Precise Planning

Concept Stormwater Management Assessment

Residential Rezoning Application – 45 Noongah Street and 25 Gwynn Hughes Street, Bargo, NSW

P1504816JR05V01
August 2015

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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

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1 Introduction

1.1 Overview

This report has been prepared to support a rezoning application for a proposed residential subdivision located at 45 Noongah Street and 25 Gwynn Hughes Street, Bargo NSW.

This concept stormwater management assessment provides a preliminary evaluation of the proposed development with respect to stormwater quality and quantity.

1.2 Scope

The scope of this assessment has been developed to address the objectives of Wollondilly Shire Council 'Planning Proposal Specialist Studies – 45 Noongah Street and 25 Gwynn Hughes Road, Bargo (2015), (WSC, 2011) *Development Control Plan (DCP)*, and water quality objectives as detailed in NSW Environment Protection Authority (EPA) (2000), *Stormwater Management Plan - Upper Nepean River Catchment Final Report*.

This report provides:

- Documentation of results of a conceptual water quality assessment.
- Preliminary treatment train specification to achieve nominated water quality objectives.
- Preliminary assessment of on-site detention (OSD) and stormwater quantity control requirements for the site.

1.3 Proposed Development

We understand that the proposal seeks to rezone the site to 'R5 – large lot residential' which will allow residential subdivision. A detailed layout has not been provided at this stage. However, the Client has indicated a yield of approximately 35 lots of minimum 4000 m^2 size.

1.4 Relevant Planning Controls and Design Principles

The following planning and engineering controls and design principles have been used:

- NSW Environment Protection Authority (EPA) (2000), Stormwater Management Plan - Upper Nepean River Catchment Final Report

- WSC (2011) Development Control Plan (DCP).

- WSC (2011) Local Environmental Plan (LEP).

- WSC (2008) Engineering Design Specification D5 – Stormwater Drainage Design.

- Sydney Metropolitan Catchment Management Authority (SMCMA) (2010) 'Draft NSW MUSIC Modelling Guidelines'.

2 Site Description

2.1 Location and Existing Land Use

The site is located at 45 Noongah Street and 25 Gwynn Hughes Road, Bargo (Lot 22 DP 619150 and Lot 95 DP13116) within the WSC local government area (LGA). It covers an area of approximately 20.69 ha and consists of undeveloped rural residential lands (Attachment A).

2.2 Site Investigation

A site inspection was completed on May 29th 2015, and included a walkover to review site conditions relating to drainage, topography, vegetation and lithology.

2.3 Topography and Vegetation

Site elevations range from 336 mAHD in the south west corner to 324.4 mAHD in the site's northernmost point. The site is split into three main areas by the confluence of Hornes Creek and an unnamed watercourse. The western portion slopes are generally towards the east and north east at 2%; while the southern and north eastern portions slopes are generally 1% towards the watercourses.

45 Noongah Street has been cleared in the past and is predominantly grassed with no existing man-made structures. The riparian areas which follow the two watercourses are thickly vegetated, making survey within the treeline difficult. 25 Gwynn Hughes Road is undeveloped and grass and shrub covered with trees 2-4m high.

2.4 Drainage

Two watercourses enter the site. Hornes Creek enters from the southern boundary. A smaller, unnamed creek from Berrico Playground enters via the eastern boundary and converges with Hornes Creek in the eastern portion of the site. Hornes Creek continues through and exits the from the north boundary. It is a tributary of the Bargo River (and then Nepean River).

Site drainage is unimpeded, with all areas draining into one or the other of the two watercourses.

2.5 Lithology and Soil Landscapes

The *Wollongong Port Hacking 1:100,000 Geological Series Sheet 9029-9129* (DME, 1985) indicates the site to be at the boundary of Wianamatta Group (Ashfield Shale) and Hawkesbury Sandstone. Ashfield Shale, mapped as underlying the eastern part of the site, consists of laminate and dark-grey siltstone. Hawkesbury Sandstone, mapped as underlying the western part of the site, typically consists of medium to coarse-grained quartz sandstone, very minor shale and laminate lenses. Sandstone and shale was encountered during borehole investigations.

The NSW Environment and Heritage eSPADE website identifies the western 2/3 of the site as having soils of the Lucas Heights soil landscape consisting of moderately deep hard setting yellow podzolic soils and yellow soloths on ridges and plateau surfaces and earthy sands in valley flats. The eastern 1/3 of the site is identified as having soils of the Blacktown soil landscape consisting of shallow to moderately deep hard setting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzic soils on lower slopes and in drainage lines.

3 Water Quality Assessment

3.1 Overview

The water quality assessment is conceptual and determines preliminary treatment measures required to achieve adopted water quality objectives for various development scenarios. It allows for a general specification of water quality structures and will require refinement at the development application (DA) stage.

3.2 Water Quality Objectives

WSC has recommended to adopt revised pollutant reduction water quality objectives based on the *Upper Nepean River Stormwater Management Plan* (EPA, 2000), *in lieu* of neutral or beneficial effect (NorBe) and regular treatment train effectiveness criteria specified in section D5.33 of WSC (2008) *'Design Specification D5: Stormwater Drainage Design'*, as per meeting with WSC on June 4th, 2015.

The following water quality objectives are to be achieved by the development when comparing the developed site with and without integration of water quality treatment measures:

- 80% reduction in total suspended solids (TSS).
- 45% reduction in total nitrogen (TN).
- 45% reduction in total phosphorus (TP).

3.3 Modelling Methodology

3.3.1 Overview

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

Modelling has been undertaken in accordance with SMCMA (2010) guidelines and the principles of WSUD.

A typical MUSIC model layout is provided in F101 (Attachment C).

3.3.2 Approach

An iterative approach was used for post development modelling to determine appropriate sizes of stormwater treatment devices for the site to achieve adopted objectives.

No proposed development layout has been provided and the assessment is for the purposes of rezoning only. Therefore, a number of post development scenarios were considered to determine minimum treatment requirements with increasing built (impervious) area. Scenarios considered were:

- 70% impervious and 30% pervious.
- 60% impervious and 40% pervious.
- 50% impervious and 50% pervious.
- 40% impervious and 60% pervious.

