Residential Subdivision
Tidapa, Chittick Lane, Cobbitty
Services and Infrastructure Delivery Strategy Report

CLIENT/ The Planning Hub

DATE/ JULY 2020

CODE/ 20-717-R001-01 CHITTICK LANE INFRASTRUCTURE STRATEGY REPORT

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1. Introduction

This Services and Infrastructure Delivery Strategy Report has been prepared to support the Planning Proposal for the rezoning of the 147-hectare site (Tidapa), at 220, 300, 350 and 360 Chittick Lane in Cobbitty. Please refer to Figure 1 for the location of the property.

AT&L were engaged by The Planning Hub in January 2020, to undertake an integrated civil infrastructure, flooding and drainage report for the proposed re-development of the site.

As part of the planning process, several studies were undertaken in relation to the infrastructure and servicing requirements.

2. Background

The Planning Hub are preparing a planning proposal for the rezoning of the Tidapa property, to facilitate future urban development. The site is approximately 147 Hectares of greenfield rural zoned land.

A pre-lodgement meeting for the Planning Proposal was held between Camden Council and The Planning Hub, on the 19th September 2019, in regards to the proponent's request to discuss the planning proposal for the potential rezoning of the rural land into large lot residential land. As part of these discussions, it was determined that a services and infrastructure delivery strategy as well as a water cycle management plan was required to support the Planning Proposal. Please refer to Appendix H for the pre-DA meeting minutes.

Please refer to Figure 1 for site location.

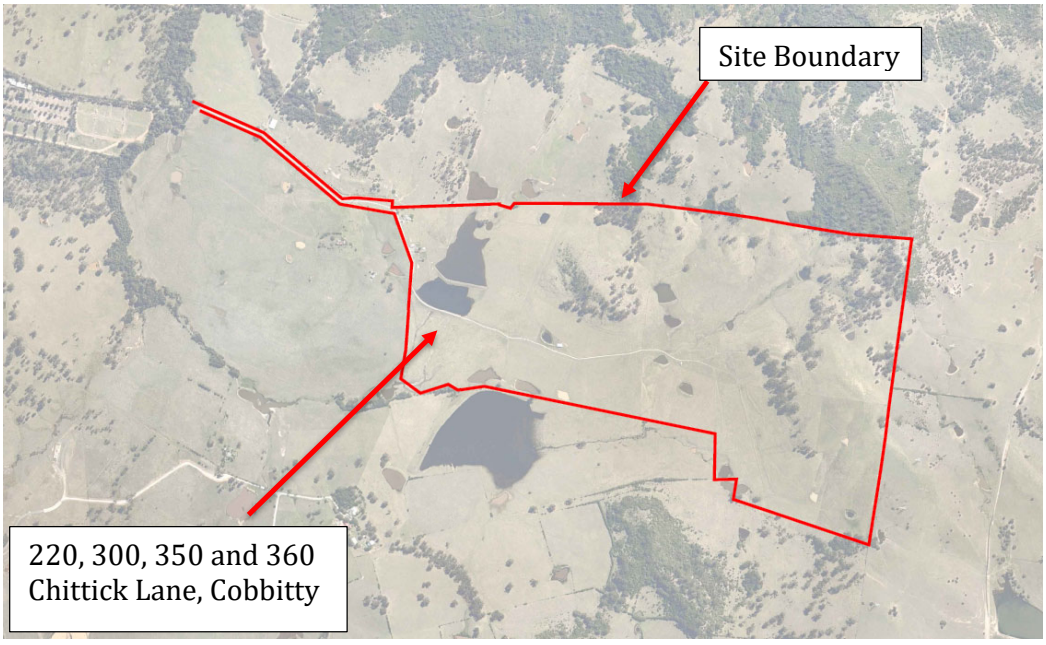


Figure 1: Tipada Location Plan

3. Site Description

Tidapa is located at 220, 300, 350 and 360 Chittick Lane, off Cobbitty Road. The site is within the Local Government Area of Camden Council. Tidapa is currently rural-use land and has several dwellings on the property.

The site generally slopes from the North-West to South-East however there are several high points and low points within the site. With a high point with 300 Chittick Lane at 145m above sea level and a low point at a dam at 220 Chittick Lane at 82m above sea level. The overland flow path is currently directed towards the existing dams as demonstrated in the overland flow path drawings, which can be found in Appendix A.

4. Servicing

A review of all the existing civil infrastructure within and surrounding site was undertaken from a combination of site inspections, topographical survey, undertaken by TTS Total Surveying Solutions, and Dial Before You Dig Records (DBYD). The findings from this review are highlighted below. For further details, refer to the Dial Before You Dig Records in Appendix B.

Overall given the isolated nature of the site there are limited existing infrastructure utilities currently servicing the site.

Based off discussions with the current owners of the property there have been historic discussions with Authorities to construct a reservoir on an adjoining property to the east which would provide adequate water pressure for the entirety of the site except for the north-western portion. Discussions have also been entered into regarding constructing a new gravity sewer along the southern boundary providing a connection with Oran Park.

It is unknown at this stage the status of these proposals and any works would need to be confirmed with Sydney Water.

4.1. Sewerage and Water

Based off the DBYD records and discussions with a Water Services Coordinator (WSC) there are no suitable Sydney Water sewer or water assets within Tidapa or within a close proximity, to service the proposed 700 to 800 lots.

The current Sydney Water assets within the area of the site are as follows:

- There is 100mm diameter Cast Iron Concrete Lined (CICL) watermain pipe along the eastern side of Chittick Lane extending from Cobbitty Road to approximately 70m South-East of 70 Chittick Lane. Refer to the Figure below.
- There is a 100mm diameter CICL watermain pipe running along the northern side of Cobbitty Road from 293 to 445 Cobbitty Road.

- There is a 200mm diameter CICL watermain pipe running along the southern side of Cobbitty Road from 294 to 455 Cobbitty Road.
- The 200mm CICL diameter watermain pipe is upsized to a 250mm diameter Ductile Iron Concrete Lined pipe at 294 Cobbitty Road. Which is approximately is 2.54km away from the site.
- There is a 600 Ductile Iron Concrete Lined (DCIL) Concrete encased watermain pipe currently located on The Northern Road. This pipe is approximately 5.4km away from the site.

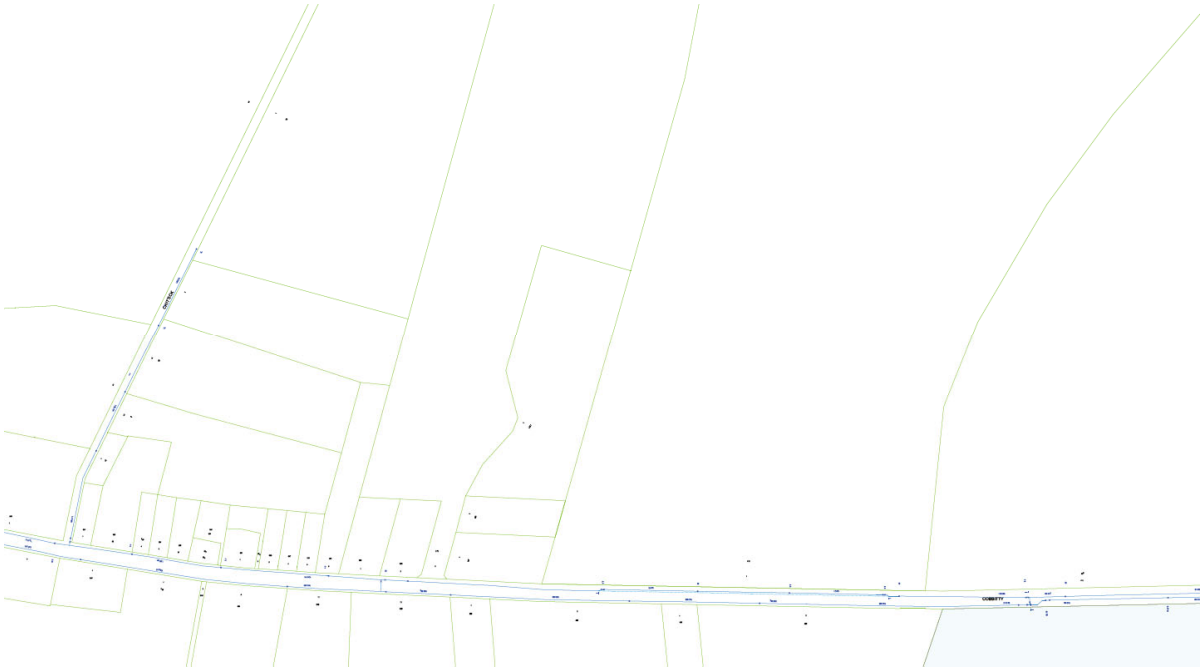


Figure 2: Sydney Water assets

It is expected that a temporary solution for both sewer and water will be required if Sydney Water have not sufficiently advanced their trunk infrastructure at the time of the works. Note, Sydney Water have not made any public plans to advance the trunk infrastructure in the immediate future therefore this infrastructure should be considered at least 8 to 10 years away.

Once the site is rezoned, Sydney Water will need to plan the upgrade and extension of the infrastructure to provide service to the area. In all likelihood, the upgrades and extensions will need to be carried out by developers and reimbursed by Sydney Water, under their procurement policy. A feasibility application should be lodged with Sydney Water as early as possible to identify any servicing strategies that may not yet be publicised, and to make Sydney Water aware of the high-level intention to develop the area.

In the interim a 200mm diameter main could be extended from the existing CICL main in into Chittick Lane to service a portion of the site. It is unlikely that this 200mm diameter main will be able to provide service to all of the proposed 700 to 800 lots. The portion of lots that can be serviced by the 200mm diameter main will be dependent on Sydney Water's ability to provide a

"level of service" (LOS) which includes pressure as a factor. Determining the portion of lots serviceable via this temporary measure, and hence its feasibility as an interim measure, will require liaison with Sydney Water.

If Sydney Water is unable to meet the LOS requirements for a commercially sufficient portion of the site, additional discussions will be required to identify a suitable alternative for servicing the site. From an engineering standpoint, a local reservoir could potentially augment the required pressures to meet that aspect of the LOS. From a development standpoint however, this solution would be expensive and time consuming and would likely only be considered feasible if Sydney Water agreed to partially or fully fund the reservoir. This would require significant liaison with Sydney Water.

To provide Sewerage service to the site, either a permanent Sewer Pumping Station (SPS) or an Interim Operating Procedure (IOP) will need to be implemented. An IOP would most likely take the form of a sewer pumping station, however being that it is temporary, the SPS could be designed for a lesser design life and therefore would be a less costly strategy.

Either solution would also require the installation of a pressure sewer line to a nearby receiving site. The nearest potential receiving site is the existing Sewer pumping station SP1161, approximately 1.2km South-East of the site. Liaison with Sydney Water would be required to determine the available capacity of SP1161 and how much of the site could be serviced via this arrangement and the suitability of any infrastructure locations. If SP1161 does not have sufficient capacity to service the site, two potential solutions would be to augment SP1161 with additional holding tanks and increased pumping capacity, or to provide a stand-alone pumping station to an alternative location to be determined on consultation with Sydney Water. Providing additional capacity to SP1161, while not a quick or cheap option, would be a more economical strategy to a stand-alone SPS and long pressure sewer.

Refer to Appendix B for all Sydney Water DBYD records

4.2. Electricity

Based off the DBYD, there is limited electricity servicing of the site. Currently there are overhead powerlines that are observed within Chittick Lane. These are approximately 600m South of Tidapa.

It is likely there will need to be an upgrade of the existing service. A new substation has been installed in Oran Park along The Northern Road which is approximately 5.5km South-East from Tidapa. Based off high level advice from an Electrical ASP Level 3 Designer, it is likely the proposed subdivision will need to be connected into this substation. As well as this upgrade, there will need to be about 9 to 12 internal substations to be installed to service the 700 to 800 lots. A further investigation will be required by Endeavour Energy who will need to undertake an internal feasibility study to determine the site requirements.

Based off the East Leppington Precinct Infrastructure delivery plan, Endeavour Energy has stated that if upgrades of the East Leppington area are required, they are willing to work with the

developers to determine the interim solutions prior to permanent upgrades. Further discussions with Endeavour Energy will need to be undertaken to determine whether they are willing to upgrade the services for this site. Refer to Appendix G for further details.

4.3. Telecommunications

Based off a desktop investigation there is a telecommunications tower located along Chittick Lane, South-West of Tidapa, as identified on the survey found in Appendix D. There are also Telstra conduits located at the entrance of the site and is currently servicing the existing buildings. Upgrades to the current connections will need to be undertaken to ensure all 700 to 800 lots are able to be serviced.

The Optus fibre network is located approximately 5.3km South-East of the site at the corner of The Northern Road and Cobbitty Road. While Nbn is currently located currently located along Chittick Lane which is likely able to service the site, however further upgrades maybe required.

4.4. Gas

Based off a desktop study, there are no Gas mains found within Chittick Lane. The closest gas main to Tidapa is 3.9km South-East of the site at the corner of Macquarie Grove Road and Cobbitty Road. This gas main is a 160mm diameter Polyethylene pipe with 210kPa. This gas main is unlikely able to service all 600-700 lots. If gas is required to service all 700 to 800 lots, an upgrade will likely be required.

The East Leppington Precinct Delivery plan dated the 19th June 2013, discussed that Jemena is looking into upgrades. Jemena may be willing to extend an existing off-site high-pressure secondary network to any development within the East Leppington Precinct, subject to commercial viability. AT&L suggests that going forward that Jemena work on the possibility of connecting into this secondary network. This will require further discussions with Jemena Gas about the timings and availability of upgrades within the Cobbitty Region. Refer to Appendix G for further details.

5. Proposed Civil Masterplan

The constraints identified, as part of this report, is to support the concept masterplan by Sitios Urban Design. This scheme demonstrates a potential civil engineering solution that responds to Tidapa constraints.

The current masterplan is proposing approximately 700 to 800 lots, this masterplan can be found in Appendix C.

6. Water Cycle Management Assessment

6.1. Flooding Mitigation

The Camden Council in conjunction with Worley Parsons undertook a flood study in April 2015. This document, Nepean River Flood Study - 15th April 2015, was undertaken to provide a more robust and detailed definition of the flood behaviours in the areas surrounding the Nepean River.

No flood modelling was undertaken as part of this report. The analysis undertaken in this report has considered the information provided in the Nepean Flood Study.

The Cobbitty Peak Discharge of 1% AEP +10% is approximately 4.2m3/s and 1% AEP +20% is approximately 4.6m3/s +20%. Based on the Nepean Flood study map below, South of the site along Chittick Lane there is a 5% Annual Event Exceedance Probability (5% AEP) and the Probable Maximum Flood (PMF) is below at Chittick Lane. The red line on the picture below demonstrates the Probable Maximum Flood based on the Tributary Flood Studies in 1999, which shows the PMF within the South Eastern part of the site. For further details please refer to Appendix E. The size of the contributing external catchment is approximately 291 hectares, while the internal catchment that is expected to be treated is 147 Hectares.

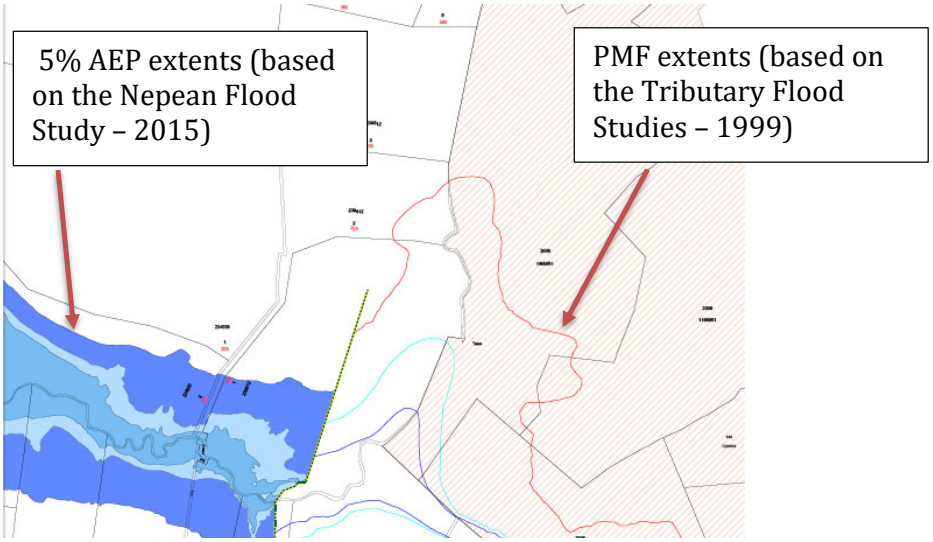


Figure 3:Nepean Flood Study Map 8A

6.2. Stormwater Drainage and Mitigation

One of the major constraints for the development of the site is the stormwater drainage and flooding.

As part of this investigation the council flooding map was interrogated to make an assessment on how best to treat the site. It was determined that the best way to treat the site was to construct two basins within the property at low points creating two catchments within the site. As the external catchment was quite large it was best to create a riparian corridor in which the stormwater, from the external areas, was diverted through the site. Refer to the figure below and Appendix F for more details.

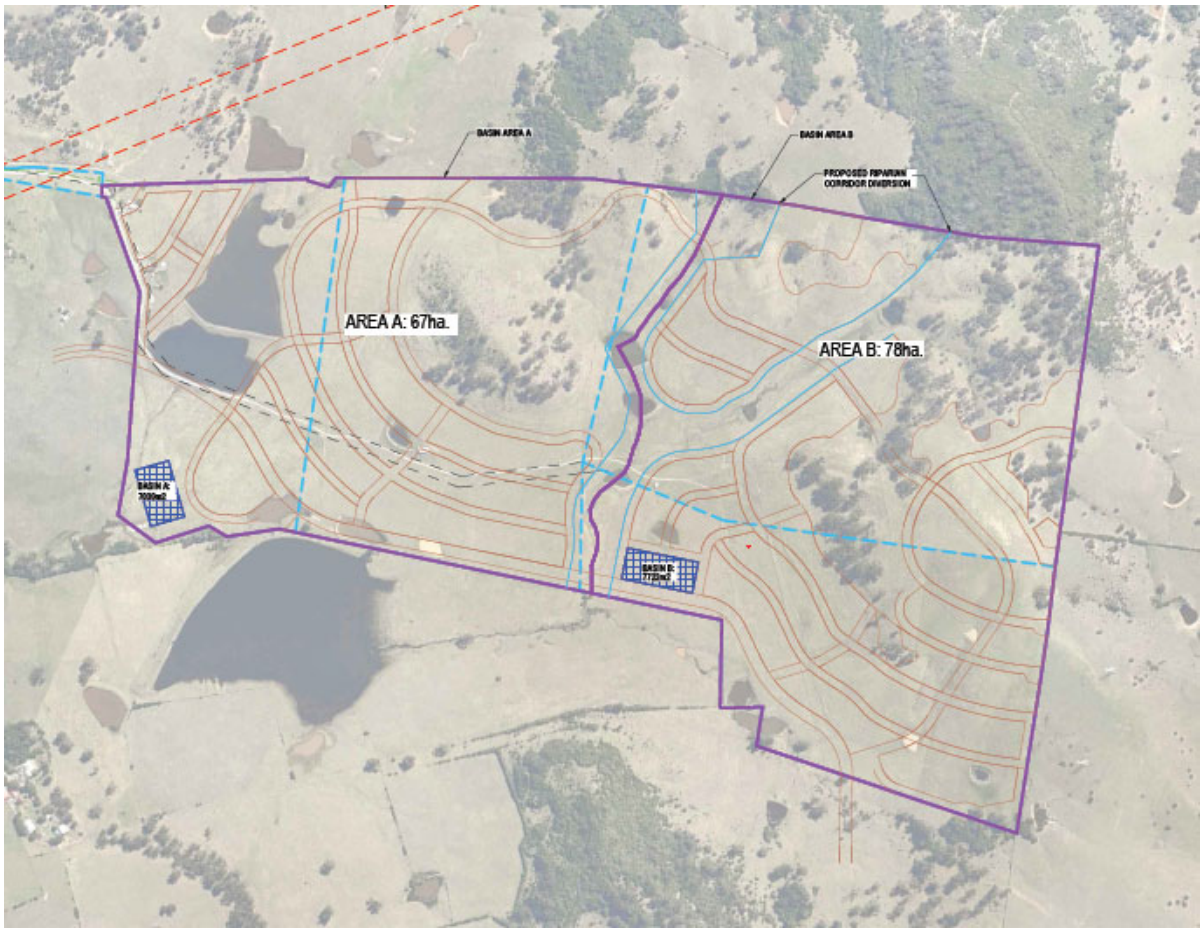


Figure 4: Basin Location

The size of catchment A is approximately 67Ha and the footprint of the proposed basin is 7030m2, with an approximate volume 450m3 per hectare, which is approximately 1% of Area A. The size of catchment B is approximately 78Ha and the footprint of the proposed basin is 7722m2, with an approximate volume of 450m3 per hectare. These basins will be located at the low points of the site, which is the South-East corner of each catchment.

Basins will have controlled outlet pits/headwalls to ensure post developed stormwater flows do not exceed predeveloped flows for all storm events up to and including the 1% AEP. This is in line with the Camden Council Stormwater guidelines.

7. Construction Staging

The development of Tidapa is likely to occur in stages. The staging boundaries will need to consider the servicing requirements and the potential flooding and stormwater impacts during the works.

These staging boundaries will likely result in the construction staging from North-West to South-East. This staging will likely allow for stormwater diversions to occur during the initial stages to mitigate the flood impacts of Tidapa.

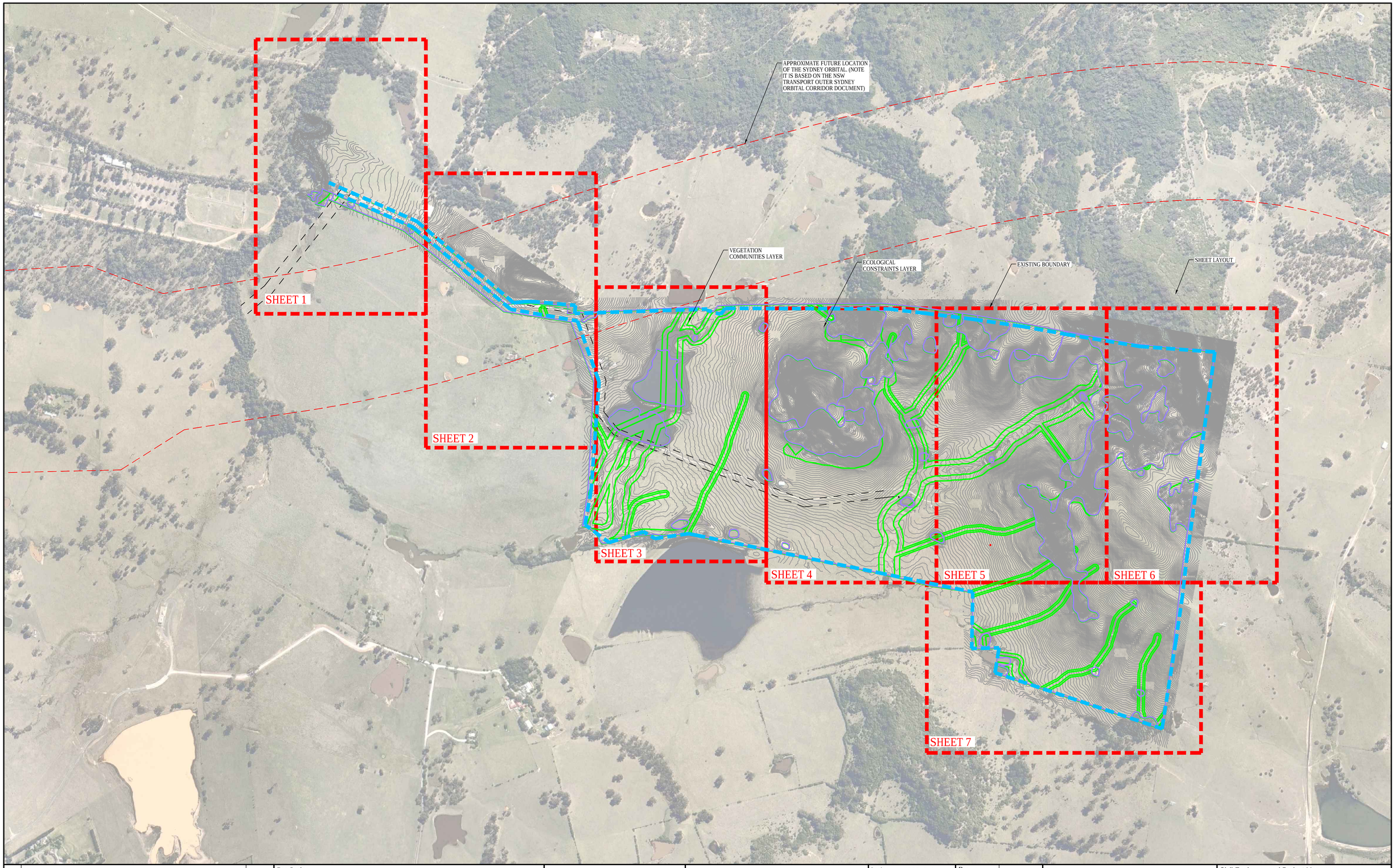
8. Conclusion

This infrastructure report was written to support the Planning Proposal for the rezoning of the 147Ha site at 220, 300, 350 and 360 Chittick Lane, in the Cobbitty Suburb.

As part of the planning, several studies were undertaken to understand the existing infrastructure and the servicing requirements. Tidapa currently has access to some existing services however these services will require upgrades. These discussions will need to be undertaken with the various authorities prior to the Development Application process.

The stormwater catchment of the site is 147Ha while the external catchment contributing to the site is approximately 291Ha. It was determined that the best option was to install two basins and divide the site into two while the external catchment is to be diverted through the site with a riparian corridor.

Appendix A – Overland Flowpath Sketches



Issue	Description	Date
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EXISTING EASEMENT

EXISTING BOUNDARY

APPROXIMATE LOCATION OF EXISTING TELSTRA TOWER

APPROXIMATE FUTURE LOCATION OF THE SYDNEY ORBITAL. (NOTE IT IS BASED ON THE NSW TRANSPORT OUTER SYDNEY ORBITAL CORRIDOR DOCUMENT)

APPROXIMATE LOCATION OF EXISTING DWELLINGS

APPROXIMATE LOCATION OF EXISTING DIRT TRACK

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EXISTING DAM

EXISTING BOUNDARY

EXISTING EASEMENT

APPROXIMATE LOCATION OF EXISTING DIRT TRACK

APPROXIMATE LOCATION OF EXISTING DWELLINGS

LEGEND

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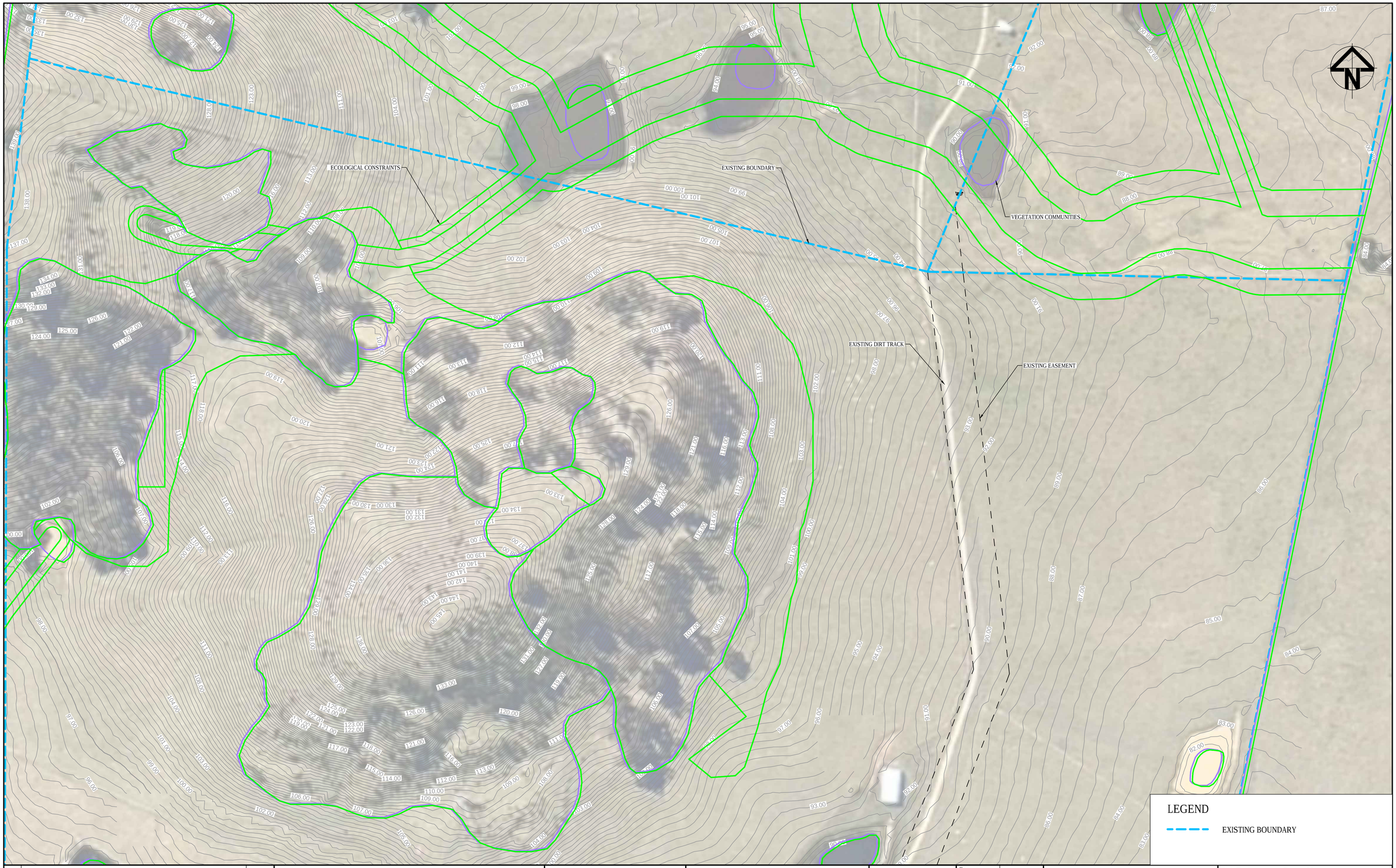
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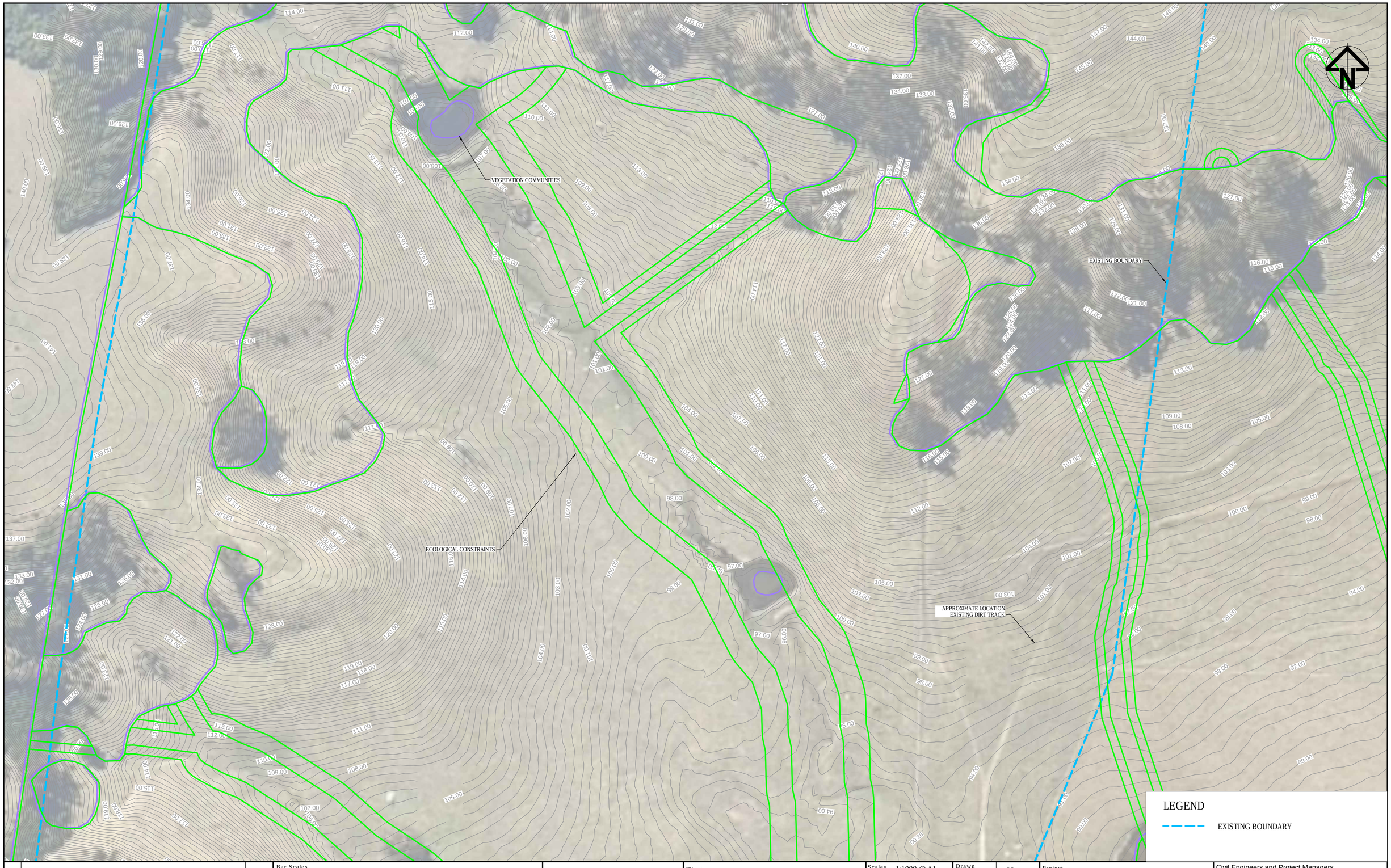
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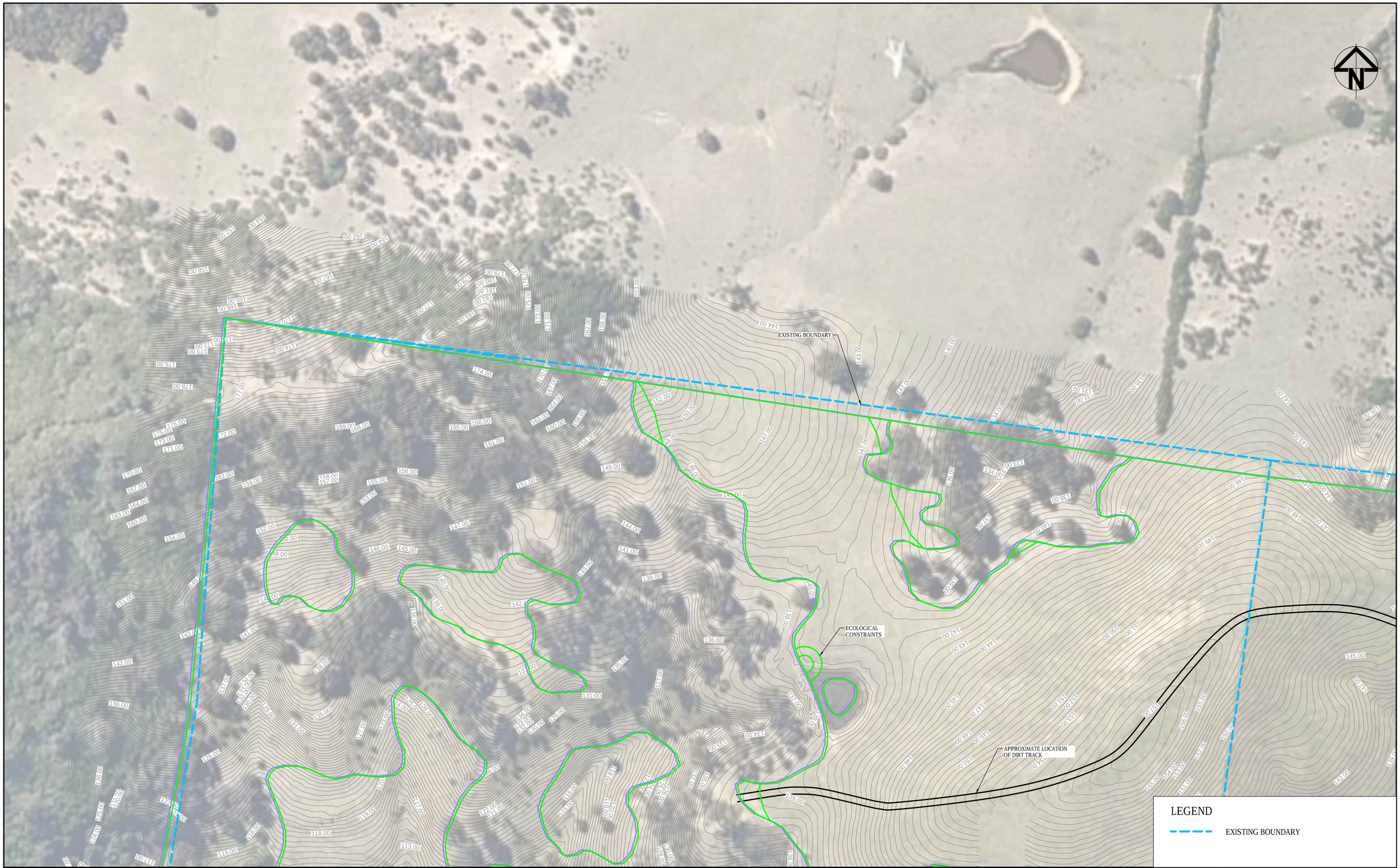
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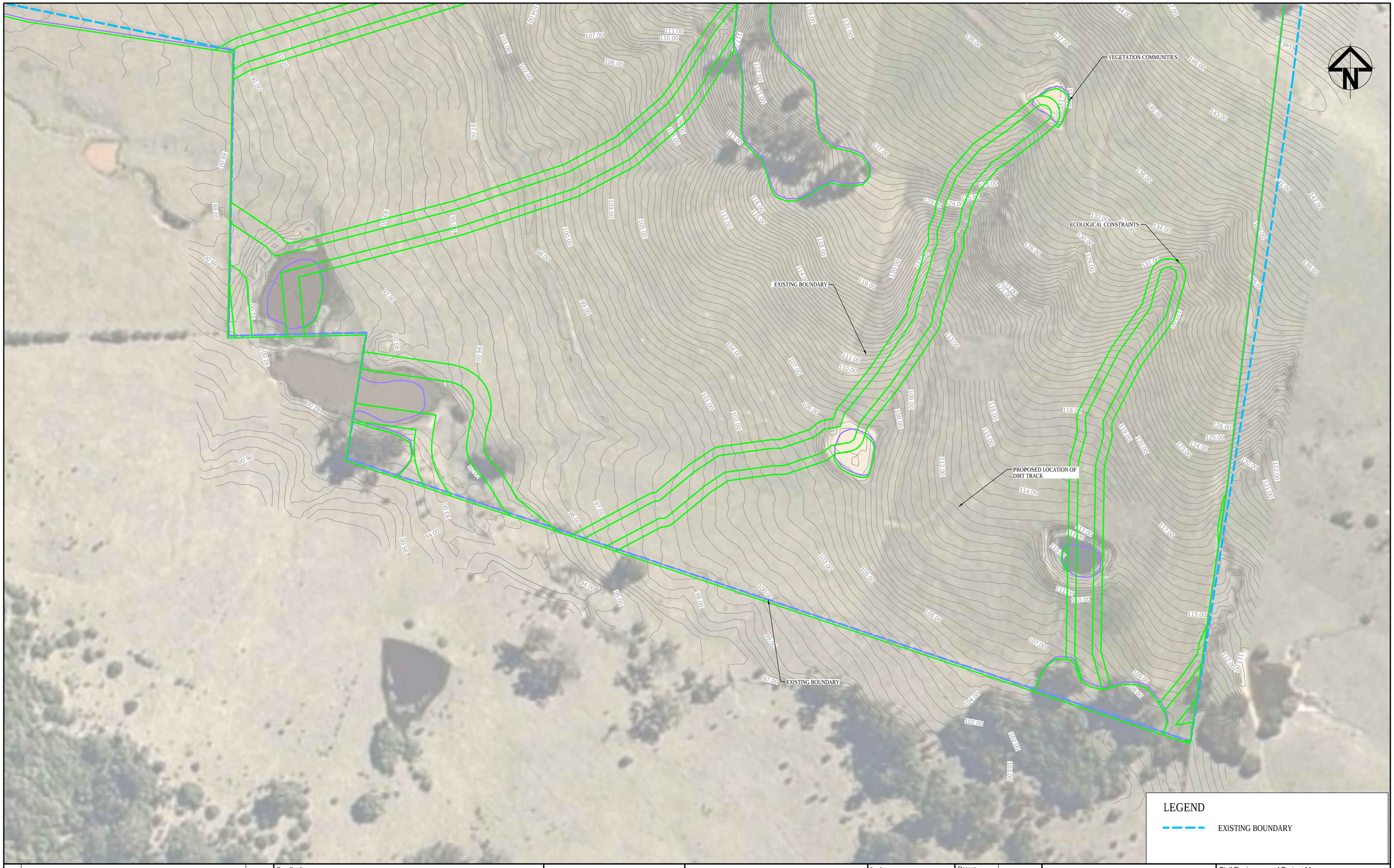
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Approved AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

EXISTING SURVEY
SHEET 7

Civil Engineers and Project Managers

at&l

Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC008

Issue
P1

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC008.dwg

APPROXIMATE FUTURE LOCATION OF THE SYDNEY ORBITAL. (NOTE IT IS BASED ON THE NSW TRANSPORT OUTER SYDNEY ORBITAL CORRIDOR DOCUMENT)

VEGETATION COMMUNITIES LAYER

ECOLOGICAL CONSTRAINTS LAYER

EXISTING BOUNDARY

SHEET LAYOUT

SHEET 1

SHEET 2

SHEET 3

SHEET 4

SHEET 5

SHEET 6

SHEET 7

LEGEND

EXISTING BOUNDARY

OVERLAND FLOW ARROWS

Issue	Description	Date
P2	ISSUED FOR INFORMATION	24-07-20
P1	ISSUED FOR INFORMATION	18-02-20

100mm on Original

Bar Scales

0 1000 2000 3000 4000 5000m

1 : 50000

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client

Scales	1:5000 @ A1
Grid	MGA
Height Datum	AHD
Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERALL OVERLAND FLOW PLAN

Civil Engineers and Project Managers

at&l

Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status

PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.

20-717-SKC009

Issue

P2

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC009.dwg



LEGEND

EXISTING BOUNDARY

OVERLAND FLOW ARROWS

Issue	Description	Date
P1	ISSUED FOR INFORMATION	18-02-20

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client

Scales	1:1000 @ A1	Drawn	PC
		Designed	PC
Grid	MGA	Checked	AT
Height Datum	AHD	Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND FLOW PLAN
SHEET 1

Civil Engineers and Project Managers
at&l
Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status: PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

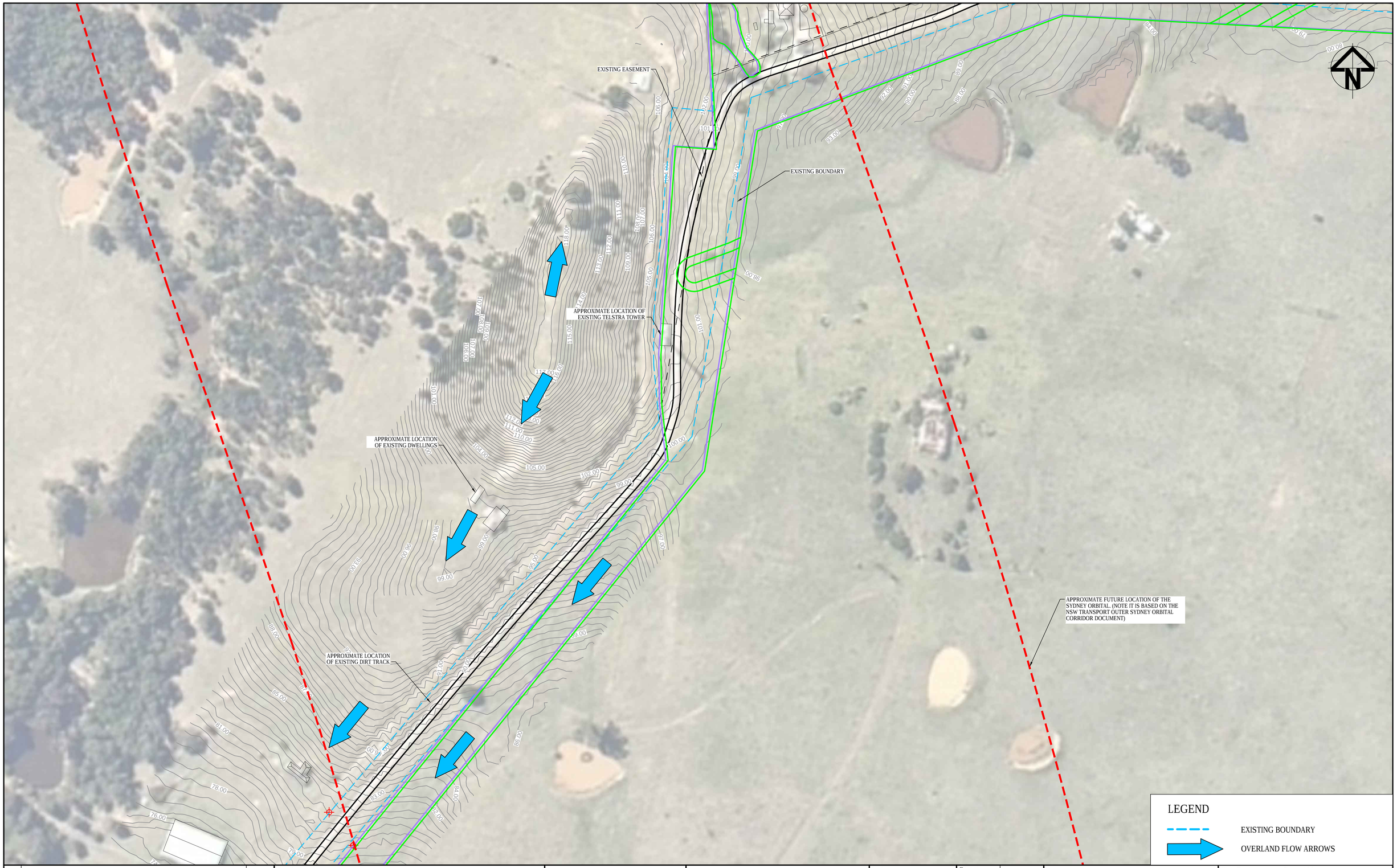
A1

Project - Drawing No.: 20-717-SKC010

Issue: P1

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC010.dwg



Issue	Description	Date
P2	ISSUED FOR INFORMATION	24-07-20
P1	ISSUED FOR INFORMATION	18-02-20

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

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Client

Scales	1:1000 @ A1	Drawn	PC
		Designed	PC
Grid	MGA	Checked	AT
Height Datum	AHD	Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND FLOW PLAN
SHEET 2

Civil Engineers and Project Managers
at&l
Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC011

Issue
P2

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC011.dwg

EXISTING DAM
EXISTING BOUNDARY
EXISTING EASEMENT
APPROXIMATE LOCATION OF EXISTING DIRT TRACK
APPROXIMATE LOCATION OF EXISTING DWELLINGS

LEGEND

EXISTING BOUNDARY

OVERLAND FLOW ARROWS

Issue	Description	Date
P1	ISSUED FOR INFORMATION	18-02-20

100mm on Original

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client

Scales 1:1000 @ A1

Grid MGA

Height Datum AHD

Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND FLOW
PLAN
SHEET 3

Civil Engineers and Project Managers

at&l

Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

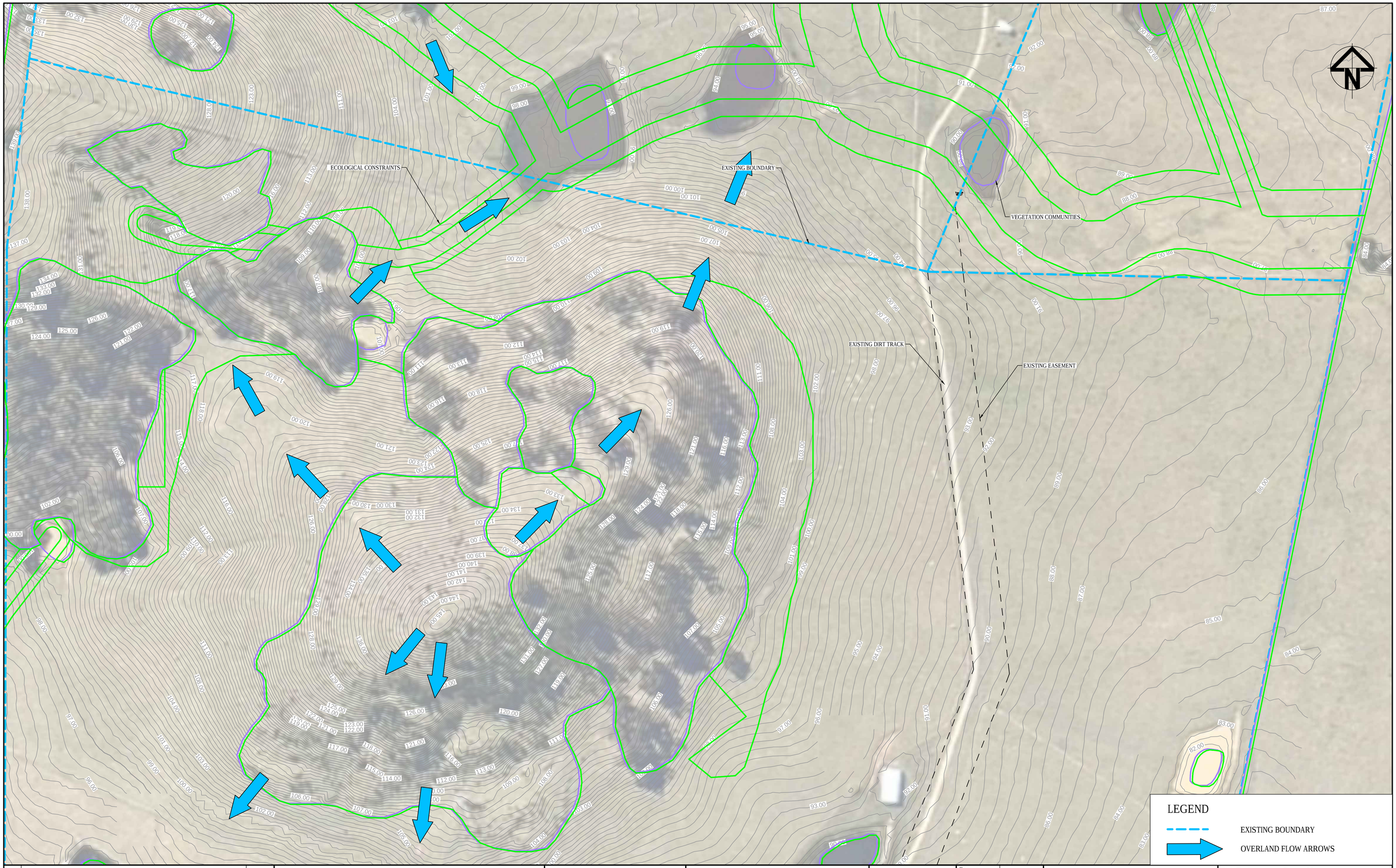
Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC012

Issue
P1

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC012.dwg



Issue	Description	Date
P1	ISSUED FOR INFORMATION	18-02-20

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client

Scales	1:1000 @ A1
Grid	MGA
Height Datum	AHD
Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND FLOW
PLAN
SHEET 4

Civil Engineers and Project Managers
at&l
Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC013

Issue
P1

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC013.dwg

VEGETATION COMMUNITIES

ECOLOGICAL CONSTRAINTS

EXISTING BOUNDARY

APPROXIMATE LOCATION
EXISTING DIRT TRACK

N

LEGEND

EXISTING BOUNDARY

OVERLAND FLOW ARROWS

Issue	Description	Date
P1	ISSUED FOR INFORMATION	18-02-20

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client

Scales	1:1000 @ A1	Drawn	PC
		Designed	PC
Grid	MGA	Checked	AT
Height Datum	AHD	Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND FLOW
PLAN
SHEET 5

Civil Engineers and Project Managers

at&l

Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC014

Issue
P1

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC014.dwg

EXISTING BOUNDARY

ECOLOGICAL CONSTRAINTS

APPROXIMATE LOCATION OF DIRT TRACK

LEGEND

EXISTING BOUNDARY

OVERLAND FLOW ARROWS

Issue	Description	Date
P1	ISSUED FOR INFORMATION	29-01-20

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

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Client

Scales	1:1000 @ A1	Drawn	PC
		Designed	PC
Grid	MGA	Checked	AT
Height Datum	AHD	Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND OVERFLOW
SHEET 6

Civil Engineers and Project Managers

at&l

Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status: PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

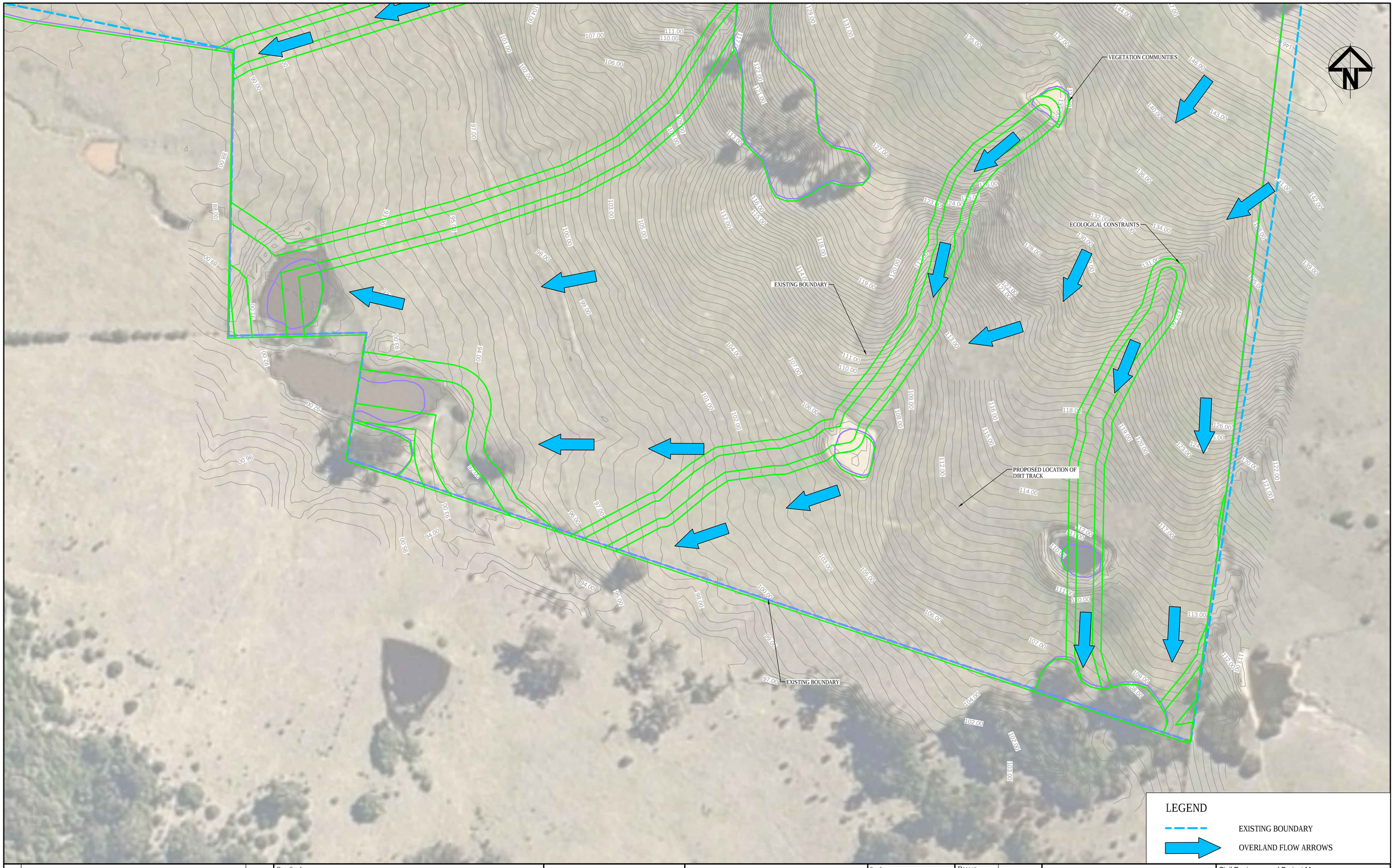
A1

Project - Drawing No.: 20-717-SKC015

Issue: P1

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC015.dwg



Issue	Description	Date
P1	ISSUED FOR INFORMATION	18-02-20

Bar Scales

0 20 40 60 80 100m

1 : 1000 @ A1 1 : 2000 @ A3

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Client

Scales	1:1000 @ A1
Grid	MGA
Height Datum	AHD
Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

OVERLAND OVERFLOW
SHEET 7

Civil Engineers and Project Managers
at&l
Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC016

Issue
P1

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC016.dwg



Issue	Description	Date
P1	ISSUED FOR INFORMATION	02-03-20

Bar Scales

0 1000 2000 3000 4000 5000m

1 : 50000

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Client

Scales	1:5000 @ A1
Grid	MGA
Height Datum	AHD
Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

PROPOSED BASINS AND LOCATIONS

Civil Engineers and Project Managers
at&l
Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC017

Issue
P1

100mm on Original

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC018.dwg



Issue	Description	Date
P2	ISSUED FOR INFORMATION	08-04-20
P1	ISSUED FOR INFORMATION	02-03-20

100mm on Original

Bar Scales

0 1000 2000 3000 4000 5000m

1 : 50000

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client

Scales	1:5000 @ A1
Grid	MGA
Height Datum	AHD
Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

PROPOSED BASINS AND LOCATIONS

Civil Engineers and Project Managers
at&l
Level 7, 153 Walker Street
North Sydney NSW 2060
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9923 1055
www.atl.net.au
info@atl.net.au

Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC018

Issue
P2

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC018.dwg

Appendix B – Dial Before You Dig Records

Job No 18875419

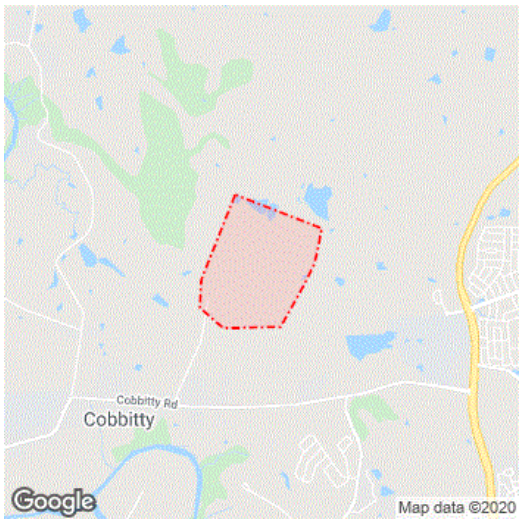
Phone: 1100
www.1100.com.au

Caller Details

Contact:	Miss Phoebe Connor	**Caller Id:**	1945172	**Phone:**	0477137224
Company:	AT&L	**Mobile:**	Not Supplied	**Fax:**	Not Supplied
Address:	7/153 Walker Street Sydney NSW 2060	**Email:**	phoebec@atl.net.au		

Dig Site and Enquiry Details

WARNING: The map below only displays the location of the proposed dig site and does not display any asset owners' pipe or cables. The area highlighted has been used only to identify the participating asset owners, who will send information to you directly.



User Reference: Not Supplied
Working on Behalf of: Other

Enquiry Date:	**Start Date:**	**End Date:**
17/01/2020	03/02/2020	06/02/2020

Address:
Lot 1 160 Chittick Ln
Cobbitty NSW 2570

Job Purpose:	**Onsite Activity:**
Excavation	Manual Excavation
Location of Workplace:	**Location in Road:**
Both	CarriageWay,Footpath,Nature Strip

- Check the location of the dig site is correct. If not submit a new enquiry.
- If the scope of works change, or plan validity dates expire, resubmit your enquiry.
- Do NOT dig without plans. Safe excavation is your responsibility. If you do not understand the plans or how to proceed safely, please contact the relevant asset owners.

Notes/Description of Works:

Your Responsibilities and Duty of Care

- The lodgement of an enquiry does not authorise the project to commence. You must obtain all necessary information from any and all likely impacted asset owners prior to excavation.
- If plans are not received within 2 working days, contact the asset owners directly & quote their Sequence No.
- ALWAYS perform an onsite inspection for the presence of assets. Should you require an onsite location, contact the asset owners directly. Please remember, plans do not detail the exact location of assets.
- Pothole to establish the exact location of all underground assets using a hand shovel, before using heavy machinery.
- Ensure you adhere to any State legislative requirements regarding Duty of Care and safe digging requirements.
- If you damage an underground asset you MUST advise the asset owner immediately.
- By using this service, you agree to Privacy Policy and the terms and disclaimers set out at **www.1100.com.au**
- **For more information on safe excavation practices, visit www.1100.com.au**

Asset Owner Details

The assets owners listed below have been requested to contact you with information about their asset locations within 2 working days.
Additional time should be allowed for information issued by post. It is **your responsibility** to identify the presence of any underground assets in and around your proposed dig site. Please be aware, that not all asset owners are registered with the Dial Before You Dig service, so it is **your responsibility** to identify and contact any asset owners not listed here directly.
** Asset owners highlighted by asterisks ** require that you visit their offices to collect plans.
Asset owners highlighted with a hash require that you call them to discuss your enquiry or to obtain plans.

Seq. No.	Authority Name	Phone	Status
93885482	Endeavour Energy	0298534161	NOTIFIED
93885484	Sydney Water	132092	NOTIFIED
93885483	Telstra NSW, Central	1800653935	NOTIFIED

END OF UTILITIES LIST

Job No 18875448

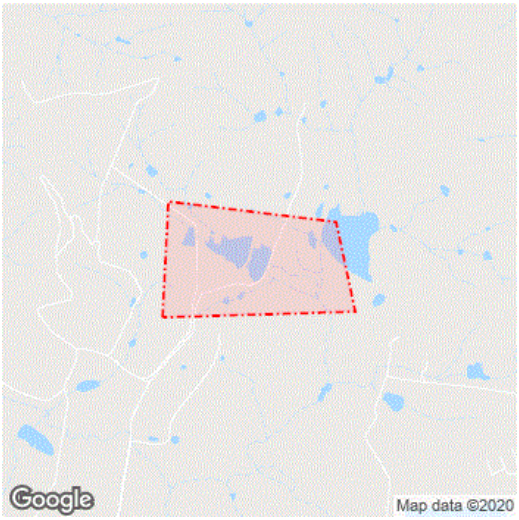
Phone: 1100
www.1100.com.au

Caller Details

Contact:	Miss Phoebe Connor	**Caller Id:**	1945172	**Phone:**	0477137224
Company:	AT&L	**Mobile:**	Not Supplied	**Fax:**	Not Supplied
Address:	7/153 Walker Street Sydney NSW 2060	**Email:**	phoebec@atl.net.au		

Dig Site and Enquiry Details

WARNING: The map below only displays the location of the proposed dig site and does not display any asset owners' pipe or cables. The area highlighted has been used only to identify the participating asset owners, who will send information to you directly.



User Reference: Not Supplied
Working on Behalf of: Other

Enquiry Date:	**Start Date:**	**End Date:**
17/01/2020	13/02/2020	14/02/2020

Address:
Lot 2 160 Chittick Ln
Cobbitty NSW 2570

Job Purpose:	**Onsite Activity:**
Excavation	Manual Excavation
Location of Workplace:	**Location in Road:**
Both	CarriageWay,Footpath,Nature Strip

- Check the location of the dig site is correct. If not submit a new enquiry.
- If the scope of works change, or plan validity dates expire, resubmit your enquiry.
- Do NOT dig without plans. Safe excavation is your responsibility. If you do not understand the plans or how to proceed safely, please contact the relevant asset owners.

Notes/Description of Works:

Your Responsibilities and Duty of Care

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- Ensure you adhere to any State legislative requirements regarding Duty of Care and safe digging requirements.
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- **For more information on safe excavation practices, visit www.1100.com.au**

Asset Owner Details

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** Asset owners highlighted by asterisks ** require that you visit their offices to collect plans.
Asset owners highlighted with a hash require that you call them to discuss your enquiry or to obtain plans.

Seq. No.	Authority Name	Phone	Status
93885634	Endeavour Energy	0298534161	NOTIFIED
93885638	Sydney Water	132092	NOTIFIED
93885636	Telstra NSW, Central	1800653935	NOTIFIED

END OF UTILITIES LIST

Job No 18875466

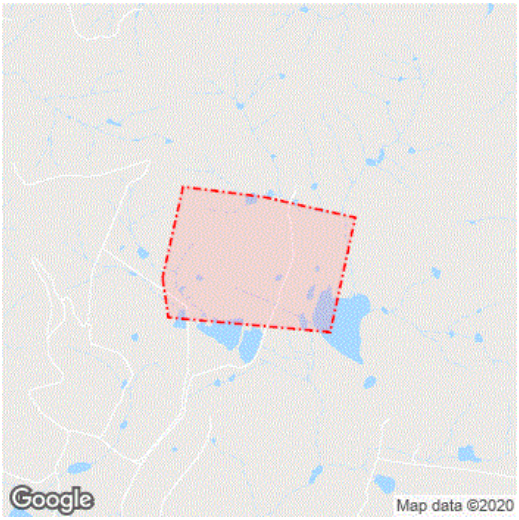
Phone: 1100
www.1100.com.au

Caller Details

Contact:	Miss Phoebe Connor	**Caller Id:**	1945172	**Phone:**	0477137224
Company:	AT&L	**Mobile:**	Not Supplied	**Fax:**	Not Supplied
Address:	7/153 Walker Street Sydney NSW 2060	**Email:**	phoebec@atl.net.au		

Dig Site and Enquiry Details

WARNING: The map below only displays the location of the proposed dig site and does not display any asset owners' pipe or cables. The area highlighted has been used only to identify the participating asset owners, who will send information to you directly.



User Reference: Not Supplied
Working on Behalf of: Other

Enquiry Date:	**Start Date:**	**End Date:**
17/01/2020	06/02/2020	07/02/2020

Address:
Lot 3 160 Chittick Ln
Cobbitty NSW 2570

Job Purpose:	**Onsite Activity:**
Excavation	Manual Excavation
Location of Workplace:	**Location in Road:**
Both	CarriageWay,Footpath,Nature Strip

- Check the location of the dig site is correct. If not submit a new enquiry.
- If the scope of works change, or plan validity dates expire, resubmit your enquiry.
- Do NOT dig without plans. Safe excavation is your responsibility. If you do not understand the plans or how to proceed safely, please contact the relevant asset owners.

Notes/Description of Works:

Your Responsibilities and Duty of Care

- The lodgement of an enquiry does not authorise the project to commence. You must obtain all necessary information from any and all likely impacted asset owners prior to excavation.
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- If you damage an underground asset you MUST advise the asset owner immediately.
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** Asset owners highlighted by asterisks ** require that you visit their offices to collect plans.
Asset owners highlighted with a hash require that you call them to discuss your enquiry or to obtain plans.

Seq. No.	Authority Name	Phone	Status
93885738	Endeavour Energy	0298534161	NOTIFIED
93885740	Sydney Water	132092	NOTIFIED
93885739	Telstra NSW, Central	1800653935	NOTIFIED

END OF UTILITIES LIST

Job No 18875517

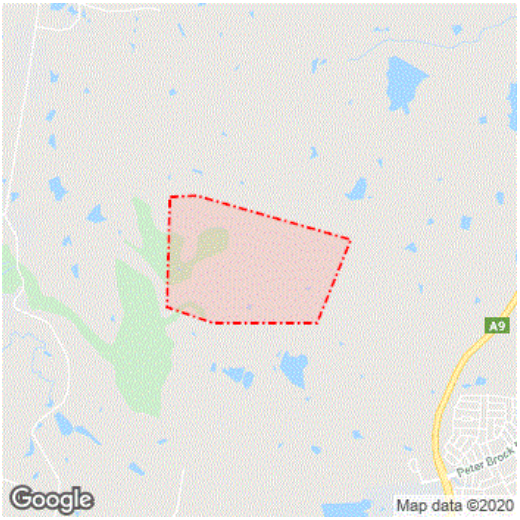
Phone: 1100
www.1100.com.au

Caller Details

Contact:	Miss Phoebe Connor	**Caller Id:**	1945172	**Phone:**	0477137224
Company:	AT&L	**Mobile:**	Not Supplied	**Fax:**	Not Supplied
Address:	7/153 Walker Street Sydney NSW 2060	**Email:**	phoebec@atl.net.au		

Dig Site and Enquiry Details

WARNING: The map below only displays the location of the proposed dig site and does not display any asset owners' pipe or cables. The area highlighted has been used only to identify the participating asset owners, who will send information to you directly.



User Reference: Not Supplied
Working on Behalf of: Other

Enquiry Date:	Start Date:	End Date:
17/01/2020	21/02/2020	22/02/2020

Address:
lot 4 and 5 160 Chittick Ln
Cobbitty NSW 2570

Job Purpose:	Onsite Activity:
Excavation	Manual Excavation
Location of Workplace:	**Location in Road:**
Both	CarriageWay,Footpath,Nature Strip

- Check the location of the dig site is correct. If not submit a new enquiry.
- If the scope of works change, or plan validity dates expire, resubmit your enquiry.
- Do NOT dig without plans. Safe excavation is your responsibility. If you do not understand the plans or how to proceed safely, please contact the relevant asset owners.

Notes/Description of Works:

Your Responsibilities and Duty of Care

- The lodgement of an enquiry does not authorise the project to commence. You must obtain all necessary information from any and all likely impacted asset owners prior to excavation.
- If plans are not received within 2 working days, contact the asset owners directly & quote their Sequence No.
- ALWAYS perform an onsite inspection for the presence of assets. Should you require an onsite location, contact the asset owners directly. Please remember, plans do not detail the exact location of assets.
- Pothole to establish the exact location of all underground assets using a hand shovel, before using heavy machinery.
- Ensure you adhere to any State legislative requirements regarding Duty of Care and safe digging requirements.
- If you damage an underground asset you MUST advise the asset owner immediately.
- By using this service, you agree to Privacy Policy and the terms and disclaimers set out at **www.1100.com.au**
- **For more information on safe excavation practices, visit www.1100.com.au**

Asset Owner Details

The assets owners listed below have been requested to contact you with information about their asset locations within 2 working days.
Additional time should be allowed for information issued by post. It is **your responsibility** to identify the presence of any underground assets in and around your proposed dig site. Please be aware, that not all asset owners are registered with the Dial Before You Dig service, so it is **your responsibility** to identify and contact any asset owners not listed here directly.
** Asset owners highlighted by asterisks ** require that you visit their offices to collect plans.
Asset owners highlighted with a hash require that you call them to discuss your enquiry or to obtain plans.

Seq. No.	Authority Name	Phone	Status
93886038	Endeavour Energy	0298534161	NOTIFIED
93886040	Jemena Gas West	1300880906	NOTIFIED
93886041	Sydney Water	132092	NOTIFIED
93886039	Telstra NSW, Central	1800653935	NOTIFIED

END OF UTILITIES LIST

Job No 19329302

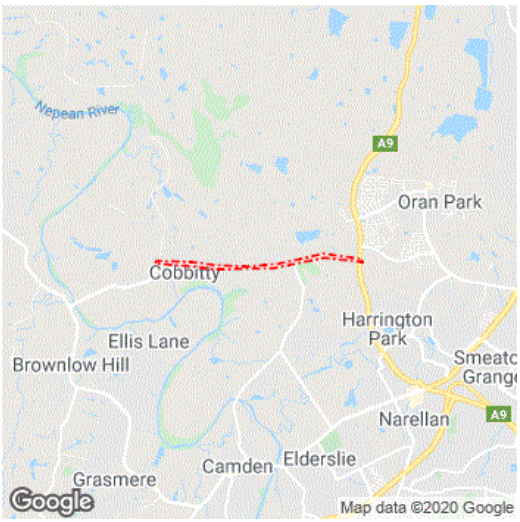
Phone: 1100
www.1100.com.au

Caller Details

Contact:	Miss Phoebe Connor	**Caller Id:**	1945172	**Phone:**	0477137224
Company:	AT&L	**Mobile:**	Not Supplied	**Fax:**	Not Supplied
Address:	7/153 Walker Street Sydney NSW 2060	**Email:**	phoebec@atl.net.au		

Dig Site and Enquiry Details

WARNING: The map below only displays the location of the proposed dig site and does not display any asset owners' pipe or cables. The area highlighted has been used only to identify the participating asset owners, who will send information to you directly.



User Reference: Not Supplied
Working on Behalf of: Other

Enquiry Date:	**Start Date:**	**End Date:**
07/04/2020	01/05/2020	02/05/2020

Address:
Chittick Ln
Cobbitty NSW 2570

Job Purpose:	**Onsite Activity:**
Excavation	Manual Excavation
Location of Workplace:	**Location in Road:**
Both	CarriageWay,Footpath,Nature Strip

- Check the location of the dig site is correct. If not submit a new enquiry.
- If the scope of works change, or plan validity dates expire, resubmit your enquiry.
- Do NOT dig without plans. Safe excavation is your responsibility. If you do not understand the plans or how to proceed safely, please contact the relevant asset owners.

Notes/Description of Works:

Your Responsibilities and Duty of Care

- The lodgement of an enquiry does not authorise the project to commence. You must obtain all necessary information from any and all likely impacted asset owners prior to excavation.
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96491435	Jemena Gas West	1300880906	NOTIFIED
96491436	Jemena Gas West	1300880906	NOTIFIED
96491439	NBN Co, NswAct	1800626329	NOTIFIED
96491438	NBN Co, NswAct	1800626329	NOTIFIED
96491434	Optus and/or Uecomm, Nsw	1800505777	NOTIFIED
96491433	Optus and/or Uecomm, Nsw	1800505777	NOTIFIED
96491437	Sydney Water	132092	NOTIFIED
96491432	Telstra NSW, Central	1800653935	NOTIFIED

END OF UTILITIES LIST

If further clarification is required, please contact:
Endeavour Energy
Phone: (02) 9853 4161 (8:00am-4:30pm Mon-Fri)
Emergency Phone Number: 131 003

BEFORE COMMENCING EXCAVATION YOU MUST READ AND UNDERSTAND ALL INFORMATION PROVIDED IN THE DBYD RESPONSE AND LISTED BELOW

BACKGROUND

Endeavour Energy is able to make available plans of its underground assets to persons who intend to undertake excavation works in Endeavour Energy's distribution area. Any plans provided to you are made available subject to the provisions set out below, in the provided plans, and in the Endeavour Energy DBYD response Cover Letter.

We have set out below important information regarding the recommended procedures that should be followed when using this service and also the extent of our responsibility in respect of any plans provided. It is very important that you read and understand all the information and disclaimers provided below before excavating.

Information Provided by Endeavour Energy:

- Any plans provided pursuant to this service are intended to show the approximate location of underground assets relative to road boundaries, property fences and other structures at the time of installation.
- Depth of underground assets may vary significantly from information provided on plans as a result of changes to road, footpath or surface levels subsequent to installation.
- Such plans have been prepared solely for use by Endeavour Energy staff for design, construction and maintenance purposes.
- All enquiry details and results are kept in a register.

DISCLAIMER

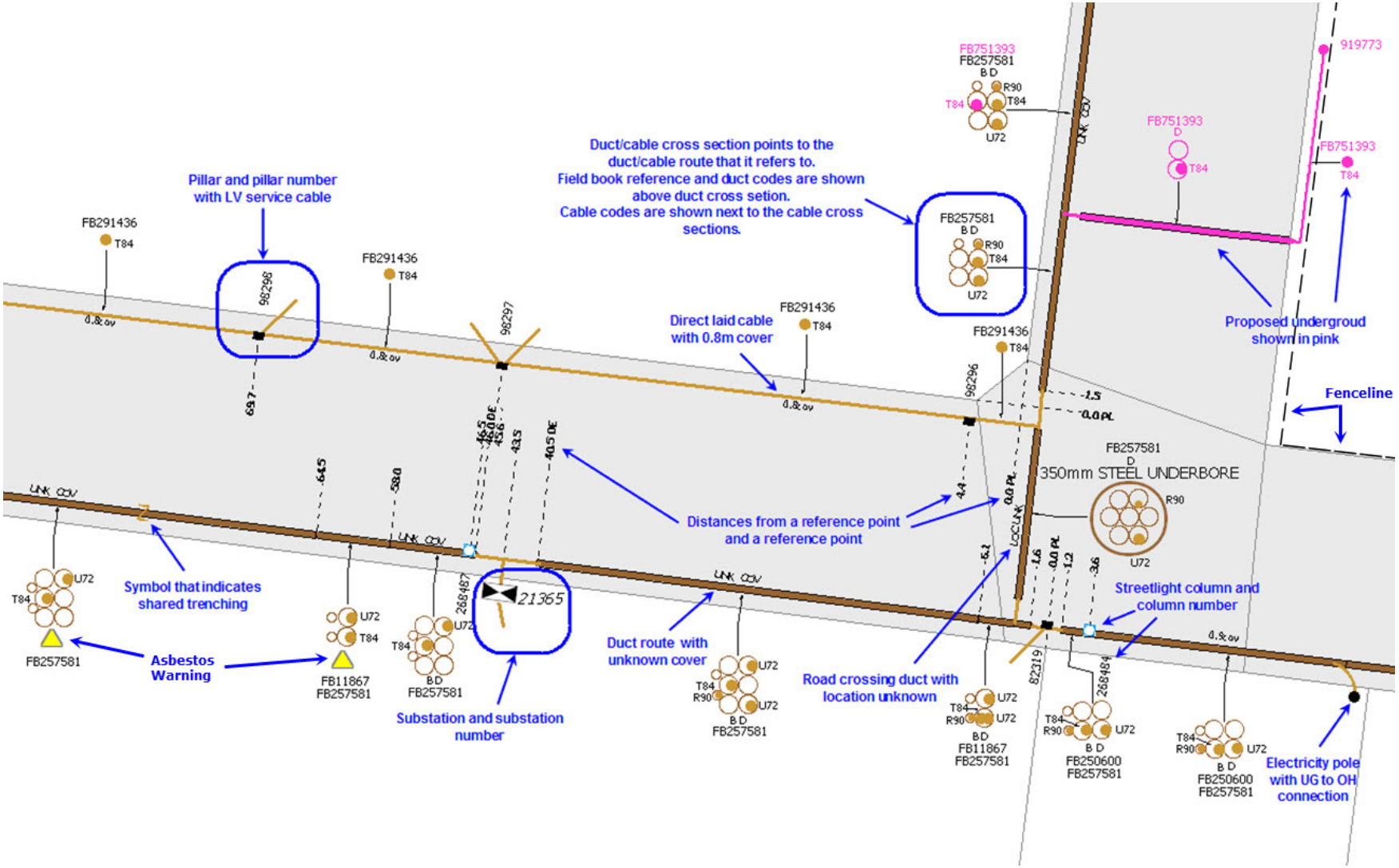
Whilst Endeavour Energy has taken all reasonable steps to ensure that the information contained in the plans is as accurate as possible it will accept no liability for inaccuracies in the information shown on such plans.

CUSTOMER REQUESTS AND RESPONSIBILITIES

- Endeavour Energy expects to be able to provide relevant plans within 48 hours after a request is made.
- If the enquiry falls within the Transmission Mains area, additional notification requirements shall be complied with as per the instructions in the response Cover Letter.
- Endeavour Energy retains copyright over all plans and details provided in response to a customer's request.
- Persons excavating are expected to exercise all due care in the vicinity where underground assets are indicated and will be held responsible for any damage to any underground assets (including any Endeavour Energy property) or any other loss caused (including consequential losses) as a result of such excavations.
- All underground assets should be visually located by soft digging (pot holing) or hand digging.
- A person who undertakes excavation work is subject to duties and responsibilities under the *Work Health and Safety Act 2011* and *Work Health and Safety Regulation 2011*. Please refer to the Work Cover NSW "*Work near underground assets: Guide*" and "*Excavation work: Code of practice*" which contain practical advice for working near underground utility services.
- Any damage to Endeavour Energy's assets must be immediately reported on **131 003**.
- In all cases of electric shock or suspected electric shock the victim shall immediately be transported to hospital or medical centre for treatment.
- If conduit material cannot be identified, it should be assumed to contain asbestos material.
- Endeavour Energy plans are frequently updated to record changes to underground assets. All plans are valid for **20** working days from the date of issue.

If further clarification is required, please contact:
Endeavour Energy
Phone: (02) 9853 4161 (8:00am-4:30pm Mon-Fri)
Emergency Phone Number: 131 003

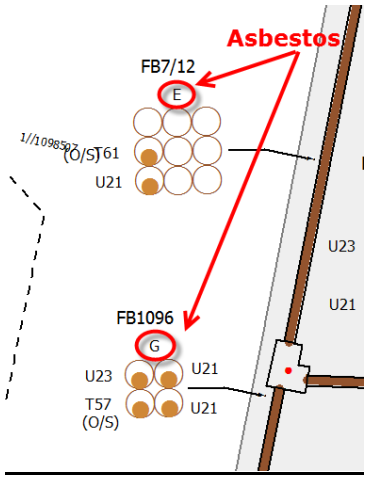
EXAMPLE OF HOW TO READ ENDEAVOUR ENERGY PLANS



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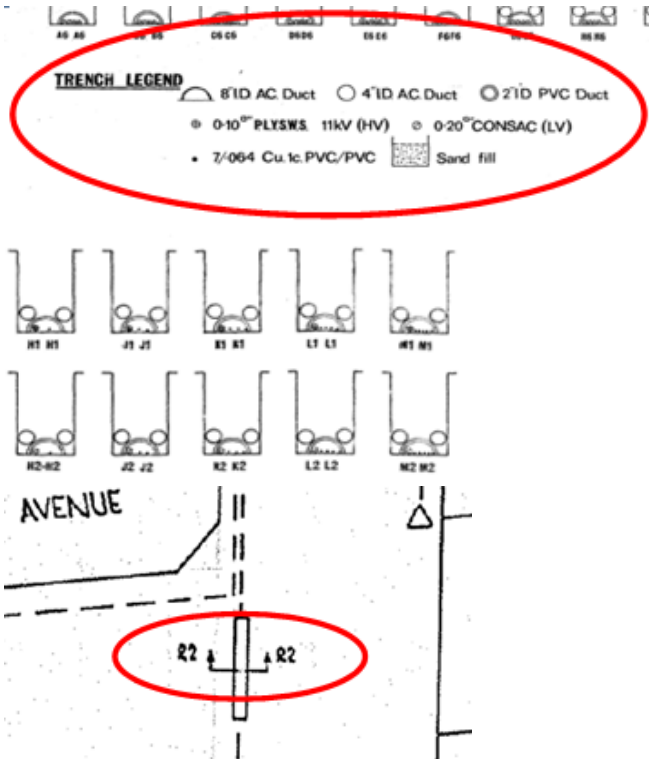
IDENTIFYING ASBESTOS DUCTS

1. Duct codes **E, F** and **G** identify Fibro Conduits

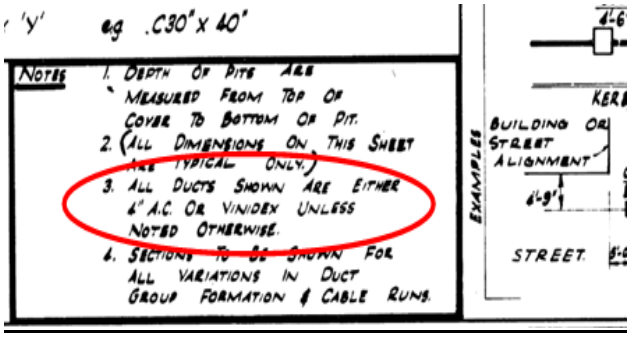


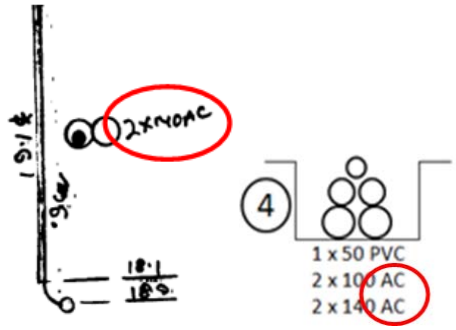
If underground details have not been captured and drawings are used, the method for identifying asbestos ducts and standards are different for the different utilities that amalgamated with Endeavour Energy. Using Reticulation Drawings, there are numerous ways to determine if a duct route has asbestos ducts, refer to following examples:

2. The duct codes **G,H,J,K,L,M Q,R,S,T,U,V,W & X** under each configuration are used on old Blue Mountains drawings to identify Asbestos

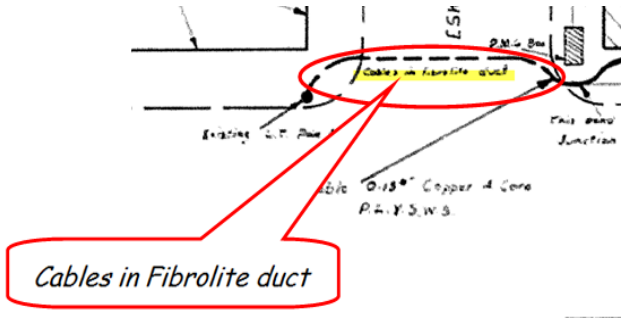


3. **AC** (Asbestos Cement) acronym

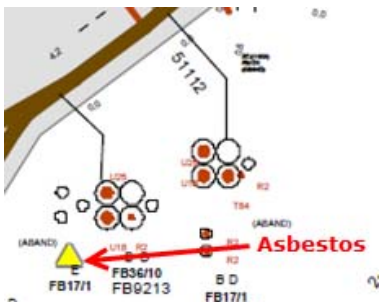




4. **Fibrolite** (asbestos) ducts



5. Yellow **triangle** identifies Fibro Conduits



If further clarification is required, please contact:
Endeavour Energy
Phone: (02) 9853 4161 (8:00am-4:30pm Mon-Fri)
Emergency Phone Number: 131 003

STANDARD UNDERGROUND SYMBOLS / LABELS

NOTE: *If symbology has not been provided on the plan use symbols as shown below.*

SYMBOLS & ACRONYMS

or — Street light column

Padmount substation

or — Overground pillar (O.G.Box)

Underground pit

Duct run

Cable run


Typical duct section


Typical underbore section

Blocked duct

Cable section

Asbestos warning

STJ, PBJ, TTJ

STJ Straight through joint

PBJ Parallel branch joint

TTJ Transition through joint

Underground to overhead pole

SL Streetlight conductor

SC Service cable

SE Cable sealed end

SF Service Feeder

OS Out of Service

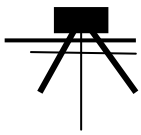
O.A.M. Over awning main

U.A.M. Under awning main

N.I.S. Not in service

Fence/dimensioning

Shared trenching


Service point of attachment

DUCT CODE LABLES

B = 50 mm PVC

D = 125mm PVC

E = 100mm Fibro Conduit (Asbestos)

F = 140mm Fibro Conduit (Asbestos)

G = 150mm Fibro Conduit (Asbestos)

DEPTH & LOCATION LABELS

0.5- 0.7 COV = 0.5m – 0.7m

0.9 COV = 0.9m Depth

UNK COV = Depth Unknown

LOC UNK = Location Unknown

0.9 PL = Located 0.9m from Property Line

If further clarification is required, please contact:
Endeavour Energy
Phone: (02) 9853 4161 (8:00am-4:30pm Mon-Fri)
Emergency Phone Number: 131 003

DBYD Underground Search Report

Date: 07/04/2020

DBYD Sequence No: 96491431 **DBYD Job No:** 19329302

ENDEAVOUR ENERGY ASSETS AFFECTED

To:	Miss Phoebe Connor		Company:	AT&L	
Address:	7/153 Walker Street, Sydney, NSW 2060				
Cust. ID:	1945172	Email:	phoebec@atl.net.au		
Phone:	0477137224	Mobile:	Not Supplied	Fax:	Not Supplied
Enquiry Location:	Chittick Ln, Cobbitty, NSW 2570				

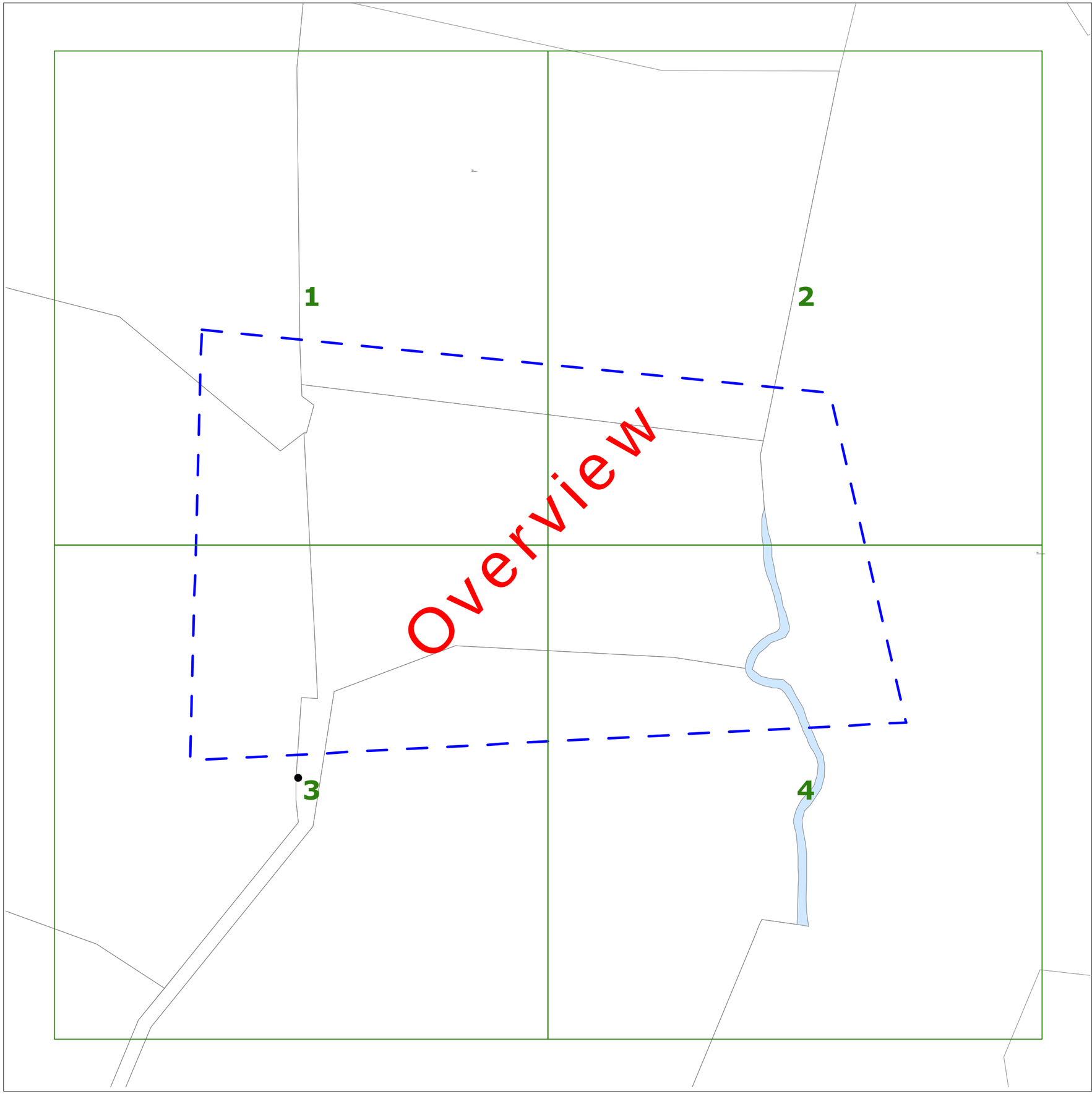
Our Search has shown that **UNDERGROUND ASSETS ARE PRESENT** on our plans within the nominated enquiry location. This search is based on the graphical position of the excavation site as denoted in the DBYD customer confirmation sheet.

WARNING

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- The customer must obtain a new set of plans from Endeavour Energy if work has not been started or completed within twenty **(20)** working days of the original plan issue date.
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- Endeavour Energy plans **do not** show any underground customer service mains or information relating to service mains within private property.
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- All plans must be printed and made available at the worksite where excavation is to be undertaken. Plans must be reviewed and understood by the crew on site prior to commencing excavation.

SUPPLEMENTARY MATERIAL

Material	Purpose	Location
DBYD Cover Letter	Endeavour Energy DBYD response Cover Letter	Attached
DBYD Important Information & Disclaimer	Endeavour Energy disclaimer, responsibilities and information on understanding plans	Attached
DBYD Response Plans	Endeavour Energy DBYD plans	Attached
Work Cover NSW *"Work near underground assets: Guide"*	Guideline for anyone involved in construction work near underground assets	Contact Work Cover NSW for a copy
Work Cover NSW *"Excavation work: Code of practice"*	Practical guidance on managing health and safety risks associated with excavation	URL [Click Here]
Safe Work Australia *"Working in the vicinity of overhead and underground electric lines guidance material"*	Provides information on how to manage risks when working in the vicinity of overhead and underground electric lines at a workplace	URL [Click Here]
Endeavour Energy Safety Brochures & Guides	To raise awareness of dangers of working on or near Endeavour Energy's assets	URL [Click Here]



Endeavour Energy

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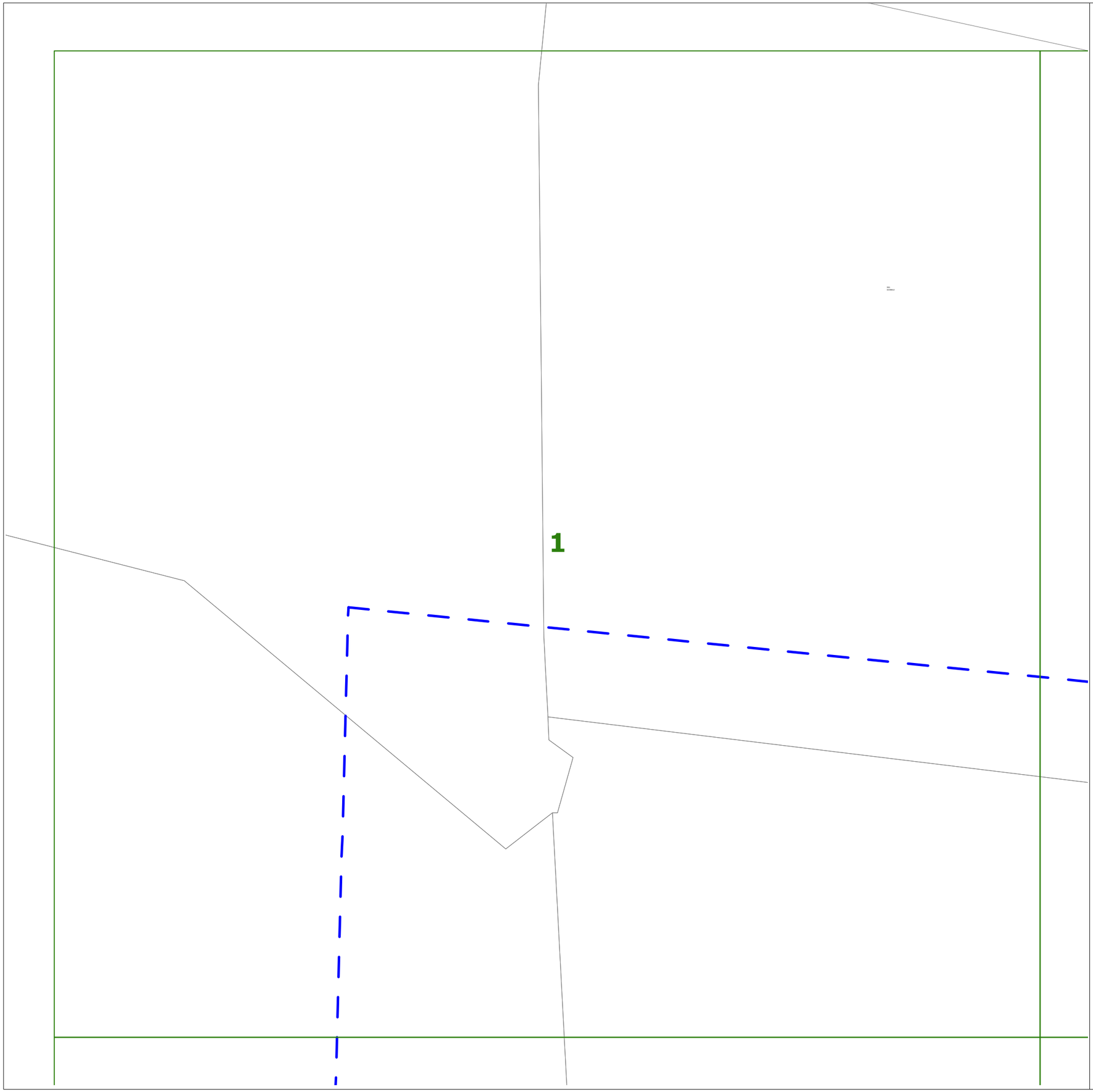
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- Padmount substation
- Overground pillar (O.G.Box) (or)
- Underground pit
- Duct run
- Cable run
- Typical duct section
- Asbestos warning

N

NOT TO SCALE

DBYD Sequence No.:	93885634
Issued Date:	17/01/2020

Cadastre: © Land and Property Information 2015, 2016



Endeavour Energy

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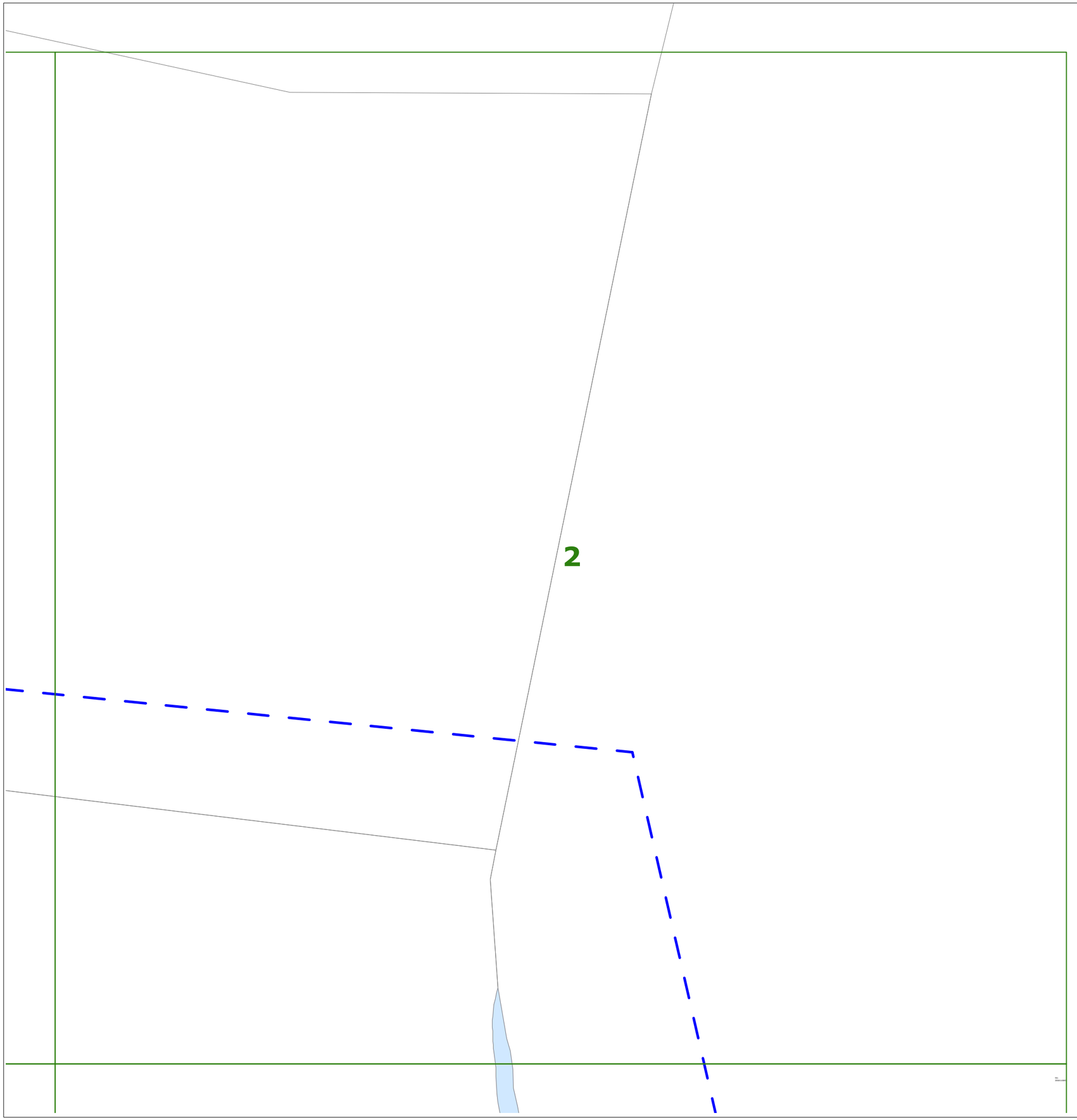
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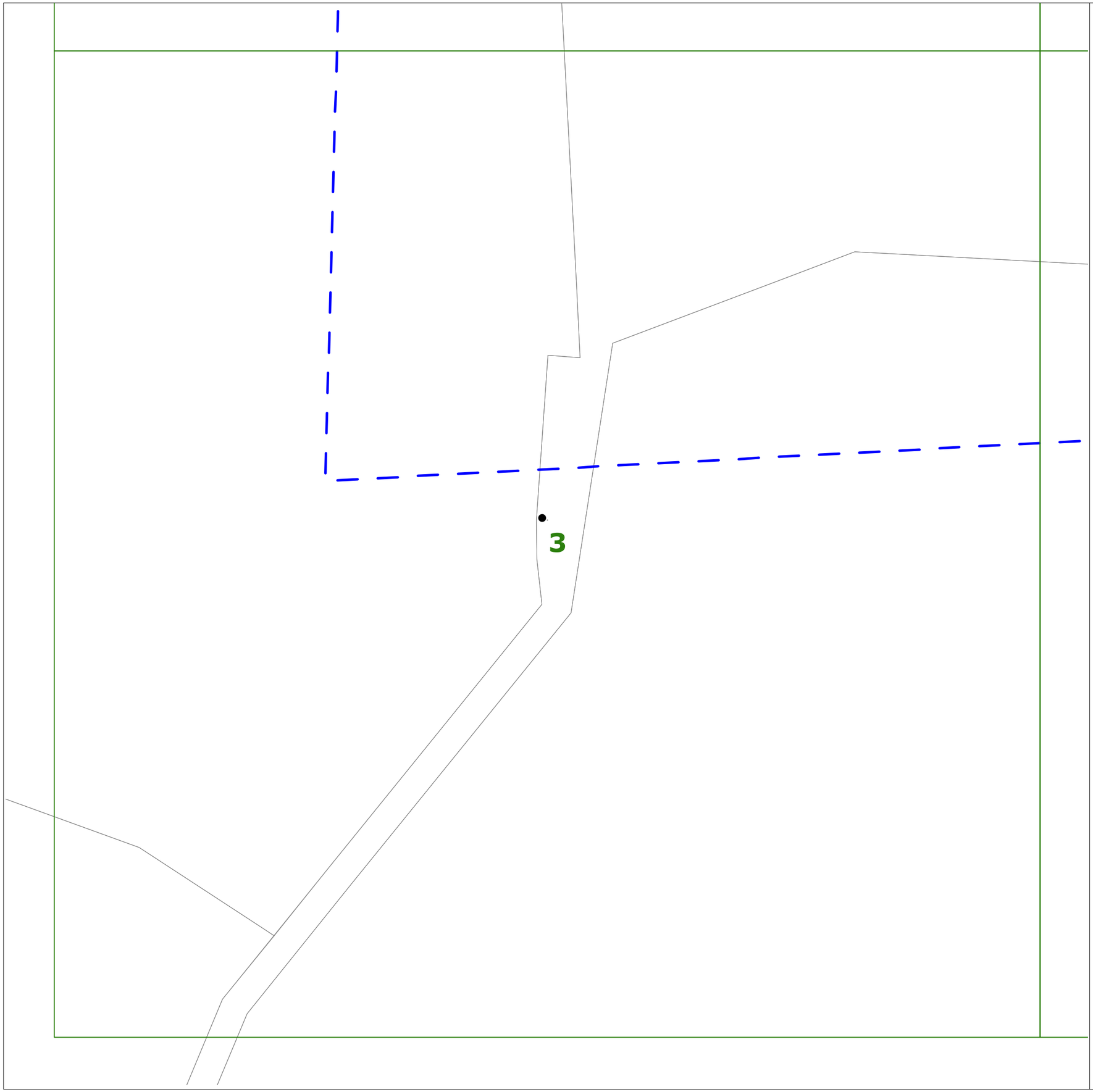
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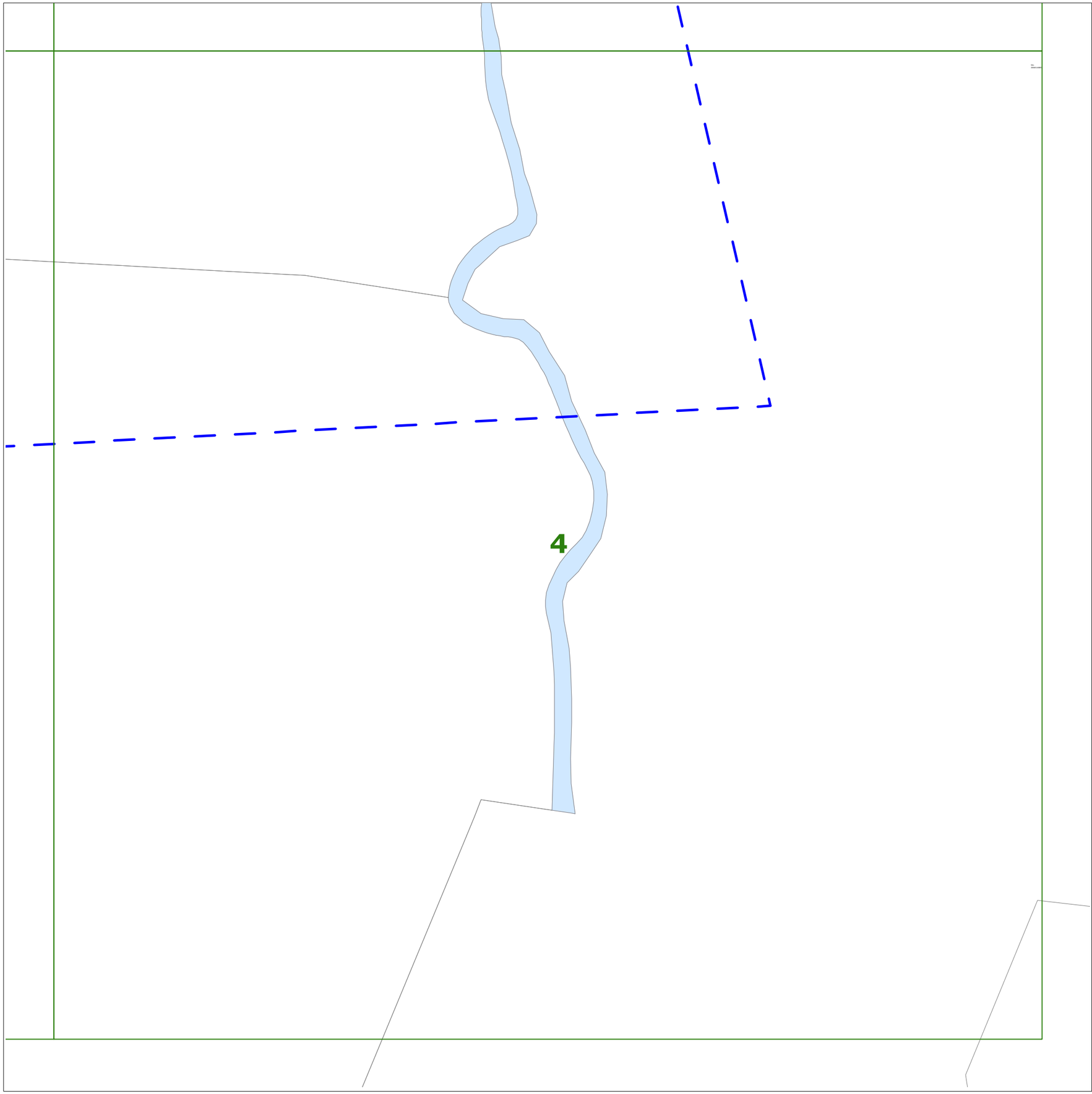
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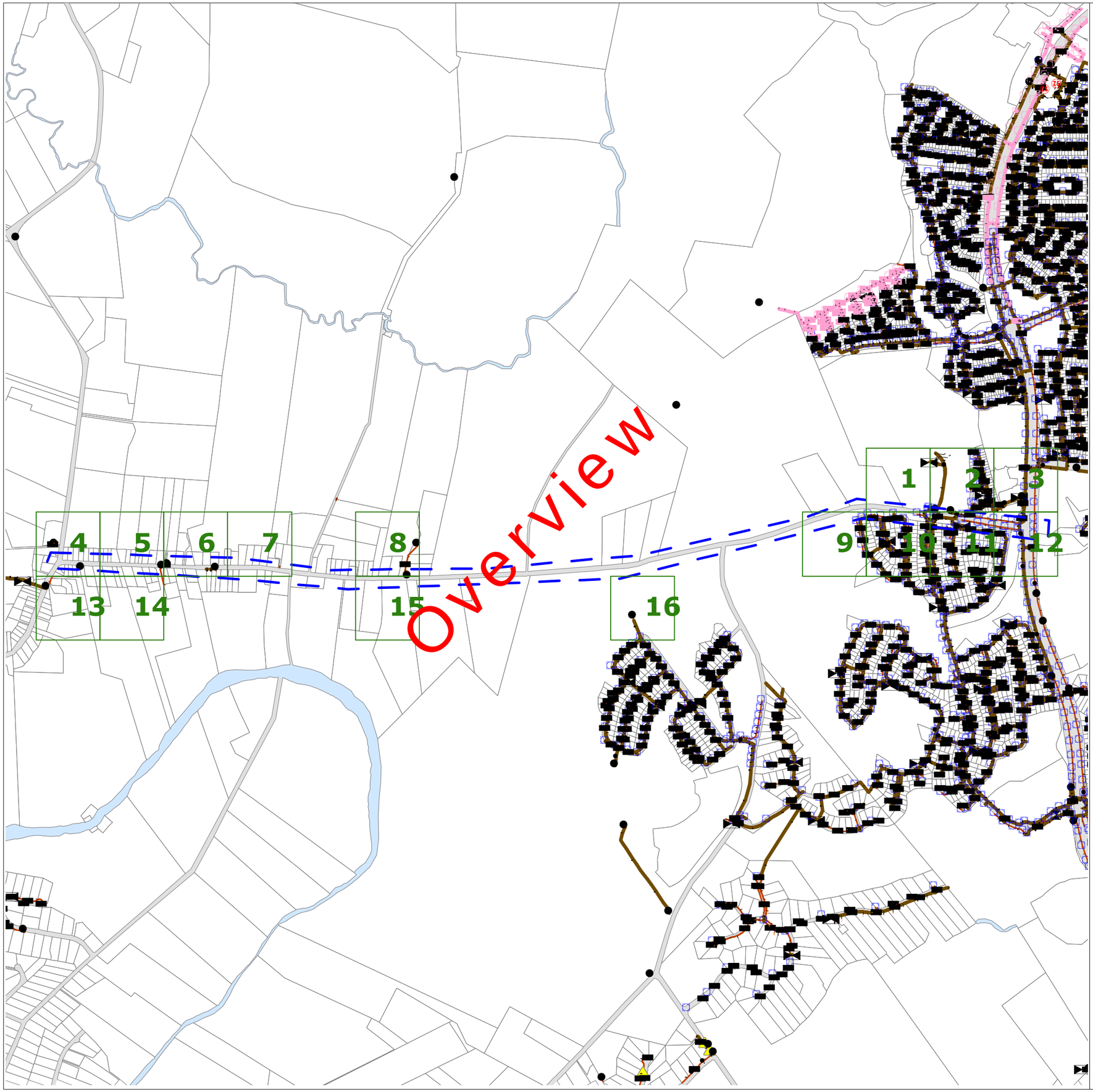
- or — Street light column
- Padmount substation
- or — Overground pillar (O.G.Box)
- Underground pit
- Duct run
- Cable run
- Typical duct section
- Asbestos warning

N

NOT TO SCALE

DBYD Sequence No.:	93885634
Issued Date:	17/01/2020

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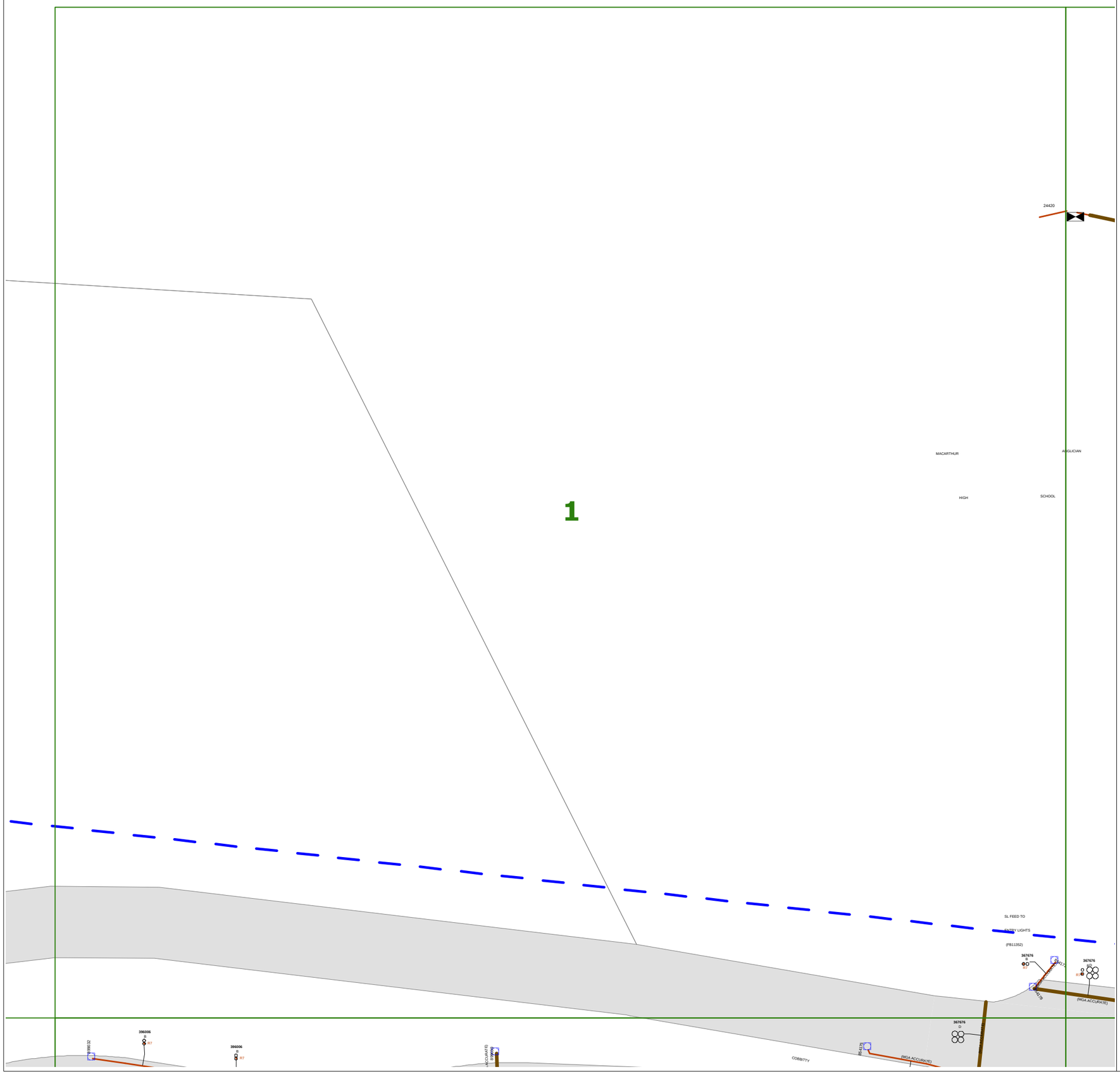
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N

NOT TO SCALE

DBYD Sequence No.:	96491431
Issued Date:	07/04/2020

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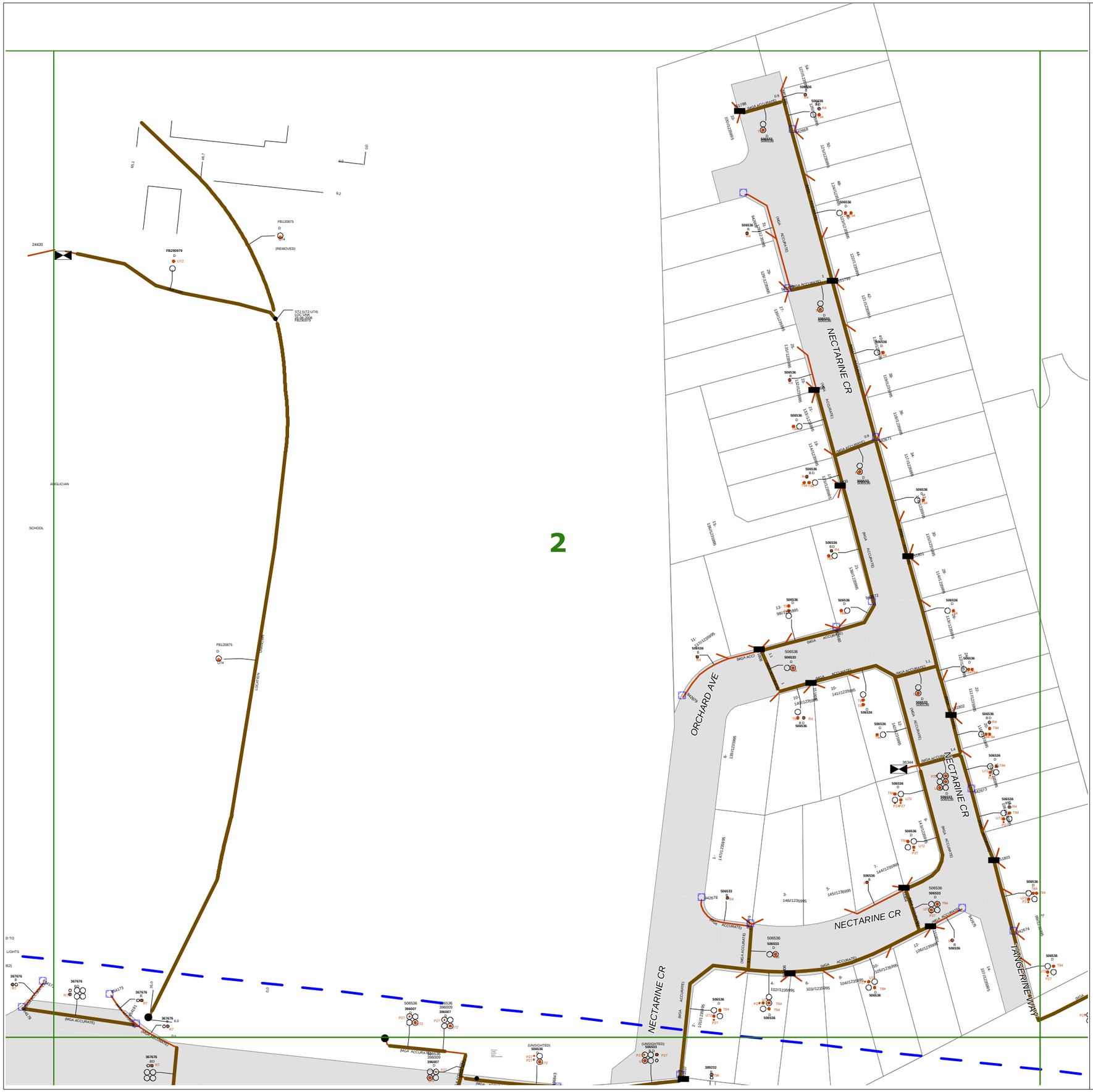
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2

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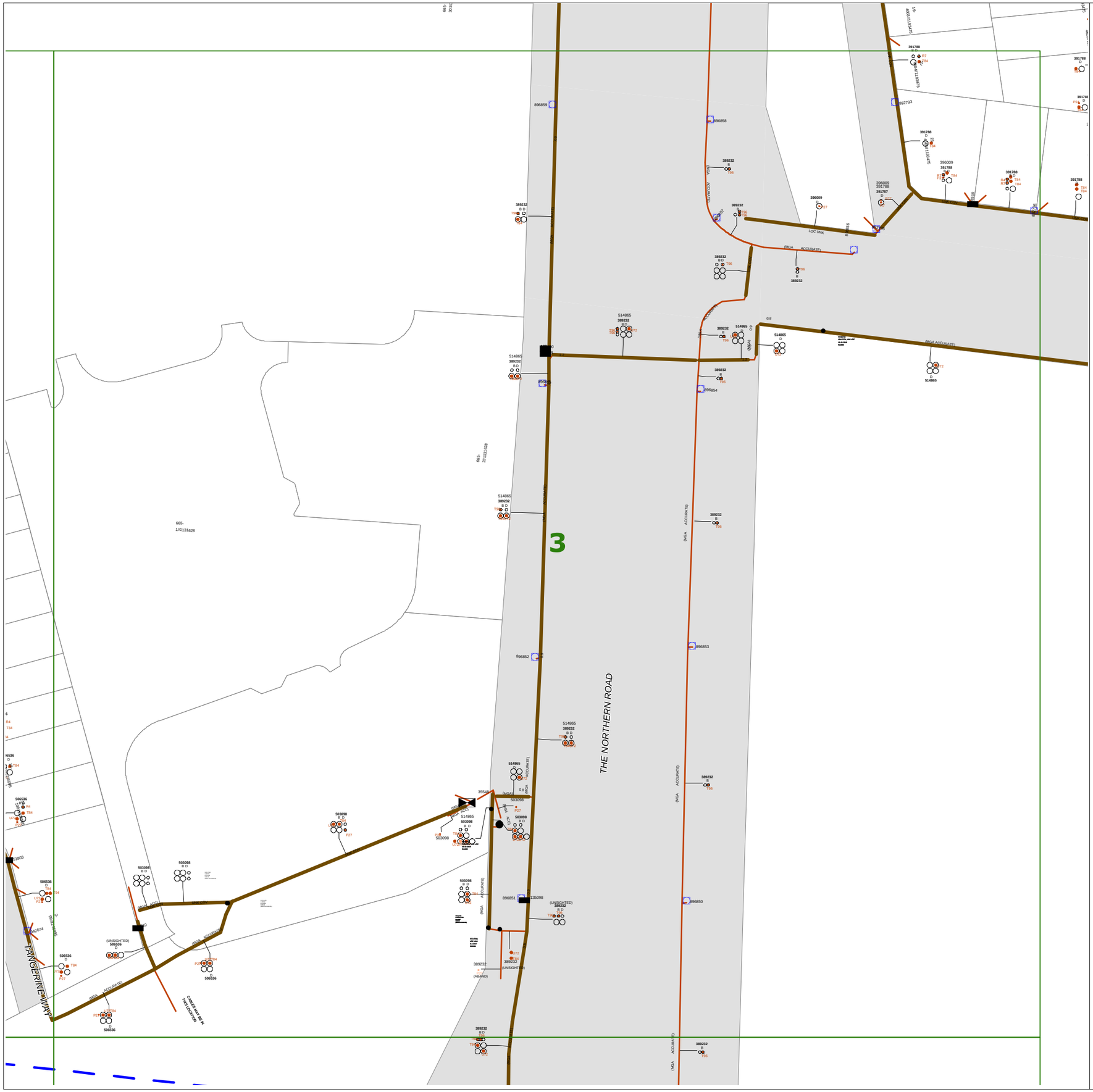
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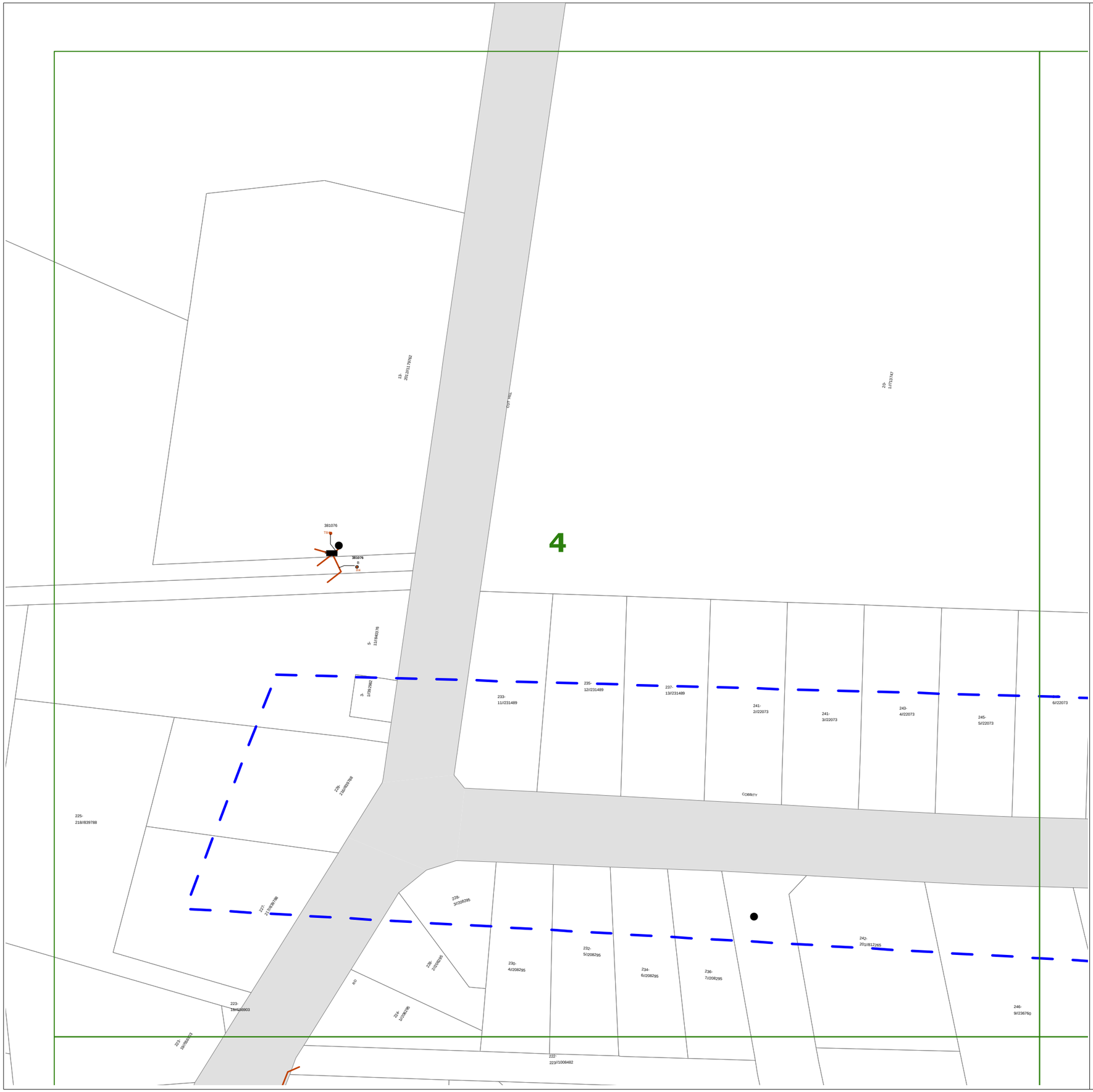
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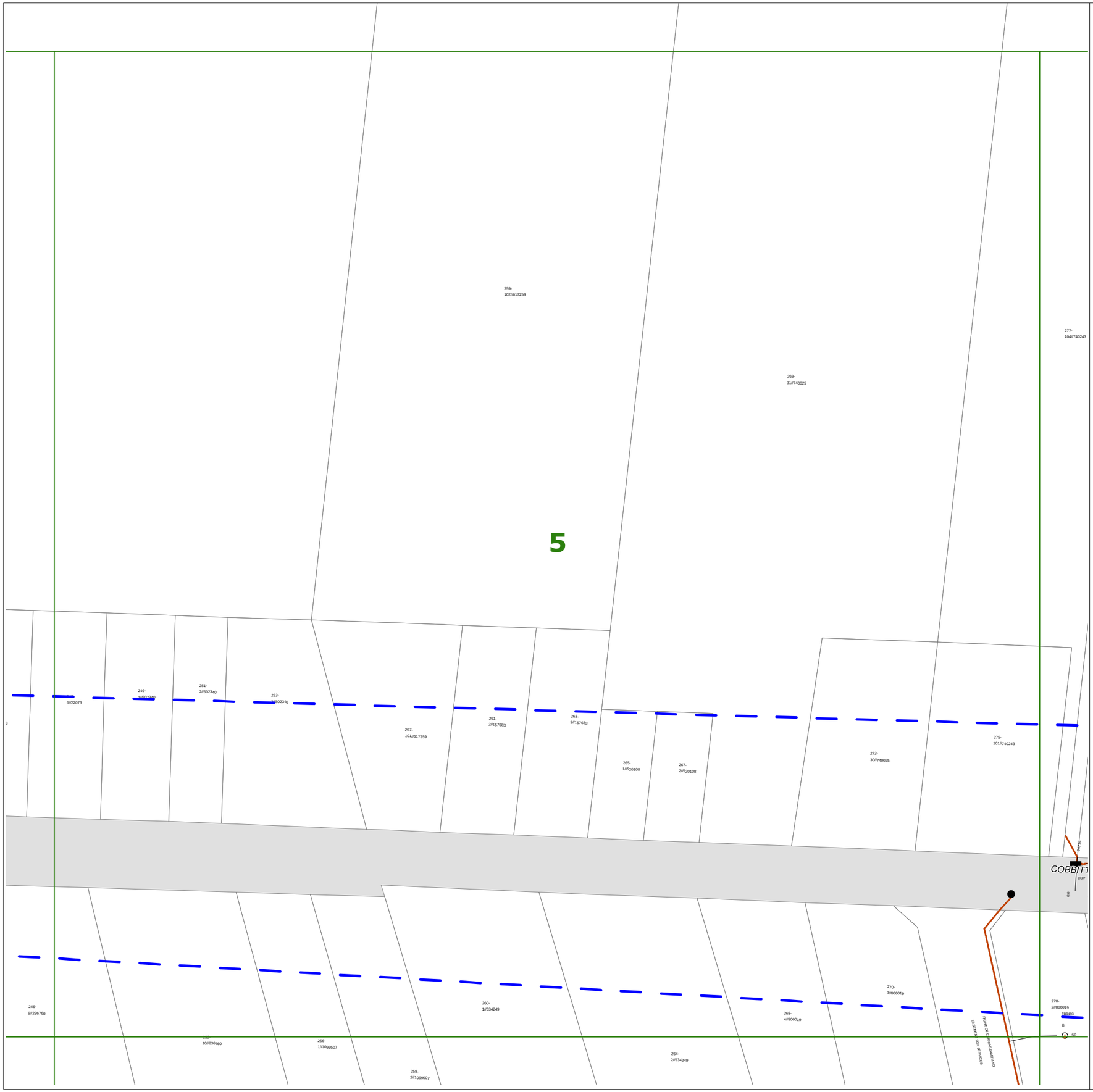
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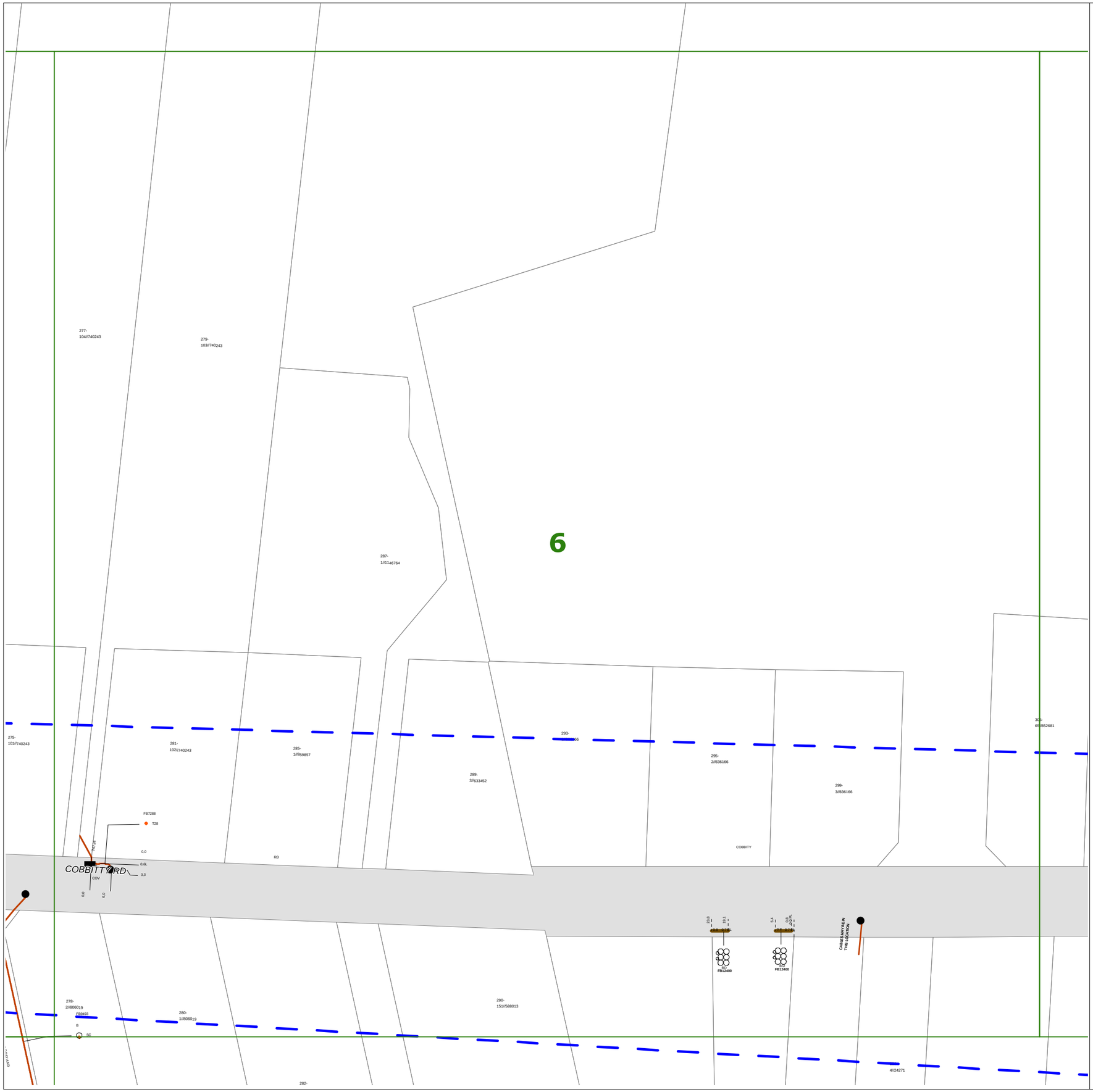
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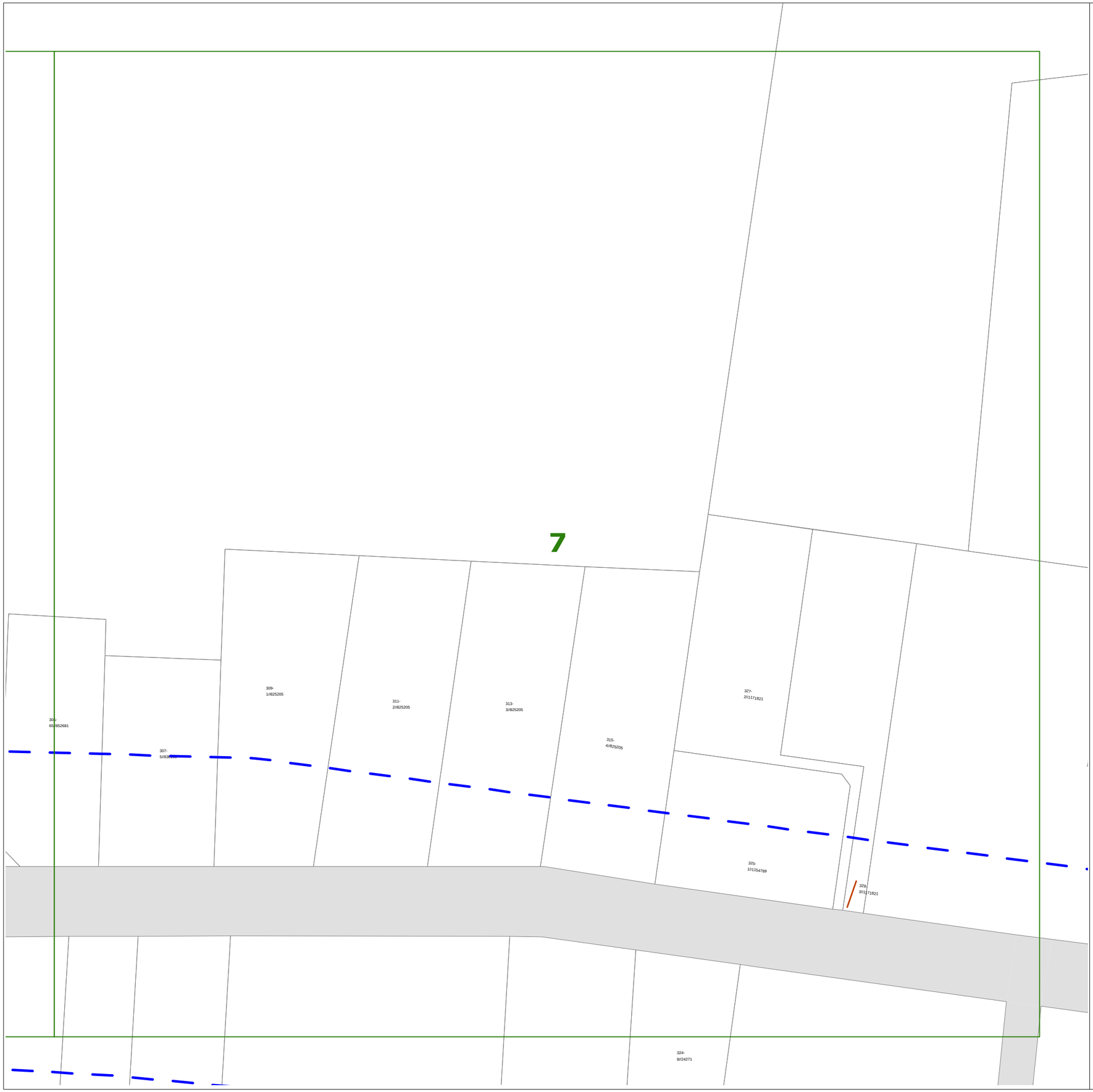
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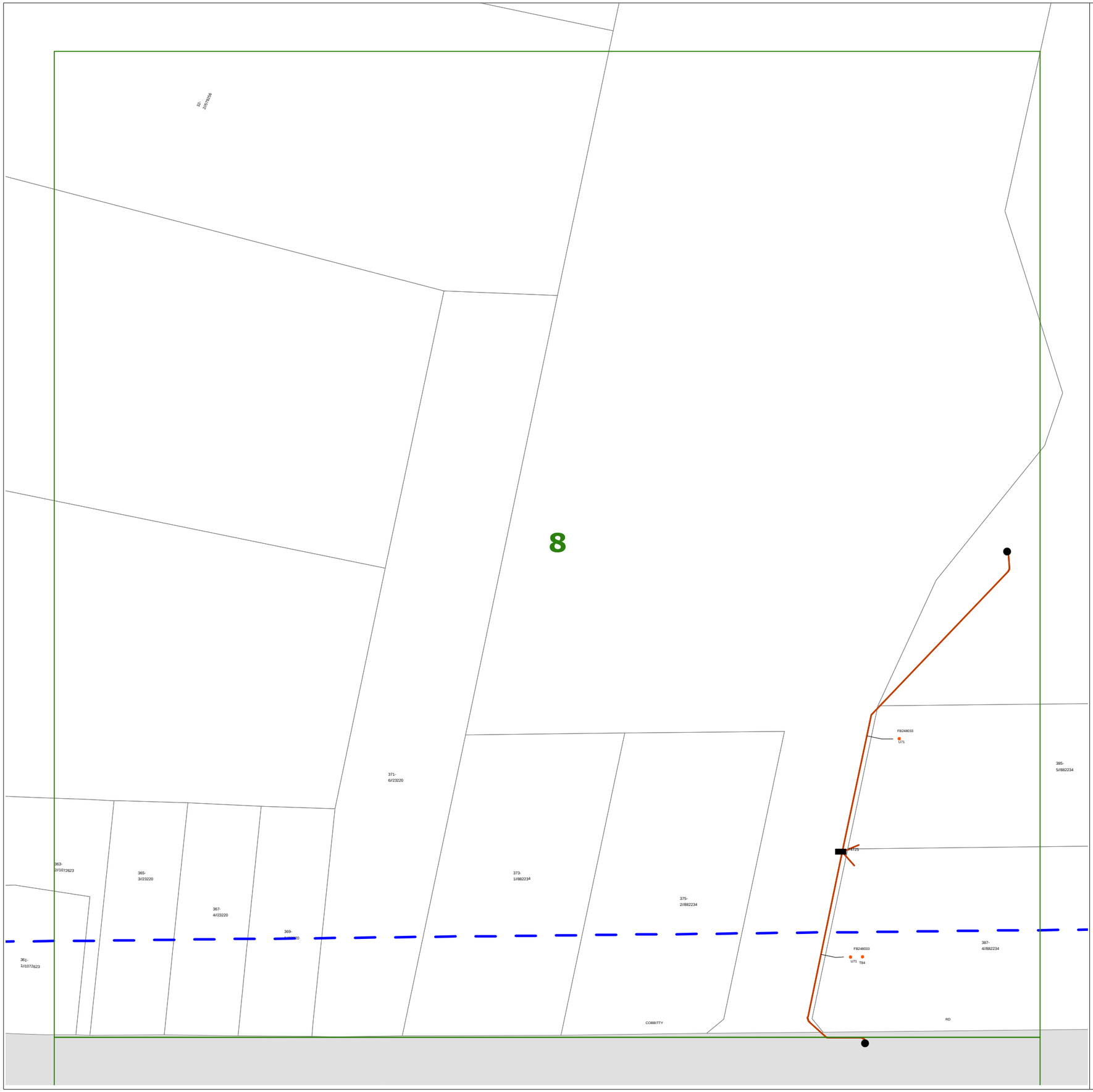
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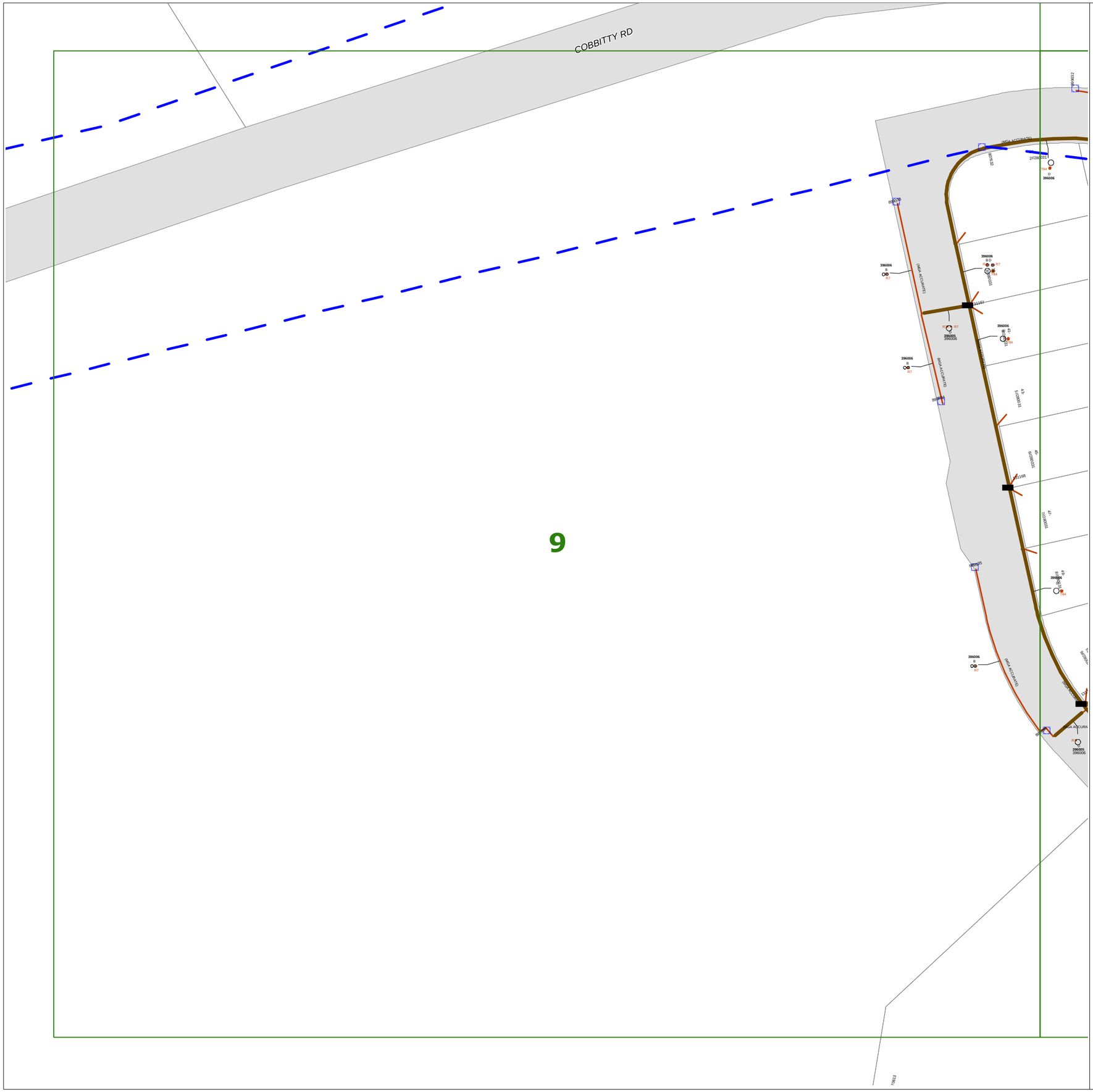
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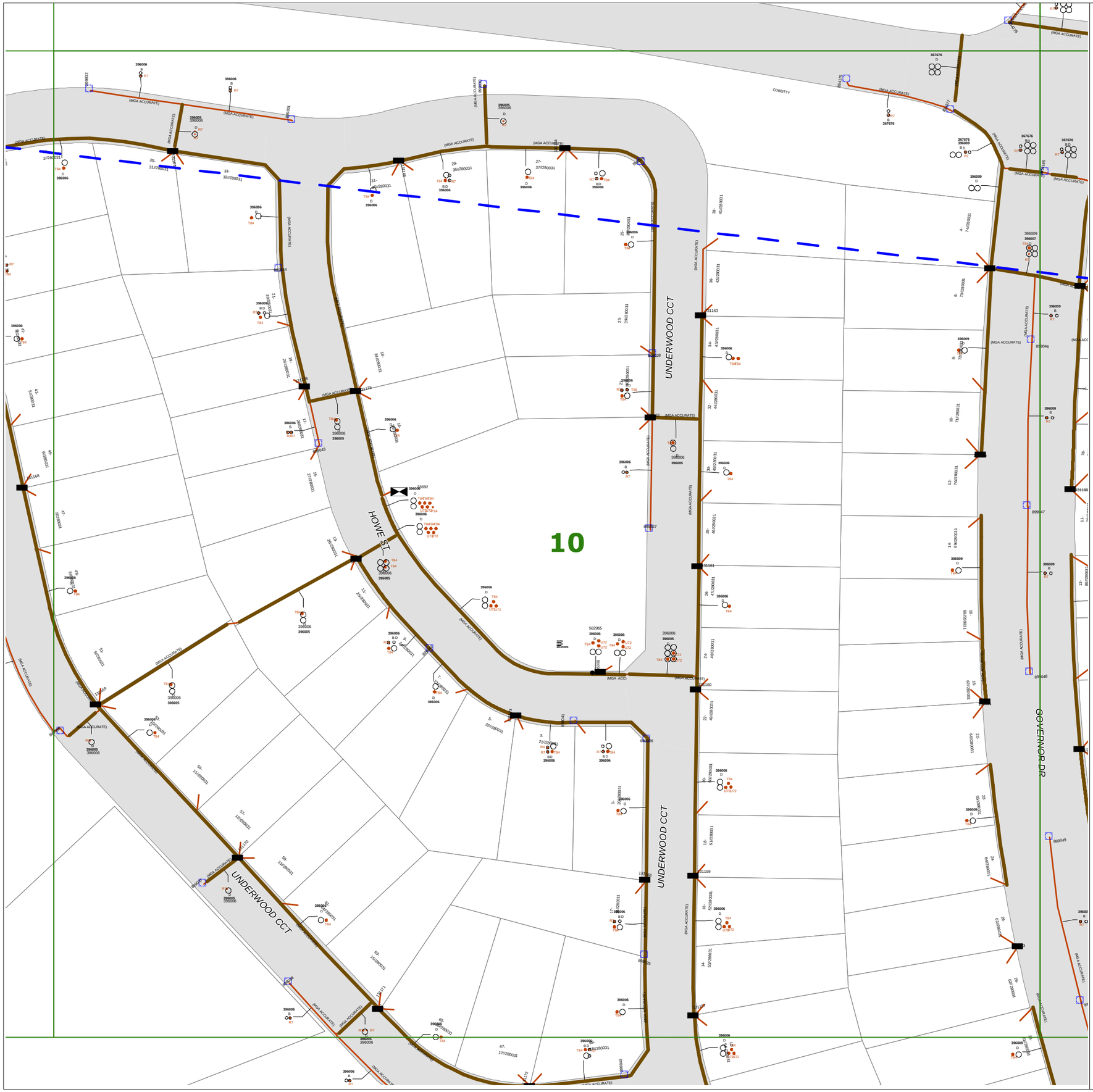
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Issued Date:	07/04/2020

Cadastre: © Land and Property Information 2015, 2016



Endeavour Energy

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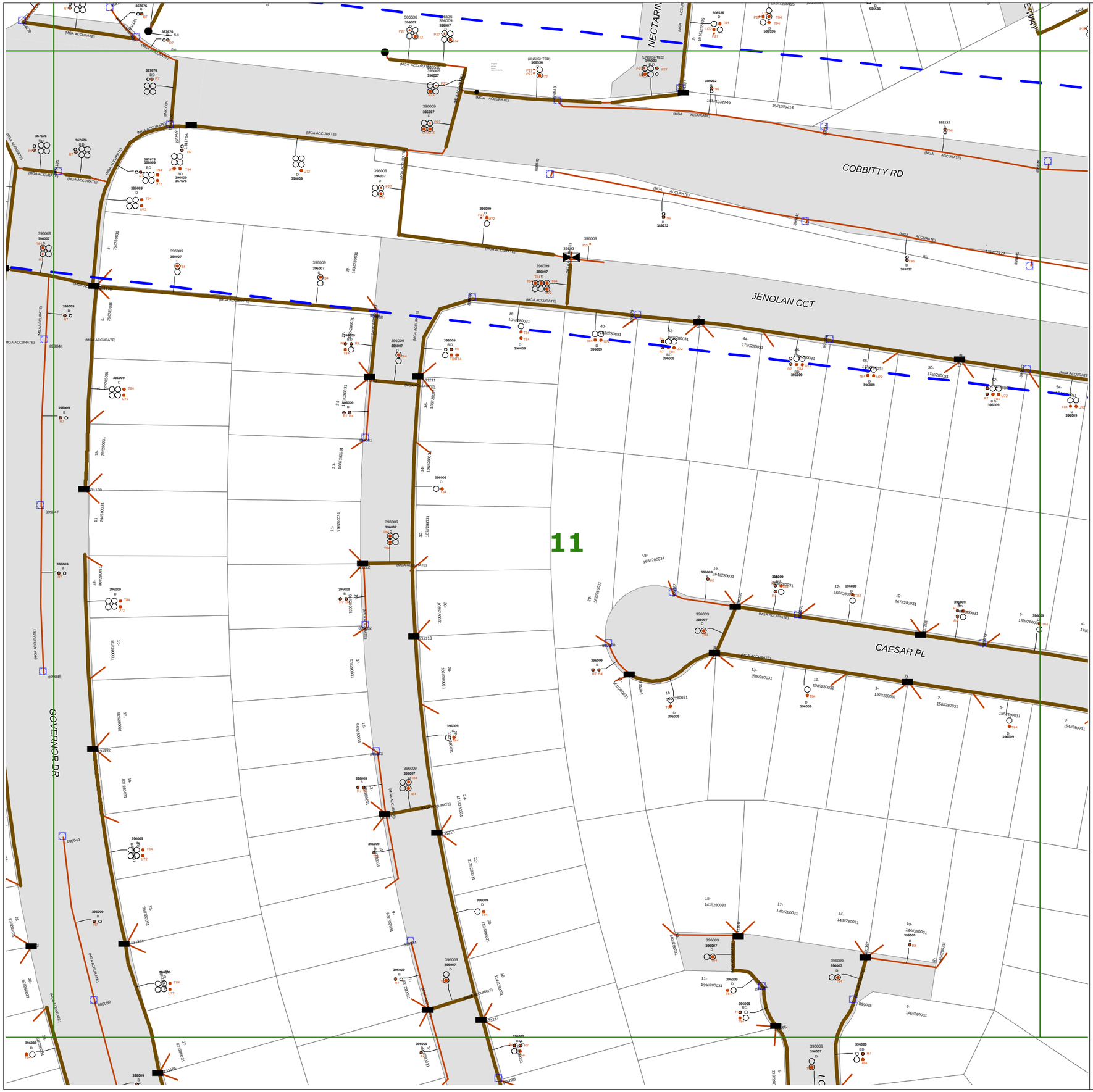
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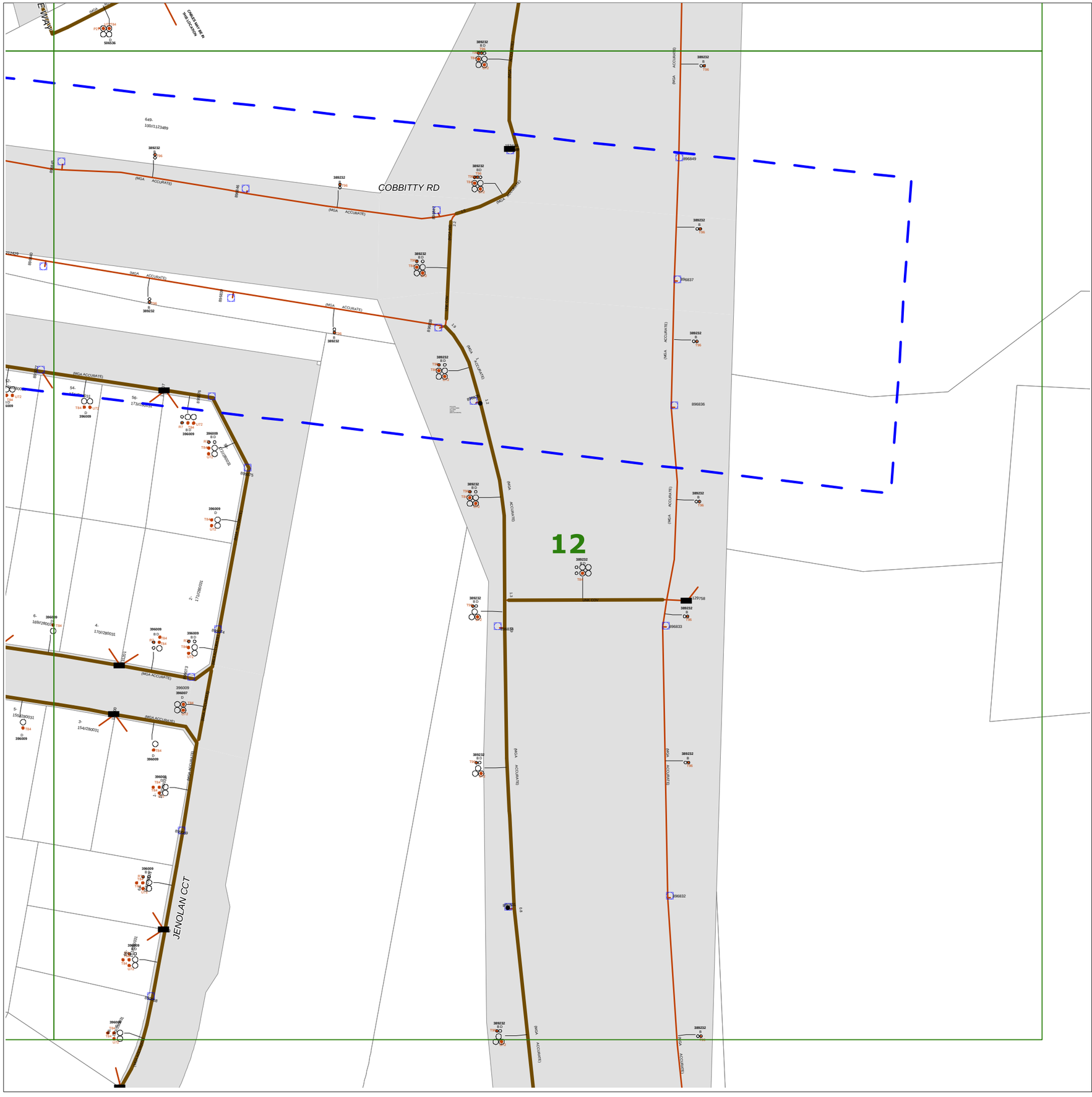
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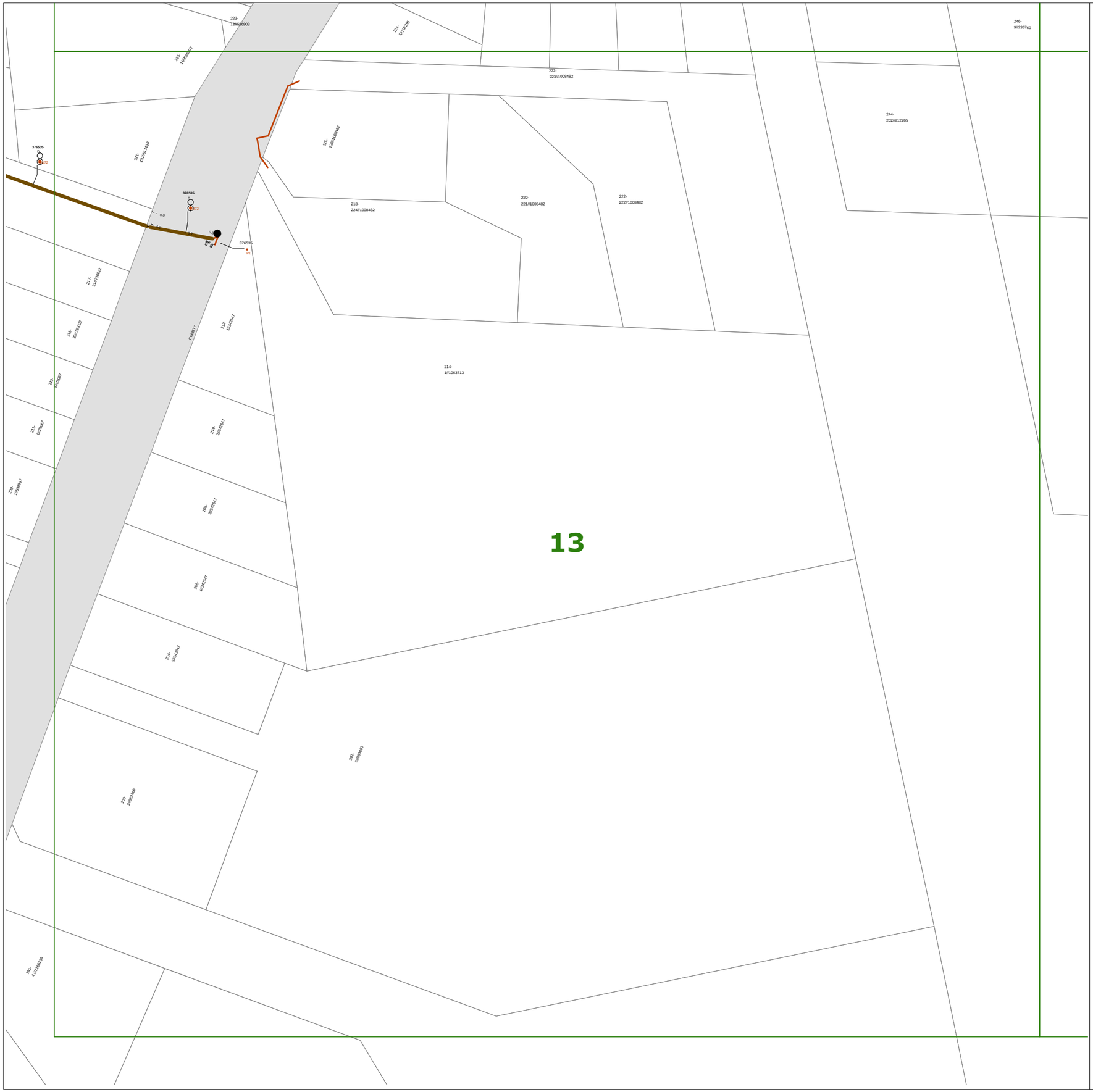
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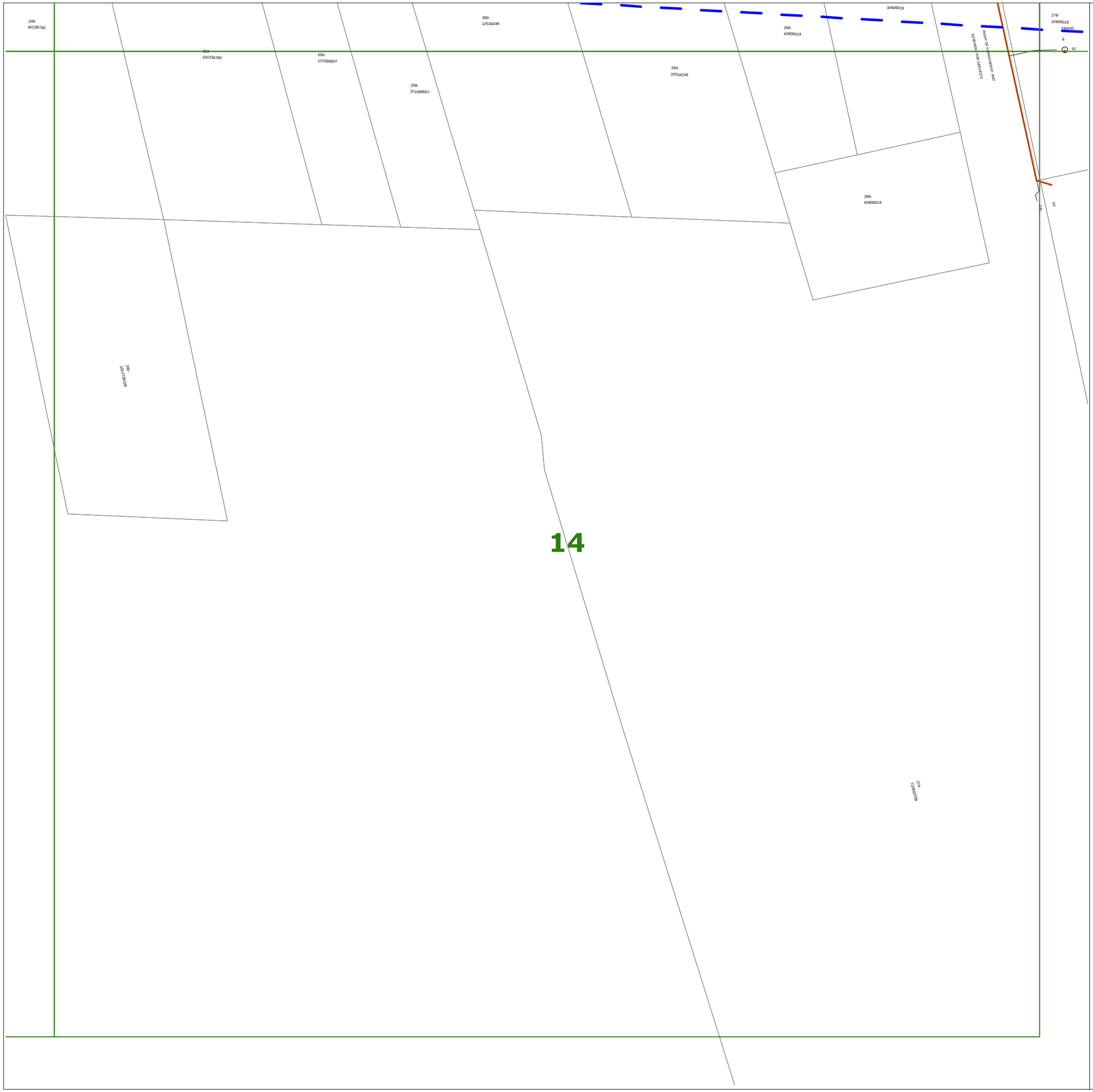
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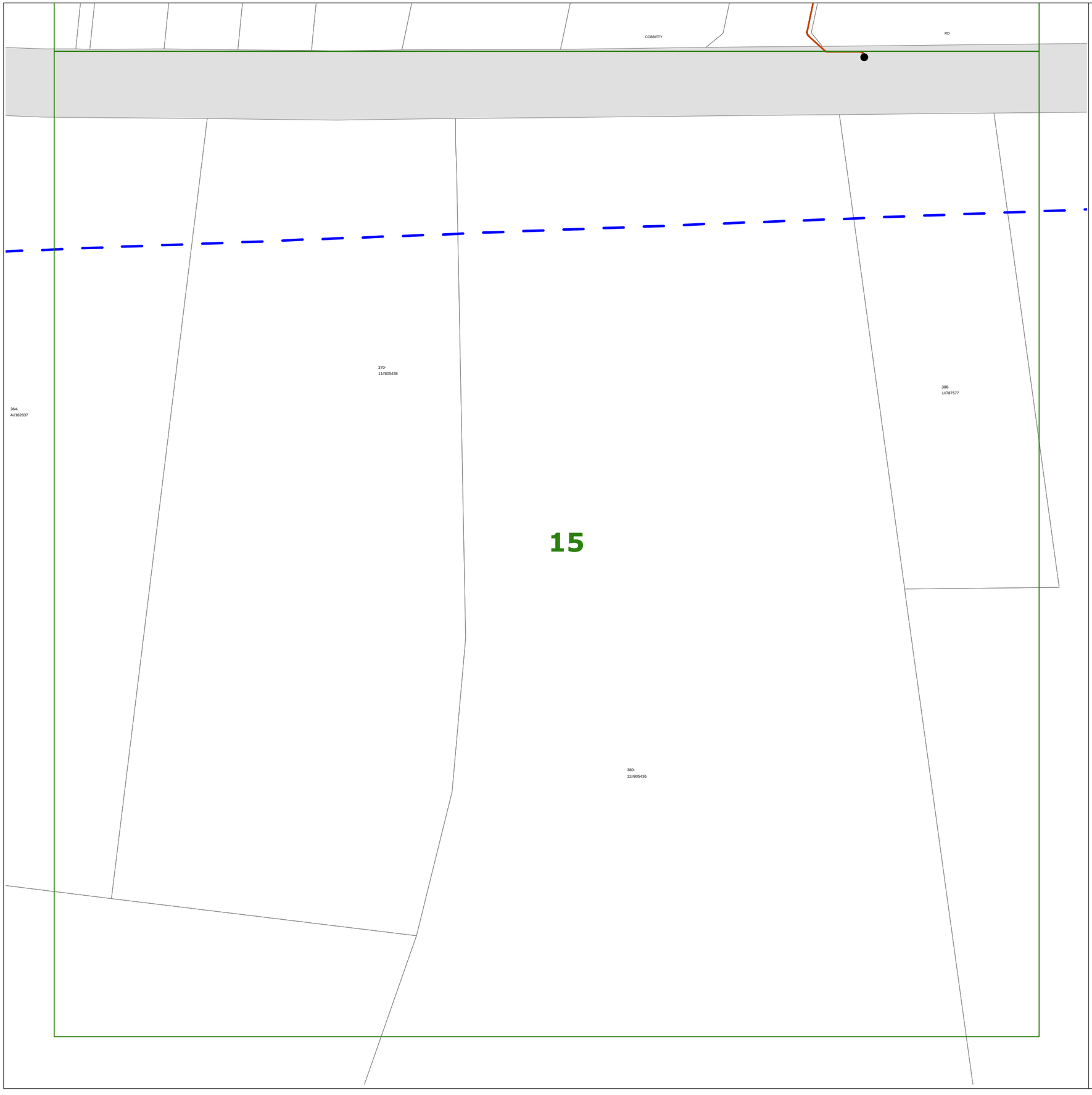
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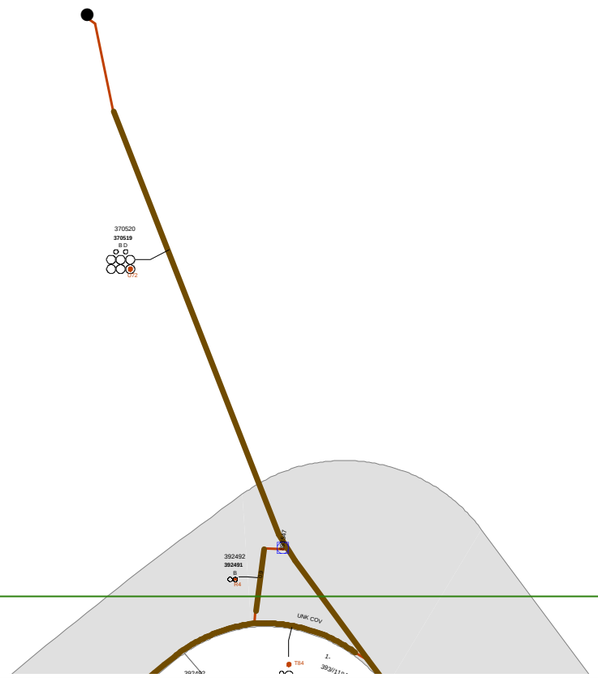
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Network Protection

Assets Affected

In reply to your enquiry, there are gas mains at the location of your intended work as per the attached map. For an explanation of the map, please see the key below. The following excavation guidelines apply.

