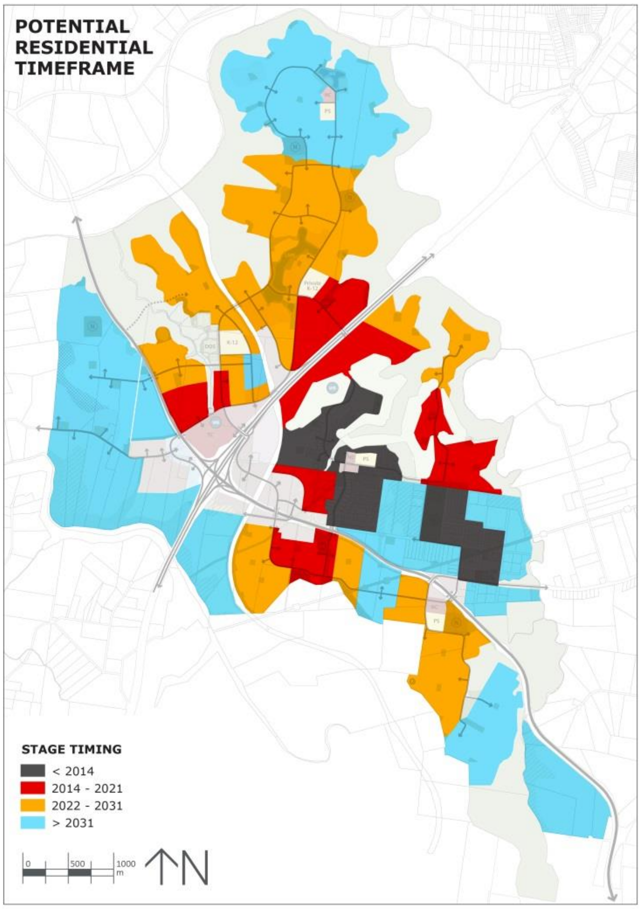


PLATE 14.1 – TIMING OF STAGES

14.1 Water Quantity

A Staged Assessment has been considered using the hydrological *(XP-RAFTS)* modelling as outlined in Section 10. "Scenario 1" has considered all Stage 1 proposed development areas with adjustments made to each sub-catchment based on fraction impervious, PERN values and the initial and continuing losses relevant for that stage of works. Results are summarised in Table 14.1.

TABLE 14.1 – STAGE 1 COMPARISON OF FLOWS

Node	Peak Flows (m³/s)				Flow Change Ratio	
	Existing Conditions		Stage 1 Developed		Stage 1 Dev / Existing	
	2 yr ARI	100 yr ARI	2 yr ARI	100 yr ARI	2 yr ARI	100 yr ARI
104.15	50.9	140	50.41	139	-0.87%	-0.61%
104.27	96.0	256	95.89	255	-0.14%	-0.57%
104.32	120	315	120	314	-0.03%	-0.33%
104.44	130	343	130	342	-0.07%	-0.32%
1.25	1796	5077	1796	5077	0.01%	0.00%
1.32	1811	5087	1811	5087	0.01%	0.00%
1.51	2126	5791	2126	5792	-0.01%	0.00%
1.55	2129	5800	2128	5800	0.00%	0.00%
1.62	2132	5815	2132	5815	0.00%	0.00%
1.63	2172	5938	2173	5939	0.03%	0.02%
1.64	2179	5965	2180	5966	0.03%	0.02%
1.65	2617	7166	2618	7167	0.05%	0.02%

Results indicate that as a result of Stage 1 works, there are only minimal increases (0.02% and 0.05%) in the peak flows during the peak 100 year and 2 year ARI storm events, respectively, in the Nepean River, along with decreases at flows in the Allens Creek Catchment. Consequently detention facilities are not required as part of Stage 1.

14.2 Water Quality

Consistent with the overall Stormwater Management Strategy, all Stage 1 development areas will include bio-retention raingardens , on-lot rainwater tanks and gross pollutant traps in order to achieve the required pollutant removal. The approximate locations of the raingardens are shown on Figure 12 in Appendix A, with exact locations to be confirmed during future design stages.