3.3.3 Climate Data

Although the site is not within SCA's drinking water catchment, pluviograph (rainfall) and potential evapotranspiration (PET) data was sourced from 'Zone 4' of SCA. This area is close in proximity to Bargo and also has similar topography. It is therefore reasonably considered to have similar climatic conditions to the site.

3.3.4 Input Parameters

Input parameters for source and treatment nodes are consistent with the SMCMA (2010). Attachment B summarises input parameters.

3.3.5 Catchment Areas

Given the conceptual nature of modelling, the development site was represented by a single source node of 20.69 ha with differing impervious/pervious percentages for each development scenario.

More detailed water quality modelling at DA stage should incorporate catchment break-down into different land use types (road, roof, etc.) and consider existing site hydrology.

3.3.6 Pollutant Generation

Stochastically generated event mean concentrations (EMC) were derived from SMCMA (2010) are summarised in Table 1.

Table 1: Adopted EMCs for source nodes.

Land Use	Parameter	Base Flow (mg/L)		Storm Flow (mg/L)	
		Log (mean)	Log (stdev)	Log (mean)	Log (stdev)
Residential	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	0.600	0.250
	SS	1.200	0.170	2.150	0.320

3.4 Treatment Train Philosophy

The preferred stormwater treatment strategy for the site aims to provide stormwater reuse, at source controls, and end of line controls in accordance with the principles of WSUD, to ensure treatment objectives are satisfied. Major treatment components include:

- Rainwater tanks.
- Bioretention structures (swale/dry bioretention basin).

The proposed treatment train is shown schematically in F101 (Attachment C).

Given that a proposed development layout has not been confirmed at this stage, stormwater solutions provide an indication of treatment requirements only. Water quality modelling requires refinement at DA stage to confirm treatment device sizing, location and type.

Individual SQIDs included in conceptual modelling are outlined in the following sub-sections.

3.4.1 Rainwater Tanks

Rainwater tanks have been included to harvest rainwater and provide some water quality treatment. Harvested rainwater will be utilised to satisfy a portion of non-potable water demands and irrigation demands. This has been included in the model as general outdoor reuse.

Each dwelling was assumed to require one 5kL rainwater tank to accommodate an approximate 1500m² minimum lot size. Rainwater tank specifications remained constant for each scenario.

The total number of dwellings (and hence the cumulative tank volume and cumulative demand) was based on discussions with the project planner.

3.4.2 Bioretention Structure(s)

Bioretention structure(s) (swales or basins) are likely to be required for end of line treatment prior to discharge to OSD structure(s). These may be separate or incorporated into the OSD structure(s) depending on proposed subdivision layout.

Bioretention structures provide treatment through filtration, biological uptake of nutrients, infiltration, evapotranspiration and detention.

For the purposes of this assessment, bioretention detention depth and filter depth remained consistent for each development scenario. This allowed surface/filter area required to be determined through iterative modelling. Results are provided in Section 3.5.

3.5 MUSIC Results

A full set of MUSIC modelling results are provided in Attachment B. Results demonstrate that water quality objectives are met for each development scenario assuming the minimum bioretention areas in Table 2 are provided.

Table 2: Conceptual bioretention sizing for each development scenario.

Scenario[1]	Surface Area[2] (m^2)	Surface Area Rate[3] (m^2 / ha)
40% Impervious	1080	52.20
50% Impervious	1180	57.03
60% Impervious	1280	61.87
70% Impervious	1380	66.70

Notes:

[1] Future impervious area may fall between these values and may need to be re-evaluated.

[2] Assuming the entire site is being developed.

[3] Rate will depend on final % impervious.

3.6 Conclusion

Conceptual MUSIC modelling demonstrates that at a maximum of 70% impervious area, water quality objectives can be met using a treatment train that utilises at source and end of line treatment structures in accordance with the principles of WSUD.

Refinement of the water quality model will be required at DA stage may alter the sizes and nature of proposed treatment structures, however, performance outcomes of final design are to achieve performance standards provided in this report.

4 Water Quantity Assessment

4.1 Overview and Objectives

The water quantity assessment is conceptual and determines the preliminary on-site detention requirement for the site. Given that the proposed development layout has not been confirmed at the time of writing this report and that this assessment is for the purposes of a rezoning application only, management requirements provide an indication only and will require further refinement at subdivision stage.

Management objectives for the site are broadly outlined as follows:

- Describe requirements for management of minor (piped) and major (overland flows) at the site.

- Provide recommendations for Site Storage Requirements (SSR) to satisfy On-site Stormwater Detention (OSD) requirements.

4.2 Stormwater Quantity Objectives

Site stormwater quantity performance objectives are consistent with WSC Engineering Design Specifications (2008). Objectives are outlined in the following sections.

4.3 Minor and Major Flow System

The site is required to include a stormwater drainage system designed based on a 'minor' and 'major' system, defined as:

1. Minor system – carry all flows up to the 10 year ARI event by way of a pit and pipe network.

2. Major system – carry all flows up to the 100 year ARI event by way of overland flow paths.

4.4 Detention and Site Discharge Requirements

1. The discharge from the post developed site is not to exceed the rate of runoff from the pre developed site for all storms up to and including the 1% Annual Exceedance Probability (AEP) storms for all durations.

2. The size of the OSD is to be based on all flows up to the 1% AEP storm.

4.5 Modelling Methodology

4.5.1 Overview

The DRAINS hydrological and hydraulic modelling package was utilised to determine preliminary requirements for site OSD including PSD and SSR. Design rainfall intensity data were in accordance with Section D5.04 of WSC Engineering Design Specifications (2008).

Key assumptions used in the modelling included the following:

- The site area was taken as 20.69ha.

- The pre development site was modelled as 100% pervious.

- The post development site had varying impervious areas based on four separate scenarios to review the variability of any proposed development:

  a) 40% impervious site coverage (including roofs and pavement) with the remaining 60% consisting of pervious site coverage (including landscaping and areas unchanged by the development).

  b) 50% impervious and 50% pervious.

  c) 60% impervious and 40% pervious.

  d) 70% impervious and 30% pervious.

