Precise Planning

# Concept Stormwater Management Assessment: Proposed Rezoning 95 Great Southern Road, Bargo, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1504741JR04V02
May 2017

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

# Contents

# 1 Introduction

## 1.1 Overview

This concept stormwater management plan has been prepared on behalf of Precise Planning to support a rezoning application for a proposed residential subdivision located at 95 Great Southern Road, Bargo, NSW. A subdivision layout was not available the time of this assessment.

We note that for the purposes of this study we have assessed water quantity and quality requirements for a range of likely impervious area alternatives. See F100 (Appendix A) for the study area location.

## 1.2 Scope of Works

The scope of this assessment has been developed to provide adequate detail in addressing objectives required by Council to support a rezoning application.

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 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 Land Use

The 28.42 ha site (Lot 1 DP996286) is located on the eastern side of Great Southern Road. The site is currently a vacant rural residential lot, existing dwelling and sheds, and a small dam to south of the dwelling.

The south western corner of the site was previously used by Sydney Water as a storage depot for the Bargo Wastewater Scheme and has recently been rehabilitated. The remainder of the site is predominantly grassed grazing paddock.

Bordered by rural residential allotments to the north, east and south, residential development to the south west and Great Southern Road to the west.

## 2.2 Site Investigation

Site investigations were completed on June 6th, 2015 as part of other studies such as preliminary contamination and salinity assessment. It included a walkover to review site conditions relating to drainage, topography, vegetation and lithology.

## 2.3 Site Topography and Vegetation

The site typically has moderate grades less than 10% towards the west and the east, with the watercourse in the eastern portion of the site the lowest elevation at 302 mAHD. Site elevation rises to 321 mAHD in the south western corner and 311 mAHD in the south eastern corner.

## 2.4 Drainage

A mapped unnamed watercourse draining south/north is located in the eastern portion of the site and is intersected by another drainage depression draining from west to east. The site drains to the north east, intercepting Dogtrap Creek (approximately 1.2 km north east) and eventually the Bargo River (approximately 3.6 km north east).

## 2.5 Lithology and Soil Landscapes

The *Wollongong 1:250,000 Geological Series Sheet SI/56-09* (DME, 1966) identifies the site as being underlain by Bringelly Shale, overlying Ashfield Shale, overlying Mittagong Formation.

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

# 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 Stormwater Quality Objectives

WSC has recommended to adopt revised pollutant reduction water quality objectives based on the *Upper Nepean River Stormwater Management Plan* (EPA, 2000).

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 F002 (Appendix 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.

Development layout has not been formalised at the time of preparing this 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:

- 75% impervious and 25% pervious.
- 65% impervious and 35% pervious.
- 55% impervious and 45% pervious.
- 45% impervious and 55% 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). Appendix 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 28.42 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 Model Parameters

Event Mean Concentration (EMC) inputs were derived from SMCMA (2010).

**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 F002 (Appendix 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 between 1kL (lots <700m$^2$) and 2kL (lots >700m$^2$) tanks. The total number of dwellings (and hence the cumulative tank volume and cumulative demand) was based on discussions with the project planner.

Rainwater tank specifications remained constant for each scenario.

### 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.

### 3.4.3 Other Structures

Other structures that may be considered in the final design of water quality control are:

- Raingardens: specifications would be determined at the subdivision stage and designed in accordance with SMCMA (2010). They may be utilised as individual lot treatment mechanisms (subject to 88b instrument) where end of line structures may not be suitable.

- Gross pollutant traps (GPT): GPT may be utilised subject to maintenance considerations (i.e. practical access to GPT locations and ongoing cost to Council/developer).

- There is a drainage depression running (west to east) through the site under existing conditions. This secondary drainage system could be retained as a vegetated swale which would further improve the quality of site water. This swale would not be required to meet water quality targets with the treatment train implemented above and thus has not been included in the MUSIC model. However it is proposed as an alternative to ease the burden of treatment on the bioretention basins.

## 3.5 MUSIC Results

A full set of MUSIC modelling results are provided in Appendix 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) |
|---|---|---|
| 45% Impervious | 1820 | 64.04 |
| 55% Impervious | 1830 | 64.39 |
| 65% Impervious | 1880 | 66.15 |
| 75% Impervious | 1900 | 66.85 |

**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 75% 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 for the lot subdivision 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 Council Specific Stormwater Quantity Objectives

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

### 4.2.1 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 greater than the 100 year ARI event by way of overland flow paths.

### 4.3 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 Exceedence 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.

### 4.4 Modelling Methodology

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 28.42 ha.

- The existing site was modelled as 99% pervious.

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

  a) 45% impervious site coverage (including roofs and pavement) with the remaining 55% consisting of pervious site coverage (including landscaping and areas unchanged by the development).

  b) 55% impervious and 45% pervious.

  c) 65% impervious and 35% pervious.

  d) 75% impervious and 25% pervious.