The following discussion is provided on Stage 1;

- Raingardens are generally located at the end of the system, prior to discharge to the nearby forested areas and / or water courses . The position of these raingardens will generally be located within the Asset Protection Zones (APZ) (where possible) with discharge to the natural environment via level spreaders /infiltration trenches or pipe scour protected discharges points (refer to Section 12.4.3 and Figure 7 for typical details)
- Landtake for the construction of raingardens is however required at locations where catchments are either (a) not positioned adjacent to an APZ; (b) positioned near an APZ with smaller widths (i.e. < 35 m); and/or (c) staging does not permit.

  Several Stage 1 development areas are positioned upslope from future Stage 2 and 3 development areas. In these instances, interim water quality devices (raingardens) will be required within the Stage 1 development footprint in order to ensure that water quality objectives are achieved. The construction of raingardens at these locations may require landtake and associated costs. Locations of possible interim raingardens are identified on Figure 12 in Appendix A;
- Several Stage 1 development areas are located downslope from future Stage 2 and 3 development areas. In these instances, the detailed design of Stage 1 infrastructure must consider future lead-in works to avoid unnecessary reconstruction of these devices in the future. Provision shall also be made for the future extension of the raingarden in order to service the upstream catchment (i.e. ensure available land take). Locations are identified on Figure 12 in Appendix A; and
- Gross Pollutant Traps are to be located over the piped outlets directly upstream from each raingarden.

15 PRELIMINARY CONSTRUCTION COST ESTIMATE

A Preliminary Cost Estimate has been prepared for Wilton Junction based on the Masterplan layout. Cost estimates are summarised in Tables 15.2 and have been broken up by *MUSIC* Catchments. Treated effluent disposal infrastructure and lake construction is also included in Table 15.2 This information will assist in the preparation of the Section 94 plan for the development.

The following assumptions have been adopted for construction purposes:

- 1% of catchment area is dedicated as the Bio-Retention Raingarden Filter Area across all sub-catchments (as per Section 12). An assumed construction rate is adopted at \$215 / m^2;
- At all raingardens, we have assumed a rock excavation depth of 0.5 m. Based on experience, cost of rock excavation for small scale earthworks such as raingarden construction can vary between \$90 - \$200 / m^2. We have adopted a mid-range rock excavation cost of \$150/ m^3 for the assessment,
- All rates include an allowance for Contingencies (15%) and for design, management and approval costs (7.5%);
- The associated timing has been divided amongst 10,735 lots (i.e. 11,900 [Total Lots] minus 1165 [Bingara Gorge lots]);
- All costs listed are inclusive of GST;
- Walls are assumed at each raingarden at a factor of 0.0516 x bed area and applied at \$350 / m^2;
- 20m long Level Spreaders are assumed at each raingarden and applied at \$50 / Lm.
- Rainwater Tanks will be adopted on-lots and are not included in the Cost Estimate since they will form part of the house construction costs;
- The costs associated with the Gross Pollutant Traps have assumed one (1) GPT per raingarden location. These are costed based on a CDS Unit and assumed at the rates shown in Table 15.1.

TABLE 15.1 - GPT COSTING RATE

CDS	
Area	**Unit Cost**
10Ha	\$50,000
10Ha - 20Ha	\$100,000
21Ha - 50Ha	\$200,000

TABLE 15.2 – COST ESTIMATE SUMMARY

Infrastructure Item	Total ($)
Water Quality	
Raingarden / Water Quality Facilities (including allowance for excavation)	$ 43,471,000
Retaining Walls associated with Raingardens	$ 2,715,000
Gross Pollutant Traps	$ 9,950,000
Level Spreaders	$ 76,000
Water Quantity	
Water Quantity (detention) Basin upstream of Picton Rd	$ 495,000
Treated Effluent Management	
Cascade Water Feature	$ 500,000
10.9Ha Lake Construction and Air Difusers	$ 11,689,255
Treated Effluent distribution Network, including (outlet controls, underboring, pumps, reticulation & rising main)	$ 9,650,000
Irrigation of open space and road verges	$ 6,432,740
Total	$ 84,978,995
Contingency (15% + 7.5% Management Fees)	$ 19,130,000
Total Stormwater Infrastructure Cost	**$ 104,110,000**