- The DRAINS model assumed that the entire site drains to one OSD system.

- OSD tank depth is 1.5m for all scenarios.

- Two low flow outlet pipes of 375mm each was assumed at the basin invert. High flow outlet was modelled as twin 750mm pipes located 0.5m above the basin invert with a circular culvert outlet.

- o OSD spillway was assumed to be 4m wide for all scenarios.

4.5.2 Approach

The DRAINS model was run for the following storms:

- o 1 in 5 year ARI.
- o 1 in 20 year ARI.
- o 1 in 100 year ARI.

For each ARI, durations of between 5 minutes and 4.5 hours were run to determine the critical storm duration(s) and peak site discharges. For the 5 and 20 year ARI, the peak event was determined to be the 90 minute storm. For the 100 year ARI, the peak event was determined to be the 60 minute storm.

4.6 DRAINS Result

Results of DRAINS modelling are summarised in Table 3.

Table 3: Results of DRAINS modelling.

Scenario[1]	ARI	Peak discharge (m^3 / s)		OSD Volume[2] (kL)	SSR[3] (kL / ha)
		Pre Development	Post Development		
40% Impervious	5	2.40	2.07	3900	188
	20	3.98	3.70		
	100	5.51	5.11		
50% Impervious	5	2.40	2.09	4350	210
	20	3.98	3.72		
	100	5.51	5.10		
60% Impervious	5	2.40	2.11	4800	232
	20	3.98	3.72		
	100	5.51	5.10		
70% Impervious	5	2.47	2.33	5300	256
	20	3.98	3.72		
	100	5.51	5.10		

Notes:

[1] Future impervious area may fall between these values and may need to be re-evaluated.

[2] OSD = on-site stormwater detention volume for the entire site.

[3] SSR = site storage requirement.

4.7 Conclusion

Results of hydraulic modelling suggest that OSD requirements increase from 188kL/ha to 256kL/ha with increasing impervious area. Although these have been modelled as one single structure, OSD requirements may be achieved by a number of smaller detention basins or tanks in individual buildings.

Detailed design of the OSD system including position, dimensions, orifice control and volume will need to be undertaken at the DA of the development. Modelling will also need to consider site hydrological catchments and catchment discharge into each watercourse to ensure environmental flows are maintained.

5 References

Engineers Australia (2015) Australian Rainfall and Runoff, 4th Edition.

Hazelton P.A. and Tille P.J. (1990) 1:100 000 Wollongong Port Hacking Soil Landscapes Series Sheet.

NSW Department of Mineral Resources (1985) 1:100,000 Wollongong Port Hacking Geological Series Sheet.

NSW Environment Protection Authority (EPA) (2000), *Stormwater Management Plan - Upper Nepean River Catchment Final Report*.

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

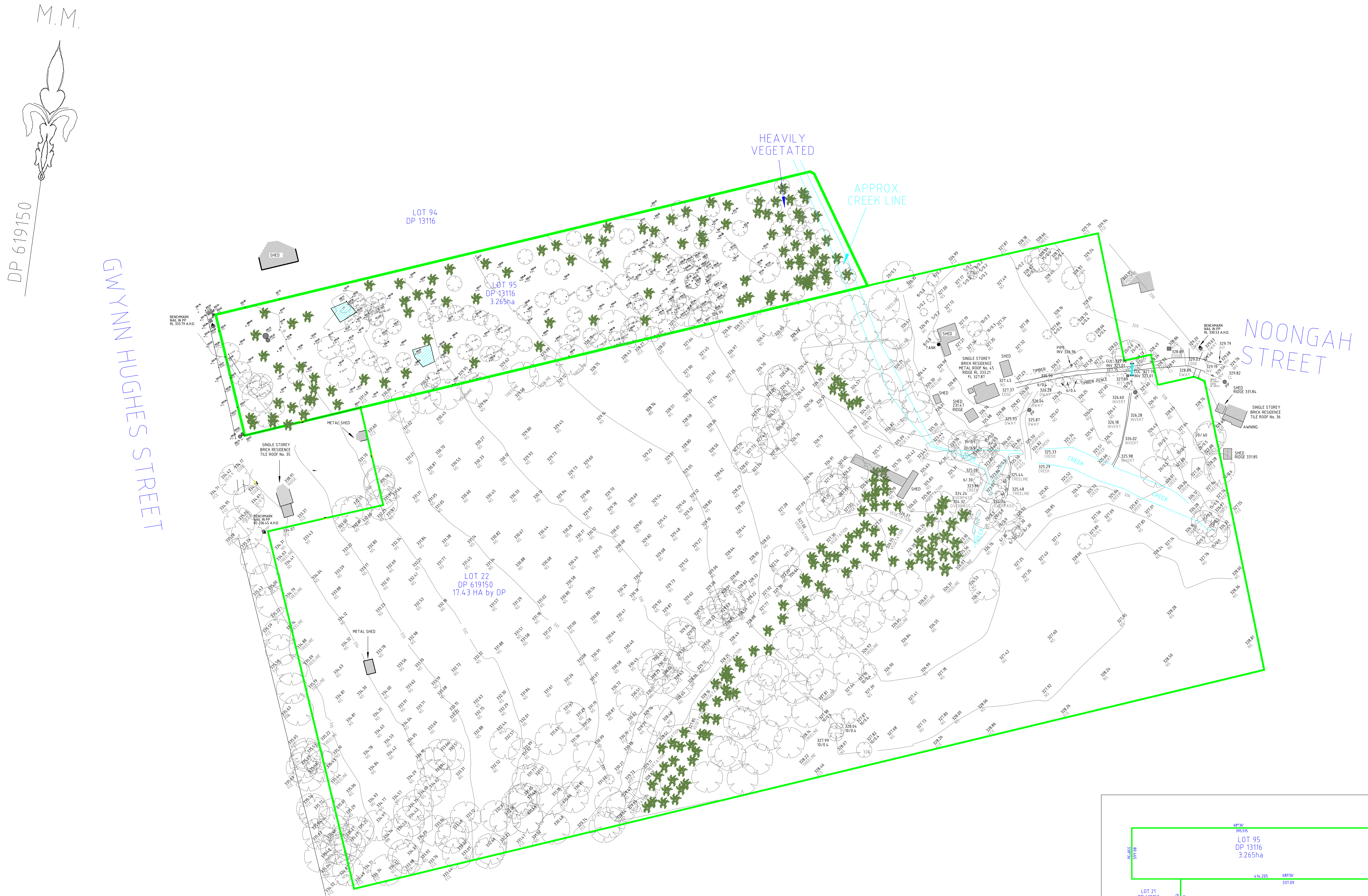
WSC (2015) *Planning Proposal Specialist Studies: 45 Noongah Street and 25 Gwynn Hughes Road, Bargo.*

