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Flood Impact & Risk Assessment

39 Redground Rd, Crookwell, NSW

Lot 1 DP 1064795

LGA: Upper Lachlan Shire Council

Report No: 20240213_23017_001
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References:

- Upper Lachlan Shire Council – Development Control Plan
- Upper Lachlan Shire Council – The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan – 2017 – Volume 1
- Australian Rainfall & Runoff – A Guide to Flood Estimation – 2019
- Flood Risk Management Manual: The policy and manual for the management of flood liable land (2023) – Department of Planning and Environment – NSW Government
- Landcom Managing Urban Stormwater Soil and Construction Volume 1 (4th Edition 2004) known as the "blue book".
- Civil Engineering Concept Design & Flood Impact Sheet Set, Ref 23017 *Revision P0* by CivPlan Pty Ltd dated 6th February 2024
- The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method – Commonwealth Bureau of Metereology

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Appendices:

- Appendix A: Civil Engineering Concept Design & Flood Impact Sheet Set
- Appendix B: ARR Data Hub
- Appendix C: IFD Data
- Appendix D: PMF Calculations
- Appendix E: REFE

1. Purpose and Scope of Plan

1.1 Purpose and Scope

The purpose of this Flood Impact and Risk Assessment (FIRA) is to provide support for a planning proposal for the proposed development, at 39 Redground Road, Crookwell, NSW. The scope of this FIRA includes the assessment of the pre-development and post-development scenarios and the extent of the flood behaviour across the site and surrounding properties. This report will also include the findings of this analysis.

2. Project Overview & Hydrology

2.1 The Site

The site is located within Lot 1 DP 1064795 at 39 Redground Rd, Crookwell, NSW, and is within the Upper Lachlan Shire Council LGA, as shown in figures 1 and 2. Access to the site is via Redground Rd. The area to the east of the site is mainly residential, and the rest of the area around the site is predominantly composed of rural residential homes and farms.

Figure 1: Site Location - NSW Imagery (SIX Maps)

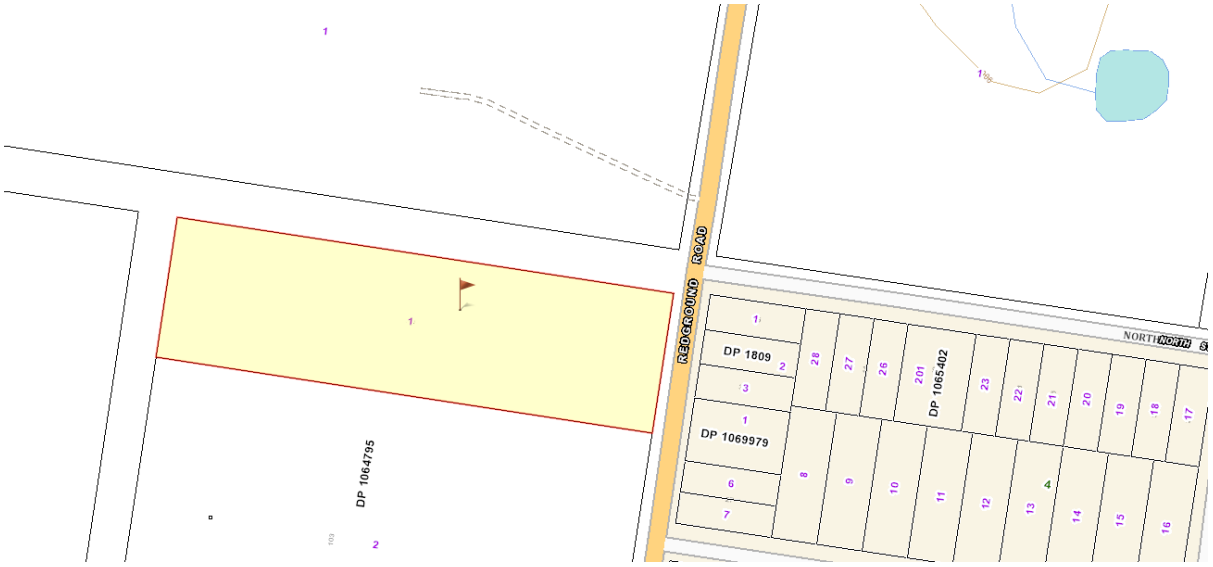


Figure 2: Site Location - NSW Topo (SIX Maps)

Lot 1 DP 1064795 has an approximate area of 2.00ha. The existing lot boundaries have approximate dimensions of 75m in the north to south direction and 267m in the east to west direction. The site is rectangular in shape. The area of the site under consideration has a gentle slope of approximately 1% falling from RL910.5 at the north-western corner of the site down to RL 902.9 at the south-eastern corner.

Currently there is a driveway into the site from the eastern boundary that leads to a dwelling and a shed in the centre of the site. The dwelling is surrounded by trees to the east and south. The rest of the site is mainly composed of medium to long grass.

The closest watercourse is 247m away from the site, as shown in figure 2. There are existing swales on both sides of Redground Rd which convey overland flows from the south to the north with pipe crossing where existing driveways are present.

There is no need to analyse the watercourse due to the distance to it and the flows are directed away from the site.

2.2 Proposed Development

The subject land is currently the subject of an ongoing planning proposal. The current site is proposed to be subdivided into 21 residential lots of minimum 800m² as shown in figure 3.

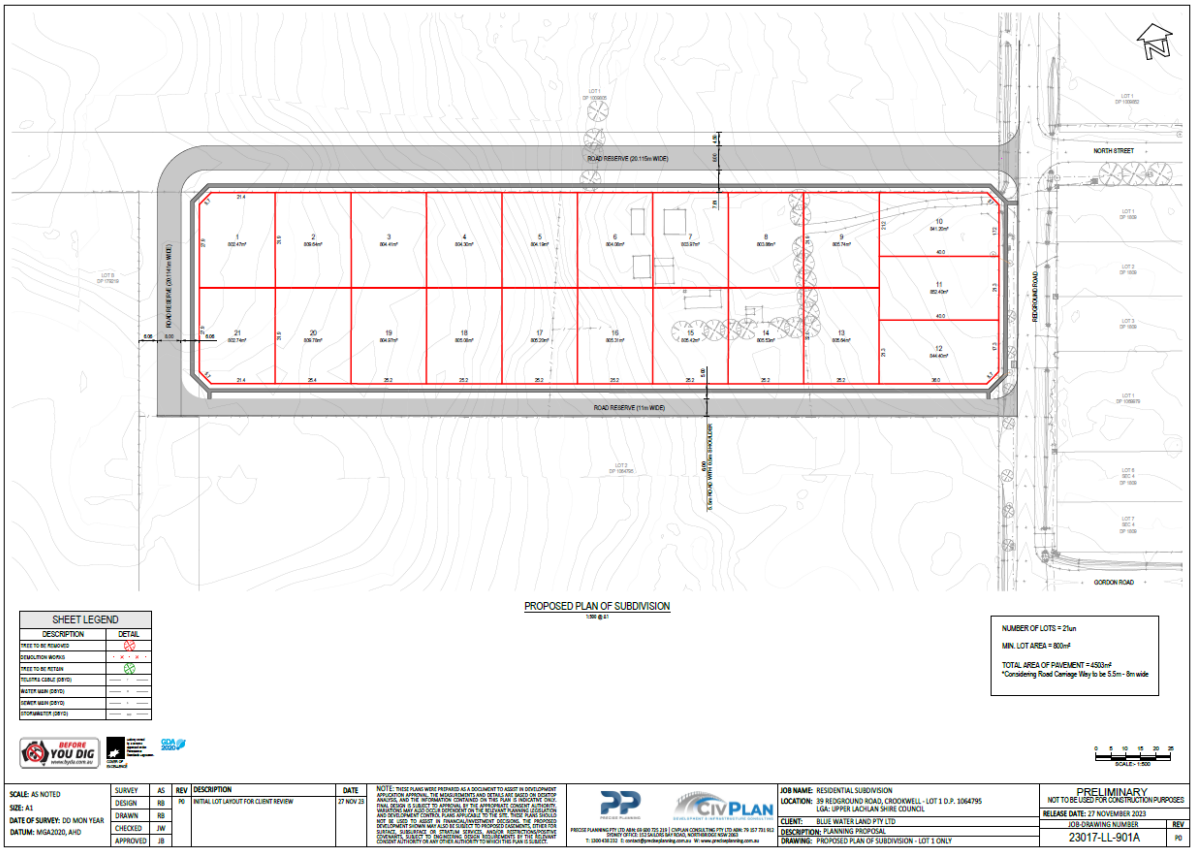


Figure 3: Proposed Residential Subdivision

This report will outline the pre-development and the post-development conditions of the site, and the overland flows through and around the proposed development using hydrology and 2D hydraulic modelling.

3. Hydrological Modelling

3.1 Model Adoption

Hydrological modelling was conducted in DRAINS using RAFTS storage routing model.

RAFTS storage routing models can model larger catchments using a lumped approach by assuming heterogeneity with sub-catchments to account for the storage and retardance of flows that occurs within the sub-catchments. Such models account for slope and roughness and use a loss model to produce a hydrograph at the sub-catchment outlet which can be input into HEC-RAS for unsteady 2D hydraulic flow analysis.

The RAFTS hydrological model was chosen because it is widely used and accepted across Australia within the industry and has been shown to be insensitive to initial conditions.

The DRAINS model configuration is shown in figure 4.

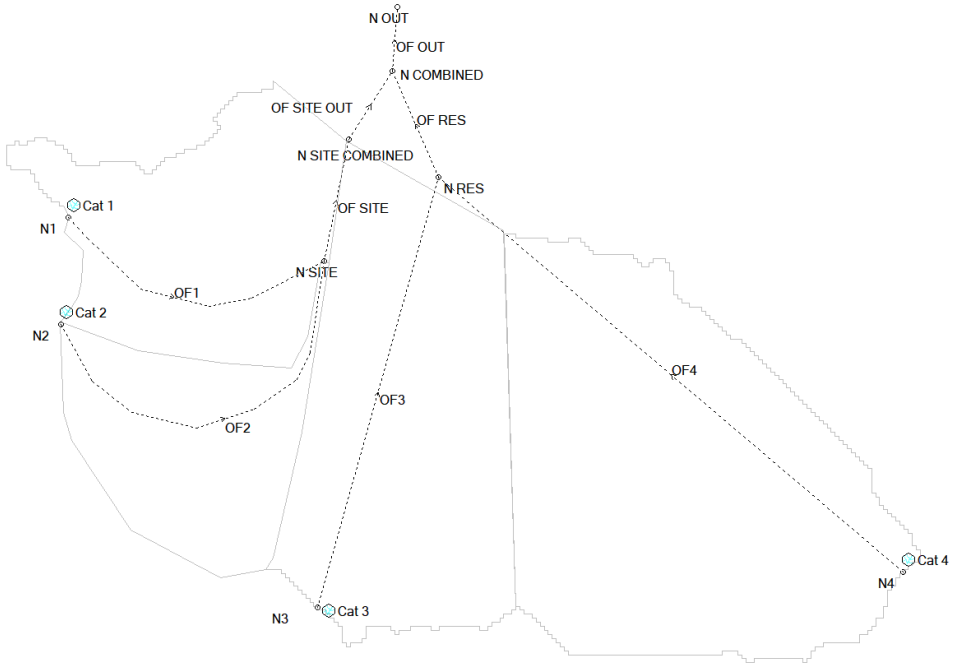


Figure 4: DRAINS Model Configuration

3.2 Catchment Areas

The catchment area draining to through the site was derived using 1m LiDAR Digital Elevation Models (DEM) sourced from ELVIS (http://elevation.fsdf.org.au).

DEM contour data was used to map sub-catchments boundaries (4 in total), determine their areas and overland flow paths. Impervious percentages for each catchment were estimated by digitising polygons of impervious areas (i.e. roads and roofs) from aerial photographs. Sub-catchment slopes were derived using slope analysis conducted on the above terrain data.

The Manning's coefficients for the DRAINS (RAFTS) model have been critically analysed for each catchment and overland flow path individually (see table 1), depending on the land use type and surface. See figure 5 below for the various Manning's coefficients used for different land applications.

Surface Type	Suggested n Values
Concrete Pipes or Box Sections	0.012
Concrete (trowel finish)	0.012 - 0.015
Concrete (formed, without finishing)	0.013 - 0.018
Concrete (gunite)	0.016 - 0.020
Bricks	0.014 - 0.016
Pitchers or Dressed Stone in Mortar	0.015 - 0.017
Random Stones in Mortar or Rubble Masonry	0.020 - 0.035
Rock Lining or Rip-Rap	0.025 - 0.030
Earth (clear)	0.018 - 0.025
Earth (with weeds or gravel)	0.025 - 0.035
Rock Cut	0.035 - 0.040
Short Grass	0.030 - 0.035
Long Grass	0.035 - 0.050

Channels

Flow across Parks	0.35
Flow across Rural Residential land	0.30
Flow across Residential (2a)	0.21
Flow across Residential (2b)	0.11
Flow across Industrial	0.06
Flow across Commercial	0.04
Flow across Paved Areas	0.01
Flow across Asphalt Roads	0.02
Flow across Gravel Areas	0.02

Overland Flow Retardance

Land Use Type	Manning 'n'
Residential areas – high density	0.2 – 0.5
Residential areas – low density	0.1 – 0.2
Industrial/commercial	0.2 – 0.5
Open pervious areas, minimal vegetation (grassed)	0.03 – 0.05
Open pervious areas, moderate vegetation (shrubs)	0.05 – 0.07
Open pervious areas, thick vegetation (trees)	0.07 – 0.12

Land Use Type	Manning 'n'
Waterways/channels – minimal vegetation	0.02 - 0.04
Waterways/channels – vegetated	0.04 – 0.1
Concrete lined channels	0.015 – 0.02
Paved roads/car park/driveways	0.02 – 0.03
Lakes (no emergent vegetation)	0.015 – 0.35
Wetlands (emergent vegetation)	0.05 – 0.08
Estuaries/Oceans	0.02 – 0.04

Figure 5: ARR19 Book 6 Section 6.2.1 & 6.2.2

The manning's coefficients have also been precisely adopted depending on the type of land cover and surface on the HEC-RAS modelling, which will be detailed on the following topics.

The sub-catchment breakup is shown below in table 1.

39 Redground Rd, Crookwell, NSW – Sub Catchments				
Flood Impact & Risk Assessment – Sub-Catchments				
Name	**Area (ha)**	**Mannings N**	**Avg. Slope**	**Impervious**
CATCHMENT 1	4.189	0.04	2.44%	1%
CATCHMENT 2	6.674	0.04	1.44%	2%
CATCHMENT 3	13.67	0.15	1.02%	60%
CATCHMENT 4	18.774	0.15	1.94%	60%
TOTAL CATCHMENT			**43.307**	**ha**

Table 1: Sub-Catchments Summary

3.3 DRAINS Modelling Input Parameters

The parameters adopted for DRAINS hydrological modelling are shown in table 2.

Parameter	Value Adopted	Justification/ Source
Impervious Area Initial Loss (mm)	1	Typical value for impervious areas.
Impervious Area Continuing Loss (mm/h)	0	Typical value for impervious areas.
Pervious Area Initial Loss (mm)	15	The value recommended in ARR Data Hub in accordance with recommended NSW loss hierarchy

Pervious Area Continuing Loss (mm/h)	4.3	The value recommended in ARR Data Hub in accordance with recommended NSW loss hierarchy
BX	1	RAFTS Default
Sub-catchment Area (km^2)	Varies	Refer to Table 1
Impervious Area (%)	Varies	Refer to Table 1 Estimated by digitising polygons of impervious areas (i.e. roads and roofs) from aerial imagery.
Sub-catchment Slope (%)	Varies	Refer to Table 1 Determined from slope analysis of LiDAR DEM data for each sub-catchment.
Manning's 'n'	0.04 0.15	Value across open areas, minimal vegetation (Grassed) Value across residential areas – low density

Table 2: DRAINS Hydrological Parameters Adopted

3.4 Rainfall Data

IFD design rainfall depth data and temporal patterns were derived in accordance with Australian Rainfall and Runoff (2019) using the Bureau of Meteorology's 2019 Rainfall IFD on-line Data System and are provided in Appendix B and C.

The temporal patterns for the East Coast South region were used as this covers the site (latitude -34.458 South, longitude 149.470 East).

A copy of the rainfall depths for the range of storm durations can be found in the Appendix C.

Flows were routed along each link using DRAINS premium hydraulic model which applies the full S.t Venant equations of unsteady flow to overland flow routes. This allows water levels along these routes to be determined accurately, allowing for varied water surface flow profiles, including subcritical and supercritical flows. It also accounts for storage effects in overland flow routes.

3.5 Results

The DRAINS model was run in 'premium' hydraulic mode for storm durations ranging from 5 minutes to 9 hours for the major and minor rainfall events, being them the 1% AEP and 10% AEP consecutively. The 2-hour storm was analysed for the 10% due to the larger flow and the 6-hour storm was analysed for the 1% due to larger flows of water during the storm event and larger volume.

The Probable Maximum Flood (PMF) was also analysed using DRAINS. The Probable Maximum Precipitation (PMP) has been calculated using intensities from Australian Rainfall & Runoff 1977 calculated using polynomial equations and in conjunction with the GDSM method in accordance with *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* document prepared by Commonwealth Bureau of Meteorology dated June 2003. The calculations can be found in Appendix E.

There are four overland flow paths that were analysed and they are identified in this study as OF1, OF2, OF3 and OF4 as shown in figure 6 below.

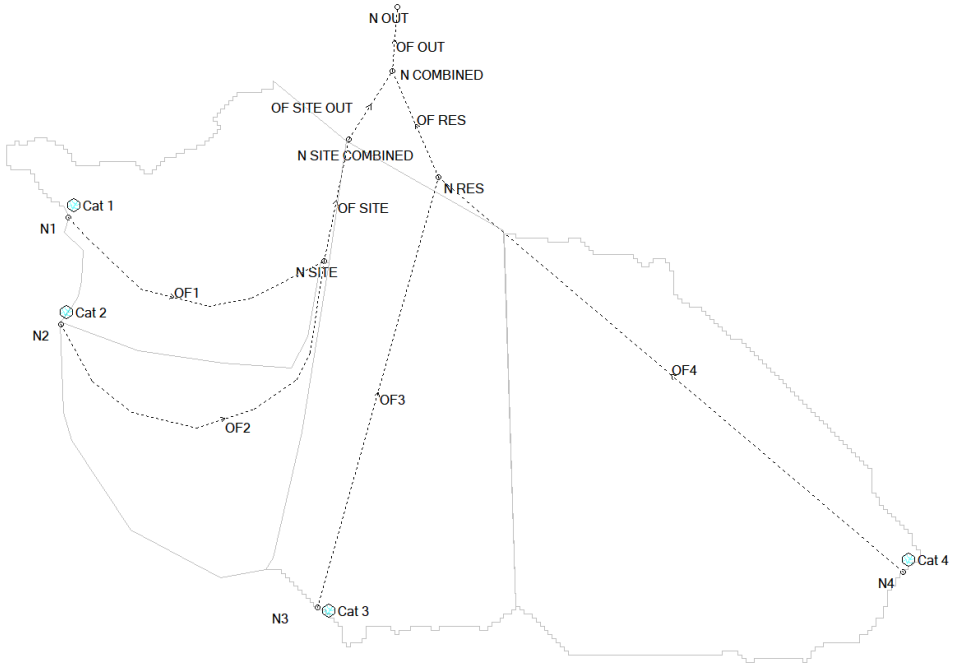


Figure 6: Outlet Overland Flow Path

The hydrograph data for OF1, OF2, OF3 and OF4 have been extracted from the DRAINS model that includes the minor (10% AEP), major (1% AEP) and the PMF. The hydrograph for these three rainfall events as shown in figures 7 to 18 below was entered into HEC-RAS for unsteady 2D flow analysis, which will be described in the following topic.