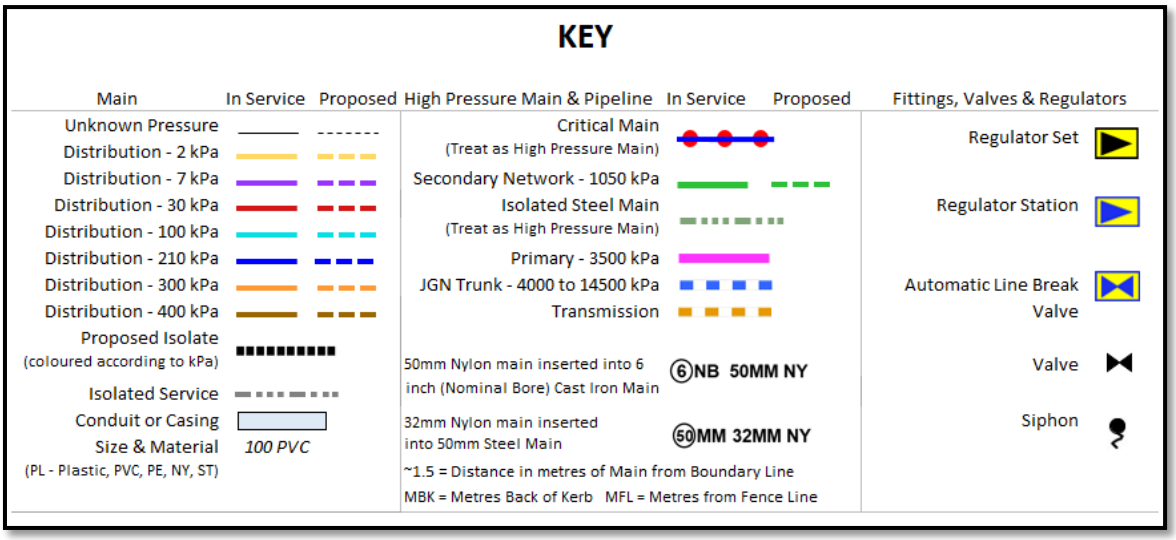
Excavation Guidelines:

It is essential the location of gas pipe/s are confirmed by carefully pot-holing by hand excavation prior to proceeding with mechanical excavation in the vicinity of gas pipes. If you cannot locate the gas main, contact the local depot.

In accordance with clause 34(5) of the Gas Supply (Safety and Network Management) Regulation 2013 (NSW), you should be informed that all excavation, (including pot-holing by hand to confirm the location of pipes) should be performed in accordance with "***Work Near Underground Assets Guideline"*** *published in 2007 by the Work Cover Authority.*

A copy of this Guideline is available at: www.workcover.nsw.gov.au

DBYD Administration 1300 880 906



Warning: The enclosed plans show the position of Jemena Gas Networks (NSW) Ltd's underground gas mains and installations in public gazetted roads only. **Individual customers' services and services belonging to other third parties are not included** on these plans. These plans have been prepared solely for the use of Jemena Gas Networks (NSW) Ltd and Jemena Asset Management Pty Ltd (together "**Jemena**") and any reliance placed on these plans by you is entirely at your own risk. The plans may show the position of underground mains and installations relative to fences, buildings etc., as they existed at the time the mains etc were installed. The plans may not have been updated to take account of any subsequent change in the location or style of those features since the time at which the plans were initially prepared. Jemena makes no warranty as to the accuracy or completeness of the enclosed plans and does not assume any duty of care to you nor any responsibility for the accuracy, adequacy, suitability or completeness of the plans or for any error, omission, lack of detail, transmission failure or corruption in the information provided. Jemena does not accept any responsibility for any loss that you or anyone else may suffer in connection with the provision of these plans, however that loss may arise (including whether or not arising from the negligence of Jemena, its employees, agents, officers or contractors). The recipient of these plans must use their own care and diligence in carrying out their works and must carry out further surveys to locate services at their work site. Persons excavating or carrying out other earthworks will be held responsible for any damage caused to Jemena's underground mains and equipment. In accordance with the Work Near Underground Assets Guideline published in 2007 by Work Cover Authority, Jemena recommends that you carry out potholing by hand to accurately confirm the location of gas mains and installation prior to commencing excavations.

In case of Emergency Phone 131 909 (24 hours)

Admin
1300 880 906

DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main
Proposed Isolate (coloured according to kPa)
Isolated Service
Conduit or Casing 100 PVC
Size & Material (PL - Plastic, PVC, PE, NY, ST)

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main (6)NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main (50)MM 32MM NY

N W E S

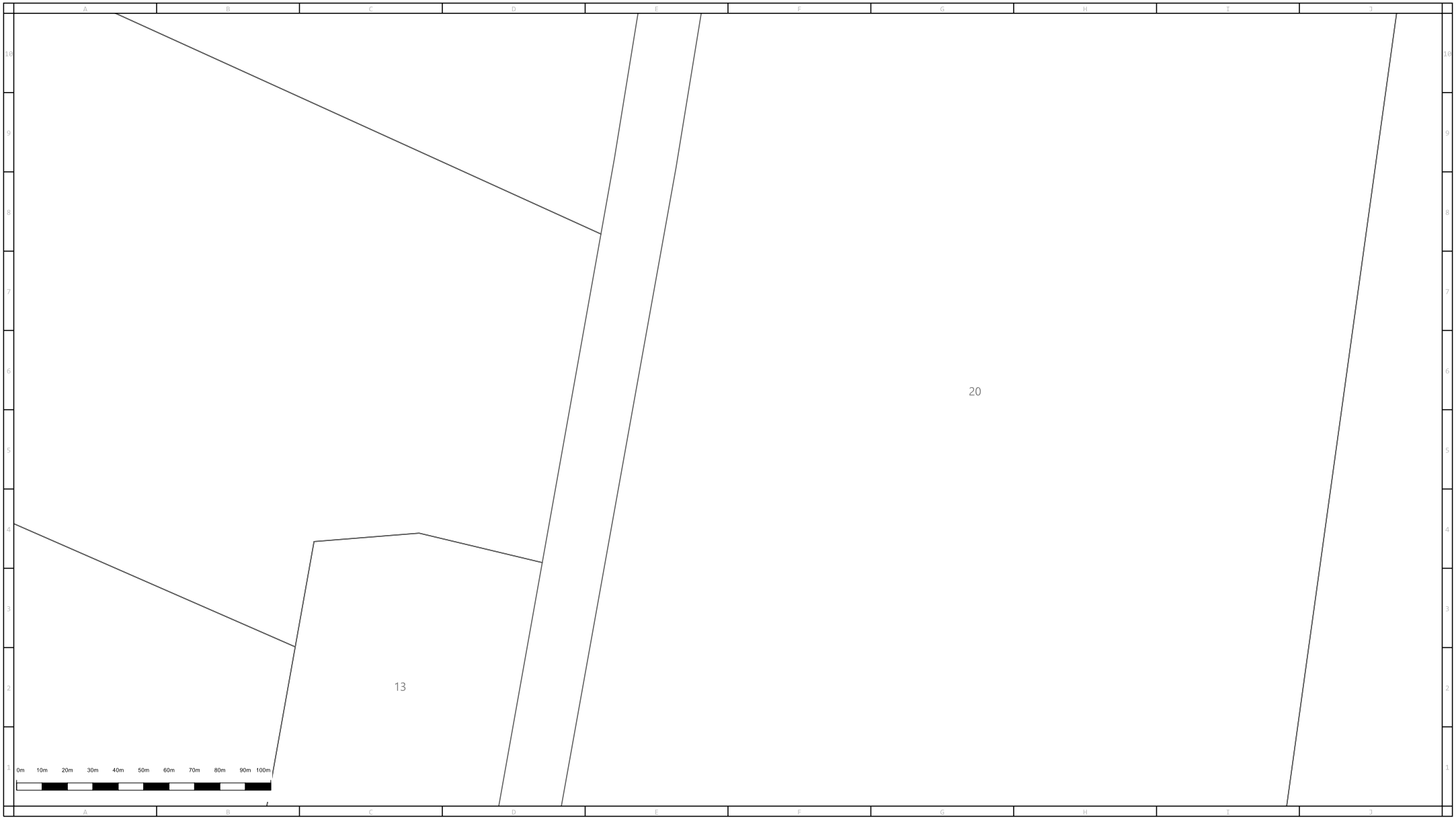
Scale: 1:2000

Issue Date: 07/04/2020
DBYD Seq No: 96491435
DBYD Job No: 19329302

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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

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Distribution - 30 kPa		
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Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
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Siphon	
Valve	
Regulator Set	
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N W E S

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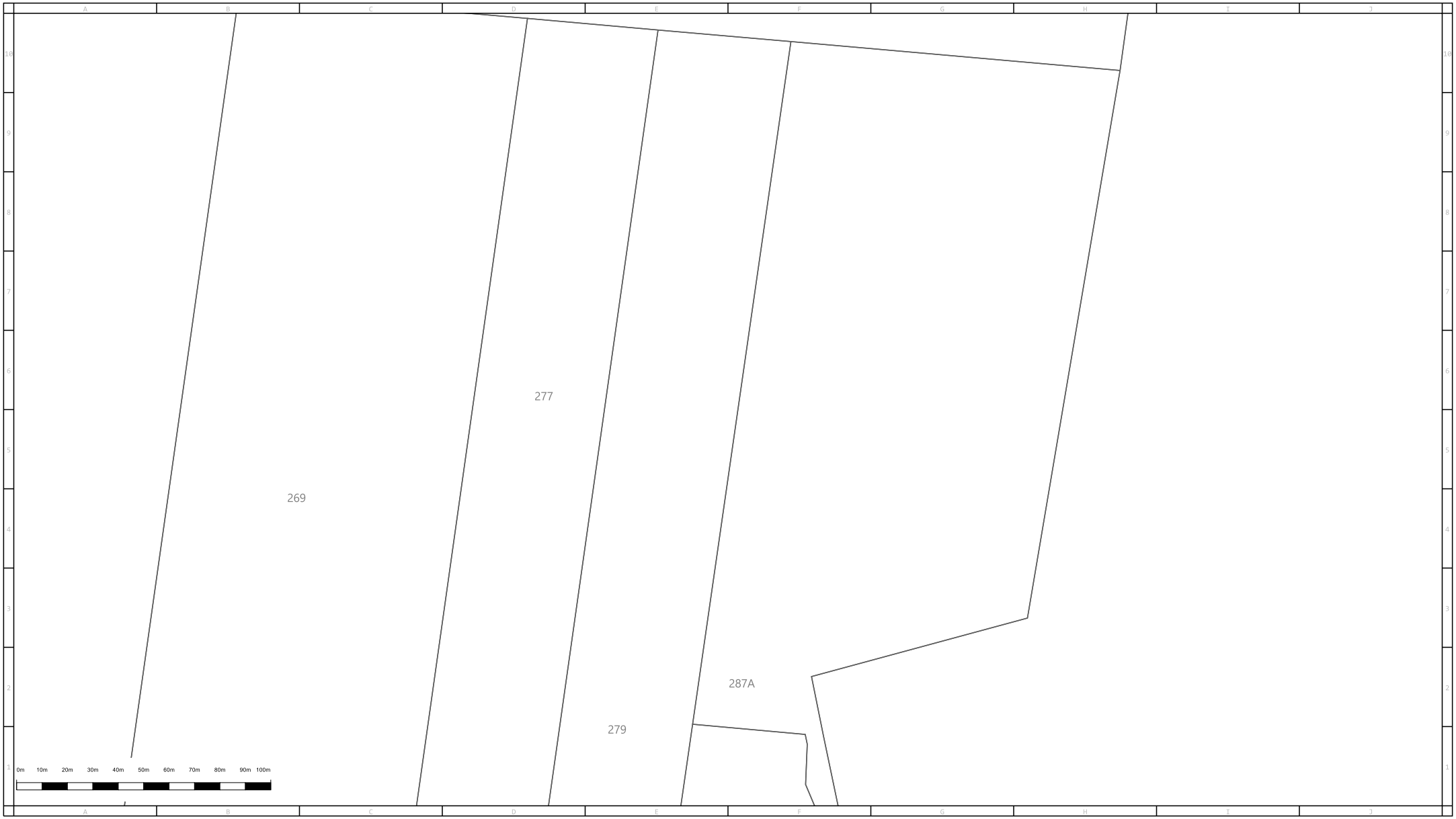
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32mm Nylon main inserted into 50mm Steel Main — (50)MM 32MM NY

N W E S

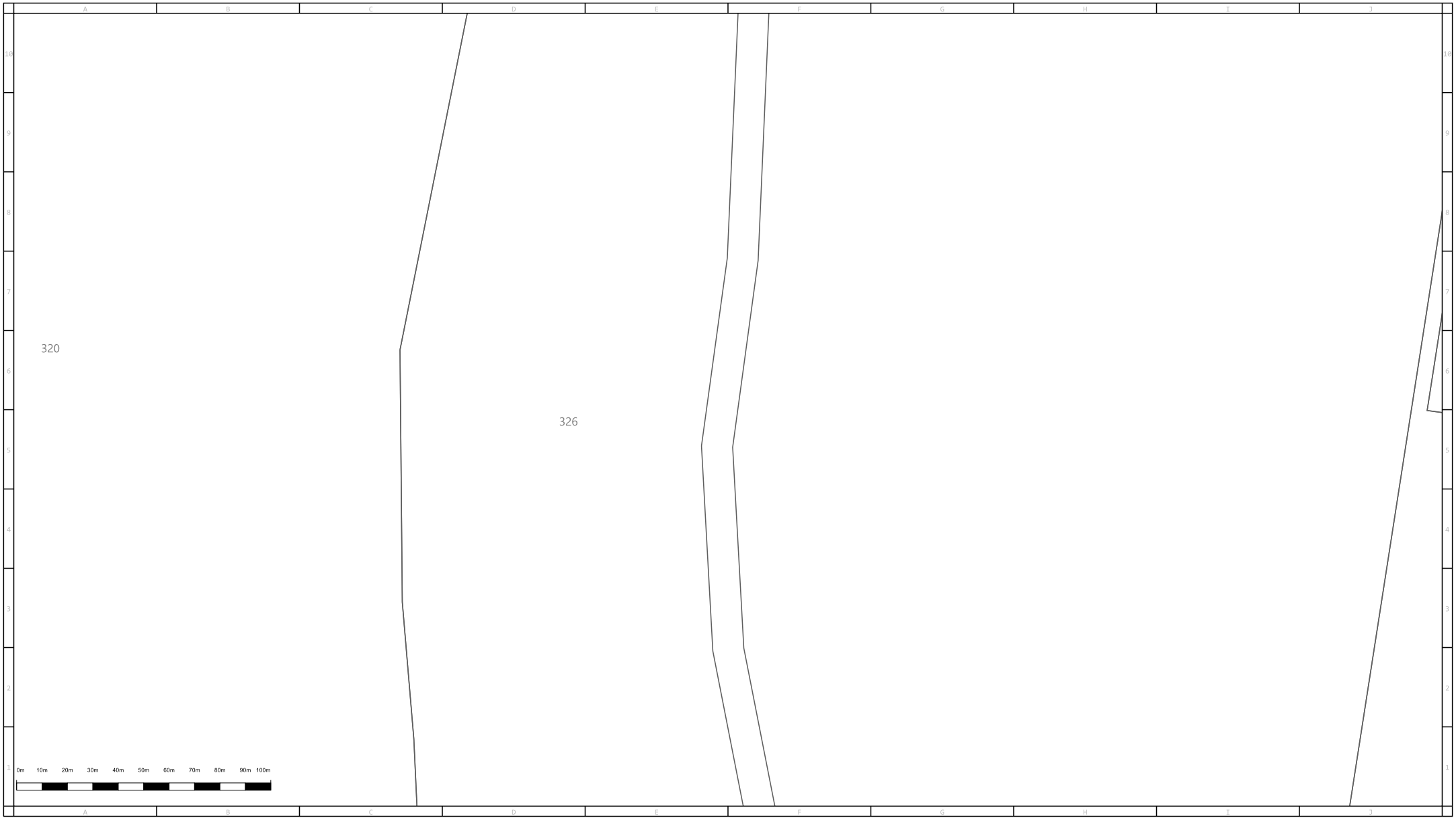
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Issue Date: 07/04/2020
DBYD Seq No: 96491435
DBYD Job No: 19329302

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DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
MBK = Metres Back of Kerb	
MFL = Metres from Fence Line	
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	(6)NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main	(50)MM 32MM NY

N W E S

Scale: 1:2000

Issue Date: 07/04/2020

DBYD Seq No: 96491435

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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	100 PVC
Size & Material (PL - Plastic, PVC, PE, NY, ST)	

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
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N W E S

Scale: 1:2000

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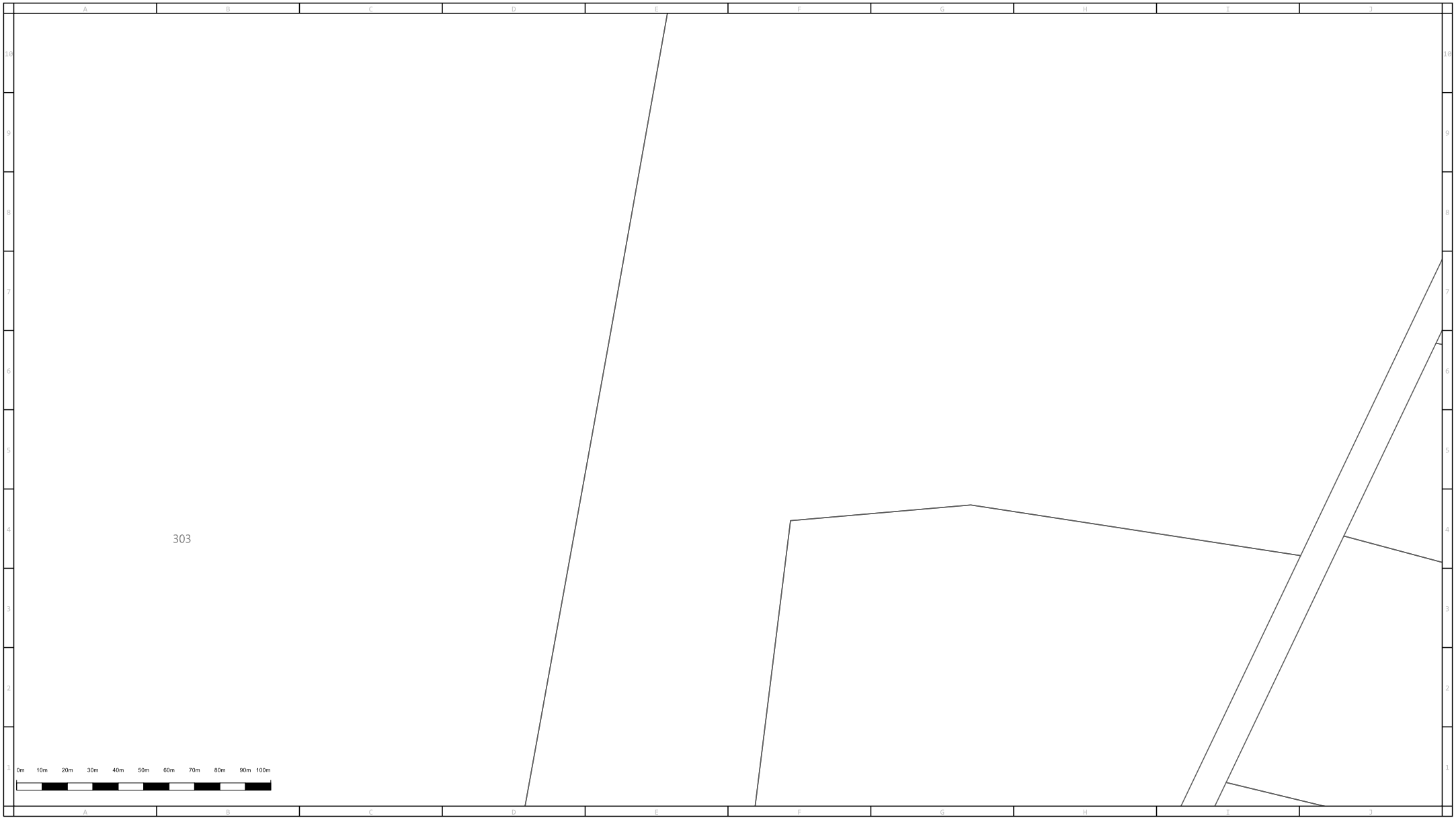
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Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
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N W E S

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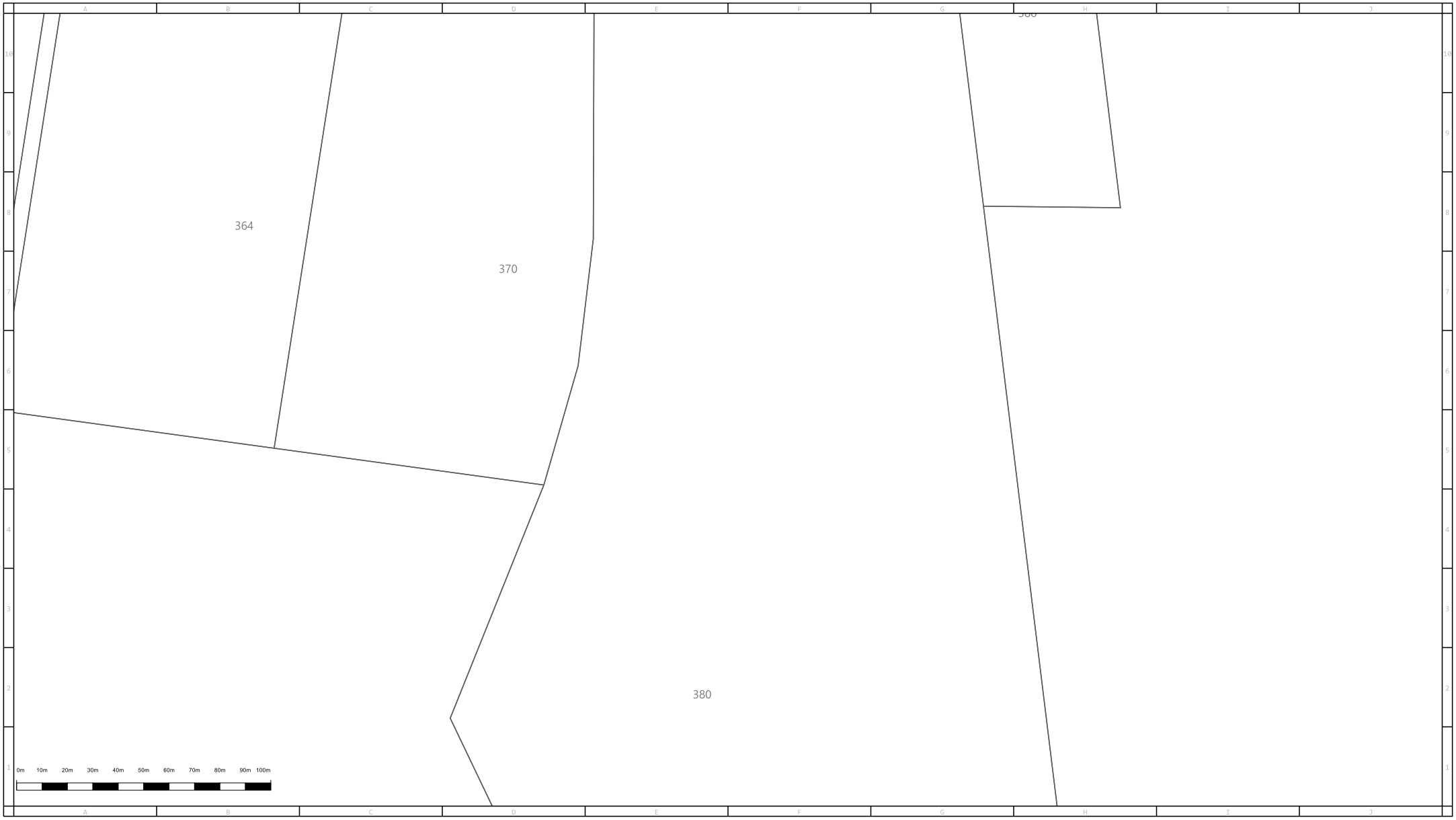
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ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — 6 NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — 50 MM 32MM NY

N W E S

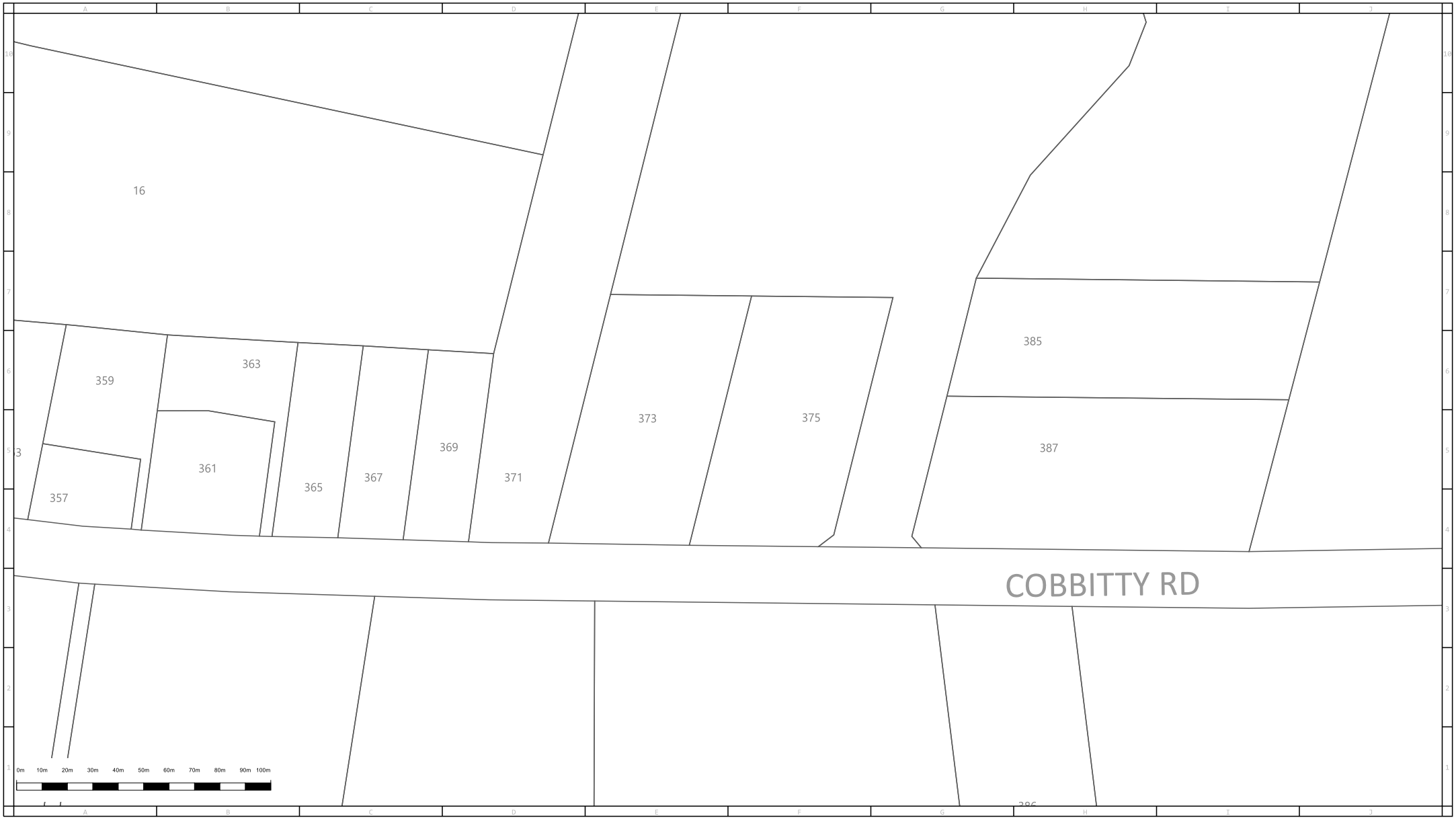
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Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
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MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — (6)NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — (50)MM 32MM NY

N W E S

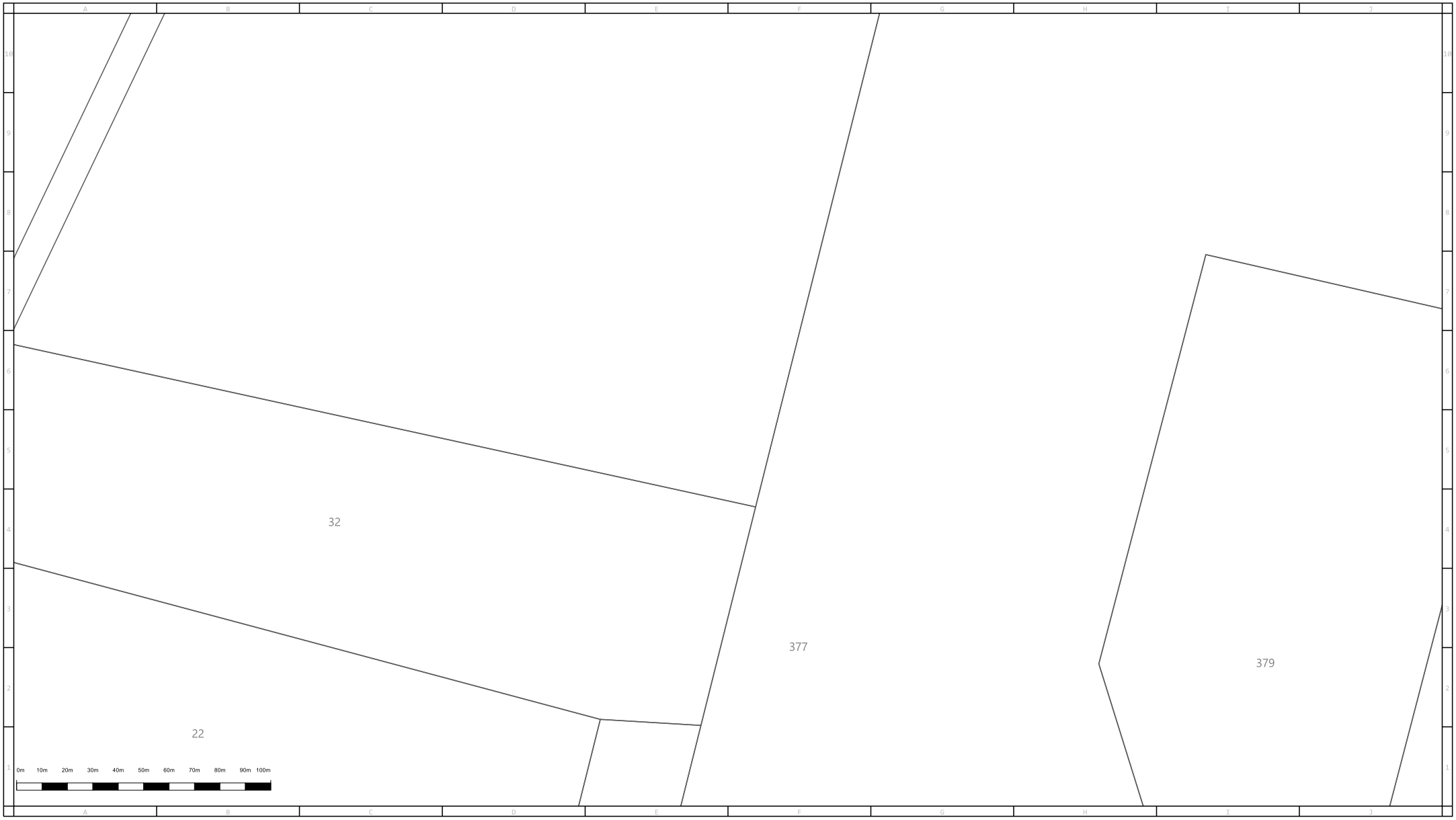
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ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — (6)NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — (50)MM 32MM NY

N W E S

Scale: 1:2000

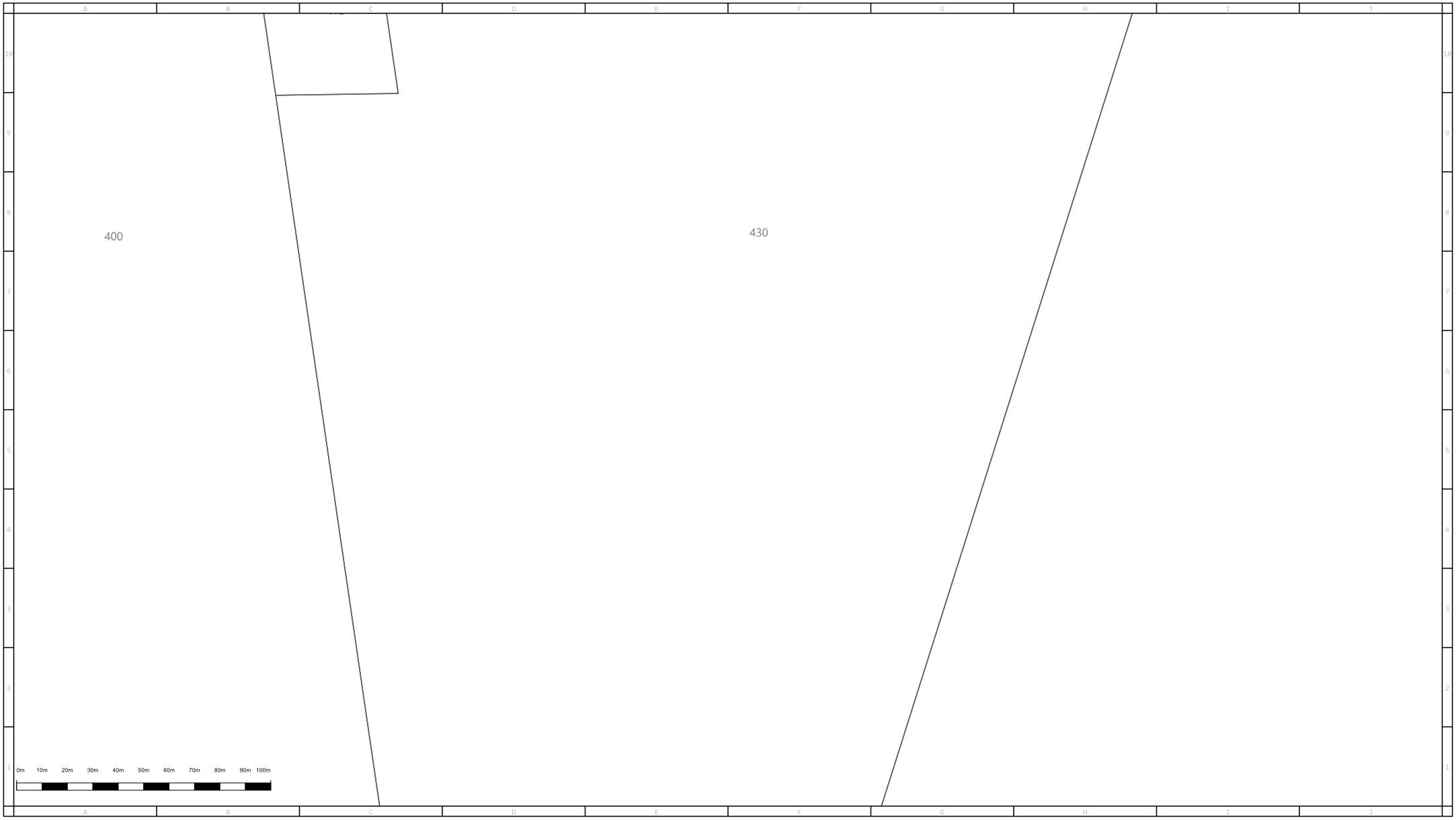
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DBYD Location: Chittick Ln Cobbitty NSW, 2570

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Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
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Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
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50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	(6)NB 50MM NY
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N W E S

Scale: 1:2000

Issue Date: 07/04/2020

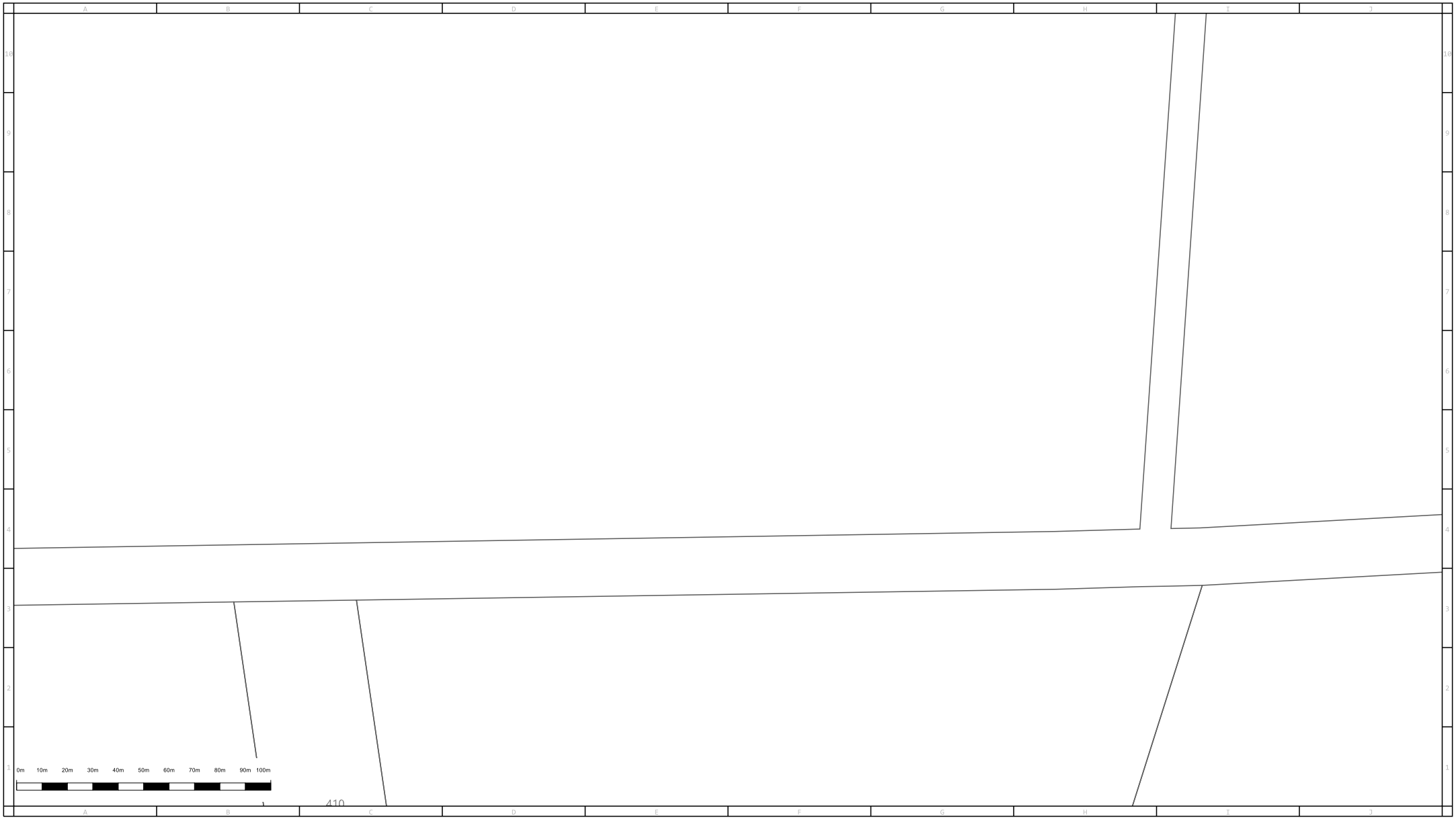
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ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — 6NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — 50MM 32MM NY

N W E S

Scale: 1:2000

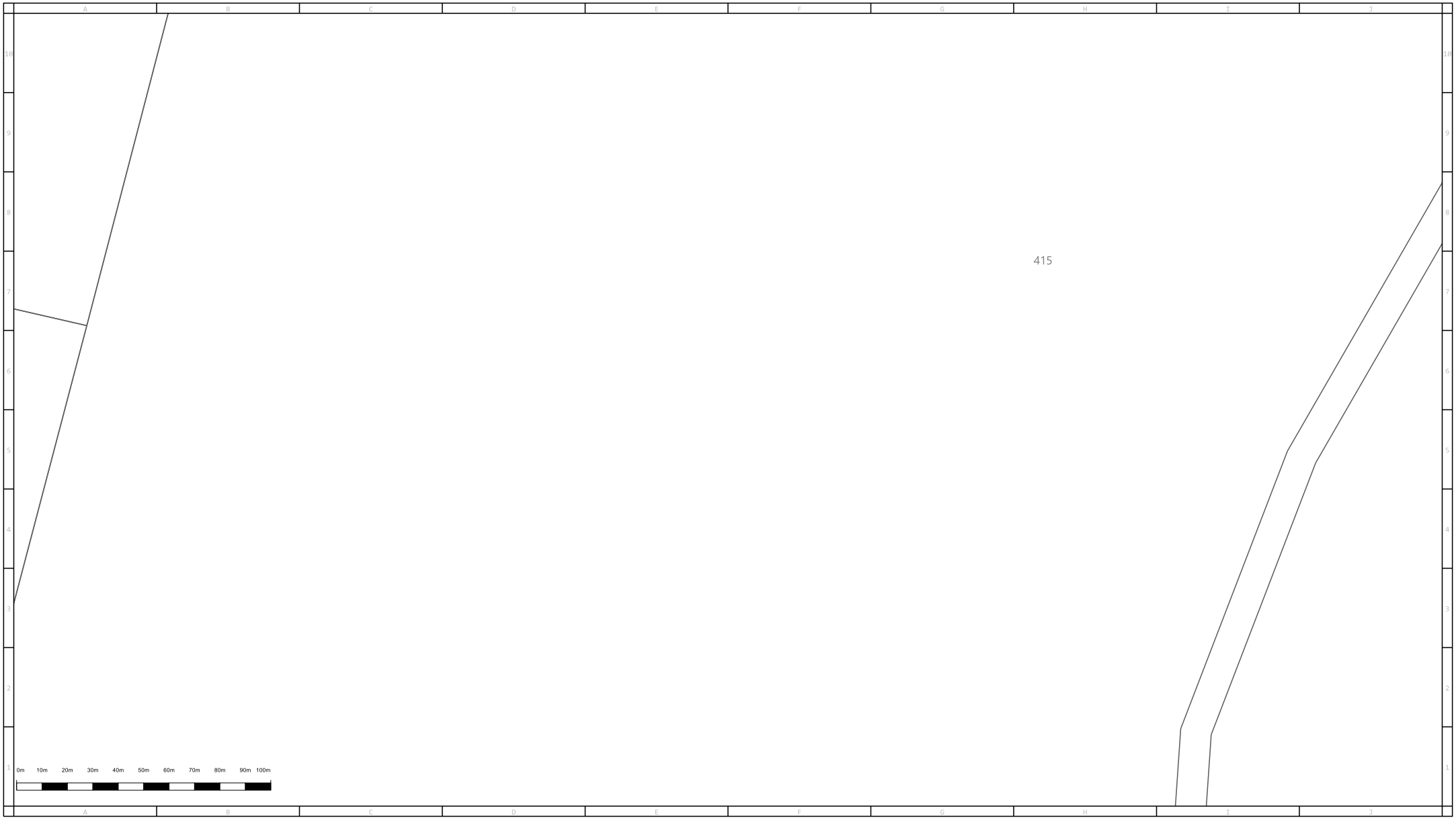
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Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
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50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — (6)NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — (50)MM 32MM NY

N W E S

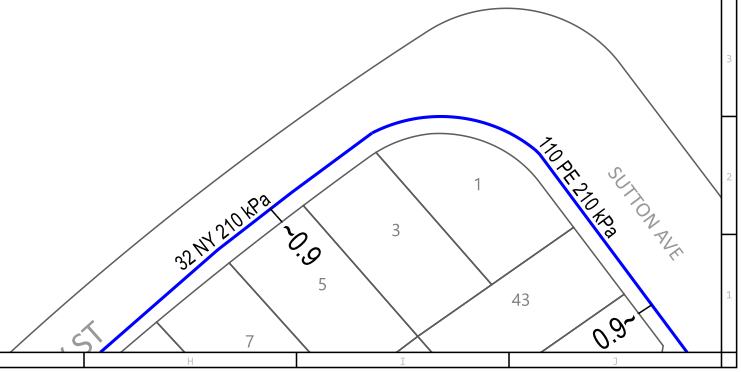
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0m 10m 20m 30m 40m 50m 60m 70m 80m 90m 100m

Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	100 PVC
Size & Material (PL - Plastic, PVC, PE, NY, ST)	

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
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Fittings, Valves & Regulators	
Siphon	
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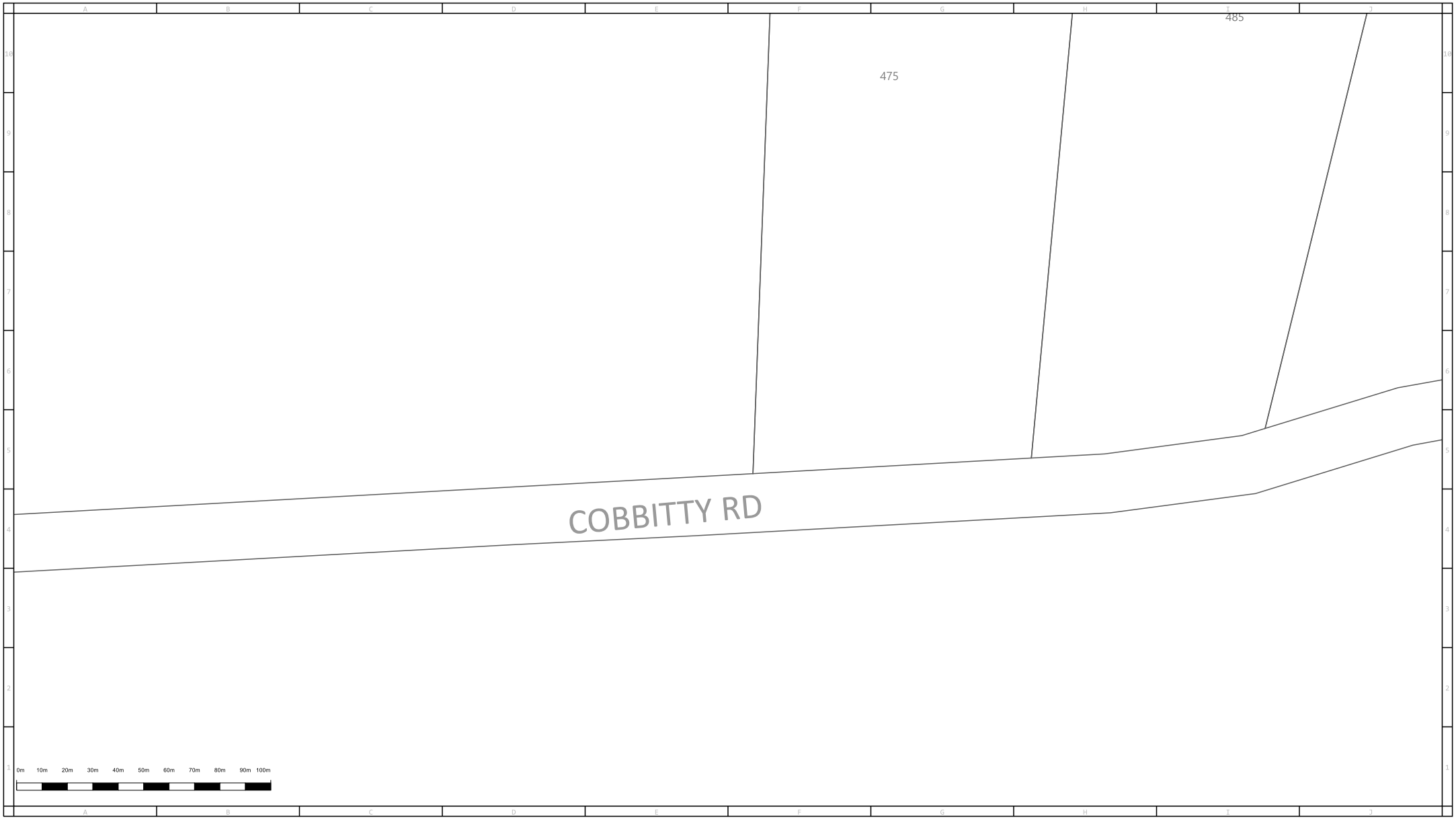
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Main	In Service	Proposed
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Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
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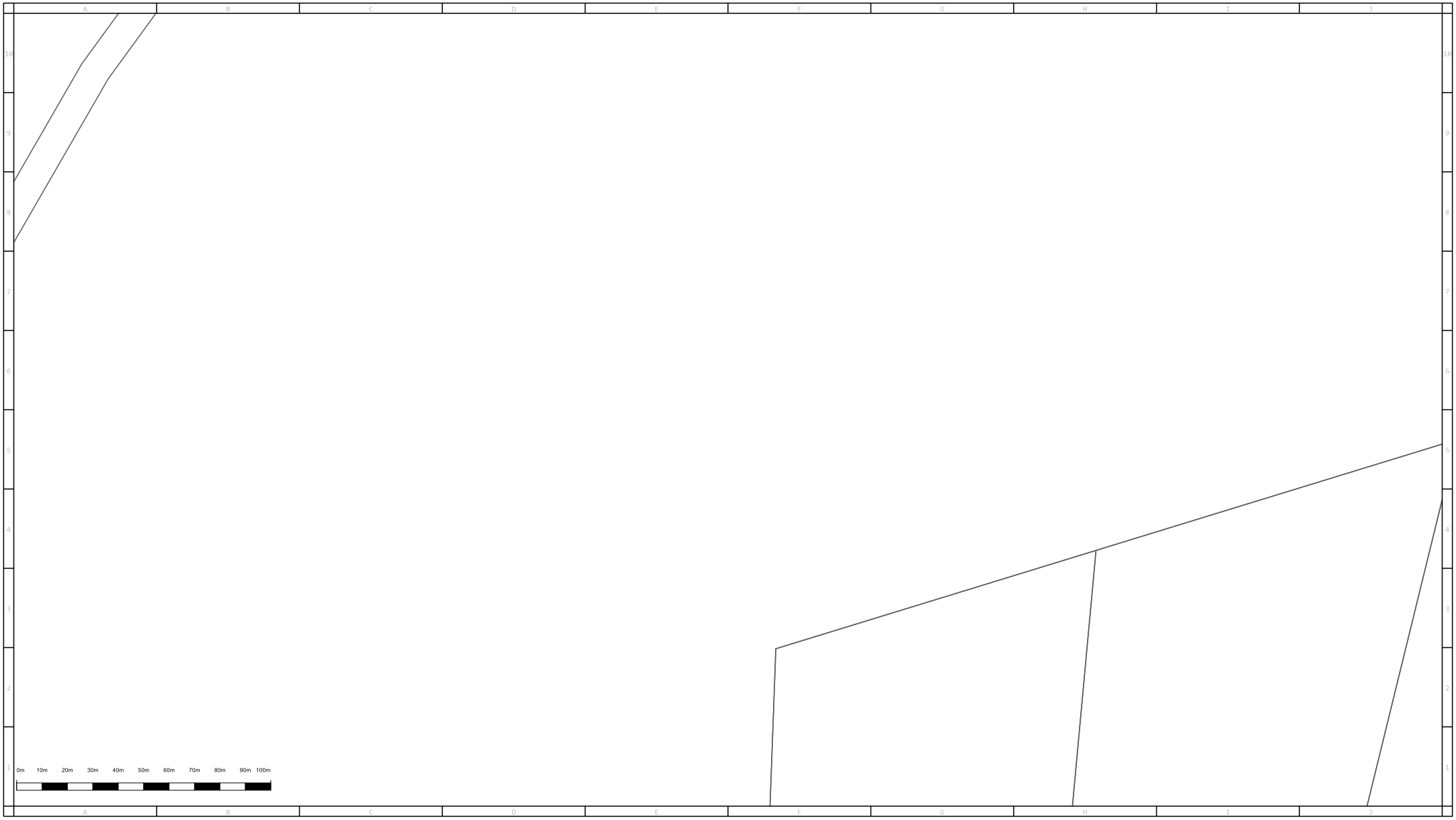
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ABN 87 003 004 322

Main	In Service	Proposed
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Distribution - 2 kPa		
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Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
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Transmission		

Fittings, Valves & Regulators	
Siphon	
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32mm Nylon main inserted into 50mm Steel Main — (50)MM 32MM NY

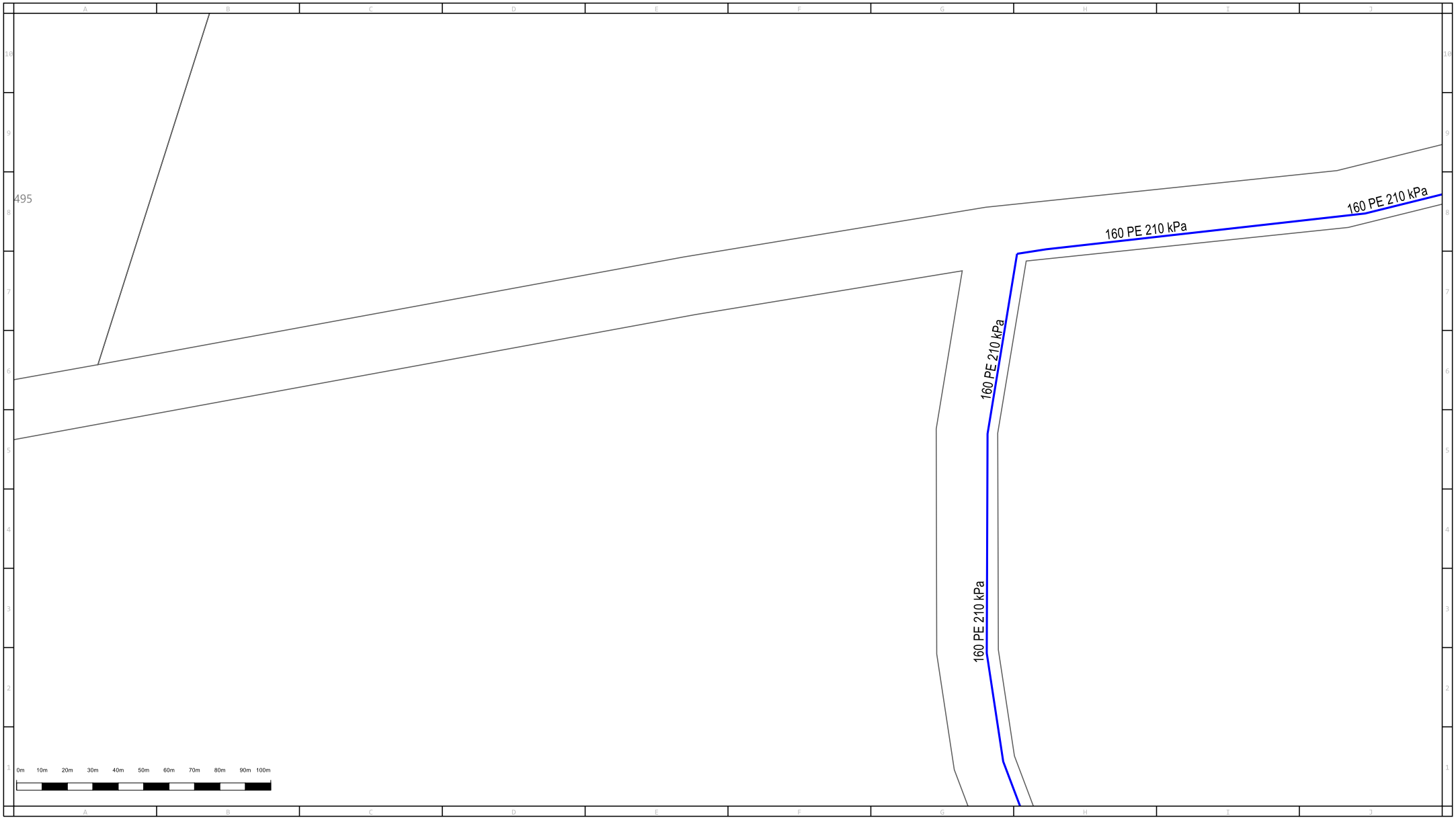
N W E S

Scale: 1:2000

Issue Date: 07/04/2020
DBYD Seq No: 96491435
DBYD Job No: 19329302

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DBYD Authority: Jemena Gas Networks (NSW) **DBYD Location:** Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
MBK = Metres Back of Kerb	
MFL = Metres from Fence Line	
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	6NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main	50MM 32MM NY

N W E S

Scale: 1:2000

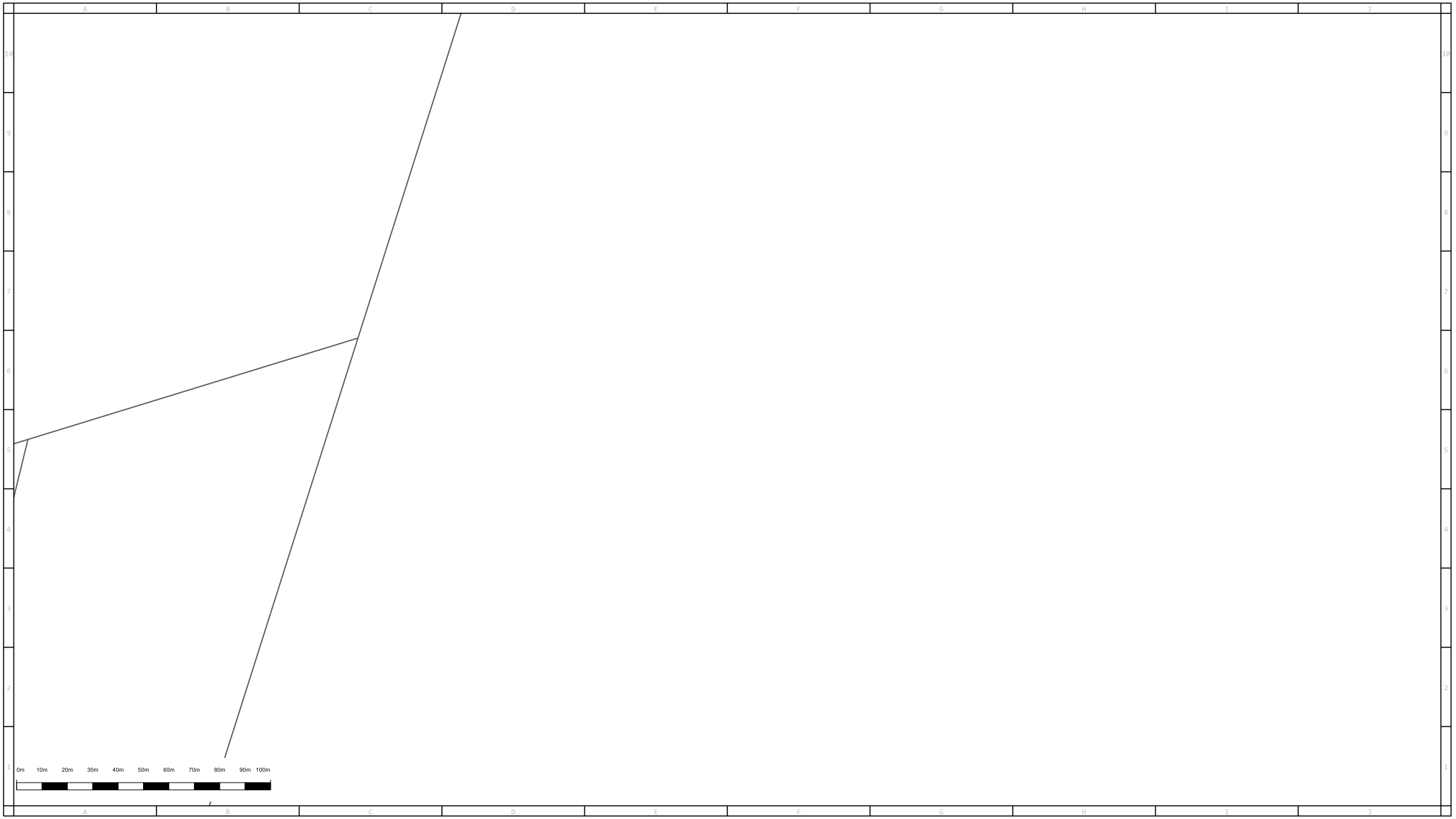
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DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570

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Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
MBK = Metres Back of Kerb	
MFL = Metres from Fence Line	
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	(6)NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main	(50)MM 32MM NY

N W E S

Scale: 1:2000

Issue Date: 07/04/2020

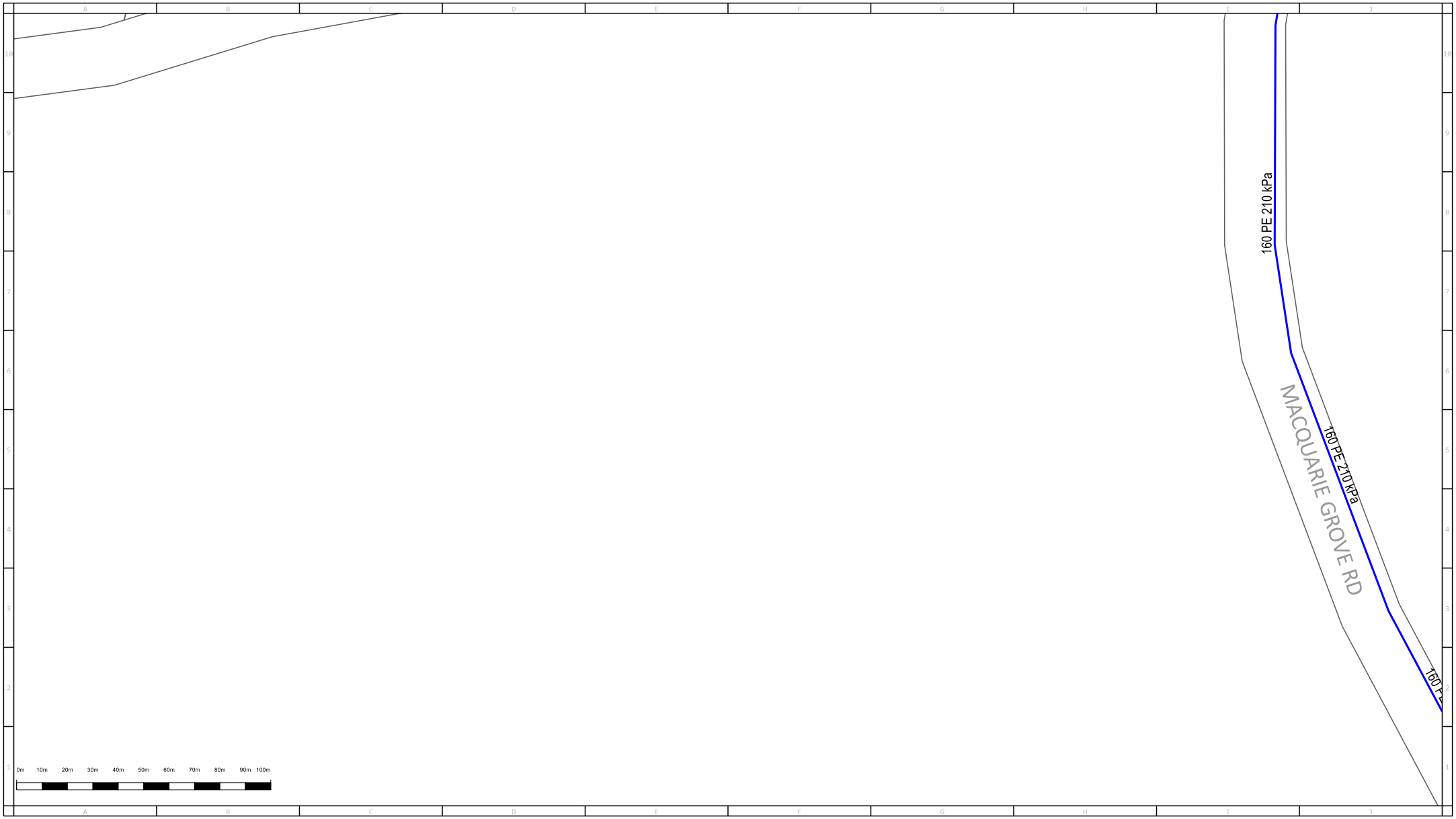
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DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — (6)NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — (50)MM 32MM NY

N W E S

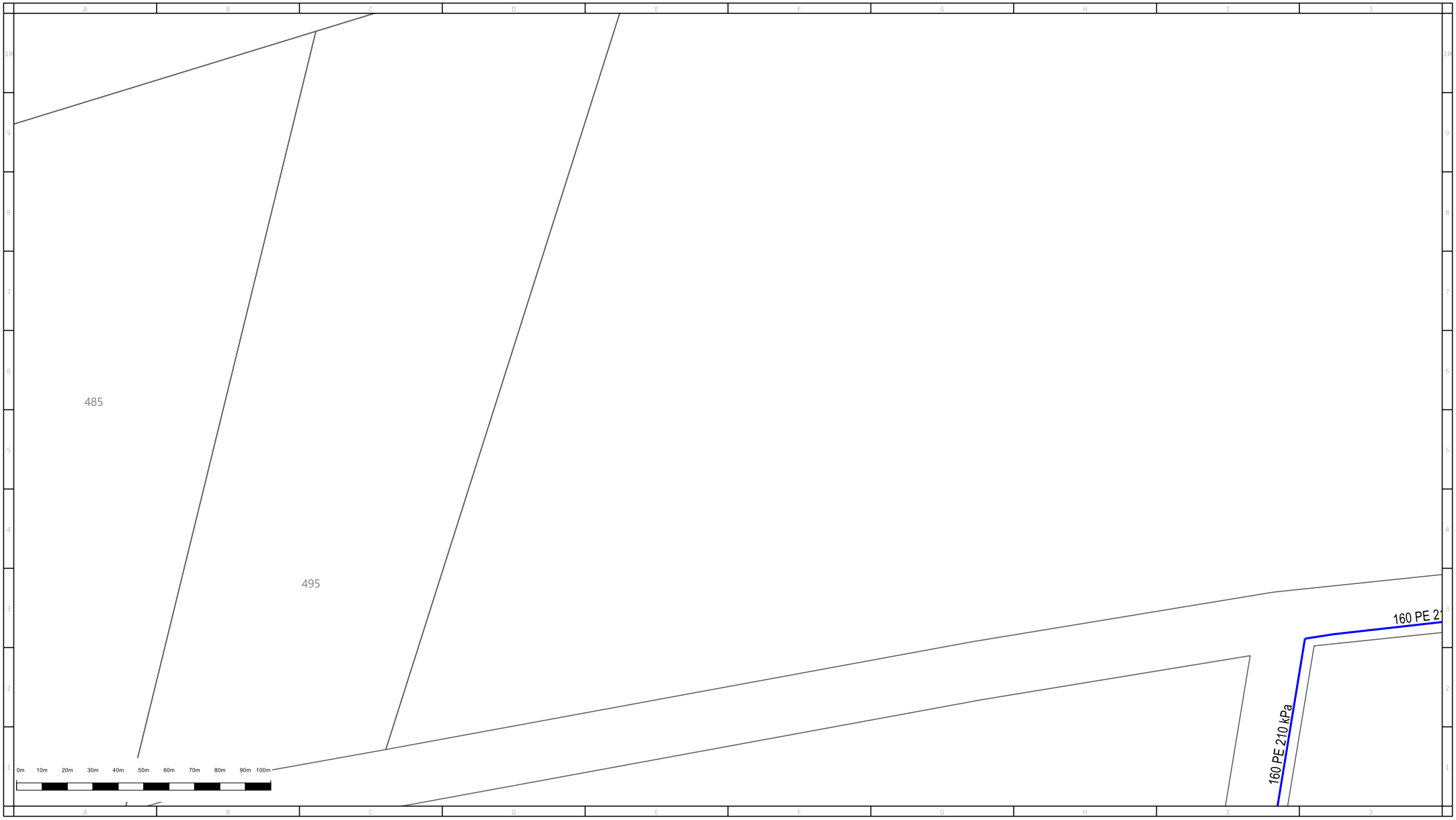
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Issue Date: 07/04/2020
DBYD Seq No: 96491436
DBYD Job No: 19329302

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DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main
Proposed Isolate (coloured according to kPa)
Isolated Service
Conduit or Casing
Size & Material (PL - Plastic, PVC, PE, NY, ST)

100 PVC

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — 6 NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — 50 MM 32MM NY

N W E S

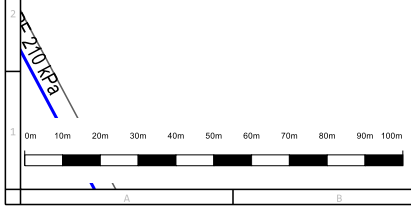
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DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570



1

Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — 6NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — 50MM 32MM NY

N W E S

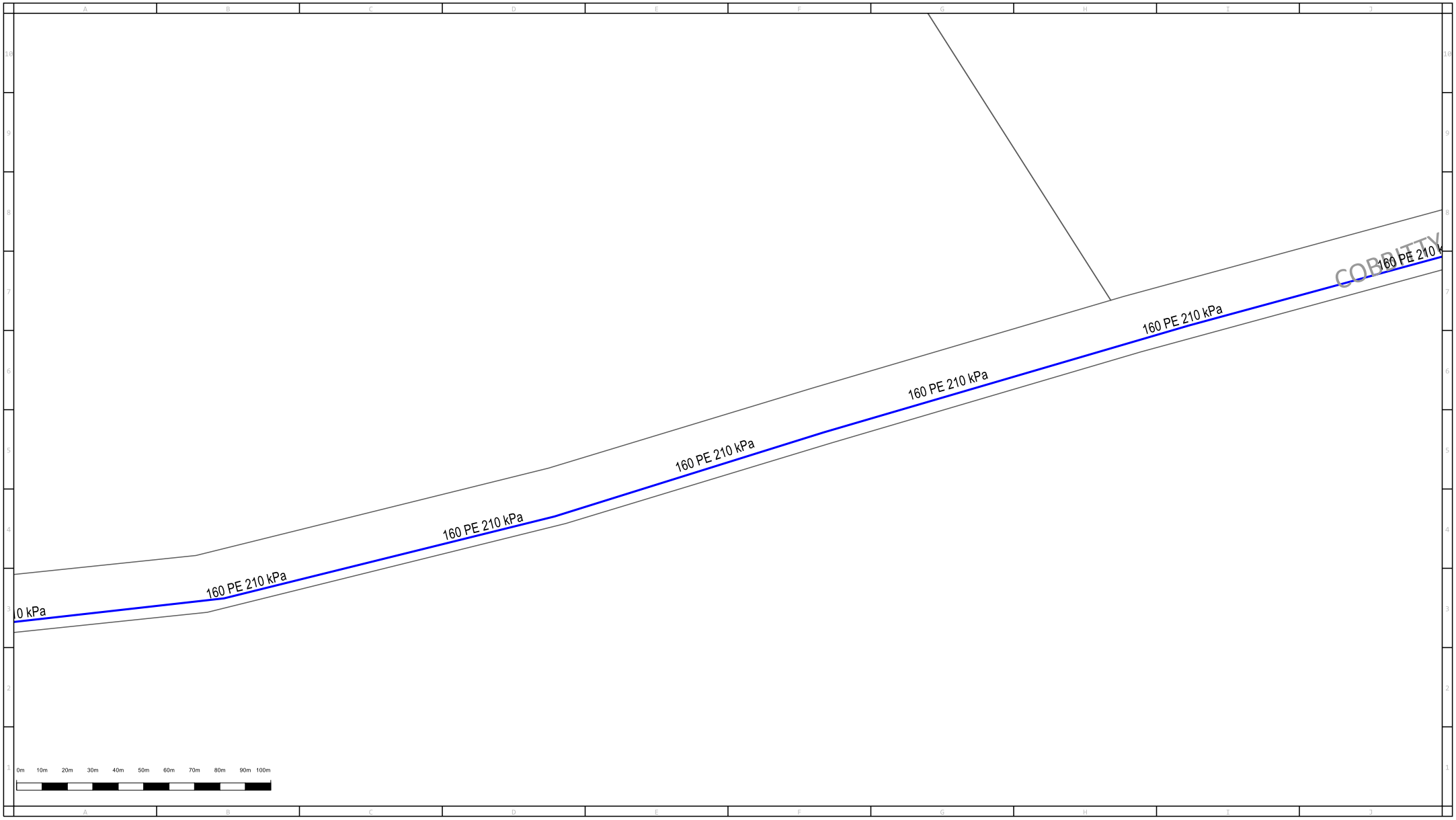
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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line

50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main — 6NB 50MM NY

32mm Nylon main inserted into 50mm Steel Main — 50MM 32MM NY

N W E S

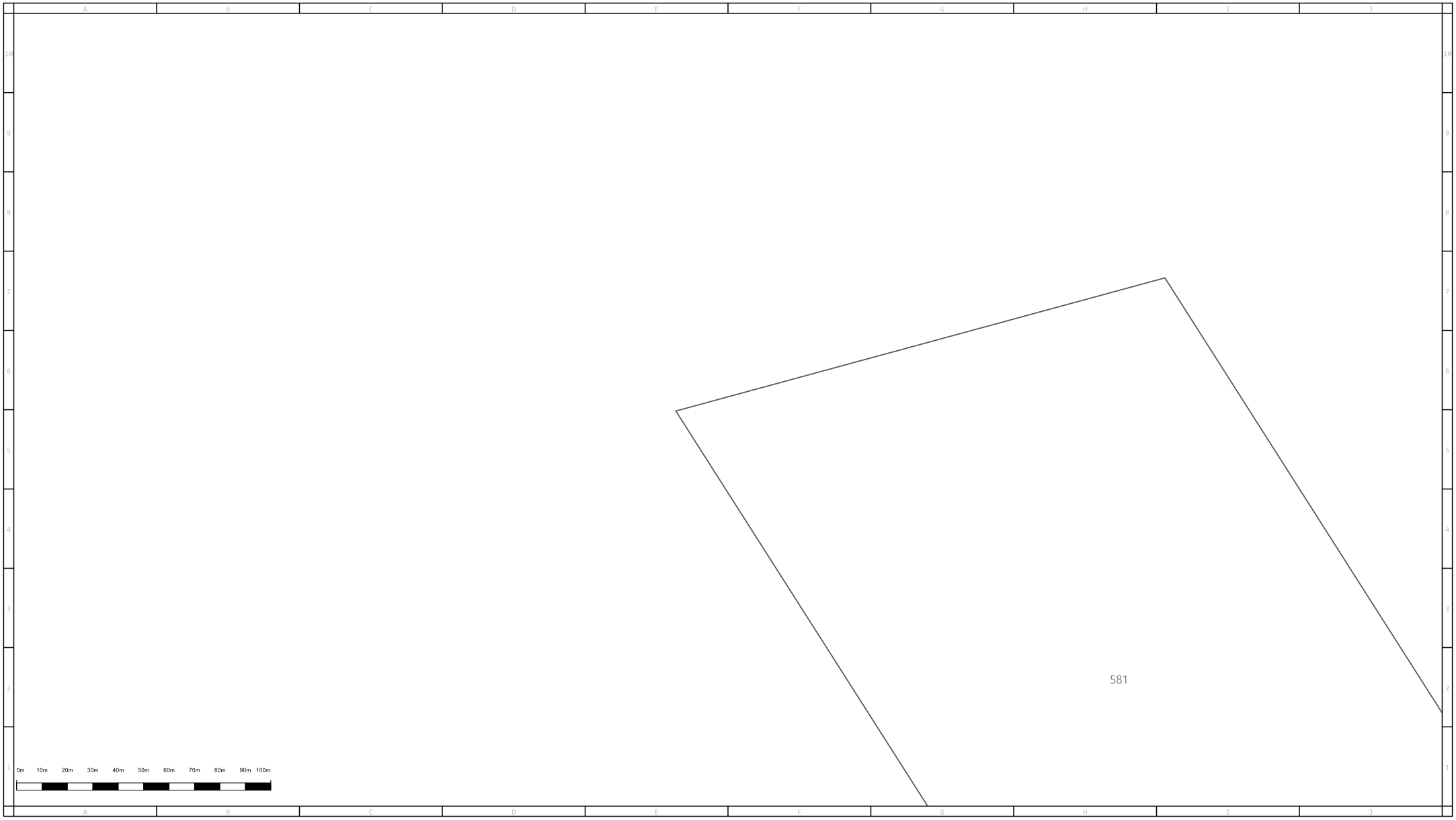
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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	
Distance in metres of Main from Boundary Line	~1.5
MBK = Metres Back of Kerb	
MFL = Metres from Fence Line	
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	(6)NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main	(50)MM 32MM NY

N W E S

Scale: 1:2000

Issue Date: 07/04/2020

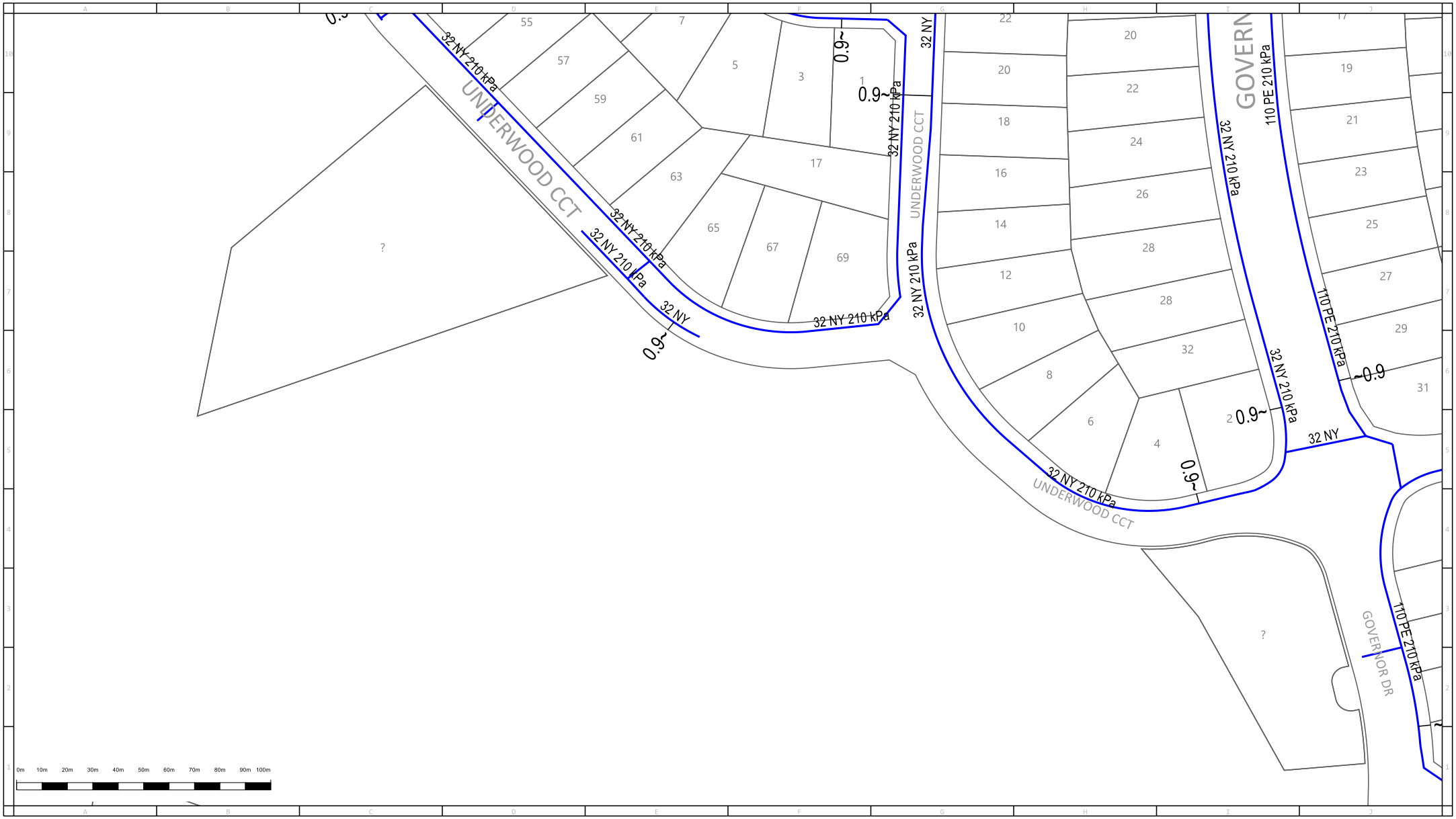
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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	100 PVC

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	
Distance in metres of Main from Boundary Line	~1.5
MBK = Metres Back of Kerb	
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50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	6NB 50MM NY
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N W E S

Scale: 1:2000

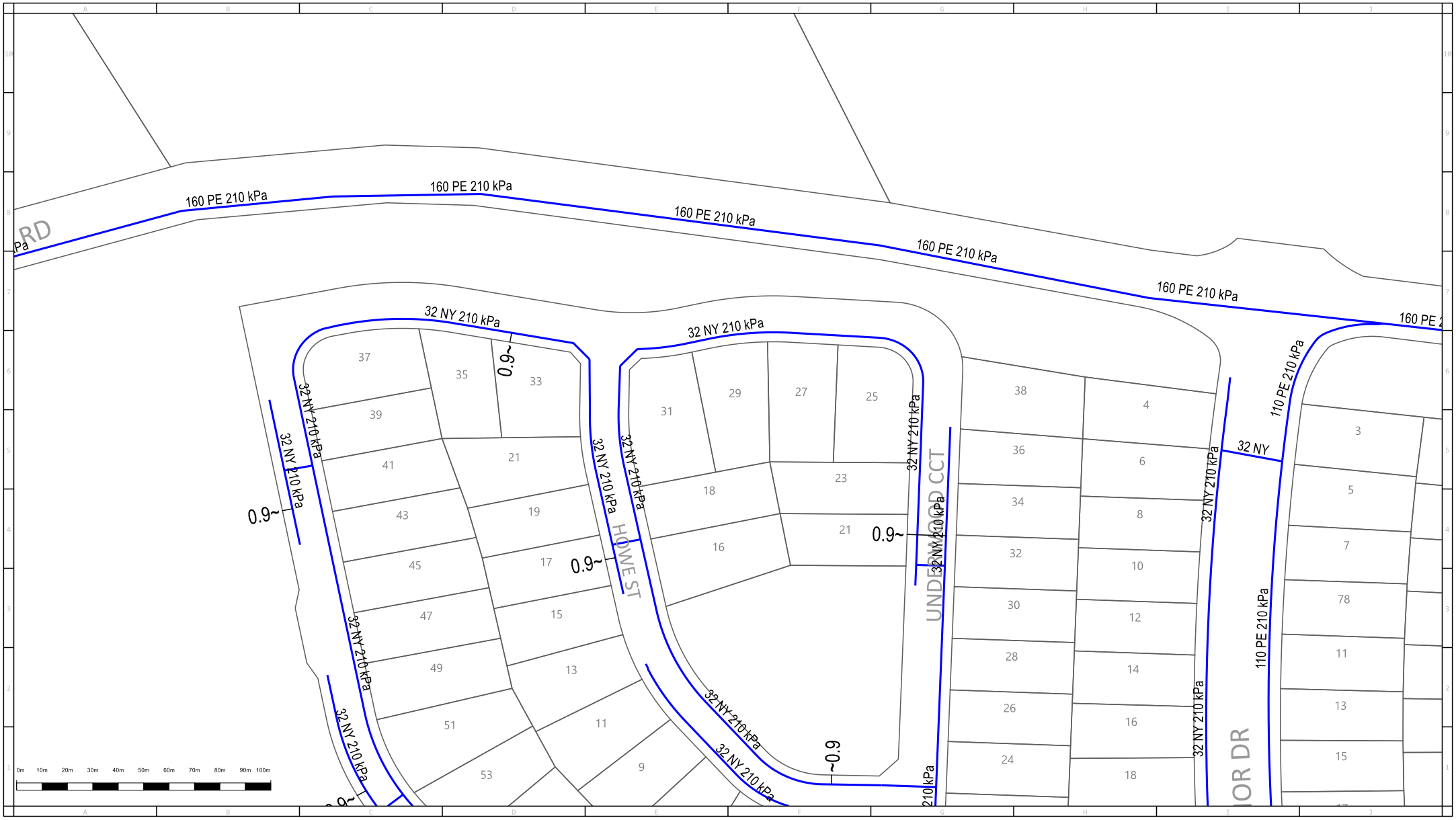
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Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	100 PVC
Size & Material (PL - Plastic, PVC, PE, NY, ST)	

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line	~1.5
MBK = Metres Back of Kerb	
MFL = Metres from Fence Line	
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	6 NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main	50 MM 32MM NY

N W E S

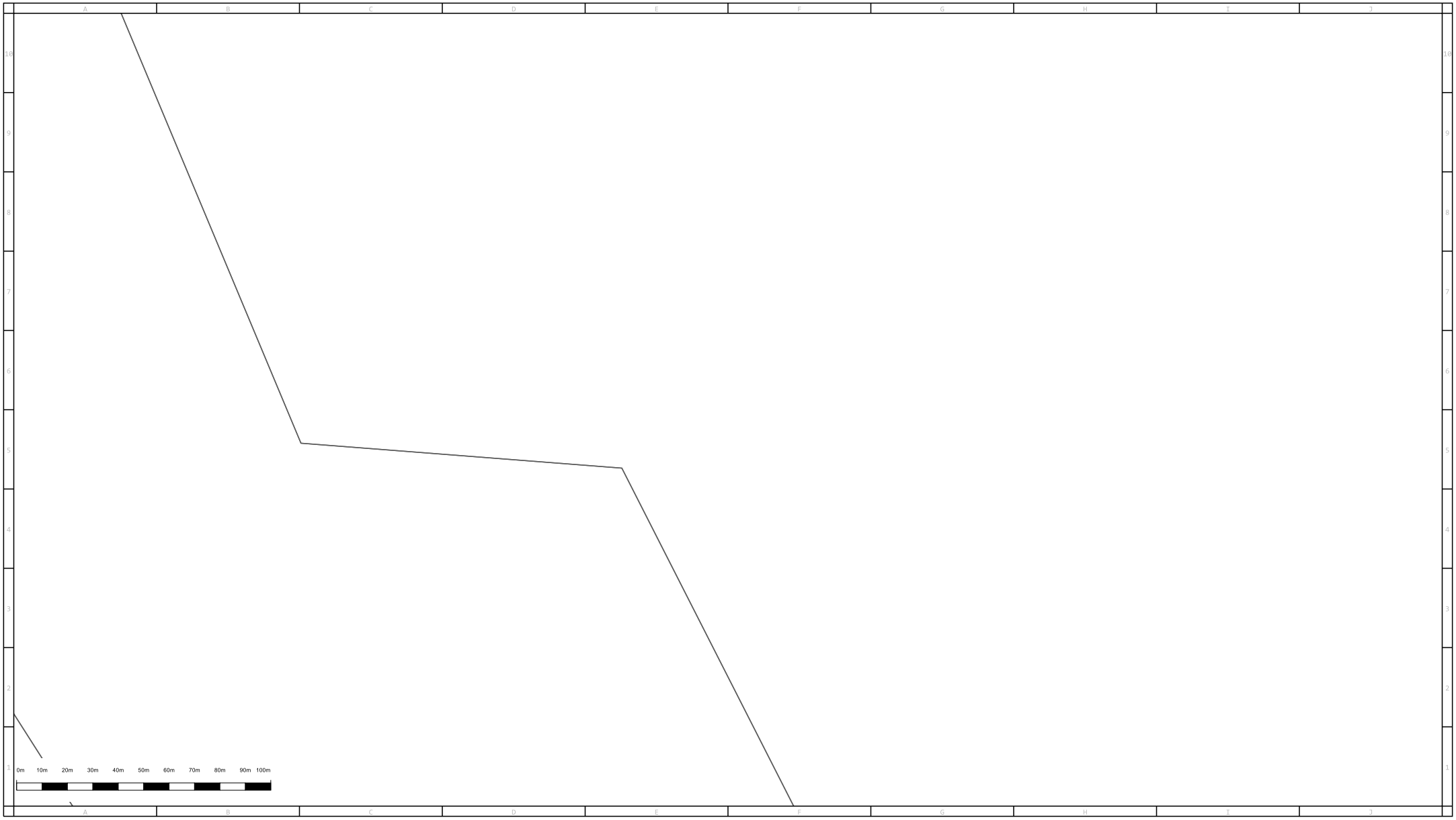
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Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
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JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5

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50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main (6)NB 50MM NY

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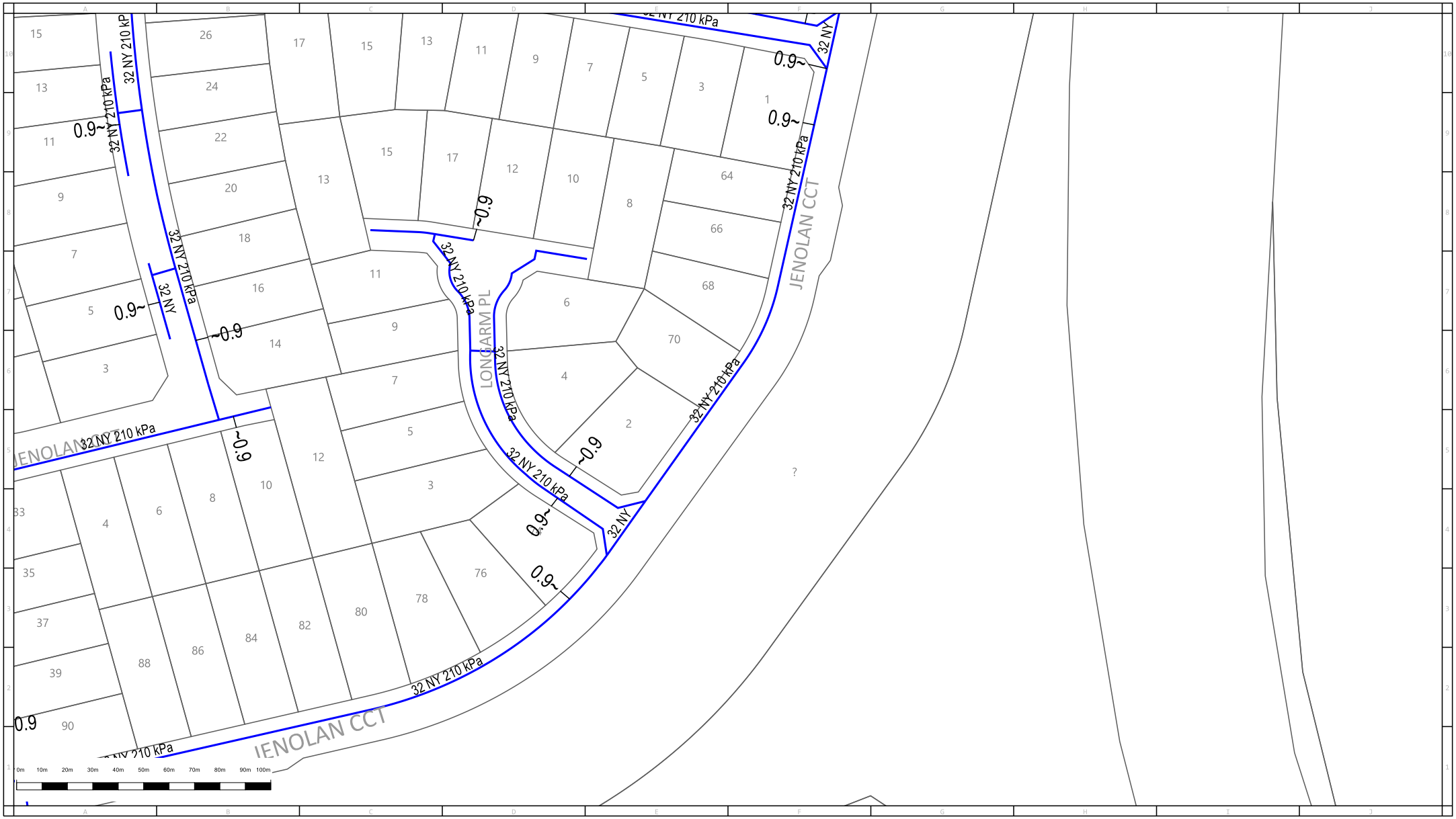
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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
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Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	100 PVC

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
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JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
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N W E S

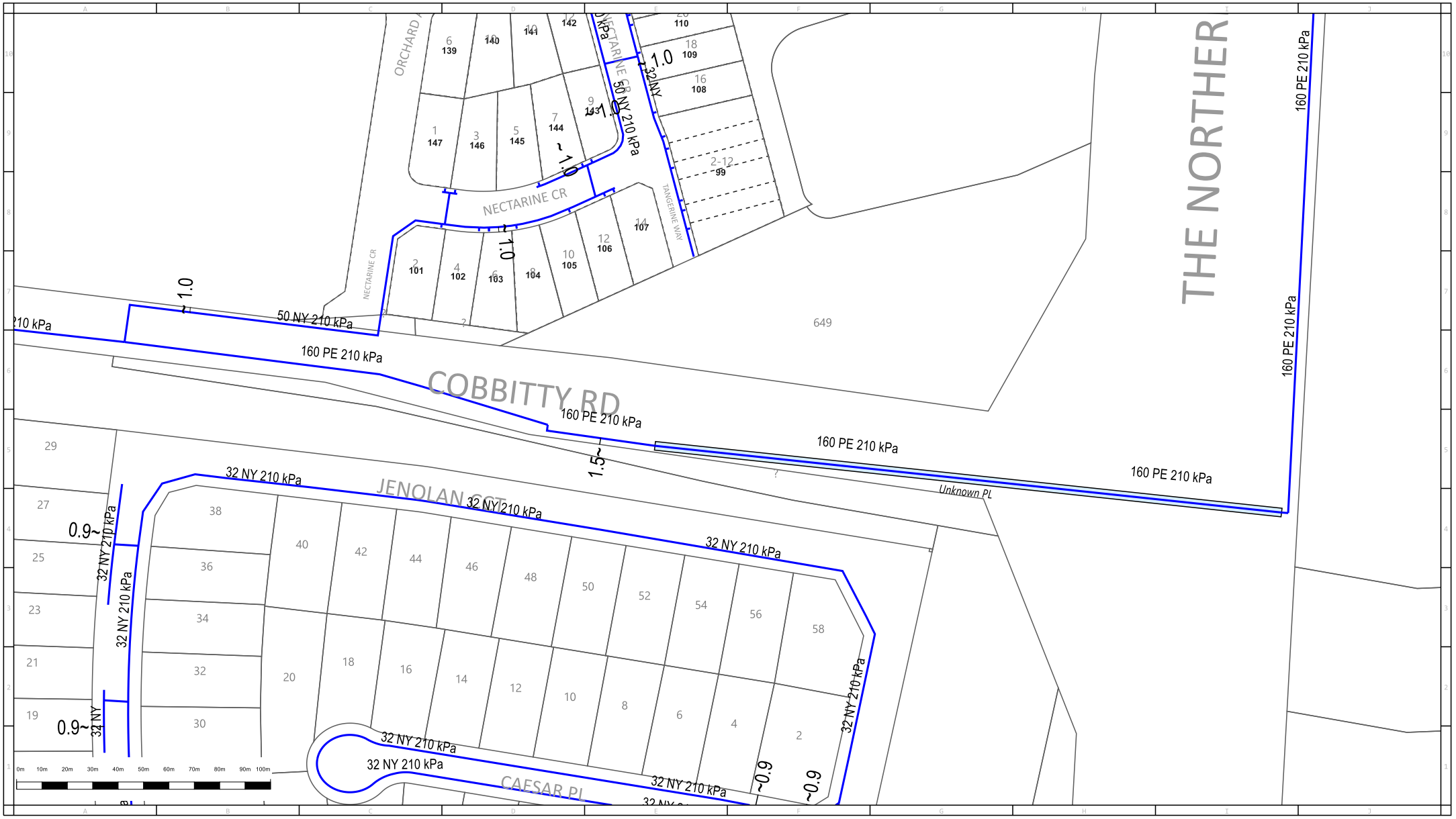
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DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	
Size & Material (PL - Plastic, PVC, PE, NY, ST)	*100 PVC*

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
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Regulator Set	
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Automatic Line Break Valve	
Distance in metres of Main from Boundary Line	~1.5
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N W E S

Scale: 1:2000

Issue Date: 07/04/2020

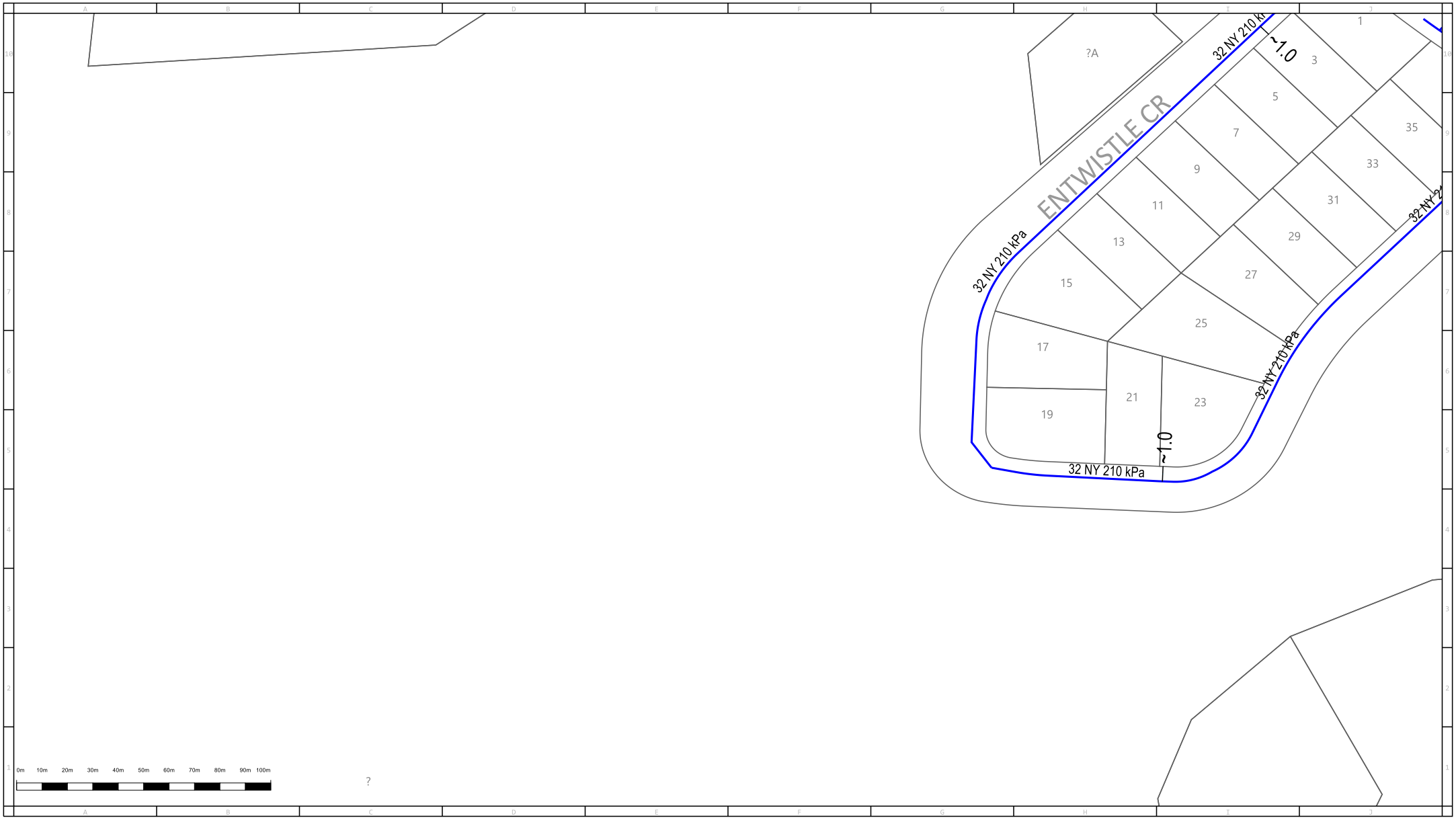
DBYD Seq No: 96491436

DBYD Job No: 19329302

WARNING: This is a representation of Jemena Gas Networks underground assets only and may not indicate all assets in the area. It must not be used for the purpose of exact asset location in order to undertake any type of excavation. This plan is diagramatic only, and distances scaled from this plan may not be accurate. Please read all conditions and information on the attached information sheet. This extract is subject to those conditions. The information contained on this plan is only valid for 28 days from the date of issue.

DBYD Authority: Jemena Gas Networks (NSW)

DBYD Location: Chittick Ln Cobbitty NSW, 2570



Jemena
ABN 87 003 004 322

Main	In Service	Proposed
Unknown Pressure		
Distribution - 2 kPa		
Distribution - 7 kPa		
Distribution - 30 kPa		
Distribution - 100 kPa		
Distribution - 210 kPa		
Distribution - 300 kPa		
Distribution - 400 kPa		

Main	
Proposed Isolate (coloured according to kPa)	
Isolated Service	
Conduit or Casing	100 PVC
Size & Material (PL - Plastic, PVC, PE, NY, ST)	

High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
Isolated Steel Main (Treat as High Pressure Main)		
Primary - 3500 kPa		
JGN Trunk - 7000 kPa		
Transmission		

Fittings, Valves & Regulators	
Siphon	
Valve	
Regulator Set	
Regulator Station	
Automatic Line Break Valve	

Distance in metres of Main from Boundary Line ~1.5
MBK = Metres Back of Kerb
MFL = Metres from Fence Line
50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main (6)NB 50MM NY
32mm Nylon main inserted into 50mm Steel Main (50)MM 32MM NY

N W E S

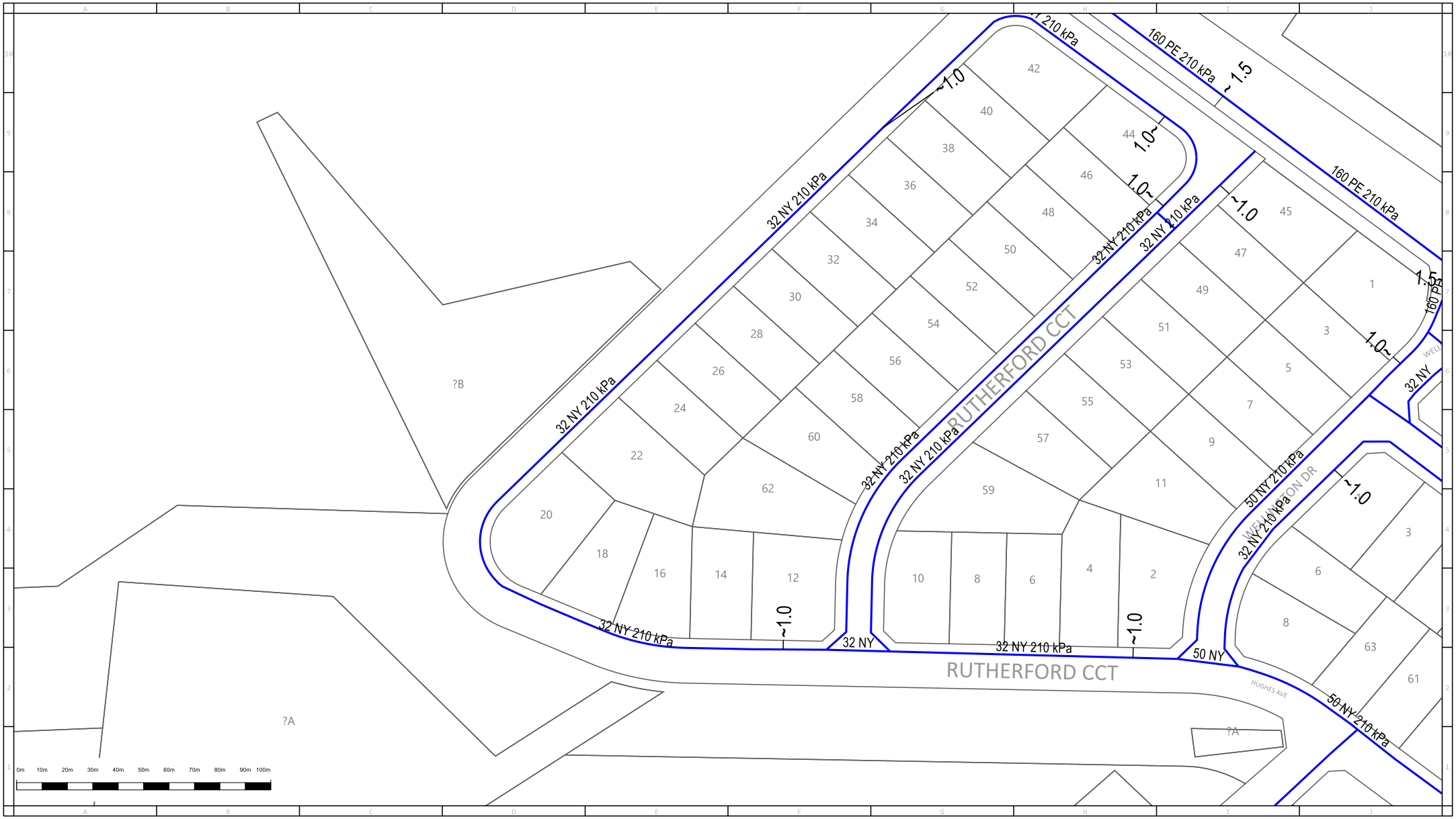
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High Pressure Main & Pipeline	In Service	Proposed
Critical Main (Treat as High Pressure Main)		
Secondary Network - 1050 kPa		
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Primary - 3500 kPa		
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Transmission		

Fittings, Valves & Regulators	
Siphon	
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50mm Nylon main inserted in 6 inch (Nominal Bore) Cast Iron Main	(6)NB 50MM NY
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N W E S

Scale: 1:2000

Issue Date: 07/04/2020

DBYD Seq No: 96491436

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Working near nbn™ cables

nbn has partnered with Dial Before You Dig to give you a single point of contact to get information about **nbn** underground services owned by **nbn** and other utility/service provider in your area including communications, electricity, gas and other services. Contact with underground power cables and gas services can result in serious injury to the worker, and damage and costly repairs. You must familiarise yourself with all of the Referral Conditions (meaning the referral conditions referred to in the DBYD Notice provided by **nbn**).

Practice safe work habits

Once the DBYD plans are reviewed, the Five P's of Excavation should be adopted in conjunction with your safe work practices (which must be compliant with the relevant state Electrical Safety Act and Safe Work Australia "Excavation Work Code of Practice", as a minimum) to ensure the risk of any contact with underground **nbn** assets are minimised.

Plan: Plan your job ensuring the plans received are current and apply to the work to be performed. Also check for any visual cues that may indicate the presence of services not covered in the DBYD plans.

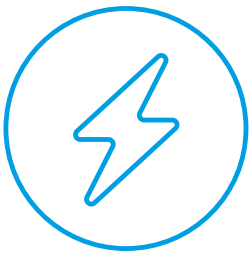
Prepare: Prepare for your job by engaging a DBYD qualified Plant Locator to help interpret plans and identify on-site assets. Contact **nbn** should you require further assistance.

Pothole: Non-destructive potholing (i.e. hand digging or hydro excavation) should be used to positively locate **nbn** underground assets with minimal risk of contact and service damage.

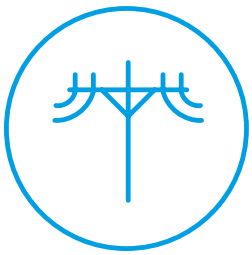
Protect: Protecting and supporting the exposed **nbn** underground asset is the responsibility of the worker. Exclusion zones for **nbn** assets are clearly stated in the plan and appropriate controls must be implemented to ensure that encroachment into the exclusion zone by machinery or activities with the potential to damage the asset is prevented.

Proceed: Proceed only when the appropriate planning, preparation, potholing and protective measures are in place.

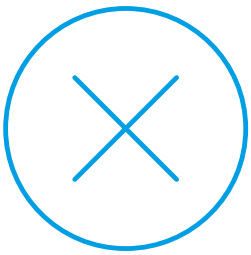
Working near **nbn**™ cables



Identify all electrical hazards, assess the risks and establish control measures.



When using excavators and other machinery, also check the location of overhead power lines.



Workers and equipment must maintain safety exclusion zones around power lines.

Once all work is completed, the excavation should be re-instated with the same type of excavated material unless specified by **nbn**. Please note:

- Construction Partners of **nbn** may require additional controls to be in place when performing excavation activities.
- The information contained within this pamphlet must be used in conjunction with other material supplied as part of this request for information to adequately control the risk of potential asset damage.

Contact

In the event of the **nbn**™ network facility damage please call 1800 626 329

Disclaimer

This brochure is a guide only. It does not address all the matters you need to consider when working near our cables. You must familiarise yourself with other material provided (including the Referral Conditions) and make your own inquiries as appropriate.

nbn will not be liable or responsible for any loss, damage or costs incurred as a result of reliance on this brochure.

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DIAL BEFORE YOU DIG
www.1100.com.au

To:	Miss Phoebe Connor
Phone:	Not Supplied
Fax:	Not Supplied
Email:	phoebec@atl.net.au

Dial before you dig Job #:	19329302	DIAL BEFORE YOU DIG www.1100.com.au
Sequence #	96491438	
Issue Date:	06/04/2020	
Location:	Chittick Ln , Cobbitty , NSW , 2570	Some impact. No onsite action required.

Information

The area of interest requested by you contains one or more assets.

nbn Assets	Search Results
Communications	Asset identified
Electricity	Asset identified

In this notice **NBN Facilities** means *underground fibre optic, telecommunications and/or power facilities, including but not limited to cables, owned and controlled by* ***nbn***

Location of Underground Power Facilities

We thank you for your enquiry. In relation to your enquiry at the above address:

- **nbn's** records indicate that there **ARE nbn** Facilities in the vicinity of the location identified above ("Location").
- **nbn** indicative plan/s are attached with this notice ("Indicative Plans").
- The Indicative Plan/s show general depth and alignment information only and are not an exact, scale or accurate depiction of the location, depth and alignment of **nbn** Facilities shown on the Plan/s.
- In particular, the fact that the Indicative Plans show that a facility is installed in a straight line, or at uniform depth along its length cannot be relied upon as evidence that the facility is, in fact, installed in a straight line or at uniform depth.
- You should read the Indicative Plans in conjunction with this notice and in particular, the notes below.
- You should note that, at the present time, the Indicative Plans are likely to be more accurate in showing location of fibre optics and telecommunications cables than power cables. There may be a variation between the line depicted on the Indicative Plans and the location of any power cables. As such, consistent with the notes below, particular care must be taken by you to make your own enquiries and investigations to precisely locate any power cables and manage the risk arising from such cables accordingly.
- The information contained in the Indicative Plan/s is valid for 28 days from the date of issue set out

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above.You are expected to make your own inquiries and perform your own investigations (including engaging appropriately qualified plant locators at your cost to locate **nbn** Facilities during any activities you carry out on site).

We thank you for your enquiry and appreciate your continued use of the Dial Before You Dig Service. If you are planning to excavate and require further information, please contact **nbn** on 1800 626 329. For any enquiries related to moving assets or Planning and Design activities, please visit the **nbn** Commercial Works website to complete the online application form.

Notes:

1. You are now aware that there are **nbn** Facilities in the vicinity of the above property that could be damaged as a result activities carried out (or proposed to be carried out) by you in the vicinity of the Location.
2. You should have regard to section 474.6 and 474.7 of the *Criminal Code Act 1995* (CoA) which deals with the consequences of interfering or tampering with a telecommunications facility. Only persons authorised by **nbn** can interact with **nbn's** network facilities.
3. Any information provided is valid only for **28 days** from the date of issue set out above.

Referral Conditions

The following are conditions on which **nbn** provides you with the Indicative Plans. By accepting the plans,you are agreeing to these conditions. These conditions are in addition, and not in replacement of, any duties and obligations you have under applicable law.

1. **nbn** does not accept any responsibility for any inaccuracies of its plans including the Indicative Plans. You are expected to make your own inquiries and perform your own investigations (including engaging appropriately qualified plant locators at your expense to locate **nbn** Facilities during any activities you carry out on site).
2. You acknowledge that **nbn** has specifically notified you above that the Indicative Plans are likely to be more accurate in showing location of fibre optics and telecommunications cables than power cables. There may be a variation between the line depicted on the Indicative Plans and the location of any power cables.
3. You should not assume that **nbn** Facilities follow straight lines or are installed at uniformed depths along their lengths, even if they are indicated on plans provided to you. Careful onsite investigations are essential to locate the exact position of cables.
4. In carrying out any works in the vicinity of **nbn** Facilities, you must maintain the following minimum clearances:
   - 300mm when laying assets inline, horizontally or vertically.
   - 500mm when operating vibrating equipment, for example: jackhammers or vibrating plates.
   - 1000mm when operating mechanical excavators.
   - Adherence to clearances as directed by other asset owner's instructions and take into account any uncertainty for power cables.
5. You are aware that there are inherent risks and dangers associated with carrying out work in the vicinity of underground facilities (such as **nbn** fibre optic,copper and coaxial cables,and power cable feed to **nbn** assets).Damage to underground electric cables may result in:
   - Injury from electric shock or severe burns, with the possibility of death.
   - Interruption of the electricity supply to wide areas of the city.
   - Damage to your excavating plant.
   - Responsibility for the cost of repairs.
6. You must take all reasonable precautions to avoid damaging **nbn** Facilities. These precautions may include but not limited to the following:
   - All excavation sites should be examined for underground cables by careful hand excavation. Cable cover slabs if present must not be disturbed. Hand excavation needs to be undertaken with extreme care to

minimise the likelihood of damage to the cable, for example: the blades of hand equipment should be aligned parallel to the line of the cable rather than digging across the cable.

- If any undisclosed underground cables are located, notify **nbn** immediately.
- All personnel must be properly briefed, particularly those associated with the use of earth-moving equipment, trenching, boring and pneumatic equipment.
- The safety of the public and other workers must be ensured.
- All excavations must be undertaken in accordance with all relevant legislation and regulations.

7. You will be responsible for all damage to **nbn** Facilities that are connected whether directly, or indirectly with work you carry out (or work that is carried out for you or on your behalf) at the Location. This will include, without limitation, all losses expenses incurred by **nbn** as a result of any such damage.
8. You must immediately report any damage to **nbn™** network that you are/become aware of. Notification may be by telephone - 1800 626 329.
9. Except to the extent that liability may not be capable of lawful exclusion, **nbn** and its servants and agents and the related bodies corporate of **nbn** and their servants and agents shall be under no liability whatsoever to any person for any loss or damage (including indirect or consequential loss or damage) however caused (including, without limitation, breach of contract negligence and/or breach of statute) which may be suffered or incurred from or in connection with this information sheet or any plans(including Indicative Plans) attached hereto. Except as expressly provided to the contrary in this information sheet or the attached plans(including Indicative Plans), all terms, conditions, warranties, undertakings or representations (whether expressed or implied) are excluded to the fullest extent permitted by law.

All works undertaken shall be in accordance with all relevant legislations, acts and regulations applicable to the particular state or territory of the Location. The following table lists all relevant documents that shall be considered and adhered to.

State/Territory	Documents
National	Work Health and Safety Act 2011
	Work Health and Safety Regulations 2011
	Safe Work Australia - Working in the Vicinity of Overhead and Underground Electric Lines (Draft)
	Occupational Health and Safety Act 1991
NSW	Electricity Supply Act 1995
	Work Cover NSW - Work Near Underground Assets Guide
	Work Cover NSW - Excavation Work: Code of Practice
VIC	Electricity Safety Act 1998
	Electricity Safety (Network Asset) Regulations 1999
QLD	Electrical Safety Act 2002
	Code of Practice for Working Near Exposed Live Parts
SA	Electricity Act 1996
TAS	Tasmanian Electricity Supply Industry Act 1995
WA	Electricity Act 1945
	Electricity Regulations 1947
NT	Electricity Reform Act 2005
	Electricity Reform (Safety and Technical) Regulations 2005
ACT	Electricity Act 1971

Thank You,

Network Operations Centre - Assurance

Date: 06/04/2020

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Indicative Plans

Issue Date:	06/04/2020
Location:	Chittick Ln , Cobbitty , NSW , 2570

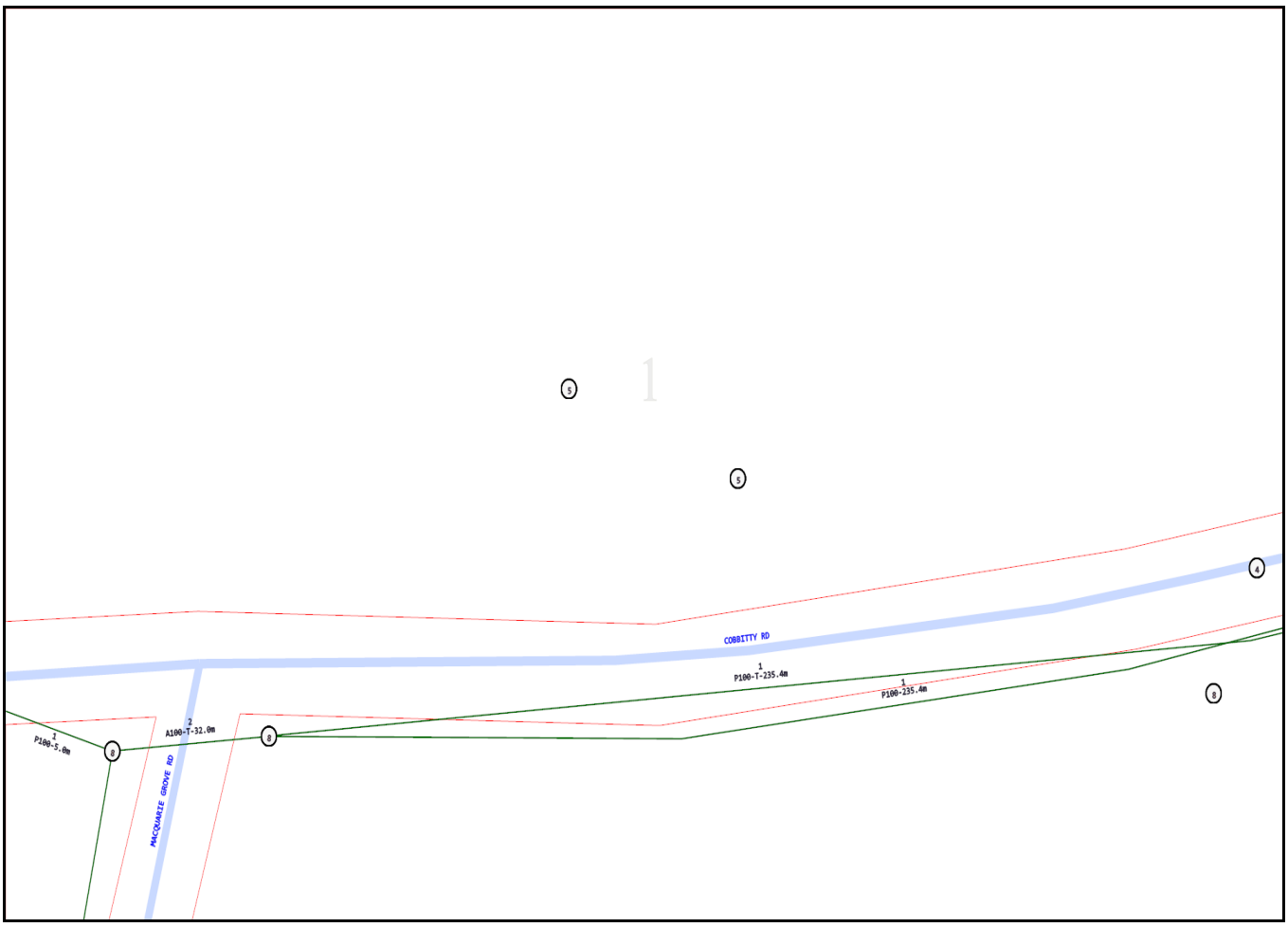
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2	4	6	8	10

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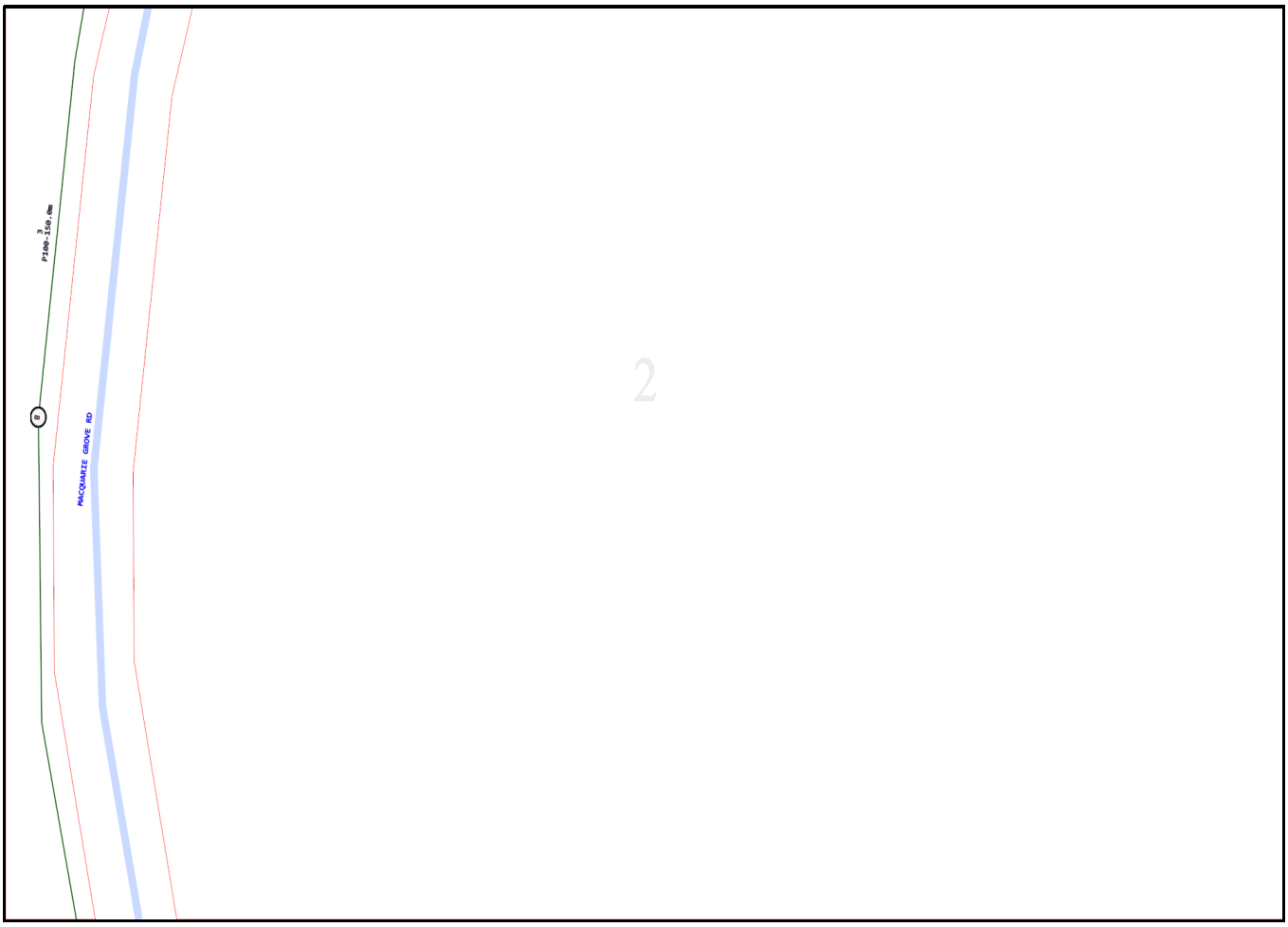
LEGEND

34	Parcel and the location
5	Pit with size "5"
2E	Power Pit with size "2E". Valid PIT Size: e.g. 2E, 5E, 6E, 8E, 9E, E, null.
	Manhole
	Pillar
2 PO – T- 25.0m P40 – 20.0m 5 9	Cable count of trench is 2. One "Other size" PVC conduit (PO) owned by Telstra (-T-), between pits of sizes, "5" and "9" are 25.0m apart. One 40mm PVC conduit (P40) owned by NBN, between pits of sizes, "5" and "9" are 20.0m apart.
2 10.0m 5 9	2 Direct buried cables between pits of sizes ,"5" and "9" are 10.0m apart.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Copper/RF/Fibre) cables.
5 9	Trench containing only DESIGNED/PLANNED (Copper/RF/Fibre/Power) cables.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Power) cables.
BROADWAY ST	Road and the street name "Broadway ST"
Scale	0 20 40 60 Meters 1:2000 1 cm equals 20 m

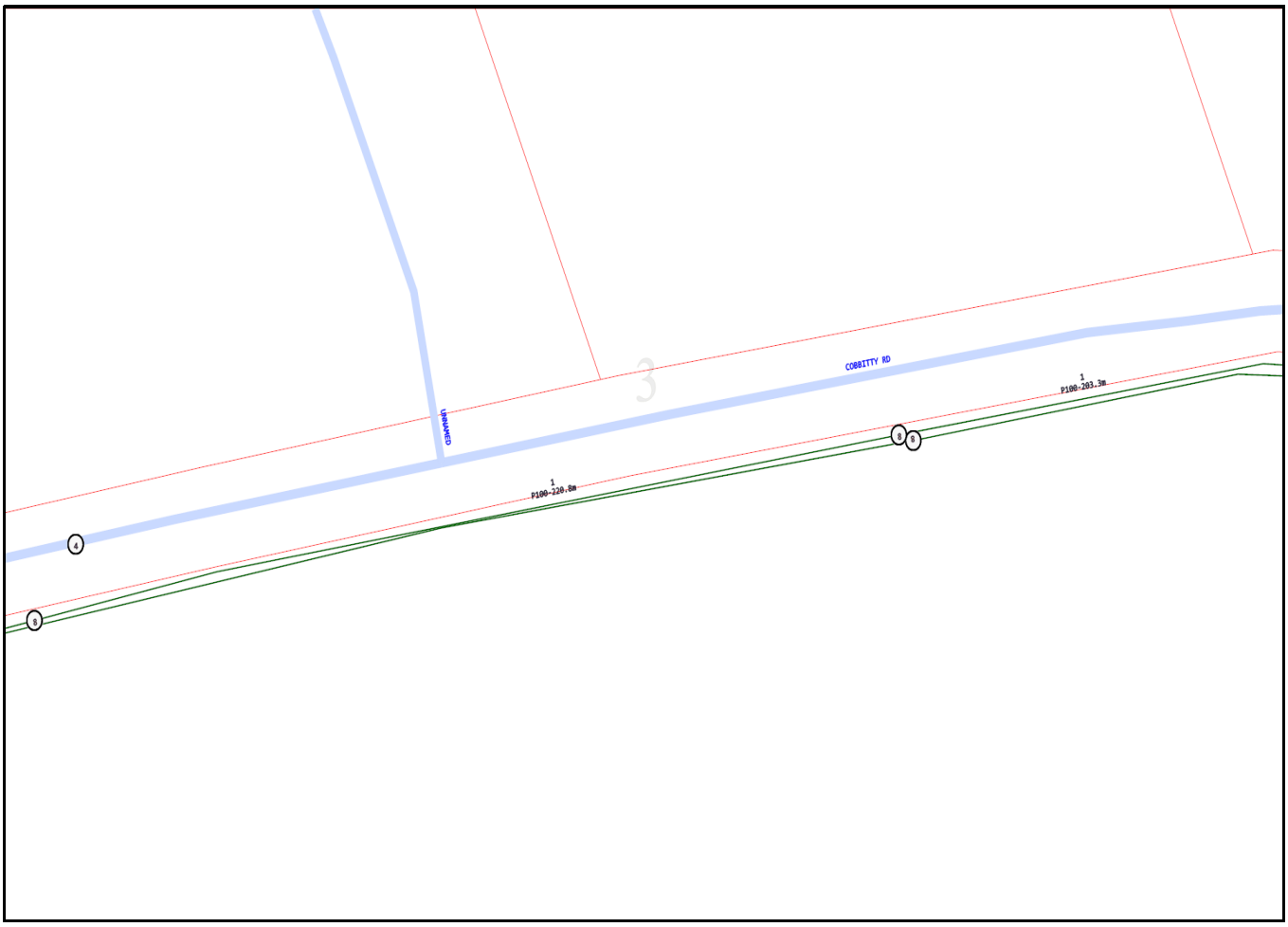
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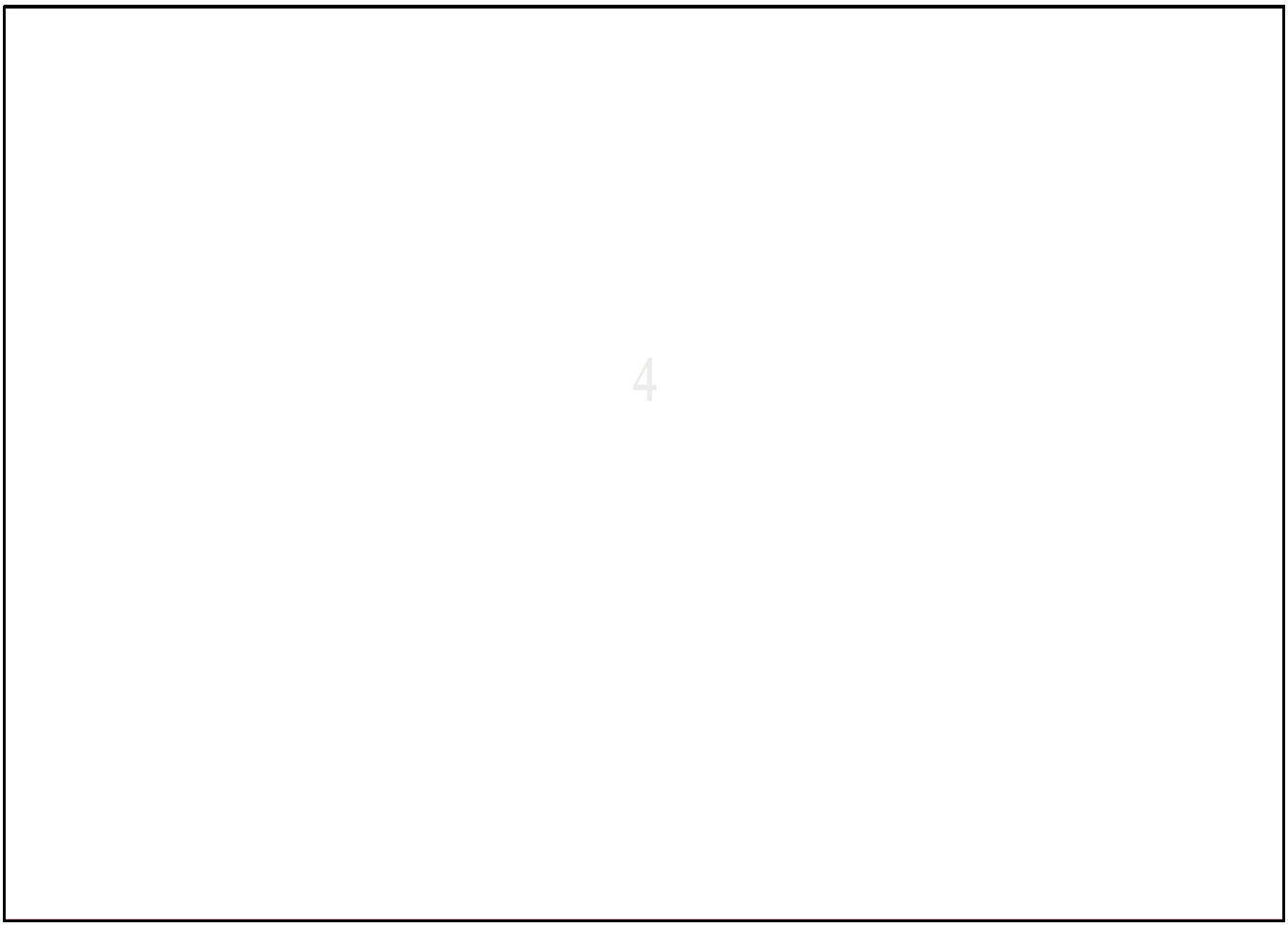
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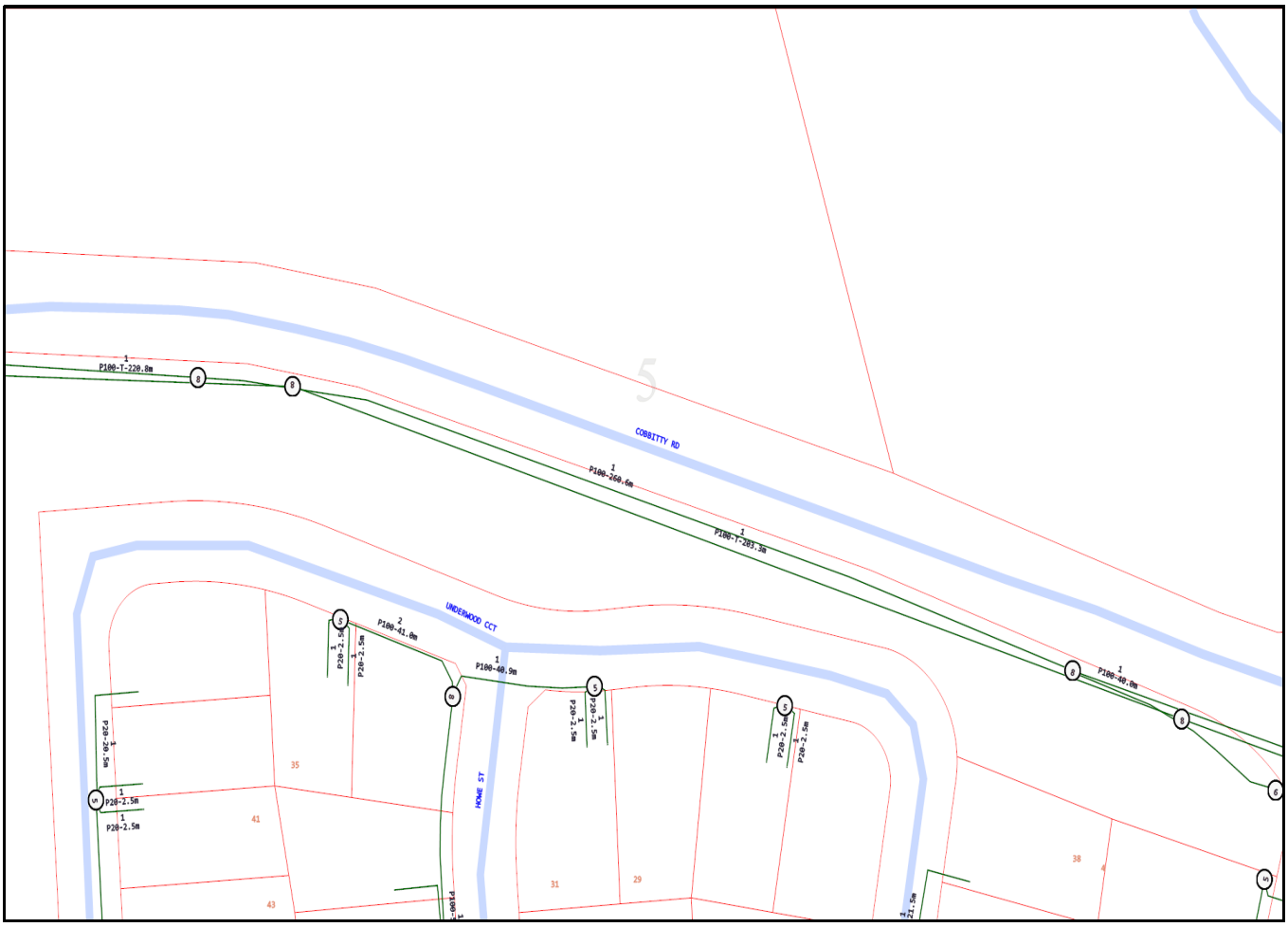
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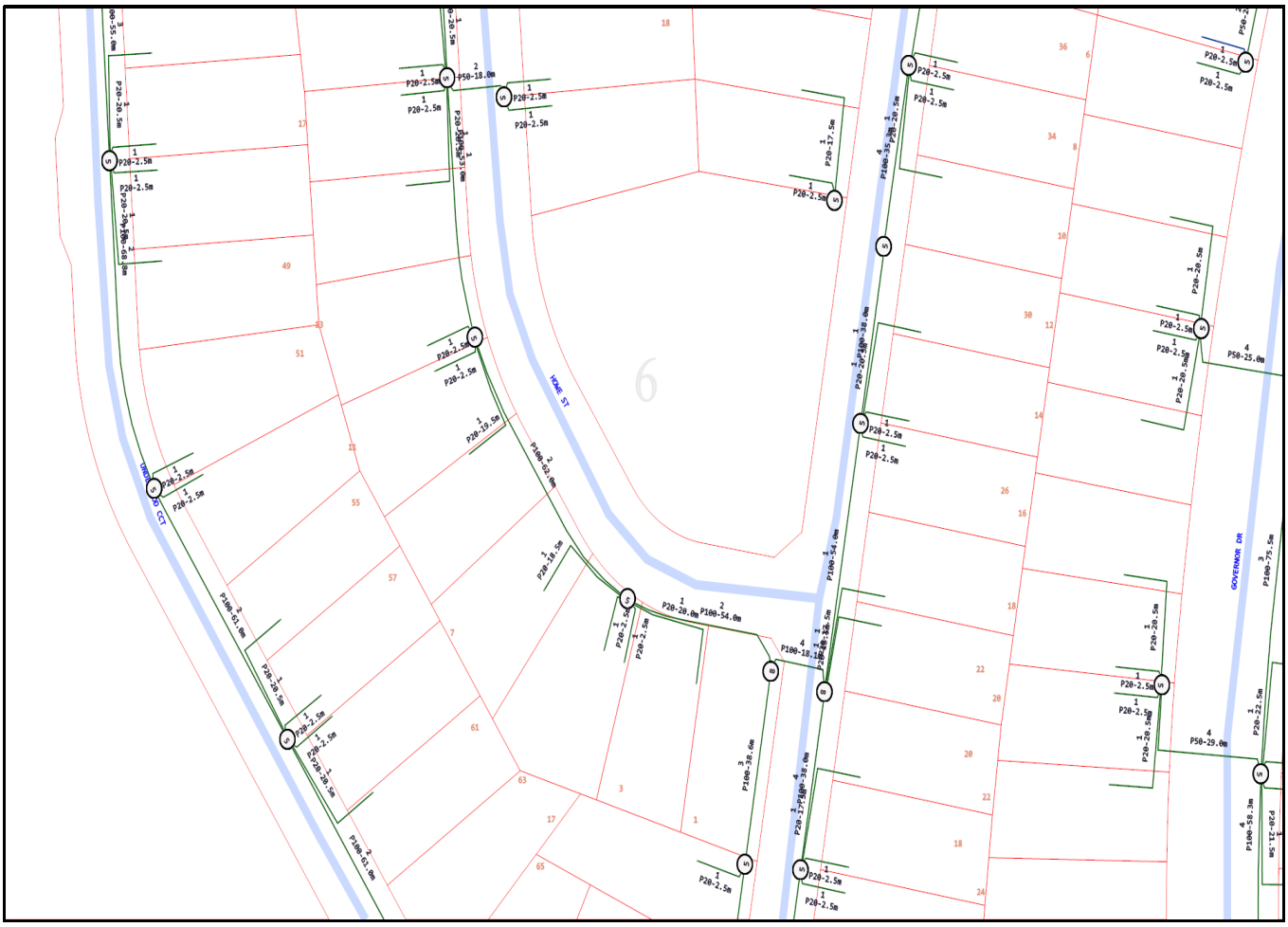
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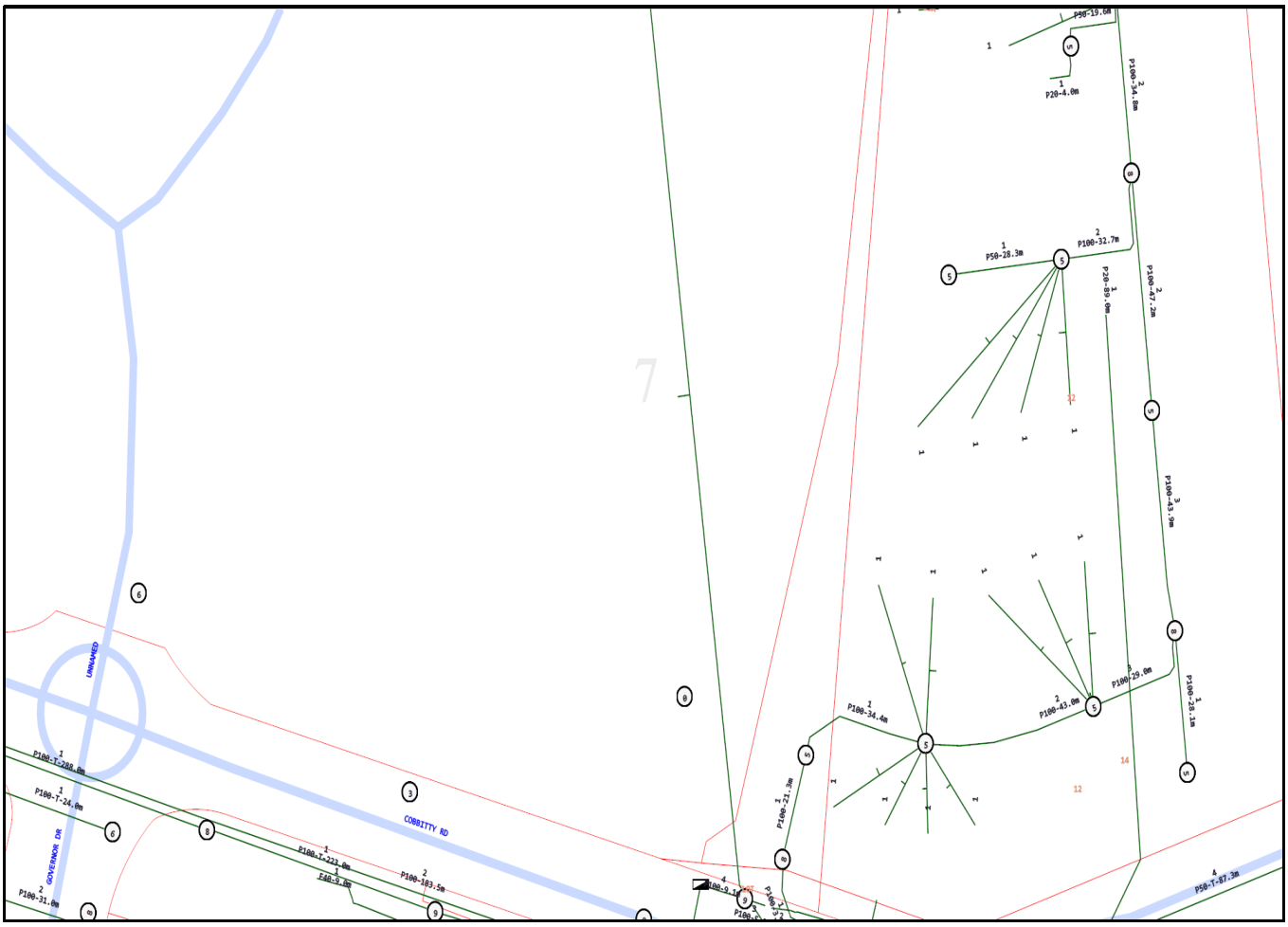
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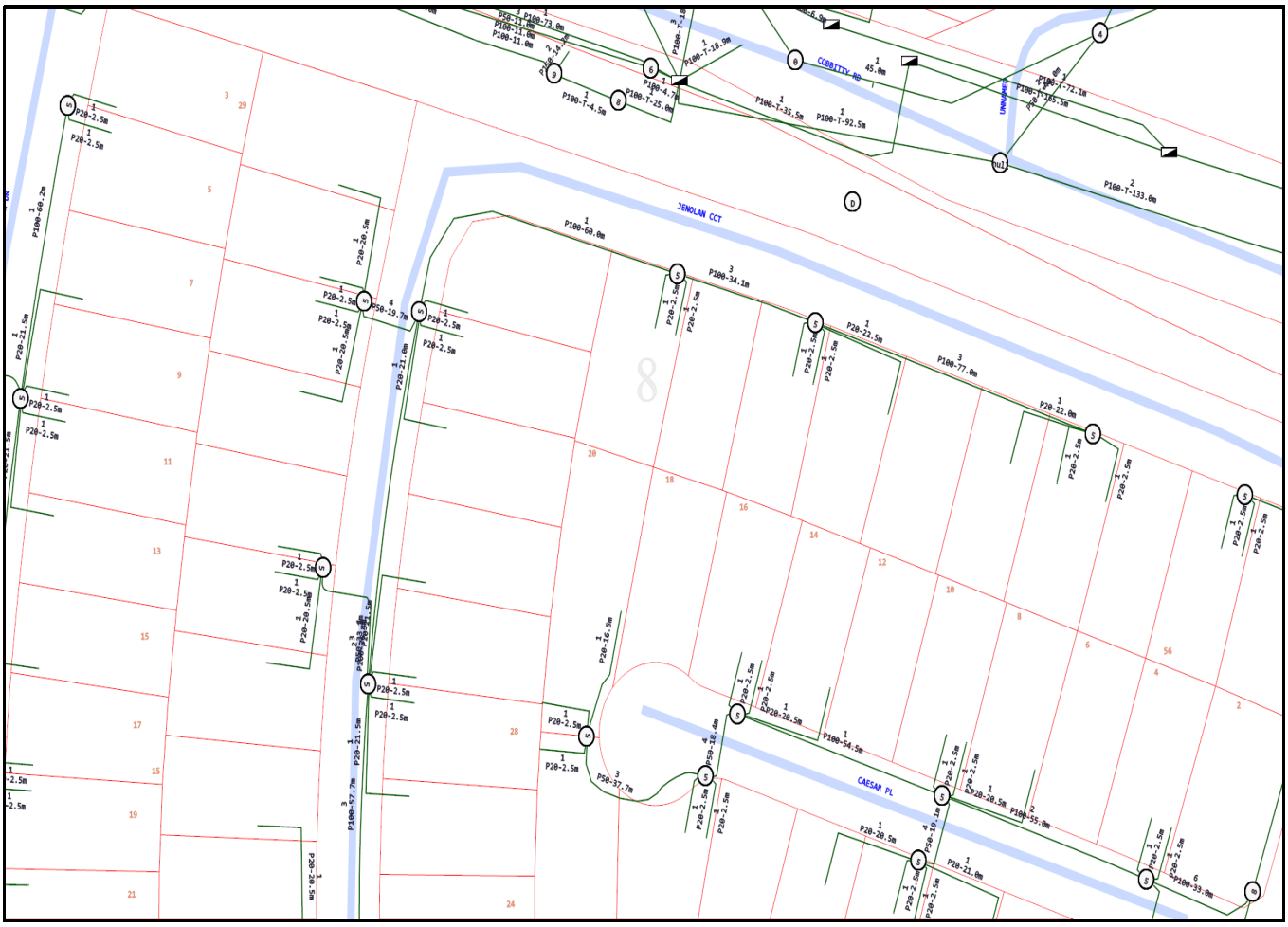
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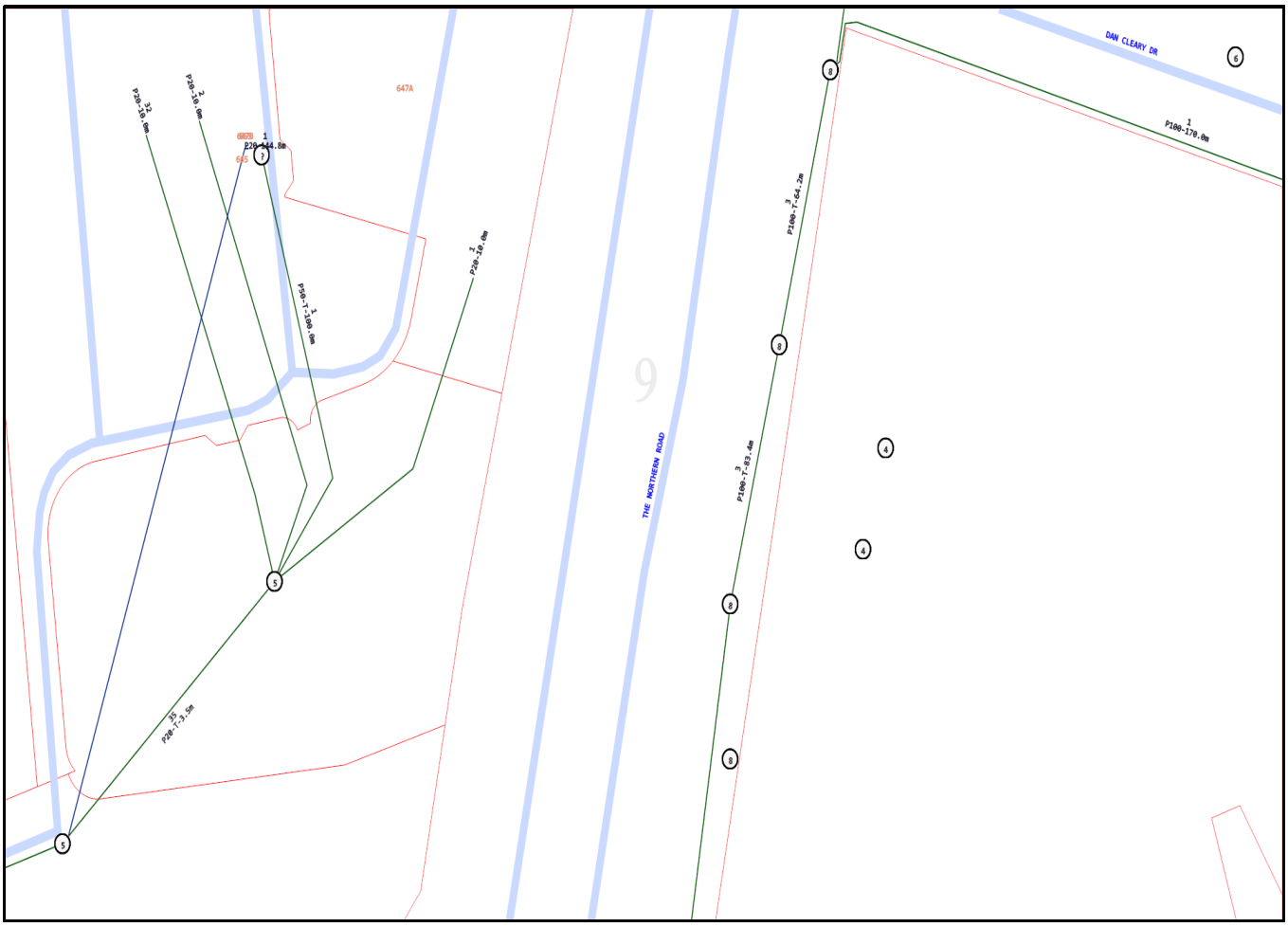
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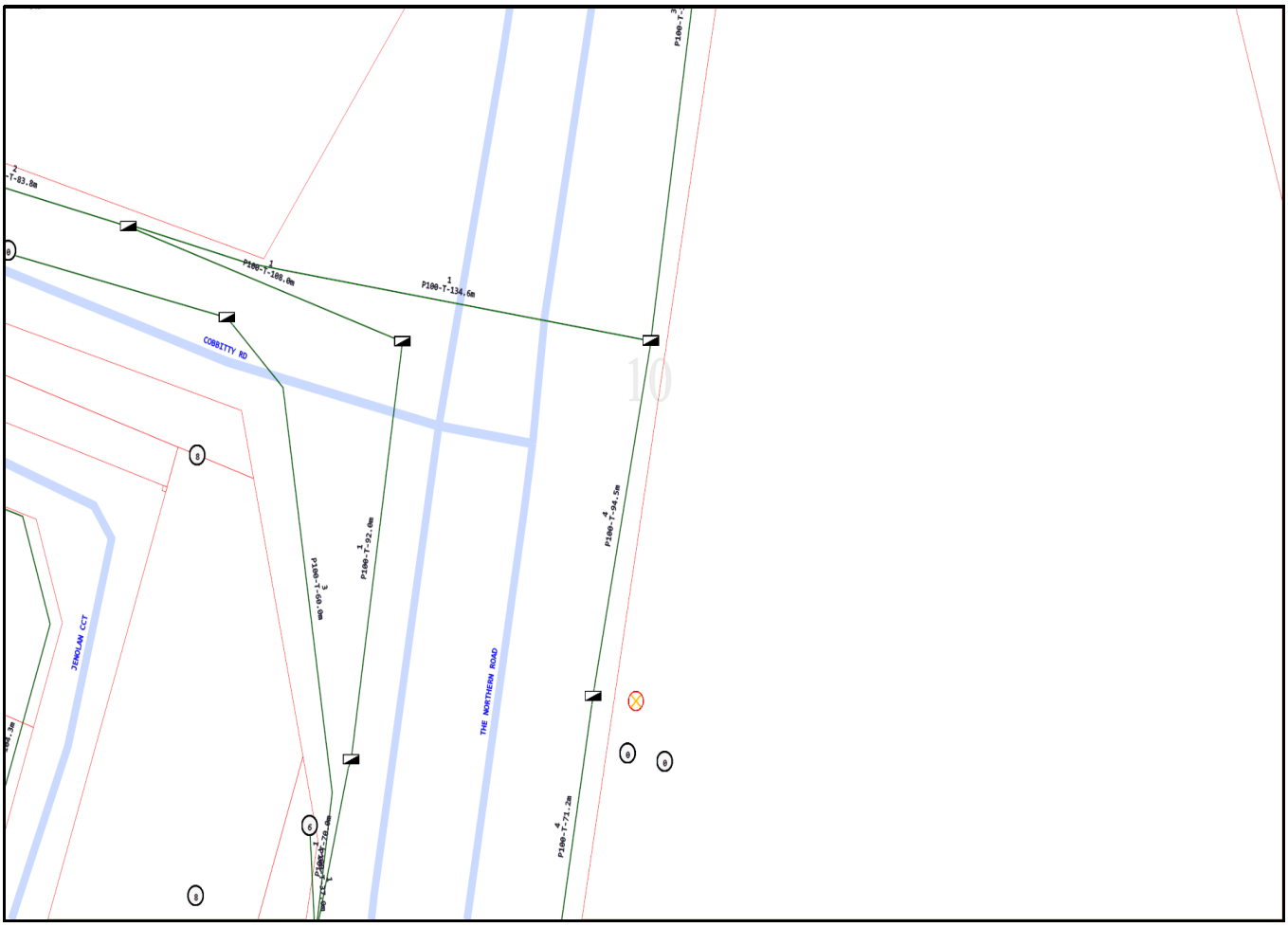
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Emergency Contacts

You must immediately report any damage to **nbn™** network that you are/become aware of. Notification may be by telephone - 1800 626 329.