- The DRAINS model assumed that the entire site drains to one OSD system and can be located in F003 (Appendix D).

- OSD tank depth is 2.25m for all scenarios.

- Six low flow outlet pipes of 450mm each was assumed at the basin invert. High flow outlet was modelled as six 300mm pipes located 0.75m above the basin invert with a circular culvert outlet.

- OSD spillway was assumed to be 27m wide for all scenarios.

### 4.4.1 Approach

The DRAINS model was run for the following storms:

- 1 in 5 year Average Recurrence Interval (ARI).
- 1 in 20 year ARI.
- 1 in 100 year ARI.

For each ARI, durations of between 5 minutes and 4.5 hours were run to determine the peak event and peak site discharges for the existing site. As the existing peak and proposed peak flow events do not coincide in terms of duration, the peak flow rates of both the existing and the proposed were used and resulted as follows:

- For the 5 year storm the peak flow rate for the existing scenario was determined to be the 4.5 hour storm and proposed scenario was determined to be the 2 hour storm.
- For the 20 year storm the peak flow rate for the existing scenario and proposed scenario was determined to be the 2 hour storm.
- For the 100 year storm the peak flow rate for the existing scenario was determined to be the 1 hour storm and proposed scenario was determined to be the 2 hour storm.

### 4.5 Site OSD Requirement

Results of hydraulic modelling are summarised in Table 1.

**Table 1**: Results of DRAINS modelling.

| Scenario[1] | ARI | Peak Discharge[2] ($m^3$ / s) | | OSD Volume[3] (kL) | SSR[4] (kL / ha) |
|---|---|---|---|---|---|
| | | Existing | Post Development | | |
| 45% Impervious | 5 | 3.22 | 2.9 | 5550 | 195 |
| | 20 | 5.00 | 4.00 | | |
| | 100 | 7.07 | 7.07 | | |
| 55% Impervious | 5 | 3.22 | 2.98 | 6100 | 215 |
| | 20 | 5.00 | 3.99 | | |
| | 100 | 7.07 | 6.99 | | |
| 65% Impervious | 5 | 3.22 | 3.05 | 6550 | 230 |
| | 20 | 5.00 | 4.00 | | |
| | 100 | 7.07 | 7.03 | | |
| 75% Impervious | 5 | 3.22 | 3.11 | 7100 | 250 |
| | 20 | 5.00 | 4.00 | | |
| | 100 | 7.07 | 6.99 | | |

**Notes**

1. Future impervious area may fall between these values and may need to be re-evaluated.
2. PSD = peak site discharge.
3. OSD = on-site stormwater detention volume for the entire site.
4. SSR = site storage requirement.

### 4.6 Conclusion

Results of hydraulic modelling suggest that OSD requirements increase from 195 KL/ha to 250 KL/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. Refer to Appendix E (MA planset PS03-E100) for a possible OSD layout, based on the 75% impervious scenario.

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

# 5 Site Waterlogging

A portion of the site has been identified as being affected by waterlogging. To ensure that the site is suitable for future residential developments methods to improve the site groundwater condition are to be considered. The list of possible management strategies includes:

- Limiting the amount and location that irrigation and wastewater disposal is allowed to occur on-site.
- Planting of deep-rooted, preferably native, trees to increase water absorption where consistent with future land use and landscaping plans.
- Lining the stormwater detention ponds and water features to reduce infiltration.
- Elevating the water logged area through the use of filling practices to reduce the accumulation of water.
- Installation of adequate surface and sub-soil drainage to address groundwater table (if exist).

The current groundwater level has not been determined at this stage. We recommend that further investigation be carried out at the Development Application (DA) stage to provide site specific groundwater management advice.

# 6 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 (2011) Development Control Plan (DCP).

WSC (2011) Local Environmental Plan (LEP).

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

# 7 Appendix A – Site Location

Site Boundary

martens

| Martens & Associates Pty Ltd ABN 85 070 240 890 | | Environment \| Water \| Wastewater \| Geotechnical \| Civil \| Management | |
|---|---|---|---|
| Drawn: | GL | Site Location<br>95 Great Southern Road, Bargo. | F001 |
| Approved: | JF | | |
| Date: | 03.12.2015 | | |
| Scale: | NA | | Job No: P1504741 |