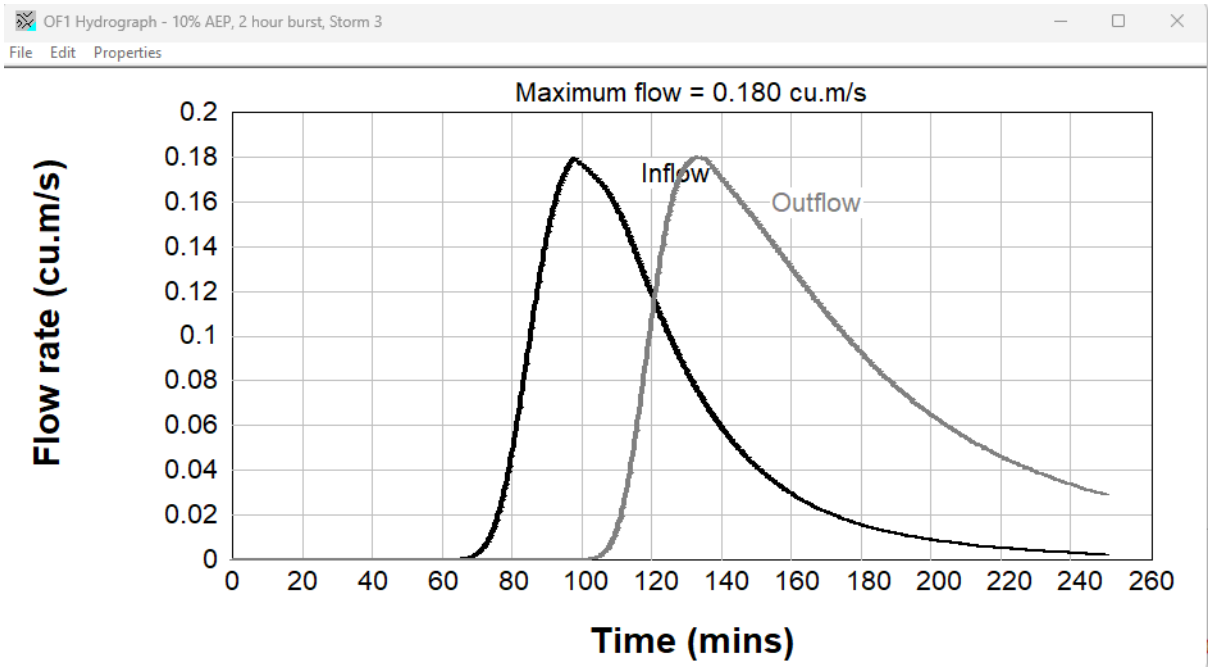


Figure 7: 10% AEP Median Hydrographs for OF1

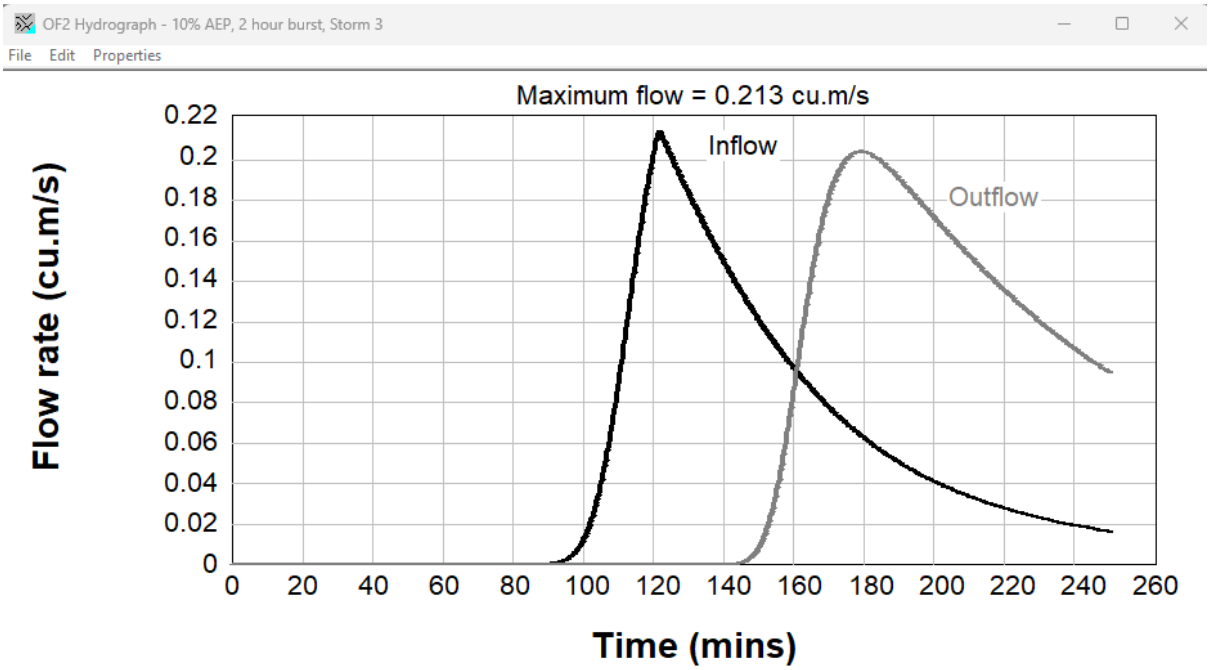


Figure 8: 10% AEP Median Hydrographs for OF2

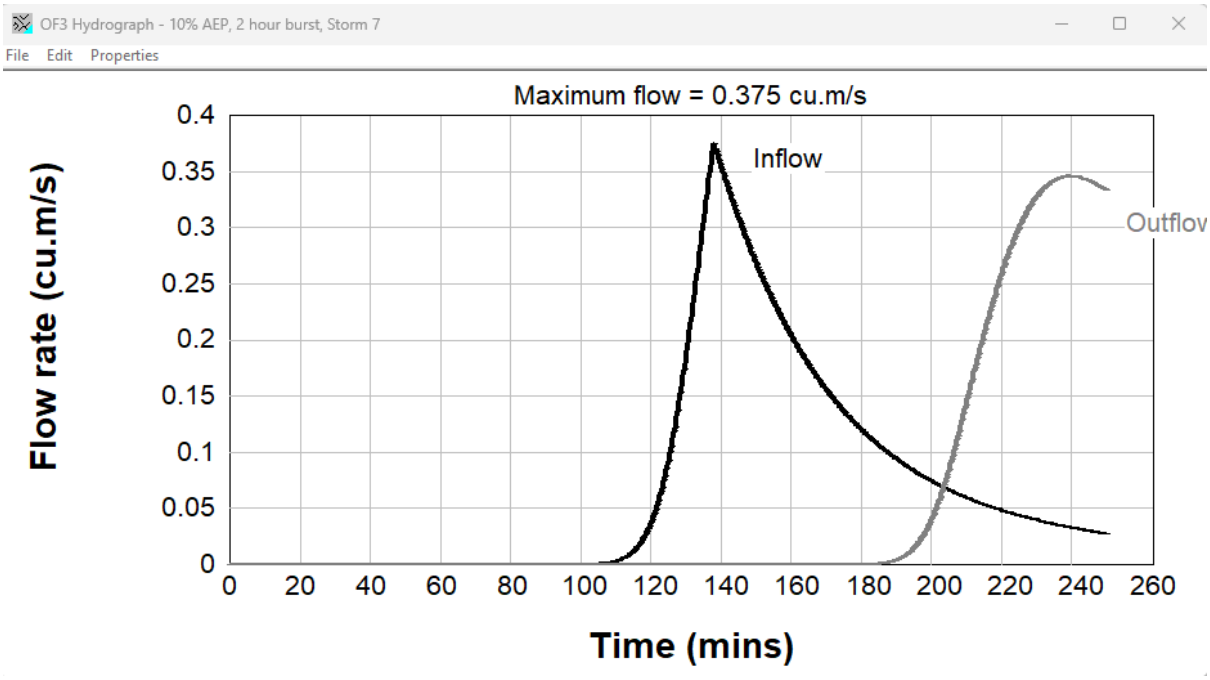


Figure 9: 10% AEP Median Hydrographs for OF3

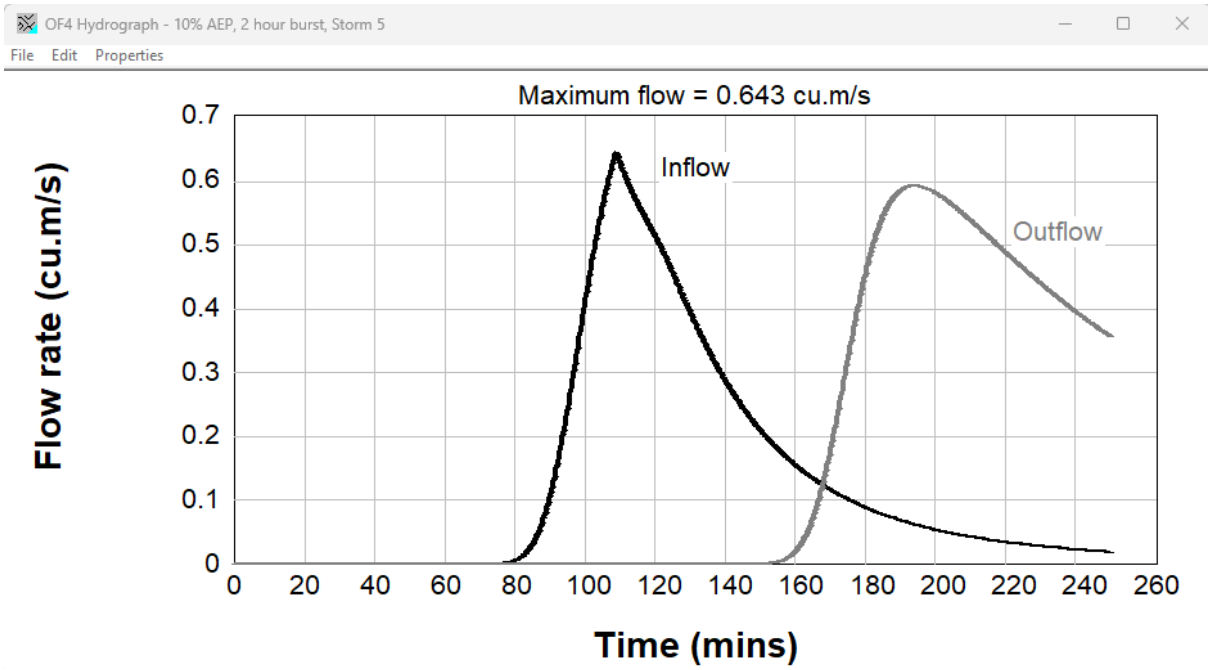


Figure 10: 10% AEP Median Hydrographs for OF4

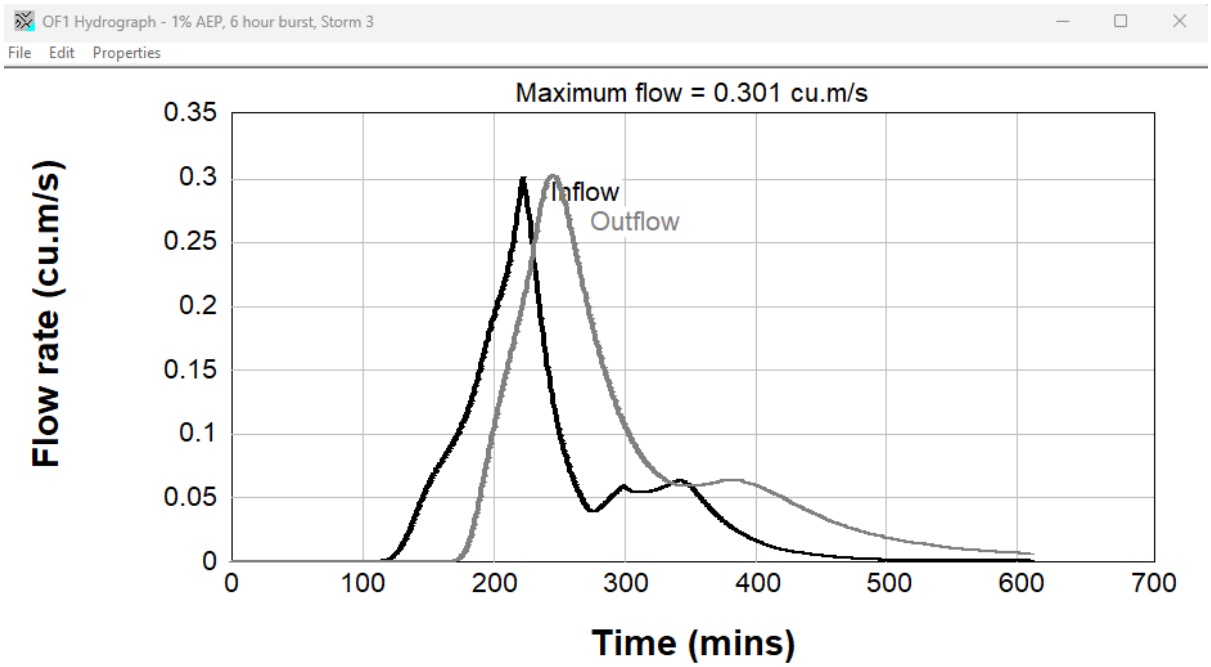


Figure 11: 1% AEP Median Hydrographs for OF1

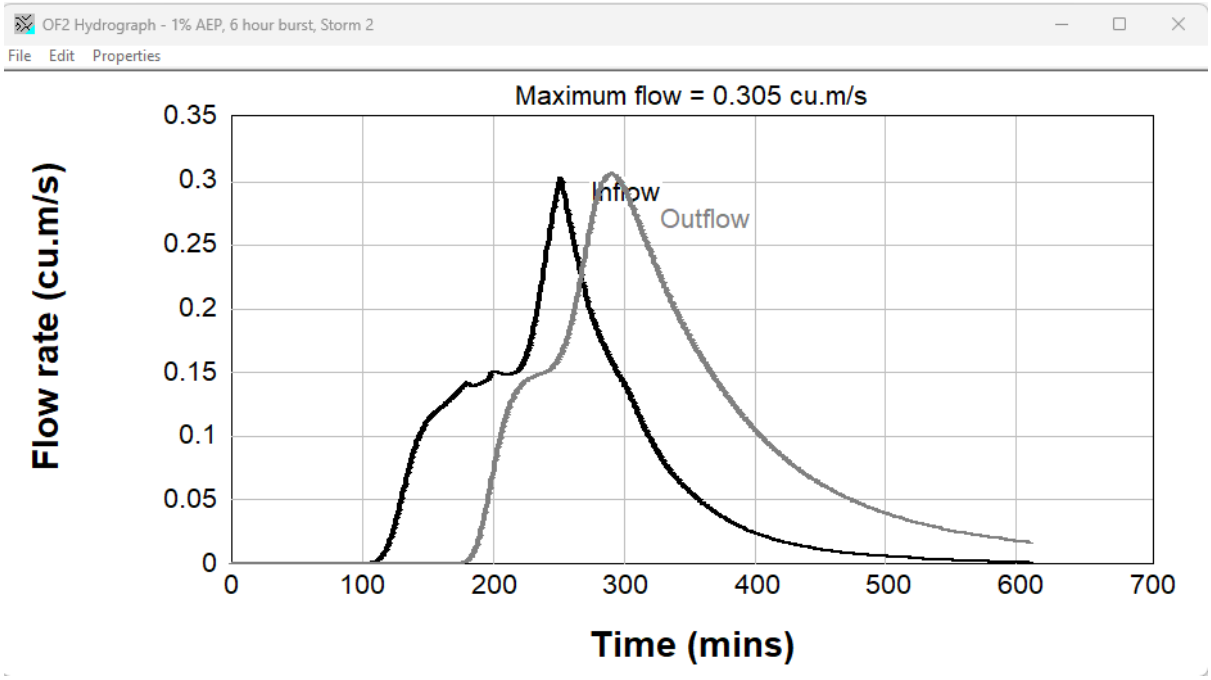


Figure 12: 1% AEP Median Hydrographs for OF2

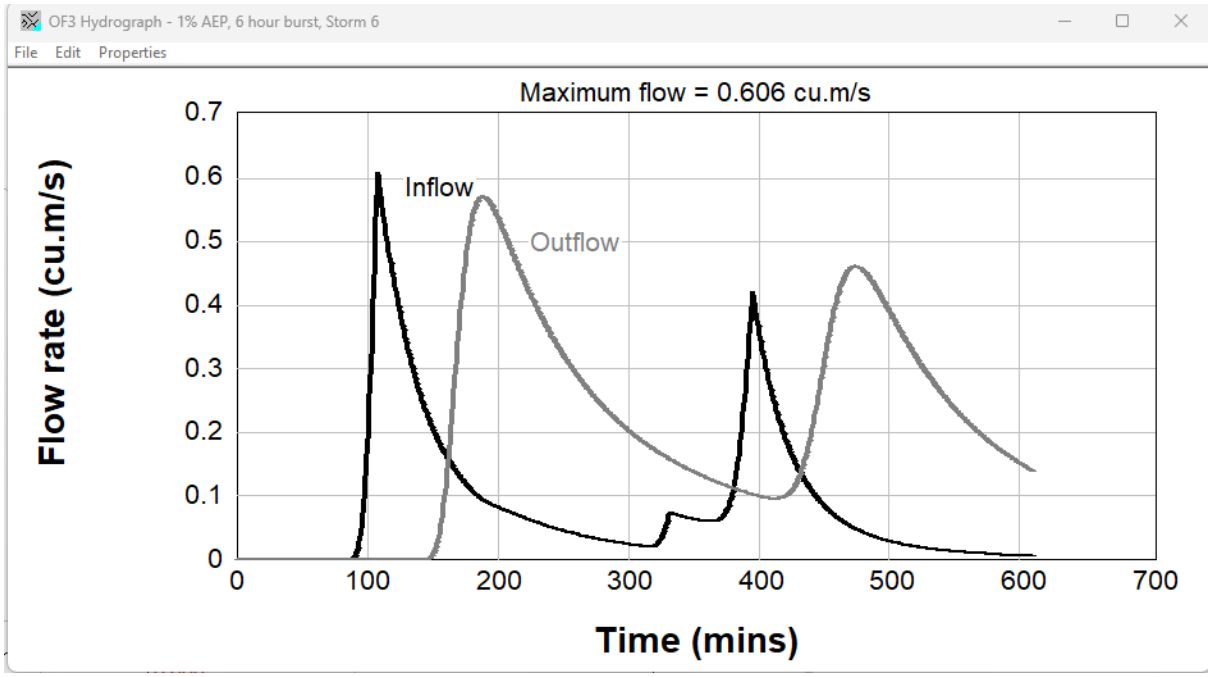


Figure 13: 1% AEP Median Hydrographs for OF3

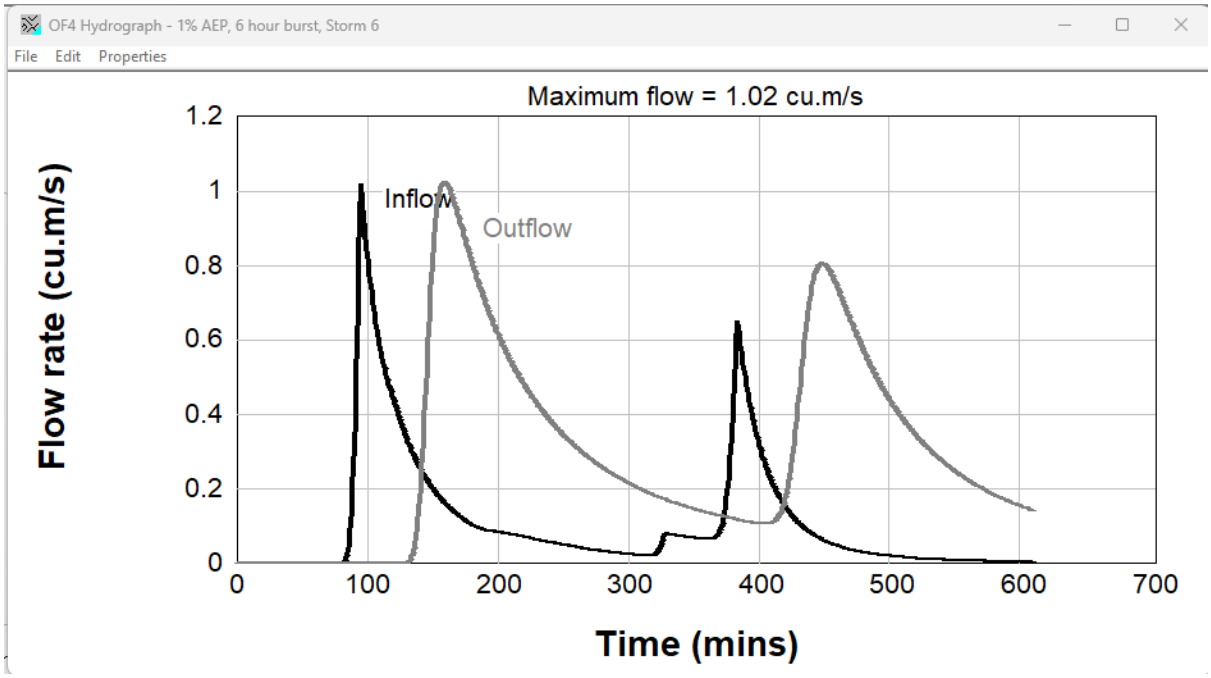


Figure 14: 1% AEP Median Hydrographs for OF4

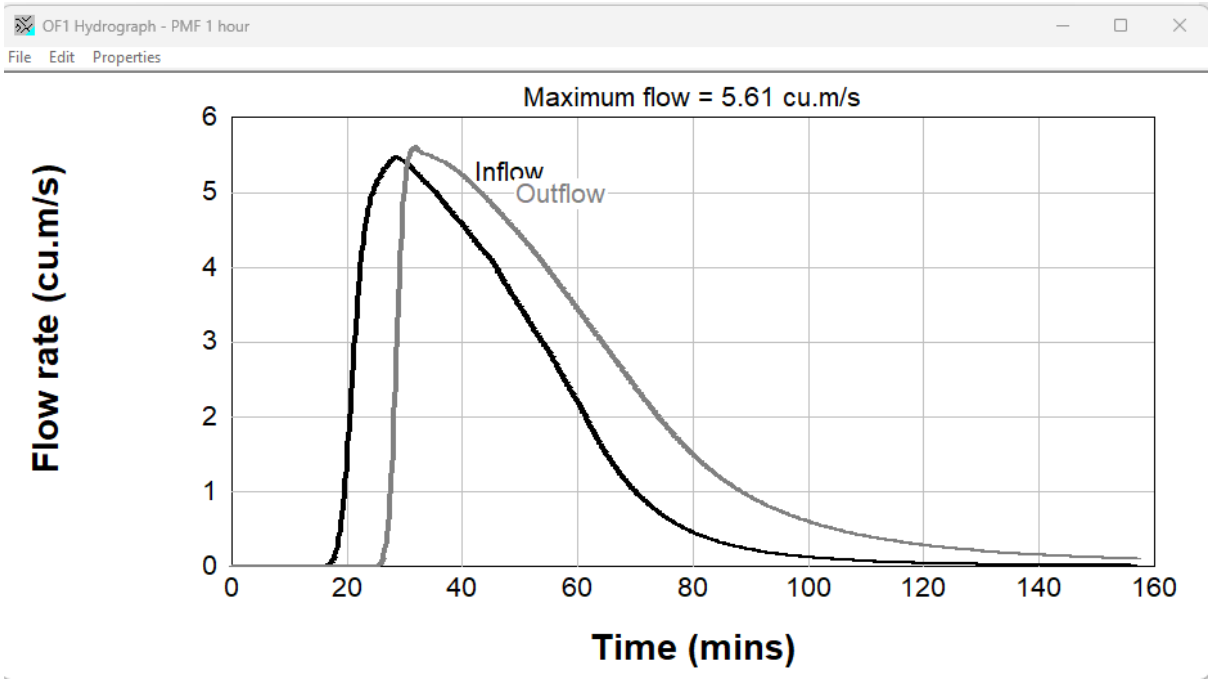


Figure 15: PMF Median Hydrographs for OF1

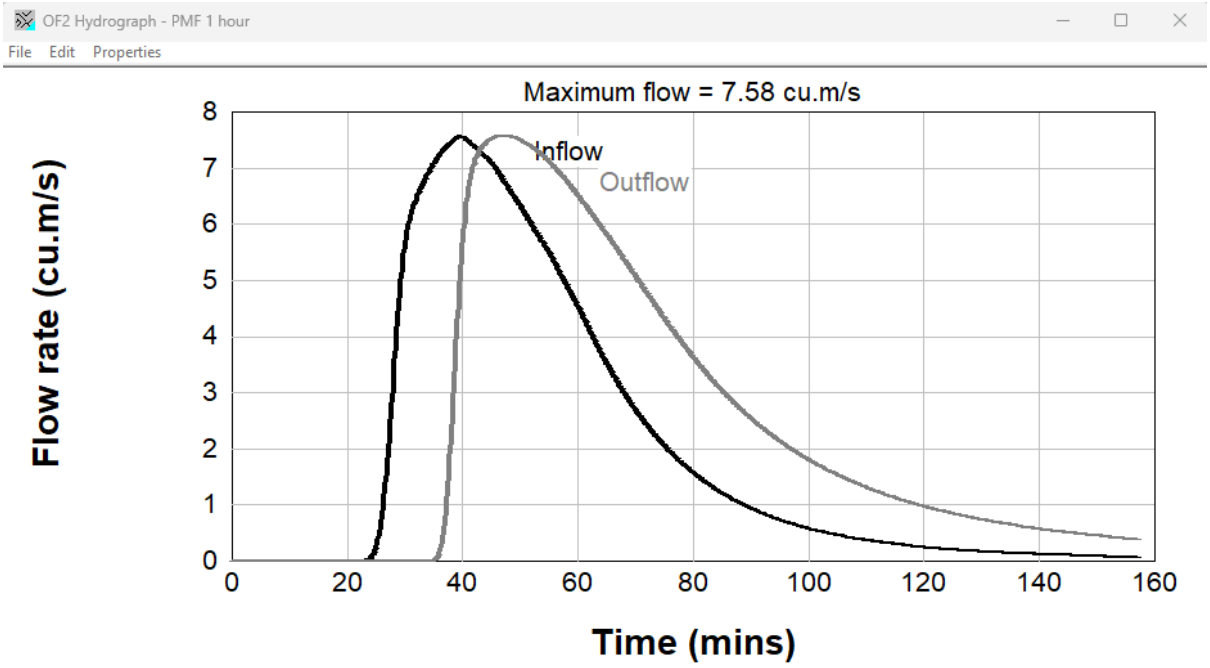


Figure 16: PMF Median Hydrographs for OF2

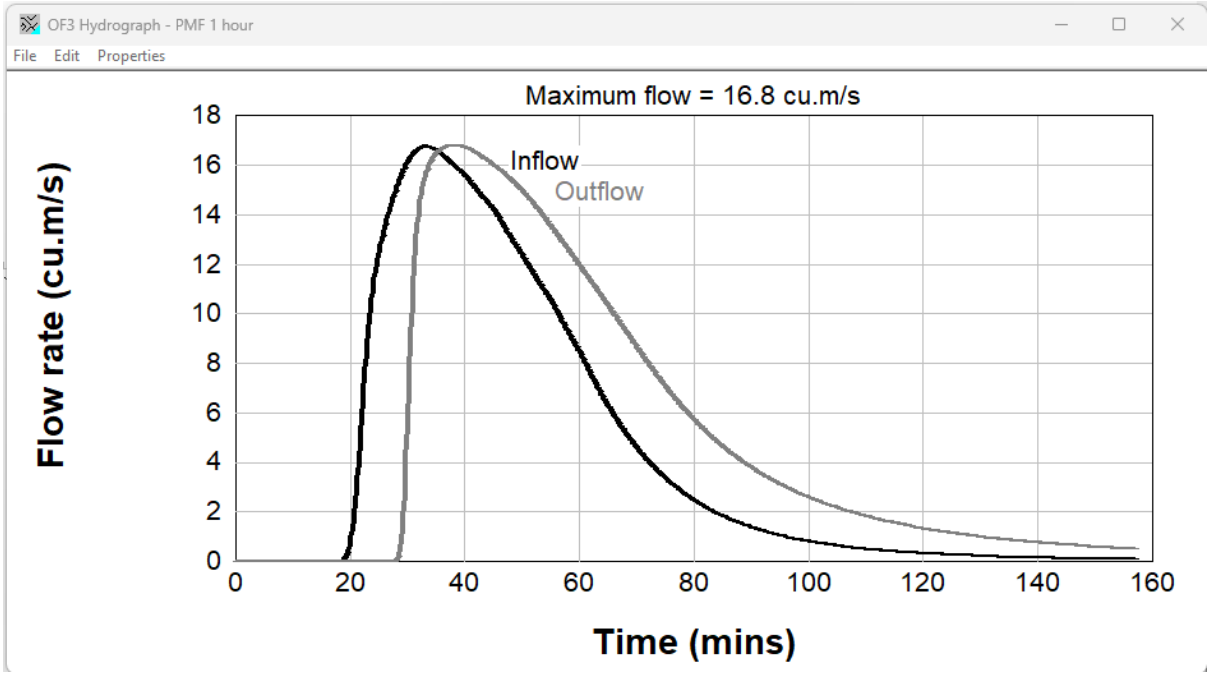


Figure 17: PMF Median Hydrographs for OF3

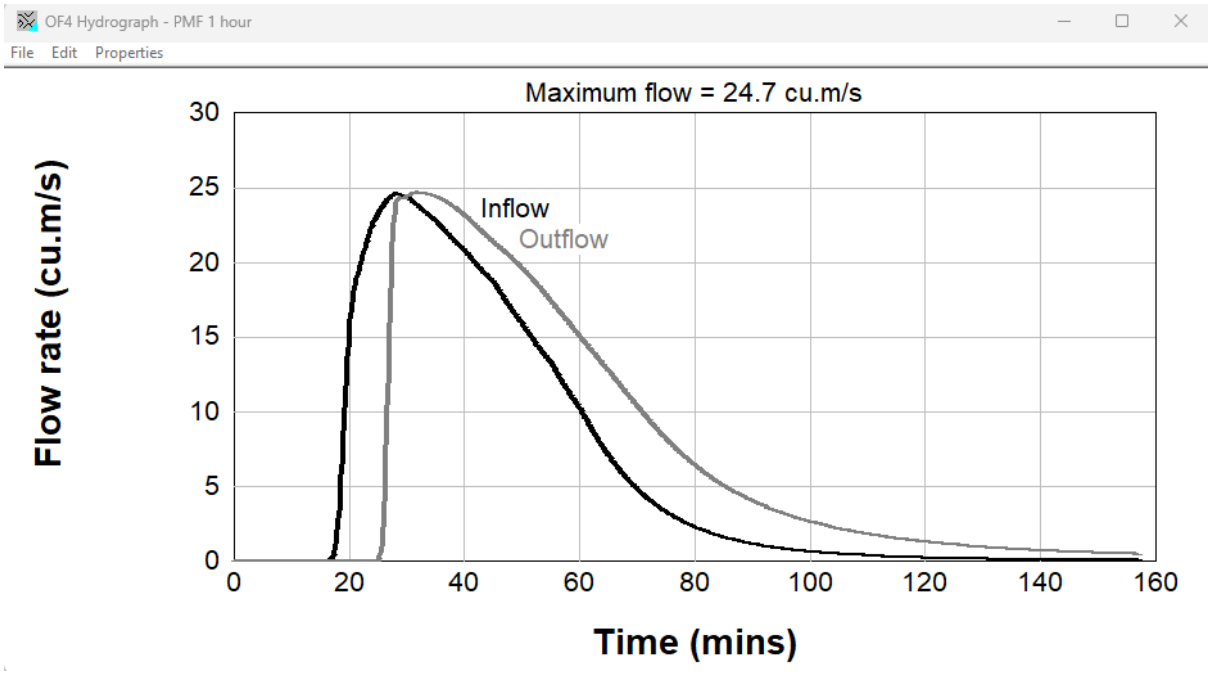


Figure 18: PMF Median Hydrographs for OF4

Critical storm duration refers to the duration of design storm that will result in the highest peak flood flows or levels at a particular location. The critical duration is influenced by various factors including upstream catchment area and may vary between locations of interest throughout a catchment or study area. With the introduction of ARR 2019 a representative temporal pattern must also be identified which produces a peak flow closest to but not less than the design peak flow (that being the average of peak flows from an ensemble set of 10 temporal patterns).

The critical storms identified for 10%, 1% AEP and PMF are shown in Table 3 below:

Critical Storms – 39 Redground Rd, Crookwell, NSW		
OF1	10% AEP	10% AEP, 2 hour burst, Storm 3
	1% AEP	1% AEP, 6 hour burst, Storm 3
	PMF	PMF, 1 hour
OF2	10% AEP	10% AEP, 2 hour burst, Storm 3
	1% AEP	1% AEP, 6 hour burst, Storm 2
	PMF	PMF, 1 hour
OF3	10% AEP	10% AEP, 2 hour burst, Storm 7
	1% AEP	1% AEP, 6 hour burst, Storm 6
	PMF	PMF, 1 hour
OF4	10% AEP	10% AEP, 2 hour burst, Storm 5
	1% AEP	1% AEP, 6 hour burst, Storm 6
	PMF	PMF, 1 hour

Table 3: Critical Storms for 10%, 1% AEP and PMF

3.6 Calibration

In the absence of recorded gauges within the catchment area, calibration of the hydrologic model was unable to be undertaken in this study, and the model validation approaches were applied to the hydraulic model as described in section 4.7 of this assessment.

Furthermore, Regional Flood Frequency Estimation Model (FFFEM) is not applicable due to the catchment size being outside the recommended of 0.5 to 1,000km^2 and results having a lower accuracy. A REFEM was used to compare results from the Upper Lachlan Shire Council which has a catchment area of 9km^2 which is within the recommended catchment size. The REFEM output can be found in Appendix E. The REFEM output for the 0.43km^2 has also been provided in Appendix E.

4. Hydraulic Modelling

Modelling was conducted using an unsteady 2D Hydraulic HEC-RAS model.

4.1 Digital Elevation Model (DEM)

A digital elevation model (DEM) over the study area was established using 1m LiDAR Digital Elevation Models (DEM) sourced from ELVIS (http://elevation.fsdf.org.au).

Using the 1m DEM, a two- dimensional flow area (i.e. active cells) was defined over the subject site and surrounding areas over an area large enough to accommodate the expected flows. The LiDAR data used can be seen in figure 19.

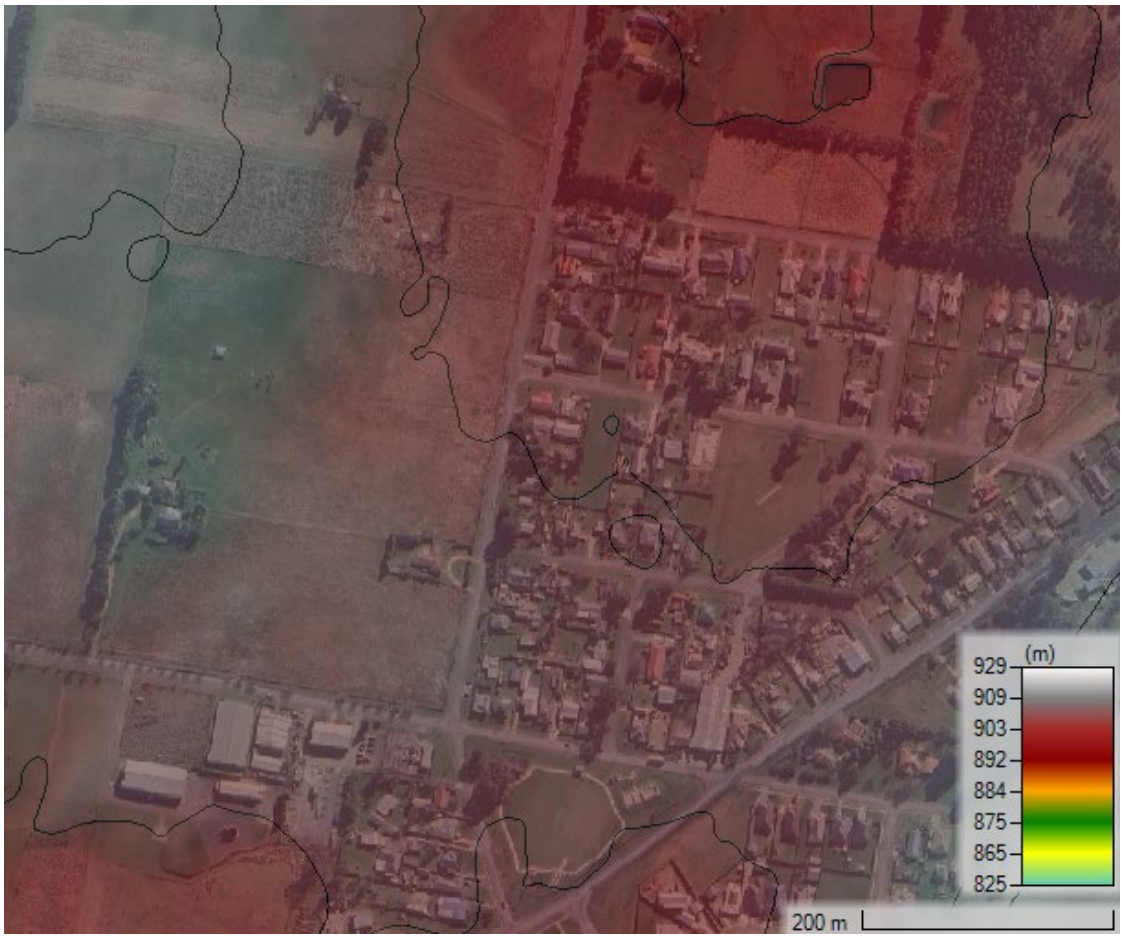


Figure 19: Unmodified LiDAR DEM (Pre-Development)

The 1m DEM grid was imported into HEC-RAS and used as the basis for development to create the terrain model for the pre-development and post-development.

4.2 Surface Modification

The DEM was used as a base surface for the post-development scenario. A land survey has been carried out within the property for more accurate data of the existing condition of the site.

The perimeter road has been modelled using Civil Site Design, and the design TIN surface has been exported into HEC-RAS and combined with the pre-development DEM to represent the post-development layout to be used for hydraulic analysis.

The post-development surface is shown in figure 20.

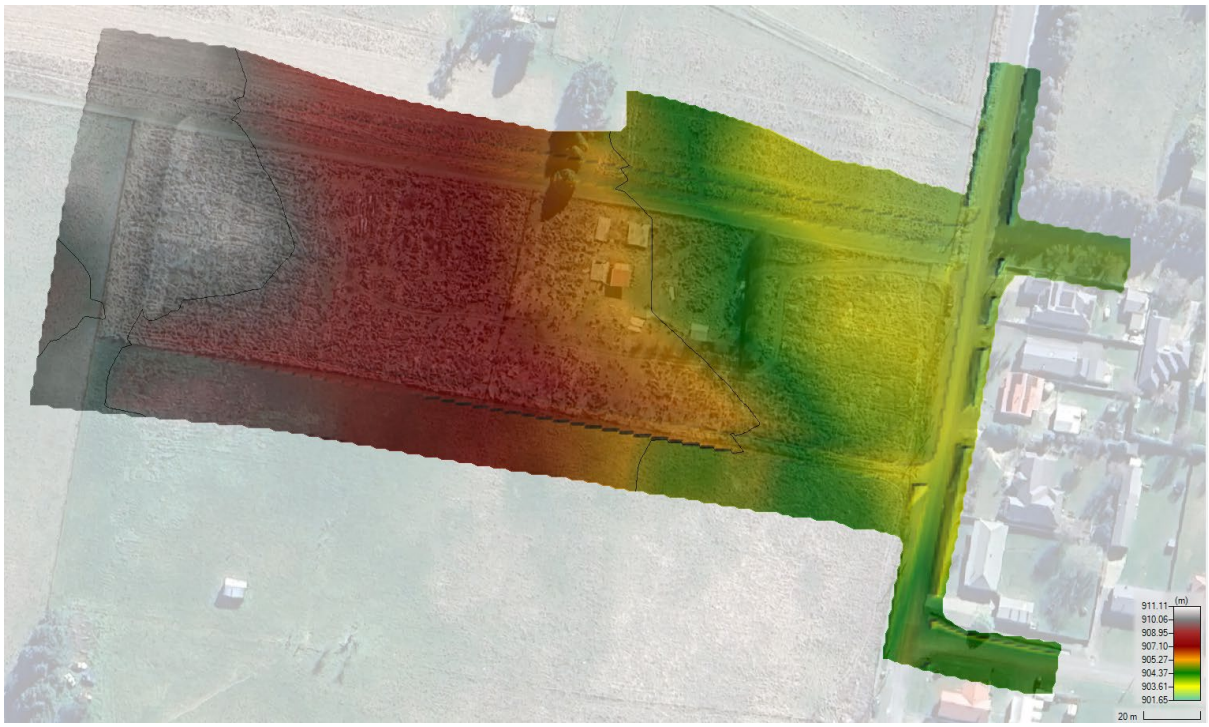


Figure 20: Design Surface (Post-Development)

4.3 2D Flow Area and Boundary Conditions

A two-dimensional flow area (mesh) and geometry has been created for pre-development and post-development scenarios, extended downstream and upstream of the site to analyse the flow characteristics and the impacts on the adjoining properties.

The flow hydrograph for the upstream boundary conditions was derived from DRAINS using the results for the rainfall events previously mentioned for the internal and external catchments that affect the site and surrounding.

The inflow boundaries were extended along the upstream face of the two-dimensional domain at each location over a sufficient length to enable the model to appropriately distribute the flow to the cells that are wet. At any given time-step, only a portion of the boundary condition line may be wet,

therefore only the cells in which the water surface elevation is higher than their outer boundary face terrain will receive water.

Flows leaving the two-dimensional area were defined with a normal depth downstream boundary condition with a friction slope of 1% which is based on the gradient of the land at the location of the boundary according to the original 1m DEM surface. The friction slope method uses the Manning's equation to compute a normal depth for each given flow, based on the cross section underneath the two-dimensional boundary condition line and is computed on a per cell basis.

The location and extent of all boundary condition lines are shown in figure 21.

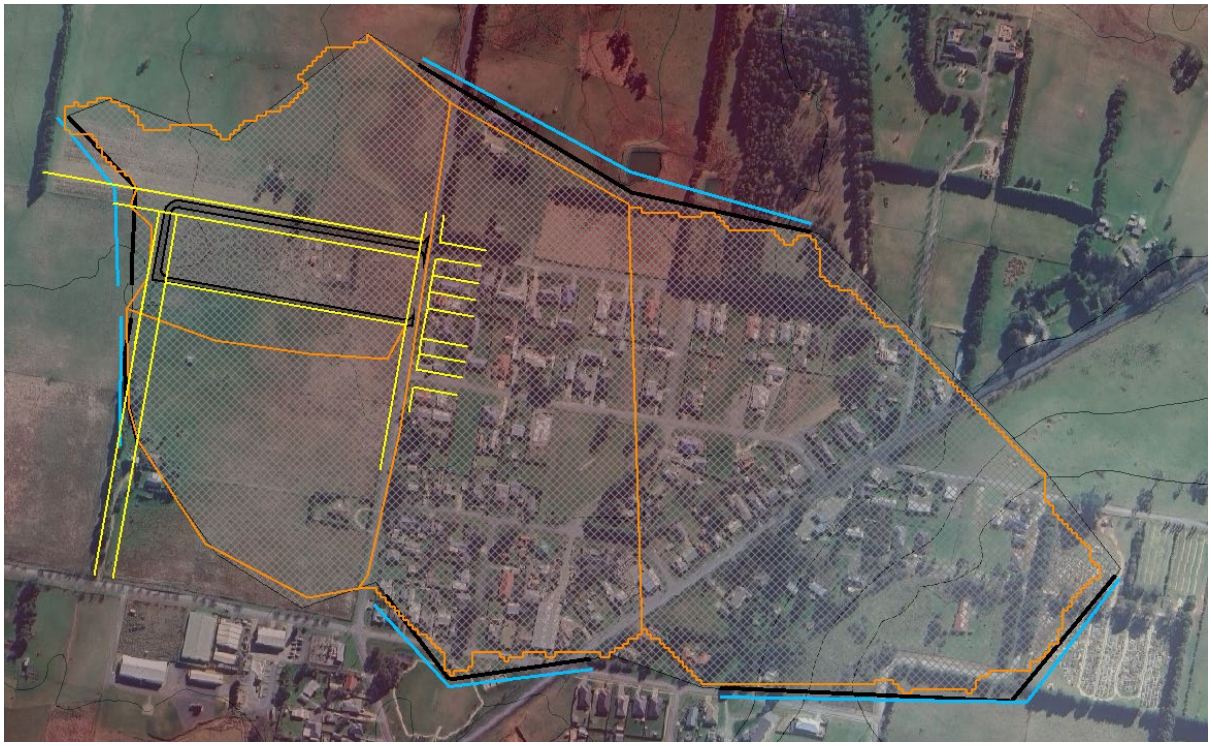


Figure 21: Location and Extent of Boundary Condition Lines

4.4 2D Hydraulic Model – Manning's Roughness

The Manning's Roughness coefficient was refined on the most critical areas within the 2D flow mesh in HEC-RAS according to the landcover and type of surface that best represents the pre-development and post-development condition of the subject site and surrounding area and adopted as shown in table 3 and figure 22 and 23 below.

Description	Manning's (N)
Open Areas with Low/Medium Vegetation	0.06
Residential Lots	0.15
Roads	0.02

Table 3: 2D Hydraulic Model – Manning's Roughness

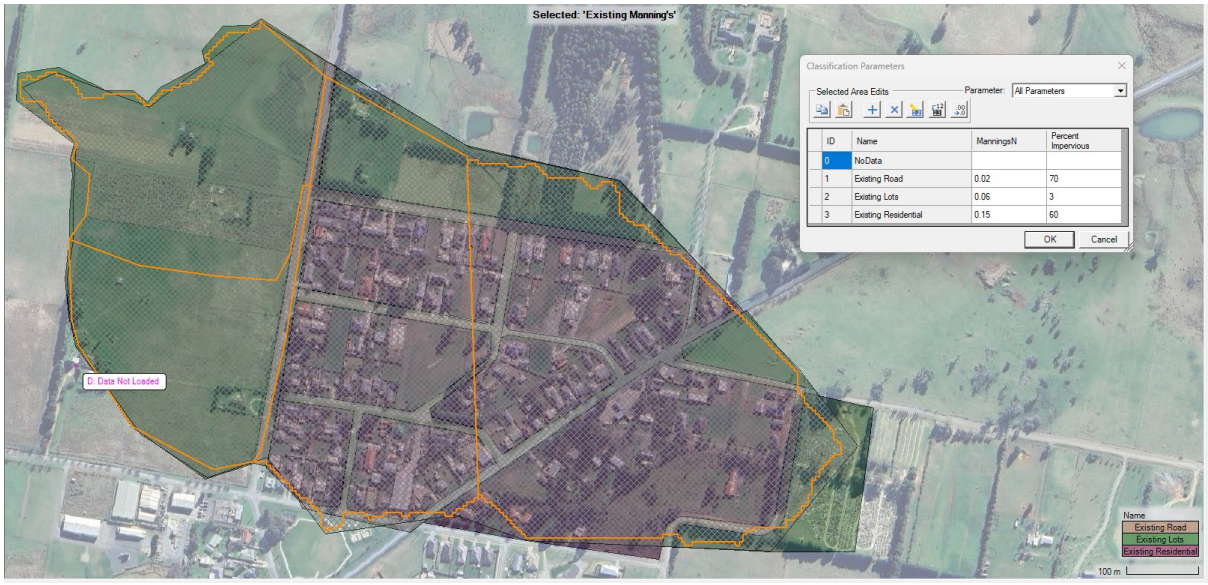


Figure 22: 2D Hydraulic Model – Manning's Roughness – Pre-Development

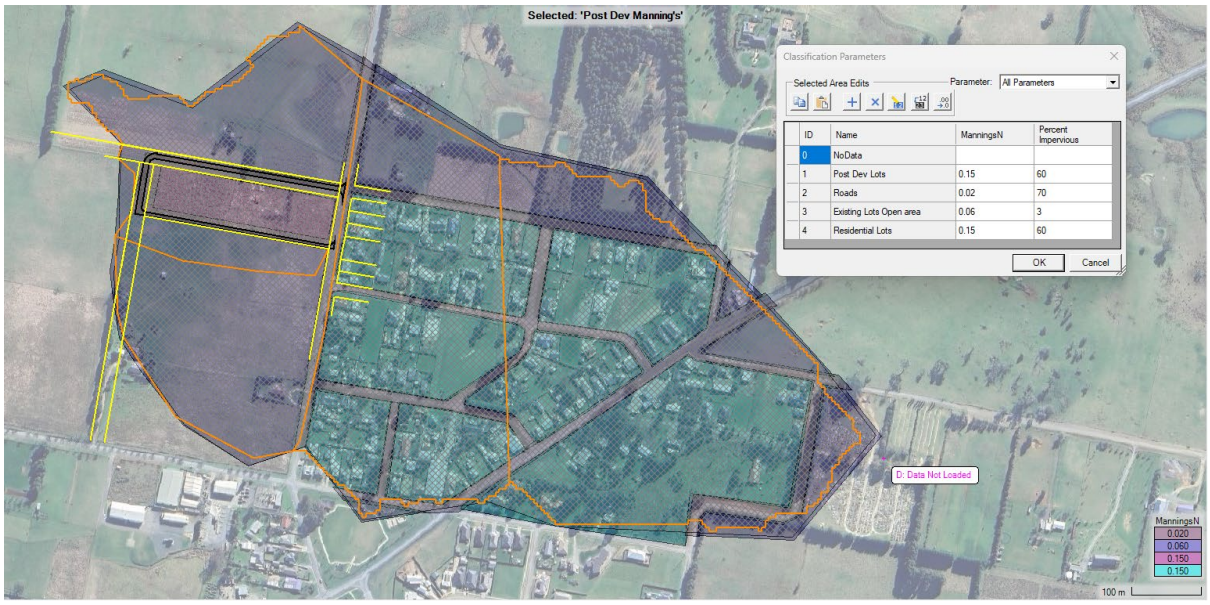


Figure 23: 2D Hydraulic Model – Manning's Roughness – Post-Development

4.5 Results

The 2D Hydraulic HEC-RAS model was run in unsteady mode with variable timestep controlled by Courant condition using the diffusion wave computational method. The model was used to simulate the flows for the 10%, 1% AEP and PMF.

Please refer to the civil engineering sheet set provided in Appendix A for the mapped results extracted from HEC-RAS where the flood characteristics (depth, velocity, and water surface elevation) for the pre-development and post-development scenarios have been compared.

Figures 24 and 25 below shows the flood depth for the 10% AEP rainfall event for the pre-development and post-development consecutively.

Figures 26 and 27 below shows the flood depth for the 1% AEP rainfall event for the pre-development and post-development consecutively.

Figures 28 and 29 below shows the flood depth for the PMF rainfall event for the pre-development and post-development consecutively.

Figure 30 and 31 below shows the flood WSE for the 10% AEP rainfall event for the pre-development and post-development consecutively.

Figure 32 and 33 below shows the flood WSE for the 1% AEP rainfall event for the pre-development and post-development consecutively.

Figures 34 and 35 below shows the flood WSE for the PMF rainfall event for the pre-development and post-development consecutively.