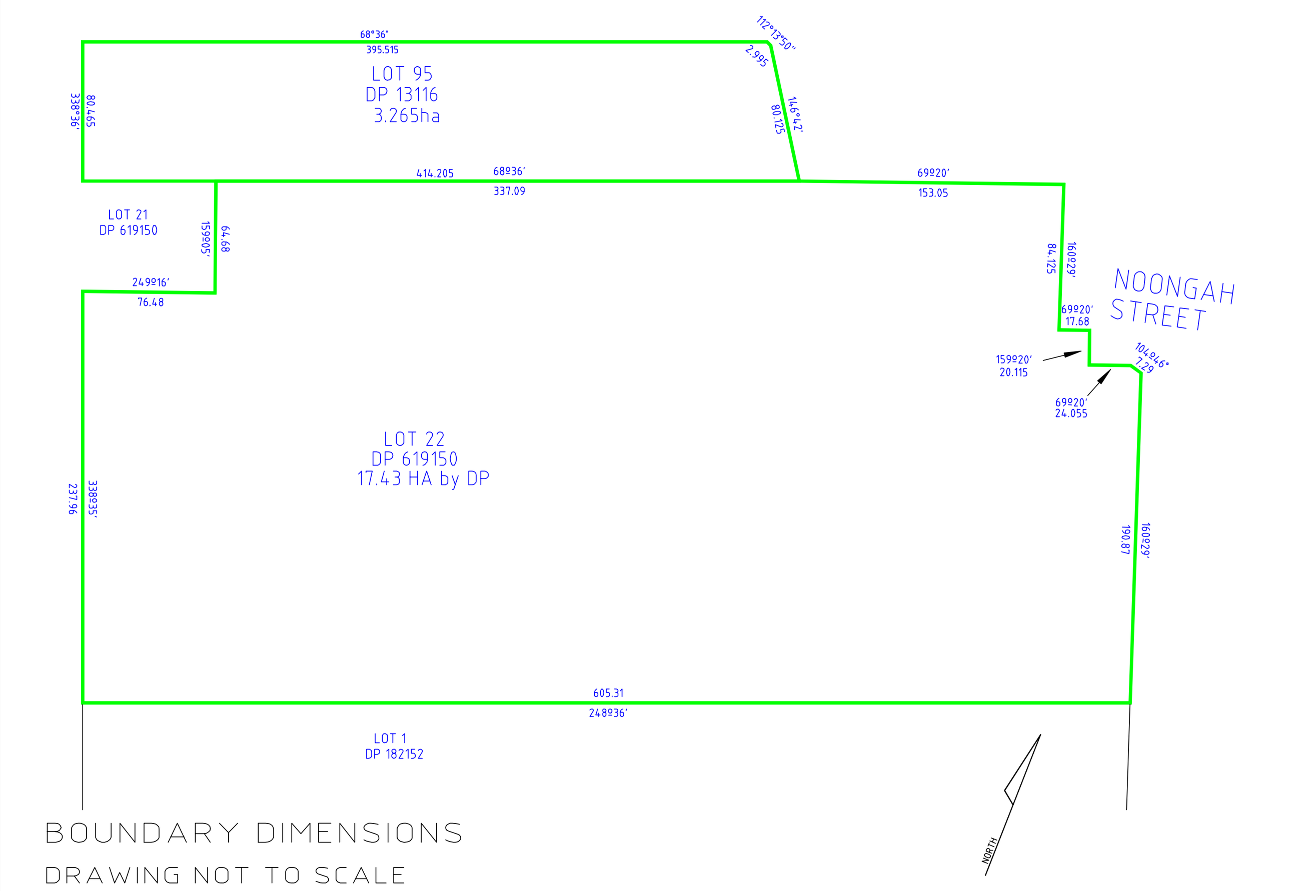
WSC (2011) Development Control Plan (DCP).

WSC (2011) Local Environmental Plan (LEP).

WSC (2008) *Design Specification D5: Stormwater Drainage Design.*

6 Attachment A – Existing Site Plan





NOTE:
SURVEY RECEIVED FROM SYDNEY REGISTERED SURVEYORS, PLAN REFERENCE 1056 NOONGAH

REV.	DESCRIPTION	DATE	ISSUED
A	FOR REZONING	05.08.2015	JF

BAR SCALE

0 25 50 75 100 125 150

UNITS - METRES

DESIGNED:	DATUM:
BL	mAHD
REVIEWED:	HORIZONTAL RATIO:
JF	1:1500
PAPER SIZE:	VERTICAL RATIO:
A1	1:1500

CLIENT / PROJECT

Preliminary Flood Study:
45 Noongah Street and
25 Gwynn Hughes Street,
Bargo, NSW

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified

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TITLE:	DRAWING ID:
EXISTING SITE SURVEY	F001

PROJECT MANAGER:	PROJECT NO.:	FILE:	REVISION:
JF	P1504816	JD03V01	A

7 Attachment B – Summary of MUSIC Input Parameters & Results

Attachment B: MUSIC modelling input parameter values and source.