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Indicative Plans

Issue Date:	06/04/2020
Location:	Chittick Ln , Cobbitty , NSW , 2570

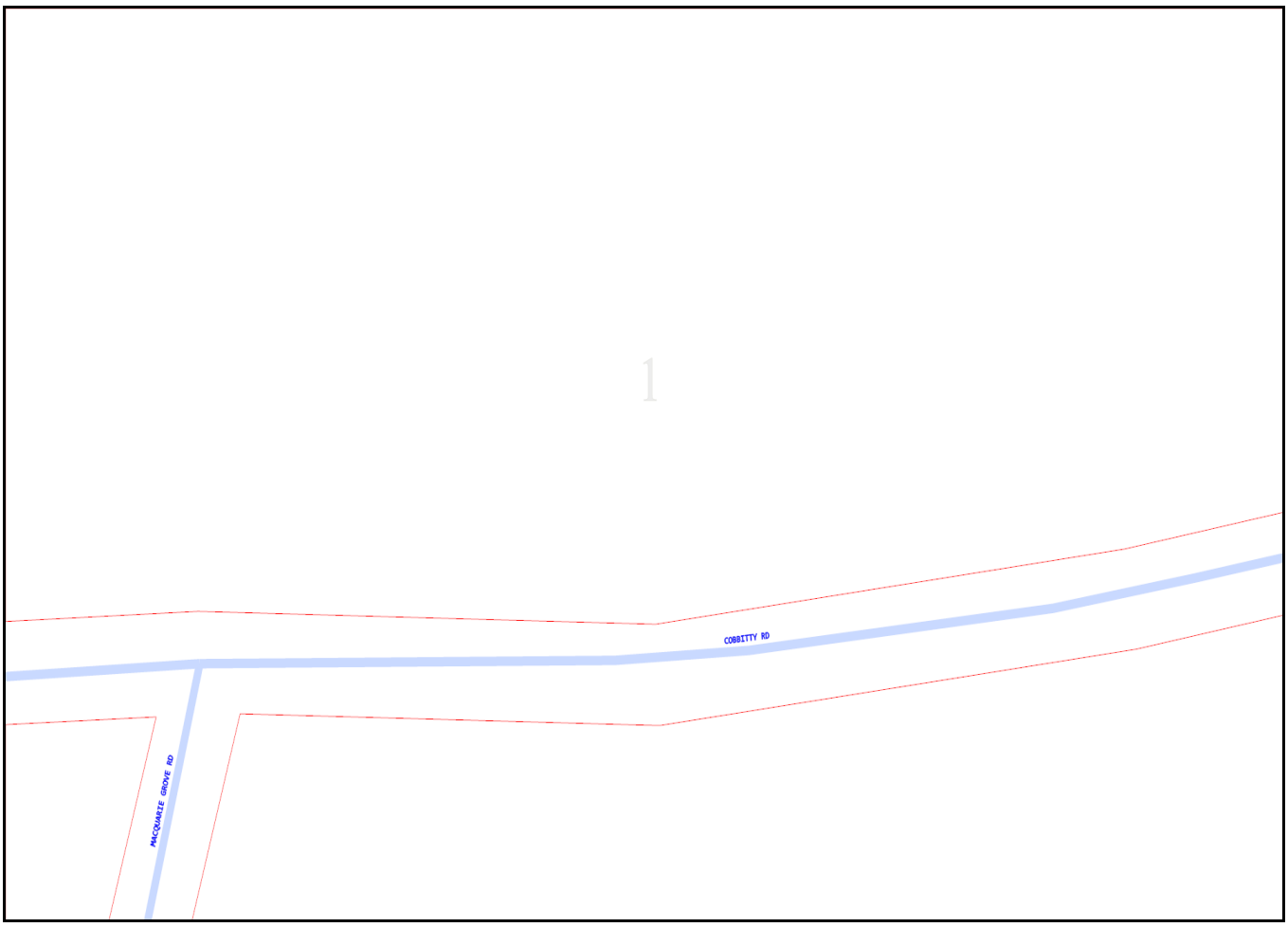
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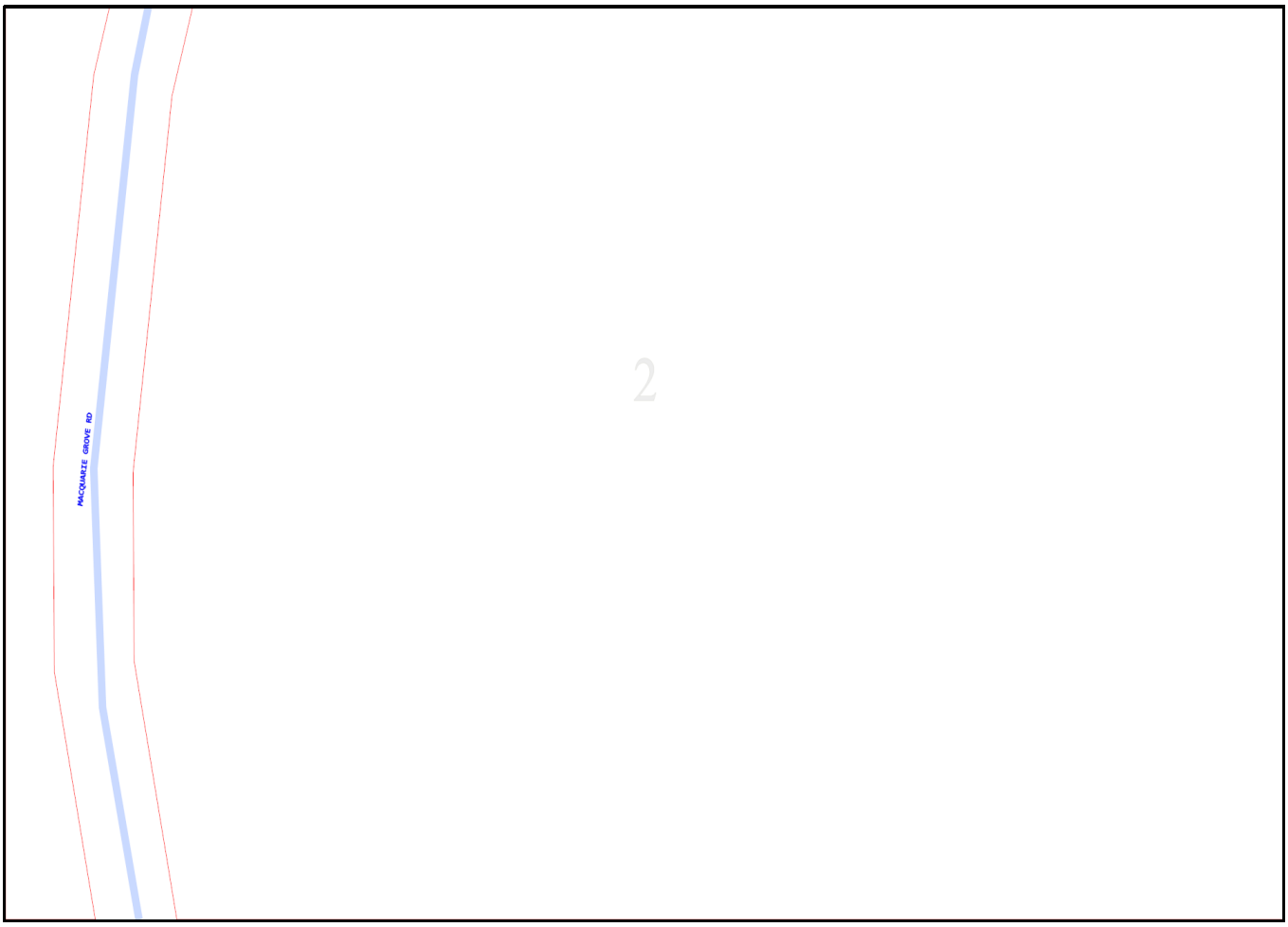
LEGEND

34	Parcel and the location
5	Pit with size "5"
2E	Power Pit with size "2E". Valid PIT Size: e.g. 2E, 5E, 6E, 8E, 9E, E, null.
	Manhole
	Pillar
2 PO – T- 25.0m P40 – 20.0m 5 9	Cable count of trench is 2. One "Other size" PVC conduit (PO) owned by Telstra (-T-), between pits of sizes, "5" and "9" are 25.0m apart. One 40mm PVC conduit (P40) owned by NBN, between pits of sizes, "5" and "9" are 20.0m apart.
2 10.0m 5 9	2 Direct buried cables between pits of sizes ,"5" and "9" are 10.0m apart.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Copper/RF/Fibre) cables.
5 9	Trench containing only DESIGNED/PLANNED (Copper/RF/Fibre/Power) cables.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Power) cables.
BROADWAY ST	Road and the street name "Broadway ST"
Scale	0 20 40 60 Meters 1:2000 1 cm equals 20 m

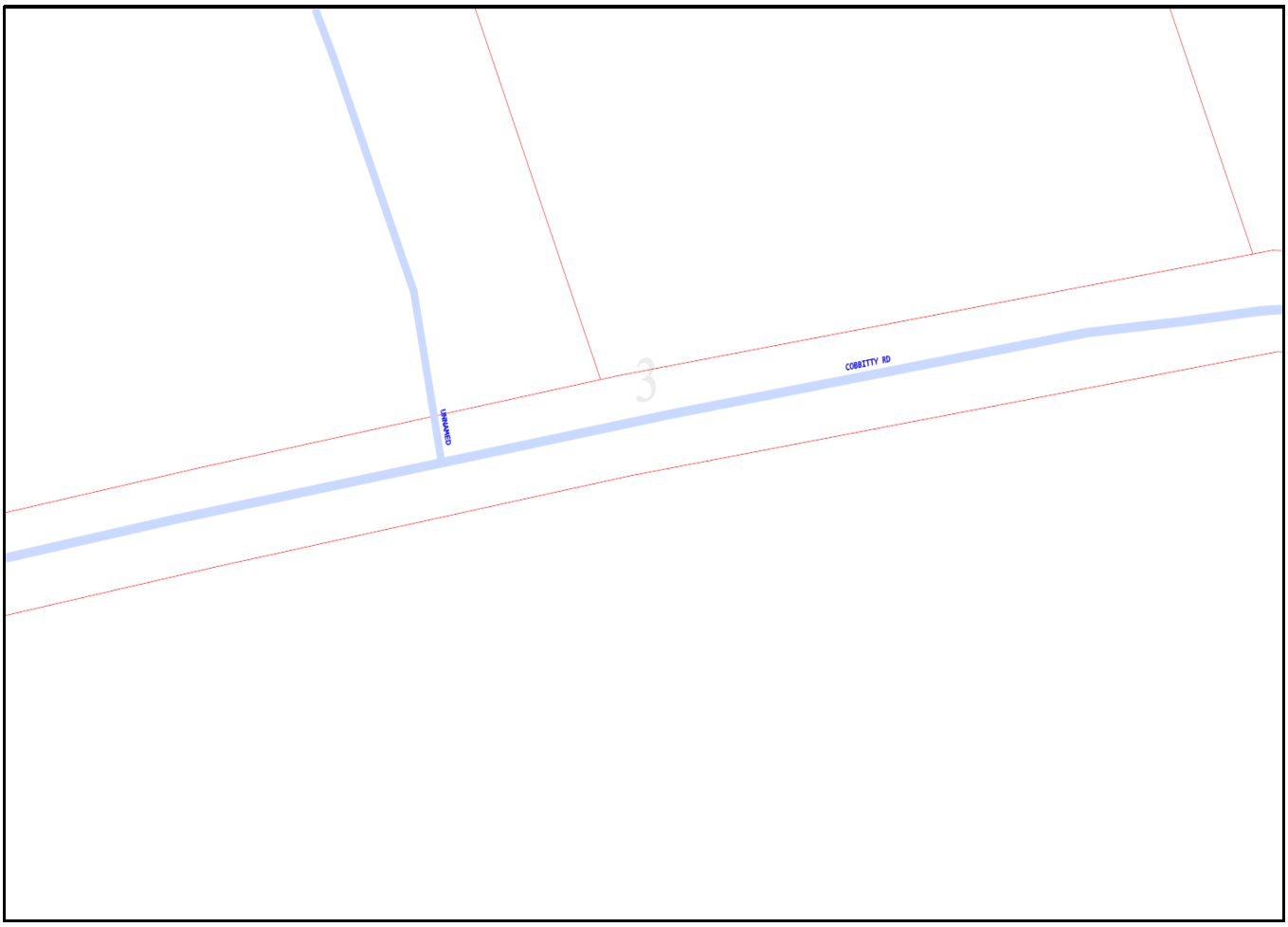
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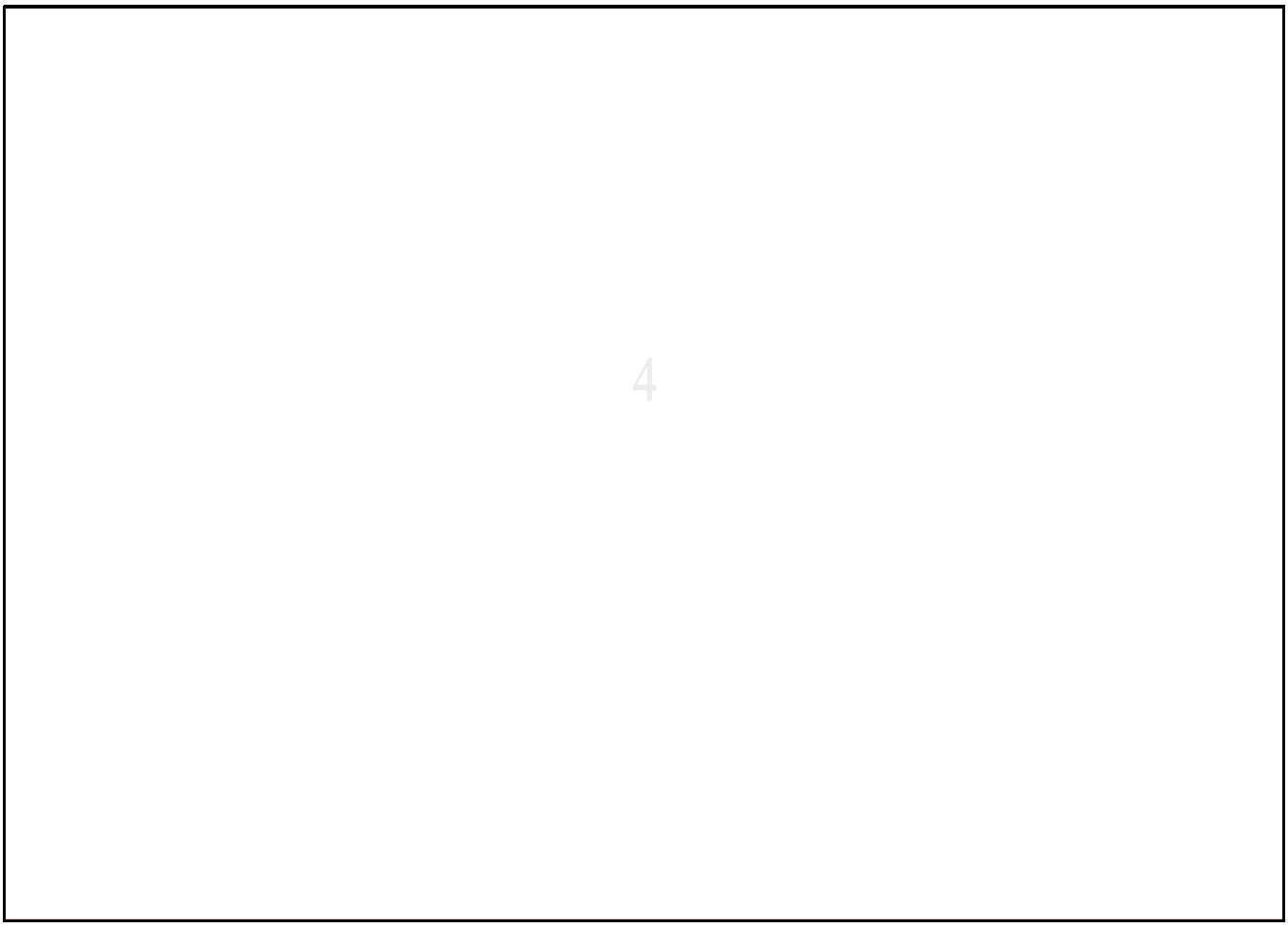
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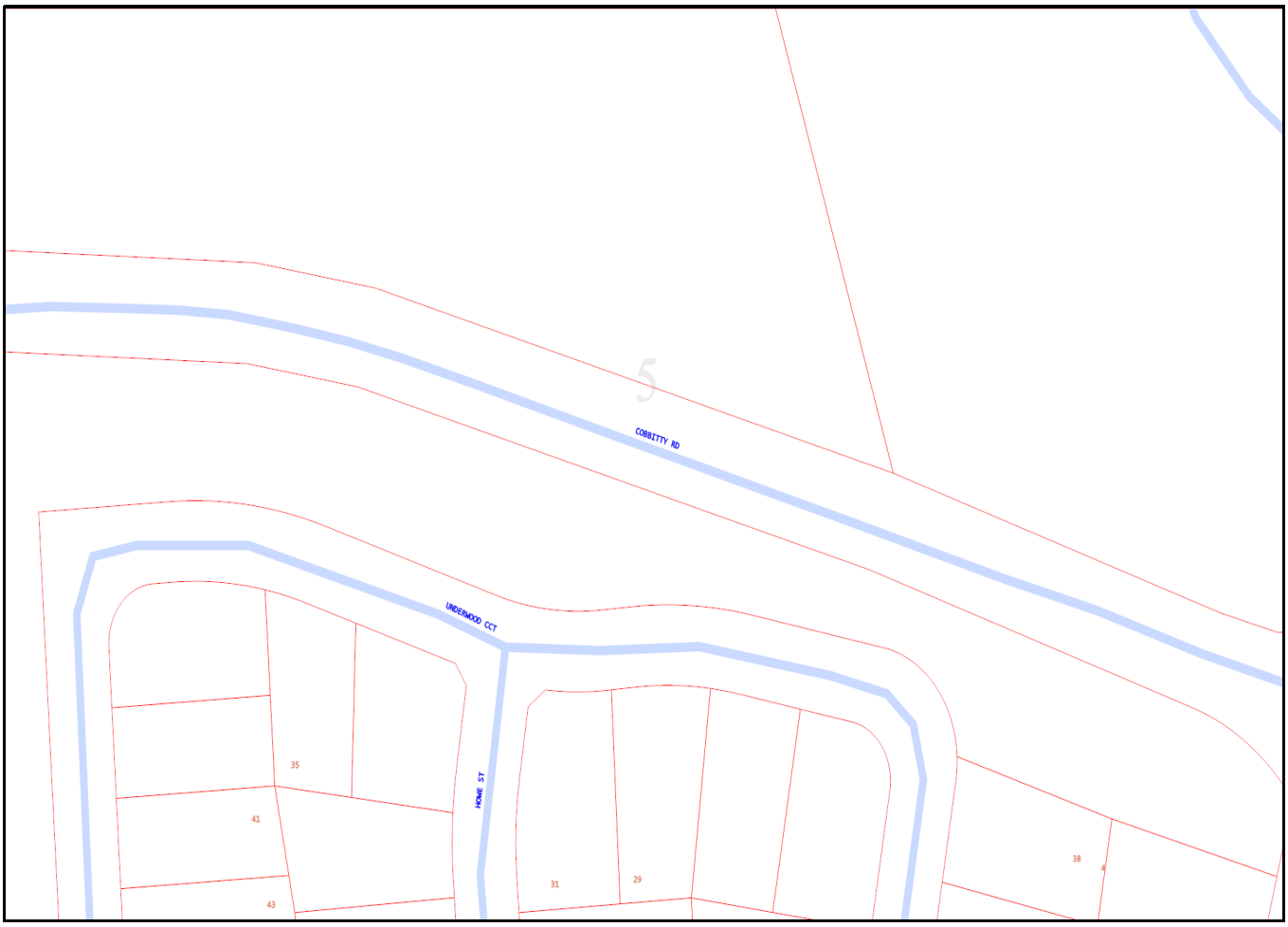
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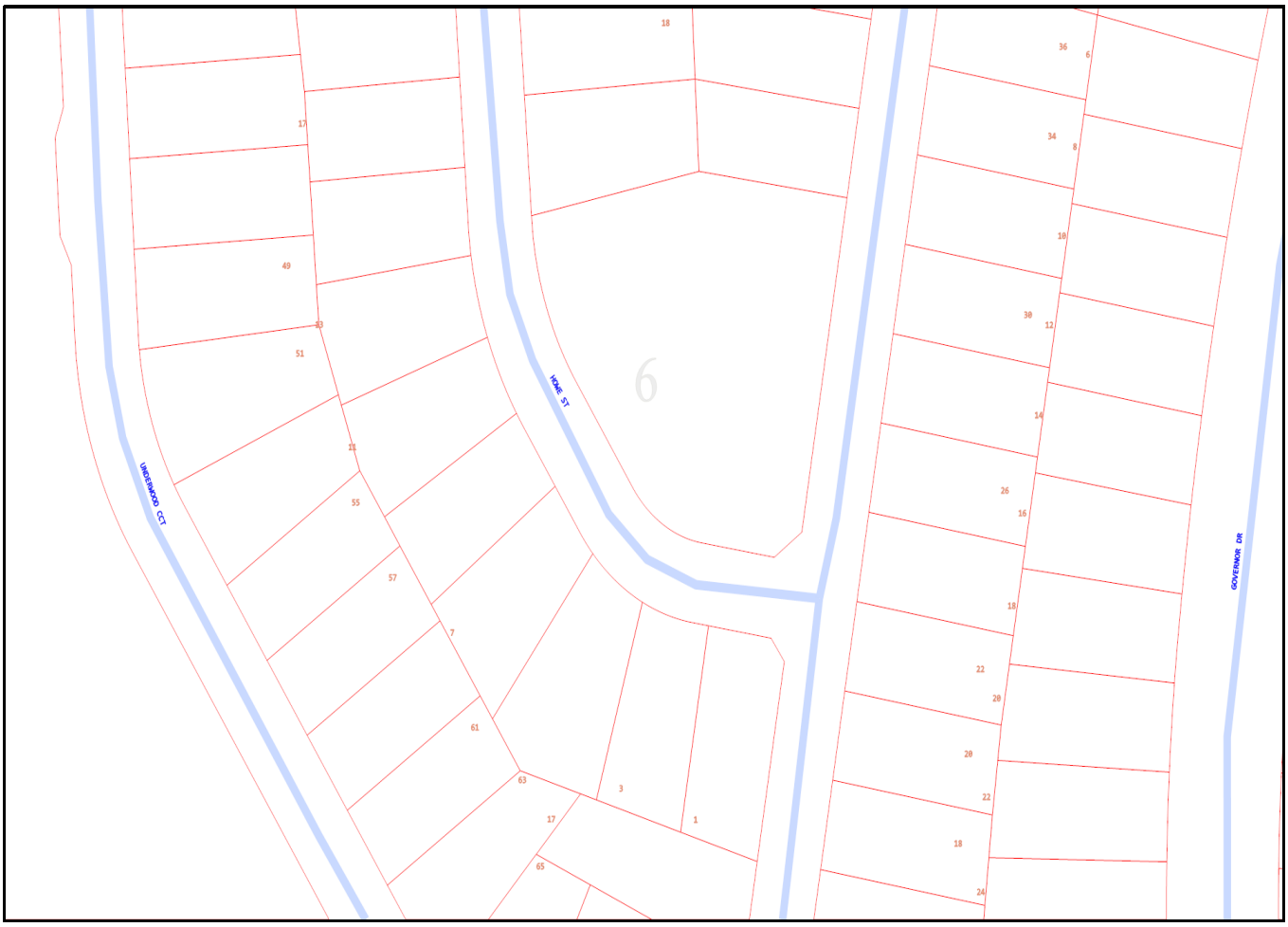
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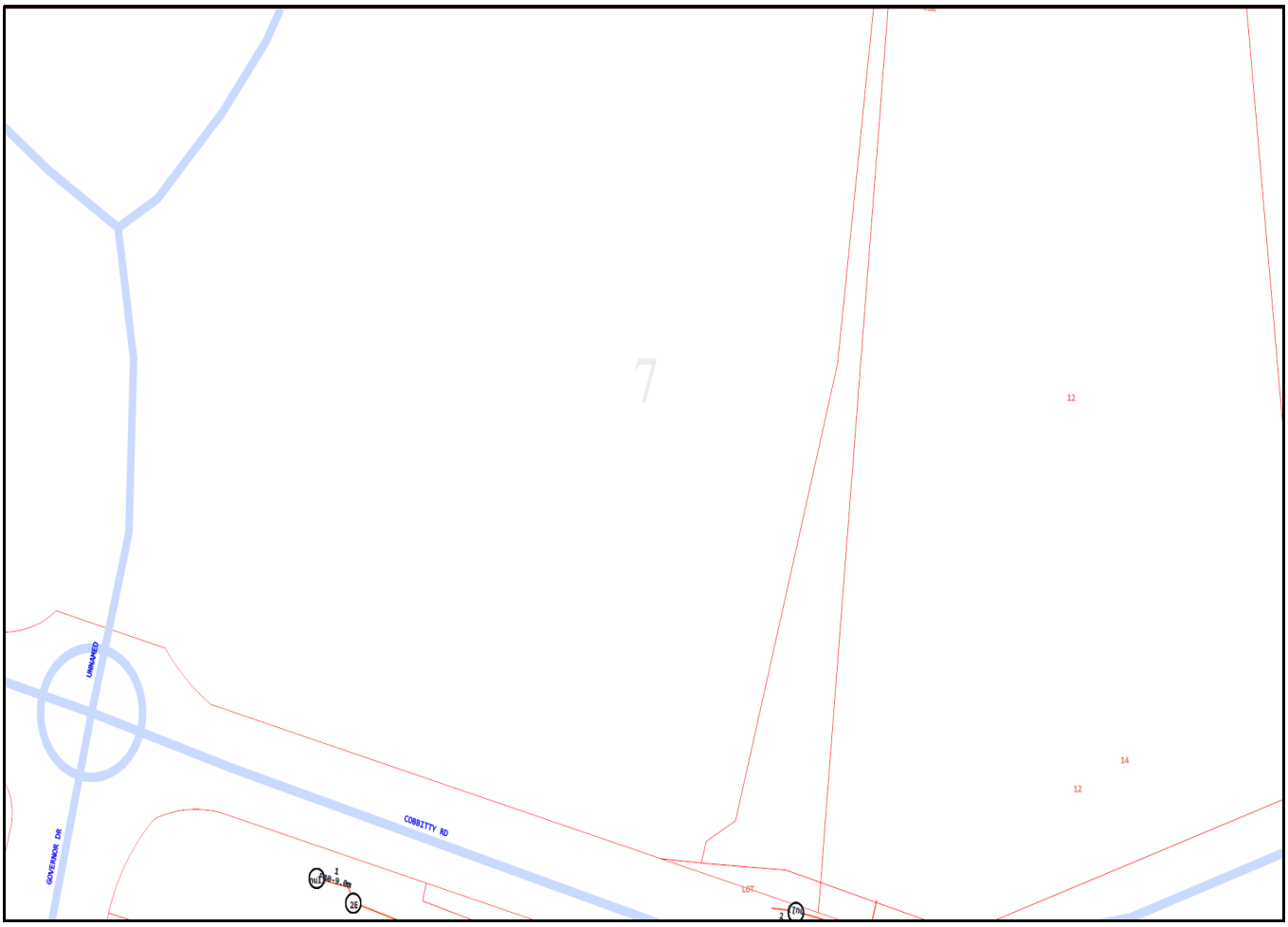
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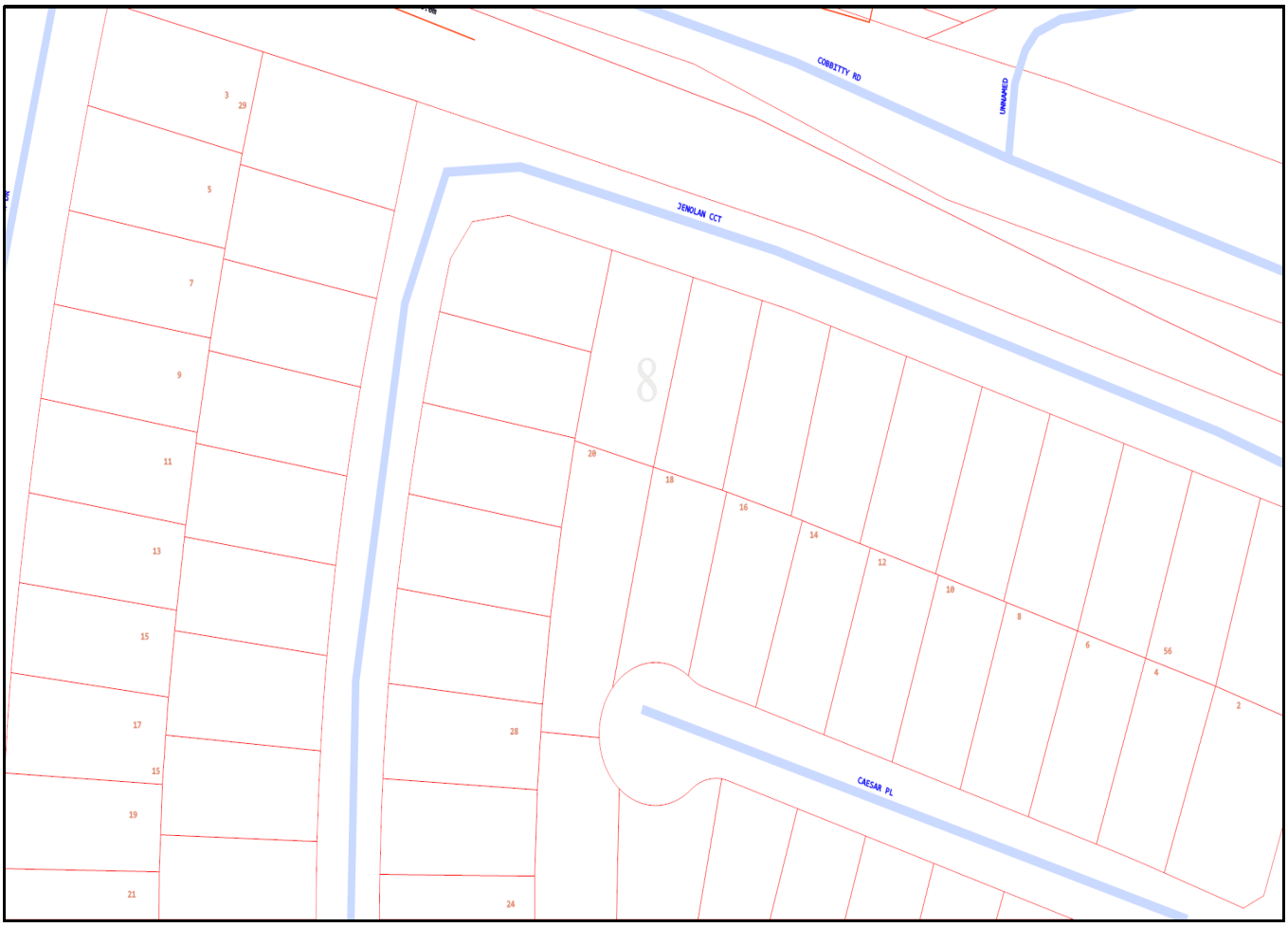
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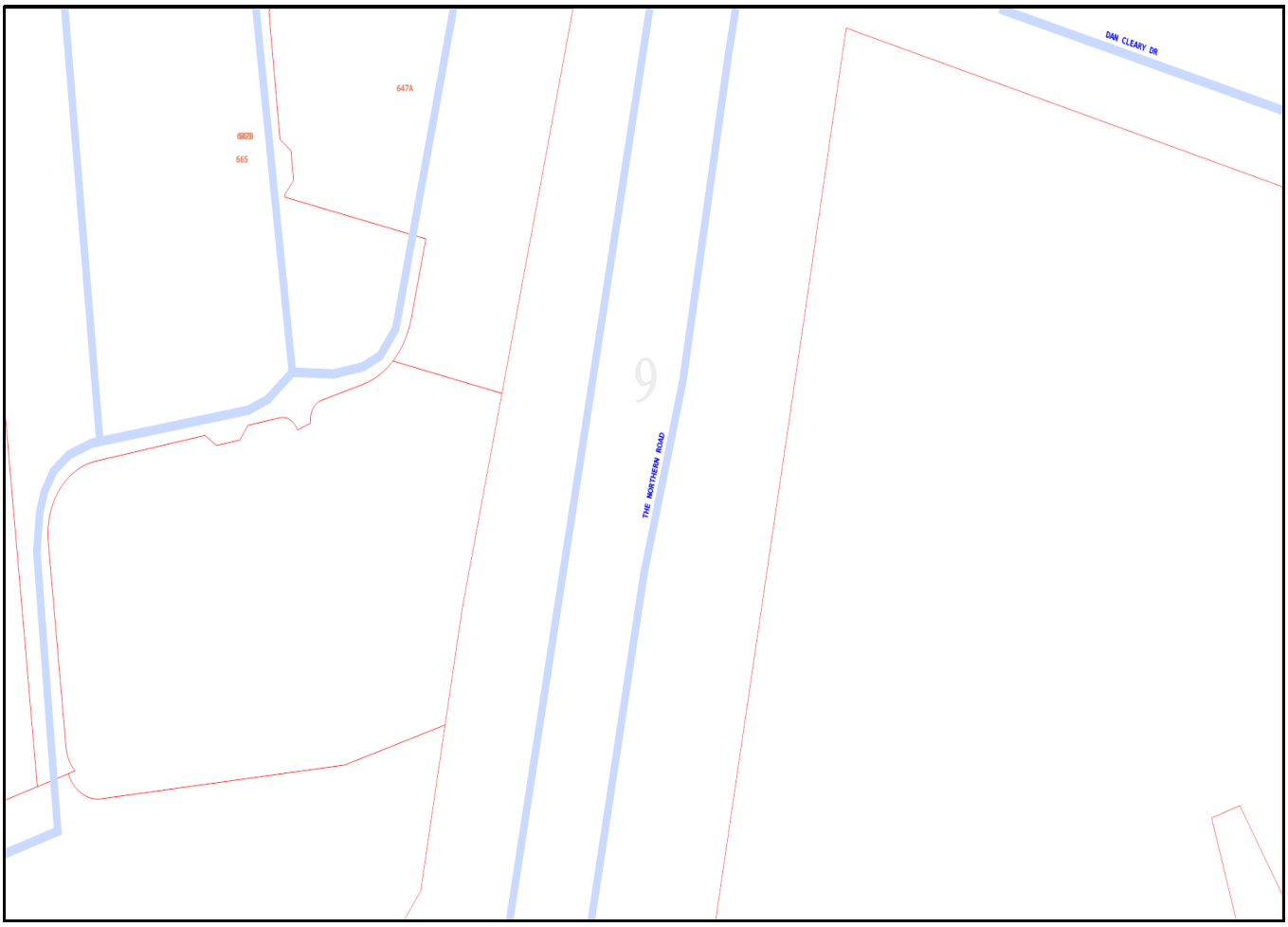
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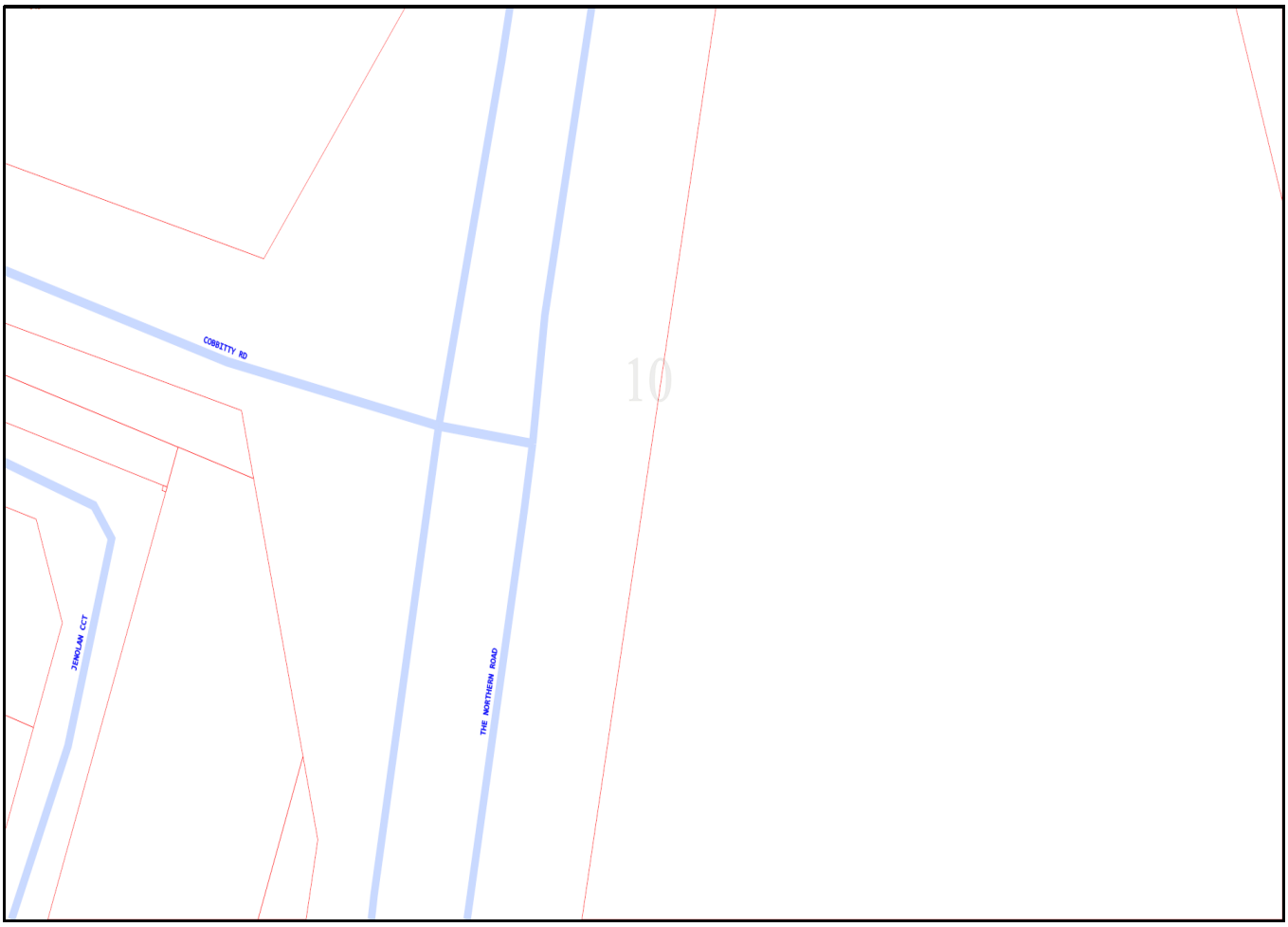
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Indicative Plans

Issue Date:	06/04/2020
Location:	Chittick Ln , Cobbitty , NSW , 2570

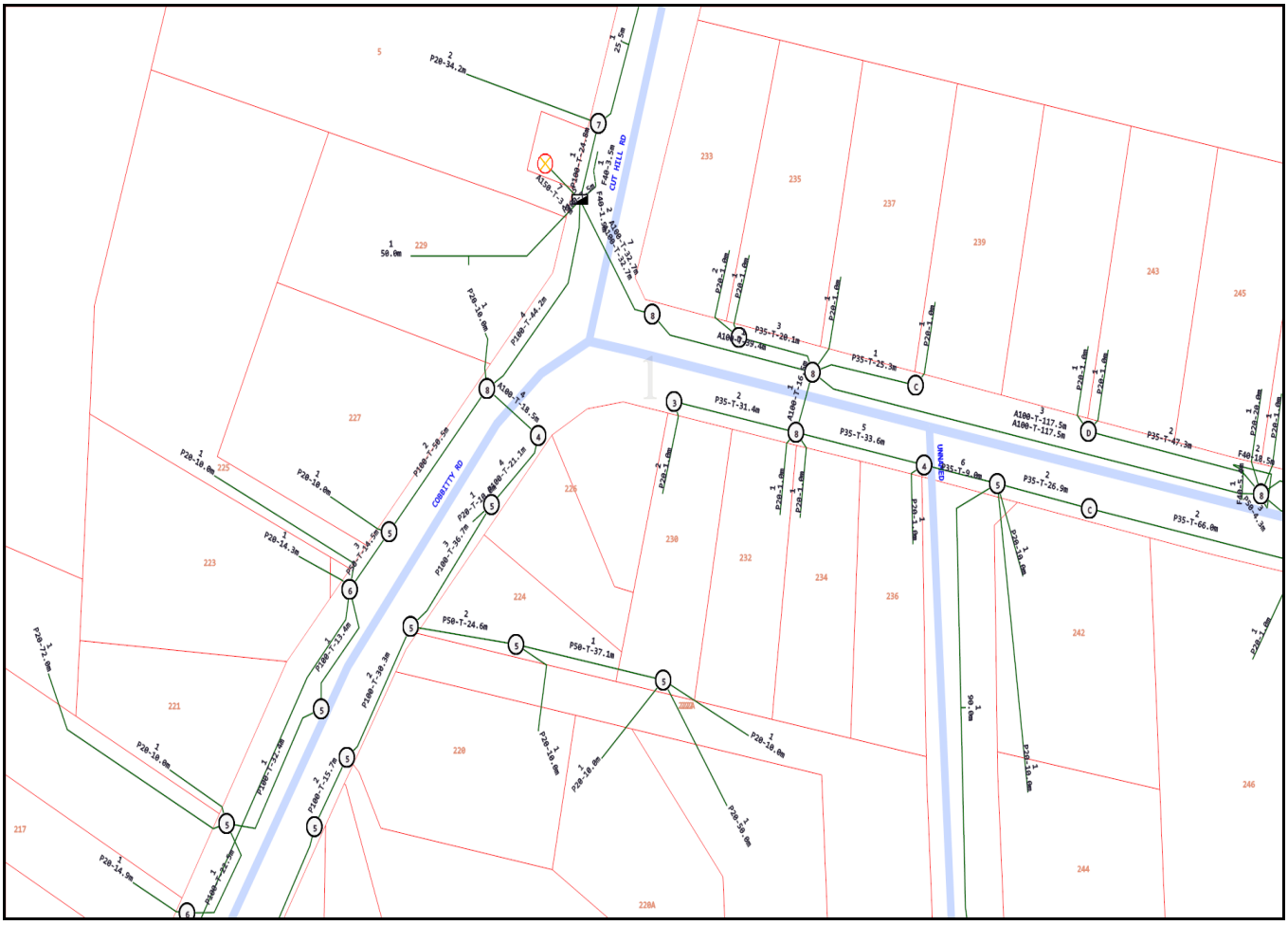
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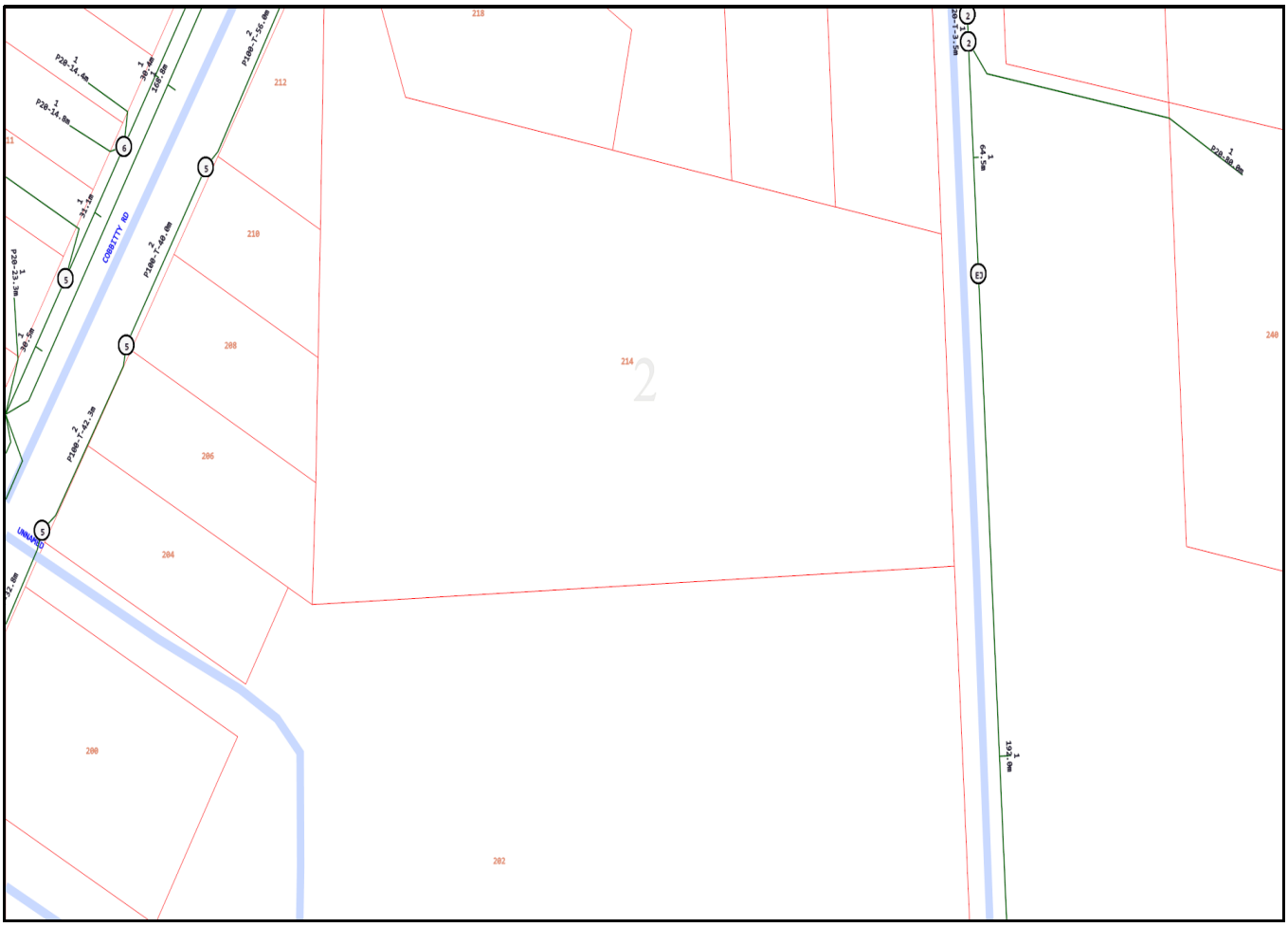
LEGEND

34	Parcel and the location
5	Pit with size "5"
2E	Power Pit with size "2E". Valid PIT Size: e.g. 2E, 5E, 6E, 8E, 9E, E, null.
	Manhole
	Pillar
2 PO – T- 25.0m P40 – 20.0m 5 9	Cable count of trench is 2. One "Other size" PVC conduit (PO) owned by Telstra (-T-), between pits of sizes, "5" and "9" are 25.0m apart. One 40mm PVC conduit (P40) owned by NBN, between pits of sizes, "5" and "9" are 20.0m apart.
2 10.0m 5 9	2 Direct buried cables between pits of sizes ,"5" and "9" are 10.0m apart.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Copper/RF/Fibre) cables.
5 9	Trench containing only DESIGNED/PLANNED (Copper/RF/Fibre/Power) cables.
5 9	Trench containing any INSERVICE/CONSTRUCTED (Power) cables.
BROADWAY ST	Road and the street name "Broadway ST"
Scale	0 20 40 60 Meters 1:2000 1 cm equals 20 m

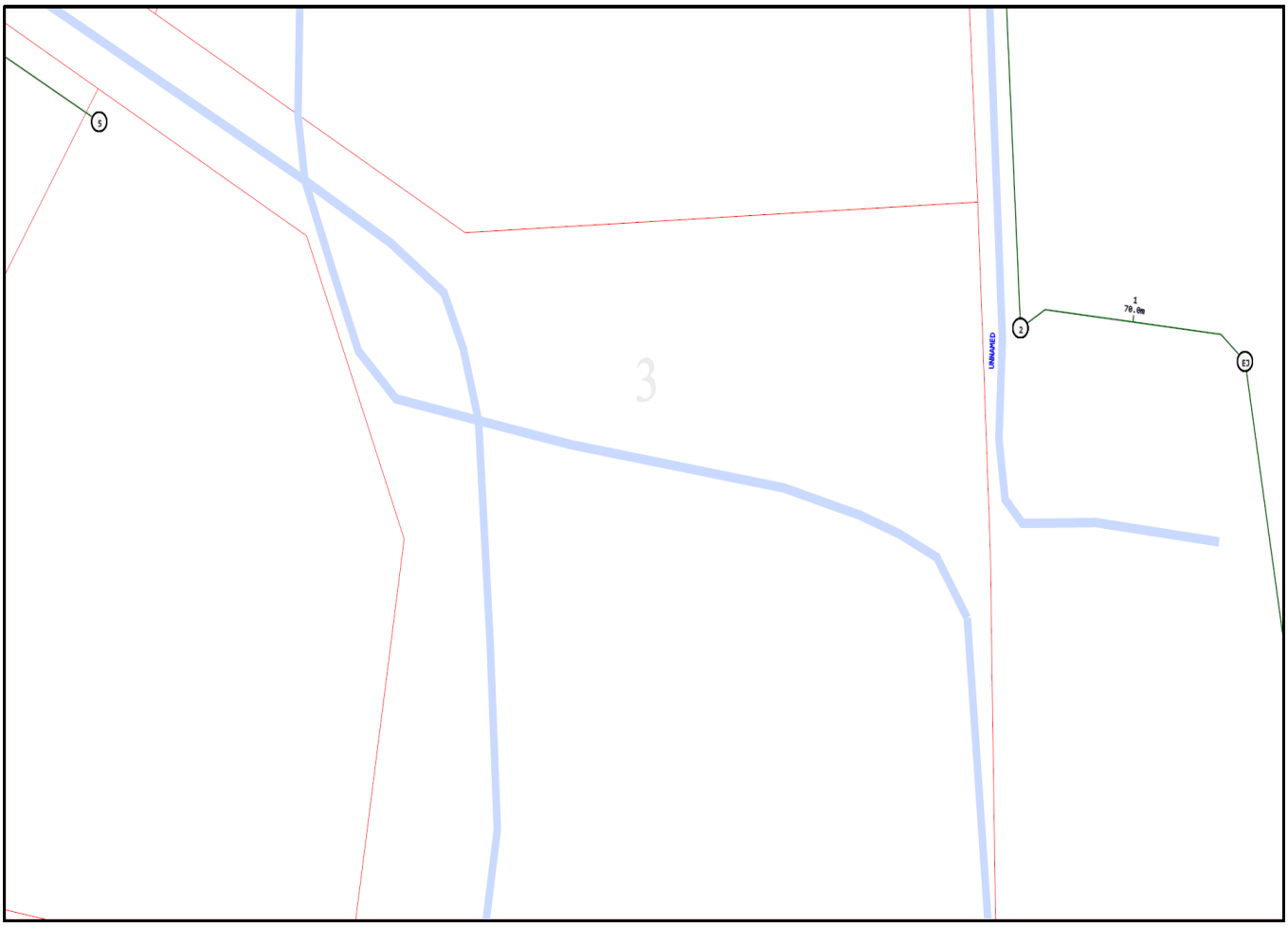
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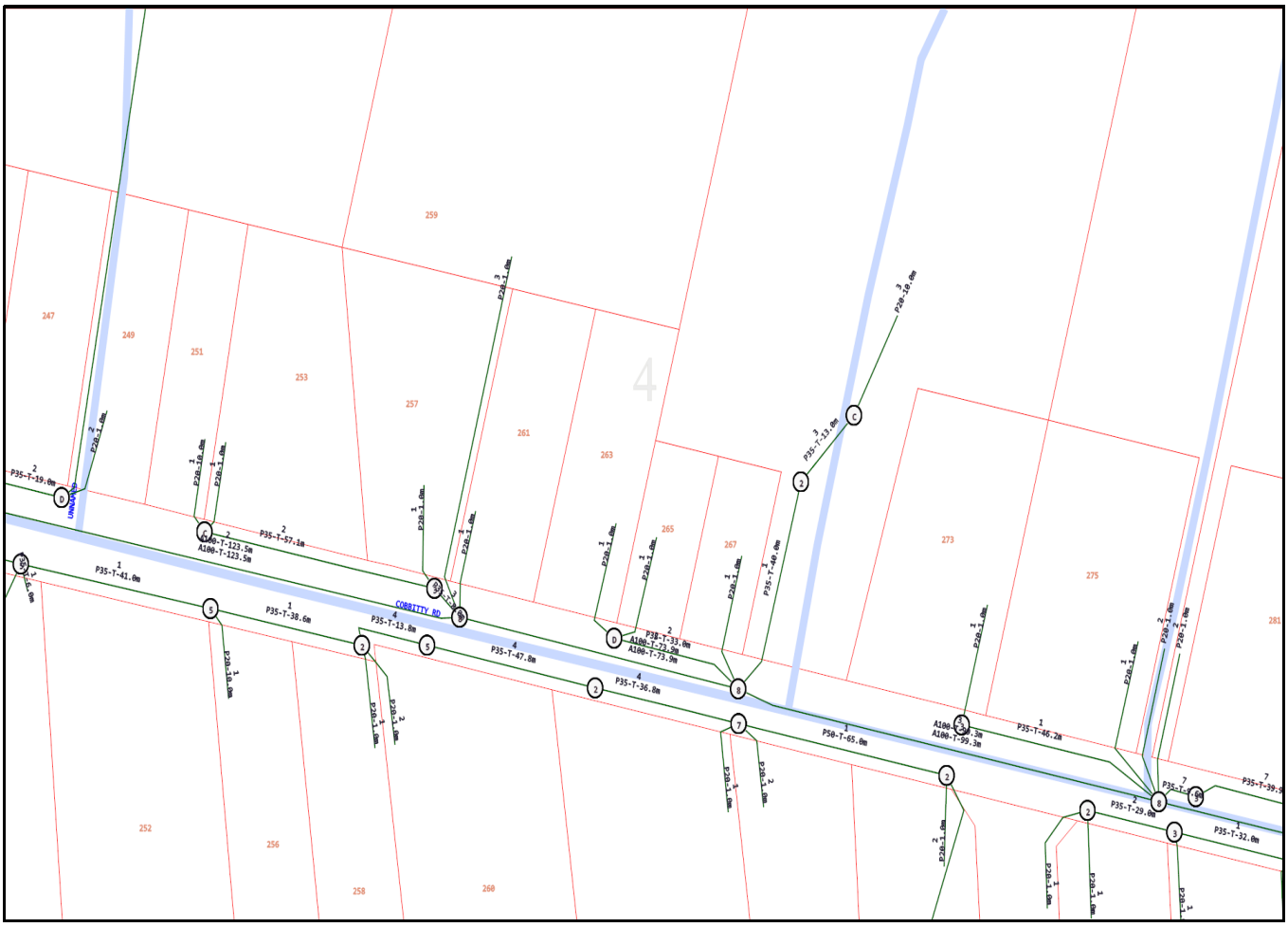
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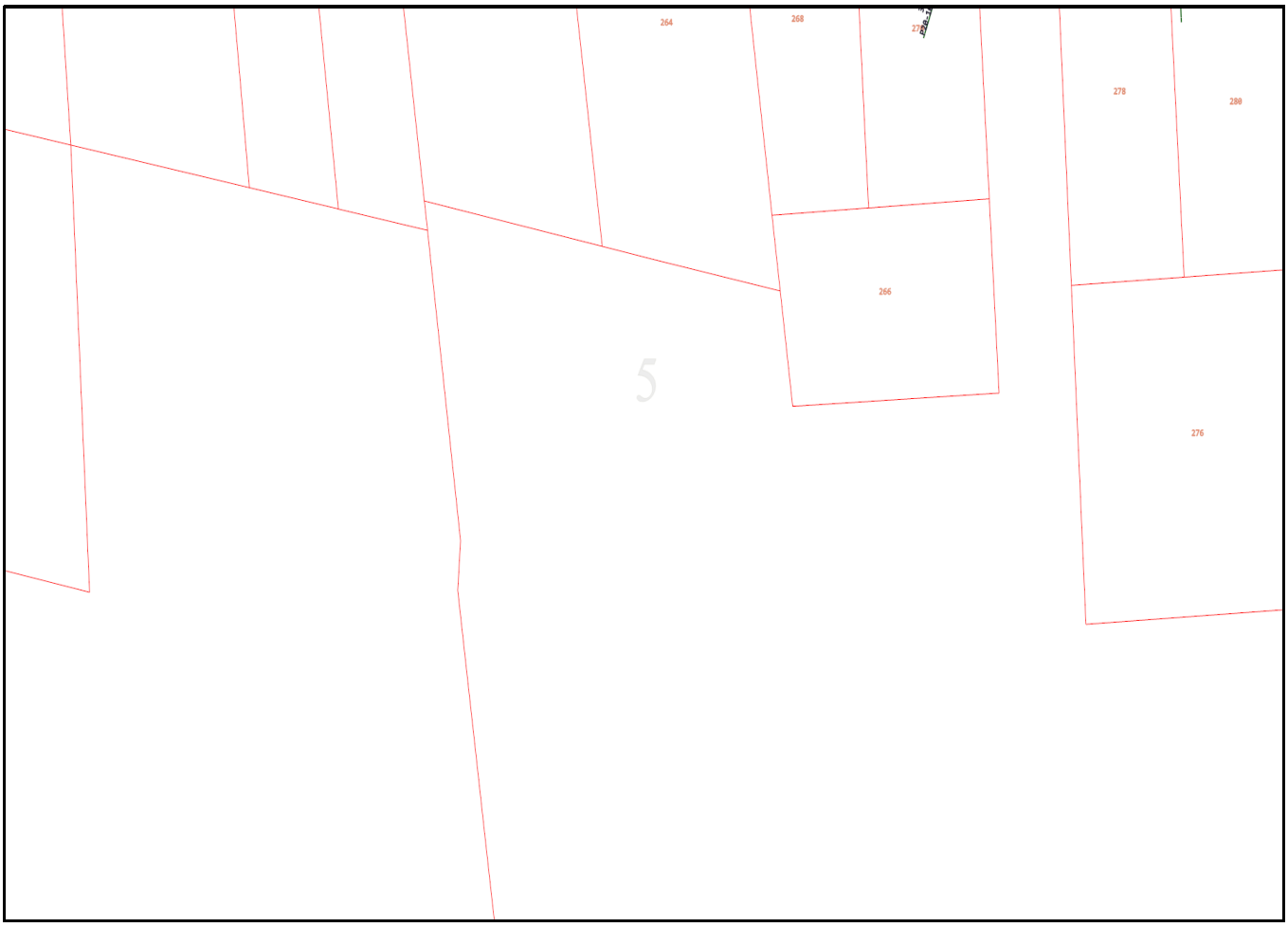
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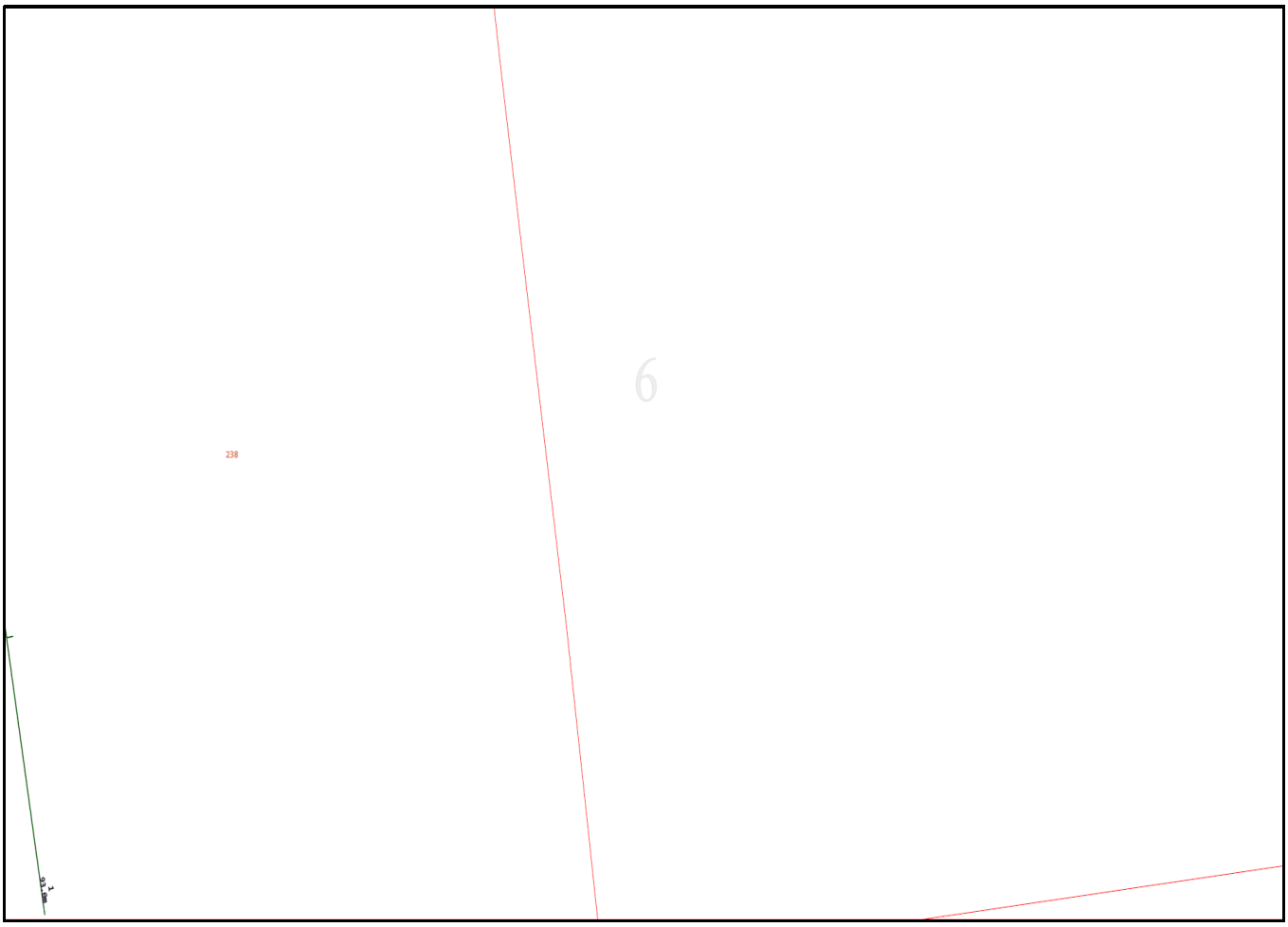
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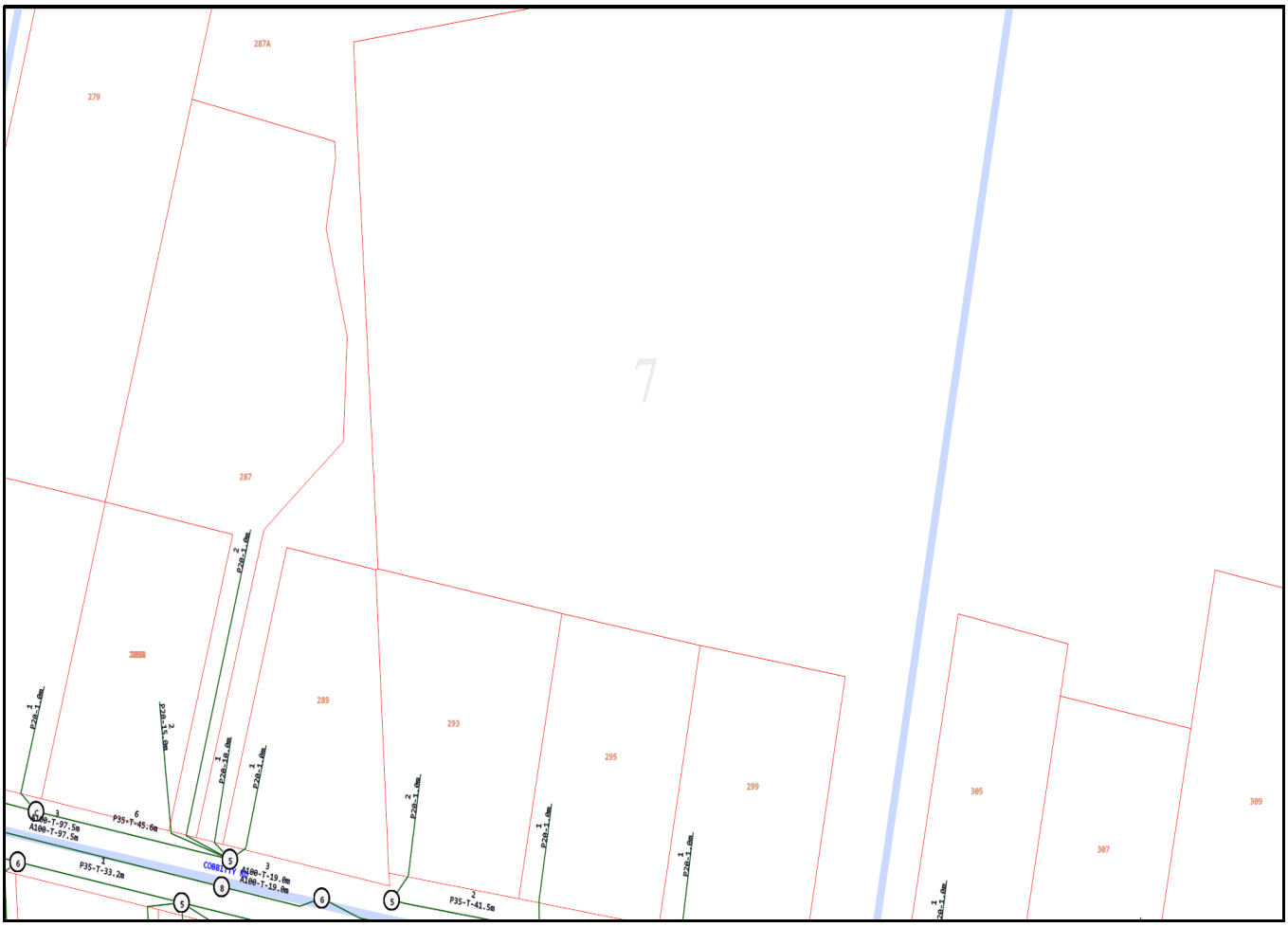
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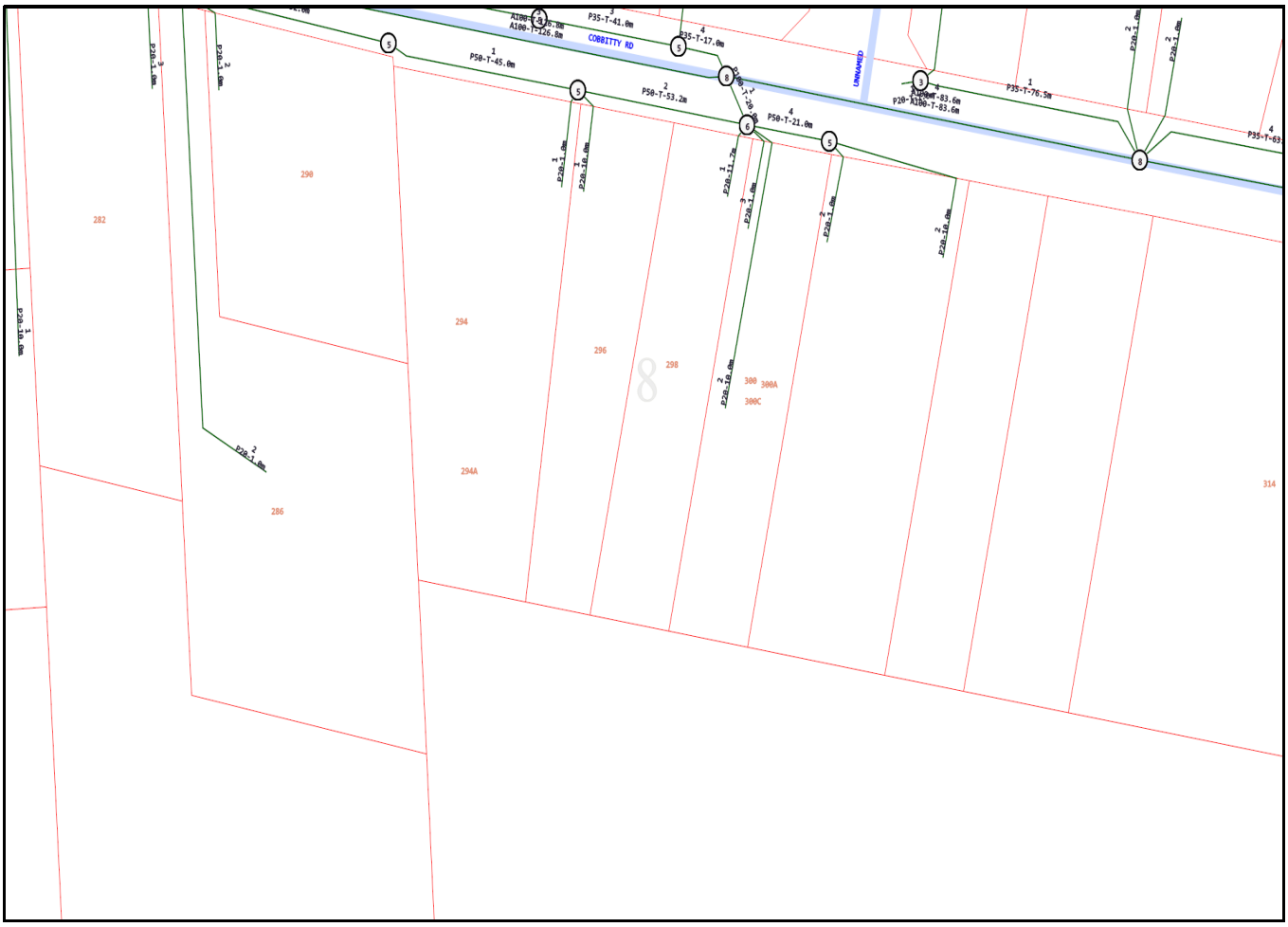
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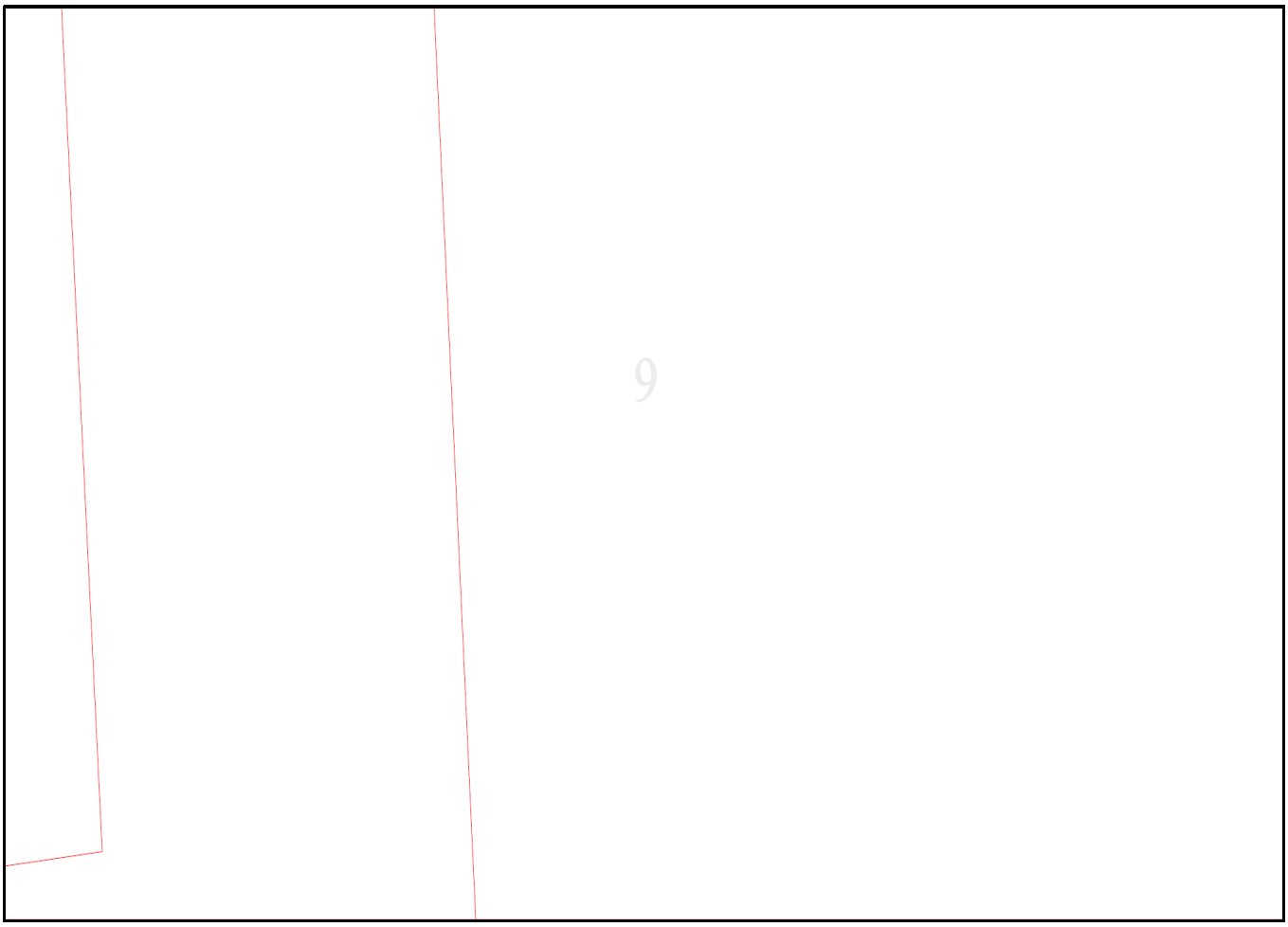
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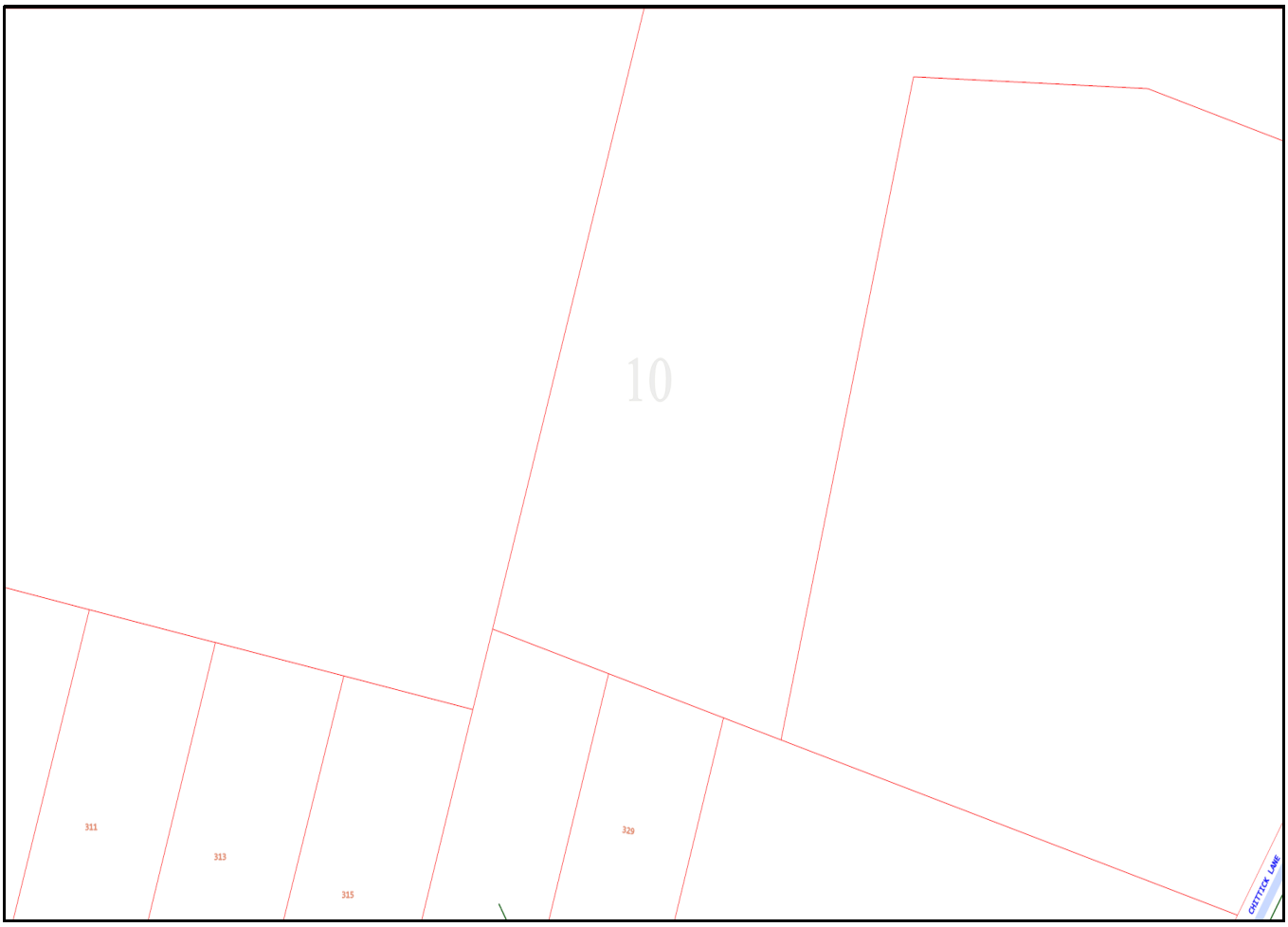
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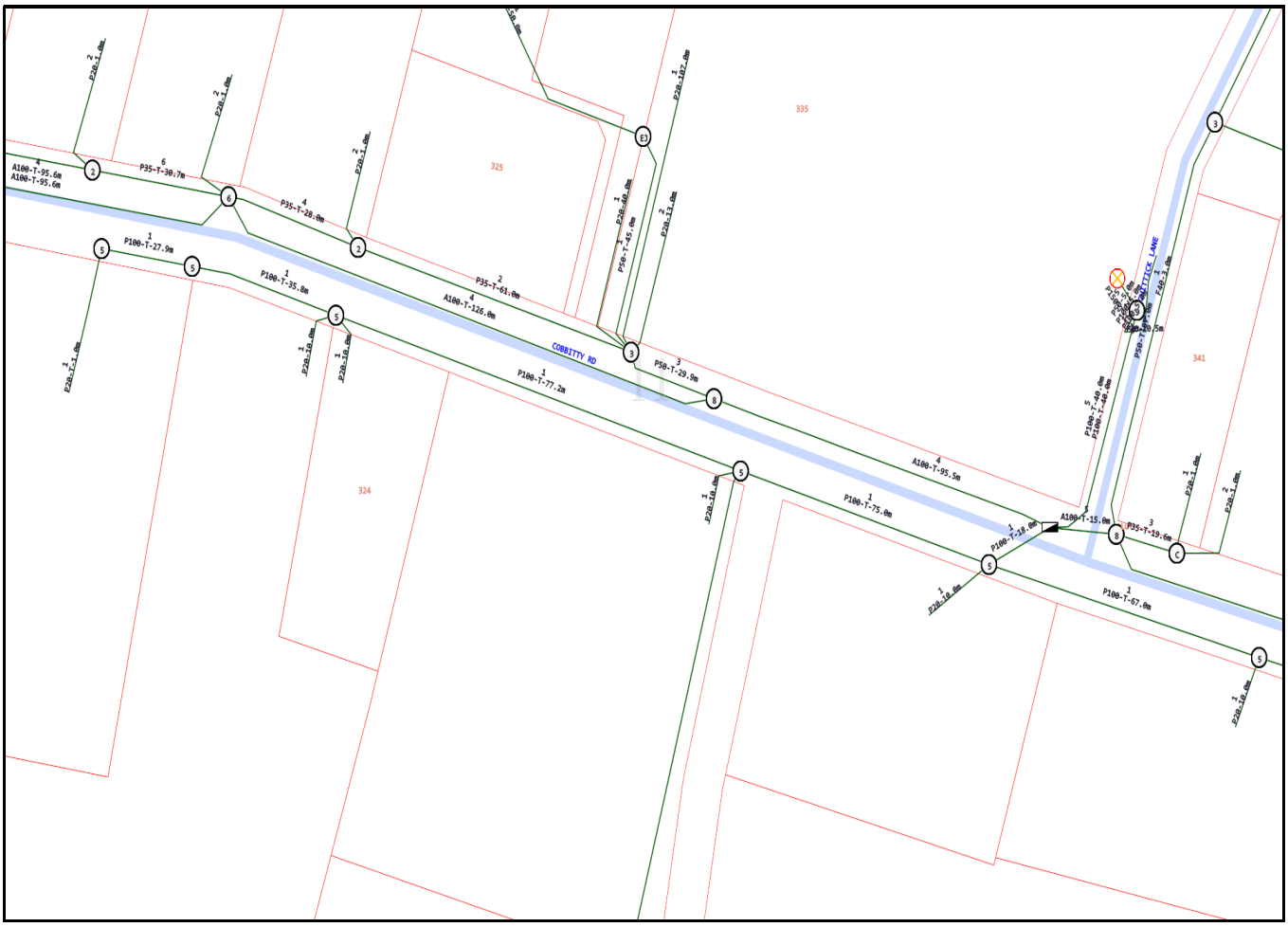
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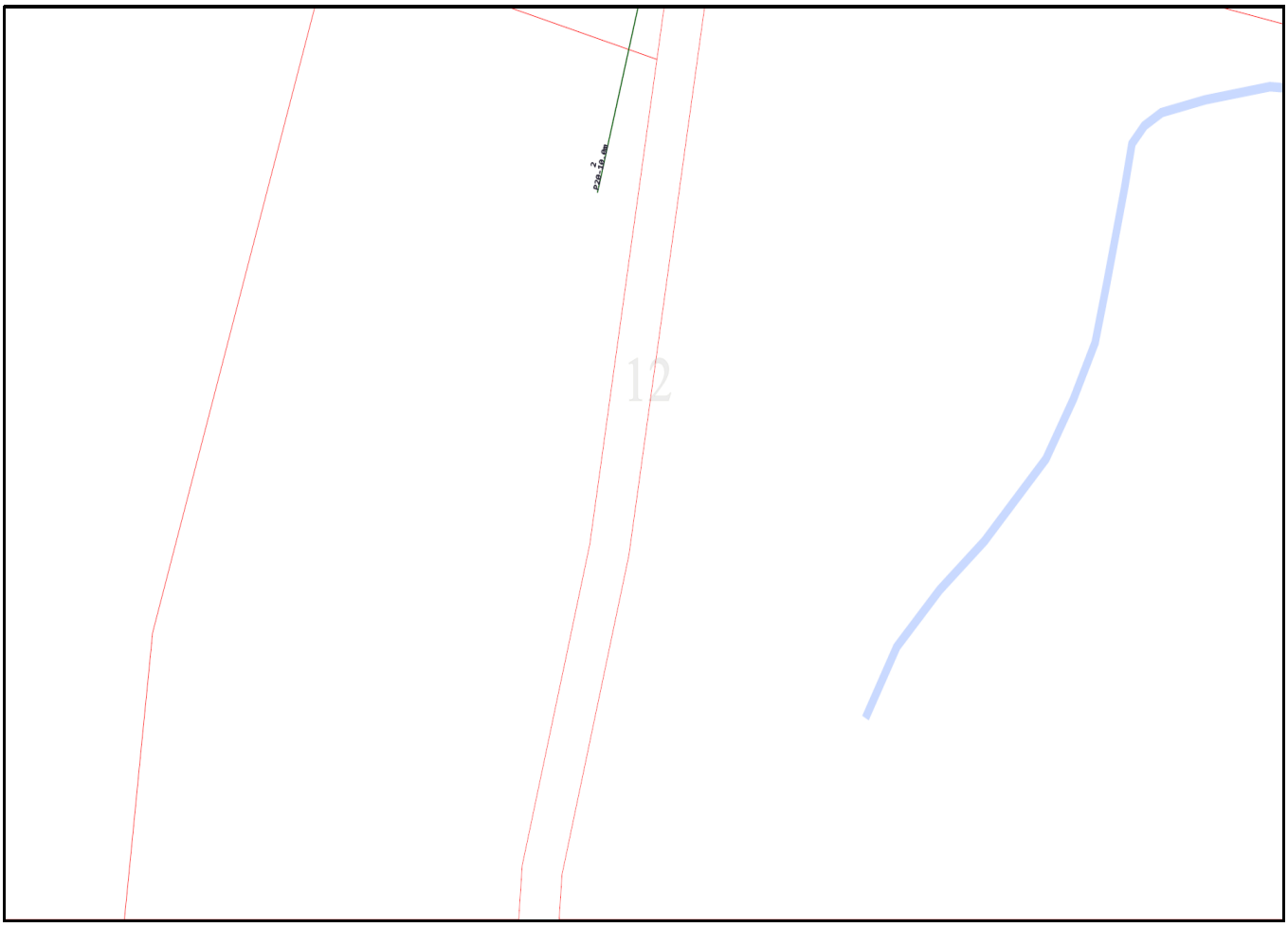
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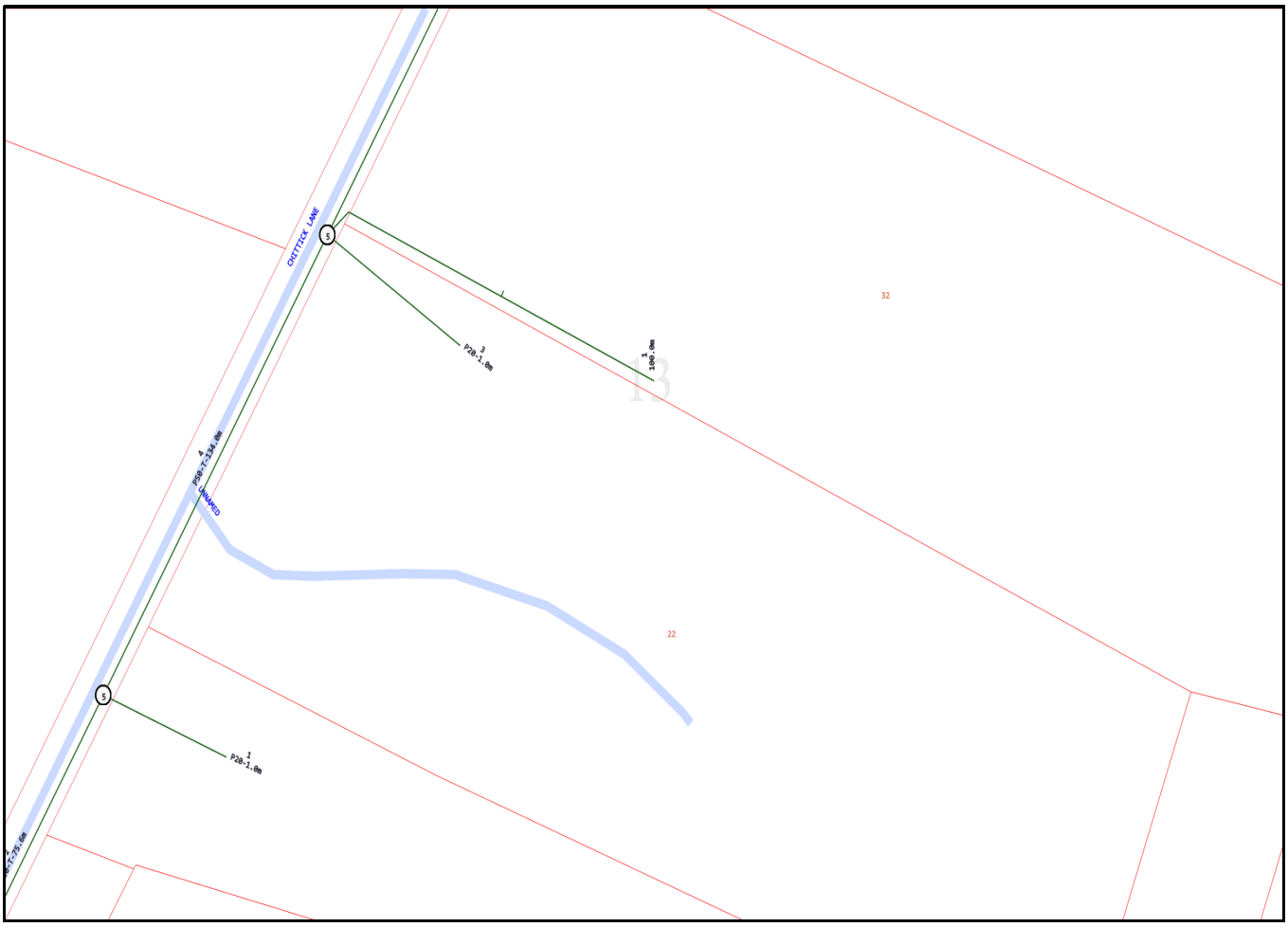
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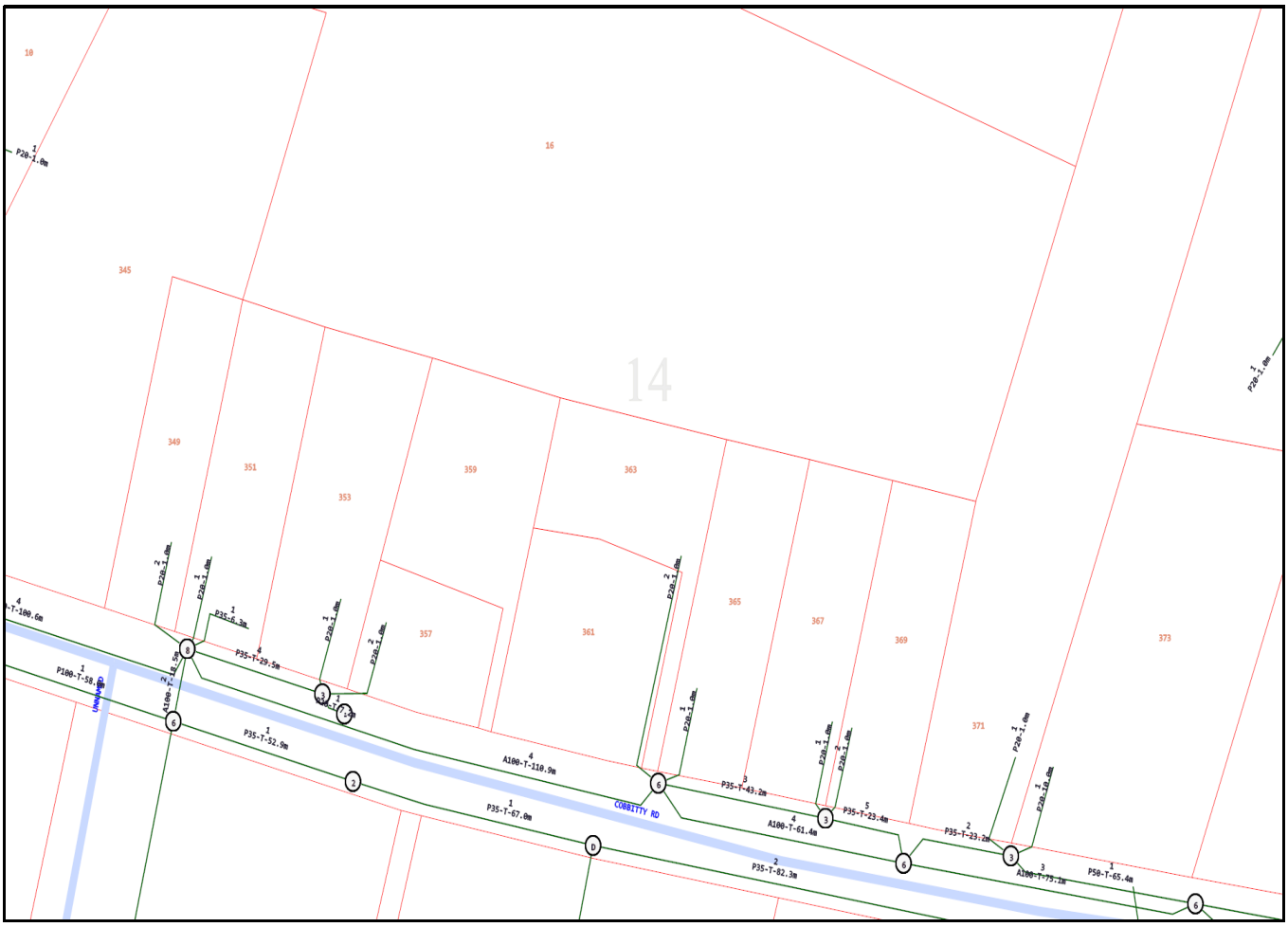
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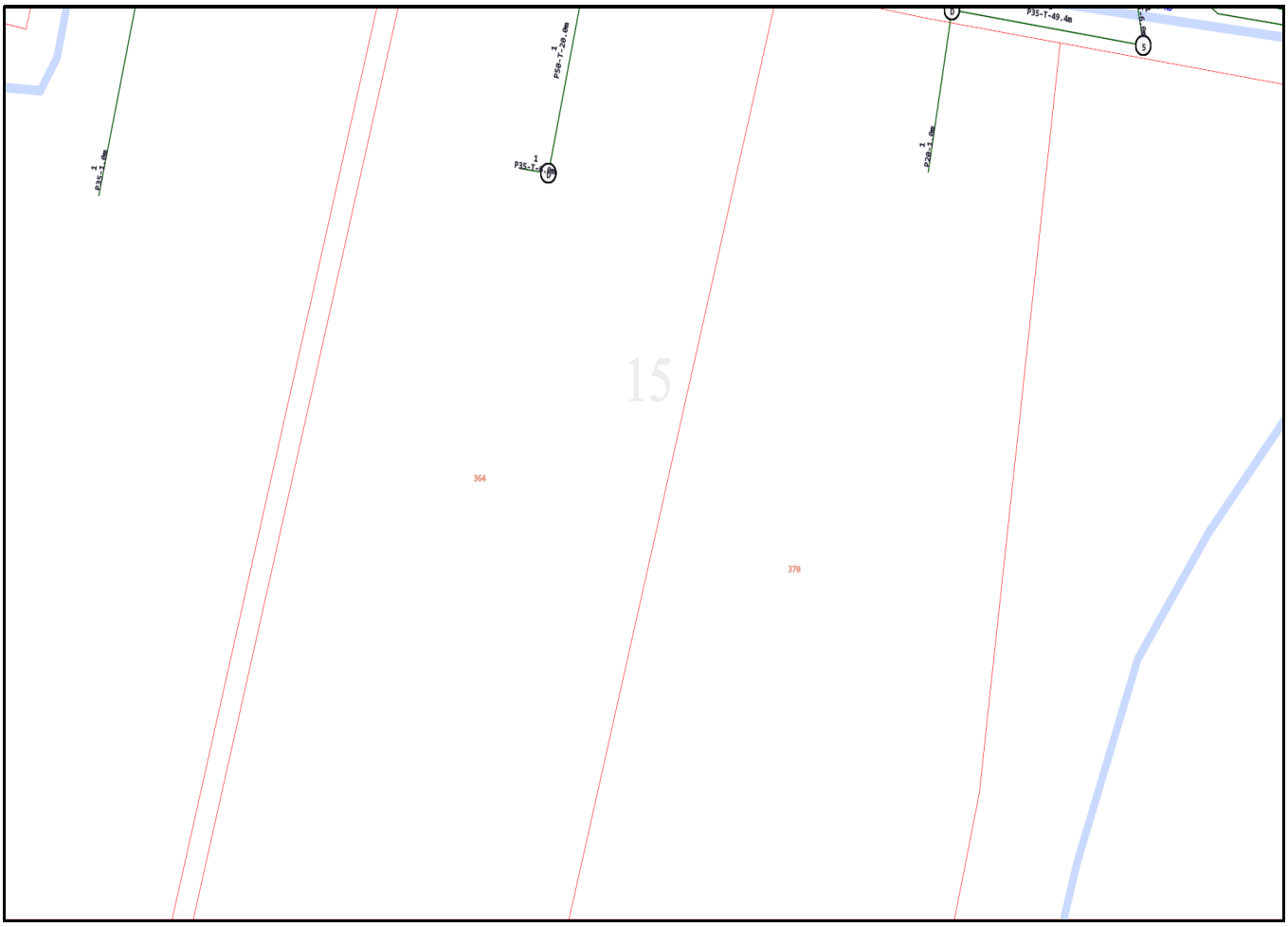
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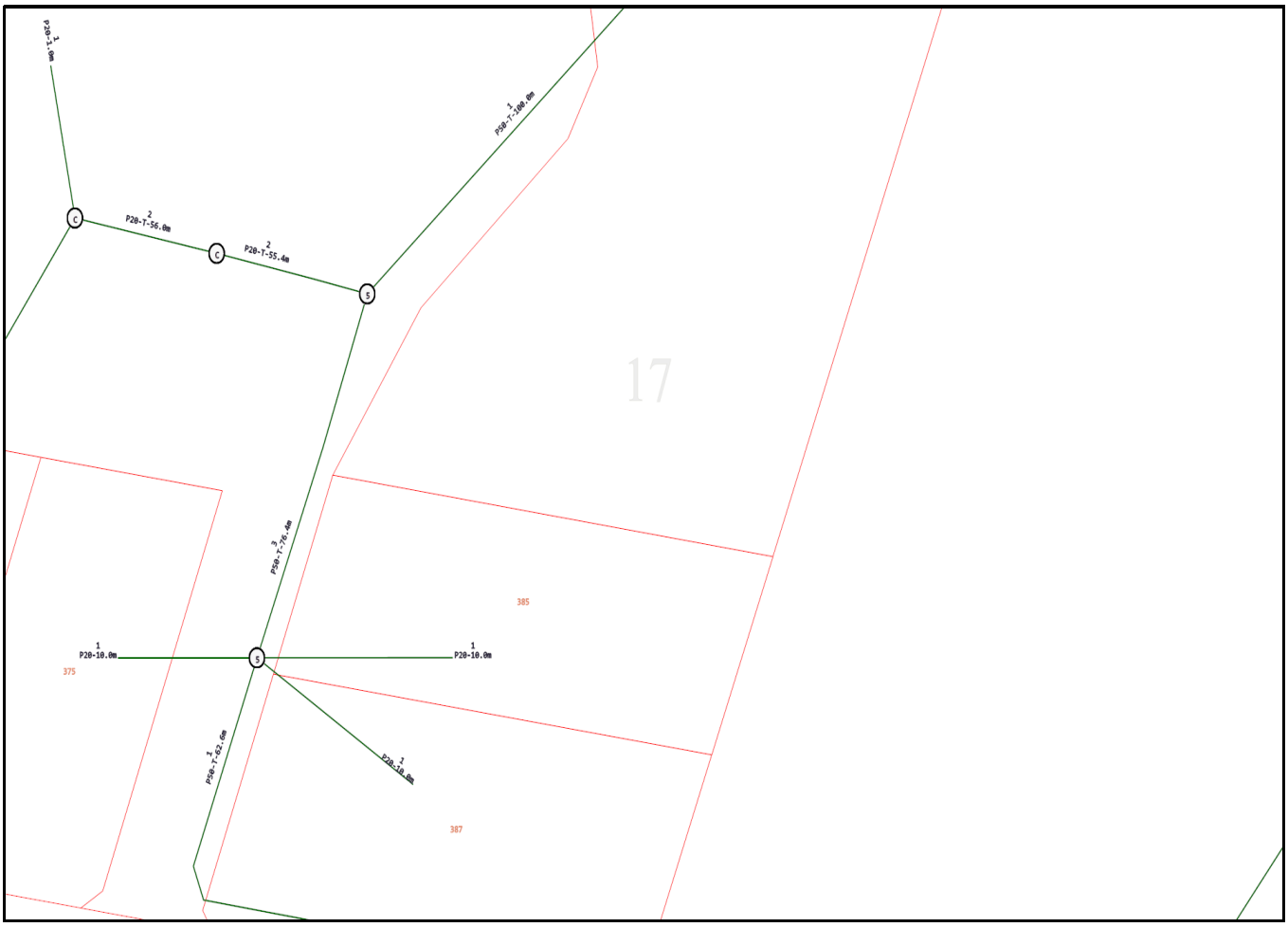
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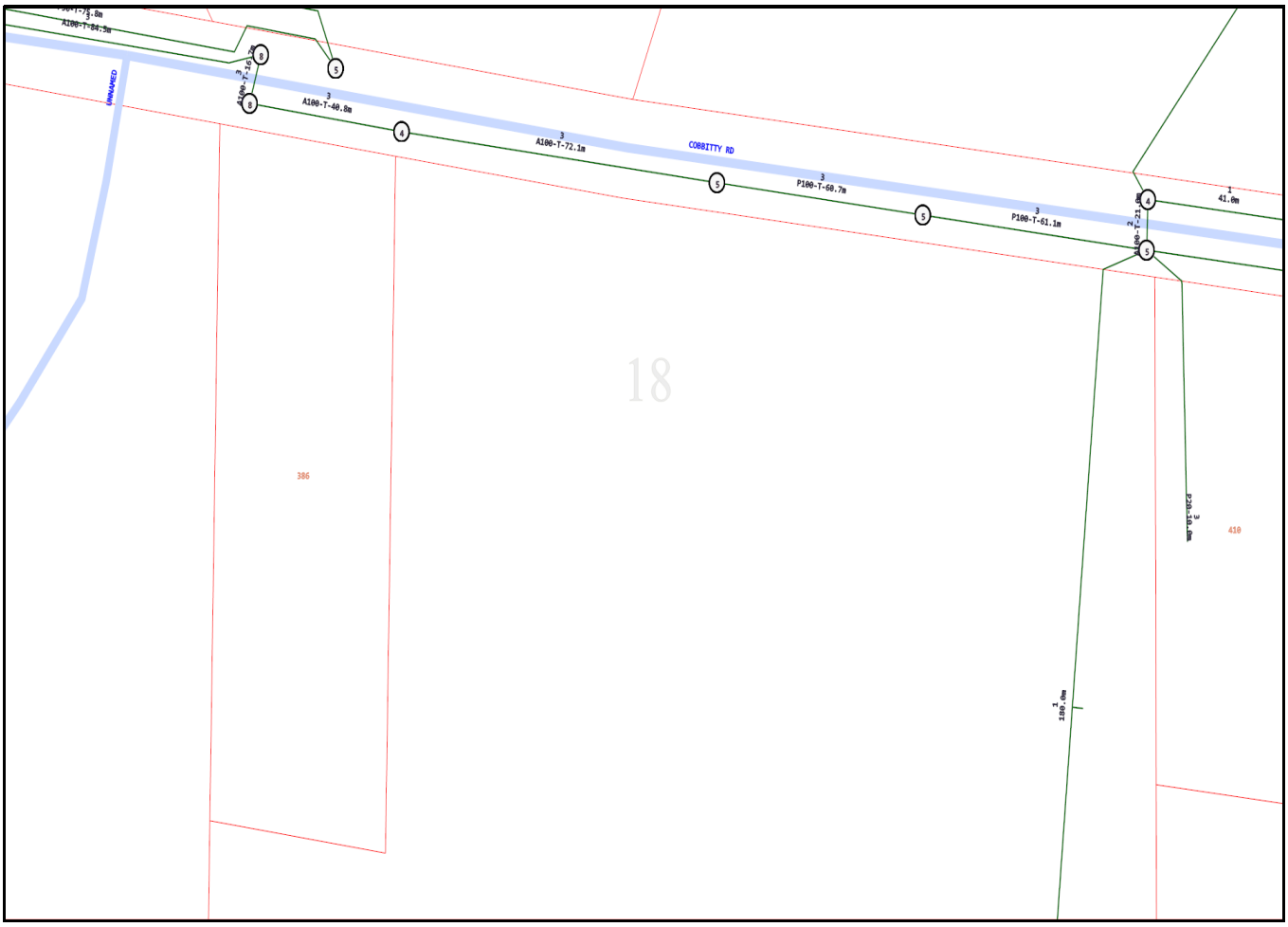
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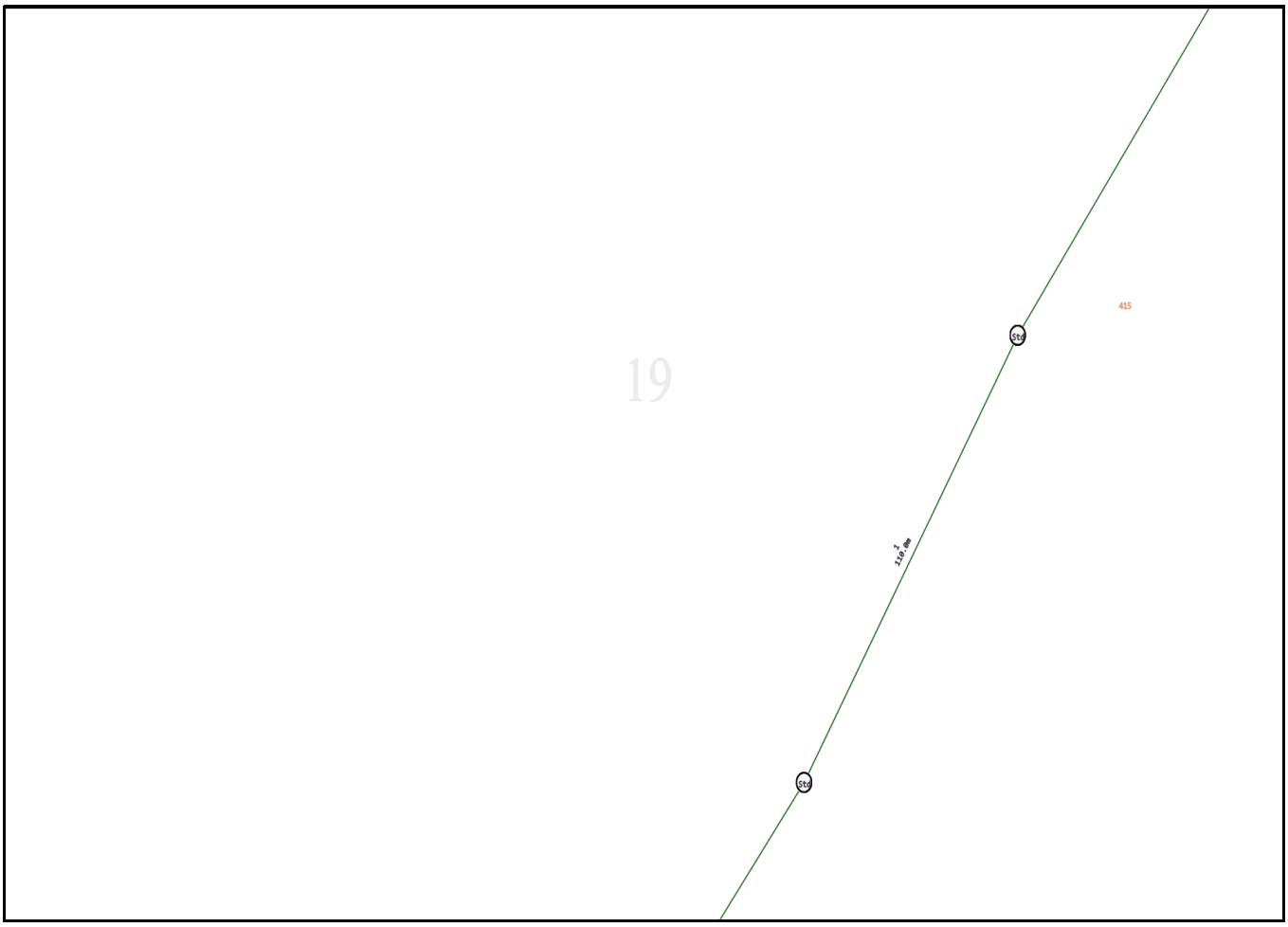
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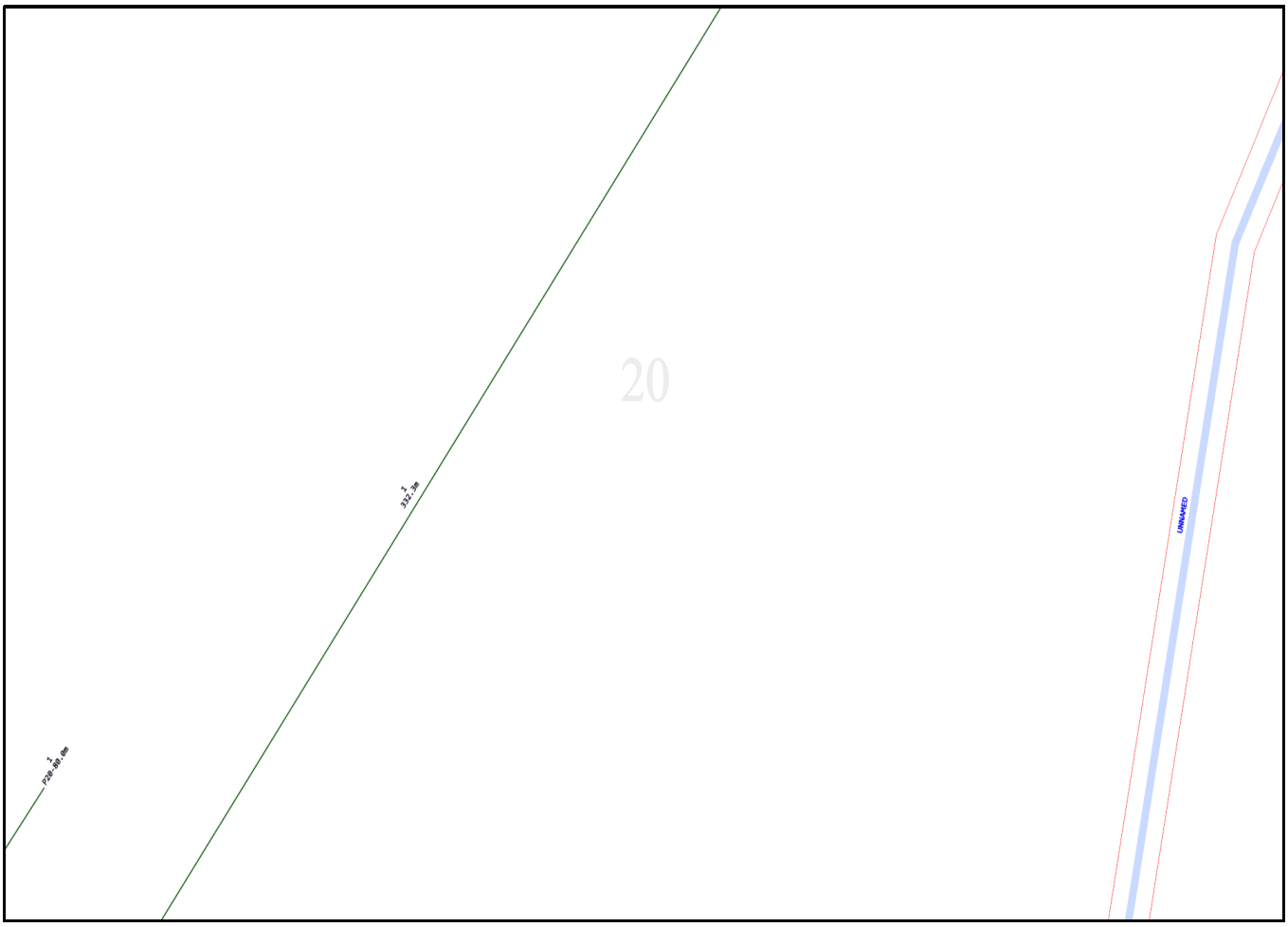
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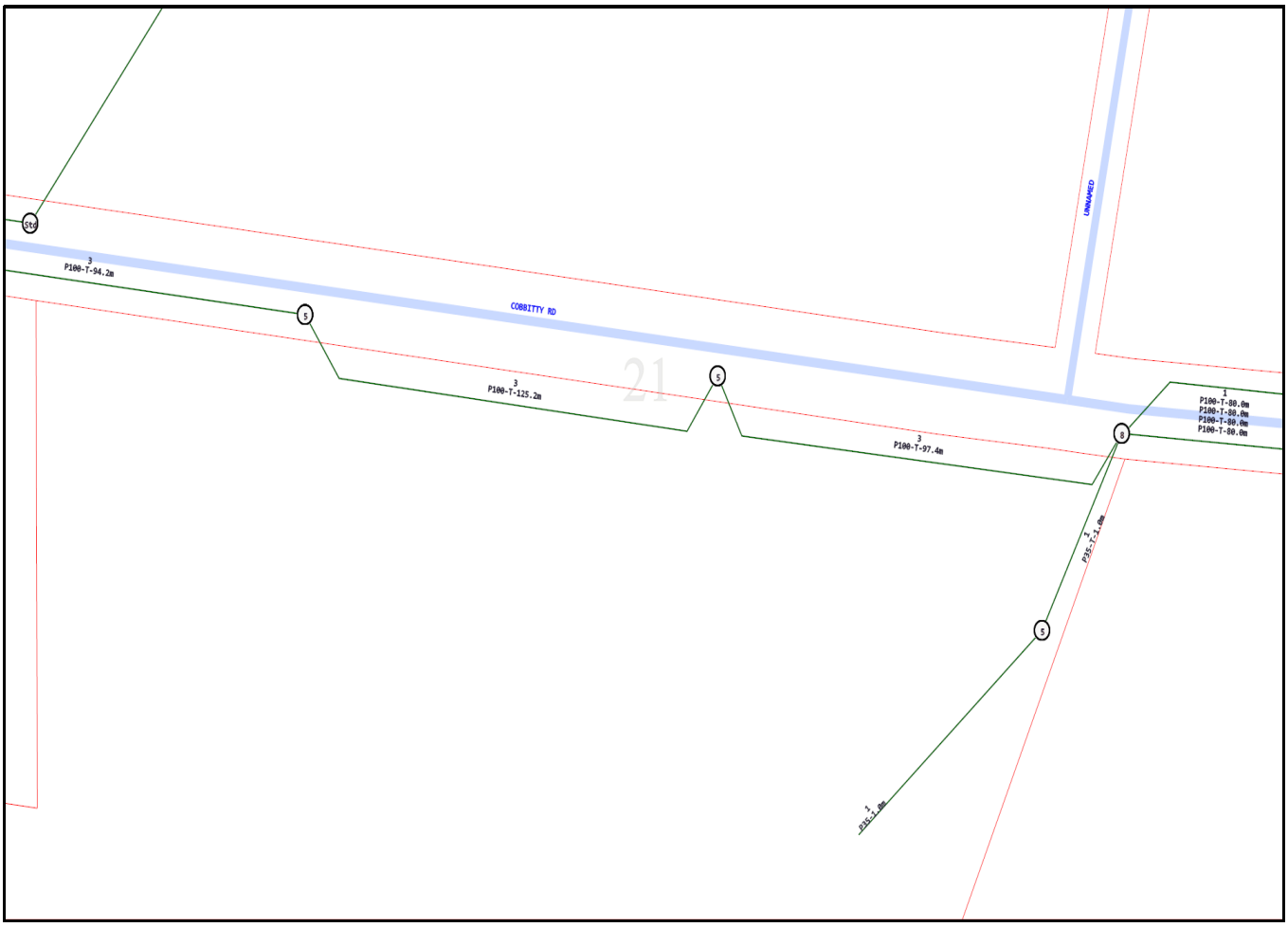
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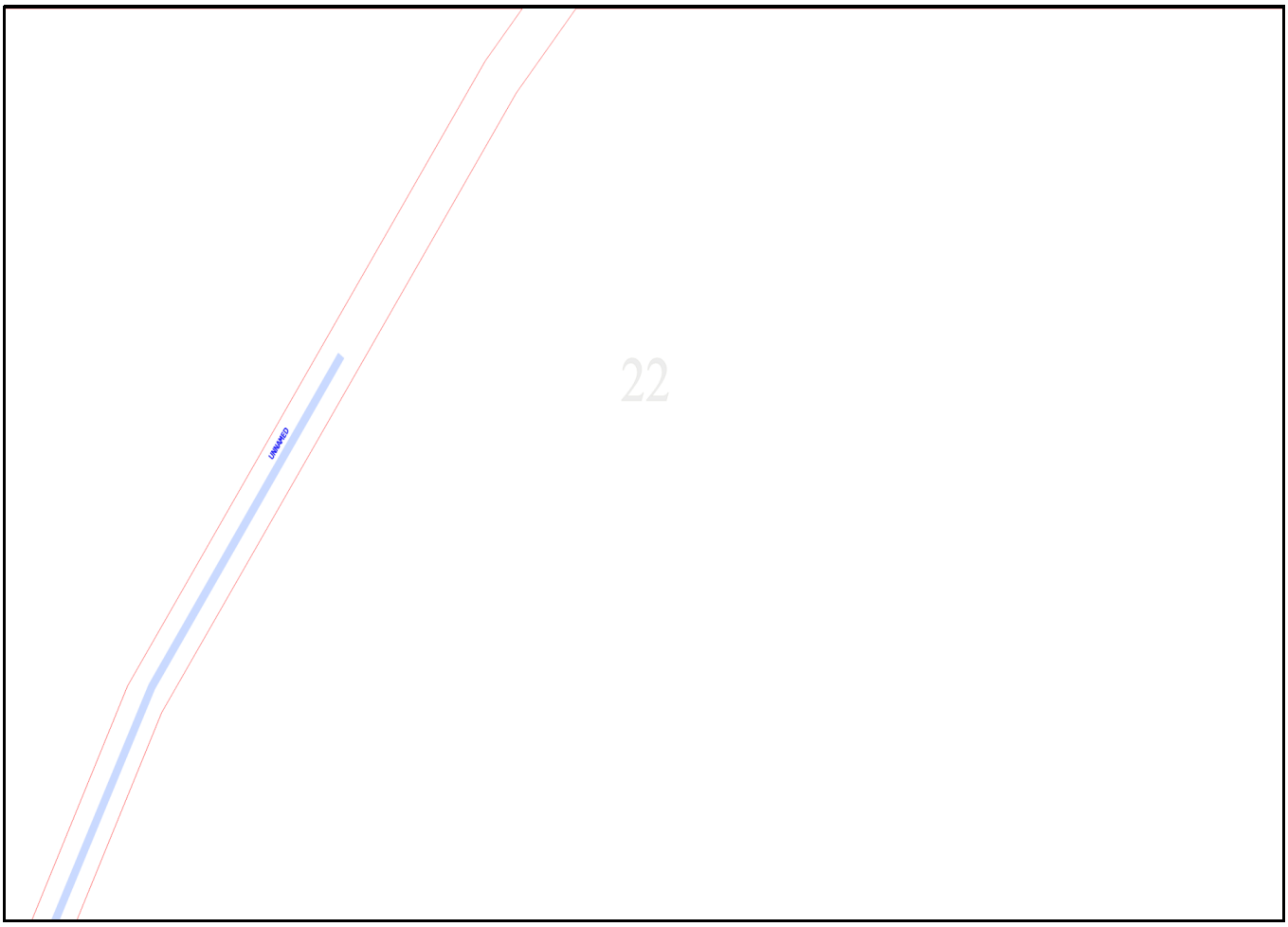
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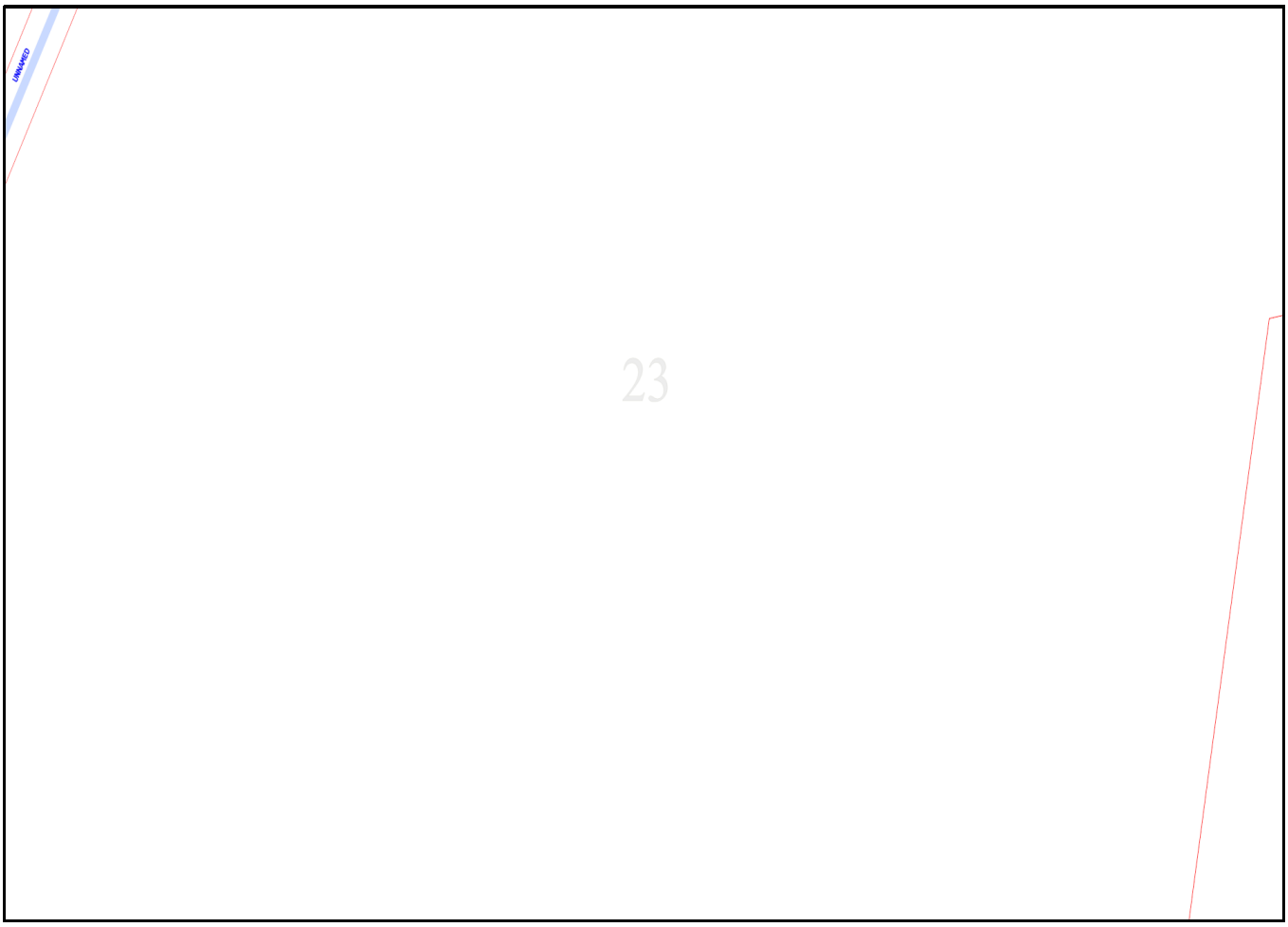
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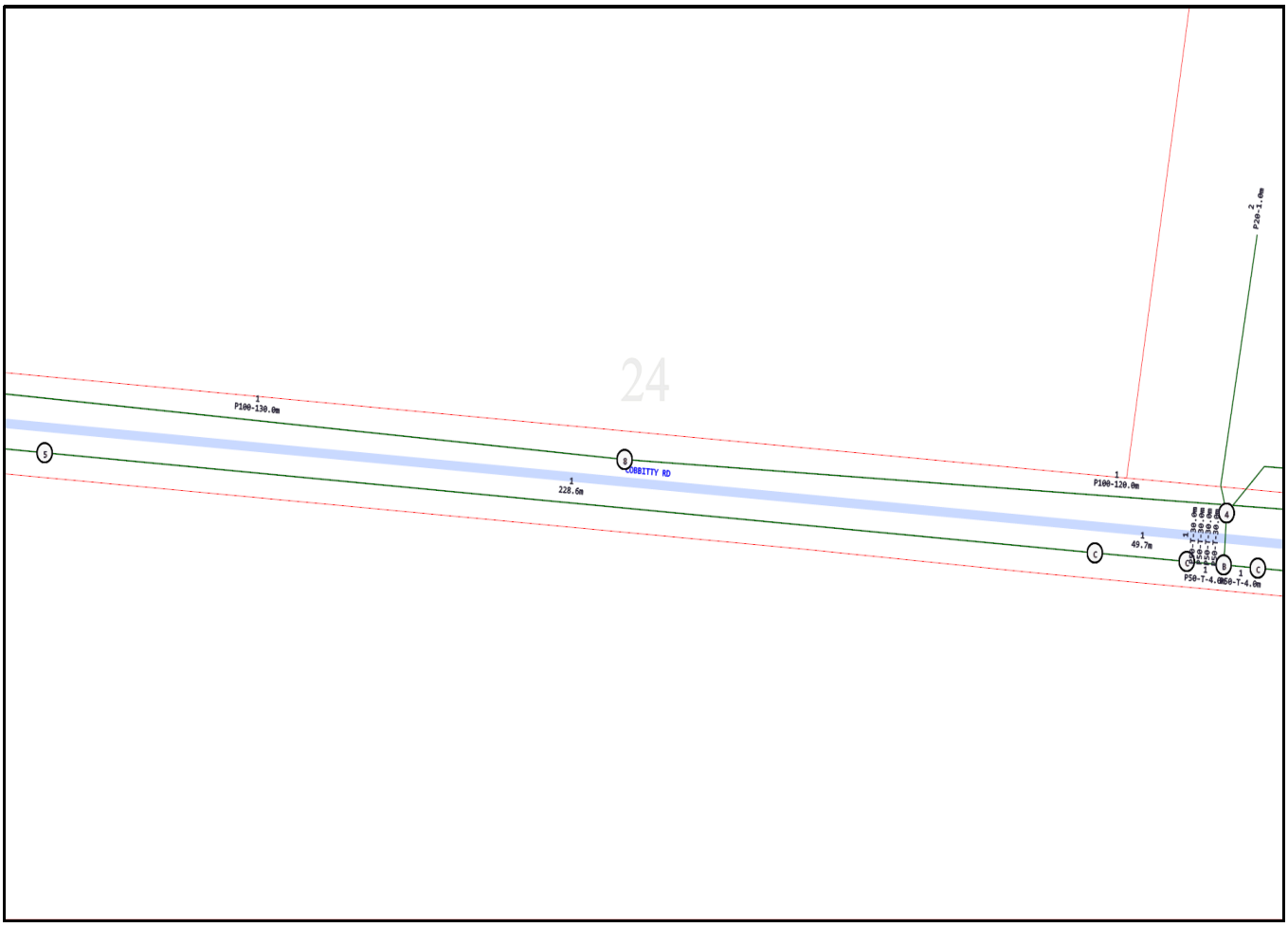
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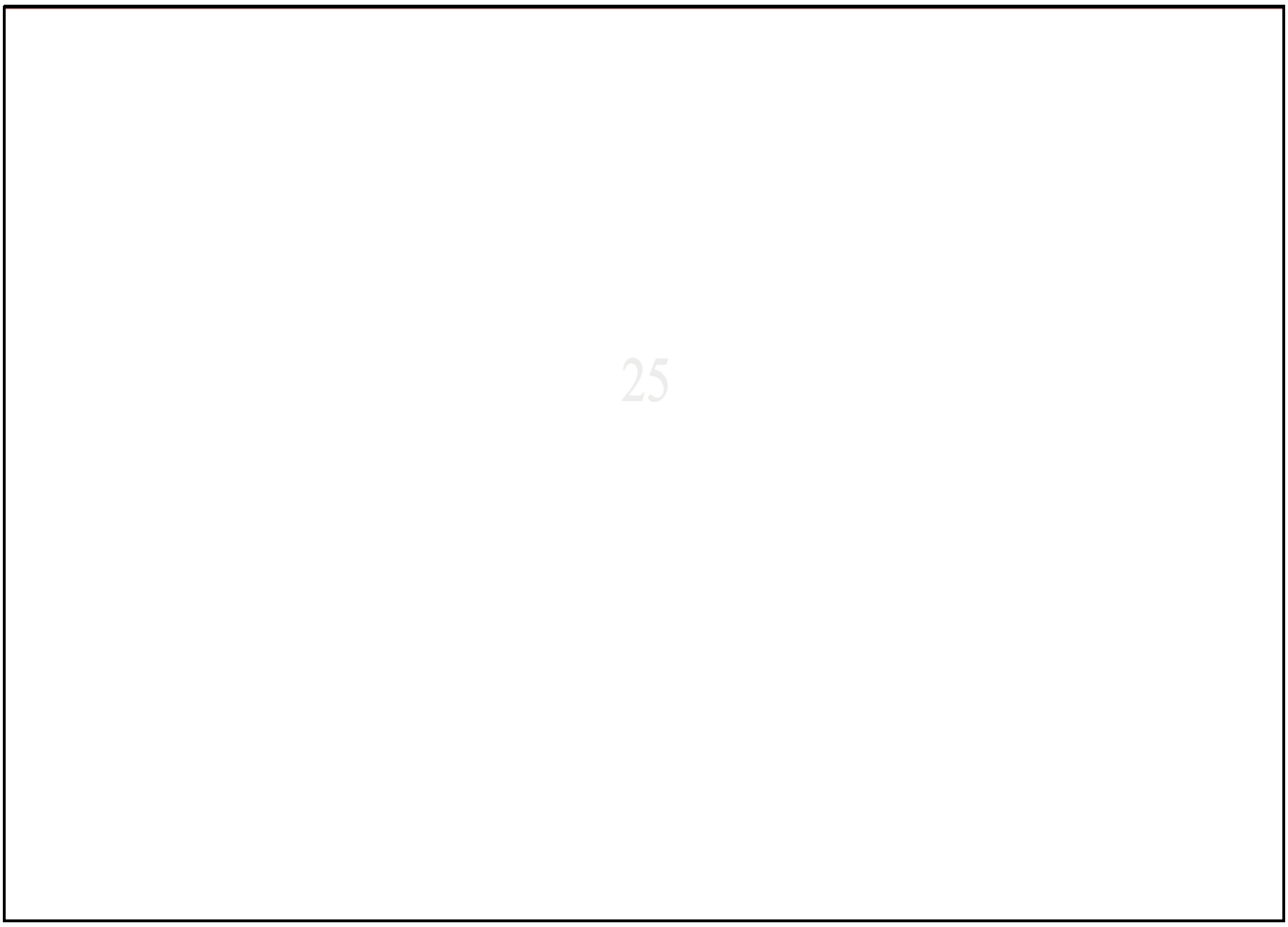
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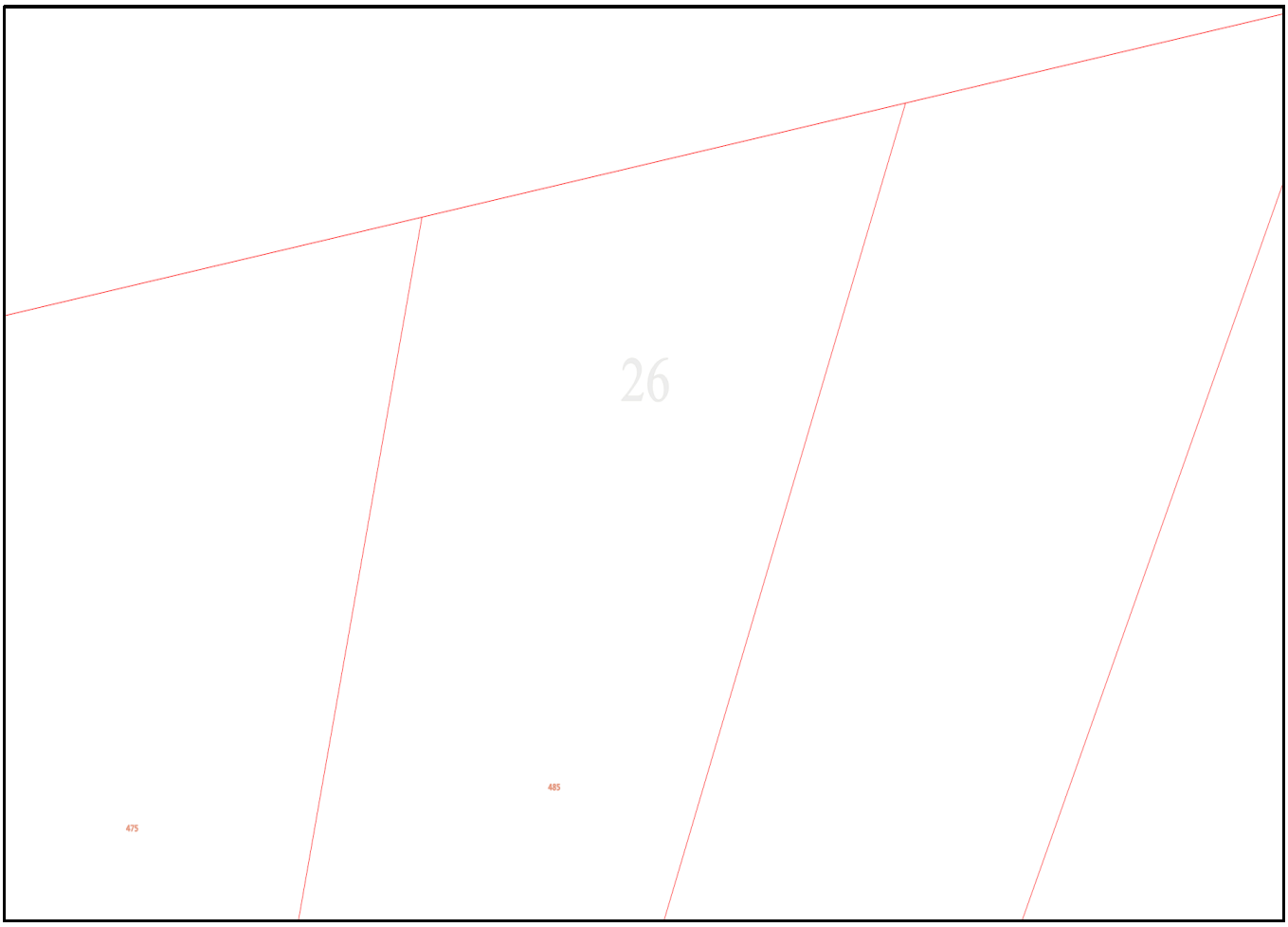
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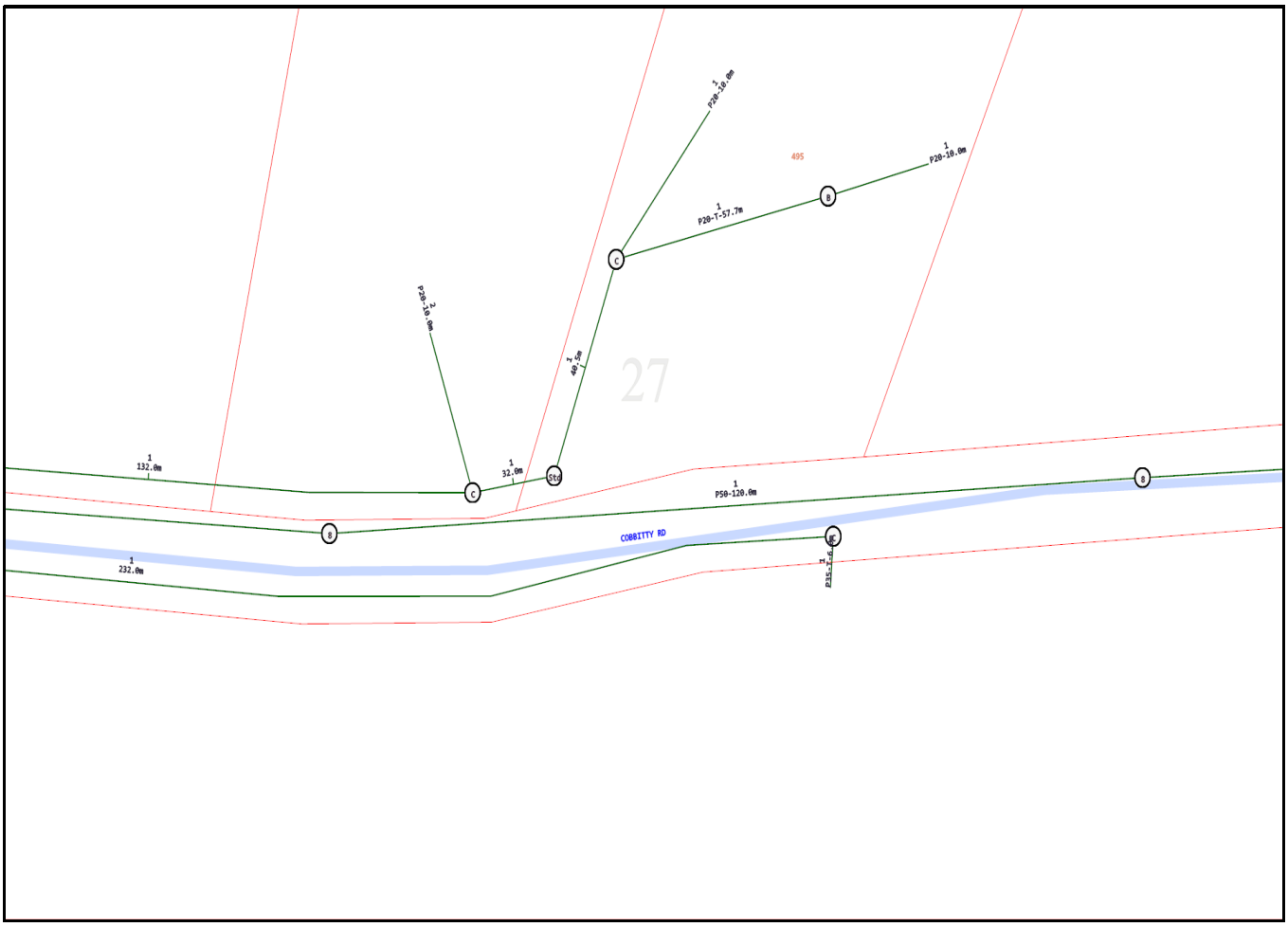
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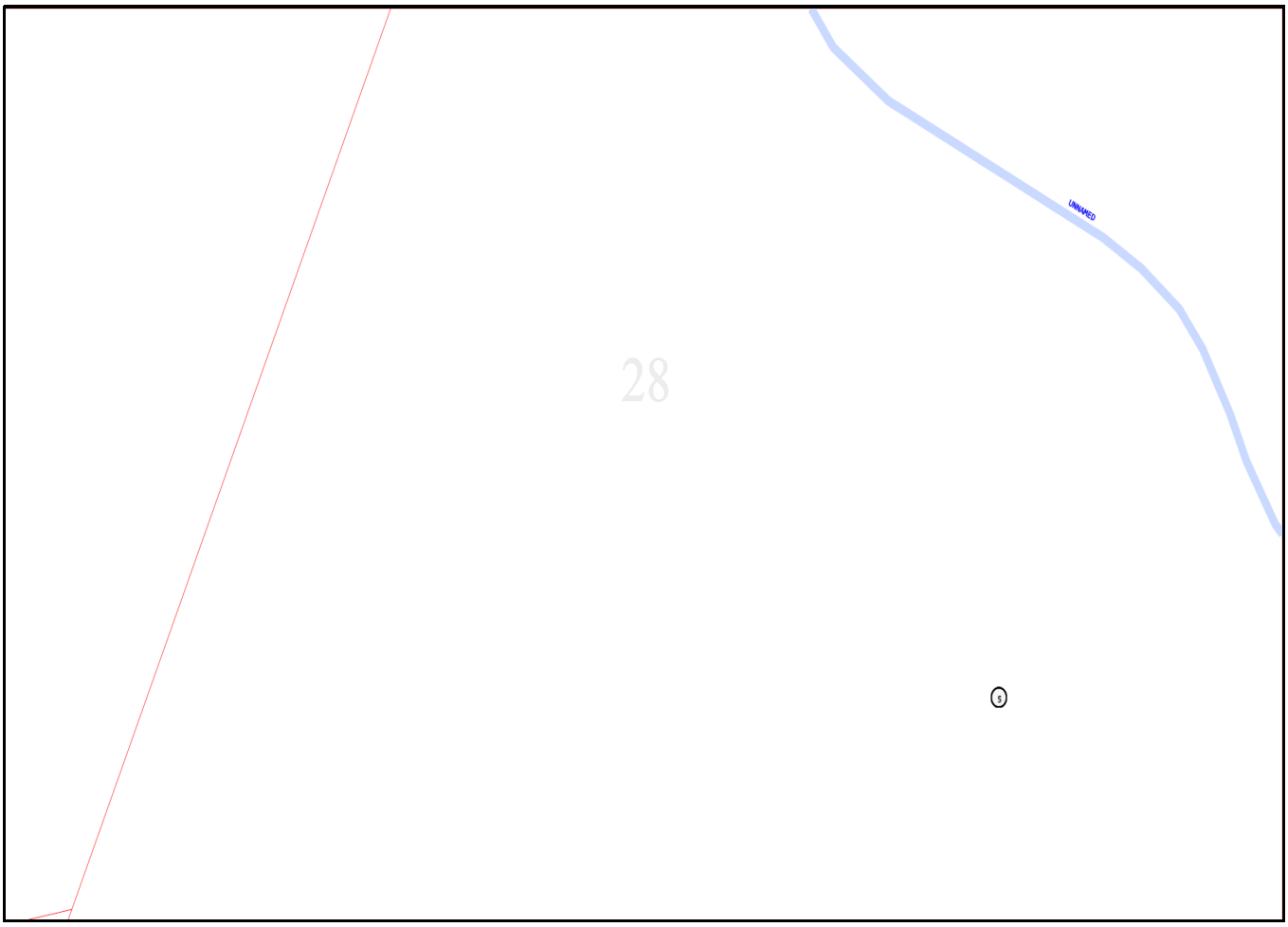
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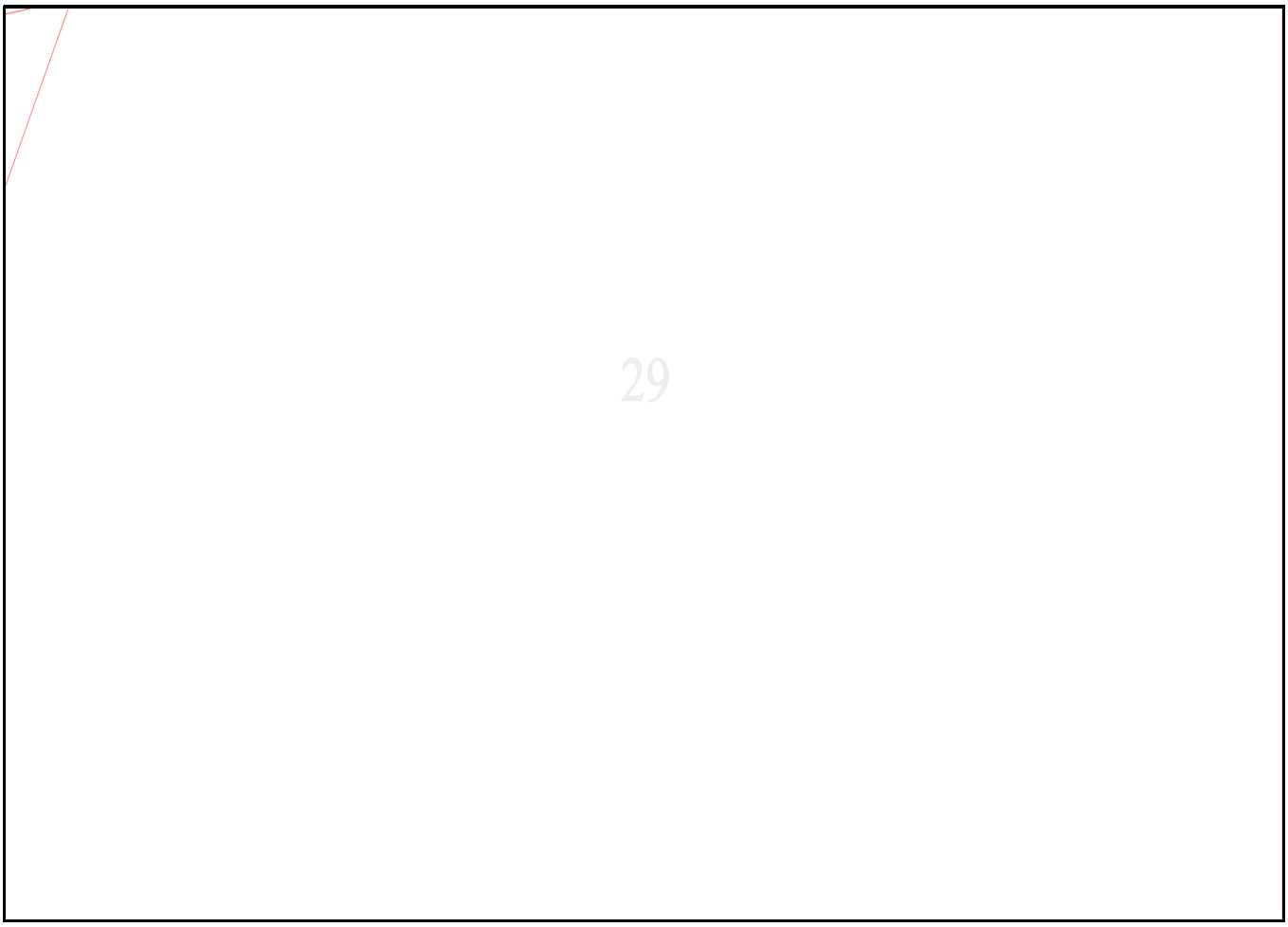
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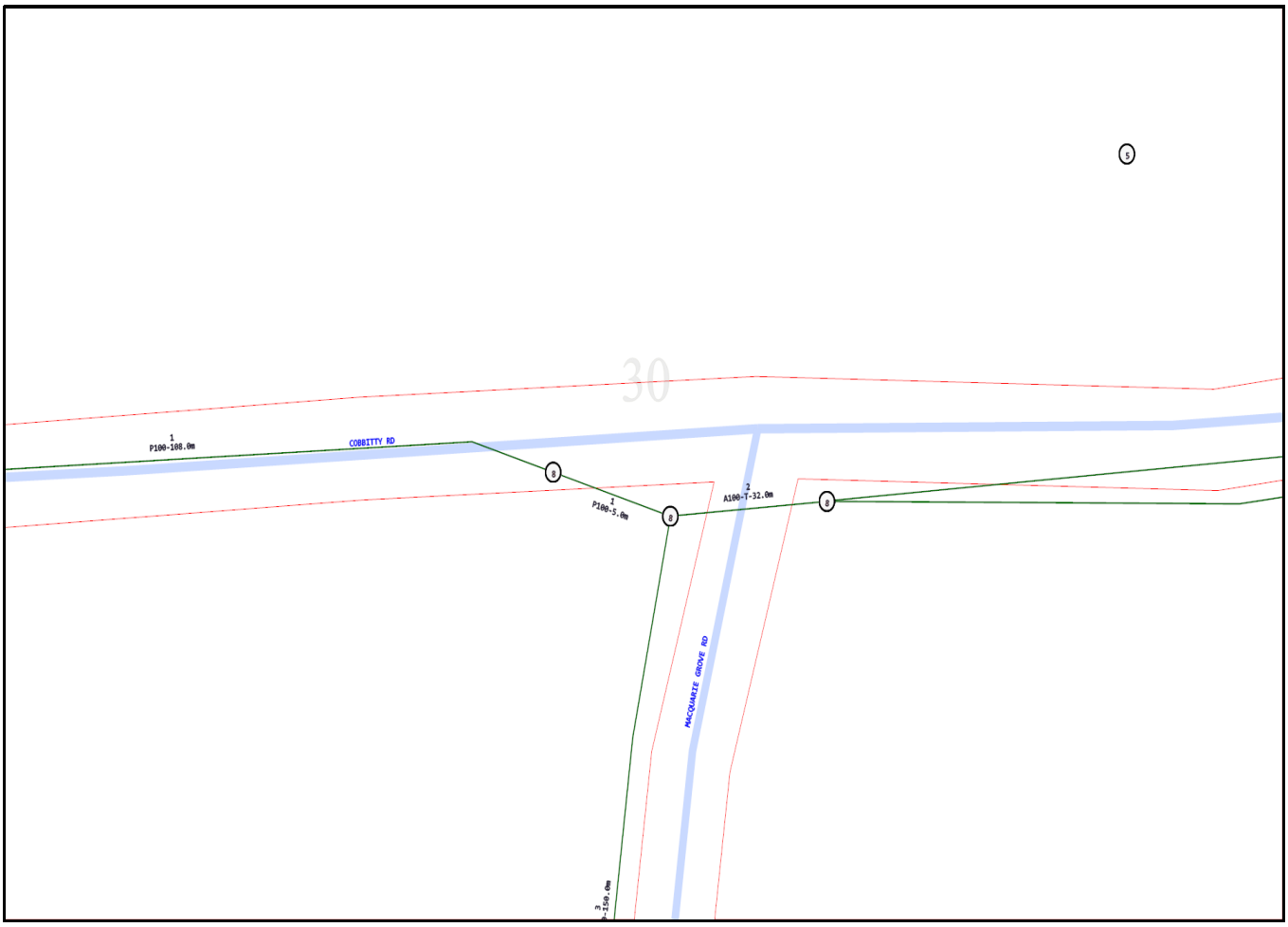
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Indicative Plans

Issue Date:	06/04/2020
Location:	Chittick Ln , Cobbitty , NSW , 2570

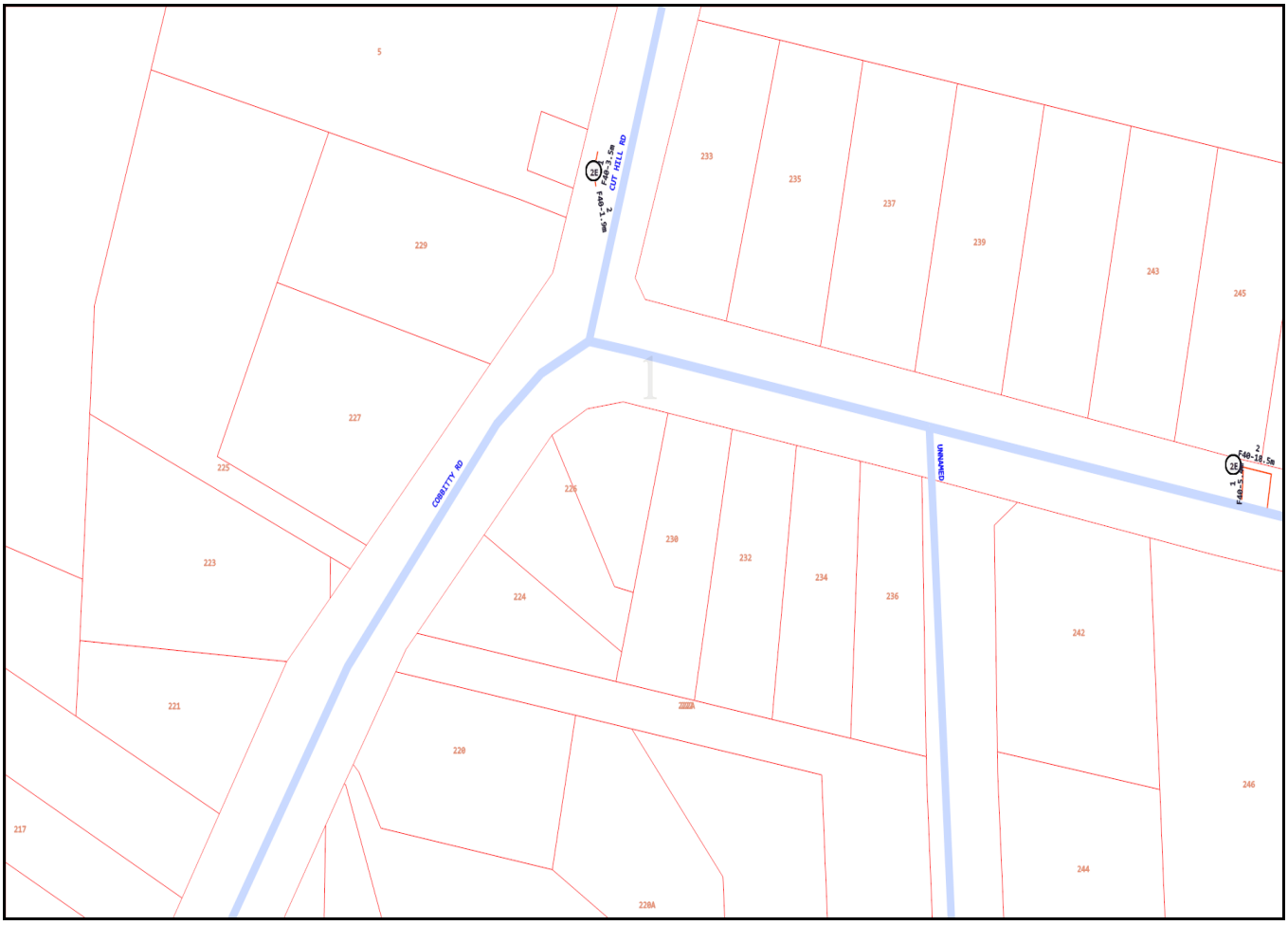
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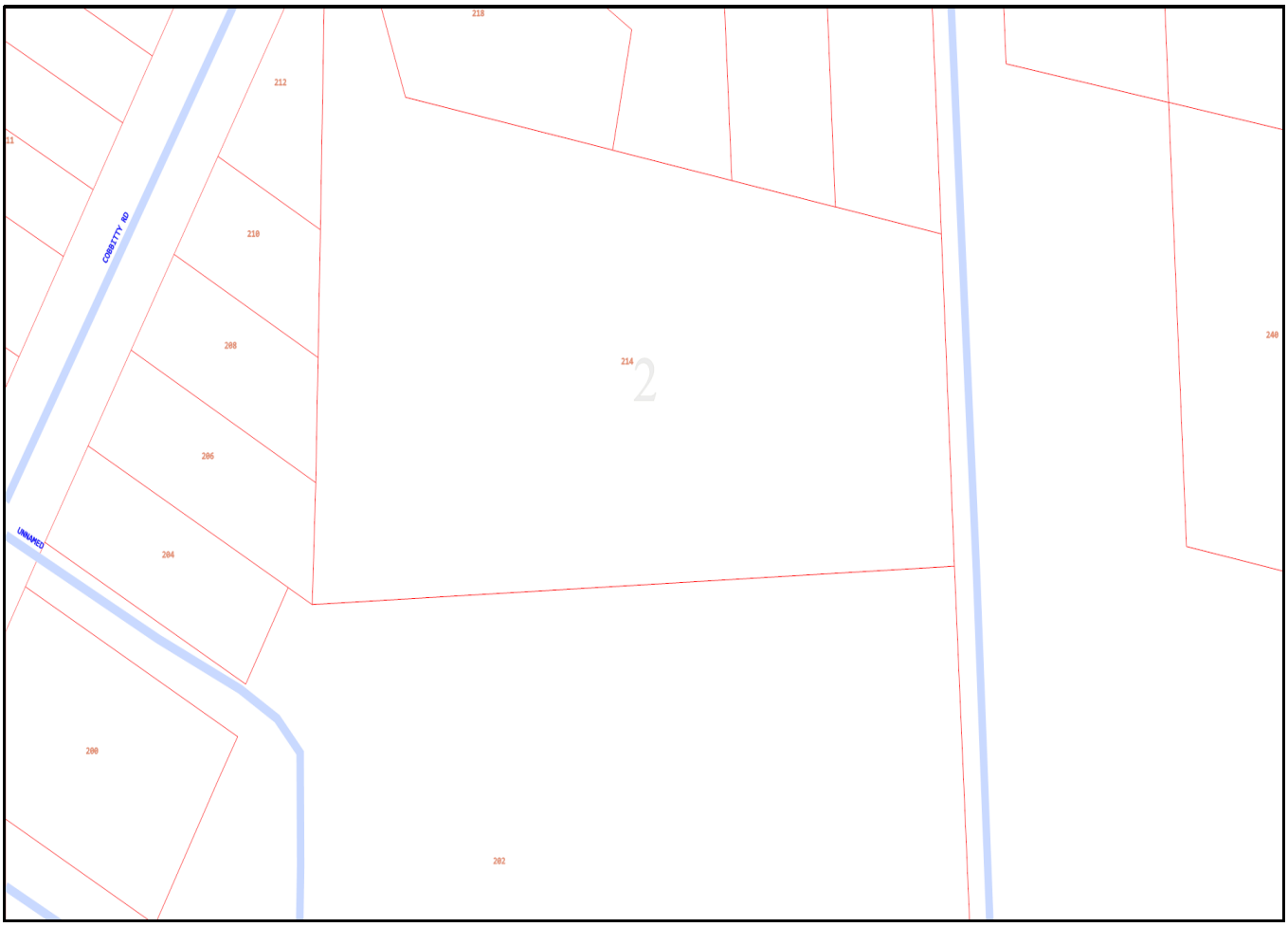
LEGEND

34	Parcel and the location
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2E	Power Pit with size "2E". Valid PIT Size: e.g. 2E, 5E, 6E, 8E, 9E, E, null.
	Manhole
	Pillar
2 PO – T- 25.0m P40 – 20.0m 5 9	Cable count of trench is 2. One "Other size" PVC conduit (PO) owned by Telstra (-T-), between pits of sizes, "5" and "9" are 25.0m apart. One 40mm PVC conduit (P40) owned by NBN, between pits of sizes, "5" and "9" are 20.0m apart.
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BROADWAY ST	Road and the street name "Broadway ST"
Scale	0 20 40 60 Meters 1:2000 1 cm equals 20 m

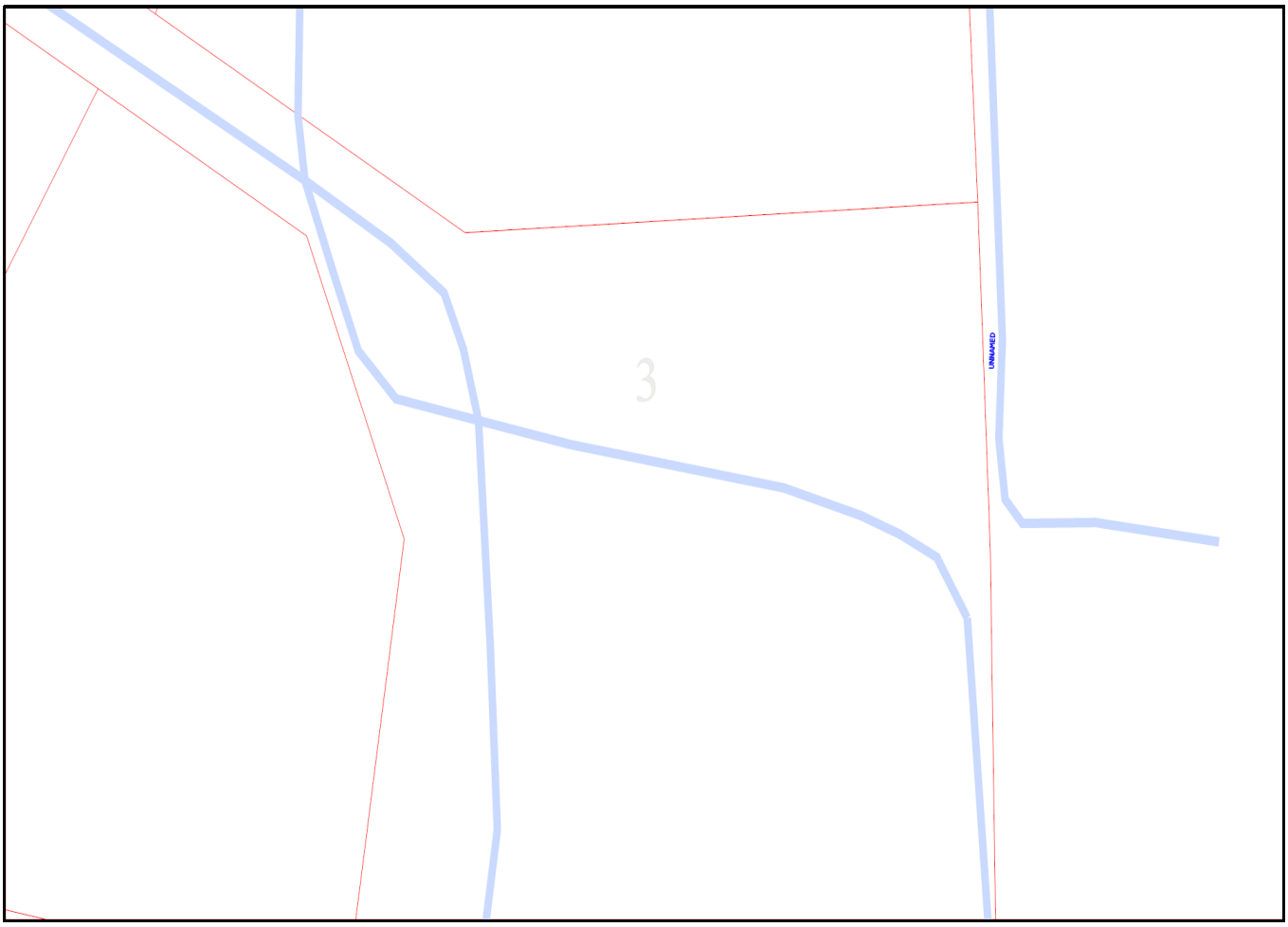
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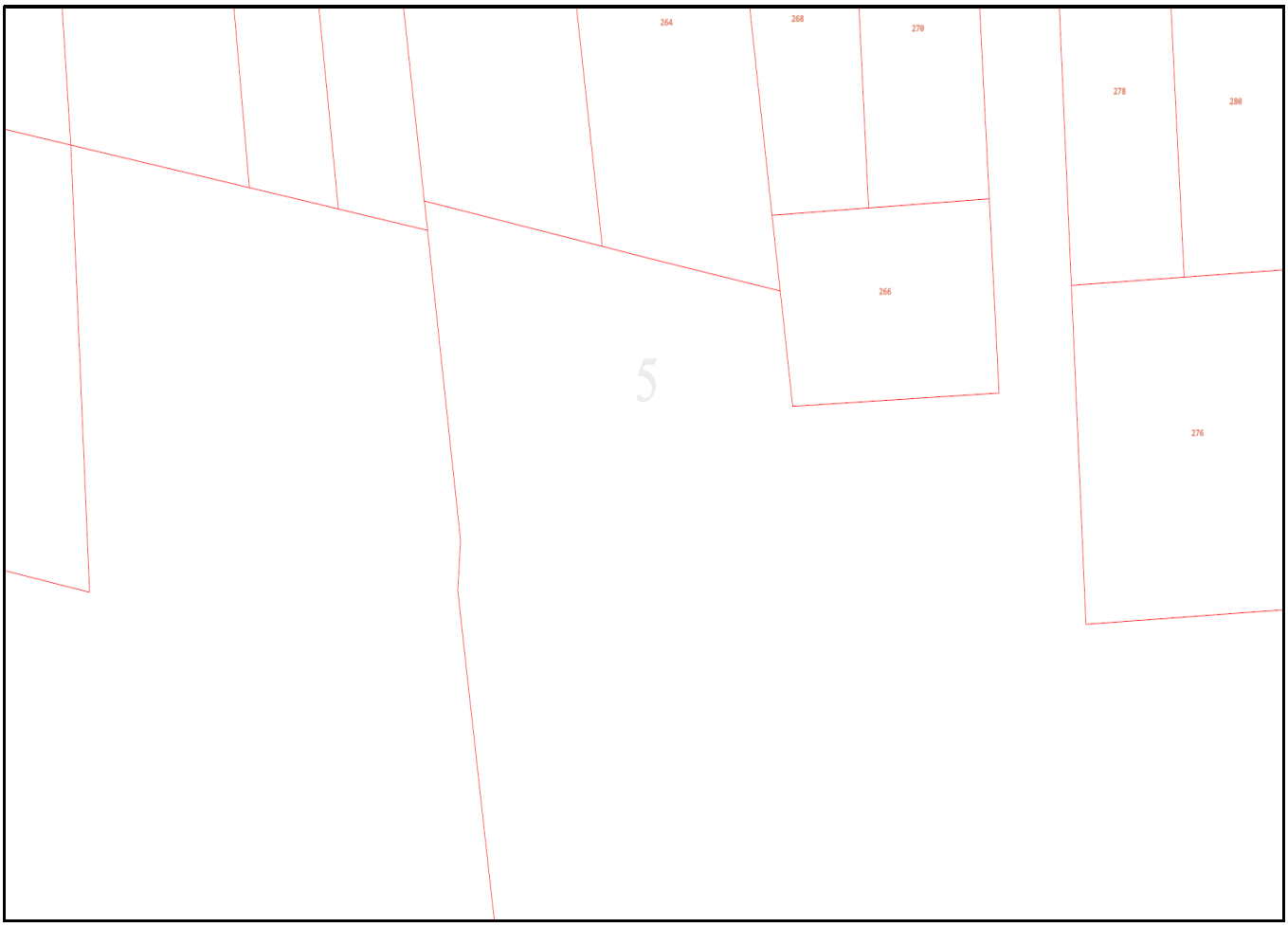
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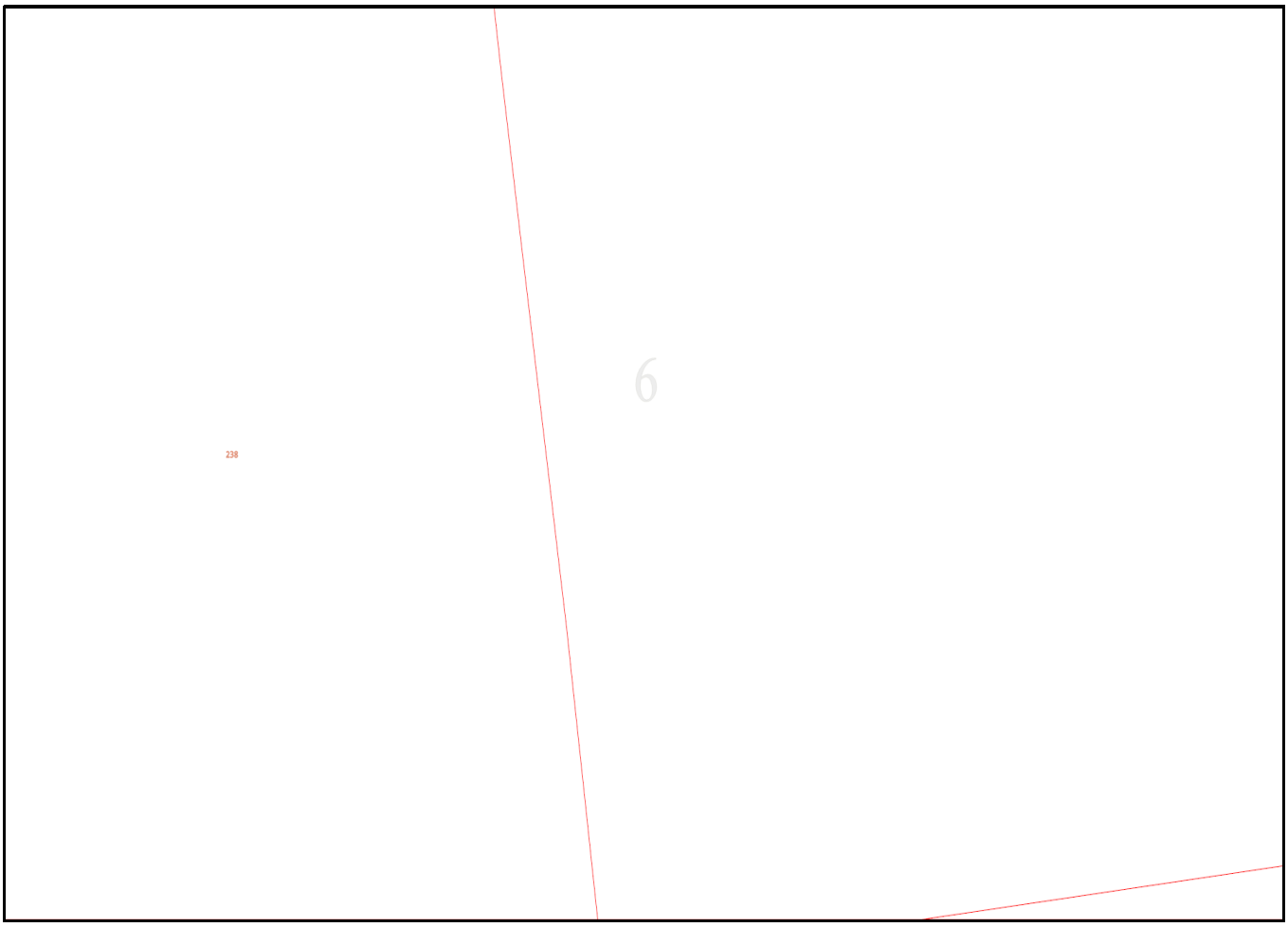
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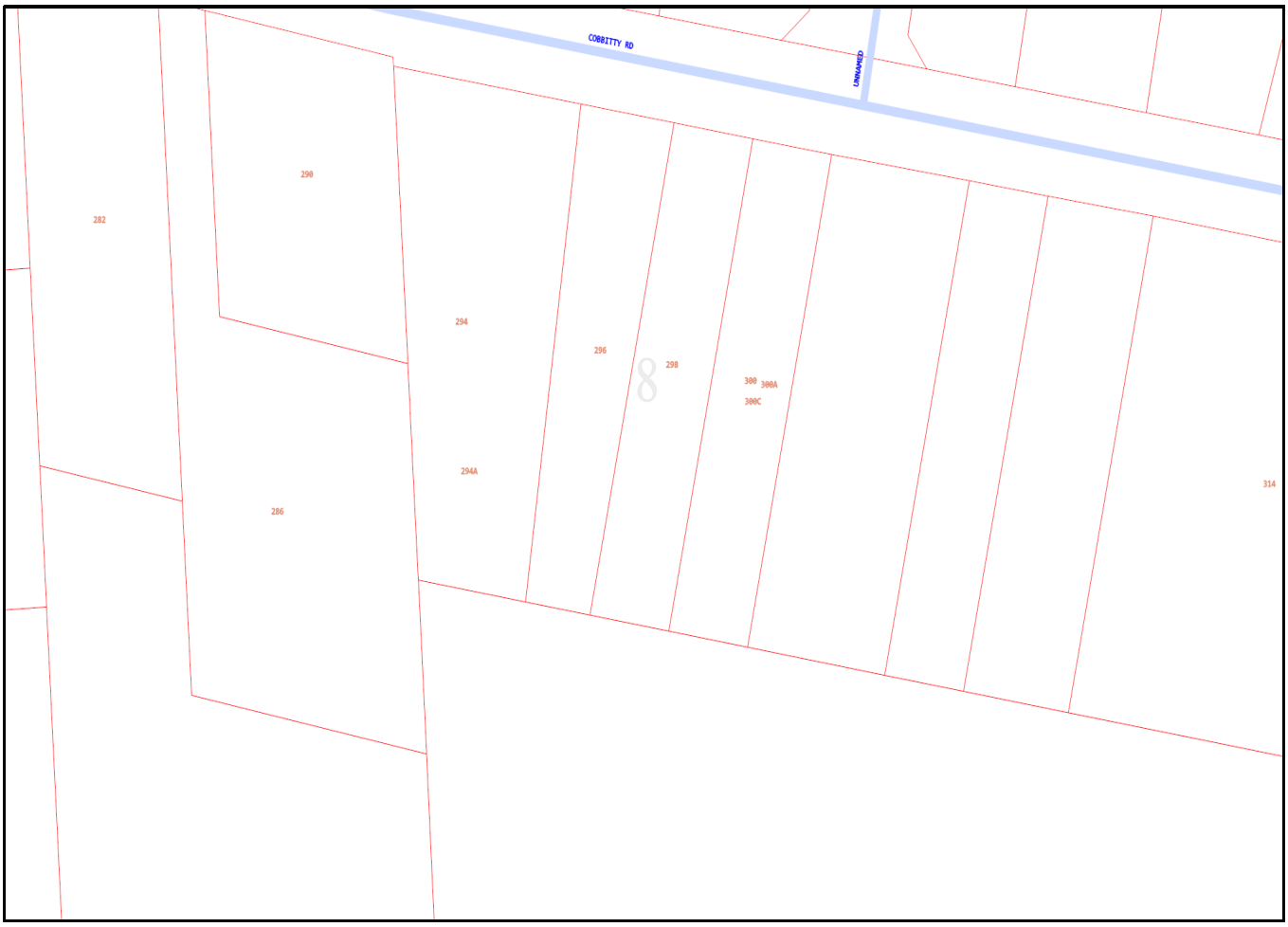
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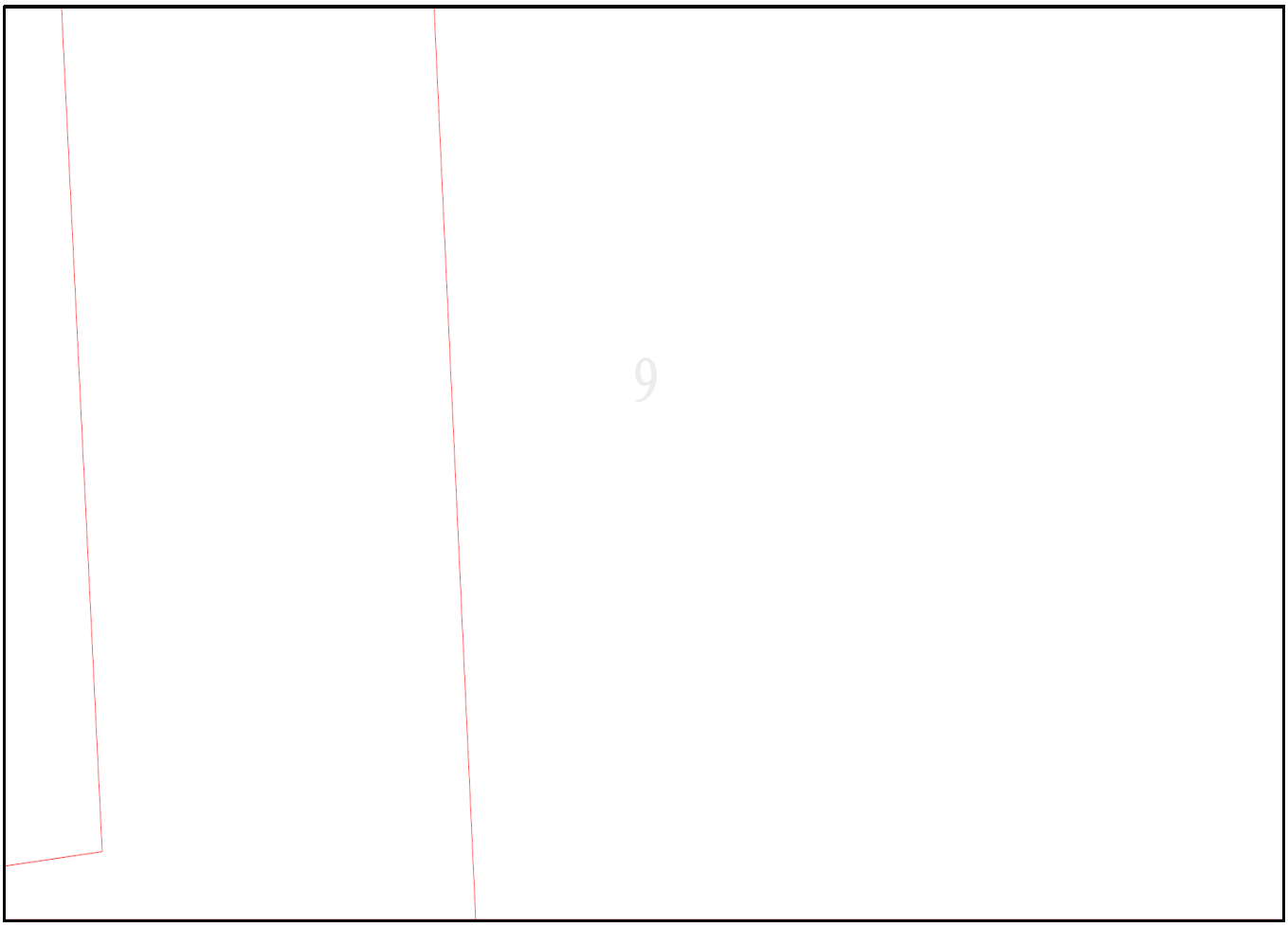
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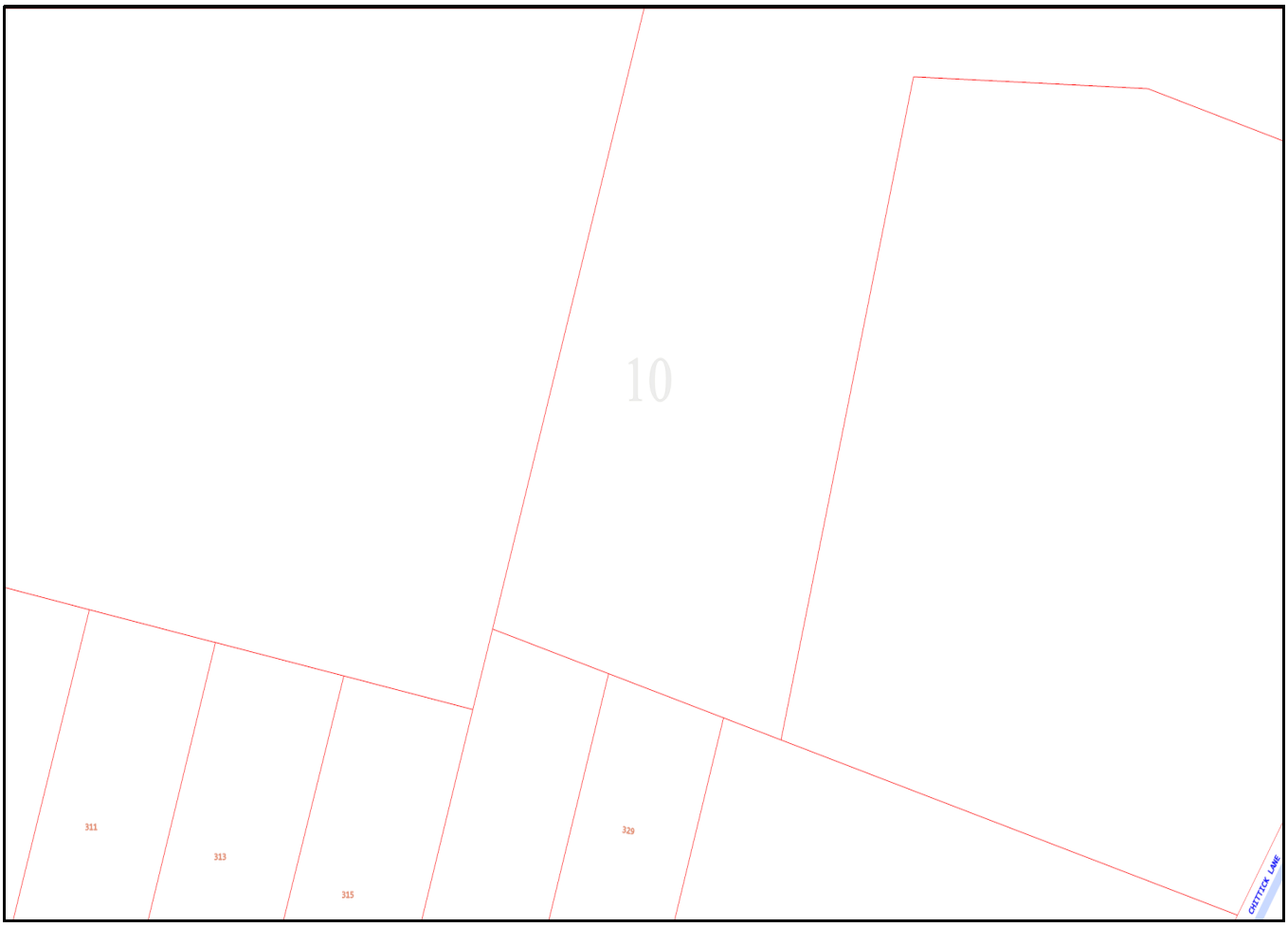
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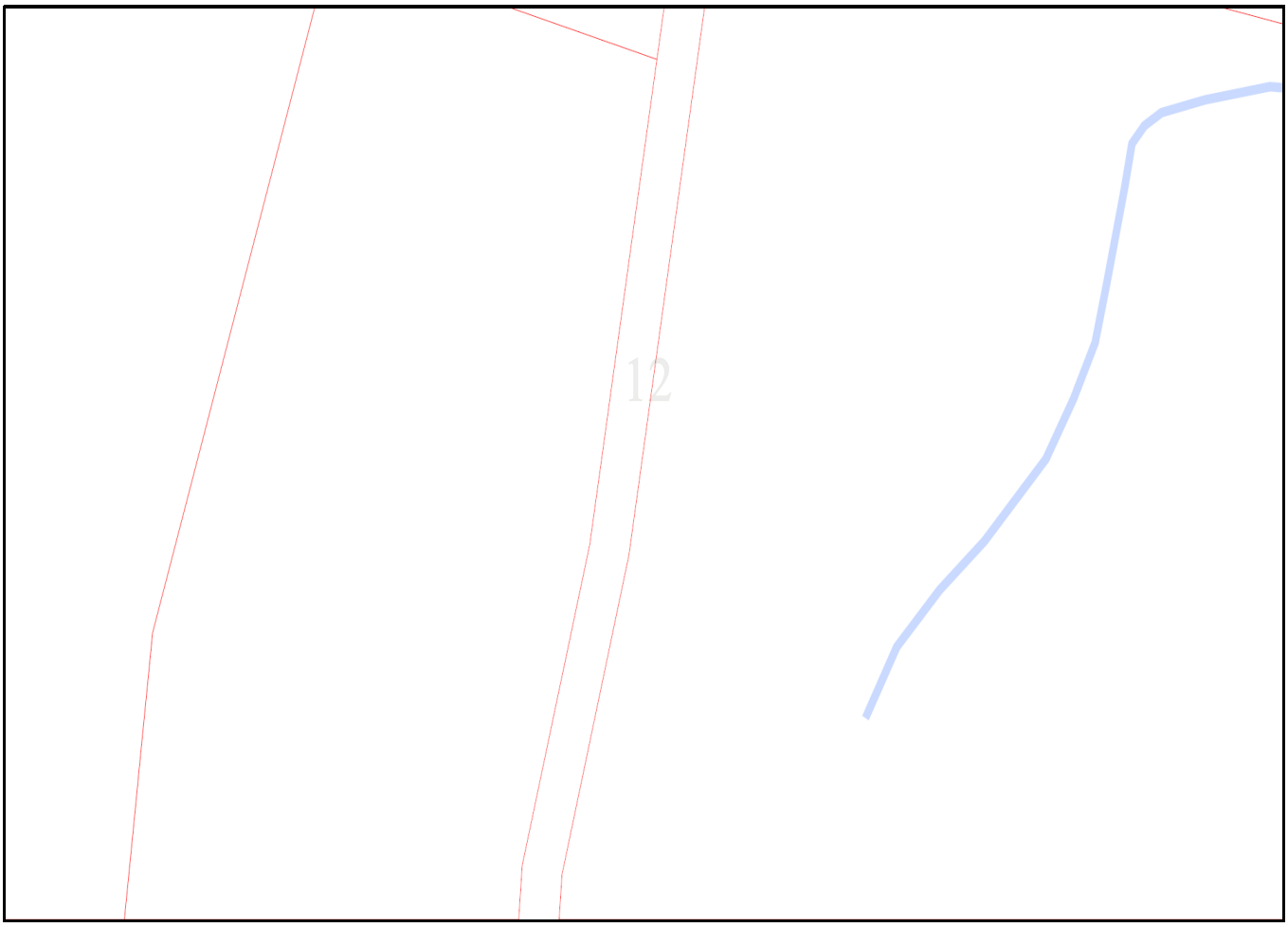
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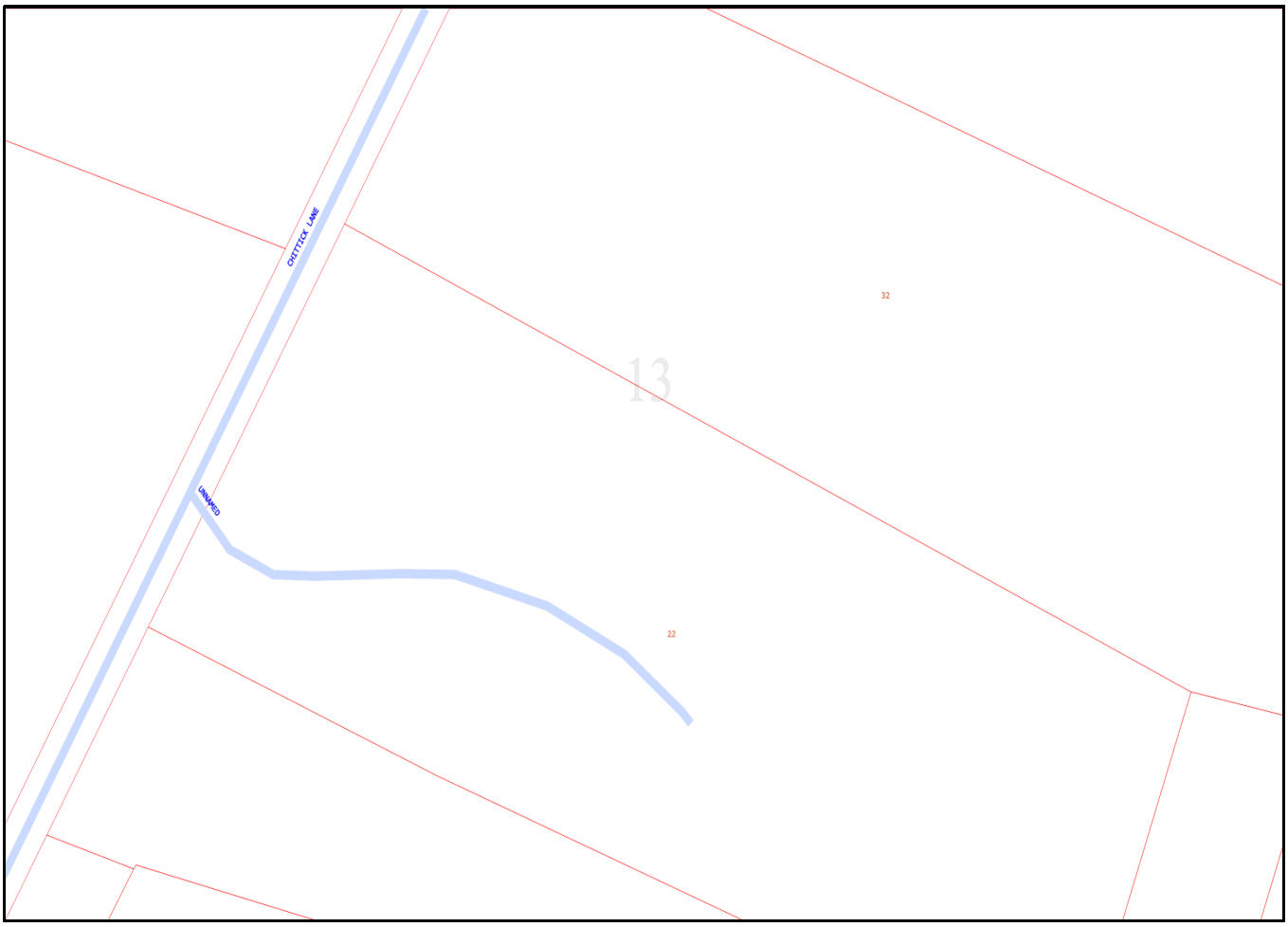
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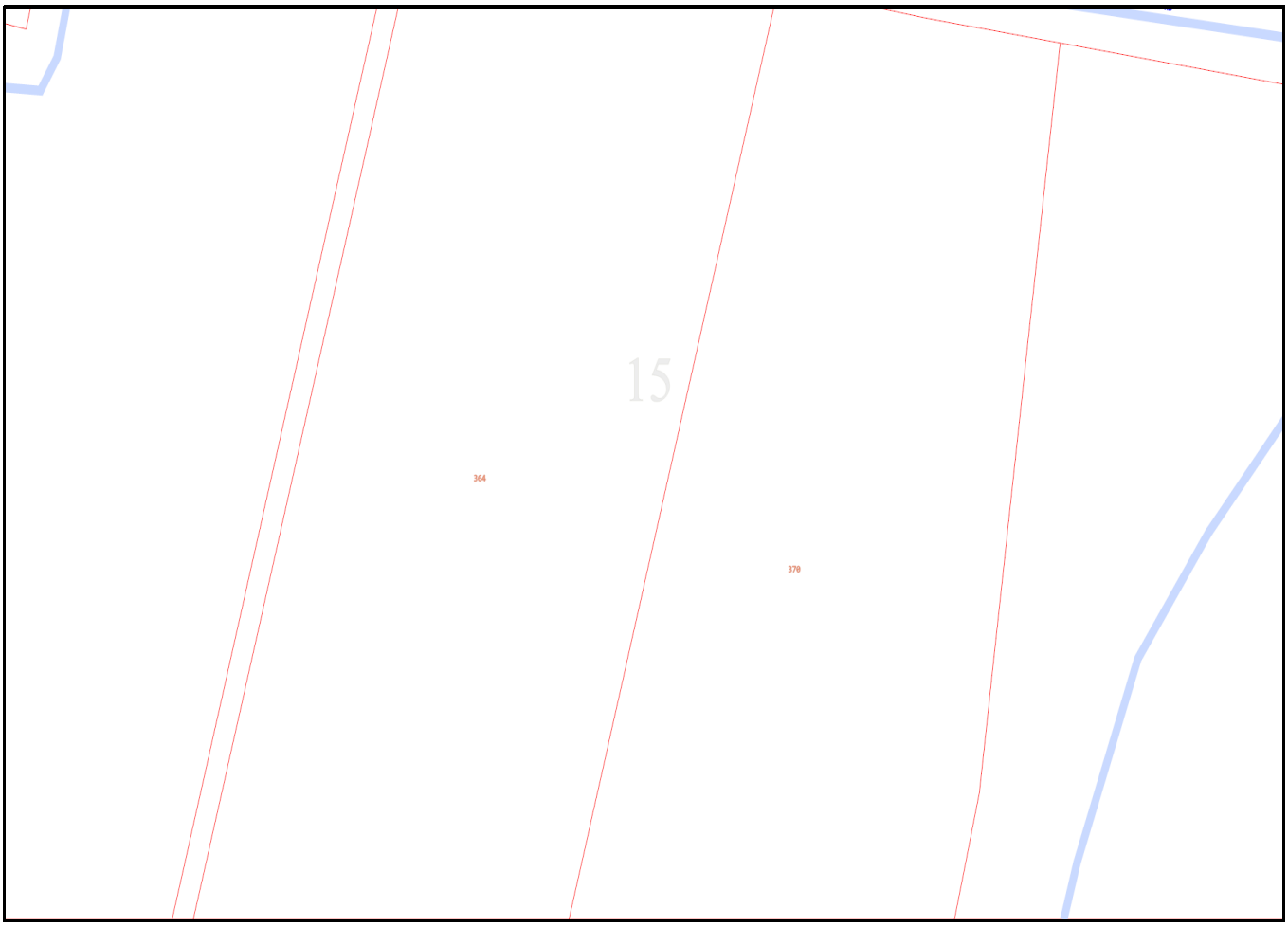
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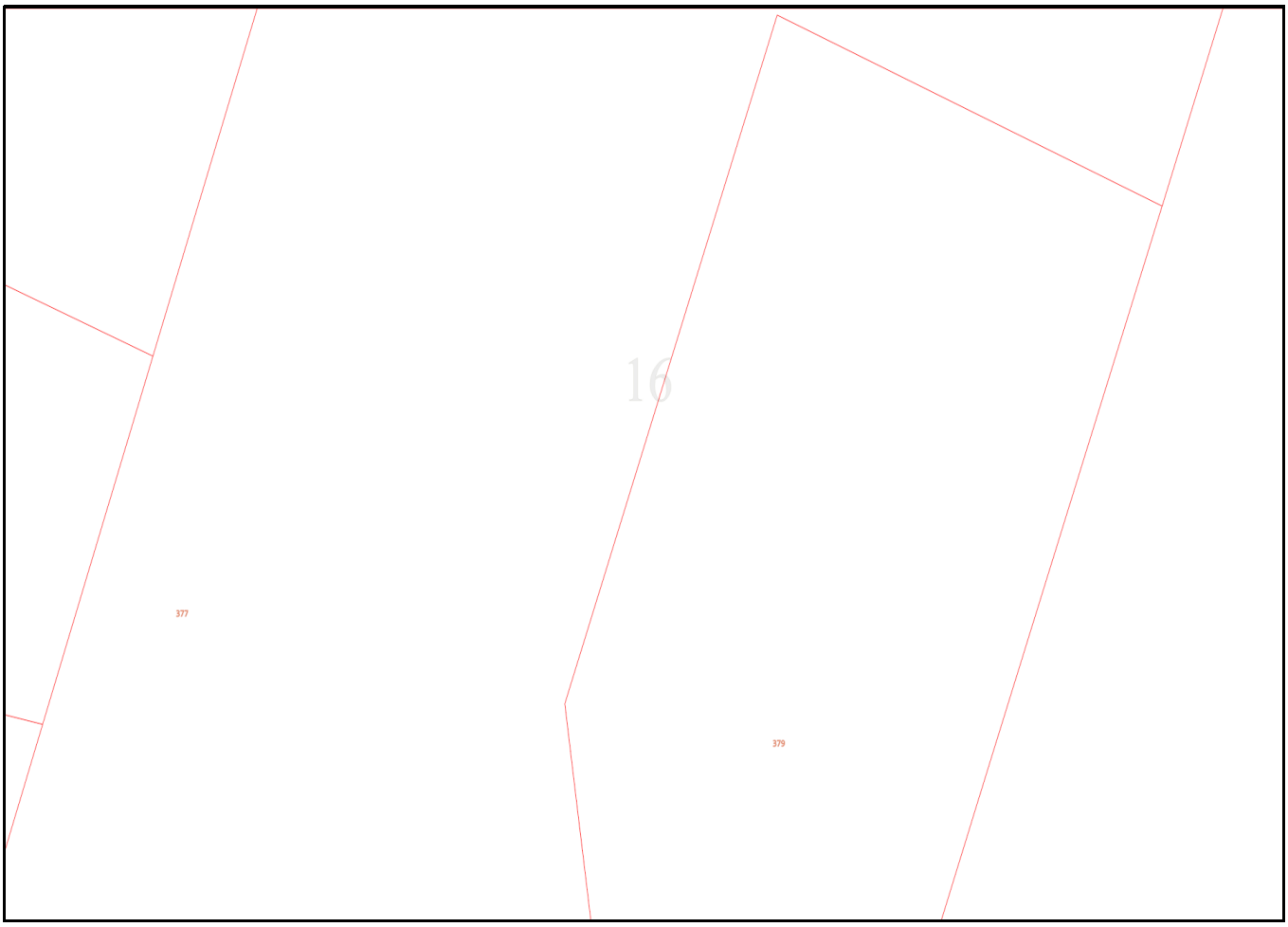
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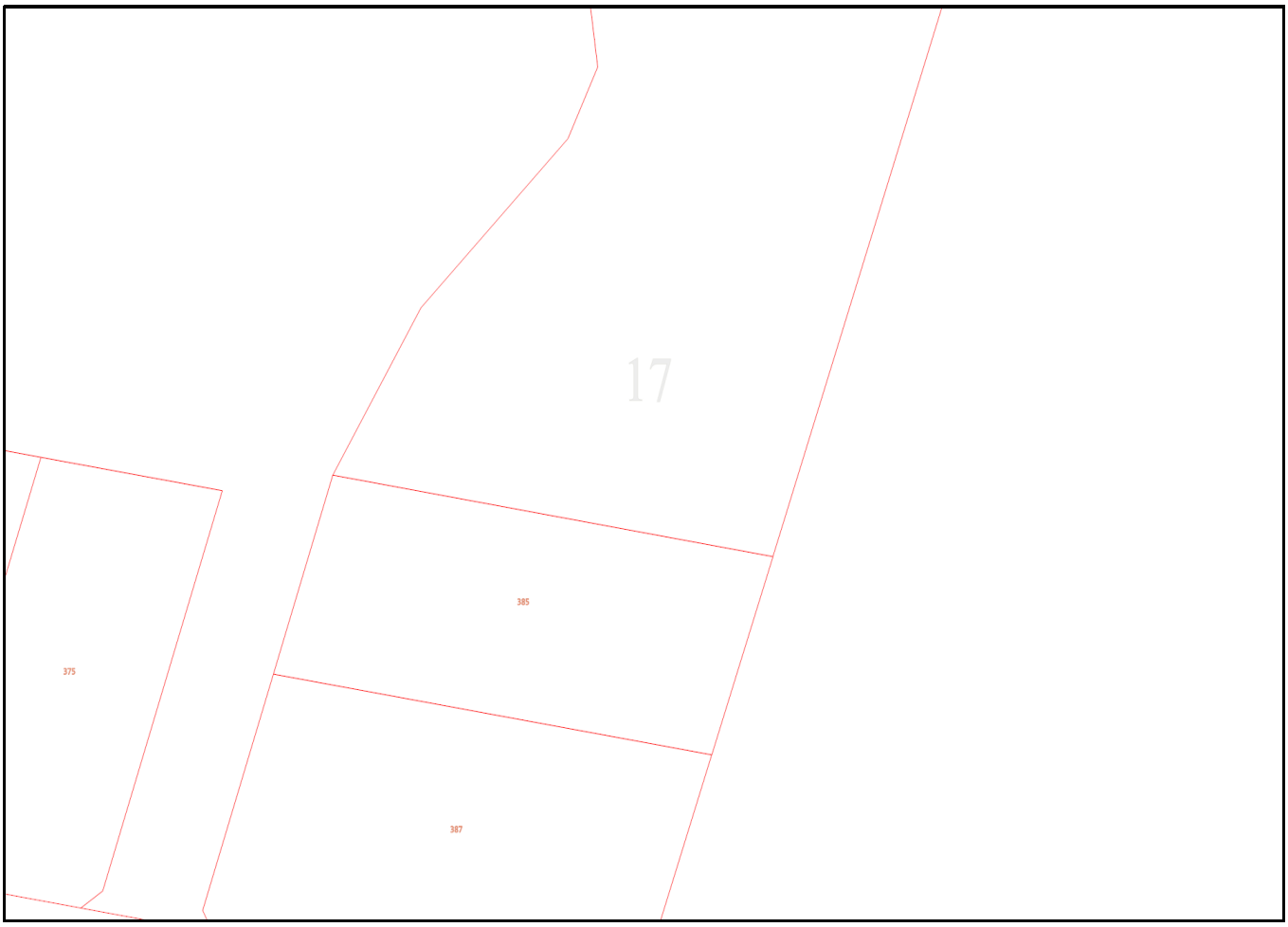
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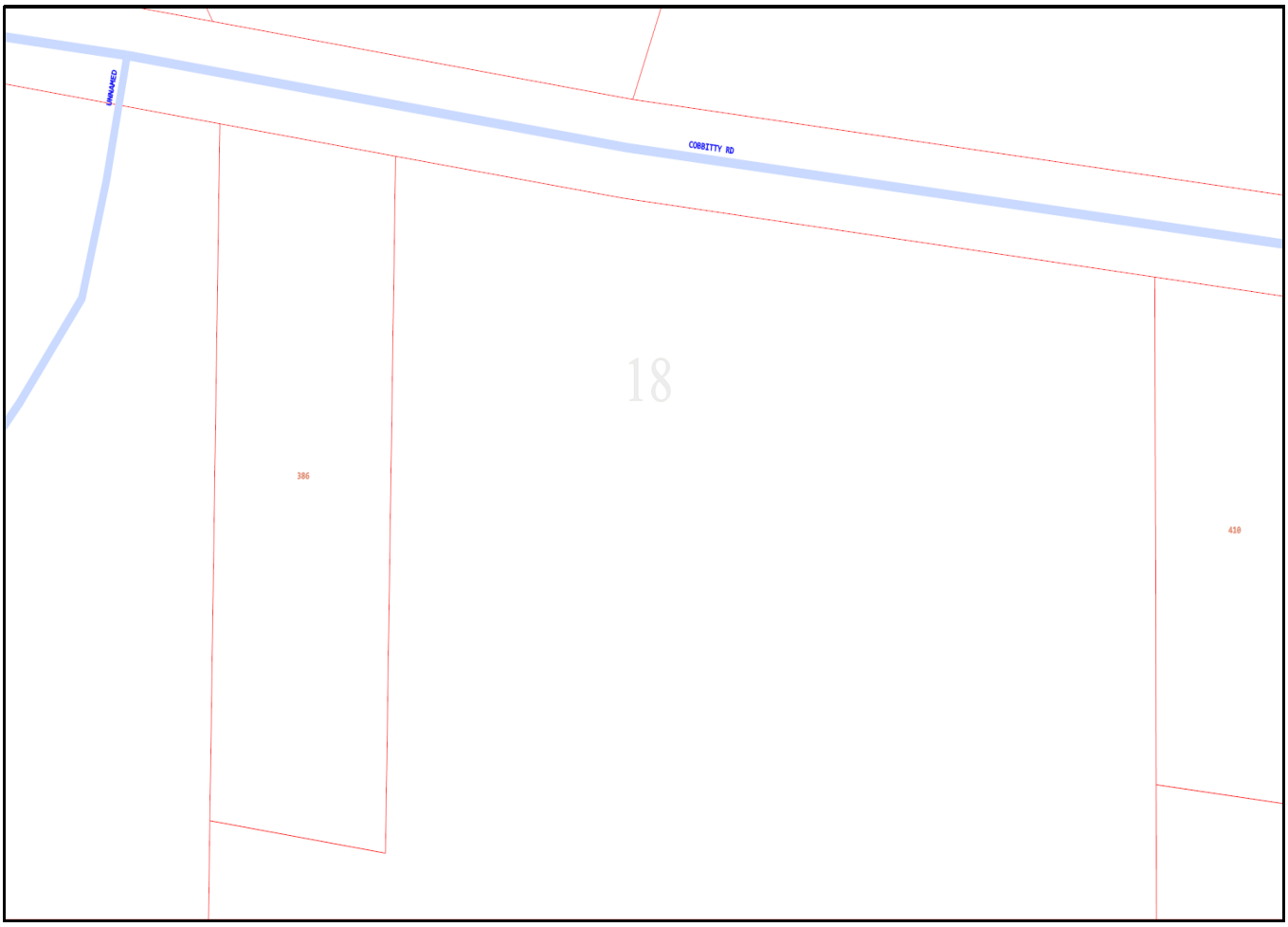
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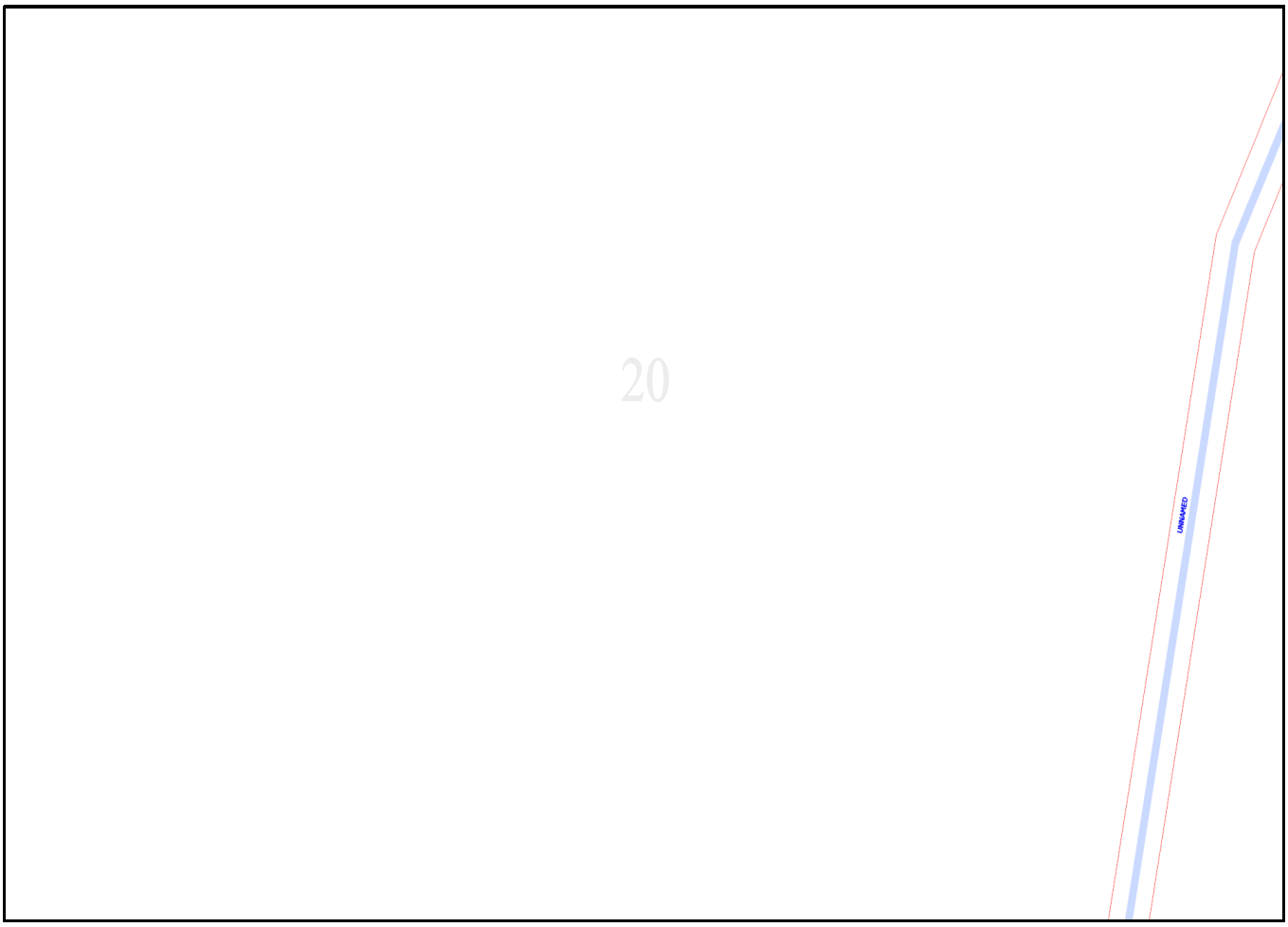