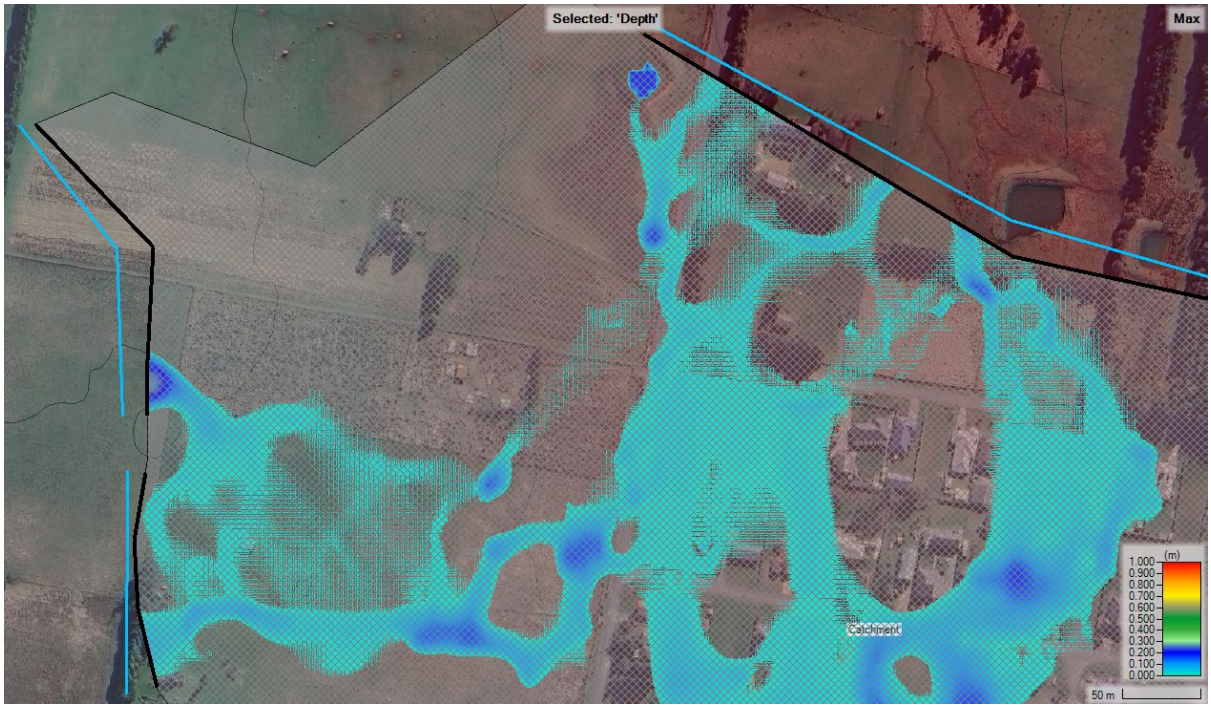


Figure 24: 10% AEP Event – Depth – Pre-Development

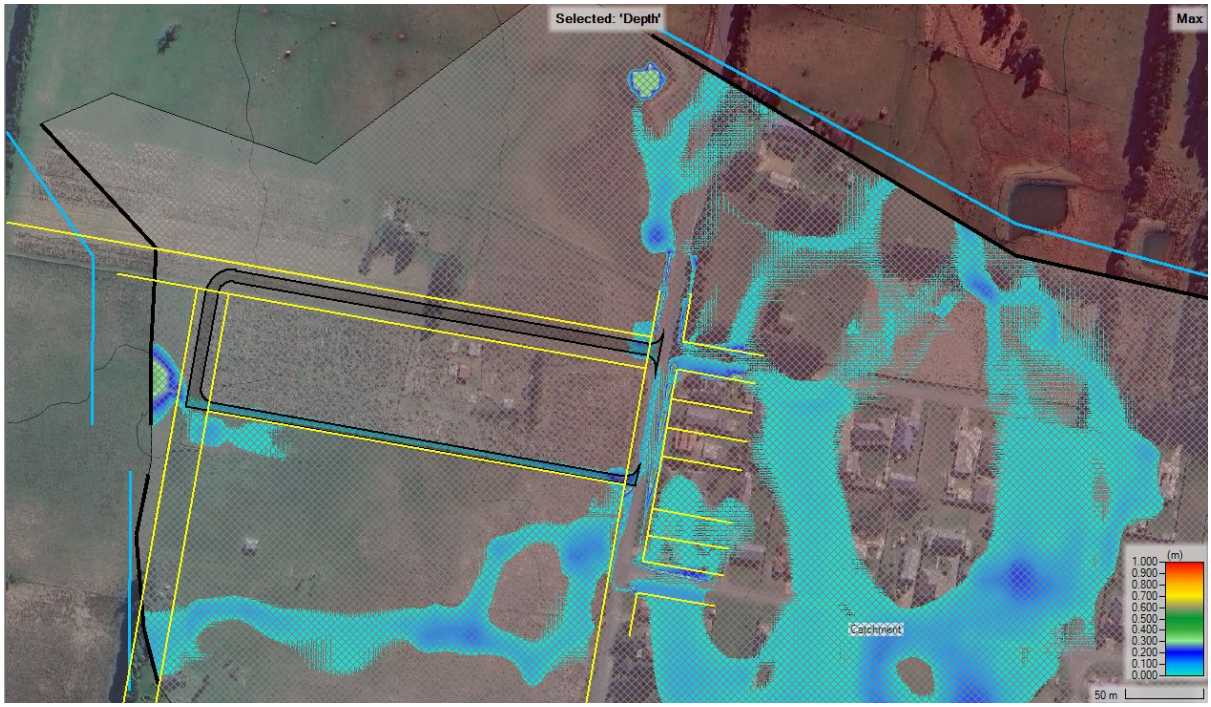


Figure 25: 10% AEP Event – Depth – Post-Development

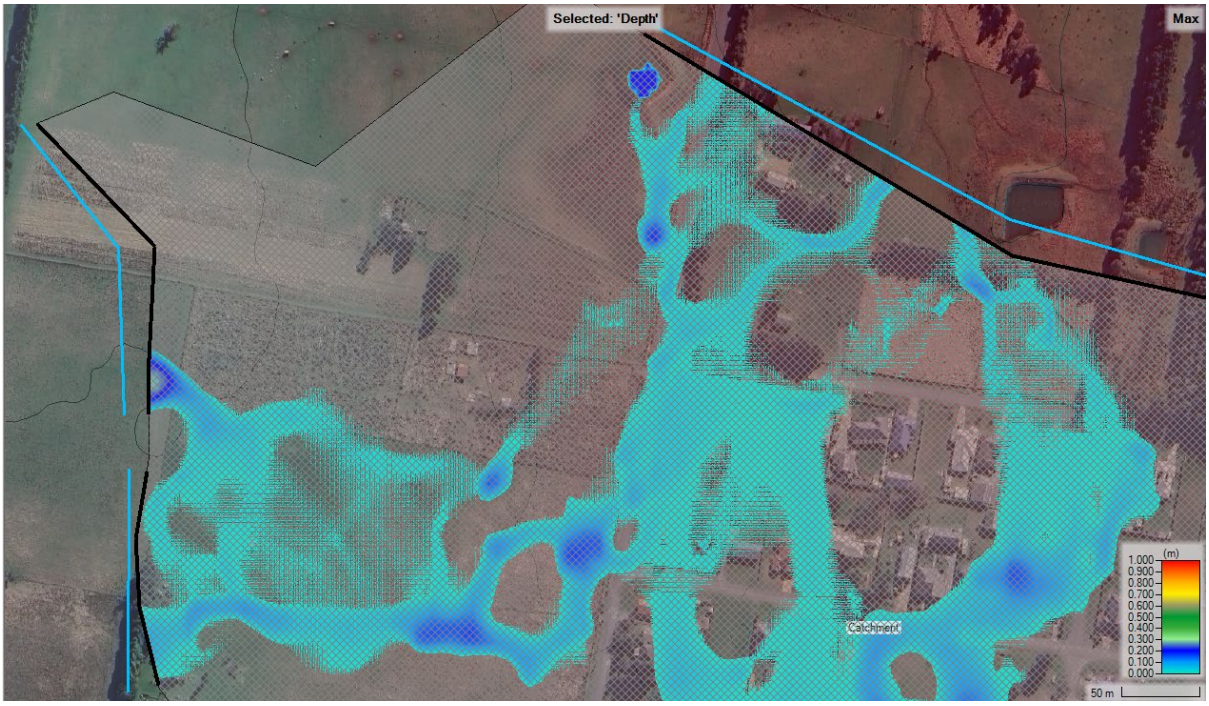


Figure 26: 1% AEP Event – Depth – Pre-Development

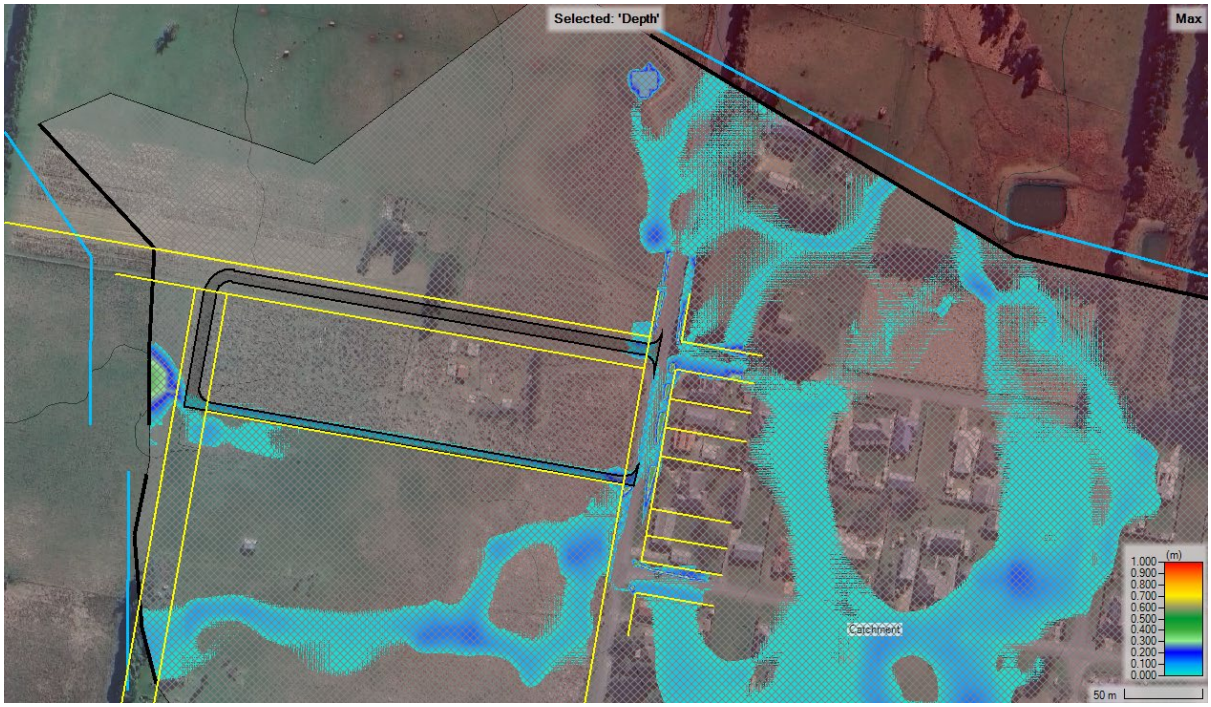


Figure 27: 1% AEP Event – Depth – Post-Development

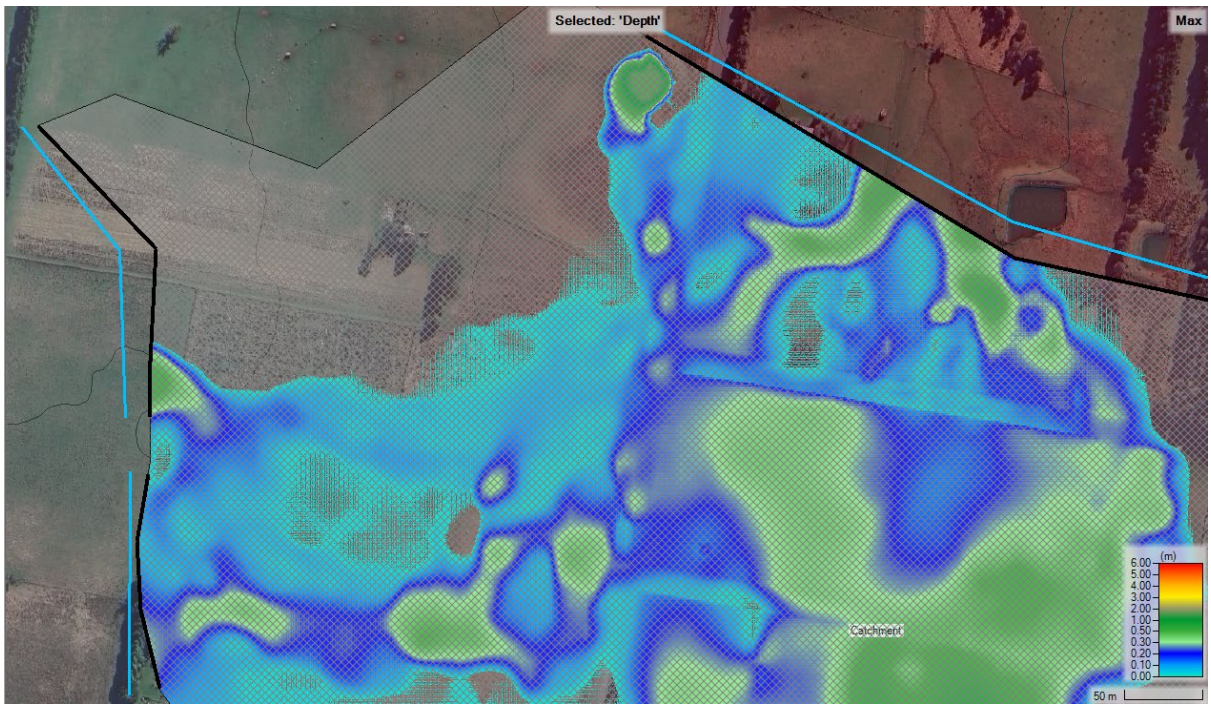


Figure 28: PMF Event – Depth – Pre-Development

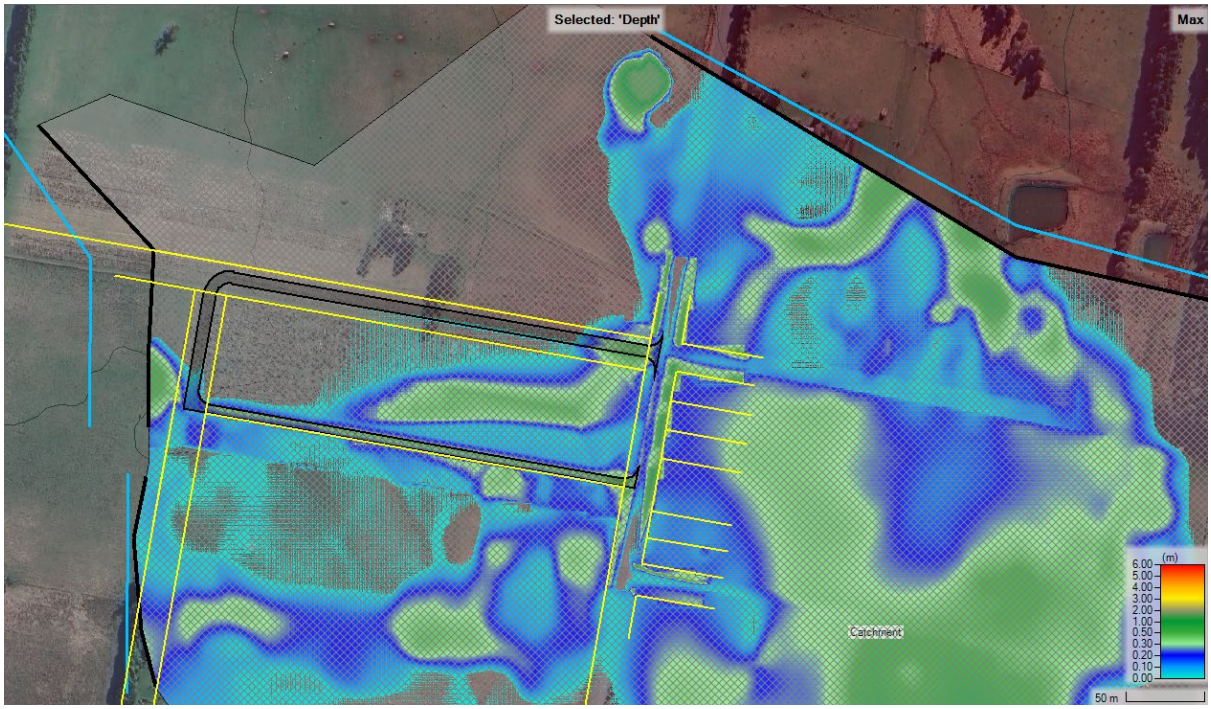


Figure 29: PMF Event – Depth – Post-Development

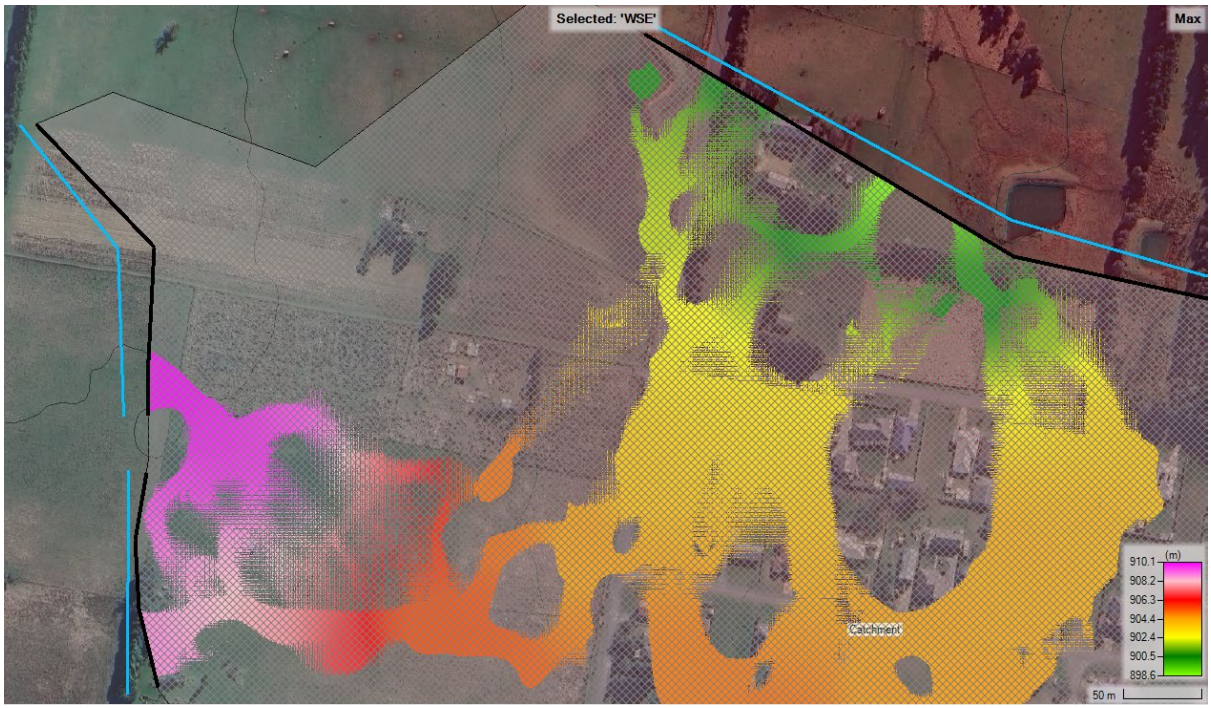


Figure 30: 10% AEP Event – WSE – Pre-Development

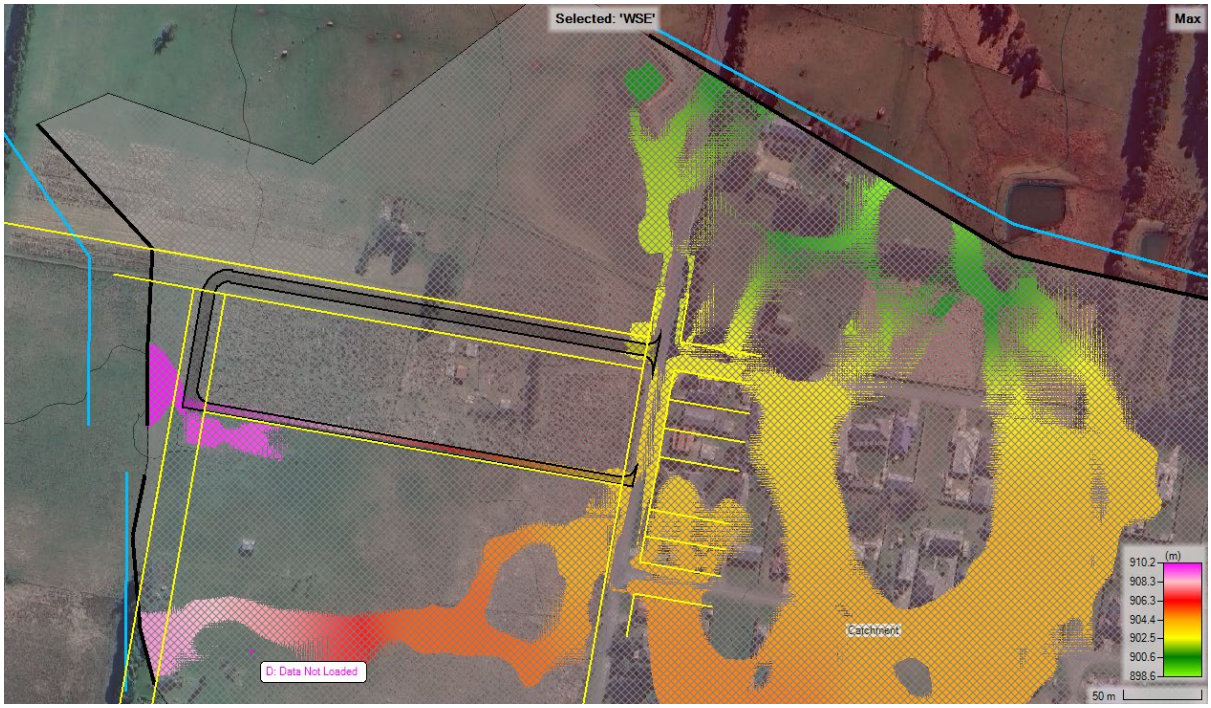


Figure 31: 10% AEP Event – WSE – Post-Development

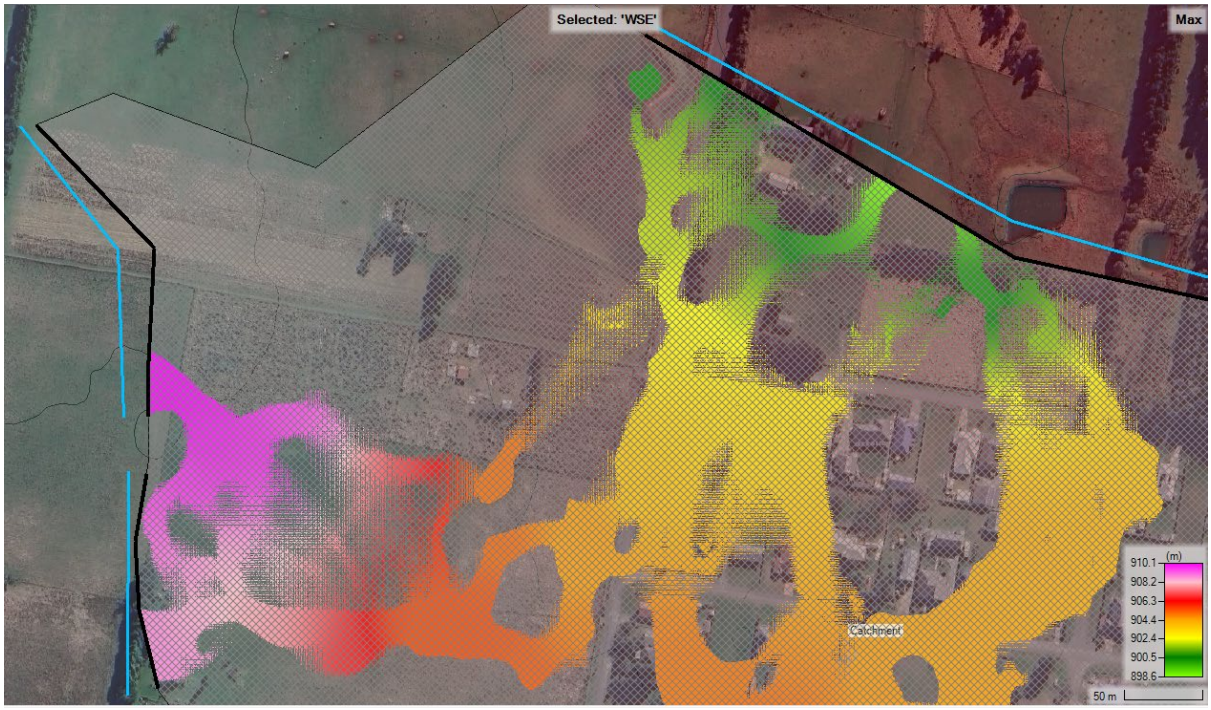


Figure 32: 1% AEP Event – WSE – Pre-Development

Figure 33: 1% AEP Event – WSE – Post-Development

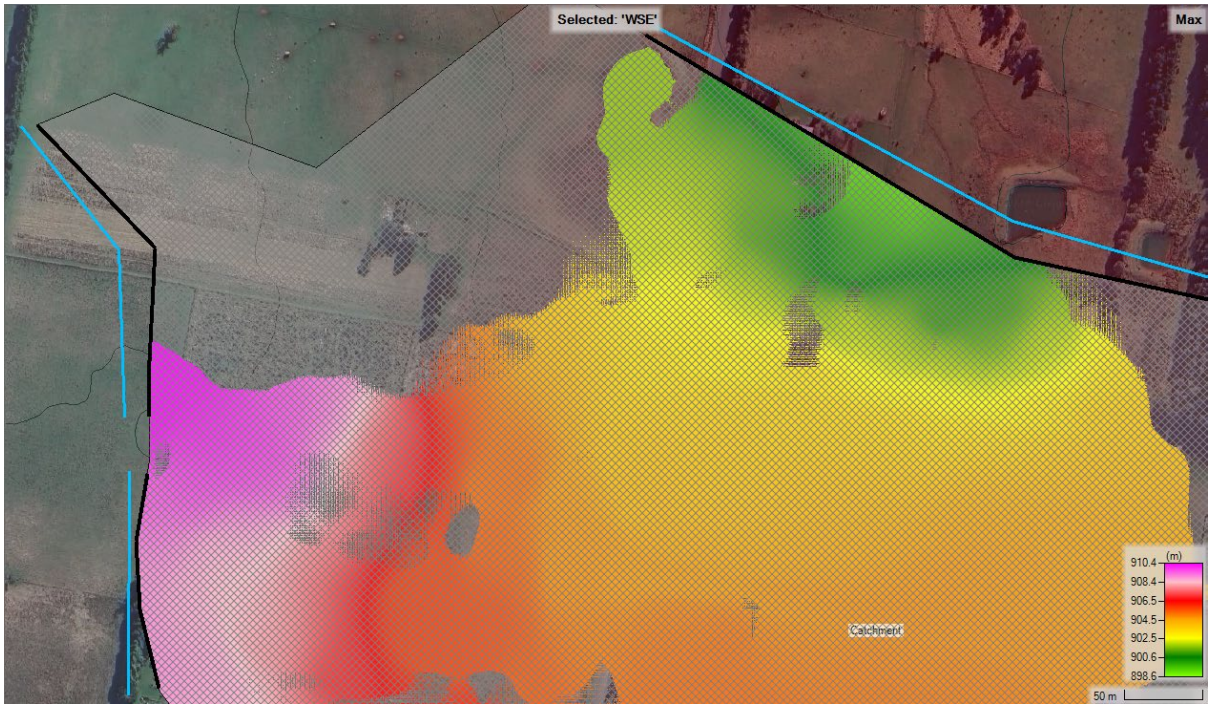


Figure 34: PMF Event – WSE – Pre-Development

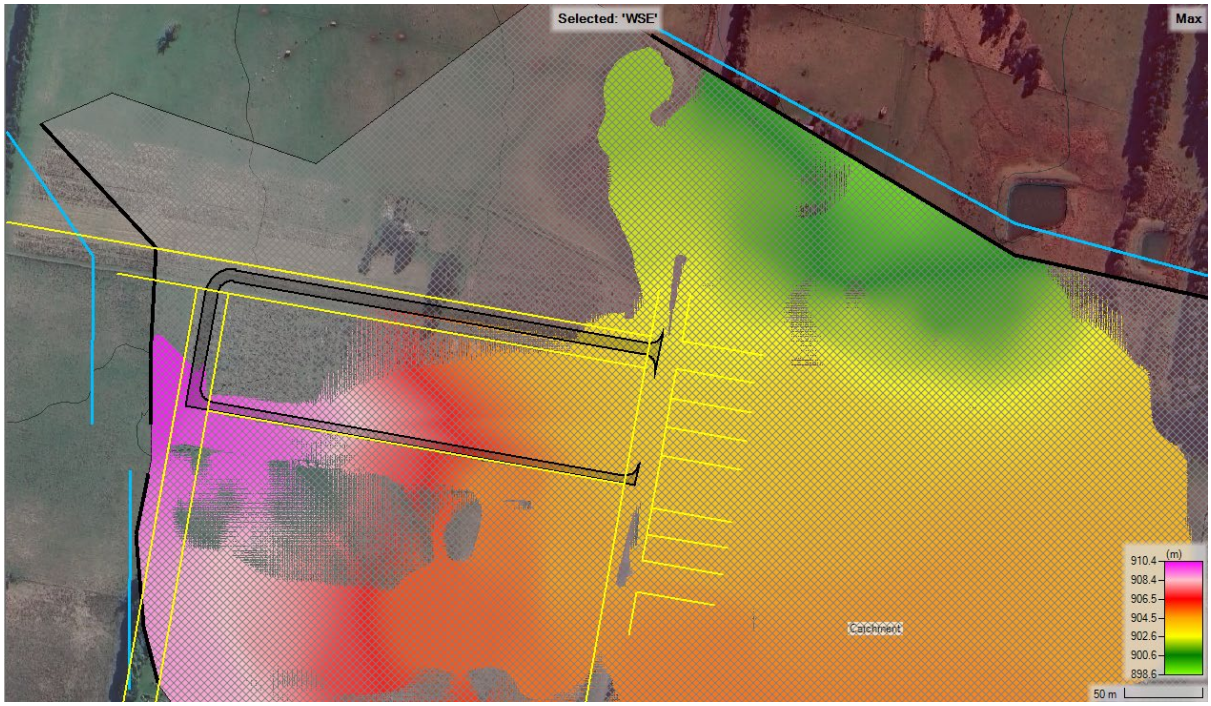


Figure 35: PMF Event – WSE – Post-Development

Figures 36, 37 and 38 below shows the 10%, 1% and PMF water surface elevation (WSE) comparison between the pre-development and post-development scenarios, including 'was wet now dry' and 'was dry now wet' areas. As shown, its conclusive that the development lots will not be impacted by the 10% and 1% AEP rainfall events. It can be seen in the figures by the light blue hatch that the flows travel down the post development roads which allows for the minor events to be treated via stormwater drainage and in major events the roads will act as overland flow paths. The sizing of the stormwater drainage will be undertaken at detailed design phase.

Figure 36: 10% AEP - WSE Comparison – Pre-Development x Post-Development

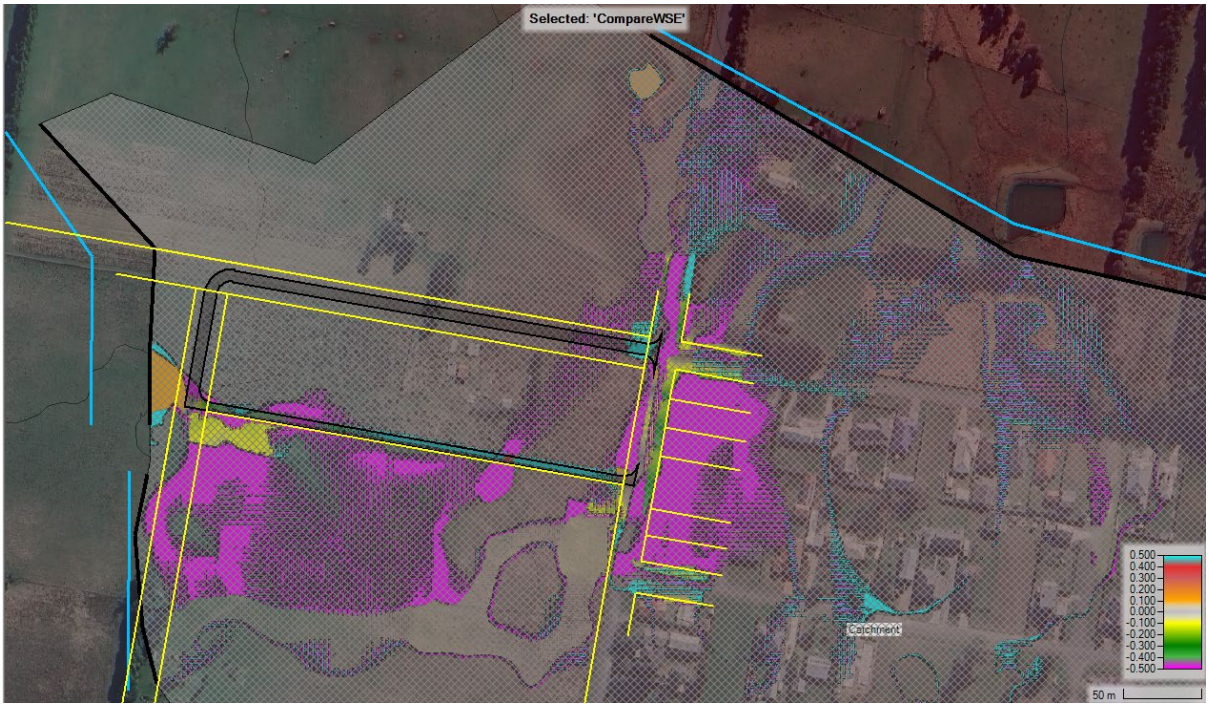


Figure 37: 1% AEP - WSE Comparison – Pre-development x Post-Development

Figure 37: PMF - WSE Comparison – Pre-development x Post-Development

It can be seen in Figure 36 above that the post-development flood inundation impacts the pre-development 10% and 1% AEP rainfall events where the new road reserves are. Taking a closer look at the post-development scenario during the 1% AEP event, the max DxV = 0.11m^2/s, being classified as H1 hazard category. This category is classified as generally safe for vehicles and people. As this is a road reserve, these results will be assessed in more detailed design phase via stormwater drainage and a DRAINS model. See figure 40 for the flood hazard classification extracted from ARR 2019 Book 6.

In Figure 37 above for the post-development flood inundation impacts the pre-development for the PMF. The flood inundation spills the road reserve boundaries and into the lots of 39 Redground, though this is generally of a very minor depth. Taking a closer look at these areas the max DxV for the roads. The majority of road 01 is 0.5m^2/s for road 02 and 0.2m^2/s for road 01. These numbers are within H2 and H1 categories which allows for vehicles to have safe access and egress. There are isolated pockets around the SAGs of the road that the kerb has a higher VxD. All flood inundation within the lots is all within the front boundary setbacks and H1 hazard categories.

See Figure 38, 39 and 40 below.

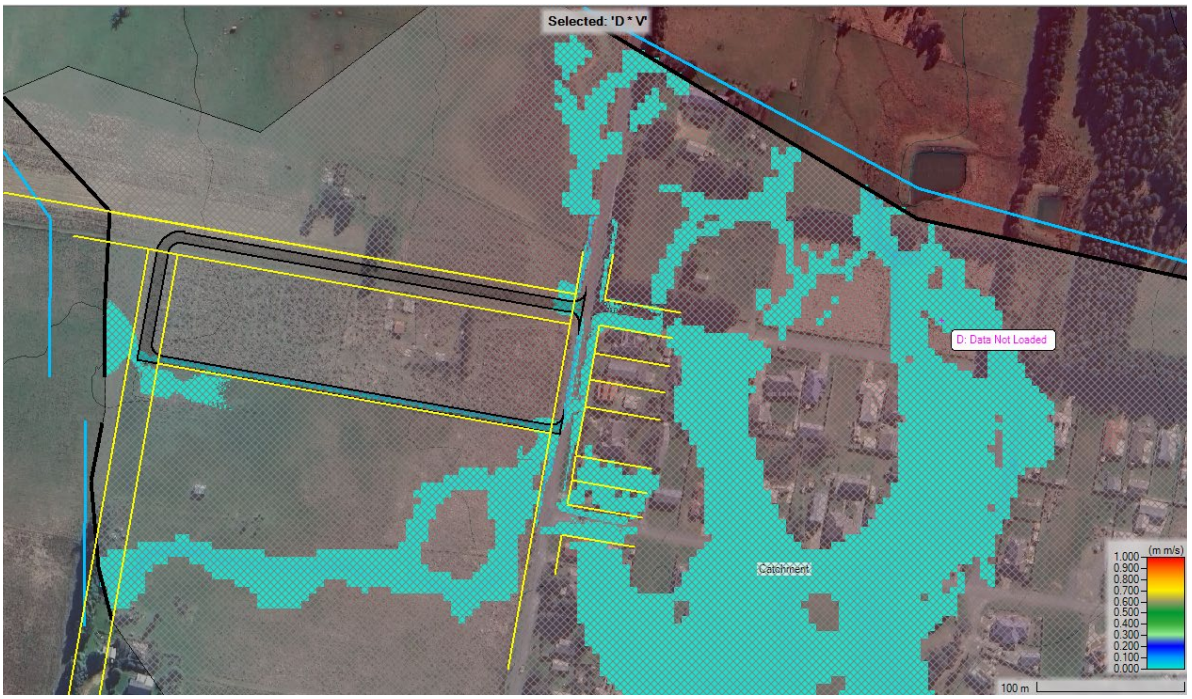


Figure 38: 10% AEP - VxD – Post-Development

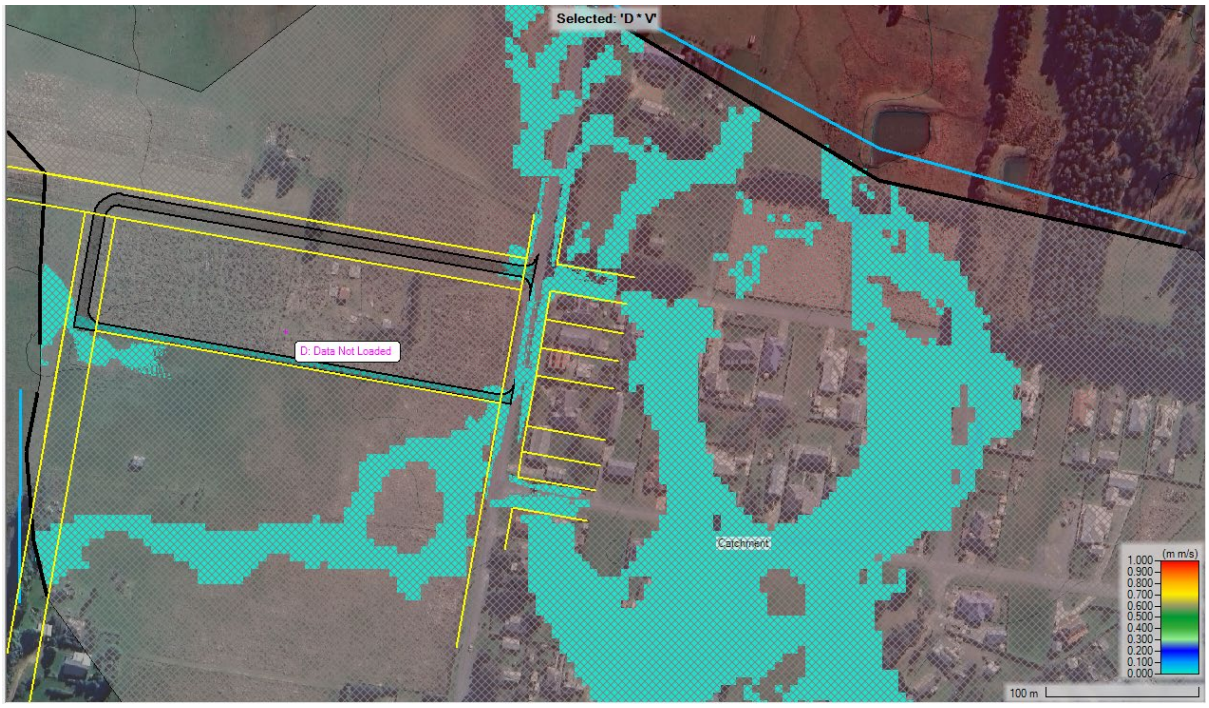


Figure 39: 1% AEP - VxD – Post-Development

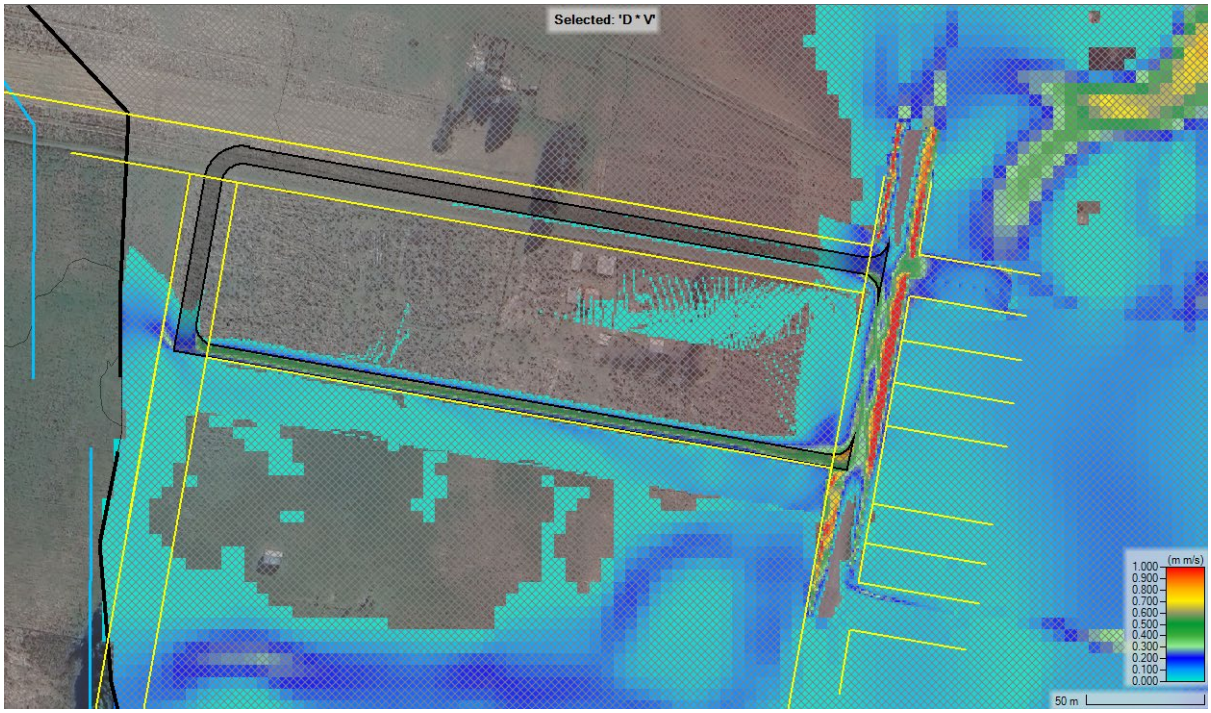


Figure 39: PMF - VxD – Post-Development

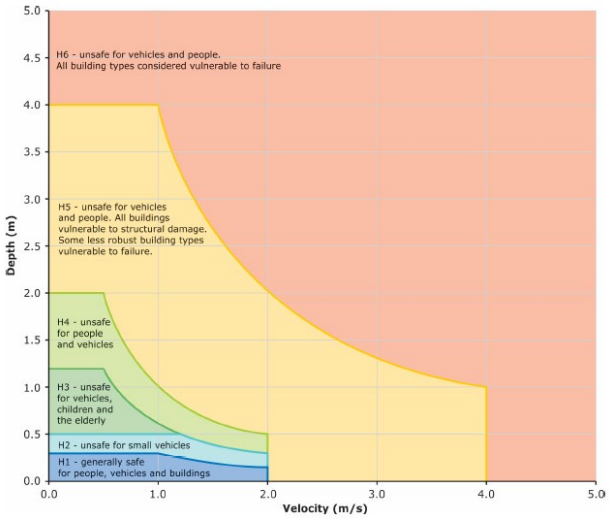


Table 6.7.3. Combined Hazard Curves - Vulnerability Thresholds (Smith et al., 2014)

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles. children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

Table 6.7.4. Combined Hazard Curves - Vulnerability Thresholds Classification Limits (Smith et al., 2014)

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

Figure 40: ARR19 Book 6 Section 6.7.3 & 6.7.4

4.7 2D Hydraulic Model Validation

The pre-development depth results from this assessment have been compared to the Crookwell Flood Study 2017 for the 1% and PMF rainfall events. The comparison is shown in figures 40 to 46 with legends shown for both studies which are matching.