Element	Factor	Input	Source
Setup	Climate File	Climate file (mlb file) from SCA Zone 4 due to close proximity to Bargo site.	SCA. Although site is not part of the SCA, it has similar topography and climate to Zone 4 of the SCA and so utilising for Bargo is considered appropriate.
Source Nodes	Node Type	Residential node with varing impervious area depending on scenario.	As per SMCMA (2010)
	Rainfall Threshold	Based on land use type or surface type as specified in Table 3.6 of SMCMA (2010)	SMCMA (2010) guidelines
	Pervious Area Parameters	Based on likely soils within the top 0.5m of existing soil profile = sandy loam	Soil properties based on 1:100 000 Soil Landscape Series Sheet for Wollongong Port Hacking and properties of the Lucas Heights soil landscape.
	EMC's	As per WBM (2010) for urban and rural residential landuse	SMCMA (2010) guidelines
	Estimation Method	Stochastically generated	SMCMA (2010) guidelines
Bioretention Basin	Low Flow By-Pass	0 m^3/s	SMCMA (2010) guidelines
	High Flow Bypass	100 m^3/s	As design is concept, model assumes all flow is directed to basin
	Extended Detention depth	Assume 0.3m	By design
	Surface Area	Determined by iterative modelling to achieve water quality objectives. Represents area at 0.5 extended detention depth.	SMCMA (2010) guidelines
	Filter Area	Model is conceptual and so assumes basin has vertical walls. Therefore filter area = surface area	Design of proposed basin
	Unlined Filter Media Perimeter	Equal to square root of surface area (actual) multiplied by 4	SMCMA (2010) guidelines
	Saturated Hydraulic Conductivity	90 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductivity of 180 mm/hr be used for sandy loams. 50% of this value has been used in modelling as a conservative estimate of realistic long-term hydraulic conductivity of system (ewater).
	Fiter Depth	Assume 0.4m	Design of proposed basin
	TN Content Of Filter Media	500 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012).
	Orthophosphate Content Of Filter Media	40 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012)
	Exfiltration Rate	3.6 mm/hr	Based on medium clay subsoils
	Based Lined?	No	Basins assumed not be lined
	Vegetation Properties	With effective nutrient removal plants	Landscaping of basins assumed to include deep rooted vegetation.
	Oveflow Weir Width	5m	Basin design
	Underdrain Present	Yes	Basin design
	Submerged Zone With Carbon Present	Assumed 0.1m	Basin design
Rainwater Tank	Low Flow Bypass	0 m^3/s	SMCMA (2010) guidelines
	High Flow Bypass	0.005 m^3/s per dwelling x 35 lots (assumed yield) = 0.175 m^3/s	SMCMA (2010) guidelines
	Volume Below Overflow	Assumed 5kL/dwelling. A volume of 80% of total tank volume is assumed	SMCMA (2010) guidelines and project planner
	Depth Above Overflow	0.1m	Assumed
	Surface Area	Cumulative surface area	Assumed
	Overflow Pipe Diameter	Cumulative pipe diameter based on 90mm per lot	WBM (2010) guidelines
	Reuse	0.31kL/lot for irrigation x 35 lots	SMCMA (2010) guidelines

Attachment B: MUSIC Results Summary

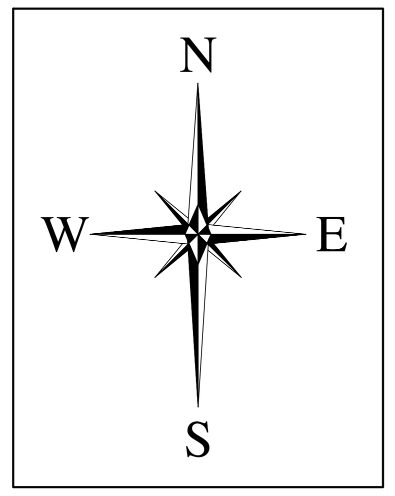
70% Impervious		
Post Development Untreated	Total Suspended Solids (kg/yr)	21700.00
	Total Phosphorus (kg/yr)	35.70
	Total Nitrogen (kg/yr)	265.00
	Gross Pollutants (kg/yr)	3400.00
Post Development Treated	Total Suspended Solids (kg/yr)	4010.00
	Total Phosphorus (kg/yr)	16.10
	Total Nitrogen (kg/yr)	145.00
	Gross Pollutants (kg/yr)	0.00
Pollutant Reduction	Total Suspended Solids (kg/yr)	82%
	Total Phosphorus (kg/yr)	55%
	Total Nitrogen (kg/yr)	45%
	Gross Pollutants (kg/yr)	100%
Bioretention Basin		
EDD	0.3	m
Surface Area	1400	m
Filter Area	1400	m
Filter Depth	0.4	m
Submerged Zone	0.1	m

60% Impervious		
Post Development Untreated	Total Suspended Solids (kg/yr)	19300.00
	Total Phosphorus (kg/yr)	32.40
	Total Nitrogen (kg/yr)	241.00
	Gross Pollutants (kg/yr)	3130.00
Post Development Treated	Total Suspended Solids (kg/yr)	3670.00
	Total Phosphorus (kg/yr)	14.50
	Total Nitrogen (kg/yr)	132.00
	Gross Pollutants (kg/yr)	0.00
Pollutant Reduction	Total Suspended Solids (kg/yr)	81%
	Total Phosphorus (kg/yr)	55%
	Total Nitrogen (kg/yr)	45%
	Gross Pollutants (kg/yr)	100%
Bioretention Basin		
EDD	0.3	m
Surface Area	1280	m
Filter Area	1280	m
Filter Depth	0.4	m
Submerged Zone	0.1	m

50% Impervious		
Post Development Untreated	Total Suspended Solids (kg/yr)	17100.00
	Total Phosphorus (kg/yr)	28.00
	Total Nitrogen (kg/yr)	211.00
	Gross Pollutants (kg/yr)	2810.00
Post Development Treated	Total Suspended Solids (kg/yr)	3330.00
	Total Phosphorus (kg/yr)	12.50
	Total Nitrogen (kg/yr)	116.00
	Gross Pollutants (kg/yr)	0.00
Pollutant Reduction	Total Suspended Solids (kg/yr)	81%
	Total Phosphorus (kg/yr)	55%
	Total Nitrogen (kg/yr)	45%
	Gross Pollutants (kg/yr)	100%
Bioretention Basin		
EDD	0.3	m
Surface Area	1190	m
Filter Area	1190	m
Filter Depth	0.4	m
Submerged Zone	0.1	m