Whist the land areas required for Water Management is an integral component of a Section 94 contribution plan, the value of the land is variable and will be dependent on 1) the time the contribution plan being finalised and 2) the market value of the land. Therefore, we have excluded the cost of landtake for the above calculation at this stage and provide Table 15.3 below, that details the expected landtake areas across the study area.

Landtake for the construction of raingardens will be dependent on the final sub division layout and the required APZ areas surrounding these devices. We have assessed the anticipated raingarden locations and identified all preliminary APZ areas which are less than 35 m (which represent the minimum width that can wholly accommodate a raingarden), to determine the possible landtake areas across the study area.

Having determined the likely landtake locations, it was than assumed that 2% of the contributing catchment area would then be required for landtake purposes (i.e. 1% raingarden bed area and 1% for curtilage and batters).

TABLE 15.3 – LANDTAKE ESTIMATE

Catchment Name	Landtake Required (assumed 2%) (Ha)
M1	0.33
M2	0.52
M3	0.00
M4	0.00
M5	0.38
M6	0.00
M7	2.02
M8	0.28
M9	1.39
M10	3.04
M11	2.14
M12 (Wilton Township)	1.50
Total	**11.6**

16 SUMMARY AND CONCLUSIONS

The Water Cycle Management Strategy for Wilton Junction has been prepared to inform the Planning process and support the rezoning process for the site. The strategy has been prepared to conform with the statutory requirements and industry best practice for stormwater management in this catchment.

The Water Cycle Management Strategy consists of a treatment train consisting of on lot treatment, street level treatment and subdivision / development treatment measures. The strategy also address the DGR's for the rezoning and provide a cost effective development which contains the following structural elements:

- Proprietary GPT units at each stormwater discharge point.
- Seventy Six (76) proposed bio-retention raingardens of total area 149,260 m^2.
- Gravel soakaway/ level spreaders to distribute flows to the bushland perimeter.
- One (1) proposed regional detention basin on-line within Allens Creek (approximate total volume 35,000 m^3).
- A Recycled Water Management System consisting of;
  - A cascading raingarden system
  - Two (2) treatment / evaporation lakes (10.9 Ha total).
  - Irrigation of 49 ha of Active open space and road verges
  - Recycled water returned to employment lands for toilet flushing, irrigation, washdown and other suitable uses. [To be confirmed]
  - Distribution pipe and control infrastructure and polishing raingardens.

Provision of the proposed water quality treatment devices with an Orthophoste content of 36.5 mg/kg will ensure that the post development stormwater discharges will meet Wollondilly Shire Council's and the Hawkesbury - Nepean water quality objectives for the development.

The provision of WSUD elements within Wilton Junction will assist in minimising the impact of urbanisation on the waterway stability of the Nepean River and Allens Creek.

The hydrological assessment completed for the strategy has demonstrated that discharges along the Nepean River have had little impact due to the proposed development within Wilton Junction and that detention storages are not required for catchments draining directly into the Nepean River. The hydrological assessment has also demonstrated that a detention storage detaining discharges within the upper reaches of Allens Creek is sufficient to effectively restrict post development peak discharges to pre-development levels within Allens Creek.

Preliminary hydraulic assessments undertaken have determined that 100 year Post Climate change discharges through the major watercourses result in flooding levels well below the lowest proposed development levels. In addition, proposed urban catchments within the site have a size that is generally less than 40 ha and flows will be managed by conventional street drainage systems. Consequently, a more detailed flood assessment is not required for the development.

The proposed Water Cycle Management Strategy for the developed site provides a basis for the detailed design and development of the site to ensure that the environmental, urban amenity, engineering and economic objectives for stormwater management and site discharge are achieved.