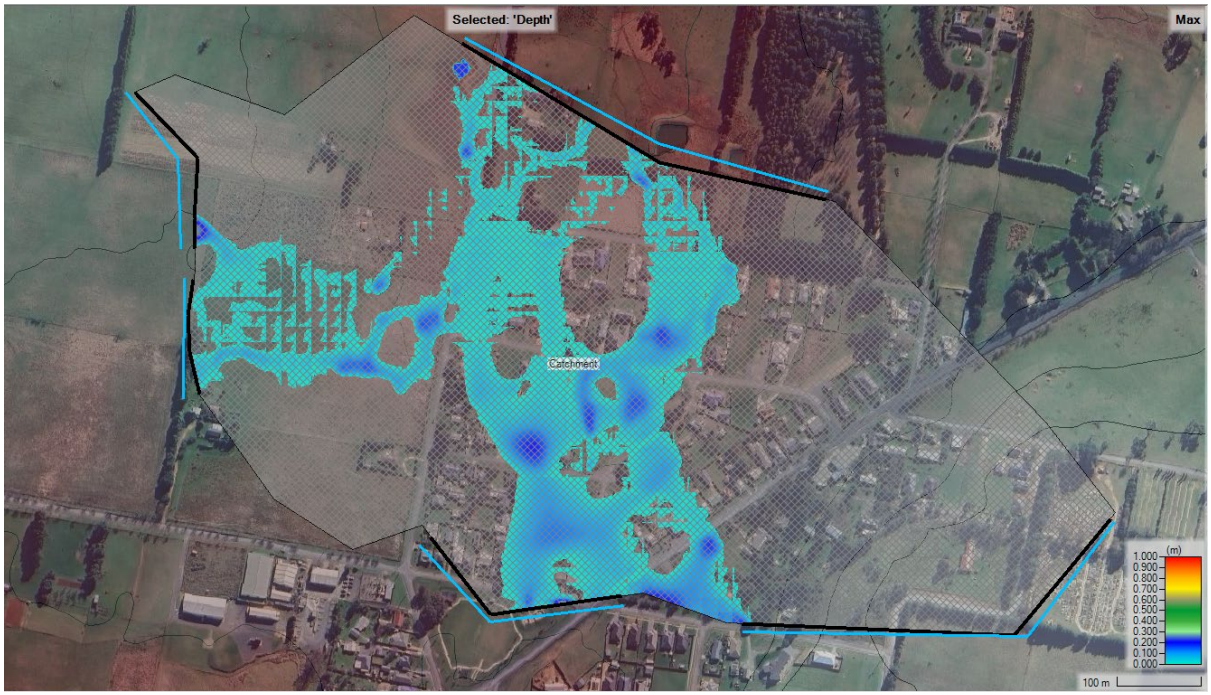


Figure 40: 1% AEP - Depths – Pre-Development model

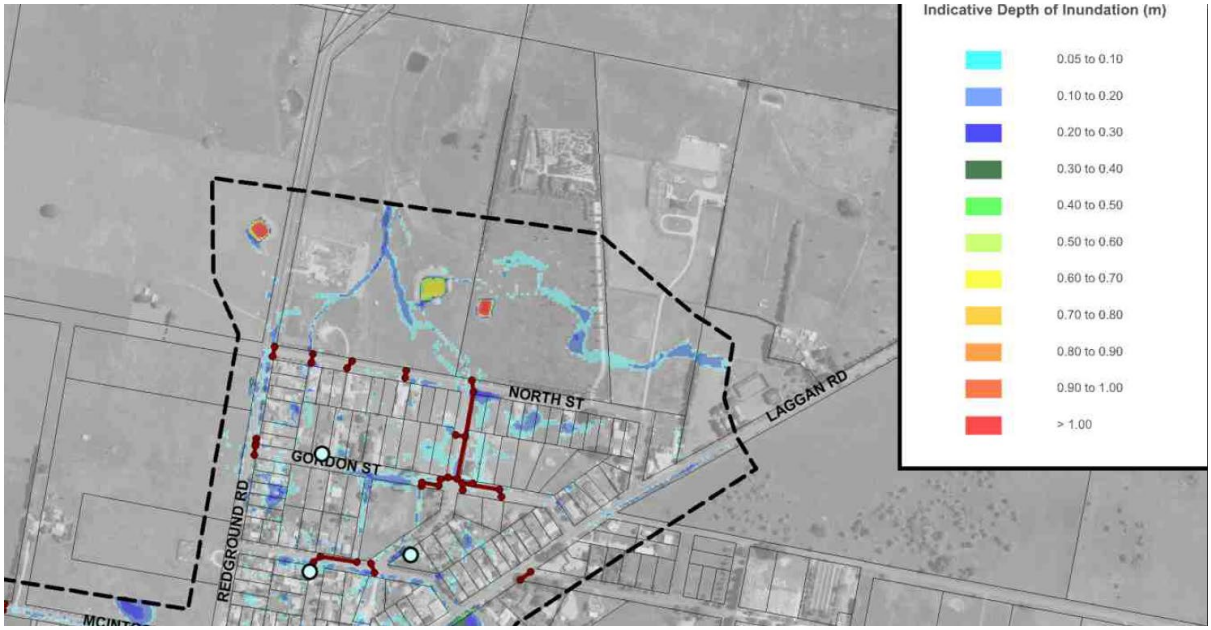


Figure 41: 1% AEP - Depths – Pre-Development Upper Lachlan Shire Council Study

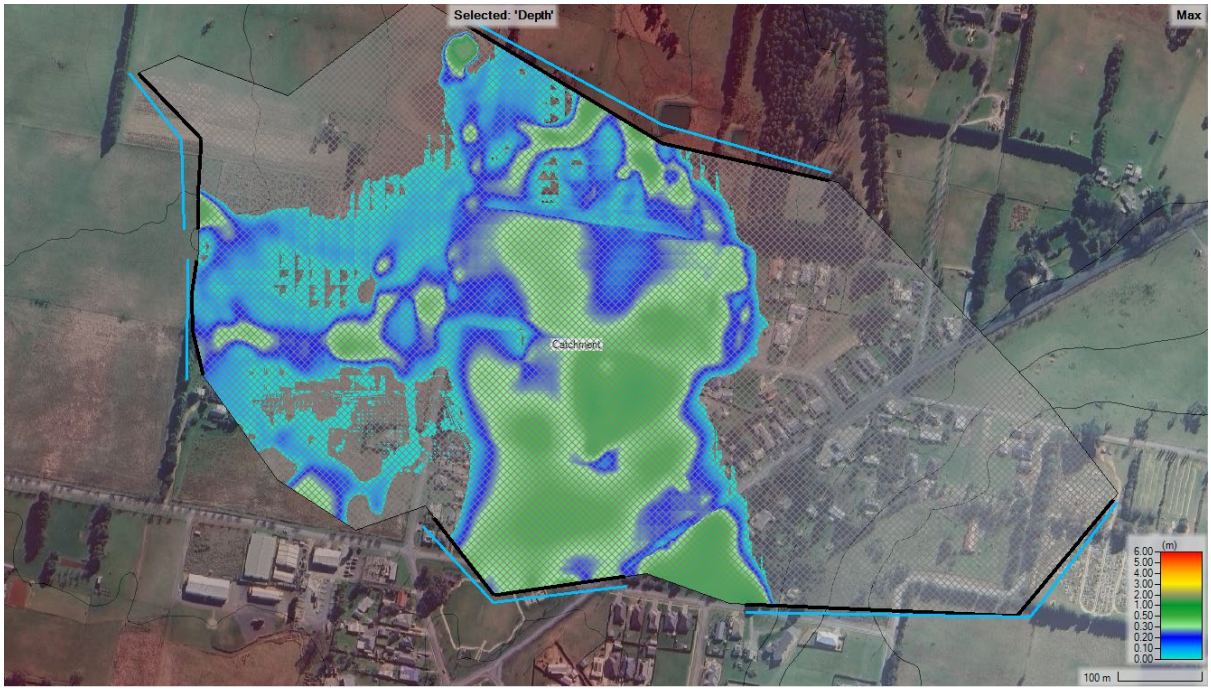


Figure 42: PMF - Depths – Pre-Development model

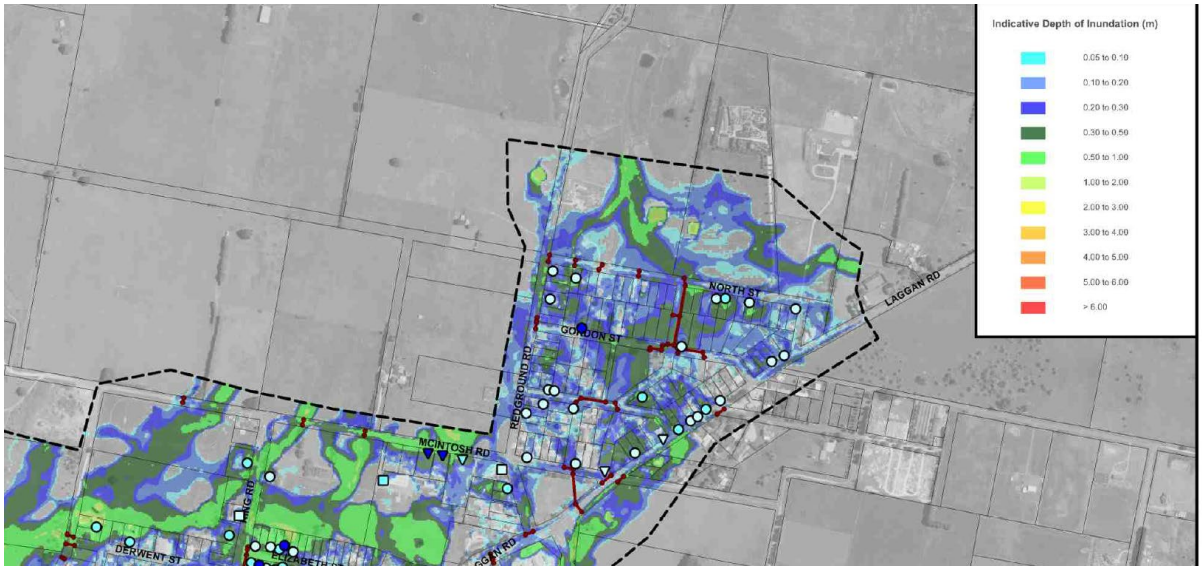


Figure 43: PMF - Depths – Pre-Development Upper Lachlan Shire Council Study

As shown in figures 40 to 43, the flood depths of this assessment are very similar to the Upper Lachlan Shire Council for the 1% and the PMF. Although the Study by the Upper Lachlan Shire Council has a different Catchment area and size, it can easily be seen the two studies have similarities. As mentioned, the one difference between the studies is that the catchment analysed is different. The site of 39 Redground and the associated catchment to the west of Redground Road, which is the subject of this FIRA, was not analysed in the Upper Lachlan Council study.

5. Conclusions

This report has summarised the outcomes of a flood impact assessment that was completed to support the viability of a proposed residential development at 39 Redground Rd, Crookwell, by

analysing the flood behaviour for the pre-development and post-development scenarios and the impacts on the flood characteristics upstream and downstream of the subject site.

Pre-development and post-development conditions have been modelled using HEC-RAS and performed using unsteady flow analysis, with internal and external catchments and hydrographic data being analysed with storm durations up to 9 hours using DRAINS (RAFTS model). Please refer to civil engineering sheet set reference number 23017_P0 prepared by CivPlan in Appendix A for all flood mappings and analysis performed for this assessment, including depths, WSE, hazard and WSE comparison map for all scenarios including the 10%, 1% AEP and PMF events.

This assessment demonstrates that the development is viable in terms of a flood perspective, with the development lots being above the 1% AEP events, without significantly impacting the surrounding properties. Appropriate flood planning levels (FPLs) 0.5m above the 1% AEP flood water level will need to be specified during the design and approval phase.

For the 10% and 1% AEP, the flows were all contained within the road reserves with generally safe values, noting that the introduction of a stormwater pit and pipe network will further improve the overland flow results. Further analysis will be undertaken at detailed phase to treat this water via this stormwater drainage and overland flow paths.

For the PMF, the flood inundation spills the road reserve boundaries and into the lots of 39 Redground, though this is generally of a very minor depth, is H1 hazard categorisation and is mostly contained within the front boundary setback. Despite this there is still safe access and egress to the lots within the 39 Redground subject site as the roads are low hazard to vehicles, generally H1 or at worst H2.

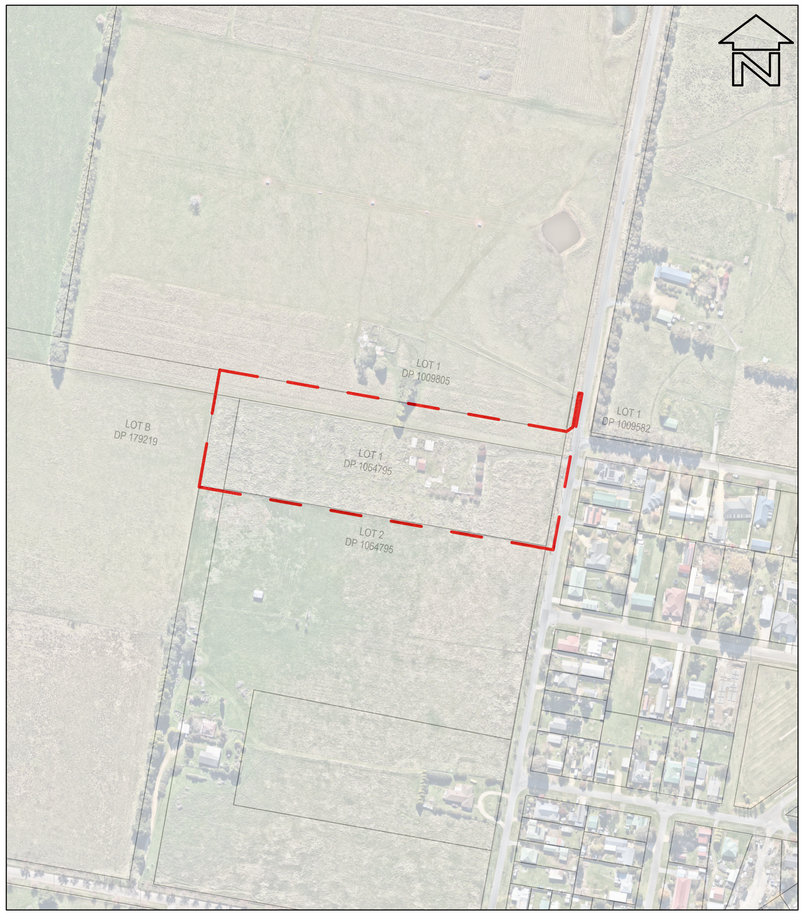
Please refer to civil engineering sheet set reference number 23017_P0 prepared by CivPlan in Appendix D for all the flood mappings and analysis performed for this assessment, including depths, WSE, hazard and WSE comparison map for both scenarios for the 10% and 1% AEP events.

Appendix A

Catchment Analysis & Flood Maps

39 REDGROUND RD, CROOKWELL, NSW - LOT 1 D.P 1064795
21 LOT RESIDENTIAL SUBDIVISION
CIVIL ENGINEERING CONCEPT DESIGN & FLOOD IMPACT ASSESSMENT

UPPER LACHLAN SHIRE COUNCIL PLANNING PROPOSAL APPLICATION



SITE LOCALITY PLAN

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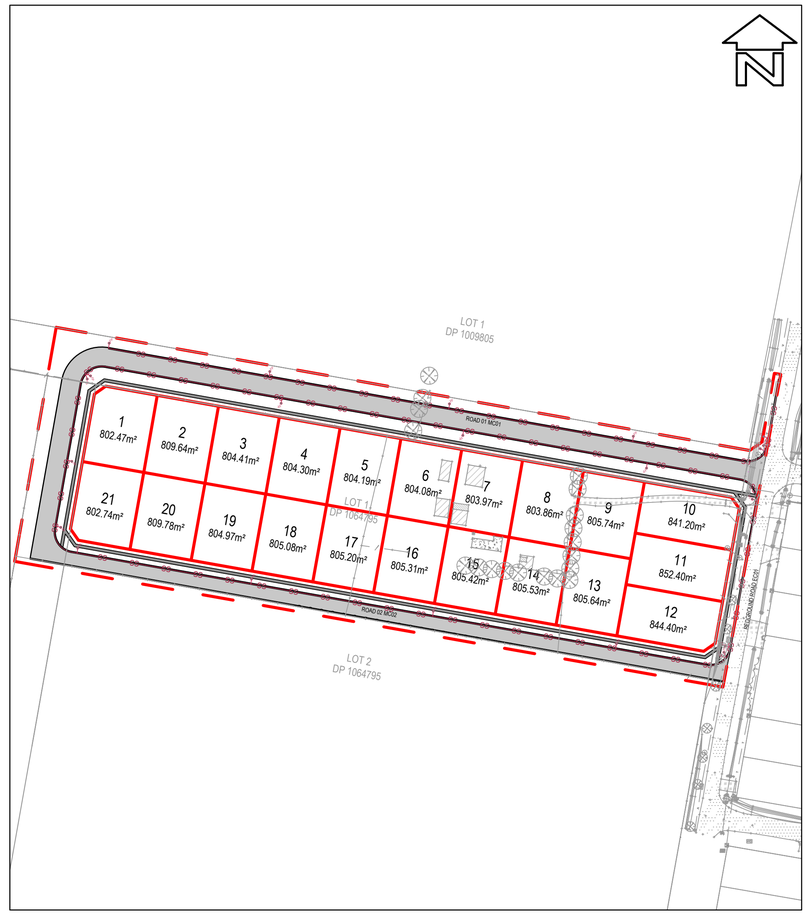
	SHEET	TITLE	REV
CIVIL ENGINEERING CONCEPT DESIGN	23017-401	COVER AND INDEX	P0
	23017-402	GENERAL ARRANGEMENT PLAN	P0
	23017-403	EXISTING AND SITE PREPARATION PLAN	P0
	23017-404	SOIL AND WATER MANAGEMENT PLAN	P0
	23017-405	SOIL AND WATER MANAGEMENT DETAILS	P0
	23017-406	BULK EARTHWORKS PLAN	P0
	23017-407	ROAD 01 MC01 LONGITUDINAL AND TYPICAL SECTIONS	P0
	23017-408	ROAD 01 MC02 LONGITIDINAL AND TYPICAL SECTION	P0
	23017-409	DRAINAGE LAYOUT PLAN	P0
	23017-410	STORMWATER QUANTITY MODELLING PLAN	P0
FLOOD IMPACT ASSESSMENT	23017-411	CATCHMENT ANALYSIS PLAN	P0
	23017-412	DRAINS MODELLING AND RESULTS	P0
	23017-413	PRE DEVELOPMENT & POST DEVELOPMENT 10% & 1% AEP RESULTS - DEPTHS	P0
	23017-414	PRE DEVELOPMENT & POST DEVELOPMENT PMF RESULTS - DEPTHS	P0
	23017-415	PRE DEVELOPMENT & POST DEVELOPMENT 10% & 1% AEP RESULTS - WSE	P0
	23017-416	PRE DEVELOPMENT & POST DEVELOPMENT PMF RESULTS - WSE	P0
	23017-417	PRE DEVELOPMENT & POST DEVELOPMENT 10% & 1% AEP RESULTS - VxD	P0
	23017-418	PRE DEVELOPMENT & POST DEVELOPMENT PMF - VxD	P0
	23017-419	PRE & POST DEVELOPMENT 10%, 1% AEP & PMF - WAY DRY NOW WET	P0



GENERAL OVERVIEW

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0 10 20 30 40 50 SCALE:- 1:1250

SCALE: AS NOTED
SIZE: A1
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DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

CIVPLAN
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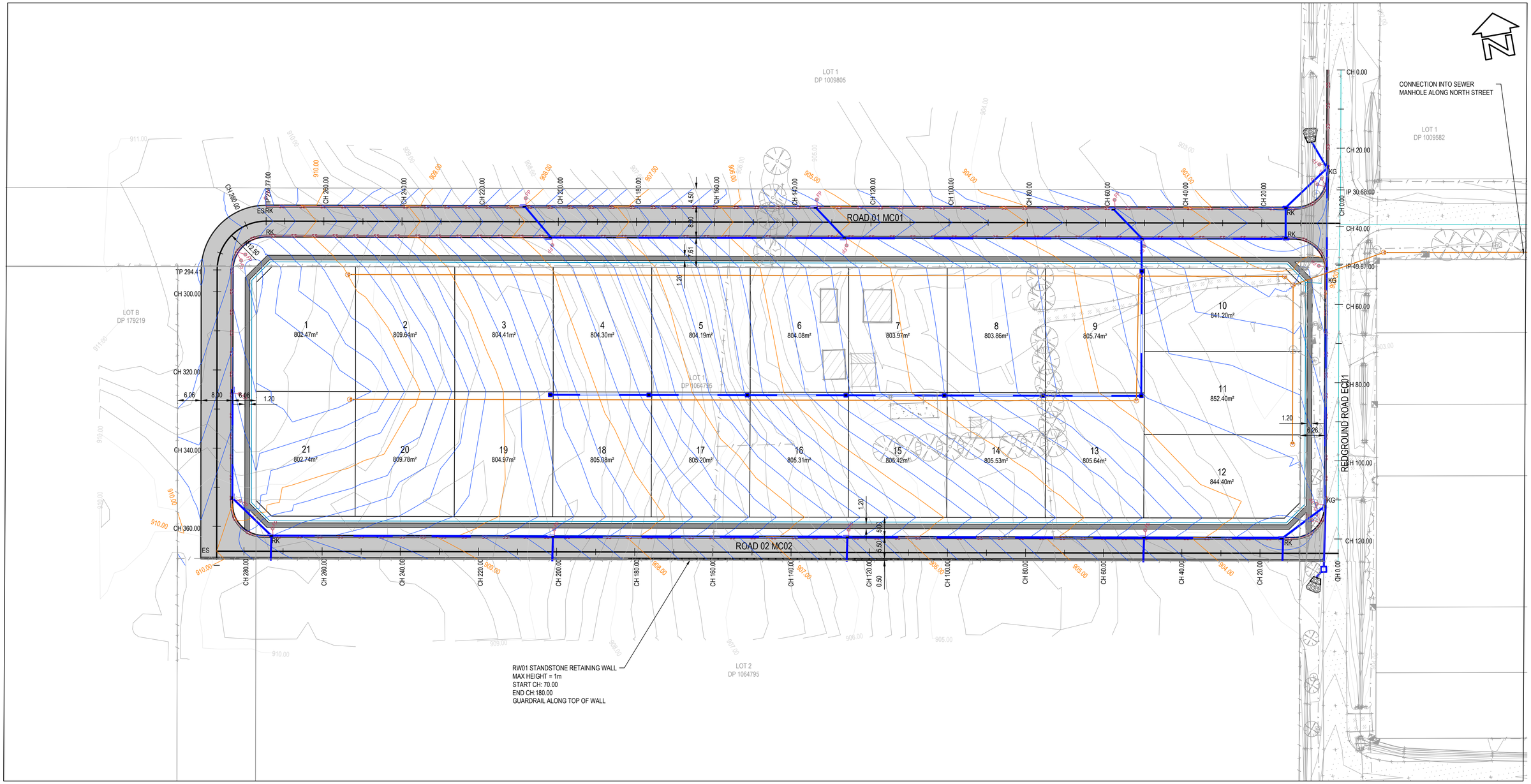
SYDNEY OFFICE: 152 SAILORS BAY ROAD, NORTHBRIDGE NSW 2063
T: 1800 318 052 E: info@civplan.com.au W: www.civplan.com.au

JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: COVER AND INDEX

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-401	P0



GENERAL ARRANGEMENT

1:500 @ A1

SHEET LEGEND

DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL
BARRIER KERB 'KG'	KG	KERB / PEDESTRIAN RAMP		SUB-SOIL AND FLUSH POINTS	SS SS	STORMWATER LOCATION (EXISTING)	SW
ROLL KERB 'RK'	RK	NOMINAL CONTROL LINE		KERB ADAPTOR / OUTLET		SEWER LOCATION (EXISTING)	S
EDGE STRIP 'ES'	ES	ROAD PAVEMENT		LIMIT OF WORKS		WATER LOCATION (EXISTING)	W
KERB ONLY 'KO'	KO	PATH PAVING (CONCRETE)		BOUNDARIES		TELSTRA LOCATION (EXISTING)	T
MOUNTABLE SF TYPE KERB 'SF'	SK	CONTOURS (MAJOR)	25	TREE AND LANDSCAPING		FIBRE OPTICS LOCATION (EXISTING)	FO
DISH DRAIN 'DD'	DD	CONTOURS (MINOR)		DRAINAGE PIT - 1.8m PIT WITH LINTEL		ELECTRICAL LOCATION (EXISTING)	E
VEHICULAR CROSSING		RETAINING WALL STRUCTURES		DRAINAGE PIT - 2.4m SAG WITH LINTEL		GAS LOCATION (EXISTING)	G

SCALE:- 1:500

WARNING
BEWARE OF UNDERGROUND SERVICES
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GDA 2020

SCALE: AS NOTED
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DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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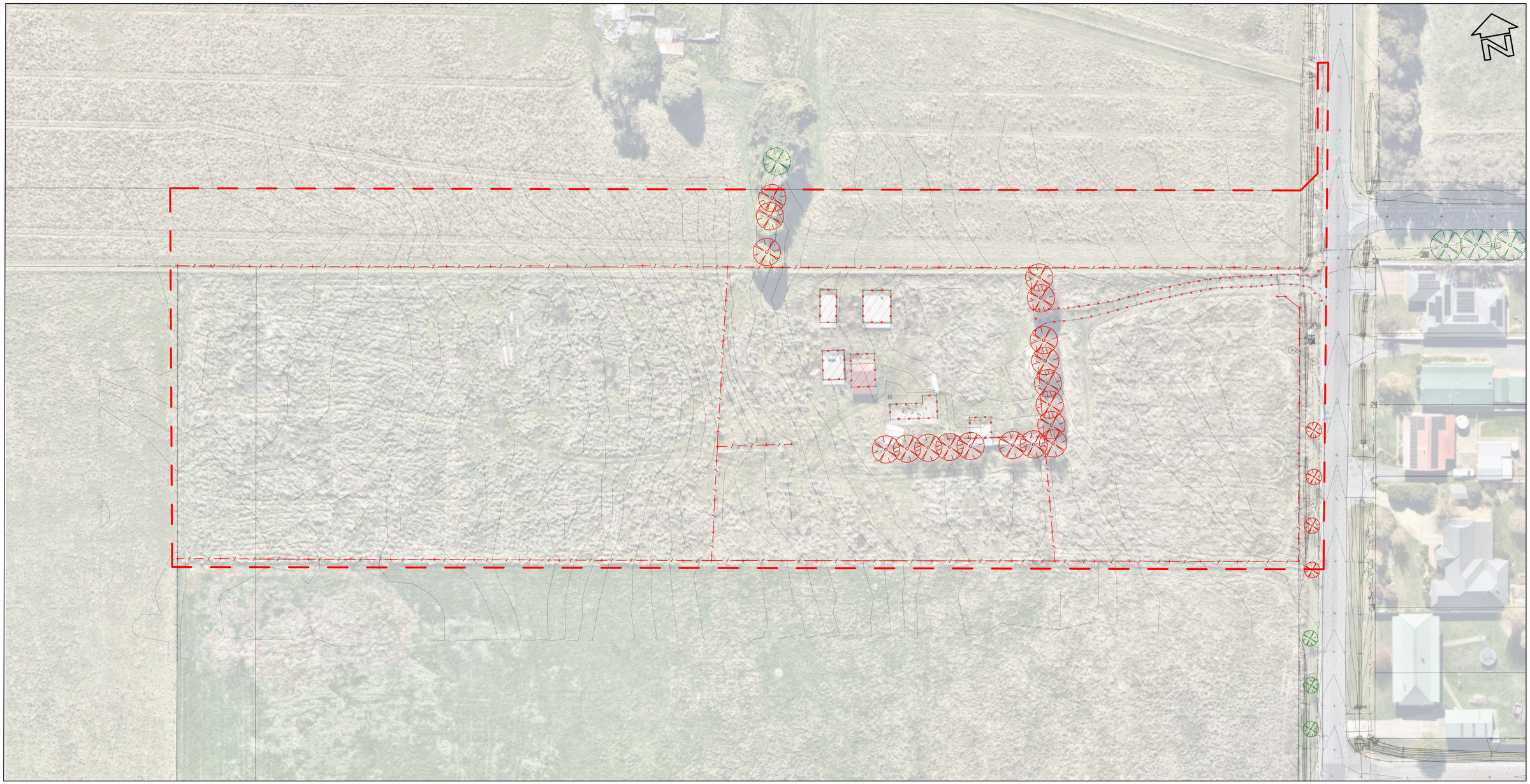
SYDNEY OFFICE: 152 SAILORS BAY ROAD, NORTHBRIDGE NSW 2063
T: 1800 318 052 E: info@civplan.com.au W: www.civplan.com.au

JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: GENERAL ARRANGMENT

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-402	P0



EXISTING AND SITE PREPARATION

1:500 @ A1

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GDA 2020

SHEET LEGEND	
DESCRIPTION	DETAIL
TREE TO BE REMOVED	
DEMOLITION WORKS	
TREE TO BE RETAIN	

DEMOLITION AND SUBSEQUENT LAND REMEDIATION (IF REQUIRED) TO BE UNDERTAKEN IN ACCORDANCE WITH THE DA CONSENT, AUSTRALIAN STANDARDS, SAFEWORK NSW CODES OF PRACTICE AND EPA GUIDELINES

ALL CLEARING IS TO BE CONDUCTED AS APPROVED BY COUNCIL AND UNDER SUPERVISION OF AN ECOLOGIST IN ACCORDANCE WITH THE ECOLOGICAL MANAGEMENT PLAN (EMP).

0 5 10 15 20 25
SCALE:- 1:500

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

		REV	DESCRIPTION	DATE
SURVEY	AS	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DESIGN	JE			
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: EXISTING AND SITE PREPARATION

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

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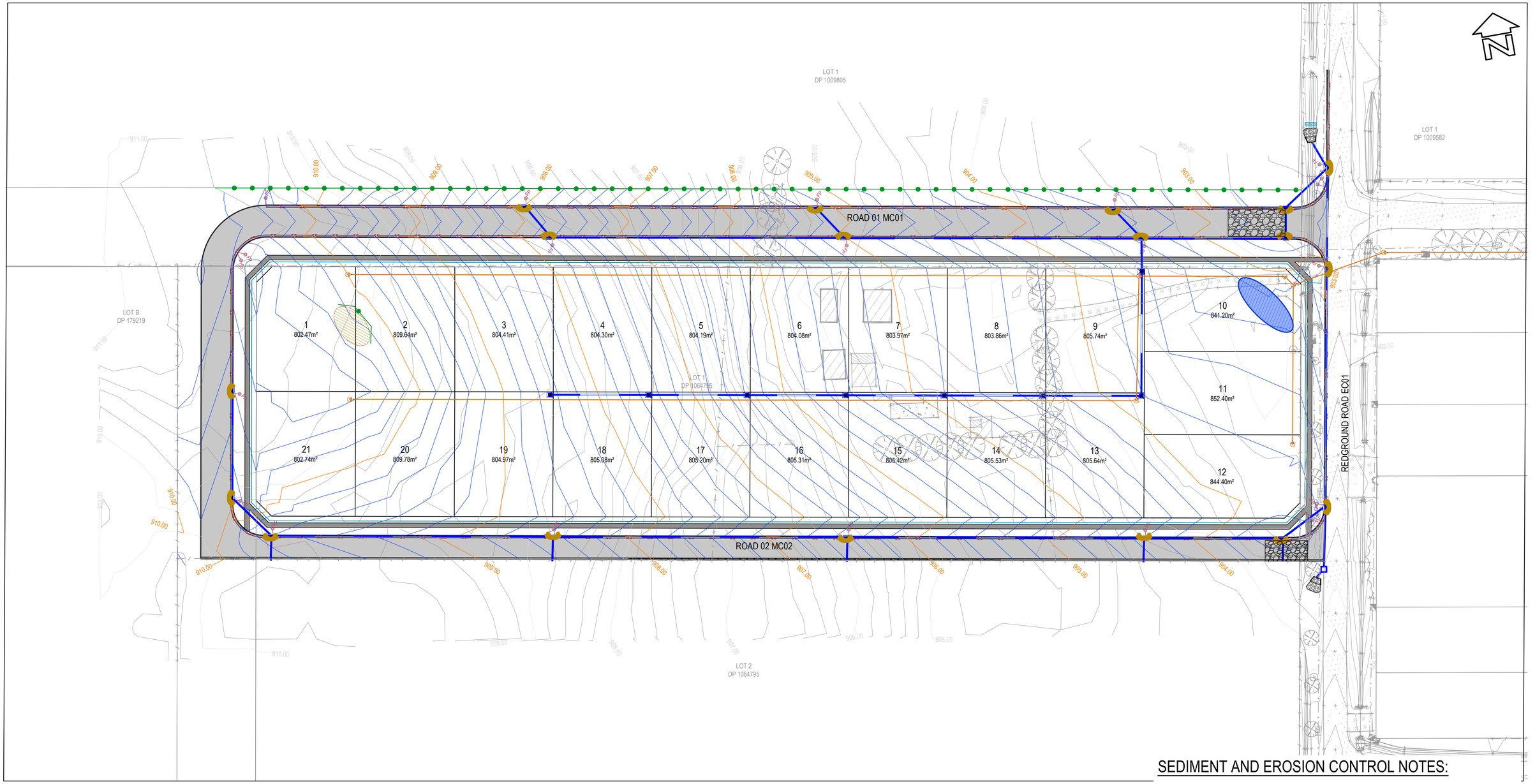

SOIL AND WATER MANAGEMENT PLAN

1:500 @ A1

SEDIMENT AND EROSION CONTROL NOTES:

1. ALL EROSION AND SEIDMENTATION CONTROLS, TREATMENT AND TESTING ARE TO BE IN ACCORDANCE WITH THE LANDCOM MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION VOLUME 1 (4TH EDITION 2004) KNOWN AS THE "BLUE BOOK".
2. ANY ALTERATIONS AND/OR REMOVAL OF CONTROLS ARE TO BE REVIEWED AND APPROVED BY THE SUPERINTENDENT PRIOR TO ANY CHANGE, INCLUDING AT THE PROJECTS CONCLUSION.
3. DISTRUBANCE IS TO BE KEPT TO A MINIMUM.
4. STOCKPILES ARE TO BE STABILISED WITHIN 10 DAYS.
5. AFTER EACH RAIN EVENT ALL EROSION AND SEDIMENTATION CONTROLS ARE TO BE INSPECTED, CLEARED OF SILT AND REINSTATED INTO WORKING ORDER.
6. EROSION AND SEDIMENTATION CONTROLS ARE TO BE MAINTAINED ON A REGULAR BASIS AND ARE TO REMAIN IN WORKING ORDER FOR THE LIFE OF THE PROJECT.
7. DISTURBED AREAS THAT ARE NOT UNDERGOING WORKS ARE TO BE STABILISED WITHIN 10 DAYS, FINISHED WORKS WITHIN 20 DAYS.
8. DISTURBED AREAS THAT ARE NOT UNDERGOING BUILDING WORK OR SOFT LANDSCAPING ARE TO BE STABILITED WITH A MINIMUM OF 100MM TOPSOIL AND SEEDED WITH AN APPROPRIATE MIX FOR THE AREA AND CLIMATE.
9. DUST CONTROLS (STABILISATION, WATERCART, SPRINKLERS ETC) ARE TO BE MAINTAINED THROUGHOUT THE LIFE OF THE PROJECT, IN PARTICULAR DURING DRY AND WINDY PERIODS.

0 5 10 15 20 25

SCALE:- 1:500

SHEET LEGEND

DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL
MAJOR DESIGN CONTOURS	25	GRAVEL INLET FILTER		HAYBALE FILTER		TOPSOIL STOCKPILES WITH DOWNSTREAM SILT FENCING	
MINOR DESIGN CONTOURS							
SILT FENCE		STABILISED ACCESS / GRID & WHEEL WASH		GEOTEXTILE COVER		TEMPORARY SEDIMENT BASIN	
CLEAN WATER DIVRSION							

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COVER OF EXCELLENCE

GDA 2020

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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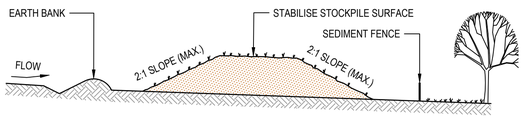
SYDNEY OFFICE: 152 SAILORS BAY ROAD, NORTHBRIDGE NSW 2063
T: 1800 318 052 E: info@civplan.com.au W: www.civplan.com.au

JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: SOIL AND WATER MANAGEMENT PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

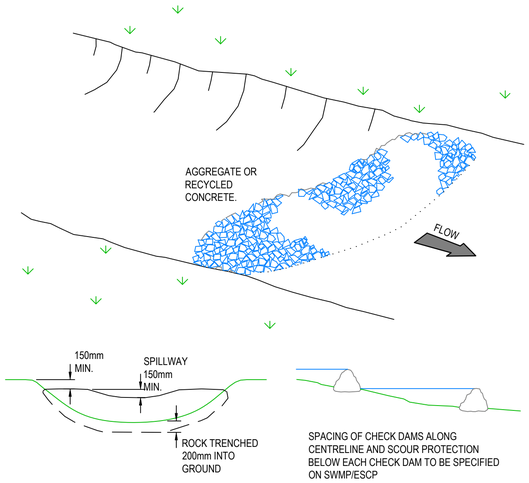
JOB-DRAWING NUMBER	REV
23017-404	P0



CONSTRUCTION NOTES

1. PLACE STOCKPILES MORE THAN 2m (PREFERABLY 5m) FROM EXISTING VEGETATION, CONCENTRATED WATER FLOW, ROADS AND HAZARD AREAS.
2. CONSTRUCT ON THE CONTOUR AS LOW, FLAT, ELONGATED MOUNDS.
3. WHERE THERE IS SUFFICIENT AREA, TOPSOIL STOCKPILES SHALL BE LESS THAN 2m IN HEIGHT.
4. WHERE THEY ARE TO BE IN PLACE FOR MORE THAN 10 DAYS, STABILISE FOLLOWING THE APPROVED ESCP OR SWMP TO REDUCE THE C-FACTOR TO LESS THAN 0.10.
5. CONSTRUCT EARTH BANKS (STANDARD DRAWING 5-5) ON THE UPSLOPE SIDE TO DIVERT WATER AROUND STOCKPILES AND SEDIMENT FENCES (STANDARD DRAWING 6-8) 1 TO 2m DOWNSLOPE.