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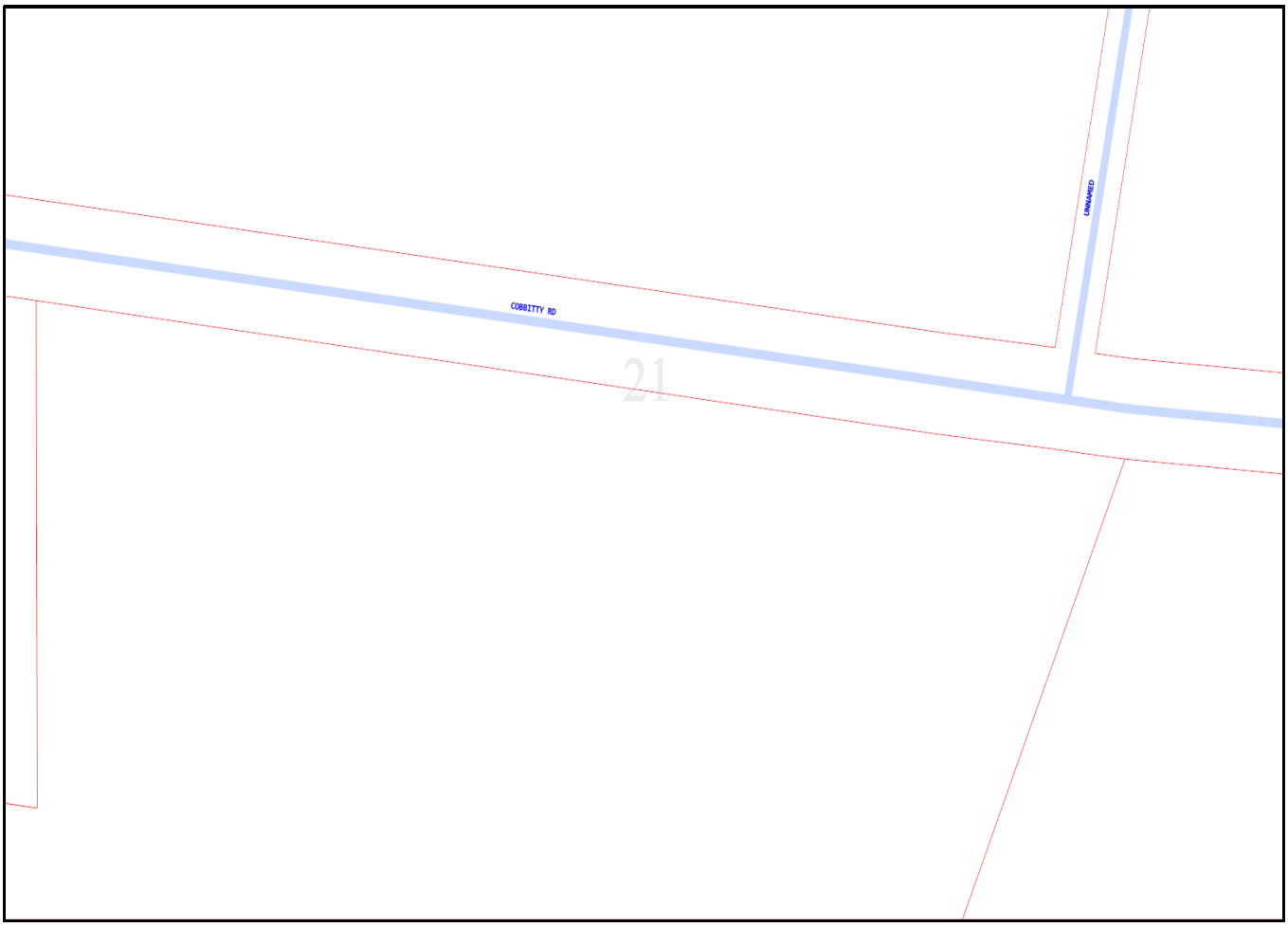
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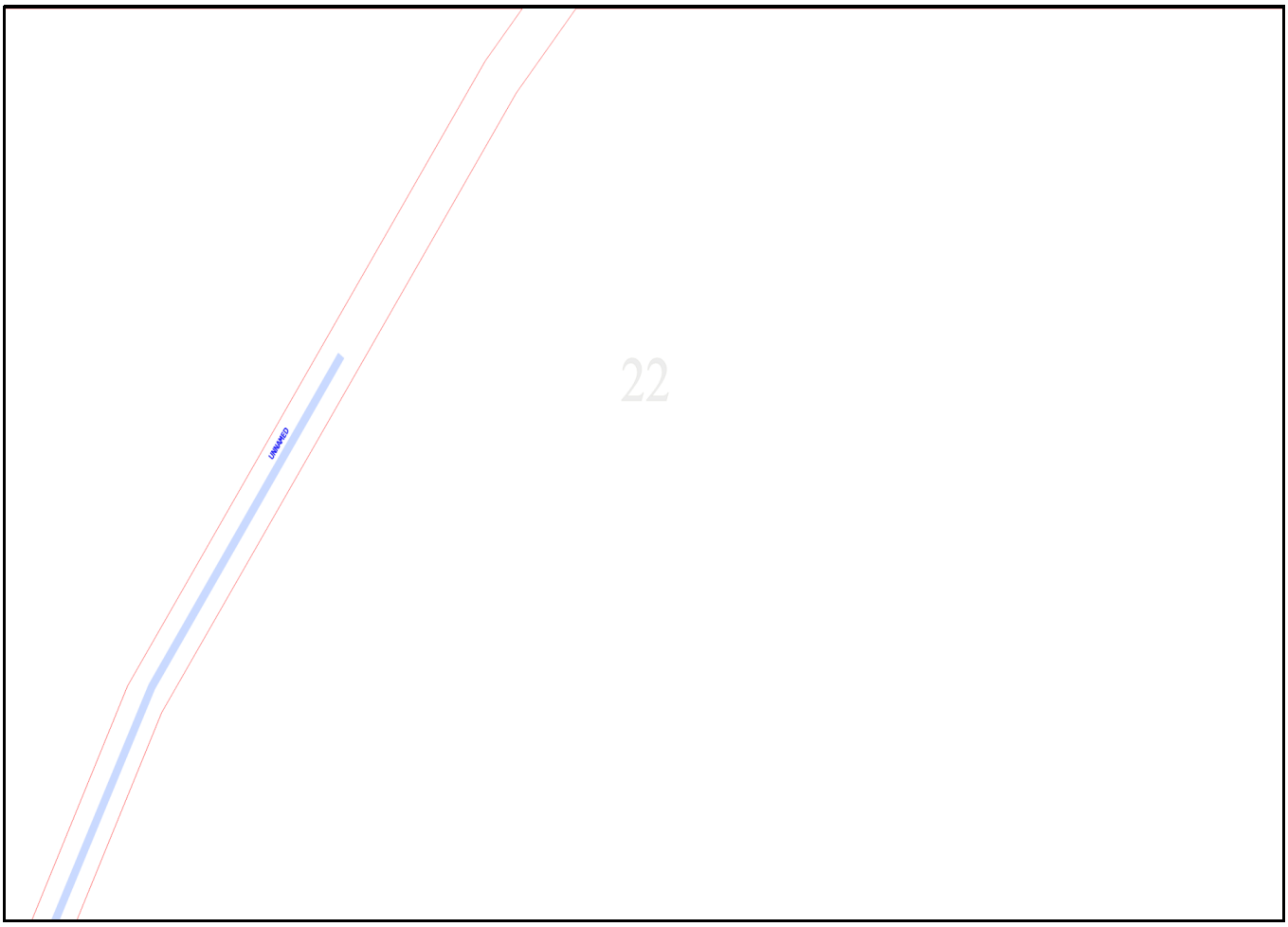
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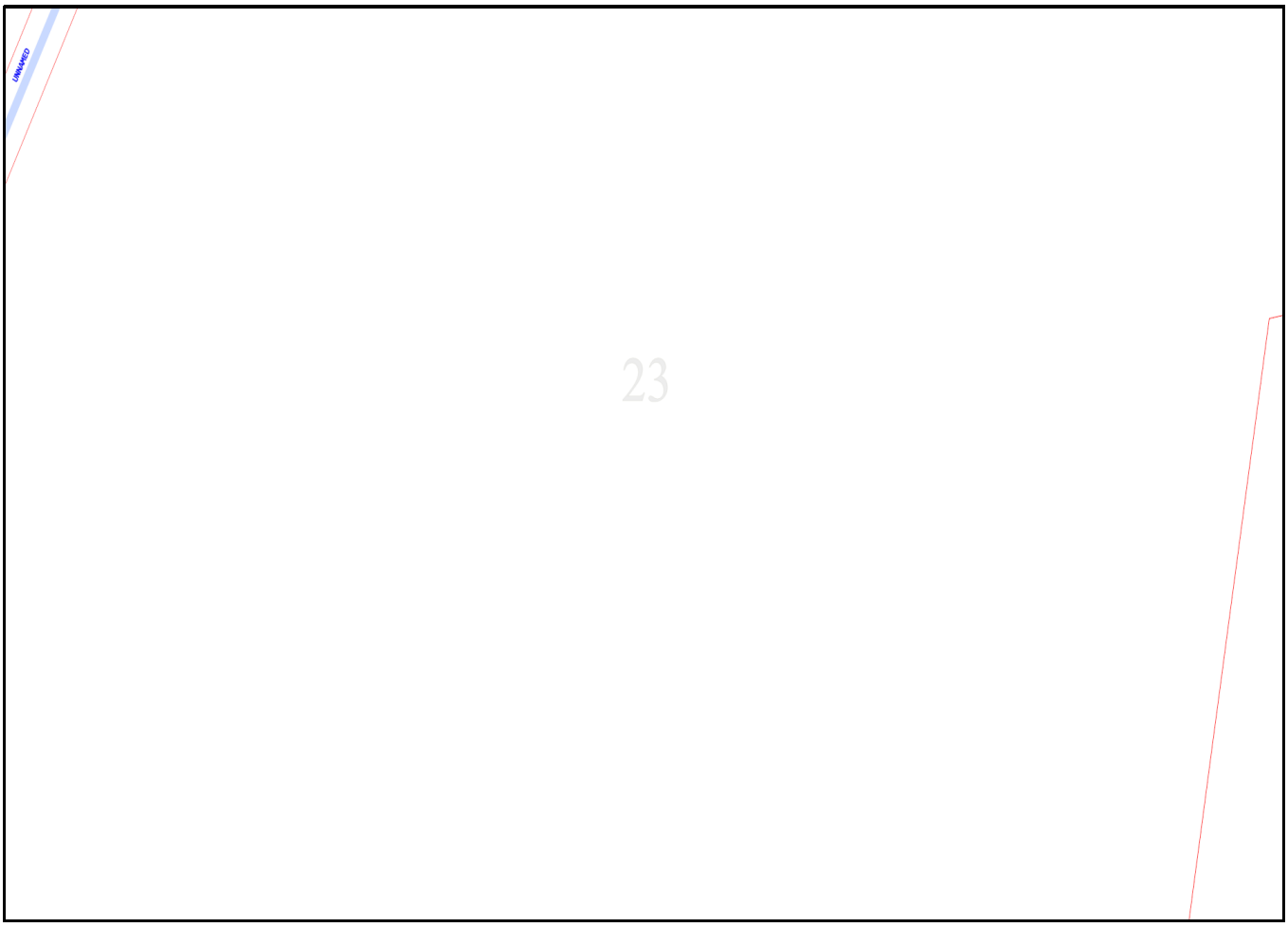
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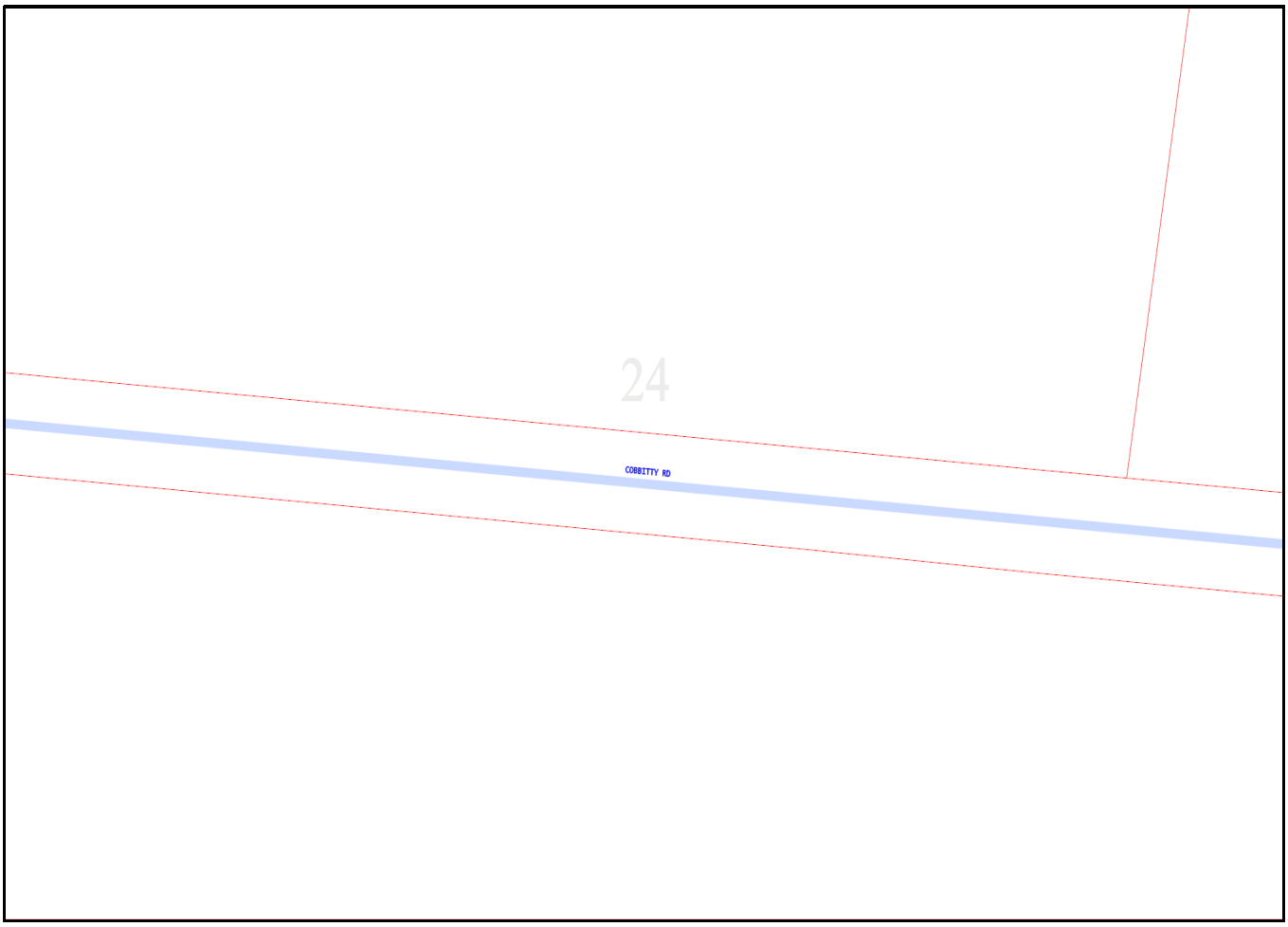
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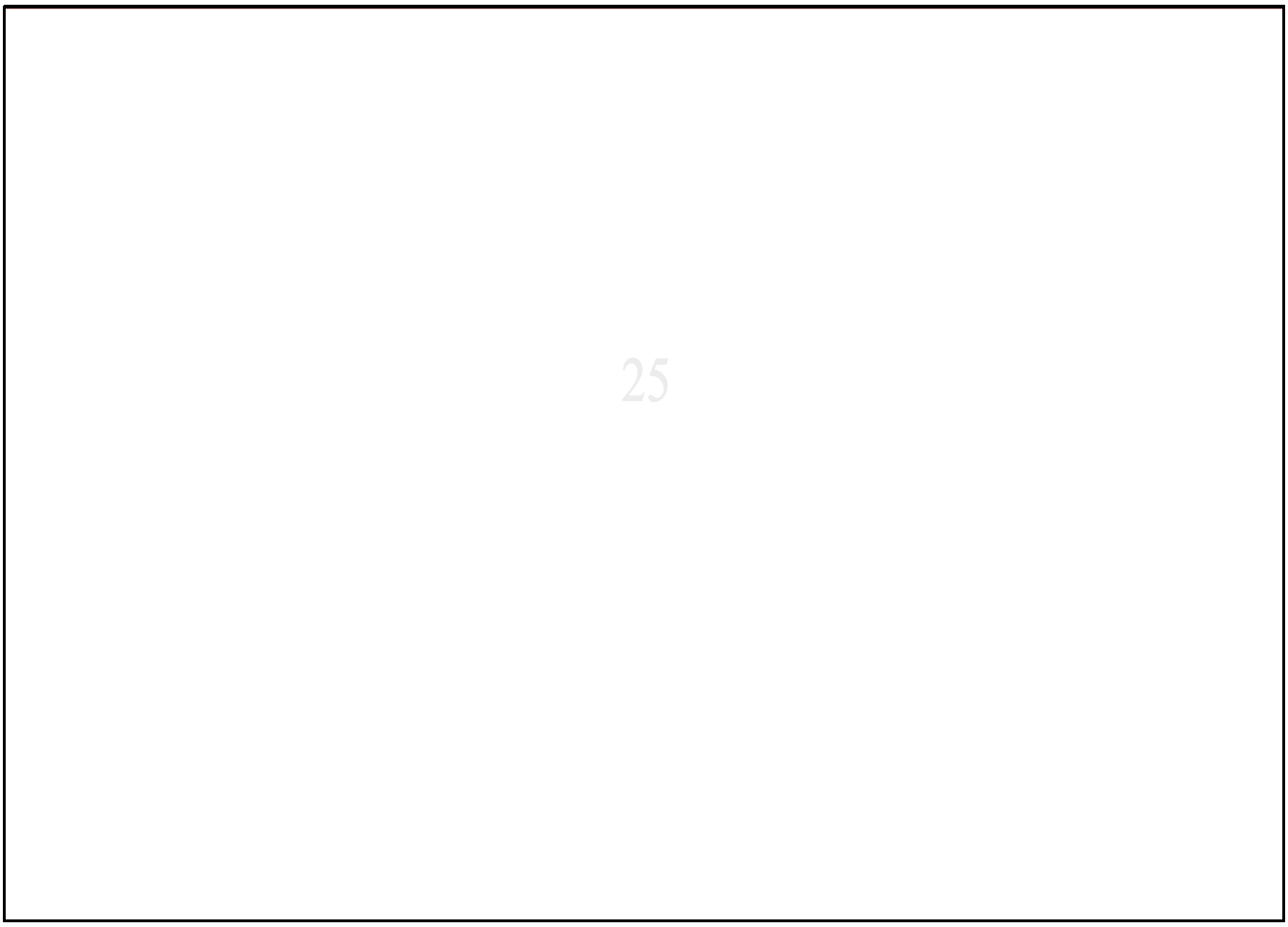
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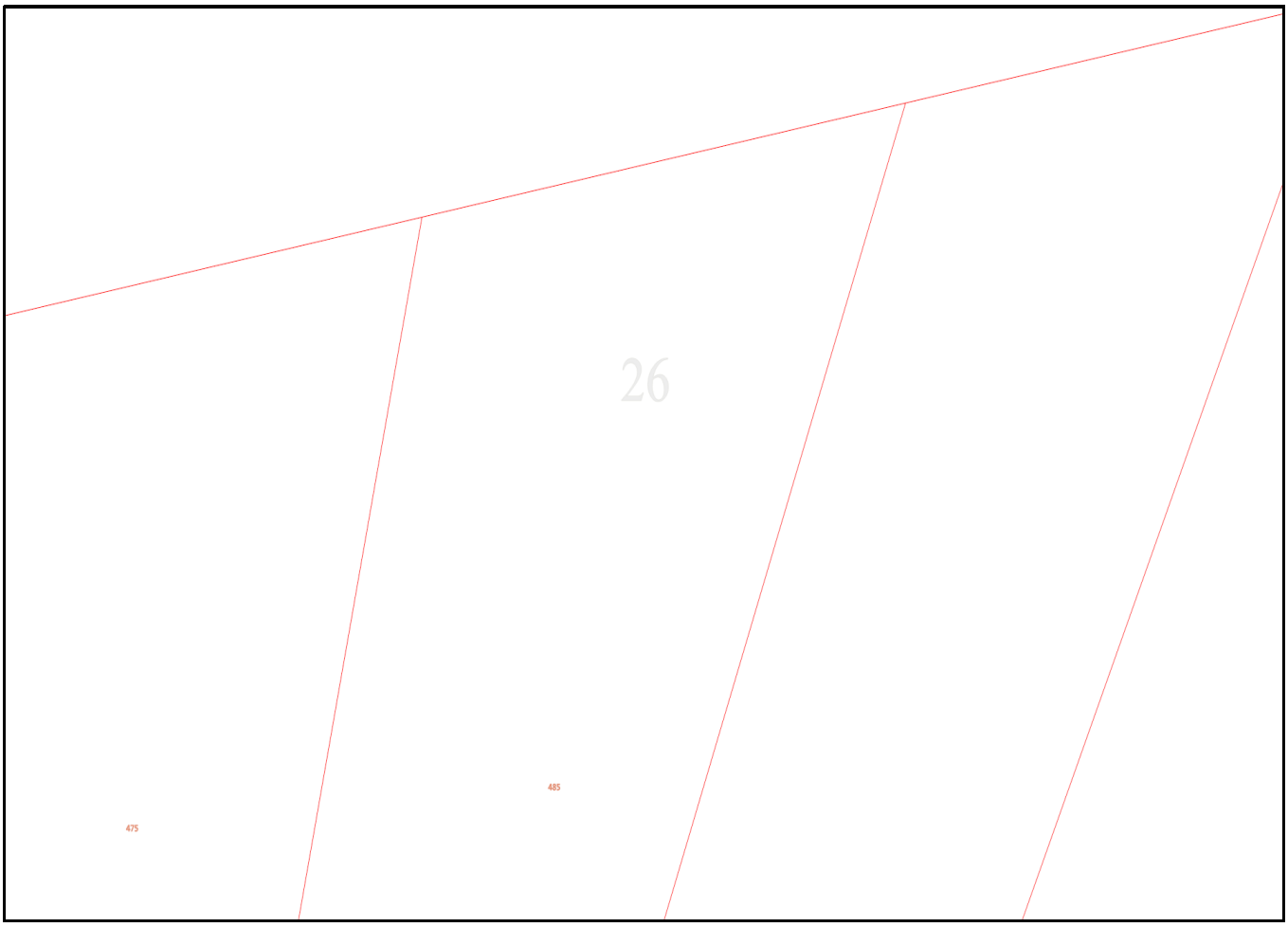
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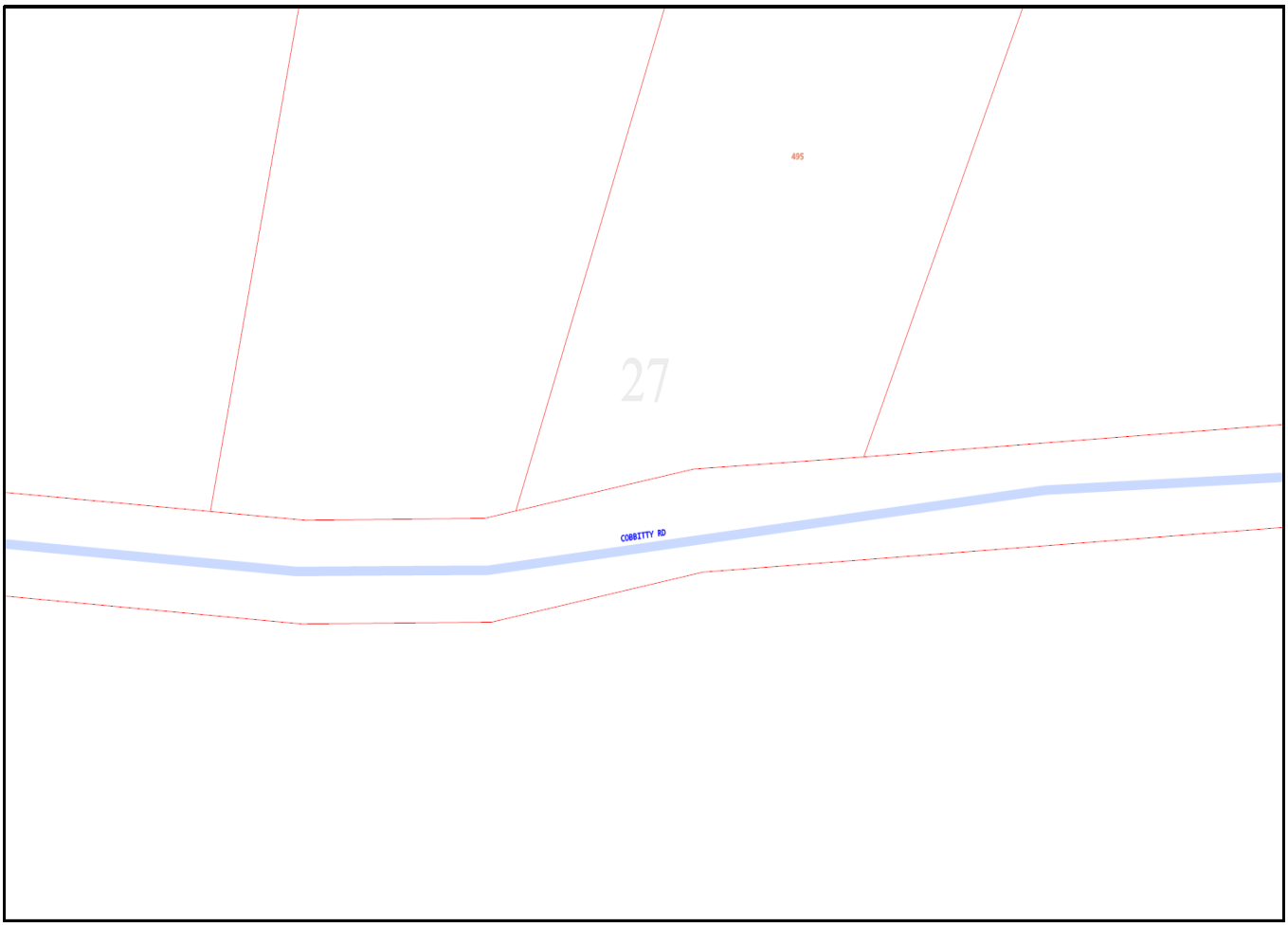
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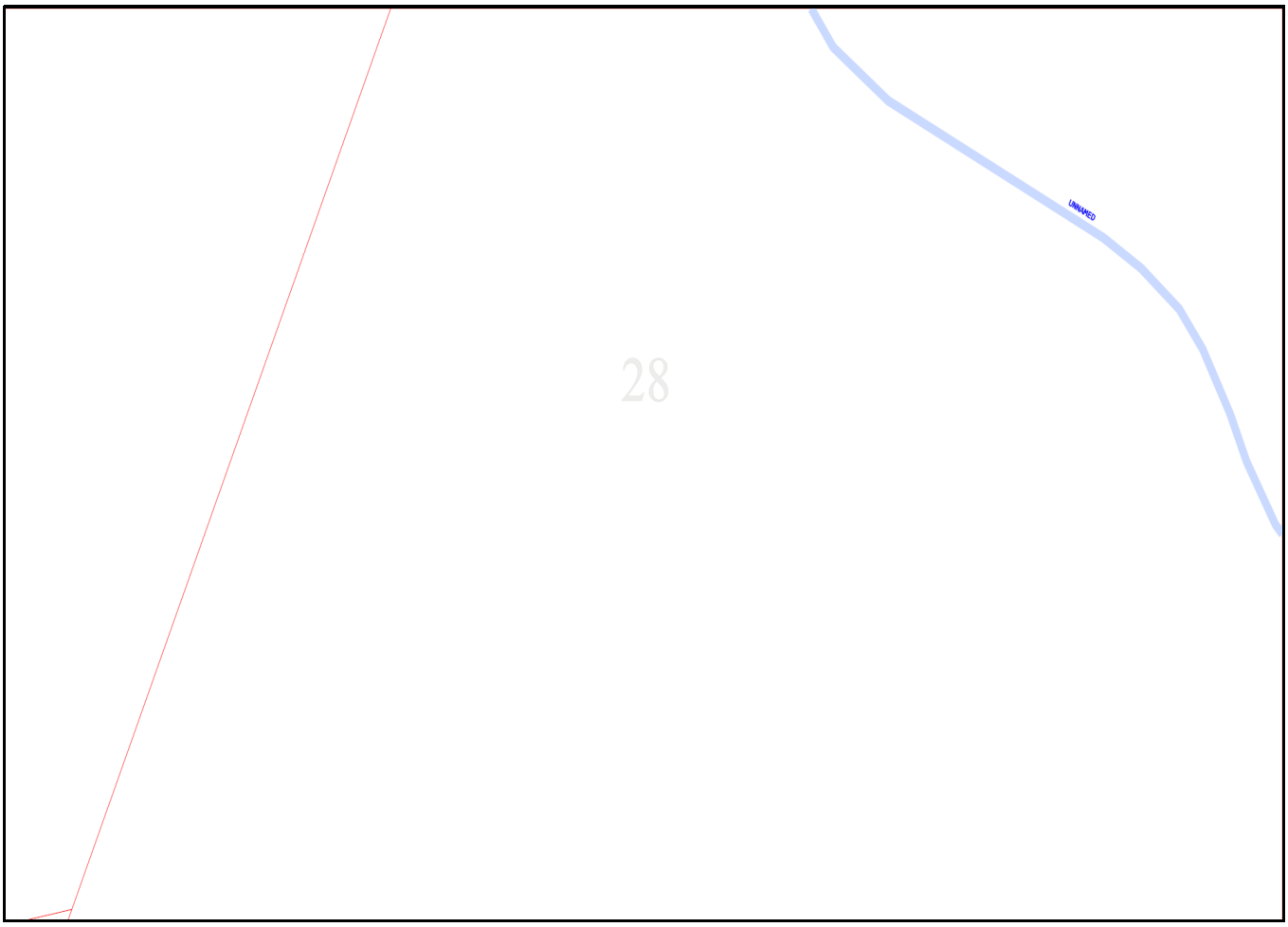
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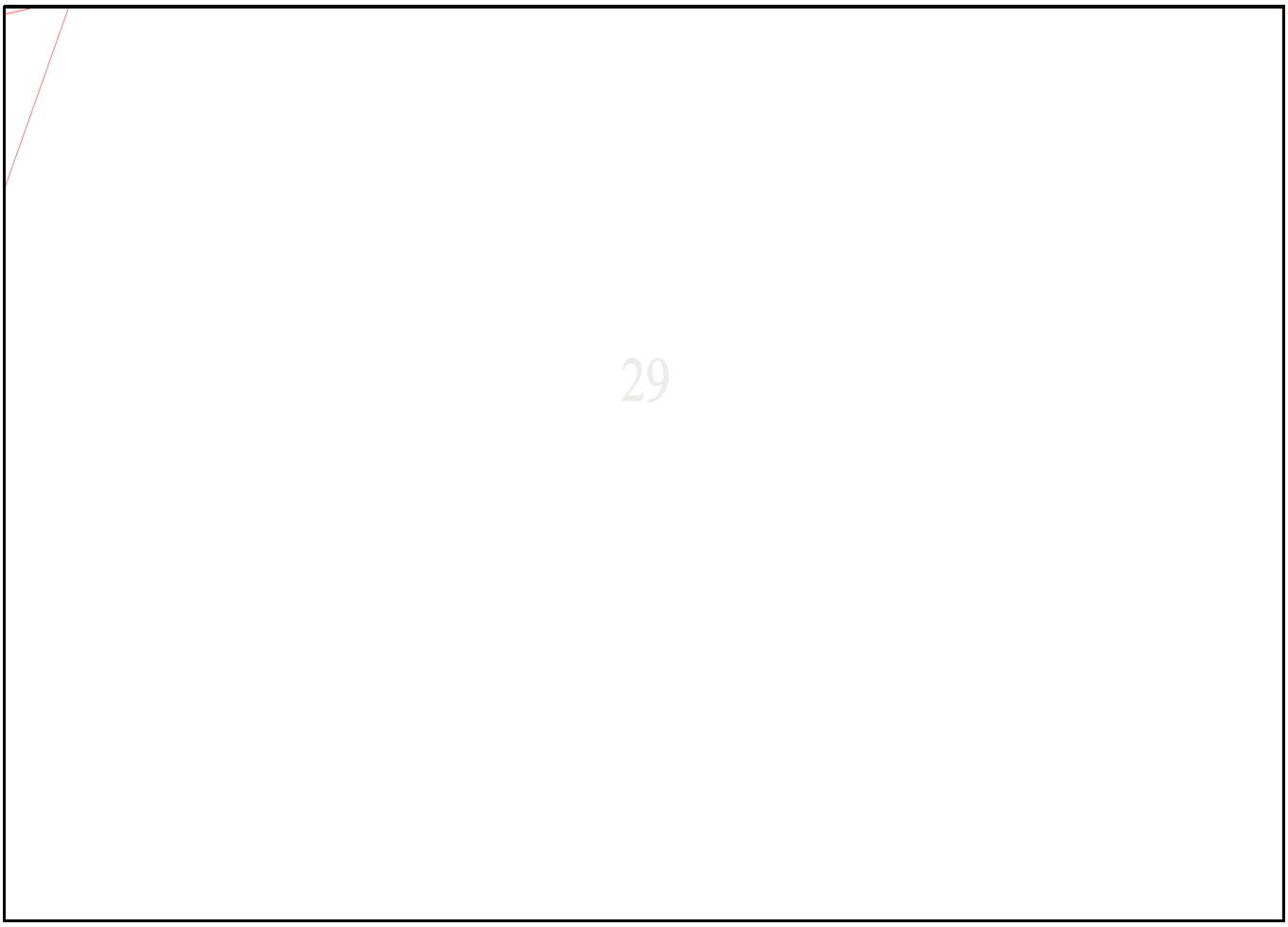
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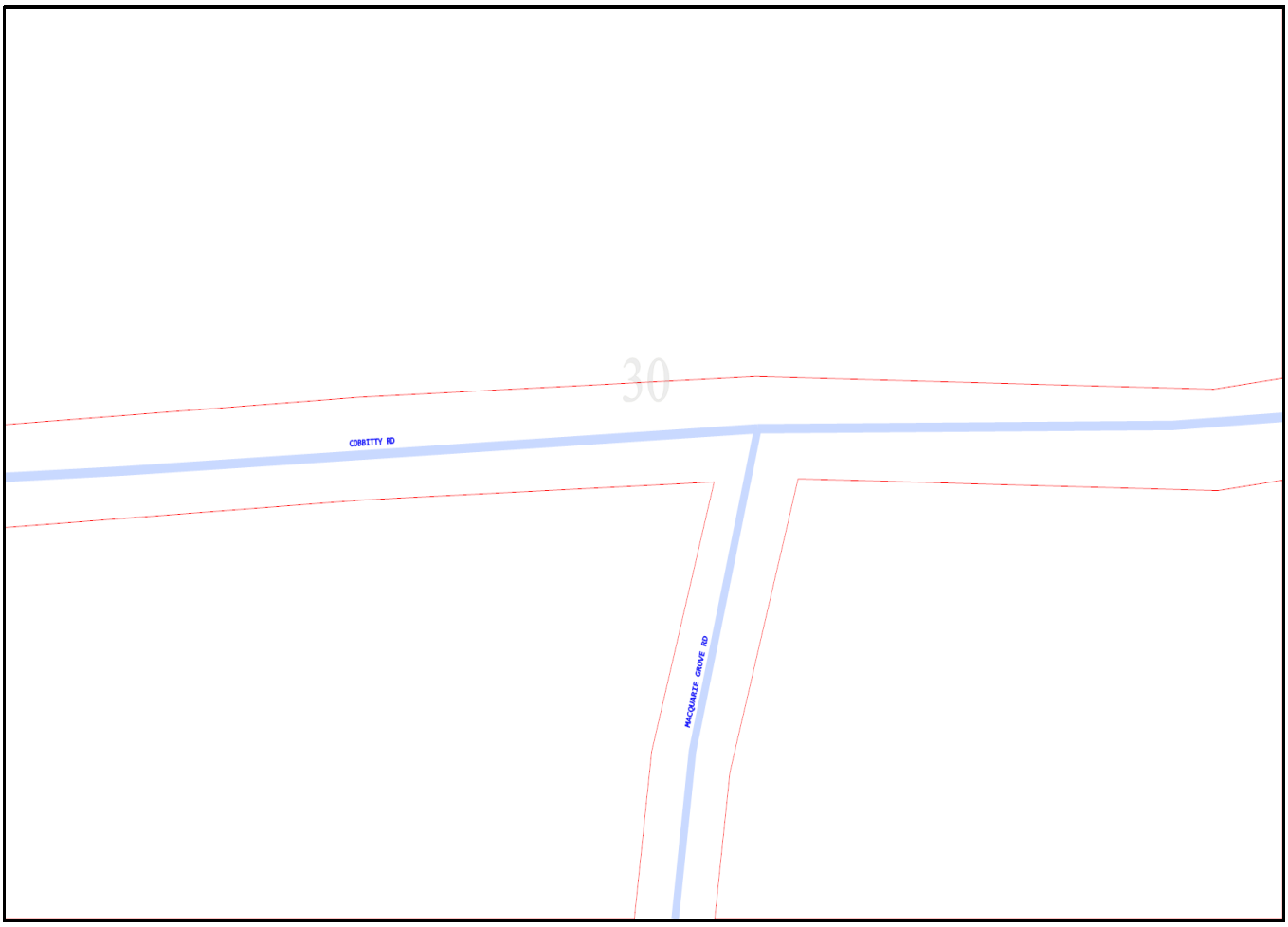
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Emergency Contacts

You must immediately report any damage to **nbn™** network that you are/become aware of. Notification may be by telephone - 1800 626 329.

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Optus Contract Management Team
Unit 9, 677 Springvale Road
Mulgrave, Victoria, 3178

Date: 07/04/2020
To: Miss Phoebe Connor
Company:
Address: 7/153 Walker Street
Sydney, NSW 2060

ENQUIRY DETAILS
Location: Chittick Ln, Cobbitty, NSW 2570
Sequence No.: 96491433
DBYD Reference: 19329302

In relation to your enquiry concerning the above location, Optus advises as follows:

Optus records indicate that there ARE NO underground Optus FIBRE OPTIC TELECOMMUNICATIONS ASSETS in the vicinity of the above location as per the attached drawing(s).

This reply is valid for a period of 30 days from the date above.

IMPORTANT INFORMATION
Asset location drawings provided by Optus are reference diagrams and are provided as a guide only. The completeness of the information in these drawings cannot be guaranteed. Exact ground cover and alignments cannot be provided with any certainty as these may have altered over time. Depths of telecommunications assets vary considerably as do alignments. It is essential to identify the location of any Optus assets in the vicinity prior to engaging in any works.

DUTY OF CARE
When working in the vicinity of telecommunications assets you have a legal "Duty of Care" and non-interference that must be observed.

It is your responsibility as the requesting party (as a landowner or any other party involved in the planned works) to design for minimal impact to any existing Optus asset. Optus can assist at the design stage through consultation.

It is also your, as the requesting party (or your representative's), responsibility to:

a) Obtain location drawings (through the Dial Before You Dig process) of any existing Optus assets at a reasonable time before any planned works begin.

b) Have an Optus Accredited Asset Locator identify the general location of the Optus asset and physically locate the asset where planned works may encroach on its alignment.

c) Contact Optus for further advice where requested to do so by this letter.

DAMAGE TO ANY OPTUS ASSET MUST BE REPORTED TO 1800 500 253 IMMEDIATELY
You, your head contractor and any relevant subcontractor are all responsible for any Optus asset damage as a result of planned activities in the vicinity of Optus assets.

This applies where works commence prior to obtaining Optus drawings, where there is failure to follow instructions or during any construction activities.

Optus reserves the right to recover compensation for loss or damage to its assets including consequential loss. Also, you, your head contractor and any relevant subcontractor may also be liable for prosecution under the Criminal Code Act 1995 (Cth).

ASSET RELOCATIONS
You are not permitted by law to relocate, alter or interfere with any Optus asset under any circumstance. Any unauthorised interference with an Optus asset may lead to prosecution under the Criminal Code Act 1995 (Cth). Enquiries relating to the relocation of Optus assets must be referred to the relevant Optus Damages and Relocations Team (refer to "FURTHER ASSISTANCE").

APPROACH DISTANCES
On receipt of Optus asset location drawings and prior to commencing any planned works near an Optus asset, engage an Optus Accredited Locator to undertake a general location of the Optus asset.

Physical location of the Optus asset by an Optus Accredited Locator will also be required where planned works are within the following approach distances of the general location of the Optus asset:

a) In built up metropolitan areas where road and footpaths are well defined by kerbs or other features a minimum clear distance of 1 meter must be maintained from the general location of the Optus asset.

b) In non-established or unformed metropolitan areas, a minimum clear distance of 3 meters must be maintained from the general location of the Optus asset.

c) In country or rural areas where wider variations may exist between the general and actual location of an Optus asset may exist, then a minimum clear distance of 5 meters must be maintained from the general location of the Optus asset.

If planned works are parallel to the Optus asset, then the Optus asset must be physically located by an Optus Accredited Locator at a minimum of 5 meter intervals along the length of the parallel works prior to work commencing.

Under no circumstances is crossing of any Optus asset permitted without physical location of the asset being carried out by an Optus Accredited Locator. Depending on the asset involved an Optus representative may be required onsite.

The minimum clearances to the physical location of Optus assets for the following specific types of works must be maintained at all times.

Note: Where the clearances in the following table cannot be maintained or where the type of work differs from those listed then advice must be sought from the relevant Optus Damages and Relocations Team (refer to "FURTHER ASSISTANCE").

Type of Works	**Clearance to Physical Location of Optus Asset**
Jackhammers / Pneumatic Breakers	Not within 1 meter.
Light duty Vibrating Plate or Wacker Packer type compactors (not heavy road construction vibrating rollers etc.)	500mm compact clearance cover before a light duty compactor can be used over any Optus conduit. No compaction permitted over Optus direct buried cable without prior approval from Optus.
Boring Equipment (in-line, horizontal and vertical)	Not within 5 meters parallel of the Optus asset location without an Accredited Optus Asset Locator physically exposing the Optus asset and with an Optus representative onsite.

Type of Works	Clearance to Physical Location of Optus Asset
	Not to cross the Optus asset without an Accredited Optus Asset Locator physically exposing the Optus asset and with an Optus representative onsite.
Heavy vehicle Traffic (over 3 tonnes)	Not to be driven across Optus conduits with less than 600mm of cover. Not to be driven across Optus direct buried cable with less than 1.2 meters of cover. Once off crossings permitted, multiple crossing (e.g. road construction or logging) will require Optus approval. Accredited Optus Asset Locator to physically expose the Optus asset to verify actual depth.
Mechanical Excavators, Farm Ploughing, Vertical Hole installation for water bore or fencing etc.	Not within 1 meter. Accredited Optus Asset Locator to physically expose the Optus asset to verify actual location.

ASSET CLEARANCES AFTER COMPLETION OF WORKS

All Optus pits and manholes must be a minimum of 1 meter from the back of any kerb, 3.5 meters of the road surface without a kerb or not within 15 meters of street intersection.

In urban areas Optus conduit must have the following minimum depth of cover:

- Footway 600mm;
- Roadway 1 meter at drain invert and at road centre crown.

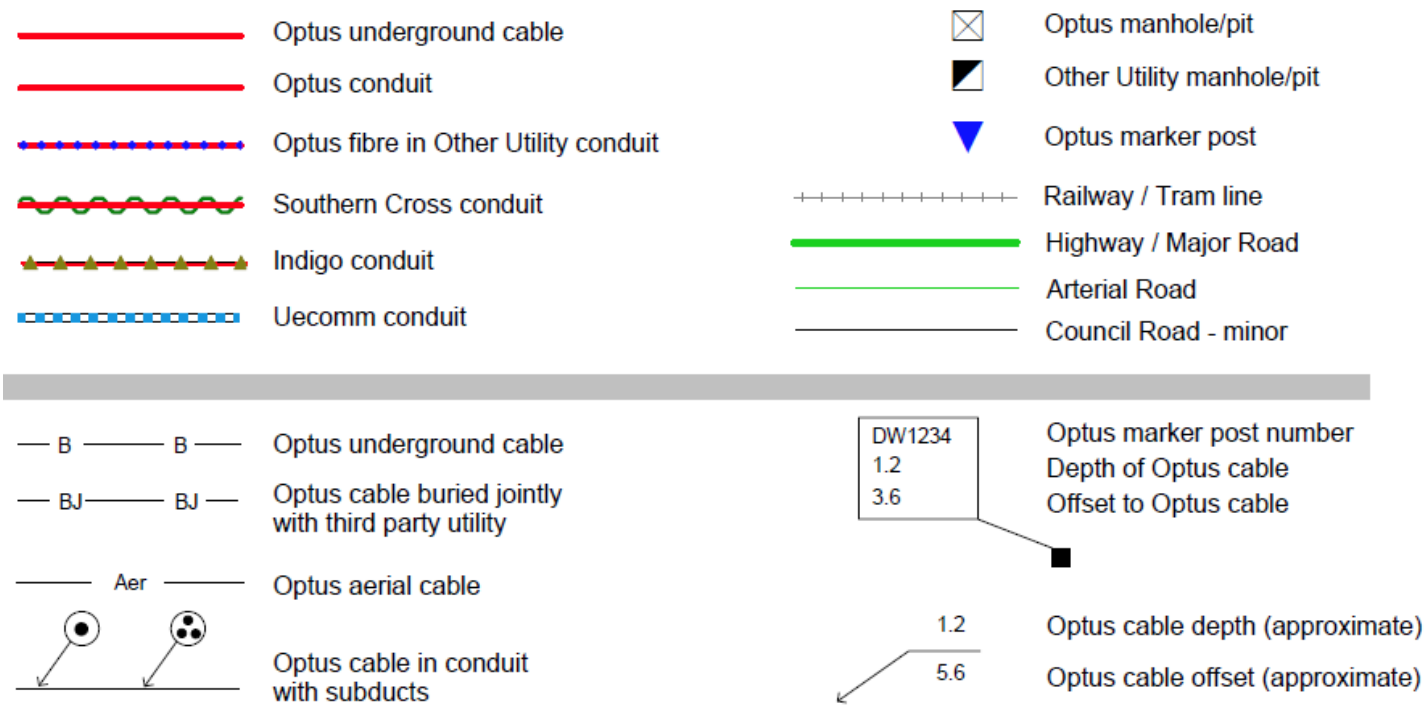
In rural areas Optus conduit must have a minimum depth of cover of 1 meter and direct buried cable 1200mm.
In cases where it is considered that the above clearances cannot be maintained at the completion of works, advice must be sought from the relevant Optus Damages and Relocations Team (refer "Further Assistance").

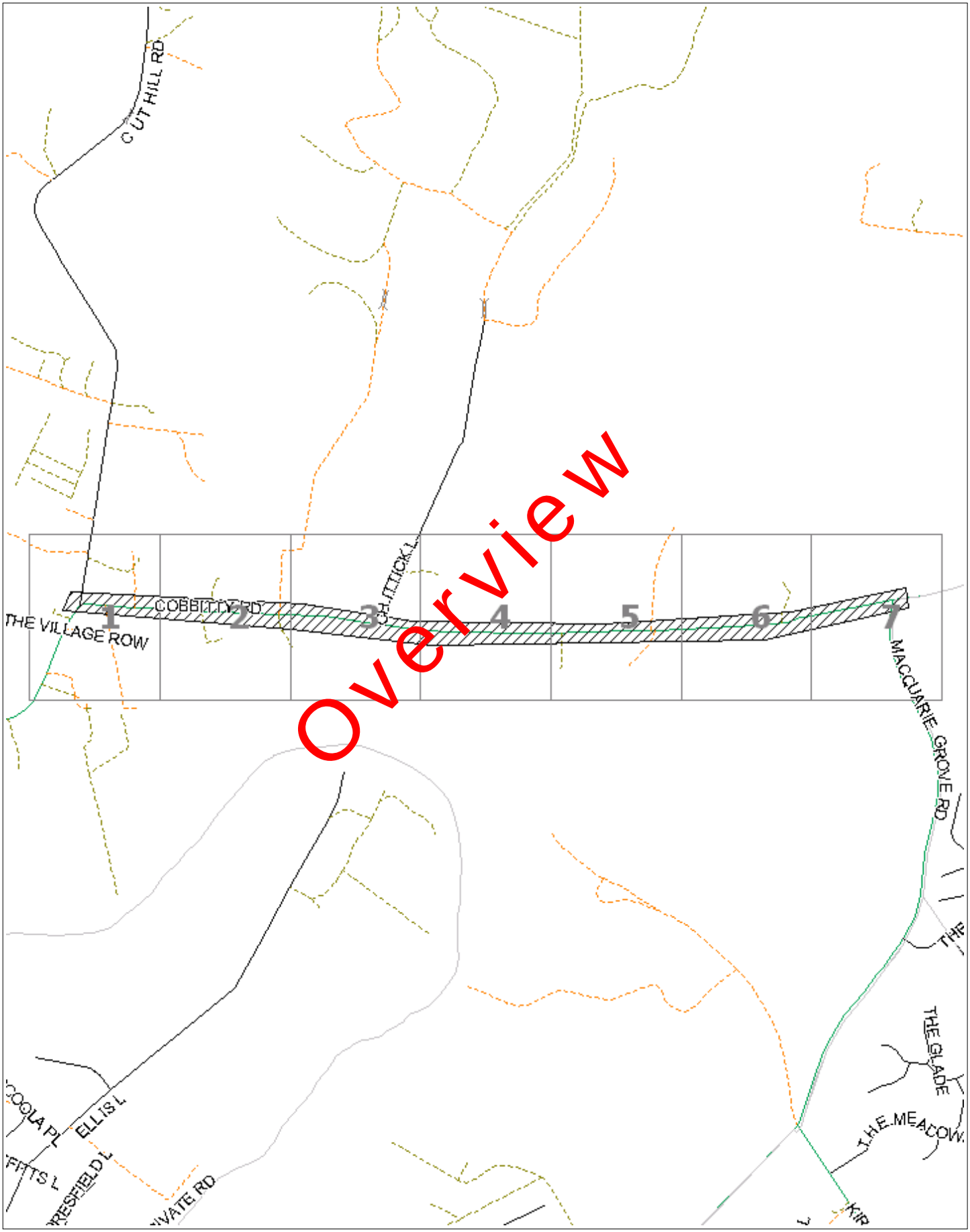
FURTHER ASSISTANCE

Further assistance on asset clearances, protection works or relocation requirements can be obtained by contacting the relevant Optus Damages and Relocations Team on the following email address:
NFODamages&RelocationsDropbox@optus.com.au

Further assistance relating to asset location drawings etc. can be obtained by contacting the Optus Network Operations Asset Analysis Team on 1800 505 777.

OPTUS ENGINEERING DRAWING SYMBOLS





Overview

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Sequence Number: 96491433

Date Generated: 07/04/2020

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Email: Fibre.Locations@optus.net.au
For urgent onsite assistance contact 1800 505 777
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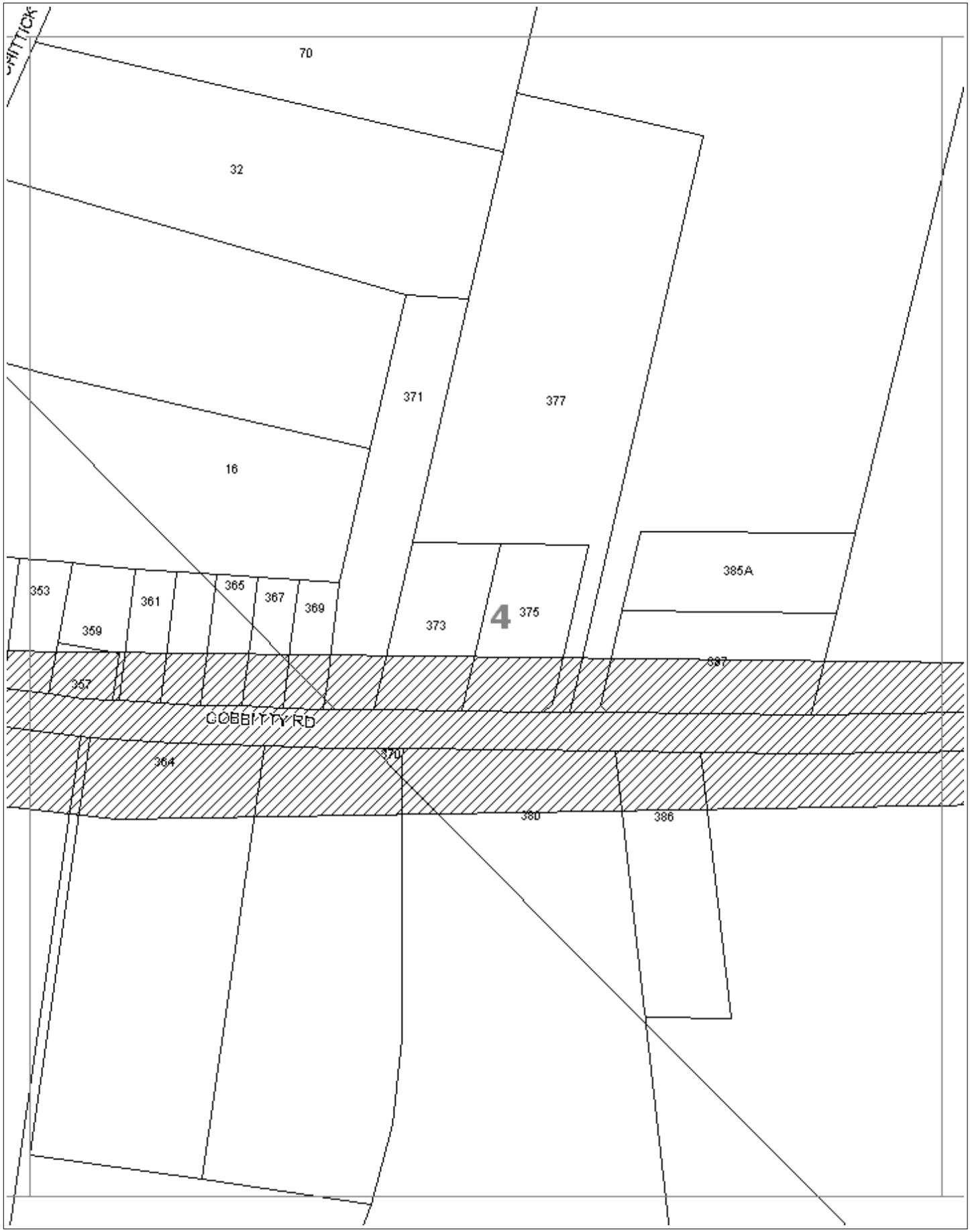


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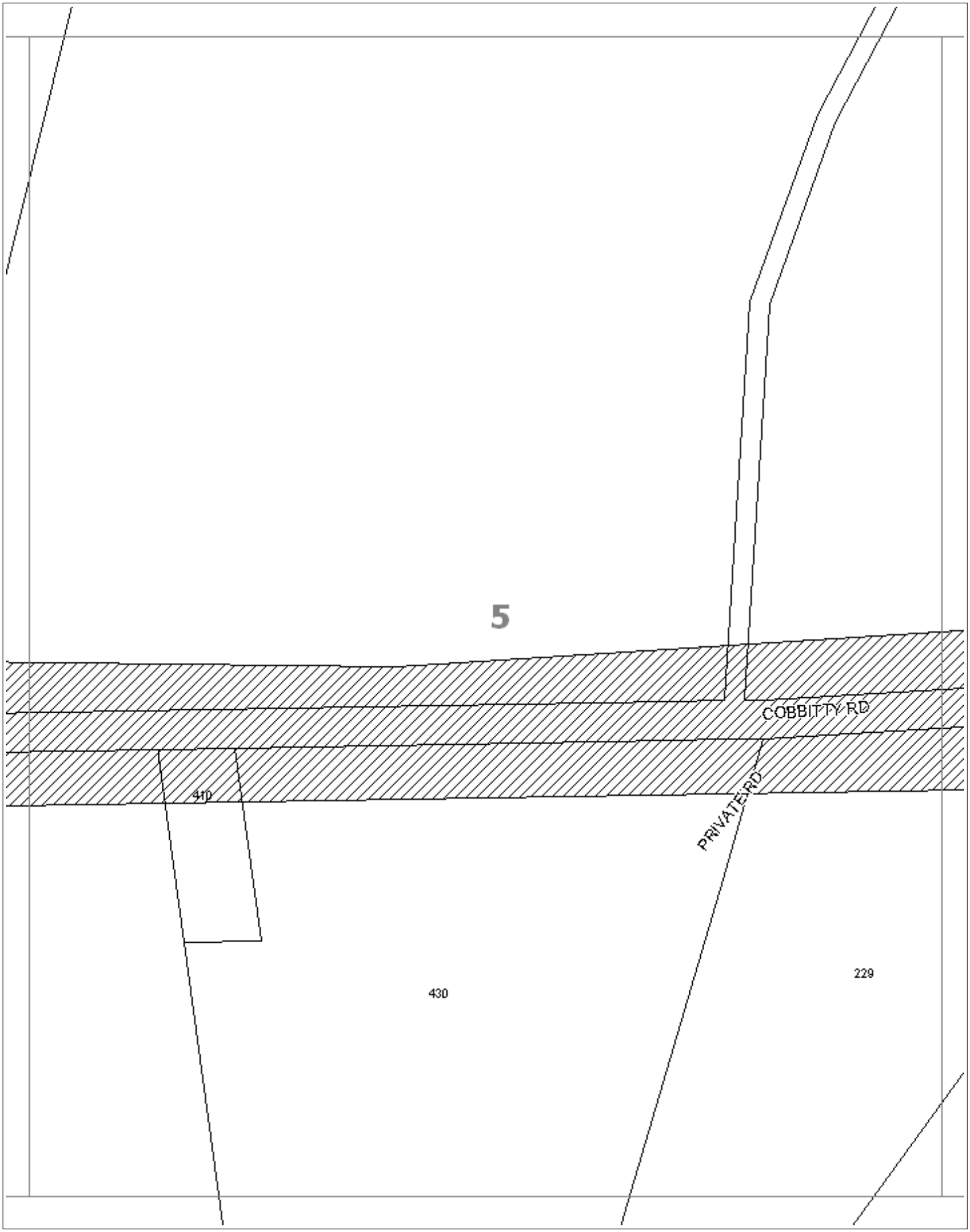


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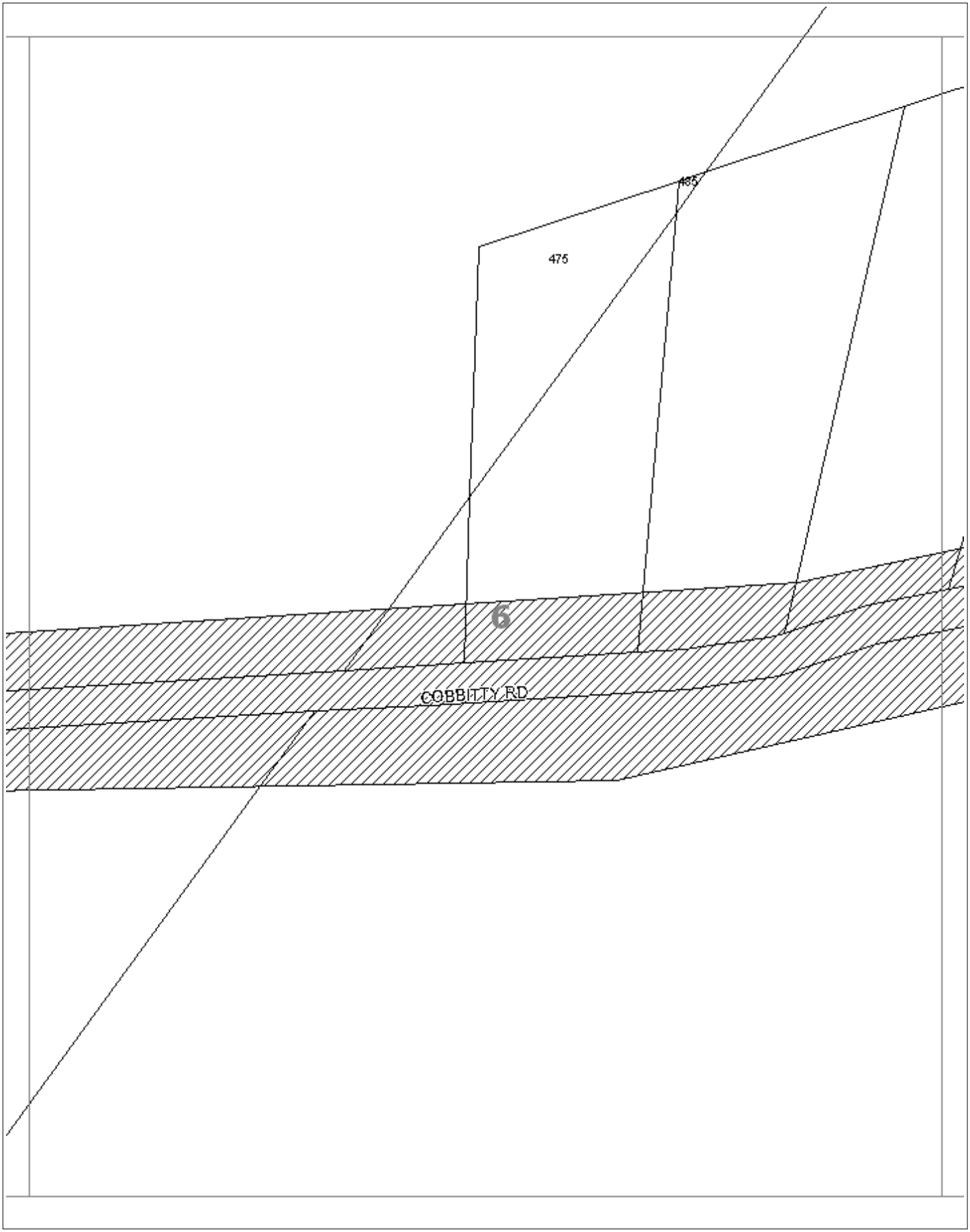


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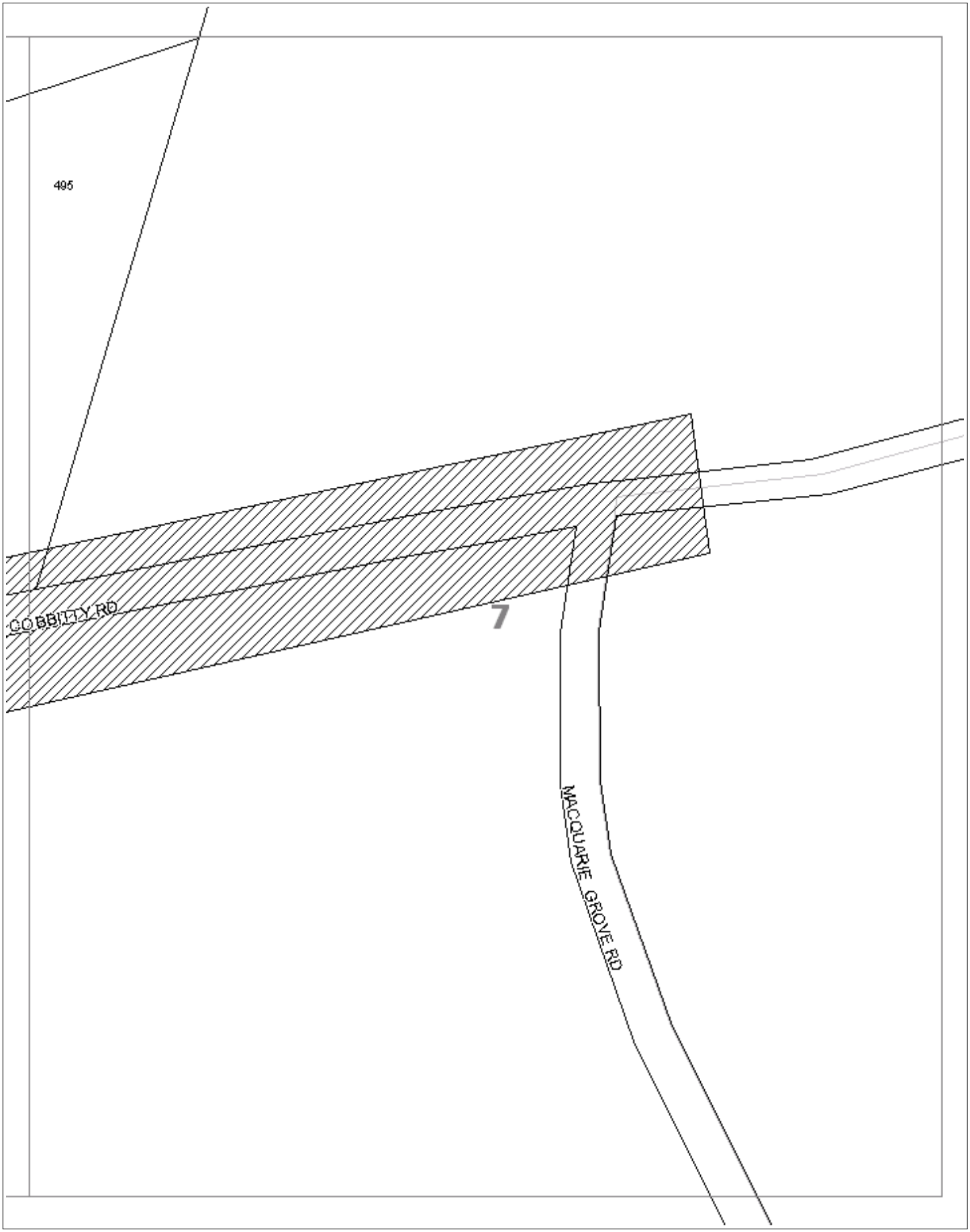


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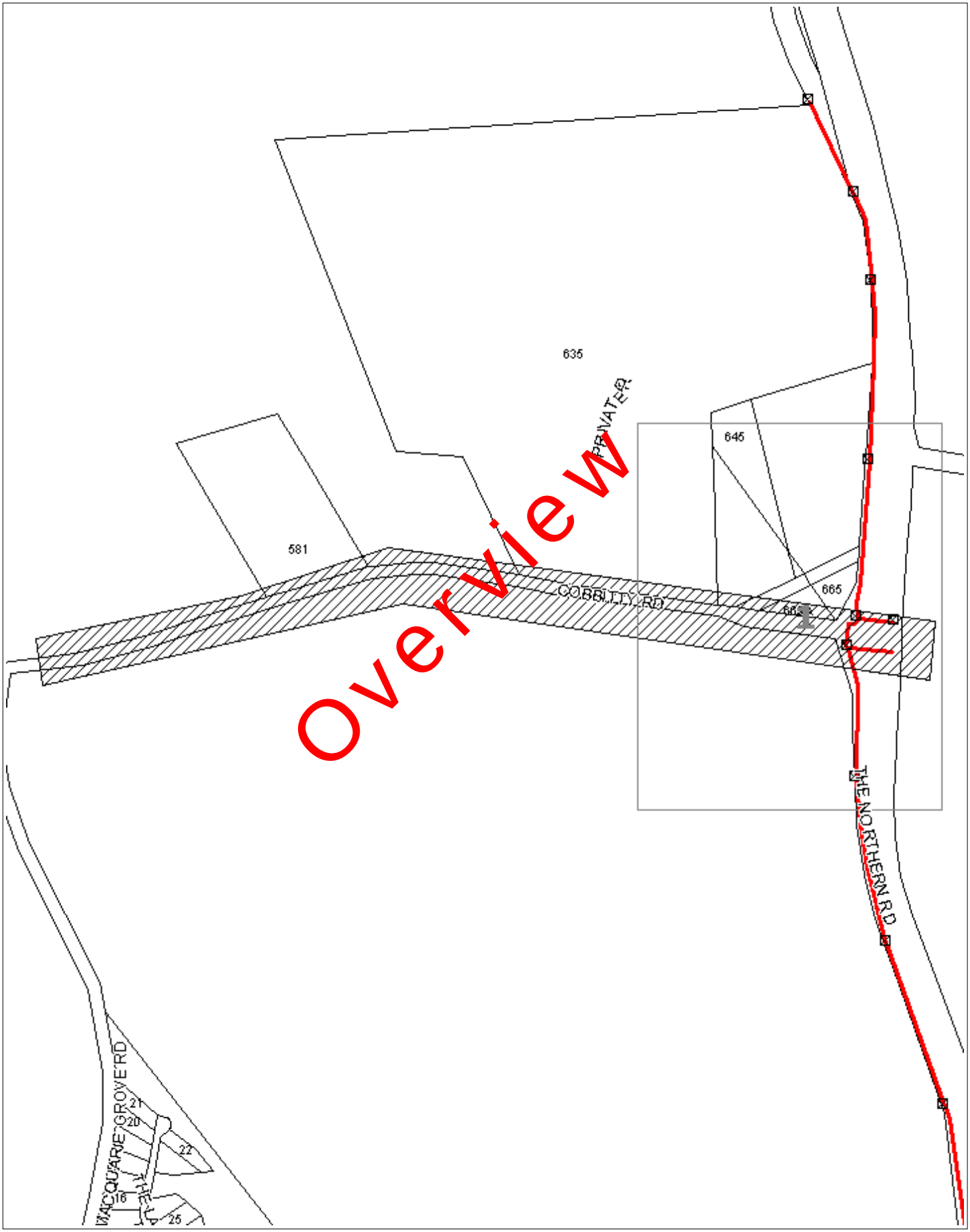


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For all Optus DBYD plan enquiries –
Email: Fibre.Locations@optus.net.au
For urgent onsite assistance contact 1800 505 777
Optus Limited ACN 052 833 208

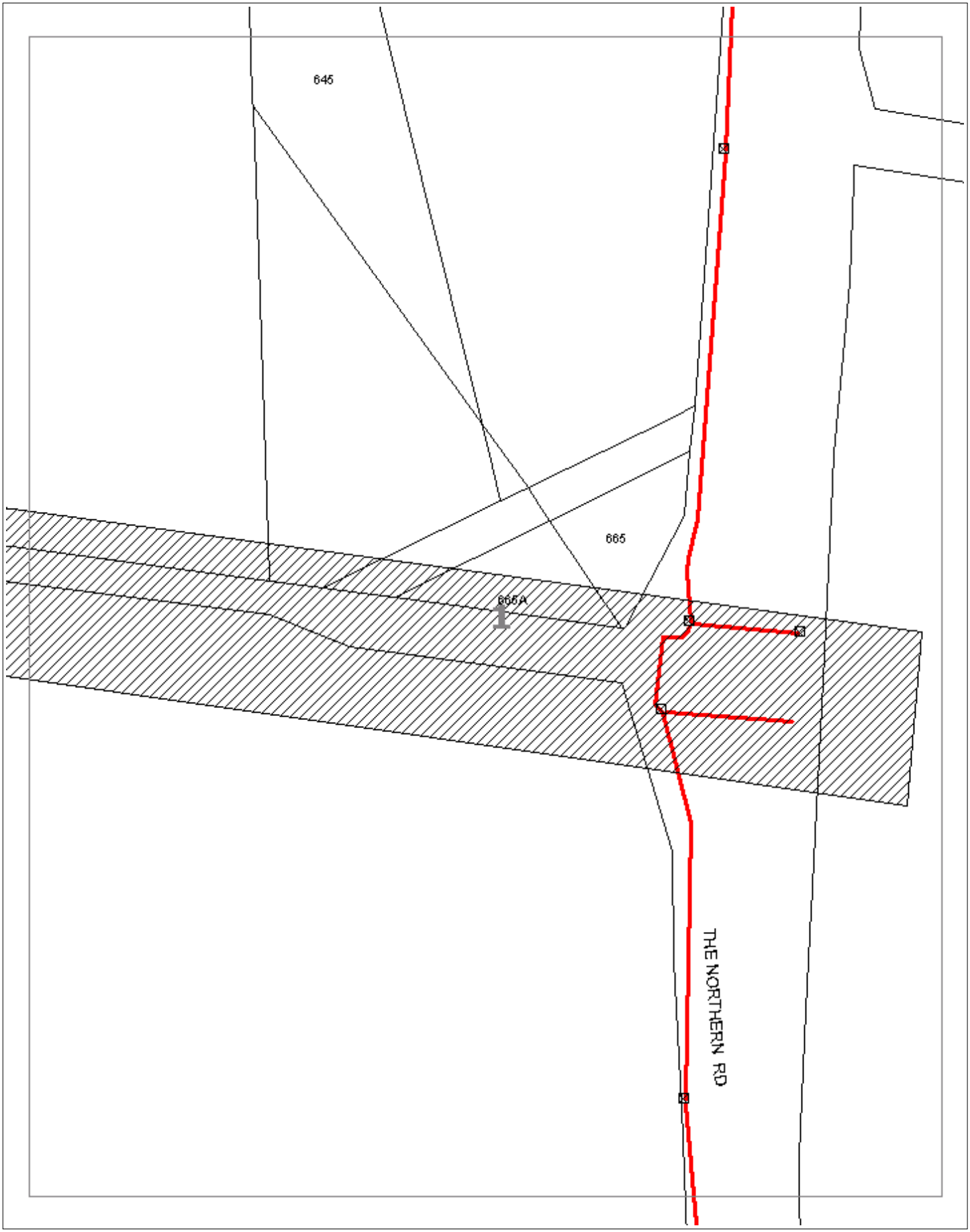


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Optus Plans and information supplied are valid for 30 days from the date of issue. If this timeline has elapsed please raise a new enquiry.

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Optus Limited ACN 052 833 208

Guide to reading Sydney Water DBYD Plans



February 2015

Asset Information

Legend

Sewer

Sewer Main (with flow arrow & size type text) — 225 PVC
Disused Main
Rising Main
Maintenance Hole (with upstream depth to invert) — 1.7
Sub-surface chamber
Maintenance Hole with Overflow chamber
Ventshalft EDUCT — VSE
Ventshaft INDUCT — VS
Property Connection Point (with chainage to downstream MH) — 10.5
Concrete Encased Section — Concrete Encased
Terminal Maintenance Shaft — TMS
Maintenance Shaft — MS
Rodding Point — RP
Lamphole
Vertical — VERT
Pumping Station — SP0882
Sewer Rehabilitation

Pressure Sewer

Pressure Sewer Main
Pump Unit (Alarm, Electrical Cable, Pump Unit) — A
Property Valve Boundary Assembly
Stop Valve
Reducer / Taper
Flushing Point — FP

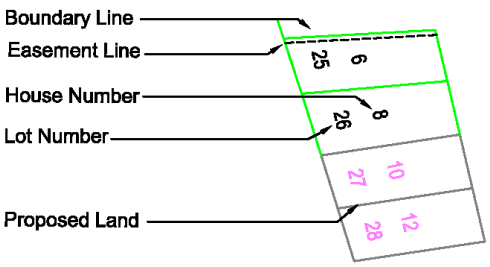
Vacuum Sewer

Pressure Sewer Main
Division Valve
Vacuum Chamber
Clean Out Point

Stormwater

Stormwater Pipe
Stormwater Channel
Stormwater Gully
Stormwater Maintenance Hole

Property Details



Sydney Water Heritage Site (please call **132 092** and ask for the **Heritage Unit**)

Water

WaterMain - Potable (with size type text) — 200 PVC
Disconnected Main - Potable
Proposed Main - Potable
Water Main - Recycled
Special Supply Conditions - Potable
Special Supply Conditions - Recycled
Restrained Joints - Potable
Restrained Joints - Recycled
Hydrant
Maintenance Hole
Stop Valve
Stop Vale with By-pass
Stop Valve with Tapers
Closed Stop Valve
Air Valve
Valve
Scour
Reducer / Taper
Vertical Bends
Reservoir
Recycled Water is shown as per Potable above. Colour as indicated

Private Mains

Potable Water Main
Recycled Water Main
Sewer Main
Symbols for Private Mains shown grey

Asset Information

Pipe Types

ABS	Acrylonitrile Butadiene Styrene	**AC**	Asbestos Cement
BRICK	Brick	**CI**	Cast Iron
CICL	Cast Iron Cement Lined	**CONC**	Concrete
COPPER	Copper	**DI**	Ductile Iron
DICL	Ductile Iron Cement (mortar) Lined	**DIPL**	Ductile Iron Polymeric Lined
EW	Earthenware	**FIBG**	Fibreglass
FL BAR	Forged Locking Bar	**GI**	Galvanised Iron
GRP	Glass Reinforced Plastics	**HDPE**	High Density Polyethylene
MS	Mild Steel	**MSCL**	Mild Steel Cement Lined
PE	Polyethylene	**PC**	Polymer Concrete
PP	Polypropylene	**PVC**	Polyvinylchloride
PVC - M	Polyvinylchloride, Modified	**PVC - O**	Polyvinylchloride, Oriented
PVC - U	Polyvinylchloride, Unplasticised	**RC**	Reinforced Concrete
RC-PL	Reinforced Concrete Plastics Lined	**S**	Steel
SCL	Steel Cement (mortar) Lined	**SCL IBL**	Steel Cement Lined Internal Bitumen Lined
SGW	Salt Glazed Ware	**SPL**	Steel Polymeric Lined
SS	Stainless Steel	**STONE**	Stone
VC	Vitrified Clay	**WI**	Wrought Iron
WS	Woodstave		

Further Information

Please consult the Dial Before You Dig enquiries page on the Sydney Water website

For general enquiries please call the Customer Contact Centre on **132 092**

In an emergency, or to notify Sydney Water of damage or threats to its structures, call 13 20 90 (24 hours, 7 days)

IMPORTANT INFORMATION - DIAL BEFORE YOU DIG

Attention: You must read the information below

The material provided or made available to you by Sydney Water (including on the Sydney Water website) in relation to your Dial Before You Dig enquiry (**Information**) is provided on each of the following conditions, which you are taken to have accepted by using the Information:

1 The Information has been generated by an automated system based on the area highlighted in the "Locality Indication Only" window on your Caller Confirmation. It is your responsibility to ensure that the dig site is properly defined when submitting your Dial Before You Dig enquiry and, if the Information does not match the dig site, to resubmit your enquiry for the correct dig site.

2 Neither Sydney Water nor Dial Before You Dig make any representation or give any guarantee, warranty or undertaking (express or implied) as to the currency, accuracy, completeness, effectiveness or reliability of the Information. The Information, including Sydney Water plans and work-as-executed diagrams, amongst other things:

(a) may not show all existing structures, including Sydney Water's pipelines, particularly in relation to newer developments and in relation to structures owned by parties who do not participate in the Dial Before You Dig service;

(b) may be out of date and not show changes to surface levels, road alignments, fences, buildings and the like;

(c) is approximate only and is therefore not suitable for scaling purposes; and

(d) does not show locations of property services (often called house service lines) belonging to or servicing individual customers, which are usually connected to Sydney Water's structures.

3 You are responsible for, amongst other things:

(a) exposing underground structures, including Sydney Water's pipelines, by pot-holing using hand-held tools or vacuum techniques so as to determine the precise location and extent of structures before any mechanical means of excavation are used;

(b) the safe and proper excavation of and for underground works and structures, including having regard to the fact that asbestos cement pipelines, which can pose a risk to health, may form part of Sydney Water's water and sewerage reticulation systems;

(c) protecting underground structures, including Sydney Water's pipelines, from damage and interference;

(d) maintaining minimum clearances between Sydney Water's structures and structures belonging to others;

(e) ensuring that backfilling of excavation work in the vicinity of Sydney Water's structures complies with Sydney Water's standards contained on its website or otherwise communicated to you;

(f) notifying Sydney Water immediately of any damage caused or threat of damage to Sydney Water's structures;

(g) ensuring that plans are approved by Sydney Water (usually signified by stamping) prior to landscaping or building over or in the vicinity of any Sydney Water structure; and

(h) ensuring that the Information is used only for the purposes for which Sydney Water and Dial Before You Dig intended.

4 You acknowledge that you use the Information at your own risk. In consideration for the provision of the Dial Before You Dig service and the Information by Sydney Water and Dial Before You Dig, to the fullest extent permitted by law:

(a) all conditions and guarantees concerning the Information (whether as to quality, outcome, fitness, care, skill or otherwise) expressed or implied by statute, common law, equity, trade, custom or usage or otherwise are expressly excluded and to the extent that those statutory guarantees cannot be excluded, the liability of Sydney Water and Dial Before You Dig to you is limited to either of the following as nominated by Sydney Water in its discretion, which you agree is your only remedy:

(i) the supplying of the Information again; or

(ii) payment of the cost of having the Information supplied again;

(b) in no event will Sydney Water or Dial Before You Dig be liable for, and you release Sydney Water and Dial Before You Dig from, any Loss arising from or in connection with the Information, including the use of or inability to use the Information and delay in the provision of the Information:

(i) whether arising under statute or in contract, tort or any other legal doctrine, including any negligent act, omission or default (including wilful default) by Sydney Water or Dial Before You Dig; and

(ii) regardless of whether Sydney Water or Dial Before You Dig are or ought to have been aware of, or advised of, the possibility of such loss, costs or damages;

(c) you will indemnify Sydney Water and Dial Before You Dig against any Loss arising from or in connection with Sydney Water providing incorrect or incomplete information to you in connection with the Dial Before You Dig service; and

(d) you assume all risks associated with the use of the Dial Before You Dig and Sydney Water websites, including risk to your computer, software or data being damaged by any virus, and you release and discharge Sydney Water and Dial Before You Dig from all Loss which might arise in respect of your use of the websites.

5 "**Sydney Water**" means Sydney Water Corporation and its employees, agents, representatives and contractors. "**Dial Before You Dig**" means Dial Before You Dig Incorporated and its employees, agents, representatives and contractors. References to "**you**" include references to your employees, agents, representatives, contractors and anyone else using the Information. References to "**Loss**" include any loss, cost, expense, claim, liability or damage (including arising in connection with personal injury, death or any damage to or loss of property and economic or consequential loss, lost profits, loss of revenue, loss of management time, opportunity costs or special damages). To the extent of any inconsistency, the conditions in this document will prevail over any other information provided to you by Sydney Water and Dial Before You Dig.

In an emergency, or to notify Sydney Water of damage or threats to its structures, call 13 20 90 (24 hours, 7 days)

Further information and guidance is available in the Building Development and Plumbing section of Sydney Water's website at www.sydneywater.com.au, where you will find the following documents under 'Dial Before You Dig':

- Avoid Damaging Water and Sewer Pipelines
- Water Main Symbols
- Depths of Mains
- Guidelines for Building Over/Adjacent to Sydney Water Assets
- Clearances Between Underground Services

Or call **13 20 92** for Customer Enquires.

Note: The lodging of enquiries via **www.1100.com.au** will enable you to receive colour plans in PDF format 24 hours a day, 7 days a week via email.

This communication is confidential. If you are not the intended recipient, please destroy all copies immediately. Sydney Water Corporation prohibits unauthorised copying or distribution of this communication.

A0

CHEEK

LANE

Proposed Subject to Final Survey

Proposed Subject to Final Survey

Proposed Subject to Final Survey

A0

DBYD Address:
n/a 160 Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 18875448

DBYD Sequence No: 93885638

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Date of Production: 17/01/2020 09:01:20

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DBYD Address:
n/a 160 Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 18875466

DBYD Sequence No: 93885740

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Date of Production: 17/01/2020 09:03:02

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DBYD Address:
n/a 160 Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 18875517

DBYD Sequence No: 93886041

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DBYD Address:
n/a 160 Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 18875517

DBYD Sequence No: 93886041

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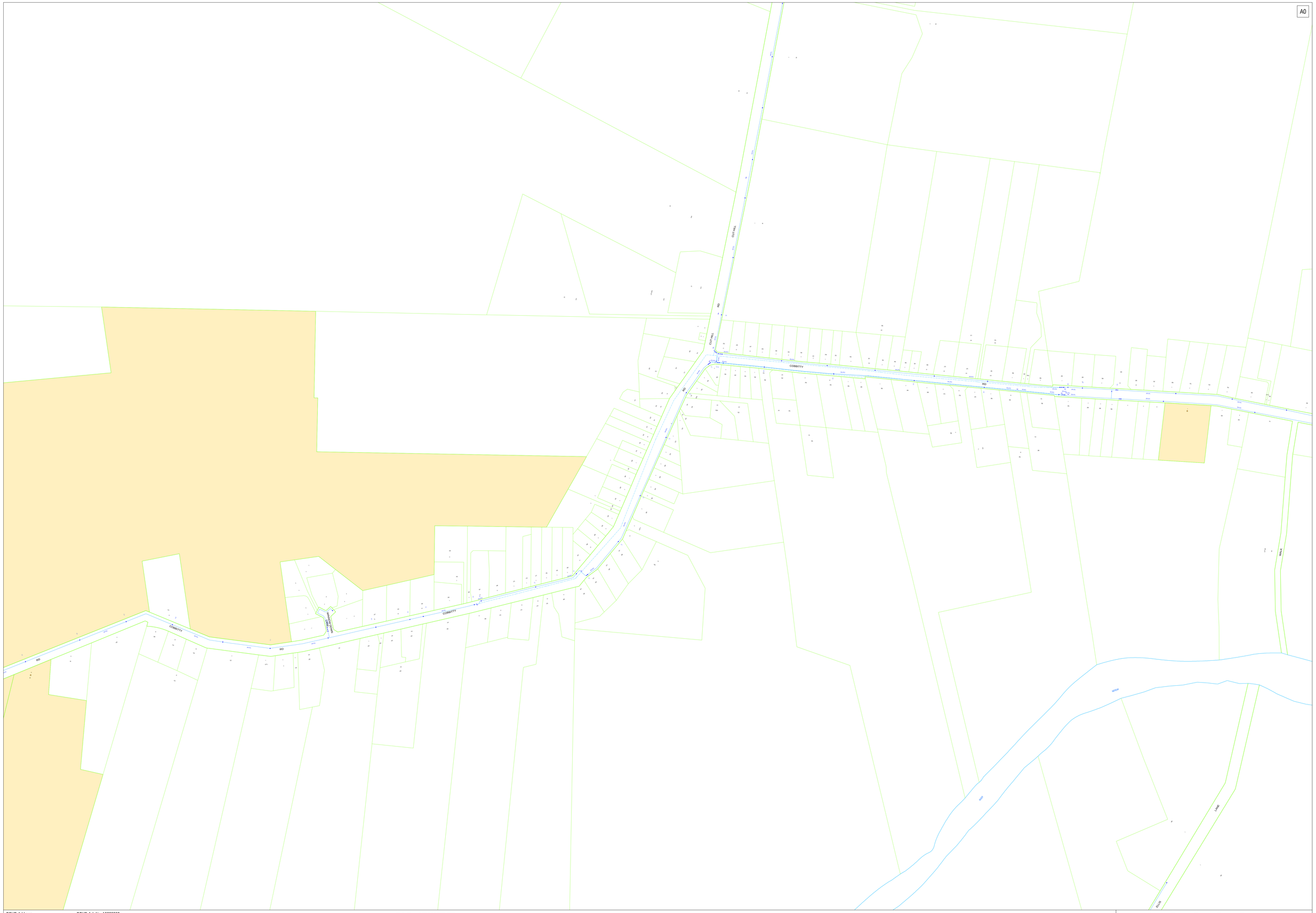
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DBYD Address:
n/a Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 19329302
DBYD Sequence No: 96491437

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A0

COBBITTY

RID

MACQUARIE GROVE

ST

DOWNEY

ELLIS

BUTTON

MORLEY

WHITMAN

LEE

RITCHIE

BLUE

THE HAMS

DBYD Address:
n/a Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 19329302

DBYD Sequence No: 96491437

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Scale: 1:2000

Date of Production: 07/04/2020 10:38:53

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A0

DBYD Address:
n/a Chittick Ln
Cobbitty NSW 2570

DBYD Job No: 19329302
DBYD Sequence No: 96491437

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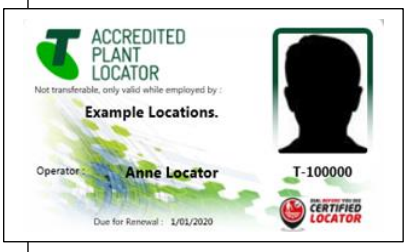
Plan 3 of 3

TELSTRA ACCREDITED PLANT LOCATORS

NEW SOUTH WALES - CENTRAL REGION

Location of Telstra Cables & Network – including Optic Fibre, must be performed by a locator with current Telstra Accreditation for Cable & Plant Locators. All Telstra Accredited Plant Locators have passed rigorous skills and knowledge testing by Dial Before You Dig as indicated by the DBYD Certified Locator symbol.

All Telstra Accredited Plant Locators carry an official Telstra Accreditation photo ID card – valid only while working for the business named on the card. This card will be produced on request.



Telstra plans are intended to be indicative only.
A Telstra Accredited plant location service is required to identify the exact location of the plant and ensure that the infrastructure is protected during construction or excavation work.
It is your responsibility as part of your 'Duty of Care' to engage a Telstra Accredited Plant Locator.

ONLY TELSTRA ACCREDITED PLANT LOCATORS HOLD PERMISSION TO ACCESS TELSTRA PITS & MANHOLES FOR THE PURPOSE OF CABLE & PLANT LOCATIONS.

Contact a Telstra Accredited Locator
from the pages following (FEES APPLY)

Telstra Accredited Plant Locators – New South Wales. CENTRAL

NSW Central.

Company Name & service areas	Pothole Service		
1 300 B4UDIG.	**YES VACUUM EXCAVATOR**	1300 248 344 admin@1300b4udig.com.au www.1300b4udig.com.au	Phone Mobile Fax Email Web
A1 Vac & Location. Port Macquarie, Laurieton, Wauchope, Kempsey, Central District, Orana District, New England Region, Nambucca, Buladelha	**YES HAND DIG & VACUUM EXCAVATOR**	Adam - 0404 958 023 hurricane.gale@hotmail.com	Mobile Fax Email Web
Abitek Pty Ltd.	**NO**	02 4580 9883 0413 327 243 abitek@bigpond.com	Phone Mobile Fax Email Web
ACT Locating & Inspection Services Pty Ltd. ACT QBYN & NSW	**NO**	0438 630 852 tp@actloc.com.au	Phone Mobile Fax Email Web
Action Locating. Sydney, Gosford, Newcastle, Wollongong and Blue Mountains.	**NO**	02 9671 5600 0415 228 466 info@actionlocating.com.au www.actionlocating.com.au	Phone Mobile Fax Email Web
Advanced Ground Locations Pty Ltd. Newcastle, Hunter Valley, Central Coast	**YES HAND DIG & VACUUM EXCAVATOR**	02 4930 3195 0412 497 488 steve_agl@hotmail.com www.advancedgroundlocations.com	Phone Mobile Fax Email Web
Aqua Freeze & Locate Pty Ltd Sydney, Blue Mountains	**Yes**	0458 774 440 service@aquafreeze.com.au www.aquafreeze.com.au	Phone Mobile Fax Email Web
Aquabend Utility Detection. Central Coast & Mid North Coast	**YES HAND DIG & VACUUM EXCAVATOR**	0409 925 472 aquabend@hotmail.com	Phone Mobile Fax Email Web
Asset Service Locating NSW The North West, Riverina, Central West, Sydney, Blue Mountains	**YES HAND DIG VACUUM EXCAVATOR**	0449 854 501 k.p.hanrahan@hotmail.com	Phone Mobile Fax Email Web
Asset Survey Solutions Pty Ltd. All of ACT NSW TAS & VIC SA Fleurieu Peninsula, Adelaide, The Murray, The Limestone Coast	**YES VACUUM EXCAVATOR**	1300 035 796 info@assetsurvey.com.au www.assetsurvey.com.au	Phone Mobile Fax Email Web
Australian Locating Services Pty Ltd. Sydney Metro, North, South, East & West Central Coast, Penrith & Blue Mountains Sutherland Shire, Illawarra & Wollongong	**YES VACUUM EXCAVATOR**	1300 761 545 admin@locating.com.au www.locating.com.au	Phone Mobile Fax Email Web
Australian Subsurface Pty Ltd. All of ACT & NSW	**YES VACUUM EXCAVATOR**	0427 879 600 admin@australiansubsurface.com www.australiansubsurface.com	Phone Mobile Fax Email Web
Australian Utilities Management Pty Ltd. Central Coast Sydney & Blue Mountains	**YES VACUUM EXCAVATOR**	02 9680 0738 0424 537 952 bookings@ausutilities.com.au www.ausutilities.com.au	Phone Mobile Fax Email Web

Telstra Accredited Plant Locators – New South Wales. CENTRAL

BCE Spatial Pty Ltd. WA - all areas Metro and Country NSW - all areas Metro and Country	**YES** **HAND DIG & VACUUM EXCAVATOR**	0437 217 049 0427 008 120 admin@bcespatial.com.au www.bcespatial.com.au	Mobile Mobile Fax Email Web
Bradmac Locating Services Pty Ltd. Sydney Metro, Bathurst, Lithgow, Mudgee, Mittagong, Campbelltown	**NO**	0434 157 409 brad.mac@bigpond.com	Phone Mobile Fax Email Web
Brandon Construction Services Pty Ltd. Sydney metro and surrounding districts, other country NSW areas on request	**NO**	0438 044 008 liam.bolger@hotmail.com	Phone Mobile Fax Email Web
Broken Hill Mini Excavation & Traffic Control Pty Ltd NSW The Far West, Orana, Albury VIC The Murray SA The Outback	**YES** **HAND DIG & VACUUM EXCAVATOR**	0418 117 114 bhtrafficcontrol@hotmail.com	Phone Mobile Fax Email Web
Chris Bates & Associates. Newcastle Hunter Valley Central Coast Mid North Coast	**NO**	02 4928 1519 0408 427 391 chrisbatesandassociates@yahoo.com.au	Phone Mobile Fax Email
Civilscan (Monstar Management Pty Ltd). Sydney, Blue Mountains Central Coast , Illawarra Southern Highlands	**YES** **HAND DIG & VACUUM EXCAVATOR**	0416 068 060 civilscan@bigpond.com www.civilscan.com.au	Phone Mobile Fax Email Web
Construction Sciences Pty Ltd. Australia Wide	**YES** **VACUUM EXCAVATOR**	07 3320 8572 csutilities@constructionsciences.net www.constructionsciences.nett	Phone Mobile Fax Email Web
CRUX Surveying Australia Pty Ltd. Sydney Metro and surrounding areas	**NO**	02 9541 9940 0404 850 381 scottallison@cruxsurveying.com.au www.cruxsurveying.com.au	Phone Mobile Fax Email Web
DATATEKS Pty Ltd. All regional areas	**YES** **VACUUM EXCAVATOR**	02 6971 7777 0408 693 660 gilbertcook@datateks.com.au www.datateks.com.au	Phone Mobile Fax Email Web
DEETECT Pty Ltd ACT and NSW	**NO**	02 6278 7548 0414 630 852 dtech@webone.com.au	Phone Mobile Fax Email Web
Dowds Pipe & Cable Locating. Sydney Wollongong South Coast Highlands	**NO**	0434 635 134 accounts@pipeandcable.com.au www.pipeandcable.com.au	Phone Mobile Fax Email Web
Down Under Detection Services.	**YES** **VACUUM EXCAVATOR**	0418 267 964 apegler@duds.net.au www.downunderdetections.com.au	Phone Mobile Fax Email Web
Down Under Pipeline Surveys Pty Ltd. Orangeville and surrounding districts	**YES** **VACUUM EXCAVATOR**	02 4653 1286 0418 675 374 02 4653 1747 office@dups.com.au www.dups.com.au	Phone Mobile Fax Email Web
Durkin Construction Pty Ltd. Central Coast, Sydney, Blue Mountains, Central & Far West, Riverina, North & North West, Clarence River, Coffs Harbour, Riverina, South West Slopes, Southern Tablelands, Far South Coast, Monaro, Albury ACT	**YES** **VACUUM EXCAVATOR**	02 9712 0308 0452 202 212 info@durkinconstruction.com.au www.durkinconstruction.com.au	Phone Mobile Fax Email Web

Telstra Accredited Plant Locators – New South Wales. CENTRAL

Dynamic Hydro Excavations Brisbane, Gold Coast, Toowoomba, Sunshine Coast, Northern NSW, Ballina, Sydney and surrounding districts.	**YES** **VACUUM EXCAVATOR**	07 5564 8142 0421 406 642 sales@dynamicexcavations.com.au www.dynamicexcavations.com.au	Phone Mobile Fax Email Web
Earth Radar (Vac group Operations Pty Ltd). QLD - All of QLD NSW - All of NSW VIC - All of VIC SA - All of SA	**YES** **VACUUM EXCAVATOR**	1300 822 835 0447 837 267 info@actionlocating.com.au www.earthradar.com.au	Phone Mobile Fax Email Web
East Coast Locating Services Maitland, Newcastle, Port Stephens, Hunter, Central Coast, Sydney	**YES** **HAND DIG**	 0431 193 111 eastcoastlocating@hotmail.com	Phone Mobile Fax Email Web
Electrostar Pty Limited. NSW North & North West, Tamworth, Northern Tablelands (Armidale, Glen Innes) Upper Hunter Valley, Liverpool Plains, Quirindi, Gunnedah, Narrabri, Moree, Central West, Coonabarabran, Coolah, Dunedoo, Mudgee	**YES** **VACUUM EXCAVATOR**	0429 620 999 0428 658 707 02 6762 0213 admin@electrostar.com.au www.electrostar.com.au	Mobile Mobile Fax Email Web
Elite Locating Services NSW - Sydney, Blue Mountains, Central West, Canberra, Riverina, Southern Tablelands, South West Slopes, South Coast, Albury VIC – Melbourne, Gippsland, Highlands Great Ocean Rd	**YES** **HAND DIG**	0413 743 618 eliteloc@gmail.com	Phone Mobile Fax Email Web
Epoca Environmental. All of NSW & ACT	**YES** **VACUUM EXCAVATOR**	02 4739 2465 0430 606 948 evelyn@epocaenvironmental.com.au www.epocaenvironmental.com.au	Phone Mobile Fax Email Web
G MAC LOCATING. Dubbo, Young, Wagga, Yass, Goulburn, Bathurst, Orange, Temora, West Wyalong, Forbes & most NSW country regions	**YES** **VACUUM EXCAVATOR**	0488 520 482 0408 822 428 enquiries@gmaclocating.com.au	Mobile Mobile Fax Email Web
Geoscope Utility Detection Services Pty Ltd. Sydney Metro Blue Mountains Southern Highlands Illawarra - South Coast	**YES** **HAND DIG & VACUUM EXCAVATOR**	1300 750 350 0432 296 323 info@geoscopelocating.com.au www.geoscopelocating.com.au	Phone Mobile Fax Email Web
Geotrace Pty Ltd The Hills District, Blacktown, Bankstown, Rose Bay, Chatswood, Penrith, Blue Mountains, Hawkesbury District, Central Coast, Sutherland, Menai, Double Bay, Sydney CBD, Balmain, Richmond, Yagoona	**NO**	02 8824 6654 0417 147 945 02 8824 5637 info@geotrace.com.au www.geotrace.com.au	Phone Mobile Fax Email Web
GTE1 Pty Ltd NSW The Far West, Orana, The North, The North West VIC The Murray SA The Outback, Flinders Ranges	**YES** **HAND DIG & VACUUM EXCAVATOR**	 0438 688 443 office@gte.net.au	Phone Mobile Fax Email Web
Hunter Ground Search. Newcastle, Upper & Lower Hunter Valley, Central Coast, Central West, Mid North Coast	**YES** **VACUUM EXCAVATOR**	02 4953 1244 0418 684 819 02 4953 1233 huntergroundsearch@bigpond.com	Phone Mobile Fax Email Web
Hydro Digga. All of NSW, ACT & South East Qld.	**YES** **VACUUM EXCAVATOR**	 0447 774 000 locator@hydrodigga.com	Phone Mobile Fax Email Web
K & K Directional Drilling. Tamworth, Gunnedah, Narrabri, Quirindi, Armidale, North & North West NSW all areas	**YES** **VACUUM EXCAVATOR**	02 6760 9917 0429 087 657 kkdrilling@bigpond.com	Phone Mobile Fax Email Web
Landmark Surveys Pty Ltd. Southern NSW and ACT areas	**YES** **HAND DIG & VACUUM EXCAVATOR**	02 6280 9608 0413 832 038 phi@landmarksurveys.com.au www.landmarksurveys.com.au	Phone Mobile Fax Email Web

Telstra Accredited Plant Locators – New South Wales. CENTRAL

LandPartners Pty Ltd NSW Central Northern NSW South East Queensland	**NO**	07 3842 1000 0439 488 545 (Roland) locators@landpartners.com.au www.landpartners.com.au	Phone Mobile Fax Email Web
Laneyrie Electrical Pty Ltd. Helensburg, Illawarra, Shoalhaven. South coast, Southern Tablelands, Far South coast, Wollongong	**YES** **VACUUM EXCAVATOR**	02 4237 9865 0412 079 079 0413 048 048 bindy@laneyrieelectrical.com.au www.laneyrieelectrical.com.au	Phone Mobile Mobile Email Web
Locate & Map Pty Ltd. Sydney, Wollongong and the Central Coast	**NO**	0431 191 669 tim@locateandmap.com.au www.locateandmap.com.au	Phone Mobile Fax Email Web
Locate the Pipes VIC - The Murray, The High Country, Melbourne NSW/ACT - Jervis Bay, Riverina, South West Slopes, Far South Coast, Albury, Canberra	**YES**	0423 111 925 hayden@locatethepipes.com.au	Phone Mobile Fax Email Web
Locaters Pty Ltd. Sydney, Penrith, Richmond, Macarthur, Wollongong	**YES** **VACUUM EXCAVATOR**	02 8214 8911 info@locators.com.au www.locators.com.au	Phone Mobile Fax Email Web
Locating Services Pty Ltd. Hawkesbury and all of NSW	**NO**	0403 065 510 sam.romano@locatingservices.com.au www.locatingservices.com	Phone Mobile Fax Email Web
Lyntet Communications (Lynco Pty Ltd). Dubbo depot, covering Forbes, Grenfell, Parkes, Bourke, Bourke North, Nyngan, Coonabarabran, Coonamble, Mudgee, Narromine, Wellington, Orange, Molong, Yeoval, Coolah, Dunedoo, Gilgandra, Mendooran	**YES** **HAND DIG & VACUUM EXCAVATOR**	0409 811 673 lyntet@bigpond.com.au	Phone Mobile Fax Email Web
MB Electrical (Mathew Barratt Electrical Pty Ltd). Far West NSW - Broken Hill, Menindee, Wilcannia, Tibooburra, Ivanhoe & surrounding areas	**YES** **VACUUM EXCAVATOR**	08 8088 7933 accounts@mbelectrical.net.au www.mbelectrical.net.au	Phone Mobile Fax Email Web
Meek Design & Construction Pty Ltd. Bathurst, Orange, Lithgow, Oberon, Mudgee and surrounding areas.	**YES** **VACUUM EXCAVATOR**	0419 633 483 ron@meekdesign.com.au	Phone Mobile Fax Email Web
Mr Mac Group. Lithgow, Mudgee, Bathurst, Wellington, Goulburn	**YES** **VACUUM EXCAVATOR**	0447 818 260 jon@mrmacgroup.com.au	Phone Mobile Fax Email Web
Mullane Maintenance Pty Ltd. Newcastle and Hunter Region, Central Coast, Mid-North Coast	**NO**	1300 608 999 02 4960 8933 maintenance@mullane.com.au www.mullane.com.au	Phone Mobile Fax Email Web
Newcastle Locating Services Pty Ltd. Sydney, Central Coast, Hunter Valley, Upper Hunter Valley, Port Stephens, Muswellbrook, Singleton, Slone, Gunnedah, Port Macquarie	**YES** **VACUUM EXCAVATOR**	0410 698 599 undergroundservices@bigpond.com.au www.newcastlelocatingservices.com.au	Phone Mobile Fax Email Web
On Point Utility Locating Pty Ltd. Sydney, Parramatta, Penrith, Wollongong, Central Coast, Highlands, Goulburn, Blue Mountains	**YES** **VACUUM EXCAVATOR**	1300 667 646 0499 990 478 info@onpointlocating.com.au www.onpointlocating.com.au	Phone Mobile Fax Email Web
One Search Locators Pty Ltd. QLD NSW ACT	**YES** **VACUUM EXCAVATOR**	1300 530 420 0499 955 571 info@onesearchlocators.com.au www.onesearchlocators.com.au	Phone Mobile Fax Email Web

Telstra Accredited Plant Locators – New South Wales. CENTRAL

Online Pipe & Cable Locating Pty Ltd. Sydney, Newcastle, Canberra, Central Coast, Wollongong, Blue Mountains and Port Macquarie	**YES** **VACUUM EXCAVATOR**	1300 665 384 0418 402 234 02 9676 6127 office@onlinepipe.com.au www.onlinepipe.com.au	Phone Mobile Fax Email Web
Peter Ellsmore and Associates. Wollongong / Illawarra / Shoalhaven / Far South Coast / Southern Highlands & Tablelands / Wollondilly / Goulburn / Macarthur area / Campbelltown & Southern Sydney	**NO**	02 4253 5616 0439 423 708 02 4253 5660 ian.brown@ellsmore.com.au www.ellsmore.com.au	Phone Mobile Fax Email Web
Pipesure Australia Pty Ltd. Sydney and surrounding areas	**NO**	1300 411 811 0428 548 281 info@pipesure.com.au www.pipesure.com.au	Phone Mobile Fax Email Web
Riteway Traffic control Pty Ltd. Central Coast Upper Hunter	**NO**	0419 212 969 kbrowne@ritewaytc.com.au	Phone Mobile Fax Email Web
RL Underground Pty Ltd WA - Perth and Peel, VIC - Melbourne, NSW - Sydney	**YES** **VACUUM EXCAVATOR**	08 6189 1211 0418 774 646 0447 933 707 andrew.hunt@rlunderground.com.au	Phone Mobile Mobile Email Web
RPS Australia East Pty Ltd. South East Qld, Gold Coast, Sunshine Coast, Brisbane, Ipswich & Scenic Rim Sydney & surrounding areas	**YES** **VACUUM EXCAVATOR**	07 3539 9586 0408 839 723 andrew.watson@rpsgroup.com.au www.rpsgroup.com.au	Phone Mobile Fax Email Web
Rutherford Electrical Engineering Services. Hunter Valley Maitland Newcastle Central Coast	**NO**	02 4932 7344 office@ruthelect.com.au www.ruthelect.com.au	Phone Mobile Fax Email Web
SA Cable and Pipe Locating **(Saverne Contractors Pty Ltd)** SA All Areas VIC The Murray NSW The Far West	**YES** **HAND DIG**	0408 850 315 www.sacable.com.au www.sacable.com.au	Phone Mobile Fax Email Web
SEEK LOCATIONS. Taree, Forster, Gloucestor, Hardington, Port Macquarie, Wauchope.	**NO**	0407 256 858 seek@seeklocations.com.au www.seeklocations.com.au	Phone Mobile Fax Email Web
Service Locator SA (Geolaird Pty Ltd) NSW -The Far West NT - Alice Springs and Uluru SA - The Outback, Flinders Ranges, Eyre Peninsula, Yorke Peninsula, The Murray	**YES**	0477 296 932 leon@servicelocatorsa.com.au	Mobile Fax Email Web
Signal Support Services Pty Ltd. Goulburn, Southern Tablelands, South West Slopes, Central West, Far South Coast & Monaro, Riverina, Far West	**YES** **VACUUM EXCAVATOR**	0418 237 668 ted@signalsupport.com.au	Phone Mobile Fax Email Web
Smartscan Locators Pty Ltd Greater Sydney Metro Area Central Coast & Newcastle Blue Mountains	**YES** **Hand Dig**	0498 025 210 jason@sslocators.com.au smartscanlocators.com.au	Phone Mobile Fax Email Web
Subsurface Utility Solutions Pty Ltd Sydney, Blue Mountains, Southern Tablelands	**YES**	0421 157 372 nick@subsurf.com.au www.subsurf.com.au	Phone Mobile Mobile Email Web
Suk Truk Services Pty Ltd. Newcastle, Upper Hunter Valley, Lower Hunter Valley, Central Coast, Lake Macquarie	**YES** **HAND DIG &** **VACUUM EXCAVATOR**	0419 125 551 suktrukservices@bigpond.com	Phone Mobile Fax Email Web

Telstra Accredited Plant Locators – New South Wales. CENTRAL

Superior Ground Locations **(Harley Michael Ingersoll)** Hunter Valley Central Coast	**YES** **HAND DIG**	0466 899 337 superiorgroundlocations@outlook.com	Phone Mobile Email Web
SureSearch (Utility Locating Pty Ltd). Sydney, Newcastle, Central & South Coasts, Raymond Terrace, Wollongong, Gosford, Tuggerah, Seven Hills, Port Stephens, Nowra, Picton, Blue Mountains, Lithgow, Narrabeen, Pymble, Muswellbrook, Forster	**YES** **VACUUM EXCAVATOR**	1300 884 520 schedule@suresearch.com.au www.suresearch.com.au	Phone Mobile Fax Email Web
Sydney Pipe & Cable Pty Ltd. Greater Sydney Basin - Wollongong, Blue Mountains, Nowra, Newcastle	**NO**	0416 215 667 glenn@spacls.com.au	Phone Mobile Fax Email Web
The Control Group Pty Ltd NSW North, NSW North West, NSW Far North, NSW Clarence River, NSW Coffs Harbour	**YES**	0421 960 017 locating@thecontrolgroup.com.au www.thecontrolgroup.com.au	Phone Mobile Mobile Email Web
Utec Solutions Pty Ltd. NSW based covers Queensland and Victoria also	**YES** **VACUUM EXCAVATOR**	02 9389 0040 0439 994 881 tim@utecsolutions.com.au www.utecsolutions.com.au	Phone Mobile Fax Email Web
Utility ID – Underground Service and Cable Locators. Darling Downs South West Toowoomba Roma	**NO**	0401 202 515 info@utilityid.com.au www.utilityid.com.au	Phone Mobile Fax Email Web
Utility Locating Services. Sydney and surrounding regions	**YES** **VACUUM EXCAVATOR**	0404 087 555 mail@utilitylocatingservices.com.au www.utilitylocatingservices.com.au	Phone Mobile Fax Email Web
Utility Mapping (Aust) Pty Ltd. Sydney and surrounding areas	**YES** **VACUUM EXCAVATOR**	1300 MAPPING (627746) sydney@utilitymapping.com.au www.utilitymapping.com.au	Phone Mobile Fax Email Web
Utility Scan. All areas	**YES** **HAND DIG**	0426 354 051 brett@utilityscan.net	Phone Mobile Fax Email Web
VERIS AUSTRALIA PTY LTD Australia wide ACT NSW QLD NT SA TAS VIC WA	**YES**	1300 765 315 0436 122 753 d.maksimovic@veris.com.au www.veris.com.au	Phone Mobile Mobile Email Web
Vertex Power & Process. Western NSW - Broken Hill, Silverton, Menindee, Wilcannia, Ivanhoe, Tibooburra SA border - Cockburn, Yunta	**YES** **VACUUM EXCAVATOR**	08 8088 4301 0428 154 450 08 8087 5729 service@vertexpp.com.au www.vertexpp.com.au	Phone Mobile Fax Email Web
Wagga Directional Drilling. Riverina & surrounds	**YES** **VACUUM EXCAVATOR**	02 6925 4660 0418 473 104 02 6925 4941 sidpowell.wdd@telstra.com	Phone Mobile Fax Email Web

DUTY OF CARE

IT'S HOW WE CONNECT

TELSTRA CORPORATION ACN 051 775 556

IMPORTANT:

When working in the vicinity of telecommunications plant you have a "Duty of Care" that must be observed. Please read and understand all the information and disclaimers provided below.

Telstra network is complex and requires expert knowledge to interpret information, to identify and locate components, to pothole underground assets for validation and to safely work around assets without causing damage. If you are not an expert and/or qualified in these areas, then you must not attempt these activities. Telstra will seek compensation for damages caused to its property and losses caused to Telstra and its customers. The 5 P's to prevent damage to Telstra assets are listed below. Construction activities and/or any activities that potentially may impact on Telstra's assets must not commence without first undertaking these steps. Construction activities can include anything that involves breaking ground, potentially affecting Telstra assets.

If you are designing a project it is recommended that you also undertake these steps to validate underground assets prior to committing to your design.

(The following pages contain more detail on each step below and the contact details to seek further advice. AS5488-2013 is the Australian Standard for the Classification of Subsurface Utility Information.)

1 PLAN:

The essential first step in preventing damage -
You must have current Telstra plans via the DBYD process. Telstra advises that the accuracy of the information provided by Telstra conforms to Quality Level D as defined in AS5488-2013. This means the information is indicative only, not a precise location. **The actual location may differ substantially from that shown on the plans** - refer to steps 2 & 3 to determine actual location prior to proceeding with construction.

2 PREPARE:

The essential second step in preventing damage -
Engage a Telstra Accredited Plant Locator. To be able to trace and identify individual subsurface cables and ducts requires access to Telstra pits and manholes. Only a Telstra Accredited Plant Locator (TAPL) is authorised to access Telstra network for locating purposes. A TAPL can interpret plans, validate visible assets and access pits and manholes to undertake electronic detection of underground assets prior to further validation. All Telstra assets must be located, validated and protected prior to commencing construction. If you are not authorised to do so by Telstra, you must not access Telstra network or locate Telstra network. All Telstra Accredited Plant Locators are required to have DBYD Locator Certification.

3 POTHOLE:

The essential third step in preventing damage -
All Telstra assets must be positively identified (i.e. validated), by physically sighting them. For underground assets this can be done by potholing by hand or using non-destructive vacuum extraction methods (Refer to 'validation' as defined in AS5488-2013 QL-A). **Underground assets located by electronic detection alone (step 2), are not deemed to be 'validated' and must not be used for construction purposes.** Some TAPL's can assist with non-destructive potholing for validation purposes. **If you cannot validate the Telstra network, you must not proceed with construction**. Telstra will seek compensation for damages caused to its property and losses caused to Telstra and its customers.

4 PROTECT:

The essential fourth step in preventing damage -
Telstra assets must be protected to avoid damage from construction activities. Minimum working distances around Telstra network must be maintained. These distances are provided in this document. Telstra can also provide advice and assistance in regards to protection – refer to the following pages.

5 PROCEED:

Only proceed when the above steps have been completed.

STEP 1 - PLAN
Dial Before You Dig / Telstra Plans

The actual location of Telstra assets may differ substantially from that shown on the plans. Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for the accuracy shown on the plans. Steps 2 and 3 must also be undertaken to determine actual location of network.

- Telstra DBYD plans are not suitable for displaying Telstra network within a Telstra exchange site. For advice on Telstra network within a Telstra exchange site contact Telstra Plan Service on 1800 653 935.
- Telstra owns and retains the copyright in all plans and details provided in conjunction with the applicant's request. The applicant is authorised to use the plans and details only for the purpose indicated in the applicant's request. The applicant must not use the plans or details for any other purpose.
- Telstra plans or other details are provided only for the use of the applicant, its servants, agents or Telstra Accredited Plant Locators. The applicant must not give the plans or details to any parties other than these, and must not generate profit from commercialising the plans or details.
- Please contact Telstra Plan Services immediately should you locate Telstra assets not indicated on these plans.
- Telstra, its servants or agents shall not be liable for any loss or damage caused or occasioned by the use of plans and or details so supplied to the applicant, its servants and agents, and the applicant agrees to indemnify Telstra against any claim or demand for any such loss or damage.
- Please ensure Telstra plans and information provided remains on-site at all times throughout the inspection, location and construction phase of any works.
- Telstra plans are valid for 60 days after issue and must be replaced if required after the 60 days.

- **Emergency situations - receiving Telstra plans** Telstra's automated mapping system (TAMS) will provide a fast response for emergency situations (faster than an operator can provide manually via a phone call - see below for fast response requirements). Automated responses are normally available 24/7.

  To receive a fast automated response from Telstra your request must **-**

  - Be a web request lodged at DBYD (**www.1100.com.au**). The request will be then forwarded to Telstra.
  - Contain your current email address so you can receive the automated email response.
  - Be for the purposes of 'mechanical excavation' or other ground breaking DBYD activity. (Requests with activity types such as conveyancing, planning & design or other non-digging activities may not be responded to until the next business day).
  - Be for an area less than 350 metres in size to obtain a PDF map (over 350 metres will default to DWF due to size) this does not include congested CBD areas where only DWF may be supplied.
  - Be for an area less than 2500 metres in size to obtain a DWF map (CBD's less)

- **Data Extraction Fees.** In some instances a data extraction fee may be applicable for the supply of Telstra information. Typically a data extraction fee may apply to large projects, planning and design requests or requests to be supplied in non-standard formats. For further details contact Telstra Plan Services.

- **Electronic plans - PDF and DWF maps** If you have received Telstra maps via email you will have received the maps as either a PDF file (for smaller areas) or DWF file (for larger area requests). All requests over approximately *350m or in congested CBD areas can only be supplied in DWF format. There are size limits on what can be provided. (* actual size depends on geographic location of requested area). If you are unable to launch any one of the softcopy files for viewing and printing, you may need to download and install one or more of the free viewing and printing products such as Adobe Acrobat Reader (for PDF files) or Autodesk Design Review (for DWF files) available from the internet

  - **Pdf files -** PDF is the default softcopy format for all requests for areas up to approx *350m in length. (*depends on geographic location of request). The PDF file is nominally formatted to A3 portrait sheet however it can be printed on any size sheet that your printer supports, e.g. either as the full sheet or selected areas to suit needs and legibility. (to print a selected area zoom up and print 'current view') If there are multiple layers of Telstra network you may receive up to 2 sheets in the single PDF file attachment supplied. There are three types or layers of network normally recorded - local network, mains cables or a combined layer of local and mains (usually displayed for rural or semi-rural areas). If mains cable network is present in addition to local cables (i.e. as separate layer in a particular area), the mains will be shown on a separate sheet. The mains cable information should be read in conjunction with the local cable information.

- **DWF files –** DWF is the default softcopy format for all requests for areas that are over 350m in length. Maximum length for a DWF automated response is approx 2500m - depending on geographic location of request (manually-processed plans may provide larger coverage). The DWF files differ from PDF in that DWF are vector files made up of layers that can be turned on or off and are not formatted to a specific sheet size. This makes them ideal for larger areas and for transmitting electronically.
    - ***How to view Telstra DWF files –***
      Telstra DWF files come with all layers turned on. You may need to turn individual layers on or off for viewing and printing clarity. Individual layer names are CC (main cable/conduit), DA (distribution area network) and sometimes a combined layer - CAC. Layer details can be viewed by either picking off the side menu or by selecting 'window' then 'layers' off the top menu bar. Use 'layers' to turn individual layers off or on (double click or right click on layer icon).
    - ***How to print Telstra DWF files –***
      DWF files can be printed on any size sheet – either their entirety or by selected areas of interest. Some DWF coverage areas are large and are not suited to printing legibly on a single A4 sheet - you may need several prints if you only have an A4 printer. Alternatively, an A3, A1 or larger printer could be used. To print, zoom in or out and then, by changing the 'print range' settings, you can print what is displayed on your screen to suit your paper size. If you only have a small printer, e.g. A4, you may need to zoom until the text is legible for printing (which is why you may need several prints). To print what is displayed on your screen the 'view' setting should be changed from 'full page' to 'current view'. The 'current sheet' setting should also be selected. You may need to print layers separately for clarity and legibility. (Details above on how to turn layers on or off)
    - ***How to change the background colour from white to black (when viewing) Telstra DWF files –***
      If using Autodesk Design Review the background colour can be changed by selecting 'Tools' then 'options' then 'sheet'. Tick the box 'override published paper colours' and select the colour required using the tab provided.

STEP 2 – PREPARE
Telstra Accredited Plant Locator (TAPL):

Utilising a TAPL is an essential part of the process to identify network and to trace subsurface network prior to validating. A TAPL can provide plan interpretation, identification and electronic detection. This will assist in determining the position of subsurface assets prior to potholing (validating). Some TAPL's can also assist in validating underground detected network. Electronic detection is only an indication of the existence of underground network and can be subject to interference from other services and local conditions. Electronic detection must not be used solely to determine location for construction purposes. The electronic (indicative) subsurface measurements must be proven by physically sighting the asset (see step 3 – Pothole).

- All TAPL's locating Telstra network must be able to produce a current photo ID card issued by Telstra. A list of TAPL's is provided with the Telstra Dial Before You Dig plans.
- All TAPL's in addition to the Telstra photo ID card must also have current DBYD Locator Certification with ID card.
- Telstra does not permit external parties (non-Telstra) to access or conduct work on Telstra network. Only Telstra staff, Telstra contractors or locators whom are correctly accredited are authorised to work on or access Telstra manholes, pits, ducts, cables etc. This is for safety as well as for legal reasons.
- The details of any contract, agreement or retainer for site assistance to locate telecommunications plant shall be for you to decide and agree with the Telstra Accredited Plant Locator engaged. Telstra is not a party to any contract entered into between you and a Telstra Accredited Plant Locator.
- Payment for the site assistance will be your responsibility and payment details must be agreed before the engagement is confirmed.
- Telstra does not accept any liability or responsibility for the performance of or advice given by a Telstra Accredited Plant Locator. Accreditation is an initiative taken by Telstra towards the establishment and

maintenance of competency standards. However, performance and the advice given will always depend on the nature of the individual engagement.

- Neither the Telstra Accredited Plant Locator nor any of its employees are an employee or agent for Telstra. Telstra is not liable for any damage or loss caused by the Telstra Accredited Plant Locator or its employees.

- **Electronically derived subsurface measurements (e.g. depths/alignments by locating devices)**

  All locator provided measurements for Telstra assets must have the AS5488-2013 quality level specified - (e.g. QL-A, B, C or D). These quality levels define the accuracy of subsurface information and are critical for determining how the information is later used – for example if suitable for excavation purposes.

  1) ***An example of a subsurface measurement with no quality level specified – (i.e. not to be used)***

     Telstra cover - **0.9m**

     *The measurement above has no AS5488-2013 quality level specified and **must not** be provided by a locator or used for design or construction. This is because it is not known whether the measurement is actual or derived (where 'actual' means validated and 'derived' means assumed and not validated, e.g. electronic or other). Typically damages occur by constructors incorrectly using unvalidated measurements as actual measurements.*

  2) ***An example of a subsurface measurement with quality level B specified –***

     Telstra cover - **0.9m** (QL-B)

     Where (QL-B) complies with AS5488-2013 QL-B (for example an electronic location that complies with QL-B)

     (Note QL-B means it has not been validated and must not be used for construction purposes around Telstra network, however it would assist further investigation to determine the actual location)

  3) ***An example of a subsurface measurement with the quality level A specified –***

     Telstra cover - **0.6m** (QL-A)

     Where (QL-A) complies with AS5488-2013 QL-A (and is deemed suitable for excavation purposes). *In this example the asset has been electronically located first, (QL-B) and then physically exposed (QL-A).*

     Note -Telstra will seek compensation for damages caused to it its property and losses caused to Telstra and its customers if unvalidated subsurface measurements are used for construction and subsequently result in damage to Telstra assets. Only measurements conforming to AS5488-2013 (QL-A) are deemed by Telstra to be validated measurements.

- **Rural landowners - Rural Locations Subsidy Scheme** Where Telstra-owned cable crosses agricultural land, Telstra may provide on-site assistance with cable location. **You must contact Telstra Plan Services to determine eligibility and to request the service**.

  Please note the following –

  - If eligible, the location assistance must be approved and organised by Telstra. Telstra will not pay for a location that has not been approved and facilitated by Telstra (Telstra is not responsible for payment assistance when a customer engages a locator directly).
  - Telstra will only "subsidise" the location up to $330 (Incl. GST). This will cover one hour on-site location only, private lead-in locations are for lead-ins 100m or longer. Any time required in addition to Telstra-funded time can be purchased directly from the assigned Telstra Accredited Plant Locator.
  - This service does NOT include the use Mechanical Aids or Hydro Excavation (Vac Trucks) to locate and should be discussed between the Accredited Plant Locator and the private rural landowner
  - The exact location, including depth of cables**,** must be validated by potholing, which may not be covered by this service.
  - This service is nominally only available to assist private rural land owners.
  - This service nominally covers one hour on-site only, private lead-in locations are for lead-ins 100m or longer. Any time required in addition to Telstra-funded time can be purchased directly from the assigned Telstra Accredited Plant Locator.
  - This service does not apply to previously located network at the same location (i.e. it is a once off).
  - This service does not apply to other carriers' cables (marked as 'OC' on Telstra plans).

STEP 3 – POTHOLE

Validation as defined in AS5488-2013 (QL-A).

After utilising a Telstra Accredited Plant Locator and prior to commencing construction, any electronically detected underground network must be positively identified (validated) by physically sighting it. This can be done by careful hand digging or using non-destructive water jet methods to expose the network.

Manual potholing needs to be undertaken with extreme care and by employing techniques least likely to damage cables. For example, align shovel blades and trowels parallel to the cable rather than digging across the cable. Some Telstra Accredited Plant Locators are able to provide or assist with non-destructive potholing methods to enable validation of underground cables and ducts.

If you cannot validate the underground network then you must not proceed with construction. Telstra will seek compensation for damages caused to its property and losses caused to Telstra and its customers.

Important note: *The construction of Telstra's network dates back over many years. Some of Telstra's pits and ducts were manufactured from asbestos-containing cement. You must take care in conducting any works in the vicinity of Telstra's pits and ducts. You must refrain from in any way disturbing or damaging Telstra's network infrastructure when conducting your works. We recommend that before you conduct any works in the vicinity of Telstra infrastructure that you ensure your processes and procedures eliminate any possibility of disturbing, damaging or interfering in any way with Telstra's infrastructure. Your processes and procedures should incorporate appropriate measures having regard to the nature of this risk. For further information -*

https://www.telstra.com.au/consumer-advice/digging-construction/relocating-network-assets

STEP 4 – Protect:

You must maintain the following minimum clearance distances between construction activity and the validated position of Telstra plant.

Jackhammers/Pneumatic Breakers	*Not within 1.0m of **actual validated location.***
Vibrating Plate or Wacker Packer Compactor	*Not within 0.5m of **actual validated location** of Telstra ducts.* *300mm compact clearance cover before compactor can be used across Telstra ducts.*
Boring Equipment (in-line, horizontal and vertical)	*Not within 2.0m of **actual validated location**.* *Constructor to hand dig or use non-destructive water jet method (pothole) and expose plant.*
Heavy Vehicle Traffic (over 3 tonnes)	*Not to be driven across Telstra ducts (or plant) with less than 600mm cover.* *Constructor to check actual depth via hand digging.*
Mechanical Excavators, Farm ploughing and Tree Removal	*Not within 1.0m of **actual validated location.*** *Constructor to hand dig or use non-destructive water jet method (pot-hole) and expose plant.*

- For blasting or controlled fire burning please contact Telstra Plan Services.
- If conducting roadworks all existing Telstra pits and manholes must be a minimum of 1.2m in from the back of kerb after the completion of your work.
- After the completion of any ground work in footways or roadway whereby the existing levels are being changed the depth of cover of the existing Telstra asset at the completion of work must not be less than the existing level before work commenced.

Regardless of whether the surface is being raised or lowered, any work impacting the depth of cover of Telstra underground assets should not commence before consultation with Telstra Network Integrity representatives, to discuss the possibility of '*protection*' or relocation (including lowering of the asset)".

- For clearance distances relating to Telstra pillars, cabinets and RIMs/RCMs please contact Telstra Plan Services.

- If Telstra plant is situated wholly or partly where you plan to work (i.e. in conflict, where a pit or manhole would be in a driveway or other vehicle thoroughfare), then Telstra's Network Integrity Group must be contacted to discuss possible engineering solutions to protect Telstra assets.
  Please phone **1800 810 443** or email NetworkIntegrity@team.telstra.com

- You are not permitted to relocate or alter or repair any Telstra assets or network under any circumstances.

  It is a criminal offence under the *Criminal Code Act 1995* (Cth) to tamper or interfere with communication facilities owned by a carrier. Heavy penalties may apply for breach of this prohibition, and any damages suffered, or costs incurred by Telstra as a result of any such unauthorised works may be claimed against you.

  Only Telstra and its contractors may access and conduct works on Telstra's network (including its plant and assets). This requirement is to ensure that Telstra can protect the integrity of its network, avoid disruption to services and ensure that the relocation meets Telstra's requirements.

- If Telstra relocation or protection works are part of the agreed solution, then payment to Telstra for the cost of this work shall be the responsibility of the principal developer, constructor or person for whom the work is performed. The principal developer or constructor will be required to provide Telstra with the details of their proposed work showing how Telstra's plant is to be accommodated and these details must be approved by the Regional Network Integrity Manager prior to the commencement of site works.
  Please phone 1800 810 443 or email NetworkIntegrity@team.telstra.com
  Further information -
  https://www.telstra.com.au/consumer-advice/digging-construction/relocating-network-assets

  Damage to Telstra's network must be reported immediately -
  https://service.telstra.com.au/customer/general/forms/report-damage-to-telstra-equipment

- You will be held responsible for all plant damage that occurs or any impacts to Telstra's network as a result of your construction activities. This includes interfering with plant, conducting unauthorised modification works and interfering with Telstra's assets in a way that prevents Telstra from accessing or using its assets in the future.

- Telstra reserves all rights to recover compensation for loss or damage to its cable network or other property including consequential losses.

FURTHER INFORMATION - CONTACTS

NATURAL DISASTERS

Natural Disasters include (amongst other things) earthquakes, cyclones, floods and tsunamis.
In the case of such events, urgent requests for plans or information relating to the location of Telstra network can be made directly to Telstra Network Integrity Team Managers as follows:

NSW –	John McInerney	0419 485 795
NT/WA/QLD –	Glenn Swift	0419 660 147
SA/VIC/TAS -	David Povazan	0417 300 947

TELSTRA PLAN SERVICES **-** for all Telstra Dial Before You Dig related enquiries

Email - **Telstra.Plans@team.telstra.com**

Phone - 1800 653 935 (general enquiries, business hours only)

Accredited plant locator enquiries -	Glen	(07)34551011
Telstra easements -	Glen	(07)34551011

***Please note** - to make a Telstra plan enquiry the plans must be current (within 60 days of issue). If your plans have expired you will need to submit a new request via DBYD prior to contacting Telstra Plan Services.*

Information for new developments (developers, builders, home owners)
Telstra Smart Communities - https://www.telstra.com.au/smart-community

Asset relocations
Please phone 1800 810 443 or email NetworkIntegrity@team.telstra.com

https://www.telstra.com.au/consumer-advice/digging-construction/relocating-network-assets

Telstra offers free Cable Awareness Presentations, if you believe you or your company would benefit from this offer please contact Network Integrity on 1800 810 443 or NetworkIntegrity@team.telstra.com

PRIVACY NOTE

Your information has been provided to Telstra by DBYD to enable Telstra to respond to your DBYD request. Telstra keeps your information in accordance with its privacy statement entitled "Protecting Your Privacy" which can be obtained from Telstra either by calling 1800 039 059 or visiting our website at www.telstra.com.au/privacy

LEGEND

IT'S HOW WE CONNECT

For more info contact a Telstra Accredited Locater or Telstra Plan Services 1800 653 935

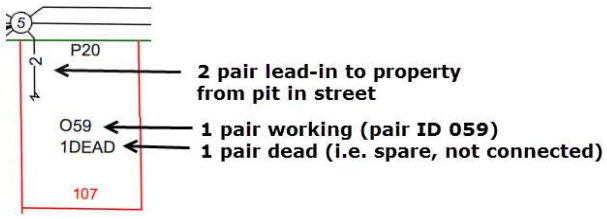
Exchange
(major cable present)

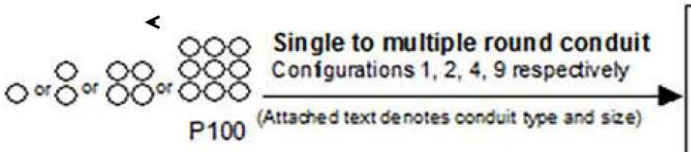
Footway access chamber
(can vary from 1-lid to 12-lid)

or **Pillar/cabinet**
(above the ground / free standing)

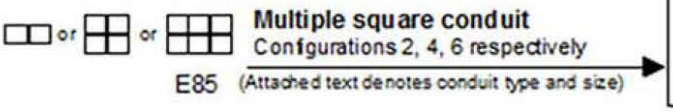
Above ground complex equipment housing (eg RIM)
Please Note: This equipment is powered by 240V electricity.

OC **other carrier**





Single to multiple round conduit
Configurations 1, 2, 4, 9 respectively
(Attached text denotes conduit type and size)



Multiple square conduit
Configurations 2, 4, 6 respectively
(Attached text denotes conduit type and size)

Some examples of conduit type and size:
A - Asbestos cement, P - PVC / plastic, C - Concrete, GI - Galvanised iron, E - Earthenware.
Conduit sizes *nominally* range from 20mm to 100mm.

P50	50mm PVC conduit
P100	100mm PVC conduit
A100	100mm asbestos cement conduit
E 85	85mm square earthenware conduit

Cable jointing pit
(number indicating pit type)

Elevated cable joint
(above ground joint on buried cable)

Telstra Plant in shared utility trench

Aerial Cable
(above ground)

Aerial Cable
(attached to joint use pole e.g. power)

Direct buried cable

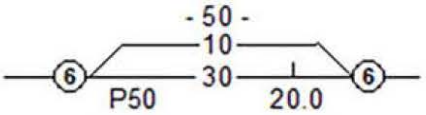
M **Marker post installed**

TR **Buried transponder**

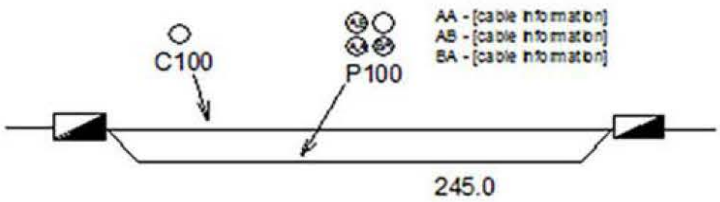
MT **Marker, transponder**

SMOF **Optical fibre cable direct buried**

Some examples of how to read Telstra plans:



One 50mm PVC conduit (P50) containing a 50-pair and a 10-pair cable between two 6-pits, 20.0m apart, with a direct buried 30-pair cable along the same route.



Two separate conduit runs between two footway access chambers (manholes) 245m apart. A nest of four 100mm PVC conduits (P100) containing assorted cables in three ducts (one being empty) and one empty 100mm concrete duct (C100) along the same route.

WARNING: Telstra plans and location information conform to Quality Level 'D' of the Australian Standard AS 5488 - Classification of Subsurface Utility Information. As such, Telstra supplied location information is indicative only. Spatial accuracy is not applicable to Quality Level D. Refer to AS 5488 for further details. Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for any inaccuracy shown on the plans. FURTHER ON SITE INVESTIGATION IS REQUIRED TO VALIDATE THE EXACT LOCATION OF TELSTRA PLANT PRIOR TO COMMENCING CONSTRUCTION WORK. A plant location service is an essential part of the process to validate the exact location of Telstra assets and to ensure the asset is protected during construction works. The exact position of Telstra assets can only be validated by physically exposing it. Telstra will seek compensation for damages caused to its property and losses caused to Telstra and its customers.