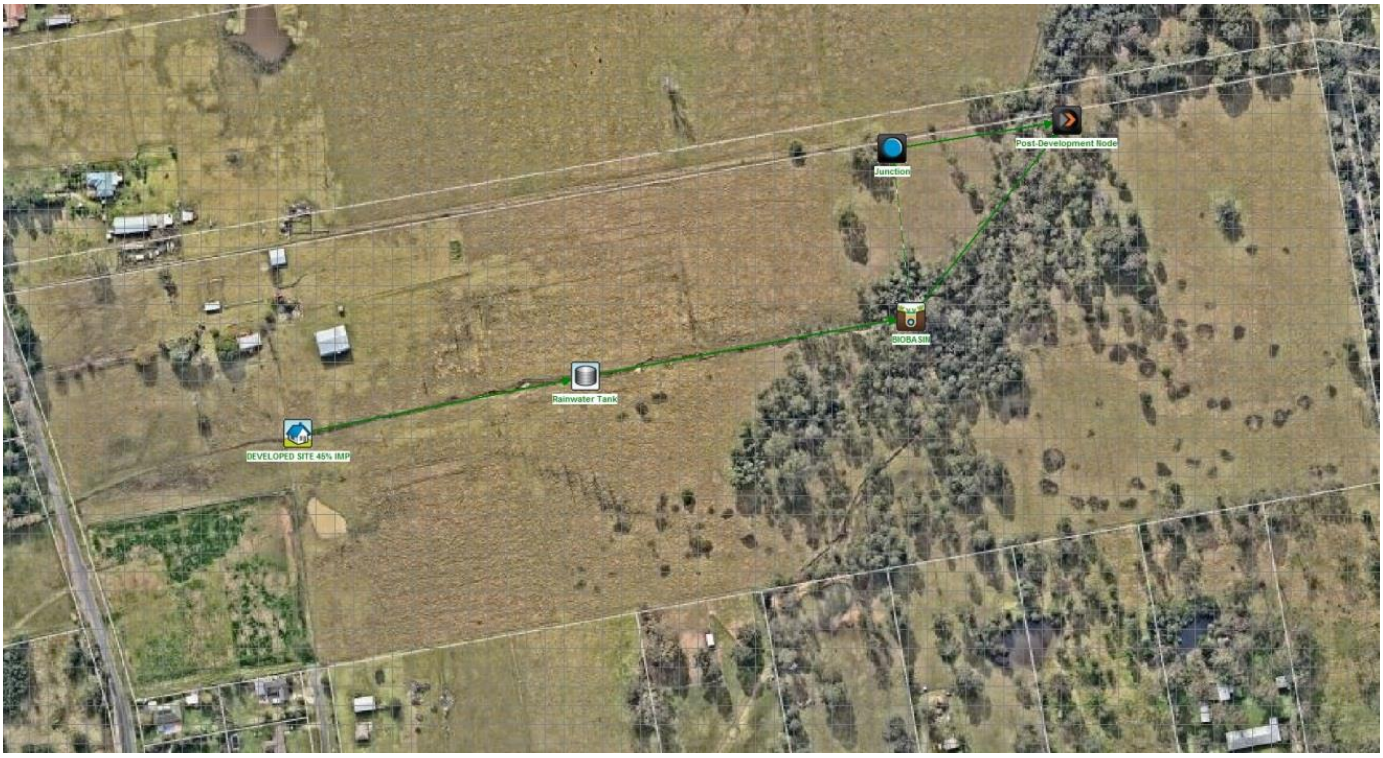
# 8 Appendix B – Summary of MUSIC Input Parameters & Results

**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 = clay | 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 to be unlined |
| | 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 222 lots (assumed yield) = 1.11 $m^3/s$ | SMCMA (2010) guidelines |
| | Volume Below Overflow | Assumed yield 1-2kL/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 222 lots | SMCMA (2010) guidelines |