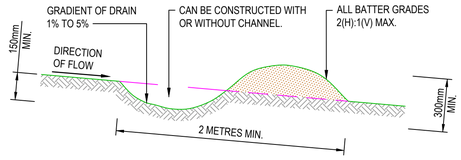
STOCKPILES (SD 4-1)



CONSTRUCTION NOTES

1. CHECK DAMS CAN BE BUILT WITH VARIOUS MATERIALS, INCLUDING ROCKS, LOGS, SANDBAGS AND STRAW BALES. THE MAINTENANCE PROGRAM SHOULD ENSURE THEIR INTEGRITY IS RETAINED, ESPECIALLY WHERE CONSTRUCTED WITH STRAW BALES. IN THE CASE OF BALES, THIS MIGHT REQUIRE THEIR REPLACEMENT EACH TWO TO FOUR MONTHS.
2. TRENCH THE CHECK DAM 200mm INTO THE GROUND ACROSS ITS WHOLE WIDTH. WHERE ROCK IS USED, FILL THE TRENCHES TO AT LEAST 100mm ABOVE THE GROUND SURFACE TO REDUCE THE RISK OF UNDERCUTTING.
3. NORMALLY, THEIR MAXIMUM HEIGHT SHOULD NOT EXCEED 600mm ABOVE THE GULLY FLOOR. THE CENTRE SHOULD ACT AS A SPILLWAY, BEING AT LEAST 150mm LOWER THAN THE OUTER EDGES.
4. SPACE THE DAMS SO THE TOE OF THE UPSTREAM DAM IS LEVEL WITH THE SPILLWAY OF THE NEXT DOWNSTREAM DAM.

ROCK CHECK DAM (SD 5-4)

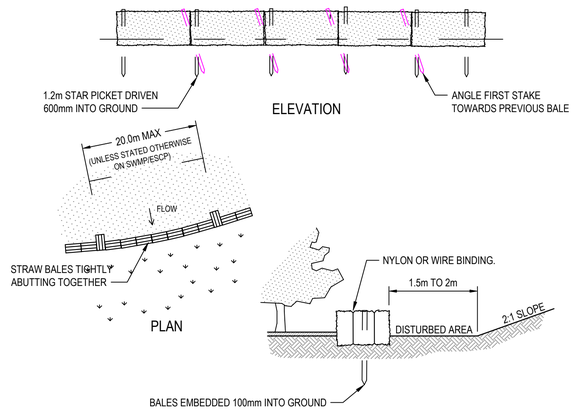


CONSTRUCTION NOTES

1. BUILD WITH GRADIENTS BETWEEN 1 AND 5 PERCENT.
2. AVOID REMOVING TREES AND SHRUBS IF POSSIBLE - WORK AROUND THEM.
3. ENSURE THE STRUCTURES ARE FREE OF PROJECTIONS OR OTHER IRREGULARITIES THAT COULD IMPEDE WATER FLOW.
4. BUILD THE DRAINS WITH CIRCULAR, PARABOLIC OR TRAPEZOIDAL CROSS SECTIONS, NOT V SHAPED.
5. ENSURE THE BANKS ARE PROPERLY COMPACTED TO PREVENT FAILURE.
6. COMPLETE PERMANENT OR TEMPORARY STABILISATION WITHIN 10 DAYS OF CONSTRUCTION.

NOTE: ONLY TO BE USED AS TEMPORARY BANK
WHERE MAXIMUM UPSLOPE LENGTH IS 80 METRES.

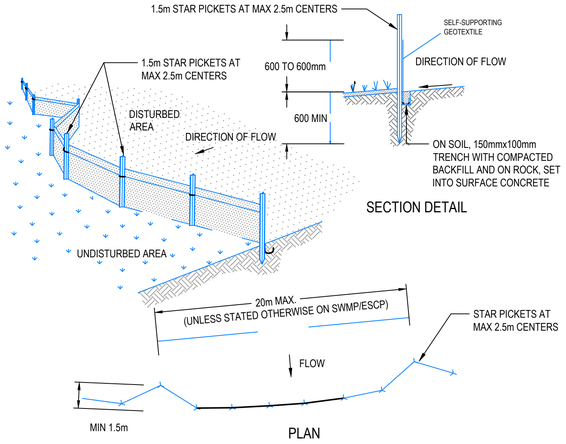
EARTH BANK - LOW FLOW (SD 5-5)



CONSTRUCTION NOTES

1. CONSTRUCT THE STRAW BALE FILTER AS CLOSE AS POSSIBLE TO BEING PARALLEL TO THE CONTOURS OF THE SITE.
2. PLACE BALES LENGTHWISE IN A ROW WITH ENDS TIGHTLY ABUTTING. USE STRAW TO FILL ANY GAPS BETWEEN BALES. STRAWS ARE TO BE PLACED PARALLEL TO GROUND.
3. ENSURE THAT THE MAXIMUM HEIGHT OF THE FILTER IS ONE BALE.
4. EMBED EACH BALE IN THE GROUND 75mm TO 100mm AND ANCHOR WITH TWO 1.2 METRE STAR PICKETS OR STAKES. ANGLE THE FIRST STAR PICKET OR STAKE IN EACH BALE TOWARDS THE PREVIOUSLY LAID BALE. DRIVE THEM 600mm INTO THE GROUND AND, IF POSSIBLE, FLUSH WITH THE TOP OF THE BALES. WHERE STAR PICKETS ARE USED AND THEY PROTRUDE ABOVE THE BALES, ENSURE THEY ARE FITTED WITH SAFETY CAPS.
5. WHERE A STRAW BALE FILTER IS CONSTRUCTED DOWNSLOPE FROM A DISTURBED BATTER, ENSURE THE BALES ARE PLACED 1 TO 2 METRES DOWNSLOPE FROM THE TOE.
6. ESTABLISH A MAINTENANCE PROGRAM THAT ENSURES THE INTEGRITY OF THE BALES IS RETAINED - THEY COULD REQUIRE REPLACEMENT EACH TWO TO FOUR MONTHS.

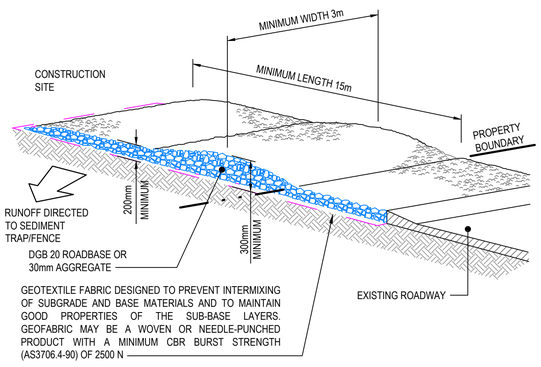
STRAW BALE FILTER (SD 6-7)



CONSTRUCTION NOTES

1. CONSTRUCT SEDIMENT FENCES AS CLOSE AS POSSIBLE TO BEING PARALLEL TO THE CONTOURS OF THE SITE, BUT WITH SMALL RETURNS AS SHOWN IN THE DRAWING TO LIMIT THE CATCHMENT AREA OF ANY ONE SECTION. THE CATCHMENT AREA SHOULD BE SMALL ENOUGH TO LIMIT WATER FLOW IF CONCENTRATED AT ONE POINT TO 50 LITRES PER SECOND IN THE DESIGN STORM EVENT, USUALLY THE 10-YEAR EVENT.
2. CUT A 150mm DEEP TRENCH ALONG THE UPSLOPE LINE OF THE FENCE FOR THE BOTTOM OF THE FABRIC TO BE ENTRENCHED.
3. DRIVE 1.5 METRE LONG STAR PICKETS INTO GROUND AT 2.5 METRE INTERVALS (MAX) AT THE DOWNSLOPE EDGE OF THE TRENCH. ENSURE ANY STAR PICKETS ARE FITTED WITH SAFETY CAPS.
4. FIX SELF-SUPPORTING GEOTEXTILE TO THE UPSLOPE SIDE OF THE POSTS ENSURING IT GOES TO THE BASE OF THE TRENCH. FIX THE GEOTEXTILE WITH WIRE TIES OR AS RECOMMENDED BY THE MANUFACTURER. ONLY USE GEOTEXTILE SPECIFICALLY PRODUCED FOR SEDIMENT FENCING. THE USE OF SHADE CLOTH FOR THIS PURPOSE IS NOT SATISFACTORY.
5. JOIN SECTIONS OF FABRIC AT A SUPPORT POST WITH A 150mm OVERLAP.
6. BACKFILL THE TRENCH OVER THE BASE OF THE FABRIC AND COMPACT IT THOROUGHLY OVER THE GEOTEXTILE.

SEDIMENT FENCE (SD 6-8)



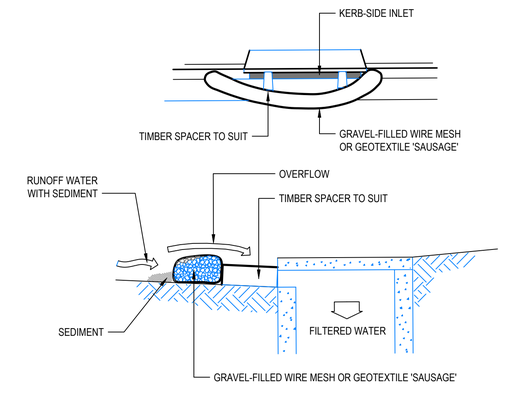
ALTERNATIVE OPTION - VIBRATING ACCESS GRID

PENDING PREFERANCE OF THE NOMINATED MANAGING CONTRACTOR A VIBRATING ACCESS GRID CAN ALSO BE UTLISED DURING CONSTRUCTION. FOR FURTHER DETAILS PLEASE REFER TO THE CATCHMENTS AND CREEKS STANDARD "CONSTRUCTION EXITS - VIBRATION GRIDS - SEDIMENT CONTROL TECHNIQUE - VERSION 2 - APRIL 2010".

CONSTRUCTION NOTES

1. STRIP THE TOPSOIL, LEVEL THE SITE AND COMPACT THE SUBGRADE.
2. COVER THE AREA WITH NEEDLE-PUNCHED GEOTEXTILE.
3. CONSTRUCT A 200mm THICK PAD OVER THE GEOTEXTILE USING ROAD BASE OR 30mm AGGREGATE.
4. ENSURE THE STRUCTURE IS AT LEAST 15 METRES LONG OR TO BUILDING ALIGNMENT AND AT LEAST 3 METRES WIDE.
5. WHERE A SEDIMENT FENCE JOINS ONTO THE STABILISED ACCESS, CONSTRUCT A HUMP IN THE STABILISED ACCESS TO DIVERT WATER TO THE SEDIMENT FENCE.

STABILISED SITE ACCESS (SD 6-14)

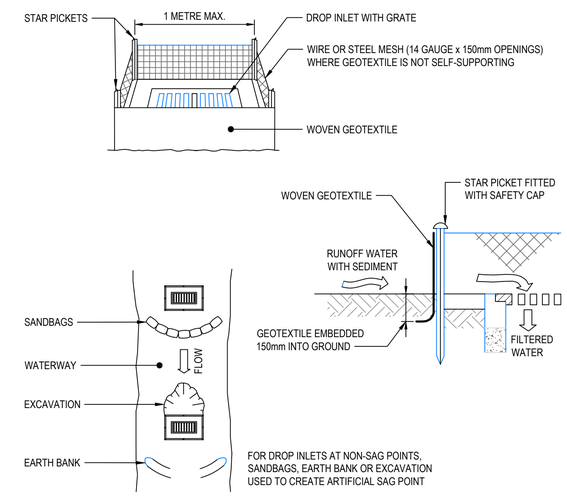


NOTE:THIS PRACTICE ONLY TO BE USED WHERE SPECIFIED IN APPROVED SWMP/ESCP.

CONSTRUCTION NOTES

1. INSTALL FILTERS TO KERB INLETS ONLY AT SAG POINTS.
2. FABRICATE A SLEEVE MADE FROM GEOTEXTILE OR WIRE MESH LONGER THAN THE LENGTH OF THE INLET PIT AND FILL IT WITH 25mm TO 50mm GRAVEL.
3. FORM AN ELLIPTICAL CROSS-SECTION ABOUT 150mm HIGH x 400mm WIDE.
4. PLACE THE FILTER AT THE OPENING LEAVING AT LEAST A 100mm SPACE BETWEEN IT AND THE KERB INLET. MAINTAIN THE OPENING WITH SPACER BLOCKS.
5. FORM A SEAL WITH THE KERB TO PREVENT SEDIMENT BYPASSING THE FILTER.
6. SANDBAGS FILLED WITH GRAVEL CAN SUBSTITUTE FOR THE MESH OR GEOTEXTILE PROVIDING THEY ARE PLACED SO THAT THEY FIRMLY ABUT EACH OTHER AND SEDIMENT-LADEN WATERS CANNOT PASS BETWEEN.

MESH AND GRAVEL INLET FILTER (SD 6-11)



CONSTRUCTION NOTES

1. FABRICATE A SEDIMENT BARRIER MADE FROM GEOTEXTILE OR STRAW BALES.
2. FOLLOW STANDARD DRAWING 6-7 AND STANDARD DRAWING 6-8 FOR INSTALLATION PROCEDURES FOR THE STRAW BALES OR GEOFABRIC. REDUCE THE PICKET SPACING TO 1 METRE CENTRES.
3. IN WATERWAYS, ARTIFICIAL SAG POINTS CAN BE CREATED WITH SANDBAGS OR EARTH BANKS AS SHOWN IN THE DRAWING.
4. DO NOT COVER THE INLET WITH GEOTEXTILE UNLESS THE DESIGN IS ADEQUATE TO ALLOW FOR ALL WATERS TO BYPASS IT.

GEOTEXTILE INLET FILTER (SD 6-12)

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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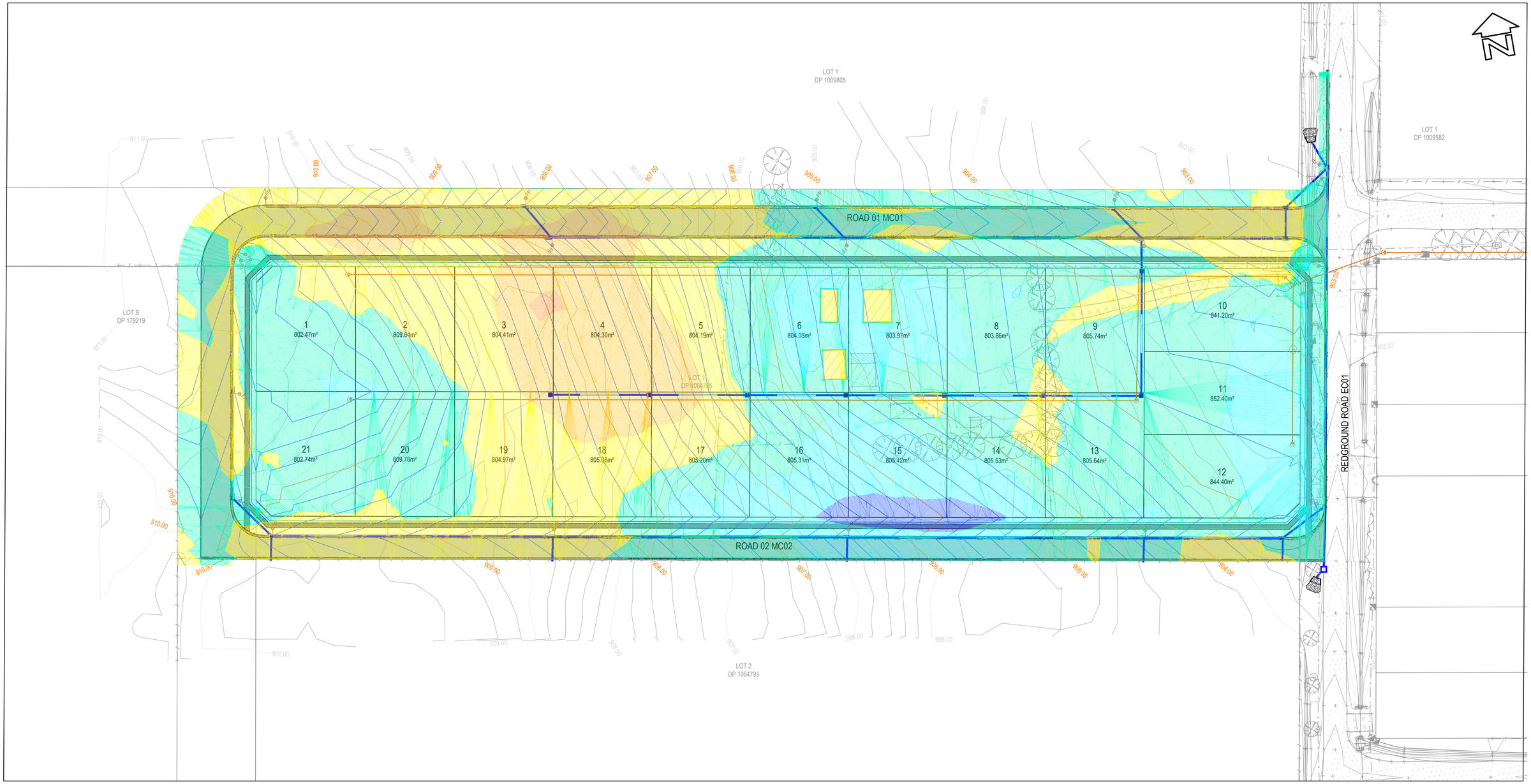
T: 1800 318 052 E: info@civplan.com.au W: www.civplan.com.au

JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: SOIL AND WATER MANAGEMENT DETAILS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-405	P0



BULK EARTHWORKS PLAN

1:500 @ A1

DEPTHS TABLE	
ELEVATION	COLOUR
3.00 to 2.50	
2.50 to 2.00	
2.00 to 1.50	
1.50 to 1.00	
1.00 to 0.50	
0.50 to 0.00	
0.00 to -0.50	
-0.50 to -1.00	
-1.00 to -1.50	
-1.50 to -2.00	
-2.00 to -2.50	
-2.50 to -3.00	

SHEET LEGEND

DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL
BARRIER KERB 'KG'	KG	KERB / PEDESTRIAN RAMP		SUB-SOIL AND FLUSH POINTS	SS SS	STORMWATER LOCATION (EXISTING)	SW
ROLL KERB 'RK'	RK	NOMINAL CONTROL LINE		KERB ADAPTOR / OUTLET		SEWER LOCATION (EXISTING)	S
EDGE STRIP 'ES'	ES	ROAD PAVEMENT		LIMIT OF WORKS		WATER LOCATION (EXISTING)	W
KERB ONLY 'KO'	KO	PATH PAVING (CONCRETE)		BOUNDARIES		TELSTRA LOCATION (EXISTING)	T
MOUNTABLE SF TYPE KERB 'SF'	SK	CONTOURS (MAJOR)	25	TREE AND LANDSCAPING		FIBRE OPTICS LOCATION (EXISTING)	FO
DISH DRAIN 'DD'	DD	CONTOURS (MINOR)		DRAINAGE PIT - 1.8m PIT WITH LINTEL		ELECTRICAL LOCATION (EXISTING)	E
VEHICULAR CROSSING		RETAINING WALL STRUCTURES		DRAINAGE PIT - 2.4m SAG WITH LINTEL		GAS LOCATION (EXISTING)	G

VOLUME SUMMARY TABLE	
ITEM	AMOUNT
TOTAL CUT	3,363m³
TOTAL FILL	5,806m³
NET VOLUME (FILL)	2,443m³
TOTAL CUT AREA	10,827m²
TOTAL FILL AREA	17,103m²
TOTAL WORKS AREA	27,930m²

0 5 10 15 20 25

SCALE:- 1:500

WARNING
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GDA 2020

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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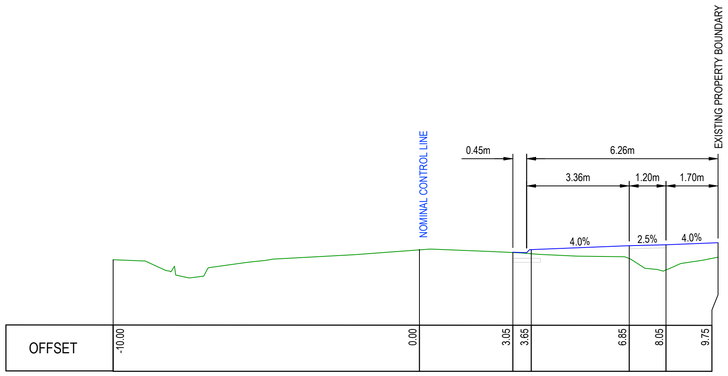
JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: BULK EARTHWORKS PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

RELEASE DATE: 6 FEBRUARY 2024

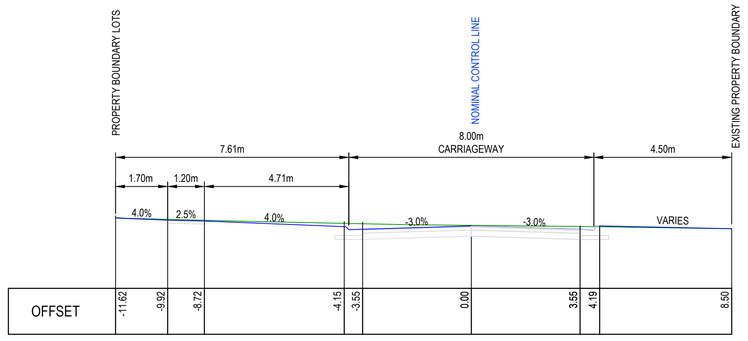
JOB-DRAWING NUMBER	REV
23017-406	P0



TYPICAL SECTION - REDGROUND RD EC01

CHAINAGE 0.000 TO 110.639

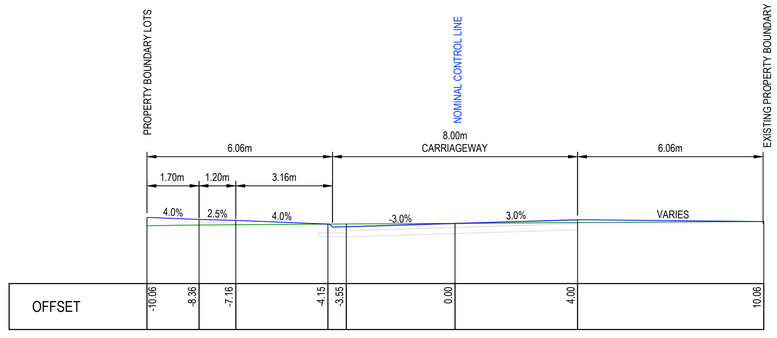
HORIZONTAL 1:100 VERTICAL 1:100 @ A1



TYPICAL SECTION - ROAD 01 MC01

CHAINAGE 0.000 TO 274.772

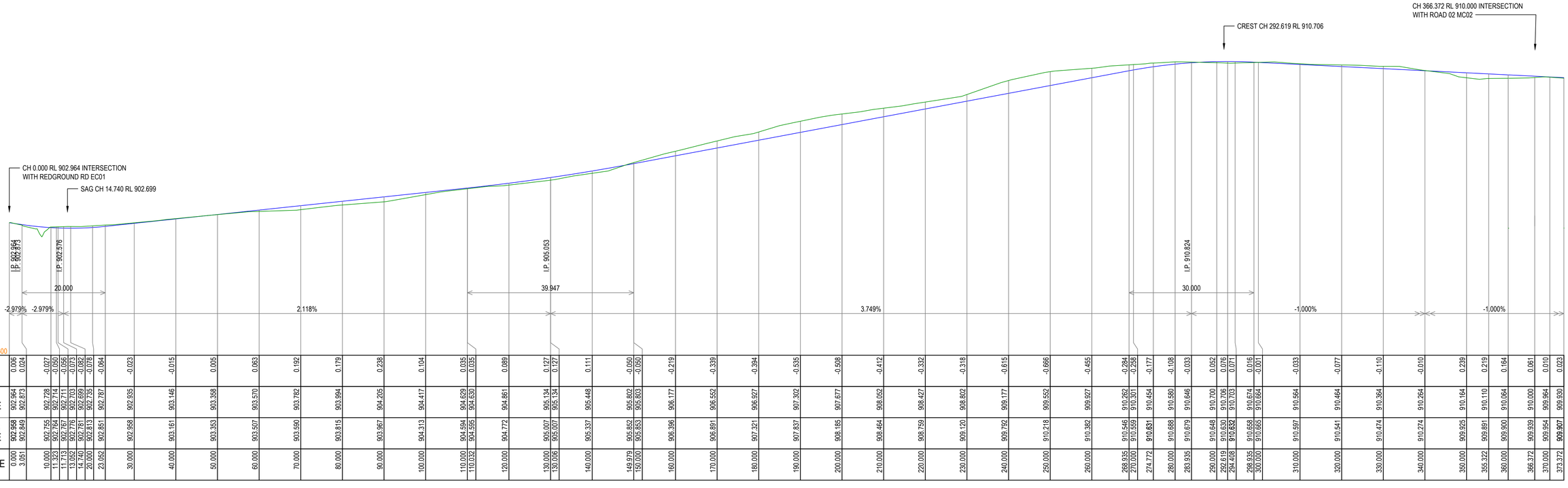
HORIZONTAL 1:100 VERTICAL 1:100 @ A1



TYPICAL SECTION - ROAD 01 MC01

CHAINAGE 274.772 TO 373.372

HORIZONTAL 1:100 VERTICAL 1:100 @ A1



LONGITUDINAL SECTION - ROAD 01 MC01

CHAINAGE 0.000 TO 373.372

HORIZONTAL 1:500 VERTICAL 1:100 @ A1

0 5 10 15 20 25 — SCALE:- 1:500

0 0.5 1 1.5 2 2.5 5 — SCALE:- 1:100

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS
DESIGN	JE
DRAWN	JE
CHECKED	RB
APPROVED	JW

REV	DESCRIPTION	DATE
P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24

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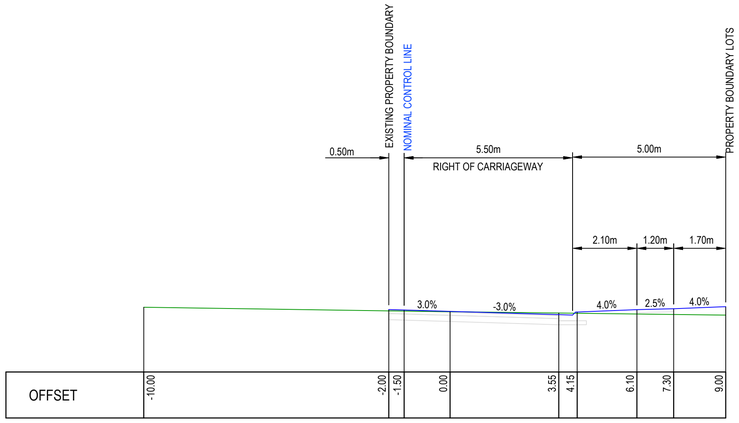
JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: ROAD MC01 LONGITUDINAL SECTIONS AND TYPICAL CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

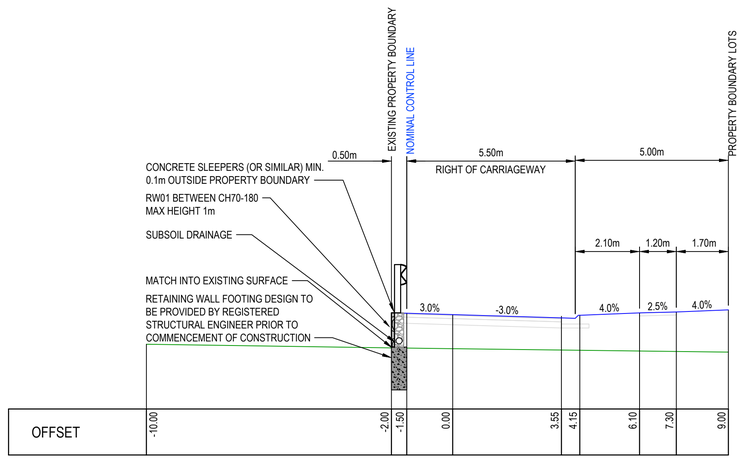
JOB-DRAWING NUMBER	REV
23017-407	P0



TYPICAL SECTION - ROAD 02 MC02

CHAINAGE 0.000 TO 70.000

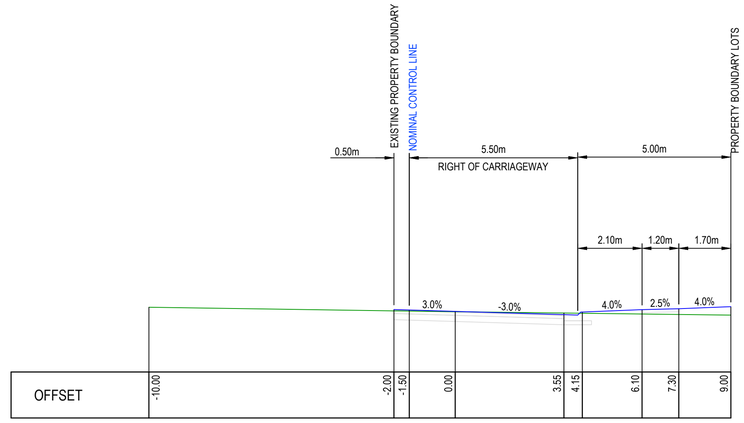
HORIZONTAL 1:100 VERTICAL 1:100 @ A1



TYPICAL SECTION - ROAD 02 MC02

CHAINAGE 70.000 TO 180.000

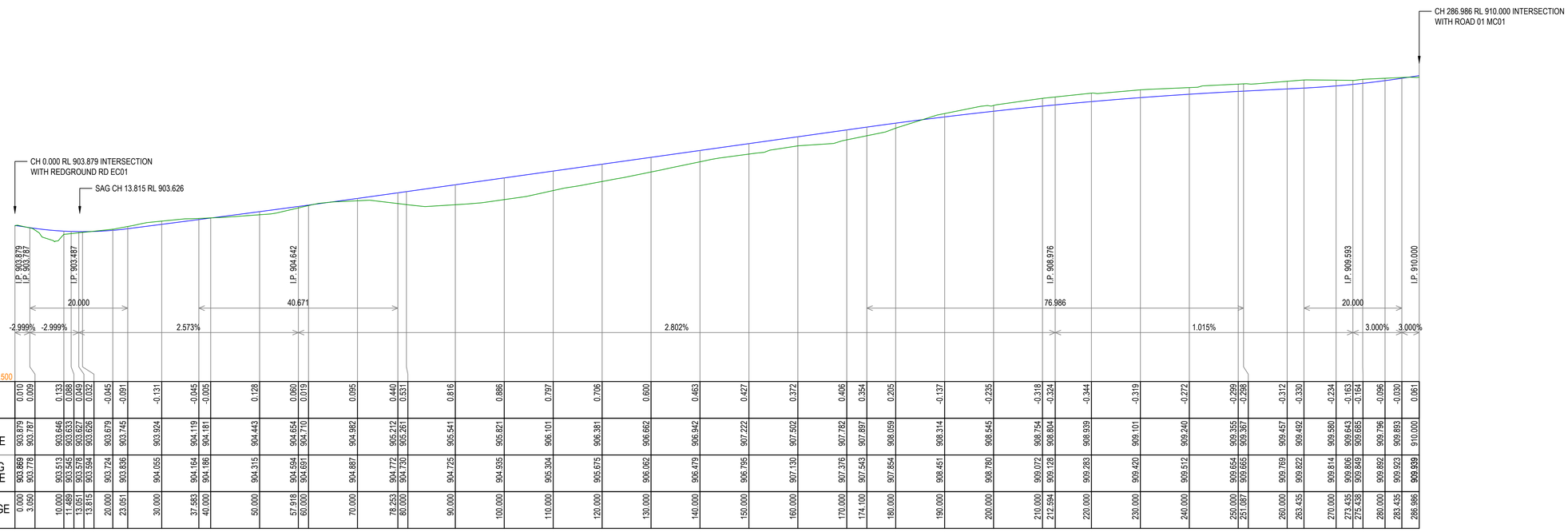
HORIZONTAL 1:100 VERTICAL 1:100 @ A1



TYPICAL SECTION - ROAD 02 MC02

CHAINAGE 180.000 TO 286.986

HORIZONTAL 1:100 VERTICAL 1:100 @ A1



LONGITUDINAL SECTION - ROAD 02 MC02

CHAINAGE 0.000 TO 286.986

HORIZONTAL 1:500 VERTICAL 1:100 @ A1

0 5 10 15 20 25
SCALE:- 1:500

0 0.5 1 1.5 2 2.5 5
SCALE:- 1:100

SCALE: AS NOTED	SURVEY	AS	REV	DESCRIPTION	DATE
SIZE: A1	DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DATE OF SURVEY: 21 MAR 2023	DRAWN	JE			
DATUM: MGA2020, AHD	CHECKED	RB			
	APPROVED	JW			

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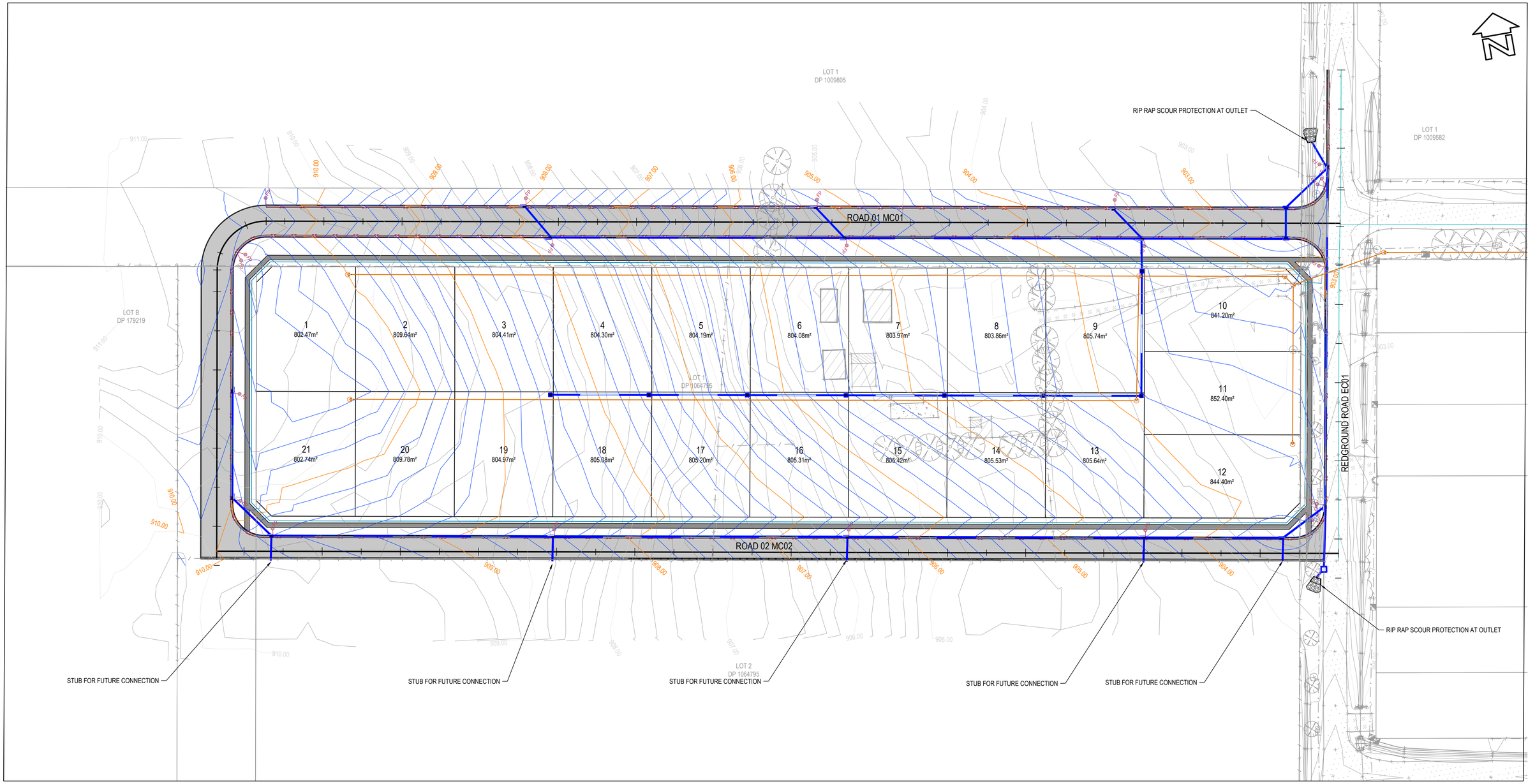
JOB NAME:	21 LOT RESIDENTIAL SUBDIVISION
LOCATION:	39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795 LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT:	BLUE WATER LAND PTY LTD
DESCRIPTION:	PLANNING PROPOSAL
DRAWING:	ROAD MC02 LONGITUDINAL SECTION AND TYPICAL CROSS SECTION

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-408	P0



DRAINAGE LAYOUT PLAN

1:500 @ A1

SHEET LEGEND

DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL	DESCRIPTION	DETAIL
BARRIER KERB 'KG'	KG	KERB / PEDESTRIAN RAMP		SUB-SOIL AND FLUSH POINTS	SS SS	STORMWATER LOCATION (EXISTING)	SW
ROLL KERB 'RK'	RK	NOMINAL CONTROL LINE		KERB ADAPTOR / OUTLET		SEWER LOCATION (EXISTING)	
EDGE STRIP 'ES'	ES	ROAD PAVEMENT		LIMIT OF WORKS		WATER LOCATION (EXISTING)	
KERB ONLY 'KO'	KO	PATH PAVING (CONCRETE)		BOUNDARIES		TELSTRA LOCATION (EXISTING)	
MOUNTABLE SF TYPE KERB 'SF'	SK	CONTOURS (MAJOR)	25	TREE AND LANDSCAPING		FIBRE OPTICS LOCATION (EXISTING)	
DISH DRAIN 'DD'	DD	CONTOURS (MINOR)		DRAINAGE PIT - 1.8m PIT WITH LINTEL		ELECTRICAL LOCATION (EXISTING)	
VEHICULAR CROSSING		RETAINING WALL STRUCTURES		DRAINAGE PIT - 2.4m SAG WITH LINTEL		GAS LOCATION (EXISTING)	G