Appendix C – Masterplan Drawing – Sitos Urban Design

CONSTRAINTS MAPPING &
DRAFT STRUCTURE PLAN

DRAFT

CONSTRAINTS MAPPING &
DRAFT STRUCTURE PLAN
TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020
2	Structure Plan	15/04/2020

FOR

O'GRADY

BY

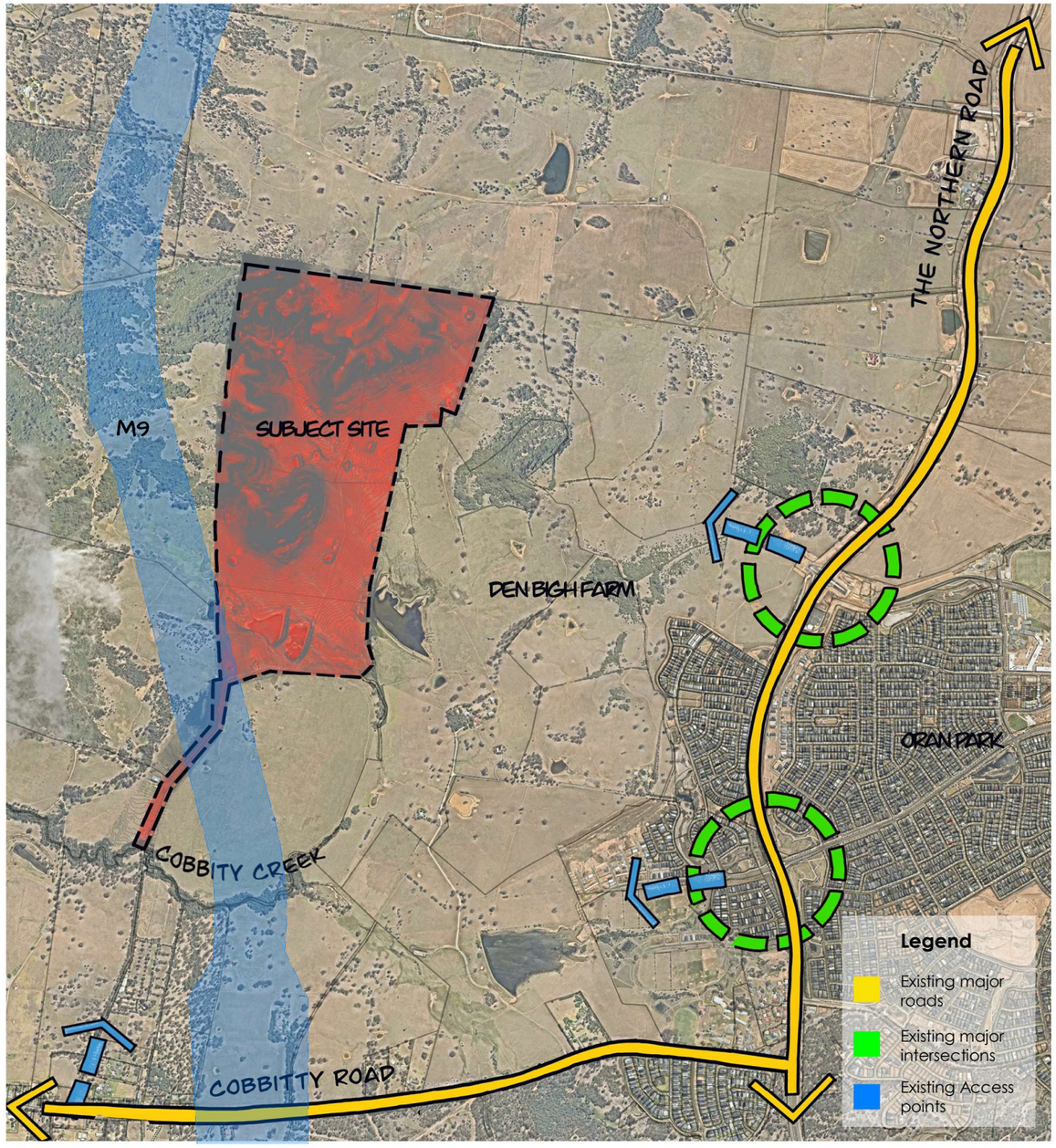
SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS
scale @ A3

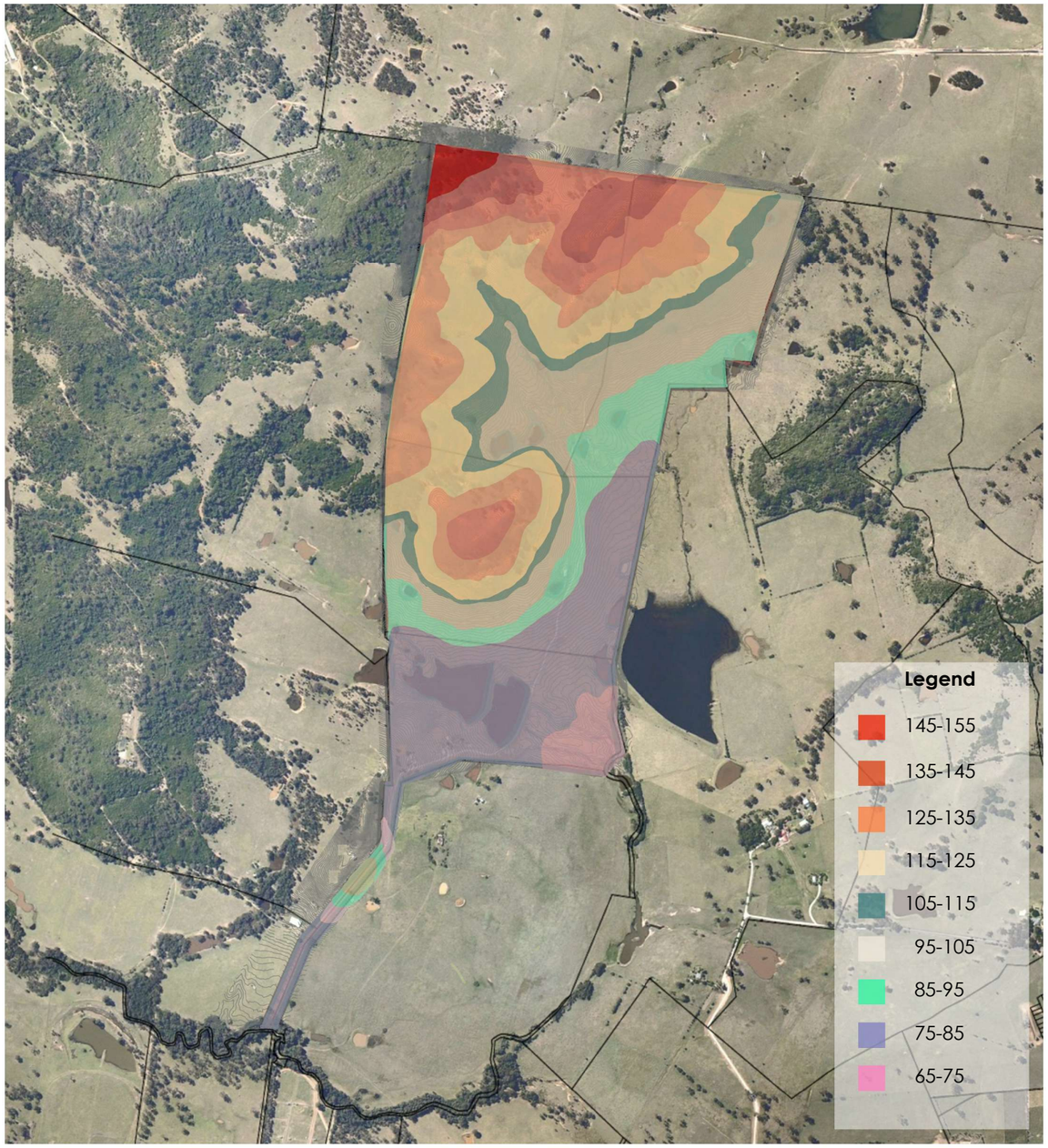
COVER PAGE

drawing number
00

revision
2

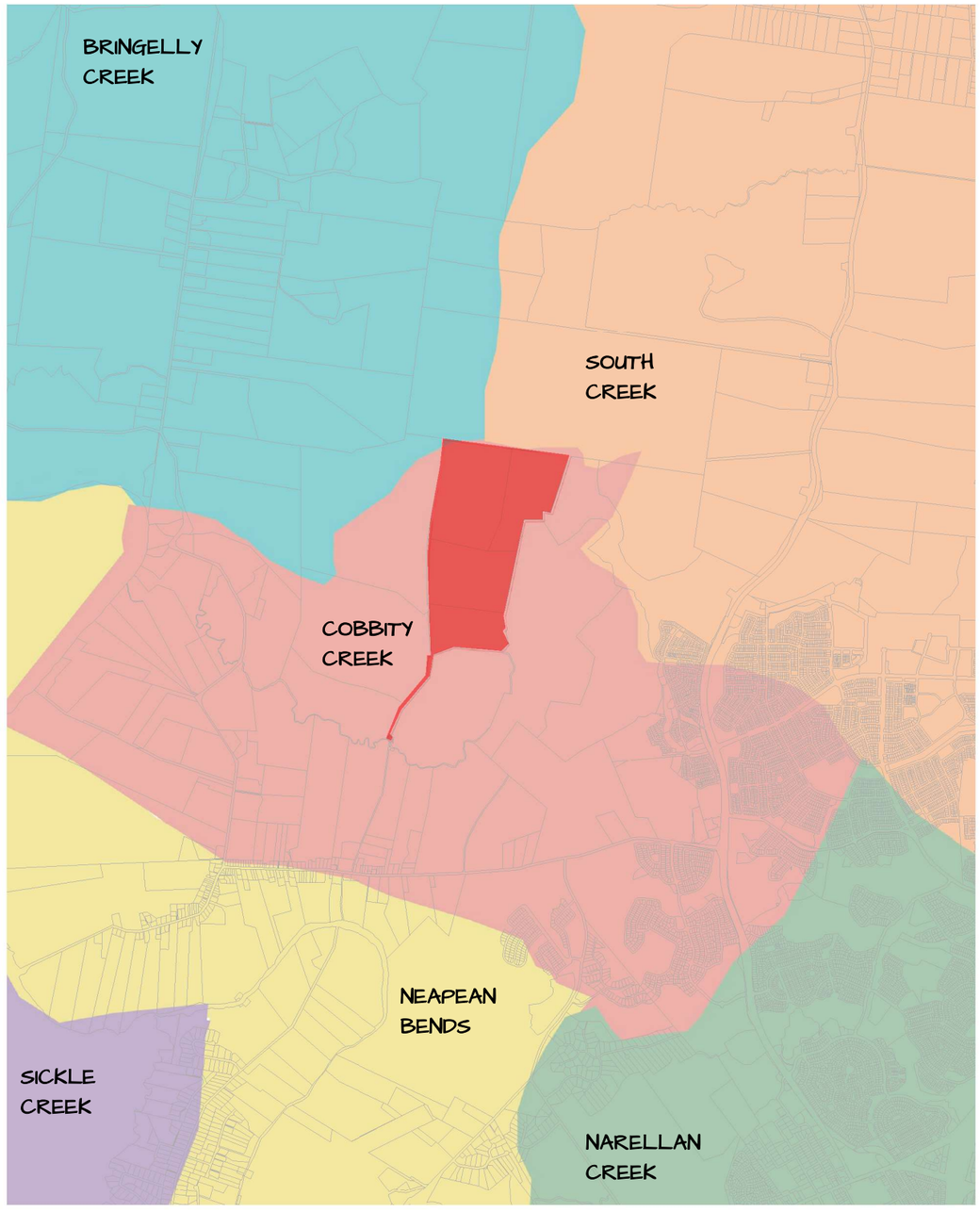


SITE LOCATION
AREA: 58.8 (ha)

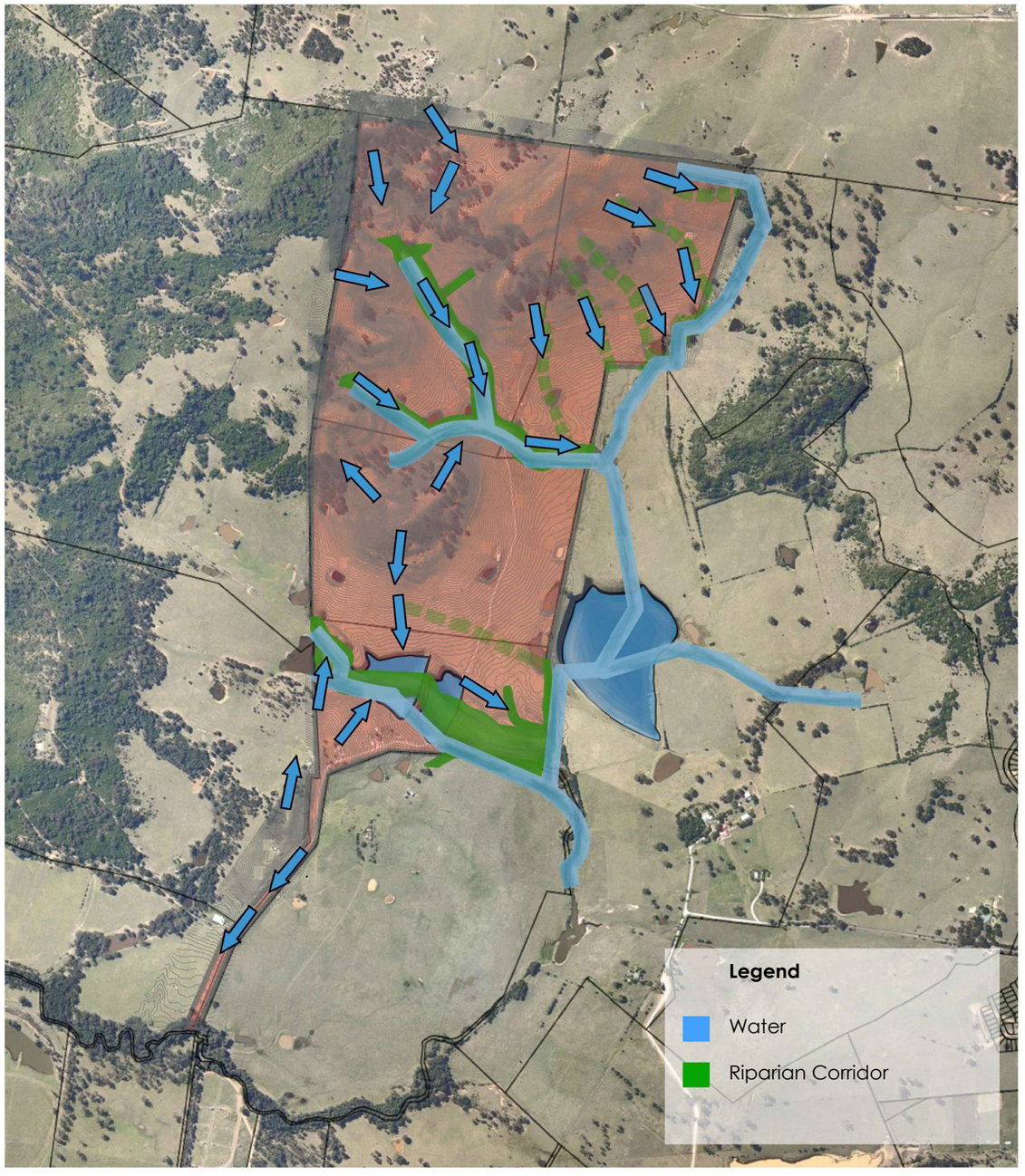


TOPOGRAPHY

CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA	**REV.**	**DESCRIPTION**	**DATE**	**FOR**	**BY**		date 16/06/2020 drawn JS scale 1 : 25000 @ A3 0 200 400 600 1000	CONSTRAINTS drawing number **01**	revision **1**
	1	Constraint mapping phase 1	03/19/2020	O'GRADY	SITIOS [URBAN DESIGN]				



SWPGA CATCHMENTS



RIPARIAN CORRIDORS AND OVERLAND FLOW PATH

CONSTRAINTS MAPPING &
DRAFT STRUCTURE PLAN
TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020
2	Structure Plan	15/04/2020

FOR O'GRADY

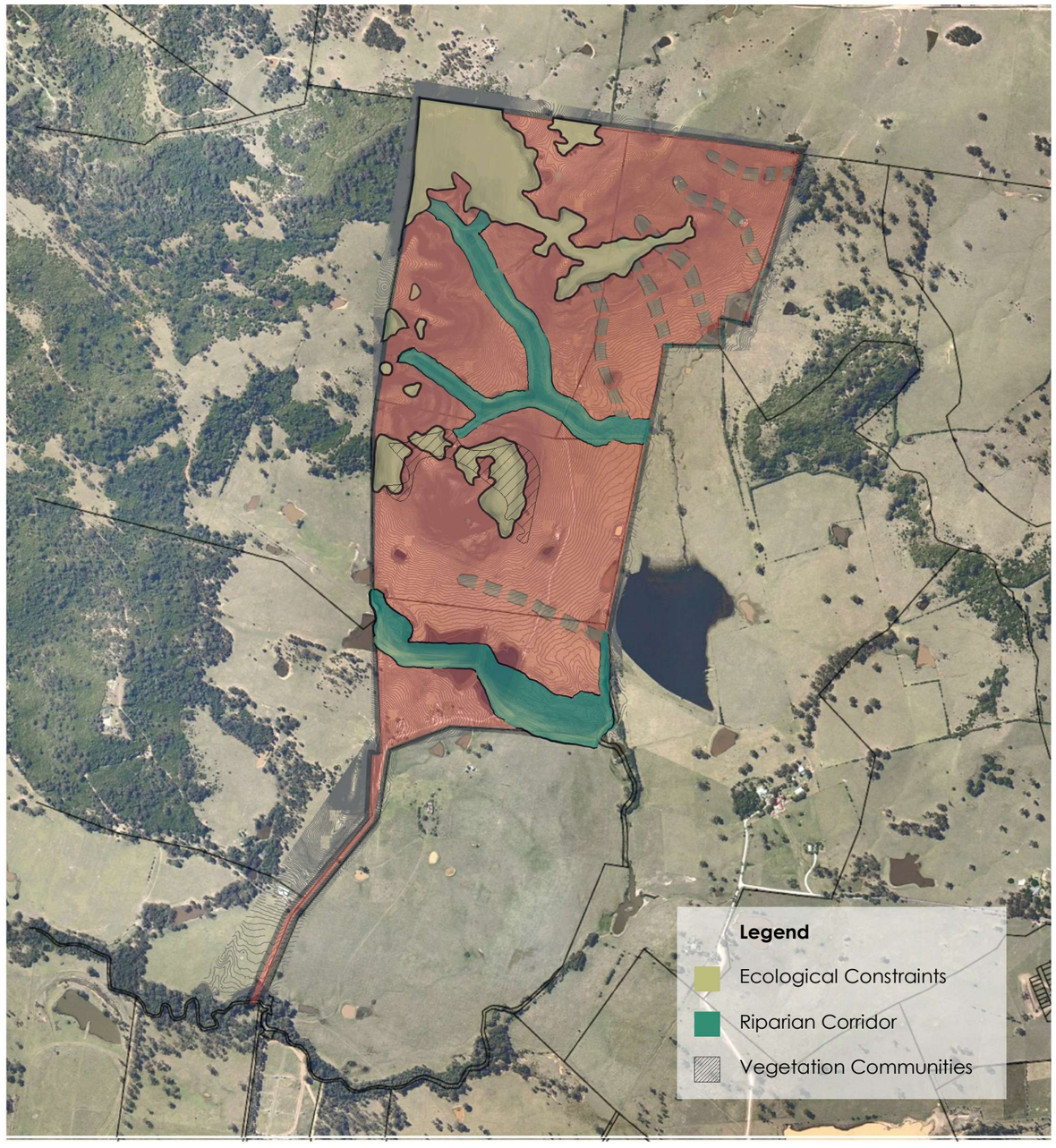
BY SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS
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CONSTRAINTS

drawing number **02**

revision **2**



VEGETATION & ECOLOGICAL

CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR O'GRADY

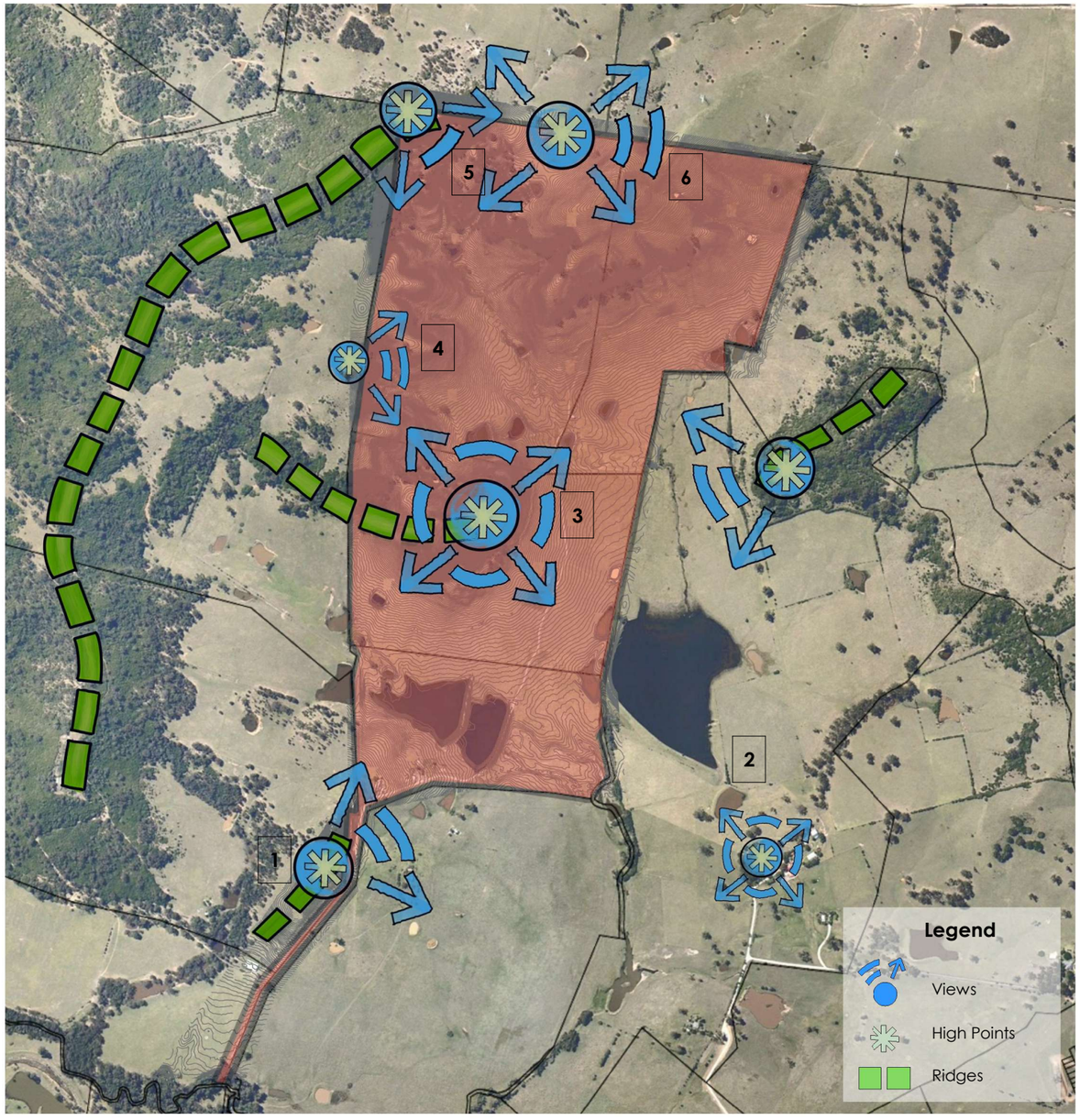
BY SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS
scale As indicated @ A3
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1:200

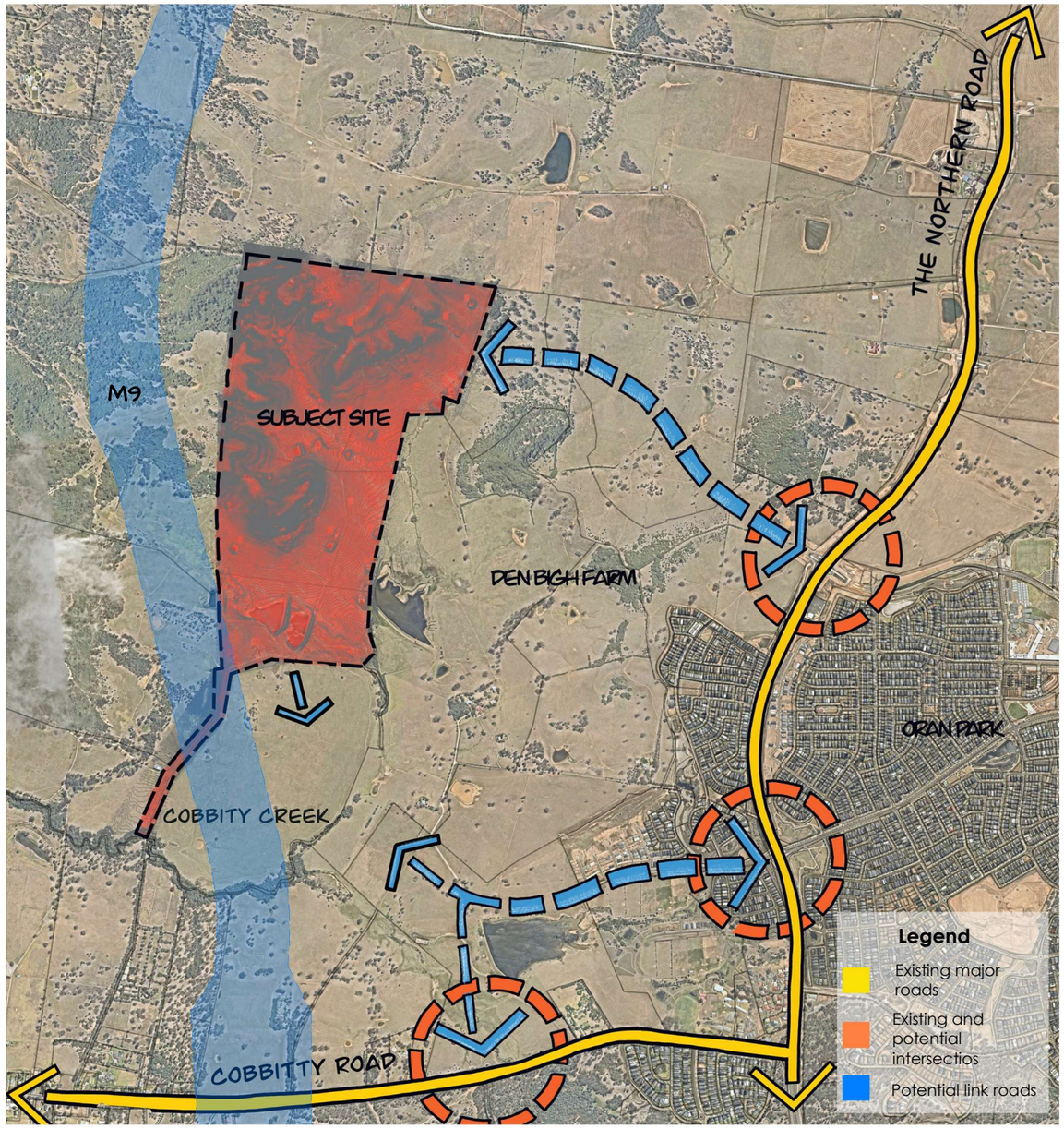
CONSTRAINTS

drawing number **02a**

revision **1**



VIEWS/HIGH POINTS/ RIDGES



ACCESS

CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR O'GRADY

BY SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS
scale As indicated @ A3
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CONSTRAINTS

drawing number **03**

revision **1**

1



2



2



3



4



5



6



CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN
TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR
O'GRADY

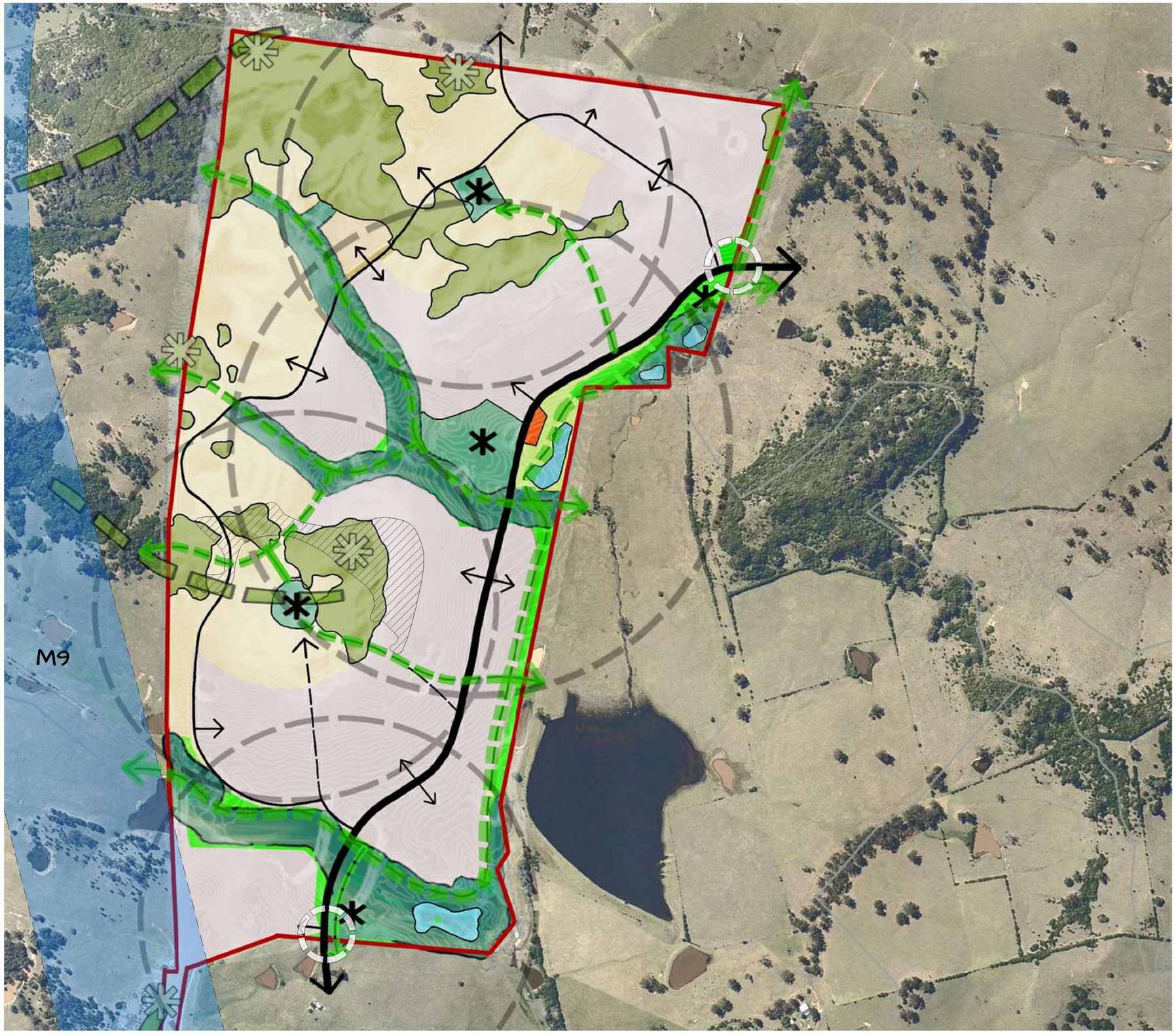
BY
SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS

PHOTOS

drawing number
04

revision
1



Legend

- Site Area
- M9
- Access Point
- Collector Road
- Local Streets
- Potential pedestrian and cycle connections
- Riparian Corridor
- Ecological Constraints
- Vegetation Communities
- Indicative Water Bodies
- Low Density Residential
- Larger Lot Residential
- Village Hub
- Active Open Space
- Linear Park
- Local Park
- 400 m Walkability Radius
- Open Space Nodes
- High Points
- Ridges

CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
2	Structure Plan	15/04/2020

FOR O'GRADY

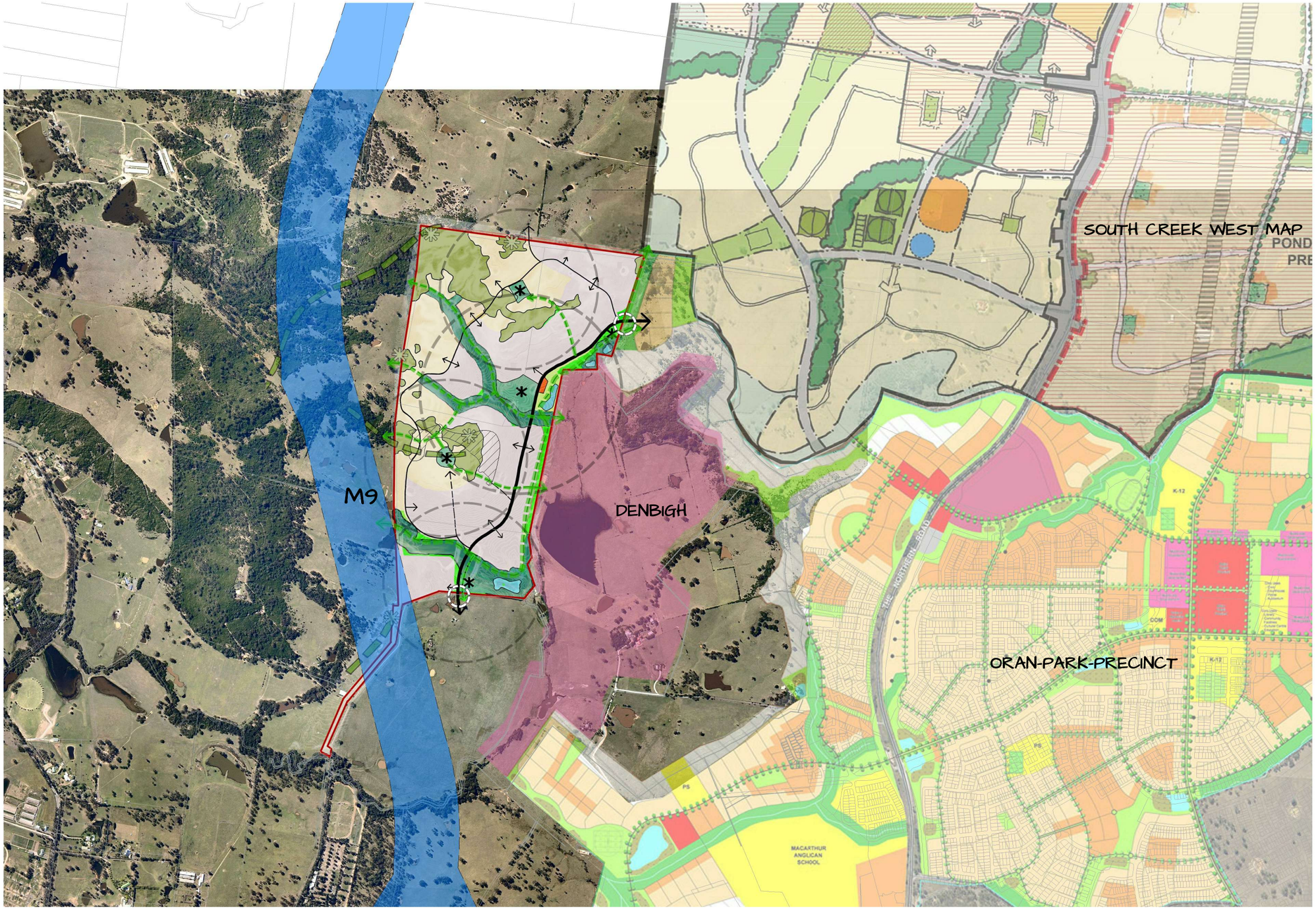
BY SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS

STRUCTURE PLAN

drawing number **05**

revision **2**



CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
2	Structure Plan	15/04/2020

FOR O'GRADY

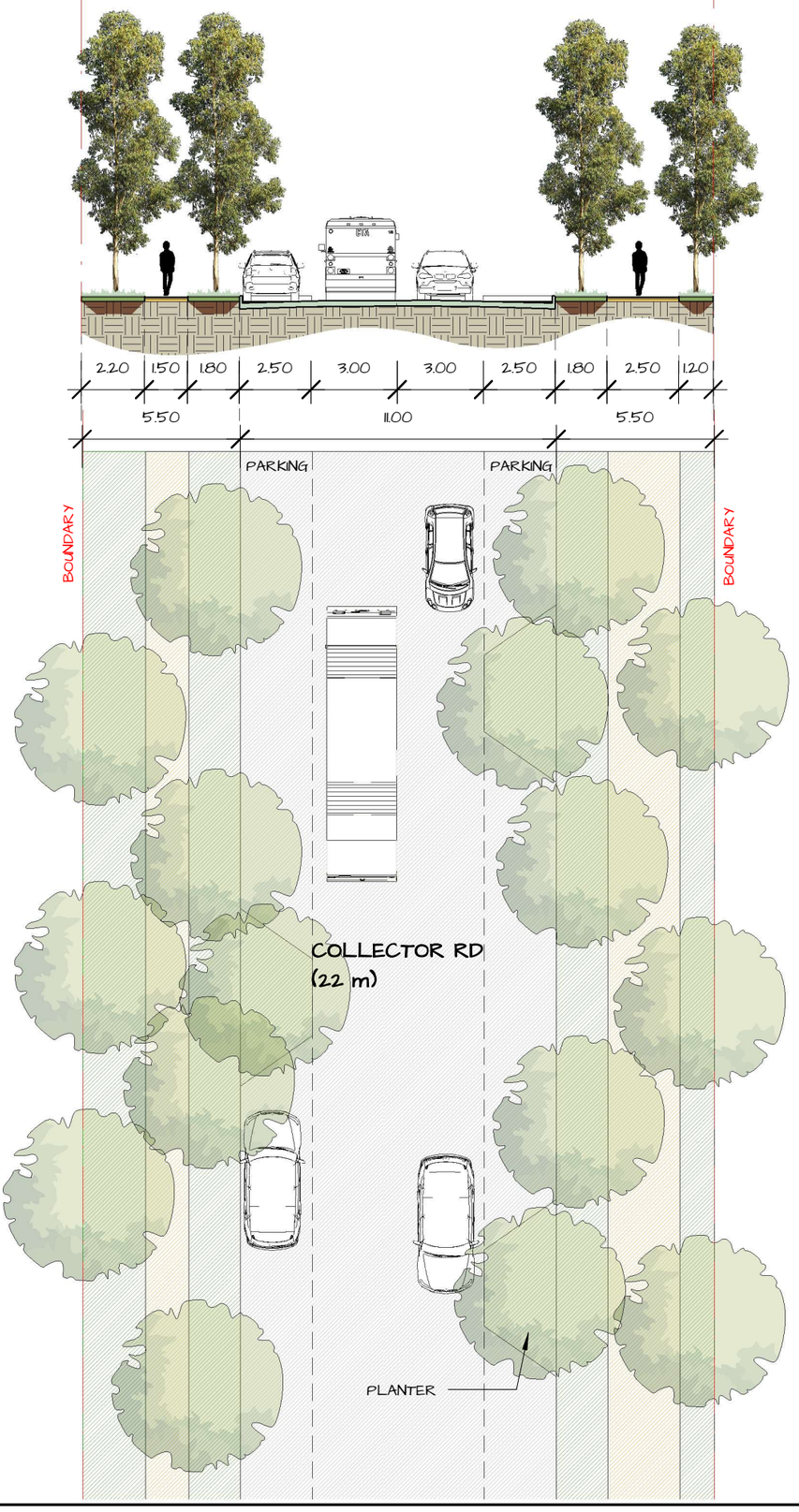
BY SITIOS [URBAN DESIGN]

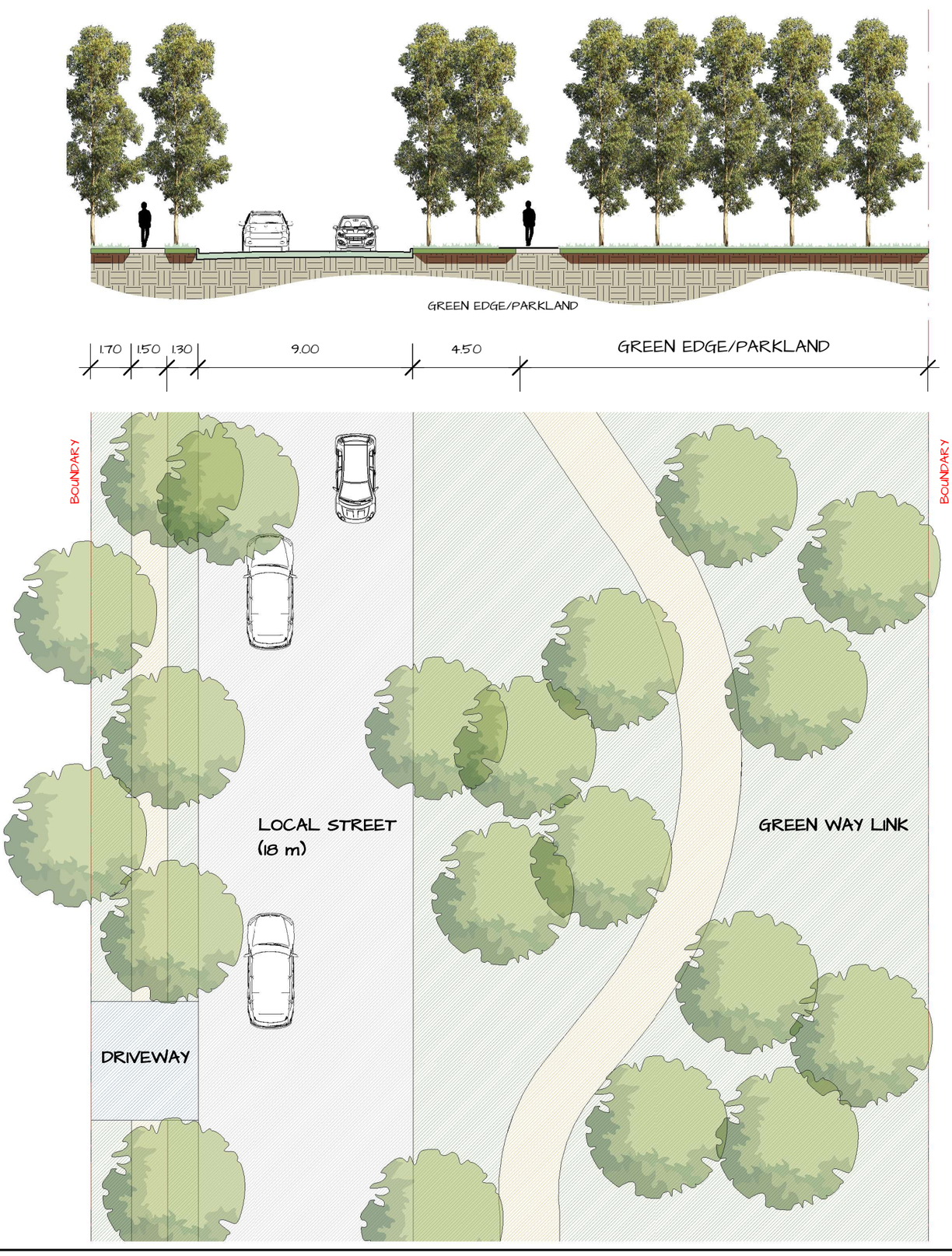
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STRUCTURE PLAN CONTEXT

drawing number **06**

revision **2**





CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN
TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR O'GRADY

BY SITIOS [URBAN DESIGN]

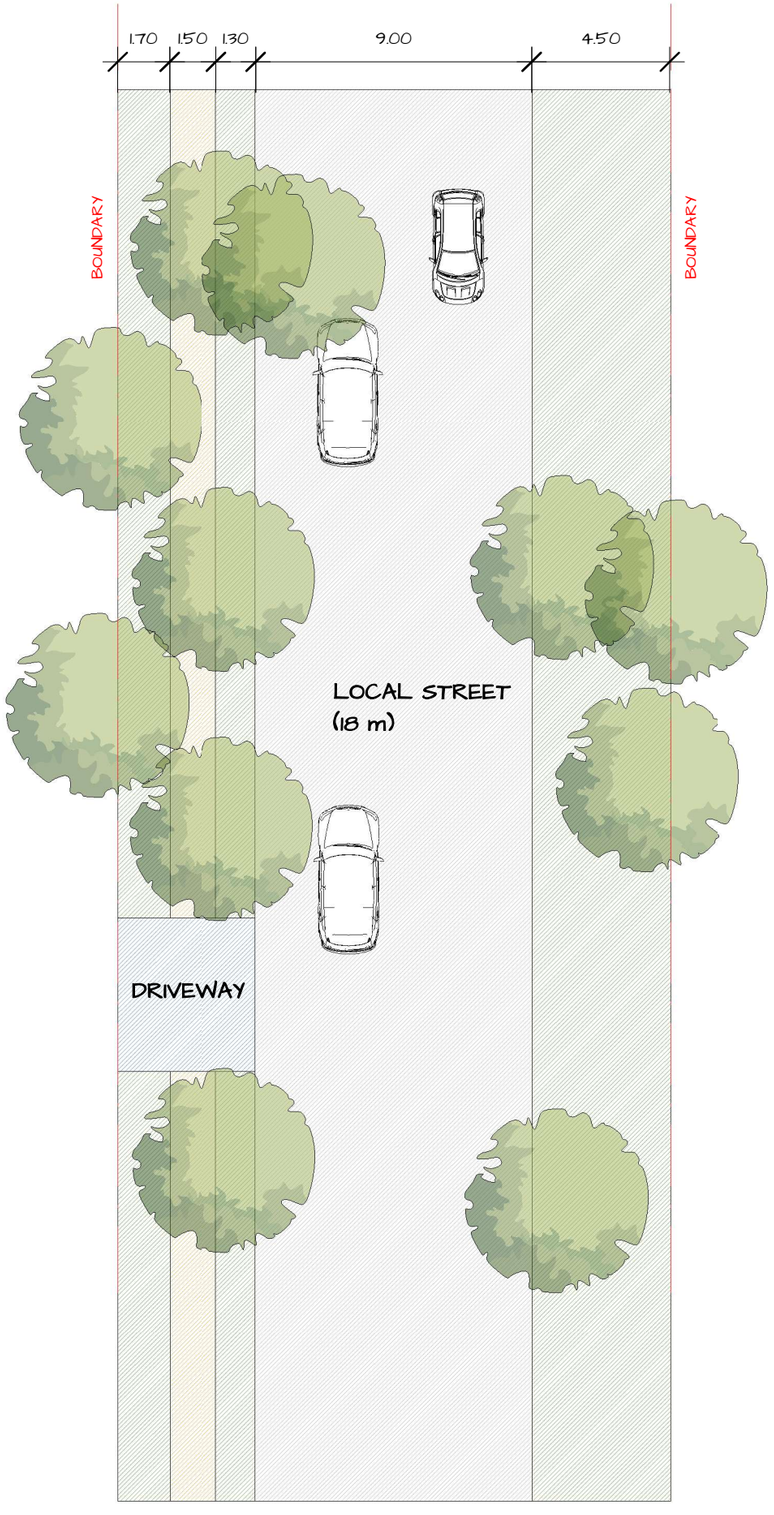
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STREET TYPOLOGIES

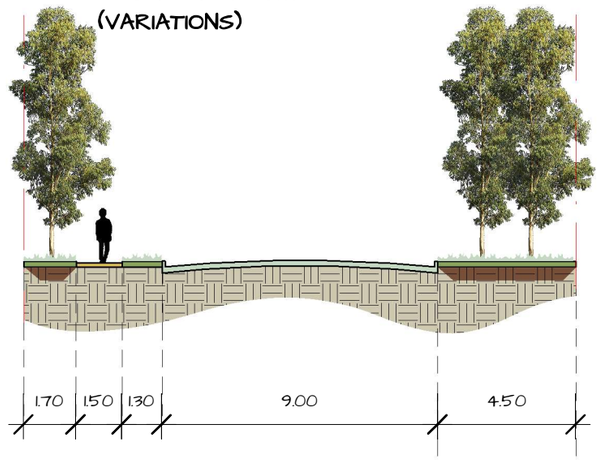
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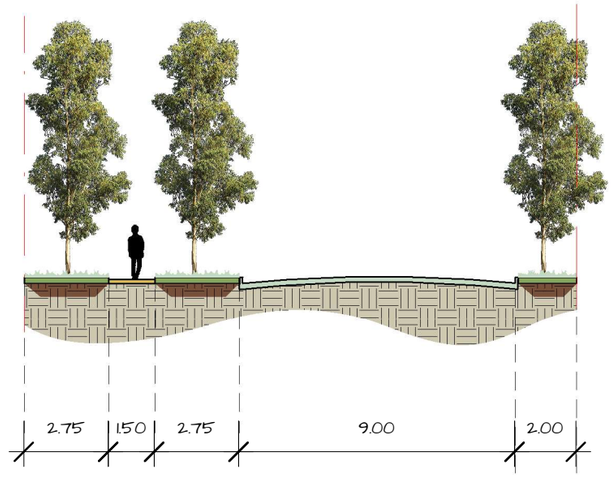
revision **1**

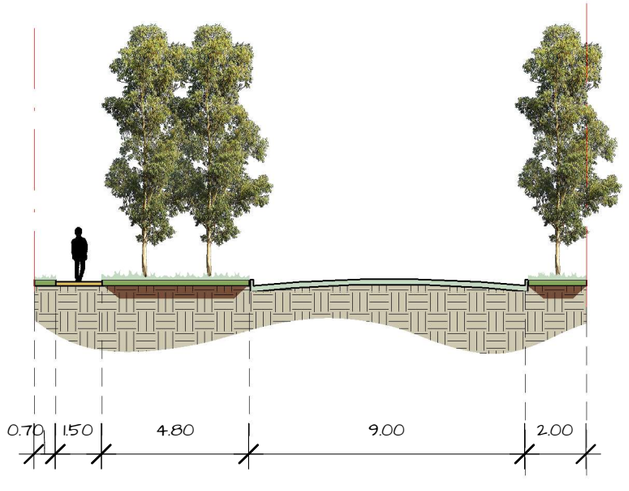




LOCAL ROAD 18m (VARIATIONS)







CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR O'GRADY

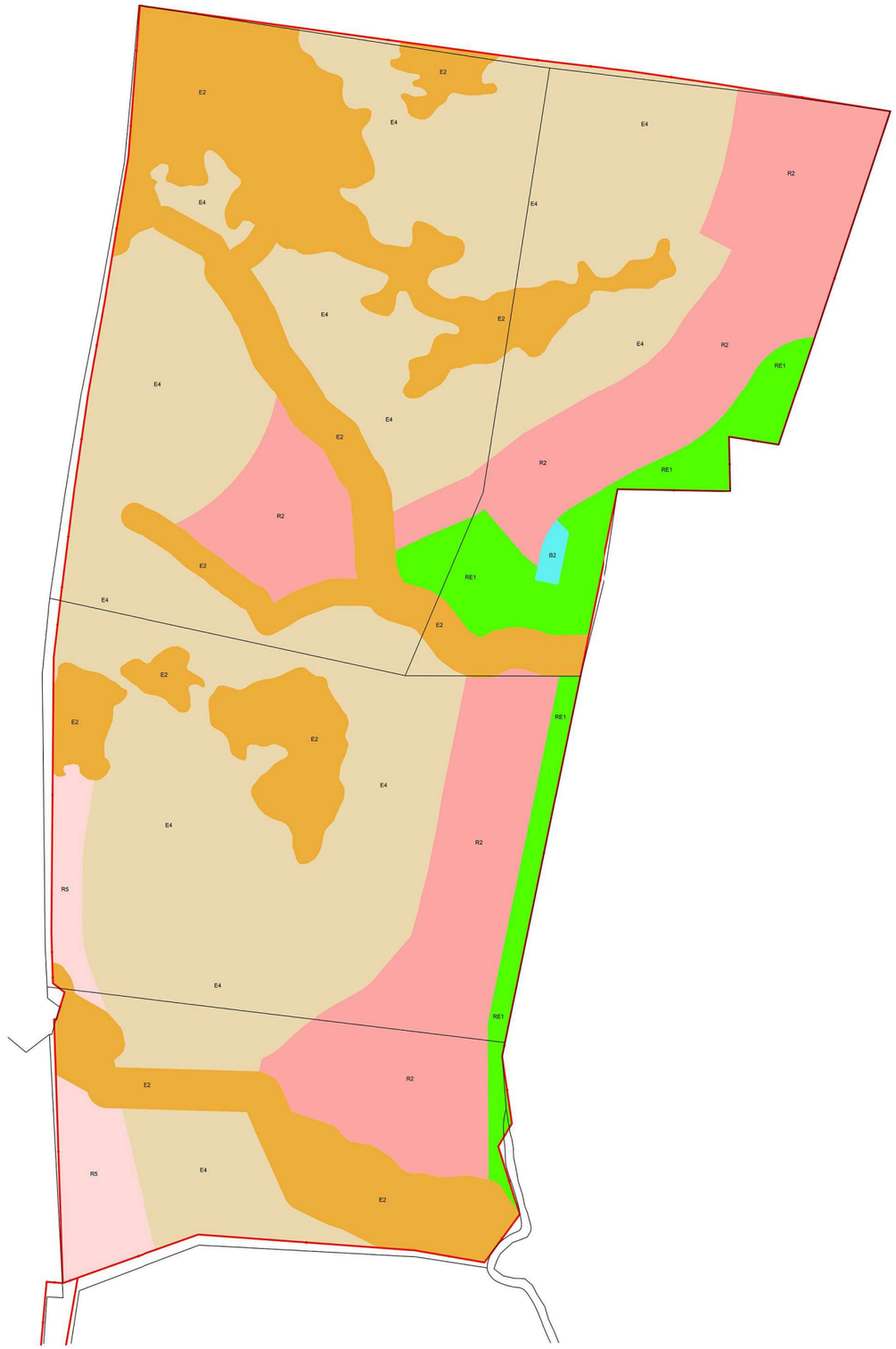
BY SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS
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0 2 4 6 8m
1:200

STREET TYPOLOGIES

drawing number **08**

revision **1**



Legend

- B2 Local Centre
- E2 Environmental Consevation
- E4 Environmental Living
- R2 Low Density Residential
- R5 Large Lot Residential
- RE1 Public Recreation

CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR O'GRADY

BY SITIOS [URBAN DESIGN]

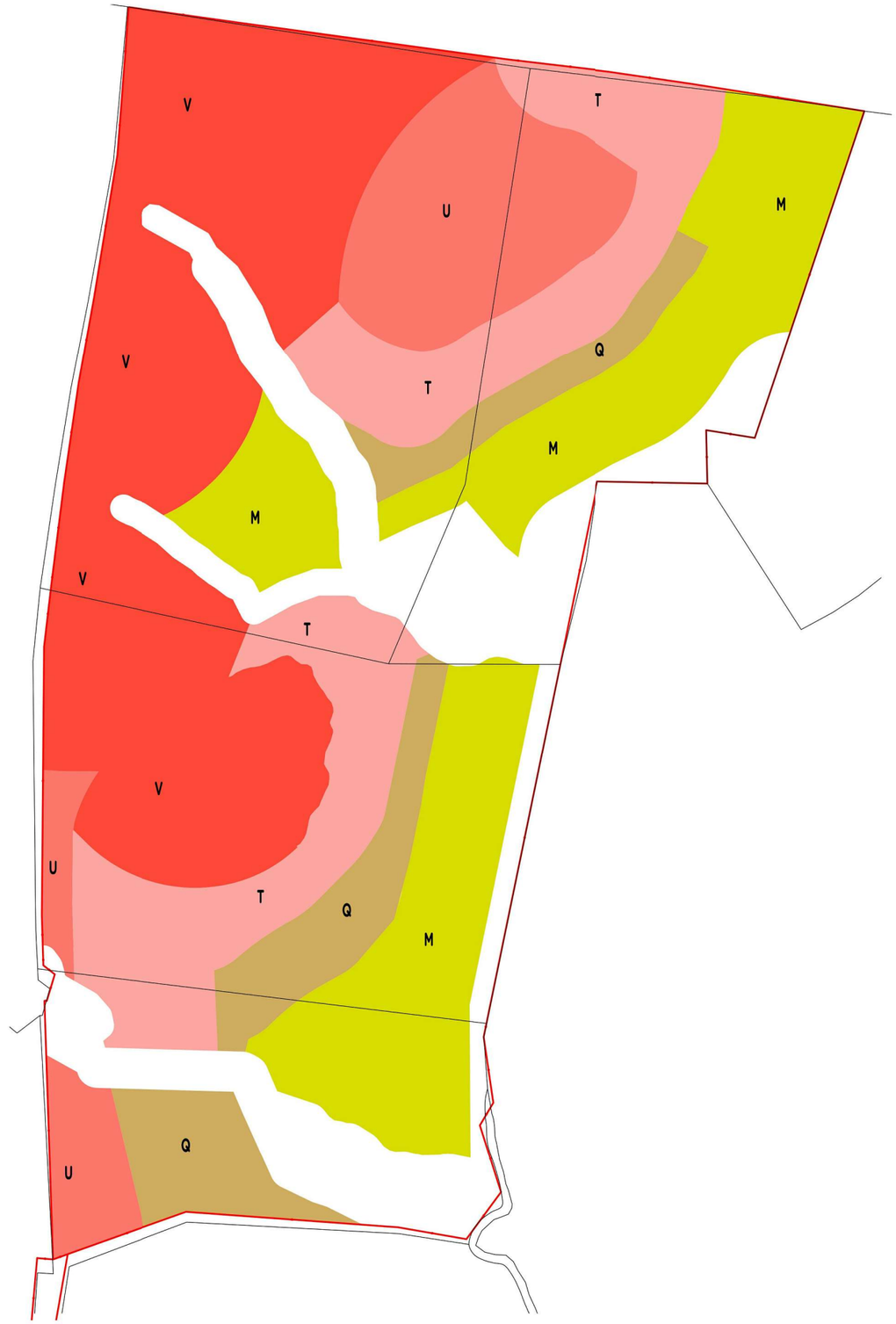
date 16/06/2020
drawn JS
scale 1 : 25000 @ A3

0 100 200 400 800

ZONING PLAN

drawing number **09**

revision **1**



Legend

M	600
Q	700
T	900
U	1500
V	2000

CONSTRAINTS MAPPING & DRAFT STRUCTURE PLAN TIDAPA

REV.	DESCRIPTION	DATE
1	Constraint mapping phase 1	03/19/2020

FOR O'GRADY

BY SITIOS [URBAN DESIGN]

date 16/06/2020
drawn JS
scale 1 : 25000 @ A3

0 100 200 400 800

LOT SIZE PLAN

drawing number **10**

revision **1**

Appendix E – Nepean Flood Study Plan

APPENDIX A

SUMMARY OF FLOOD FREQUENCY ANALYSIS

CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

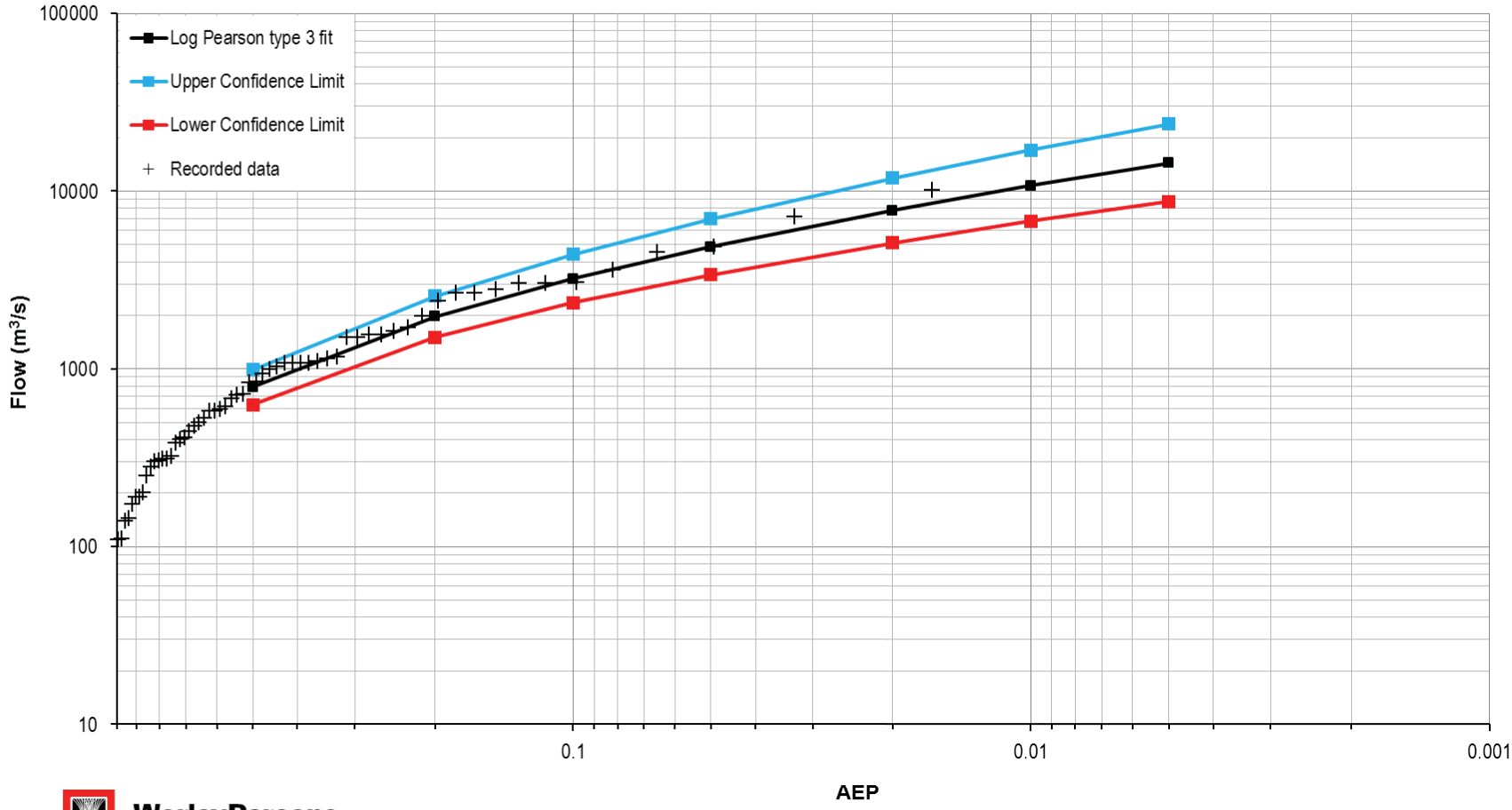
PARTIAL SERIES FLOOD FREQUENCY ANALYSIS FOR CAMDEN – INCLUDING HIGHEST THREE VALUES

Average Flow	Sum of $\{(\log Q - avg(\log Q))^2\}$	Variance
121699	12.71	0.2154
Average(Log(Q))	Sum of $\{(\log Q - avg(\log Q))^3\}$	Standard Deviation
4.84	0.74	0.4642
Number of Records		Skew Coefficient
60		0.1302
Number of Years		
139		

Rank	Date	Flow	Flow	Log(Q)	$\{(\log Q - avg(\log Q))^2\}$	$\{(\log Q - avg(\log Q))^3$	Return Period	Exceedence Probability	Plotting Position	Adjusted Plotting Position
		[ML/day]	[m^3/s]				[years]	[%]		
1	25/2/1873	869184	10060	5.9391	1.2008	1.3159	61	1.64%	0.0043	0.0100
2	14/2/1898	619488	7170	5.7920	0.9001	0.8540	31	3.28%	0.0115	0.0266
3	18/10/1860	419904	4860	5.6232	0.6082	0.4743	20	4.92%	0.0187	0.0433
4	12/06/1964	389664	4510	5.5907	0.5586	0.4175	15	6.56%	0.0259	0.0599
5	20/03/1978	309312	3580	5.4904	0.4188	0.2710	12	8.20%	0.0330	0.0766
6	30/04/1988	263520	3050	5.4208	0.3335	0.1926	10	9.84%	0.0402	0.0932
7	5/04/1972	261792	3030	5.4180	0.3303	0.1898	9	11.48%	0.0474	0.1098
8	21/06/1975	261792	3030	5.4180	0.3303	0.1898	8	13.11%	0.0546	0.1265
9	18/06/1949	240192	2780	5.3806	0.2887	0.1551	7	14.75%	0.0618	0.1431
10	5/06/1950	229824	2660	5.3614	0.2684	0.1391	6	16.39%	0.0690	0.1598
11	11/02/1956	229824	2660	5.3614	0.2684	0.1391	6	18.03%	0.0761	0.1764
12	19/02/1956	208224	2410	5.3185	0.2259	0.1073	5	19.67%	0.0833	0.1931
13	27/07/1952	170208	1970	5.2310	0.1503	0.0583	5	21.31%	0.0905	0.2097
14	14/11/1969	147744	1710	5.1695	0.1064	0.0347	4	22.95%	0.0977	0.2263
15	30/08/1963	139968	1620	5.1460	0.0917	0.0277	4	24.59%	0.1049	0.2430
16	7/04/1950	134784	1560	5.1296	0.0820	0.0235	4	26.23%	0.1121	0.2596
17	28/08/1974	134784	1560	5.1296	0.0820	0.0235	4	27.87%	0.1193	0.2763
18	2/08/1990	129740	1502	5.1131	0.0728	0.0196	3	29.51%	0.1264	0.2929
19	29/04/1963	129600	1500	5.1126	0.0725	0.0195	3	31.15%	0.1336	0.3096
20	11/06/1991	100436	1162	5.0019	0.0252	0.0040	3	32.79%	0.1408	0.3262
21	18/08/1998	98678	1142	4.9942	0.0228	0.0034	3	34.43%	0.1480	0.3428
22	4/03/1977	95040	1100	4.9779	0.0181	0.0024	3	36.07%	0.1552	0.3595
23	7/08/1967	93312	1080	4.9699	0.0160	0.0020	3	37.70%	0.1624	0.3761
24	27/05/1974	93312	1080	4.9699	0.0160	0.0020	3	39.34%	0.1695	0.3928
25	2/06/1978	93312	1080	4.9699	0.0160	0.0020	2	40.98%	0.1767	0.4094
26	6/08/1986	93312	1080	4.9699	0.0160	0.0020	2	42.62%	0.1839	0.4261
27	25/10/1987	88992	1030	4.9494	0.0113	0.0012	2	44.26%	0.1911	0.4427
28	10/02/1992	85736	992	4.9332	0.0081	0.0007	2	45.90%	0.1983	0.4593
29	12/03/1974	81216	940	4.9096	0.0044	0.0003	2	47.54%	0.2055	0.4760
30	5/03/1976	72576	840	4.8608	0.0003	0.0000	2	49.18%	0.2126	0.4926
31	6/07/1986	71712	830	4.8556	0.0002	0.0000	2	50.82%	0.2198	0.5093
32	14/06/1962	62208	720	4.7938	0.0024	-0.0001	2	52.46%	0.2270	0.5259
33	4/02/1990	61470	711	4.7887	0.0030	-0.0002	2	54.10%	0.2342	0.5426
34	5/06/1963	58752	680	4.7690	0.0055	-0.0004	2	55.74%	0.2414	0.5592
35	20/03/1963	52704	610	4.7218	0.0147	-0.0018	2	57.38%	0.2486	0.5758
36	4/07/1975	50976	590	4.7074	0.0185	-0.0025	2	59.02%	0.2557	0.5925
37	16/04/1969	50112	580	4.6999	0.0205	-0.0029	2	60.66%	0.2629	0.6091
38	11/03/1975	50112	580	4.6999	0.0205	-0.0029	2	62.30%	0.2701	0.6258
39	24/10/1999	45367	525	4.6567	0.0348	-0.0065	2	63.93%	0.2773	0.6424
40	9/11/1966	43200	500	4.6355	0.0432	-0.0090	2	65.57%	0.2845	0.6591
41	16/06/2007	40966	474	4.6124	0.0533	-0.0123	1	67.21%	0.2917	0.6757
42	19/04/1990	38459	445	4.5850	0.0667	-0.0172	1	68.85%	0.2989	0.6923
43	7/09/1967	35424	410	4.5493	0.0864	-0.0254	1	70.49%	0.3060	0.7090
44	8/11/1984	34560	400	4.5386	0.0928	-0.0283	1	72.13%	0.3132	0.7256
45	9/04/1978	32832	380	4.5163	0.1069	-0.0350	1	73.77%	0.3204	0.7423
46	23/04/1964	27648	320	4.4417	0.1613	-0.0648	1	75.41%	0.3276	0.7589
47	13/12/1963	26784	310	4.4279	0.1726	-0.0717	1	77.05%	0.3348	0.7756
48	13/01/1974	26784	310	4.4279	0.1726	-0.0717	1	78.69%	0.3420	0.7922
49	25/09/1995	26378	305	4.4212	0.1781	-0.0752	1	80.33%	0.3491	0.8088
50	18/05/1995	26031	301	4.4155	0.1830	-0.0783	1	81.97%	0.3563	0.8255
51	8/03/2012	24136	279	4.3827	0.2122	-0.0977	1	83.61%	0.3635	0.8421
52	31/08/1996	21514	249	4.3327	0.2607	-0.1331	1	85.25%	0.3707	0.8588
53	15/01/1972	17280	200	4.2375	0.3669	-0.2223	1	86.89%	0.3779	0.8754
54	24/01/1976	16416	190	4.2153	0.3944	-0.2477	1	88.52%	0.3851	0.8920
55	17/10/1976	16416	190	4.2153	0.3944	-0.2477	1	90.16%	0.3922	0.9087
56	25/05/1990	14958	173	4.1749	0.4468	-0.2986	1	91.80%	0.3994	0.9253
57	11/02/2012	12396	143	4.0933	0.5625	-0.4219	1	93.44%	0.4066	0.9420
58	19/04/2012	11947	138	4.0773	0.5868	-0.4495	1	95.08%	0.4138	0.9586
59	22/03/2011	9505	110	3.9780	0.7488	-0.6479	1	96.72%	0.4210	0.9753
60	14/12/1991	9409	109	3.9736	0.7564	-0.6579	1	98.36%	0.4282	0.9919

Required ARI				
ARI	k	log Q	Q	Q
			[ML/day]	[m^3/s]
2	-0.0218	4.8331	68100	788
5	0.8342	5.2305	170009	1968
10	1.2947	5.4442	278116	3219
20	1.6811	5.6236	420329	4865
50	2.1227	5.8285	673802	7799
100	2.4217	5.9673	927532	10735
200	2.6980	6.0956	1246208	14424

FIGURE A.1



Flood Frequency Analysis
Nepean River at Camden Weir

CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

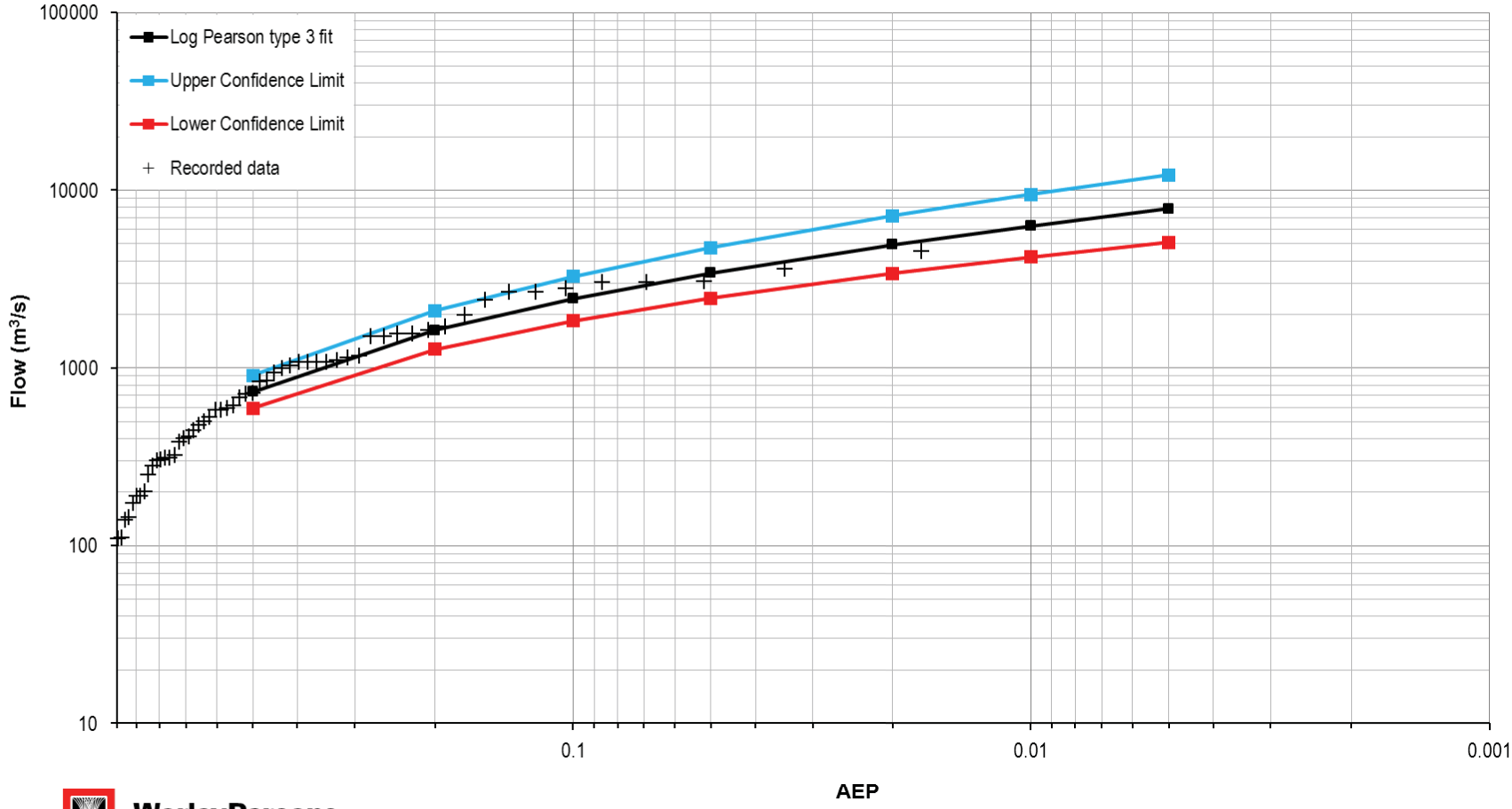
PARTIAL SERIES FLOOD FREQUENCY ANALYSIS FOR CAMDEN – EXCLUDING HIGHEST THREE VALUES

Average Flow	Sum of $\{(\log Q - \text{avg}(\log Q))^2\}$	Variance
94620	9.86	0.1761
Average(Log(Q))	**Sum of $\{(\log Q - \text{avg}(\log Q))^3\}$**	**Standard Deviation**
4.79	-0.43	0.4196
Number of Records		**Skew Coefficient**
57		-0.1074
Number of Years		
63		

Rank	Date	Flow	Flow	Log(Q)	$\{(\log Q - \text{avg}(\log Q))^2\}$	$\{(\log Q - \text{avg}(\log Q))^3$	Return Period	Exceedence Probability	Plotting Position	Adjusted Plotting Position
		[ML/day]	[m^3/s]				[years]	[%]		
1	12/06/1964	389664	4510	5.5907	0.6351	0.5062	58	1.72%	0.0095	0.0105
2	20/03/1978	309312	3580	5.4904	0.4853	0.3381	29	3.45%	0.0253	0.0280
3	30/04/1988	263520	3050	5.4208	0.3932	0.2466	19	5.17%	0.0411	0.0455
4	5/04/1972	261792	3030	5.4180	0.3897	0.2432	15	6.90%	0.0570	0.0630
5	21/06/1975	261792	3030	5.4180	0.3897	0.2432	12	8.62%	0.0728	0.0804
6	18/06/1949	240192	2780	5.3806	0.3444	0.2021	10	10.34%	0.0886	0.0979
7	5/06/1950	229824	2660	5.3614	0.3222	0.1829	8	12.07%	0.1044	0.1154
8	11/02/1956	229824	2660	5.3614	0.3222	0.1829	7	13.79%	0.1203	0.1329
9	19/02/1956	208224	2410	5.3185	0.2754	0.1445	6	15.52%	0.1361	0.1504
10	27/07/1952	170208	1970	5.2310	0.1912	0.0836	6	17.24%	0.1519	0.1679
11	14/11/1969	147744	1710	5.1695	0.1412	0.0531	5	18.97%	0.1677	0.1854
12	30/08/1963	139968	1620	5.1460	0.1241	0.0437	5	20.69%	0.1835	0.2029
13	7/04/1950	134784	1560	5.1296	0.1128	0.0379	4	22.41%	0.1994	0.2204
14	28/08/1974	134784	1560	5.1296	0.1128	0.0379	4	24.14%	0.2152	0.2378
15	2/08/1990	129740	1502	5.1131	0.1020	0.0326	4	25.86%	0.2310	0.2553
16	29/04/1963	129600	1500	5.1126	0.1017	0.0324	4	27.59%	0.2468	0.2728
17	11/06/1991	100436	1162	5.0019	0.0433	0.0090	3	29.31%	0.2627	0.2903
18	18/08/1998	98678	1142	4.9942	0.0402	0.0081	3	31.03%	0.2785	0.3078
19	4/03/1977	95040	1100	4.9779	0.0339	0.0062	3	32.76%	0.2943	0.3253
20	7/08/1967	93312	1080	4.9699	0.0311	0.0055	3	34.48%	0.3101	0.3428
21	27/05/1974	93312	1080	4.9699	0.0311	0.0055	3	36.21%	0.3259	0.3603
22	2/06/1978	93312	1080	4.9699	0.0311	0.0055	3	37.93%	0.3418	0.3777
23	6/08/1986	93312	1080	4.9699	0.0311	0.0055	3	39.66%	0.3576	0.3952
24	25/10/1987	88992	1030	4.9494	0.0242	0.0038	2	41.38%	0.3734	0.4127
25	10/02/1992	85736	992	4.9332	0.0194	0.0027	2	43.10%	0.3892	0.4302
26	12/03/1974	81216	940	4.9096	0.0134	0.0016	2	44.83%	0.4051	0.4477
27	5/03/1976	72576	840	4.8608	0.0045	0.0003	2	46.55%	0.4209	0.4652
28	6/07/1986	71712	830	4.8556	0.0038	0.0002	2	48.28%	0.4367	0.4827
29	14/06/1962	62208	720	4.7938	0.0000	0.0000	2	50.00%	0.4525	0.5002
30	4/02/1990	61470	711	4.7887	0.0000	0.0000	2	51.72%	0.4684	0.5177
31	5/06/1963	58752	680	4.7690	0.0006	0.0000	2	53.45%	0.4842	0.5351
32	20/03/1963	52704	610	4.7218	0.0052	-0.0004	2	55.17%	0.5000	0.5526
33	4/07/1975	50976	590	4.7074	0.0075	-0.0006	2	56.90%	0.5158	0.5701
34	16/04/1969	50112	580	4.6999	0.0088	-0.0008	2	58.62%	0.5316	0.5876
35	11/03/1975	50112	580	4.6999	0.0088	-0.0008	2	60.34%	0.5475	0.6051
36	24/10/1999	45367	525	4.6567	0.0188	-0.0026	2	62.07%	0.5633	0.6226
37	9/11/1966	43200	500	4.6355	0.0250	-0.0040	2	63.79%	0.5791	0.6401
38	16/06/2007	40966	474	4.6124	0.0329	-0.0060	2	65.52%	0.5949	0.6576
39	19/04/1990	38459	445	4.5850	0.0436	-0.0091	1	67.24%	0.6108	0.6750
40	7/09/1967	35424	410	4.5493	0.0597	-0.0146	1	68.97%	0.6266	0.6925
41	8/11/1984	34560	400	4.5386	0.0651	-0.0166	1	70.69%	0.6424	0.7100
42	9/04/1978	32832	380	4.5163	0.0770	-0.0214	1	72.41%	0.6582	0.7275
43	23/04/1964	27648	320	4.4417	0.1239	-0.0436	1	74.14%	0.6741	0.7450
44	13/12/1963	26784	310	4.4279	0.1338	-0.0490	1	75.86%	0.6899	0.7625
45	13/01/1974	26784	310	4.4279	0.1338	-0.0490	1	77.59%	0.7057	0.7800
46	25/09/1995	26378	305	4.4212	0.1387	-0.0517	1	79.31%	0.7215	0.7975
47	18/05/1995	26031	301	4.4155	0.1431	-0.0541	1	81.03%	0.7373	0.8150
48	8/03/2012	24136	279	4.3827	0.1690	-0.0695	1	82.76%	0.7532	0.8324
49	31/08/1996	21514	249	4.3327	0.2125	-0.0980	1	84.48%	0.7690	0.8499
50	15/01/1972	17280	200	4.2375	0.3093	-0.1720	1	86.21%	0.7848	0.8674
51	24/01/1976	16416	190	4.2153	0.3346	-0.1936	1	87.93%	0.8006	0.8849
52	17/10/1976	16416	190	4.2153	0.3346	-0.1936	1	89.66%	0.8165	0.9024
53	25/05/1990	14958	173	4.1749	0.3830	-0.2370	1	91.38%	0.8323	0.9199
54	11/02/2012	12396	143	4.0933	0.4906	-0.3436	1	93.10%	0.8481	0.9374
55	19/04/2012	11947	138	4.0773	0.5133	-0.3678	1	94.83%	0.8639	0.9549
56	22/03/2011	9505	110	3.9780	0.6655	-0.5429	1	96.55%	0.8797	0.9724
57	14/12/1991	9409	109	3.9736	0.6727	-0.5517	1	98.28%	0.8956	0.9898

Required ARI				
ARI	k	log Q	Q	Q
			[ML/day]	[m^3/s]
2	0.0182	4.8014	63294	733
5	0.8463	5.1489	140888	1631
10	1.2691	5.3263	211985	2454
20	1.6138	5.4709	295761	3423
50	1.9959	5.6313	427865	4952
100	2.2465	5.7365	545086	6309
200	2.4750	5.8324	679768	7868

FIGURE A.2



Flood Frequency Analysis
Nepean River at Camden Weir

CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

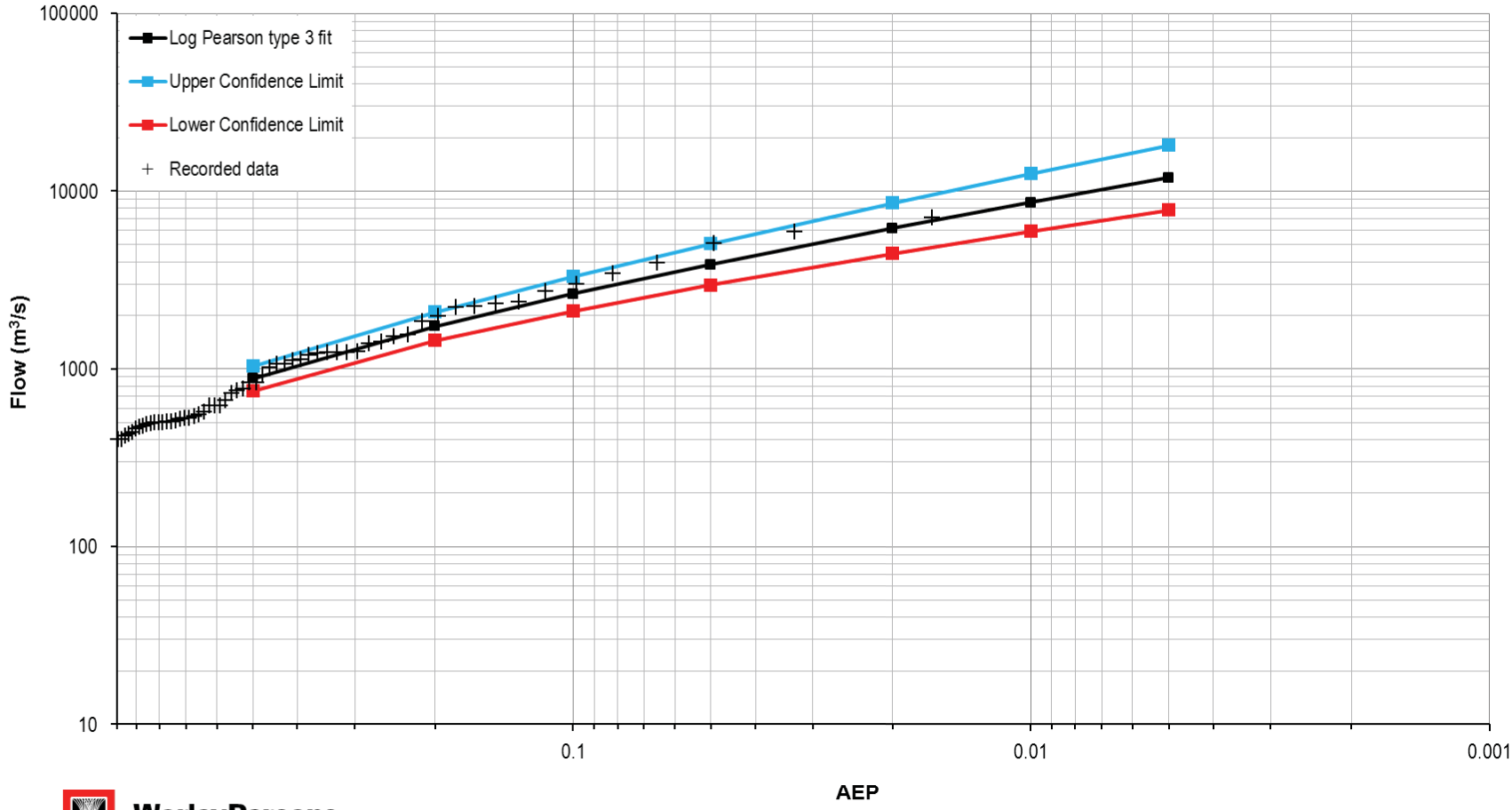
PARTIAL SERIES FLOOD FREQUENCY ANALYSIS FOR WALLACIA – INCLUDING HIGHEST THREE VALUES

Average Flow	Sum of $\{(\log Q - avg(\log Q))^2\}$	Variance
116344	6.14	0.1040
Average(Log(Q))	Sum of $\{(\log Q - avg(\log Q))^3\}$	Standard Deviation
4.93	1.65	0.3225
Number of Records		Skew Coefficient
60		0.8629
Number of Years		
139		

Rank	Date	Flow	Flow	Log(Q)	$\{(\log Q - avg(\log Q))^2\}$	$\{(\log Q - avg(\log Q))^3$	Return Period	Exceedence Probability	Plotting Position	Adjusted Plotting Position
		[ML/day]	[m^3/s]				[years]	[%]		
1	2/1873	611712	7080	5.7865	0.7387	0.6349	61	1.64%	0.0043	0.0100
2	2/1898	509760	5900	5.7074	0.6088	0.4751	31	3.28%	0.0115	0.0266
3	10/1860	439776	5090	5.6432	0.5129	0.3673	20	4.92%	0.0187	0.0433
4	11/06/1964	340416	3940	5.5320	0.3659	0.2214	15	6.56%	0.0259	0.0599
5	11/1961	297216	3440	5.4731	0.2981	0.1628	12	8.20%	0.0330	0.0766
6	21/03/1978	258956	2997	5.4132	0.2363	0.1149	10	9.84%	0.0402	0.0932
7	05/1988	234307	2712	5.3698	0.1960	0.0868	9	11.48%	0.0474	0.1098
8	2/08/1990	205248	2376	5.3123	0.1484	0.0572	8	13.11%	0.0546	0.1265
9	06/1949	200448	2320	5.3020	0.1406	0.0527	7	14.75%	0.0618	0.1431
10	02/1956	192672	2230	5.2848	0.1280	0.0458	6	16.39%	0.0690	0.1598
11	06/1975	190944	2210	5.2809	0.1252	0.0443	6	18.03%	0.0761	0.1764
12	06/1925	171072	1980	5.2332	0.0937	0.0287	5	19.67%	0.0833	0.1931
13	07/1952	158976	1840	5.2013	0.0752	0.0206	5	21.31%	0.0905	0.2097
14	12/06/1991	133840	1549	5.1266	0.0398	0.0079	4	22.95%	0.0977	0.2263
15	7/08/1986	131611	1523	5.1193	0.0369	0.0071	4	24.59%	0.1049	0.2430
16	25/10/1987	122688	1420	5.0888	0.0262	0.0042	4	26.23%	0.1121	0.2596
17	25/10/1987	119539	1384	5.0775	0.0226	0.0034	4	27.87%	0.1193	0.2763
18	11/1969	108000	1250	5.0334	0.0113	0.0012	3	29.51%	0.1264	0.2929
19	30/08/1963	107136	1240	5.0299	0.0106	0.0011	3	31.15%	0.1336	0.3096
20	10/02/1992	106204	1229	5.0261	0.0098	0.0010	3	32.79%	0.1408	0.3262
21	18/08/1998	106178	1229	5.0260	0.0098	0.0010	3	34.43%	0.1480	0.3428
22	06/1950	105408	1220	5.0229	0.0092	0.0009	3	36.07%	0.1552	0.3595
23	06/1974	102816	1190	5.0121	0.0072	0.0006	3	37.70%	0.1624	0.3761
24	07/1922	96768	1120	4.9857	0.0034	0.0002	3	39.34%	0.1695	0.3928
25	3/06/1978	96526	1117	4.9846	0.0033	0.0002	2	40.98%	0.1767	0.4094
26	30/03/1963	91584	1060	4.9618	0.0012	0.0000	2	42.62%	0.1839	0.4261
27	7/07/1988	91554	1060	4.9617	0.0012	0.0000	2	44.26%	0.1911	0.4427
28	02/1934	87264	1010	4.9408	0.0002	0.0000	2	45.90%	0.1983	0.4593
29	5/03/1977	79445	920	4.9001	0.0007	0.0000	2	47.54%	0.2055	0.4760
30	05/1925	71712	830	4.8556	0.0051	-0.0004	2	49.18%	0.2126	0.4926
31	06/1956	71712	830	4.8556	0.0051	-0.0004	2	50.82%	0.2198	0.5093
32	4/02/1990	66287	767	4.8214	0.0112	-0.0012	2	52.46%	0.2270	0.5259
33	06/1974	64800	750	4.8116	0.0133	-0.0015	2	54.10%	0.2342	0.5426
34	08/1967	63072	730	4.7998	0.0162	-0.0021	2	55.74%	0.2414	0.5592
35	05/1943	57024	660	4.7561	0.0292	-0.0050	2	57.38%	0.2486	0.5758
36	01/1951	53568	620	4.7289	0.0393	-0.0078	2	59.02%	0.2557	0.5925
37	05/1955	53568	620	4.7289	0.0393	-0.0078	2	60.66%	0.2629	0.6091
38	03/1974	53568	620	4.7289	0.0393	-0.0078	2	62.30%	0.2701	0.6258
39	5/03/1976	49373	571	4.6935	0.0546	-0.0127	2	63.93%	0.2773	0.6424
40	04/1933	47520	550	4.6769	0.0626	-0.0157	2	65.57%	0.2845	0.6591
41	9/11/1984	46787	542	4.6701	0.0660	-0.0170	1	67.21%	0.2917	0.6757
42	10/1929	45792	530	4.6608	0.0709	-0.0189	1	68.85%	0.2989	0.6923
43	05/1962	45792	530	4.6608	0.0709	-0.0189	1	70.49%	0.3060	0.7090
44	08/1969	44928	520	4.6525	0.0754	-0.0207	1	72.13%	0.3132	0.7256
45	07/1959	44064	510	4.6441	0.0801	-0.0227	1	73.77%	0.3204	0.7423
46	3/04/1989	43700	506	4.6405	0.0821	-0.0235	1	75.41%	0.3276	0.7589
47	20/04/1990	43552	504	4.6390	0.0830	-0.0239	1	77.05%	0.3348	0.7756
48	05/1919	43200	500	4.6355	0.0850	-0.0248	1	78.69%	0.3420	0.7922
49	04/1921	43200	500	4.6355	0.0850	-0.0248	1	80.33%	0.3491	0.8088
50	04/1927	43200	500	4.6355	0.0850	-0.0248	1	81.97%	0.3563	0.8255
51	07/1931	42336	490	4.6267	0.0902	-0.0271	1	83.61%	0.3635	0.8421
52	25/10/1999	42170	488	4.6250	0.0912	-0.0276	1	85.25%	0.3707	0.8588
53	19/02/1984	41072	475	4.6136	0.0983	-0.0308	1	86.89%	0.3779	0.8754
54	04/1969	40608	470	4.6086	0.1014	-0.0323	1	88.52%	0.3851	0.8920
55	17/06/2007	39497	457	4.5966	0.1092	-0.0361	1	90.16%	0.3922	0.9087
56	19/10/1976	37929	439	4.5790	0.1212	-0.0422	1	91.80%	0.3994	0.9253
57	04/1978	37152	430	4.5700	0.1275	-0.0455	1	93.44%	0.4066	0.9420
58	01/1966	36288	420	4.5598	0.1349	-0.0496	1	95.08%	0.4138	0.9586
59	01/1918	34560	400	4.5386	0.1509	-0.0586	1	96.72%	0.4210	0.9753
60	07/1928	34560	400	4.5386	0.1509	-0.0586	1	98.36%	0.4282	0.9919

Required ARI				
ARI	k	log Q	Q	Q
			[ML/day]	[m^3/s]
2	-0.1421	4.8813	76080	881
5	0.7731	5.1764	150104	1737
10	1.3379	5.3585	228315	2643
20	1.8516	5.5242	334342	3870
50	2.4813	5.7273	533661	6177
100	2.9325	5.8728	746057	8635
200	3.3679	6.0132	1030864	11931

FIGURE A.3



Flood Frequency Analysis
Nepean River at Wallacia

CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

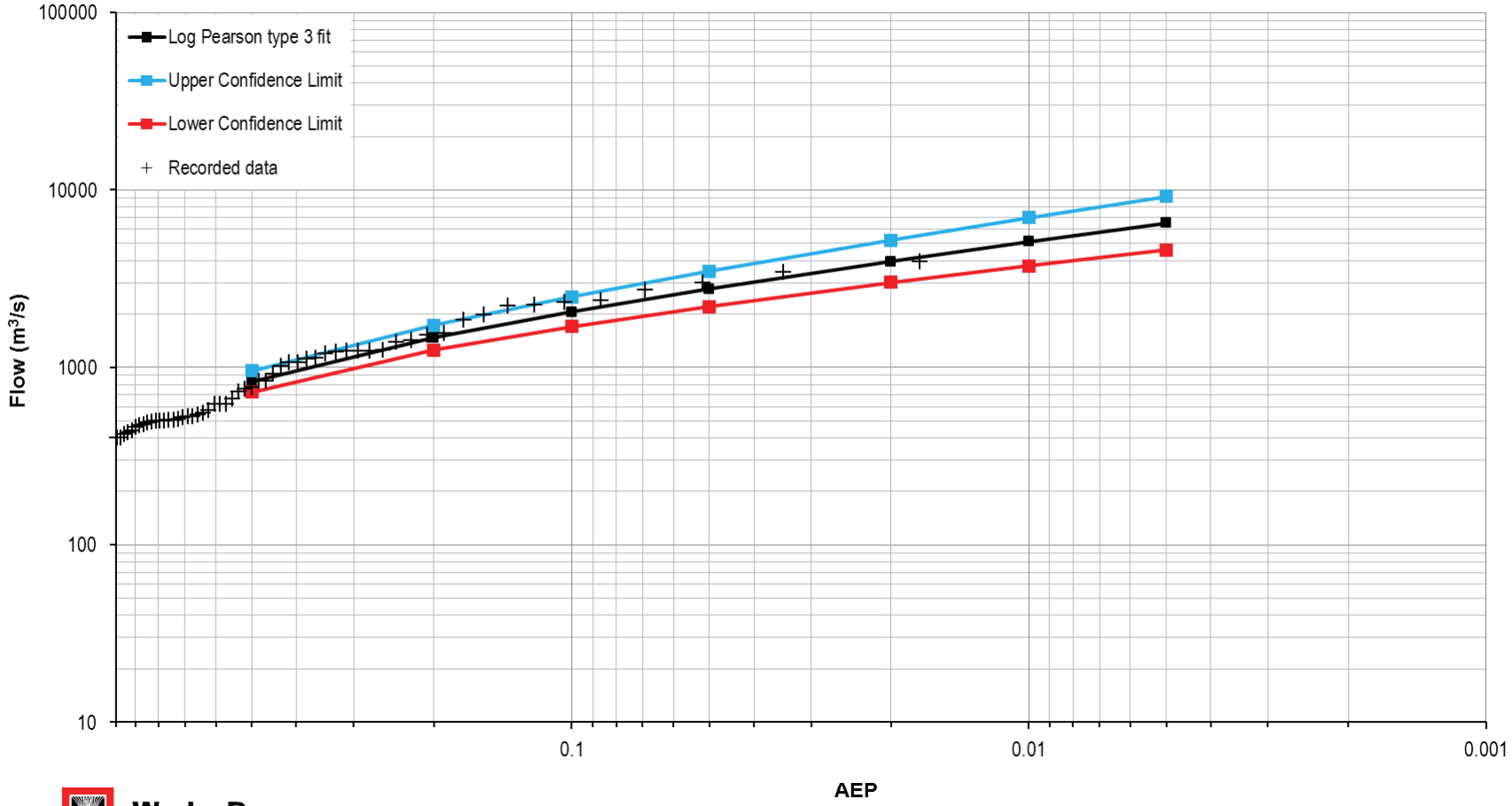
PARTIAL SERIES FLOOD FREQUENCY ANALYSIS FOR WALLACIA – EXCLUDING HIGHEST THREE VALUES

Average Flow	Sum of $\{(\log Q - \text{avg}(\log Q))^2\}$	Variance
95077	4.18	0.0746
Average(Log(Q))	**Sum of $\{(\log Q - \text{avg}(\log Q))^3\}$**	**Standard Deviation**
4.89	0.70	0.2731
Number of Records		**Skew Coefficient**
57		0.6314
Number of Years		
64		

Rank	Date	Flow	Flow	Log(Q)	$\{(\log Q - \text{avg}(\log Q))^2\}$	$\{(\log Q - \text{avg}(\log Q))^3$	Return Period	Exceedence Probability	Plotting Position	Adjusted Plotting Position
		[ML/day]	[m^3/s]				[years]	[%]		
1	11/06/1964	340416	3940	5.5320	0.4177	0.2699	58	1.72%	0.0093	0.0105
2	11/1961	297216	3440	5.4731	0.3449	0.2026	29	3.45%	0.0249	0.0280
3	21/03/1978	258956	2997	5.4132	0.2782	0.1468	19	5.17%	0.0405	0.0455
4	05/1988	234307	2712	5.3698	0.2343	0.1134	15	6.90%	0.0561	0.0630
5	2/08/1990	205248	2376	5.3123	0.1819	0.0776	12	8.62%	0.0717	0.0805
6	06/1949	200448	2320	5.3020	0.1733	0.0721	10	10.34%	0.0872	0.0979
7	02/1956	192672	2230	5.2848	0.1593	0.0636	8	12.07%	0.1028	0.1154
8	06/1975	190944	2210	5.2809	0.1561	0.0617	7	13.79%	0.1184	0.1329
9	06/1925	171072	1980	5.2332	0.1207	0.0419	6	15.52%	0.1340	0.1504
10	07/1952	158976	1840	5.2013	0.0996	0.0314	6	17.24%	0.1495	0.1679
11	12/06/1991	133840	1549	5.1266	0.0580	0.0140	5	18.97%	0.1651	0.1854
12	7/08/1986	131611	1523	5.1193	0.0545	0.0127	5	20.69%	0.1807	0.2029
13	25/10/1987	122688	1420	5.0888	0.0412	0.0084	4	22.41%	0.1963	0.2204
14	25/10/1987	119539	1384	5.0775	0.0368	0.0071	4	24.14%	0.2118	0.2379
15	11/1969	108000	1250	5.0334	0.0218	0.0032	4	25.86%	0.2274	0.2553
16	30/08/1963	107136	1240	5.0299	0.0208	0.0030	4	27.59%	0.2430	0.2728
17	10/02/1992	106204	1229	5.0261	0.0197	0.0028	3	29.31%	0.2586	0.2903
18	18/08/1998	106178	1229	5.0260	0.0197	0.0028	3	31.03%	0.2741	0.3078
19	06/1950	105408	1220	5.0229	0.0188	0.0026	3	32.76%	0.2897	0.3253
20	06/1974	102816	1190	5.0121	0.0160	0.0020	3	34.48%	0.3053	0.3428
21	07/1922	96768	1120	4.9857	0.0100	0.0010	3	36.21%	0.3209	0.3603
22	3/06/1978	96526	1117	4.9846	0.0098	0.0010	3	37.93%	0.3364	0.3778
23	30/03/1963	91584	1060	4.9618	0.0058	0.0004	3	39.66%	0.3520	0.3953
24	7/07/1988	91554	1060	4.9617	0.0058	0.0004	2	41.38%	0.3676	0.4127
25	02/1934	87264	1010	4.9408	0.0030	0.0002	2	43.10%	0.3832	0.4302
26	5/03/1977	79445	920	4.9001	0.0002	0.0000	2	44.83%	0.3988	0.4477
27	05/1925	71712	830	4.8556	0.0009	0.0000	2	46.55%	0.4143	0.4652
28	06/1956	71712	830	4.8556	0.0009	0.0000	2	48.28%	0.4299	0.4827
29	4/02/1990	66287	767	4.8214	0.0041	-0.0003	2	50.00%	0.4455	0.5002
30	06/1974	64800	750	4.8116	0.0055	-0.0004	2	51.72%	0.4611	0.5177
31	08/1967	63072	730	4.7998	0.0074	-0.0006	2	53.45%	0.4766	0.5352
32	05/1943	57024	660	4.7561	0.0168	-0.0022	2	55.17%	0.4922	0.5527
33	01/1951	53568	620	4.7289	0.0246	-0.0039	2	56.90%	0.5078	0.5701
34	05/1955	53568	620	4.7289	0.0246	-0.0039	2	58.62%	0.5234	0.5876
35	03/1974	53568	620	4.7289	0.0246	-0.0039	2	60.34%	0.5389	0.6051
36	5/03/1976	49373	571	4.6935	0.0370	-0.0071	2	62.07%	0.5545	0.6226
37	04/1933	47520	550	4.6769	0.0436	-0.0091	2	63.79%	0.5701	0.6401
38	9/11/1984	46787	542	4.6701	0.0465	-0.0100	2	65.52%	0.5857	0.6576
39	10/1929	45792	530	4.6608	0.0506	-0.0114	1	67.24%	0.6012	0.6751
40	05/1962	45792	530	4.6608	0.0506	-0.0114	1	68.97%	0.6168	0.6926
41	08/1969	44928	520	4.6525	0.0544	-0.0127	1	70.69%	0.6324	0.7101
42	07/1959	44064	510	4.6441	0.0584	-0.0141	1	72.41%	0.6480	0.7276
43	3/04/1989	43700	506	4.6405	0.0602	-0.0148	1	74.14%	0.6636	0.7450
44	20/04/1990	43552	504	4.6390	0.0609	-0.0150	1	75.86%	0.6791	0.7625
45	05/1919	43200	500	4.6355	0.0626	-0.0157	1	77.59%	0.6947	0.7800
46	04/1921	43200	500	4.6355	0.0626	-0.0157	1	79.31%	0.7103	0.7975
47	04/1927	43200	500	4.6355	0.0626	-0.0157	1	81.03%	0.7259	0.8150
48	07/1931	42336	490	4.6267	0.0671	-0.0174	1	82.76%	0.7414	0.8325
49	25/10/1999	42170	488	4.6250	0.0680	-0.0177	1	84.48%	0.7570	0.8500
50	19/02/1984	41072	475	4.6136	0.0741	-0.0202	1	86.21%	0.7726	0.8675
51	04/1969	40608	470	4.6086	0.0768	-0.0213	1	87.93%	0.7882	0.8850
52	17/06/2007	39497	457	4.5966	0.0836	-0.0242	1	89.66%	0.8037	0.9024
53	19/10/1976	37929	439	4.5790	0.0941	-0.0289	1	91.38%	0.8193	0.9199
54	04/1978	37152	430	4.5700	0.0997	-0.0315	1	93.10%	0.8349	0.9374
55	01/1966	36288	420	4.5598	0.1063	-0.0346	1	94.83%	0.8505	0.9549
56	01/1918	34560	400	4.5386	0.1205	-0.0418	1	96.55%	0.8660	0.9724
57	07/1928	34560	400	4.5386	0.1205	-0.0418	1	98.28%	0.8816	0.9899

Required ARI				
ARI	k	log Q	Q	Q
			[ML/day]	[m^3/s]
2	-0.1043	4.8572	71986	833
5	0.7969	5.1034	126885	1469
10	1.3296	5.2489	177386	2053
20	1.8039	5.3785	239048	2767
50	2.3741	5.5342	342157	3960
100	2.7767	5.6442	440751	5101
200	3.1606	5.7491	561123	6494

FIGURE A.4

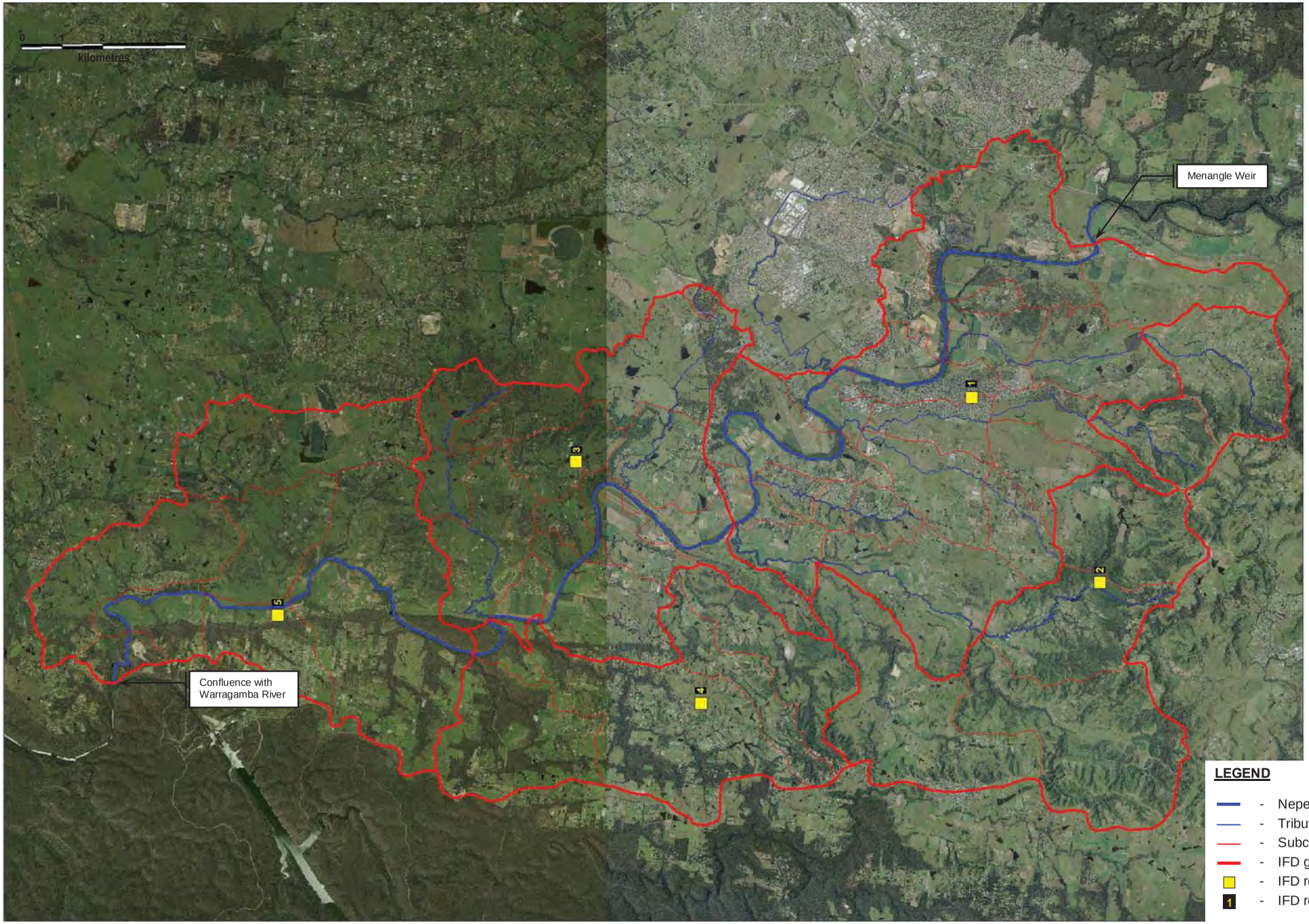


Flood Frequency Analysis
Nepean River at Wallacia

APPENDIX B

SUMMARY OF HYDROLOGIC MODEL SUBCATCHMENT PARAMETERS

FIGURE B.1



WorleyParsons
resources & energy

301015-03107 – Nepean River Flood Study
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LOCATION OF INTENSITY-FREQUENCY DURATION (IFD) REFERENCE POINTS USED IN HYDROLOGIC MODEL

CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

HYDROLOGIC MODEL PARAMETERS

Watercourse	Sub	ID	TUFLOW Boundary	Area	Stream Length	U/S Elev	D/S Elev	Slope	Reach Length	Reach U/S Elev	Reach D/S Elev	AR&R Lag	Bransby Lag	Average Lag	IFD Category	1978 Calibration Rainfall	1988 Calibration Rainfall	1990 Calibration Rainfall	PMP Rainfall
				[sq km]	[km]	[mAHD]	[mAHD]	[%]	[km]	[mAHD]	[mAHD]	[mins]	[mins]	[mins]					
Navigation Creek	A	NAVI A		11.450	6.45	305	95	3.26	-	-	-	-	-	-	2	Narellan	Camden Park	West Camden	PMP1.25
Navigation Creek	B	NAVI B	US_Navigation	8.811	5.61	180	70	1.96	4.05	95	70	63	63	63	1	Narellan	Camden Park	West Camden	PMP1.15
Navigation Creek	C	NAVI C	Navigation_C	4.769	3.46	110	55	1.59	3.40	70	55	50	59	54	1	Narellan	Camden Park	West Camden	PMP1.15
Narellan Creek			US_Narellan																
Narellan Creek		NARELL DS	DS_Narellan	5.316	3.90	110	55	1.41	0.84	55	55	52	15	33	1	Narellan	West Camden	West Camden	PMP1.15
Matahil Creek East	A	MAT E A		6.267	5.02	300	100	3.99	-	-	-	-	-	-	2	Narellan	West Camden	West Camden	PMP1.25
Matahil Creek East	B	MAT E B		11.460	7.30	310	95	2.95	-	-	-	-	-	-	2	Oakdale	Camden Park	West Camden	PMP1.25
Matahil Creek East	C	MAT E C		5.281	6.66	280	75	3.08	3.76	100	75	51	56	54	1	Narellan	Camden Park	West Camden	PMP1.15
Matahil Creek East	D	MAT E D	US_MatahilE	5.161	4.23	125	75	1.18	3.13	95	75	51	57	54	1	Narellan	West Camden	West Camden	PMP1.25
Matahil Creek East	E	MAT E E	MatahilE_E	4.649	4.44	75	60	0.34	4.44	75	60	49	105	77	1	Narellan	West Camden	West Camden	PMP1.15
Matahil Creek West	A	MAT W A	US_MatahilW	4.631	3.91	200	80	3.07	-	-	-	-	-	-	1	Oakdale	West Camden	West Camden	PMP1.25
Matahil Creek West	B	MAT W B	MatahilW_B	7.395	5.94	120	60	1.01	4.87	80	60	59	88	73	1	Narellan	West Camden	West Camden	PMP1.15
Sickles Creek	A	SICKLES A	Sickles_A	2.769	2.46	115	80	1.42	-	-	-	-	-	-	1	Narellan	West Camden	West Camden	PMP1.25
Sickles Creek	B	SICKLES B	Sickles_B	1.372	1.68	100	65	2.08	1.13	80	65	31	21	26	1	Narellan	West Camden	West Camden	PMP1.15
Sickles Creek	C	SICKLES C	Sickles_C	1.911	3.02	90	50	1.33	2.57	65	50	35	50	43	1	Narellan	West Camden	West Camden	PMP1.15
Cobbitty Creek	A	COBBITTY A	US_Cobbitty	0.611	1.23	120	90	2.44	-	-	-	-	-	-	3	Pondicherry	Pondicherry	Pondicherry	PMP1.05
Cobbitty Creek	B	COBBITTY B	Cobbitty_B	11.690	4.35	130	65	1.49	3.73	90	65	70	60	65	3	Pondicherry	Pondicherry	Pondicherry	PMP1.15
Cobbitty Creek	C	COBBITTY C	Cobbitty_C	7.085	4.97	95	50	0.91	4.44	65	50	58	82	70	3	Pondicherry	Brownlow	Brownlow	PMP1.15
Wattle Creek	A	UNNAMED1A		7.099	10.40	300	55	2.36	-	-	-	-	-	-	4	Pondicherry	Brownlow	Brownlow	PMP1.45
Wattle Creek	B	UNNAMED1B	US_Unnamed1	10.730	10.99	290	55	2.14	-	-	-	-	-	-	4	Pondicherry	Brownlow	Brownlow	PMP1.35
Wattle Creek	C	UNNAMED1C	Unnamed1_C	4.599	3.98	55	50	0.13	2.27	50	50	49	65	57	3	Pondicherry	Brownlow	Brownlow	PMP1.25
Unnamed Trib2		UNNAMED2	Unnamed2	5.367	3.70	150	60	2.43	-	-	-	-	-	-	3	Pondicherry	Pondicherry	Pondicherry	PMP1.15
Bringelly Creek	A	BRING A		2.426	2.02	120	90	1.49	-	-	-	-	-	-	3	Pondicherry	Pondicherry	Pondicherry	PMP1.15
Bringelly Creek	B	BRING B		4.564	5.71	150	75	1.31	-	-	-	-	-	-	3	Pondicherry	Pondicherry	Pondicherry	PMP1.15
Bringelly Creek	C1	BRING C1	US_Bringelly	1.501	2.07	115	75	1.93	1.27	90	75	32	24	28	3	Pondicherry	Pondicherry	Pondicherry	PMP1.25
Bringelly Creek	C2	BRING C2	Bringelly_C2	3.118	3.04	110	65	1.48	2.89	75	65				3	Pondicherry	Pondicherry	Pondicherry	PMP1.25
Bringelly Creek	D	BRING D	Bringelly_D	10.080	8.92	115	50	0.73	5.87	65	50	66	110	88	3	Pondicherry	Pondicherry	Pondicherry	PMP1.25
Mt Hunter Rivulet	A	MT HUNT A		12.020	8.34	290	85	2.46	-	-	-	-	-	-	2	Oakdale	West Camden	West Camden	PMP1.35
Mt Hunter Rivulet	B	MT HUNT B		21.310	9.91	300	85	2.17	-	-	-	-	-	-	2	Oakdale	West Camden	West Camden	PMP1.45
Mt Hunter Rivulet	C	MT HUNT C	US_MtHunter	13.880	7.17	200	70	1.81	6.03	85	70	74	91	83	1	Oakdale	West Camden	West Camden	PMP1.35
Mt Hunter Rivulet	D	MT HUNT D	MtHunter_D	4.035	5.36	90	50	0.75	4.41	70	50	46	90	68	2	Pondicherry	Brownlow	Brownlow	PMP1.25
Flaggy Creek		FLAGGY		20.050	13.18	280	70	1.59	-	-	-	-	-	-	2	Oakdale	Brownlow	Brownlow	PMP1.35
Eagle Creek		EAGLE	US_Eagle	21.490	12.62	300	50	1.98	0.31	50	50	88	4	46	4	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.45
Forest Hill Creek		FOREST	US_Forest	13.630	6.65	260	45	3.23	-	-	-	-	-	-	4	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.53
Duncans Creek	A	DUNCANS A	Duncans_A	15.170	8.18	105	45	0.73	-	-	-	-	-	-	5	Badgerys	Badgerys	Badgerys	PMP1.25
Duncans Creek	B	DUNCANS B	Duncans_B	8.739	7.79	90	30	0.77	7.55	50	30	62	142	102	5	Badgerys	Badgerys	Badgerys	PMP1.35
Jerrys Creek		JERRYS	Jerrys	13.960	6.31	95	25	1.11	1.40	25	25	75	23	49	5	Badgerys	Badgerys	Badgerys	PMP1.45
Nepean River	A	NEPEAN A	US_Nepean_A	9.304	7.50	170	60	1.47	0.86	60	60	64	14	39	1	Narellan	Camden Park	West Camden	PMP1.15
Nepean River	B	NEPEAN B	Nepean_B	17.850	7.20	160	60	1.39	5.55	60	60	82	86	84	1	Narellan	Camden Park	West Camden	PMP1.05
Nepean River	C1	NEPEAN C1	Nepean_C1	6.034	4.51	130	60	1.55	1.77	60	60	54	30	42	1	Narellan	West Camden	West Camden	PMP1.05
Nepean River	C2	NEPEAN C2	Nepean_C2	6.213	4.21	80	55	0.59	3.23	60	55	55	66	60	1	Narellan	West Camden	West Camden	PMP1.15
Nepean River	D1	NEPEAN D1	Nepean_D1	3.049	2.68	60	55	0.19	2.26	55	55	42	63	52	1	Narellan	West Camden	West Camden	PMP1.15
Nepean River	D2	NEPEAN D2	Nepean_D2	10.300	7.87	105	50	0.70	6.73	55	50	66	127	97	1	Pondicherry	West Camden	West Camden	PMP1.15
Nepean River	D3	NEPEAN D3	Nepean_D3	2.414	3.29	90	50	1.21	1.60	50	50	38	31	35	1	Pondicherry	Brownlow	Brownlow	PMP1.15
Nepean River	E	NEPEAN E	Nepean_E	6.869	8.47	140	50	1.06	4.19	50	50	57	76	66	3	Pondicherry	Brownlow	Brownlow	PMP1.25
Nepean River	F1	NEPEAN F1	Nepean_F1	2.480	2.72	90	50	1.47	0.86	50	50	39	16	27	3	Pondicherry	Brownlow	Brownlow	PMP1.25
Nepean River	F2	NEPEAN F2	Nepean_F2	10.400	5.75	165	50	2.00	2.34	50	50	67	36	51	3	Pondicherry	Brownlow	Brownlow	PMP1.35
Nepean River	G	NEPEAN G	Nepean_G	30.120	11.08	245	25	1.99	7.37	45	25	100	101	100	5	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.25
Nepean River	H	NEPEAN H	Nepean_H	5.094	5.90	160	25	2.29	4.12	25	25	51	66	58	5	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.53
Nepean River	I	NEPEAN I	Nepean_I	2.437	3.12	140	15	4.01	2.06	25	15	38	32	35	5	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.53
Nepean River	J	NEPEAN J	Nepean_J	2.22	2.92	80	50	1.03	1.16	50	50	37	24	30	3	Pondicherry	Brownlow	Brownlow	PMP1.35
Nepean River	K	NEPEAN K	Nepean_K	2.12	3.31	180	40	4.23	1.84	50	40	36	28	32	4	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.45
Nepean River	L	NEPEAN L	Nepean_L	7.11	5.65	190	30	2.83	2.69	30	30	58	40	49	5	Warragamba Met	Warragamba Met	Warragamba Met	PMP1.45

= upstream boundary for TUFLOW hydrodynamic model
= local inflow on Nepean River
= local inflow on tributary
= inflows derived from Narellan Creek model

INTENSITY-FREQUENCY-DURATION (IFD) DATA CATEGORIES FOR THE CATCHMENT

01	Easting	287,328	>>> From BoM	DURATION	1 year	2 years	5 years	10 years	20 years	50 years	100 years	Into XP-RAFTS>>>	59.4	12	3.96		
	Northing	6,226,956		5 mins	76	98.3	127	144	167	196	219						
				6 mins	71	91.8	119	135	156	184	205		29.9	5.77	1.75		
	Long	150.700 E		10 mins	58	74.9	97.2	110	127	150	167						
	Lat	34.075 S		20 mins	42.5	54.8	70.9	80.2	92.6	109	121						
				30 mins	34.5	44.5	57.5	65.1	75.1	88.2	98.3			Location Skew	0.01	f2	4.29
				1 hour	23.2	29.9	38.7	43.8	50.6	59.4	66.2					f50	15.79
				2 hours	14.9	19.2	24.9	28.3	32.7	38.5	42.9						
				3 hours	11.3	14.6	19	21.6	25	29.4	32.8						
				6 hours	7.05	9.14	11.9	13.6	15.7	18.6	20.8						
				12 hours	4.44	5.77	7.59	8.67	10.1	12	13.4						
				24 hours	2.84	3.71	4.94	5.68	6.63	7.91	8.88						
				48 hours	1.8	2.36	3.19	3.7	4.35	5.23	5.9						
				72 hours	1.33	1.75	2.39	2.78	3.28	3.96	4.49						

02	Easting	281,973	>>> From BoM	DURATION	1 year	2 years	5 years	10 years	20 years	50 years	100 years	Into XP-RAFTS>>>	59.4	12.9	4.52		
	Northing	6,222,287		5 mins	74.7	96.7	126	143	166	195	218						
				6 mins	69.8	90.5	118	134	155	183	205		29.6	6.49	1.86		
	Long	150.625 E		10 mins	57.1	73.9	96.2	109	127	149	167						
	Lat	34.125 S		20 mins	41.7	53.8	69.8	79.3	91.6	108	120						
				30 mins	33.8	43.7	56.6	64.3	74.3	87.5	97.6			Location Skew	0.02	f2	4.29
				1 hour	22.9	29.6	38.4	43.6	50.4	59.4	66.2					f50	15.78
				2 hours	15.1	19.6	25.3	28.7	33.2	39.1	43.5						
				3 hours	11.8	15.3	19.7	22.4	25.8	30.3	33.8						
				6 hours	7.76	10	12.9	14.5	16.7	19.7	21.9						
				12 hours	5.03	6.49	8.4	9.53	11	12.9	14.4						
				24 hours	3.17	4.13	5.48	6.28	7.34	8.74	9.81						
				48 hours	1.92	2.54	3.49	4.08	4.85	5.88	6.69						
				72 hours	1.4	1.86	2.61	3.09	3.69	4.52	5.17						

03	Easting	285,497	>>> From BoM	DURATION	1 year	2 years	5 years	10 years	20 years	50 years	100 years	Into XP-RAFTS>>>	59.9	12.9	3.99		
	Northing	6,237,575		5 mins	74.5	96.5	126	144	167	197	220						
				6 mins	69.7	90.3	118	135	156	184	206		29.5	6.31	1.89		
	Long	150.675 E		10 mins	56.9	73.8	96.5	110	127	150	168						
	Lat	33.975 S		20 mins	41.5	53.7	70.1	79.8	92.5	109	122						
				30 mins	33.6	43.6	56.9	64.7	75	88.6	99			Location Skew	0.02	f2	4.3
				1 hour	22.8	29.5	38.5	43.8	50.8	59.9	67					f50	15.78
				2 hours	15	19.4	25.3	28.8	33.3	39.4	44						
				3 hours	11.6	15	19.6	22.3	25.9	30.6	34.2						
				6 hours	7.53	9.75	12.7	14.5	16.8	19.8	22.1						
				12 hours	4.87	6.31	8.25	9.39	10.9	12.9	14.4						
				24 hours	3.13	4.07	5.34	6.09	7.08	8.38	9.39						
				48 hours	1.96	2.55	3.37	3.86	4.49	5.35	6						
				72 hours	1.45	1.89	2.5	2.87	3.35	3.99	4.48						

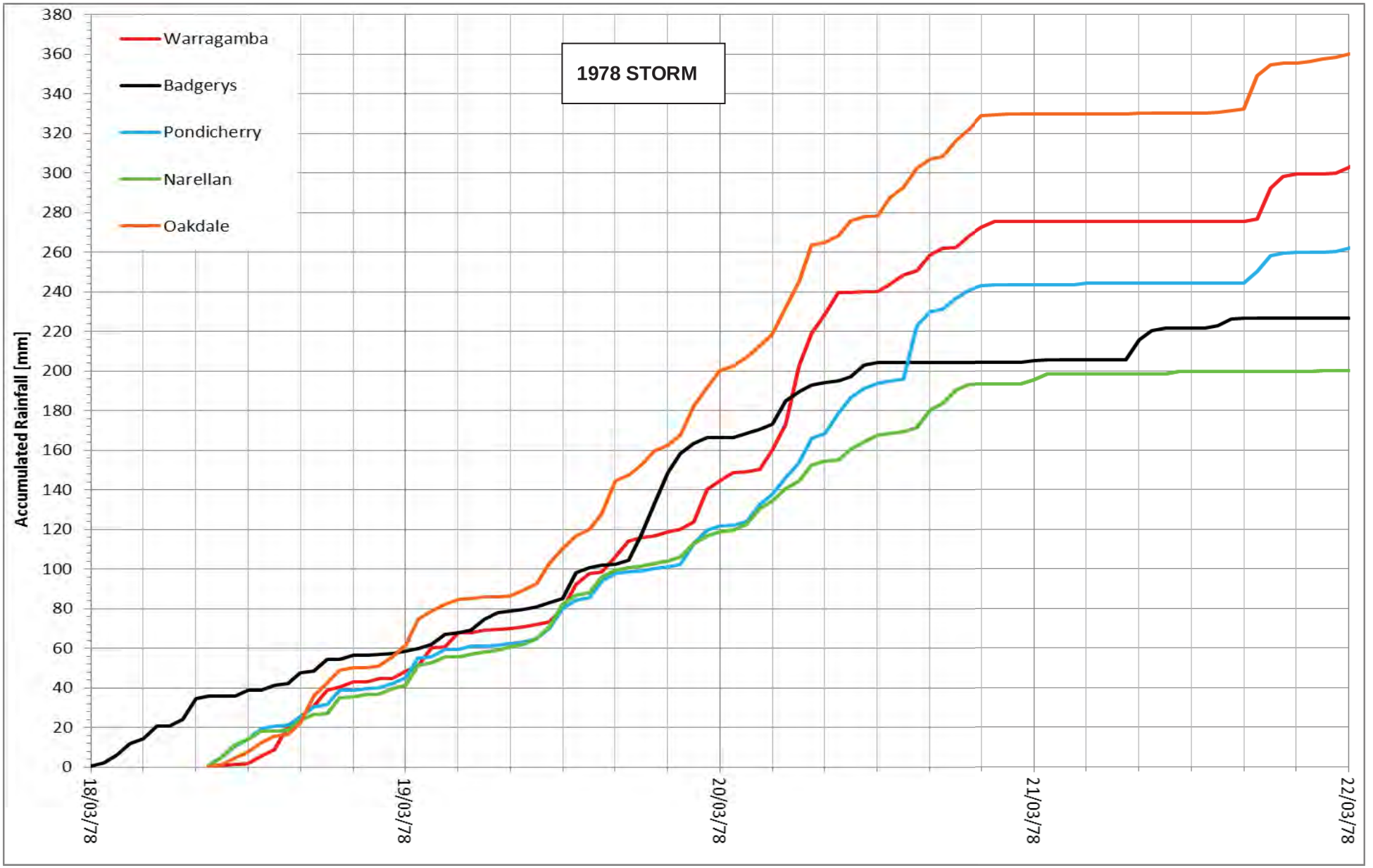
04	Easting	278,449	>>> From BoM	DURATION	1 year	2 years	5 years	10 years	20 years	50 years	100 years	Into XP-RAFTS>>>	60.5	14	4.6		
	Northing	6,233,913		5 mins	75.1	97.2	127	144	167	197	221						
				6 mins	70.2	90.9	119	135	157	185	207		29.7	6.62	1.9		
	Long	150.600 E		10 mins	57.4	74.3	97	110	128	151	169						
	Lat	34.000 S		20 mins	41.8	54.1	70.5	80.1	92.8	109	122						
				30 mins	33.9	43.9	57.2	65	75.3	88.8	99.2			Location Skew	0.02	f2	4.3
				1 hour	23	29.7	38.8	44.2	51.2	60.5	67.7					f50	15.77
				2 hours	15.2	19.7	25.8	29.4	34.1	40.4	45.2						
				3 hours	11.9	15.5	20.2	23.1	26.8	31.7	35.5						
				6 hours	7.82	10.2	13.3	15.2	17.7	21	23.5						
				12 hours	5.08	6.62	8.76	10.1	11.7	14	15.7						
				24 hours	3.22	4.22	5.69	6.58	7.74	9.29	10.5						
				48 hours	1.96	2.59	3.58	4.2	4.99	6.07	6.91						
				72 hours	1.43	1.9	2.66	3.15	3.76	4.6	5.27						

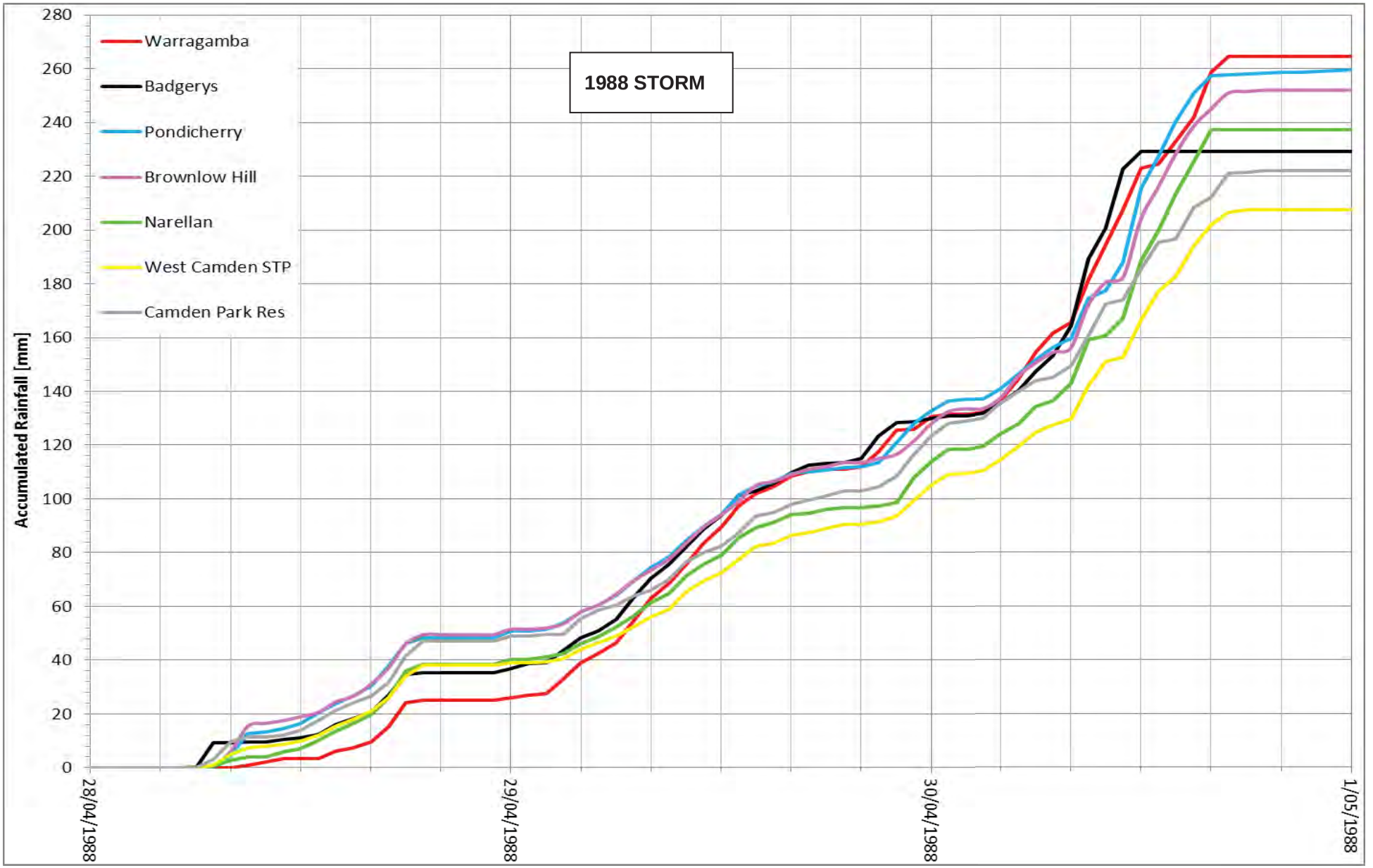
CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

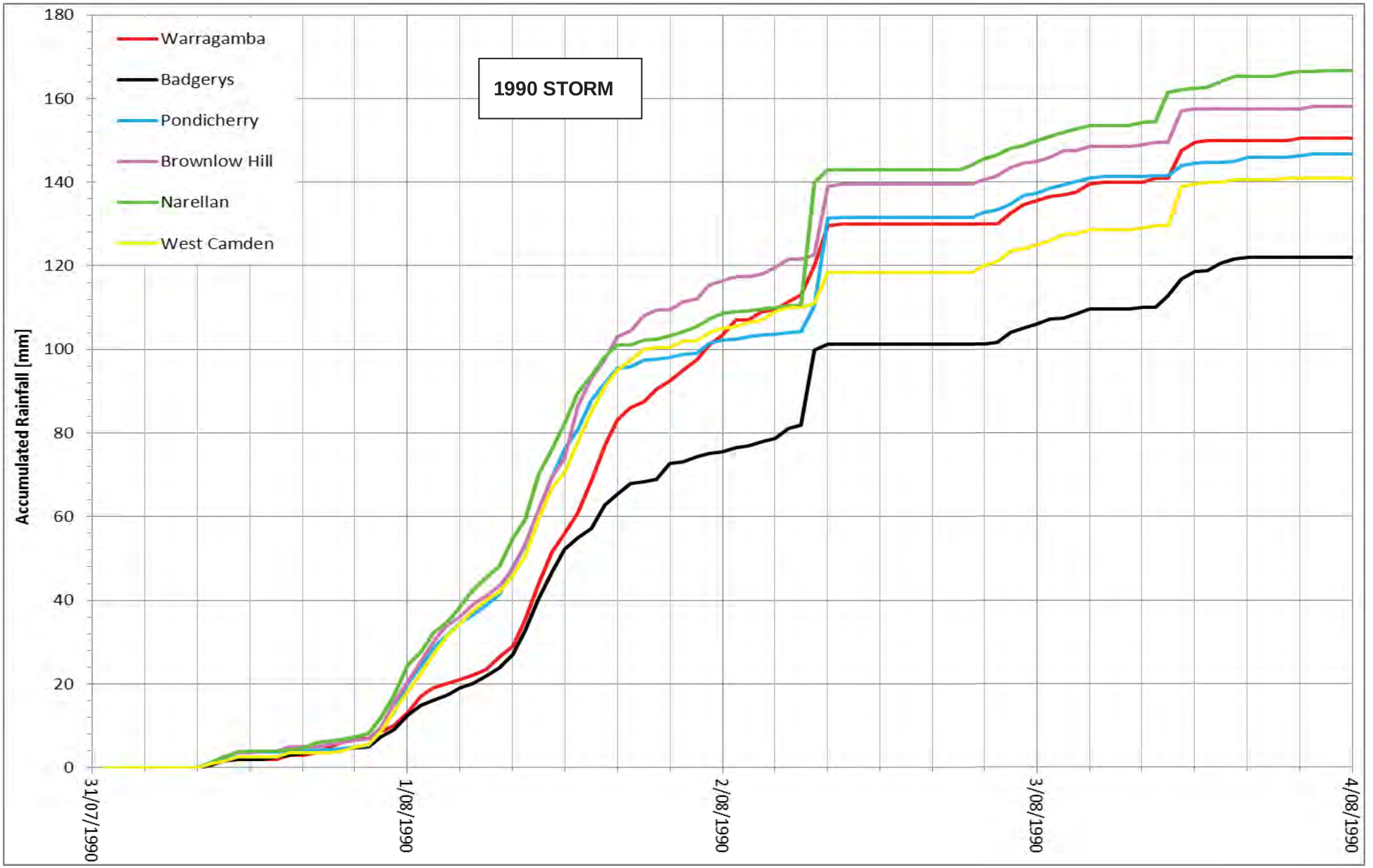
05	Easting	281,012		>>> From BoM	DURATION	1 year	2 years	5 years	10 years	20 years	50 years	100 years		Into XP-RAFTS>>>	60.6	14.1	4.66			
	Northing	6,246,272			5 mins	74	96.1	126	144	167	198	221								
					6 mins	69.3	89.9	118	135	157	185	208			29.4	6.85	2			
	Long	150.625 E			10 mins	56.7	73.5	96.4	110	128	151	170								
	Lat	33.900 S			20 mins	41.1	53.4	69.8	79.7	92.6	110	123								
					30 mins	33.3	43.3	56.6	64.6	75.1	88.9	99.5				Location Skew	0.03		f2	4.3
					1 hour	22.7	29.4	38.6	44	51.2	60.6	67.9							f50	15.78
					2 hours	15.2	19.7	25.8	29.4	34.2	40.5	45.4								
					3 hours	12	15.6	20.3	23.2	26.9	31.9	35.7								
					6 hours	8.01	10.4	13.5	15.4	17.9	21.2	23.7								
					12 hours	5.28	6.85	8.98	10.2	11.9	14.1	15.8								
					24 hours	3.37	4.4	5.86	6.74	7.88	9.4	10.6								
					48 hours	2.06	2.71	3.69	4.31	5.08	6.14	6.97								
					72 hours	1.51	2	2.75	3.23	3.84	4.66	5.31								

APPENDIX C

RECORDED RAINFALL USED IN HYDROLOGIC MODEL CALIBRATION


1978 STORM
Warragamba
Badgerys
Pondicherry
Narellan
Oakdale
Accumulated Rainfall [mm]
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
18/03/78
19/03/78
20/03/78
21/03/78
22/03/78


1988 STORM
Warragamba
Badgerys
Pondicherry
Brownlow Hill
Narellan
West Camden STP
Camden Park Res
Accumulated Rainfall [mm]
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
28/04/1988
29/04/1988
30/04/1988
1/05/1988


1990 STORM
Warragamba
Badgerys
Pondicherry
Brownlow Hill
Narellan
West Camden
Accumulated Rainfall [mm]
0
20
40
60
80
100
120
140
160
180
31/07/1990
1/08/1990
2/08/1990
3/08/1990
4/08/1990

APPENDIX D

SUMMARY OF HYDROLOGIC MODEL CALIBRATION

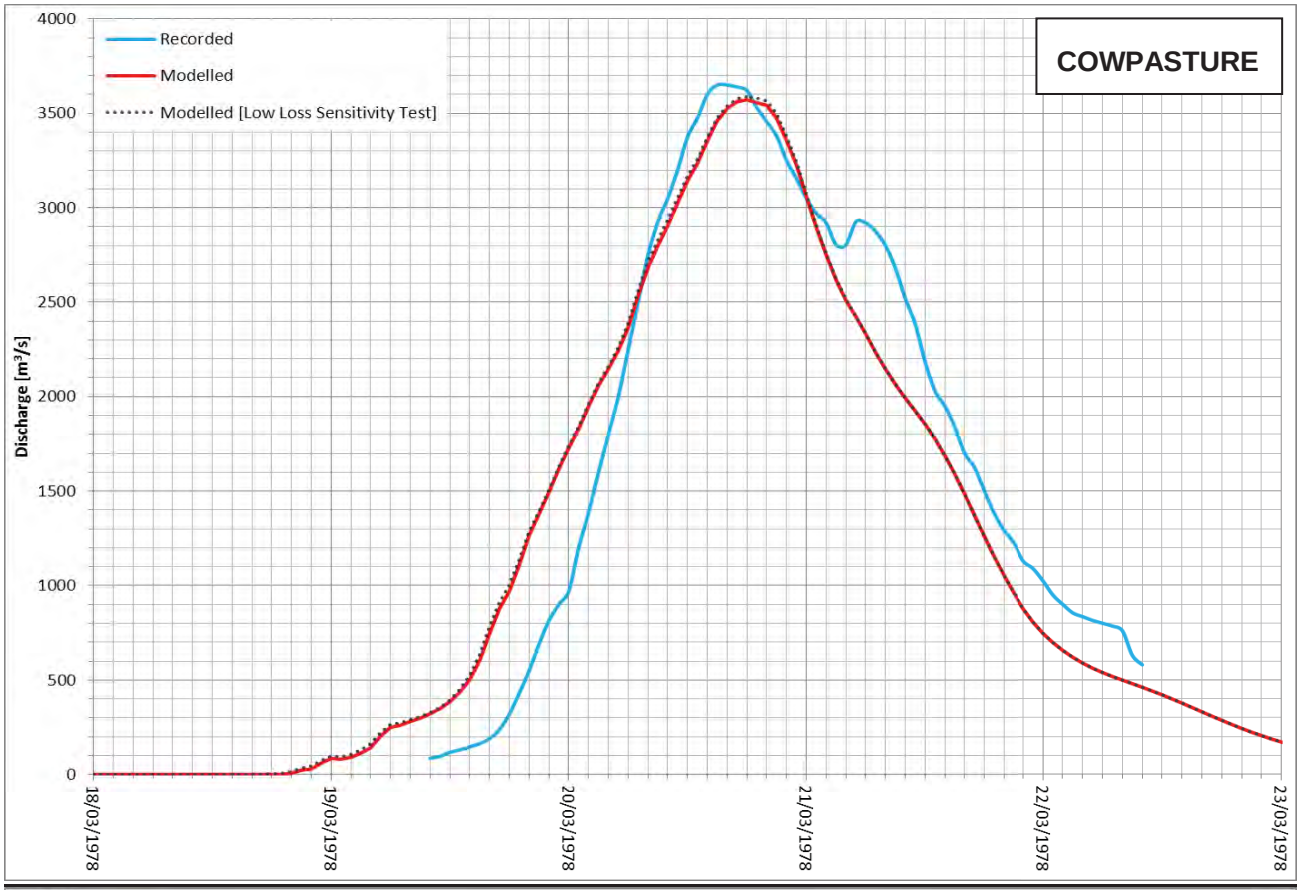
CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

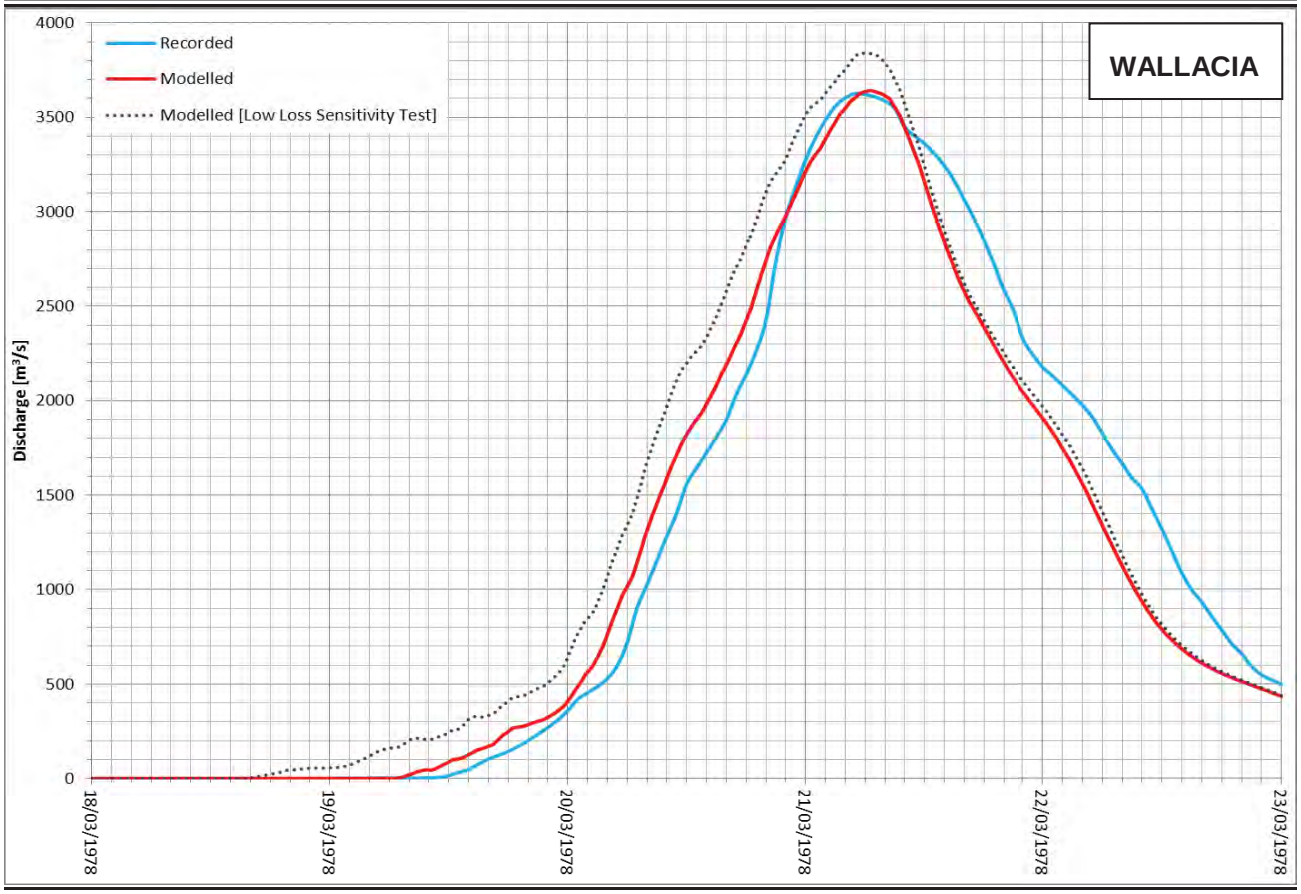
HYDROLOGIC MODEL CALIBRATION PARAMETERS

				1978				1988				1990				ADOPTED		
	Total [km²]	Slope [%]	Lag [mins]	IL	CL	n	Storm	IL	CL	n	Storm	IL	CL	n	Storm	IL	CL	n
NEPEAN A	930.40	1.47		60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_CamdenPk	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NEPEAN B	1791.00	1.39	84	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_CamdenPk	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NAVI A	1145.00	3.26		60	10.0	0.06	1978_Narellan	15	2.5	0.06	1988_CamdenPk	15	2.5	0.06	1990_WCamden	15	2.5	0.06
NAVI B	881.10	1.96	63	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_CamdenPk	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NAVI C	476.90	1.59	54	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_CamdenPk	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NEPEAN C1	625.10	1.55	42	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NEPEAN C2	621.80	0.59	60	60	10.0	0.03	1978_Narellan	15	2.5	0.03	1988_WCamden	15	2.5	0.03	1990_WCamden	15	2.5	0.03
NARELL DS	71.90	1.41		60	10.0	0.03	1978_Narellan	15	2.5	0.03	1988_WCamden	15	2.5	0.03	1990_WCamden	15	2.5	0.03
MAT E A	626.70	3.99		60	10.0	0.06	1978_Narellan	15	2.5	0.06	1988_WCamden	15	2.5	0.06	1990_WCamden	15	2.5	0.06
MAT E B	1146.00	2.95		60	10.0	0.06	1978_Oakdale	15	2.5	0.06	1988_WCamden	15	2.5	0.06	1990_WCamden	15	2.5	0.06
MAT E C	528.10	3.08	54	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
MAT E D	516.10	1.18	54	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
MAT E E	464.90	0.34	77	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
MAT W A	463.10	3.07		60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_Narellan	15	2.5	0.04	1990_WCamden	15	2.5	0.04
MAT W B	739.50	1.01	73	60	10.0	0.04	1978_Oakdale	15	2.5	0.04	1988_Narellan	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NEPEAN D1	306.20	0.19	52	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
NEPEAN D2	1028.00	0.70	97	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
SICKLES B	137.20	2.08	26	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
SICKLES A	276.90	1.42		60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
MT HUNT A	1202.00	2.46		60	10.0	0.06	1978_Oakdale	15	2.5	0.06	1988_WCamden	15	2.5	0.06	1990_WCamden	15	2.5	0.06
MT HUNT B	2131.00	2.17		60	10.0	0.06	1978_Oakdale	15	2.5	0.06	1988_WCamden	15	2.5	0.06	1990_WCamden	15	2.5	0.06
MT HUNT C	1388.00	1.81	83	60	10.0	0.04	1978_Oakdale	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
FLAGGY	2005.00	1.59		60	10.0	0.04	1978_Oakdale	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
MT HUNT D	403.50	0.75	68	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
NEPEAN D3	241.40	1.21	35	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
NEPEAN E	686.90	1.06	66	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
COBBITTY A	62.70	2.44		60	10.0	0.06	1978_Pondi	15	2.5	0.06	1988_Pondi	15	2.5	0.06	1990_Pondi	15	2.5	0.06
COBBITTY B	1167.00	1.49	65	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
COBBITTY C	708.50	0.91	70	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
UNNAMED 1C	4599.00	0.13	63	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
NEPEAN F1	248.00	1.47	27	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
NEPEAN F2	1040.00	2.00	51	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
EAGLE	2149.00	1.98		60	10.0	0.06	1978_WarraMet	15	2.5	0.06	1988_WarraMet	15	2.5	0.06	1990_WarraMet	15	2.5	0.06
NEPEAN K	212.20	4.23	32	60	10.0	0.06	1978_WarraMet	15	2.5	0.06	1988_WarraMet	15	2.5	0.06	1990_WarraMet	15	2.5	0.06
FOREST	1363.00	3.23		60	10.0	0.06	1978_WarraMet	15	2.5	0.06	1988_WarraMet	15	2.5	0.06	1990_WarraMet	15	2.5	0.06
NEPEAN J	221.80	1.03	30	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
BRING D	1008.00	0.73	88	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
BRING C2	311.80	1.48	47	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
BRING C1	150.10	1.93	28	60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
BRING A	242.60	1.49		60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
BRING B	456.40	1.31		60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
UNNAMED 2	536.70	2.43		60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Pondi	15	2.5	0.04	1990_Pondi	15	2.5	0.04
NEPEAN G	3012.00	1.99	100	60	10.0	0.04	1978_WarraMet	15	2.5	0.04	1988_WarraMet	15	2.5	0.04	1990_WarraMet	15	2.5	0.04
DUNCANS A	1517.00	0.73		60	10.0	0.04	1978_Badgerys	15	2.5	0.04	1988_Badgerys	15	2.5	0.04	1990_Badgerys	15	2.5	0.04
DUNCANS B	873.90	0.77	102	60	10.0	0.04	1978_Badgerys	15	2.5	0.04	1988_Badgerys	15	2.5	0.04	1990_Badgerys	15	2.5	0.04
NEPEAN L	711.40	2.83	49	60	10.0	0.04	1978_WarraMet	15	2.5	0.04	1988_WarraMet	15	2.5	0.04	1990_WarraMet	15	2.5	0.04
NEPEAN H	509.40	2.29	58	60	10.0	0.06	1978_WarraMet	15	2.5	0.06	1988_WarraMet	15	2.5	0.06	1990_WarraMet	15	2.5	0.06
NEPEAN I	243.70	4.01	35	60	10.0	0.04	1978_WarraMet	15	2.5	0.04	1988_WarraMet	15	2.5	0.04	1990_WarraMet	15	2.5	0.04
JERRYS	1396.00	1.11		60	10.0	0.04	1978_Badgerys	15	2.5	0.04	1988_Badgerys	15	2.5	0.04	1990_Badgerys	15	2.5	0.04
SICKLES C	191.10	1.33	43	60	10.0	0.04	1978_Narellan	15	2.5	0.04	1988_WCamden	15	2.5	0.04	1990_WCamden	15	2.5	0.04
UNNAMED 1A	709.90	2.36		60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04
UNNAMED 1B	1073.00	2.14		60	10.0	0.04	1978_Pondi	15	2.5	0.04	1988_Brownlow	15	2.5	0.04	1990_Brownlow	15	2.5	0.04

CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

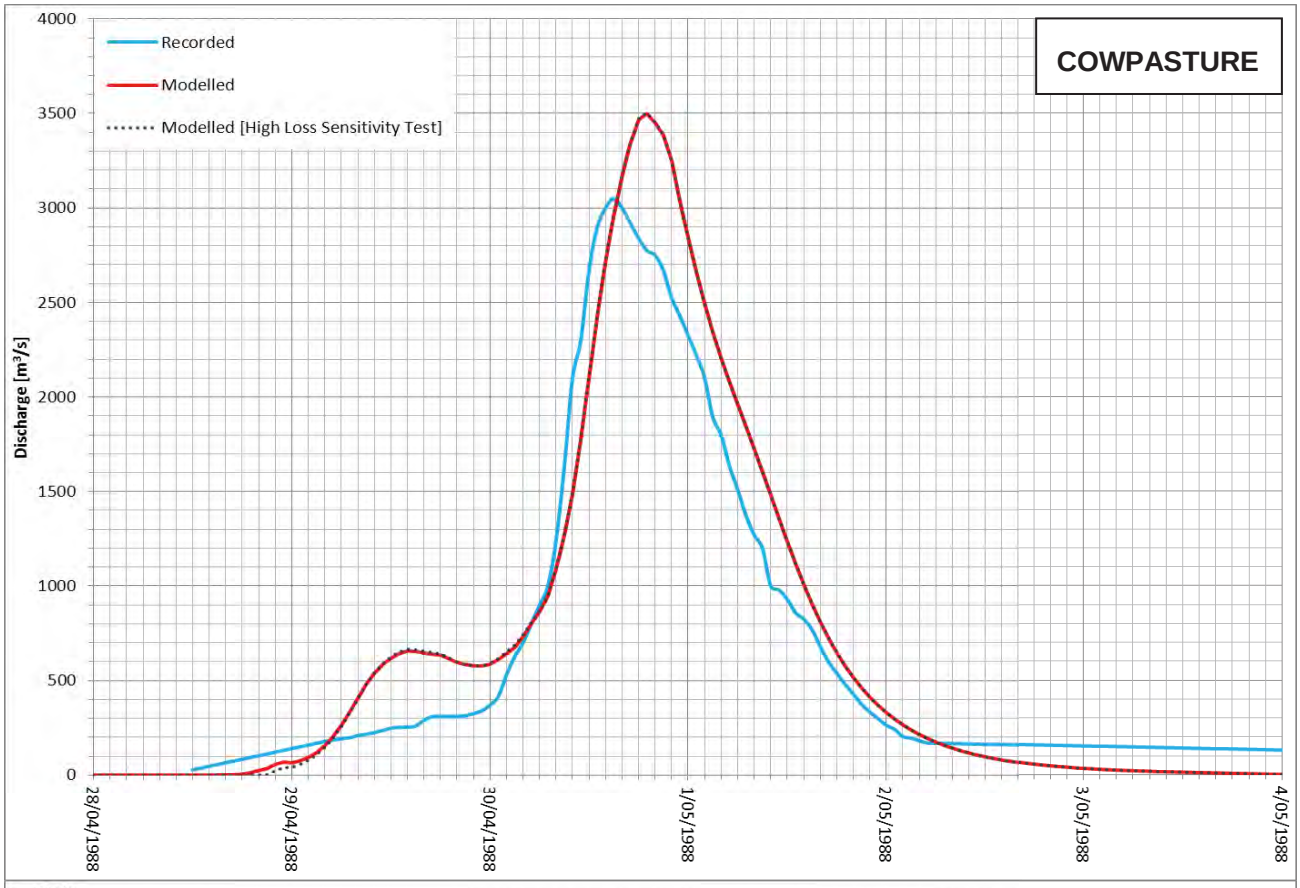
MARCH 1978 FLOOD EVENT

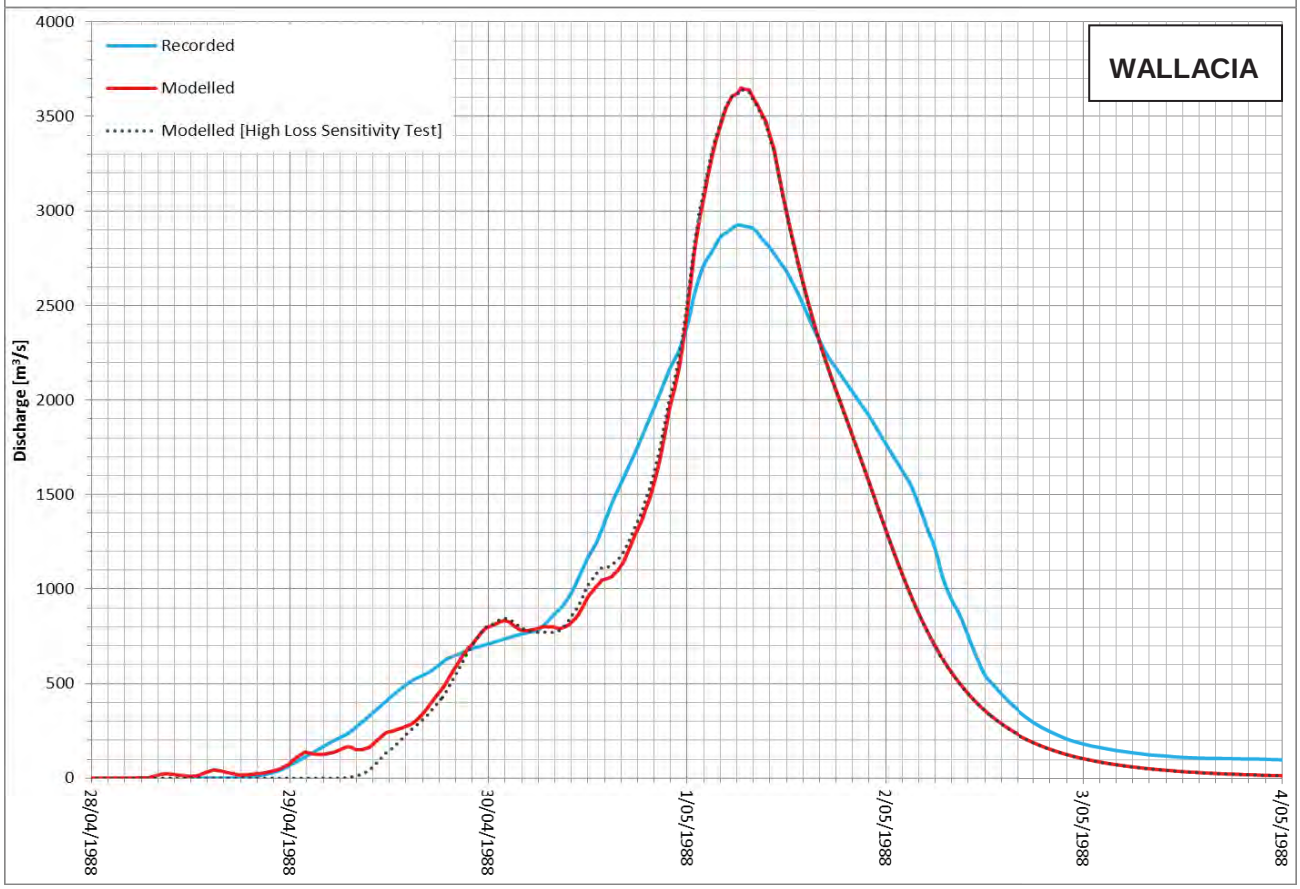




CAMDEN COUNCIL
NEPEAN RIVER FLOOD STUDY

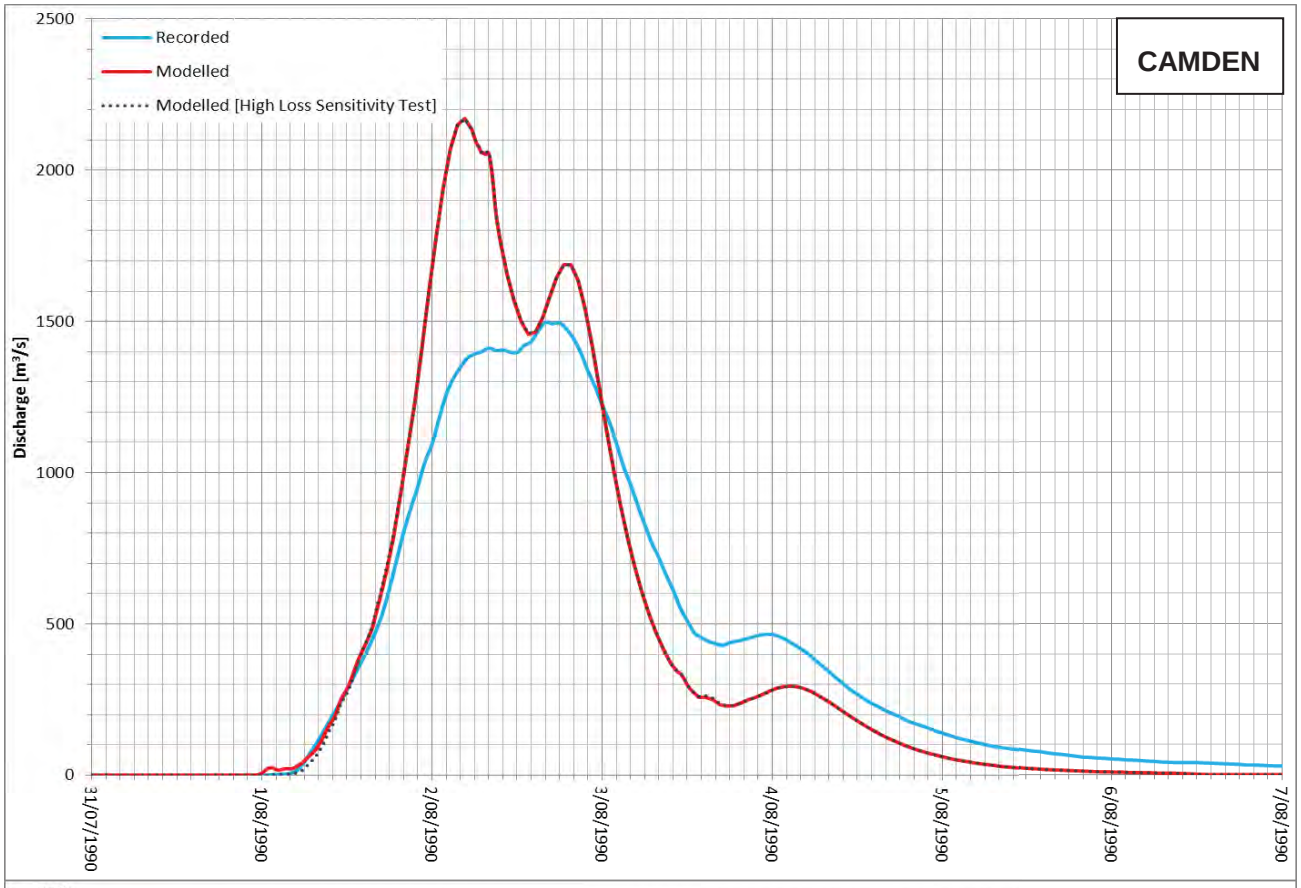
APRIL1988 FLOOD EVENT

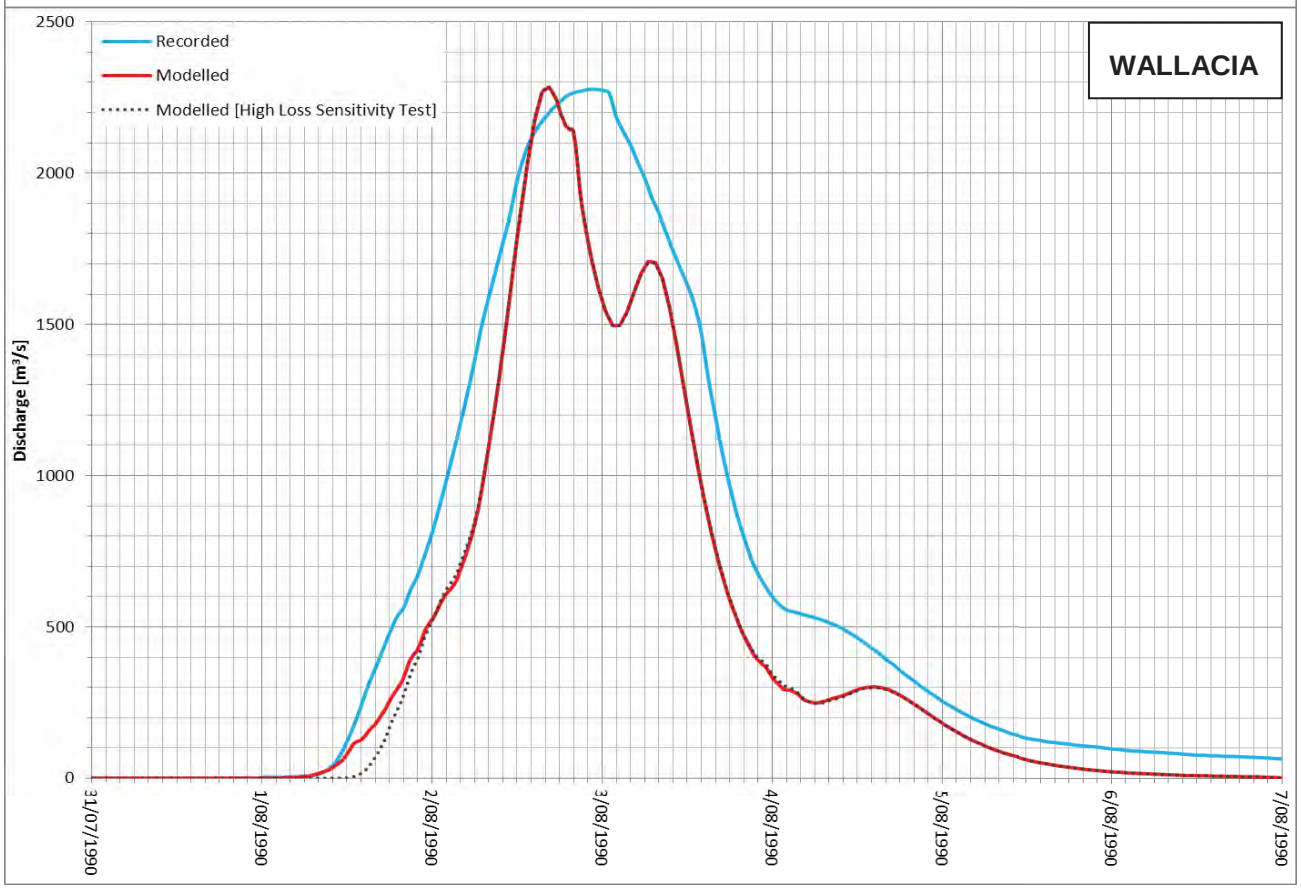




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AUGUST 1990 FLOOD EVENT

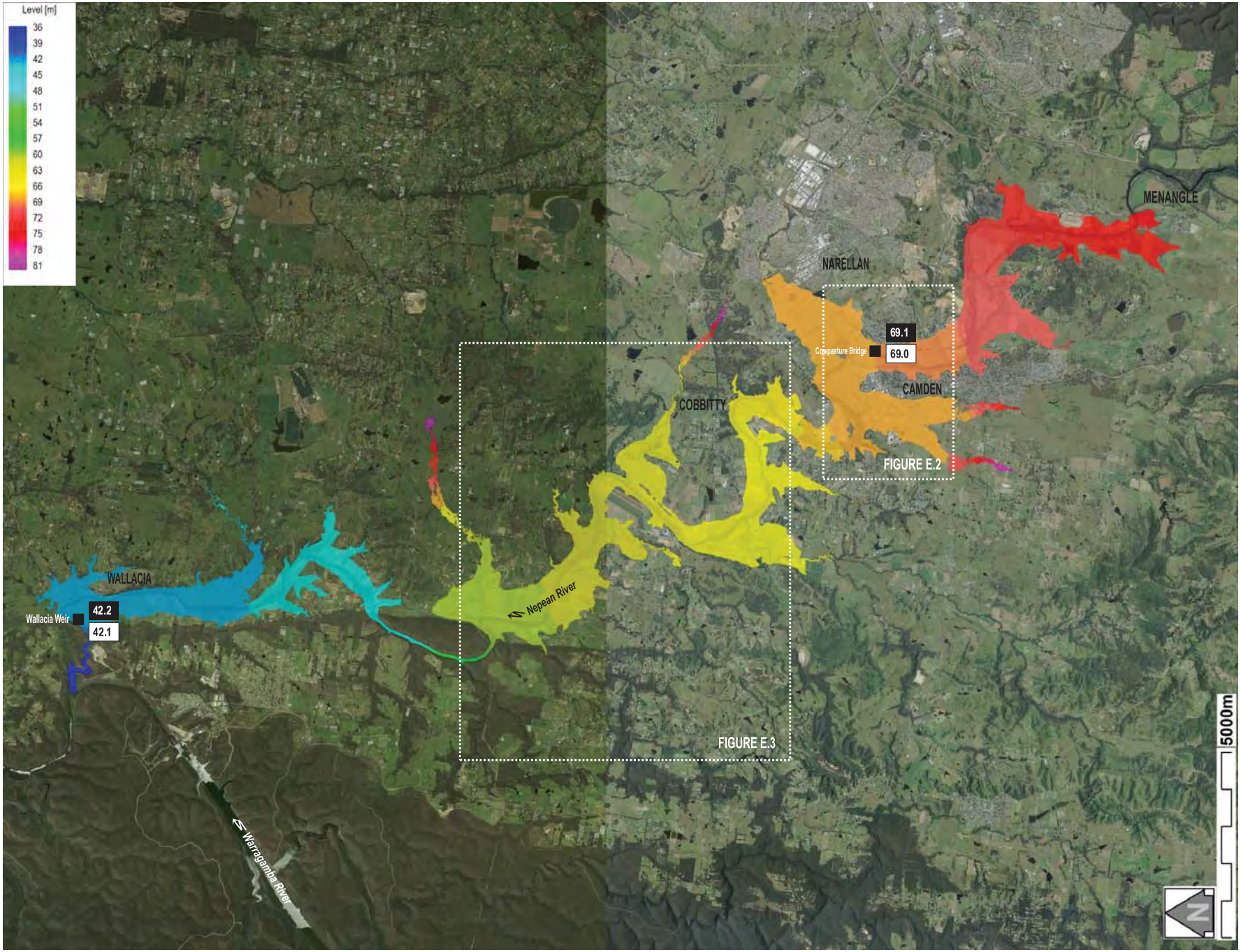




APPENDIX E

SUMMARY OF TUFLOW MODEL CALIBRATION

FIGURE E.1



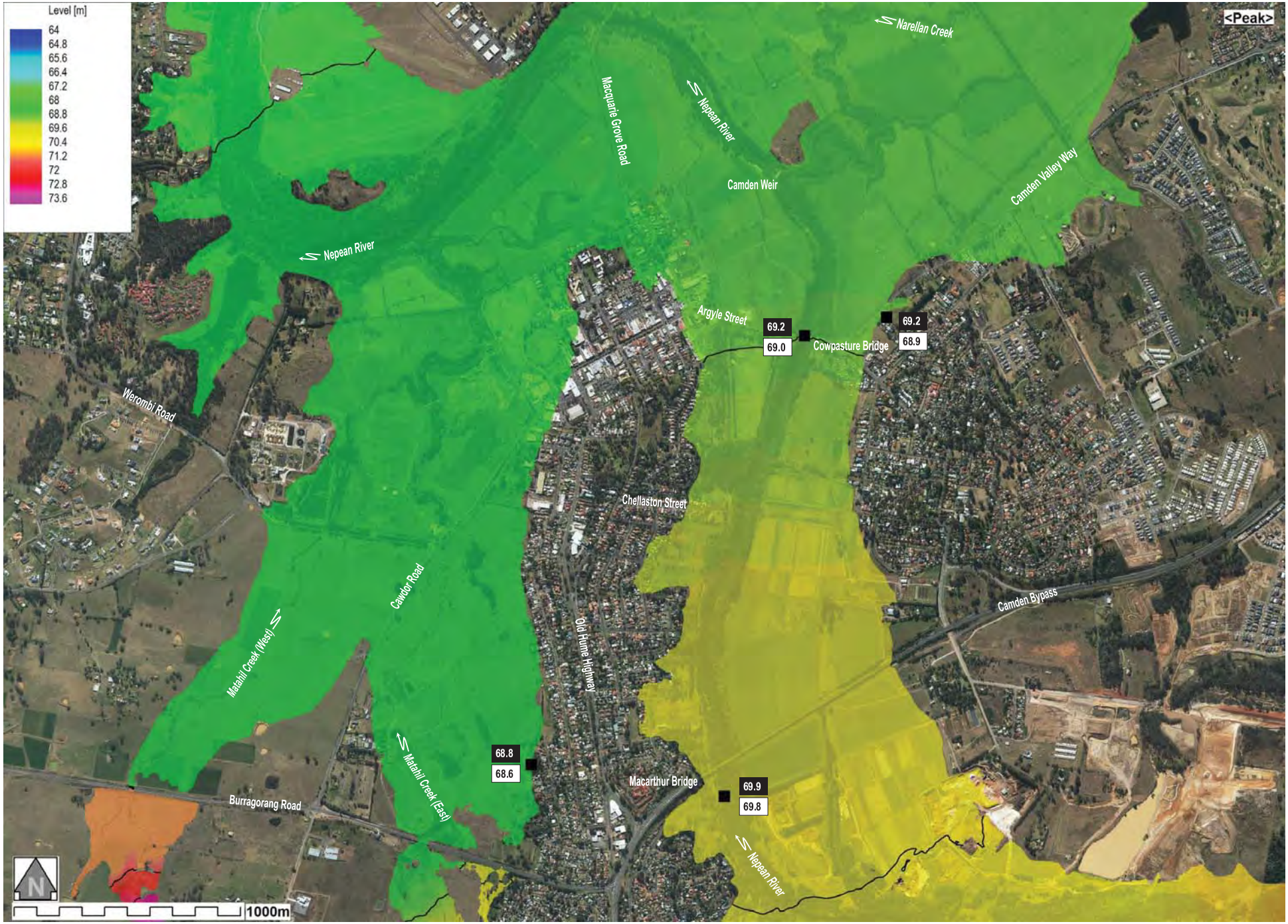
LEGEND:

- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

WorleyParsons
resources & energy

MODELLED FLOOD LEVELS AT THE PEAK OF THE 1978 EVENT

FIGURE E.2



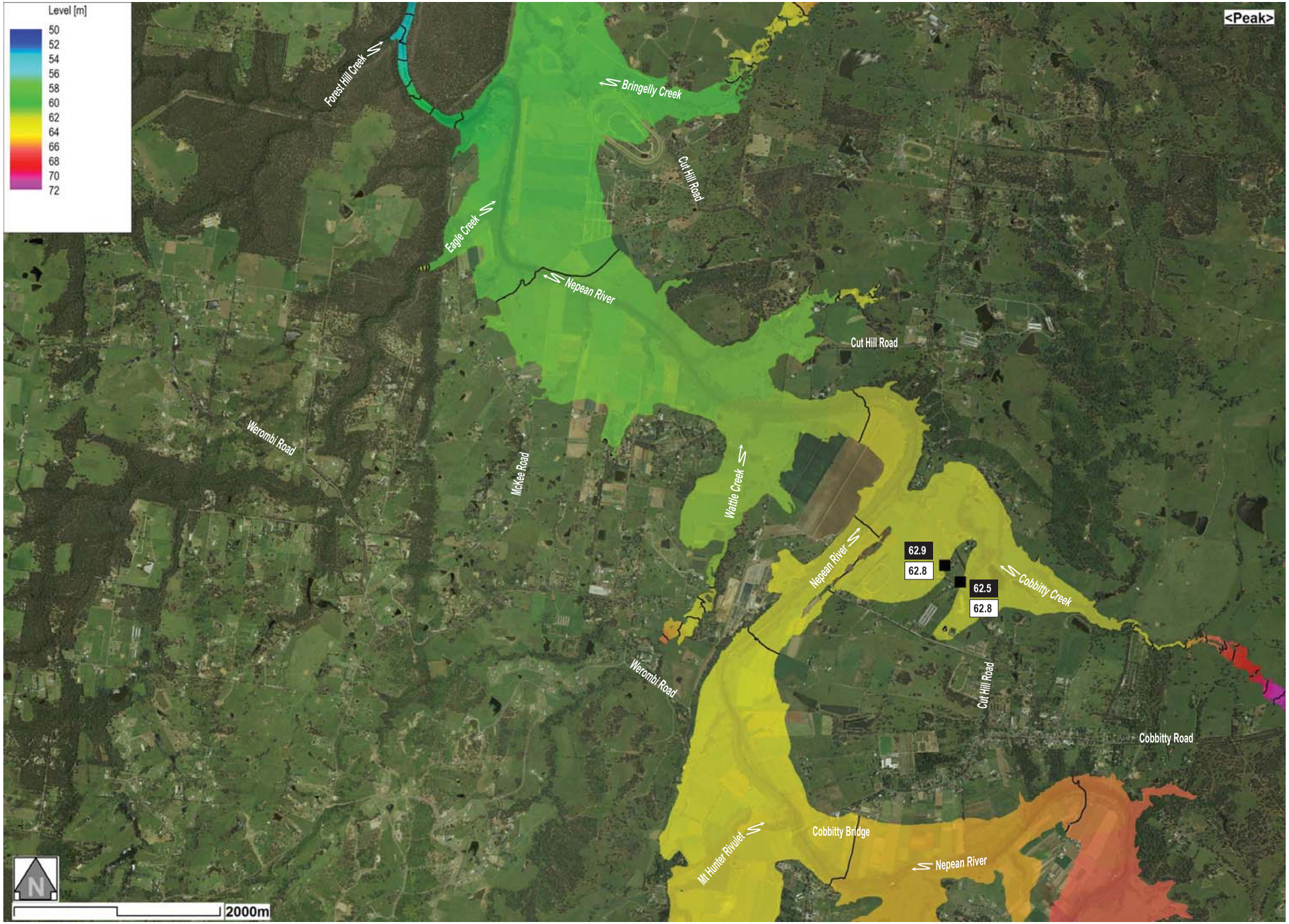
LEGEND:

- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

WorleyParsons
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COMPARISON OF MODELLED & OBSERVED FLOOD LEVELS AT THE PEAK OF THE 1978 EVENT (CAMDEN)

FIGURE E.3



LEGEND:

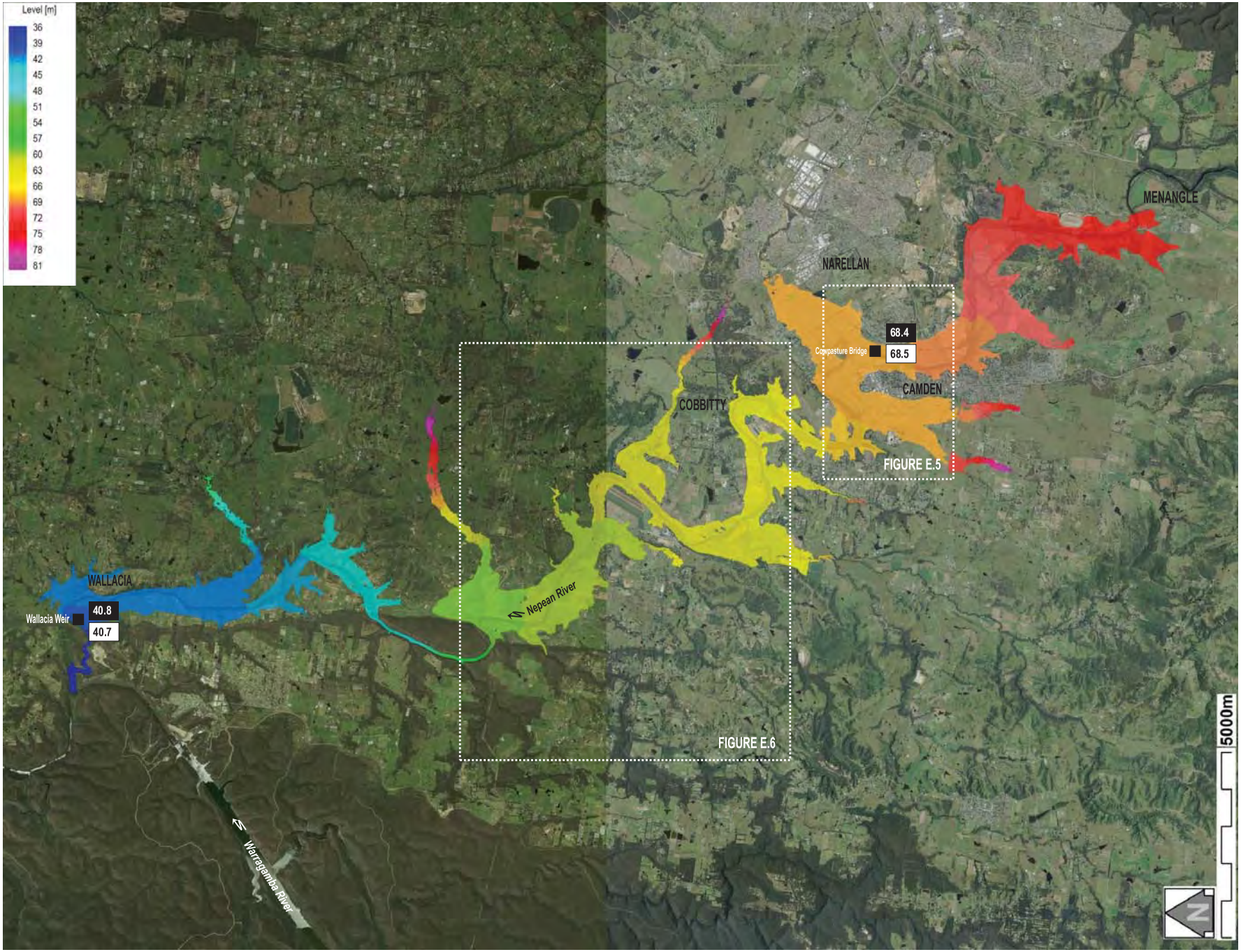
- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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COMPARISON OF MODELLED & OBSERVED FLOOD LEVELS AT THE PEAK OF THE 1978 EVENT (COBBITTY)

FIGURE E.4



LEGEND:

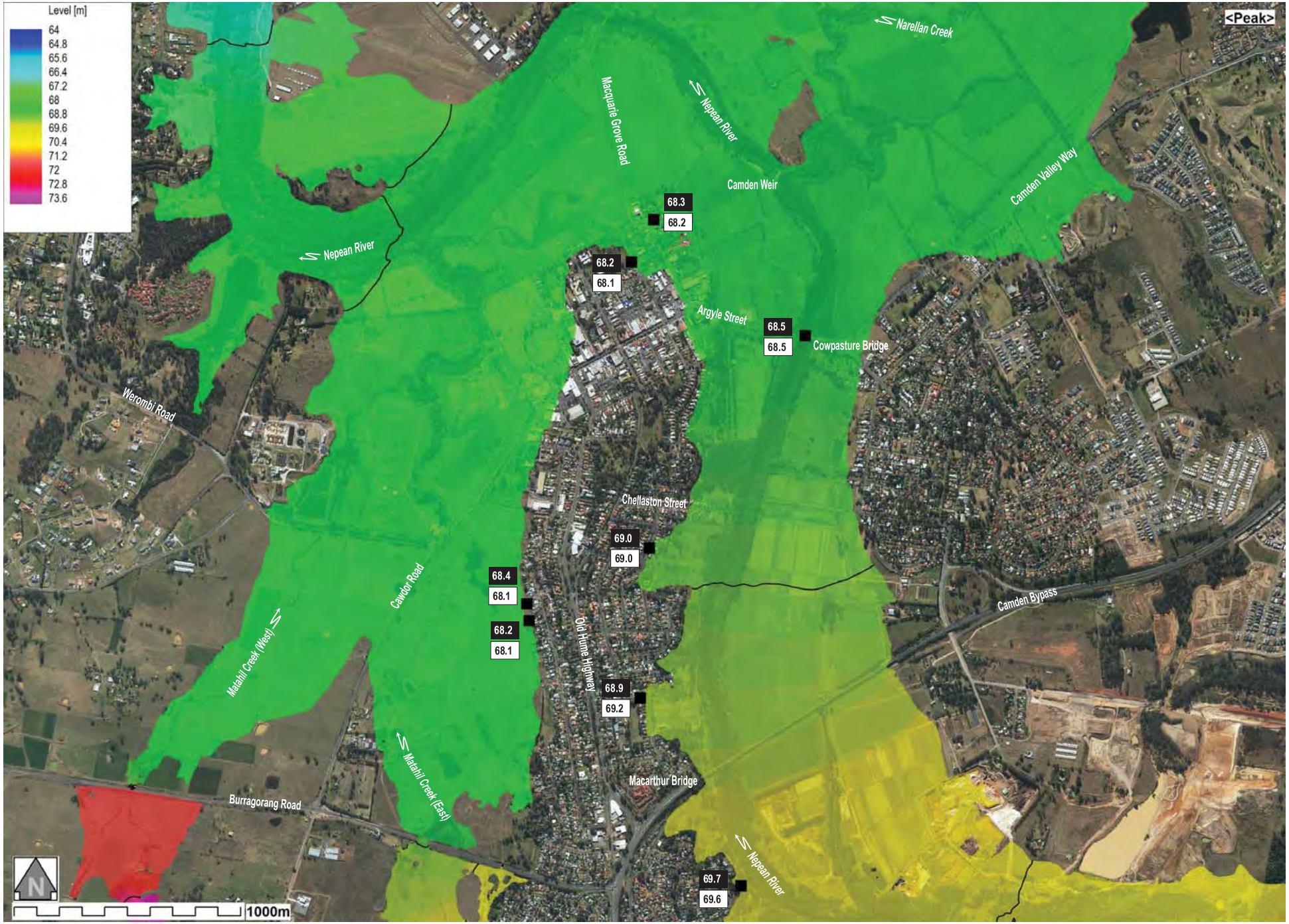
- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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301015-03107 – Nepean River Flood Study
E.04_fg301015-03107nm130628-1988 Overview.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 1988 EVENT

FIGURE E.5



LEGEND:

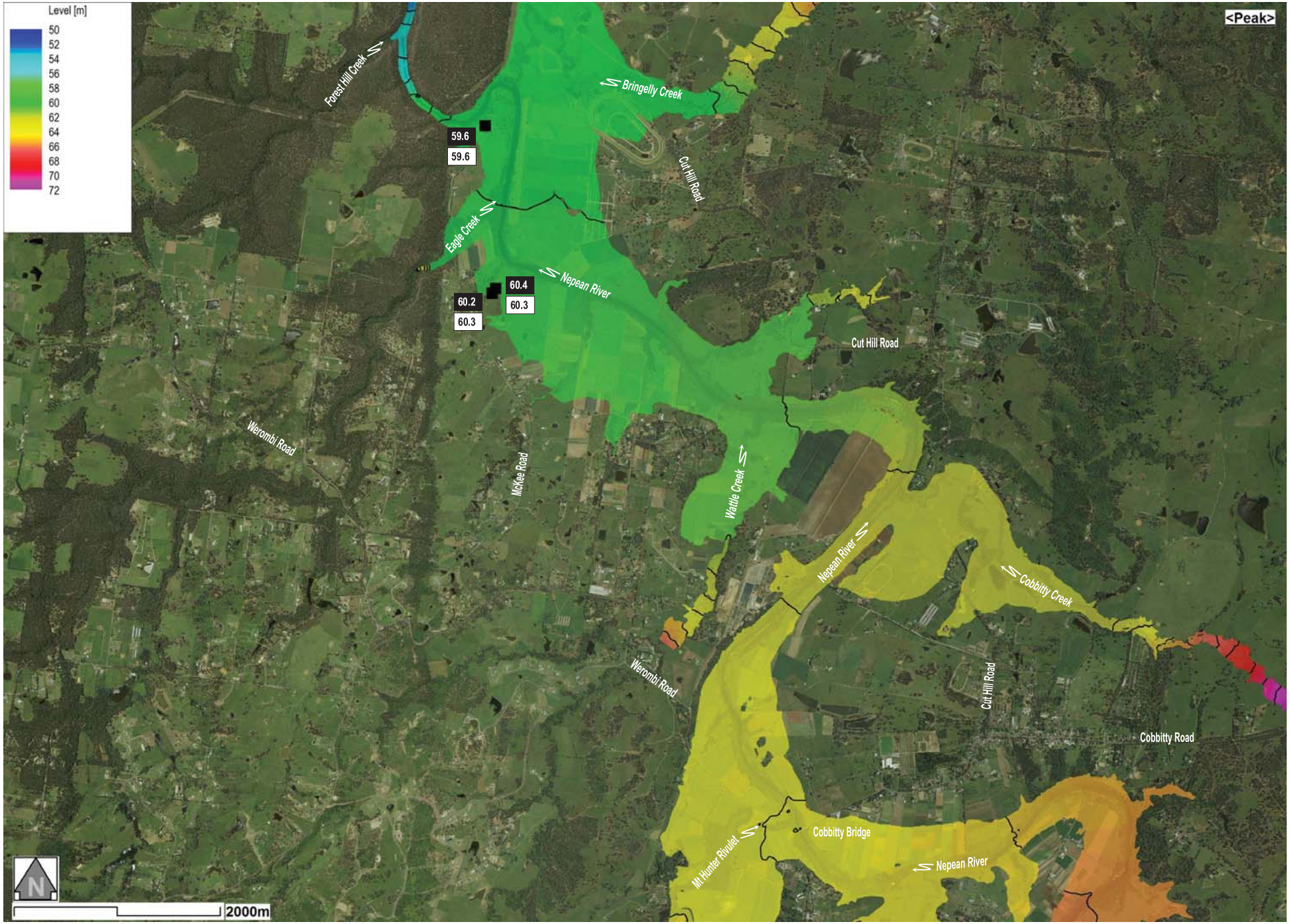
- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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301015-03107 – Nepean River Flood Study (Camden Council)
E.05_fg301015-03107nm130712-Camden Cali 1988.doc

COMPARISON OF MODELLED & OBSERVED FLOOD LEVELS AT THE PEAK OF THE 1988 EVENT (CAMDEN)

FIGURE E.6



LEGEND:

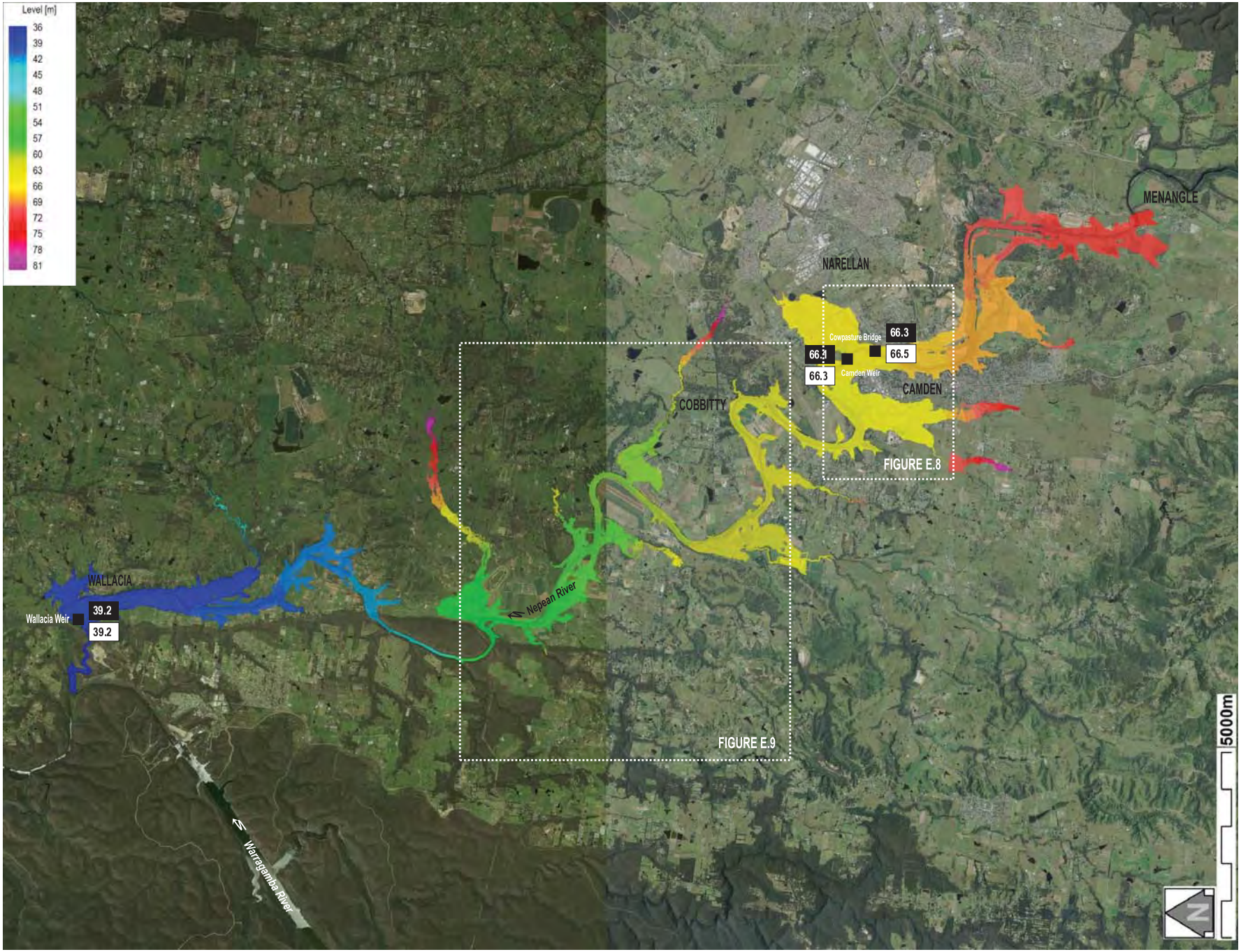
- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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301015-03107 – Nepean River Flood Study (Camden Council)
E.06_fg301015-03107nm130611-Cobbitty Cali 1988.doc

COMPARISON OF MODELLED & OBSERVED FLOOD LEVELS AT THE PEAK OF THE 1988 EVENT (COBBITTY)

FIGURE E.7



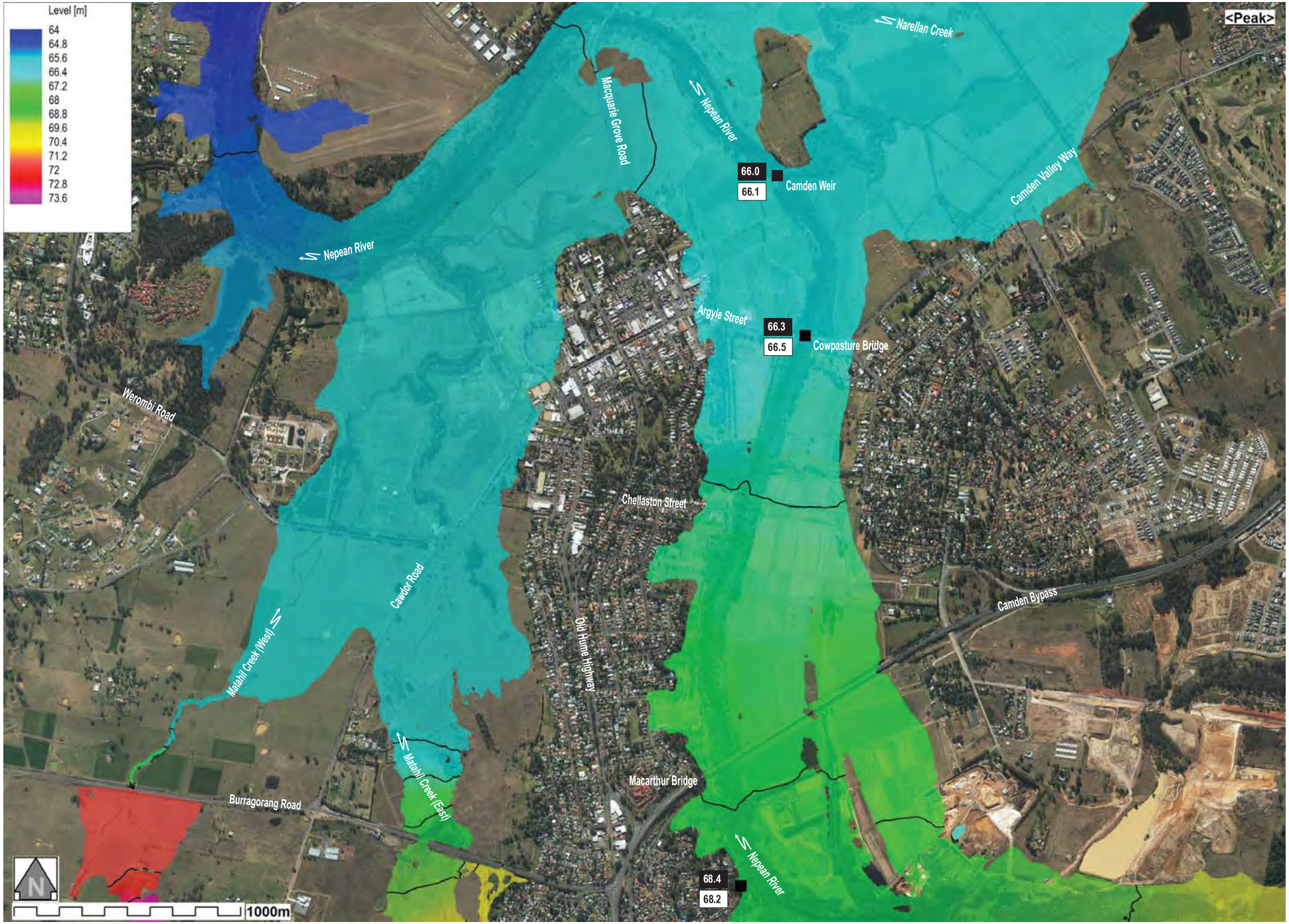
LEGEND:

- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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MODELLED FLOOD LEVELS AT THE PEAK OF THE 1990 EVENT

FIGURE E.8



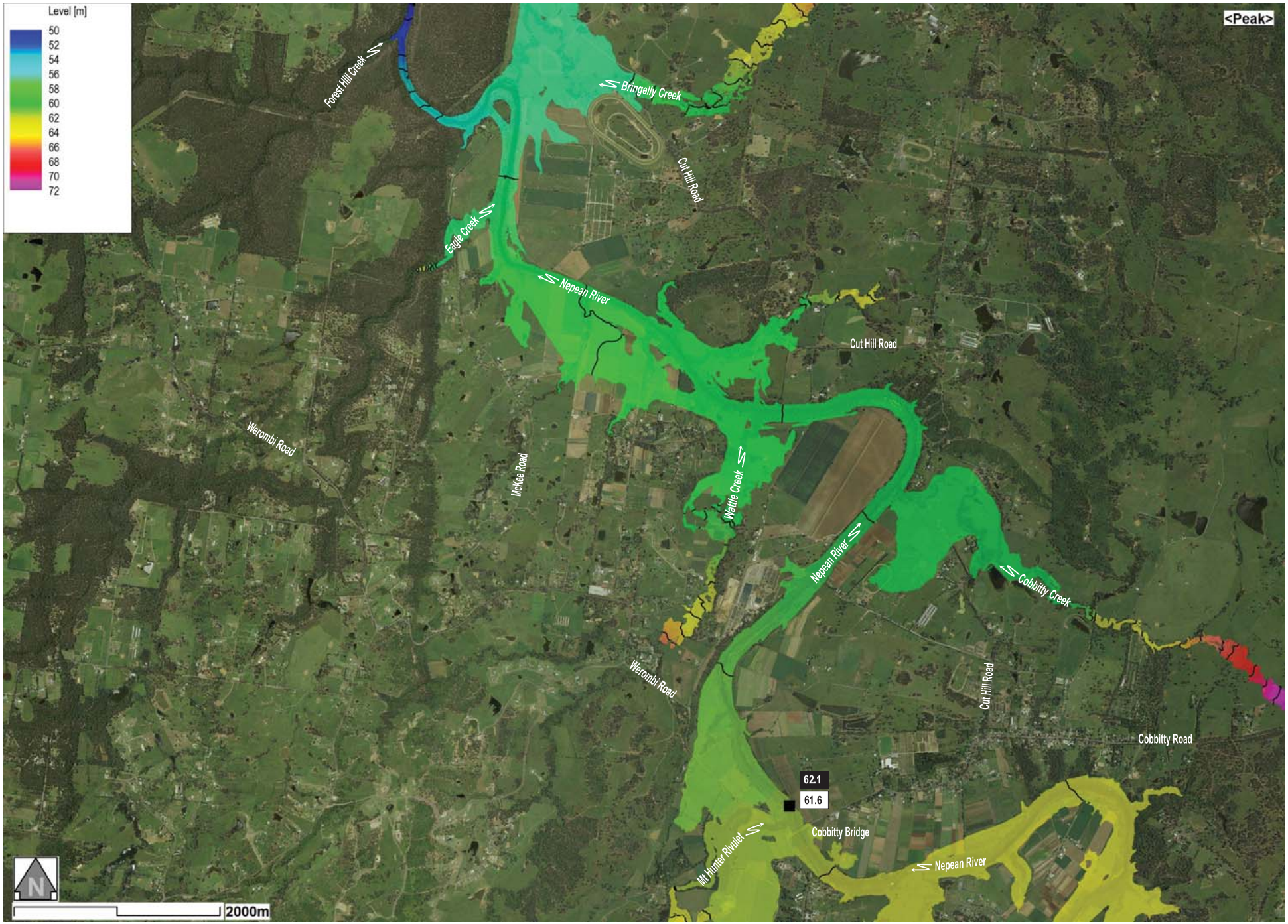
LEGEND:

- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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COMPARISON OF MODELLED & OBSERVED FLOOD LEVELS AT THE PEAK OF THE 1990 EVENT (CAMDEN)

FIGURE E.9



LEGEND:

- Observed level location
- 99.9 Observed peak stream level [mAHD]
- 99.9 Modelled peak stream level [mAHD]

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COMPARISON OF MODELLED & OBSERVED FLOOD LEVELS AT THE PEAK OF THE 1990 EVENT (COBBITTY)

APPENDIX F

NOTES ON PROBABILITY TERMINOLOGY FOR DESIGN EVENTS

A draft discussion paper prepared as part of the current Australian Rainfall & Runoff revision project attempts to clarify the terminology currently in use and that proposed for future use (*Engineers Australia, 2013*).