40% Impervious		
Post Development Untreated	Total Suspended Solids (kg/yr)	14500.00
	Total Phosphorus (kg/yr)	24.80
	Total Nitrogen (kg/yr)	184.00
	Gross Pollutants (kg/yr)	2440.00
Post Development Treated	Total Suspended Solids (kg/yr)	2900.00
	Total Phosphorus (kg/yr)	11.10
	Total Nitrogen (kg/yr)	101.00
	Gross Pollutants (kg/yr)	0.00
Pollutant Reduction	Total Suspended Solids (kg/yr)	80%
	Total Phosphorus (kg/yr)	55%
	Total Nitrogen (kg/yr)	45%
	Gross Pollutants (kg/yr)	100%
Bioretention Basin		
EDD	0.3	m
Surface Area	1090	m
Filter Area	1090	m
Filter Depth	0.4	m
Submerged Zone	0.1	m

8 Attachment C - Figures



NOTES:

MODEL FOR 70% IMPERVIOUS RESIDENTIAL SOURCE NODE SHOWN.
MUSIC MODEL WAS RERUN SEPARATELY FOR DIFFEREING IMPREVIOUS PERCENTAGE SCENARIOS (60%, 50%, 40%).

REV.	DESCRIPTION	DATE	ISSUED
A	FOR REZONING	05.08.2015	JF

BAR SCALE: 0 25 50 75 100 125 150 — UNITS - METRES

DESIGNED:	BL
DATUM:	mAHD
REVIEWED:	JF
HORIZONTAL RATIO:	1:1500
PAPER SIZE:	A1
VERTICAL RATIO:	1:1500

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Bargo, NSW

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All measurements in mm unless otherwise specified