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GDA 2020

0 5 10 15 20 25
SCALE:- 1:500

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

		REV	DESCRIPTION	DATE
SURVEY	AS	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DESIGN	JE			
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: DRAINAGE LAYOUT PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-409	P0

CATCHMENT SUMMARY				
PRE-DEVELOPMENT				
SITE	2.73	ha	1%	IMPERVIOUS
POST-DEVELOPMENT				
SITE - ROADS	1.03	ha	70%	IMPERVIOUS
SITE - LOTS	1.70	ha	60%	IMPERVIOUS

NOTE: THE UNDISTURBED VEGETATED AREA IS NOT INCLUDED ON THE STORMWATER QUANTITY AND QUALITY CALCULATIONS

LOT PERMISSIBLE SITE DISCHARGE (PSD) REQUIREMENT

CRITICAL STORM (% AEP)	PRE DEV SITE (m3/s)	POST DEV LOTS (m3/s)	POST DEV ROADS (m3/s)	PRE DEV SITE - POST DEV ROADS (m3/s)	PSD REQUIRED FOR LOTS (m3/s/ha)	L/s/ha
50	0.131	0.120	0.069	0.062	0.02	22.71
20	0.263	0.198	0.115	0.148	0.05	54.21
10	0.333	0.247	0.145	0.188	0.07	68.86
5	0.384	0.282	0.166	0.218	0.08	79.85
2	0.448	0.329	0.196	0.252	0.09	92.31
1	0.499	0.364	0.217	0.282	0.10	103.30

CONSIDERED LOT AREA: 2.73ha

CRITICAL STORM IS THE MEDIAN OF THE RELEVANT 1 MIN TO 2 HOUR DURATION USING ARR2019 PROTOCOLS

SITE STORAGE (SSR) REQUIREMENT

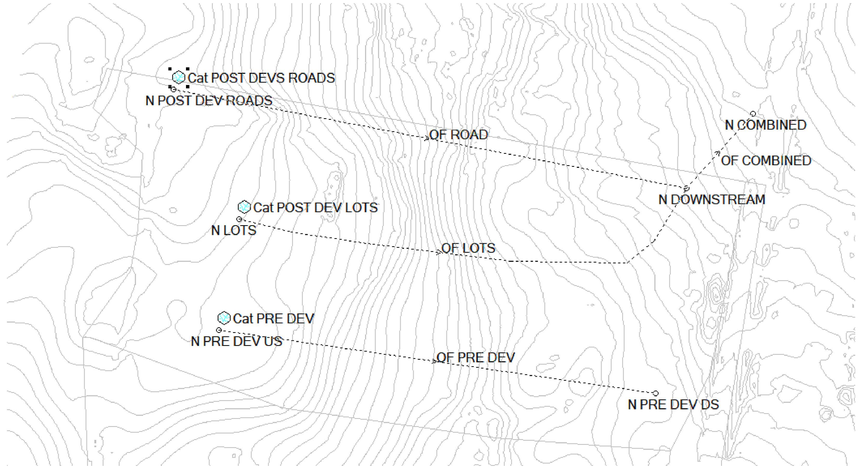
CRITICAL STORM (% AEP)	PRE DEV VOL (m3)	POST DEV VOL (m3)	SSR FOR LOTS (m3)	m3/ha
1(2hr)	930.2	999.5	69.3	25

SUMMARY

EACH LOT IS TO :

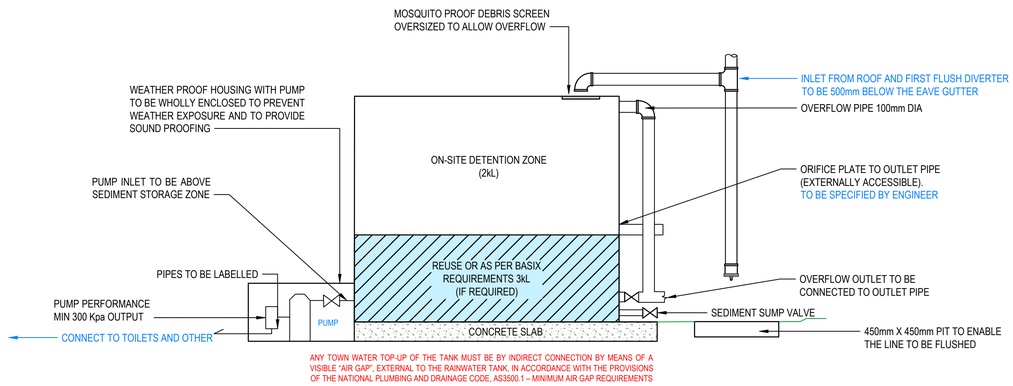
- PROVIDE 25m³/ha OF OSD TO SATISFY THE SITE STORAGE REQUIREMENT (SSR)
- COMPLY WITH THE FOLLOWING PERMISSIBLE SITE DISCHARGE (PSD) FLOWS NOTING THAT THE FINAL DWELLING DESIGN TO BE CHECKED BY A COMPETENT ENGINEER:

% AEP	L/s/ha
50	28
20	54
10	69
5	80
2	92
1	103



DRAINS MODEL SET-UP: PSD SSR

NTS



TYPICAL RAINWATER / OSD AT-SOURCE TANK

NTS

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
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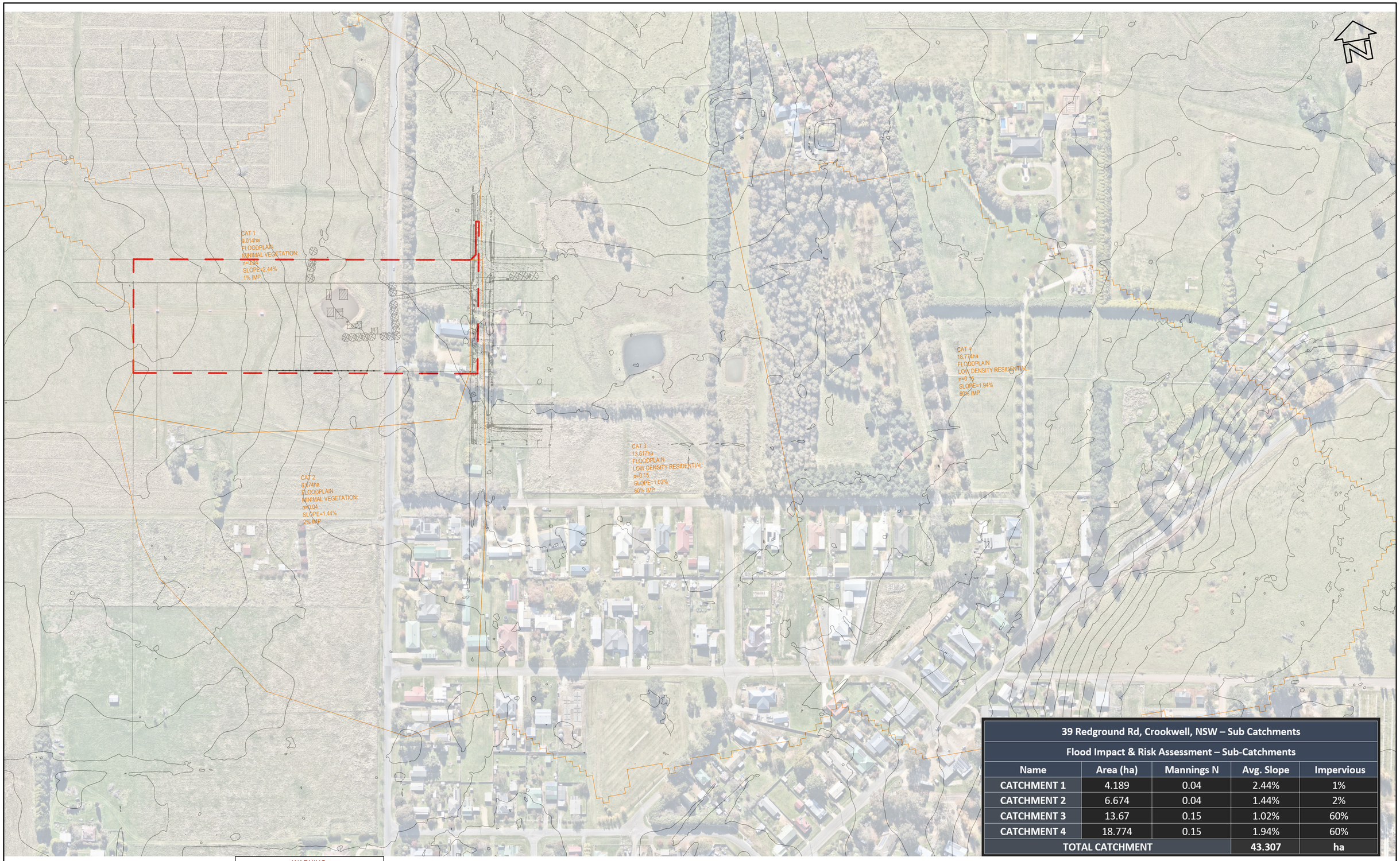
JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: STORMWATER QUANTITY MODELLING PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-410	P0



39 Redground Rd, Crookwell, NSW – Sub Catchments				
Flood Impact & Risk Assessment – Sub-Catchments				
Name	Area (ha)	Mannings N	Avg. Slope	Impervious
CATCHMENT 1	4.189	0.04	2.44%	1%
CATCHMENT 2	6.674	0.04	1.44%	2%
CATCHMENT 3	13.67	0.15	1.02%	60%
CATCHMENT 4	18.774	0.15	1.94%	60%
TOTAL CATCHMENT			43.307	ha

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CATCHMENT ANALYSIS PLAN

1:1500 @ A1

0 10 20 30 40 50
SCALE:- 1:1500

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
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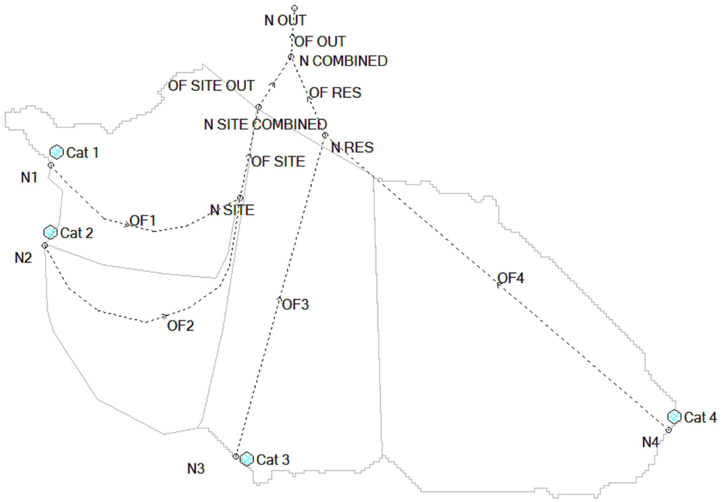
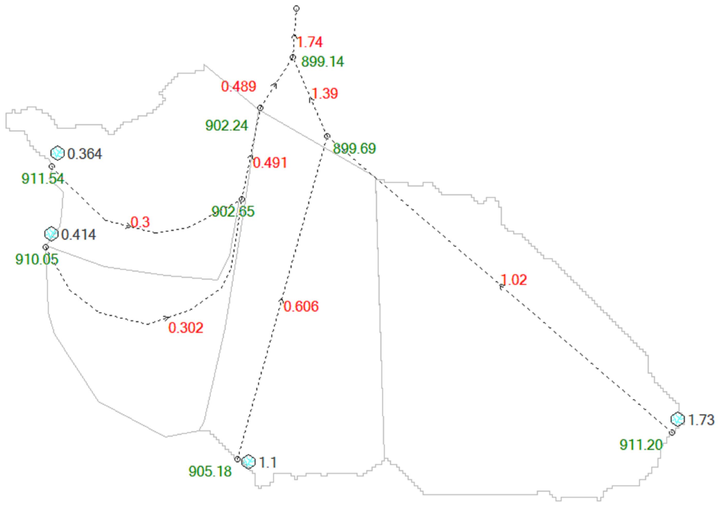
DRAWING: CATCHMENT ANALYSIS PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

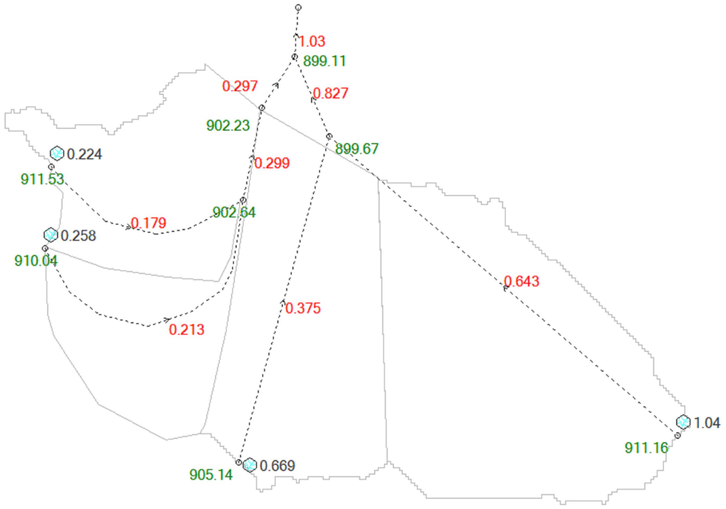
JOB-DRAWING NUMBER	REV
23017-411	P0



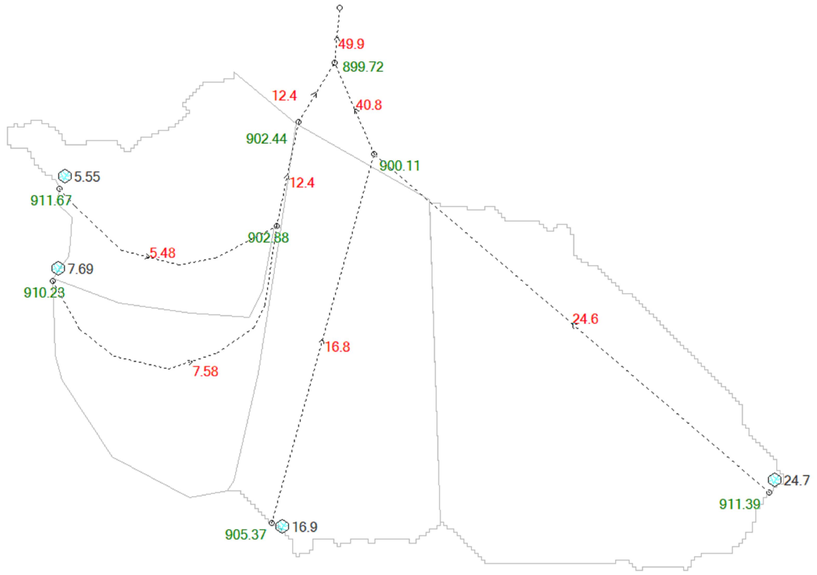
DRAINS (RAFTS MODELLING) SET UP OVERVIEW
NTS



DRAINS (RAFTS MODELLING) RESULTS 1% AEP
NTS



DRAINS (RAFTS MODELLING) RESULTS 10% AEP
NTS



DRAINS (RAFTS MODELLING) RESULTS PMF

SCALE: AS NOTED SIZE: A1 DATE OF SURVEY: 21 MAR 2023 DATUM: MGA2020, AHD	SURVEY	AS	REV	DESCRIPTION	DATE	CIVPLAN PTY LIMITED ALL RIGHTS RESERVED. THIS DOCUMENT IS PRODUCED BY CIVPLAN PTY LTD SOLELY FOR THE BENEFIT OF AND USE BY THE CLIENT IN ACCORDANCE WITH THE TERMS OF THE RETAINER. CIVPLAN PTY LTD DOES NOT AND SHALL NOT ASSUME ANY RESPONSIBILITY OR LIABILITY WHATSOEVER TO ANY THIRD PARTY ARISING OUT OF ANY USE OF RELIANCE BY THIRD PARTY ON THE CONTENT OF THIS DOCUMENT.	JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795 LGA: UPPER LACHLAN SHIRE COUNCIL	PRELIMINARY NOT TO BE USED FOR CONSTRUCTION PURPOSES
	DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24				
	DRAWN	JE						CLIENT: BLUE WATER LAND PTY LTD	RELEASE DATE: 6 FEBRUARY 2024
	CHECKED	RB						DESCRIPTION: PLANNING PROPOSAL	JOB-DRAWING NUMBER: 23017-412 REV: P0
	APPROVED	JW						DRAWING: DRAINS MODELLING AND RESULTS	

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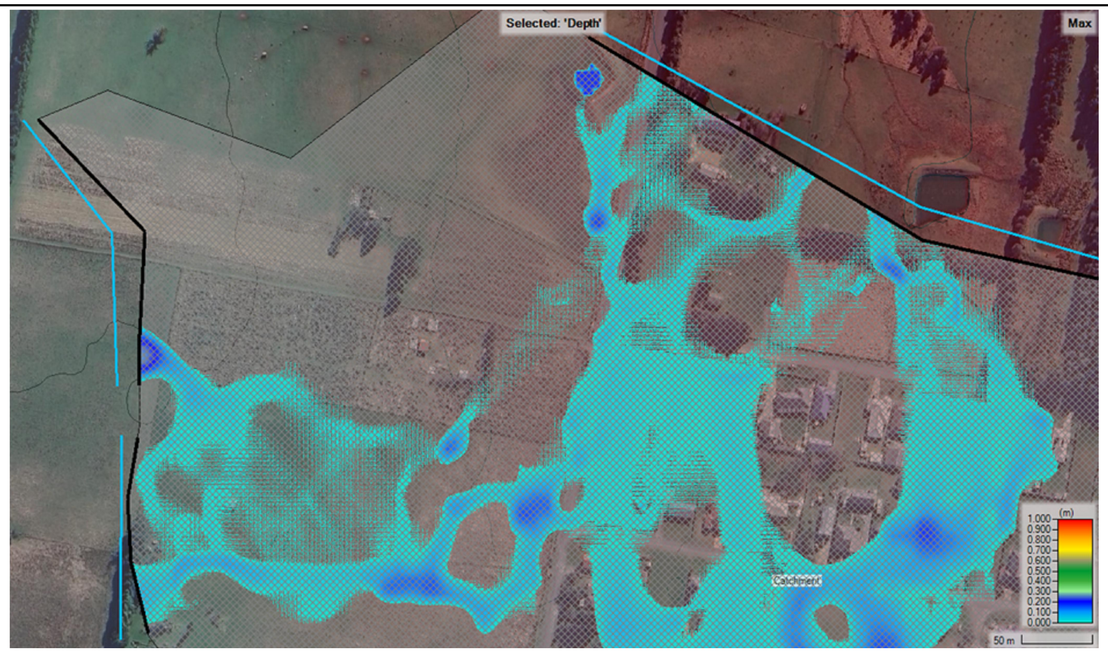
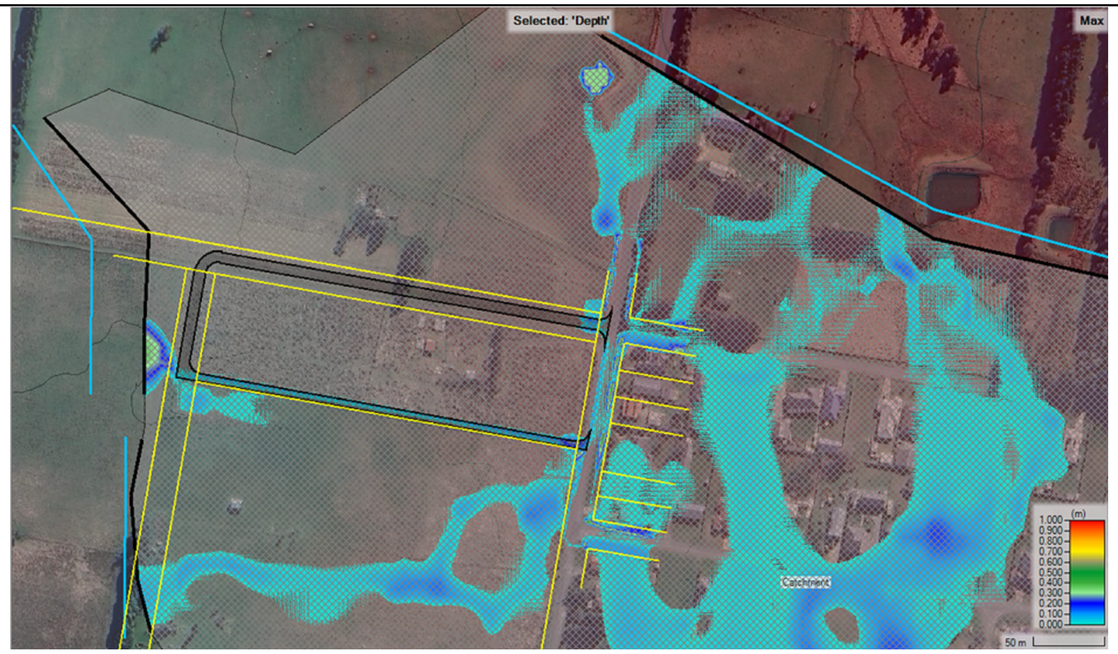


PRE DEVELOPMENT - 10% AEP - DEPTH
NTS



POST DEVELOPMENT - 10% AEP - DEPTH
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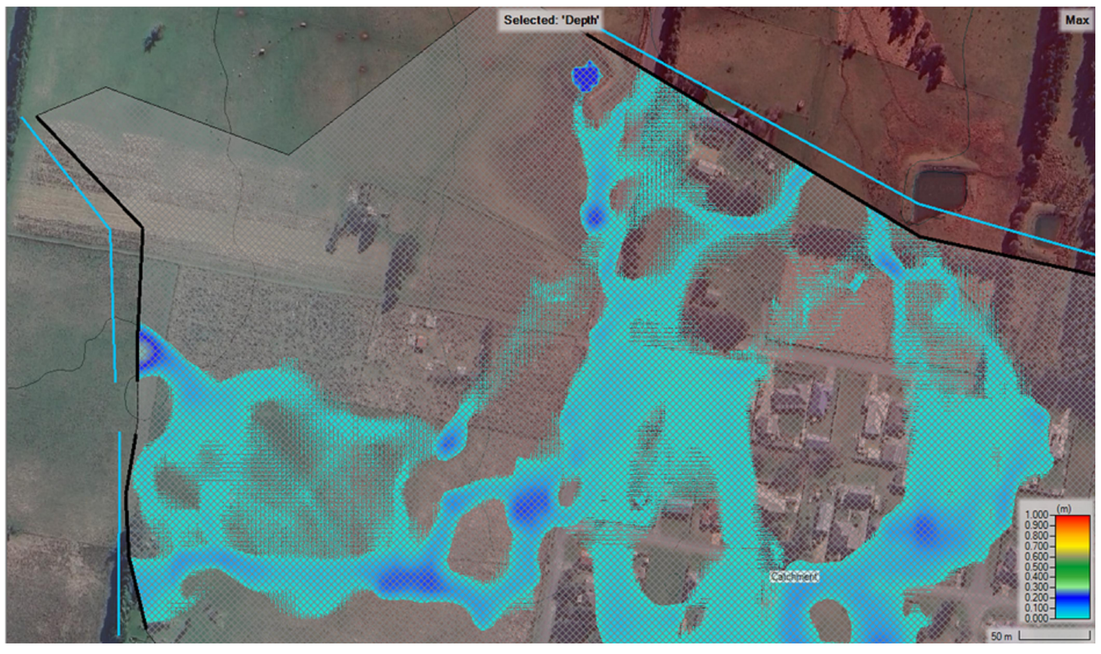
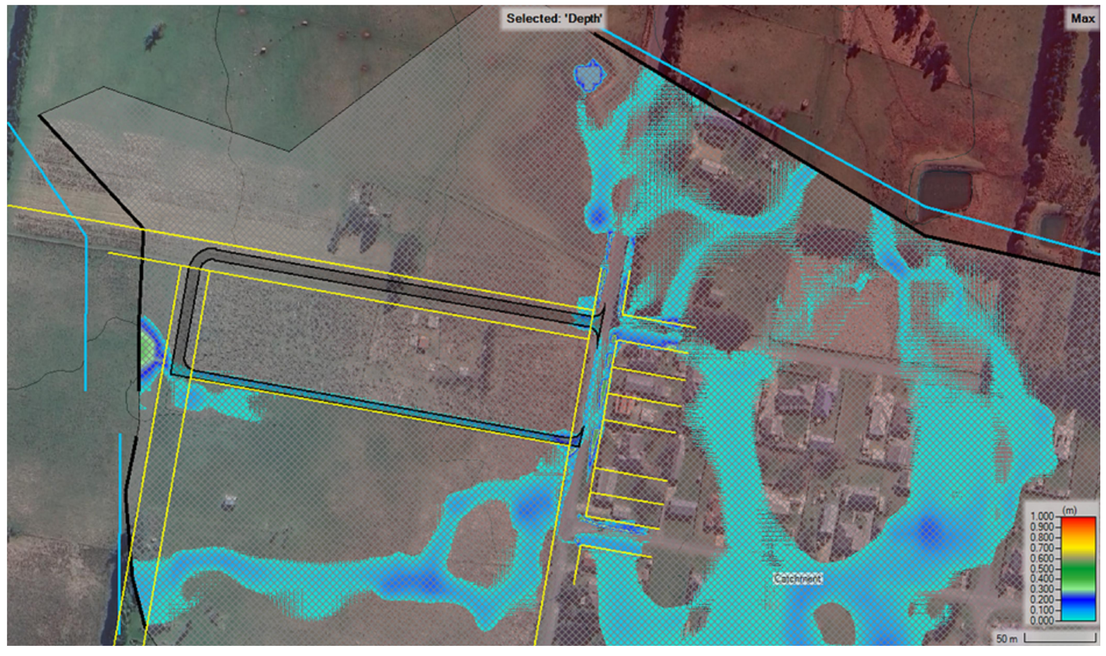


PRE DEVELOPMENT - 1% AEP - DEPTH
NTS



POST DEVELOPMENT - 1% AEP - DEPTH
NTS

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS		
DESIGN	JE		
DRAWN	JE		
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REV	DESCRIPTION	DATE
P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24

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LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: PRE DEVELOPMENT & POST DEVELOPMENT 1% & 10% AEP RESULTS - DEPTHS

PRELIMINARY
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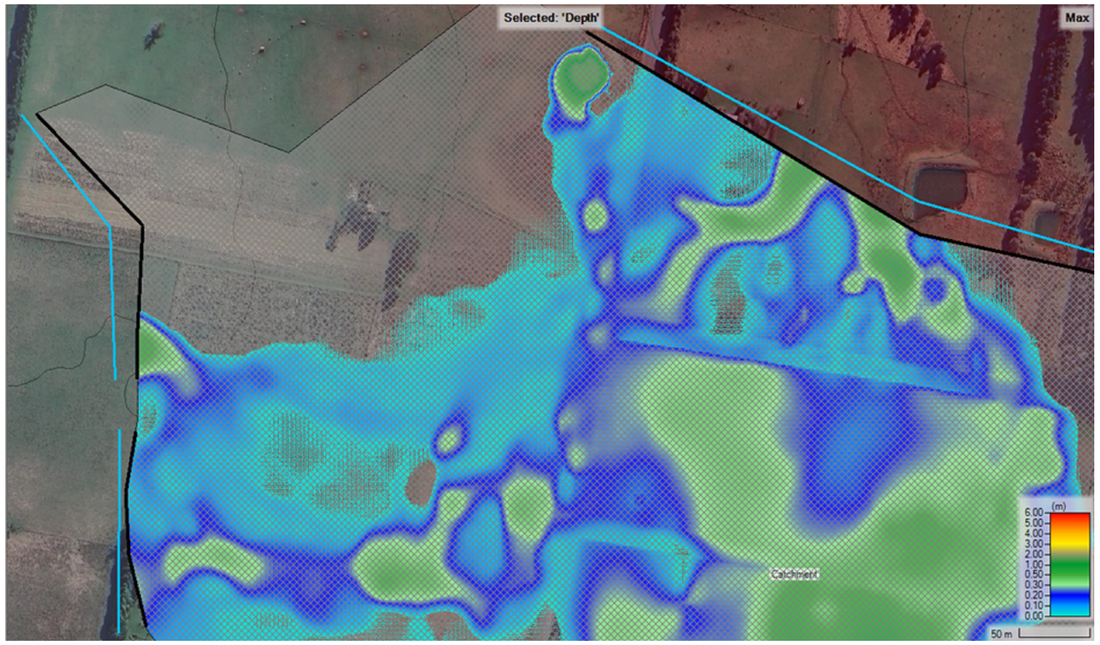
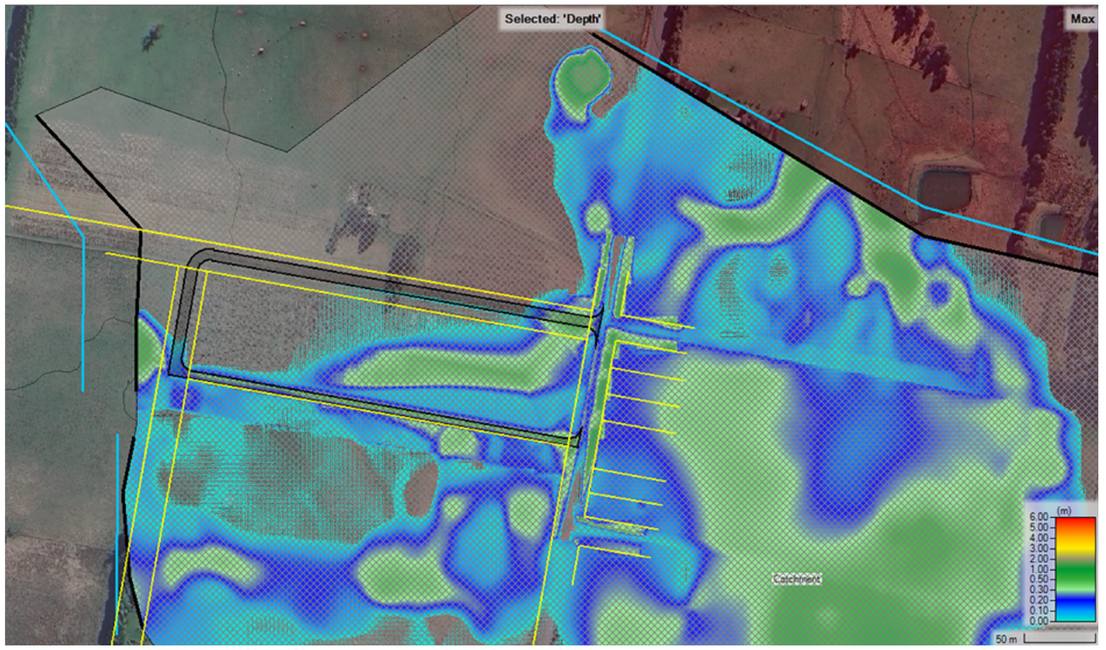
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-413	P0



PRE DEVELOPMENT - PMF - DEPTH

NTS



POST DEVELOPMENT - PMF - DEPTH

NTS

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
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SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
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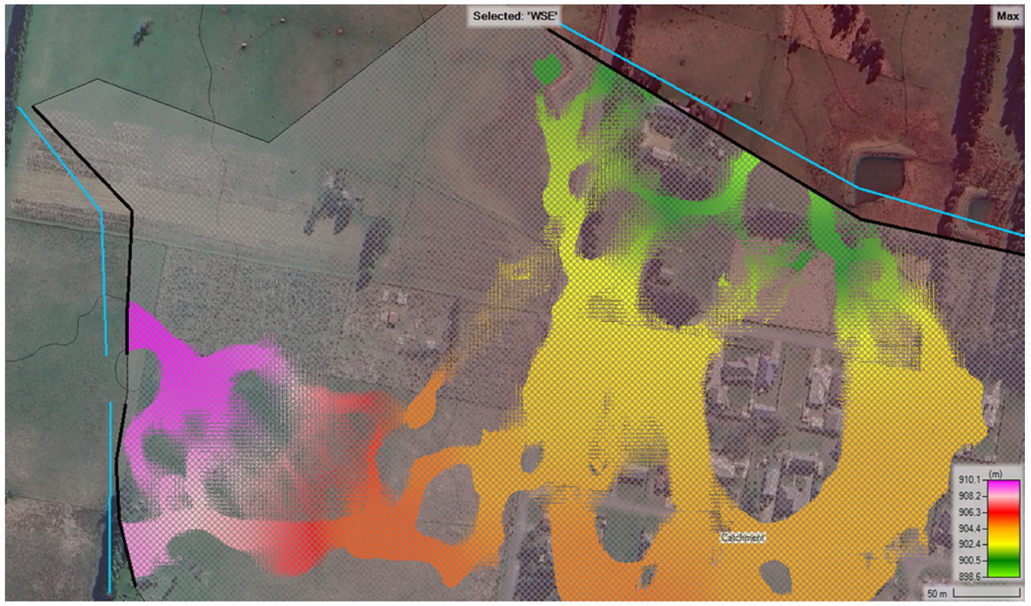
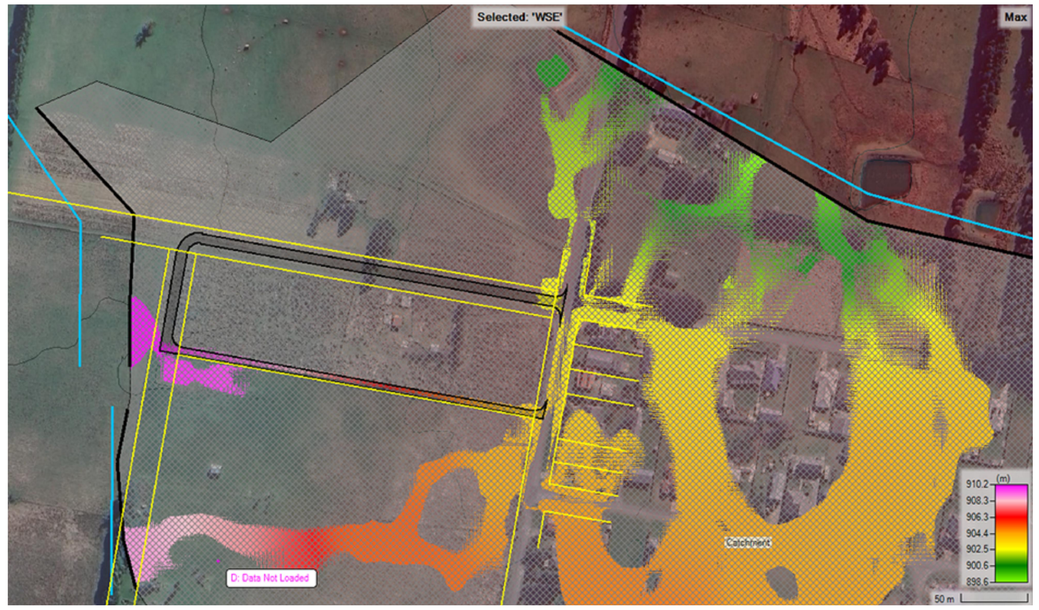
JOB-DRAWING NUMBER	REV
23017-414	P0

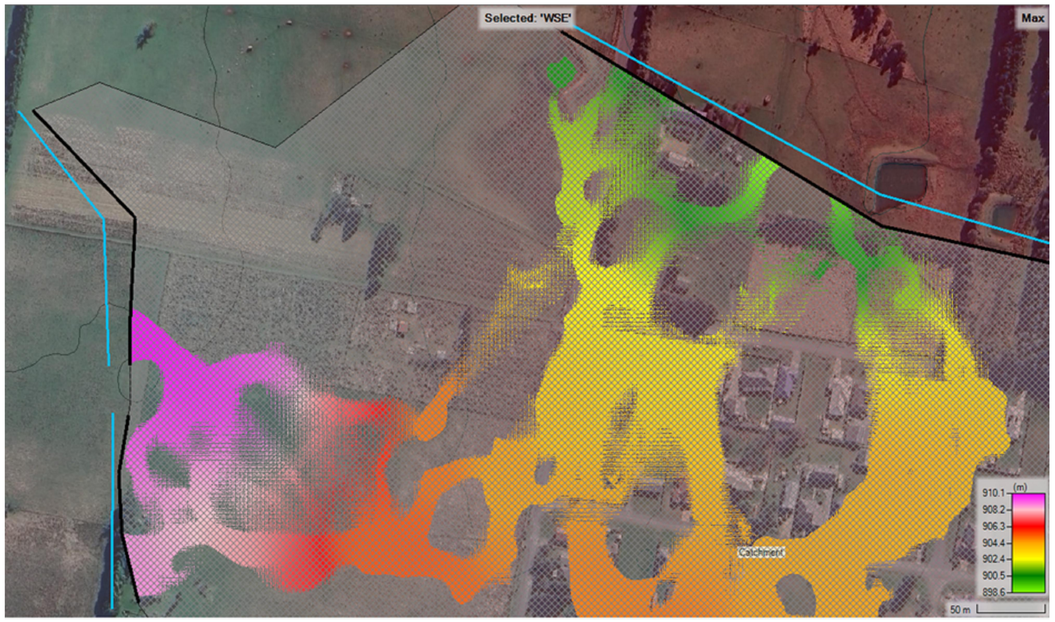


PRE DEVELOPMENT - 10% AEP - WSE



POST DEVELOPMENT - 10% AEP - WSE

NTS



PRE DEVELOPMENT - 1% AEP - WSE

NTS

POST DEVELOPMENT - 1% AEP - WSE

SCALE: AS NOTED
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DATE OF SURVEY: 21 MAR 2023
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CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: PRE DEVELOPMENT & POST DEVELOPMENT 1% & 10% AEP RESULTS - WSE