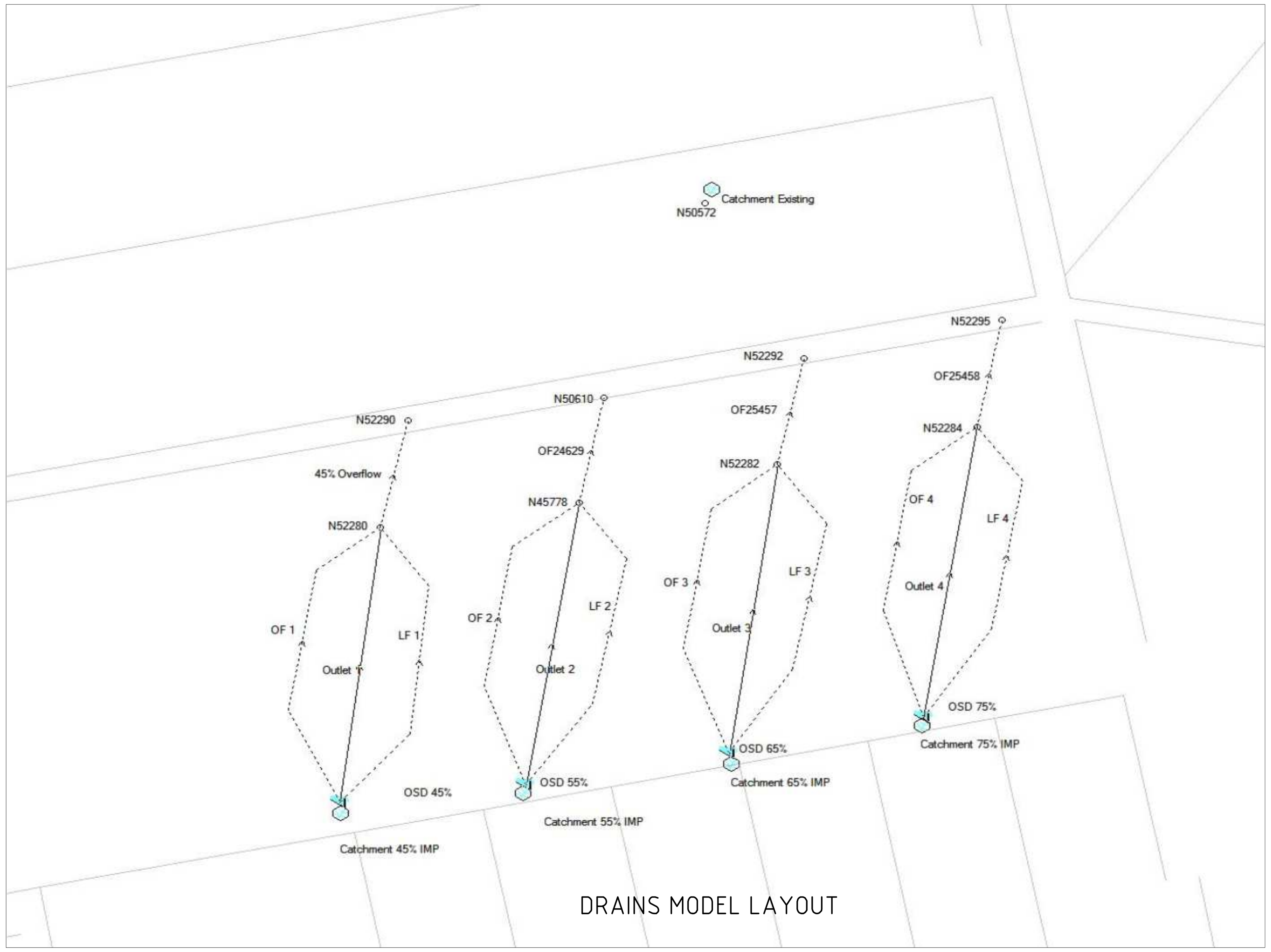
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **75% Impervious** | | | **65% Impervious** | | | **55% Impervious** | | | **45% Impervious** | | |
| | Flow (ML/yr) | 179.00 | | Flow (ML/yr) | 164.00 | | Flow (ML/yr) | 149.00 | | Flow (ML/yr) | 134.00 |
| | Total Suspended Solids (kg/yr) | 32400.00 | | Total Suspended Solids (kg/yr) | 30400.00 | | Total Suspended Solids (kg/yr) | 27800.00 | | Total Suspended Solids (kg/yr) | 24600.00 |
| **Post Untreated** | Total Phosphorus (kg/yr) | 52.00 | **Post Untreated** | Total Phosphorus (kg/yr) | 49.40 | **Post Untreated** | Total Phosphorus (kg/yr) | 44.20 | **Post Untreated** | Total Phosphorus (kg/yr) | 40.10 |
| | Total Nitrogen (kg/yr) | 391.00 | | Total Nitrogen (kg/yr) | 362.00 | | Total Nitrogen (kg/yr) | 327.00 | | Total Nitrogen (kg/yr) | 294.00 |
| | Gross Pollutants (kg/yr) | 4870.00 | | Gross Pollutants (kg/yr) | 4500.00 | | Gross Pollutants (kg/yr) | 4090.00 | | Gross Pollutants (kg/yr) | 3620.00 |
| | Flow (ML/yr) | 168.00 | | Flow (ML/yr) | 153.00 | | Flow (ML/yr) | 138.00 | | Flow (ML/yr) | 123.00 |
| | Total Suspended Solids (kg/yr) | 6450.00 | | Total Suspended Solids (kg/yr) | 6090.00 | | Total Suspended Solids (kg/yr) | 5510.00 | | Total Suspended Solids (kg/yr) | 4940.00 |
| **Post Treated** | Total Phosphorus (kg/yr) | 23.10 | **Post Treated** | Total Phosphorus (kg/yr) | 21.40 | **Post Treated** | Total Phosphorus (kg/yr) | 19.40 | **Post Treated** | Total Phosphorus (kg/yr) | 17.40 |
| | Total Nitrogen (kg/yr) | 216.00 | | Total Nitrogen (kg/yr) | 196.00 | | Total Nitrogen (kg/yr) | 180.00 | | Total Nitrogen (kg/yr) | 157.00 |
| | Gross Pollutants (kg/yr) | 0.00 | | Gross Pollutants (kg/yr) | 0.00 | | Gross Pollutants (kg/yr) | 0.00 | | Gross Pollutants (kg/yr) | 0.00 |
| | Flow (ML/yr) | 6% | | Flow (ML/yr) | 7% | | Flow (ML/yr) | 8% | | Flow (ML/yr) | 9% |
| | Total Suspended Solids (kg/yr) | 80% | | Total Suspended Solids (kg/yr) | 80% | | Total Suspended Solids (kg/yr) | 80% | | Total Suspended Solids (kg/yr) | 80% |
| **Reductino** | Total Phosphorus (kg/yr) | 55.7% | **Reduction** | Total Phosphorus (kg/yr) | 56.7% | **Reduction** | Total Phosphorus (kg/yr) | 56.0% | **Reduction** | Total Phosphorus (kg/yr) | 56.7% |
| | Total Nitrogen (kg/yr) | 45% | | Total Nitrogen (kg/yr) | 46% | | Total Nitrogen (kg/yr) | 45% | | Total Nitrogen (kg/yr) | 47% |
| | Gross Pollutants (kg/yr) | 100% | | Gross Pollutants (kg/yr) | 100% | | Gross Pollutants (kg/yr) | 100% | | Gross Pollutants (kg/yr) | 100% |