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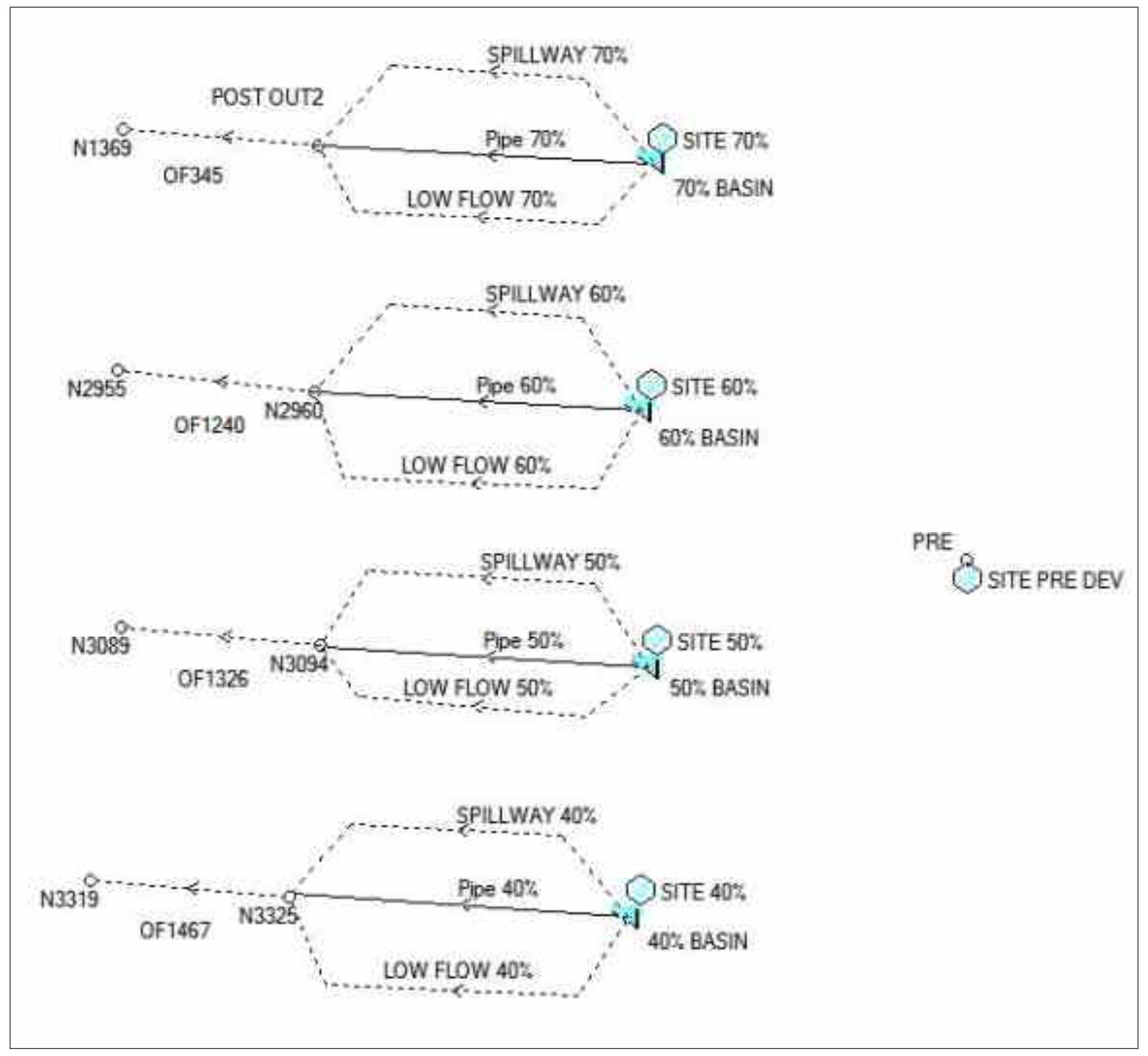
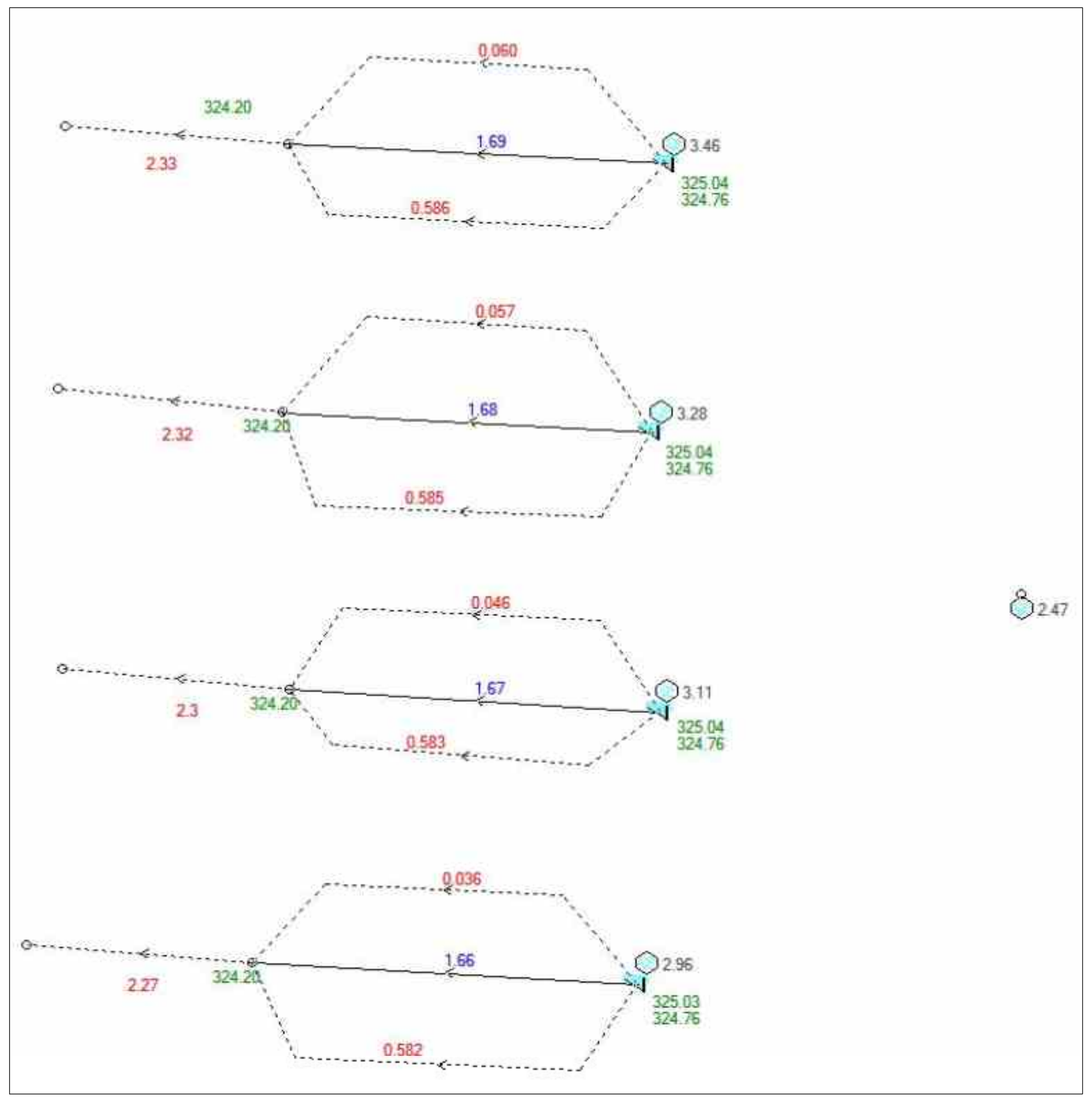
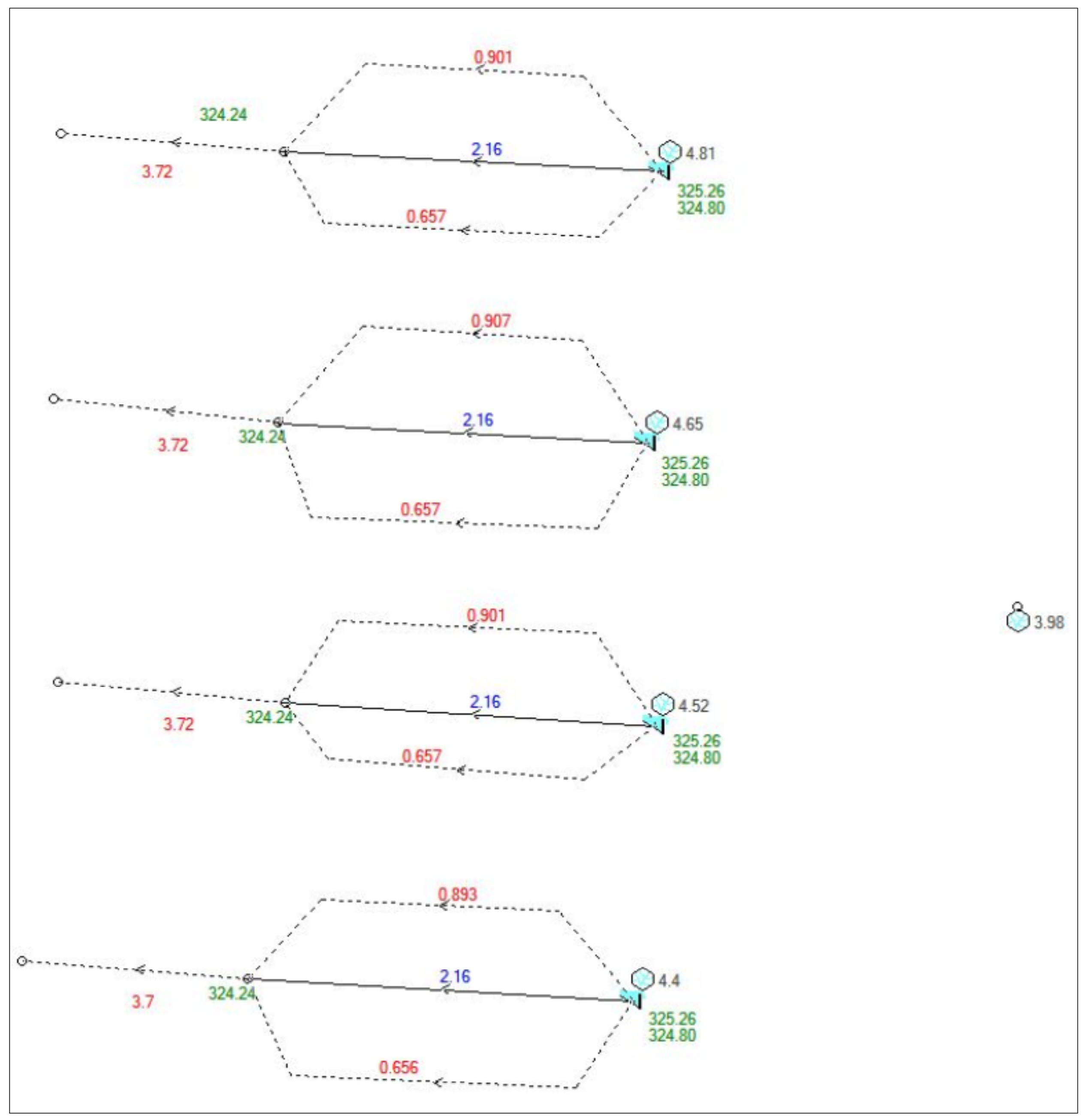
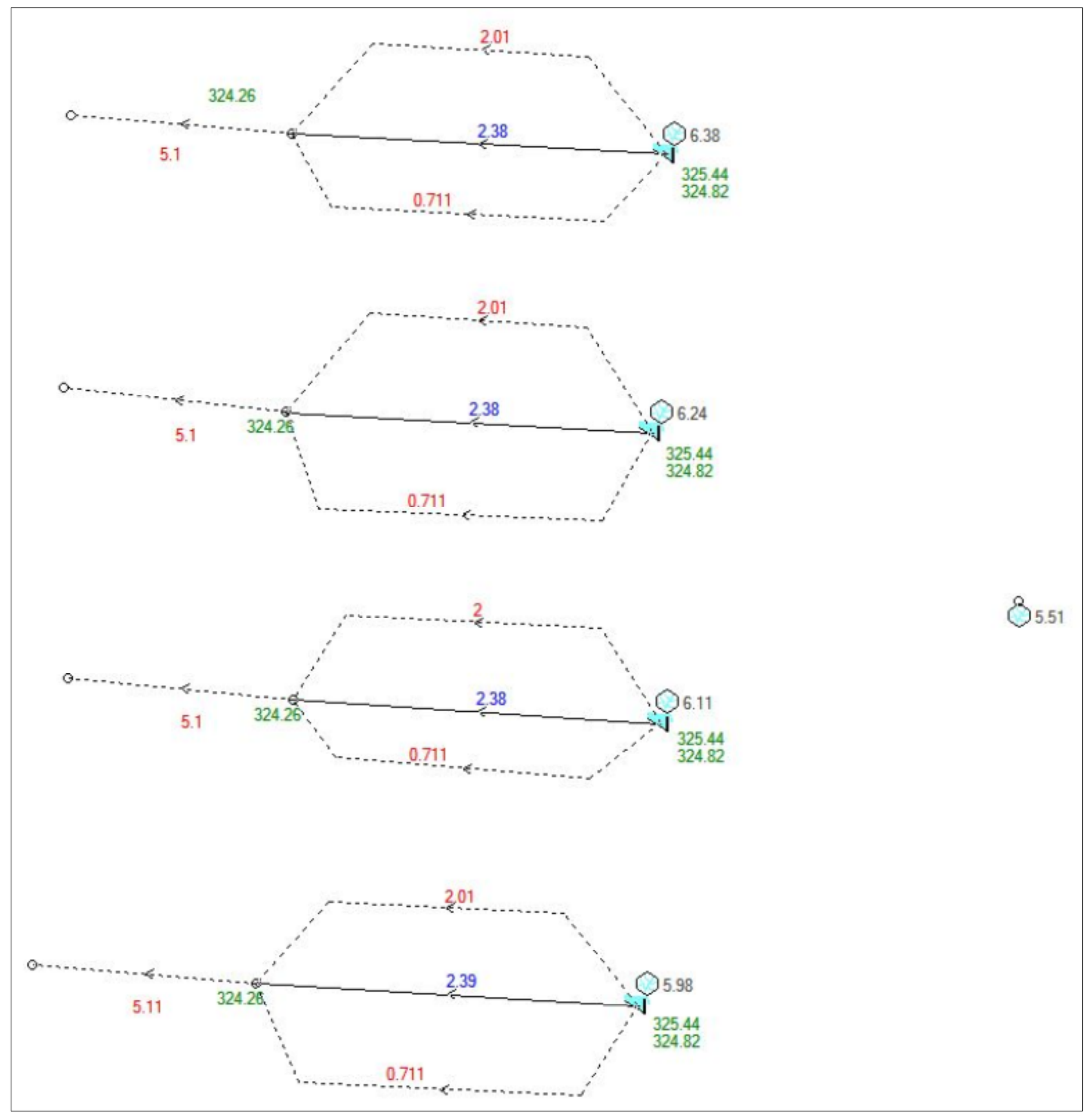
TITLE:	TYPICAL MUSIC MODEL LAYOUT
DRAWING ID:	F101
PROJECT MANAGER:	JF
PROJECT NO.:	P1504816
FILE:	JD03V01
REVISION:	A



DRAINS MODEL LAYOUT







1 IN 5 YEAR CRITICAL STORM RESULT

1 IN 20 YEAR CRITICAL STORM RESULT

1 IN 100 YEAR CRITICAL STORM RESULT

REV.	DESCRIPTION	DATE	ISSUED
A	FOR REZONING	05.08.2015	JF

BAR SCALE

DESIGNED:	DATUM:
BL	mAHD
REVIEWED:	HORIZONTAL RATIO:
JF	NTS
PAPER SIZE:	VERTICAL RATIO:
A1	NTS

CLIENT / PROJECT
Preliminary Flood Study:
45 Noongah Street and
25 Gwynn Hughes Street,
Bargo, NSW

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified

martens & Associates Pty Ltd
Consulting Engineers
Environment
Water
Geotechnical
Civil

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Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE:
DRAINS MODEL LAYOUT AND RESULTS

DRAWING ID:
F201

PROJECT MANAGER:	PROJECT NO.:	FILE:	REVISION:
JF	P1504816	JD03V01	A