PRELIMINARY
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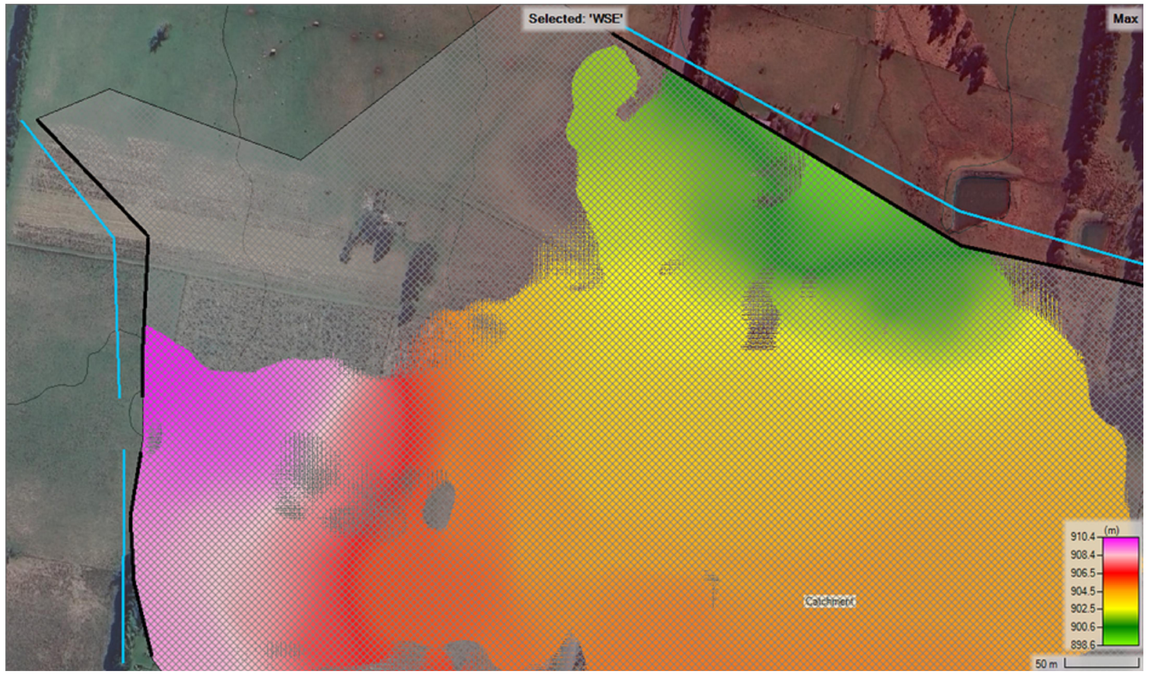
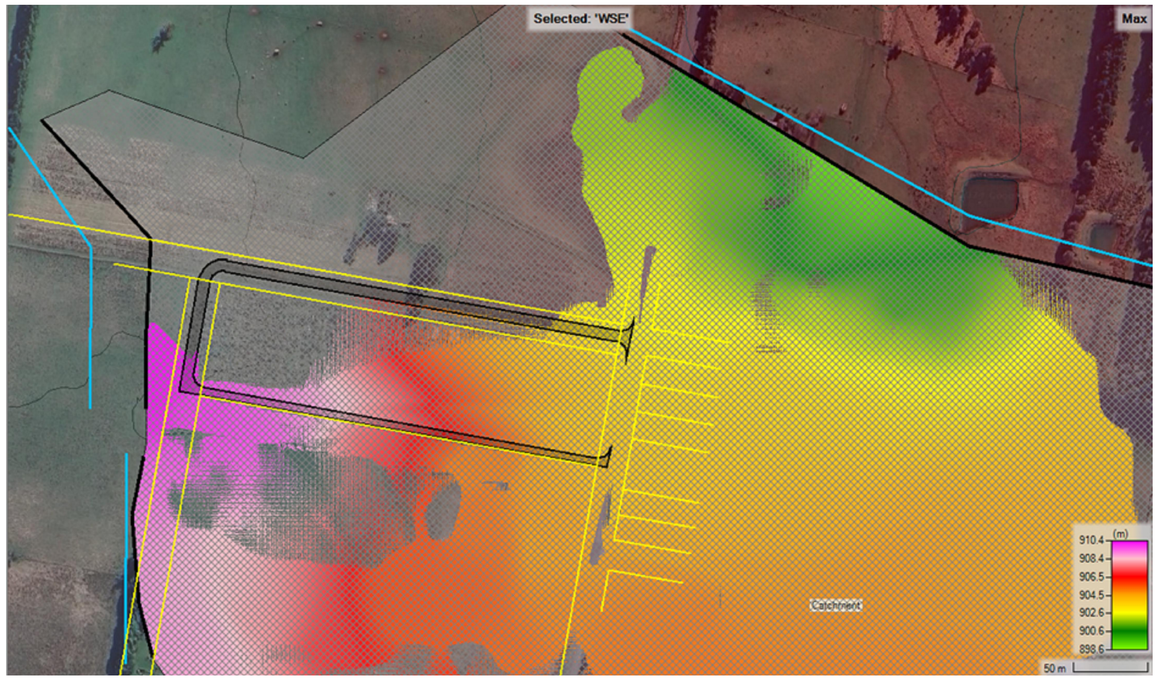
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-415	P0



PRE DEVELOPMENT - PMF - WSE



POST DEVELOPMENT - PMF - WSE

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DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
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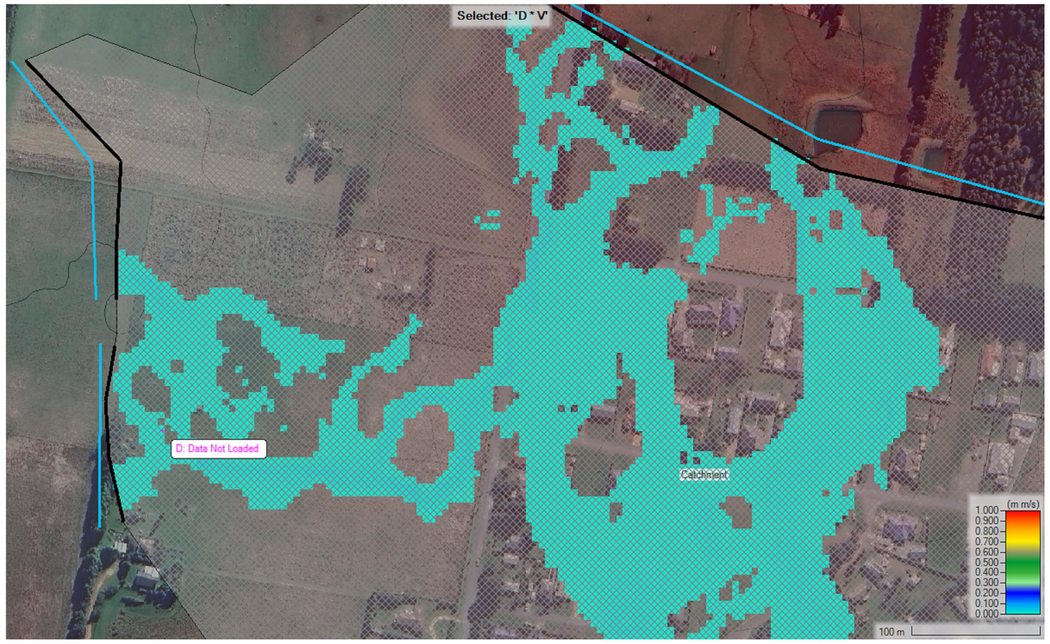
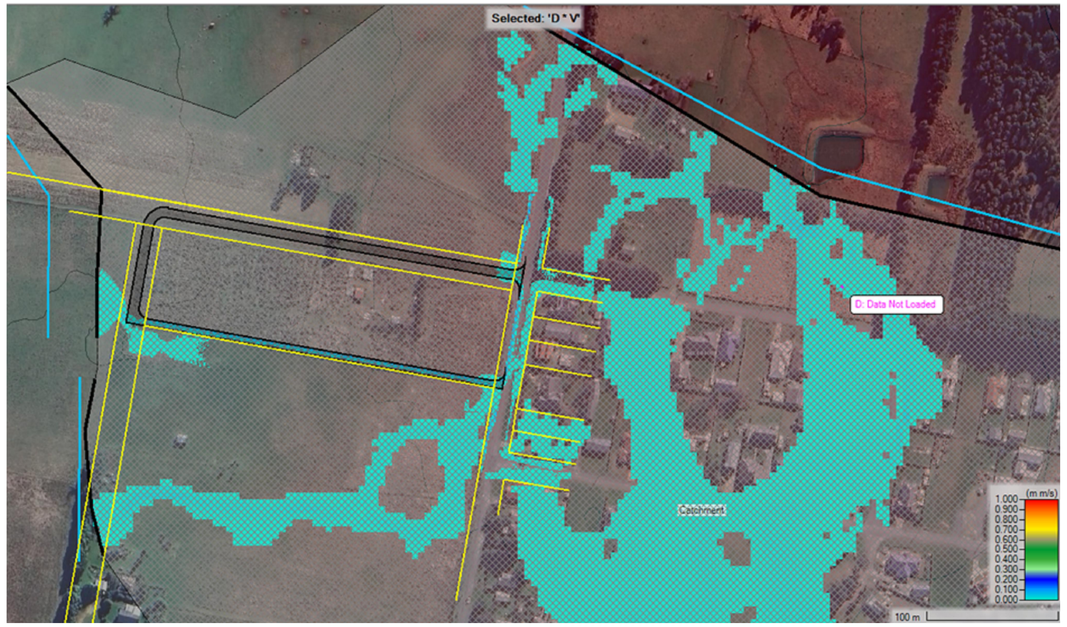
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: PRE DEVELOPMENT & POST DEVELOPMENT PMF RESULTS - WSE

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-416	P0

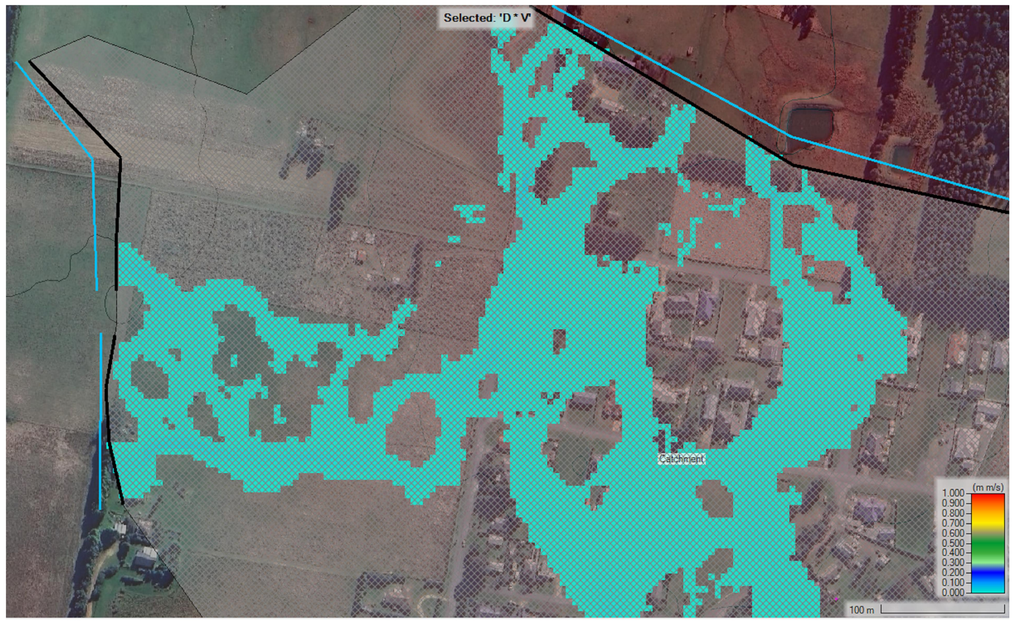


PRE DEVELOPMENT - 10% AEP - VxD



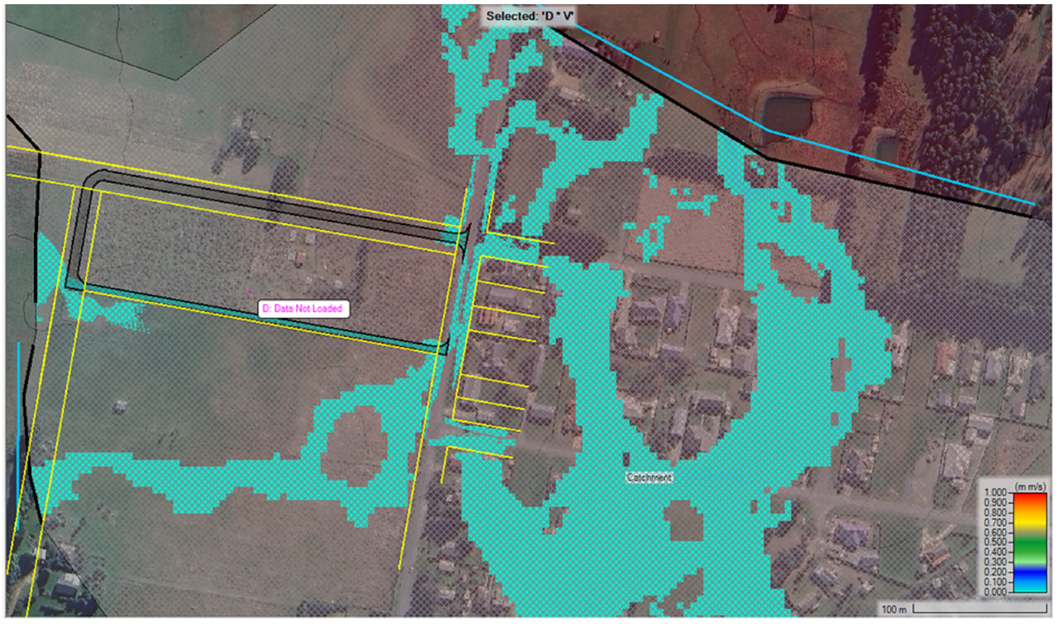
POST DEVELOPMENT - 10% AEP - VxD

NTS



PRE DEVELOPMENT - 1% AEP - VxD

NTS



POST DEVELOPMENT - 1% AEP - VxD

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS		
DESIGN	JE		
DRAWN	JE		
CHECKED	RB		
APPROVED	JW		

REV	DESCRIPTION	DATE
P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24

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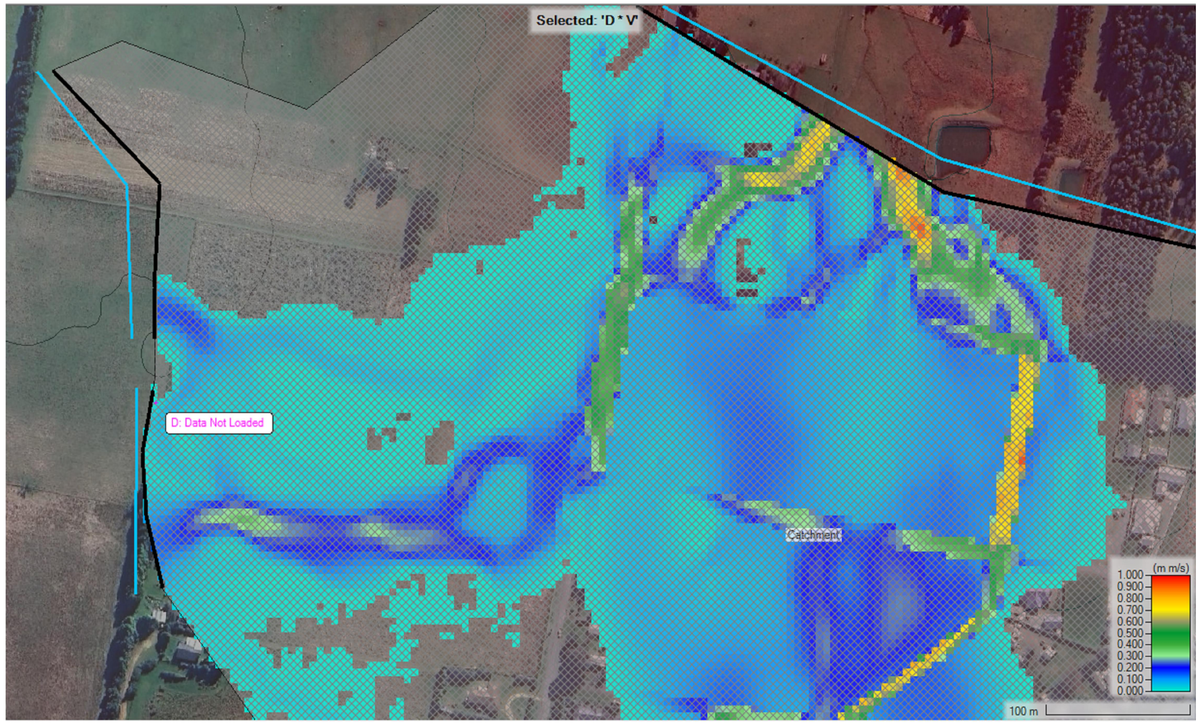
DEVELOPMENT & INFRASTRUCTURE CONSULTING
CIVPLAN PTY LTD ABN: 49 620 926 114 | CIVPLAN CONSULTING PTY LTD ABN: 79 157 731 912
SOUTH COAST OFFICE: 390 PRINCES HIGHWAY, BOMADERRY NSW 2541
SYDNEY OFFICE: 152 SAILORS BAY ROAD, NORTHBRIDGE NSW 2063
T: 1800 318 052 E: info@civplan.com.au W: www.civplan.com.au

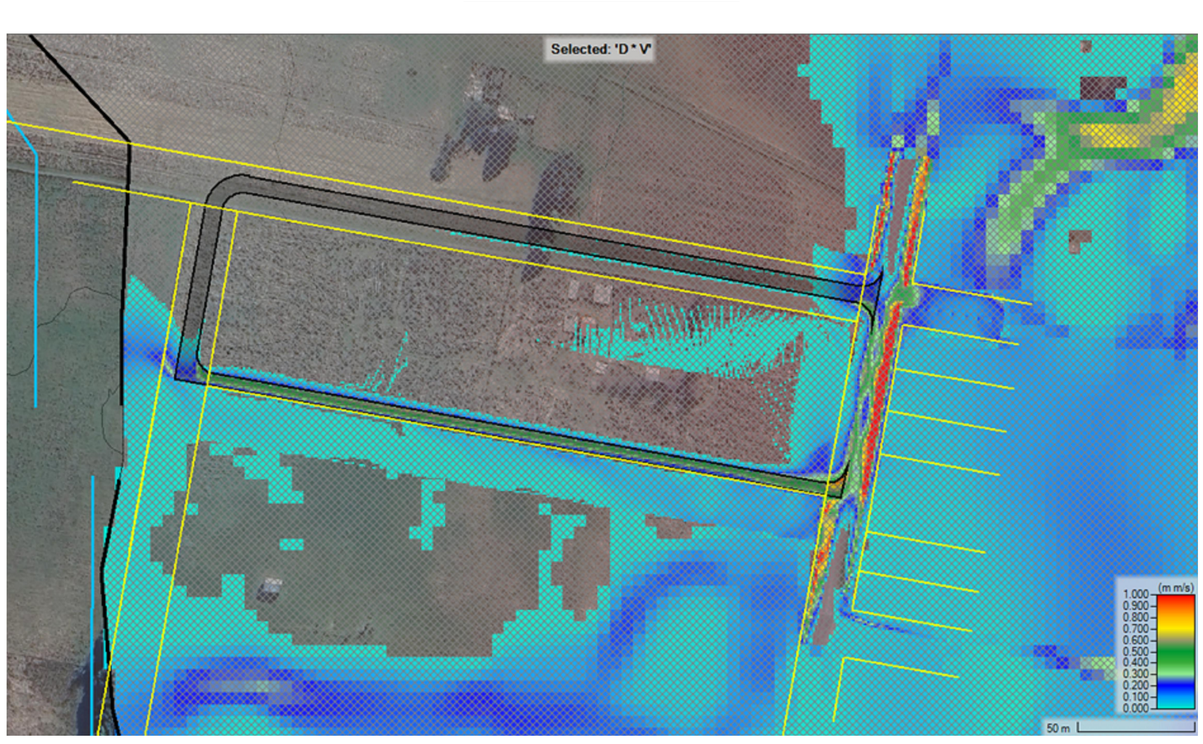
JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: PRE DEVELOPMENT & POST DEVELOPMENT 1% & 10% AEP RESULTS - VxD

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-417	P0



PRE DEVELOPMENT - PMF - VxD



POST DEVELOPMENT - PMF - VxD

NTS

SCALE: AS NOTED	SURVEY	AS	REV	DESCRIPTION	DATE
SIZE: A1	DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DATE OF SURVEY: 21 MAR 2023	DRAWN	JE			
DATUM: MGA2020, AHD	CHECKED	RB			
	APPROVED	JW			

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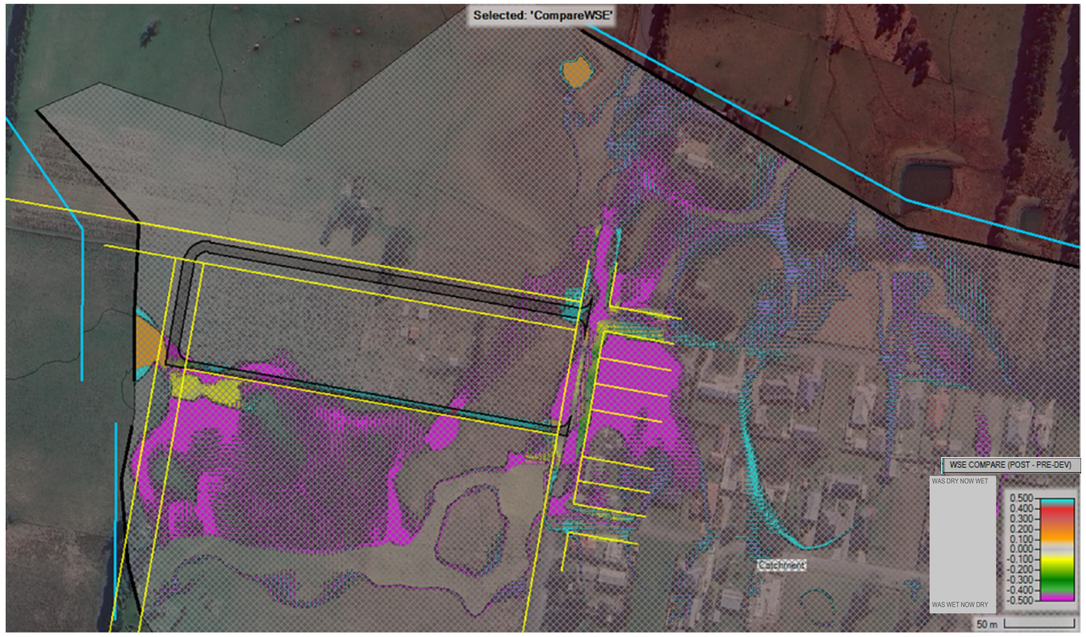
JOB NAME:	21 LOT RESIDENTIAL SUBDIVISION
LOCATION:	39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795 LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT:	BLUE WATER LAND PTY LTD
DESCRIPTION:	PLANNING PROPOSAL
DRAWING:	PRE DEVELOPMENT & POST DEVELOPMENT PMF RESULTS - VxD

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

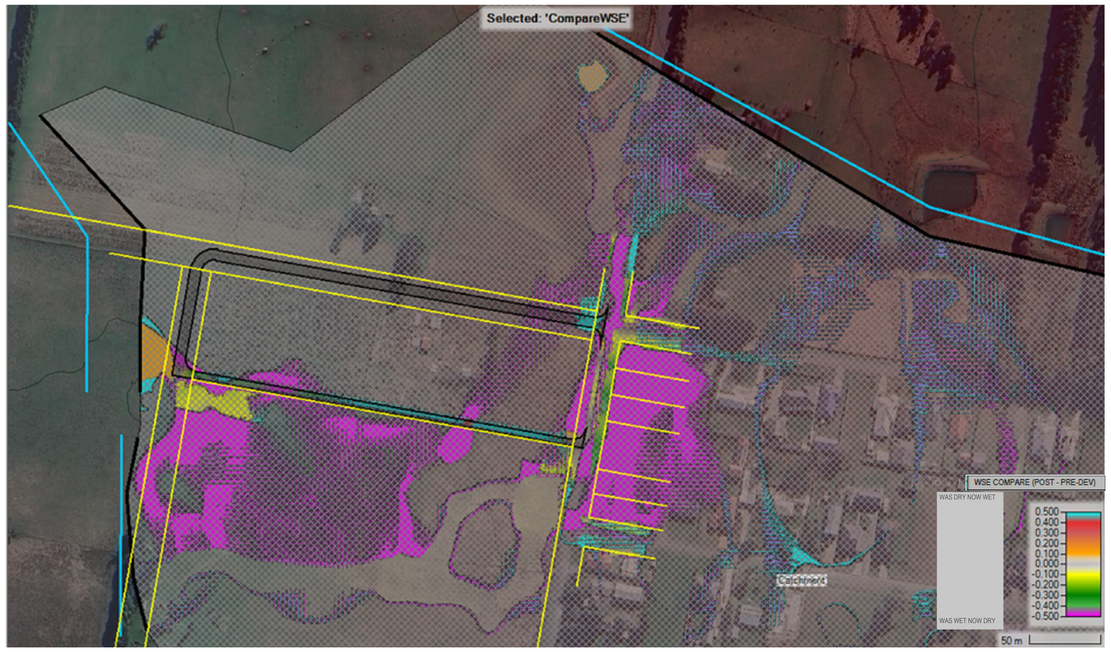
RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-418	P0



PRE DEVELOPMENT x POST DEVELOPMENT - 10% AEP - WAS DRY NOW WET

NTS



PRE DEVELOPMENT x POST DEVELOPMENT - 1% AEP - WAS DRY NOW WET

NTS

PRE DEVELOPMENT x POST DEVELOPMENT - PMF - WAS DRY NOW WET

NTS

SCALE: AS NOTED
SIZE: A1
DATE OF SURVEY: 21 MAR 2023
DATUM: MGA2020, AHD

SURVEY	AS	REV	DESCRIPTION	DATE
DESIGN	JE	P0	PRELIMINARY PLANNING PROPOSAL DESIGN	6 FEB 24
DRAWN	JE			
CHECKED	RB			
APPROVED	JW			

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JOB NAME: 21 LOT RESIDENTIAL SUBDIVISION
LOCATION: 39 REDGROUND, CROOKWELL, NSW - LOT 1 D.P. 1064795
LGA: UPPER LACHLAN SHIRE COUNCIL
CLIENT: BLUE WATER LAND PTY LTD
DESCRIPTION: PLANNING PROPOSAL
DRAWING: PRE & POST DEVELOPMENT 10%, 1% AEP & PMF - WAS DRY NOW WET

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

RELEASE DATE: 6 FEBRUARY 2024

JOB-DRAWING NUMBER	REV
23017-419	P0

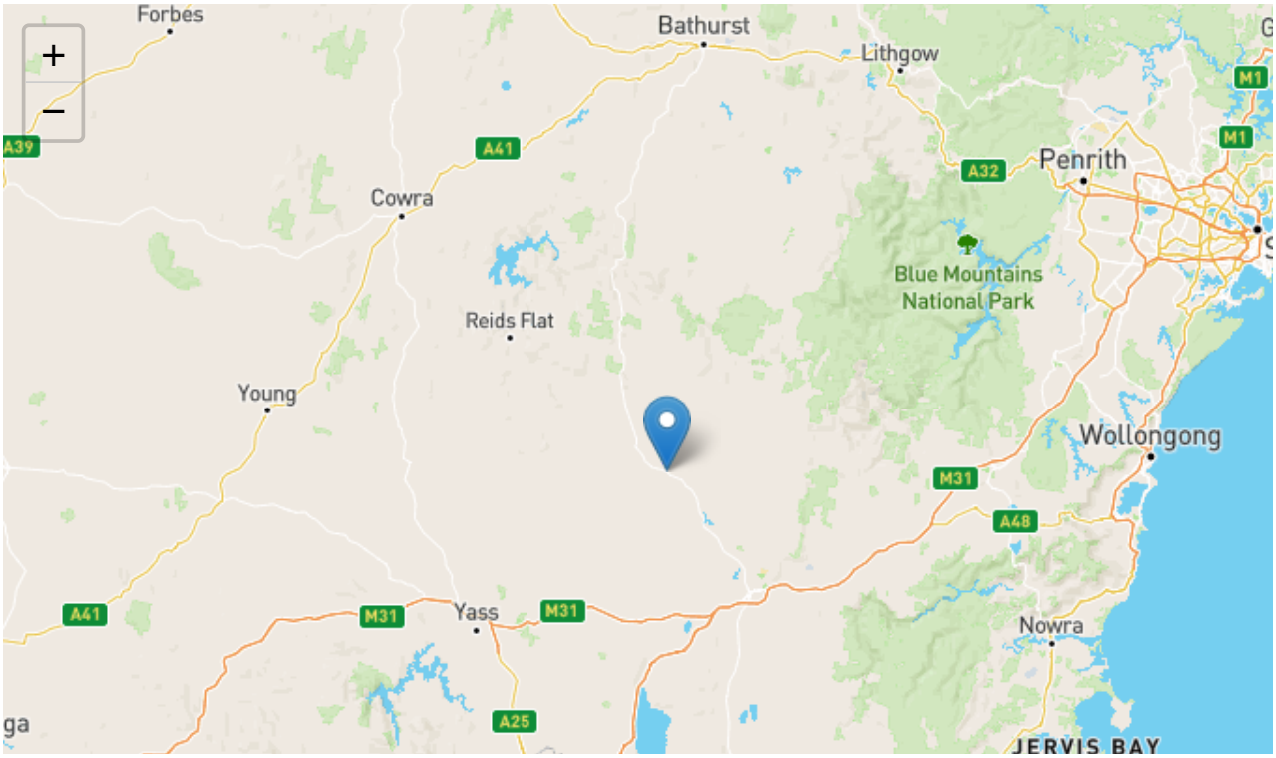
Appendix B

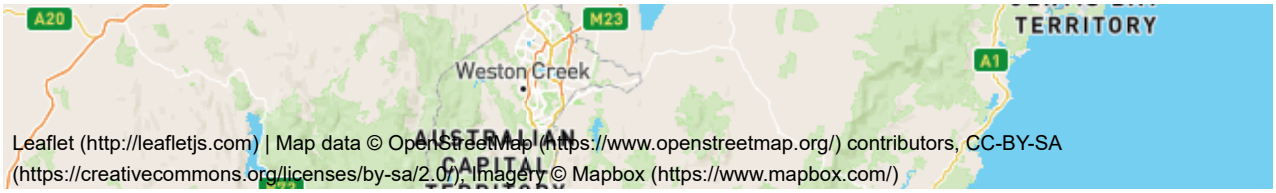
ARR Hub Data

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	149.47
Latitude	-34.458
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show





Data

River Region

Division	Murray-Darling Basin
River Number	13
River Name	Lachlan River

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} + eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
Central NSW	0.265	0.241	0.505	0.321	0.00056	0.414	-0.021	0.015	-0.00033

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26\ \text{x}\ 10^{-3}\ \text{x}\ Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141\ \text{x}\ Area^{0.213}\ \text{x}\ 10^{-0.021\frac{(Duration-180)^{2}}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	29172.0
Storm Initial Losses (mm)	25.0
Storm Continuing Losses (mm/h)	4.3

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/MB.zip)

code	MB
Label	Murray Basin

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_MB.zip)

code	MB
arealabel	Murray Basin

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-34.458&longitude=149.47&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	16 January 2024 10:22AM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.002)	0.1 (0.004)	0.1 (0.005)	0.2 (0.006)	0.1 (0.002)	0.0 (0.000)
90 (1.5)	0.1 (0.007)	0.1 (0.004)	0.1 (0.002)	0.0 (0.001)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.4 (0.018)	0.3 (0.009)	0.2 (0.005)	0.1 (0.002)	0.1 (0.003)	0.2 (0.004)
180 (3.0)	0.5 (0.019)	0.4 (0.014)	0.4 (0.011)	0.4 (0.009)	0.6 (0.012)	0.7 (0.014)
360 (6.0)	1.4 (0.044)	1.7 (0.039)	1.8 (0.037)	1.9 (0.035)	1.2 (0.019)	0.7 (0.010)
720 (12.0)	0.2 (0.004)	1.1 (0.020)	1.8 (0.026)	2.3 (0.031)	6.9 (0.077)	10.3 (0.103)
1080 (18.0)	0.0 (0.000)	1.4 (0.021)	2.4 (0.030)	3.3 (0.036)	6.5 (0.060)	8.8 (0.073)
1440 (24.0)	0.0 (0.000)	0.3 (0.004)	0.5 (0.005)	0.7 (0.006)	2.9 (0.023)	4.5 (0.033)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.5 (0.004)	0.9 (0.006)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	5.9 (0.357)	5.9 (0.279)	6.0 (0.243)	6.0 (0.217)	7.2 (0.225)	8.1 (0.230)
90 (1.5)	8.9 (0.467)	8.7 (0.356)	8.6 (0.305)	8.5 (0.267)	8.0 (0.220)	7.7 (0.193)
120 (2.0)	11.1 (0.526)	11.1 (0.409)	11.1 (0.355)	11.1 (0.315)	10.9 (0.271)	10.8 (0.244)
180 (3.0)	12.4 (0.506)	12.3 (0.389)	12.2 (0.335)	12.1 (0.294)	15.2 (0.323)	17.6 (0.340)
360 (6.0)	9.5 (0.294)	14.7 (0.350)	18.1 (0.374)	21.4 (0.389)	22.0 (0.344)	22.4 (0.316)
720 (12.0)	7.4 (0.171)	11.6 (0.204)	14.3 (0.216)	17.0 (0.223)	29.2 (0.327)	38.3 (0.385)
1080 (18.0)	1.5 (0.029)	7.8 (0.115)	11.9 (0.150)	16.0 (0.174)	24.0 (0.222)	30.0 (0.248)
1440 (24.0)	0.3 (0.005)	4.0 (0.052)	6.4 (0.072)	8.8 (0.085)	16.3 (0.133)	21.9 (0.160)
2160 (36.0)	0.1 (0.001)	2.0 (0.023)	3.3 (0.031)	4.5 (0.037)	8.7 (0.060)	11.8 (0.073)
2880 (48.0)	0.0 (0.000)	1.4 (0.014)	2.3 (0.020)	3.1 (0.023)	6.0 (0.038)	8.1 (0.046)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.6 (0.003)	1.0 (0.005)

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	18.7 (1.137)	19.1 (0.896)	19.3 (0.788)	19.6 (0.706)	21.0 (0.659)	22.1 (0.629)
90 (1.5)	20.6 (1.083)	20.8 (0.850)	20.9 (0.744)	21.1 (0.664)	22.3 (0.611)	23.2 (0.578)
120 (2.0)	21.8 (1.035)	23.5 (0.868)	24.6 (0.791)	25.7 (0.732)	24.5 (0.608)	23.7 (0.533)
180 (3.0)	26.6 (1.086)	27.2 (0.861)	27.5 (0.757)	27.8 (0.679)	33.2 (0.704)	37.2 (0.717)
360 (6.0)	20.9 (0.644)	31.7 (0.756)	38.9 (0.802)	45.8 (0.832)	54.4 (0.852)	60.9 (0.861)
720 (12.0)	24.0 (0.553)	35.5 (0.624)	43.1 (0.649)	50.4 (0.663)	67.5 (0.758)	80.3 (0.809)
1080 (18.0)	15.0 (0.294)	25.0 (0.369)	31.6 (0.397)	38.0 (0.414)	54.4 (0.504)	66.8 (0.553)
1440 (24.0)	8.4 (0.148)	16.0 (0.210)	21.0 (0.234)	25.9 (0.249)	38.2 (0.312)	47.5 (0.346)
2160 (36.0)	6.4 (0.098)	10.8 (0.123)	13.8 (0.131)	16.6 (0.136)	29.6 (0.206)	39.3 (0.244)
2880 (48.0)	8.6 (0.121)	13.6 (0.141)	17.0 (0.147)	20.2 (0.151)	25.7 (0.162)	29.8 (0.168)
4320 (72.0)	1.0 (0.013)	5.6 (0.052)	8.6 (0.067)	11.5 (0.077)	11.2 (0.064)	10.9 (0.056)

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.816 (4.1%)**	0.726 (3.6%)	**0.934 (4.7%)**
2040	**1.046 (5.2%)**	1.015 (5.1%)	**1.305 (6.6%)**

2050	**1.260 (6.3%)**	1.277 (6.4%)	**1.737 (8.8%)**
2060	**1.450 (7.3%)**	1.520 (7.7%)	**2.214 (11.4%)**
2070	**1.609 (8.2%)**	1.753 (8.9%)	**2.722 (14.2%)**
2080	**1.728 (8.8%)**	1.985 (10.2%)	**3.246 (17.2%)**
2090	**1.798 (9.2%)**	2.226 (11.5%)	**3.772 (20.2%)**

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	**50.0**	**20.0**	**10.0**	**5.0**	**2.0**	**1.0**
60 (1.0)	16.6	11.3	9.5	8.9	8.6	8.0
90 (1.5)	19.2	11.2	9.4	9.2	9.1	8.1
120 (2.0)	18.9	10.6	9.1	9.2	8.7	8.1
180 (3.0)	18.3	10.3	9.2	9.7	9.1	6.5
360 (6.0)	18.4	12.1	10.0	9.9	8.9	6.1
720 (12.0)	18.9	13.3	12.6	12.1	9.5	5.0
1080 (18.0)	21.5	16.4	15.3	14.7	12.1	6.3
1440 (24.0)	23.5	18.8	18.1	18.8	15.5	9.5
2160 (36.0)	24.4	20.4	20.2	22.6	17.8	11.2
2880 (48.0)	24.5	20.5	20.3	23.5	18.5	13.0
4320 (72.0)	26.0	22.8	23.3	26.6	23.9	19.0

Layer Info

Time Accessed	16 January 2024 10:22AM
Version	2018_v1

Note As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Download TXT (downloads/8e616cab-f95e-49e8-a578-43127bd56dcc.txt)

Download JSON (downloads/a3ea17bd-5909-4545-9733-d06ac411247a.json)

Generating PDF... (downloads/b0fbcb0e-f336-4d08-bb67-d47bd45d5b13.pdf)

Appendix C

IFD Data

Australian Government
Bureau of Meteorology

Location

Label: Not provided

Latitude: -34.458 [Nearest grid cell: 34.4625 (S)]

Longitude: 149.47 [Nearest grid cell: 149.4625 (E)]

IFD Design Rainfall Depth (mm)

Issued: 16 January 2024

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.33	1.48	1.94	2.25	2.55	2.95	3.25
2 min	2.24	2.47	3.17	3.62	4.06	4.63	5.05
3 min	3.10	3.41	4.39	5.04	5.67	6.48	7.09
4 min	3.85	4.25	5.50	6.34	7.15	8.21	9.02
5 min	4.51	5.00	6.50	7.51	8.49	9.78	10.8
10 min	6.95	7.72	10.1	11.8	13.4	15.5	17.2
15 min	8.55	9.50	12.5	14.5	16.5	19.2	21.2
20 min	9.75	10.8	14.2	16.5	18.8	21.8	24.1
25 min	10.7	11.9	15.6	18.1	20.5	23.8	26.3
30 min	11.5	12.8	16.7	19.4	22.0	25.4	28.1
45 min	13.4	14.8	19.3	22.3	25.2	29.1	32.1
1 hour	14.9	16.4	21.3	24.6	27.7	31.9	35.1
1.5 hour	17.2	19.0	24.5	28.2	31.8	36.5	40.1
2 hour	19.1	21.1	27.1	31.2	35.1	40.4	44.4
3 hour	22.3	24.6	31.5	36.3	41.0	47.1	51.9
4.5 hour	26.2	28.8	37.1	42.8	48.5	56.0	61.8
6 hour	29.5	32.4	42.0	48.5	55.1	63.9	70.7
9 hour	34.8	38.4	50.1	58.3	66.4	77.5	86.1
12 hour	39.1	43.3	56.9	66.5	76.1	89.1	99.3
18 hour	45.8	51.0	67.8	79.7	91.7	108	121
24 hour	50.8	56.8	76.2	89.9	104	123	137
30 hour	54.8	61.4	82.9	98.2	114	134	150
36 hour	58.1	65.2	88.4	105	122	144	161
48 hour	63.1	71.0	96.9	115	134	158	177
72 hour	69.7	78.7	108	128	149	176	196
96 hour	74.2	83.8	115	136	158	186	208
120 hour	77.6	87.6	120	142	164	193	215
144 hour	80.5	90.8	123	146	169	199	221
168 hour	83.3	93.7	127	150	173	203	227

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD.
Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD.
Rather it corresponds to the 4.48 ARI.