The Water Cycle Management Strategy proposed for Wilton Junction is functional; delivers the required technical performance; lessens environmental degradation and pressure on downstream ecosystems and infrastructure; and provides for a 'soft' sustainable solution for stormwater management within the release area.

Wilton Junction includes a large number of 1st and 2nd order watercourses which are not considered to be "rivers" under the Water Management Act 2000 and are proposed for removal and / or to be replaced by urban drainage infrastructure.

A site inspection was undertaken to assess all watercourses which are proposed for removal. This assessment indicated that the majority of watercourses across Wilton Junction generally exhibit (a) no defined channel; (b) no overland flow (only a dry gully); and (c) only pasture grass. In most instances a defined channel was not observed and instead includes a very wide natural depression / flowpath. Where defined channels were observed, it is noted that the channel was typically eroded (due to livestock) and appears to have little ecological significance.

Those watercourses which are proposed for removal have been assessed with a description (and photographs) provided as to whether a defined stream banks exists, and made recommendations on whether the watercourse is a "river" under the act.

It is noted that there is a few watercourses which have currently been "undetermined" due to limited site access in some areas. We expect that these watercourses could also be removed, but will need to be confirmed during a future application to the NSW Office of Water in conjunction with development of these areas.

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18 GLOSSARY OF TERMS

12D Model is a powerful terrain modelling, surveying and civil engineering software package used to develop the underlying surface for the 2D modelling.

Airborne Laser Survey (ALS) is a technique for obtaining a definition of the surface elevation (ground, buildings, power lines, trees, etc.) by pulsing a laser beam at the ground from an airborne vehicle (generally a plane) and measuring the time taken for the laser beam to return to a scanning device fixed to the plane. The time taken is a measure of the distance which, when ground truthed, is generally accurate to + 150mm.

Average Recurrence Interval (ARI) means the average statistical interval (in years) between occurrences of floods, storms and flows of a particular magnitude.

Australian Rainfall and Runoff (AR&R) refers to the current edition of Australian Rainfall and Runoff published by the Institution of Engineers, Australia.

CatchmentSIM is a 3D-GIS application specifically tailored to hydrology based applications. CatchmentSIM is used to delineate a catchment, break it up into sub catchments, determine their areas and spatial topographic attributes and analyse each sub catchment's hydrologic characteristics to provide insight into the rainfall response of various catchments and the resultant assignment of hydrologic modelling parameters.

Council refers to Wollondilly Shire Council

Digital Terrain Model (DTM) is a spatially referenced three-dimensional (3D) representation of the ground surface represented as discrete point elevations where each cell in the grid represents an elevation above an established datum.

Floodplain Development Manual (FDM) and Guidelines (April 2005), the FDM is a document issued by DECCW that provides a strategic approach to floodplain management. The guidelines have been issued by the NSW DoP to clarify issues regarding the setting of FPL's.

Hydrograph is a graph that shows how the stormwater discharge changes with time at any particular location.

Hydrology The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.

J. Wyndham Prince Pty Ltd (JWP) Consultant Civil Infrastructure Engineers and Project Managers undertaking these investigations

MUSIC is a modelling package designed to help urban stormwater professionals visualise possible strategies to tackle urban stormwater hydrology and pollution impacts. MUSIC stands for Model for Urban Stormwater Improvement Conceptualisation and has been developed by Cooperative Research Centre (CRC),

Peak Discharge is the maximum stormwater runoff that occurs during a flood event

Probable Maximum Flood (PMF) is the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends." largest flood that could be

Triangular Irregular Network (TIN) is a technique used in the created DTM by developing a mass of interconnected triangles. For each triangle, the ground level is defined at each of the three vertices, thereby defining a plane surface over the area of the triangle

XP-RAFTS runoff routing model that uses the Laurenson non-linear runoff routing procedure to develop a subcatchment stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or a design storm utilising Intensity-Frequency-Duration data together with dimensionless storm temporal patterns as well as standard AR&R 1987 data.