The range of available terminology is shown **Table F.1** below. The terminology preferred by the National Committee on Water Engineering and the National Flood Risk Advisory Group (*NFRAG*) is highlighted in green. Annual Exceedance Probability (*AEP*) has been adopted as the preferred terminology for this study. Despite the minor discrepancies in probability shown below, the adopted 50% and 20% AEP events are assumed to be equivalent to the 2 and 5 year ARI events, respectively (*and to the 0.5 and 0.2 EY*).

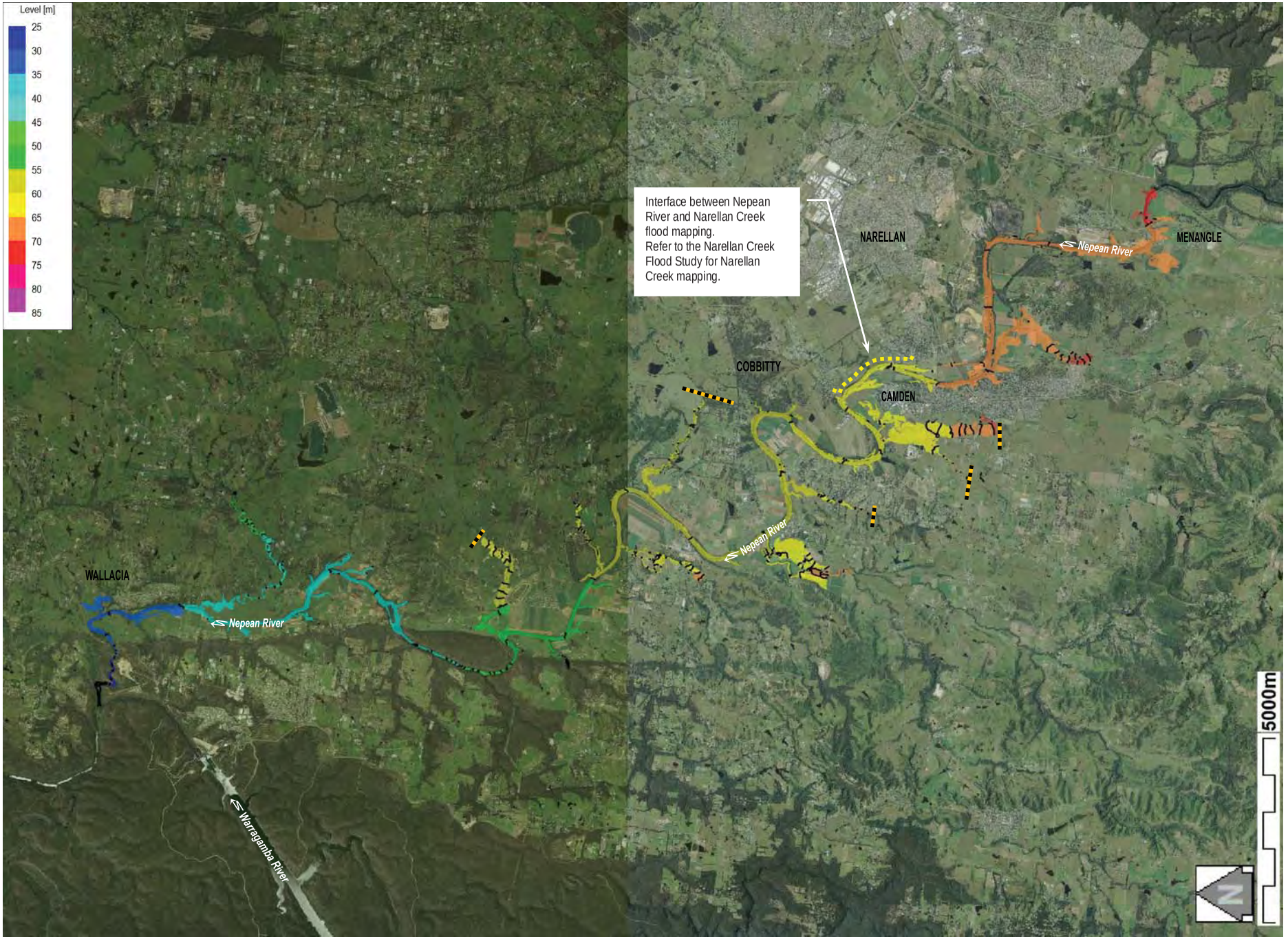
Table F.1 COMPARISON OF COMMON FLOOD PROBABILITY TERMINOLOGY

EXCEEDANCES PER YEAR (*EY*)	ANNUAL EXCEEDANCE PROBABILITY (*AEP %*)	ANNUAL EXCEEDANCE PROBABILITY (*1 in X*)	AVERAGE RECURRENCE INTERVAL (*ARI*)
6	99.75	1.002	0.17
4	98.17	1.02	0.25
3	95.02	1.05	0.33
2	86.47	1.16	0.5
1	63.21	1.58	1
0.69	**50**	2	1.44
0.5	39.35	2.54	**2**
0.22	**20**	5	4.48
0.2	18.13	5.52	**5**
0.11	10	10	9.49
0.05	5	20	19.5
0.02	2	50	49.5
0.01	1	100	99.5
0.005	0.5	200	199.5
0.002	0.2	500	499.5
0.001	0.1	1000	999.5
0.0005	0.05	2000	1999.5
0.0002	0.02	5000	4999.5

APPENDIX G

FLOOD LEVEL MAPPING

FIGURE G.1



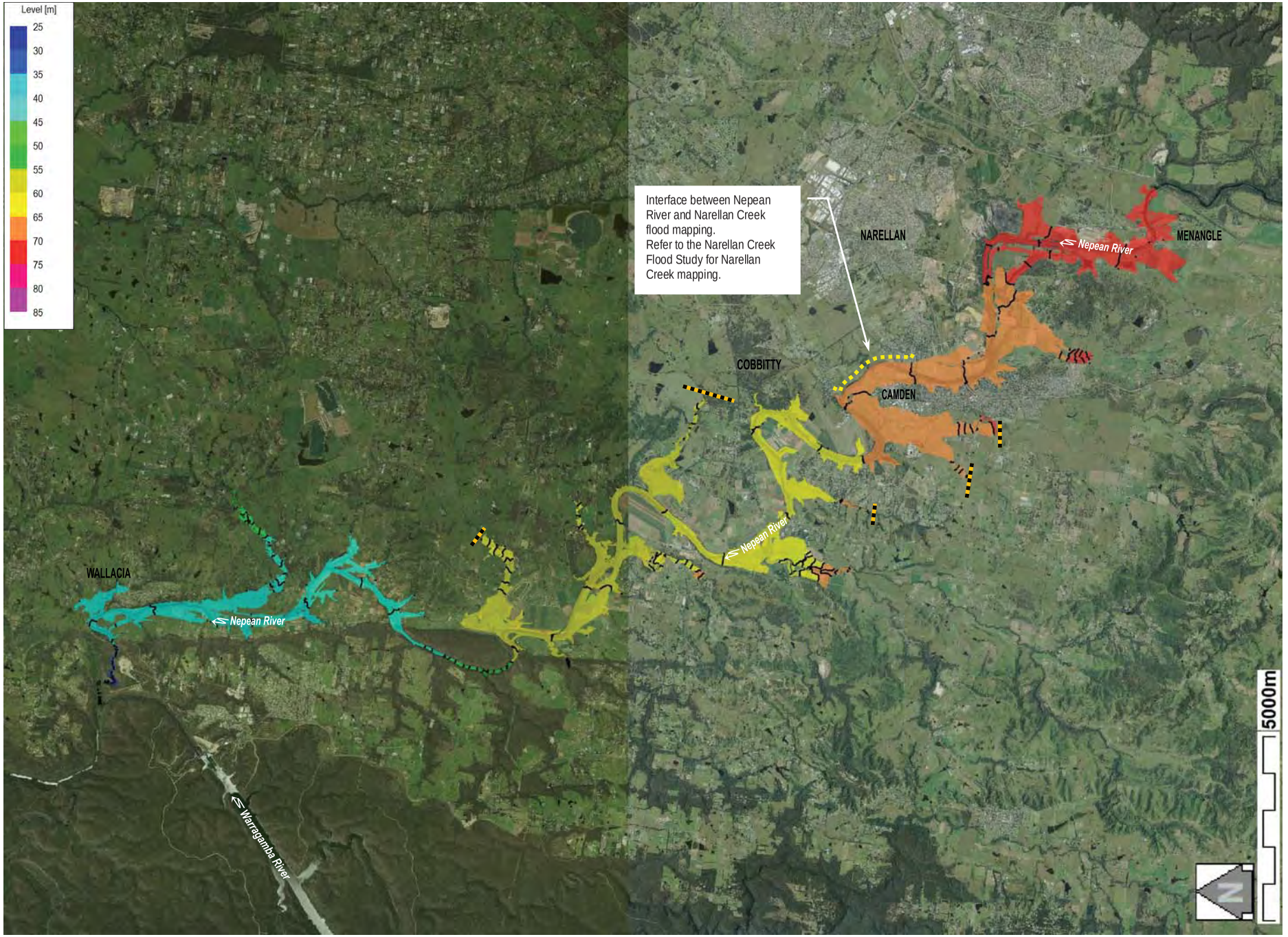
LEGEND:

- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD LEVELS AT THE PEAK OF THE 50% AEP EVENT

FIGURE G.2



LEGEND:

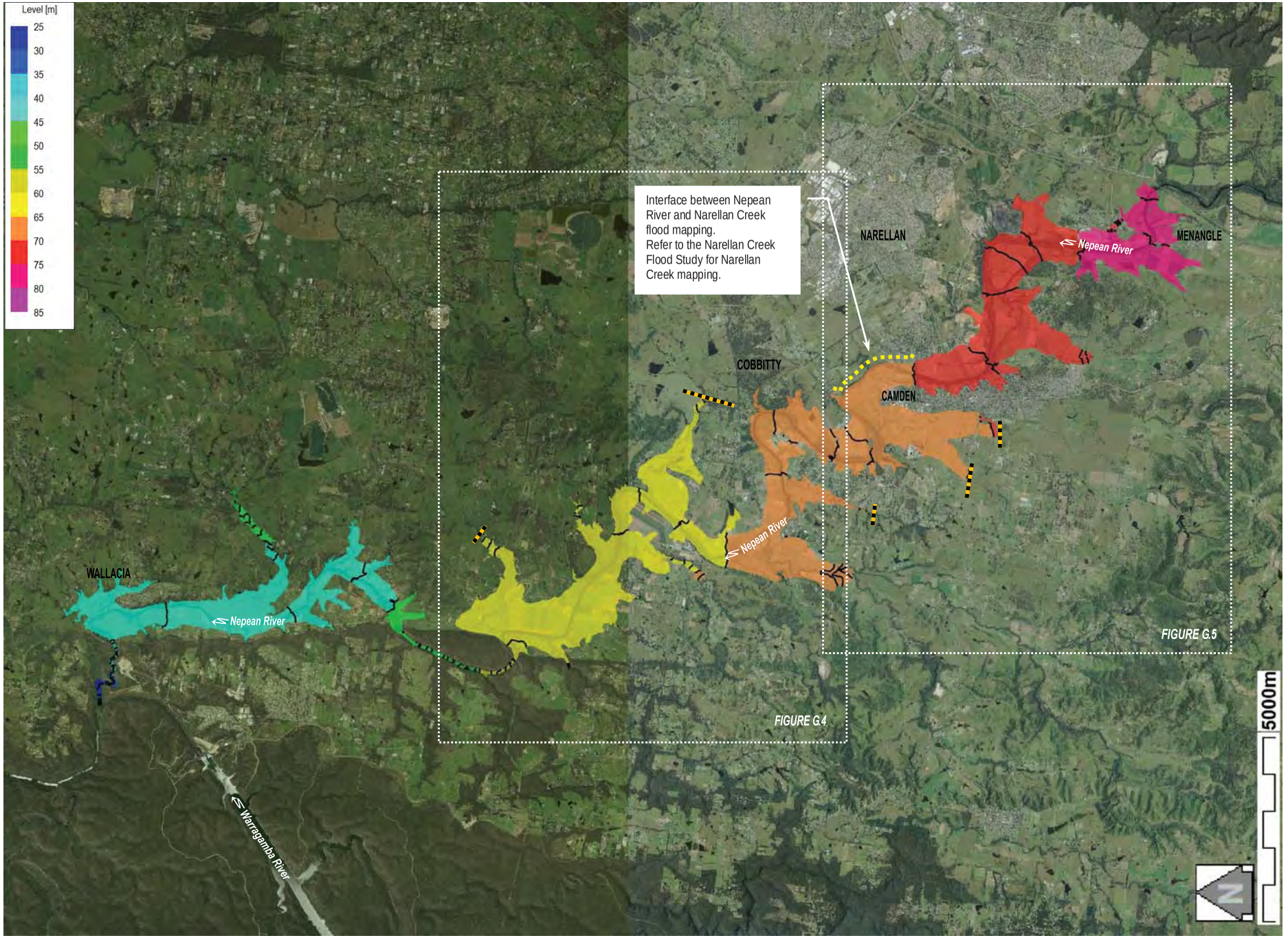
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study
G.02_fg301015-03107eh150326-Level_005yr_ALL.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 20% AEP EVENT

FIGURE G.3



LEGEND:

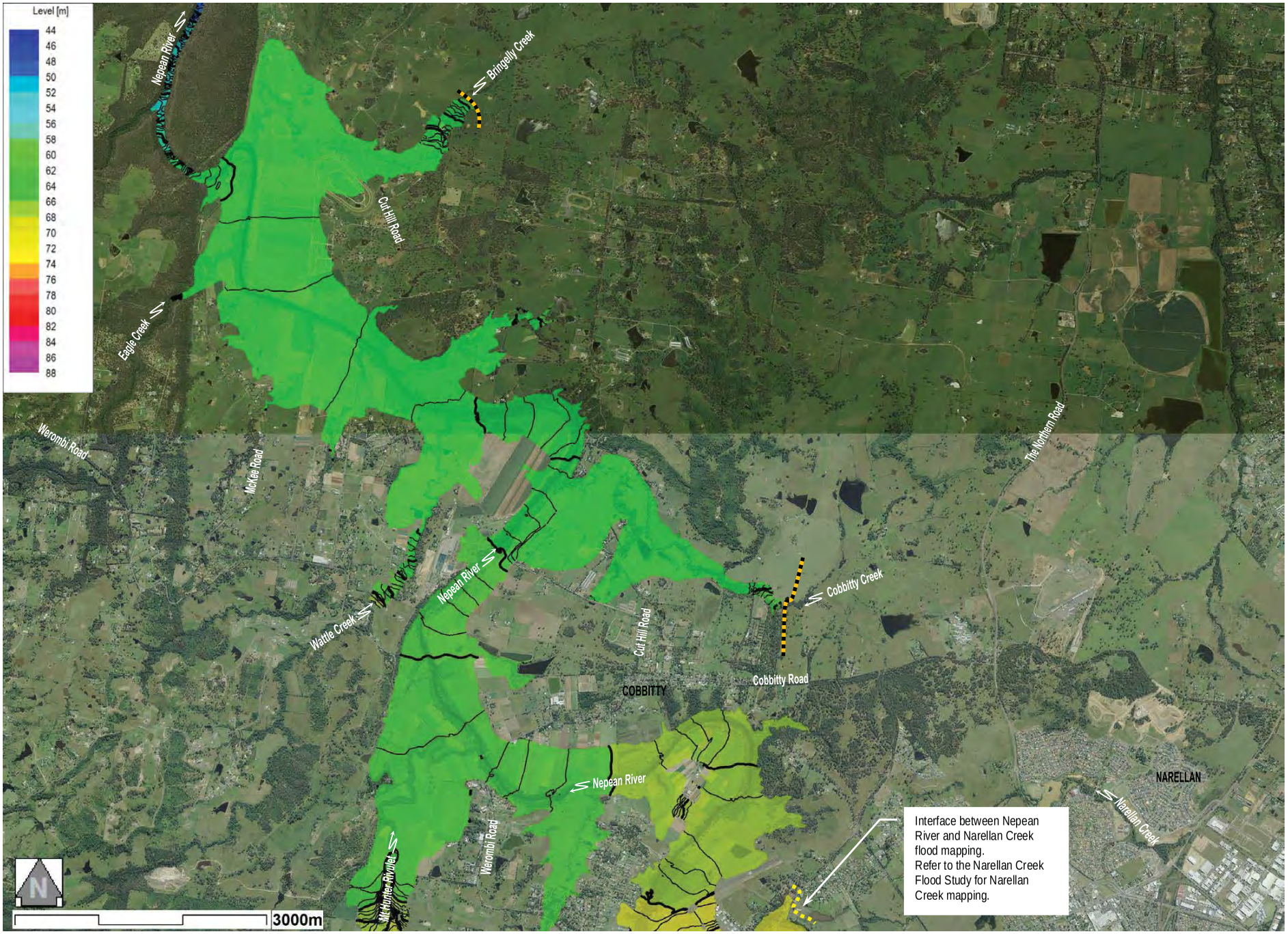
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study
G.03_fg301015-03107eh150326-Level_020yr_ALL.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 5% AEP EVENT

FIGURE G.4



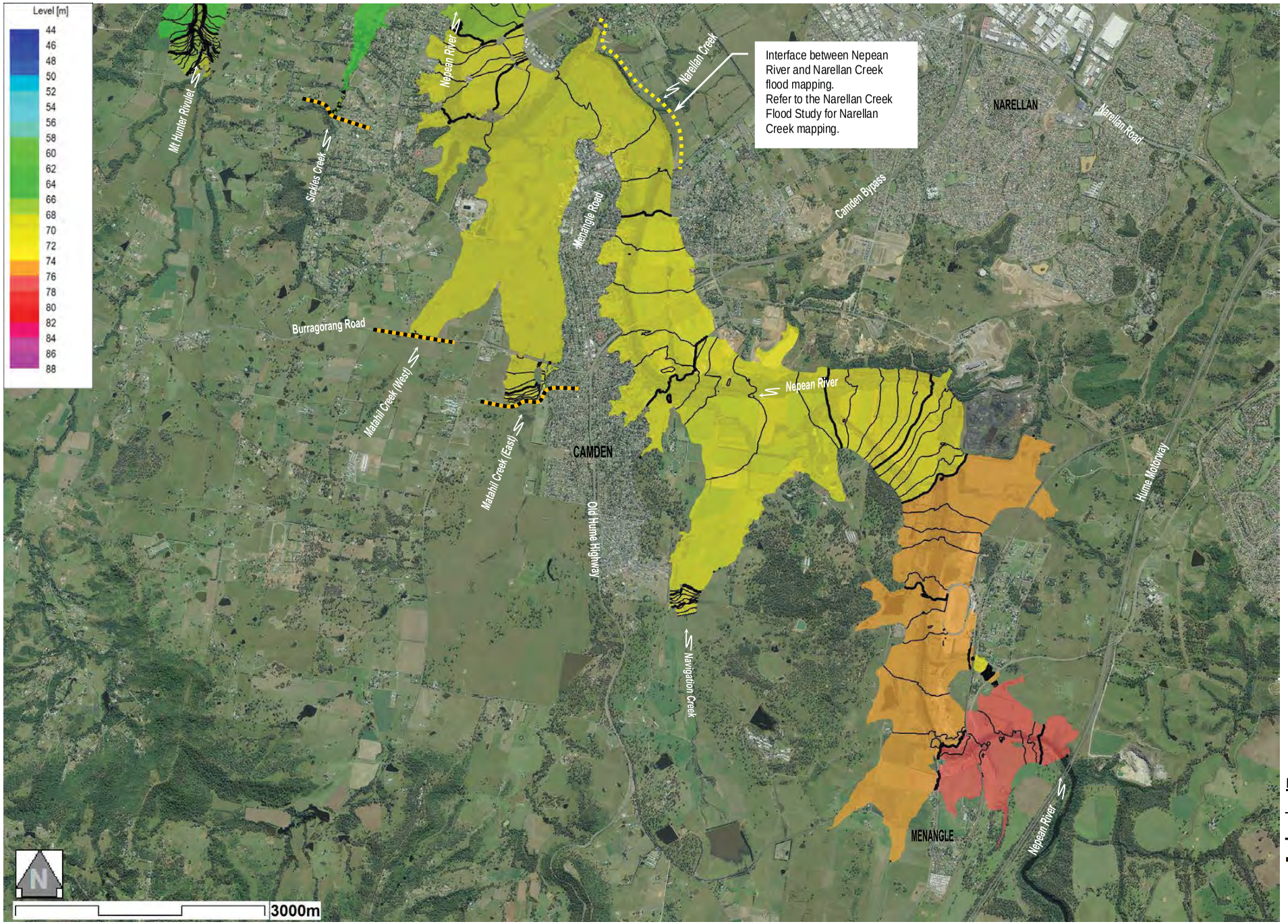
LEGEND:

- 0.2 metre contour line
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD LEVELS AT THE PEAK OF THE 5% AEP EVENT (NORTH)

FIGURE G.5



LEGEND:

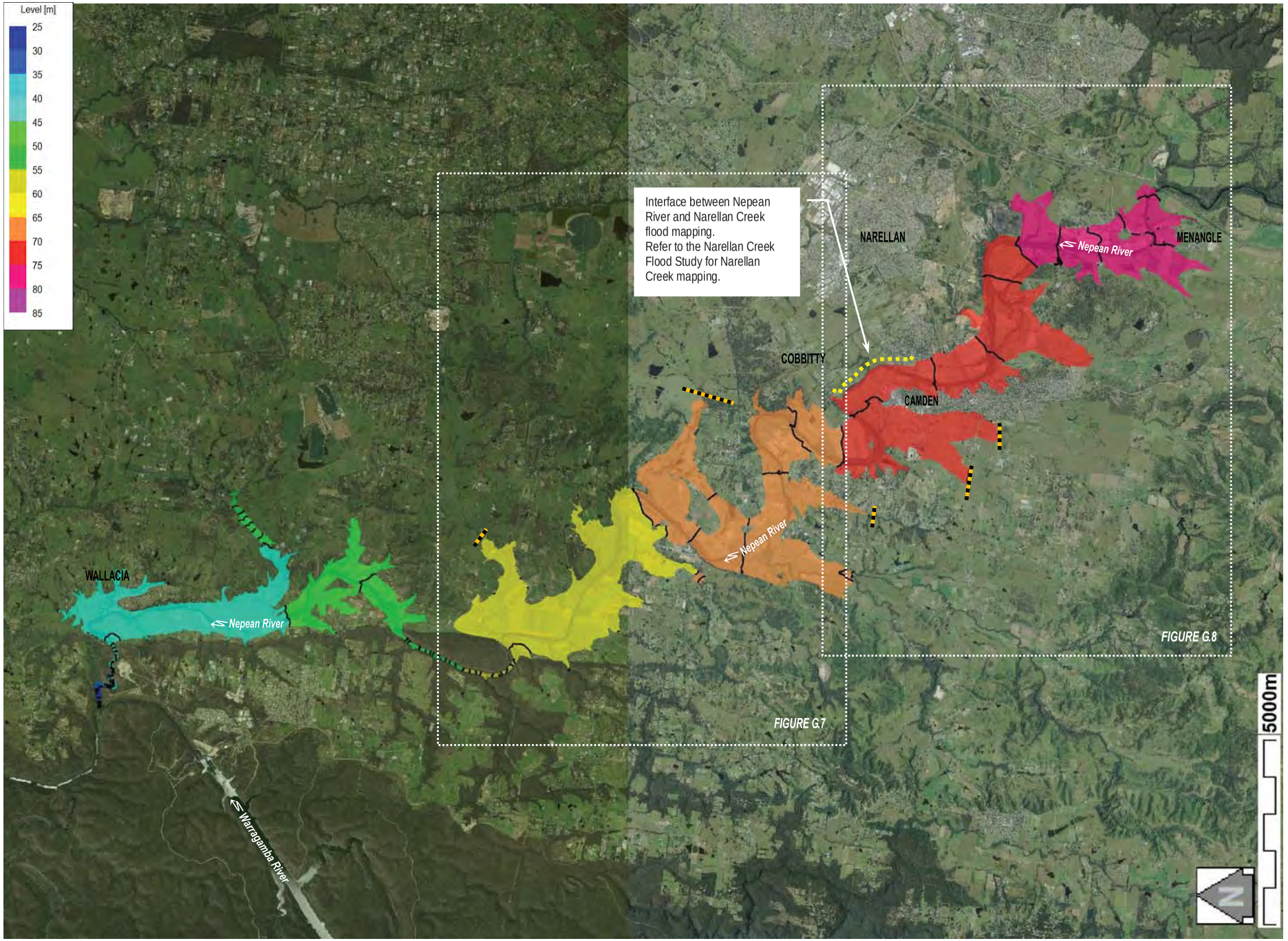
- 0.2 metre contour line
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
G.05_fg301015-03107nm_eh140625-Level_020yr_South.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 5% AEP EVENT (SOUTH)

FIGURE G.6



LEGEND:

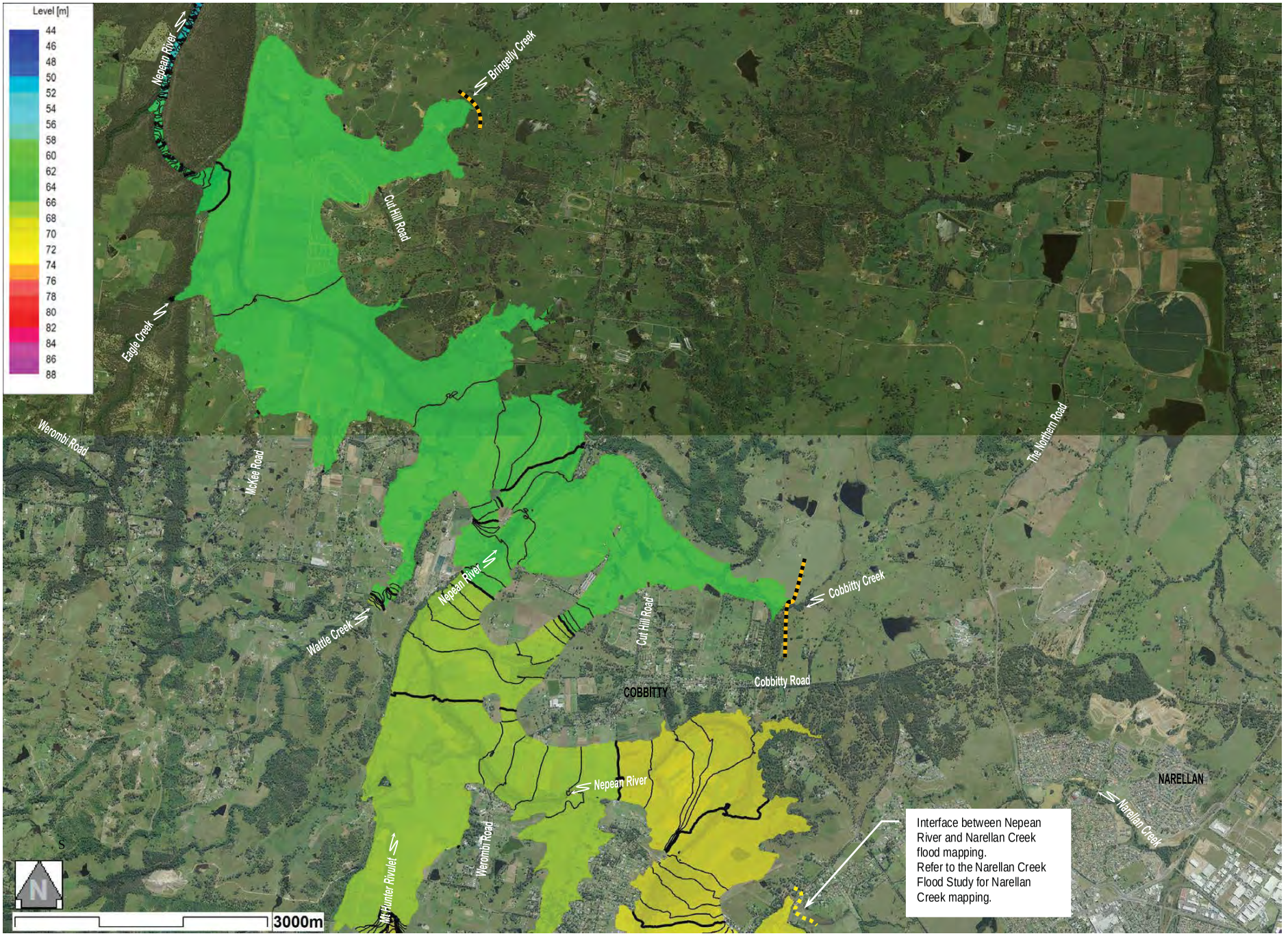
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study
G.06_fg301015-03107eh150325-Level_100yr_ALL.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 1% AEP EVENT

FIGURE G.7



LEGEND:

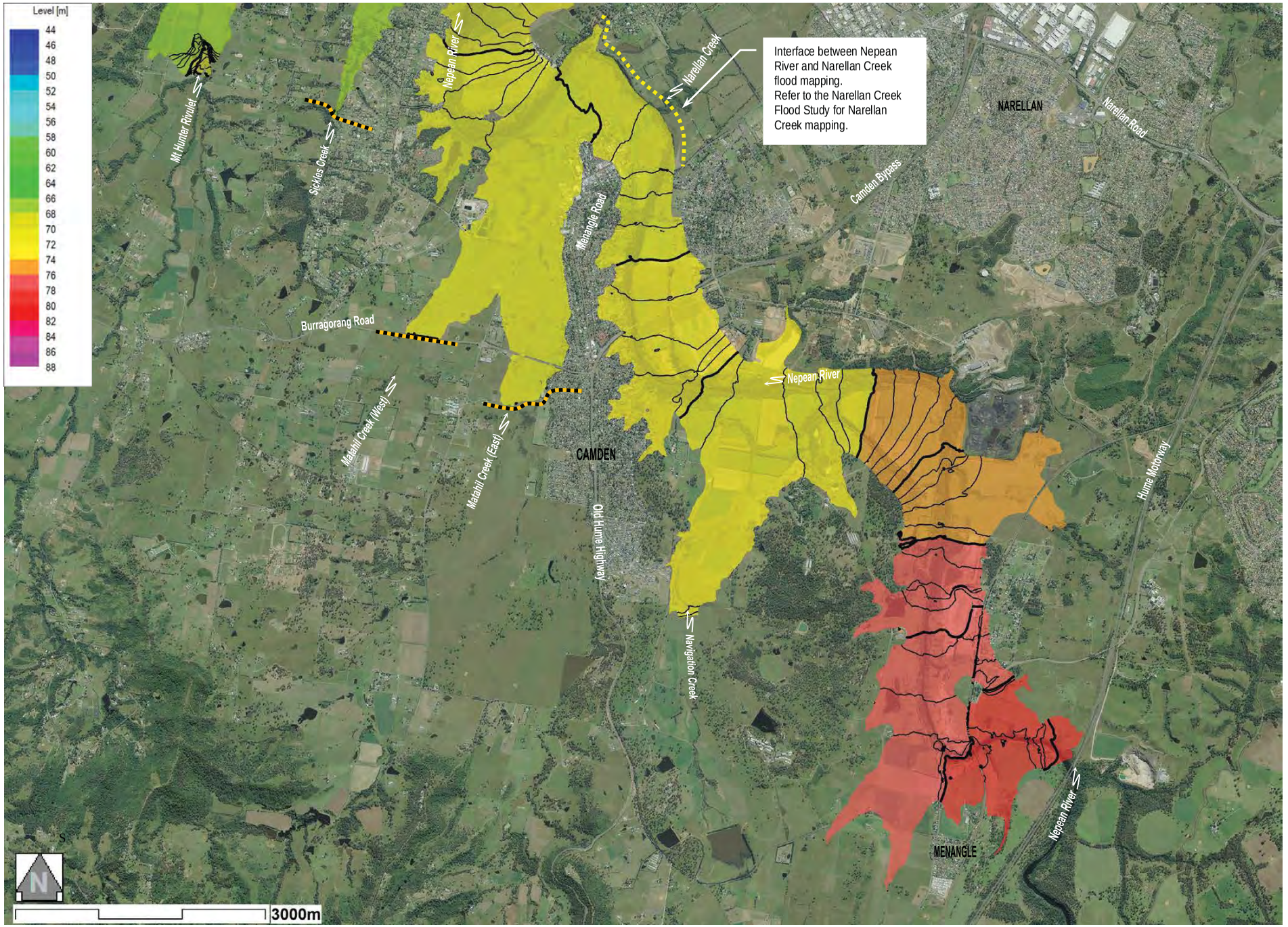
- 0.2 metre contour line
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
G.07_fg301015-03107eh150325-Level_100yr_North.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 1% AEP EVENT (NORTH)

FIGURE G.8



LEGEND:

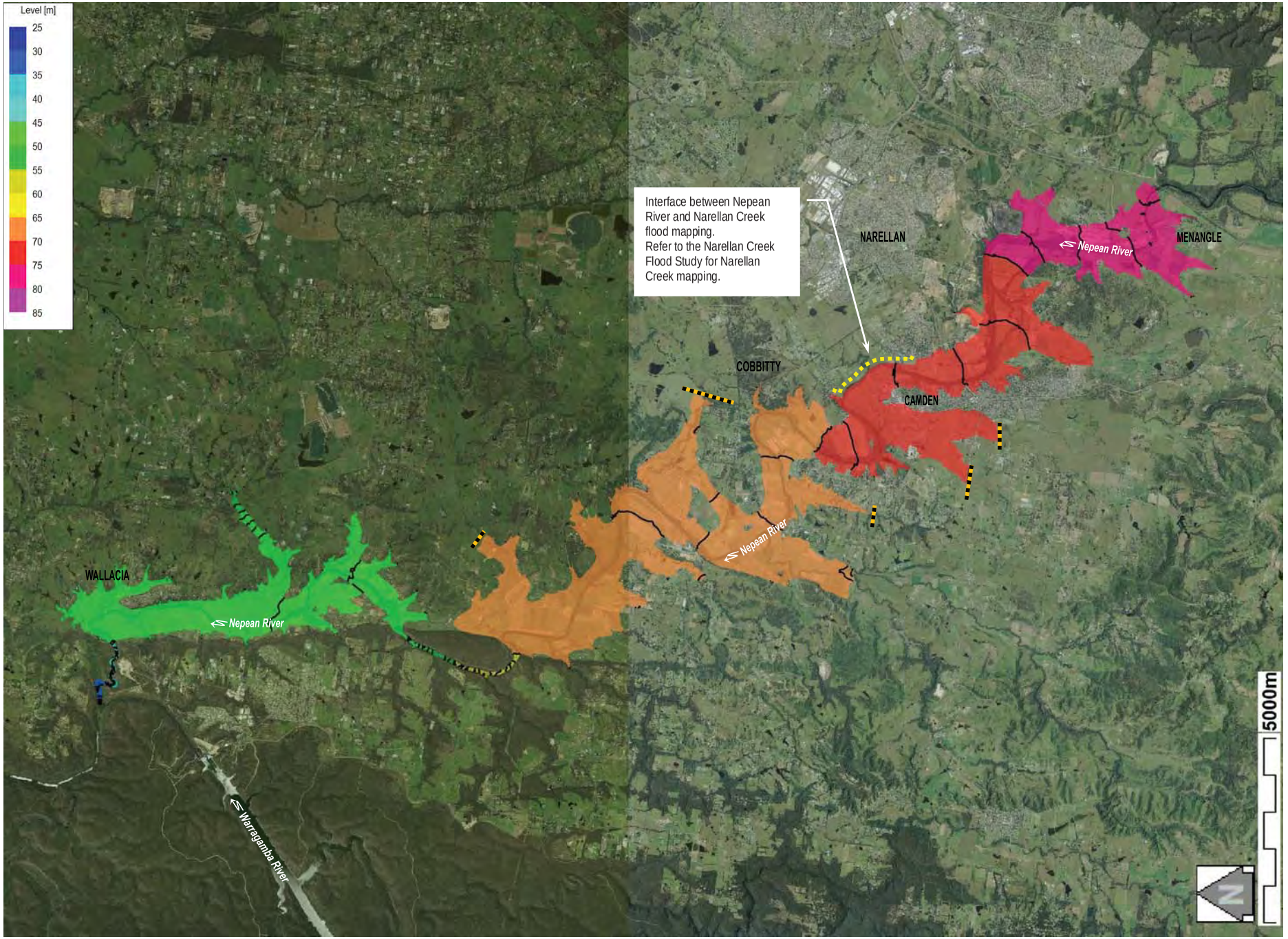
- 0.2 metre contour line
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
G.08_fg301015-03107eh150326-Level_100yr_South.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 1% AEP EVENT (SOUTH)

FIGURE G.9



LEGEND:

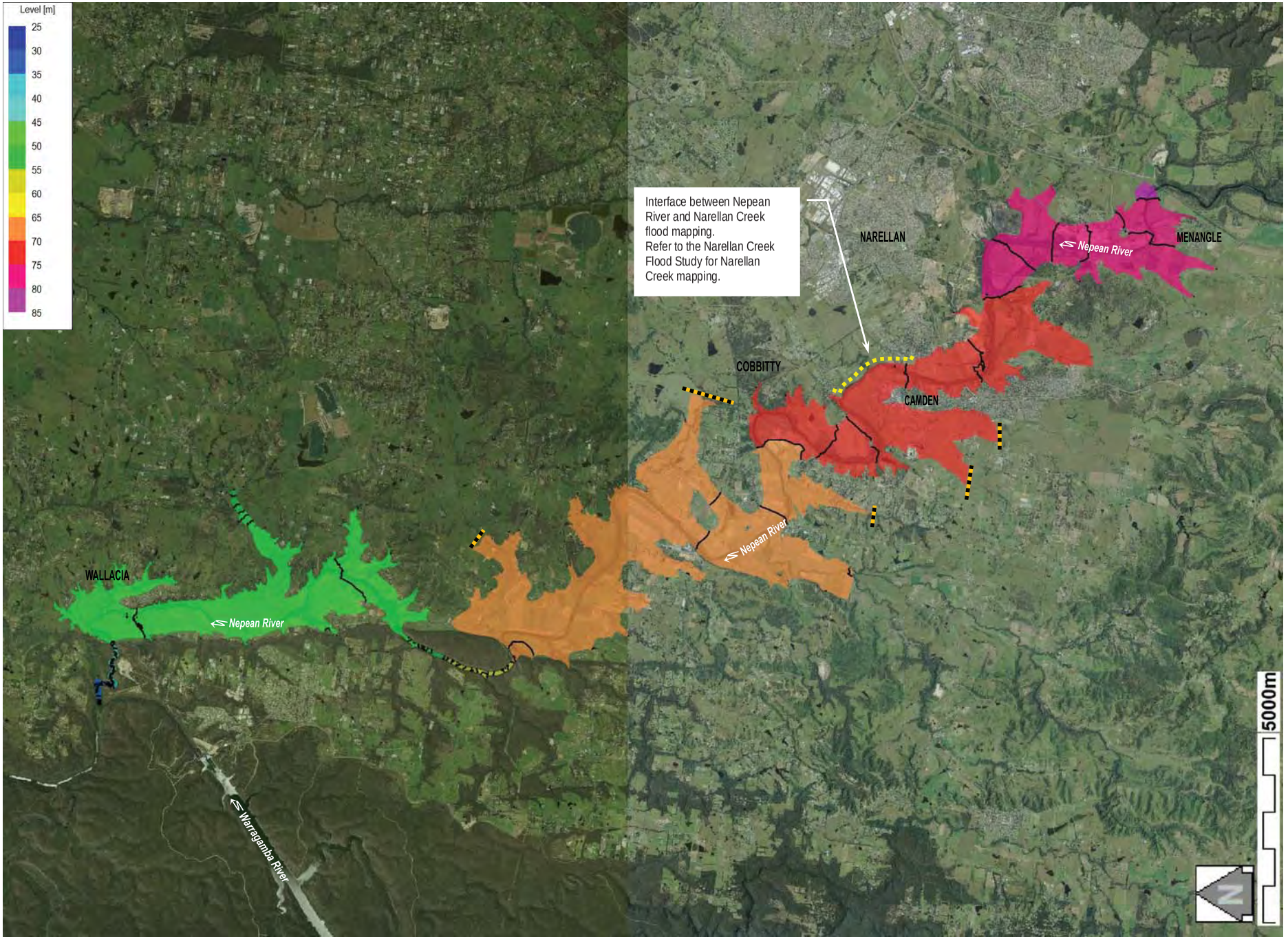
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study
G.09_fg301015-03107eh150325-Level_200yr_ALL.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE 0.5% AEP EVENT

FIGURE G.10



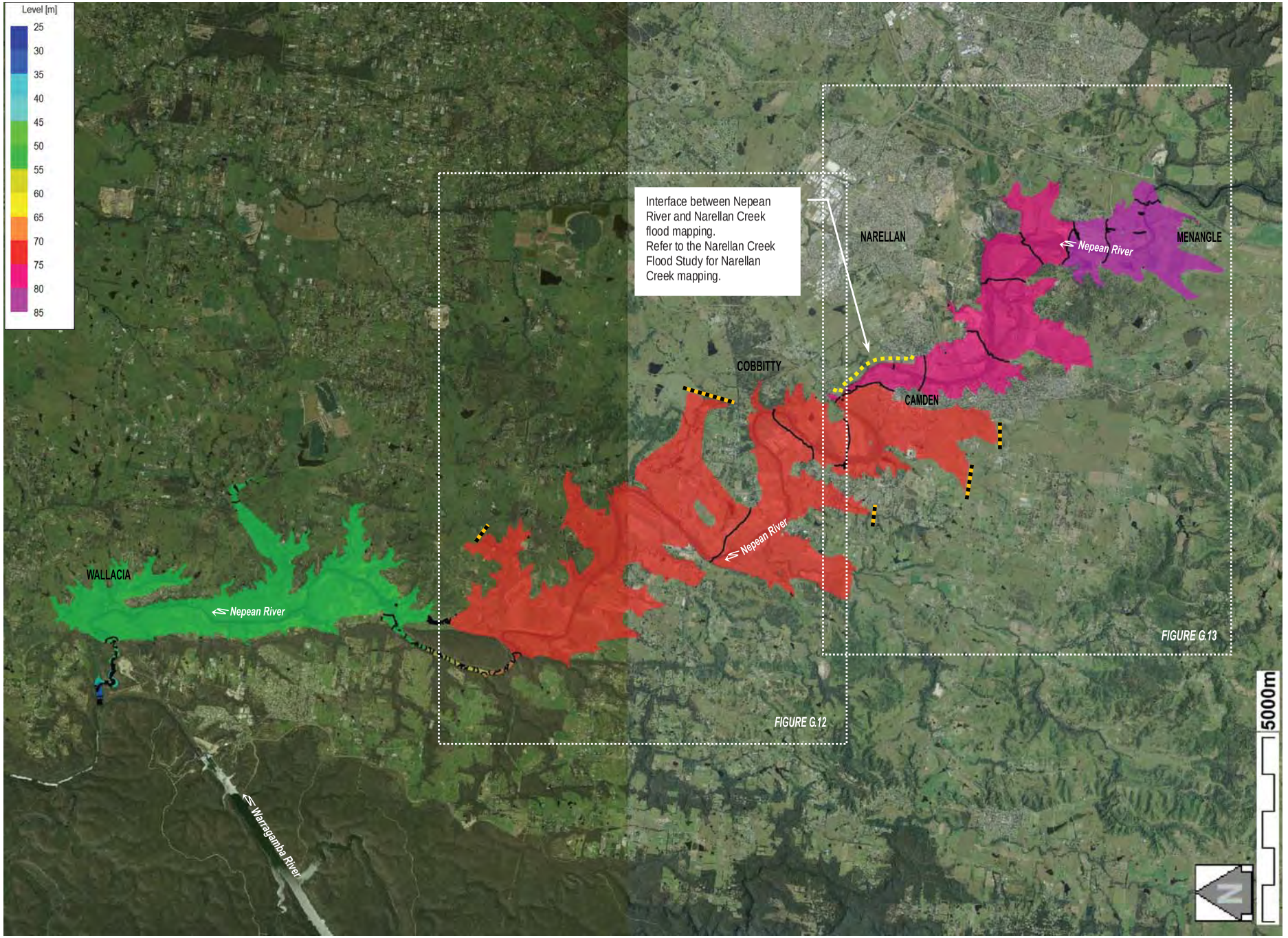
LEGEND:

- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD LEVELS AT THE PEAK OF THE 0.2% AEP EVENT

FIGURE G.11



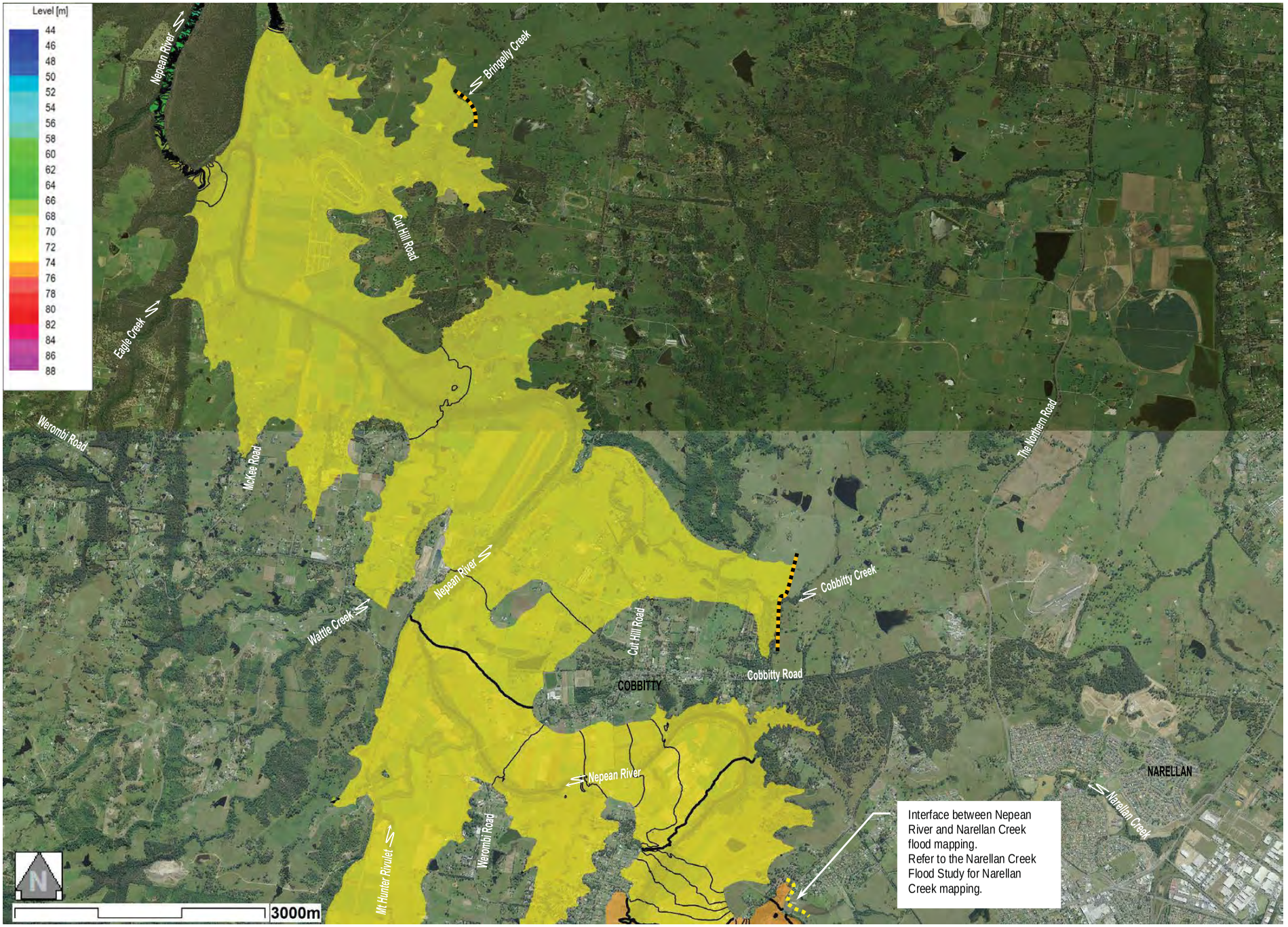
LEGEND:

- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD LEVELS AT THE PEAK OF THE PMF EVENT

FIGURE G.12



LEGEND:

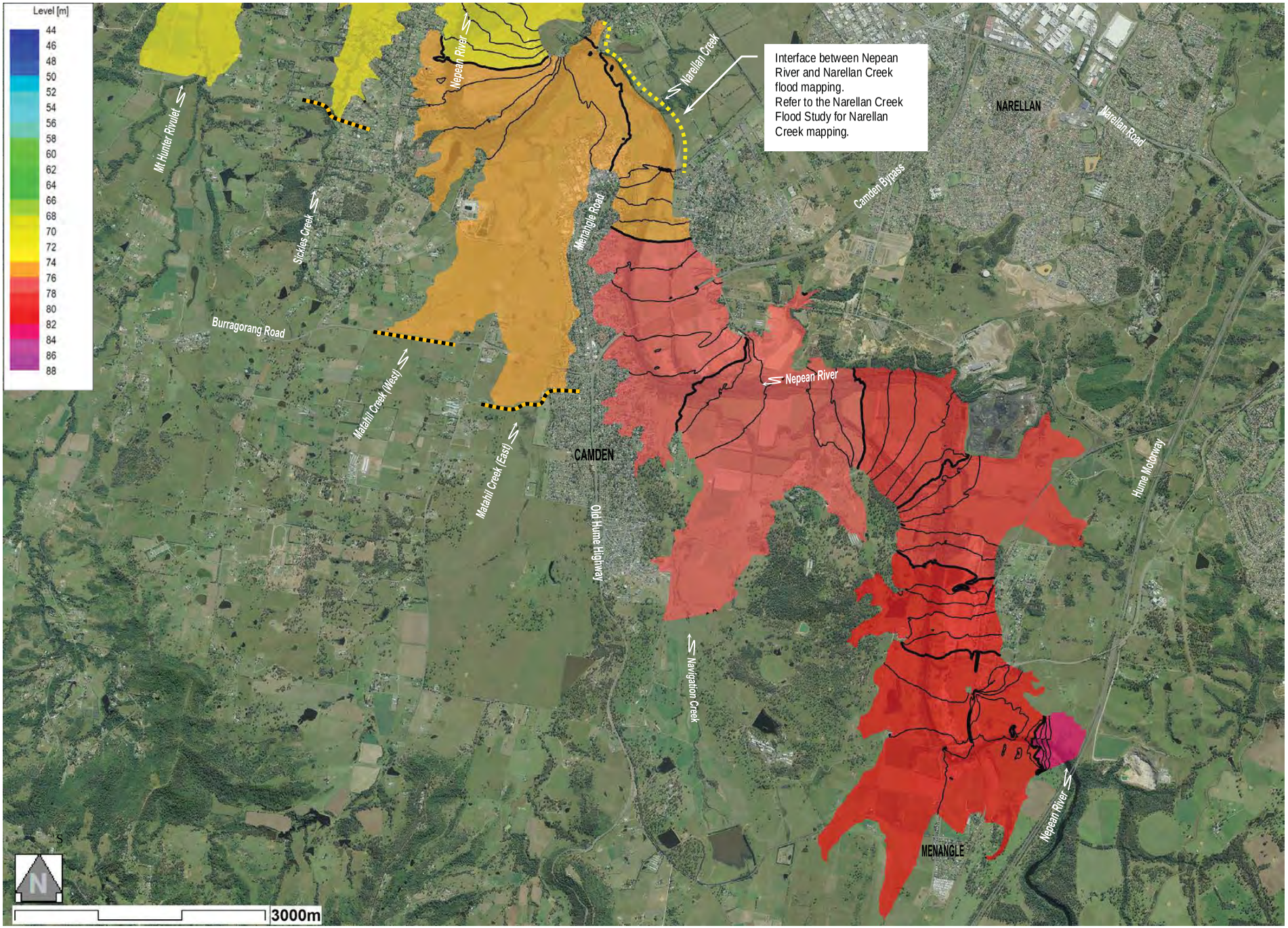
- 0.2 metre contour line
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
G.12_fg301015-03107eh150326-Level_PMF_North.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE PMF EVENT (NORTH)

FIGURE G.13



LEGEND:

- 0.2 metre contour line
- 1.0 metre contour line
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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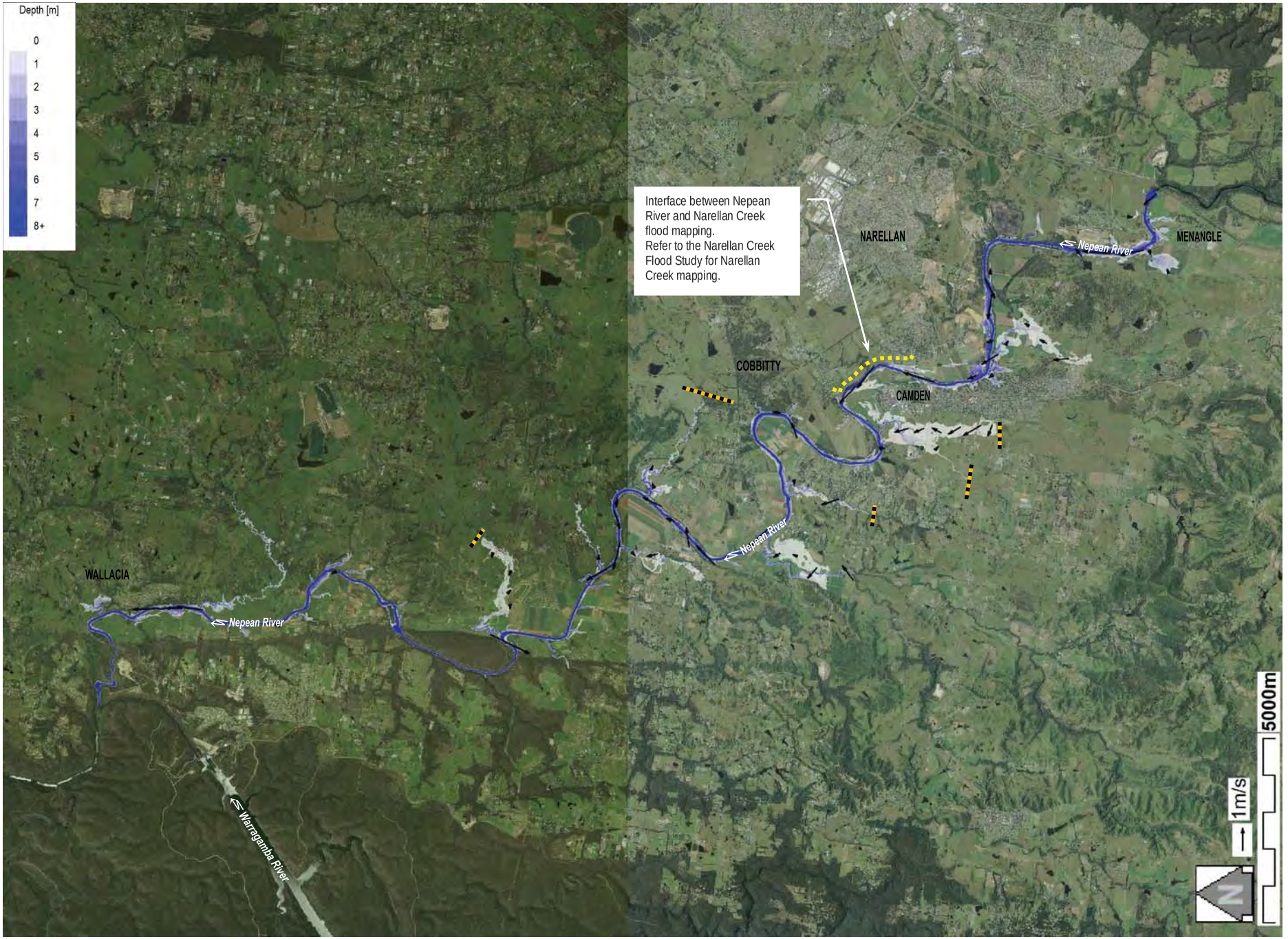
301015-03107 – Nepean River Flood Study (Camden Council)
G.13_fg301015-03107nm_eh140625-Level_PMF_South.doc

MODELLED FLOOD LEVELS AT THE PEAK OF THE PMF EVENT (SOUTH)

APPENDIX H

DEPTH & VELOCITY VECTOR MAPPING

FIGURE H.1



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

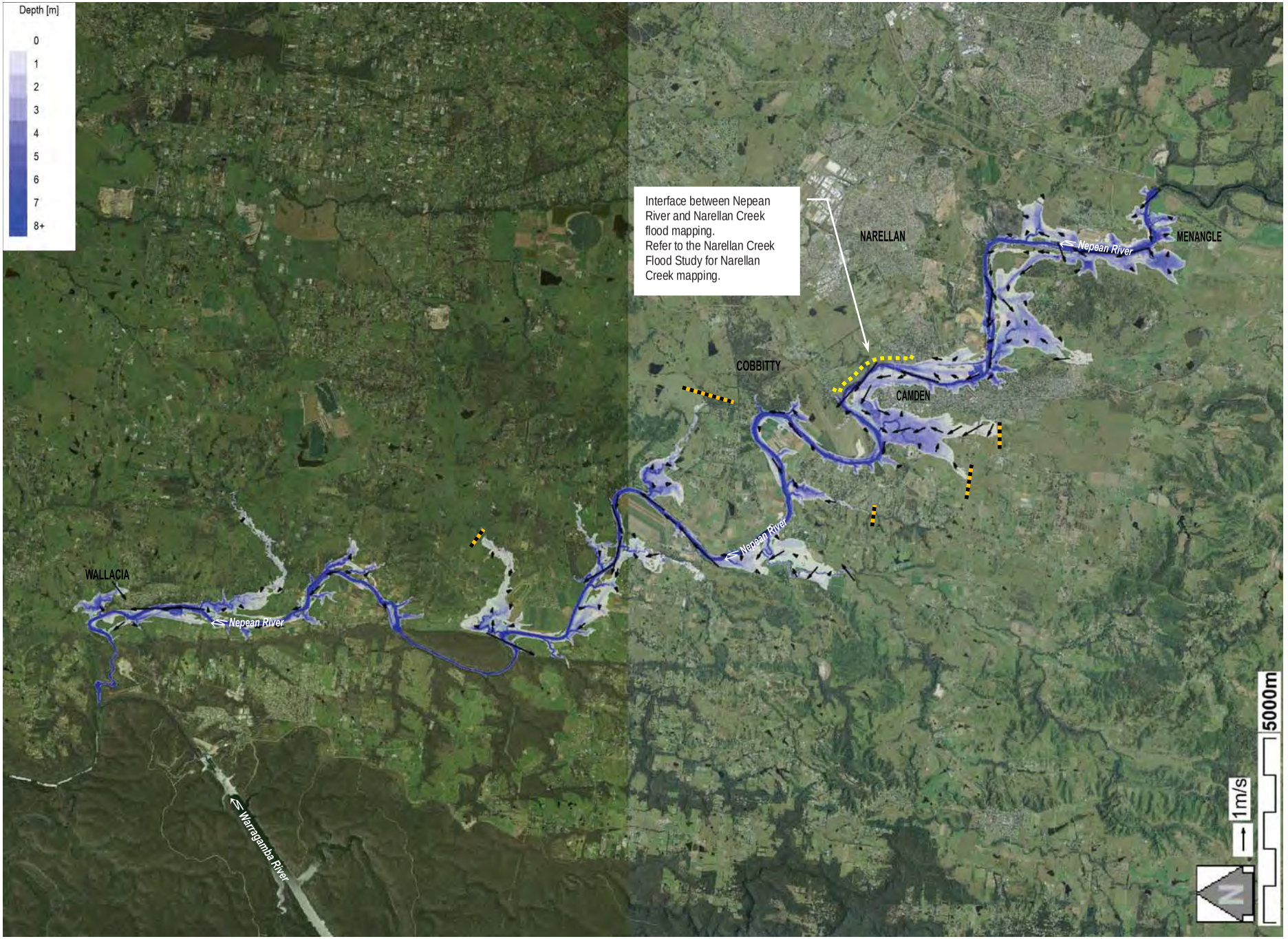
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 50% AEP EVENT

FIGURE H.2



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

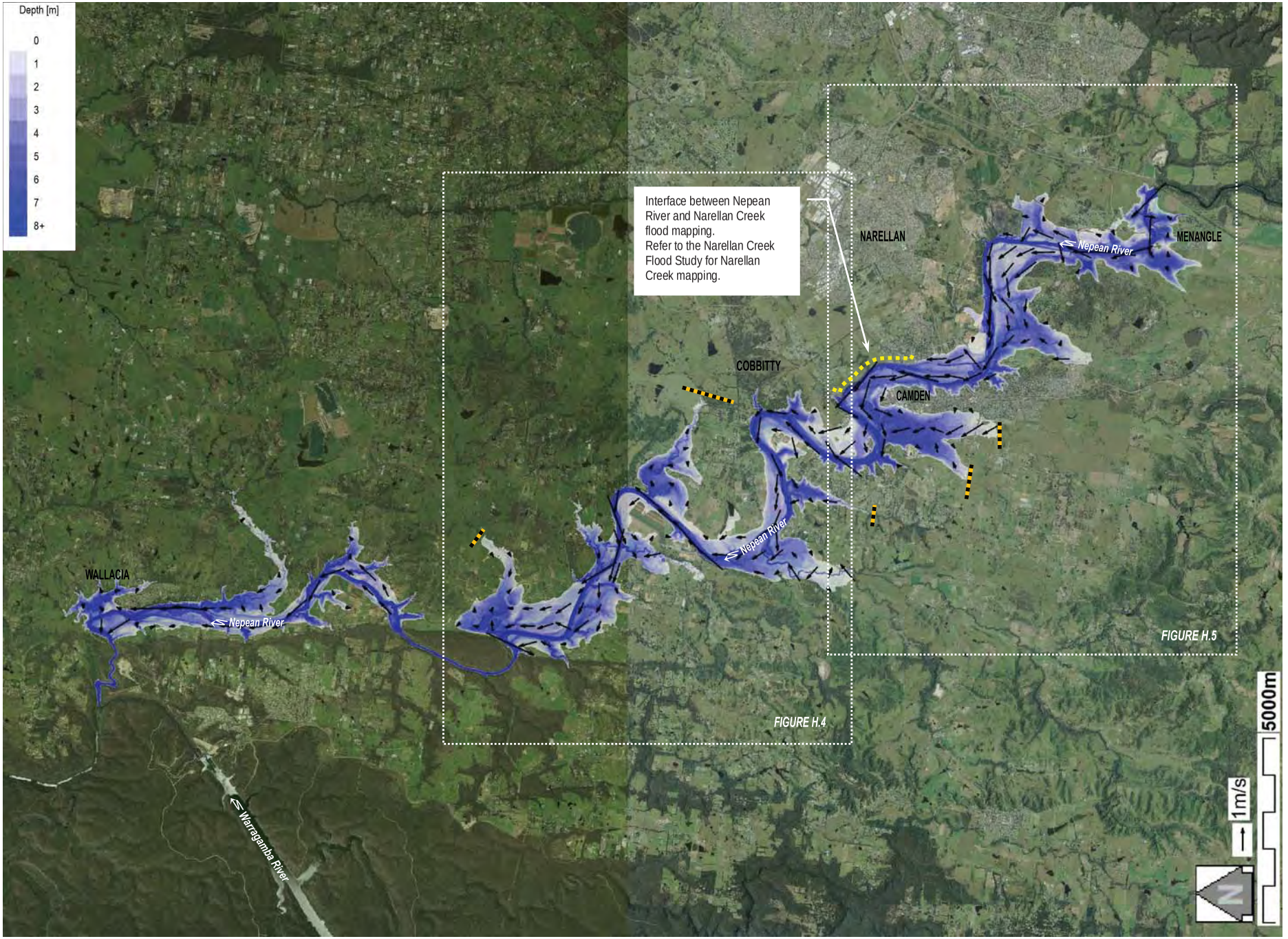
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 20% AEP EVENT

FIGURE H.3



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

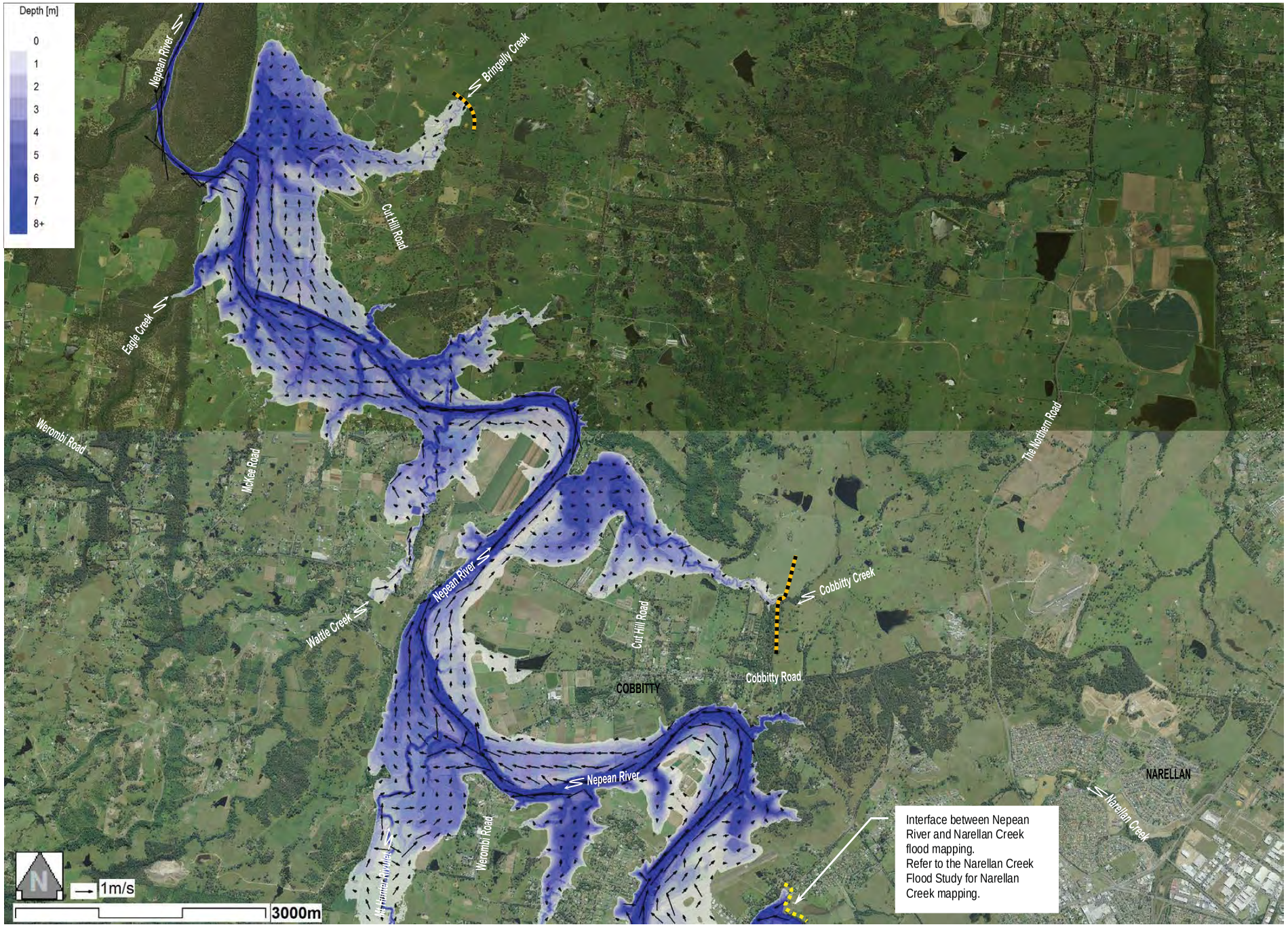
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 5% AEP EVENT

FIGURE H.4



NOTES:

- Flood depths greater than 8 meters shown as darkest blue

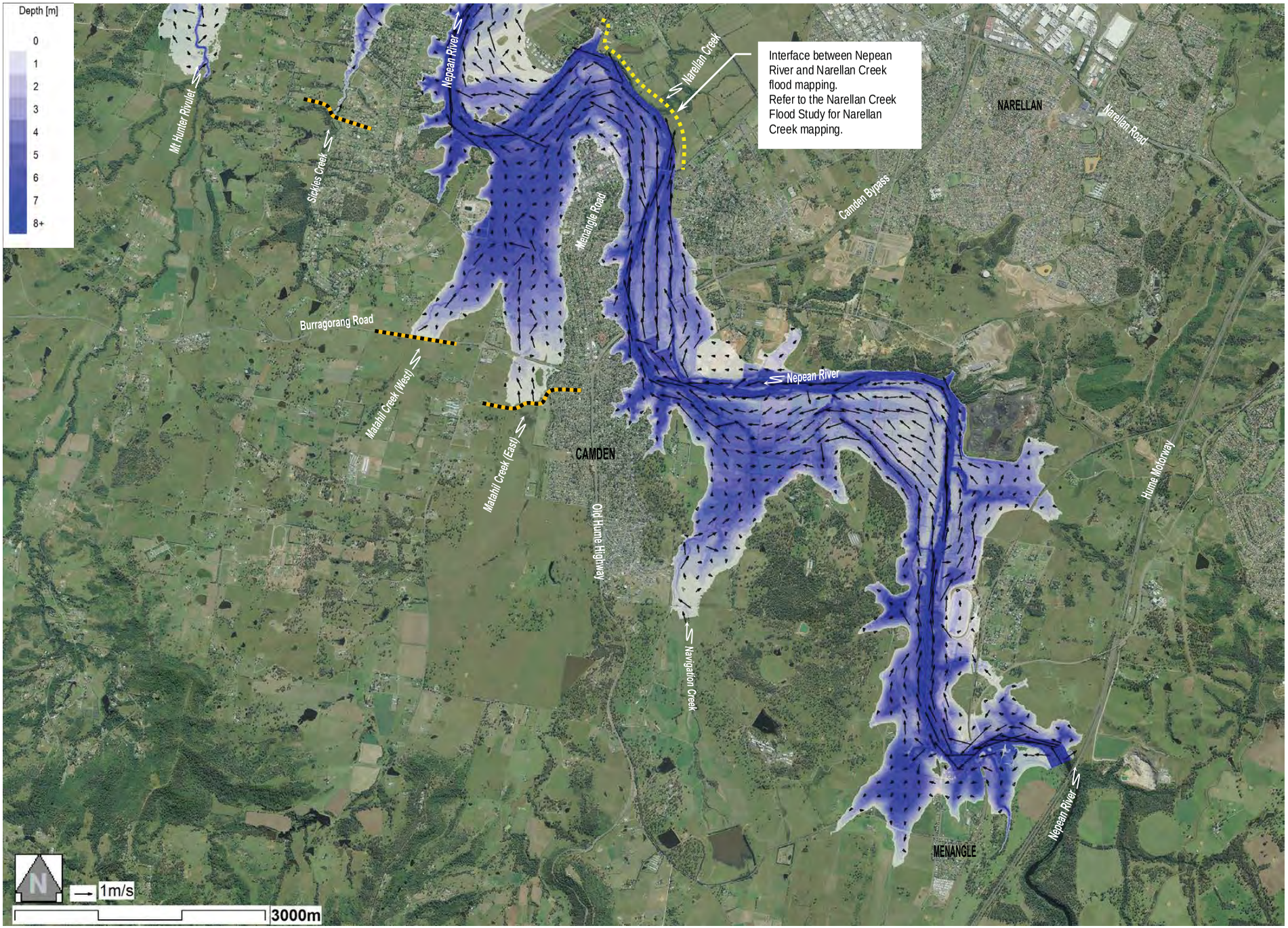
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 5% AEP EVENT (NORTH)

FIGURE H.5



NOTES:

- Flood depths greater than 8 meters shown as darkest blue

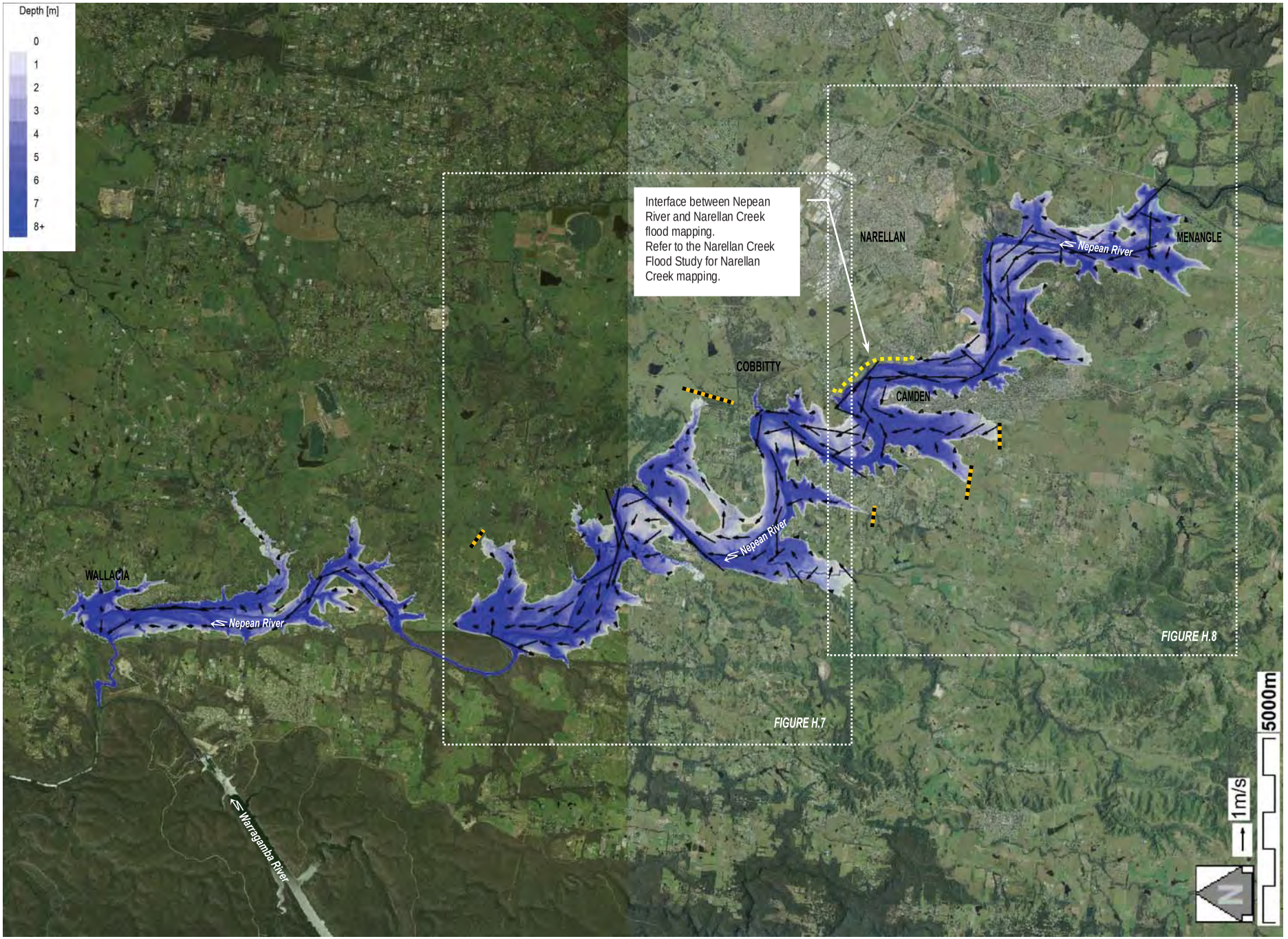
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 5% AEP EVENT (SOUTH)

FIGURE H.6



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

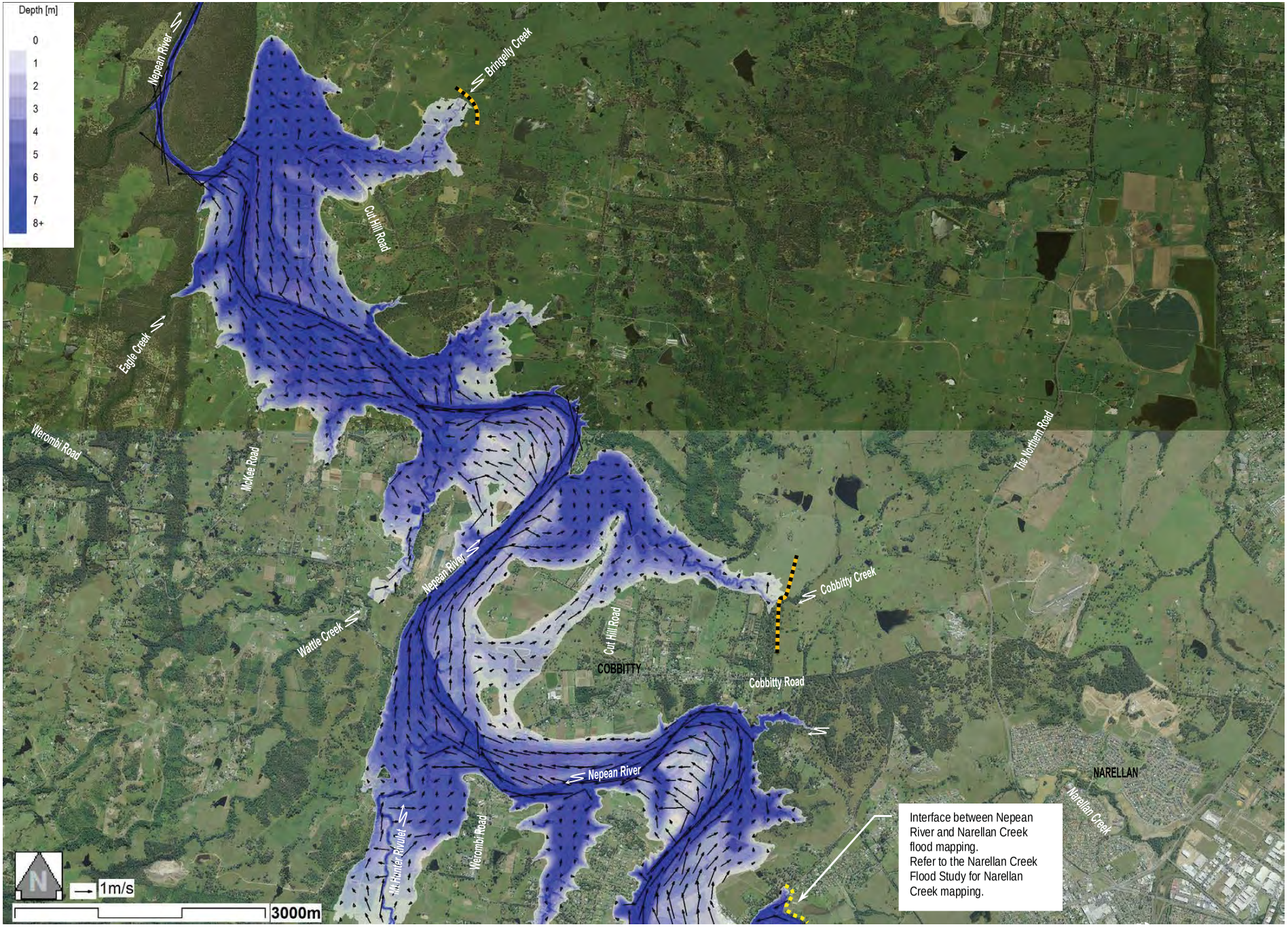
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 1% AEP EVENT

FIGURE H.7



NOTES:

- Flood depths greater than 8 meters shown as darkest blue

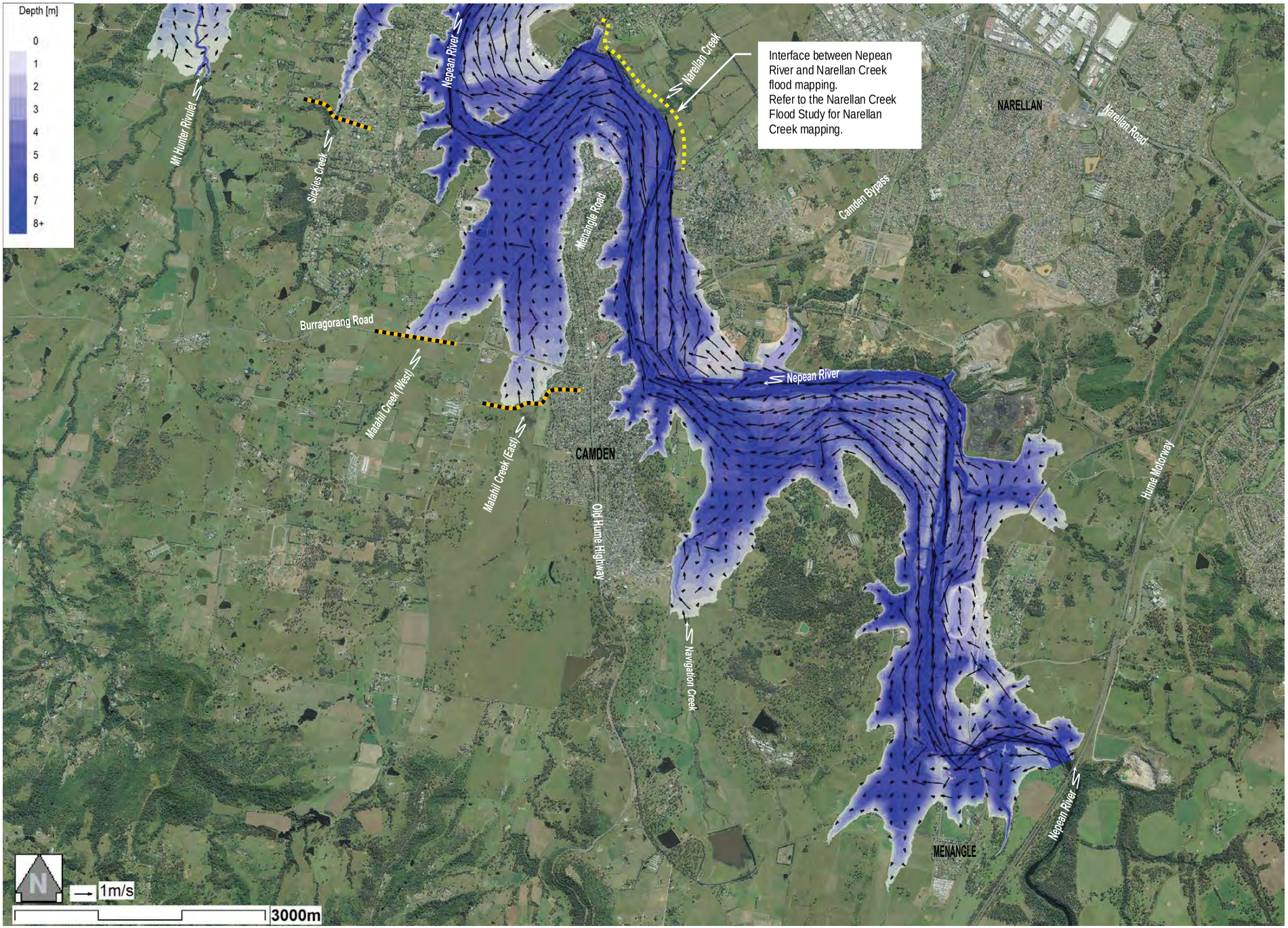
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 1% AEP EVENT (NORTH)

FIGURE H.8



NOTES:

- Flood depths greater than 8 meters shown as darkest blue

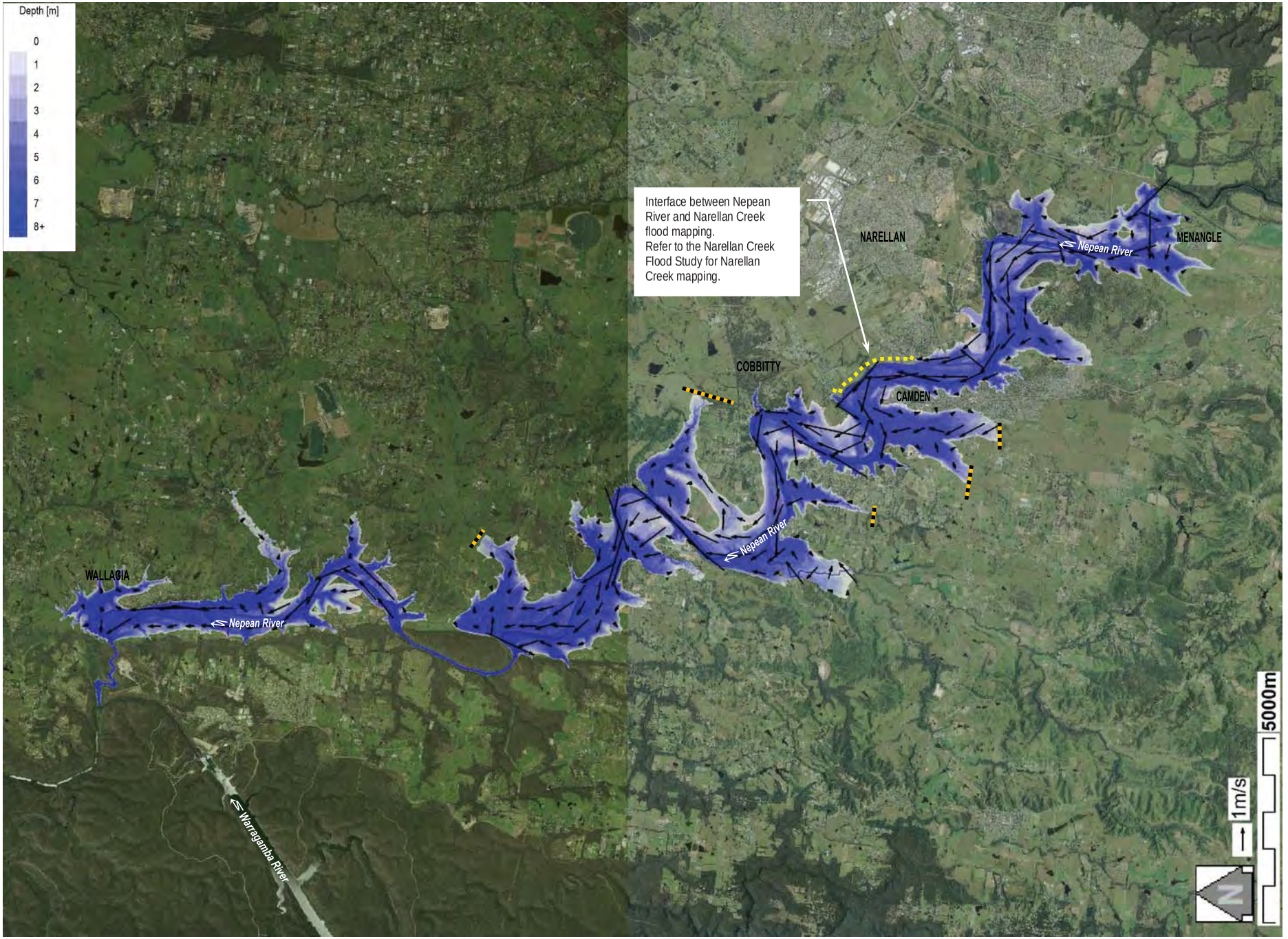
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 1% AEP EVENT (SOUTH)

FIGURE H.9



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

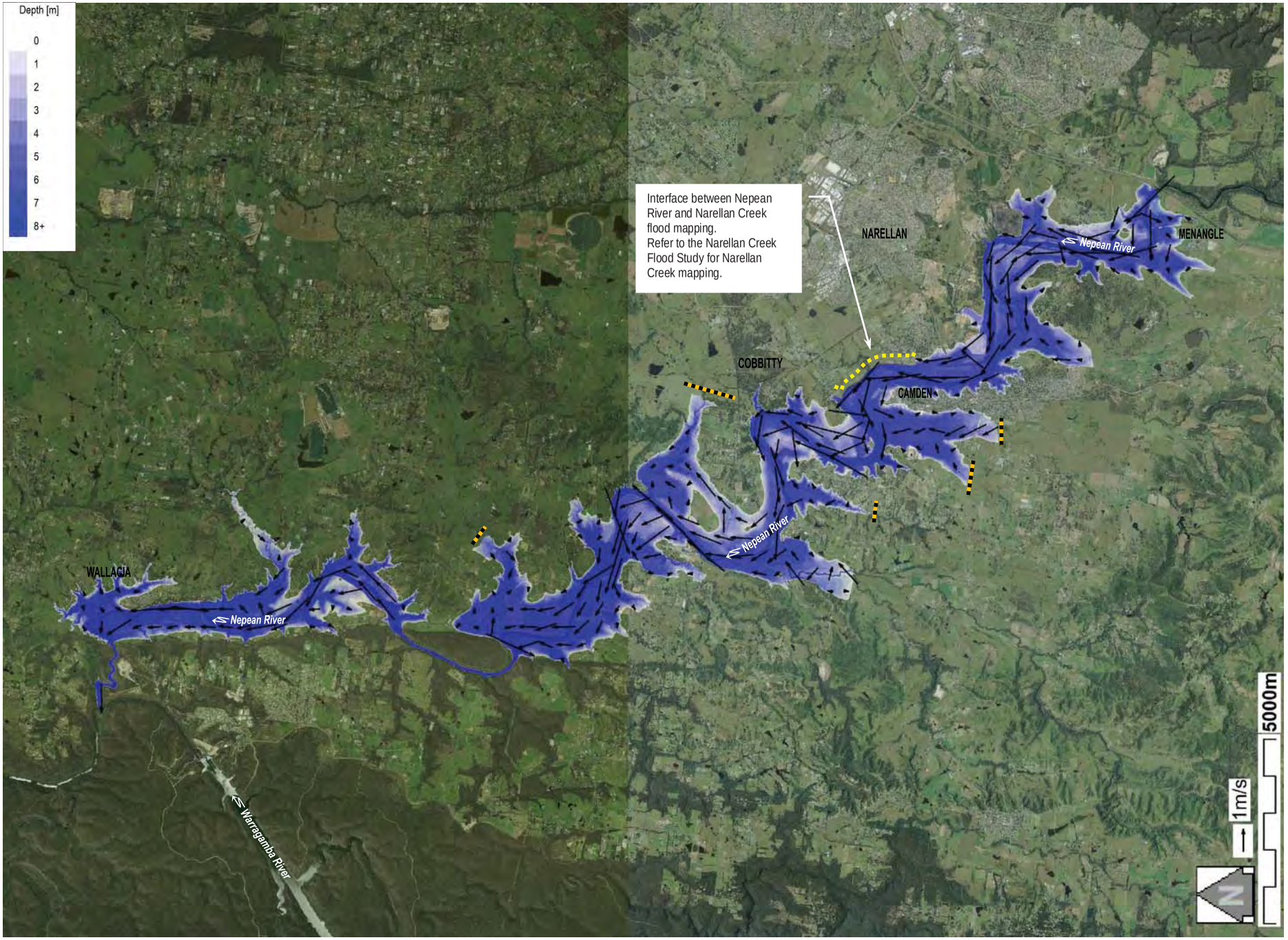
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 0.5% AEP EVENT

FIGURE H.10



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

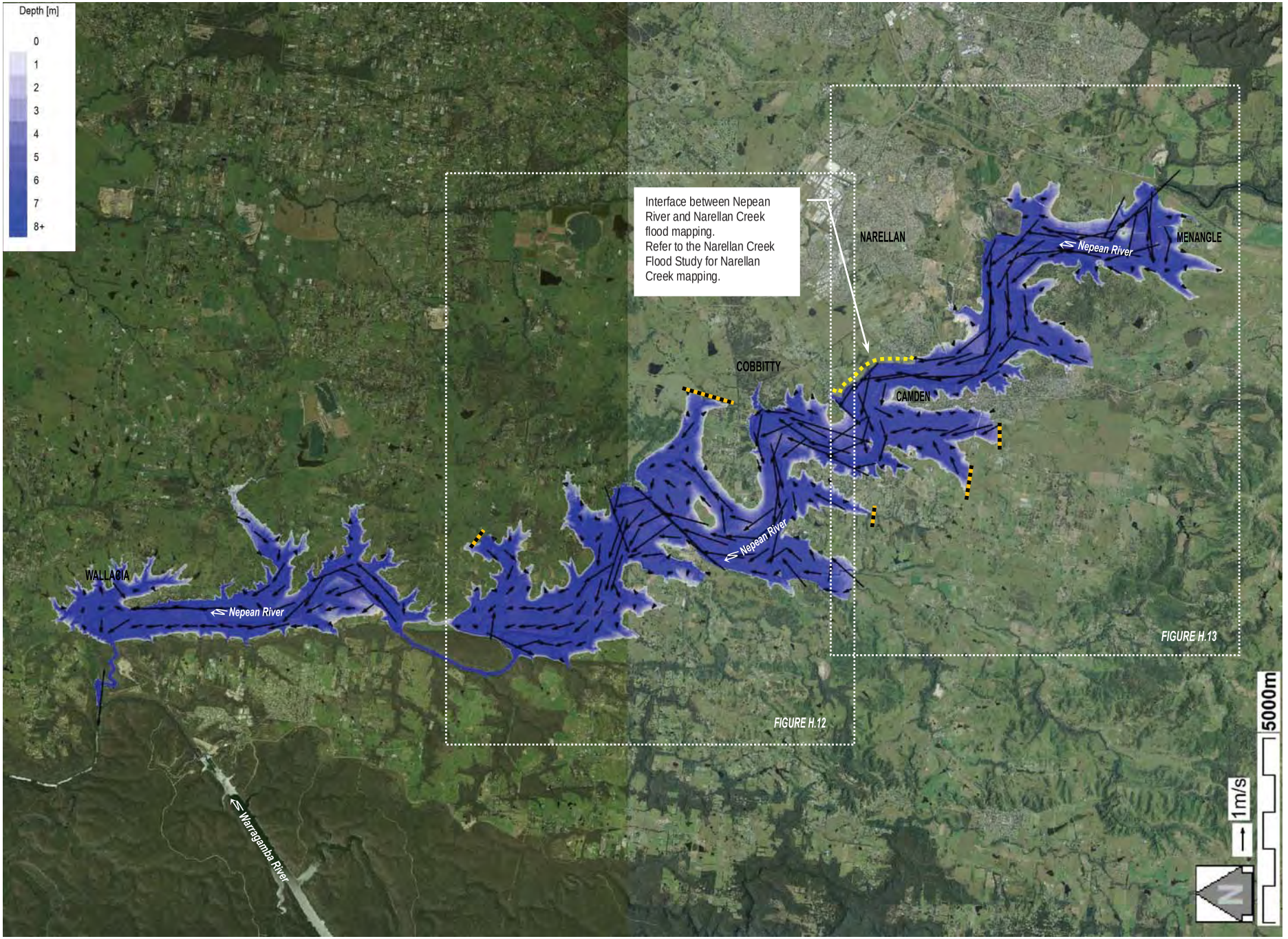
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE 0.2% AEP EVENT

FIGURE H.11



NOTES:

- Flood depths greater than 8 meters shown as darkest blue
- For flood mapping for Narellan Creek refer to the Narellan Creek Flood Study.

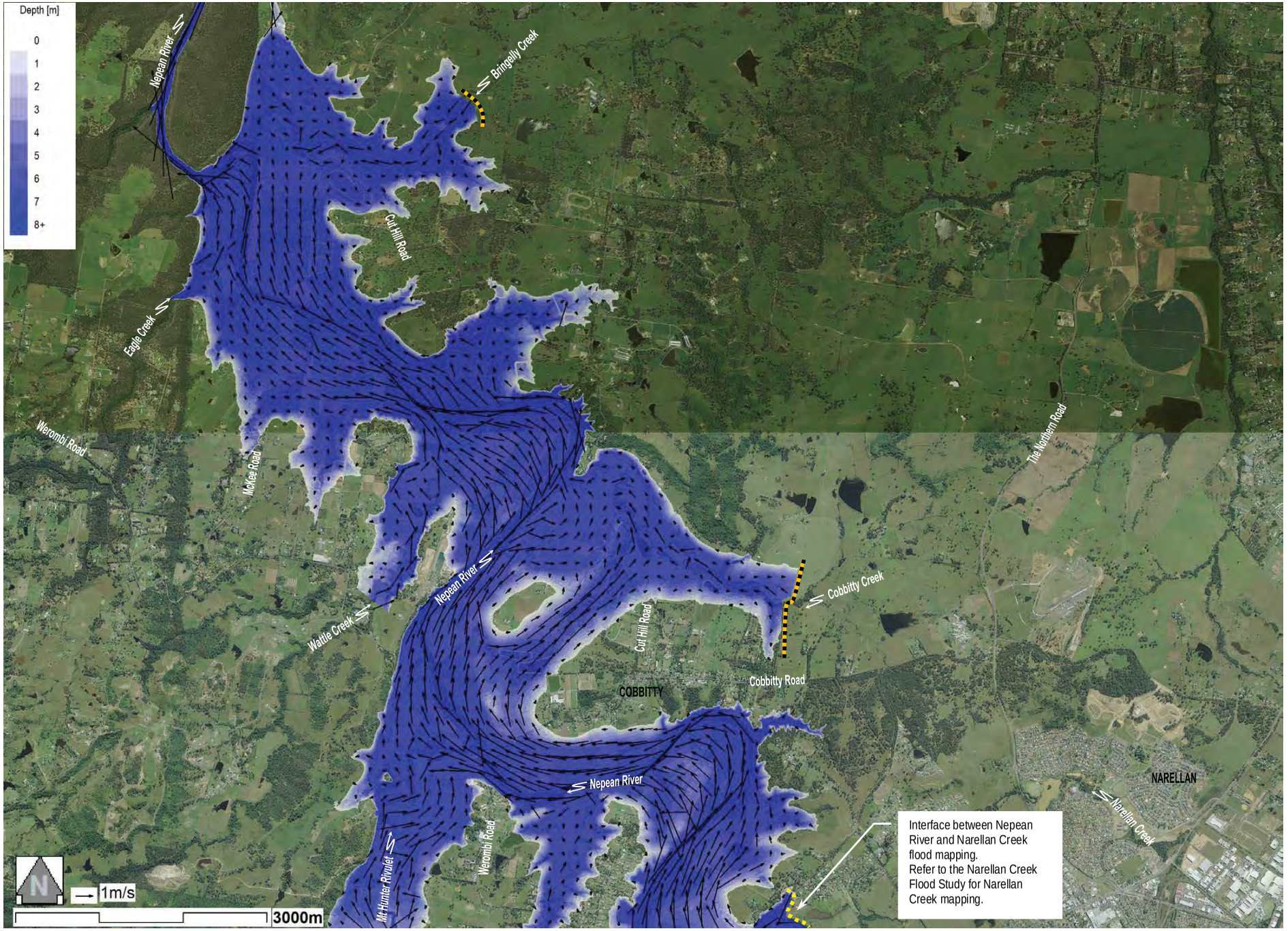
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE PMF EVENT

FIGURE H.12



NOTES:

- Flood depths greater than 8 meters shown as darkest blue

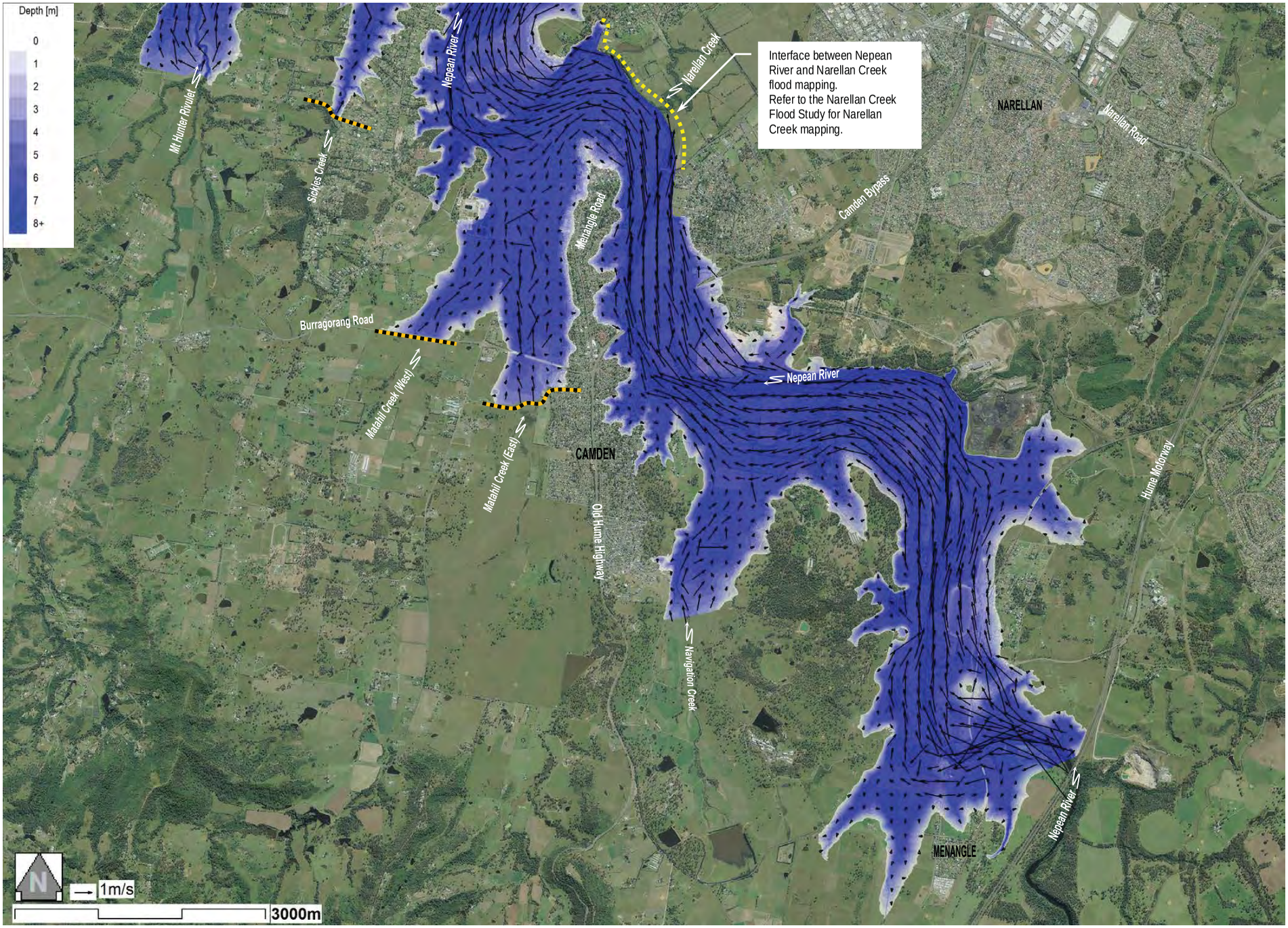
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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MODELLED FLOOD DEPTHS AT THE PEAK OF THE PMF EVENT (NORTH)

FIGURE H.13



NOTES:

- Flood depths greater than 8 meters shown as darkest blue

LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

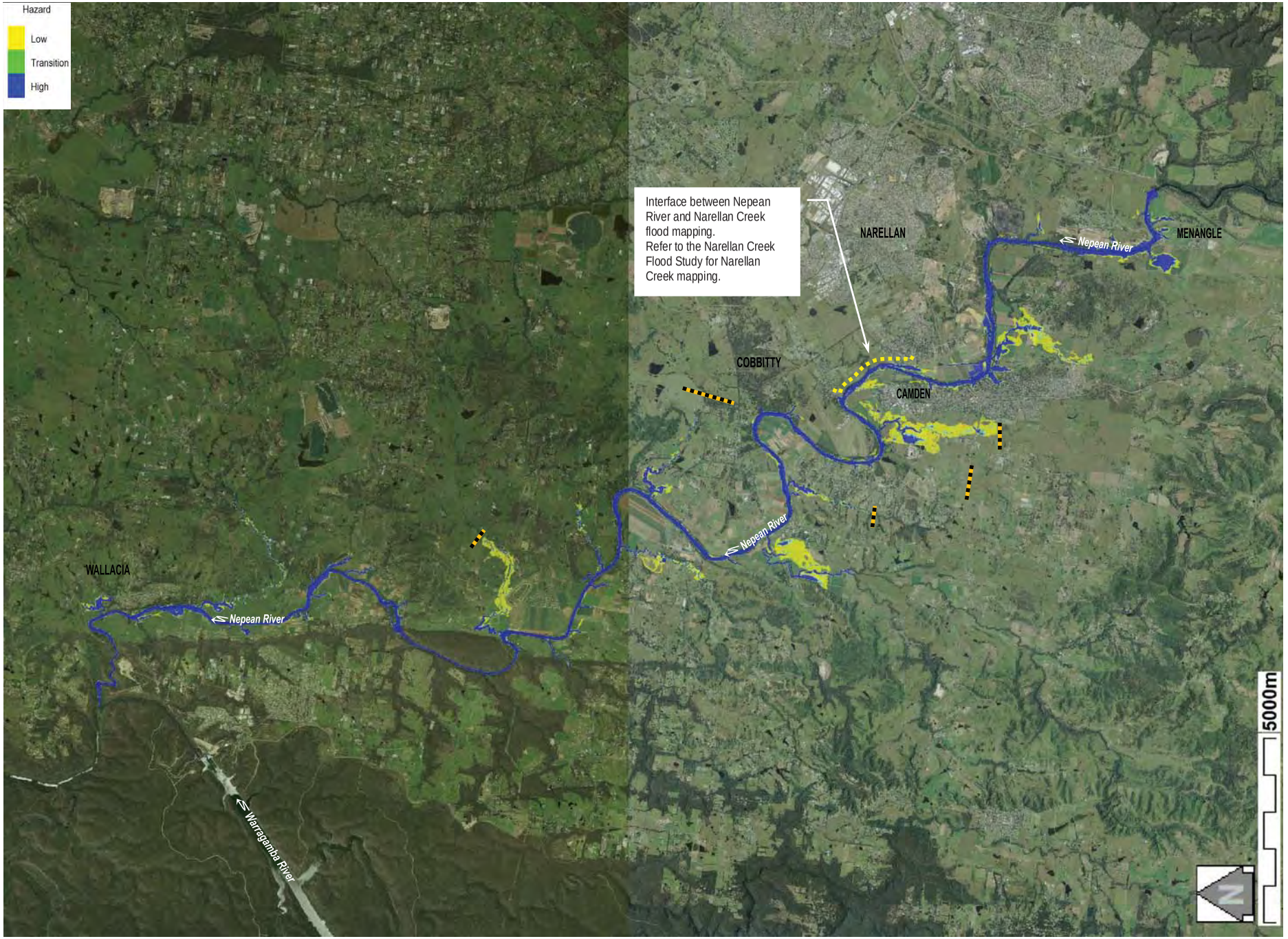
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MODELLED FLOOD DEPTHS AT THE PEAK OF THE PMF EVENT (SOUTH)

APPENDIX I

PROVISIONAL FLOOD HAZARD MAPPING

FIGURE I.1



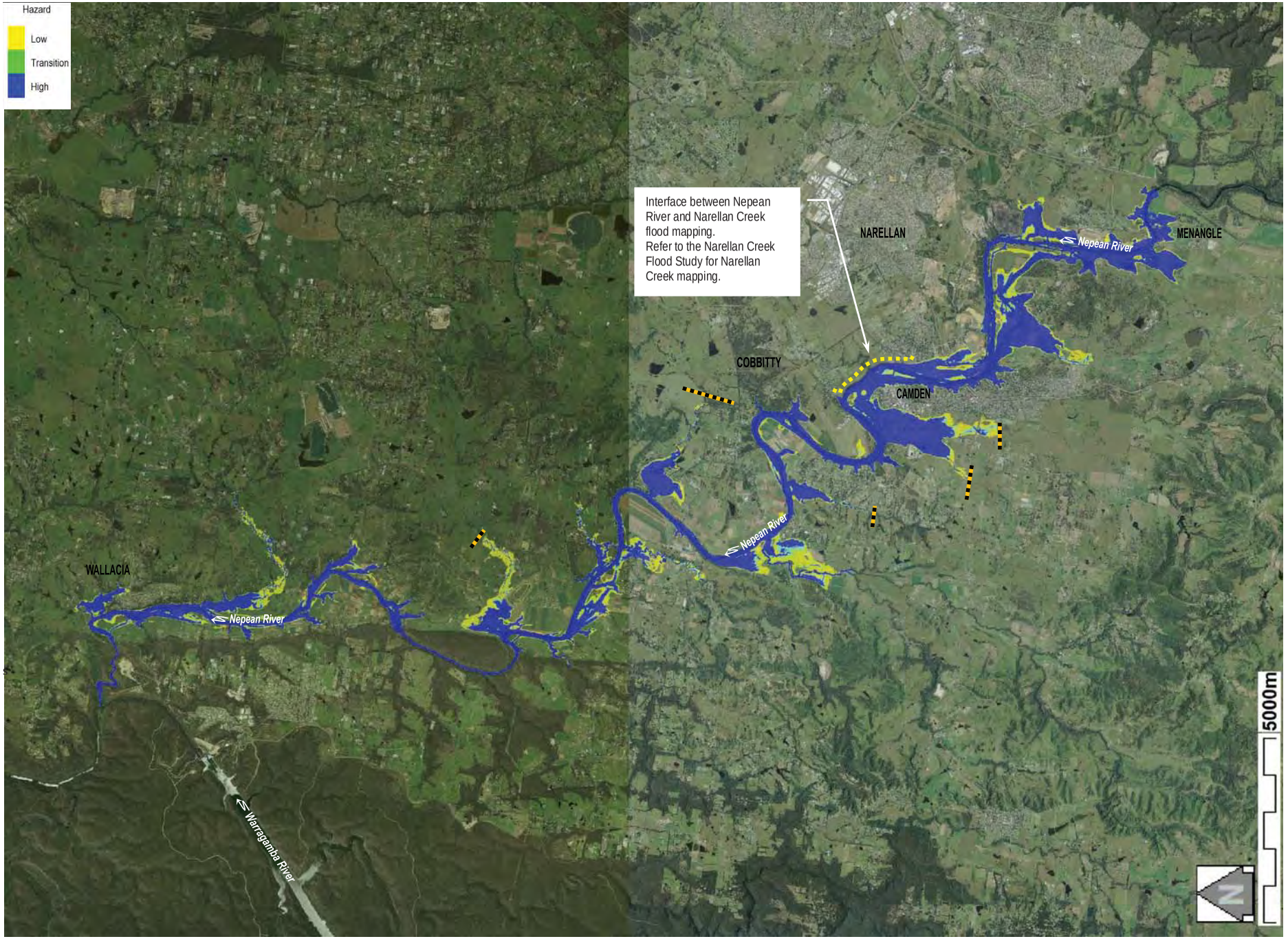
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE 50% AEP EVENT

FIGURE I.2



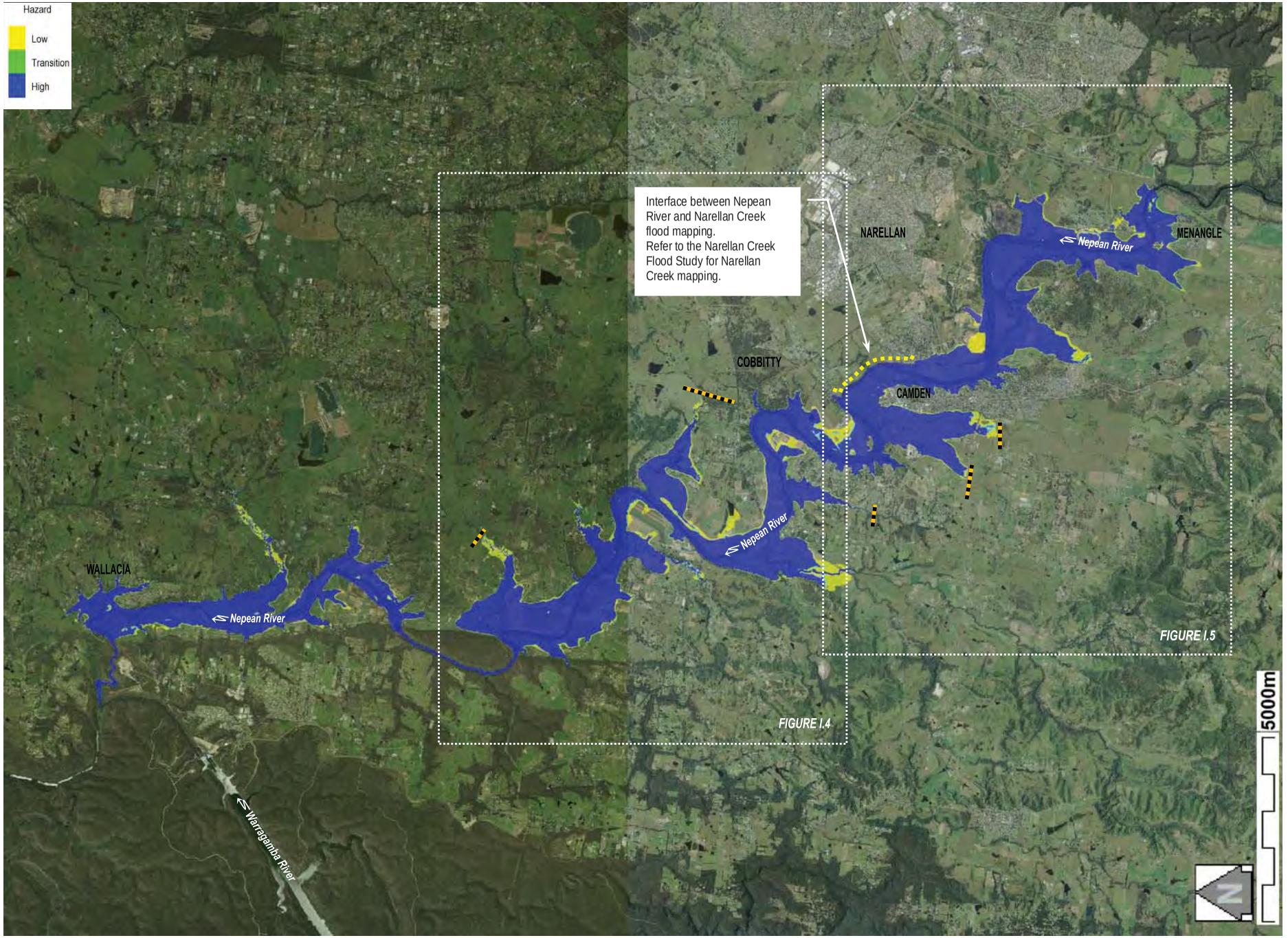
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE 20% AEP EVENT

FIGURE I.3



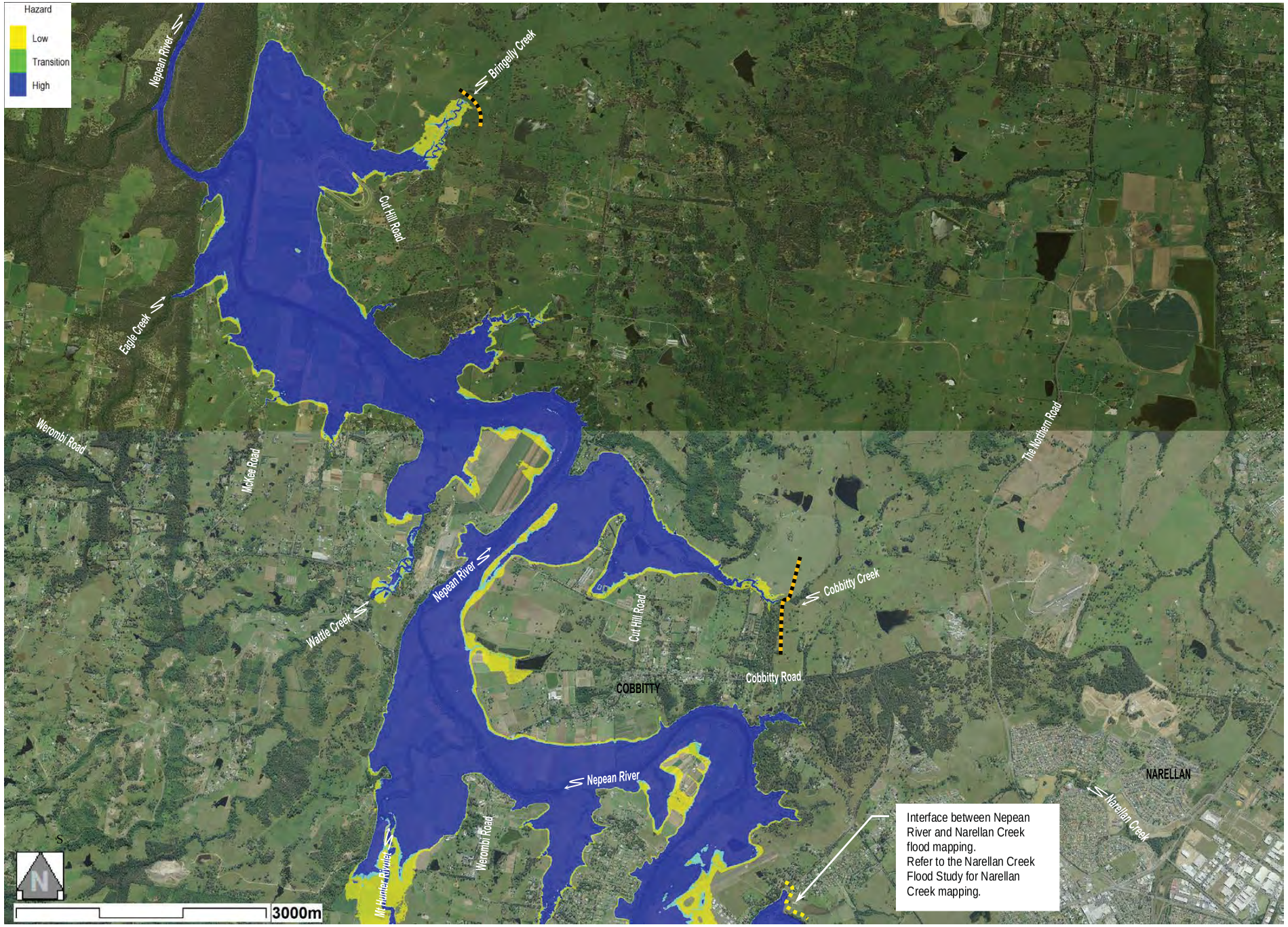
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE 5% AEP EVENT

FIGURE I.4



LEGEND:

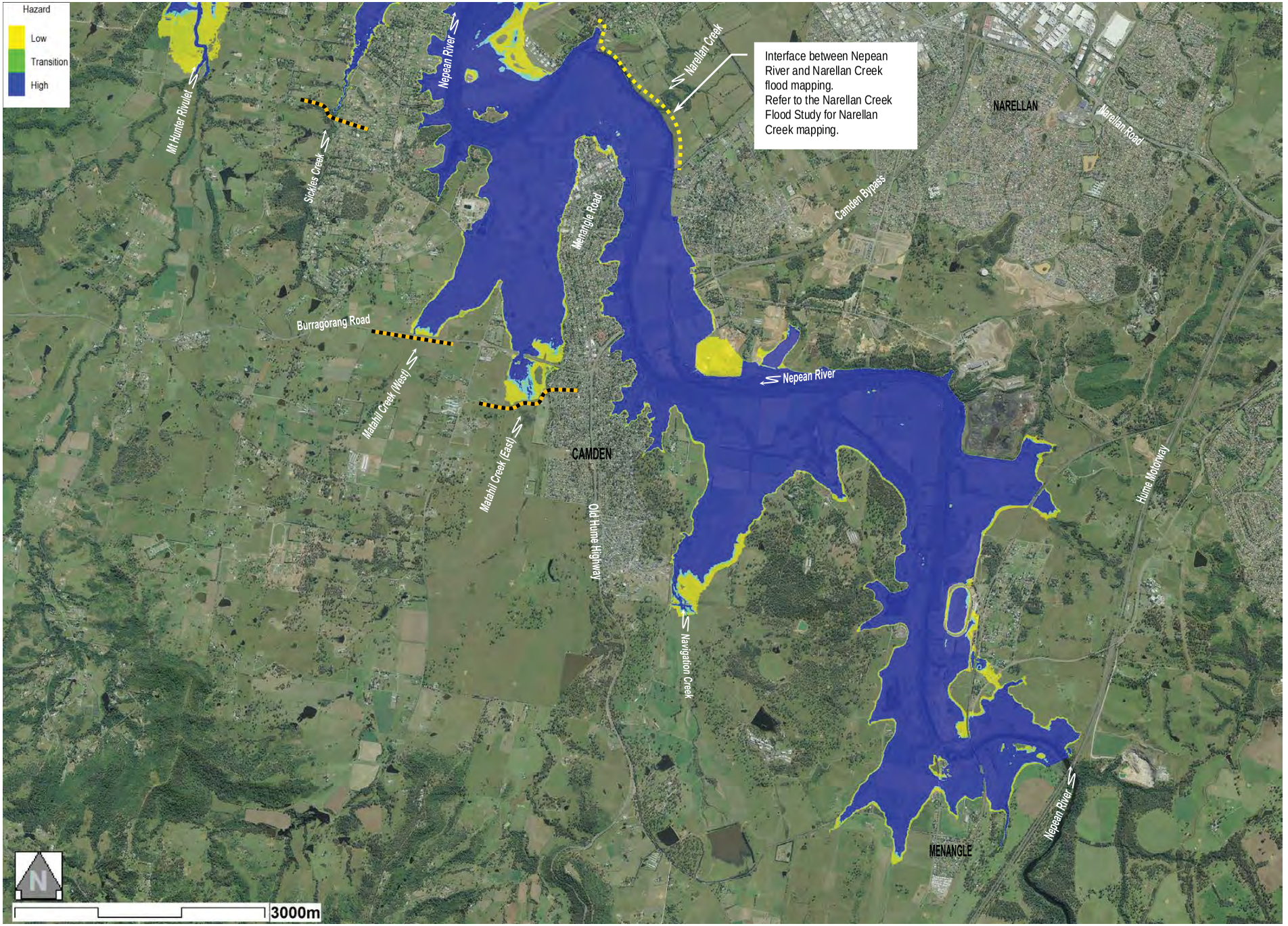
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
I.04_fg301015-03107eh150326-Hazard_020yr_North.doc

PROVISIONAL FLOOD HAZARD MAPPING FOR THE 5% AEP EVENT (NORTH)

FIGURE I.5



LEGEND:

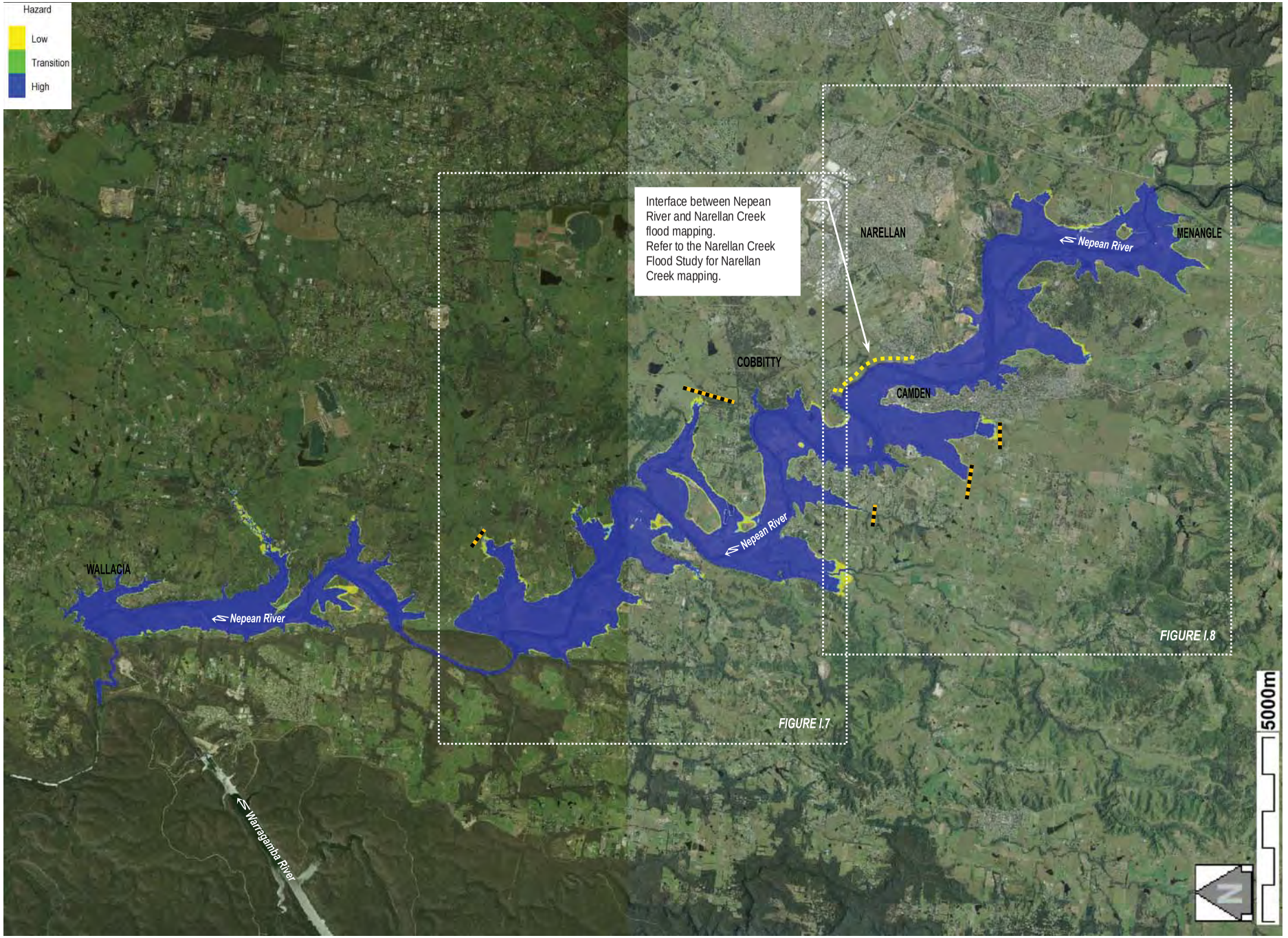
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
I.05_fg301015-03107eh140619-Hazard_020yr_South.doc

PROVISIONAL FLOOD HAZARD MAPPING FOR THE 5% AEP EVENT (SOUTH)

FIGURE I.6



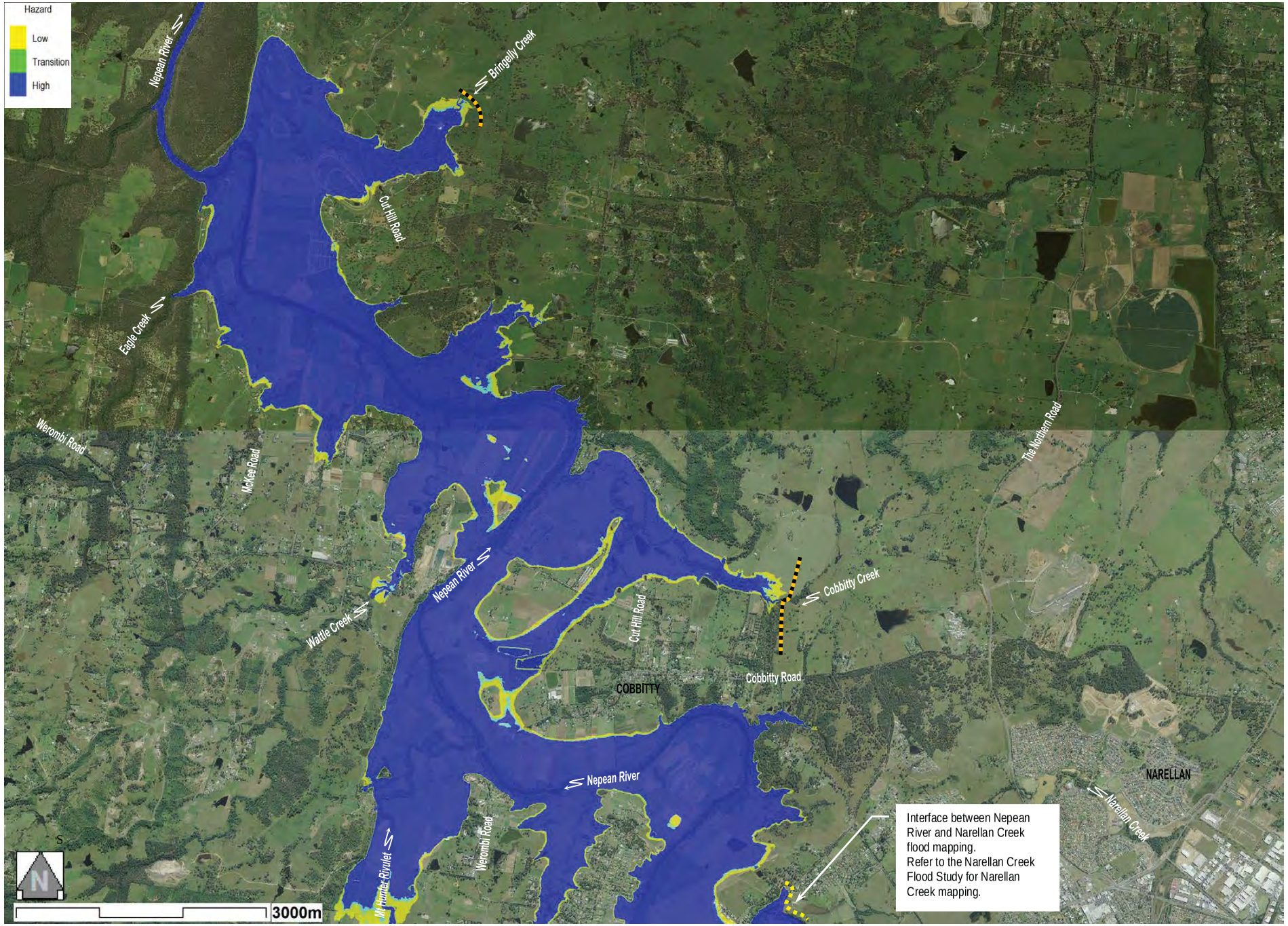
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE 1% AEP EVENT

FIGURE I.7



LEGEND:

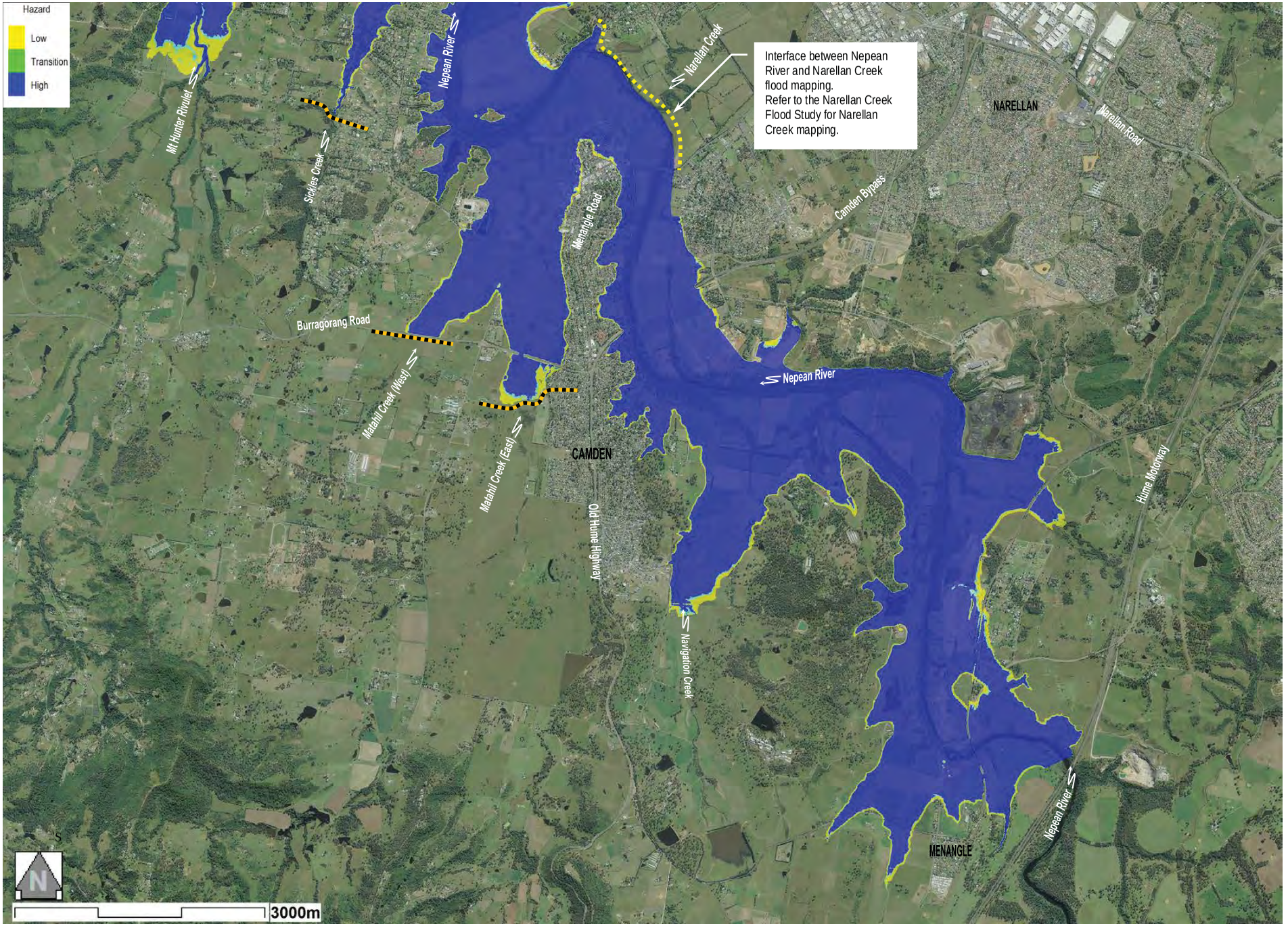
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
I.07_fg301015-03107eh150326-Hazard_100yr_North.doc

PROVISIONAL FLOOD HAZARD MAPPING FOR THE 1% AEP EVENT (NORTH)

FIGURE I.8



LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
I.08_fg301015-03107eh150326-Hazard_100yr_South.doc

PROVISIONAL FLOOD HAZARD MAPPING FOR THE 1% AEP EVENT (SOUTH)

FIGURE I.9



LEGEND:

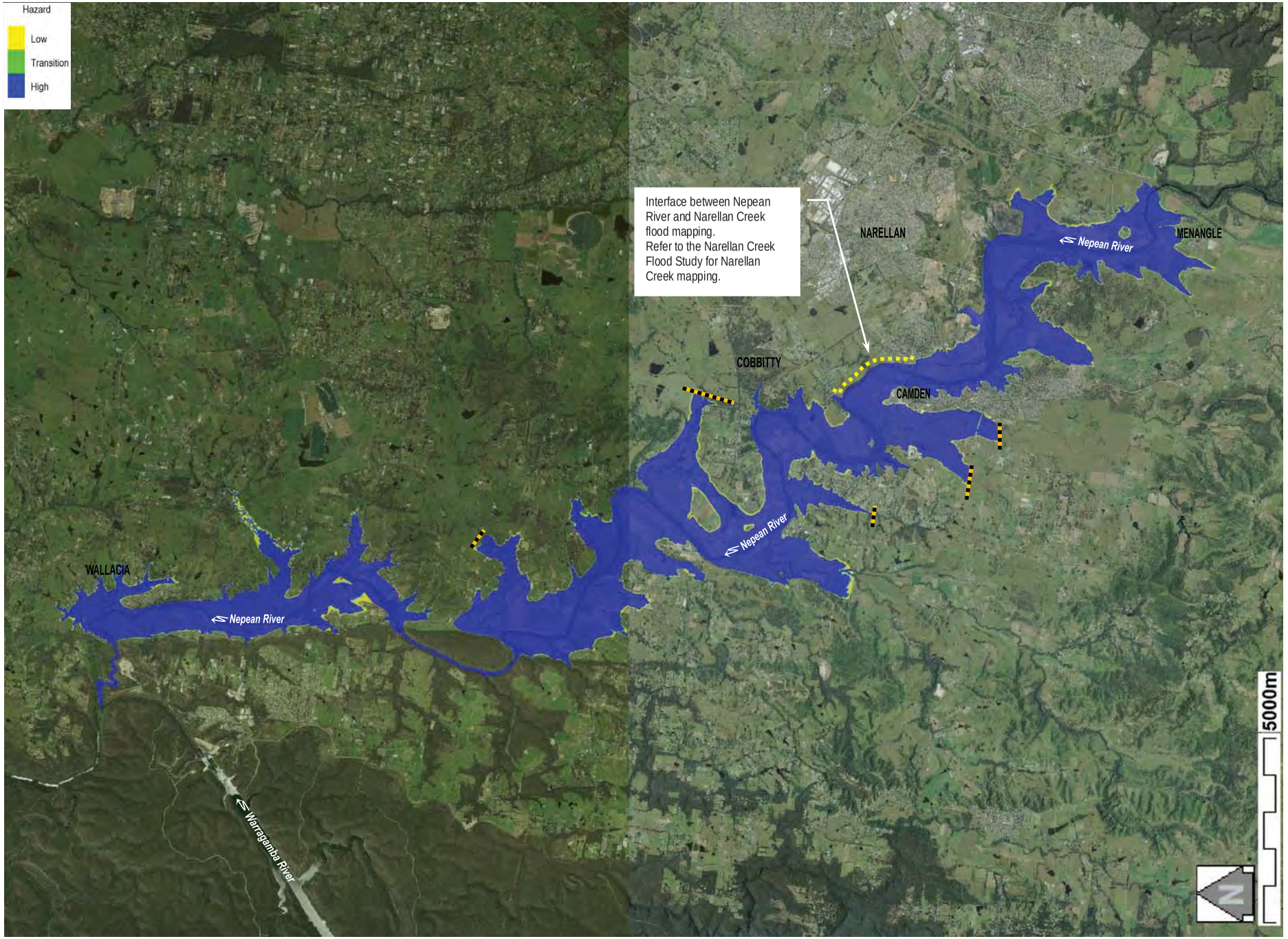
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study
I.09_fg301015-03107eh150326-Hazard_200yr_ALL.doc

PROVISIONAL FLOOD HAZARD MAPPING FOR THE 0.5% AEP EVENT

FIGURE I.10



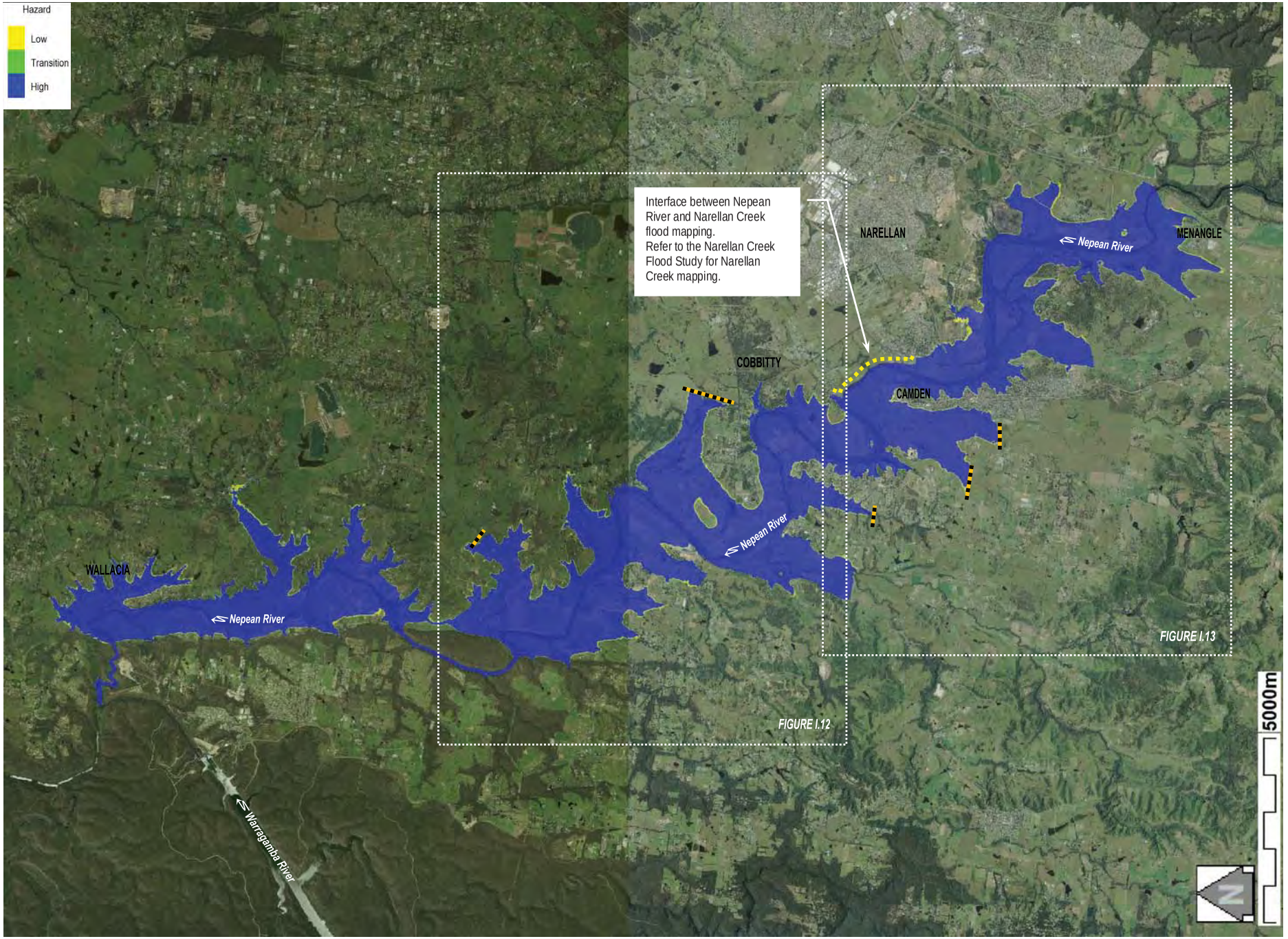
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE 0.2% AEP EVENT

FIGURE I.11



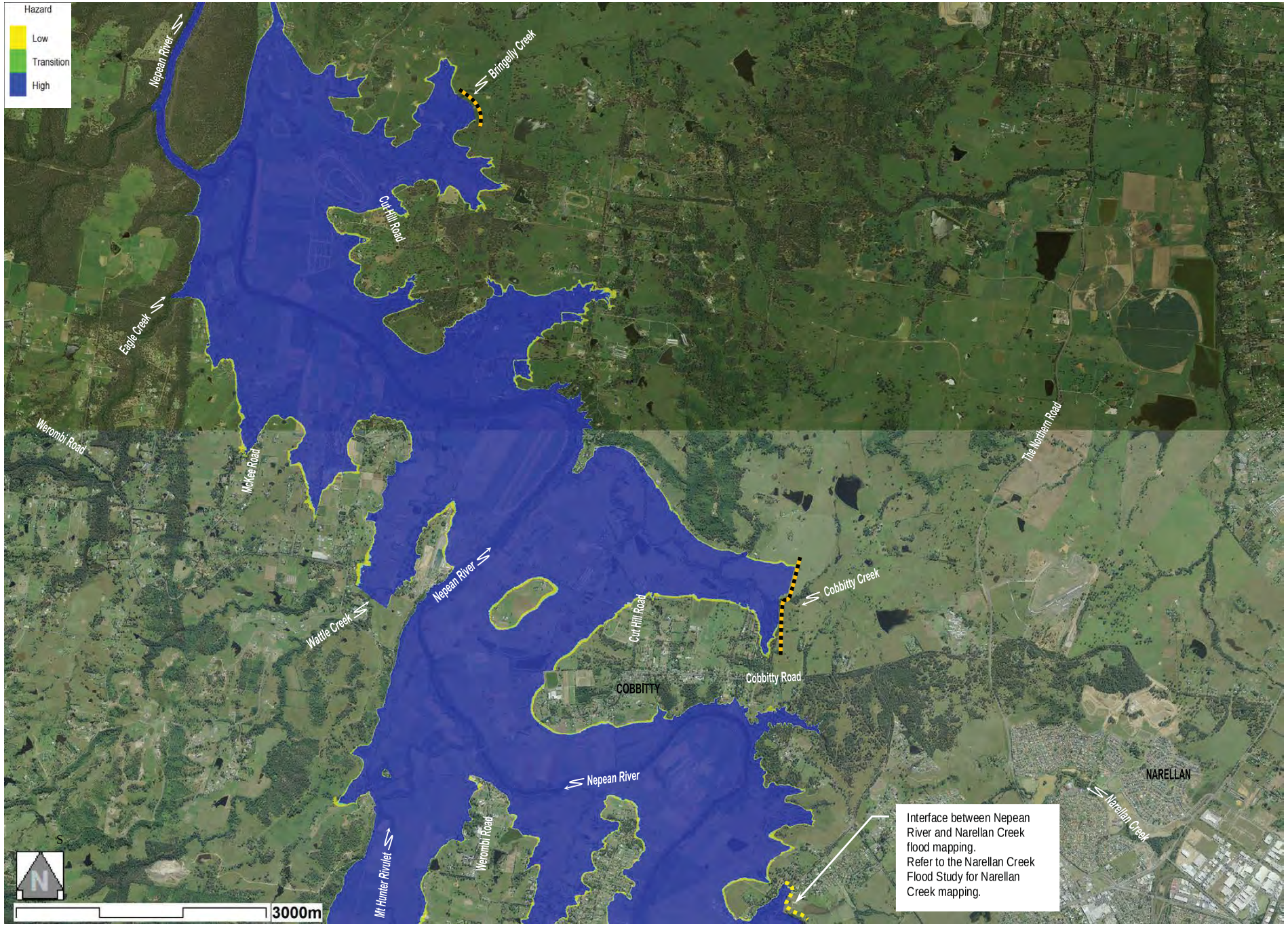
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE PMF EVENT

FIGURE I.12



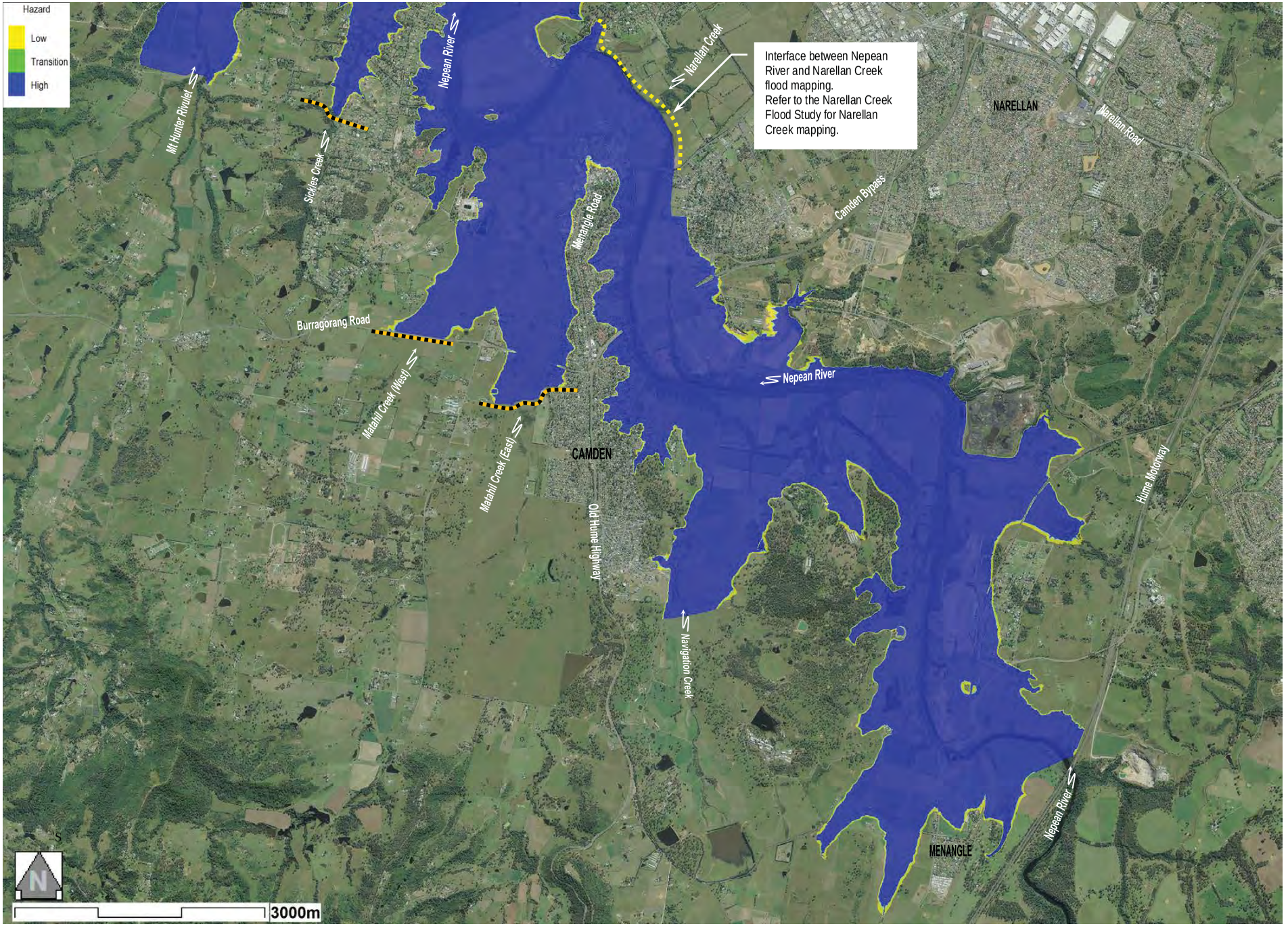
LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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PROVISIONAL FLOOD HAZARD MAPPING FOR THE PMF EVENT (NORTH)

FIGURE I.13



LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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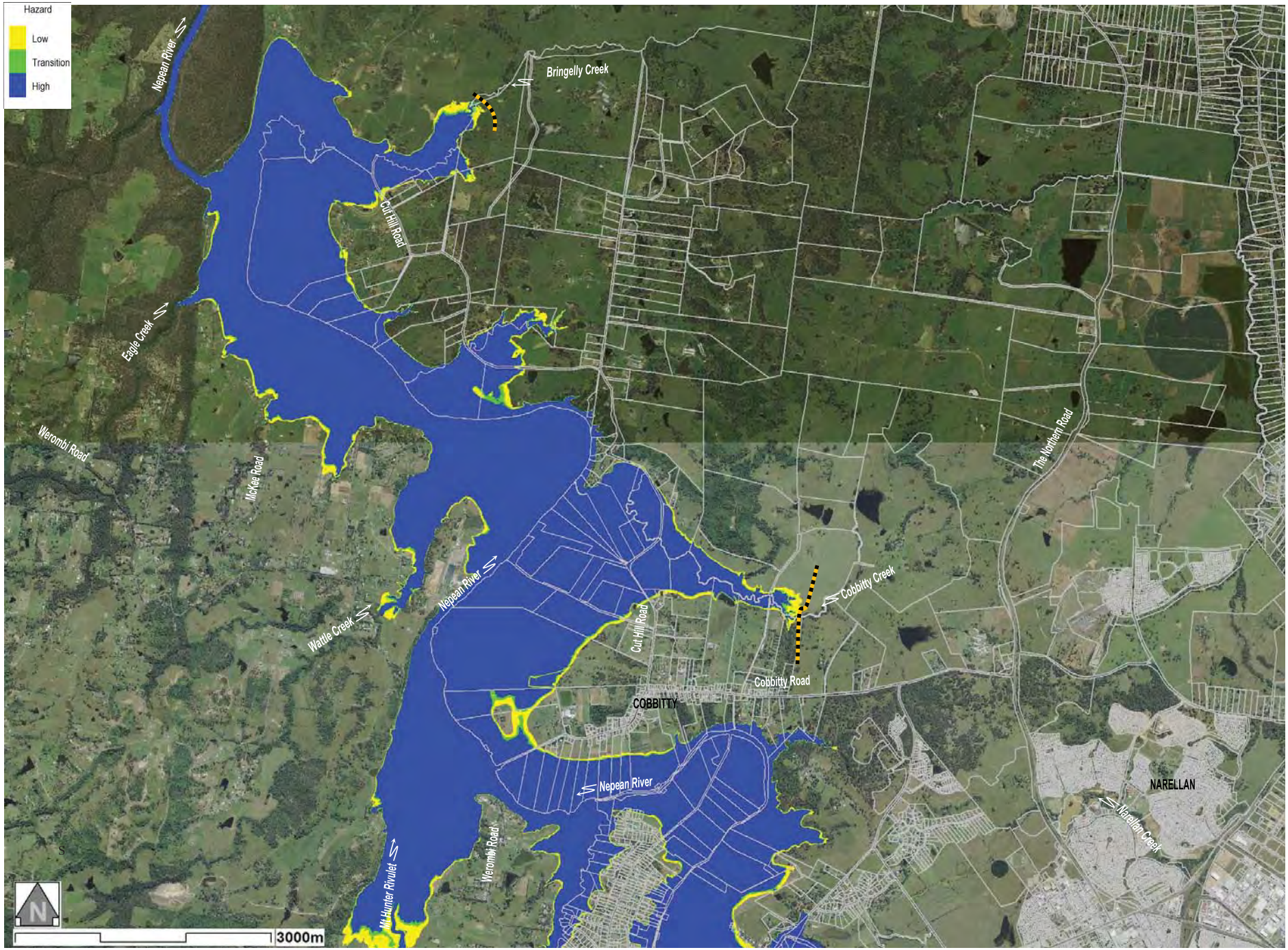
301015-03107 – Nepean River Flood Study (Camden Council)
I.13_fg301015-03107eh150326-Hazard_PMF_South.doc

PROVISIONAL FLOOD HAZARD MAPPING FOR THE PMF EVENT (SOUTH)

APPENDIX J

PRELIMINARY TRUE HAZARD MAPPING

FIGURE J.1



LEGEND:

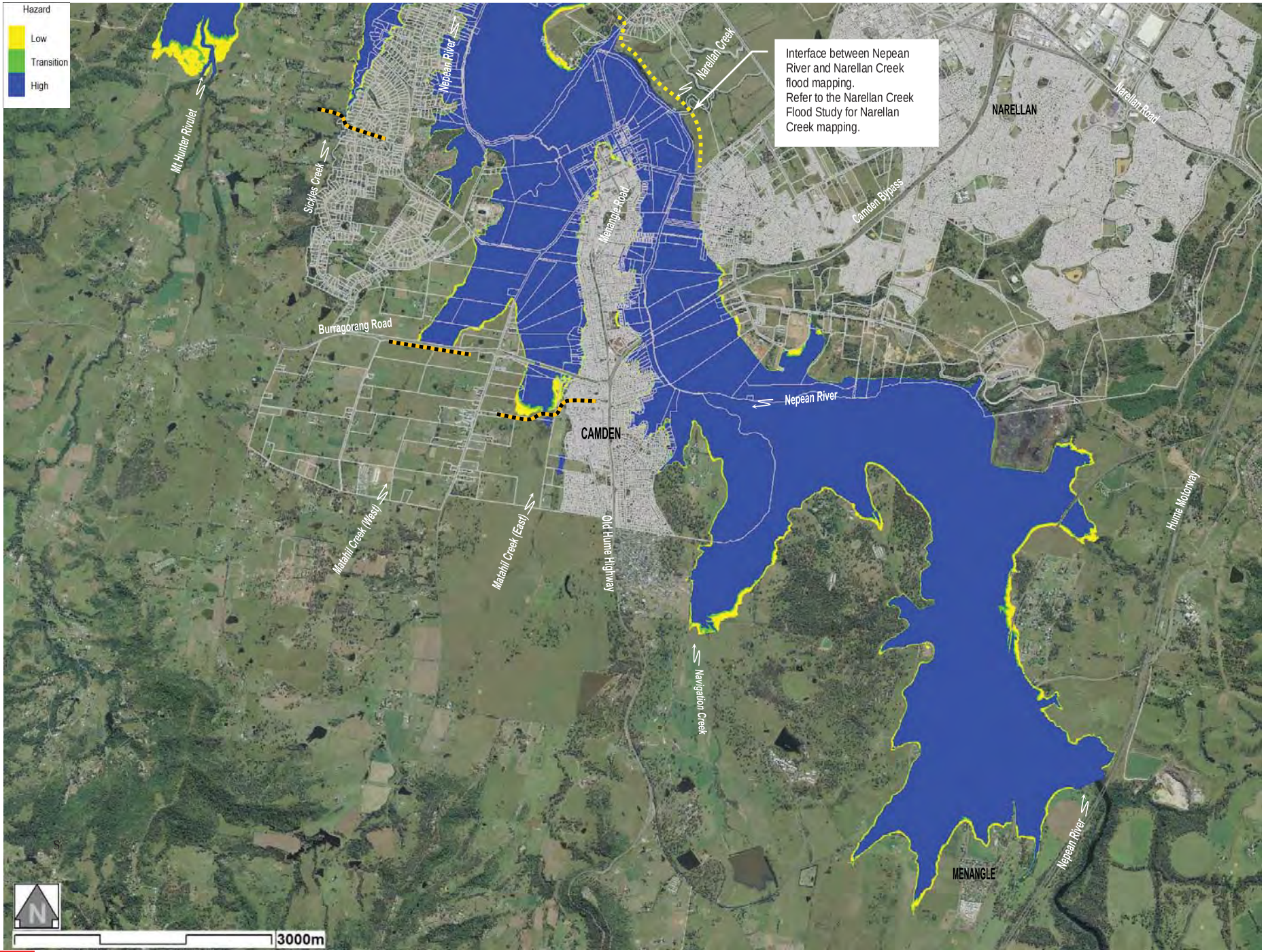
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
J.01_fg301015-03107nm140224-TrueHazard_100yr_North.doc

PRELIMINARY TRUE HAZARD MAPPING FOR THE 1% AEP EVENT (NORTH)

FIGURE J.2



LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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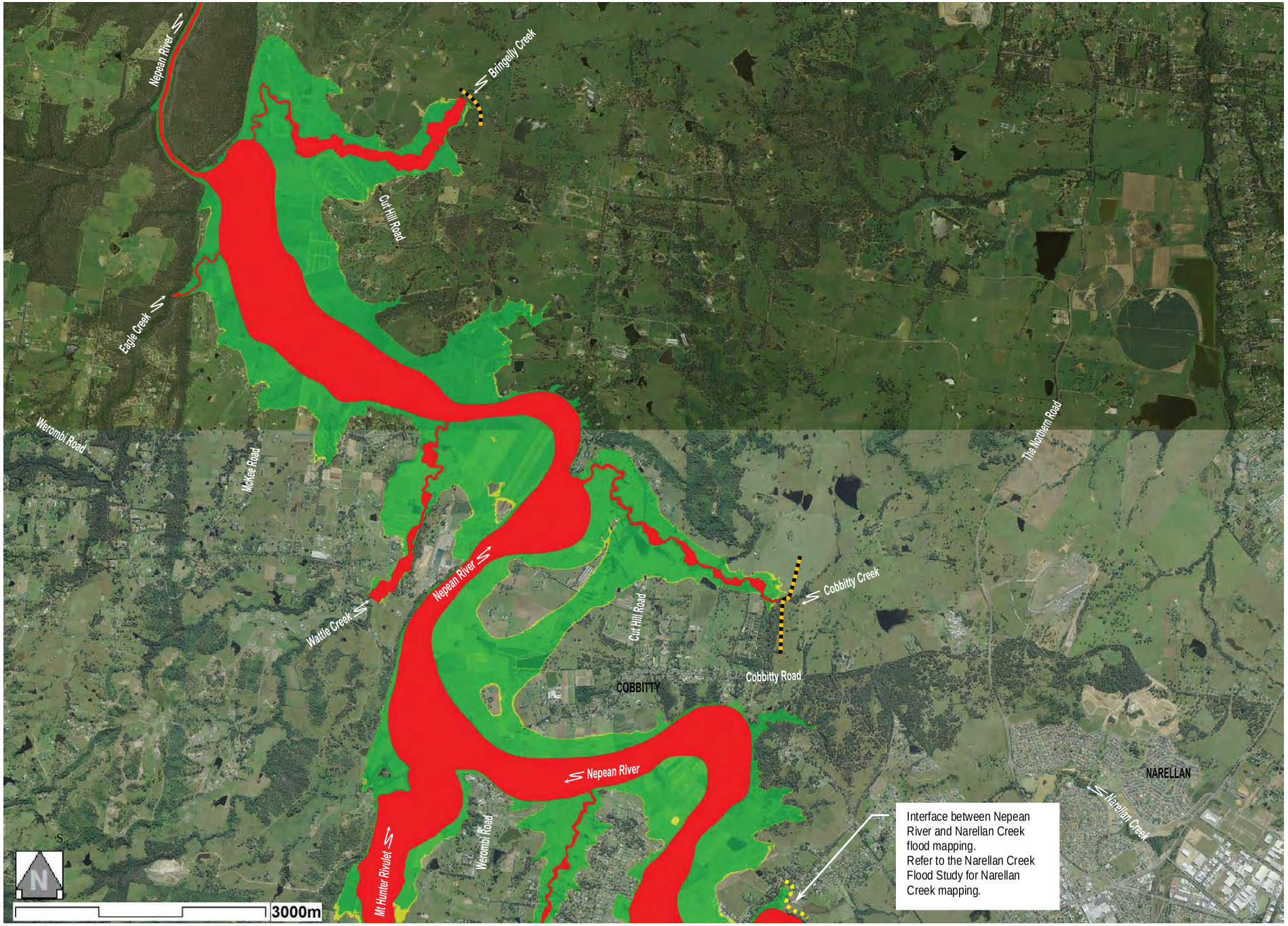
301015-03107 – Nepean River Flood Study (Camden Council)
J.02_fg301015-03107nm140224-TrueHazard_100yr_South.doc