This page was created at **10:23 on Tuesday 16 January 2024 (AEDT)**

Appendix D

PMF Calculations

Four sheets are provided here.

1. Worksheet Calculating Intensities from Australian Rainfall & Runoff 1977 Polynomials

Enter the 49 required factors in the table below. Results appear in the green cells.

ARI (years)	Factors A	B	C	D	E	F	G
1	2.830027	-0.60219	-0.0319	0.00991	-0.000232	-0.0005299	0.0000536
2	3.086687	-0.60784	-0.0311	0.009557	-0.000229	-0.0004687	0.0000447
5	3.33667	-0.62283	-0.0295	0.00887	-0.000107	-0.0003311	0.0000166
10	3.463772	-0.63056	-0.0287	0.00832	-0.000038	-0.0002439	-0.0000010
20	3.612309	-0.63808	-0.0277	0.008317	0.000086	0.0002150	-0.0000021
50	3.783772	-0.64612	-0.0269	0.008017	-0.000009	0.0001529	-0.0000156
100	3.90044	-0.65194	-0.0261	0.00809	-0.000065	0.0001446	-0.0000148

This method calculates design rainfall intensities for several average recurrence intervals (ARIs using seven polynomial equations.

These factors can be copied directly from the site:
http://www.bom.gov.au/cgi-bin/hydro/has/CDIRSWebBasic
which is provided by the Hydrometeorological Advisory Service (HAS) of the Australian Bureau of Meteorology. If you select the "non flash" version, and enter the latitude and longitude of a site, you can copy the 49 factors out directly from the webpage, and paste these into the yellow cells to the left. The intensities will automatically be adjusted to provide relevant intensities.

Duration (minutes)	Average Recurrence Interval (years) 1	2	5	10	20	50	100
5	56.3	74.0	99.2	115.3	131.8	161.0	184.1
6	52.6	69.1	92.5	107.4	124.1	151.2	172.6
7	49.5	65.0	86.9	100.9	117.3	142.5	162.5
8	47.0	61.7	82.2	95.3	111.2	134.9	153.7
9	44.8	58.7	78.2	90.5	105.9	128.2	145.9
10	42.9	56.2	74.6	86.3	101.1	122.2	139.0
12	39.7	51.9	68.6	79.2	92.9	112.0	127.2
15	35.8	46.8	61.6	70.9	83.2	100.0	113.5
20	31.2	40.6	53.2	61.0	71.4	85.6	96.9
25	27.8	36.2	47.2	54.0	63.1	75.4	85.3
30	25.3	32.8	42.6	48.6	56.7	67.8	76.5
35	23.2	30.1	39.0	44.4	51.8	61.7	69.6
40	21.5	27.9	36.0	41.0	47.7	56.9	64.1
45	20.1	26.0	33.6	38.2	44.4	52.8	59.5
50	18.9	24.4	31.5	35.8	41.6	49.4	55.6
55	17.9	23.1	29.7	33.7	39.2	46.5	52.3
60	16.9	21.9	28.1	31.9	37.1	44.0	49.4
1.5	13.2	17.0	21.8	24.6	28.5	33.7	37.8
2	11.0	14.2	18.1	20.4	23.6	27.8	31.1
3	8.5	10.9	13.8	15.6	18.0	21.2	23.7
4	7.1	9.1	11.5	12.9	14.9	17.4	19.5
6	5.4	7.0	8.8	9.8	11.4	13.3	14.8
9	4.2	5.4	6.7	7.5	8.8	10.2	11.4
12	3.5	4.4	5.5	6.2	7.4	8.5	9.5
18	2.6	3.4	4.2	4.7	6.0	6.7	7.5
24	2.2	2.8	3.5	3.9	5.2	5.7	6.4
36	1.6	2.1	2.6	2.9	4.4	4.7	5.2
48	1.3	1.7	2.1	2.3	4.1	4.1	4.6
60	1.1	1.4	1.8	2.0	3.9	3.8	4.2
72	0.9	1.2	1.5	1.7	3.9	3.6	3.9

Times from 5 minutes to 72 hours can be added by inserting extra rows and filling the cells in these.

2. Worksheet Calculating Probable Maximum Precipitation Patterns from Bureau of Meteorology (2003)

A developed version of the method given in previous Bulletins 51 and 53 is available for download from www.bom.gov.au/hydro/has/gsdm_document.shtml
This procedure only determines the rainfall patterns. It does not apply the spatial distribution procedure described in Section 6 of the document.

FOLLOW THE PROCEDURES BELOW, ENTERING VALUES IN THE YELLOW BOXES

1. Use one of the procedures below to determine probable maximum precipitation depths for various durations.

If area >= 1 km^2,

Catchment Area (km^2)	9	
Percent Rough (%)	0	Section 4.2
Elevation of Catchment (m)	905	Section 4.3
Moisture Adjustment Factor (%)	66	Figure 3

Duration (h)	Smooth Depth (mm)	Rough Depth (mm)	Averaged Depth (mm)	Adjusted Depth (mm)	Rounded Depth (mm)
0.25	212	0	212	140	140
0.5	315	0	315	208	210
0.75	400	0	400	264	260
1	465	0	465	307	310
1.5	527	0	527	348	350
2	595	0	595	393	390
2.5	637	0	637	420	420
3	665	0	665	439	440
4	730	0	730	482	480
5	790	0	790	521	520
6	840	0	840	554	550

Enter depths from Figure 4 for the particular catchment area.

If area < 1 km^2,

Catchment Area (km^2)	0.43	
Percent Rough (%)	0	Section 4.2
Elevation of Catchment (m)	905	Section 4.3
Moisture Adjustment Factor (%)	66	Figure 3

Duration (h)	Smooth Depth (mm)	Rough Depth (mm)	Averaged Depth (mm)	Adjusted Depth (mm)	Rounded Depth (mm)
0.25	247.85	247.85	248	164	160
0.5	355.7	355.7	356	235	230
0.75	451.4	451.4	451	298	300
1	544.2	544.2	544	359	360
1.5	614.2	703.45	614	405	410
2	682.91	832.7	683	451	450
2.5	729.9	930.66	730	482	480
3	772.16	1024.64	772	510	510
4	853.99	1170.45	854	564	560
5	915.28	1280.88	915	604	600
6	957	1360.56	957	632	630

Note: Depths are calculated from those in Bulletin 53 corresponding to zero area and to 1 km^2.

Check - Depths taken from Figure 4

Point Value (Smooth) (mm)	1 km^2 Value	Point Value (Rough) (mm)	1 km^2 Value (Rough) (mm)
250	245	250	245
360	350	360	350
460	440	460	440
570	510	570	510
640	580	740	655
710	647	880	770
760	690	990	852
810	722	1090	938
900	793	1250	1065
960	856	1360	1176
1000	900	1450	1242

2. Transfer the results from either of the above procedures to the coloured columns below.

Adjusted Depth (mm)
160
230
300
360
410
450
480
510
564
604
632

3. The intensities in the coloured columns given below can be transferred directly to the rainfall data base in *DRAINS*.
Using your mouse, select the numbers in the pairs of columns required and choose Copy from the View menu.
Go to the *DRAINS* rainfall data base using the **Project -> Rainfall Data…** option in *DRAINS*. Click the **Add a New Storm** button.
When the new window appears, click the **Paste** button. The numbers and accompanying graph will appear. Enter a suitable title.
Repeat the process as required.

15 Minute Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	845	44
5	730	38
10	346	18
15		

30 Minute Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	552	20
5	662	24
10	552	20
15	497	18
20	331	12
25	166	6
30		

45 Minute Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	432	12
5	612	17
10	540	15
15	504	14
20	468	13
25	396	11
30	324	9
35	216	6
40	108	3
45		

60 Minute Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	346	8
5	518	12
10	518	12
15	518	12
20	475	11
25	432	10
30	389	9
35	346	8
40	302	7
45	216	5
50	173	4
55	86	2
60		

1.5 Hour Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	246	5
5	344	7
10	394	8
15	443	9
20	394	8
25	344	7
30	344	7
35	344	7
40	295	6
45	295	6
50	295	6
55	295	6
60	246	5
65	197	4
70	148	3
75	148	3
80	98	2
85	49	1
90		

2 Hour Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	252	14
15	324	18
30	306	17
45	270	15
60	252	14
75	198	11
90	126	7
105	72	4
120		

2.5 Hour Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	192	10
15	288	15
30	269	14
45	250	13
60	230	12
75	211	11
90	192	10
105	134	7
120	96	5
135	58	3
150		

3 Hour Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	163	8
15	245	12
30	245	12
45	245	12
60	224	11
75	204	10
90	184	9
105	163	8
120	143	7
135	102	5
150	82	4
165	41	2
180		

4 Hour Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	135	6
15	180	8
30	226	10
45	203	9
60	203	9
75	180	8
90	180	8
105	158	7
120	158	7
135	135	6
150	135	6
165	113	5
180	90	4
195	68	3
210	45	2
225	45	2
240		

5 Hour Pattern

Time (minutes)	Intensities (mm/h)	Percentages (%)
0	97	4
15	145	6
30	193	8
45	169	7
60	169	7
75	169	7
90	169	7
105	169	7
120	145	6
135	145	6
150	121	5
165	121	5
180	121	5
195	121	5
210	97	4
225	72	3
240	72	3
255	48	2
270	48	2
285	24	1
300		

6 Hour Pattern

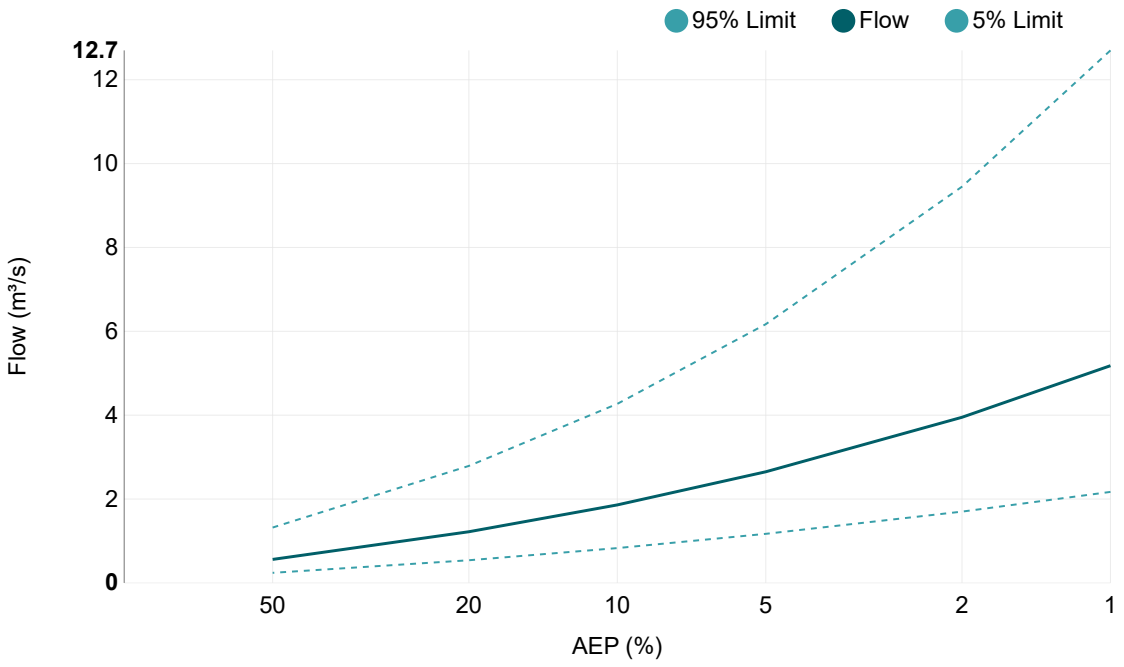
Time (minutes)	Intensities (mm/h)	Percentages (%)
0	101	4
15	101	4
30	152	6
45	152	6
60	152	6
75	152	6
90	152	6
105	152	6
120	152	6
135	126	5
150	126	5
165	126	5
180	126	5
195	126	5
210	101	4
225	101	4
240	76	3
255	76	3
270	76	3
285	51	2
300	51	2
315	51	2
330	25	1
345	25	1
360		

Note: The method can only be used for durations up to 3 hours over a large part of southern and central Australia, including South Australia, western NSW and western Victoria - see Figure 2 of the Bulletin.

Appendix F

RFFEM Outputs

Results | Regional Flood Frequency Estimation Model



*The catchment is outside the recommended catchment size of 0.5 to 1,000 km^2.
Results have lower accuracy and may not be directly applicable in practice.

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	0.560	0.240	1.32
20	1.22	0.540	2.79
10	1.86	0.830	4.27
5	2.65	1.17	6.17
2	3.95	1.70	9.45
1	5.18	2.17	12.7

Input Data

Date/Time	2024-02-13 12:51
Catchment Name	Catchment1
Latitude (Outlet)	-34.444
Longitude (Outlet)	149.476
Latitude (Centroid)	-34.447
Longitude (Centroid)	149.474
Catchment Area (km^2)	0.43*
Distance to Nearest Gauged Catchment (km)	19.37
50% AEP 6 Hour Rainfall Intensity (mm/h)	5.420007
2% AEP 6 Hour Rainfall Intensity (mm/h)	10.693985
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.58
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.274

Statistics

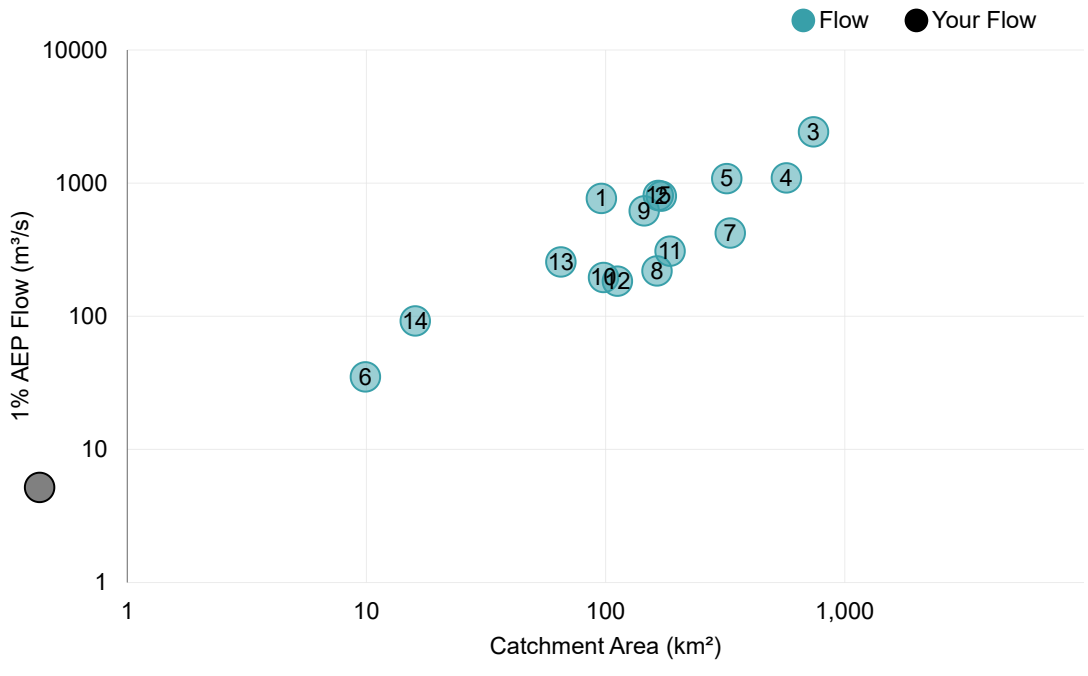
Variable	Value	Standard Dev
Mean	-0.313	0.428
Standard Dev	0.881	0.138
Skew	0.092	0.026

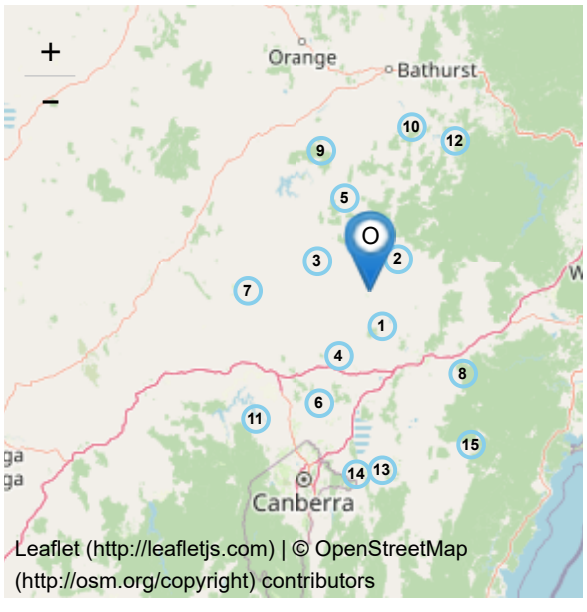
Note: These statistics come from the nearest gauged catchment. Details.

Correlation		
1.000		
-0.330	1.000	
0.170	-0.280	1.000

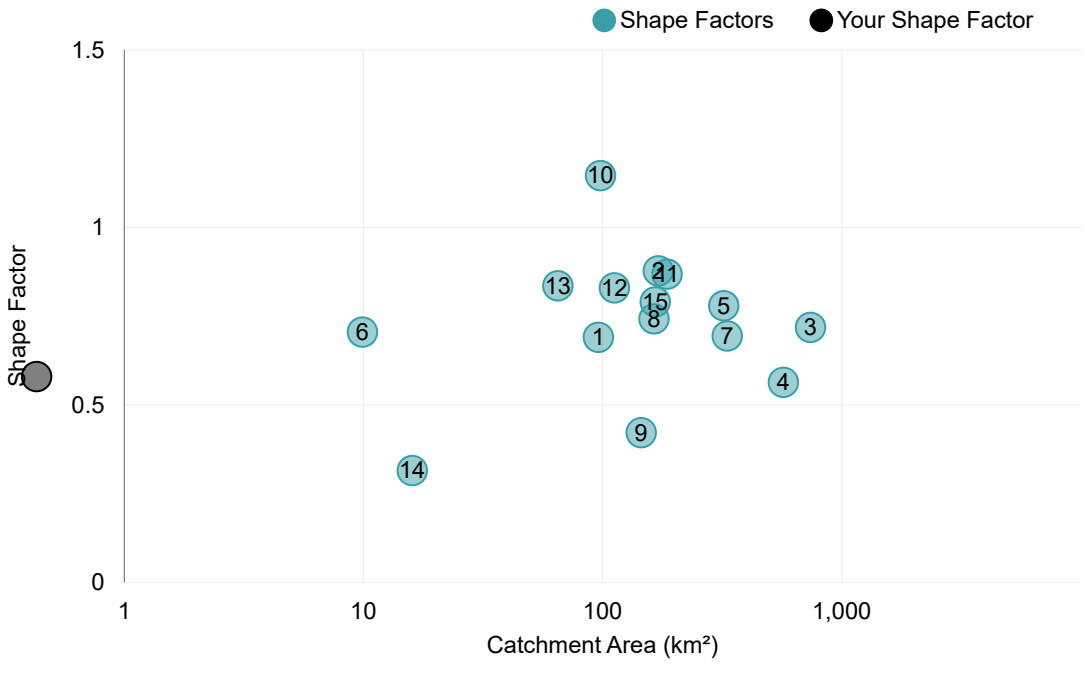
Note: These statistics are common to each region. Details.

1% AEP Flow vs Catchment Area

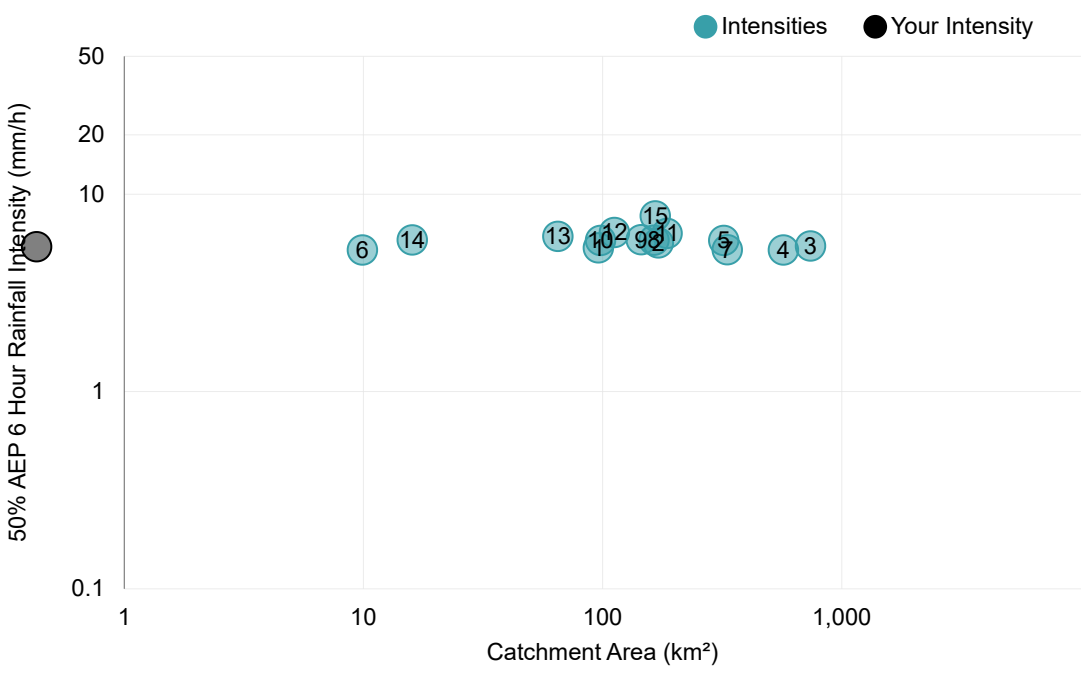




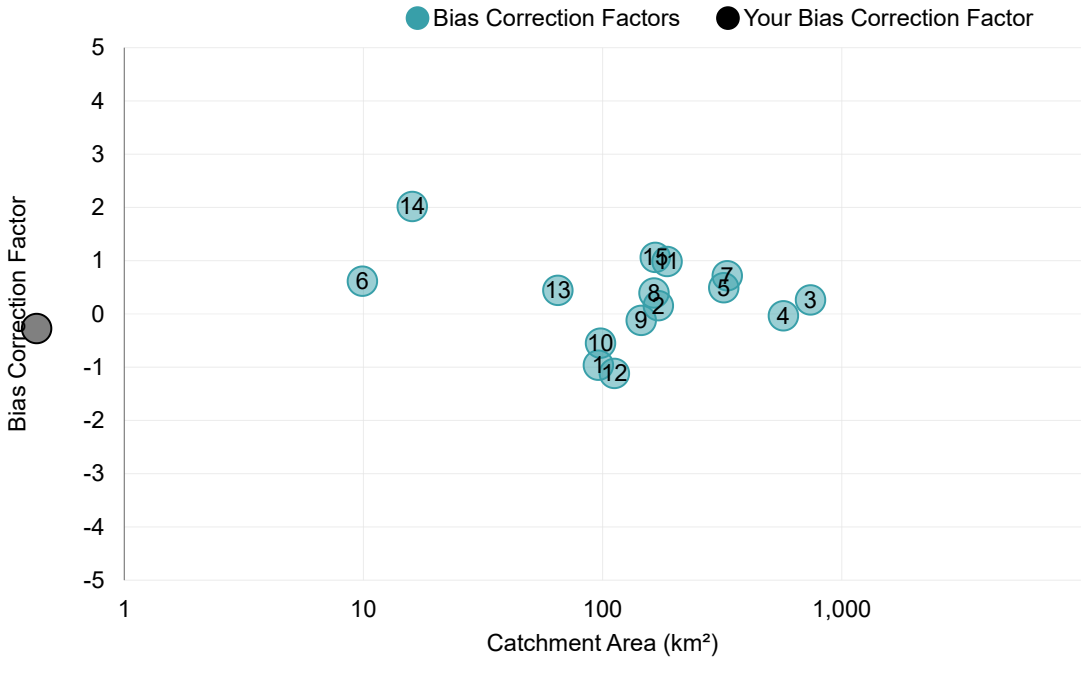
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



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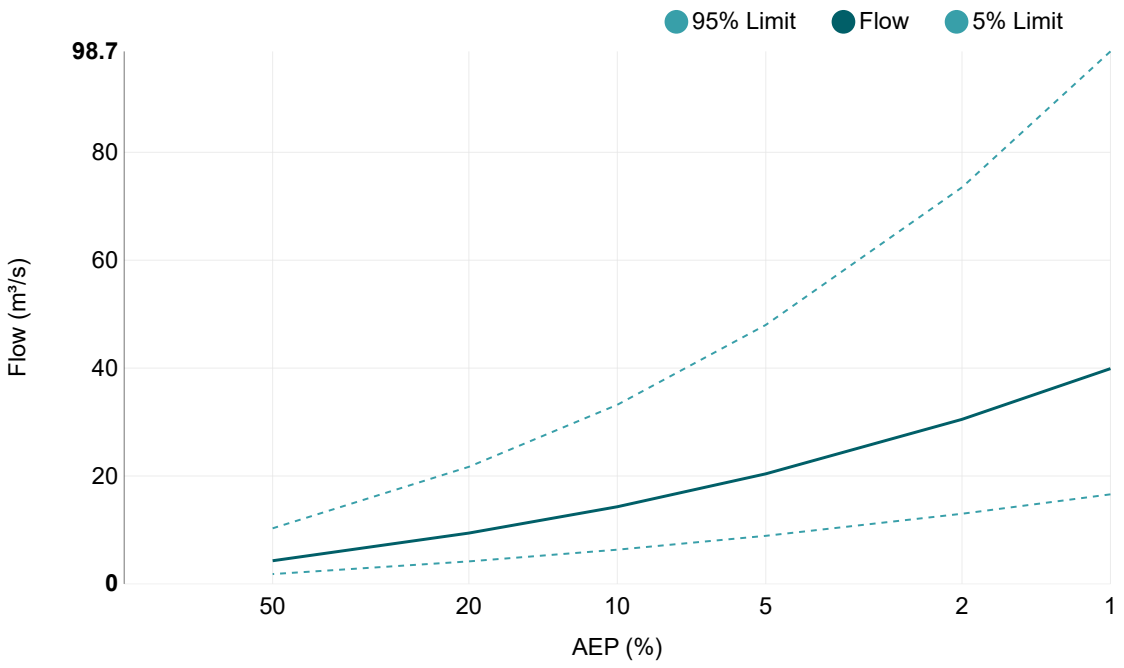
TXT Nearby JSON

Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (http://arr.ga.gov.au/revision-projects/project-list/projects/project-5) on the ARR website. Send any questions regarding the method or project here (mailto:admin@arr-software.org).

(http://www.engineersaustralia.org.au)

(http://www.uws.edu.au)

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	4.29	1.82	10.3
20	9.42	4.17	21.7
10	14.3	6.34	33.2
5	20.4	8.91	48.0
2	30.5	13.0	73.5
1	39.9	16.6	98.7

Input Data

Date/Time	2024-02-06 08:19
Catchment Name	Crookwell
Latitude (Outlet)	-34.445
Longitude (Outlet)	149.455
Latitude (Centroid)	-34.462
Longitude (Centroid)	149.466
Catchment Area (km^2)	9.0
Distance to Nearest Gauged Catchment (km)	19.93
50% AEP 6 Hour Rainfall Intensity (mm/h)	5.407097
2% AEP 6 Hour Rainfall Intensity (mm/h)	10.636885
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.71
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.249

Statistics

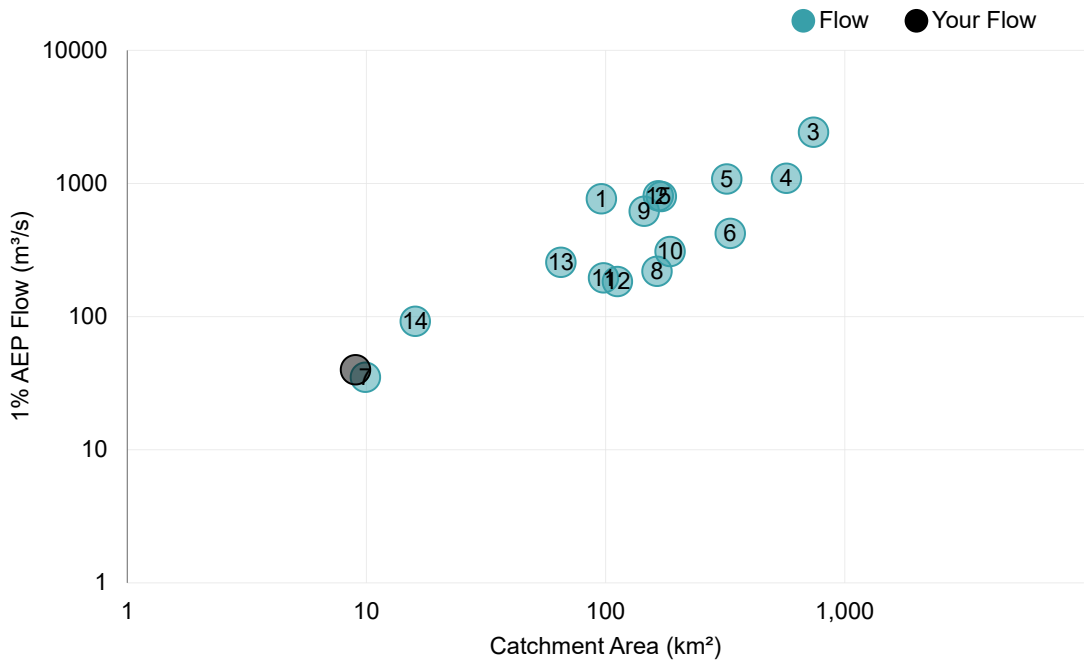
Variable	Value	Standard Dev
Mean	1.731	0.428
Standard Dev	0.881	0.138
Skew	0.092	0.026

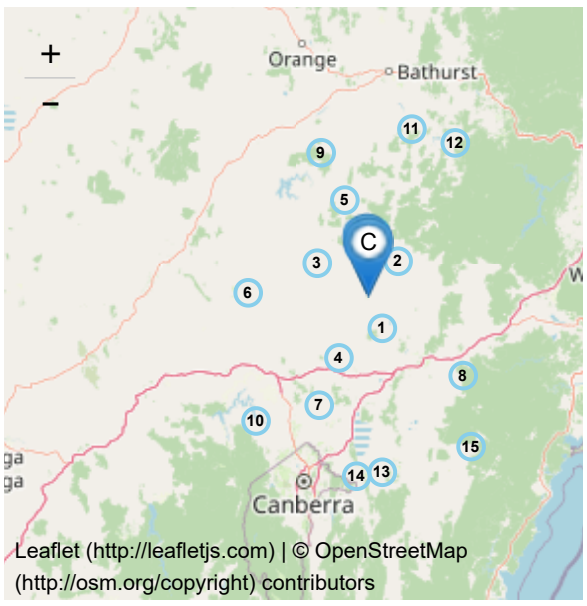
Note: These statistics come from the nearest gauged catchment. Details.

Correlation		
1.000		
-0.330	1.000	
0.170	-0.280	1.000

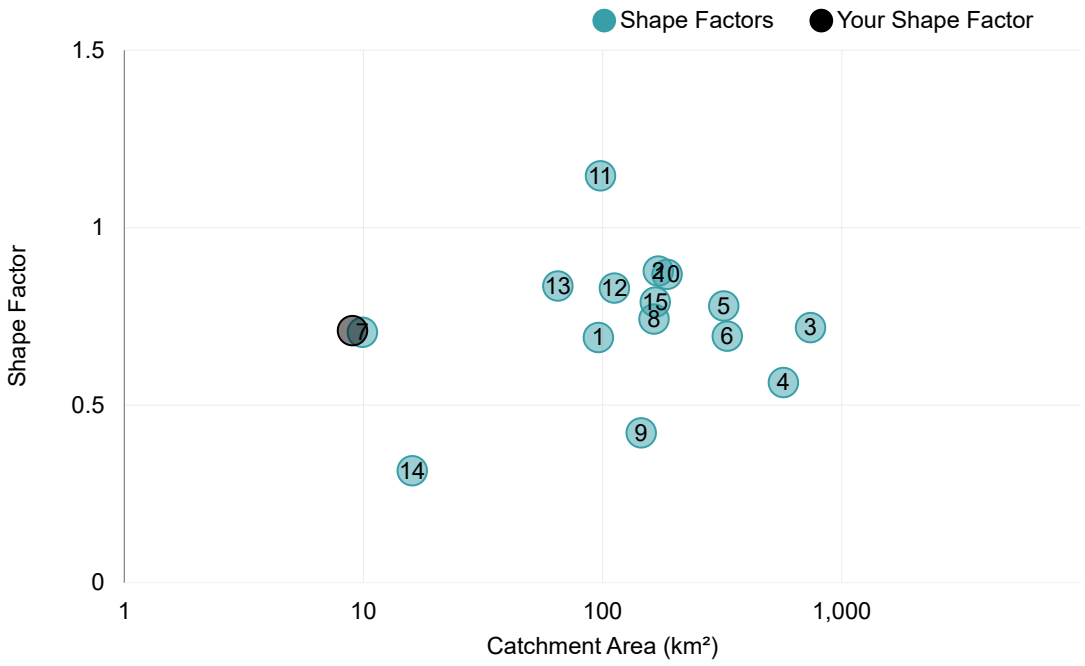
Note: These statistics are common to each region. Details.

1% AEP Flow vs Catchment Area

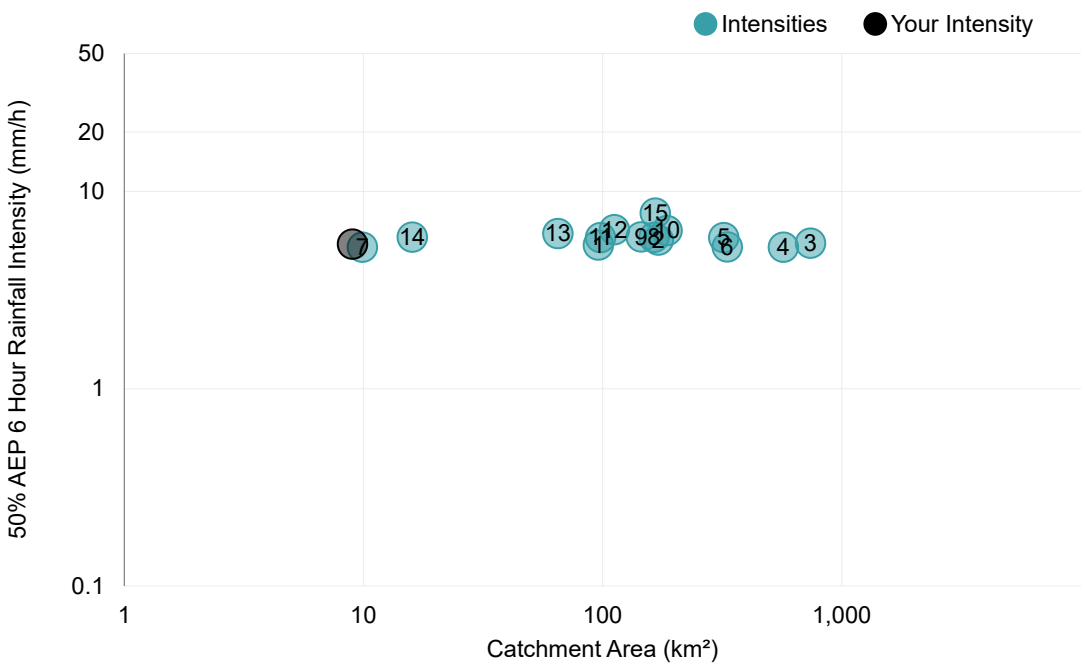




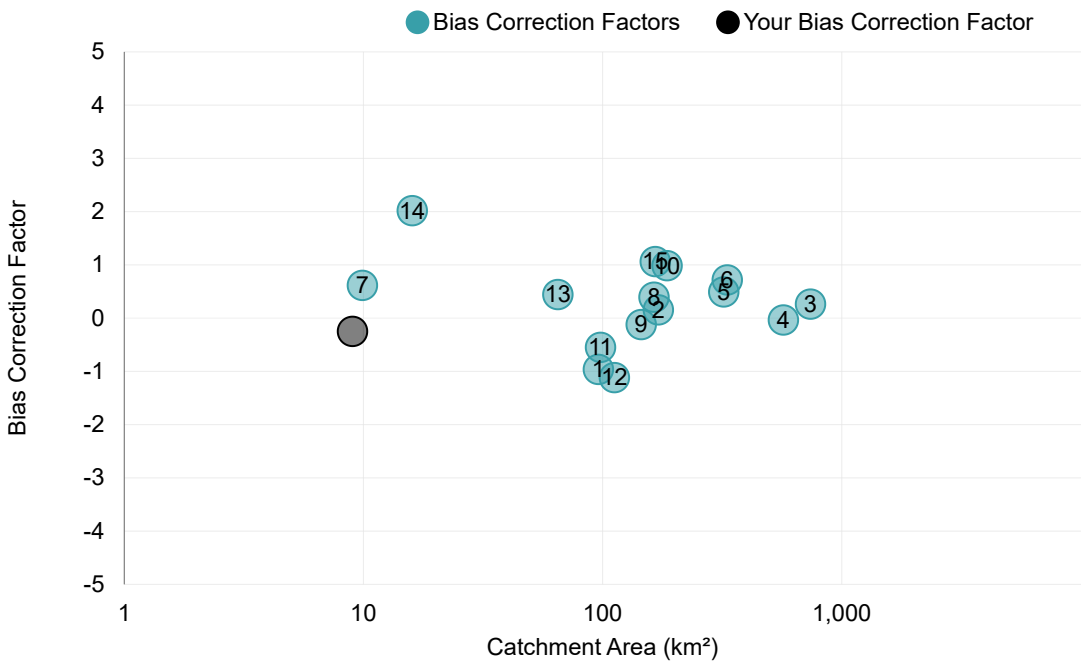
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



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(http://www.uws.edu.au)