# 9 Appendix C – Pre- and Post-Development MUSIC Layouts

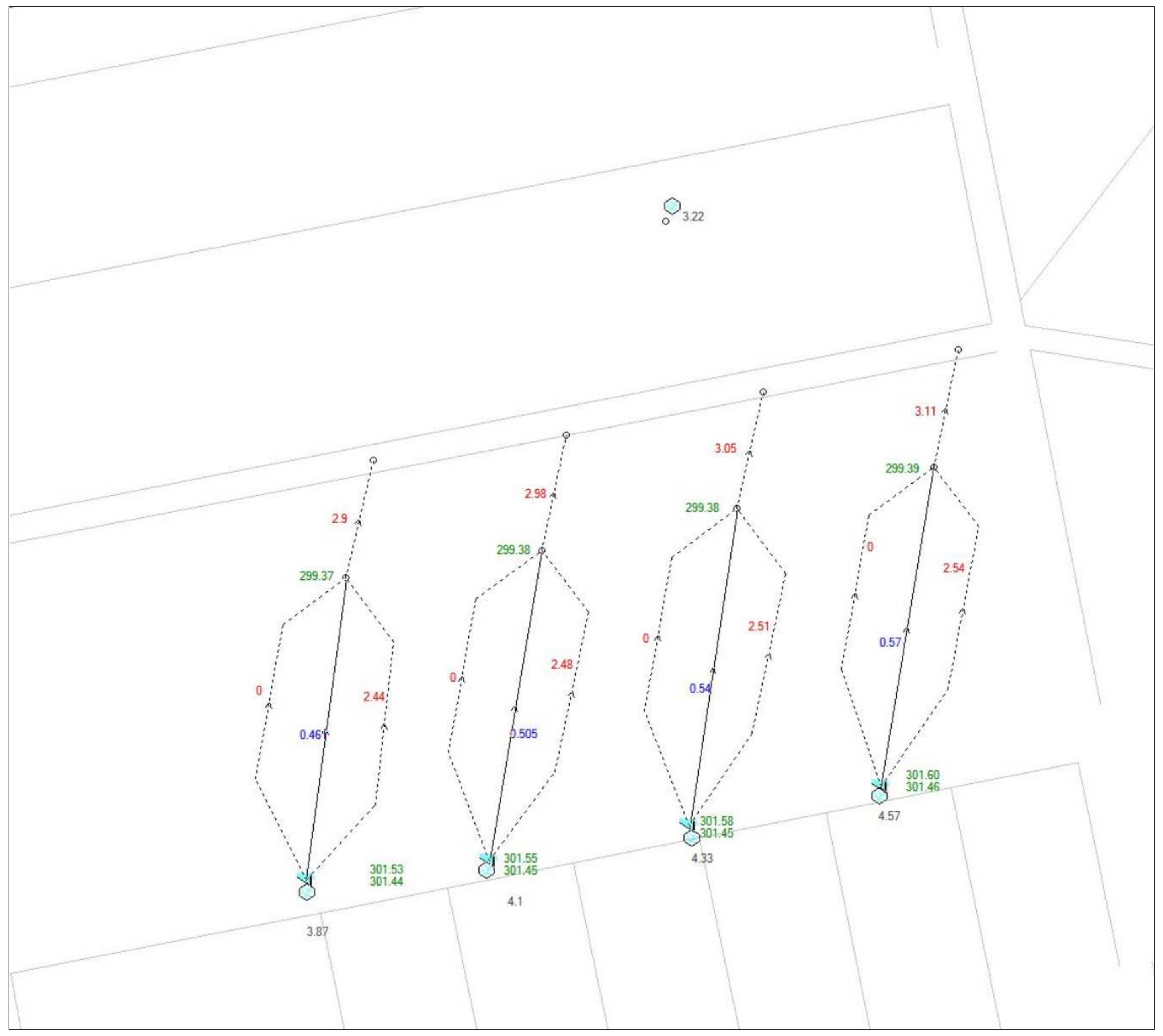



| | | | |
|---|---|---|---|
| **Martens & Associates Pty Ltd** ABN 85 070 240 890 | | **Environment \| Water \| Wastewater \| Geotechnical \| Civil \| Management** | |
| Drawn: | GL | **Concept Post-Development MUSIC Model Layout**<br>**95 Great Southern Road, Bargo** | **F002** |
| Approved: | JF | | |
| Date: | 01.12.2015 | | |
| Scale: | NA | | Job No: P1504741 |