PRELIMINARY TRUE HAZARD MAPPING FOR THE 1% AEP EVENT (SOUTH)

APPENDIX K

PROVISIONAL HYDRAULIC CATEGORY MAPPING

FIGURE K.1

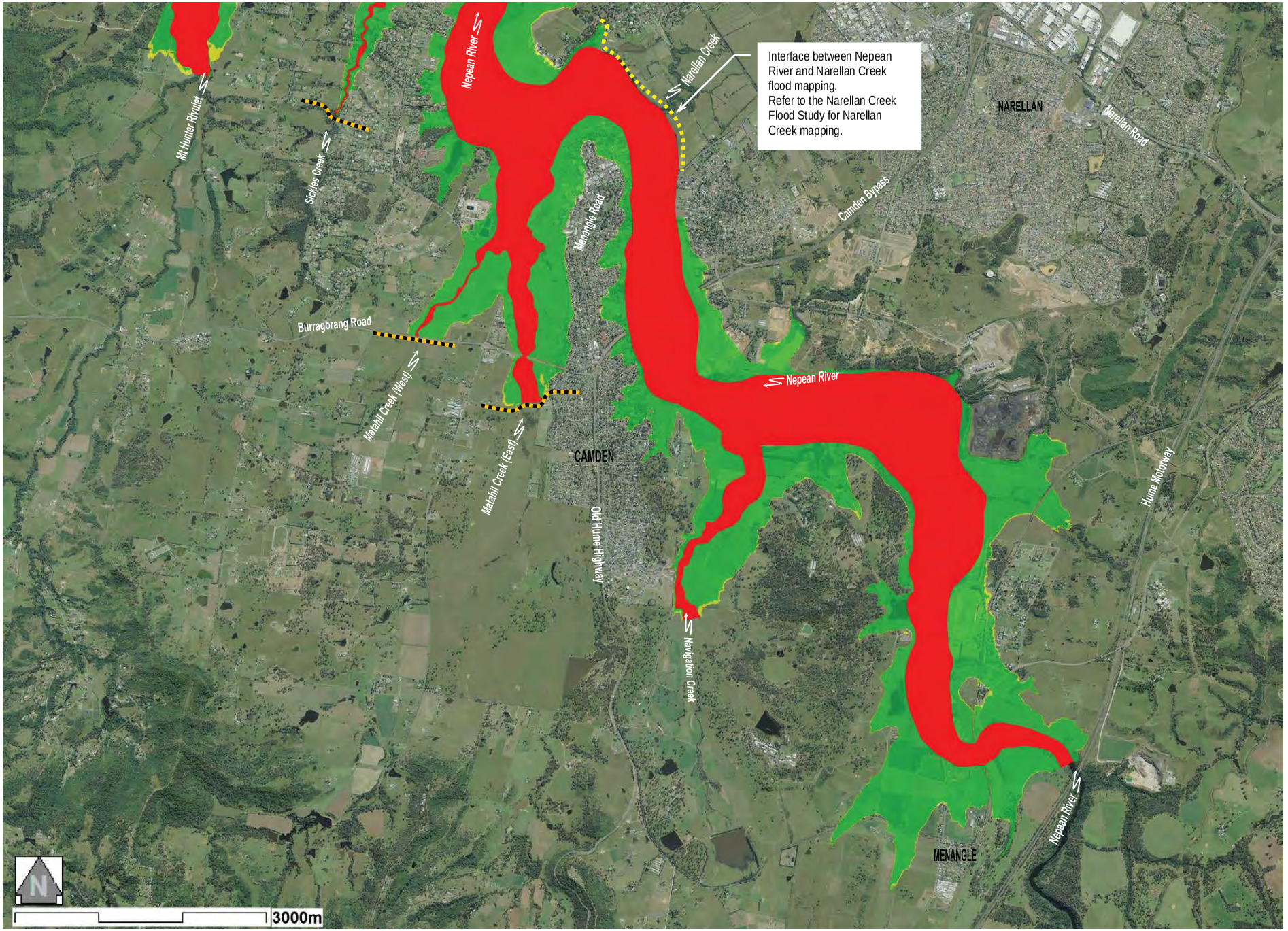


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301015-03107 – Nepean River Flood Study (Camden Council)
K.01_fg301015-03107eh150326-Floodway_100yr_North.doc

HYDRAULIC CATEGORY MAPPING (NORTH)

FIGURE K.2



LEGEND:

- Floodway
- Flood Storage
- Flood Fringe
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

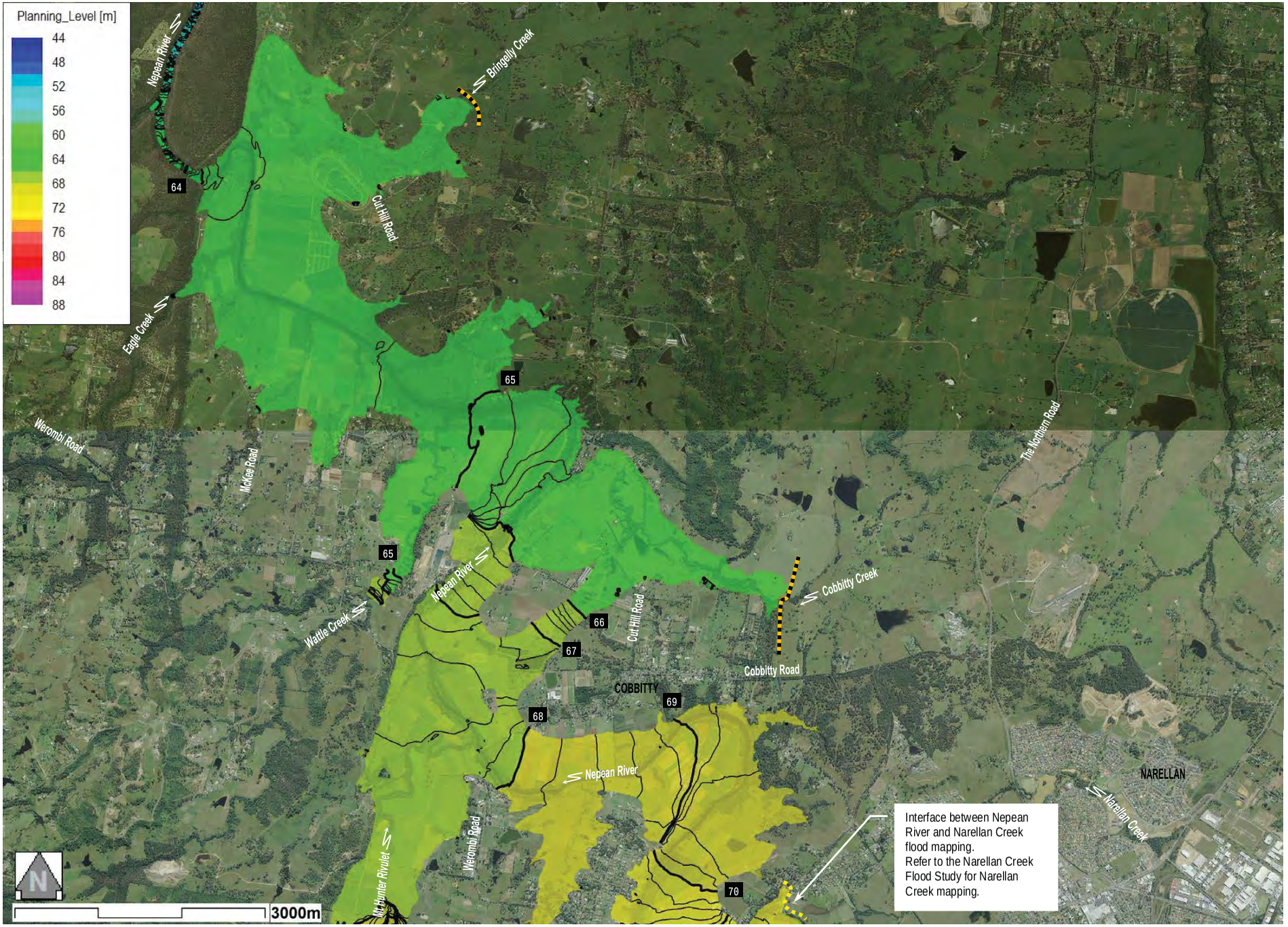
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HYDRAULIC CATEGORY MAPPING (SOUTH)

APPENDIX L

FLOOD PLANNING AREA MAPPING

FIGURE L.1



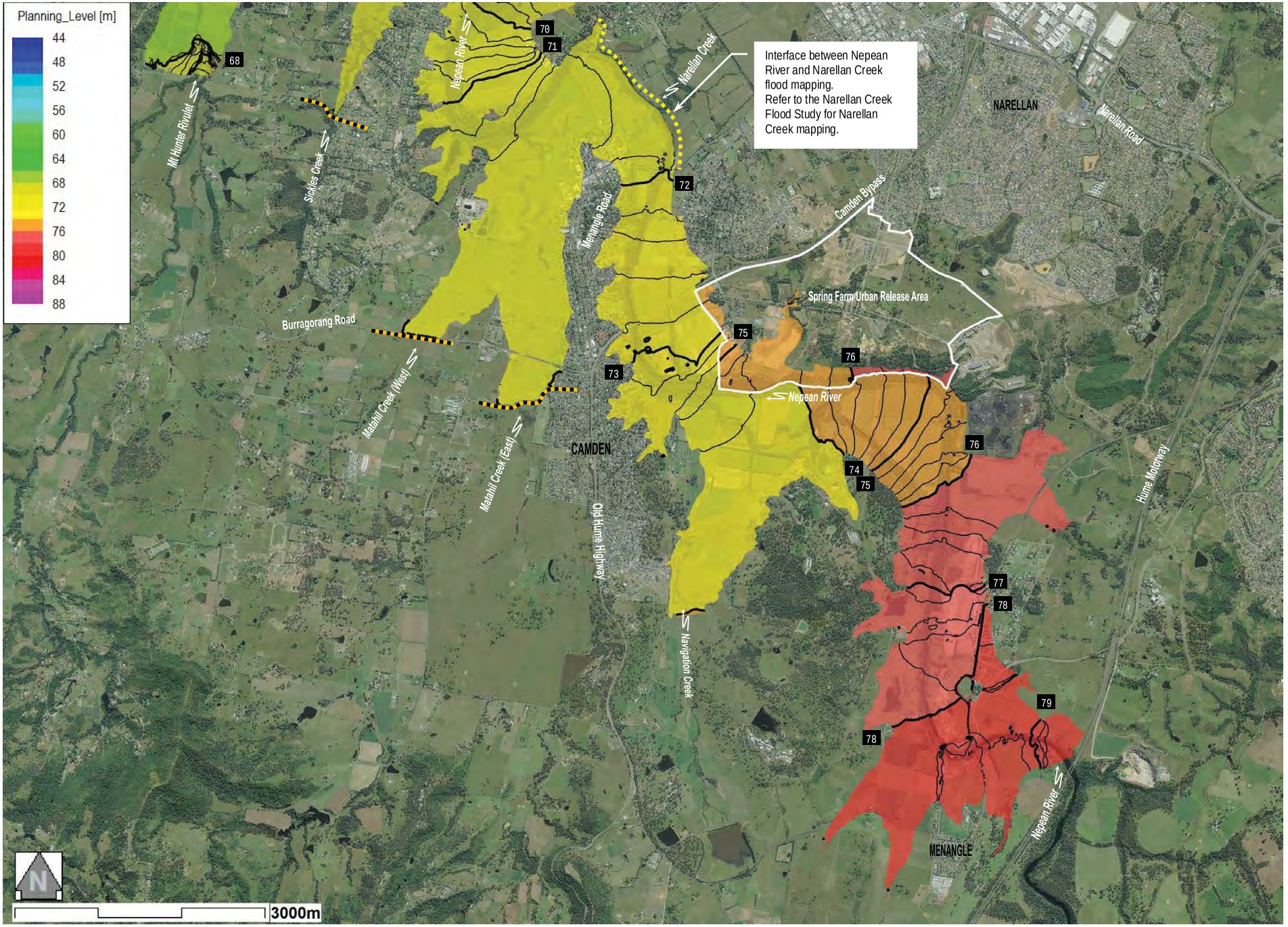
LEGEND:

- 0.2 metre contour line
- 1.0 metre contour line
- 99 Flood Planning Level [*mAHD*]
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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FLOOD PLANNING LEVEL MAPPING (NORTH)

FIGURE L.2



LEGEND:

- 0.2 metre contour line
- 1.0 metre contour line
- 99 Flood Planning Level [*mAHD*]
- Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

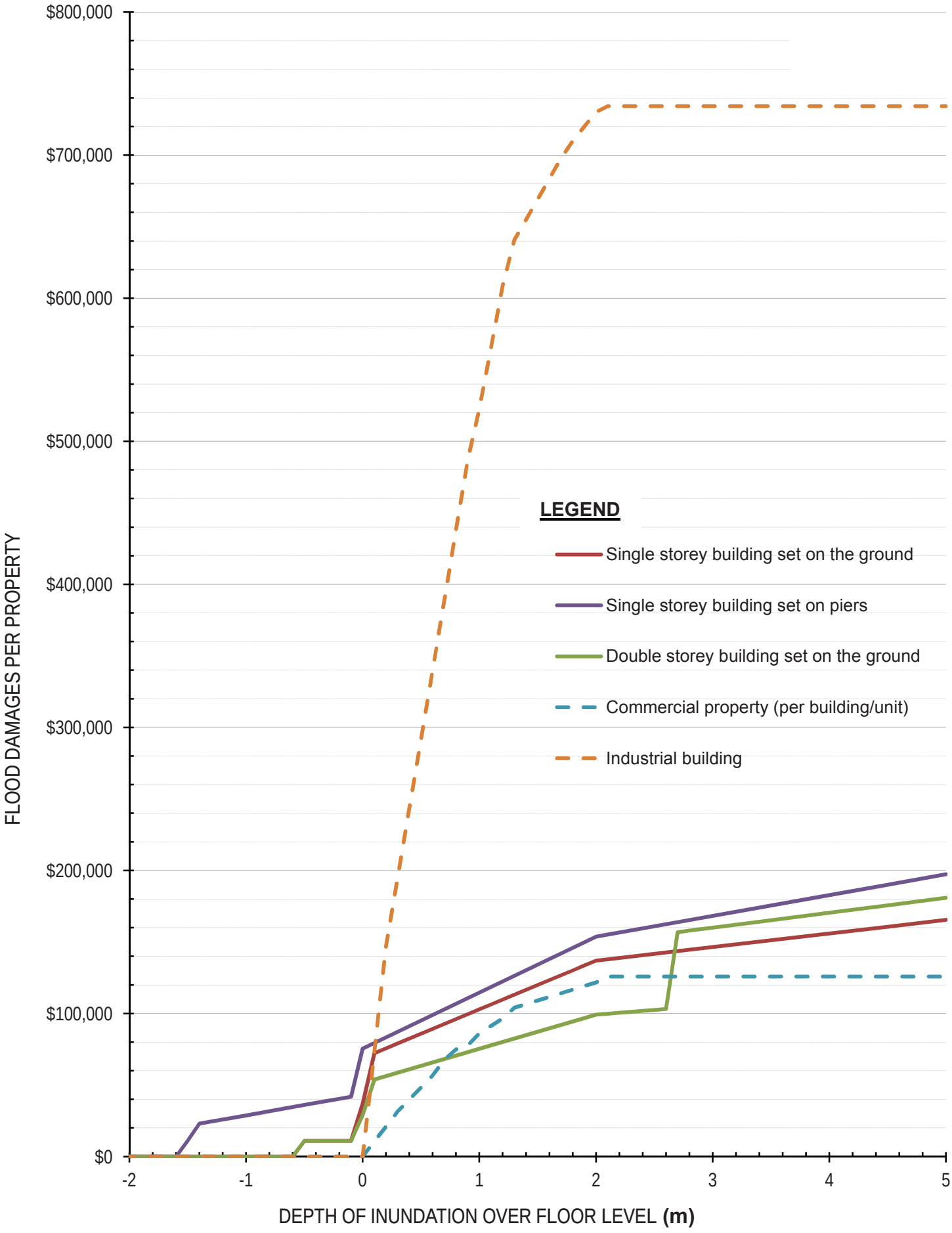
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FLOOD PLANNING LEVEL MAPPING (SOUTH)

APPENDIX M

STAGE-DAMAGE CURVES

FIGURE M1



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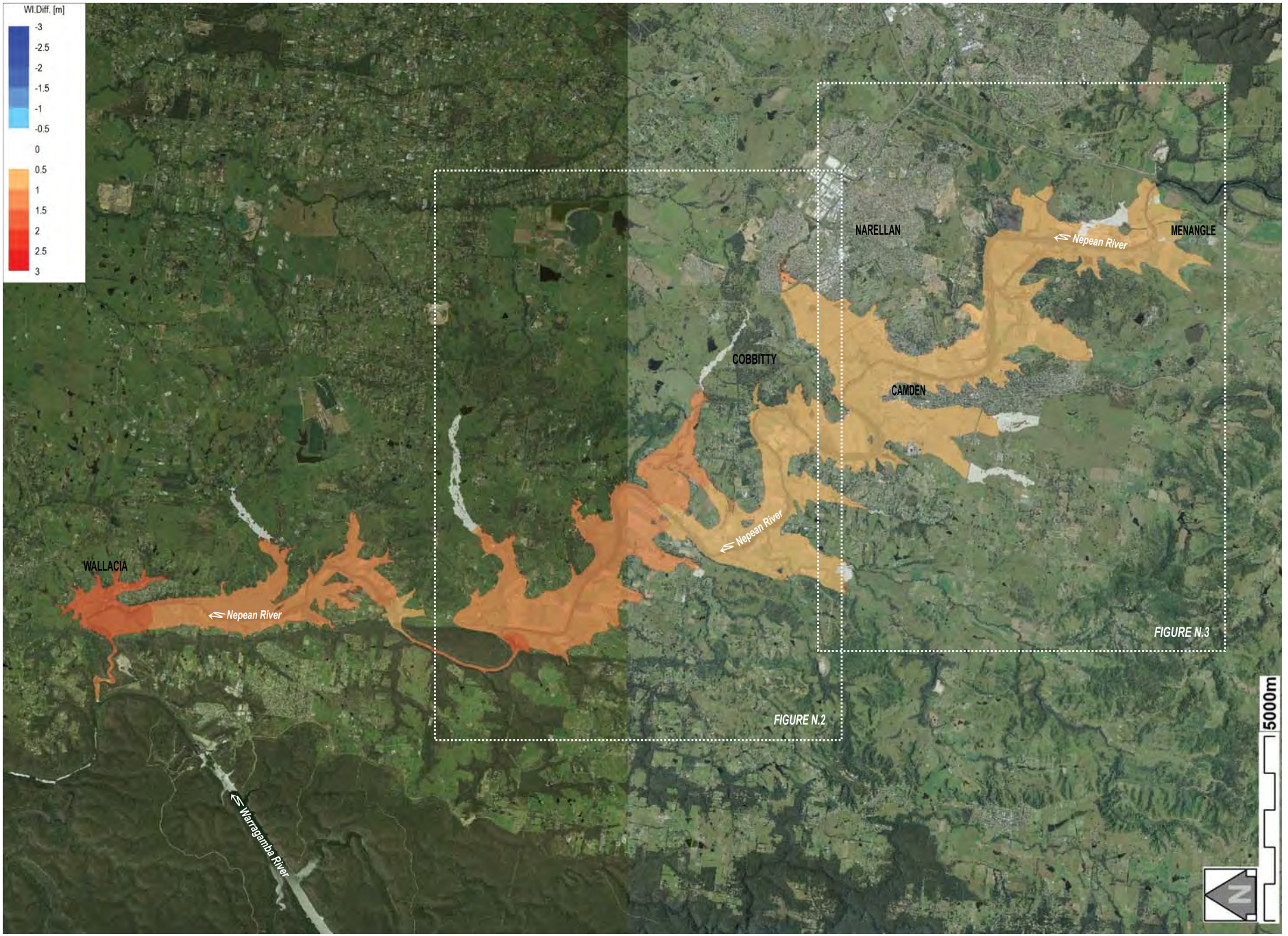
301015-03107 - Nepean River FS
DamageCurves_OEH.xlsx

ADOPTED STAGE DAMAGE CURVES FOR NEPEAN RIVER

APPENDIX N

SENSITIVITY TESTING MAPPING

FIGURE N.1



NOTES:

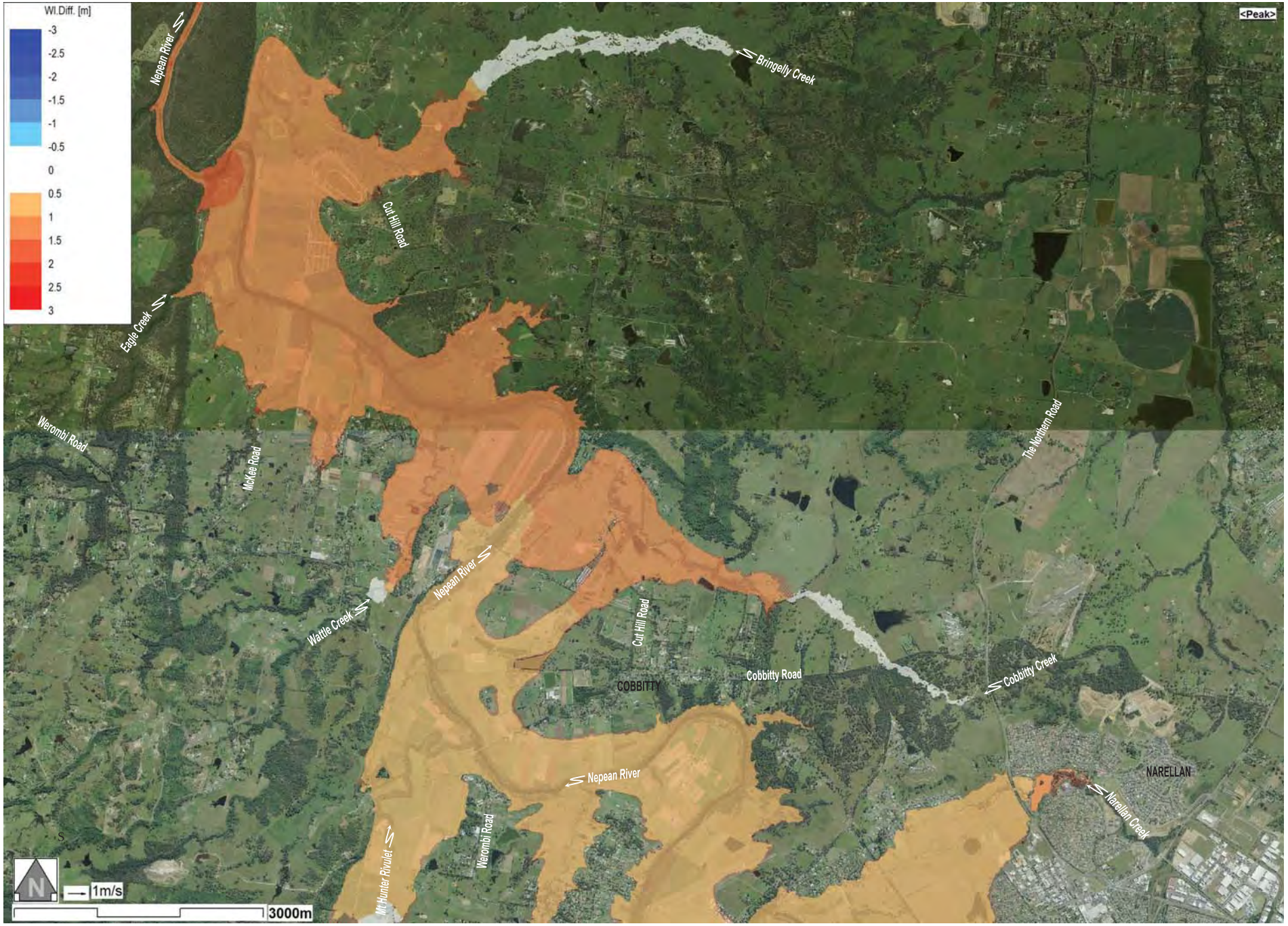
Hatching indicates land that is inundated during the climate change scenario that remains dry during the present day scenario

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301015-03107 – Nepean River Flood Study
N.01_fg301015-03107nm140224-CC_100yr+10%_ALL.doc

CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 10% INCREASE IN RAINFALL INTENSITIES DURING THE 1% AEP EVENT

FIGURE N.2



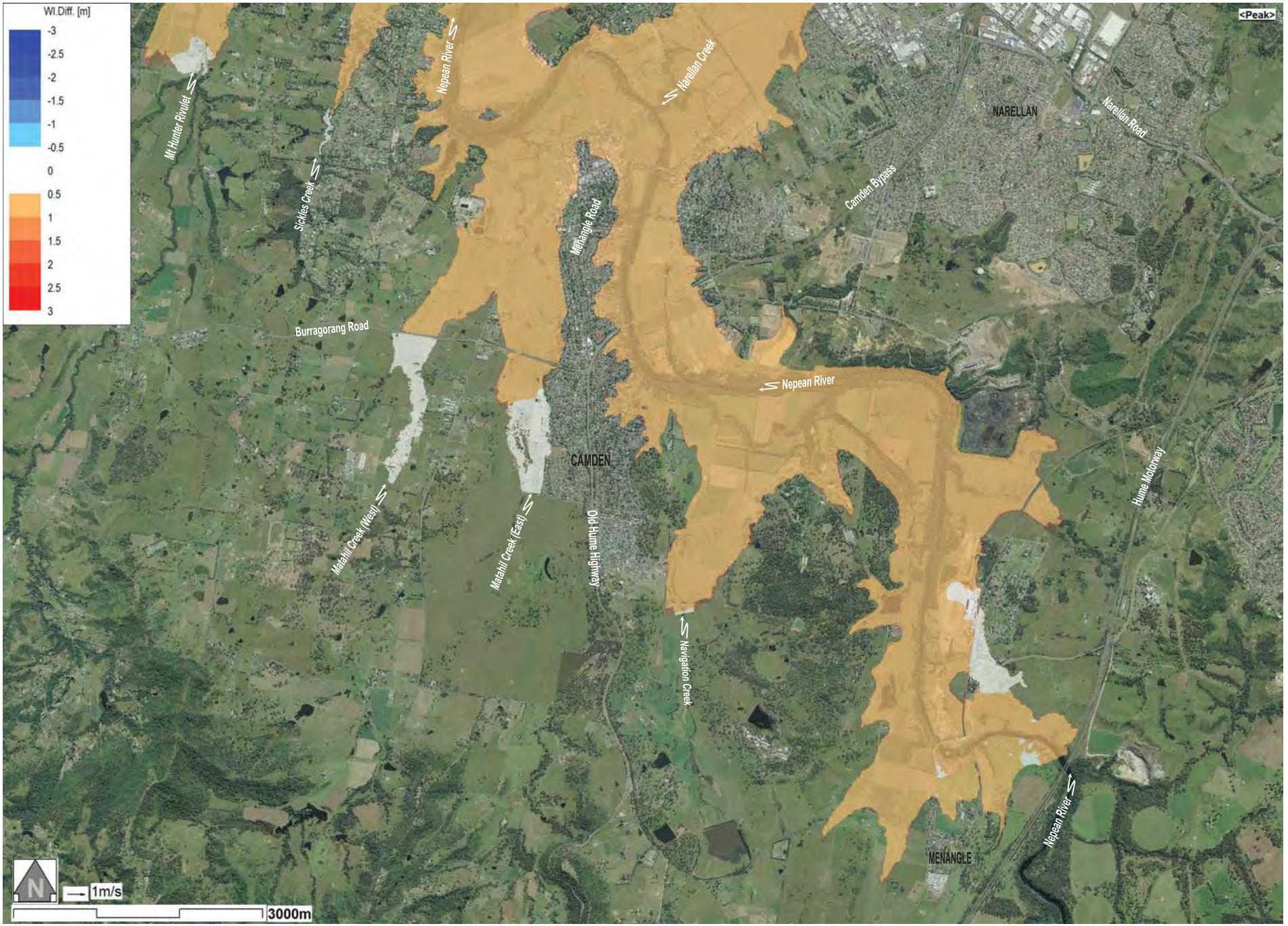
NOTES:

Hatching indicates land that is inundated during the climate change scenario that remains dry during the present day scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 10% INCREASE IN RAINFALL INTENSITIES DURING THE 1% AEP EVENT (NORTH)

FIGURE N.3



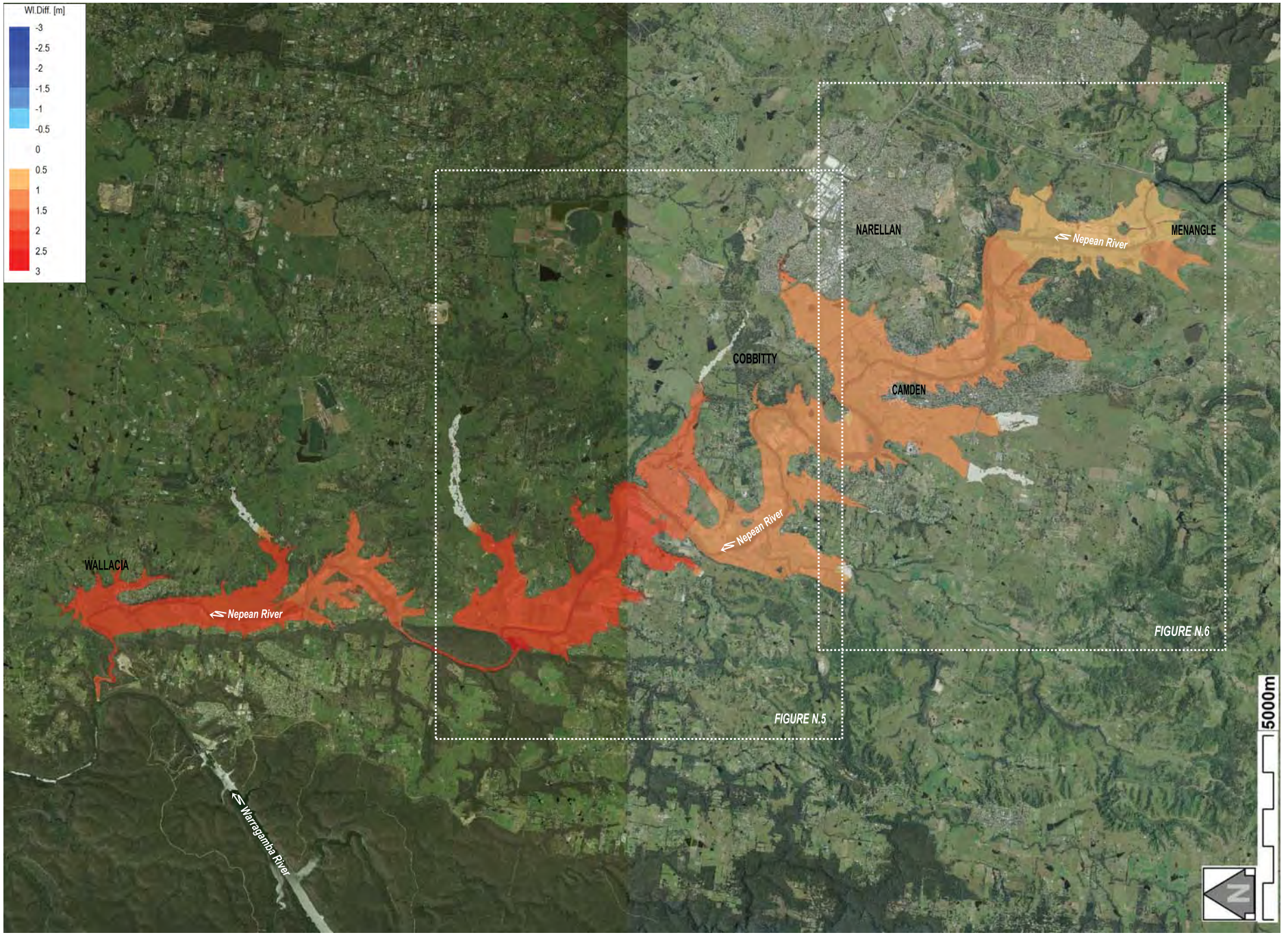
NOTES:

Hatching indicates land that is inundated during the climate change scenario that remains dry during the present day scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 10% INCREASE IN RAINFALL INTENSITIES DURING THE 1% AEP EVENT (SOUTH)

FIGURE N.4



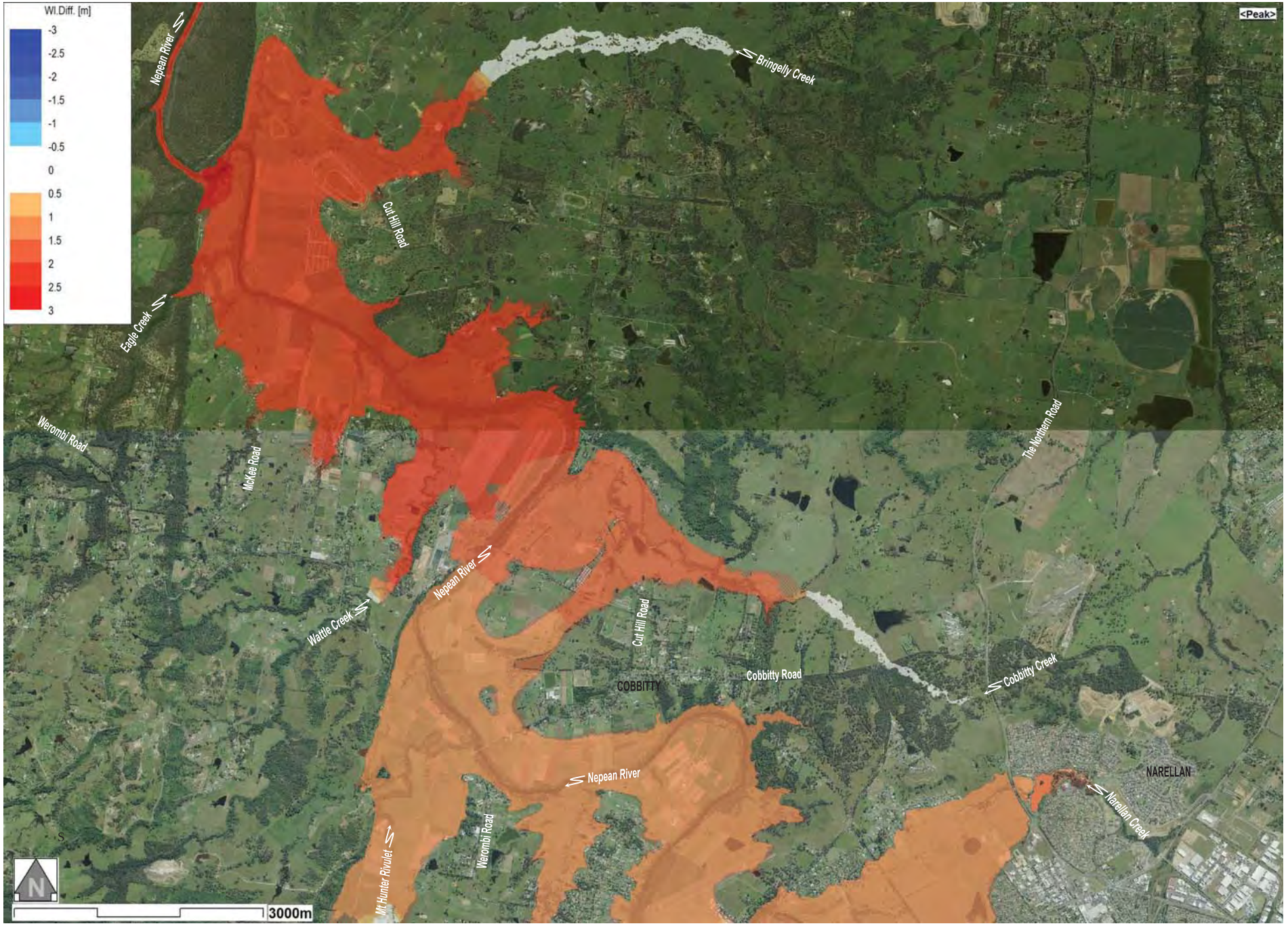
NOTES:

Hatching indicates land that is inundated during the climate change scenario that remains dry during the present day scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 20% INCREASE IN RAINFALL INTENSITIES DURING THE 1% AEP EVENT

FIGURE N.5
DRAFT



NOTES:

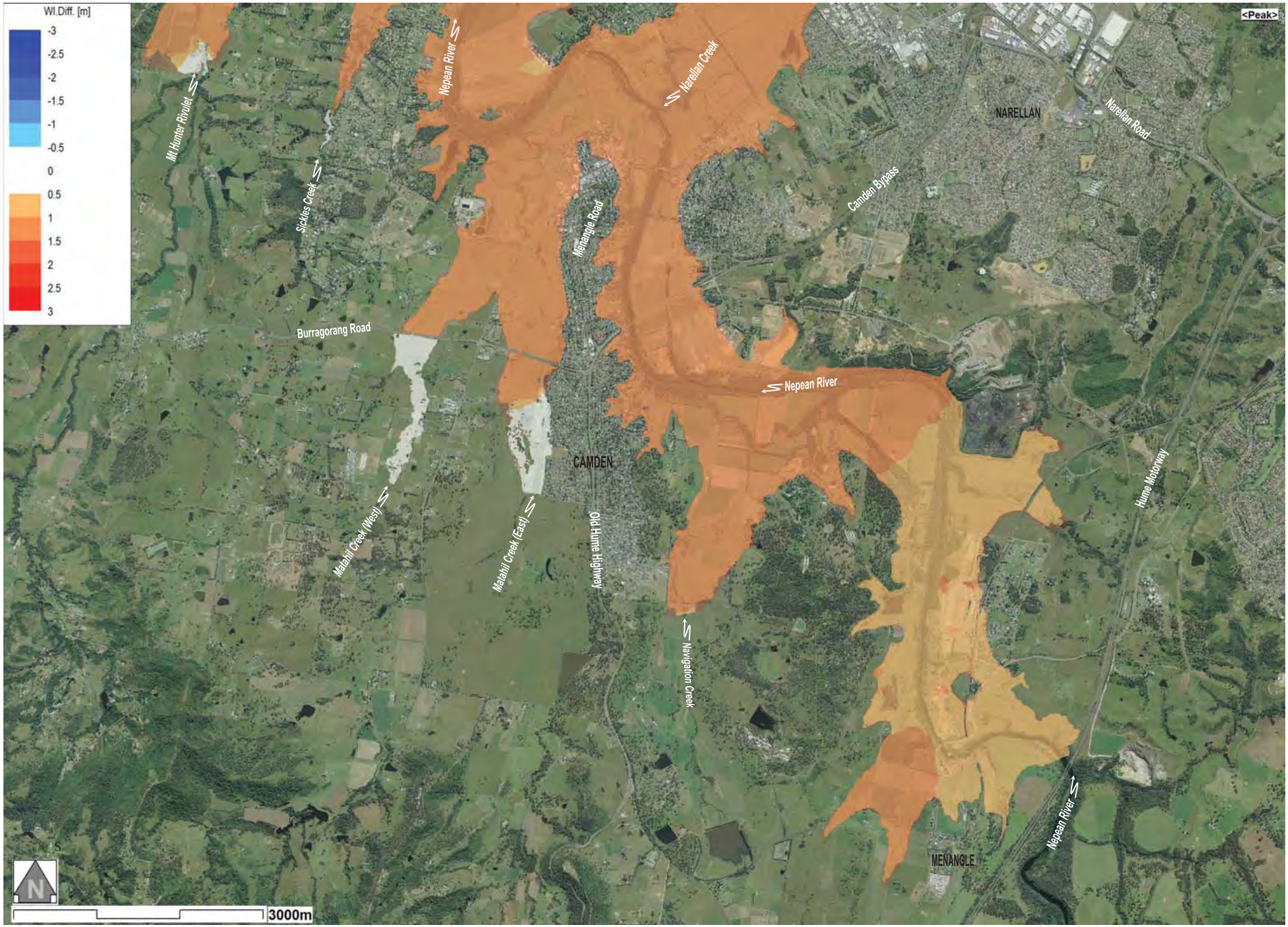
Hatching indicates land that is inundated during the climate change scenario that remains dry during the present day scenario

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N.05_fg301015-03107nm140224-CC_100yr+20%_North.doc

CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 20% INCREASE IN RAINFALL INTENSITIES DURING THE 1% AEP EVENT (NORTH)

FIGURE N.6
DRAFT



NOTES:

Hatching indicates land that is inundated during the climate change scenario that remains dry during the present day scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 20% INCREASE IN RAINFALL INTENSITIES DURING THE 1% AEP EVENT (SOUTH)

FIGURE N.7
DRAFT



NOTES:

Hatching indicates land that is inundated during the blockage scenario that remains dry during the standard scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 50% BLOCKAGES IN STRUCTURES DURING THE 1% AEP EVENT (NORTH)

FIGURE N.8
DRAFT



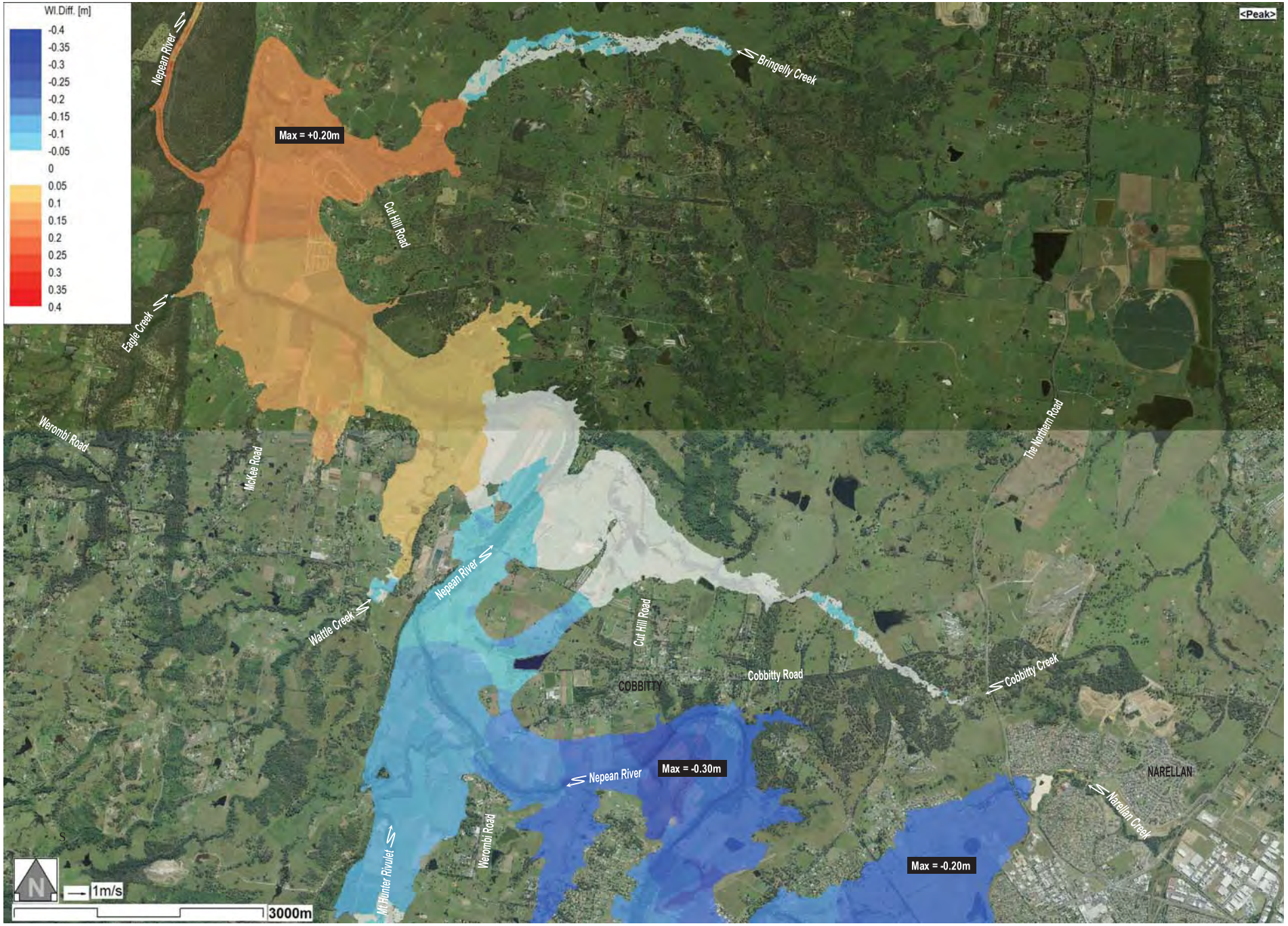
NOTES:

Hatching indicates land that is inundated during the blockage scenario that remains dry during the standard scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM 50% BLOCKAGES IN STRUCTURES DURING THE 1% AEP EVENT (SOUTH)

FIGURE N.9
DRAFT



NOTES:

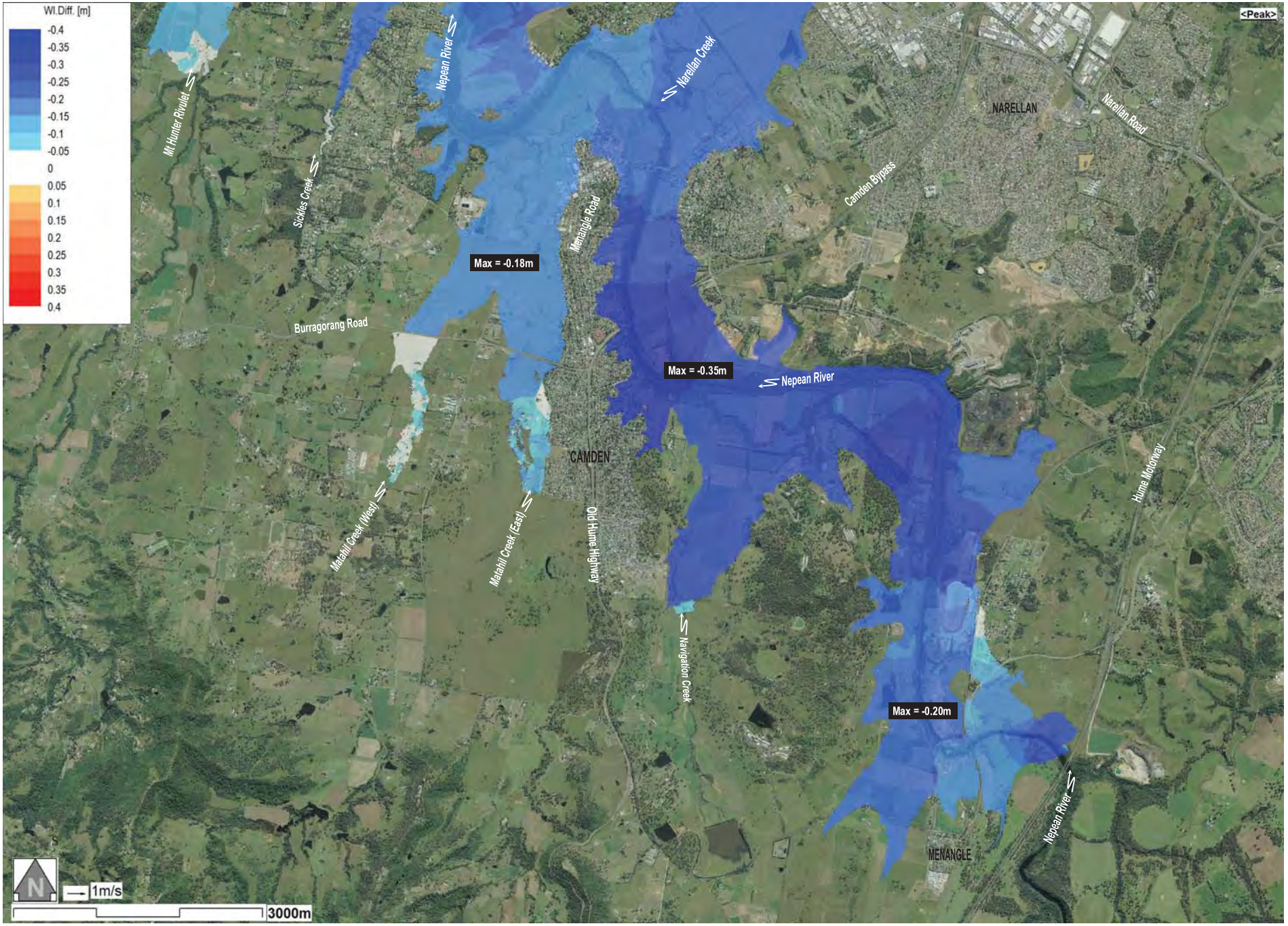
Hatching indicates land that is inundated during the reduced roughness scenario that remains dry during the standard scenario

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301015-03107 – Nepean River Flood Study (Camden Council)
N.09_fg301015-03107nm140224-Roughness_100yr_North.doc

CHANGE IN PEAK FLOOD LEVEL RESULTING FROM REDUCED FLOODPLAIN ROUGHNESS DURING THE 1% AEP EVENT (NORTH)

FIGURE N.10
DRAFT



NOTES:

Hatching indicates land that is inundated during the reduced roughness scenario that remains dry during the standard scenario

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CHANGE IN PEAK FLOOD LEVEL RESULTING FROM REDUCED FLOODPLAIN ROUGHNESS DURING THE 1% AEP EVENT (SOUTH)

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NEPEAN RIVER FLOOD STUDY



Issue No. 4

15th April 2015

rp301015-03107nm_wjh150525-Nepean River Flood Study.doc

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REV	DESCRIPTION	AUTHOR	REVIEWER	WORLEY-PARSONS APPROVAL	DATE
A	Issued for Internal Review	NM N Martin	WJH W Honour		07/02/2014
1	Draft Issued for Client Review	NM N Martin	WJH W Honour		21/02/2014
2	Draft Report	NM N Martin	WJH W Honour		16/01/2015
3	Final Draft Report	NM N Martin	WJH W Honour		31/03/2015
4	Final Report	NM N Martin	WJH W Honour	C Thomas	15/04/2015

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1. INTRODUCTION

The Nepean River enters the Camden LGA by passing through its southern border just southeast of the township of Camden (*refer* **Figure 1.1**). From there, the river meanders some 30 kilometres to the northwest before exiting the Camden LGA and entering the Bents Basin State Conservation Area.

The Nepean River then turns to the north and flows a further 15 kilometres before reaching the township of Wallacia. North of Wallacia the river turns markedly to the west before finding its confluence with the Warragamba River a further 3 kilometres downstream.

The catchment of the Upper Nepean River within the LGA (*including the Narellan Creek catchment*) covers an area of some 14,345 hectares. The study area for this Flood Study encompasses the catchment of the Upper Nepean River within the Camden LGA (*excluding the Narellan Creek subcatchment, modelled separately*) which covers a total area of some 10,930 hectares. A number of tributaries flow into the main stream in the vicinity of Camden. The most notable of these are Navigation Creek, Narellan Creek, Matahil Creek, Sickles Creek, Cobbitty Creek and Bringelly Creek.

The Nepean River flows along the northern and eastern boundaries of the Camden township. The subcatchment area of Navigation Creek drains into the river downstream of Camden, while the subcatchment areas of Matahil Creek, Narellan Creek, Sickles Creek, Cobbitty Creek and Bringelly Creek drain into the river downstream of Camden (*refer* **Figure 1.1**).

The total catchment of the Upper Nepean River considered within this study covers an approximate area of 1,800 square kilometres and comprises the Nepean River (*and its tributaries*) upstream of its confluence with the Warragamba River. Menangle Weir and Cowpasture Bridge / Camden Weir are the key reference locations within the Camden LGA used in this study. The catchment areas upstream of these locations are approximately 1,280 and 1,380 square kilometres respectively. Although not within the LGA of Camden Council, Wallacia is the key reference location at the downstream extent of the study and is located 15 kilometres downstream of the northern LGA boundary and approximately 2 kilometres east of the Nepean / Warragamba confluence. The catchment area upstream of this location is 1,795 square kilometres.

Three major population centres exist within the LGA of Camden; Camden / South Camden (*on the southern side of the Nepean River*), Elderslie (*on the northern side of the river adjacent to Camden*) and Narellan further to the east (*refer* **Figure 1.1**). It is understood that the suburbs of Harrington Park, Currans Hill and Mount Annan, in the vicinity of Narellan, have all expanded rapidly since the completion of the previous Upper Nepean Flood Study in 1995. Several areas in the vicinity of Camden itself have also expanded significantly since the previous study was completed, including Cobbitty, Ellis Lane, Grasmere and Kirkham. Furthermore, a new subdivision known as Spring Farm has introduced approximately 4,000 new lots to the northern side of the Nepean River.

Flooding events are rare within the study area. However, when such events do occur, flows escaping from the Nepean River are known to inundate the low lying areas of Camden and certain

sections within South Camden and Elderslie. Floodplain areas along many of the tributaries of the river (*particularly Narellan Creek and Matahil Creek*) are also known to be affected by backwater flooding from the Nepean River during flood events. Although the current study focuses on flooding from the Nepean River, flooding from these and other tributary streams are thought to represent potential flooding sources in their own right during extreme rainfall events.

The modelling undertaken during the study aims to provide a more robust and detailed definition of flooding behaviour within the study area and produce a series of maps and datasets that summarise the outputs of the models. It is intended that this information and the associated models will then be used in the development of flood management measures as part of the subsequent Floodplain Risk Management Study and Plan.

2. STUDY METHODOLOGY

2.1 STUDY AREA

The study area defined by Council is as follows (*refer* **Figure 1.1**):

- The Nepean River from Menangle Weir (*4.5 kilometres upstream of Camden Council's LGA boundary*) to the river's confluence with the Warragamba River near Warragamba Park; and
- Five tributaries of the Nepean River within Camden Council's LGA boundary, namely Navigation Creek, Matahil Creek, Sickles Creek, Cobbitty Creek and Bringelly Creek.

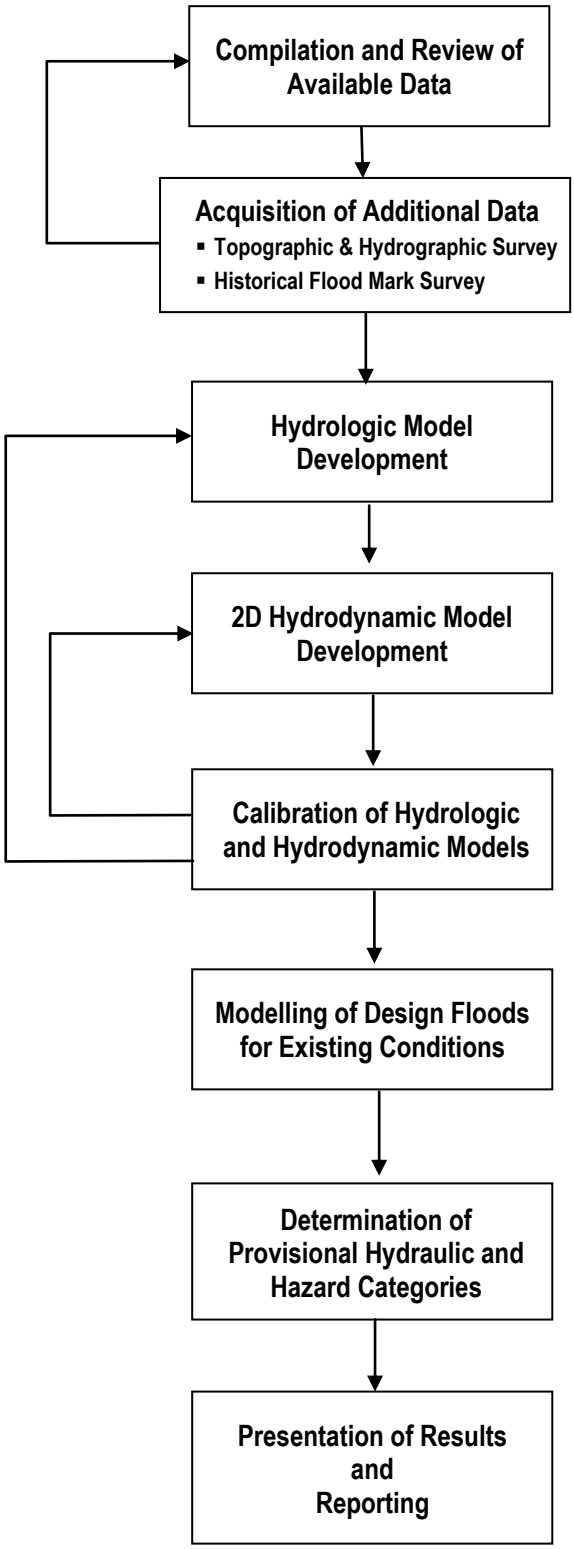
It should be noted that the Narellan Creek catchment is being modelled as a separate project and hence has not been specifically incorporated into the Nepean River study area.

2.2 ADOPTED APPROACH

The general approach and methodology employed to achieve the study objectives involved:

- Compilation and review of available information, including previously completed flood studies, streamflow gauge records, rainfall records, topographic mapping of the floodplain and details of bridge crossings and other structures;
- Site inspections and interrogation of aerial photography and other geographical data in order to establish catchment roughness, slope and land-use attributes;
- The collection of historical flood information, including records of peak flood levels for historical floods;
- The development of a computer based hydrologic model to simulate the transfer of rainfall into runoff and its concentration in local streams during flood events;
- The development of a computer based hydrodynamic model to simulate the movement of floodwaters through the reaches of the Nepean River floodplain that lie both within and downstream of the boundaries of the Camden Shire Council LGA area;
- Calibration and verification of the models; and
- The determination of peak flood levels and flow velocities at selected locations along the selected reach of the Nepean River for the predicted 500, 200, 100, 50, 20, 10, 5 and 2 year Average Recurrence Interval (*ARI*) floods and the Probable Maximum Flood (*PMF*).

The flow chart shown overleaf outlines the key steps and the sequence of work that has been undertaken in preparing this Flood Study.


Compilation and Review of Available Data
Acquisition of Additional Data
Topographic & Hydrographic Survey
Historical Flood Mark Survey
Hydrologic Model Development
2D Hydrodynamic Model Development
Calibration of Hydrologic and Hydrodynamic Models
Modelling of Design Floods for Existing Conditions
Determination of Provisional Hydraulic and Hazard Categories
Presentation of Results and Reporting

2.3 COMPUTER MODELS

Computer models are the most reliable and cost-effective tools available to simulate flood behaviour in rivers and streams. Two types of computer models were developed as part of the Flood Study for use in assessing and quantifying flooding characteristics within the Nepean River catchment. These are:

- A hydrologic model, covering the Nepean River and its tributaries upstream of and within the study area; and
- A hydrodynamic model, extending along the Nepean River between Menangle Weir and its confluence with Warragamba River.

The **hydrologic model** simulates catchment runoff following a particular rainfall event. The main outputs from the hydrologic model are discharge hydrographs which define the quantity of runoff as well as the rate of rise, timing and magnitude of peak discharges resulting from the rainfall event. The discharge hydrographs are utilised as inputs into the hydrodynamic model.

The **hydrodynamic model** simulates the passage of floodwater along waterway reaches and across floodplain areas. The hydrodynamic model calculates key flooding characteristics such as flood levels, flow velocities, floodwater depths and flood hazard at selected points of interest throughout the study area.

3. REVIEW OF AVAILABLE DATA

3.1 HISTORY OF FLOODING

Flooding events have proven to be rare within the study area since European settlement of the area. However, when such events do occur, flows escaping from the Nepean River are known to inundate the low lying areas of Camden itself and certain sections within South Camden and Elderslie. Floodplain areas along many of the minor tributaries of the river (*particularly Narellan Creek and Matahil Creek*) are also known to be affected by backwater flooding from the Nepean River during flood events. Flooding from these and other tributary streams also represent potential flooding sources in their own right during extreme rainfall events.

Reliable streamflow records have been recorded in Camden since 1949. Several large floods have occurred during this time, notably in June 1964, June 1975, March 1978, April 1988 and August 1990. Significant flooding also occurred in 1873. However, data relating to this event is limited to peak flood levels at isolated locations along the river.

The June 1964 flood is the largest to have occurred since records at Camden commenced. Despite limited data, the 1964 flood was estimated to have an Average Recurrence Interval (*ARI*) of 15 years in the '*Upper Nepean River Flood Study*'. The second largest flood on record is the March 1978 event.

During large flood events, residential and commercial areas in Camden are inundated. A number of bridges over the Nepean River upstream of Theresa Park are inundated during relatively minor flood events resulting in potential isolation of local residents.

Table 3.1 provides a list of the major floods and the estimated peak heights during these events at Cowpasture Bridge and Camden Weir (*in Camden*) and at Wallacia (*refer* **Figure 1.1**).

Table 3.1 RECORDED PEAK FLOOD HEIGHTS

FLOOD EVENT	PEAK FLOOD HEIGHT(*mAHD*)		
	Cowpasture Bridge	Camden Weir	Wallacia Weir
June 1964	69.75	-	43.93
March 1978	69.12	-	42.24
April 1988	68.45	-	40.81
August 1990	66.30	66.11	39.21

3.2 PREVIOUS INVESTIGATIONS

A number of previous flood studies have been undertaken that relate to flooding within the study area. A synopsis of those investigations considered relevant to this study is provided in the following sections.

3.2.1 Camden Floodplain Management Strategy Study (1985)

This study, completed by Lyall Macoun and Joy, assessed the 100 year ARI flood extent for Camden (*generally northern areas*) as well as the damages across residential, industrial and commercial areas during an event of this magnitude. Mitigation options were also established, with a final proposed option strategy considering a combination of property purchases, development controls, zoning changes and flood proofing.

3.2.2 Camden Flood Study (1986)

A flood study was undertaken by the Water Resources Commission for Camden in 1986 which used a HEC-2 steady state analysis in order to determine water surface profiles for both the 20 and 100 year ARI flood events. Cross-sections were derived from orthophotomaps and incorporated into the hydraulic model.

The primary aims of the study were to delineate floodways and inundation limits within the study area. The study assessed flood damages, flood hazard and identified possible flood mitigation measures. Model calibration utilised data collected from the June 1964 and March 1978 flood event. A simple flood frequency analysis was also undertaken using the existing streamflow data for Cowpasture Bridge.

3.2.3 Macarthur South Water Quality, Drainage and Flood Study (1990)

This study, undertaken by Sinclair Knight & Partners, involved the development of a RORB hydrologic model for the entire Upper Nepean River catchment. The model was calibrated for the March 1978 flood event and generated design flows for the 5, 20 and 100 year ARI flood events. As part of the calibration, pluviograph data was obtained from the Water Board (*now Sydney Water*).

A MIKE11 hydrodynamic model was constructed using 30 cross-sections of the river between Maldon Weir and Wallacia.

3.2.4 Warragamba Flood Mitigation Dam Environmental Impact Statement Flood Study (1995)

The Upper Nepean River was modelled in 1995 as part of the Warragamba Flood Mitigation Dam EIS by Webb McKeown and Associates. The investigation involved the construction of a RUBICON hydraulic model extending as far upstream as Camden in order to derive flow hydrographs at the Nepean River / Warragamba River confluence. As such, only the peak water surface profiles between Wallacia and the Nepean River / Warragamba River confluence derived in this study hold relevance to the Upper Nepean River as the majority of the recorded data was collected downstream of the confluence.

3.2.5 Upper Nepean River Flood Study (1995)

This study was undertaken by Lyall and Macoun Consulting Engineers (*LMCE*). The objective of this study was to define flood behaviour in the Upper Nepean River in terms of flooding behaviour for flood frequencies between the 0.5% and 20% AEP, as well as the Probable Maximum Flood (*PMF*) extreme event.

A RORB hydrologic model was produced and was calibrated to the June 1964, June 1975, March 1978, April 1988 and August 1990 historical flood events.

MIKE11 hydrodynamic modelling was undertaken in order to generate peak flood level results for the design runs utilising the hydrographic cross-sections of the Nepean River completed as part of the Camden Flood Study by the Water Resources Commission in 1986.

One model was used to determine small to medium flood events (*5 to 20 year ARI*), while another, shorter model was used for major flooding (*100 year ARI and larger*) where out-of-channel flows effectively 'shortened' the relative channel lengths along the river. This study found that backwater flooding from the Nepean River controlled flood levels for a considerable distance upstream along the tributaries.

3.2.6 Upper Nepean River – Tributary Flood Studies Volume 1 (1997 & 1998)

Following the Upper Nepean River Flood Study (*1995*), Lyall and Macoun Consulting Engineers (*LMCE*) completed a staged approach in defining flood characteristics of Upper Nepean River tributaries located in the vicinity of Camden. Stage 1 involved defining flooding in Navigation, Sickles, Matahil (*East and West*) and Cobbitty Creeks, while Stage 2 investigated flooding on Bringelly Creek and the lower reaches of the Narellan Creek catchment.

Both stages involved creating separate RORB hydrologic models for each of the tributaries (*except Narellan Creek*). These models were calibrated to peak discharges obtained by the probabilistic rational method (*PRM*) for the 10 and 100 year ARI events. An XP-RAFTS model of Narellan Creek, provided by Council and adjusted by LMCE, was used to derive flows generated from the Narellan Creek catchment.

The construction of the hydraulic model involved refining the existing MIKE11 model used for the Upper Nepean River Flood Study (*1995*). The updated model contained 70 cross-sections along the main river channel but also included 50 sections along the tributaries in the vicinity of Camden. During this stage of the overall series of studies undertaken by LMCE, additional sections were added in order to refine localised conditions (*i.e. bridges, culvert, and changes in channel dimensions*) that were not deemed critical in the original, broader Upper Nepean River Flood Study.

3.2.7 Upper Nepean River – Tributary Flood Studies Volume 2 (1999)

The second volume of the Upper Nepean River Tributary Flood Studies, completed by Lyall and Macoun Consulting Engineers (*LMCE*) involved determining the Probable Maximum

Flood (*PMF*) flood levels along Narellan Creek upstream of Northern Road and its six tributaries. The study involved adjustments and extensions to the existing XP-RAFTS model as well as a PMP estimation based on the Generalised Short Duration Method.

The existing MIKE11 hydraulic model was initially to be utilised for the downstream extent of the catchment and extended upstream. However, instabilities at drop structure locations meant that a HEC-RAS hydraulic model was used to model flows in the upper reaches of the Narellan Creek catchment. The depth, velocity and peak discharges during the PMF were then examined in detail at various road crossings. Sensitivities to culvert blockages were also examined in the study.

3.3 AVAILABLE DATA

A range of data is required in order to develop a hydrodynamic flood model and for that model to be applied to simulate flood behaviour. Typically, contours of the land surface and cross-sections of the river and creek system are required to represent the floodplain topography and channel bathymetry. Details of critical hydraulic controls such as bridges and roadway embankments also need to be defined as they can influence flooding characteristics. In addition, surface roughness parameters are required to reflect the influence that land features and vegetation may have on the way floodwaters travel overland. These are usually based on consideration of vegetation density and floodplain geomorphology with reference to published recommendations (*e.g., Chow, 1959*).

Streamflow data and historical flood level information are needed for calibration and verification of a flood model. Streamflow data is typically available from gauges where flows or water levels have been recorded over time. Historical flood levels can also be established by field survey after a flood or from anecdotal information provided by those who witnessed or experienced the flood. This data is extremely valuable and can be used to calibrate and verify the flood model.

The data for this study has been obtained from a number of sources including Camden Council, the Sydney Catchment Authority and the Office of Environment & Heritage (*formerly the Department of Environment, Climate Change & Water* (*DECCW*)).

Historical flood information was gathered from previously published flood level and stream flow records, most of which was obtained from government agency archives. This was supplemented by data contained in previous investigations and anecdotal recollections and photographs gathered from community members as part of consultation activities for this study.

3.3.1 Topographic Data

Between 25th February 2011 and 23rd March 2011, an aerial laser survey was undertaken across a large area of land in that encompasses Camden Shire and the study area upstream and downstream of Council's boundaries. This data has been made available by the New South Wales Government Department of Land and Property Information (*LPI*).

The survey generated *Light Detection and Ranging* (*LiDAR*) data for the study area. The processed LiDAR data was provided as spot elevations in a grid with a spacing of one metre across all terrestrial sections of the study area. Available documentation from those

responsible for procurement of the data indicates that spot elevations have a vertical accuracy of 0.3 metres and a horizontal accuracy of 0.8 metres.

The LiDAR data is considered to provide the most reliable and extensive data-set defining the topography of the Nepean River floodplain and has, therefore, been utilised as the primary source of topographic data used in the study.

Aerial laser survey techniques are unable to penetrate through water. Therefore, the LiDAR data does not include hydrographic features that are often important for flood modelling, most notably the bathymetry of streams that carry water under normal flow conditions. That is, the LiDAR data does not typically include data defining the bed and lower banks of the river and creek channels.

Given the size and channel characteristics of the main Nepean River channel, aerial surveys are likely to have been conducted during times when the volumes of water within the river were considerable. However, trapezoidal extrapolations of the LiDAR data according to known river depths revealed that the volumes of water present in the channel are considered to only represent a small percentage of the total bank-to-bank river channel volume in many locations and a significantly smaller percentage of the wider floodplain volume. Despite this, in a number of locations the apparent volumes present in the channel at the time of the LiDAR capture was significant.

Accordingly, it is considered inappropriate to assume that the LiDAR data adequately represents the channel dimensions and correct conveyance capacity of the Nepean River channel. Thus an additional source of topographic data was required in order to adequately capture the bathymetry of the Nepean River appropriately for use in a two-dimensional hydrodynamic flood model.

With this in mind, Camden Council was able to acquire additional data in the form of a detailed hydrographic survey of the river channel captured by the Sydney Water Monitoring Services Hydrometric Services Group (*refer below*).

Analysis of the tributaries of the Nepean River indicated that the channels contained low volumes of water during the capture period of the aerial laser survey data. As such, it was deemed appropriate to assume that the LiDAR data could be used to adequately represent the hydrographic topography along these tributaries.

3.3.2 Hydrographic Data

Hydrographic survey of the Hawkesbury Nepean Valley was undertaken by Sydney Water throughout 2011 and 2012. This survey encompassed the majority of the study area, with cross-sections beginning just downstream of Menangle Bridge (*approximately 500 metres downstream of Menangle Weir*) and ending at Wallacia Weir.

Utilising the data set available, a hydrographic surface of the main Nepean River channel was able to be created through the use of data point interpolation. This surface was used to complement the LiDAR within the model's topographic database.

It should be noted that a 3 kilometre section of the Nepean River as it flows through the gorge between Theresa Park and Bents Basin was deemed inaccessible by Sydney Water and thus, data for this area has not been recorded. However, a suitable interpolation of the stream channel geometry within the gorge was obtained using the upstream and downstream cross sections and the nearby LiDAR topographic data.

3.3.3 Hydrologic Data

Extensive searches were undertaken to obtain as much hydrologic data as possible for the Nepean River catchment within and in the vicinity of the study area. Hydrologic data usually exists in two forms, namely:

- Pluviometer and daily read rain gauges rainfall records; and
- Stream discharge records.

A summary of the data that was obtained is outlined in the following sections.

Historical Rainfall Data

Continuous rainfall data for specific storms is required for the calibration and verification of hydrologic computer models. This data is usually obtained from pluviometers located within or in the immediate vicinity of the catchment being modelled. Pluviometers generate plots of the instantaneous variation in rainfall with time.

An investigation was carried out to determine the location and details of rainfall gauges within the catchment of the Nepean River upstream and within the study area. The investigation included a search of the Bureau of Meteorology's (*BOM*) Water Resources Station Catalogue and New South Wales' Government's Water Information Database. Rainfall data utilised within the previous modelling of the catchment (*in particular, the Upper Nepean River Flood Study, 1995*) was also used to guide the availability and suitability of the various sources of rainfall data.

The investigation determined that a total of four pluviometer stations are located within the study area (*including Narellan*). Moreover, a further four pluviometer stations were identified in nearby catchments immediately east and west of the catchment boundary in the vicinity of the study area.

The distribution of the pluviometer stations investigated for the catchment is shown in **Figure 3.1**. A summary of the gauges and the recorded rainfall data available for each of these gauges is listed in **Table 3.2**.

Table 3.2 SUMMARY OF INVESTIGATED PLUVIOMETER RAINFALL GAUGES

RAINFALL GAUGE NAME	LOCATION *[lat/long]*
Camden Park Reservoir	-34.1164, 150.716
West Camden STP	-34.0590, 150.681
Camden Airport[1]	-34.0400, 150.690
Narellan	-34.0333, 150.783
Brownlow Hill	-34.0254, 150.646
Oakdale	-34.0694, 150.441
Campbelltown (Mt Annan)[2]	-34.0600, 150.770
Pondicherry	-33.9876, 150.736
Badgerys Creek	-33.8833, 150.750
Warragamba Met Station	-33.8902, 150.593

1 Not required as data available during calibration periods for nearby gauges at Camden Park Reservoir, West Camden STP and Narellan.

2 Data not available during calibration periods.

Streamflow Data

Streamflow data is generated from rating curves for gauging stations that are located along streams and rivers. A time series of flood level over the duration of a flood is recorded at the gauging station and the corresponding rating table is used to generate a discharge hydrograph. The discharge hydrograph provides a measure of the rate of flow at any particular time during the flood (*i.e., the number of megalitres per day or cubic metres per second*).

The NSW Office of Water's PINNEENA database (*2001*), NSW Government's Water Information Database and the Sydney Catchment Authority's stream database was interrogated in order to identify the location of all stream flow gauges within and upstream of the study area. The search identified that records exist for three gauges on the Nepean River within the study area, in addition to a gauging station at the upstream boundary of the study area at Menangle Weir. The locations of these gauges are shown in **Figure 3.2**. A summary of the gauges and the extent of the streamflow record at each gauge is provided in **Table 3.3**.

Table 3.3 SUMMARY OF INVESTIGATED STREAM GAUGING STATIONS

GAUGE No	GAUGING STATION NAME	LOCATION *[lat/long]*	RECORD AVAILABLE
212238	Menangle Weir	-34.1183, 150.7430	1968 to present
212900	Cowpasture Bridge	-34.0544, 150.7047	1949 to present
212216	Camden Weir	-34.0479, 150.7035	1989 to present
212202	Wallacia	-33.8611, 150.6302	1908 to present

3.3.4 Historical Flood Levels

A number of details from historical flood events collected as part of the Nepean River Flood Study (*1995*) were obtained as part of the study. This data was in the form of surveyed flood marks, as reported by local residents and businesses relating to past flood events. The levels (*in metres above Ordnance Datum*), river chainages and / or locations were included within Appendix C of the final Nepean River Flood Study (*1995*).

Further information relating to historical recollections was also obtained as part of the community consultation process of this study. A total of 126 questionnaires were completed and returned by local residents, primarily within the town centre of Camden. Of these, nine contained location and peak water level information that was specific enough to be utilised as historical flood level data.

3.3.5 Other Geographic Data

Various other sets of geographic data relating to the study area were also obtained from Camden Shire Council and other public domain / government sources. This includes aerial photography, cadastre, roadway, drainage and watercourse information.

4. FLOOD FREQUENCY ANALYSIS

Flood frequency analysis enables the magnitude of floods of a selected Annual Exceedance Probability (*AEP*) to be estimated by statistical analysis of recorded floods. Methods have been developed that allow a probability distribution to be fitted mathematically to observed data so that flood magnitudes of required probabilities can be calculated. These procedures are outlined in Chapter 10 of the 1987 edition of *'Australian Rainfall and Runoff'*, and in Book IV of the revised edition published in 1998.

The procedures apply primarily to peak discharges at a site and generally should not be applied to peak water levels. This is because the distribution of water level at a site can include discontinuities due to sudden changes in cross-sectional area as discharges increase. Furthermore, the relationship between flood stage and discharge may vary throughout the period of record due to changes in the river channel geometry caused by scouring or bank erosion.

Notwithstanding, it needs to be recognised that flood discharges are typically determined at streamflow gauge locations from recorded water levels. This is because it is not practical to constantly gauge stream velocities and flow rates at all locations where flow estimates are required. Therefore, by relating flow rate to a level or stage at a certain point on a stream, and developing a rating curve similar to that used for measuring flumes or weirs, flows can be estimated continuously by simply monitoring stream stages. Most stream gauges are 'rated' and the rating curve is used to determine the flow that corresponds to the recorded flood level.

To undertake a valid flood frequency analysis at least 10 to 15 years of streamflow data is required. The data should constitute a random sample of independent values from a homogenous population (*Institution of Engineers Australia, 1987*). If the flow records are too short the calculated probabilities cannot be expected to be reliable.

4.1 METHODOLOGY

4.1.1 Choice of Series

Flood frequency analysis can be based on either an annual or a partial series. The annual series is the most common analysis method. For annual series analysis, missing record periods are of no consequence and can be included in the period of record, provided it can be determined that no major floods occurred during years for which data was unavailable.

The annual series approach uses the maximum instantaneous discharge in each year of record. The year may be a calendar year, or if there is seasonality in flow, a water year commencing at the end of the low flow period. For N years of data there will be N values in the annual flood series.

A partial series analysis uses discharges for all floods above a specified minimum discharge, irrespective of the number that occur in a given year (*although the events should be independent*). There may be more than one flood in the analysed record for some years and none for others.

Either approach is acceptable, but can result in a different flood frequency distribution. ARR 98 suggests a general preference for the annual series if floods rarer than the 10 year ARI flood event are of primary interest (*as they are in this study*). This is because annual and partial series analyses give similar results in this probability range, and the annual series also has the advantages of likely independence of annual peaks (*this can be checked by examination of the record at the end of each year*), unambiguous extraction of records, and conformity of the annual flood frequency distribution to many theoretical distributions.

4.1.2 Frequency Distribution

Several types of probability distributions are available for flood frequency analysis, including:

- The generalised extreme value distribution (*also known as the Gumbel distribution*);
- The three parameter log-normal distribution;
- The log Pearson III distribution; and,
- The Wakeby distribution.

In flood frequency analysis, discharges in the series are plotted on a frequency diagram. This has discharge as the ordinate (*linear or log scale*) plotted against Annual Exceedance Probability (*AEP*) or Average Recurrence Interval (*ARI*) as the abscissa (*probability scale*). For the abscissa (*x axis*) Normal, Exponential or Gumbel (*Extreme Value Type I*) probability scales are most commonly used, corresponding to the commercially available graph papers of these types.

The type of plot chosen is generally a convenience, and also allows the presentation of data in such a way that deviations from the distribution assumed by the axes can be judged.

Each discharge in the annual series was given a "plotting position" (*PP*); that is, an AEP for plotting purposes, using the recommended formula in ARR 98, namely:

$$PP = \frac{m - 0.4}{N + 0.2}$$

where m is the rank in the flood series (*the highest flood in the series having rank m = 1*), and N is the number of peaks in the record (*in this case 20 years*). As the number of peaks in the data series used for the flood frequency analysis is different from the number of years, this plotting position is modified using the formula:

$$P = PP \cdot \frac{N}{n}$$

where *n* is the total length of record represented by the series.

ARR 98 recommends fitting a log Pearson III distribution for an annual series. The methodology presented in ARR 98 is based on the method of moments, preserving the moments of the logarithms of flows. The log Pearson III distribution was fitted to the partial series presented in **Table 4.1** and plotted on log normal probability scales is shown in **Appendix A**.

4.2 FLOOD FREQUENCY ANALYSIS FOR NEPEAN RIVER

Stream discharge records for three stations along the Nepean River were obtained from the Sydney Catchment Authority's stream database. In order to conduct the analysis on a longer period of data, additional historical data was also obtained from Appendix B of the Upper Nepean River Flood Study (*1995*). The data obtained is summarised in **Table 4.1**.

Table 4.1 SUMMARY OF AVAILABLE STREAM DISCHARGE DATA

LOCATION	SCA RECORD	ADDITIONAL RECORD[1]
Menangle Road Bridge / Weir	07/1990 to 12/2012	10/1860 to 02/1991
Cowpasture Bridge / Camden Weir	08/1989 to 12/2012	10/1860 to 02/1992
Wallacia Weir	12/1975 to 12/2012	10/1860 to 02/1992

1 Upper Nepean River Flood Study (DLWC 1995).

4.2.1 Nepean River at Menangle

Stream level records were recorded at a location on Menangle Road Bridge (*212904*) as far back as 1891. However, the station did not regularly begin to record day-to-day readings until 1963. A continuous recording station at nearby Menangle Weir (*212238*) has been operated by Sydney Water since July 1990.

According to the analysis of recorded data at Menangle Road Bridge undertaken during the Upper Nepean River Flood Study (*1995*), the river in this location is sandy in nature and subject to river morphology issues which would necessitate regular assessment and updates of rating curves. Similarly, the report states that an historical lack of reliable rating curves for the location appears to have resulted in data that consistently underestimates discharges when compared to discharge estimates made upstream and downstream of the station during high flow events. As such, the report concluded that data from this station is not reliable enough to be used in a flood frequency analysis.

The data taken at Menangle Weir is thought to be more reliable. However, the station stopped recording midway through the August 1990 flood event in the area and no major events have since been experienced. As such, the record at Menangle Weir is not suitable for a standalone flood frequency analysis.

Accordingly, as no truly suitable data could be obtained, flood frequency analysis was not undertaken for Menangle Road Bridge or Menangle Weir.

4.2.2 Nepean River at Camden

Informal stream level records have been recorded at Cowpasture Bridge in Camden (*212900*) since 1860, although records prior to 1949 were only taken during flood events. Whilst undertaking the Camden Flood Study (*1986*), the Water Resources Commission was able to derive a series of annual peak discharges using records from the station itself and estimations derived from nearby stations. The three highest flows assumed in the study were from 1860, 1873 and 1898 (*4860, 10060 and 7170 m^3/s, respectively*). The fourth highest discharge was the first to be experienced after the introduction of formal recordings at Cowpasture Bridge in 1949 and occurred in June 1964.

A continuous recording station at nearby Camden Weir (*212216*) has been operated by Sydney Water since August 1989. Records from this location were used in conjunction with the data from Cowpasture Bridge to create a list of the largest events in the Camden area and were used as the basis of the flood frequency analysis.

Excluding all flow events with a peak discharge less than 100 m^3/s resulted in a total of 60 records being available for inclusion in the analysis. A partial series flood frequency analysis was undertaken based on this data, which is listed in **Appendix A**. The analysis was undertaken using a log Pearson Type III distribution.

Considering that the three highest flow events assumed to have occurred were based on estimates taken up to 150 years ago, investigations were conducted with *and* without this older / higher data. The results of the analysis are presented in **Table 4.2**.

Table 4.2 SUMMARYOF FLOOD FREQUENCY ANALYSIS FOR CAMDEN

	PEAK DISCHARGE [m^3/s]						
	2yr	**5yr**	**10yr**	**20yr**	**50yr**	**100yr**	**200yr**
1860 – 2012	788	1968	3219	4865	7799	10735	14424
1964 – 2012	733	1631	2454	3423	4952	6309	7868

The results of the individual analyses suggest that the three floods that occurred in the late 19th century have a heavy influence on the overall results of the calculations, particularly for the larger events. The results of the analyses when undertaken purely on the recordings taken since 1949 (*of which the first major flood was in 1964*) are markedly lower. It is difficult to assess the accuracy or validity of the three highest flows as they relate to the flood

frequency analysis results. However, in reality it appears likely that the "true" discharges for the various design flood events would lie somewhere between the two scenarios tested.

These values are generally within the range of values for Camden reported in the Upper Nepean River Flood Study (*1995*), which also investigated cases with and without the earlier, higher data. The partial series results for the dataset including the events from 1860, 1873 and 1898 (*a peak 100 year ARI discharge of 10700 m^3/s*) is similar to the equivalent annual series analysis conducted as part of the Nepean River Flood Study (*1995*). Similarly, the partial series result for the data recorded between 1950 and the present day reflects the corresponding annual series result reported in the 1995 report. The previous study also investigated additional flood frequency analysis trials. However, it is unclear what methodology was adopted during these calculations.

4.2.3 Nepean River at Wallacia

Stream level records have been recorded at Wallacia Weir (*212202*) since 1908 and continuous records commenced in 1962. As with the stream records at Camden, the three highest flows assumed at this location in the study were from 1860, 1873 and 1898 (*5090, 7080 and 5900 m^3/s, respectively*) and are based on less reliable information from the nearby area. The fourth highest discharge was the first to be experienced after the introduction of formal recordings at Wallacia commenced in 1908 also occurred in June 1964. A number of other large events were observed, starting in 1917.

Once again, the total number of records for inclusion in the analysis was restricted to 60 records, meaning that all flow events with a peak discharge less than 400 m^3/s were excluded. A partial series flood frequency analysis was undertaken based on this data, which is listed in **Appendix A**. The analysis was undertaken using a log Pearson Type III distribution.

Considering that the three highest flow events assumed to have occurred were based on estimates taken up to 150 years ago, investigations for Wallacia were also conducted with *and* without the pre-1917 data. The results of the analysis are presented in **Table 4.3**.

Table 4.3 SUMMARYOF FLOOD FREQUENCY ANALYSIS FOR WALLACIA

	PEAK DISCHARGE [m^3/s]						
	2yr	**5yr**	**10yr**	**20yr**	**50yr**	**100yr**	**200yr**
1860 – 2012	881	1737	2643	3870	6177	8635	11931
1917 – 2012	833	1469	2053	2767	3960	5101	6494

The results of the individual analyses again suggest that the three floods that occurred in the late 19th century had a heavy influence on the overall results of the calculations. The results of the analyses when undertaken purely on the recordings taken since 1917 (*of which the first major flood was in 1964*) are markedly lower. It is interesting to note that the peaks assumed at Wallacia for the 1873 and 1898 flood events were calculated as being lower at Wallacia than at Camden, suggesting that a significant degree of uncertainty is inherent in the discharge calculations undertaken for these three events. This confirms yet again that the, while it is likely that the three pre-1917 discharges do have some validity, it is likely that the "true" discharges for the various design flood events would lie somewhere between the two scenarios tested.

The values listed in **Table 4.3** are also generally in agreement with the values for Wallacia reported in the Upper Nepean River Flood Study (*1995*), which also investigated cases with and without the earlier, higher data.

5. HYDROLOGIC MODELLING

5.1 HYDROLOGIC MODEL DEVELOPMENT

A hydrologic model of the Nepean River Catchment within the study area was developed to simulate rainfall and runoff processes in the catchment and produce the river / creek flows (*discharges*) that are required to determine flood levels in the subsequent hydrodynamic model. The Runoff Analysis and Flow Training Simulation (*XP-RAFTS*) software package was used with the objective of quantifying design flood discharges from the catchments.

XP-RAFTS can be used to develop a deterministic runoff routing model for the simulation of catchment runoff processes. It incorporates a range of common catchment parameters into its calculation procedures and is recognised in *'Australian Rainfall and Runoff – A guide to Flood Estimation'* (*1987*) as a suitable tool for use in flood routing within Australian catchments.

XP-RAFTS was chosen for this investigation because it has the following attributes:

- It can account for spatial and temporal variations in storm rainfalls across a catchment;
- It can accommodate variations in catchment characteristics;
- It can be used to estimate discharge hydrographs at any location within a catchment; and,
- It has been widely used across eastern NSW and therefore, where suitable calibration data is not available, the results from modelling of other similar catchments can be used as a guide in the determination of model parameters.

The XP-RAFTS model was developed using a range of physical characteristics of the catchment. These include subcatchment area, average slope, percentage impervious area and roughness. The model accounts for rainfall losses and routes rainfall excess through the catchment of interest.

The model was used to estimate subcatchment runoff peaks and to generate discharge hydrographs which can be compared with historical, recorded flows during the calibration process and to generate design inflow hydrographs in the subsequent hydrodynamic model simulations.

5.1.1 Subcatchment Details

Although LiDAR terrain data was provided for the areas of the catchment within the Camden Shire LGA area, high resolution drainage line data of these areas was also used to define the subcatchment areas where LiDAR data was not provided. LIDAR data and aerial photography were then used to refine the subcatchment subdivisions within the LGA boundary.

As a detailed and calibrated RORB model of the Upper Nepean River had already been completed as part of the Upper Nepean Flood Study (*1995*) it was considered appropriate to only complete a detailed XP-RAFTS model of the immediate study area (*i.e., downstream of Menangle Weir*). Therefore, the pre-existing RORB model was obtained and manipulated in

order to provide inflow hydrographs at Menangle Weir for all design and calibration events for use in the current study. The extent of the RORB model used to provide inflows for the catchment upstream of Menangle Weir (*i.e., for upstream catchment areas*) is shown in **Figure 5.1**.

It should be noted that, although stream level information was recorded at Menangle Weir during the 1964, 1978 and 1988 calibration events, the location was not used within the hydrologic model calibration process during the previous study. This relates to stream morphology issues at the weir and the resulting lack of reliable rating curves to convert the recorded levels into discharges (*refer* **Section 4.2.1**).

The catchment definition process resulted in the creation of 52 subcatchments within the study area downstream of Menangle Weir. As flooding in the Camden area was the primary focus of the study, the resolution of subcatchments was reduced slightly downstream of the LGA boundary at Bents Basin. Three to five subcatchments were typically used to define inflows to each of the tributaries of the Nepean River.

Subcatchments were differentiated on the basis of the alignment of major tributary flow paths and watershed boundaries, as well as the homogeneity of land use, vegetation and ground slope. Parameters such as catchment area, slope, roughness and percentage impervious area were established from the available data and assigned to each subcatchment accordingly.

Initially, subcatchments were formed by delineation of subcatchment boundaries from the intersections of major streams. Subcatchments were also defined at the locations of existing streamflow gauges so that XP-RAFTS hydrographs at these locations could be compared to recorded hydrographs to aid in calibration. Finally, subcatchment boundaries were inserted at the locations where input hydrographs were to be supplied during the hydrodynamic modelling stage.

The adopted subcatchment break-up is shown in **Figure 5.2**. A summary of the adopted sub catchment parameters is provided in **Appendix B**.

5.1.2 Adopted XP-RAFTS Model Structure

The XP-RAFTS model was developed by superimposing the model over the subcatchment break-up shown in **Figure 5.2**. The node and link arrangement was created to provide the pathways for rainfall excess to be “routed” through each of the tributary subcatchments. Details of the parameters adopted for each model node, including lag times for floodwater distribution between nodes, is contained in **Appendix B**.

5.1.3 Rainfall Loss Model

In a typical rainfall event, not all of the rainfall that falls onto the catchment is converted to runoff. Depending on the prevailing ‘wetness conditions’ of the catchment at the commencement of the storm (*i.e., the antecedent wetness conditions*), some of the rainfall may be lost to the groundwater system through infiltration into the soil, or may be intercepted

by vegetation and stored. This component of the overall rainfall is considered to be 'lost' from the system and does not contribute to the catchment runoff.

To account for rainfall losses of this nature, a rainfall loss model can be incorporated within the XP-RAFTS hydrologic model. For this study, the ***Initial-Continuing Loss Model*** was employed to simulate rainfall losses across the catchment. This model assumes that a specified amount of rainfall (*e.g., 10 millimetres*) is lost from the system to simulate initial catchment wetting when no runoff is produced, and that further losses occur at a specified rate per hour (*e.g., 1.5 millimetres per hour*). These further losses are referred to as continuing losses which aim to account for infiltration once the catchment is saturated. Both the initial and continuing losses are effectively deducted from the total rainfall over the catchment, thereby leaving the remaining rainfall to be distributed through the watershed as runoff.

As no definitive loss rate data is available for the Nepean River catchment, initial estimates of rainfall loss rates were based on data contained in previous studies and on recommendations outlined in the XP-RAFTS User Manual and documented in *'Australian Rainfall and Runoff'* (*1987 and 1998*). The loss rates were further refined during calibration of the hydrologic model using available rainfall and streamflow data. The adopted loss rates are listed in **Appendix B**.

5.2 HYDROLOGIC MODEL CALIBRATION

Flood routing models such as XP-RAFTS should be calibrated and verified using rainfall and streamflow data from specific historic flood events. Rainfall records from a major storm that caused flooding can be used as rainfall input into the model to reflect the variability of rainfall over the catchment through the course of the storm.

For model calibration, the rainfall excess is routed through the model and discharge hydrographs are generated at locations where streamflow records for the flood corresponding to the storm have been gathered. Calibration is completed by refining hydrologic model parameters (*within reasonable limits*) to achieve the best match between recorded and simulated hydrographs.

Calibration typically involves adjustment of model loss rates, roughness coefficients and lag times until a good match is obtained between the computer-generated hydrograph and the hydrograph recorded at streamflow gauging locations. A good calibration is considered to be achieved when the peak discharges, the relative timing of the peak discharges and the total volume of runoff (*hydrograph shape*) derived from simulation of an historical event "agree" with data recorded for that historic event.

Calibration is a complex process and is often hindered by hidden or intangible factors, such as geomorphic changes to the catchment over time and equipment or datum changes at gauging stations.

5.2.1 Model Calibration Data

Continuous rainfall data for specific storms is required for the calibration and verification of hydrologic computer models. This data is usually obtained from pluviometers located within the catchment that is to be modelled.

Pluviometers generate plots of the instantaneous variation in rainfall over time. Proper calibration of hydrologic models without pluviograph records is generally not achievable.

As discussed above, eight pluviometer stations are located within or in the vicinity of the study area (*refer* **Figure 3.1**). The details of these pluviometers are listed in **Table 3.2**.

As outlined in **Section 3**, a number of major floods have occurred in the study area in the last 50 years. These include floods in June 1964, June 1975, March 1978, April 1988, and August 1990. A summary of these events, as recorded at the Cowpasture Bridge stream gauging station, is listed in **Table 5.1**.

Table 5.1 SUMMARY OF HISTORIC FLOODS AT COWPASTURE BRIDGE

FLOOD EVENT	PEAK FLOOD HEIGHT[1] *[metres gauge]*	GAUGE ZERO *[mAHD]*	PEAK FLOOD LEVEL *[mAHD]*	PEAK DISCHARGE[1] *[m^3/s]*	APPROX. RECURRENCE INTERVAL[2] *[years]*
1964	14.08	55.71	69.79	4500	15
1975	12.70	55.71	68.41	3030	7
1978	13.45	55.71	69.16	3580	12
1988	12.80	55.71	68.51	3050	7
1990	10.63	55.71	66.34	1470	3

1 Directly from gauge record for station 212900.

2 Based on Flood Frequency Analysis contained in 1995 Upper Nepean Flood Study (LCME), which included the three larger events reported to have occurred prior to 1917.

Aside from the three large events that were reported to have occurred prior to 1917, the June 1964 flood is the largest event to have been recorded in the study area and would ideally be the most suited for hydrologic and hydraulic model calibration. However, minimal suitable pluviograph rainfall data is available for this event in the downstream extents of the catchment. Similarly, recorded pluviograph rainfall data was not extensive in the catchment during the June 1975 event, nor did hydrographs include the recession limbs experienced at Camden and Wallacia.

However, good quality, continuous pluviograph data was recorded at various locations in the catchment during the three remaining flood events (*1978, 1988 and 1990*). A discussion of the suitability of the various recorded datasets for the hydrologic model calibration process is provided in the following sections.

1978 Storm Event

The 1978 flood event was the result of a continuous period of heavy rainfall that occurred over a three day period between Saturday 18th March 1978 and Monday 20th March 1978. Pluviograph rainfall data was recorded during this period at Badgerys Creek, Narellan, Pondicherry, Warragamba Met Station and Oakdale. As such, a good range of data is available for the Nepean River catchment between Menangle Weir and Wallacia and can be used to reliably represent the rainfall that occurred within the Nepean River catchment downstream of Menangle Weir during the event.

The period of heavy rainfall was experienced throughout the catchment on the morning of Saturday 18th March 1978 and ceased late on Monday 20th March 1978. Falls of between 200 and 330 millimetres were recorded at a variety of stations in the vicinity of the study area during this period. A graph displaying the cumulative rainfall recorded at the various stations during this period are presented in **Appendix C**. The steepest sections of the graphs indicate intense rainfall over a relatively short period (*i.e., a rainfall burst*).

Stream levels throughout the study area were recorded to have risen consistently across a two day period as a result of the continuous nature of this rainfall, which is likely to have occurred over a similar period in the upper catchment areas upstream of Menangle Weir. As such, a single peak level was reached at each gauge location (*Cowpasture Bridge, Wallacia*) during the event. Flood levels peaked at Cowpasture Bridge during the afternoon of Monday 20th March 1978 and then at Wallacia early on Tuesday 21st March 1978 as flows progressed downstream. At Cowpasture Bridge the peak flood level was just below the “Major” flood classification level, while at Wallacia the peak flood level was just above the “Major” flood classification level.

1988 Storm Event

The 1988 flood event was the result of a period of heavy rainfall that occurred over a three day period between Thursday 28th April 1988 and Saturday 30th April 1988.

Pluviograph rainfall data was recorded during this period at Badgery’s Creek, Brownlow Hill, Camden Park Reservoir, Narellan, Pondicherry, Warragamba Met Station and West Camden STP in the vicinity of the study area. As such, a good range of data is available for the Nepean River catchment between Menangle Weir and the Warragamba River confluence.

Moderate rainfall commenced in the study area early on Thursday 28th April 1988. Rainfall intensity remained relatively consistent in the days that followed, before increasing in intensity on Saturday 30th April 1988. Rainfall ceased in the vicinity of the study area later that evening. The observed temporal patterns across all pluviometer stations were relatively

consistent; between 200 and 260 millimetres of accumulated rainfall was recorded across the three day period. This includes the high intensity period recorded during the final 10 hours of the rainfall event where between 80 and 100 millimetres of rainfall was recorded.

A graph showing the cumulative rainfall recorded during this period is presented in **Appendix C**.

Stream levels throughout the study area were recorded to have risen steeply as a result of the initial burst of rainfall on Thursday 28th April 1988. Peak levels were recorded at Cowpasture Bridge during the afternoon of Saturday 30th April 1988. Peak river levels were subsequently recorded at Wallacia during the morning of Sunday 1st May 1988 as flows progressed towards the downstream extent of the study area. At Cowpasture Bridge the peak flood level was just below the "Major" flood classification level, while at Wallacia the peak flood level was just above the "Major" flood classification level.

1990 Storm Event

The 1990 flood event was the result of a period of heavy rainfall that occurred between the Tuesday 31st July 1990 and Thursday 2nd August 1990. This event represents both the most current and most minor flood event of the three selected.

Low intensity rainfall commenced in the study area on the afternoon of Tuesday 31st July 1990. Rainfalls then increased in intensity at around 21:00 that night delivering between 70 and 100 millimetres of rainfall over the 22 hour period that followed. Another shorter burst of rainfall contributed a further 20 to 30 millimetre over the two hour period between 06:00 and 08:00 on Thursday 2nd August 1990.

A graph showing the cumulative rainfall recorded during this period is presented in **Appendix C**.

Stream levels throughout the study area began to rise on Wednesday 1st August 1990 as a result of local rainfall and rainfall from the upper catchment areas above Menangle Weir. Peak levels were recorded at Camden Weir during the evening on Thursday 2nd August 1990. Peak levels were recorded at Wallacia later that night. At Camden the peak flood level was above the "Moderate" flood classification level, while at Wallacia the peak flood level was just above the "Major" flood classification level. It should be noted that in this case the hydrograph at Wallacia is thought to have given an overestimate of flow due to backwater effects from flows in the Warragamba River system.

Adopted Calibration Events

An appropriate 'calibration event' requires the availability of both time and spatially varying pluviograph rainfall and time varying records of flood discharge at key points along the primary catchment streams.

The data presented in the preceding sections indicates that streamflow data has only been available in the Camden area on a regular basis since 1949, with the installation of a

streamflow gauge at Cowpasture Bridge. A streamflow gauge at Camden Weir was installed in 1989. The earliest significant flood events to have occurred within the study area during the lifetime of these stations were the events experienced in 1964 and 1975. However, streamflow gauging data is incomplete for both the 1964 and 1975 events. For this reason, and the shortage of good quality pluviometric data, it is not possible to reliably calibrate the hydrologic model to these historic events.

Data searches established that time and spatially varying pluviometer rainfall data is available for the flood events that occurred in March 1978, April 1988 and August 1990. Similarly, a substantial amount of streamflow data is available at the three stream gauging stations located in the study area during these three events (*refer* **Table 3.3**). Accordingly, based on consideration of the availability, quality and extent of hydrologic and flood level data, it was determined that the XP-RAFTS hydrologic model should be calibrated to data recorded during these three events. A matrix summarising the rainfall and streamflow datasets used during the calibration of the events is presented in **Table 5.2**.

Table 5.2 SUMMARY OF RAINFALL & STREAMFLOW DATA USED FOR CALIBRATION

GAUGE No	STREAMFLOW GAUGE NAME	March 1978	April 1988	August 1990
212202	Wallacia	✔	✔	✔
212900	Cowpasture Bridge	✔	✔	
212216	Camden Weir			✔
GAUGE No	**RAINFALL GAUGE NAME**	**March 1978**	**April 1988**	**August 1990**
067108	Badgerys Creek	✔	✔	✔
-	Narellan	✔	✔	✔
068007	Brownlow Hill		✔	✔
-	Pondicherry	✔	✔	✔
067027	Warragamba Met Station	✔	✔	✔
-	Camden Park Reservoir		✔	
068125	Oakdale	✔		
-	West Camden STP		✔	✔

5.2.2 Calibration Simulations and Results

The temporal rainfall patterns for the March 1978, April 1988, August 1990 events were extracted and entered into the hydrologic model. The rainfall records applied for the calibration and verification of the XP-RAFTS model for the three chosen historical events are shown in **Appendix C**. The relevant rainfall record location used to define rainfall during the calibration events at each subcatchment node is tabulated in **Appendix D**.

Upstream inflow hydrographs at Menangle Weir were extracted from the previously calibrated RORB model constructed as part of the Upper Nepean River Flood Study (*1995*) for each event and incorporated directly into the XP-RAFTS model. The development and calibration of this model, for the significantly larger upstream catchment areas, was deemed to be rigorous for the three chosen events. Therefore, in this study, calibration related purely to adjusting the model parameters for the subcatchment areas located within the study area (*i.e., downstream of Menangle Weir*). It was expected that direct inflow hydrographs at Menangle Bridge would significantly contribute to flows observed within the modelled study area as the catchment upstream of Menangle Weir covers some 1,200 square kilometres. By comparison, the local subcatchment areas between Menangle Weir and Wallacia Weir only account for approximately 500 square kilometres of the total catchment (*refer* **Figure 5.1**).

In order to obtain an acceptable match between simulated and recorded flood hydrographs for the March 1978, April 1988, August 1990 floods, the parameters within the XP-RAFTS hydrologic model that define initial loss, continuing loss, average catchment roughness (*Manning's 'n' co-efficient*) and lag time between catchments were adjusted until a suitable "fit" was achieved. Although loss parameters for a given subcatchment are often varied between calibration events to obtain the best possible fit, lag parameters for a given location are assumed to be constant across all calibrated events, as are roughness parameters.

For the initial calibration stage of the hydrologic modelling, the lag times had been estimated by taking the average of the lag times calculated by the AR&R and the Bransby-William methods (*refer* **Appendix B**). These lag times were then adjusted when calibrating the model through several iterations to obtain a good "fit" to the historical hydrographs.

Initial and continuing rainfall loss rates generally affect the shape of the rising limb of the hydrograph and the flow magnitudes. At the commencement of each calibration the calibrated model assumed initial losses of 15 millimetres and continuing losses of 2.5 millimetres per hour (*absolute*). These parameters generally produced simulated hydrograph peaks close to the historical peaks, largely due to the goodness of fit inherent in the previously calibrated hydrographs at Menangle Weir. However, some variation of the loss parameters was necessary to better match the peaks across all of the historical hydrographs. Variation of the rainfall loss rates between events is considered acceptable since the pre-flood catchment conditions (*wet vs. dry*) would realistically differ depending on the historic event.

A summary of the parameters used to calibrate the model during the three chosen events is presented in **Appendix D**, while **Table 5.3** provides a summary of the recorded and modelled peak flows at key locations during each calibration event. A series of plots comparing the modelled discharge hydrograph with respect to the recorded discharge hydrograph at each stream gauging station during each calibration event is also shown in **Appendix D**.

Table 5.3 COMPARISON OF RECORDED AND MODELLED PEAK DISCHARGES FOR HISTORIC FLOOD EVENTS

GAUGING STATION	PEAK DISCHARGE [m^3/s]					
	1978		1988		1990	
	Recorded	Modelled	Recorded	Modelled	Recorded	Modelled
Nepean River at Menangle Weir	-	3568	-	3423	-	2167
Nepean River at Cowpasture Bridge	3650	3572	3050	3503	-	-
Nepean River at Camden Weir	-	-	-	-	1502	2170
Nepean River at Wallacia	3626	3642	2925	3644	2277	2285

1978 Storm Event

Overall, the applicable rainfall data and model parameters were selected such that the best balance of fit was achieved across the event, and suitable fits were achieved at the two key downstream locations along the Nepean River (*Cowpasture Bridge and Wallacia*) (*refer* **Appendix D)**. This did result in a minor "shortfall" in peak discharge of 78 m^3/s (2*%*) at Cowpasture Bridge and an "overestimation" of 16 m^3/s (*0.3%*) at Wallacia during the peak event on Monday 20th March 1978 and Tuesday 21st March 1978, respectively.

While the majority of the characteristics of the calibrated model hydrographs were governed by the significant inflow at Menangle Weir, adjustments to losses, roughness and lag time were made to subcatchments located within the study area. The final adopted initial loss, continuing loss, roughness and lag time parameters for each subcatchment and figures comparing the recorded and modelled hydrographs for the 1978 event are presented in **Appendix D**.

It was noted that the peak discharge recorded at Cowpasture Bridge during this event was, in fact, slightly higher than the peak discharge recorded downstream at Wallacia (*refer* **Table 5.3**). This would suggest that either the peak discharge calculated for Cowpasture Bridge is overestimated for this event or that the peak flow was somehow attenuated between Menangle Weir and Wallacia during the event, perhaps due to the relative timing of local versus upstream inflows.

The originally modelled loss rates of 15 mm (*initial*) and 2.5 mm/hr (*continuing*) resulted in yet a higher peak discharge at Wallacia of 3842 m^3/s (*refer sensitivity test for low losses hydrograph in* **Appendix D**).

Accordingly, higher loss parameters of up to 60 mm (*initial*) and 10 mm/hr (*continuing*) were trialled in order to account for the apparent attenuation/storage within the Camden area between Menangle and Wallacia and thereby reduce the discharge at Wallacia Weir as close as possible to the recorded value of 3626 m^3/s. The sensitivity tests suggested that the peak discharge at Wallacia was somewhat sensitive to variation in the loss parameters during this particular event. The higher loss values provided a more suitable fit for this event and were used in the final calibration simulation (*refer 1978 event hydrographs in* **Appendix D**).

It was also noted that a minor secondary peak was recorded at Cowpasture Weir on Tuesday 21st of March 1978. This was not captured in the falling limb of the hydrograph as the modelled rainfall pattern upstream of the study area did not account for an additional minor rainfall burst that appeared to occur in the mid to upper catchment area. At Wallacia, the single peak discharge estimation closely matched the shape of the recorded hydrograph.

The overall fits achieved at these locations are considered to be appropriate and are typically equivalent to or better than the corresponding fits achieved for this event as part of the Upper Nepean Flood Study (*LMCE, 1995*).

1988 Storm Event

Overall, the applicable rainfall data and model parameters were selected such that the best balance of fit was achieved across the event, and suitable fits were achieved at the two key downstream locations along the Nepean River (*Cowpasture Bridge and Wallacia*) (*refer* **Appendix D)**. This resulted in an "overestimation" in peak discharge of 453 m^3/s (15*%*) at Cowpasture Bridge and an "overestimation" of 719 m^3/s (*25%*) at Wallacia during the peak event on Saturday 30th April 1988 and Sunday 1st May 1988, respectively.

As indicated above, while the majority of the characteristics of the calibrated model hydrographs were governed by the inflows at Menangle Weir, adjustments to losses, roughness and lag time were made to subcatchments located within the study area in order to attain a better "fit" at the two local gauging stations. The final, adopted initial loss, continuing loss, roughness and lag time parameters for each subcatchment and figures comparing the recorded and modelled hydrographs for the 1988 event are presented in **Appendix D**.

While the peak discharge levels are overstated at both locations within the model, the overall timing and shape are reliably represented. However, it was again noted that the peak discharge recorded at Cowpasture Bridge during this event was slightly higher than the peak discharge recorded downstream at Wallacia (*refer* **Table 5.3**). This again suggests that either the peak discharge calculated for Cowpasture Bridge is overestimated during the event or that the peak flow is attenuated between Menangle Weir and Wallacia.

Further to this, the peak discharge of the hydrograph imported from the previous study (*at Menangle Weir*) was significantly higher than the recorded value at Cowpasture Bridge (*refer* **Table 5.3**). Accordingly, initial loss parameters as high as 50 mm were tested during the calibration process in an attempt to achieve a discharge at Wallacia Weir as close to the recorded value as possible. However, the peak discharge at Wallacia proved to be insensitive to the loss parameter values tested (*refer 1988 event hydrographs* **Appendix D**). Accordingly, more "typical" loss rates of 15 mm (*initial*) and 2.5 mm/hr (*continuing*) were again used in the final calibration simulation.

The overall fits achieved at these locations are considered appropriate and are typically equivalent to or better than the corresponding fits achieved for this event as part of the Upper Nepean Flood Study (*LMCE, 1995*).

1990 Storm Event

The August 1990 flood event differed from the two previous calibration events in that the event was primarily the result of lower rainfall totals overall. An additional burst of rainfall specific only to the lower catchment was also modelled.

Overall, the applicable rainfall data and model parameters were selected such that the best balance of fit was achieved across the event, and suitable fits were achieved at the two key downstream locations along the Nepean River (*Camden and Wallacia*) (*refer* **Appendix D)**. This resulted in an "overestimation" in peak discharge of 673 m^3/s (*45%*) at Camden Weir, but only 8 m^3/s (*0.4%*) at Wallacia during the peak of the event on Thursday 2nd August 1990 and Friday 3rd August 1990, respectively.

Of particular note in this case are the peak discharge values observed at Camden Weir, which appear to be inconsistent with the recorded and modelled totals at the gauging station location downstream at Wallacia and with the modelled totals further upstream at Menangle Weir (*refer* **Table 5.3**). This would seem to suggest an error in the recordings or in the rating curve used to derive discharge values during this event.

Aside from this discrepancy, the overall fits achieved at these locations are considered to be appropriate and are typically equivalent to or better than the corresponding fits achieved for this event as part of the Upper Nepean Flood Study (*LMCE, 1995*). It should again be noted that the model results proved to be largely unaffected by any variance in loss parameters (*refer 1990 event hydrographs* **Appendix D**) and so typical acceptable values of initial and continuing loss were again used in the final calibration simulations.

5.2.3 Adopted Hydrologic Model Parameters

The values of initial loss, continuing loss, roughness and lag time parameters that are to be adopted for each subcatchment in the later design simulations are also presented in **Appendix D**.

As outlined above, sensitivity testing undertaken during the calibration process revealed that the selection of loss parameters in the subcatchment areas between Menangle Weir and Wallacia Weir generally did little to impact the peak discharge values the calibration locations (*Cowpasture Bridge, Camden and Wallacia Weir*) during the events calibrated. The exception to this was observed at Wallacia Weir during the 1978 calibration event, when higher parameters of 60 mm initial loss and 10 mm/hr continuing loss provided a better fit than the more "typical" values of 15 mm initial loss and 2.5 mm/hr continuing loss.

As no streamflow data exists along the tributaries within this area, direct calibration of these subcatchments is not possible. Accordingly, guidance contained within Australian Rainfall and Runoff (*1987*) was used in order to estimate more conservative "typical" values of initial and continuing losses; an initial loss value of 15 mm and a continuing loss value of 2.5 mm/hr were selected (*refer* **Appendix D**).

6. HYDRODYNAMIC MODELLING

6.1 GENERAL

One of the most important outcomes from the study is the determination of peak flood levels and velocities for a range of design floods. This information can be used to determine hydraulic categories (*floodway, flood storage and flood fringe*) and the variability in flood hazard across the floodplain. It will assist Camden Council in future land use planning and in the assessment of development proposals.

As outlined in **Section 2.3**, computer models can be used to simulate flood behaviour and quantify key flood characteristics such as flood levels, flow velocities, floodwater depths and flood hazard at selected points of interest. The TUFLOW hydraulic modelling software package was chosen as the tool for this purpose and was applied to develop a computer model for the Nepean River and its tributaries within the study area.

TUFLOW utilises a finite difference, two-dimensional (*2D*) approach based around a regular grid. This grid serves as the basis on which the continuity and conservation of momentum equations (*Saint Venant equations*) are solved. Constraints to the equations, such as the catchment topography, catchment roughness, inflow and outflow boundaries or links to one-dimensional (*1D*) elements are all included in the model as exports from a GIS database. This database approach makes TUFLOW a powerful tool for developing complex one-dimensional (*1D*), two-dimensional (*2D*) and linked 1D / 2D flood models.

The upstream end of the area to be modelled is defined by the location of Menangle Weir, approximately 4.7 kilometres upstream of the location where the Nepean River crosses the LGA boundary of Camden Council. The size and shape of the study area is such that it is practical to create a single two-dimensional model network that incorporates the entire area at a suitable level of resolution (*refer* **Figure 6.1**).

Development of the computer flood model was carried out over several stages that addressed the different processes of flood hydrology (*conversion of rainfall to runoff*) and flood hydraulics (*the routing of runoff*). The methodology that was employed to develop the flood model involved the following:

- Collate all available topographic data and develop a digital terrain model of the area that is to be covered by the flood model. This data is converted to a grid with specified dimensions within the 2D network of the TUFLOW model simulations.

- Define Nepean River channel using surveyed cross-section data.

- Augment the digital terrain model to include important topographical features that may not have been included in the aerial survey data or that may be too fine to be easily “picked up” by the size of the grids within the TUFLOW network. For example, levees or flood walls with widths of less than 5 metres are typically not adequately recognised within model networks with grid sizes of

between 5 and 10 metres. Therefore, topographic information needs to be manually defined to override the default elevations at vital locations.

- Use aerial photography and other GIS data to define land-use areas for definition of hydraulic roughness throughout model area.
- Calibrate and verify the flood model to historic flood events such as the March 1978, April 1988 and August 1990 flood events.

6.2 HYDRODYNAMIC MODEL DEVELOPMENT

6.2.1 Available Hydrographic and Topographic Survey Data

A hydrodynamic model is developed from data that defines the topography of the waterways and floodplain areas. It also needs to incorporate critical hydraulic controls such as bridges, culverts and roadway embankments that may influence the downstream movement of floodwaters. Accordingly, the Light Detection and Ranging (*LiDAR*) data recorded in the study area between 25th February 2011 and 23rd March 2011 and hydrographic survey of the Hawkesbury Nepean Valley undertaken in the study area throughout 2011 and 2012 (*refer* **Section 3.3.2**) was used to generate the topographic data used within the hydrodynamic model network.

6.2.2 2D Model Network Development

The hydrodynamic was required to simulate flows within the Nepean River from Menangle Weir (*4.5 kilometres upstream of Camden Council's LGA boundary*) to the river's confluence with the Warragamba River near Warragamba Park. Therefore, the model network was defined to incorporate the Nepean River and all potential floodplain areas within this reach of the river. Furthermore, the five major tributaries of the river that exist within Council's LGA boundary were modelled within agreed extents (*refer* **Figure 6.1**), viz.:

- Navigation Creek near Macarthur Circuit (*LGA boundary*);
- Sickles Creek near Benwerrin Crescent (*LGA boundary*);
- Matahil Creek East at Wire Lane (*LGA boundary*);
- Matahil Creek West at Westbrook Road (*LGA boundary*);
- Narellan Creek at Kirkham Lane (*upstream from this point to be modelled separately*);
- Cobbitty Creek at The Northern Road; and
- Bringelly Creek at the dam adjacent to the LGA boundary.

Two additional tributaries within the study area (*but outside of the LGA boundary for Camden Council*) were also specifically defined within the model network, viz.:

- Foot Onslow Creek (*500 metres upstream of confluence with Nepean River*) and;
- Mount Hunter Rivulet (*downstream of Downes Bridge*).

It should be noted that the above extents were used as the minimum required modelled extents for these watercourses. Where it was more convenient or otherwise necessary to extend the model further upstream, the extent of the hydrodynamic model was modified to accommodate the overall requirements of the model in achieving its task of modelling the floodplain of the Nepean River. For instance, the modelled extent of Narellan Creek was extended upstream of Kirkham Lane to The Northern Road in the TUFLOW model, as flooding is likely to back up towards the elevated ground along the road during the design flood events. In such cases, the modelled inflows from the hydrologic model at the required boundary locations remained the same and the variations to the hydrodynamic network merely reflected the minor adjustments required to properly distribute floodwaters from the greater Nepean River system.

Model Topography & Bathymetry

The floodplain topography within the study area is generally well represented by the terrain model constructed using the available LiDAR data. Accordingly, the two-dimensional model network was primarily developed using this data-set. As discussed in **Section 3.3**, levels recorded within the streams in the model network were assumed to inadequately represent the stream bed levels as it was demonstrated that the volumes of water present within the streams were significant at the time the data was recorded. Accordingly, a hydrographic surface of the main Nepean River channel needed to be created through the use of data point interpolation using the surveyed hydrographic cross-section data for the river. This surface was used to complement the LiDAR within the river channel areas (*refer* **Figure 6.2**).

Analysis of the LiDAR data within the seven tributaries listed above also revealed that small areas of ponding and inadequate definition existed within the LiDAR data-set along these stream channels. In such cases, the topography of the channels could be adjusted by defining the banks of the channel and interpolating creek bed levels along the channel using nearby data.

These modifications were generally minor and adjustments were made in the interests of completeness. However, the channel of Narellan Creek downstream of The Northern Road appeared to contain several sections of notably deeper water in the LiDAR dataset. This was confirmed by analysis of the available aerial photography data. Although the water within the channel appeared to be no more than a metre deep in most of the affected locations, an alternative source of data was required to better estimate the topography of the creek bed in these locations. This was achieved by interpolating cross-section data for the stream that had previously been used in the MIKE11 one-dimensional model created as part of the Upper Nepean River – Tributary Flood Studies (*1997 & 1998*).

The combined topographic data was then used to define a grid within the 2D network of the model which consisted of square grids with a width of 8 metres. TUFLOW further divides each grid into four smaller squares in order to perform its hydraulic calculations. Therefore, the topography is eventually sampled at 4 metre intervals. Trial simulations of a preliminary model network setup indicated that the definition of flowpaths and terrain objects was generally adequate at this resolution.

The extent of the two-dimensional section of the TUFLOW model network is shown in **Figure 6.1**.

Floodplain Roughness

Main channel and overbank roughnesses were estimated for the study area from aerial photograph analysis and field observations of channel and floodplain vegetation density. The initial roughness values adopted were determined by comparing vegetation density and soil types observed in the field, with standard photographic records of stream and floodplain condition for which roughness values are documented. A total of seven roughness categories were defined throughout the model network. The final selection of these parameters is discussed in **Section 6.3**.

Hydraulic Features

Further augmentation of the topographic data was also required in order to ensure that any important topographical features that may not have been captured in the LiDAR data-set or that may have been too fine to be "picked up" within the 8 metre grid size were adequately defined. It is also important that the crest levels are used as the elevation value for the representative grid cell for such features. Therefore, locations where such adjustment of topographic information was required were defined during the TUFLOW network setup. Locations that received particular attention within the study area included the tributaries within Camden Council's LGA area (*Navigation Creek, Narellan Creek, Matahil Creek, Sickles Creek, Cobbitty Creek and Bringelly Creek catchments*), weir structures along the main Nepean River channel, the railway and the Former National Equestrian Sports Centre near Menangle Park and abutments to the north of Camden. The topography incorporated into the TUFLOW model network is shown in **Figure 6.2**.

The locations of all bridge crossings, culverts and other structures across watercourses and flowpaths within the model were determined using the available LiDAR data, aerial photography and online topographic sources such as Bing Maps, Google Street View and the New South Wales Government's Six Maps database. A total of 27 potential structures were identified, as listed in **Table 6.1** and shown in **Figure 6.3**.

The Camden Valley Way / Camden Bypass crossing of the Nepean River in Camden, known as the Macarthur Bridge, consists of an elevated bridge structure which covers some one kilometre of the river channel and floodplain. As the bridge was found to have its deck levels above the predicted peak modelled flood levels, it was not deemed necessary to model constrictions through the bridge pylons as a specific "hydraulic structures" in the model.

Table 6.1 IDENTIFIED STRUCTURES WITHIN HYDRODYNAMIC MODEL EXTENT

WATERCOURSE	TYPE	NAME / LOCATION	SUBURB	MODELLED?
Bringelly Creek	Bridge	Cut Hill Road	Cobbitty	Yes
Nepean River	Bridge	Cobbitty Bridge	Brownlow Hill	Yes
Nepean River	Bridge	Macquarie Grove Road	Camden	Yes
Nepean River	Bridge	Cowpasture Bridge (Argyle Street)	Camden	Yes
Nepean River	Bridge	Macarthur Bridge (Camden Bypass)	Camden	*No*
Nepean River	Footbridge	(adjacent to) Chellaston Street	Camden	Yes
Mt Hunter Rivulet	Bridge	Lower Mt Hunter Bridge (Werombi Road)	Brownlow Hill	Yes
Sickles Creek	Culvert	Werombi Road	Ellis Lane	Yes
Sickles Creek	Culvert	Smalls Road	Grasmere	*No*
Matahil Creek East	Culverts	(adjacent to) Onslow Park	Camden	*No*
Matahil Creek East	Bridge	Cawdor Road	Camden	Yes
Wetland adjacent to Matahil Creek East	Bridge	Burragarong Road	Mt Hunter	Yes
Matahil Creek East	Culvert	Burragorang Road	Mt Hunter	Yes
Matahil Creek East	Bridge	(adjacent to) Ron Dine Memorial Reserve	Camden South	Yes
Cobbitty Creek	Culvert	Cut Hill Road	Cobbitty	Yes
Cobbitty Creek	Culvert	Chittick Lane	Cobbitty	*No*
Cobbitty Creek	Culvert	Cobbitty Road	Oran Park	Yes
	Railway underpass	Racecourse Avenue	Menangle	Yes
	Culvert	Springs Road	Menangle	Yes
Matahil Creek West	Bridge	Burragarong Road	Bickley Vale	Yes
Matahil Creek West	Culvert	Sheathers Lane	Grasmere	Yes
Foot Onslow Creek	Bridge	Macarthur Bridge (Woodbridge Road)	Menangle	Yes
Narellan Creek	Bridge	Kirkham Lane	Kirkham	Yes
Mt Hunter Rivulet	Culvert	Downes Bridge (Brownlow Hill Loop Road)	Brownlow Hill	Yes
Nepean River	Bridge	Menangle Bridge (Menangle Road)	Menangle	Yes
Nepean River	Bridge	Blaxland Crossing Bridge (Silverdale Road)	Wallacia	Yes
Navigation Creek	Bridge	Elizabeth Macarthur Avenue	Camden Park	*No*

However, the abutments / pylons of the structure were included in the model network by increasing the hydraulic roughness value of the stream in the vicinity of the crossing, in addition to their representation in LiDAR topographic data.

Three small culvert structures at Smalls Road in Grasmere, Onslow Park in Camden and Chittick Lane in Cobbitty and a small bridge structure crossing Navigation Creek along Elizabeth Macarthur Avenue in Camden Park were identified to occur within low lying embankments in the network. These structures were all deemed to be designed to convey only small volumes during low flow conditions. The associated embankments are likely to be readily overtopped during flood events and the culverts themselves are unlikely to provide any significant conveyance capacity. Accordingly, these culvert structures were not specifically modelled within the hydrodynamic network.

The remaining 22 structures were predicted to be submerged during some or all of the design flood events and it was necessary to specifically include the hydraulic characteristics of these structures in the final hydrodynamic model network. Data was entered into the TUFLOW network that defined the dimensions of the structure (*e.g., bridge deck level or culvert dimensions*) as well as a corresponding rise in the hydraulic roughness value of the stream in the vicinity of the crossing, where applicable.

Six weir structures were also identified along the Nepean River as it passes through the model network, as listed in **Table 6.2**. The crest levels of these structures was approximated using the available LiDAR data in conjunction with the aerial photography; the crests were generally visible in the photography, allowing their levels to be estimated using the corresponding bank levels. The weirs were then modelled within the TUFLOW network by simply raising the topography across the stream (*by one grid width*) at this location.

Table 6.2 IDENTIFIED WEIRS WITHIN HYDRODYNAMIC MODEL EXTENT

WATERCOURSE	NAME / LOCATION	CREST LEVEL *(mAHD)*	MODELLED?
Nepean River	Camden Weir	57.0	Yes
Nepean River	Sharpes Weir	54.1	Yes
Nepean River	Cobbitty Weir	50.5	Yes
Nepean River	Mt Hunter Rivulet Weir	49.5	Yes
Nepean River	Brownlow Hill Weir	48.0	Yes
Nepean River	Theresa Park Weir	46.5	Yes
Nepean River	Wallacia Weir	26.5	Yes

6.2.3 Model Boundary Conditions

Flood models require upstream inflow boundaries to define stream discharges entering the model at the upstream limits, local inflows to define runoff that enters the model from subcatchments located within the network itself and a relationship to define the hydraulic conditions at the downstream limit. The locations of these boundaries are shown in **Figure 6.4**.

Upstream Inflow Boundaries

As discussed in **Section 5**, the upstream boundary conditions for the hydrodynamic model are provided by discharge hydrographs generated from hydrologic modelling of the upstream subcatchments. Discharge hydrographs were generated at each of the upstream inflow locations identified in **Figure 6.4** from the results of the hydrologic modelling that was undertaken using the XP-RAFTS model. These hydrographs generally enter the model network along boundary lines that are defined across the watercourse channels at the required locations. This method has been employed at ten of the upstream inflow locations.

At locations where the subcatchment definition or local topography determine that the use of boundary lines to define upstream inflows is difficult or inappropriate, inflow hydrographs can be directed to enter the model network via small local inflow polygons. This method has been employed at five upstream inflow locations.

The most notable of these locations is the downstream inflow from Narellan Creek. The Narellan Creek subcatchment is highly urbanised and is being modelled as part of a separate study. Prior to commencement of both projects it was agreed that the interface between the two models would be located along Kirkham Road and that inflows from the downstream end of the Narellan Creek XP-RAFTS model would enter the larger Nepean River model along this interface. However, initial testing of the TUFLOW hydrodynamic model revealed that flooding from the Nepean River is likely to would overtop Kirkham Lane during flood events and inundate much of the floodplain area between Kirkham Lane and The Northern Road to the northeast. Accordingly, the TUFLOW model network was extended to include the area between Kirkham Lane and The Northern Road, and a local inflow polygon was used to input the discharge hydrograph from the Narellan Creek catchment into the creek within this area.

The upstream inflow locations and the method employed to introduce the corresponding inflow hydrographs into the model network at these locations is summarised in **Table 6.3**. The XP-RAFTS model nodes corresponding to each of these inflow locations are also listed.

Local Inflow Boundaries

Runoff that is generated within subcatchments downstream of the upstream boundaries enter the model as local inflows directly into the network. The local inflow polygons are shown in in **Figure 6.4**, which represent those parts of the corresponding subcatchment polygon that intersect with the TUFLOW model network. The discharge hydrograph

calculated for each subcatchment is distributed directly into watercourses within the inflow polygons.

Table 6.3 UPSTREAM BOUNDARY CONDITIONS FOR TUFLOW MODEL

WATERCOURSE	LOCATION *(refer Figure 5.2)*	XP-RAFTS MODEL NODE *(refer Figure 4.1)*	INFLOW METHODOLOGY
Nepean River	Menangle Weir	(MENANGLEIN)	Boundary Line
Navigation Creek	Near Macarthur Circuit	NAVI B	Boundary Line
Matahil Creek East	Wire Lane	MAT E DMY	Boundary Line
Matahil Creek West	Westbrook Road	MAT W A	Boundary Line
Sickles Creek	Benwerrin Crescent to Smalls Road	SICKLES A	Local Polygon
Narellan Creek	The Northern Road to Kirkham Lane	(NARELL IN)	Local Polygon
Mt Hunter Rivulet	West of Silverwood Road	MT H C DMY	Boundary Line
Cobbitty Creek	The Northern Road	COBBITTY A	Boundary Line
Wattle Creek	North of Taylor Place	UNNMD1 DMY	Boundary Line
Unnamed Creek 2	Coates Park Road	UNNAMED2	Local Polygon
Eagle Creek	West of McKee Road	EAGLE	Boundary Line
Forest Hill Creek	Nepean River	FOREST	Boundary Line
Bringelly Creek	LGA boundary	BRI C1 DMY	Boundary Line
Duncans Creek	Silverwood Avenue	DUNCANS A	Local Polygon
Jerrys Creek	Nepean River	JERRYS	Local Polygon

Downstream Boundary

For hydrodynamic models located within inland areas, the downstream boundary of the model is required to create an interface within a flowing river system that can effectively remove flows from the model while not impacting on upstream hydraulic behaviour or on the overall stability of the model itself. This is typically achieved by specifying a data table that defines the relationship between river level and discharge at that location. Recorded streamflows or rating curve information can be used. However, no such information is available at the downstream end of the study area.

Accordingly, a normal-depth stage-discharge relationship was derived using a sample cross-section of the river at the downstream boundary location using the Manning Formula, viz:

$$Q = A\,R^{2/3}\,S^{1/2}\,n^{-1}$$

where Q = discharge [m^3/s]

A = cross-sectional area [m^2]

n = Manning's roughness co-efficient

S = slope of channel [m/m]

R = hydraulic radius [m]

6.3 TUFLOW MODEL CALIBRATION

Calibration and verification of the hydrodynamic flood model is an important step in the model development process. If an acceptable calibration of the model to recorded events can be achieved, it ensures the reliability of the results of the subsequent design flood simulations.

In order to maintain consistency with the hydrologic modelling, calibration of the hydrodynamic model was undertaken for the March 1978, April 1988 and August 1990 historical floods. Streamflows derived from hydrologic modelling of rainfall-runoff processes across the upper and local subcatchment areas for each of these historic storm events were simulated in the hydrodynamic flood model.

Flood levels generated from the simulations were then compared to recorded gauge levels and historical flood recollections. Calibration of the model was achieved by adjusting floodplain roughness parameters within acceptable limits to obtain the best 'fit' between simulated and recorded peak flood levels.

6.3.1 Available Historic Flood Level Information

Recorded stream level information was available for the Nepean River at the Cowpasture Bridge, Camden Weir and Wallacia gauging stations (*refer* **Table 3.3**) for the March 1978, April 1988 and August 1990 historical floods.

As part of the study, a flooding questionnaire was distributed to residents within the study area. A total of 127 responses were received to the questionnaire, which requested respondents provide details of any specific recollections they may have with respect to observed peak flood levels or known debris marks. From the received responses, eight observations were provided that could reliably be used to determine peak flood levels or extents during the calibration process for the three chosen historical flood events.

Similar data was also obtained during the Upper Nepean River Flood Study (*1995*). However, on inspection of the data, many of the readings appeared to be inaccurate. For

example, differences of several metres were often reported at similar locations during the same event. Notwithstanding this, a selection of the most representative data was chosen from this set in order to complement the data within areas of interest.

The historical flood level data chosen for calibration to the three events is summarised in **Table 6.4**.

Table 6.4 HISTORIC FLOOD LEVEL INFORMATION USED IN MODEL CALIBRATION

EVENT	LOCATION	PEAK FLOOD LEVEL *[mAHD]*	SOURCE OF INFORMATION
March 1978	U/S Macarthur Bridge, Camden	69.9	Previous study[1]
March 1978	5 Wilkinson Street, Camden	69.2	Community questionnaire
March 1978	Cowpasture Bridge	69.2	Stream level records
March 1978	44 Engesta Avenue, Camden	68.8	Community questionnaire
March 1978	161 Cut Hill Road, Cobbitty	62.9	Previous study[1]
March 1978	Cut Hill Reserve, Cobbitty	62.5	Previous study[1]
March 1978	Wallacia Weir	42.2	Stream level records
April 1988	Arndell Street, Camden South	69.7	Previous study[1]
April 1988	22 Lerida Avenue, Camden	69.0	Community questionnaire
April 1988	1 Belgenny Avenue, Camden	68.9	Community questionnaire
April 1988	11 Pindari Avenue, Camden	68.4	Community questionnaire
April 1988	19 Pindari Avenue, Camden	68.2	Community questionnaire
April 1988	Cowpasture Bridge	68.5	Stream level records
April 1988	8 Edward Street, Camden	68.3	Community questionnaire
April 1988	17 Elizabeth Street, Camden	68.2	Community questionnaire
April 1988	300 McKee Road, Theresa Park	60.4	Previous study[1]
April 1988	340 McKee Road, Theresa Park	60.2	Previous study[1]
April 1988	409 McKee Road, Theresa Park	59.6	Previous study[1]
April 1988	Wallacia Weir	40.8	Stream level records
August 1990	Arndell Street, Camden South	68.4	Previous study[1]
August 1990	Cowpasture Bridge	66.3	Stream level records
August 1990	Mt Hunter Rivulet Weir	62.1	Previous study[1]
August 1990	Wallacia Weir	39.2	Stream level records

1 Upper Nepean River Flood Study (DLWC 1995)

6.3.2 Boundary Condition Data

The available historic pluviograph rainfall data was routed through the XP-RAFTS hydrologic model as part of the model's calibration process (*refer* **Section 5.2**). The final, calibrated version of the XP-RAFTS hydrologic model was then used to generate inflow hydrographs for the March 1978, April 1988 and August 1990 at the appropriate upstream and local inflow boundary locations to the TUFLOW model.

6.3.3 Calibration Simulations

The TUFLOW flood model was used to simulate the March 1978, April 1988 and August 1990 flood events.

During the calibration process, modifications were made to the model network, primarily the adjustment of roughness parameter values. These changes were made to achieve an improved "fit" between simulated and recorded flood levels throughout the study area.

It was noted during the initial model simulations that the resulting peak flood levels in the vicinity of Wallacia were highly sensitive to the tailwater levels assumed at the downstream limit of the model (*i.e., at the confluence of the Nepean River and the Warragamba River just downstream of Wallacia*). Comprehensive testing of the hydraulic mechanisms of the model suggested that the tailwater level impacted the peak flood levels in this area significantly more than variation in roughness.

Peak level information during the three historical events was available for the Warragamba River confluence (*Upper Nepean River Flood Study, 1995*). However, the timing of the rise and fall of river levels in the Warragamba River during these events was not available. Accordingly, in the absence of accurate time-varying level data at the confluence of the two rivers, a series of sensitivity tests were undertaken whereby the tailwater levels in the Warragamba River were varied in relation to the recorded levels in the Nepean River at Wallacia.

A number of peak levels were tested (*using the peak levels from the previous study as a guide*) in conjunction with the overall hydrograph shape recorded at Wallacia to define the assumed variation of the tailwater level throughout the course of the event. The final calibration simulations utilised stage-time relationships at the downstream end of the model that resulted in the most suitable peak flood levels being achieved at the Wallacia gauging station location. The final peak tailwater levels were in general agreement with the levels assumed in the Upper Nepean Flood Study (*1995*).

A comparison of the final calibrated model results and the recorded flood levels at the Cowpasture Bridge, Camden Weir and Wallacia Weir gauging station locations is provided in **Table 6.5**. Comparisons between the recorded and simulated flood levels at the locations listed in **Table 6.4** for the three events are shown in the figures contained in **Appendix E**.

Table 6.5 COMPARISON OF RECORDED AND MODELLED PEAK LEVELS FOR HISTORICAL FLOOD EVENTS

GAUGING STATION	PEAK FLOOD LEVEL [*mAHD*]					
	1978		1988		1990	
	Recorded	Modelled	Recorded	Modelled	Recorded	Modelled
Nepean River at Cowpasture Bridge	69.2	69.0	68.5	68.5	66.3	66.5
Nepean River at Camden Weir	-	-	-	-	66.1	66.3
Nepean River at Wallacia Weir	42.2	42.1	40.8	40.7	39.2	39.2

6.3.4 Discussion

The modelling results for all three calibration events (*refer* **Appendix E**) indicate that a generally good agreement between recorded and simulated flood levels was obtained using the TUFLOW model. The differences between recorded gauge levels and simulated levels at Cowpasture Bridge, Camden Weir and Wallacia Weir were within 200 millimetres for all three events simulated.

As discussed in **Section 6.3.3**, levels in the Wallacia area were highly influenced by the adopted tailwater levels at the confluence of the Nepean River and the Warragamba River. The tailwater level patterns applied at the downstream boundary resulted in peak flood levels at the Wallacia Weir gauging station that closely matched those recorded for all three events.

In order to ensure uniformity between the three events, a single set of final roughness parameter values was chosen to represent the modelled area for the three selected events. Accordingly, it was necessary to select parameters that resulted in the best overall “fit” for the modelled results in relation to the observed data across the three events. As a result, the agreement between observed and modelled peak flood levels was poor in a small number of locations for each event. However, these instances mostly related to data that was less reliable or based on estimated levels or flood extents. Recorded gauge levels are assumed to provide more reliable indications of peak flood levels than other sources of observed data, and decent matches were achieved in the modelled results at these locations for all three events.

In conclusion, it is considered that appropriate fits were achieved for the majority of the observations utilised in the calibration process. Therefore, it is considered that the TUFLOW model provides a reliable and suitably calibrated tool for the simulation of design floods for the study area. The final roughness parameter values applied to all three calibrated events are listed in **Table 6.6**. These values are in general agreement with the calibrated roughness parameters derived during the Upper Nepean River Flood Study (*1995*), where

values for the one-dimensional cross-sections along the modelled reaches of the river were generally between 0.050 and 0.065.

Table 6.6 FINAL ROUGHNESS PARAMETER VALUES USED IN TUFLOW MODEL

CATEGORY	ROUGHNESS PARAMETER *[Manning's 'n']*
Urban Areas	0.08
Open Watercourses	0.04
Heavily Vegetated Creeks	0.06
Grass / Pasture / Brush	0.06
Forested Areas	0.10
Roads	0.02
Bridge Abutment Areas	0.08

The distribution of these roughness parameter values within the TUFLOW model network are shown in **Figures 6.5** and **6.6**.

7. DESIGN FLOOD ESTIMATION

7.1 GENERAL

Design floods are hypothetical floods that are commonly used for planning and floodplain risk management investigations. Design floods are based on statistical analysis of rainfall and flood records and are defined by their probability of occurrence. For example, the 100 year recurrence flood can also be expressed as the 1% Annual Exceedance Probability (*AEP*) flood. That is, there is a 1% chance of the 100 year recurrence flood occurring in any given year. The same flood probability may also be expressed as the 100 year Average Recurrence Interval (*ARI*) flood.

The X% AEP terminology has been adopted for the design flood mapping prepared as part of this flood study, as per the following:

- 50% AEP refers to the 2 year ARI event;
- 20% AEP refers to the 5 year ARI event;
- 5% AEP refers to the 20 year ARI event;
- 1% AEP refers to the 100 year ARI event;
- 0.5% AEP refers to the 200 year ARI event; and
- 0.2% AEP refers to the 500 year ARI event.

It should be noted that there is no guarantee that the design 1% AEP event will occur just once in a one hundred year period. It may occur more than once, or at no time at all in a given one hundred year period. This is because the design floods are based upon a statistical 'average'. Further notes regarding the adopted terminology in relation to a recent discussion paper prepared as part of the AR&R revision project (*Engineers Australia, 2013*) is provided in **Appendix F**.

The Probable Maximum Flood (*PMF*) has also been modelled as an extreme event.

7.2 HYDROLOGIC MODELLING

7.2.1 Design Flood Simulations

The XP-RAFTS hydrologic model described in **Section 5** was used to simulate runoff from the subcatchments downstream of Menangle for design storm conditions. The design storm conditions were based on rainfall intensities and temporal patterns for the study area, which were derived using standard procedures outlined in *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (*1987*) (*ARR 87*). The design storm rainfall data was generated by applying the principles of rainfall intensity estimation described in Chapter 2 of ARR 87. Upstream inflows at Menangle Weir were again derived from the RORB model developed during the Upper Nepean Flood Study (*1995*).

It should be noted that Engineers Australia and the Bureau of Meteorology published updated intensity-frequency-duration (*IFD*) data and recommendations in relation to their implementation (*Engineers Australia, 2013*) during the course of the study. This included additional information in relation to the derivation and implementation of areal reduction factors (*ARFs*) (*Engineers Australia, 2013*).

However, following discussions with the OEH and Engineers Australia it was recommended that the latest information was not suitable for the study. This was primarily because the temporal patterns within the XP-RAFTS model for the catchment are based on the ARR 87 methods and are considered incompatible with the 2013 IFD data. Furthermore, the latest methods for deriving ARFs are untested and it is not recommended to integrate such ARFs with ARR 87 data. Accordingly, it was decided that the most conservative approach was to continue to adopt the IFD data and temporal patterns from the ARR 87 documentation and adopt the same ARF factors as those used in the RORB model developed during the Upper Nepean Flood Study (*1995*) and used to define flows upstream of Menangle Weir.

An estimate of Probable Maximum Precipitation (*PMP*) rainfall was also derived for the subcatchments downstream of Menangle Weir. The PMP is defined as the greatest depth of precipitation that is meteorologically possible for a given duration at a specific location. The PMP can be routed through the hydrologic model to provide discharge hydrographs for the Probable Maximum Flood (*PMF*) at specified locations throughout the subcatchments.

According to guidance contained within the '*Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method'*, the catchment lies within the 'GSAM Zone'. Accordingly, the GSAM methodology was employed in the study.

Again, as the upstream inflows at Menangle Weir were derived from the RORB model developed during the Upper Nepean Flood Study (*1995*), a 12 hour critical storm duration was assumed in order to achieve consistency between the previous methodology and the latest study. Likewise, the GSAM PMP rainfall depth for the catchment was assumed to be 550 millimetres in accordance with Figure 5.6 of Upper Nepean Flood Study (*1995*). The spatial distribution of the rainfall was then determined using the procedure outlined in Section 3 of the guidebook using a reference Terrain Adjustment Factor (*TAF*) of 1.3.

Critical Storm Duration

A range of storm durations were first considered to establish the critical storm duration for the locations within the study area. The critical storm duration was assumed to correspond to the duration that generated the maximum peak discharges along the Nepean River at Menangle and Camden (*the focus of interest for Council*). Both locations were tested for a range of durations for all design events. A critical storm duration of 48 hours was determined to be critical at both locations for the 50%, 20% and 5% AEP design events, while 36 hours was deemed to be critical for the 1%, 0.5% and 0.2% AEP design events.

The hydrology of the tributaries feeding to the Nepean River has been incorporated into the flood modelling for the 36 and 48 hour duration storms so that the critical flood behaviour can

be determined for the Nepean River. However, it should be noted that for areas upstream of the backwater influence of the Nepean River the peak level of flooding along the tributaries will be the result of a shorter critical duration storm (*e.g., the 2 hour duration storm*). Council intends to assess the critical case for local catchment flooding as part of separate future investigations. Accordingly, the design event model results and mapping for this study have been 'clipped' to remove the sections of local tributary flooding located upstream from the Nepean River backwater.

Areal Reduction Factors

Design rainfall information (*IFD data*) is provided in *ARR 87* in the form of point rainfall intensity. Such data reflects the peak rainfall intensity during a specified design event at a single point location. However, such rainfall events are unlikely to be experienced simultaneously across large catchment areas.

An areal reduction factor (*ARF*) is the ratio between the areal average rainfall across a catchment and the point rainfall values provided within IFD charts. Applying an ARF to the point rainfall intensities provides an "adjusted" rainfall intensity to apply across the catchment when deriving design event information.

An updated methodology for deriving ARFs for Australian catchments was published during the period of the study *(Engineers Australia, 2013*). However, OEH and Engineers Australia recommendations suggested that the latest information was not suitable for use until the full revision of ARR has been completed. Furthermore, as the dominant flows in the Nepean River in the study area were derived from the RORB model developed during the Upper Nepean Flood Study (*1995*), it was decided that the areal reduction factors used during the former study should be incorporated into the current XP-RAFTS model. These factors are listed in **Table 7.1**.

Table 7.1 AREAL REDUCTION FACTORS USED IN XP-RAFTS MODEL

AEP *[%]*	**ARF** *[%]*
50	96
20	96
5	94
1	90
0.5	88
0.2	88

Discharge hydrographs were then generated throughout the catchment for all design events using the appropriate critical storm duration and the appropriate rainfall intensities, design temporal patterns and areal reduction factors.

7.2.2 Hydrologic Modelling Results

Design discharge hydrographs determined using the XP-RAFTS hydrologic model and based on the derived critical durations were used to define inflows into the TUFLOW hydrodynamic model. A summary of the peak discharges for each upstream model boundary location is provided in **Table 7.2**.

Table 7.2 PEAK UPSTREAM INFLOWS USED IN TUFLOW MODEL

LOCATION (*refer* Figure 6.4)	XP-RAFTS MODEL NODE	PEAK DISCHARGE[1] (m^3/s)						
		PMF	0.2%	0.5%	1%	5%	20%	50%
		12hr	36hr	36hr	36hr	48hr	48hr	48hr
Nepean River	(MENANGLEIN)	18421	11048	9469	8314	5220	2447	1074
Navigation Creek	NAVI B	327	143	121	108	86.0	58.4	36.3
Matahil Creek East	MAT E DMY	467	204	173	155	124	84.6	53.3
Matahil Creek West	MAT W A	80.4	33.0	28.0	25.1	21.3	14.6	9.4
Mt Hunter Rivulet	MT H C DMY	1202	447	379	339	256	169	103
Cobbitty Creek	COBBITTY A	9.1	4.8	4.1	3.7	3.1	2.3	1.6
Wattle Creek	UNNMD1 DMY	333	140	118	105	86.3	56.7	34.9
Eagle Creek	EAGLE	408	156	132	118	90.5	57.8	34.5
Forest Hill Creek	FOREST	286	111	93.1	82.9	68.8	45.6	28.0
Bringelly Creek	BRI C1 DMY	132	55.3	47.3	42.7	35.3	24.4	15.9

1. *Peak discharges listed do not necessarily occur simultaneously.*

7.3 HYDRODYNAMIC MODELLING

7.3.1 Design Flood Simulations

The TUFLOW hydrodynamic model that was developed for the project was then used to simulate each of the design flood events. However, prior to the final simulations, adjustments were made to the local topography data in order to account for changes that had occurred within the study area in the time since the calibration period. This primarily included changes to the local topography resulting from the Spring Farm development on the northern side of the Nepean River approximately four kilometres upstream of Camden. Details of these works were provided by Council.

Upstream boundary conditions were defined for each design flood based on the inflow hydrographs generated using the XP-RAFTS hydrologic model (*refer* **Table 7.2**). For example, design 1% AEP flood discharge hydrographs for river inflows were extracted from the model output and used to define the rate of flow into the TUFLOW model.

A total of ten upstream boundary inflows were adopted to input flows into the upstream extents of the flood model (*refer* **Table 7.2**). A further 35 local inflows were specified throughout the model allowing localised flows to be input into the hydrodynamic model network at the location of the corresponding subcatchment.

7.3.2 Hydrodynamic Modelling Results

Flood Levels and Extent of Inundation

The predicted extent of inundation across the floodplain for the design events have been extracted from the modelling results and are presented for the model network area in a series of maps within **Appendix G**. The figures also indicate the peak flood levels at each location in the study area via flood level contour lines. Individual figures have been included for two smaller areas within the Camden LGA area for the key design events (*5% and 1% AEP and PMF*).

Flooding in the lower reaches of Narellan Creek has been captured in the flood modelling for the Nepean River (*as a combination of backwater flooding and local flows*) and also separately for Narellan Creek as part of the Narellan Creek Flood Study (*in draft*). In this area an envelope has been taken of the maximum level of flooding between the two sets of model results. The mapping has then been 'clipped' along a boundary agreed with Council (*adjacent to the Nepean River*), to provide a set of flood maps for each Flood Study report with no overlap between.

The flood mapping has also been 'clipped' along the tributaries of Matahil Creek, Sickles Creek, Cobbitty Creek and Bringelly Creek, to remove those sections of mapping upstream from the limit of the 1% AEP backwater from the Nepean River. As discussed in Section 7.2, the peak level of flooding along tributaries (*according to the critical duration of local catchment rainfall*) will be assessed as part of separate investigations.

All flood mapping in this report has been prepared using this approach, including for flood levels, depths, hazards and hydraulic categories.

Floodwater Depths & Velocities

Peak floodwater depths were also extracted from the modelling results for each of the design flood events and are presented for the model network area in a series of maps within **Appendix H**. Individual figures have been included for two smaller areas within the Camden LGA area for the key design events (*5% and 1% AEP and PMF*). Peak floodwater flow velocities for the adopted design flood events have been superimposed over the floodwater depth plots shown in **Appendix H** as velocity vectors.

Model Validation

A final analysis of the hydrodynamic modelling results was undertaken by comparing the peak flows simulated at Cowpasture Bridge in Camden with the corresponding peak flows derived during the Flood Frequency Analysis and hydrodynamic modelling undertaken during the Upper Nepean Flood Study (*LMCE, 1995*). The results indicate that the flows at Cowpasture Bridge simulated within the derived TUFLOW model are similar to those obtained from the previous study for the 1%, 5% and 20% AEP design flood events (*refer* **Table 7.3**).

Table 7.3 COMPARISON OF MODELLED PEAK DISCHARGES AT COWPASTURE BRIDGE WITH PREVIOUS STUDY

STUDY	PEAK DISCHARGE [m^3/s]		
	1%	5%	20%
1995 – Flood Frequency Analysis[1]	7900	4900	2100
1995 – Hydrodynamic Modelling[2]	7400	4900	2200
Present Study	7550	4820	2160

1 Lyall and Macoun Consulting Engineers (1995), 'Upper Nepean River Flood Study', Table B4.1.

2 Lyall and Macoun Consulting Engineers (1995), 'Upper Nepean River Flood Study', Table 6.3.

8. FLOOD HAZARD AND HYDRAULIC CATEGORIES

8.1 GENERAL

The personal danger and physical property damage caused by a flood varies both in time and place across the floodplain. Accordingly, the variability of flood patterns across the floodplain over the full range of floods needs to be understood by flood prone landholders and by floodplain risk managers.

Representation of the variability of flood hazard across the floodplain provides floodplain risk managers with a tool to assess the existing flood risk and to determine the suitability of land use and future development. The hazard associated with a flood is represented by the static and dynamic energy of the flow, which is in essence, the depth and velocity of the floodwaters. Therefore, the flood hazard at a particular location within the floodplain is a function of the velocity and depth of the floodwaters at that location and is related to the ability to wade or drive a vehicle through the floodwaters.

The NSW Government's *'Floodplain Development Manual'* (*2005*), characterises hazards associated with flooding into a combination of three hydraulic categories and two hazard categories. Hazard categories are broken down into high and low hazard for each hydraulic category as follows:

- Low Hazard – Flood Fringe
- Low Hazard – Flood Storage
- Low Hazard – Floodway
- High Hazard – Flood Fringe
- High Hazard – Flood Storage
- High Hazard - Floodway

As a result, the manual effectively divides hazard into two categories, namely, high and low. An interpretation of the hazard at a particular site can be established from **Figure L1** and **L2** on the following page, which have been taken directly from the manual.

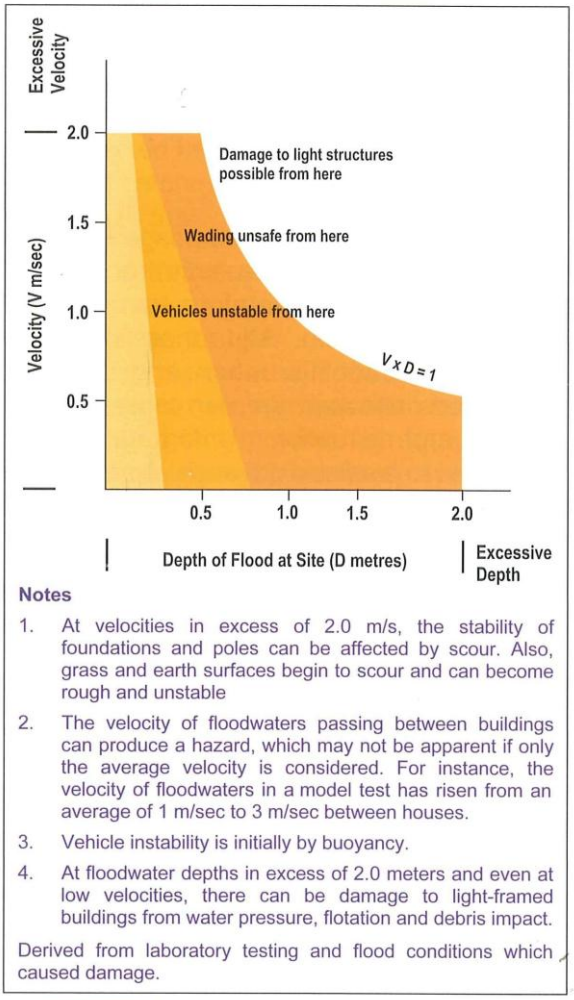
The first of these graphs shows approximate relationships between the depth and velocity of floodwaters and resulting hazard. This relationship has been used to define the provisional low and high hazard categories represented in the second of these plots.

8.2 FLOOD HAZARD

8.2.1 Adopted Provisional Hazard Categorisation

As shown in **Figures L1** and **L2**, flood hazard is a measure of the degree of difficulty that pedestrians, cars and other vehicles will have in egressing flooded areas, and the likely damage to property and infrastructure. At low hazard, passenger cars and pedestrians (*adults*) are able to move out of a flooded area. At high hazard, wading becomes unsafe, cars are immobilised and damage to light timber-framed houses would occur.

Flood hazard is categorised according to a combination of the flow velocity and the depth of floodwater. The categories are defined by lower and upper bound values for the product of flow velocity and floodwater depth.

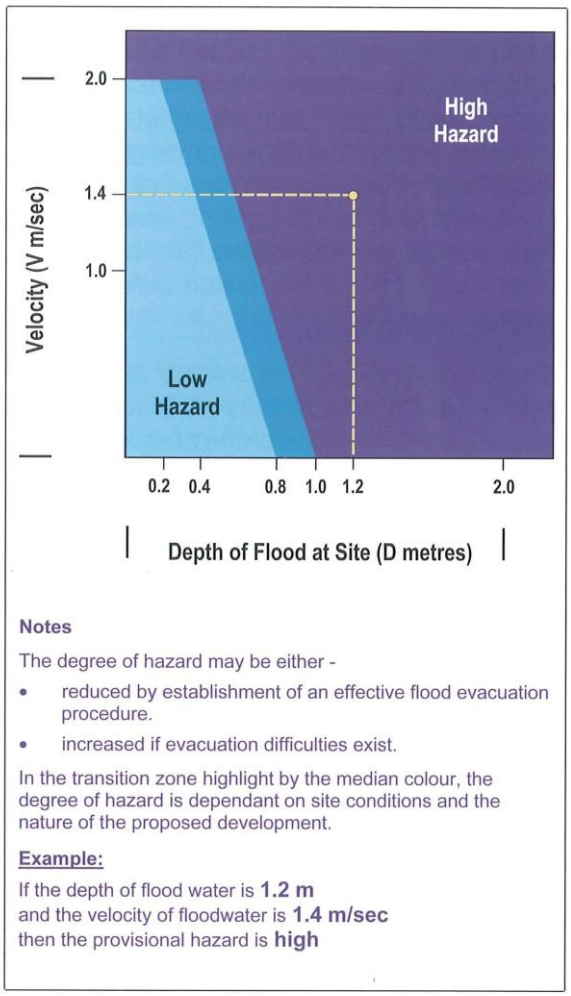


Notes

1. At velocities in excess of 2.0 m/s, the stability of foundations and poles can be affected by scour. Also, grass and earth surfaces begin to scour and can become rough and unstable
2. The velocity of floodwaters passing between buildings can produce a hazard, which may not be apparent if only the average velocity is considered. For instance, the velocity of floodwaters in a model test has risen from an average of 1 m/sec to 3 m/sec between houses.
3. Vehicle instability is initially by buoyancy.
4. At floodwater depths in excess of 2.0 meters and even at low velocities, there can be damage to light-framed buildings from water pressure, flotation and debris impact.

Derived from laboratory testing and flood conditions which caused damage.

FIGURE L1 - Velocity & Depth Relationships



Notes

The degree of hazard may be either -

- reduced by establishment of an effective flood evacuation procedure.
- increased if evacuation difficulties exist.

In the transition zone highlight by the median colour, the degree of hazard is dependant on site conditions and the nature of the proposed development.

Example:

If the depth of flood water is **1.2 m**
and the velocity of floodwater is **1.4 m/sec**
then the provisional hazard is **high**

FIGURE L2 - Provisional Hydraulic Hazard Categories

Spatial and temporal distributions of flow, velocity and water level determined from the computer modelling undertaken as part of this study were used to determine the flood hazard categorisation of the Nepean River floodplain within the study area. Interpretation of this data indicates that for large events such as the 1% AEP flood event, the majority of flooded land would fall within the high hazard category defined in the *'Floodplain Development Manual'* (*2005*).

Hence, for the purpose of understanding how the flood hazard affects existing development and areas of potential future development, it is useful to further subdivide areas falling within the high hazard category, into High Hazard, Very High Hazard and Extreme Hazard.

Similarly, the low hazard category defined in the manual has been subdivided to create a Low Hazard and a Transitional Hazard category.

8.2.2 Provisional Flood Hazard

Provisional flood hazard mapping generated for the study area simulated events is presented in **Appendix I**.

The mapping indicates that a large proportion of the floodplain would be subject to high hazard flooding during events greater than and including the 1% AEP event. This is predominantly a function of the high floodwater depths across much of the floodplain at the peak of the events, although high velocities are experienced in many areas.

8.2.3 Preliminary True Flood Hazard

The hazard represented in this mapping is provisional only. This is because it is based only on an interpretation of the flood hydraulics and does not reflect the effects of other factors that influence hazard (*see clause L6 to Appendix L of the Floodplain Development Manual*). For example, access to an otherwise low hazard area may be through a high hazard area and this may present an unacceptable risk to life and limb and as such the provisional low hazard area may be changed to high hazard.

According to the NSW Government's 'Floodplain Development Manual' (*2005*), the preparation of mapping for the true flood hazard also needs to consider other factors, including:

- The size of the flood;
- Effective warning time;
- Flood readiness of the community;
- The rate of rise of the flood waters;
- Duration of the flooding;
- Any evacuation problems that may be encountered;
- Effective flood access;
- The type of development present;

Evacuation away from areas of immediate hazard is not expected to be problematic at most locations along the tributaries. However, floodwaters are likely to block access along roads that cross these creeks and access from outside the area may not be possible for the duration of the flood event.

The duration of flooding from the Nepean River (including backwater floodwater from the river along the tributaries) is expected to be relatively long; floodwaters are not expected to recede from most properties for two or three days after the commencement of flooding

during the 1% AEP event. As a result, any trapped residents may be isolated for extended periods of time and may need to be supplied with food or other provisions.

The mapping for preliminary true flood hazard has been prepared for the design 1% AEP flood event (*refer* **Appendix J**). In most locations, this mapping was derived from the provisional flood hazard mapping by removing islands of lower hazard or other areas that become substantially surrounded by high hazard floodwaters.

8.3 HYDRAULIC CATEGORIES

8.3.1 Adopted Hydraulic Categorisation

The NSW Government's *'Floodplain Development Manual'* (*2005*) also characterises flood prone areas according to the hydraulic categories presented in **Table 8.1**. The hydraulic categories provide an indication of the potential for development across different sections of the floodplain to impact on existing flood behaviour.

Table 8.1 HYDRAULIC CATEGORY CRITERIA

HYDRAULIC CATEGORY	DESCRIPTION
FLOODWAY	• those areas where a significant volume of water flows during floods • often aligned with obvious natural channels • they are areas that, even if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow, which may in turn adversely affect other areas • they are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
FLOOD STORAGE	• those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood • If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. • Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
FLOOD FRINGE	▪ the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. ▪ Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Unlike for the hazard categorisation outlined in **Section 8.2**, the *'Floodplain Development Manual'* (*2005*) does not provide explicit quantitative criteria for defining hydraulic categories. This is because the extent of floodway, flood storage and flood fringe areas is largely dependent on the geomorphic characteristics of the floodplain in question.

Although there are no specific procedures for identifying or determining hydraulic categories, a rigorous methodology involving several stages of analytical analysis in conjunction with flood modelling has been developed by Thomas & Golaszewski (*2012*). This methodology has been applied with success to similar floodplains in NSW and has been shown to provide a robust procedure for defining floodway extent. Most recently, this methodology was successfully applied to the Lower Hastings River floodplain as part of investigations for the *'Hastings Floodplain Risk Management Study*' (*2012*).

The hydraulic category mapping that was prepared for the Nepean River floodplain as part of the investigations for this study is provided in **Appendix K**.

The following sections describe the methodology that was employed to determine the hydraulic category mapping.

8.3.2 Adopted Methodology for Determination of Floodway Corridors

The adopted methodology for determination of hydraulic categories for Nepean River floodplain involved several stages of assessment that relied on analysis of all available hydraulic, topographic, cadastral and geomorphic data-sets.

Once the detailed investigations to determine the extents of floodway corridors were completed, an assessment was also undertaken to determine the extent of flood storage and flood fringe areas. Each of these hydraulic categories was then combined to develop hydraulic category mapping for the study area which can be incorporated into future mapping layers linked to Council's Development Control Plan.

A preliminary floodway extent was firstly determined based on an assessment of aerial photography, topographic data and existing 1% AEP flood modelling results. Determination of this extent or "line" considered the following:

- The location of flood storages that are readily identifiable from aerial photography;
- The location and potential impact of hydraulic controls and geomorphic features that could influence floodwater movement and flood characteristics (*e.g., velocity*);
- Mapping of contours of 'velocity-depth' product (*V x D*); and,
- Mapping of the variation in peak flow velocity.

Because of the complex nature of flooding along the Nepean River within the study area and the varied floodplain types encountered across the study area, establishment of a standard set of criteria was not considered appropriate for the determination of all floodway extents. For example, definition of the floodway extent based on a single target value for velocity or velocity-depth product (*V x D*) would limit the reliability of the investigation findings.

Accordingly, to ensure the assessment of floodway extent was completed reliably, the study area was divided into numerous precincts to enable assessment on a '*local*' scale.

A set of interactive flood maps was produced for each of these precincts to show key hydraulic data including the variation in V x D, peak flow velocities and peak flood depths. The results of modeling of the design 1% AEP flood were used as the benchmark for the analysis.

The interactive flood maps were used to identify areas of the floodplain representing:

- High depth and high velocities; i.e., high V x D (*generally considered floodway*);
- High depth and low velocities (*generally considered flood storage*); and
- Low depth and low velocity (*generally considered flood fringe*).

In this regard, a typical "first pass" assessment of floodway extents was undertaken to identify areas where the velocity-depth product is greater than 3 m^2/s and where flow velocities are greater than 1 m/s. The alignment of significant flow paths across the floodplain (*i.e., potential flood runners*), as inferred by the velocity and V x D contour mapping, was also considered in determining the preliminary floodway extents.

The Preliminary Floodway Extent was further verified by comparison with mapping of the width of the floodplain that would be required to convey 80% of the peak flow. Trial analyses for this project and similar floodplain risk management studies have shown a good correlation between the transitions in velocity-depth product contour mapping, geomorphic characteristics and the width of the floodplain that conveys about 80% of the flood flow. A discussion of this criteria and its appropriateness for defining floodway extent is provided in Thomas & Golaszewski (*2012*).

The width occupied by 80% of the flow was readily determined for any location within the lower reaches of the floodplain using the *Flow Extraction* tool within waterRIDE™. This width was then used to verify and adjust the Preliminary Floodway Extent where appropriate. The resultant floodway mapping is shown in **Appendix K**.

8.3.3 Adopted Methodology for Determining Flood Storage and Flood Fringe

Following determination of those areas of the floodplain categorised as floodway, investigations were focused towards identifying the remaining hydraulic categories, namely flood storage and flood fringe. As outlined in the NSW *'Floodplain Development Manual'* (*2005*), flood storage and flood fringe make up the remainder of the floodplain outside of the floodway corridor.

Flood storage areas are typically defined as those flood prone areas that afford significant temporary storage of floodwaters during a major flood. If filled or obstructed (*through the construction of levees or road embankments*) the reduction in storage would be expected to result in a commensurate increase in flood levels in nearby areas. The remaining flood prone areas not classified as floodway or flood storage are termed flood fringe.

In order to determine the boundary between flood storage and flood fringe, the variation in peak flood depths in areas outside of the floodway extent was mapped to identify areas inundated to depths of approximately 0.5 metres. A depth of 0.5 metres is considered to be upper limit of the transitionary point between flood storage and flood fringe.

In terms of the Nepean River floodplain within the study area, peak depths below 0.5 metres are generally considered to correspond to areas where negligible flow is conveyed and represent a relatively small proportion of storage for floodwaters.

In accordance with the Floodplain Development Manual (*2005*), this represents areas which are unlikely to have any significant impact on the pattern of floodwater distribution through a river and floodplain system and associated flood levels. Accordingly, the boundary between flood storage and flood fringe was defined by a peak 1% AEP flood depth of 0.5 metres.

Flood storage and flood fringe mapping for the floodplain of the Nepean River within the study area is presented within **Appendix K**.

9. PRELIMINARY FLOOD PLANNING AREA

The Preliminary Flood Planning Area within the study area has been determined for the present day situation by mapping the extent of the Flood Planning Levels which were determined according to the peak 1% AEP flood level plus a freeboard of 0.5 metres.

Furthermore, part of the study area is underlain with coal deposits and is within the South Campbelltown Mine Subsidence District. The area of interest, which encompasses an area bordered by Camden Valley Way, Narellan Road and the Nepean River, can be further divided into two subareas as follows:

- Elderslie Urban Release Area (*north of Camden Bypass*) – additional mine subsidence allowance of 1.3 metres; and
- Spring Farm Urban Release Area (*south of Camden Bypass*) – additional mine subsidence allowance of 1.6 metres.

WorleyParsons' *waterRIDE* software has been used to apply the 0.5 metre freeboard and the additional mine subsidence allowances (*where required*) to the peak 1% AEP flood levels in order to determine the Flood Planning Area outlines. The final, composite Flood Planning Area extents are presented in **Appendix L**.

10. FLOOD DAMAGES ANALYSIS

10.1 WHAT ARE FLOOD DAMAGES?

Flood damages are adverse impacts that private and public property owners experience as a consequence of flooding. They can be both tangible and intangible and are usually measured in terms of a dollar cost.

Tangible damages include direct damages such as the damage to property as a consequence of inundation (*e.g. the cost of replacing carpets*). Tangible damages can also be indirect damages such as the cost to the community of individuals being unable to get to work because they are isolated due to flooding. These costs can usually be measured and data has been gathered over many years to provide a reliable indication of the likely damage costs that can be incurred by residential, commercial and industrial property owners.

It is more difficult to quantify intangible damages. Intangible damages include less 'concrete' impacts such as the trauma felt by individuals as a result of a major flood and the associated health related impacts. Only limited data is available, but it has been stated that intangible damages could be as much or more than the tangible damage cost.

As part of the floodplain risk management process, it is necessary to determine the total damages that could be incurred as a consequence of flooding. If the total damage cost is significant, it can be argued that works or planning measures to reduce the cost can be justified.

10.2 FLOOD DAMAGE ASSESSMENT METHOD

10.2.1 Flood Damage Categories

Flood damage costs within the study area were determined based on consideration of the different types of land use within the floodplain. The predominant land uses are classified as:

- Residential;
- Commercial; and
- Industrial.

Residential, commercial and industrial flood damages include damage to structures (*e.g. buildings, houses, factories, offices*) and damage to the items within those structures. They also include damages to outdoor facilities and associated infrastructure, and to the land on which the structures are sited.

Damage to infrastructure as a result of flooding includes losses associated with damage caused by inundation of roads, water supply and sewerage services, and damage to utilities such as electricity, gas and telecommunications systems.

Residential, commercial and industrial damages can be separated into direct and indirect damages. Direct damages are the result of the physical contact of floodwaters with the structure and may include the costs associated with repair, replacement or the loss in value of inundated items. Indirect damages represent all other costs not associated with physical damage to property and typically include the loss of income incurred by residents affected by flooding, as well as flood recovery items such as clean-up costs.

The approach developed to calculate flood damages for the study area is based upon the development of a representative damage curve for typical structures in the floodplain. A damage curve is a numerical relationship that correlates the depth of flooding to the cost of damages that would result from that flooding. The cost of the damages associated with the flooding increases as the depth of flooding increases.

The approach employs the procedures outlined in the DECC (*now OEH*) Floodplain Risk Management Guideline for 'Residential Flood Damages' (*2007*). It involves the application of the damage curves documented in the literature with flood data that has been updated as part of this study. The flood data is compared to floor level data for structures or properties to determine the quantum of damages.

Based on data collected during a site survey conducted by WorleyParsons, residential properties within the study area were classified as either:

- Single storey set directly on the ground;
- Single storey high set (*i.e., on piers*); or
- Double storey building set directly on the ground.

Commercial properties include shops, pubs, offices and large shopping complexes, while industrial premises include metal fabrication works and distribution warehouses. For commercial properties, a distinction was made between stand-alone commercial buildings, and shopping complexes.

An estimate of the direct damages associated with the inundation of commercial and industrial premises was based on recorded damage costs for similar premises reported in the literature. This literature includes a range of previous floodplain management studies and recorded data presented in intergovernmental reports. OEH has advised that this approach is suitable, provided that the damage curve data is updated to reflect current Average Weekly Earnings (*AWE*) and Goods and Services Tax (*GST*), where applicable.

The OEH guidelines for residential properties incorporate some allowance for indirect damages, such as clean-up costs and loss of rental income.

Indirect damages for commercial and industrial premises were assumed to be 50% of the corresponding direct damages which is based on values used previously in the background literature. This accounts for the significant impact of indirect influences, such as the

slowdown that a business could experience due to employees being unable to get to work due to inundation of roads.

There is no specific data available to define the extent of the public and corporate infrastructure that could be damaged as a result of flooding. Additional infrastructure damages were applied to reflect 30% of the total direct and indirect costs for residential, commercial and industrial properties. This is consistent with approaches employed for other areas of NSW.

10.2.2 Stage-Damage Relationships

Stage-damage curves reflect the potential flood damage as a function of the depth of over floor flooding of a building. DECC's Floodplain Risk Management Guideline for 'Residential Flood Damages' (*2007*) outlines the method for determining stage-damage curves for residential dwellings. This procedure is recommended as the basis for derivation of average annual damages and net present values of damages to enable the comparison of flood management options.

Standard stage-damage curves have also been developed from records of damages gathered from interviews with residents and landowners in flood affected communities. For example, Smith et al (*1979*) determined stage-damage relationships for different land use types based on data gathered during and following the Lismore floods in 1974. These curves were adopted for analysis of commercial and industrial damages.

The standard stage-damage curves for commercial and industrial properties were scaled to account for indirect damages. Infrastructure costs have been calculated separately.

The adopted stage-damage curves are included within **Appendix M**.

10.2.3 Average Annual Damage

The relative cost of potential flood damages is typically expressed in terms of the Average Annual Damage (*AAD*). The AAD is the average damage per year that would occur from flooding over an extended period of time.

It should be noted that there may be long periods where no floods occur or the floods that do occur are too small to cause significant damage. Conversely, some floods will be large enough to cause extensive damage. Accordingly, the Average Annual Damage is equivalent to the total damage caused by all floods over an extended period of time divided by the number of years within that period (*DECC, 2007*). It provides a quantitative measure for comparing the relative economic benefits of potential flood damage reduction options..