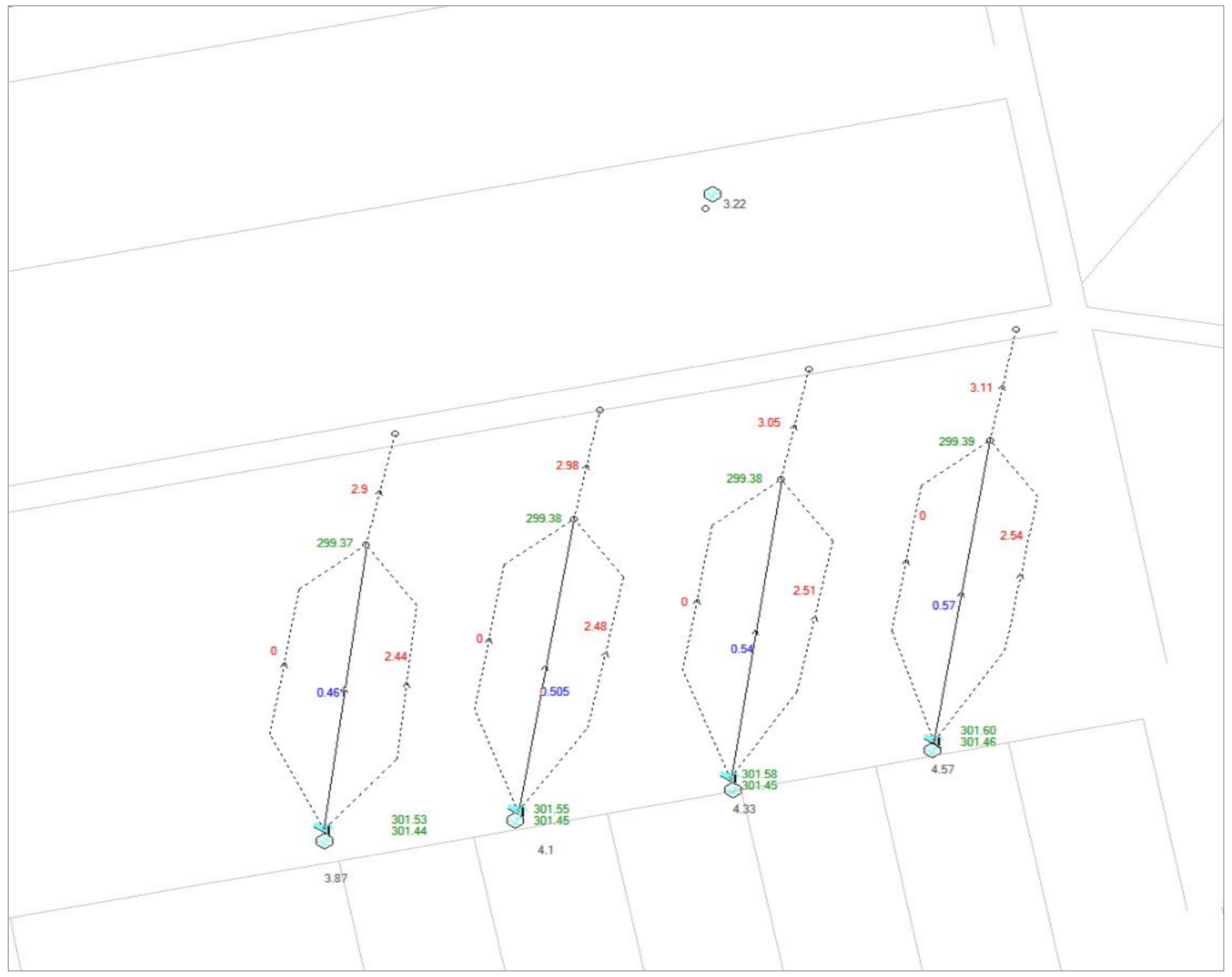
# 10 Appendix D – DRAINS Model



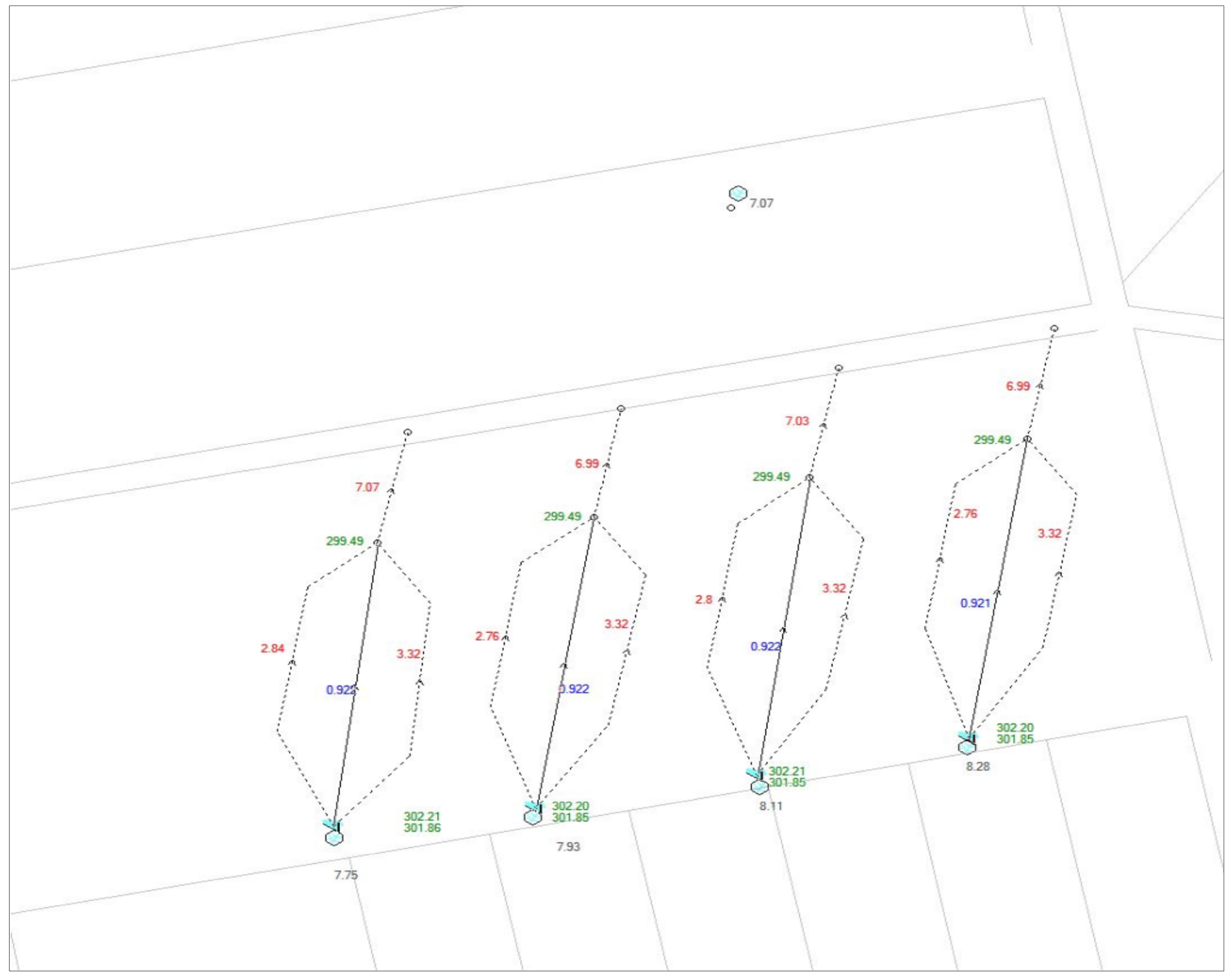

DRAINS MODEL LAYOUT



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 | 02.12.15 | JF |

BAR SCALE



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

CLIENT / PROJECT
Preliminary Flood Study:
95 Great Southern Road,
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
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Geotechnical
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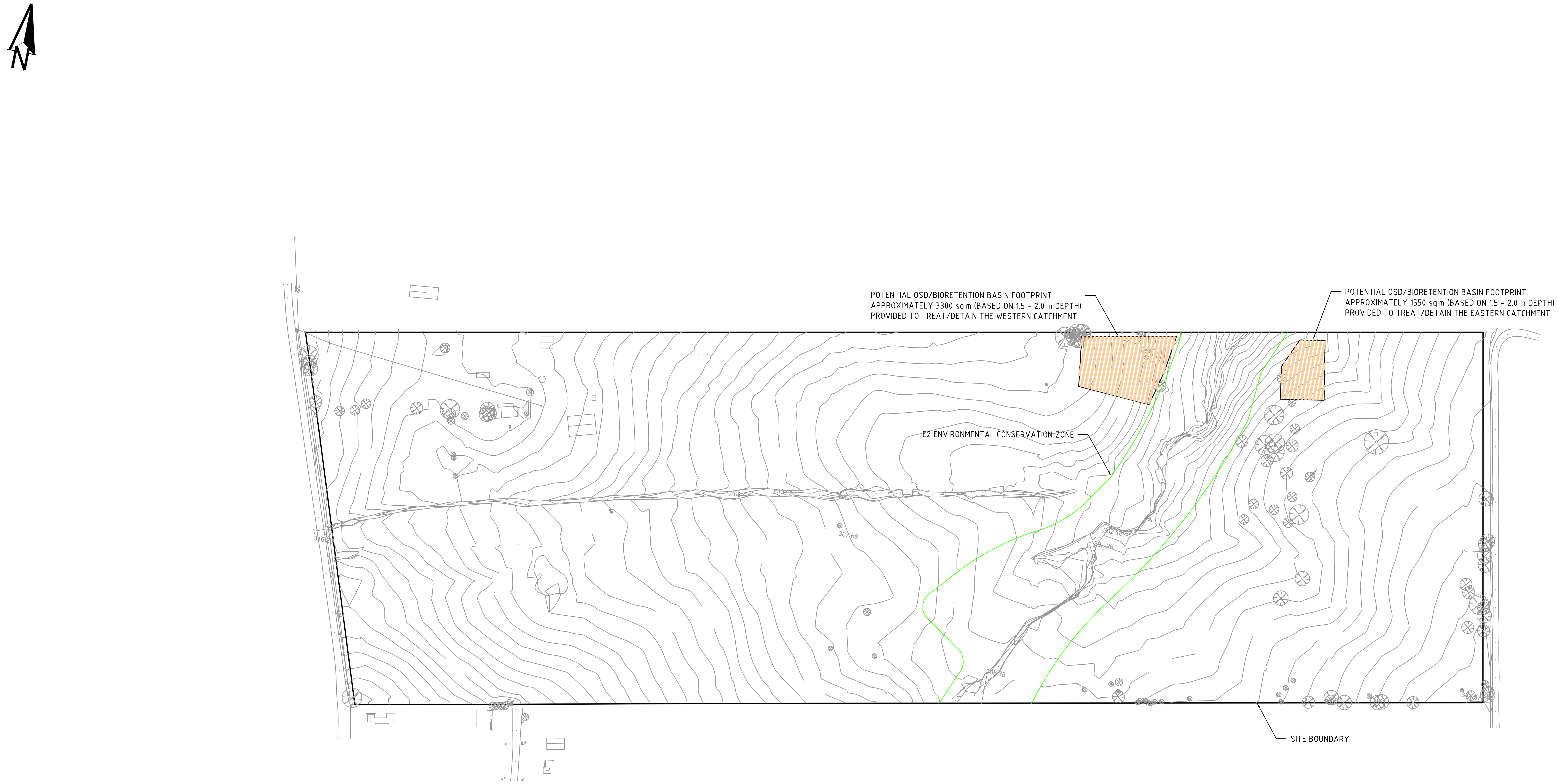
Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE: DRAINS MODEL LAYOUT AND RESULTS
DRAWING ID: F003
PROJECT MANAGER: JF
PROJECT NO.: P1504741
FILE: JD03V01
REVISION: A

# 11 Appendix E – Potential OSD Layout




# REZONING APPLICATION

| REV | DESCRIPTION | DATE | DRAWN | DESIGNED | CHECKED | APPRVD |
|---|---|---|---|---|---|---|
| A | PER COUNCIL REQUEST | 09/05/2017 | AVG | AVG | SL | SL |

SCALE: 0 20 40 60 80 100 120 140 160 180 200 METRES — A1 (A3) 1:2,000 (1:4,000)

| GRID | DATUM | PROJECT MANAGER |
|---|---|---|
| | mAHD | JF |

DISCLAIMER & COPYRIGHT



CLIENT: PRECISE PLANNING

PROJECT NAME/PLANSET TITLE: REZONING APPLICATION
STORMWATER MANAGEMENT PLAN
95 GREAT SOUTHERN ROAD
BARGO, NSW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Email: mail@martens.com.au Internet: www.martens.com.au


DRAWING TITLE: OSD LAYOUT

| PROJECT NO. | PLANSET NO. | RELEASE NO. | DRAWING NO. | REVISION |
|---|---|---|---|---|
| P1504741 | PS03 | R01 | PS03-E100 | A |

DRAWING ID: P1504741-PS03-R01-E100