10.3 FLOOD DAMAGES ANALYSIS FOR THE STUDY AREA

In order to calculate the potential flood damages, it is necessary to have data that defines the floor levels of structures and infrastructure that could potentially be flooded and details of the type of structure (*e.g., residential dwelling or commercial premises*). This data can be used with peak flood

levels generated from the flood modelling undertaken as part of this study to determine the depth of "over floor" flooding for each residential and commercial property.

Data defining the minimum floor elevations of residential, commercial and industrial buildings was collected by WorleyParsons using on-site observations of the height of floor levels above the adjacent ground elevation. This information was then superimposed over the available terrain data to estimate the finished floor level of each structure. This floor level data was then used alongside the peak flood levels generated from the hydrodynamic modelling study to determine the depth of over floor flooding at each structure.

Estimates of the tangible flood damages associated with the 50%, 20%, 5%, 1%, 0.5% and 0.2% AEP flood events and the Probable Maximum Flood (*PMF*) event are outlined in **Table 10.1**.

The results indicate that the total damage bill is estimated to be approximately $31,660,000 for the design 1% AEP event. The Average Annual Damage for the study area, incorporating all events up to the PMF, is estimated to be **$4,538,000**.

Table 10.1 TANGIBLE FLOOD DAMAGES

FLOOD EVENT	RESIDENTIAL		COMMERCIAL & INDUSTRIAL		INFRASTRUCTURE DAMAGES	TOTAL
	Number[1]	Damages	Number	Damages		
50% AEP	4 (0)	$43,900	-	-	$13,200	$57,000
20% AEP	23 (7)	$837,700	4	$771,800	$482,900	$2,092,400
5% AEP	179 (126)	$14,493,300	24	$3,152,400	$5,293,700	$22,939,300
1% AEP	**333 (222)**	**$30,631,600**	**43**	**$6,841,900**	**$11,242,100**	**$48,715,600**
0.5% AEP	469 (303)	$41,471,400	55	$9,980,424	$15,435,500	$66,887,400
0.2% AEP	632 (467)	$60,552,008	62	$14,705,808	$22,577,300	$97,835,200
Probable Maximum Flood	1609 (1420)	$172,404,926	97	$26,513,686	$59,675,600	$258,594,200

1 Number of residential dwellings subject to over-floor inundation shown in parentheses

The location of properties that are damaged during the design 1% AEP event are shown in **Figure 10.1** and **Figure 10.2**, including those subject to both below-floor and over-floor inundation.

10.4 INTANGIBLE FLOOD DAMAGES

Intangible flood damages are those that are unable to be quantified in monetary terms. These damages are related to the physical and mental health of individuals, environmental concerns, the ability to undertake necessary evacuation measures and disruption to essential community services and operations.

Emotional stress and mental illness can stem from a number of experiences associated with damage to family homes and businesses. These include:

- Destruction of memorabilia (i.e., family photos);
- Death of pets;
- Financing the replacement of damaged property;
- Living in temporary accommodation;
- Children attending a different school;
- Loss of business income and potential clients;
- Loss of wages; and
- Anxiety experienced by young children.

This type of intangible damage to the wellbeing of residents could be significant in the event of a major flood. Accordingly, it is possible that the intangible damage cost could be as high as or higher than the total tangible damage cost.

11. SENSITIVITY TESTING

11.1 IMPACT OF CLIMATE CHANGE

The NSW government has published a number of documents which provide guidance to account for climate change impacts on flooding. The Department of Environment and Climate Change (*DECC*) Floodplain Risk Management Guideline titled: 'Practical Consideration of Climate Change' (*2007*) is most relevant to the present study.

This guideline provides estimates for the change in "Extreme Rainfall" under future climate change conditions for different parts of NSW. The guideline recommends consideration of increased rainfall intensities of between 10% and 30%. Accordingly, it was agreed with Council that the following climate change scenarios would be tested:

- 1% AEP rainfall event with 10% increase in rainfall intensities; and
- 1% AEP rainfall event with 20% increase in rainfall intensities.

11.1.1 Hydrologic Modelling

In order to derive the inflow hydrographs for the two climate change scenarios, the XP-RAFTS hydrologic model was updated to include intensity-frequency-duration (*IFD*) data with the appropriate percentage increases in intensities applied.

Updated inflow hydrographs for all upstream boundary locations and local subcatchment inflows were derived for both climate change scenarios. A summary of the peak discharges for each upstream model boundary location is provided in **Table 11.1**.

11.1.2 Hydrodynamic Modelling

The updated upstream and local subcatchment inflow hydrographs were then used within two further simulations of the TUFLOW hydrodynamic model. The results from these two scenarios provide a suitable indication of the flooding characteristics that could be expected within the study under the assumed climate change conditions.

11.1.3 Observed Impacts on Local Flooding

The predicted impact on peak flood level resulting from the increased rainfall due to climate change have been extracted from the modelling results and are presented in **Figures N.1** *and* **N.4** for the two climate change sensitivity events. The figures display the total increase at each location in the network (*i.e., the peak flood level under climate change conditions minus the corresponding present day peak flood level*). Individual figures have also been included for two sub-areas within the Camden LGA area (*refer* **Figures N.2**, **N.3**, **N.5** *and* **N.6**).

Table 11.1 PEAK UPSTREAM INFLOWS USED IN TUFLOW MODEL (CLIMATE CHANGE)

LOCATION (*refer* Figure 6.4)	XP-RAFTS MODEL NODE	PEAK DISCHARGE[1] (m^3/s)	
		1% AEP+10%	1% AEP+20%
		36hr	36hr
Nepean River	(MENANGLEIN)	9526	10516
Navigation Creek	NAVI B	122	135
Matahil Creek East	MAT E DMY	174	193
Matahil Creek West	MAT W A	28.2	31.4
Mt Hunter Rivulet	MT H C DMY	381	424
Cobbitty Creek	COBBITTY A	4.2	4.6
Wattle Creek	UNNMD1 DMY	118	131
Eagle Creek	EAGLE	132	146
Forest Hill Creek	FOREST	93.2	104
Bringelly Creek	BRI C1 DMY	48.1	53.5

1. Peak discharges listed do not necessarily occur simultaneously.

The observed results generally suggest that impacts are relatively constant from the upstream end of the model (*at Menangle*) to the confluence of the Nepean River with Cobbitty Creek. Further downstream of this location, the influence of the gorge between Theresa Park and Bents Basin becomes more apparent. The flow constriction created by the gorge inlet causes the area immediately upstream of it to accumulate excess flows during flood events and this appears to be exacerbated by the increased flows assumed during climate change scenarios (*refer* **Figures N.1** *and* **N.4**).

The impacts appear to then lessen slightly downstream of the gorge, before rising slightly once again when a similar situation occurs in the river as it approaches the second gorge that links Wallacia with the Nepean River's confluence with the Warragamba River (*refer* **Figures N.1** *and* **N.4**).

Increasing rainfall intensities by 10% resulted in peak flood level increases of between 0.50 and 0.70 metres in the areas upstream of the Cobbitty Creek confluence (*refer* **Figures N.2** *and* **N.3**). Typical impacts as the river passes the urban centre of Camden are between 0.65 and 0.70 metres.

Impacts on levels in the river downstream of Cobbitty Creek increase markedly and are approximately 1.5 metres upstream of the gorge and within the gorge itself (*refer* **Figure N.1**). Although the impacts decrease to around 1.0 metres downstream of the gorge and Bents Basin, they are observed to rise once again in the vicinity of Wallacia and the gorge just upstream of the confluence with the Warragamba River. The observed impacts of increasing rainfall intensities by 10% are also around 1.5 metres in these areas.

A similar pattern of impacts was observed when increasing the rainfall intensities by 20%. Peak flood level increases of between 1.0 and 1.2 metres are predicted in the floodplain areas upstream of the Cobbitty Creek confluence (*refer* **Figures N.5** *and* **N.6**). Typical impacts as the river passes the urban centre of Camden are between 1.1 and 1.2 metres.

Impacts on levels in the river downstream of Cobbitty Creek again increase markedly and are observed to be approximately 2.5 metres upstream of the gorge and slightly lower within the gorge itself (*refer* **Figure N.4**). Although the impacts decrease to around 1.0 metres downstream of the gorge and Bents Basin, they are observed to rise once again in the vicinity of Wallacia and the gorge just upstream of the confluence with the Warragamba River. The observed impacts of increasing rainfall intensities by 20% are around 2.4 metres in these areas.

11.2 IMPACT OF STRUCTURE BLOCKAGE

11.2.1 Hydrodynamic Modelling

In order to simulate the obstruction of flow through structures within the model network as a result of debris accumulation during large flood events, a number of additional model simulations were undertaken that assumed that all structures within the model were blocked for the duration of the design 1% AEP flood event. These simulations assumed a series of blockage levels up to and including 50%. The blockages were applied to all culverts and bridges represented within the model network (*refer* **Table 6.1**).

11.2.2 Observed Impacts on Flooding

As the extent of flooding during the 1%AEP flood event was typically observed to be well in excess of the width of the culverts and bridges within the model, blocking of these structures was generally seen to have a minimal impact on peak flood levels. The pattern of impacts observed during the highest blockage scenario simulated (*50% blockage of all identified structures*) suggests that the blockage of these structures tends to only result in localised impacts immediately upstream and downstream of the structures.

The predicted impact on peak flood level resulting from the assumed structure blockage have been extracted from the modelling results and are presented in **Figures N.7** *and* **N.8**.

The figures display the total increase at each location for two sub-areas within the Camden LGA (*i.e., the peak flood level under blockage conditions minus the corresponding unblocked peak flood level*).

Impacts are observed to be typically less than 0.2 metres and restricted to localised areas in the immediate vicinity of the blockages themselves. The only notable exception to this pattern can be observed as flows within Matahil Creek (*West*) attempt to pass beneath Burragorang Road approximately 2 kilometres west of Camden (*refer* **Figure N.8**). However, the peak flood levels are only predicted to rise by a maximum level of 0.2 metres and are restricted to an area that extends approximately 350 metres upstream of the blockage. The impacts observed elsewhere within the model network are generally much less.

11.3 IMPACT OF LOWER FLOODPLAIN ROUGHNESS

11.3.1 Hydrodynamic Modelling

In order to assess the sensitivity of the peak flood levels within the study area to changes in floodplain roughness a number of additional simulations were performed using a variety of alternative roughness values. The final adopted model simulations assume a Manning's 'n' roughness of 0.060 in accordance with standard values for areas of pasture with light brush cover. The lowest of the roughness values tested during the sensitivity simulations assumed a reduction of this value to 0.045. The impact on peak flood levels in the study area resulting from this assumption were assessed by undertaking a further simulation of the TUFLOW hydrodynamic model for the 1% AEP flood event under the reduced floodplain roughness condition.

11.3.2 Observed Impacts on Flooding

The predicted impact on peak flood level resulting from the assumed lowering of floodplain roughness have been extracted from the modelling results and are presented in **Figures N.9** and **N.10**. The figures display the change in flood levels at two sub-areas within the Camden LGA (*i.e., the peak flood level under reduced roughness conditions minus the adopted roughness peak flood level*).

As with the assessment of climate change impacts (*refer* **Section 11.1**), the observed impacts appear to be largely affected by the flow regime as the Nepean River approaches and enters the gorge that flows between Theresa Park and Bents Basin.

The results observed across the floodplain from the upstream end of the model (*at Menangle*) to the confluence of the Nepean River with Cobbitty Creek are typical of those that would be assumed from a reduction in floodplain roughness; peak flood levels are observed to reduce by as much as 0.35 metres (*refer* **Figures N.9** *and* **N.10**). Accordingly, flows are likely to be flowing at slightly higher velocities as they approach the hydraulic control imposed by the gorge downstream.

As such, a marked "switch" in the impacts in peak flood level is observed downstream of the Cobbitty Creek confluence. The increased flows approaching the entrance to the gorge at

Theresa Park appear to result in a build-up of floodwaters in this area, causing an increase in peak flood levels of up to 0.20 metres during the reduced roughness scenario. These impacts can be observed to dissipate within the gorge and reductions in peak flood levels are again observed by the time the river reaches Bents Basin further downstream.

It is worth noting that this issue was first observed during the calibration of the hydrodynamic model (*refer* **Section 6.3**). Varying and testing the floodplain roughness was undertaken while obtaining a suitable compromise between flood levels in the upstream and downstream sections of the LGA during the model calibration process. The assumed grass/pasture/brush roughness of n=0.060 was found to provide the best overall fit during the model calibration and is considered to offer a conservative approach for design flood level estimation within the urbanised areas of Camden and Elderslie.

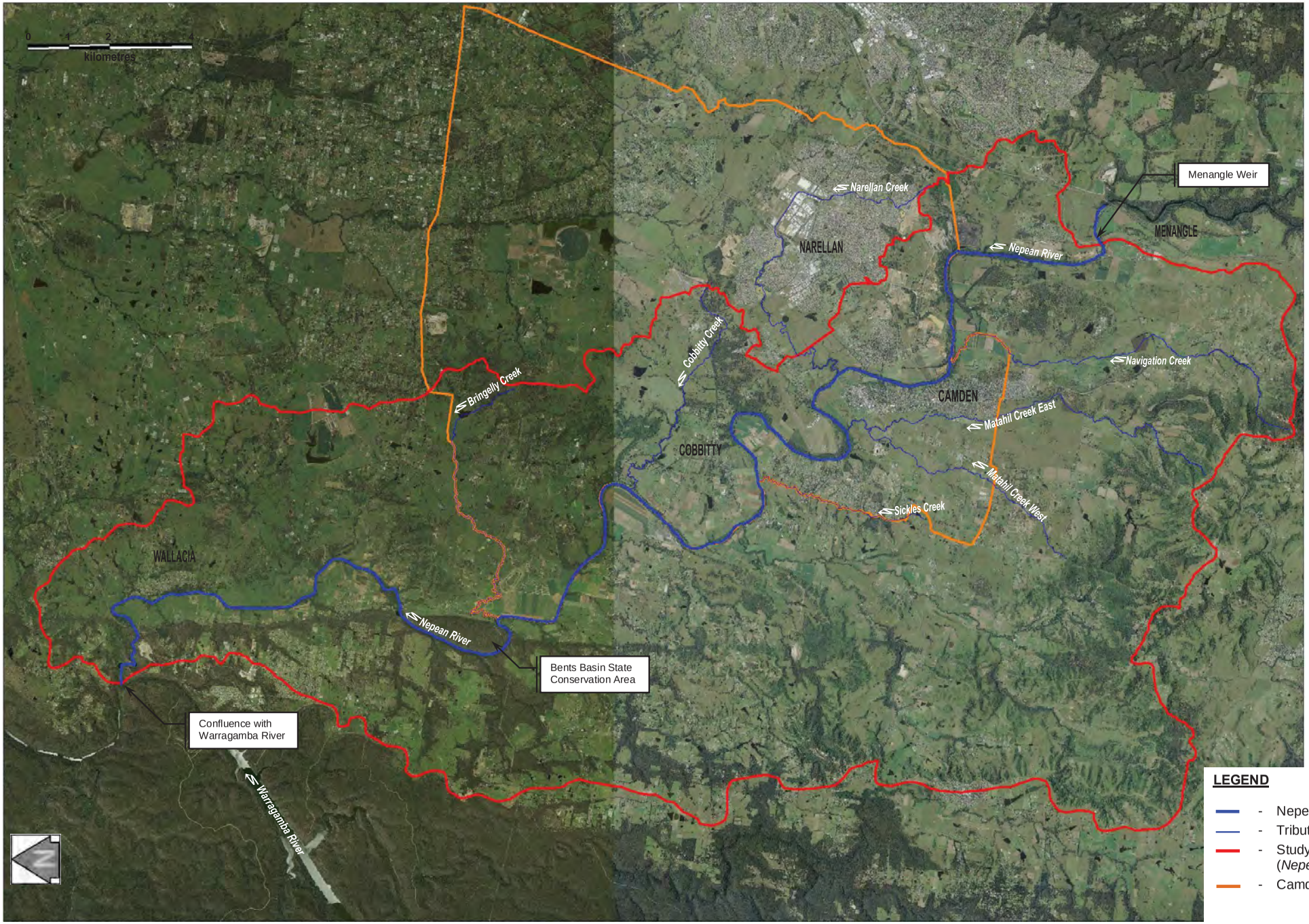
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REPORT FIGURES

FIGURE 1.1

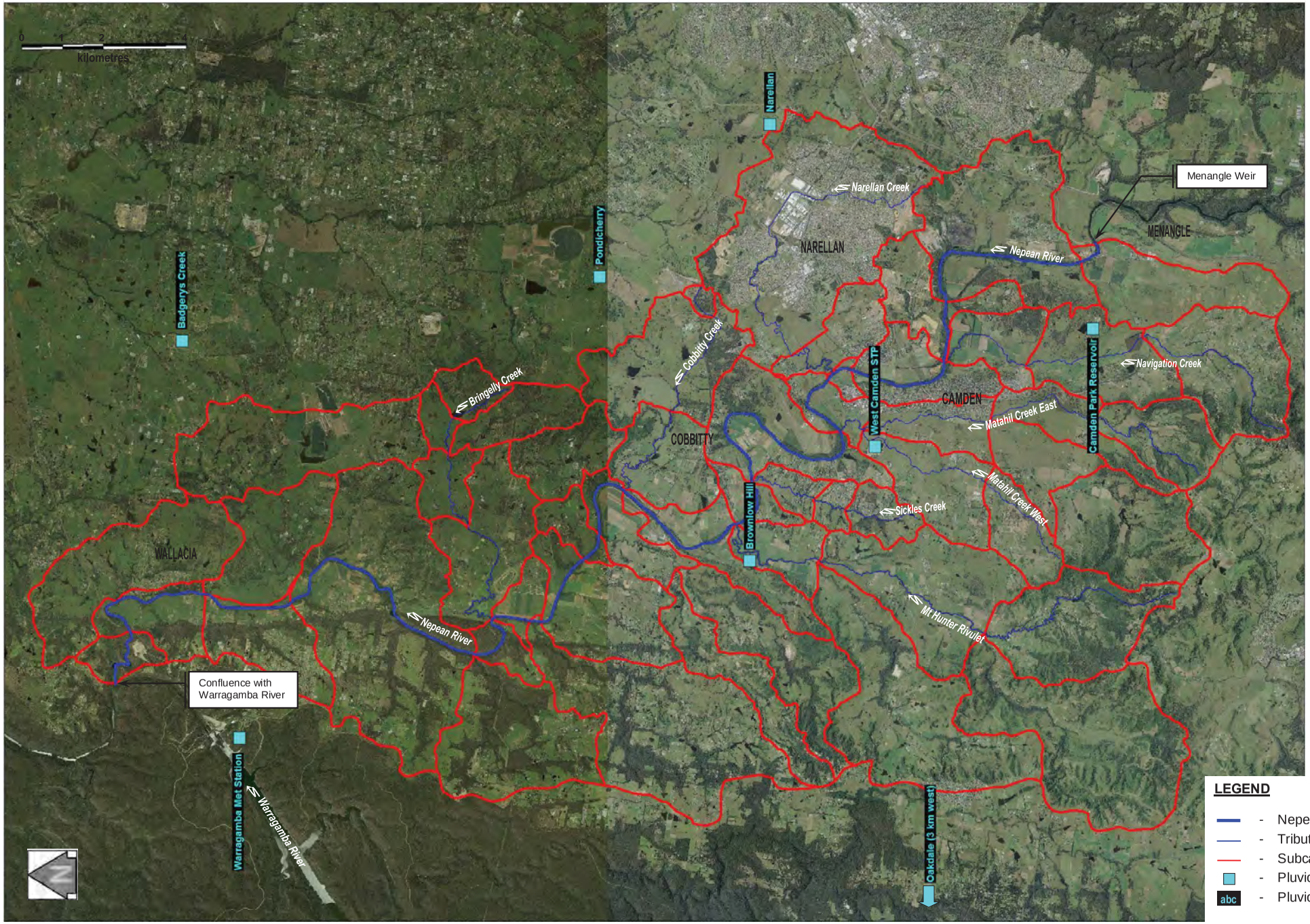


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301015-03107 – Nepean River Flood Study
1.01_fg301015-03107nm140218-Study Area.doc

LOCATION OF STUDY AREA

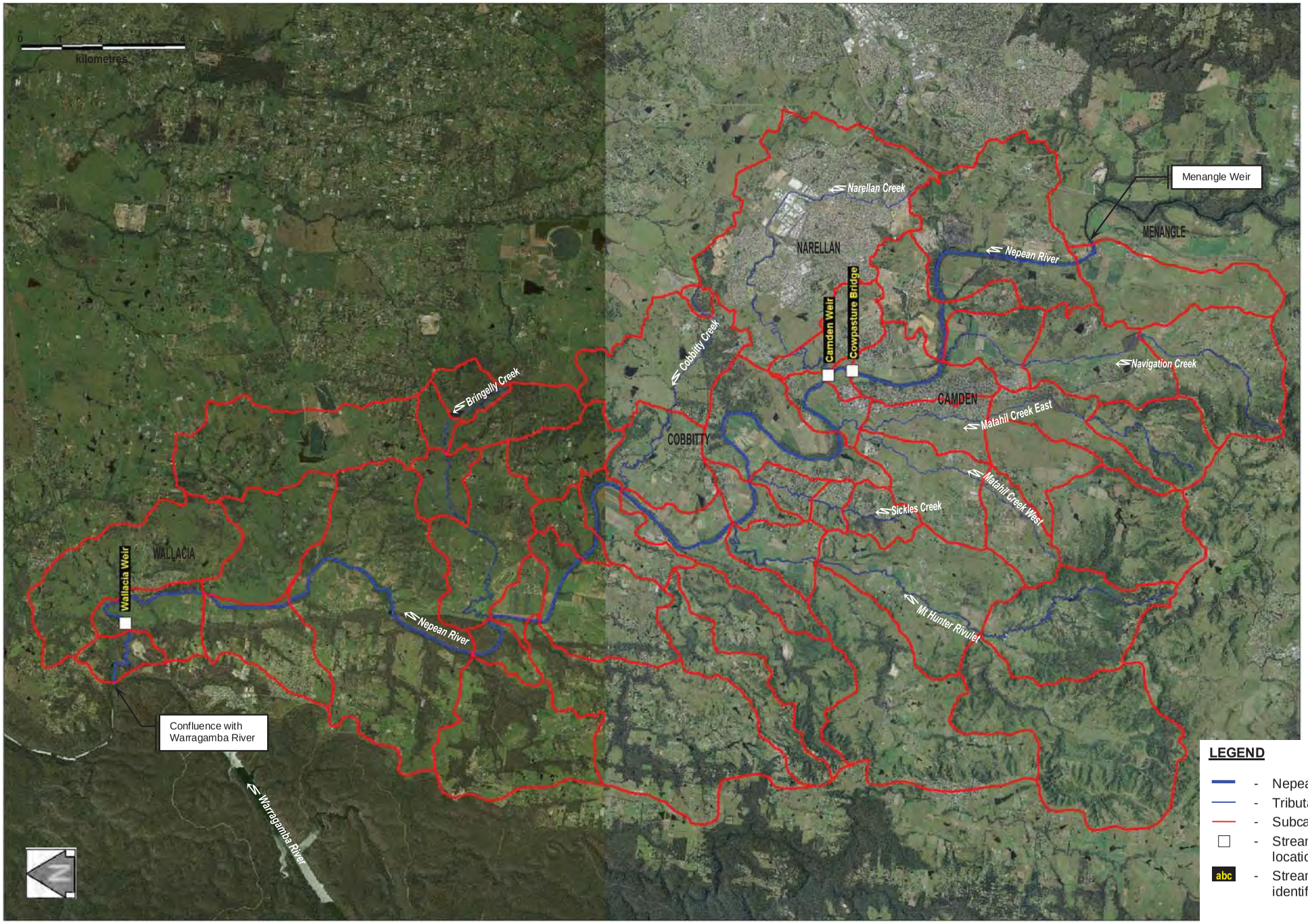
FIGURE 3.1



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LOCATION OF PLUVIOMETER RAINFALL STATIONS USED IN CALIBRATION OF HYDROLOGIC MODEL

FIGURE 3.2

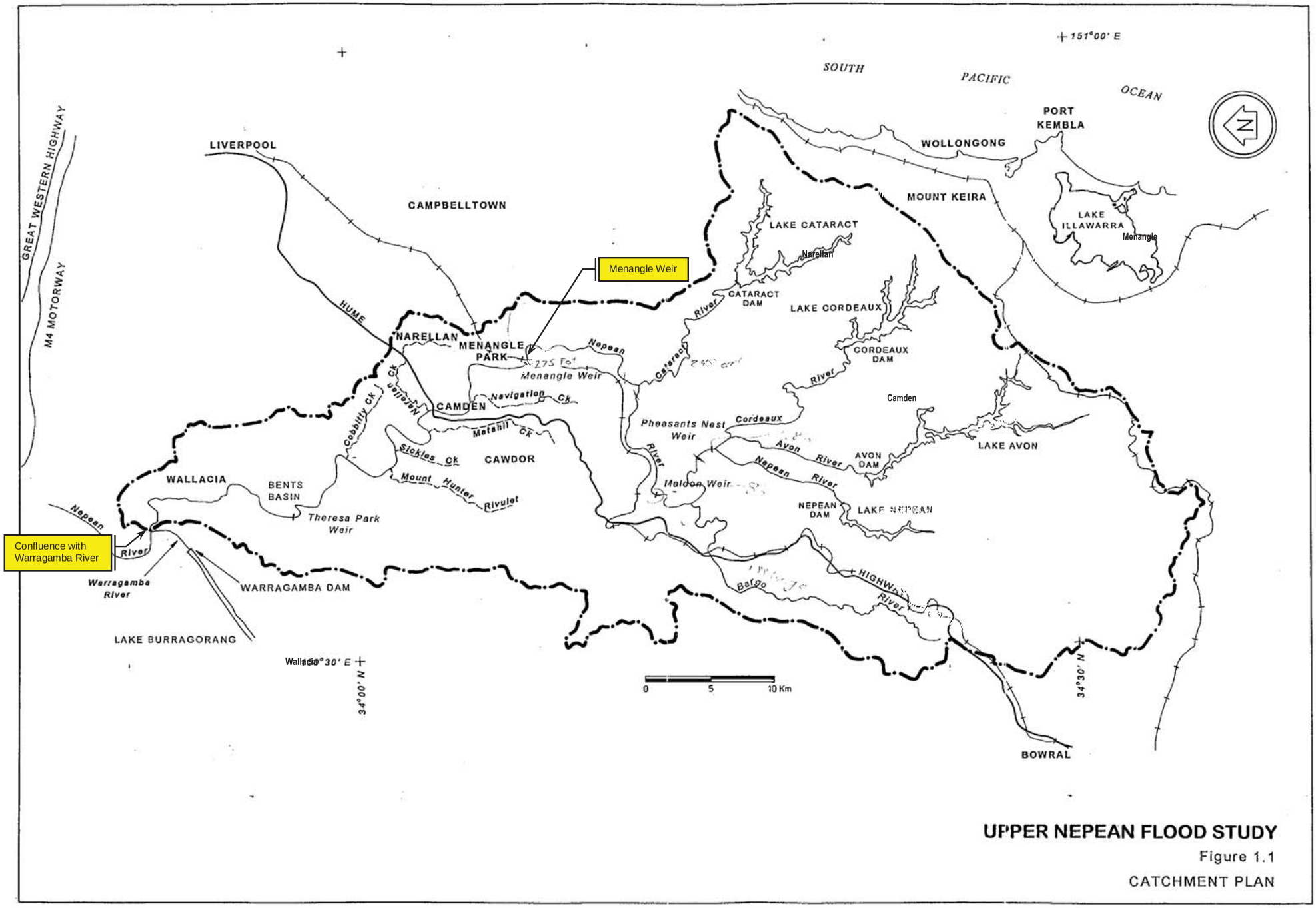


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3.02_fg301015-03107nm140113-Gauging Stations.doc

LOCATION OF STREAMFLOW GAUGING STATIONS

FIGURE 5.1

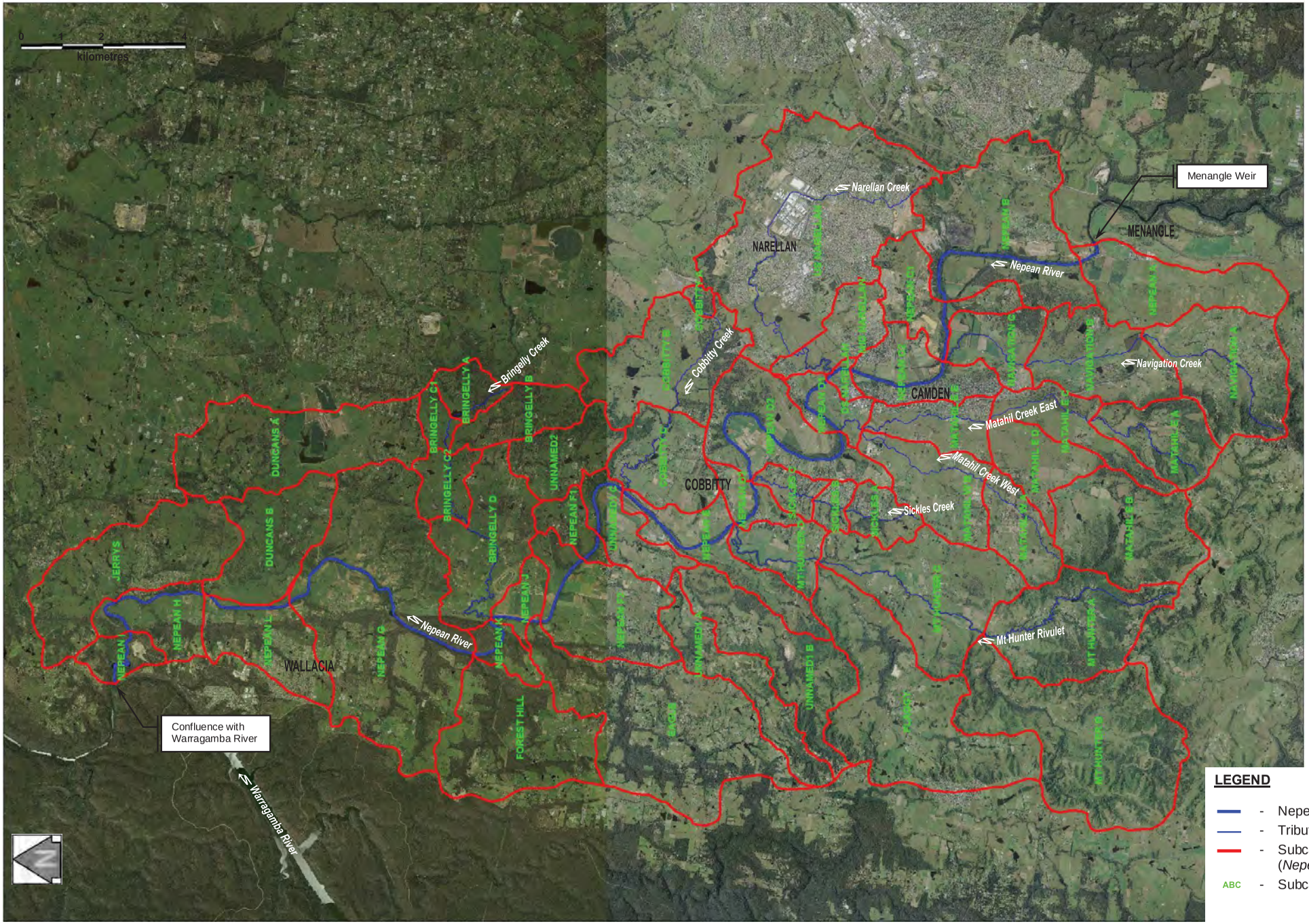


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5.01_fg301015-03107nm140113-RORB Subcatchments.doc

CATCHMENT LAYOUT OF HYDROLOGIC MODEL FROM UPPER NEPEAN RIVER FLOOD STUDY (1995)

FIGURE 5.2

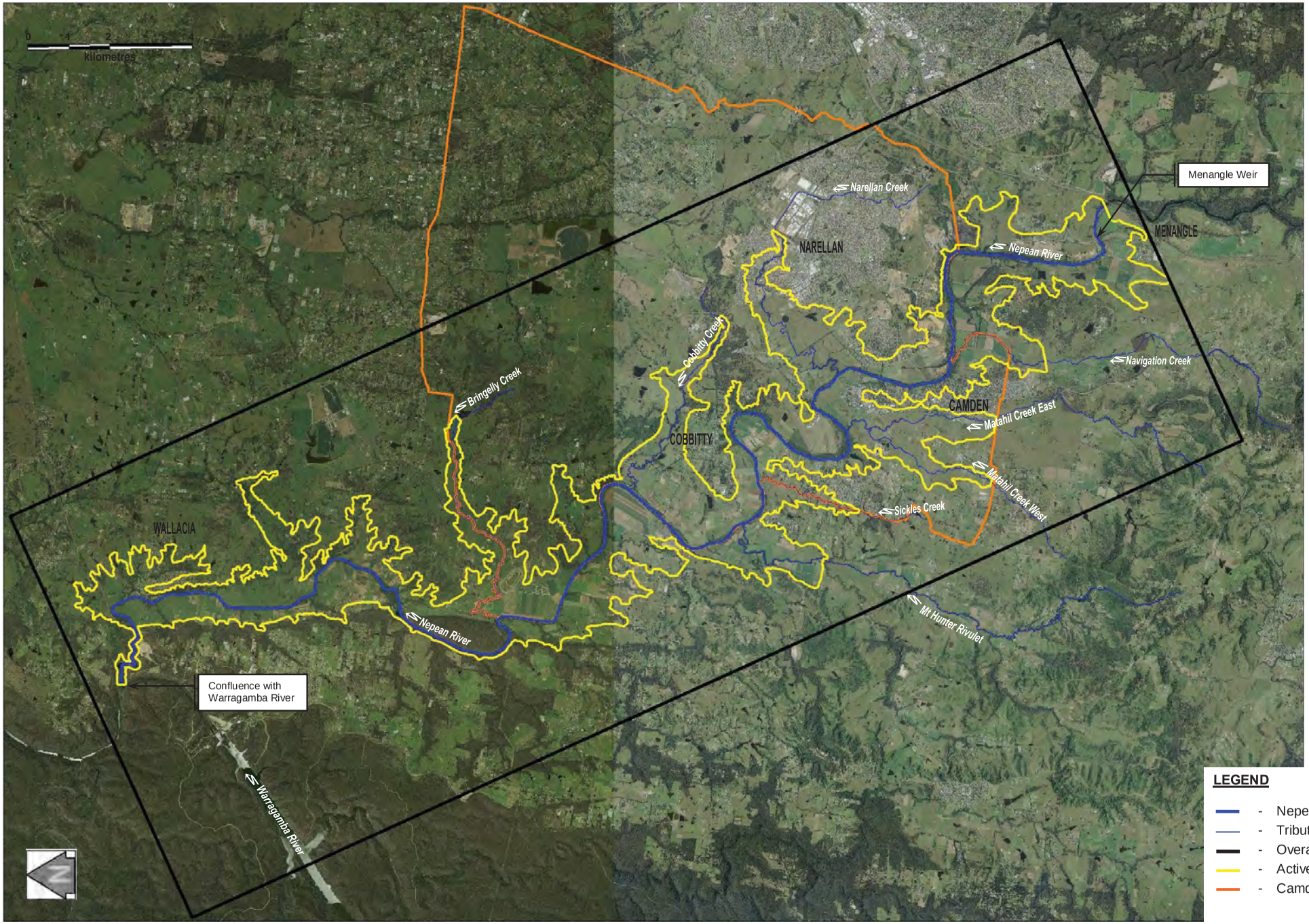


Note: Subcatchments draining to Nepean River upstream from Menangle Weir not shown – modelled previously as part of the Upper Nepean River Flood Study (*1995*). Subcatchments 'US NARELLAN' and 'MID NARELLAN' were modelled separately and in more detail as part of the Narellan Creek Flood Study (*currently undertaken*). The subcatchment outlines shown represent the overall areas of these subcatchments only

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SUBCATCHMENT LAYOUT OF XP-RAFTS HYDROLOGIC MODEL

FIGURE 6.1

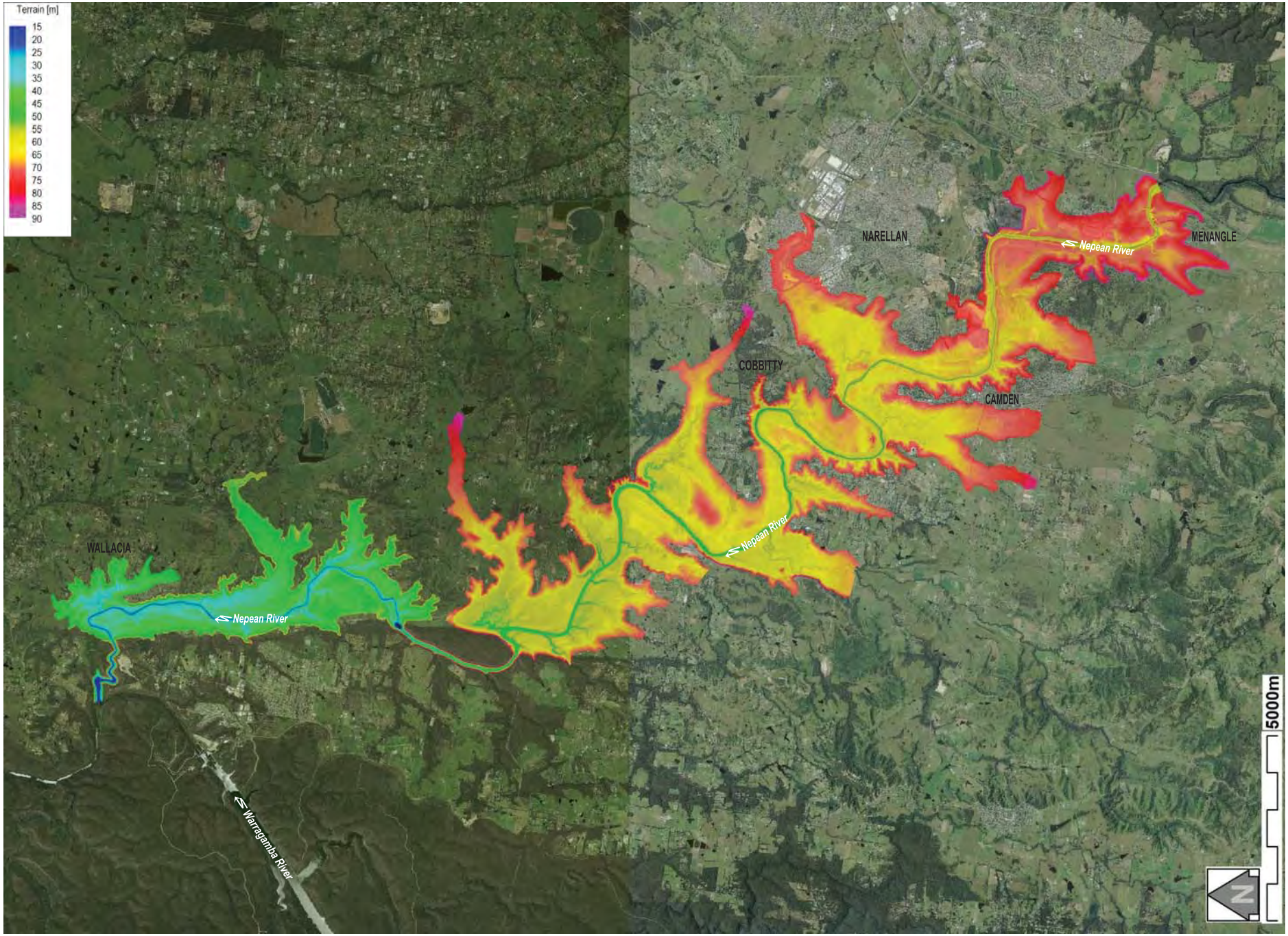


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TUFLOW HYDRODYNAMIC MODEL LAYOUT

FIGURE 6.2

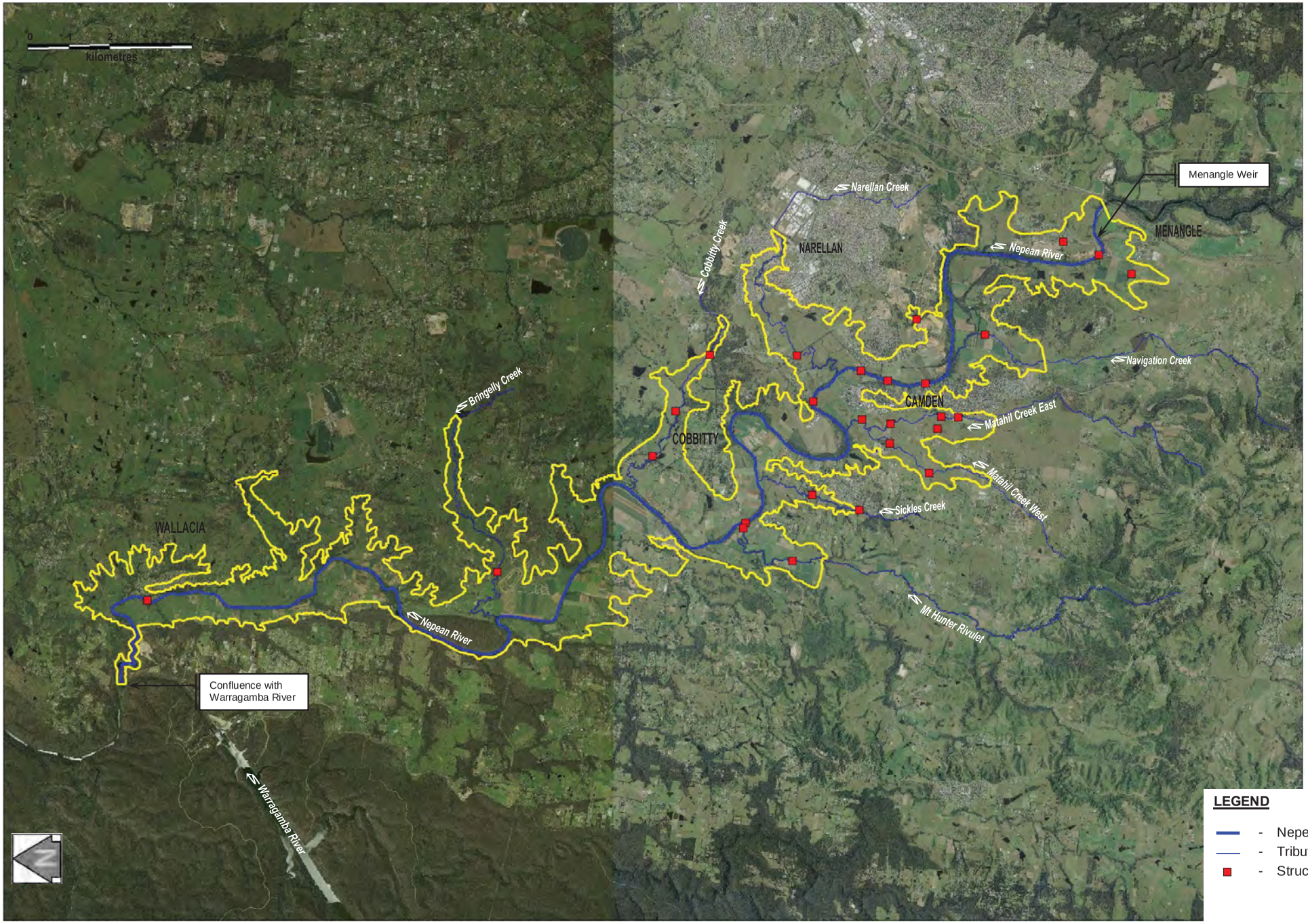


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301015-03107 – Nepean River Flood Study
6.02_fg301015-03107nm140211-TUFLOW Terrain.doc

DIGITAL TERRAIN MODEL (DTM) USED IN TUFLOW HYDRODYNAMIC MODEL

FIGURE 6.3

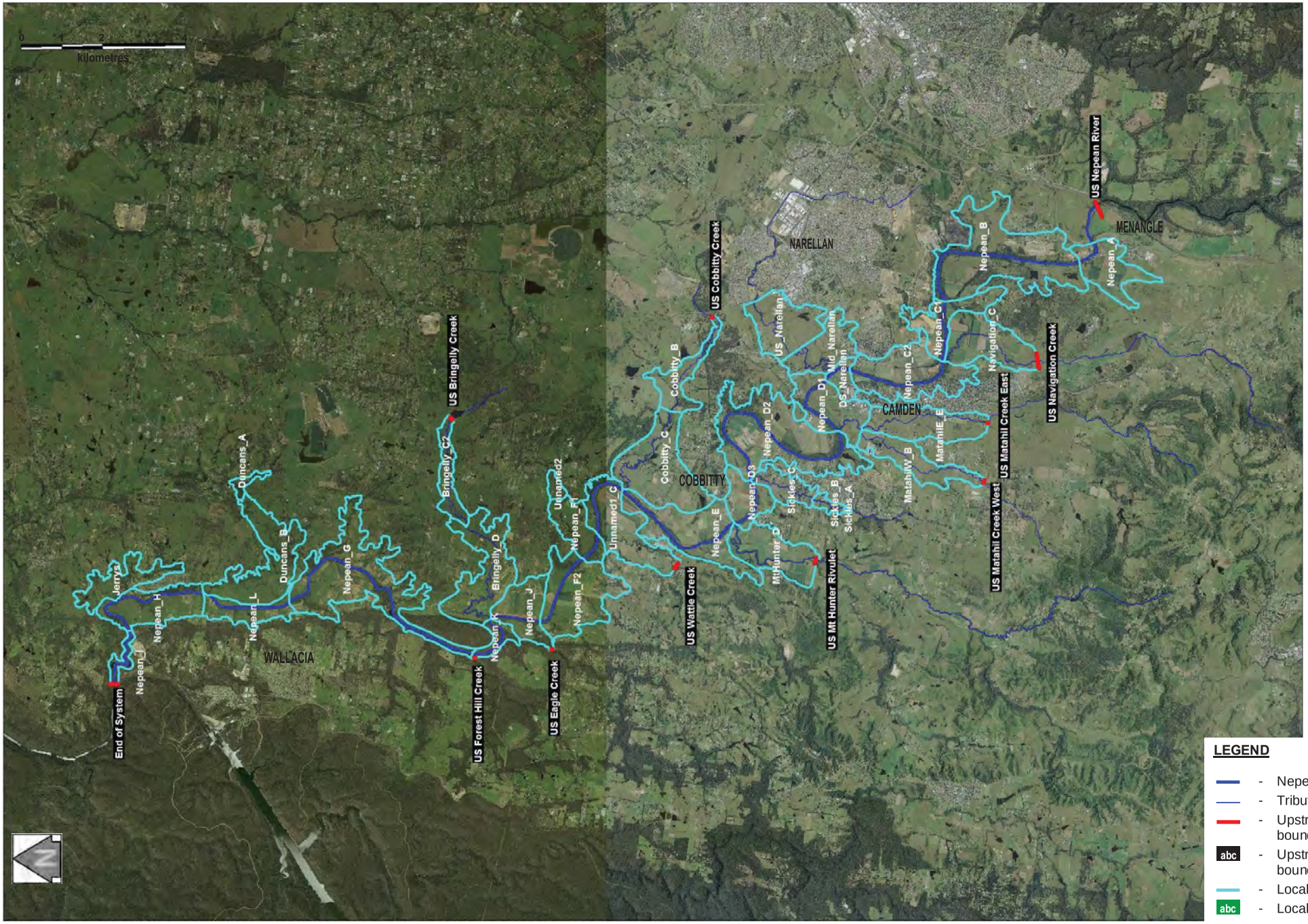


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301015-03107 – Nepean River Flood Study
6.03_fg301015-03107nm140211-TUFLOW Structures.doc

SCHEMATIC REPRESENTATION OF STRUCTURE LOCATIONS FOR TUFLOW HYDRODYNAMIC MODEL

FIGURE 6.4

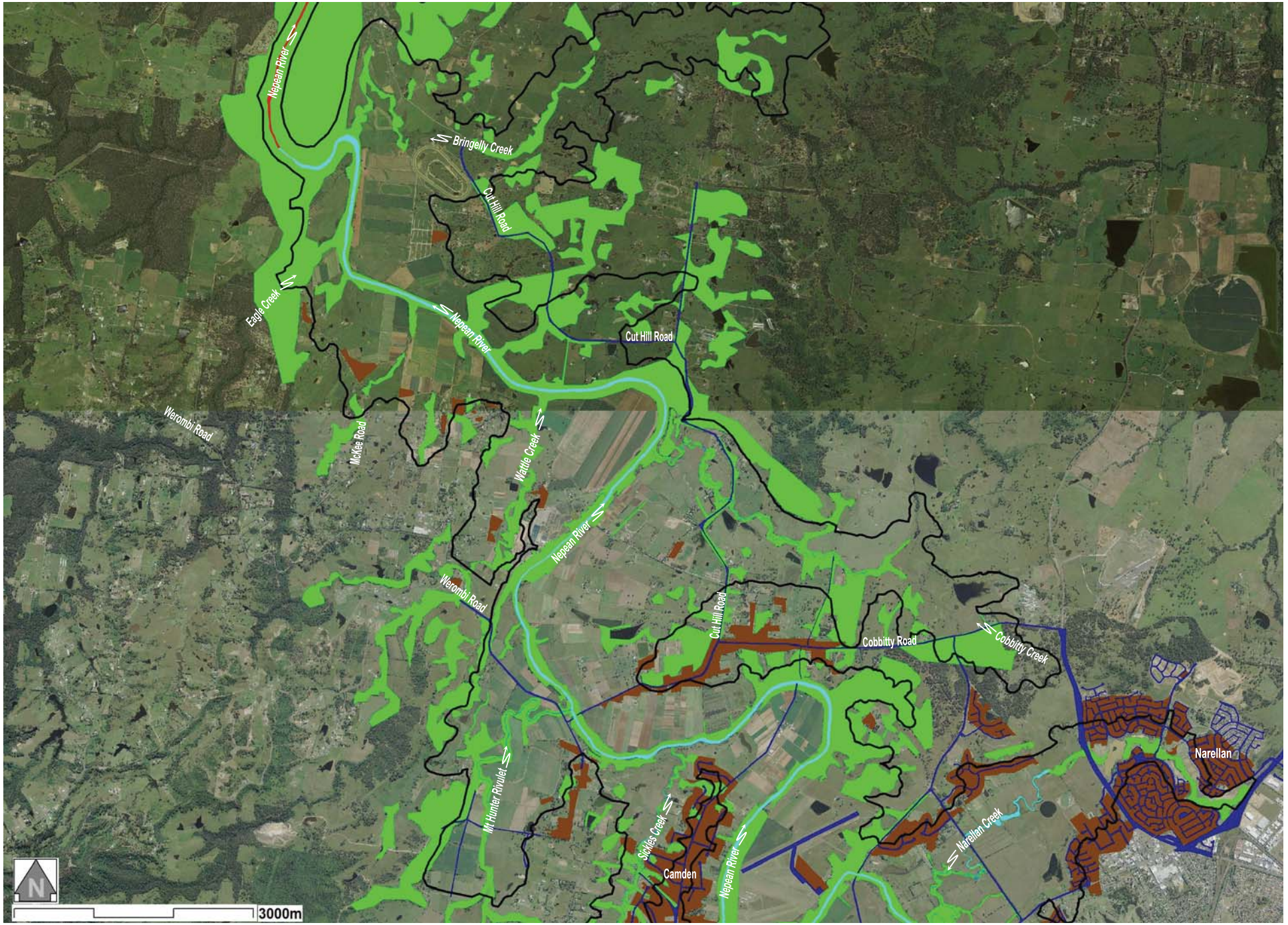


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301015-03107 – Nepean River Flood Study
6.04_fg301015-03107nm140114-TUFLOW Boundaries.doc

SCHEMATIC REPRESENTATION OF BOUNDARY CONDITIONS FOR TUFLOW HYDRODYNAMIC MODEL

FIGURE 6.5



LEGEND:

- Model network outline
- Roads (n=0.02)
- Gorge (n=0.04)
- Watercourses (n=0.04)
- Heavily vegetated watercourses (n=0.06)
- Urban areas (n=0.15)
- Trees (n=0.10)

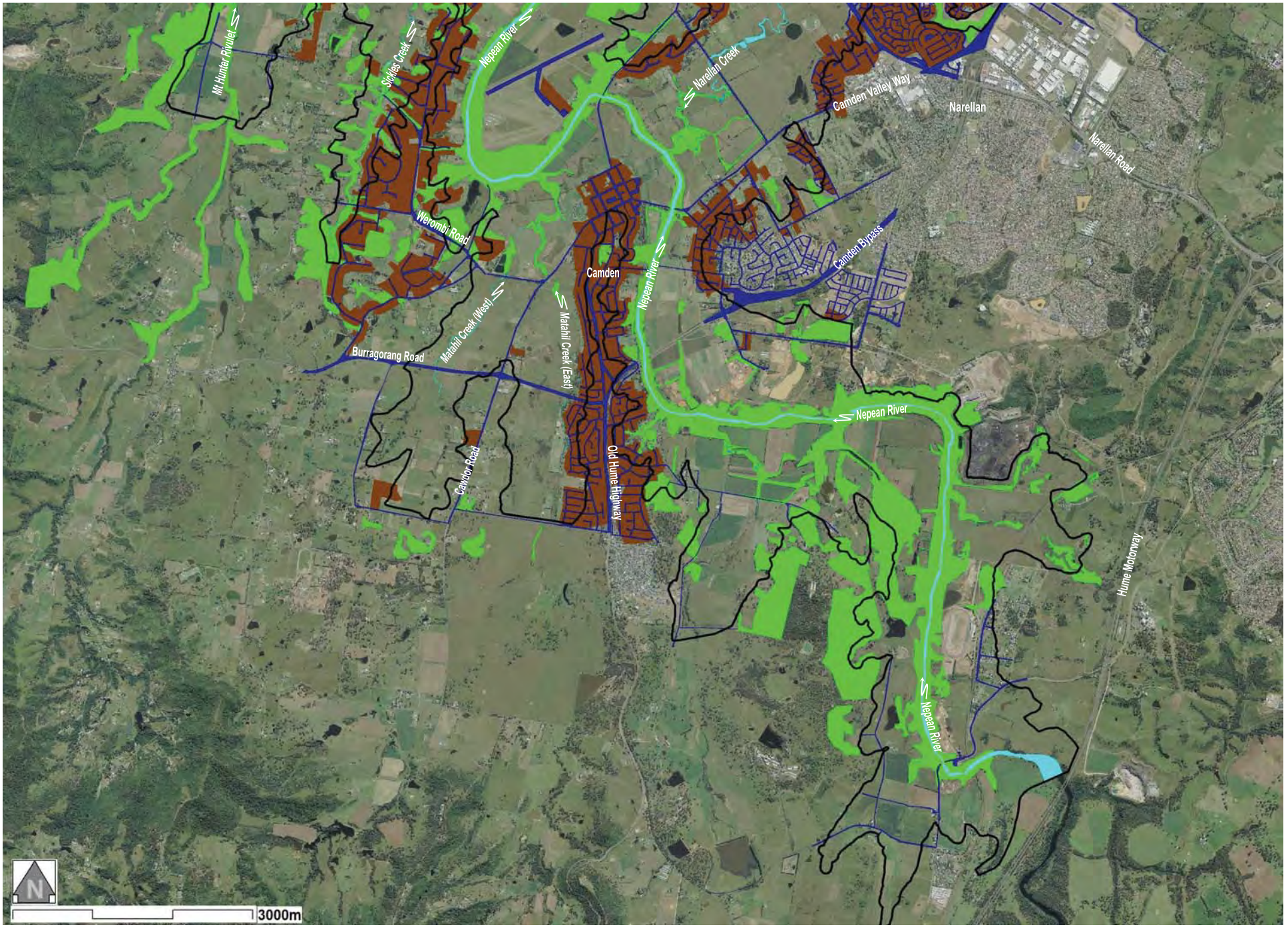
NOTES:

Floodplain areas within model extent but not marked reflect areas defined as Grass/Pasture/Brush (n=0.06)

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DISTRIBUTION OF FLOODPLAIN ROUGHNESS WITHIN TUFLOW MODEL NETWORK (DOWNSTREAM)

FIGURE 6.6



LEGEND:

- Model network outline
- Roads (n=0.02)
- Gorge (n=0.04)
- Watercourses (n=0.04)
- Heavily vegetated watercourses (n=0.06)
- Urban areas (n=0.15)
- Trees (n=0.10)

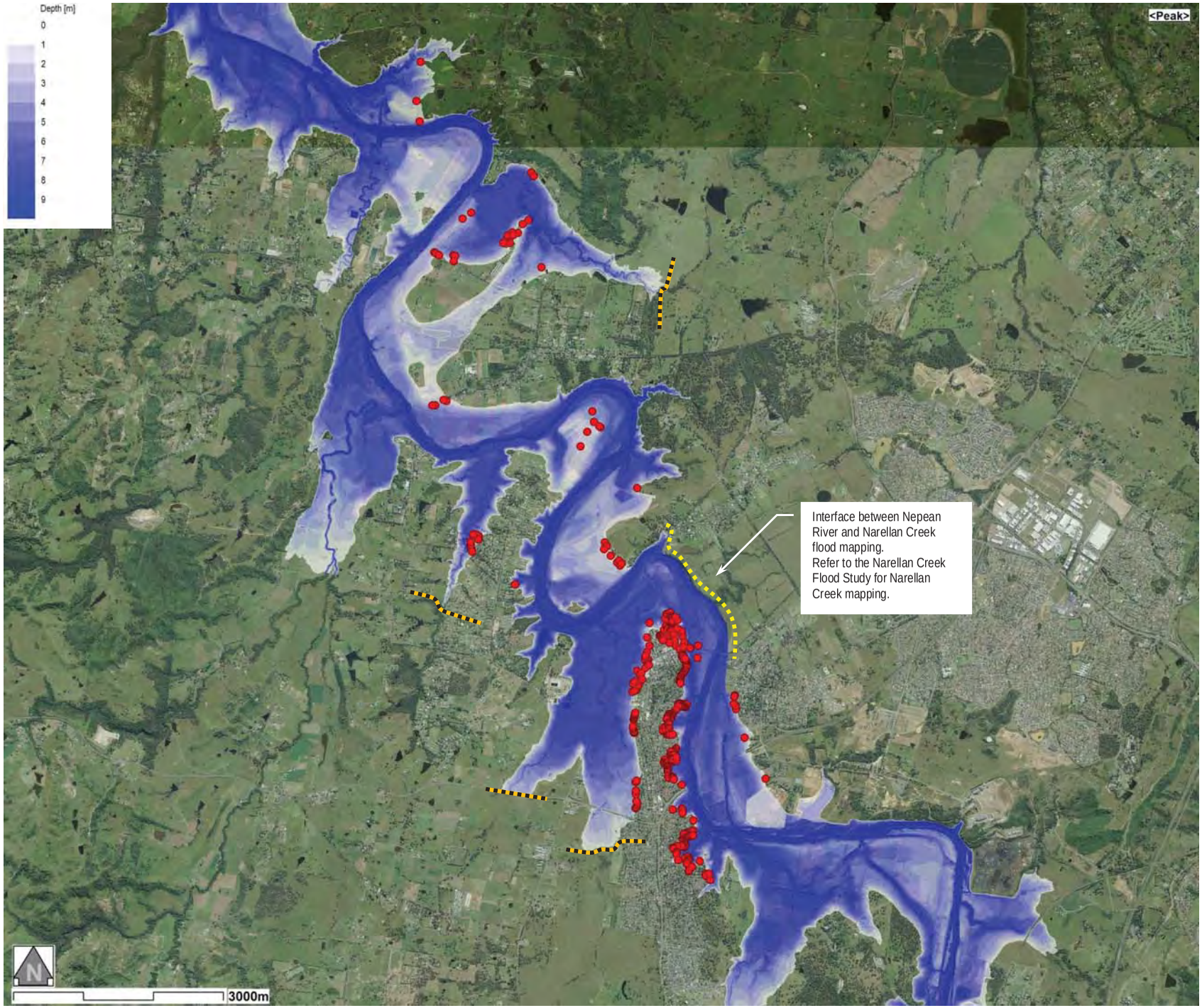
NOTES:

Floodplain areas within model extent but not marked reflect areas defined as Grass/Pasture/Brush (n=0.06)

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DISTRIBUTION OF FLOODPLAIN ROUGHNESS WITHIN TUFLOW MODEL NETWORK (UPSTREAM)

FIGURE 10.1



NOTES:

- Properties shown include those subject to below-floor and over-floor inundation

LEGEND:

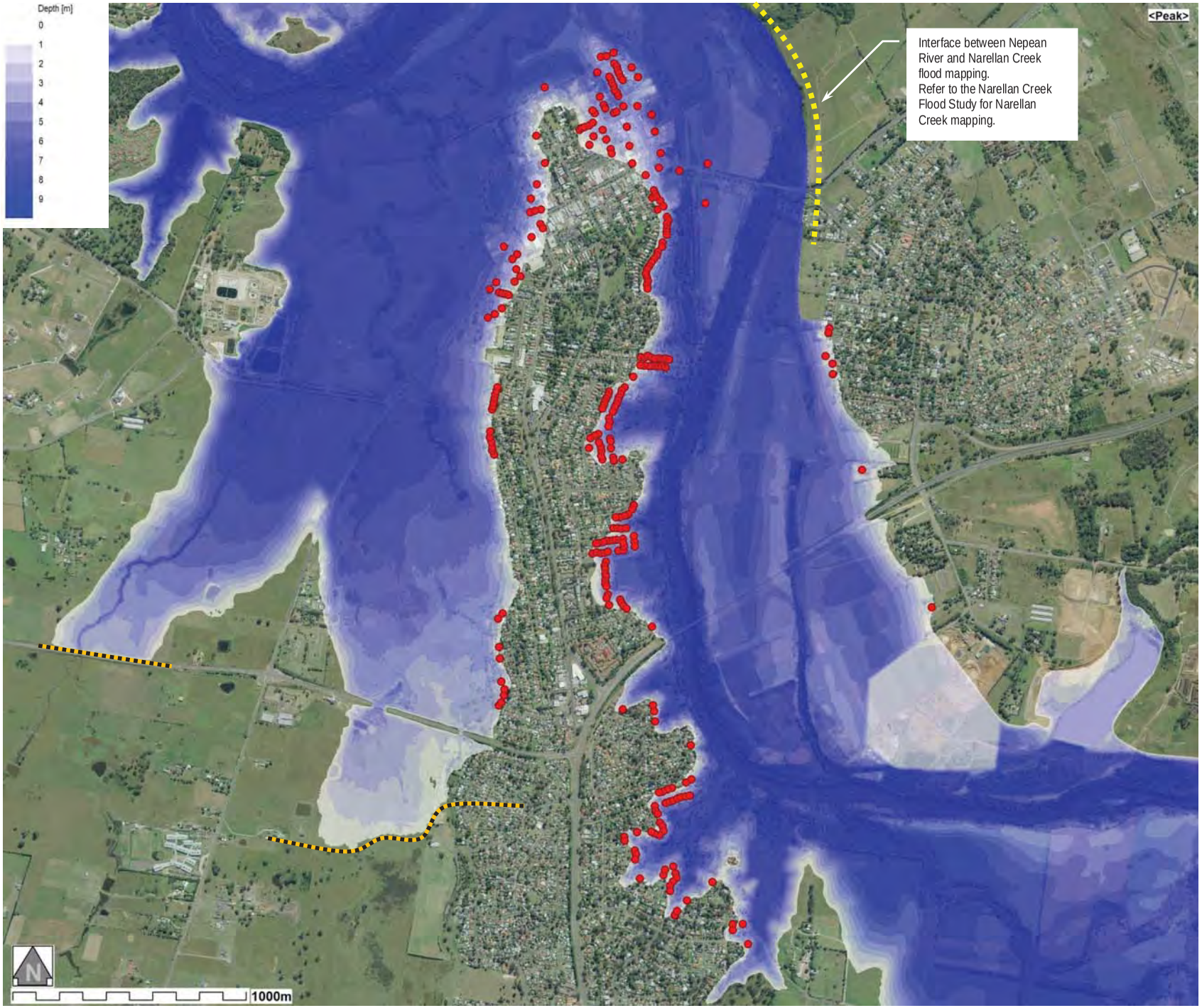
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
10.1_fg301015-03107eh150326-100yr_Damages_Overview.docx

PROPERTIES SUBJECT TO FLOOD DAMAGE DURING THE 1% AEP EVENT [OVERVIEW]

FIGURE 10.2



NOTES:

- Properties shown include those subject to below-floor and over-floor inundation

LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

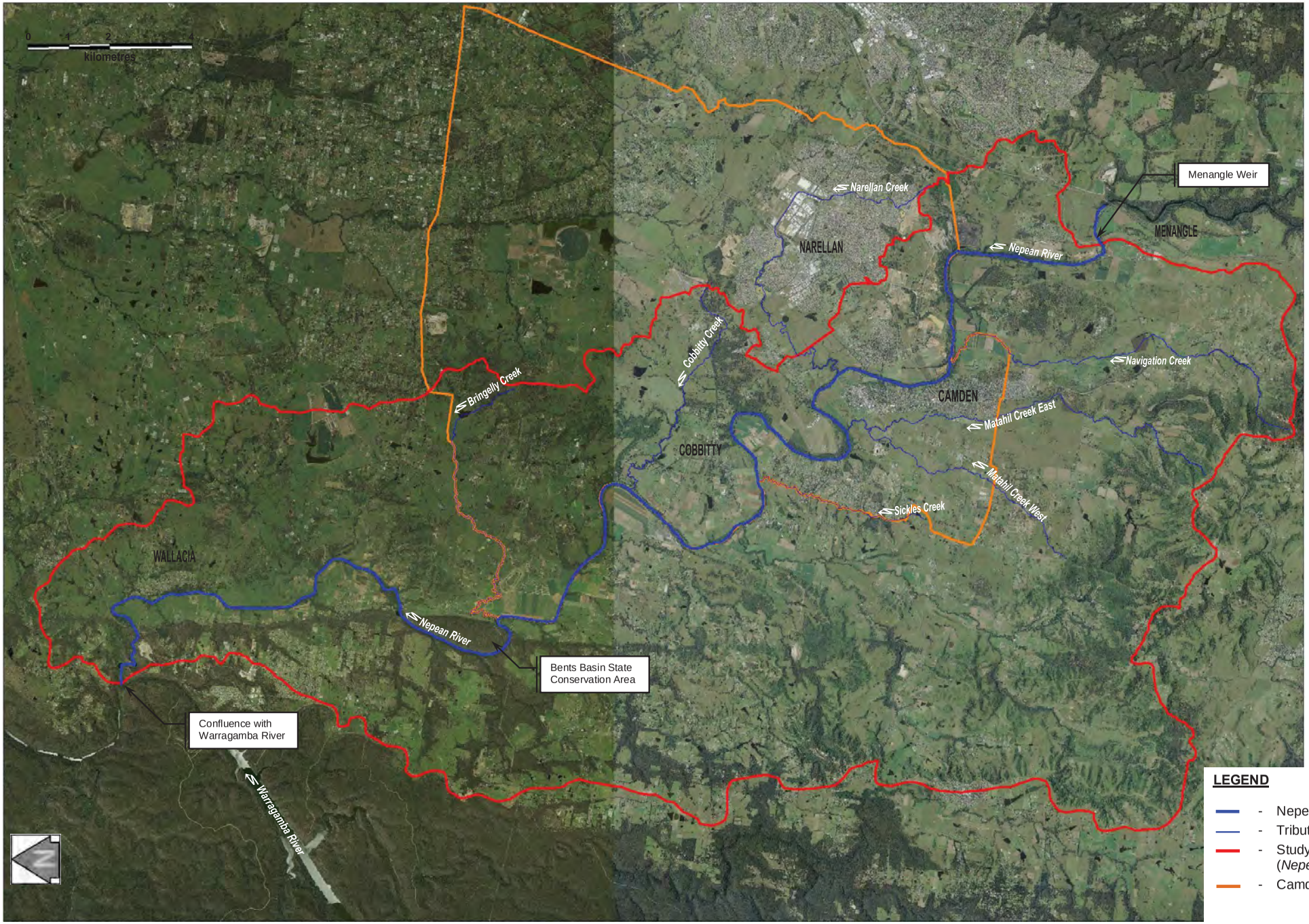
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301015-03107 – Nepean River Flood Study (Camden Council)
10.2_fg301015-03107eh150326-100yr_Damages_Zoomed.docx

PROPERTIES SUBJECT TO FLOOD DAMAGE DURING THE 1% AEP EVENT [CAMDEN]

REPORT FIGURES

FIGURE 1.1

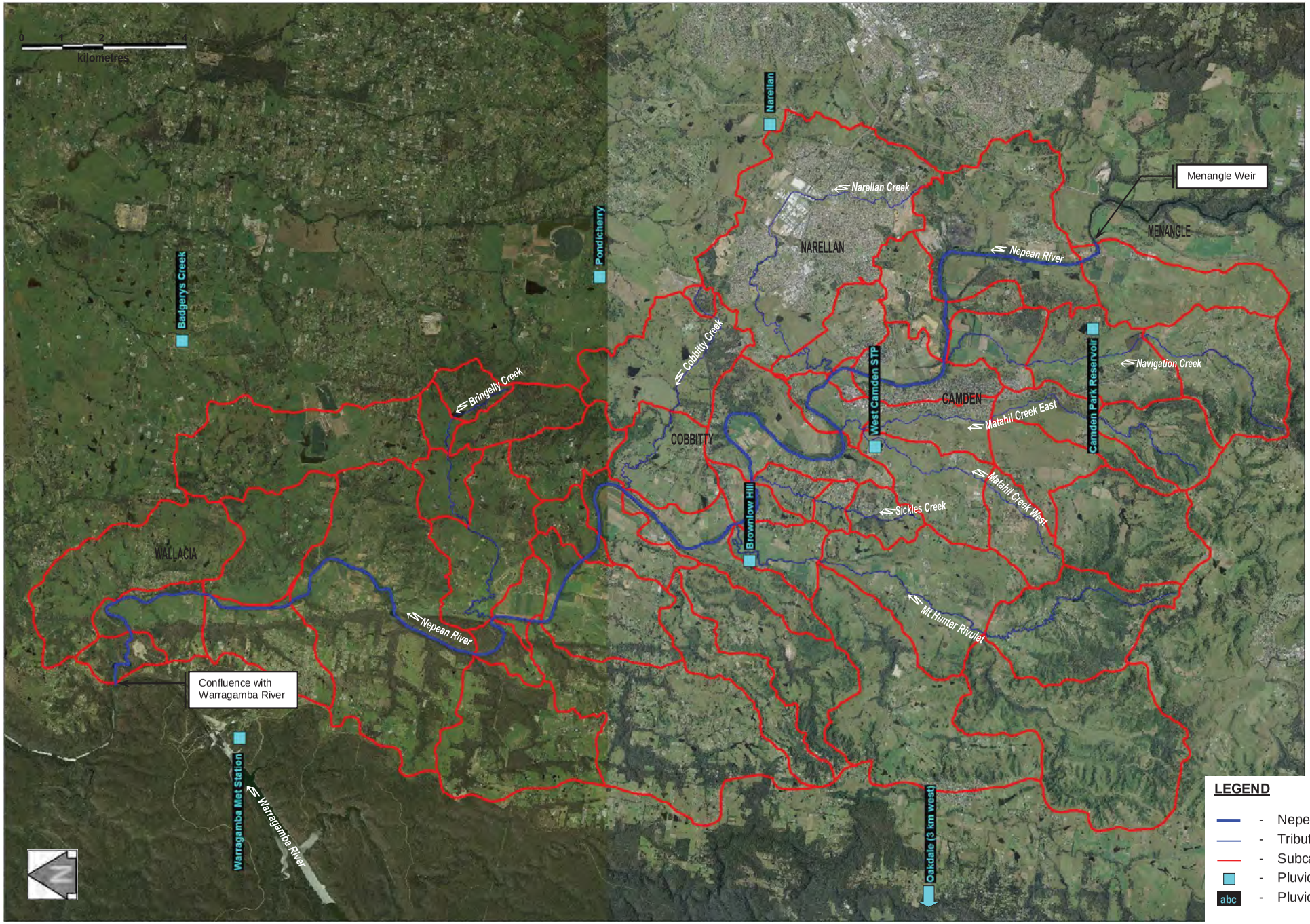


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301015-03107 – Nepean River Flood Study
1.01_fg301015-03107nm140218-Study Area.doc

LOCATION OF STUDY AREA

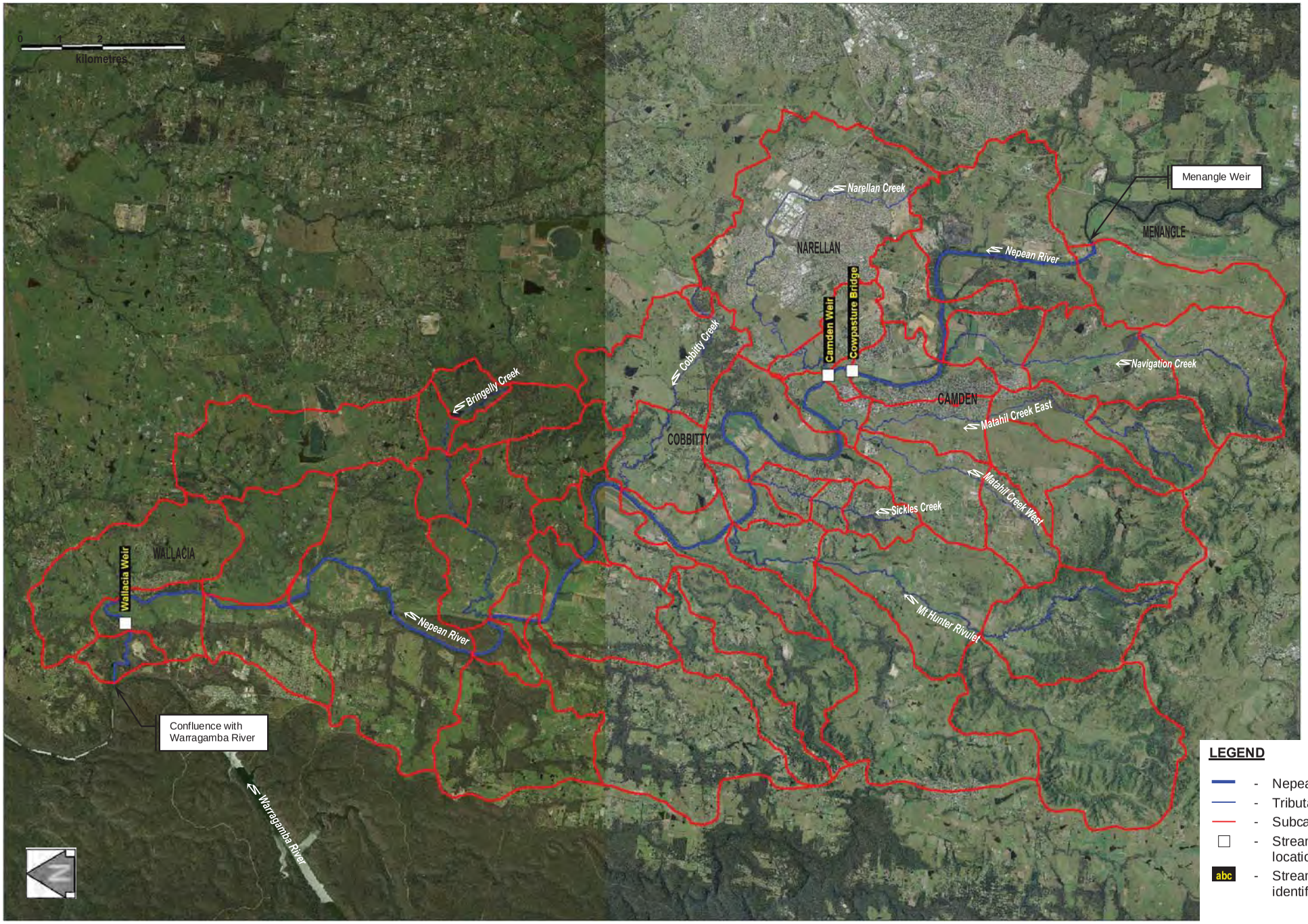
FIGURE 3.1



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LOCATION OF PLUVIOMETER RAINFALL STATIONS USED IN CALIBRATION OF HYDROLOGIC MODEL

FIGURE 3.2

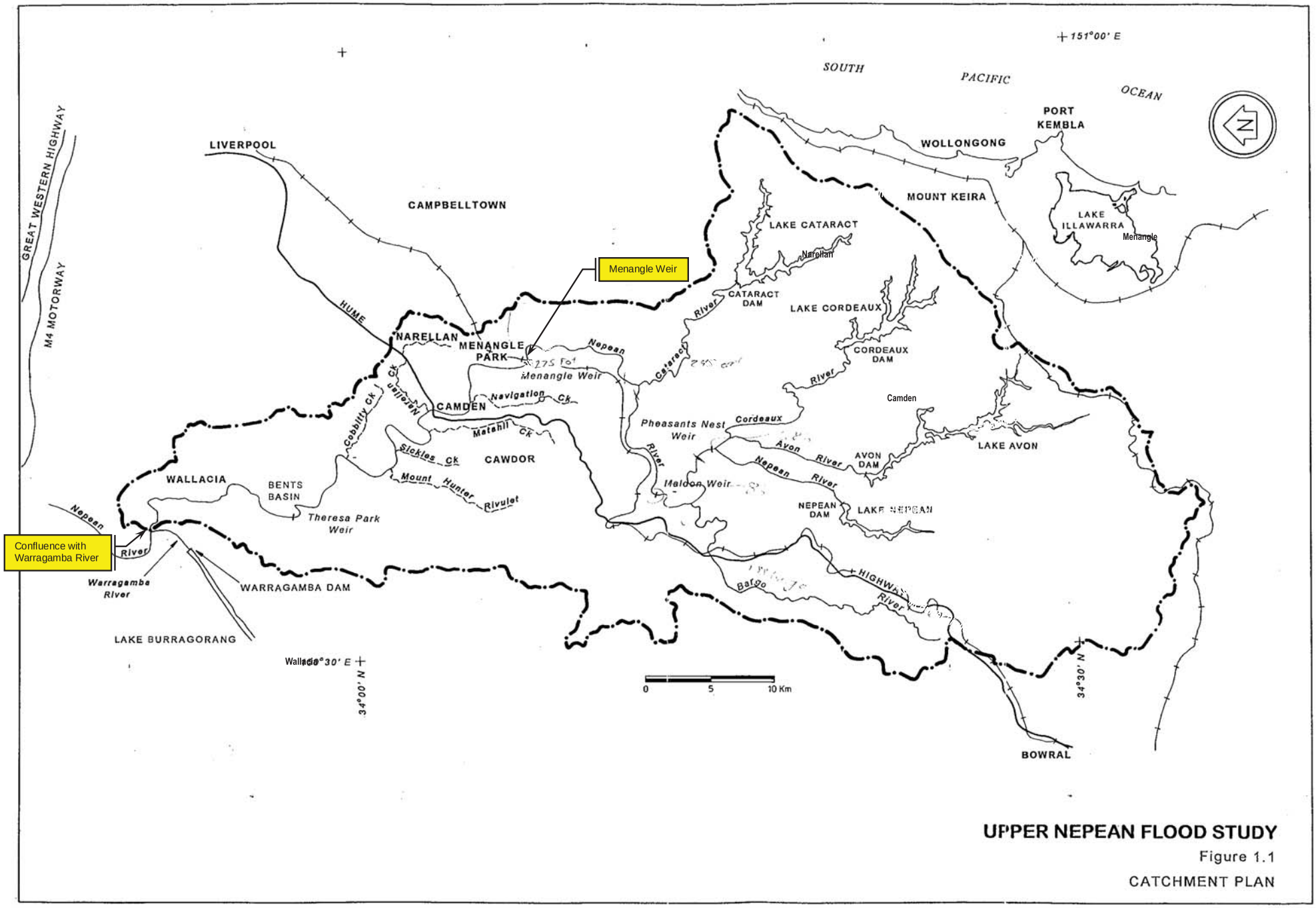


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301015-03107 – Nepean River Flood Study
3.02_fg301015-03107nm140113-Gauging Stations.doc

LOCATION OF STREAMFLOW GAUGING STATIONS

FIGURE 5.1

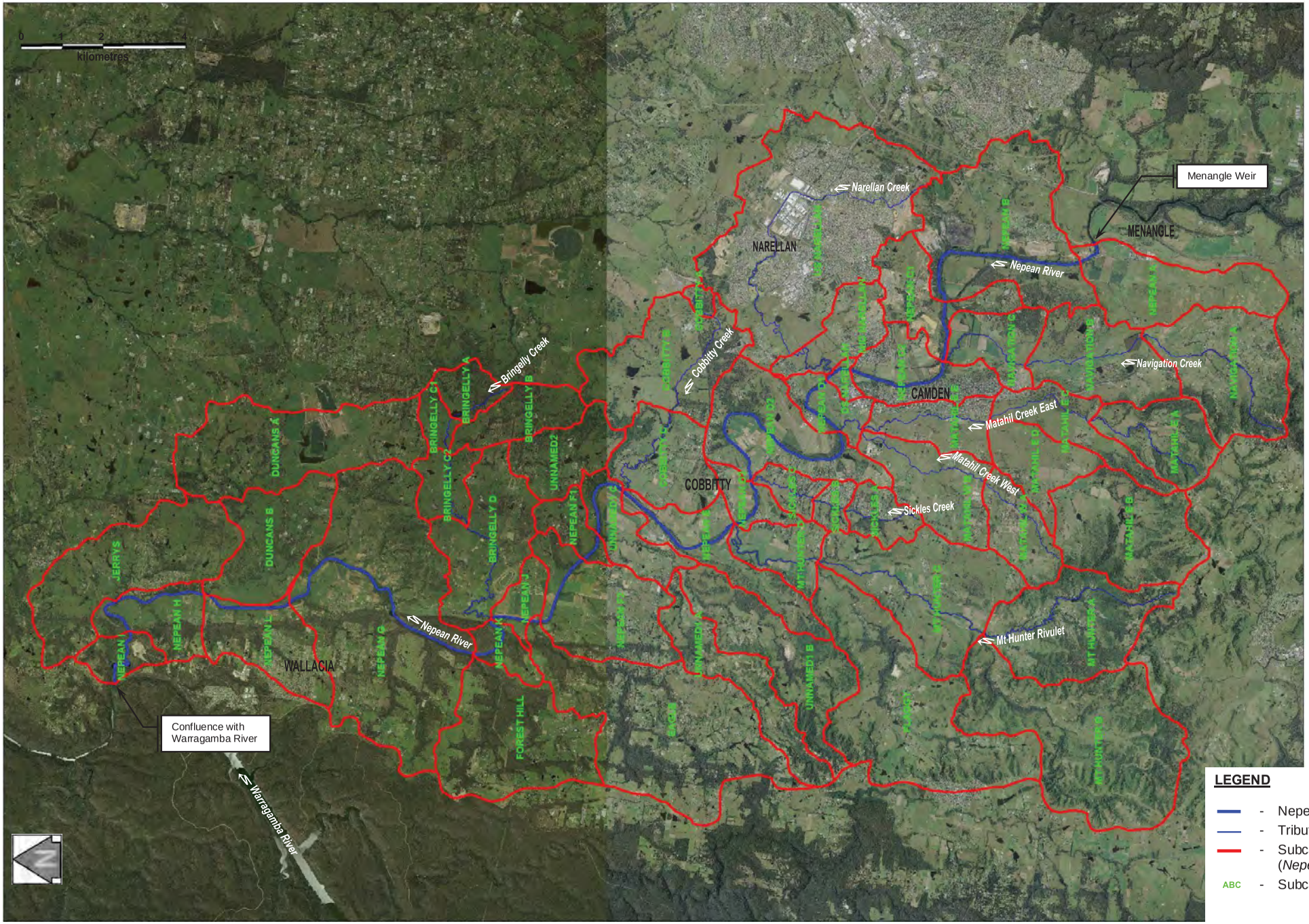


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301015-03107 – Nepean River Flood Study
5.01_fg301015-03107nm140113-RORB Subcatchments.doc

CATCHMENT LAYOUT OF HYDROLOGIC MODEL FROM UPPER NEPEAN RIVER FLOOD STUDY (1995)

FIGURE 5.2

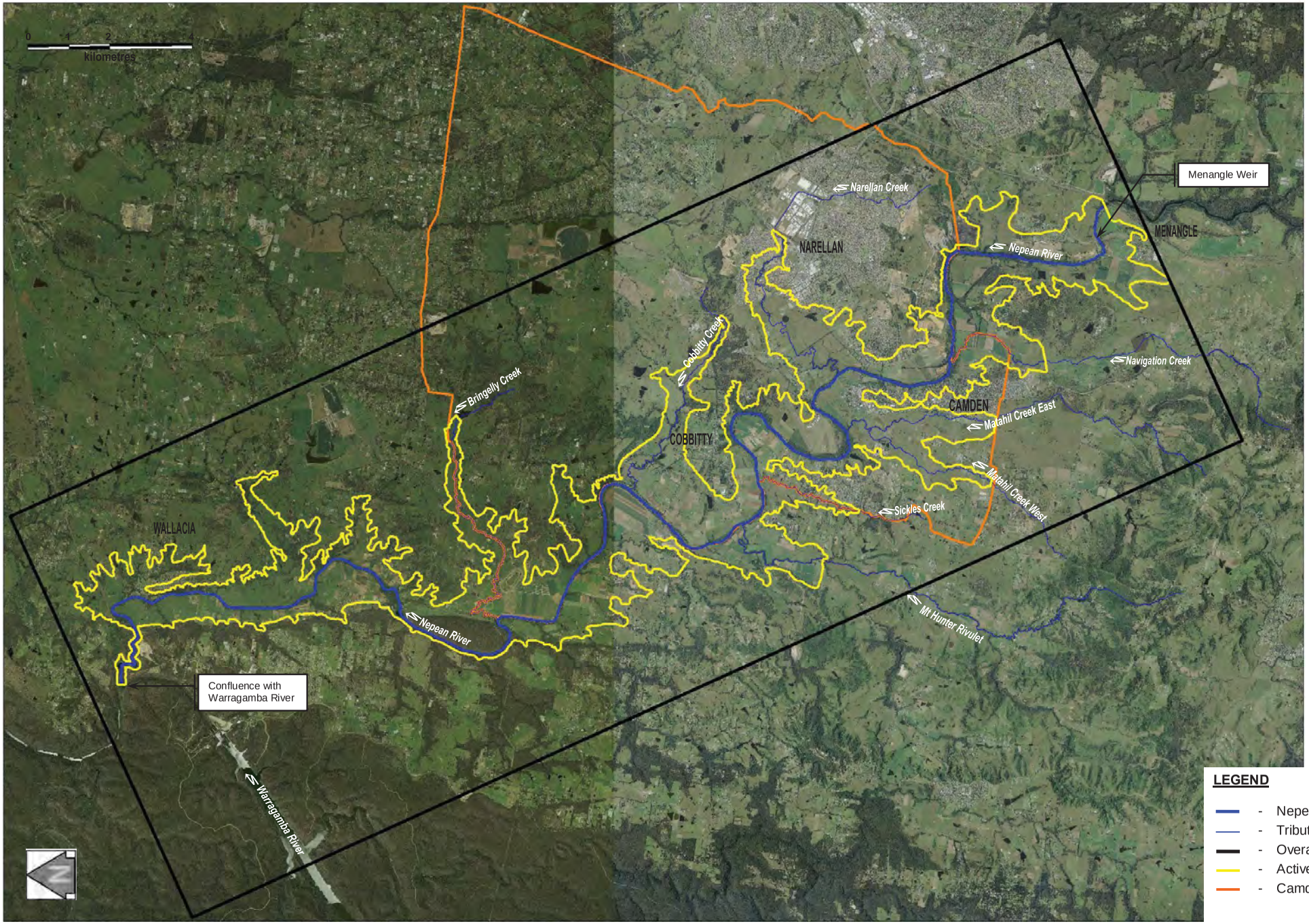


Note: Subcatchments draining to Nepean River upstream from Menangle Weir not shown – modelled previously as part of the Upper Nepean River Flood Study (*1995*). Subcatchments 'US NARELLAN' and 'MID NARELLAN' were modelled separately and in more detail as part of the Narellan Creek Flood Study (*currently undertaken*). The subcatchment outlines shown represent the overall areas of these subcatchments only

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SUBCATCHMENT LAYOUT OF XP-RAFTS HYDROLOGIC MODEL

FIGURE 6.1

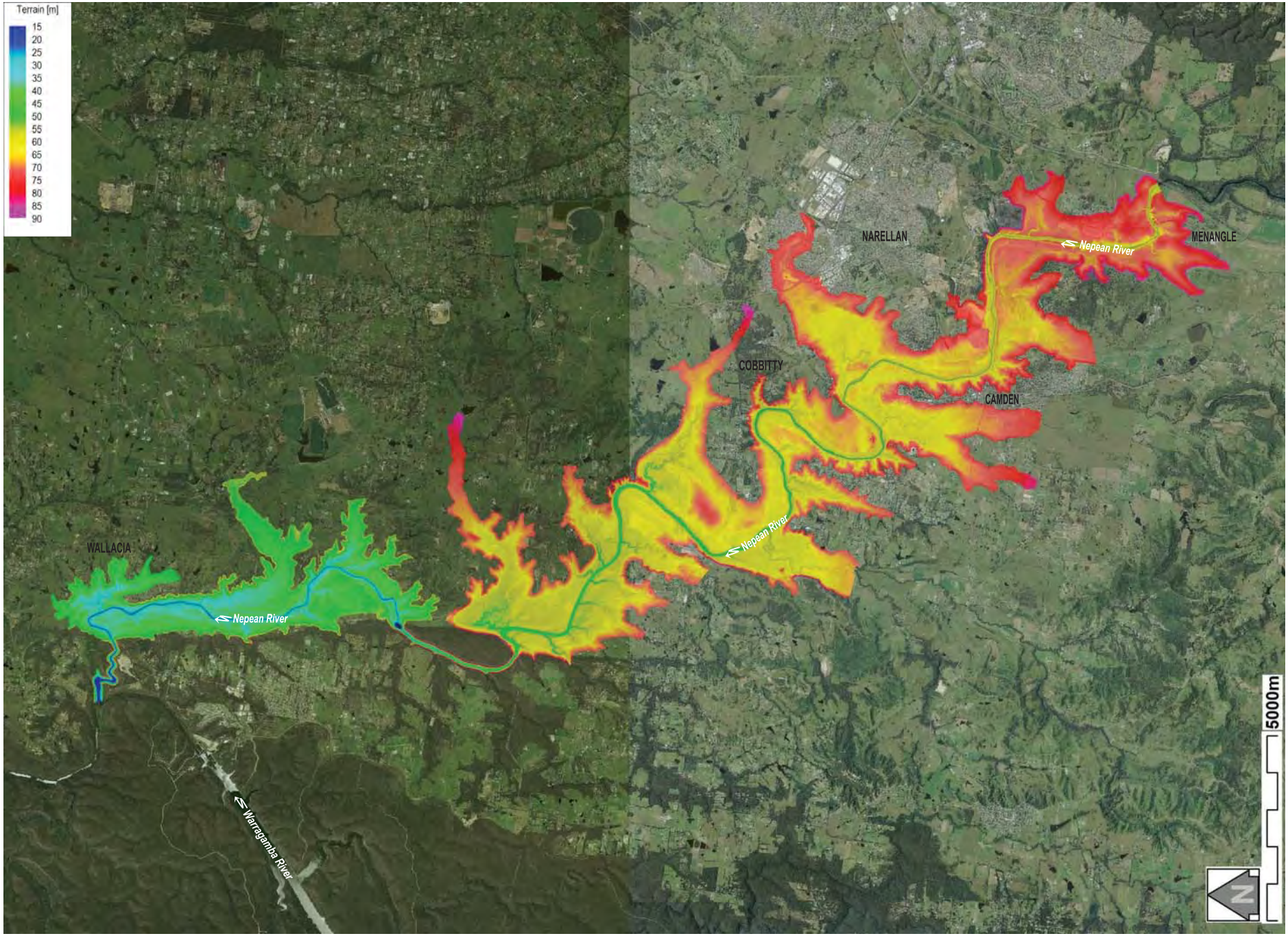


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301015-03107 – Nepean River Flood Study
6.01_fg301015-03107nm140113-TUFLOW Layout.doc

TUFLOW HYDRODYNAMIC MODEL LAYOUT

FIGURE 6.2

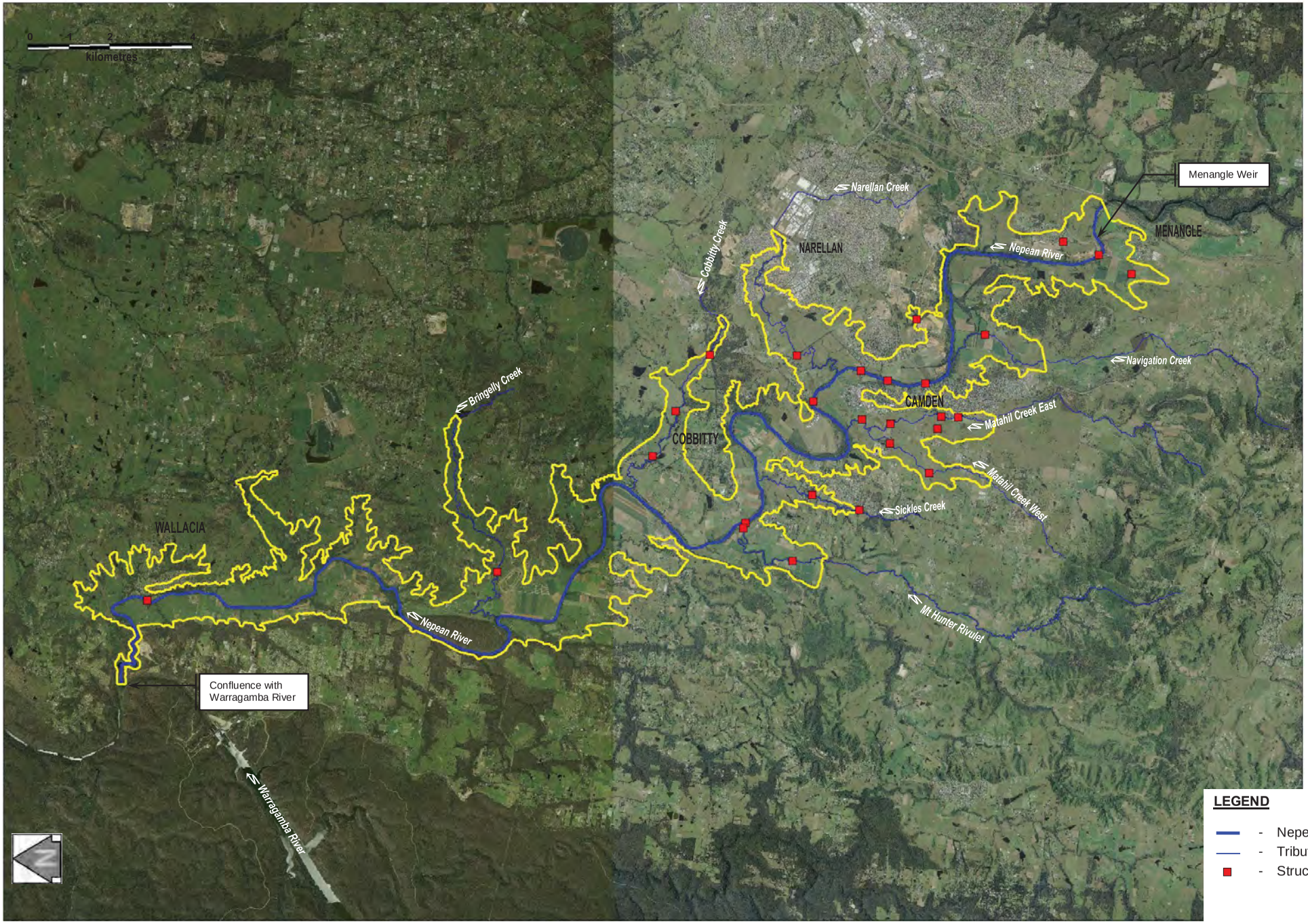


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301015-03107 – Nepean River Flood Study
6.02_fg301015-03107nm140211-TUFLOW Terrain.doc

DIGITAL TERRAIN MODEL (DTM) USED IN TUFLOW HYDRODYNAMIC MODEL

FIGURE 6.3

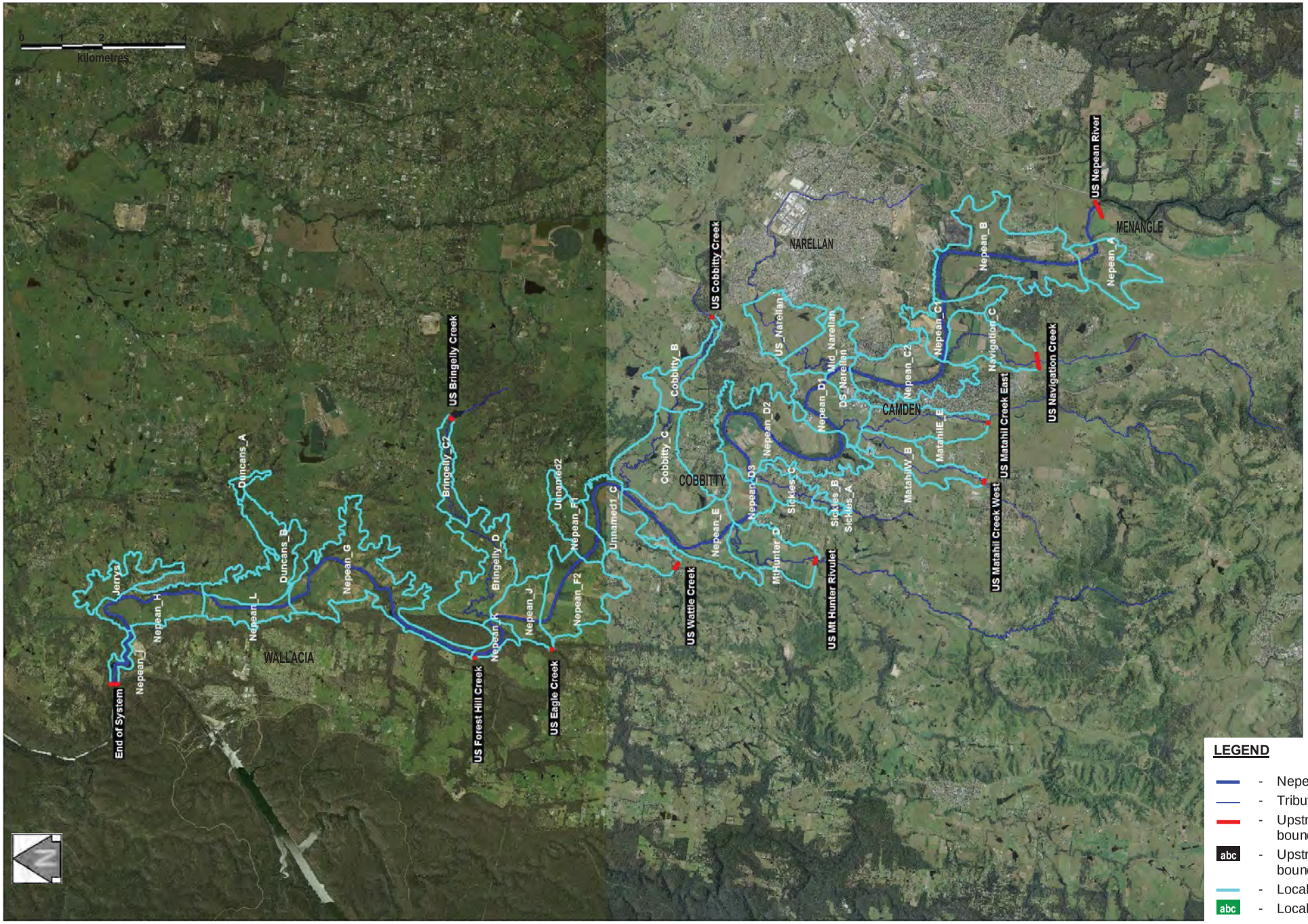


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301015-03107 – Nepean River Flood Study
6.03_fg301015-03107nm140211-TUFLOW Structures.doc

SCHEMATIC REPRESENTATION OF STRUCTURE LOCATIONS FOR TUFLOW HYDRODYNAMIC MODEL

FIGURE 6.4

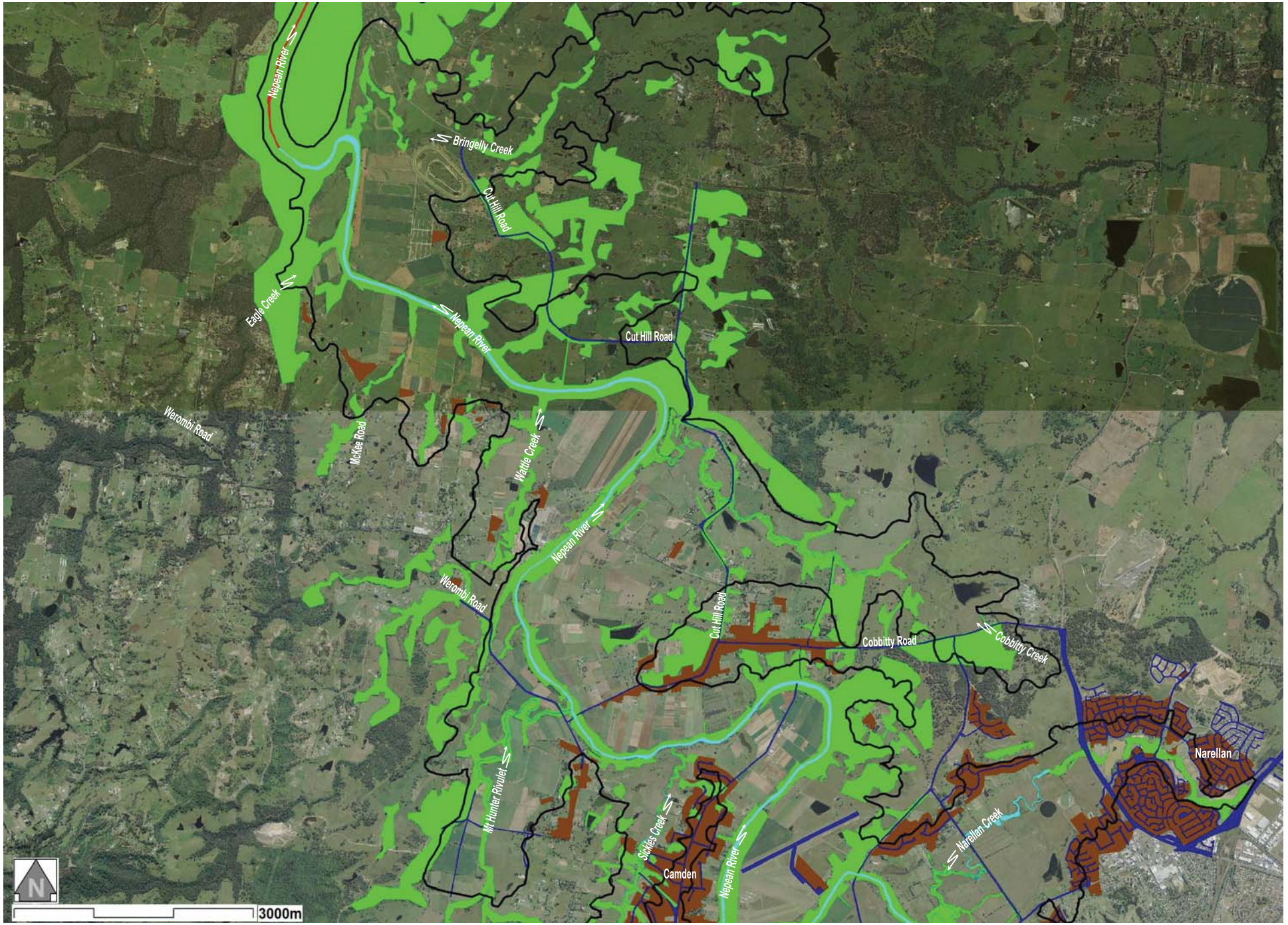


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301015-03107 – Nepean River Flood Study
6.04_fg301015-03107nm140114-TUFLOW Boundaries.doc

SCHEMATIC REPRESENTATION OF BOUNDARY CONDITIONS FOR TUFLOW HYDRODYNAMIC MODEL

FIGURE 6.5



LEGEND:

- Model network outline
- Roads (n=0.02)
- Gorge (n=0.04)
- Watercourses (n=0.04)
- Heavily vegetated watercourses (n=0.06)
- Urban areas (n=0.15)
- Trees (n=0.10)

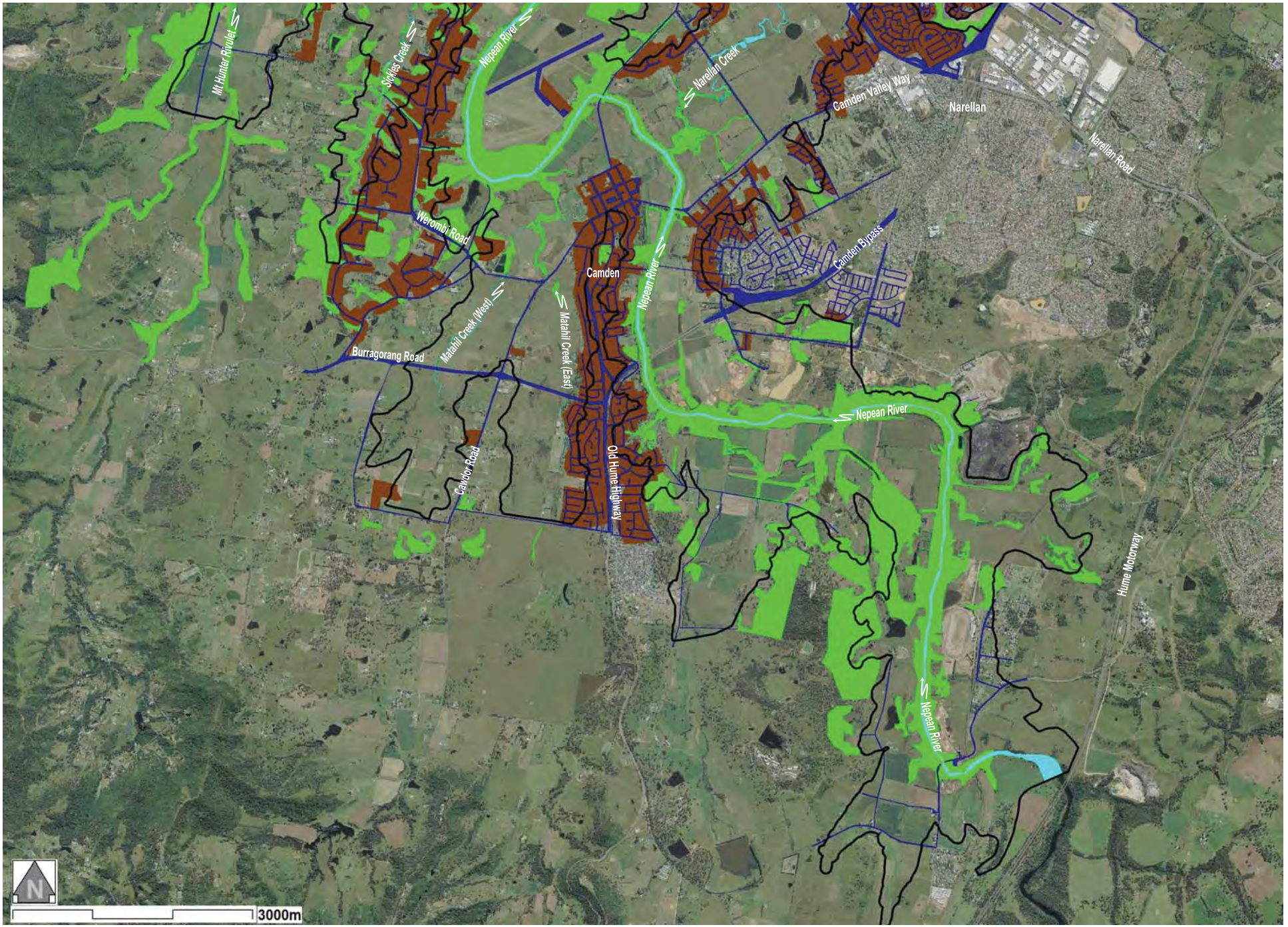
NOTES:

Floodplain areas within model extent but not marked reflect areas defined as Grass/Pasture/Brush (n=0.06)

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DISTRIBUTION OF FLOODPLAIN ROUGHNESS WITHIN TUFLOW MODEL NETWORK (DOWNSTREAM)

FIGURE 6.6



LEGEND:

- Model network outline
- Roads (n=0.02)
- Gorge (n=0.04)
- Watercourses (n=0.04)
- Heavily vegetated watercourses (n=0.06)
- Urban areas (n=0.15)
- Trees (n=0.10)

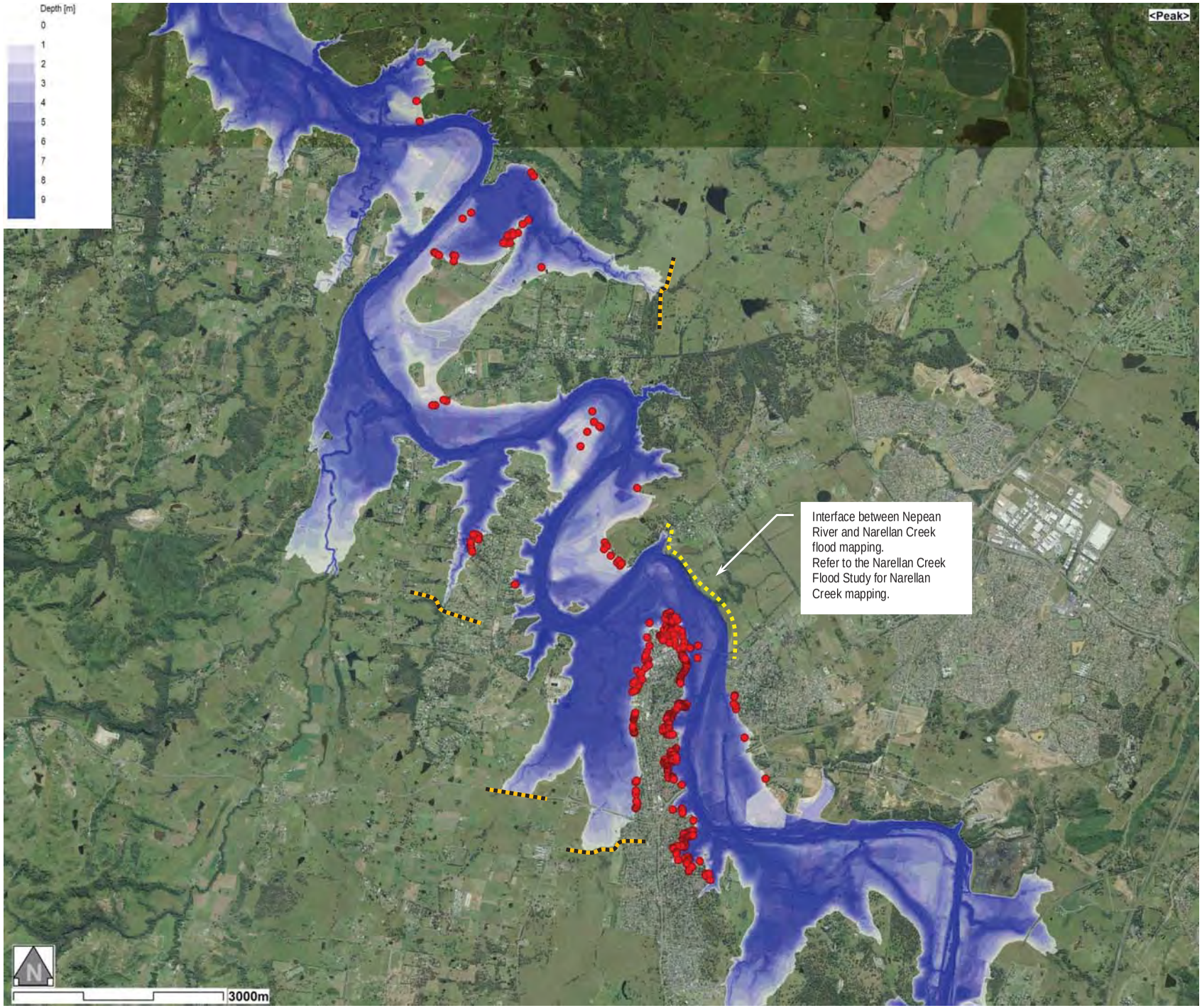
NOTES:

Floodplain areas within model extent but not marked reflect areas defined as Grass/Pasture/Brush (n=0.06)

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DISTRIBUTION OF FLOODPLAIN ROUGHNESS WITHIN TUFLOW MODEL NETWORK (UPSTREAM)

FIGURE 10.1



NOTES:

- Properties shown include those subject to below-floor and over-floor inundation

LEGEND:

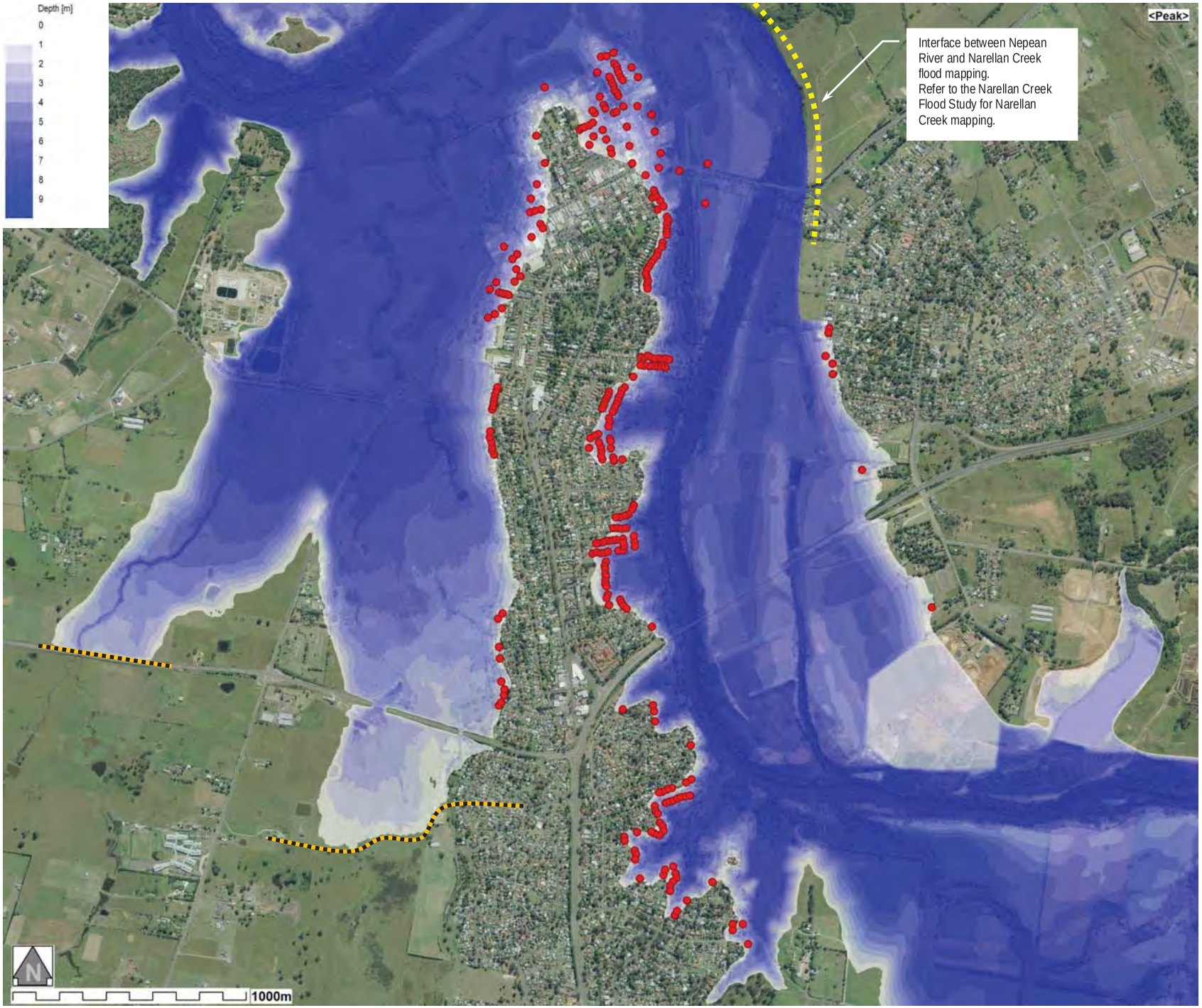
Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
10.1_fg301015-03107eh150326-100yr_Damages_Overview.docx

PROPERTIES SUBJECT TO FLOOD DAMAGE DURING THE 1% AEP EVENT [OVERVIEW]

FIGURE 10.2



NOTES:

- Properties shown include those subject to below-floor and over-floor inundation

LEGEND:

Upstream extent of tributary flood mapping. Local catchment flooding to be investigated in future studies.

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301015-03107 – Nepean River Flood Study (Camden Council)
10.2_fg301015-03107eh150326-100yr_Damages_Zoomed.docx

PROPERTIES SUBJECT TO FLOOD DAMAGE DURING THE 1% AEP EVENT [CAMDEN]

Flood Extents: 1% AEP, 5% AEP and PMF Flood Events. Nepean River Flood Study, March 2015

Legend

- Probable Maximal Flood (PMF), Nepean River Flood Study, 2015
- 1% Annual Exceedance Probability (1% AEP), Nepean River Flood Study. 2015
- 5% Annual Exceedance Probalility (5% AEP), Nepean River Flood Study, 2015
- Probable Maximum Flood (PMF), Tributary Flood Studies 1999.
- 1% Annual Exceedance Propability (1% AEP), Tributary Flood Studies 1999.
- 5% Annual Exceedance Probability (5% AEP), Tributary Flood Studies 1999.
- The hatched areas are currently undergoning development and as such, may be subject to changes
- Limits of Nepean River Flood Mapping in other Tributaries)
- Camden LGA Boundary

NOTES:

1. Nepean River Flood Maps have been prepared by Council's Infrastructure Planning and Land Information sections based on the results provided in Nepean River Flood Study, 2015 and existing Tributary Flood Studies 1999.

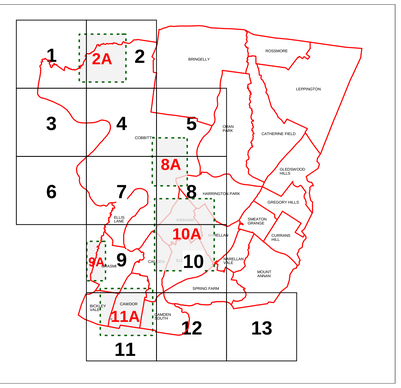
2. Maps 1 to 13 include Flood Extents from Nepean River Flood Study, 2015.

3. Inset Maps 2A, 8A, 9A, 10A and 11A include flood extents (flood lines) of tributaries (excluding Narellan Creek), upsteam of Nepean River backwater limits based on Tributary Flood Studies 1999.

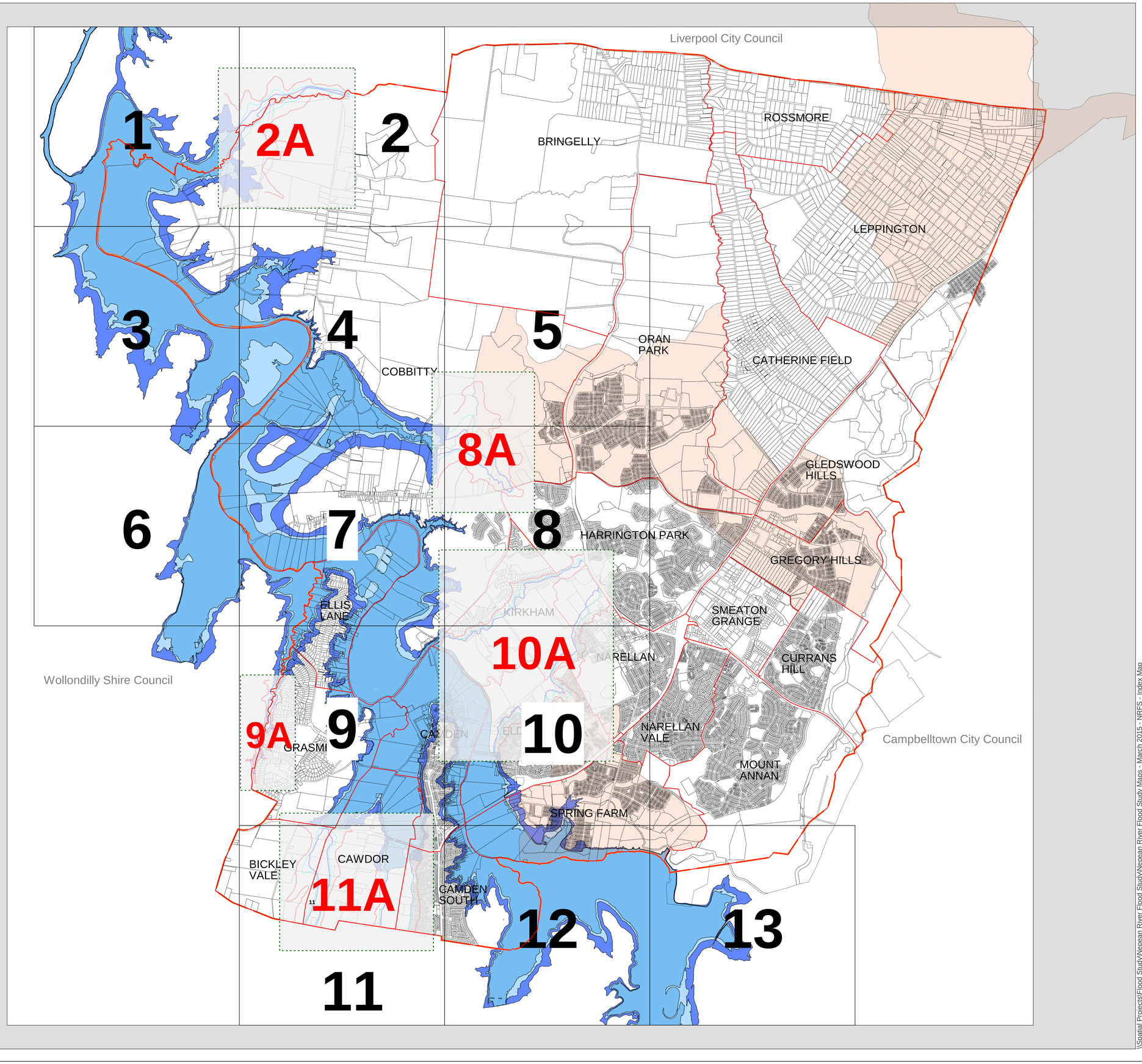
4. The information contained on these maps is to the best of Council's belief, correct. However, no warranty or guarantee is provided by Council and no liability is accepted for any loss or damage resulting from any person relying upon or using the information contained in the map. Flood information and levels are subject to change (without notice) based upon matters such as new or improved flood study data, climate change and changes to the built / natural environments.

5. In accordance with section 733 of the Local Government Act 1993, Council is not liable in respect of any advice furnished in good faith by the Council relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or anything done or omitted to be done in good faith by the Council in so far as relateds to the likelihood of land being flooded or the nature of extent of any such flood.

Index Map



Scale: 1:25000 @A0
Printed Date: 05:08:16



\\Spatial Projects\Flood Study\Nepean River Flood Study\Maps - March 2015 - NRFS - Index Map

Flood Extents: 1% AEP, 5% AEP and PMF Flood Events. Nepean River Flood Study, March 2015

Legend

- Probable Maximal Flood (PMF), Nepean River Flood Study, 2015
- 1% Annual Exceedance Probability (1% AEP), Nepean River Flood Study. 2015
- 5% Annual Exceedance Probalility (5% AEP), Nepean River Flood Study, 2015
- Probable Maximum Flood (PMF), Tributary Flood Studies 1999.
- 1% Annual Exceedance Propability (1% AEP), Tributary Flood Studies 1999.
- 5% Annual Exceedance Probability (5% AEP), Tributary Flood Studies 1999.
- The hatched areas are currently undergoning development and as such, may be subject to changes
- Limits of Nepean River Flood Mapping in other Tributaries (see Note 6)
- Camden LGA Boundary

FLOOD INFORMATION

Information only relevant to this page is provided here.

1. The Flood Mapping (1% AEP, 5% AEP & PMF flood lines) shown in the Inset Maps for Upper Catchment of Sickles, East & West Matahil, Cobbitty and Bringelly Creeks has been prepared by Council Land Information Section, based on the results provided in Flood Study, 1995 and Tributary Flood Studies 1999 (which is currently being used) as this area is outside the limits of Nepean River Flood Study, 2015.

2. The extents of flood inundation indicated by flood lines are approximate only. For greater accuracy, you should obtain a Flood Certificate from Camden Council which will provide flood levels to Australian Height Datum (AHD) and these can be compared to actual site levels.

3. Limits of Nepean River Flood Mapping in tributaries: Flood Mapping upstream of tributaries, beyond Nepean river backwater limits is not provided under Nepean river Flood Study 2015.

4. The flood shown on these plans is for main stream flooding. Overland flow paths are not shown.

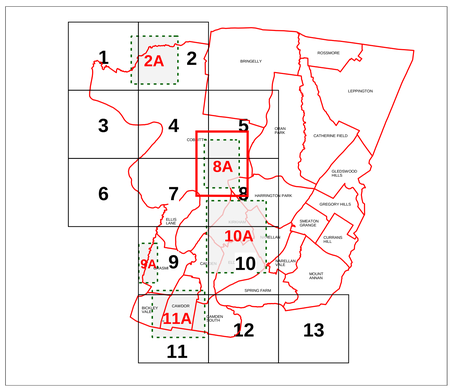
5. Climate change has not been considered in the Nepean River Flood Mapping at this stage. It is expected that existing flood behaviour and levels will change due to the impacts of Climate Change.

6. Limit of Nepean River Flood Mapping: The limit of Nepean River Flood Mapping is up to the confluence of Nepean River and Narellan Creek. Nepean River flood extents (backwater) along Narellan Creek, upstream of this limit of mapping will be provided in Narellan Creek Flood Study.

7. The information contained on these maps is correct to the best of Council's knowlegde. However, no warranty or guarantee is provided by Council and no liability is accepted for any loss or damage resulting from any person relying upon or using the information contained in the map. Flood information and levels are subject to change (without notice) based upon matters such as new or improved flood study data, climate change and changes to the built / natural environments.

8. In accordance with section 733 of the Local Government Act 1993, Council is not liable in respect of any advice furnished in good faith by the Council relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or anything done or omitted to be done in good faith by the Council in so far as relateds to the likelihood of land being flooded or the nature of extent of any such flood.

Inset Map 8A



Scale: 1:5000 @A0
Printed Date: 05:08:16

\\Spatial Projects\Flood Study\Nepean River Flood Study\Maps - March 2015 - Inset Map - 8A

Flood Extents: 1% AEP, 5% AEP and PMF Flood Events. Nepean River Flood Study, March 2015

Legend

- Probable Maximal Flood (PMF)
- 1% Annual Exceedance Probability (1% AEP)
- 5% Annual Exceedance Probability (5% AEP)
- The hatched areas are currently undergoing development and as such, may be subject to changes
- Limit of Nepean River flood Mapping for Narellan Creek (see Note 5)
- Limits of Nepean River Flood Mapping in other Tributaries (see Note 6)
- Camden LGA Boundary

FLOOD INFORMATION

1. This map has been prepared by Council's Land Information Section based on the results provided in Nepean River Flood Study, 2015, Aerial Laser Survey February, 2011 and other survey data.

2. Aerial Laser Survey (Source of Data: LPI - NSW Department of Finance and Services [February 2011], Panorama Avenue, Bathurst 2795: www.lpi.nsw.gov.au) is based on Land and Property Management Authority (LPMA) Standard LIDAR Product Specifications, Version 2.0, July 2010, NSW.

3. The extent of flood inundation is approximate only. For greater accuracy, you should obtain a Flood Certificate from Camden Council which will provide flood levels to Australian Height Datum (AHD) and these can be compared to actual site levels.

4. The flood extents shown in this map are for part of the Nepean River Catchment (including its tributaries up to the limits shown and excluding Narellan Creek) only, and areas that may be subject to flooding but are not part of the Nepean River Catchment are not shown.

5. Limit of Nepean River Flood Mapping: The limit of Nepean River Flood Mapping is up to the confluence of Nepean River and Narellan Creek. Nepean River flood extents (backwater) along Narellan Creek, upstream of this limit of mapping will be provided in Narellan Creek Flood Study.

6. Limits of study of Nepean River Flood Mapping in Tributaries: Flood Mapping is up to Nepean River backwater limits as shown. Flood Mapping upstream of these limits is based on existing Nepean RiverTributary Studies (1999) and as shown in Inset Maps.

7. The flooding shown on these plans is for main stream flooding. Overland flow paths are not shown.

8. Climate Change has not been considered in Nepean River Flood Mapping. It is expected that existing flood behaviour and levels will change due to the impacts of Climate Change.

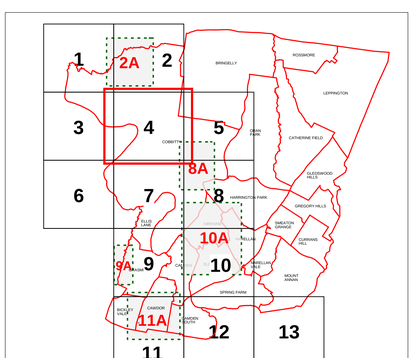
9. Flood Mapping for the entire Nepean River Catchment is to be further refined after completion of Floodplain Risk Management Study & Plan.

10. The hatched areas are currently undergoing development and as such, may be subject to changes.

11. The information contained on these maps is to the best of Council's belief, correct. However, no warranty or guarantee is provided by Council and no liability is accepted for any loss or damage resulting from any person relying upon or using the information contained in the map. Flood information and levels are subject to change (without notice) based upon matters such as new or improved flood study data, climate change and changes to the built / natural environments.

12. In accordance with section 733 of the Local Government Act 1993, Council is not liable in respect of any advice furnished in good faith by the Council relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or anything done or omitted to be done in good faith by the Council in so far as it relates to the likelihood of land being flooded or the nature of extent of any such flooding.

Map 4



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Wollondilly Shire Council

FOR TRIBUTARY FLOOD MAPPING SEE INSET MAP 8A

\\Spatial Projects\Flood Study\Nepean River Flood Study\Maps - March 2015 - Map 4

Flood Extents: 1% AEP, 5% AEP and PMF Flood Events. Nepean River Flood Study, March 2015

Legend

- Probable Maximal Flood (PMF)
- 1% Annual Exceedance Probability (1% AEP)
- 5% Annual Exceedance Probability (5% AEP)
- The hatched areas are currently undergoing development and as such, may be subject to changes
- Limit of Nepean River flood Mapping for Narellan Creek (see Note 5)
- Limits of Nepean River Flood Mapping in other Tributaries (see Note 6)
- Camden LGA Boundary

FLOOD INFORMATION

1. This map has been prepared by Council's Land Information Section based on the results provided in Nepean River Flood Study, 2015, Aerial Laser Survey February, 2011 and other survey data.

2. Aerial Laser Survey (Source of Data: LPI - NSW Department of Finance and Services [February 2011], Panorama Avenue, Bathurst 2795: www.lpi.nsw.gov.au) is based on Land and Property Management Authority (LPMA) Standard LIDAR Product Specifications, Version 2.0, July 2010, NSW.

3. The extent of flood inundation is approximate only. For greater accuracy, you should obtain a Flood Certificate from Camden Council which will provide flood levels to Australian Height Datum (AHD) and these can be compared to actual site levels.

4. The flood extents shown in this map are for part of the Nepean River Catchment (including its tributaries up to the limits shown and excluding Narellan Creek) only, and areas that may be subject to flooding but are not part of the Nepean River Catchment are not shown.

5. Limit of Nepean River Flood Mapping: The limit of Nepean River Flood Mapping is up to the confluence of Nepean River and Narellan Creek. Nepean River flood extents (backwater) along Narellan Creek, upstream of this limit of mapping will be provided in Narellan Creek Flood Study.

6. Limits of study of Nepean River Flood Mapping in Tributaries: Flood Mapping is up to Nepean River backwater limits as shown. Flood Mapping upstream of these limits is based on existing Nepean RiverTributary Studies (1999) and as shown in Inset Maps.

7. The flooding shown on these plans is for main stream flooding. Overland flow paths are not shown.

8. Climate Change has not been considered in Nepean River Flood Mapping. It is expected that existing flood behaviour and levels will change due to the impacts of Climate Change.

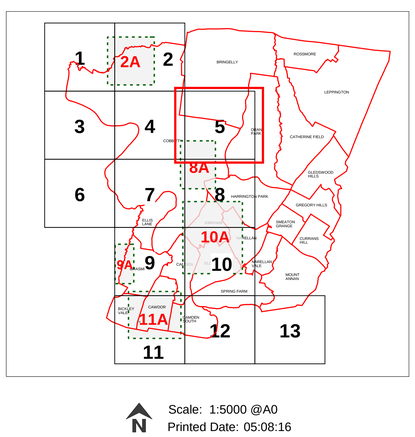
9. Flood Mapping for the entire Nepean River Catchment is to be further refined after completion of Floodplain Risk Management Study & Plan.

10. The hatched areas are currently undergoing development and as such, may be subject to changes.

11. The information contained on these maps is to the best of Council's belief, correct. However, no warranty or guarantee is provided by Council and no liability is accepted for any loss or damage resulting from any person relying upon or using the information contained in the map. Flood information and levels are subject to change (without notice) based upon matters such as new or improved flood study data, climate change and changes to the built / natural environments.

12. In accordance with section 733 of the Local Government Act 1993, Council is not liable in respect of any advice furnished in good faith by the Council relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or anything done or omitted to be done in good faith by the Council in so far as it relates to the likelihood of land being flooded or the nature of extent of any such flooding.

Map 5



Scale: 1:5000 @A0
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FOR TRIBUTARY FLOOD MAPPING SEE INSET 8A

Oran Park Precinct

\Spatial Projects\Flood Study\Nepean River Flood Study\Maps - March 2015 - Map 5

Flood Extents: 1% AEP, 5% AEP and PMF Flood Events. Nepean River Flood Study, March 2015

Legend

- Probable Maximal Flood (PMF)
- 1% Annual Exceedance Probability (1% AEP)
- 5% Annual Exceedance Probability (5% AEP)
- The hatched areas are currently undergoing development and as such, may be subject to changes
- Limit of Nepean River flood Mapping for Narellan Creek (see Note 5)
- Limits of Nepean River Flood Mapping in other Tributaries (see Note 6)
- Camden LGA Boundary

FLOOD INFORMATION

1. This map has been prepared by Council's Land Information Section based on the results provided in Nepean River Flood Study, 2015, Aerial Laser Survey February, 2011 and other survey data.

2. Aerial Laser Survey (Source of Data: LPI - NSW Department of Finance and Services [February 2011], Panorama Avenue, Bathurst 2795: www.lpi.nsw.gov.au) is based on Land and Property Management Authority (LPMA) Standard LIDAR Product Specifications, Version 2.0, July 2010, NSW.

3. The extent of flood inundation is approximate only. For greater accuracy, you should obtain a Flood Certificate from Camden Council which will provide flood levels to Australian Height Datum (AHD) and these can be compared to actual site levels.

4. The flood extents shown in this map are for part of the Nepean River Catchment (including its tributaries up to the limits shown and excluding Narellan Creek) only, and areas that may be subject to flooding but are not part of the Nepean River Catchment are not shown.

5. Limit of Nepean River Flood Mapping: The limit of Nepean River Flood Mapping is up to the confluence of Nepean River and Narellan Creek. Nepean River flood extents (backwater) along Narellan Creek, upstream of this limit of mapping will be provided in Narellan Creek Flood Study.

6. Limits of study of Nepean River Flood Mapping in Tributaries: Flood Mapping is up to Nepean River backwater limits as shown. Flood Mapping upstream of these limits is based on existing Nepean RiverTributary Studies (1999) and as shown in Inset Maps.

7. The flooding shown on these plans is for main stream flooding. Overland flow paths are not shown.

8. Climate Change has not been considered in Nepean River Flood Mapping. It is expected that existing flood behaviour and levels will change due to the impacts of Climate Change.

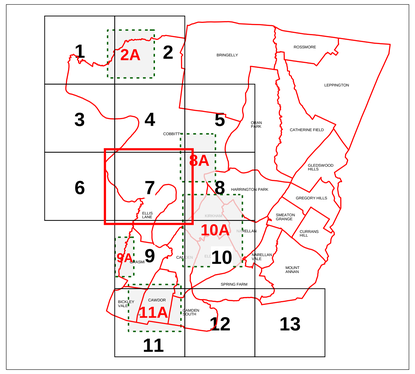
9. Flood Mapping for the entire Nepean River Catchment is to be further refined after completion of Floodplain Risk Management Study & Plan.

10. The hatched areas are currently undergoing development and as such, may be subject to changes.

11. The information contained on these maps is to the best of Council's belief, correct. However, no warranty or guarantee is provided by Council and no liability is accepted for any loss or damage resulting from any person relying upon or using the information contained in the map. Flood information and levels are subject to change (without notice) based upon matters such as new or improved flood study data, climate change and changes to the built / natural environments.

12. In accordance with section 733 of the Local Government Act 1993, Council is not liable in respect of any advice furnished in good faith by the Council relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or anything done or omitted to be done in good faith by the Council in so far as it relates to the likelihood of land being flooded or the nature of extent of any such flooding.

Map 7



Scale: 1:5000 @A0
Printed Date: 05:08:16

Flood Extents: 1% AEP, 5% AEP and PMF Flood Events. Nepean River Flood Study, March 2015

Legend

- Probable Maximal Flood (PMF)
- 1% Annual Exceedance Probability (1% AEP)
- 5% Annual Exceedance Probability (5% AEP)
- The hatched areas are currently undergoing development and as such, may be subject to changes
- Limit of Nepean River flood Mapping for Narellan Creek (see Note 5)
- Limits of Nepean River Flood Mapping in other Tributaries (see Note 6)
- Camden LGA Boundary

FLOOD INFORMATION

1. This map has been prepared by Council's Land Information Section based on the results provided in Nepean River Flood Study, 2015, Aerial Laser Survey February, 2011 and other survey data.

2. Aerial Laser Survey (Source of Data: LPI - NSW Department of Finance and Services [February 2011], Panorama Avenue, Bathurst 2795: www.lpi.nsw.gov.au) is based on Land and Property Management Authority (LPMA) Standard LiDAR Product Specifications, Version 2.0, July 2010, NSW.

3. The extent of flood inundation is approximate only. For greater accuracy, you should obtain a Flood Certificate from Camden Council which will provide flood levels to Australian Height Datum (AHD) and these can be compared to actual site levels.

4. The flood extents shown in this map are for part of the Nepean River Catchment (including its tributaries up to the limits shown and excluding Narellan Creek) only, and areas that may be subject to flooding but are not part of the Nepean River Catchment are not shown.

5. Limit of Nepean River Flood Mapping: The limit of Nepean River Flood Mapping is up to the confluence of Nepean River and Narellan Creek. Nepean River flood extents (backwater) along Narellan Creek, upstream of this limit of mapping will be provided in Narellan Creek Flood Study.

6. Limits of study of Nepean River Flood Mapping in Tributaries: Flood Mapping is up to Nepean River backwater limits as shown. Flood Mapping upstream of these limits is based on existing Nepean RiverTributary Studies (1999) and as shown in Inset Maps.

7. The flooding shown on these plans is for main stream flooding. Overland flow paths are not shown.

8. Climate Change has not been considered in Nepean River Flood Mapping. It is expected that existing flood behaviour and levels will change due to the impacts of Climate Change.

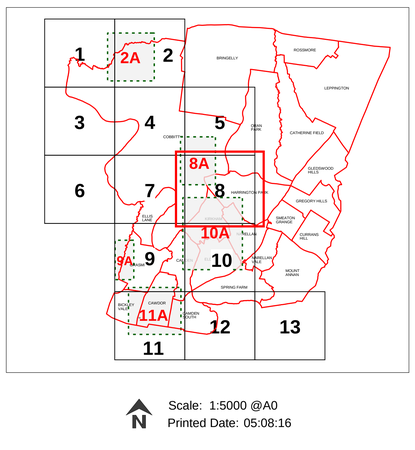
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Map 8



Scale: 1:5000 @A0
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FOR TRIBUTARY FLOOD MAPPING SEE INSET 8A

FOR TRIBUTARY FLOOD MAPPING SEE INSET 10A

Oran Park Precinct

\\Spatial Projects\Flood Study\Nepean River Flood Study\Nepean River Flood Study Maps - March 2015 - Map - 8

Appendix F – Basin Location Sketch



Issue	Description	Date
P2	ISSUED FOR INFORMATION	08-04-20
P1	ISSUED FOR INFORMATION	02-03-20

100mm on Original

Bar Scales

0 1000 2000 3000 4000 5000m

1 : 50000

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Client

Scales	1:5000 @ A1
Grid	MGA
Height Datum	AHD
Drawn	PC
Designed	PC
Checked	AT
Approved	AT

Project

RESIDENTIAL SUBDIVISION
160-360 CHITTICK LANE
COBBITTY

Title

PROPOSED BASINS AND LOCATIONS

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Status
PRELIMINARY ONLY
NOT TO USED FOR CONSTRUCTION

A1

Project - Drawing No.
20-717-SKC018

Issue
P2

F:\20-717 Chittick Lane Cobbitty\6.0 Drgs\Civil\Sketches\20-717-SKC018.dwg

Appendix G – East Leppington Precinct

Department of Planning and Infrastructure

19 June 2013

East Leppington Precinct - Infrastructure Delivery Plan



East Leppington Precinct - Infrastructure Delivery Plan

Prepared for

Department of Planning and Infrastructure

Prepared by

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19 June 2013

60264853

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Quality Information

Document East Leppington Precinct - Infrastructure Delivery Plan

Ref 60264853

Date 19 June 2013

Prepared by Katrie Lowe/Robbie Williams

Reviewed by John McDermott

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
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B	07-Jun-2012	For Review	Roger Swinbourne Associate Director	
C	08-Jun-2012	For Review	Roger Swinbourne Associate Director	
D	16-July-2012	Final	Roger Swinbourne Associate Director	
E	29-Nov-2012	Final	Roger Swinbourne Associate Director	
F	18-Dec-2012	Final	Roger Swinbourne Associate Director	
G	18-Jan-2013	Final	Roger Swinbourne Associate Director	
H	11-Jun-2013	For Council Review	Roger Swinbourne Associate Director	
I	19-Jun-2013	Final – Updated with Council comments	Roger Swinbourne Associate Director	

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Executive Summary

Each of the primary utility suppliers has identified interim and ultimate infrastructure strategies for providing utility services to the East Leppington Precinct.

The key service infrastructure delivery program items are as follows:

- Sydney Water has committed to funding the water infrastructure for servicing the Precinct with potable water and has made a preliminary commitment to deliver ultimate water infrastructure for the precinct by mid-2015. The initial infrastructure works will have capacity to serve a small number of lots and servicing of development exceeding this will be dependent on the delivery of subsequent Sydney Water infrastructure packages.
- Interim sewer servicing arrangements have been identified by Sydney Water in the form of a pump-out system. This interim measure will be employed until such time as the ultimate servicing scheme is rolled out by Sydney Water. Sydney Water has made a preliminary commitment to deliver ultimate wastewater infrastructure for the precinct by mid-2015.
- Electricity supply will require the delivery of a dedicated 132kV zone substation. It is understood that Endeavour Energy has already commenced planning of upgrade works to supply the Precinct and the required infrastructure (as described in Section 1.4) is scheduled for delivery in mid-2014.
- Jemena has committed to supply the proposed development within the precinct, however has not yet concluded whether they will commit full funding or request contributions from developers. This decision will be based on a business case assessment of the required works and commitment from the developers.
- Service reticulation will require installation of infrastructure in proposed road alignments that are planned for construction in later development stages. This should be considered in the delivery of service infrastructure for Phase 1 and Phase 8.
- Trunk infrastructure will generally be provided by the primary utility suppliers, and the majority of secondary infrastructure will be delivered by developers.

1.0 Introduction

The Department of Planning and Infrastructure (DP&I) has engaged AECOM to prepare an Infrastructure Delivery Plan (IDP) for the East Leppington Precinct in Sydney's South West Growth Centre.

This Infrastructure Delivery Plan (IDP) is a summary of the infrastructure requirements for the East Leppington Precinct that have been previously identified through a number of specialised reports and reviews the mechanisms for planning, delivering and funding those requirements. Other purposes of the IDP are as follows:

- Provide an information source for infrastructure providers and encourage the coordination of infrastructure provision between providers.
- Provide a basis for both ongoing discussion between the Department of Planning and Infrastructure and the infrastructure agencies, and for the refinement and iteration of infrastructure delivery plans of those agencies.
- Discuss the funding, planning and delivery issues affecting infrastructure roll-out.
- Consider the relationship between projected staging of development and planned infrastructure provision.
- Define responsibilities for the provision of infrastructure.
- Provide a basis for efficient allocation of resources towards infrastructure that is to meet the Precinct's development demands.
- Inform land owners, developers, the community and other stakeholders about the Precinct's infrastructure imperatives, development sequencing issues, and the role that land owners must play in enabling development to occur.

Infrastructure assessed as part of the IDP comprises:

- Services infrastructure;
- Transport infrastructure;
- Water cycle management infrastructure; and
- Social infrastructure and open space

As part of the precinct planning process, a number of technical studies of the infrastructure requirements and servicing strategies required to support the proposed development within the East Leppington Precinct have been undertaken. These studies have formed the basis of the infrastructure requirements documented in this IDP and include:

- Transport Assessment (Cardno, May 2013);
- Water Cycle Management Report (Cardno, May 2013);
- Social Infrastructure and Open Space Assessment (Elton Consulting, May 2012) and Letter – Open Space: East Leppington Precinct (Elton Consulting 14 May 2013); and
- Utility Servicing Strategy (Cardno July 2012)

Advice regarding the provision of utility infrastructure for the Precinct has been drawn from letters from the relevant utility provider, provided as part of the Utility Servicing Strategy (Cardno July 2012), and advice from DP&I arising through liaison/consultation with infrastructure agencies including RMS during the precinct planning process. The letters referred to are dated as follows:

- Sydney Water, 21 October 2011
- Endeavour Energy, no date provided
- NBN Co Limited, 14 December 2011
- Jemena Gas Networks, 25 November 2011

The IDP considers two key stages in the delivery of enabling infrastructure:

- An interim servicing strategy to ensure essential infrastructure is available for early stages of development; and
- The ultimate or long term servicing strategy, which requires major investment in large scale infrastructure to ensure services are available across the whole of the South West Growth Centre Precincts.

1.1 Background to Infrastructure Provision

The *Metropolitan Plan for Sydney 2036* (NSW Government 2010) defines infrastructure as follows:

> *Infrastructure comprises the physical assets required to satisfy the public's need for access to major economic and social facilities and services.*

This has been translated into the recently release a *Draft Metropolitan Strategy for Sydney 2031* (NSW Government 2013) into the provision of 'economic infrastructure', 'green infrastructure' and 'social infrastructure'.

For the purposes of this IDP, the following infrastructure categories are considered:

- Services infrastructure
  - Water related headworks, treatment and reticulation facilities
  - Sewage servicing, treatment and reticulation facilities
  - Electricity generation and reticulation
  - Natural gas distribution
  - Telecommunications
- Transport infrastructure
  - Roads
  - Railways
- Water cycle management infrastructure
  - Stormwater drainage infrastructure
  - Flood management works
  - Water quality management facilities
- Social infrastructure and open space
  - Schools and other education facilities
  - Hospitals, clinics and other health facilities
  - Recreational and sporting facilities
  - Arts and cultural facilities, entertainment venues
  - Law and order facilities
  - Cemeteries

The *Draft Metropolitan Strategy for Sydney 2031* establishes a need for around 427,000 new homes in South-West Subregion of Sydney, to which the 4,400 dwellings proposed for the East Leppington Precinct will contribute.

New residential development makes additional demands on infrastructure, requiring new or upgraded roads, services, public transport, health and community facilities and parks. Utility providers, State Government agencies, Councils and the developers of greenfield areas each will have a role in delivering the necessary infrastructure that will sustain these new communities.

1.2 East Leppington Precinct

The whole East Leppington Precinct comprises an area of approximately 463 hectares located within three Local Government Areas: Liverpool, Campbelltown and Camden. This Infrastructure Development Plan (IDP) considers the entire East Leppington Precinct. This IDP has been written to reflect the latest information for the Campbelltown and Camden LGAs, which has previously been addressed in a separate IDP. It also provides information on the updated ILP for Liverpool soon to be placed on public exhibition.

The current Indicative Layout Plan (ILP) for the Precinct proposes approximately 4,400 residential dwellings to provide housing for around 14,800 people, with accompanying retail, open space, community and educational land uses.

East Leppington Precinct is located approximately equidistant between Liverpool city centre, 15 kms to the north east and Campbelltown city centre, 15 km to the south. The location of the East Leppington Precinct within the South West Growth Centre is presented in Figure 1.

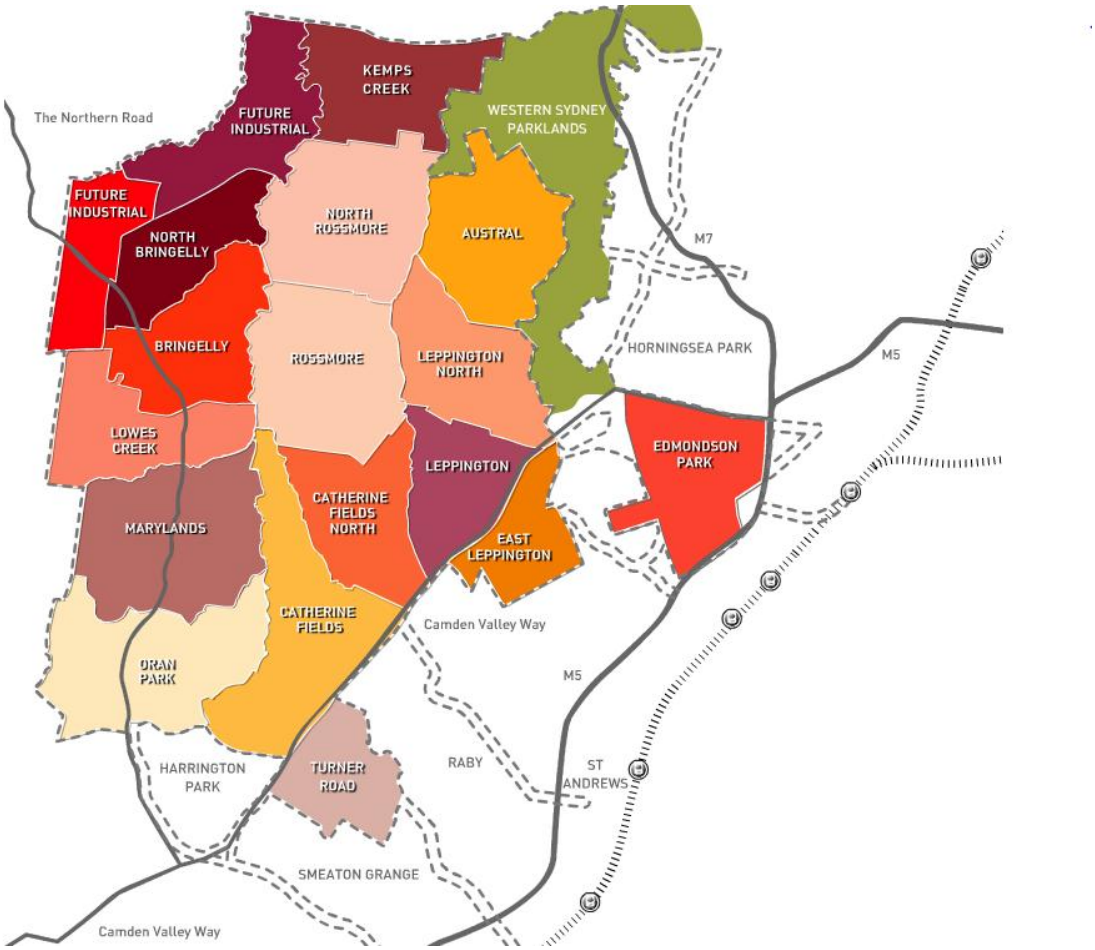


Figure 1 South West Growth Centre Precinct Layout

Approximately three quarters of the Precinct is currently owned by one major landowner, and comprises rural uses. The remainder consists of smaller rural enterprises, rural residential properties, market gardens, bushland and other rural holdings.

The Precinct is traversed by several large existing infrastructure corridors which run broadly parallel to Camden Valley Way, including:

- The Sydney Water Upper Supply Channel;
- Two underground gas pipelines (Eastern Gas Pipeline and Moomba Sydney Gas Pipeline);
- Electricity transmission lines; and
- The Bonds Creek system.

The latest East Leppington Precinct Indicative Layout Plan (ILP) is presented as Figure 2.

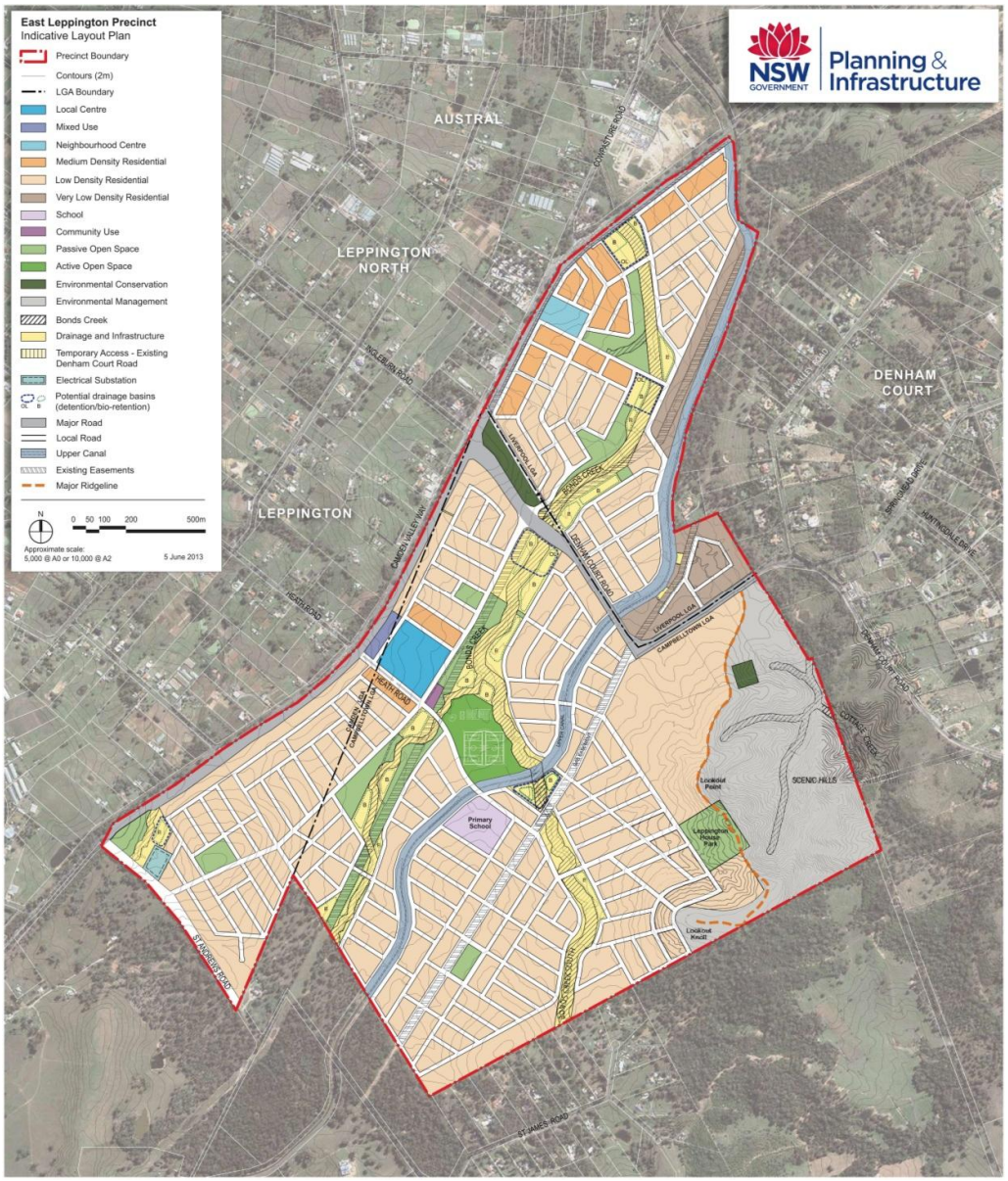


Figure 2 East Leppington Precinct ILP

1.3 Growth Centres Development Code

Service infrastructure provision to the East Leppington Precinct will need to comply with the Growth Centres Development Code (GCDC) (Department of Planning, 2006). This document requires the following to be considered in the provision of services infrastructure to the Growth Centre Precincts:

- Existing main/trunk service layouts;
- Typical street sections demonstrating allocation of essential services and other verge components; and
- Capability and requirements for sufficiently servicing land consistent with GCDC Development Parameters.

The objectives from the GCDC have been considered in this Infrastructure Services Assessment. The relevant objectives are:

- Facilitate the provision of infrastructure necessary to serve future communities;
- Locate utility services appropriately;
- Locate services to be as visually unobtrusive as possible;
- Share services trenching wherever possible;
- Provide footpaths capable of accommodating the necessary services;
- Use of underground electrical reticulation in the Precinct; and
- Provide opportunities for services that allow for flexibility in street design and minimise maintenance costs wherever possible.

1.4 East Leppington Infrastructure Context

Existing infrastructure and essential services within the East Leppington Precinct is consistent with the current predominantly rural land use. As such, there is limited existing infrastructure available in the Precinct to facilitate the proposed new urban development.

Liaison with the relevant authorities suggests that the critical infrastructure such as water, sewer and electricity can be provided to the early stages of development. However, there will need to be commitments to further and substantial investment in the short, medium and long term to serve the ultimate development infrastructure demands.

Infrastructure providers typically allocate resources for infrastructure delivery on the principles of efficiency, value for money and return on investment. This applies to the range of infrastructure delivery authorities, including private infrastructure companies (such as Jemena), State Owned Corporations (SOCs) (such as Sydney Water) or other government authorities (such as the Roads and Maritime Services). Private sector and SOCs in particular, seek to make investment in areas that will provide the greatest return and are therefore reluctant to invest in an area unless there is evidence of future returns based on strong and steady development.

Considering the extent of additional infrastructure to be delivered to the East Leppington Precinct, there needs to be willingness and cooperation between agencies, landowners and developers for the development to proceed in an orderly and economic way. This will require a joint approach and communication and understanding of the issues which are touched upon in this Infrastructure Delivery Plan.

This IDP collates information from existing background studies for the East Leppington Precinct, each of these contain detail appropriate to the current stage of planning. Initial advice from key infrastructure agencies regarding the infrastructure needs of the Precincts has been provided, however this will be developed and modified through future design development.

The conclusion reached in this report is that servicing of the East Leppington Precinct can be achieved providing that a number of clear steps and processes are followed so that infrastructure is delivered in an orderly and cost efficient manner.

2.0 Overview of Infrastructure Delivery

This Section of the IDP provides an overview of how infrastructure is typically delivered by both State and local government for greenfield development areas in Sydney, and considers how this may apply to the East Leppington Precinct.

2.1 State Infrastructure

The NSW State Government is committed to the timely and efficient provision of utility, transport, community, recreation and communications infrastructure for developing 'greenfield' urban release areas, which includes the East Leppington Precinct. The Metropolitan Development Program (or MDP) is the Government's key program for managing land supply and assisting infrastructure coordination. The MDP is the main mechanism used to match rezoning of land to the timing and sequencing of new and upgraded urban infrastructure, and to inform infrastructure agencies in planning their budget programs for future infrastructure works. In turn, infrastructure agencies have a major input into the Government's decisions on land release and when release areas are included on the land release program.

The Government will meet the growing needs of the community through a wide range of measures including provision of essential new infrastructure, using existing assets more productively and ensuring regulatory settings do not discourage private investment in infrastructure.

The State's infrastructure investment program is guided by the State Plan, the State Infrastructure Strategy and the Budget Papers. The program recognises the need to deliver infrastructure in a way that is fiscally sustainable.

Infrastructure NSW will be responsible for directing and overseeing the delivery of the 20-year State Infrastructure Strategy for New South Wales, along with detailed five-year infrastructure plans which set out the details of projects and sequencing and funding arrangements in the NSW Budget from year to year for the delivery of those projects consistent with the 20-year strategy.

State Government delivers major facilitating infrastructure to service new release areas including:

- Arterial roads and motorways;
- Rail infrastructure;
- Health infrastructure;
- Education; and
- Law and order facilities.

The infrastructure identified in this IDP is in addition to the State Government's current program of major infrastructure that will serve the South West Growth Centre. Projects which are in the planning stage or are currently underway, of benefit to the South West Growth Centre, include the following:

- Major redevelopment of Liverpool Hospital
- South West Rail Link - Glenfield to the new Leppington Major Centre (to be completed by 2016)
- Glenfield rail junction upgrade and Glenfield railway station commuter car park
- Kingsgrove to Revesby rail quadruplication
- Widening of Camden Valley Way from Bernera Road, Prestons to Cowpasture Road, Edmondson Park
- Planning and pre-construction works for the widening of Camden Valley Way from Cowpasture Road, Edmondson Park to Cobbitty Road, Harrington Park
- Widening of Hoxton Park Road between Banks Road and Cowpasture Road, Hoxton Park
- Widening the F5 Freeway between Ingleburn and Campbelltown, jointly funded with the Australian Government
- M5 widening, Camden Valley Way, Prestons to King Georges Road, Beverly Hills

2.1.1 Infrastructure Agency Funding

Infrastructure Agency Funding is a means of funding State Services – Gas and Electricity, Water Supply and Sewerage and Education.

The Government's infrastructure funding decisions take place within a budgetary framework that responds to types of services provided by its agencies, and the ability of those agencies to charge for those services.

Government infrastructure agencies fall into two main types:

- General government agencies; and
- Public trading enterprises (PTEs).

General government agencies provide essential public services such as health, education, roads and police, typically with minimal user charges. Most general government agencies are dependent on the budget for funding.

PTEs provide commercial and social services, including electricity, water, ports, housing and public transport. Most PTEs have a commercial charter and generate revenue through user charges. Some PTEs also receive budget funding because they do not fully recover their costs when providing services required by the Government.

Each agency has its own processes for planning and provision of capital works and recurrent expenditure. Often lengthy lead times are involved with a range of competing pressures for expenditure which can change over time.

For some PTE infrastructure (such as electricity and water) there is some scope for commercial investments (i.e. debt financing) in new infrastructure to be repaid through user charges.

Users are charged for Government services where they are of significant direct benefit to the users and they are in a position to pay. The payment may not always be for the full cost of the service, which allows for the financial circumstances of individual users, and benefits received by the wider community, to be taken into account. Prices charged by the majority of commercial PTEs (such as electricity networks and water) are set by independent regulators which allow for a commercial rate of return on efficient capital expenditure.

2.1.2 Special Infrastructure Contributions

Special Infrastructure Contributions (SICs) are another funding option for State Services.

The State Government requires developers of land in Sydney's North West and South West Growth Centres to make monetary contributions toward the provision of State and regional infrastructure through Special Infrastructure Contributions (SICs).

State and regional infrastructure funded by the contributions includes roads; land for education, health and emergency service facilities; environmental conservation purposes; and planning delivery. SICs are intended to meet 75 percent of the cost of these infrastructure items, with the Government meeting the balance (i.e. 25 percent) of the cost. However, a discounted development contribution equivalent to 50 percent of the infrastructure cost (and increased Government contribution to 50 percent of the infrastructure cost) was in place until mid-2012.

The costs of other State and regional infrastructure required in the Growth Centres, i.e. the construction and operation of rail infrastructure, bus subsidies as well as social infrastructure facilities such as schools and TAFEs, hospitals, justice and emergency services will be borne by the Government.

The requirements for SICs in respect to the development of land in the South West Growth Centre are contained in the Environmental Planning and Assessment (Special Infrastructure Contribution - Western Sydney Growth Areas) Determination 2011.

2.1.3 Private Sector Partnerships

The State Government works with the private sector, where appropriate, to introduce new investment and deliver new and improved infrastructure and services. Public Private Partnerships (PPPs) that have been executed for a range of service sectors have realised major operational savings and increased quality of service delivery. The Government proceeds with a PPP only where it provides the best value for money for the service outcomes required. PPPs focused on the augmentation of urban infrastructure of the type found in greenfield areas have in the past included new public hospitals and public schools.

2.2 Local Council Infrastructure

Councils play a number of roles in supporting the development of the Growth Centres through the delivery of infrastructure. Councils are required to produce Community Strategic Plans as the key documents guiding their works in the coming decades. Supporting the implementation of the strategic plans are resourcing strategies, delivery plans and operational plans.

The Community Strategic Plans are prepared with due consideration of the various strategies and policies that impact on the local area from both the State (including the Draft Metropolitan Strategy 2031) and Federal Government levels. The effective management of development growth will require a significant ongoing commitment from the State Government, particularly in the delivery of infrastructure and services.

Councils fund the construction and operation of infrastructure in new urban areas including:

- Local roads, cycle paths and footpaths;
- Drainage and flood works;
- Local open space; and
- Local community facilities and civic services, such as libraries and community centres.

Local infrastructure in new development areas (i.e. that provided by Councils), in the first instance, is generally funded under the Section 94 development funding process. Section 94 of the Environmental Planning and Assessment Act 1979 allows Councils to levy developers for contributions towards public amenities and services that will be required as a result of the development. This includes Essential Works, which are considered primary infrastructure such as:

- land for open space (for example, parks and sporting facilities) including 'base level embellishment';
- land for community services (for example, childcare centres and libraries);
- land and facilities for transport (for example, critical road works, traffic management, bridges and pedestrian and cyclist facilities), not including car parking; and
- land and facilities for stormwater management.

It also includes Other Local Government services, which include:

- facilities and works for local community facilities; and
- works required for active open space use.

Section 94 contributions plans are being prepared for development within the East Leppington Precinct and will define the local infrastructure required as a result of urban development and the contributions rates that relate to such infrastructure. In cases where a Section 94 contribution plan is not in place a voluntary planning agreement can be entered into where the developer agrees with council and the state government to provide appropriate infrastructure to meet the infrastructure demand of the development.

Much of the capital cost of local infrastructure in new urban areas is funded by Section 94 contributions as there is a clear relationship between the need for new or upgraded infrastructure and population growth attributable to new development. Recently, the State Government has imposed restrictions on the amount of monetary contributions Councils can impose on residential developments. At present, Section 94 developer contributions are capped at $30,000 per lot. The intent of this cap is to deliver Essential Works under this cap, with Other Local Government services to be delivered either under the cap if there is money remaining, or under alternative funding streams.

2.3 Services Infrastructure

Services infrastructure is delivered by the relevant utility authorities as part of their strategic planning processes. Responsibilities for the provision of services infrastructure within the Precinct are outlined in Table 1.

Table 1 Authorities Responsible for the Provision of Services Infrastructure

Utility	Provider
Potable water and sewer	Sydney Water
Power	Endeavour Energy
Natural gas	Jemena
Telecommunications	NBN Co

The critical authorities for commencement of development are Sydney Water and Endeavour Energy, both of which are State Owned Corporations (SOCs) and have defined processes for infrastructure delivery, as discussed in the following Sections. Jemena is a private company and makes decisions on investment in infrastructure based on a review of the business case and their expected commercial return.

2.3.1 Sydney Water Infrastructure Planning Process

Sydney Water Corporation (Sydney Water) prepares annual Growth Servicing Plans (GSPs) setting out their proposed programs for water and wastewater infrastructure delivery to service urban growth over 5 years.

Sydney Water invests in new assets based on assessment of the need for those assets. The primary influence is the forecast lot and dwelling production targets set out in the MDP. Sydney Water also considers other factors such as:

- Broad macro-economic trends
- NSW government benchmarks for zoned and serviced land
- Sub regional analysis of greenfield areas
- Comparison of previous MDP data with current data
- Comparison of new connection rates to corresponding lot production forecasts
- New connection rates across Sydney
- Capacity of existing infrastructure
- Consultation with the Department of Planning and Infrastructure and the development industry
- Level of land fragmentation in greenfield areas

Sydney Water's policy is that it will invest in trunk services when there is demonstrated demand and the risk of delay is low.

2.3.2 Endeavour Energy Infrastructure Planning Process

As stated in its Annual Planning Statement 'EE investigates both supply-side and demand side solutions to ensure the optimisation of energy supply.' Endeavour Energy publishes annual planning statements into these investigations.

Endeavour Energy's 2011 Electricity System Development Review contains plans for the network based on local government areas and is intended to:

- Provide details and information on network constraint areas in accordance with the Demand Management Code of Practice;

- Invite stakeholder input and feedback on this Electricity System Development Review, particularly in relation to suggesting alternative proposals to relieving specific network constraints;
- Outline actions taken and results achieved as a result of feedback received since the last Planning Statement was issued; and
- Explain Endeavour Energy's energy efficiency strategy.

Endeavour Energy's 2011 Electricity System Development Review also describes in some detail a range of planning processes with the Strategic Asset Management Approach containing a ten year capital works program.

2.4 Infrastructure Delivery for the East Leppington Precinct

2.4.1 Services Infrastructure

Trunk services infrastructure will be delivered by the relevant utility authority, with the local reticulation delivered by the developer. Details of the specific funding arrangements for each service are discussed below.

Water and Sewer

Sydney Water will fund and construct trunk water and sewer infrastructure, and will be responsible for all design and approvals for external trunk infrastructure. Developers will be required to connect to trunk infrastructure by constructing lead-in and reticulation mains as development necessitates (to Sydney Water standards as part of the Section 73 process).

Where interim works or trunk works in line with Sydney Water's servicing strategy within the precinct are delivered by the developer under the Section 73 process, Sydney Water will reimburse the cost of works once the mains are transferred to Sydney Water ownership. Sydney Water's procurement process and Funding Infrastructure to Service Growth policy will be required to be followed for all reimbursable works.

Electricity

All trunk infrastructure including 132kV feeders and the zone substation will be funded by Endeavour Energy. The site for the zone substation was rezoned on 15th March 2013, which enables Endeavour Energy to commence their detailed planning.

The distribution network and other required infrastructure including distribution substations will be funded by the developer. This includes any temporary works.

Natural Gas

Jemena funds the delivery of natural gas infrastructure (trunk and reticulation) where their financial review determines that an appropriate commercial return will be achieved. Where Jemena does not consider the expansion of their natural gas network to be commercially viable, the developer will be requested to make a contribution.

Telecommunications

NBN Co. is responsible for delivery of trunk infrastructure to the site boundary and for reticulation of optic fibre throughout the development. The developer is responsible for installation of the pit and pipe network within the development.

2.4.2 Water Cycle Management Infrastructure

Water cycle management infrastructure will be delivered by a number of funding mechanisms.

Local infrastructure serving a broad catchment will be funded by Section 94 contributions, this will include:

- Retarding basins, including bio-retention areas incorporated with these basins; and
- Riparian corridor upgrades and channelisation works (for drainage purposes only).

Much of the water quality management infrastructure proposed for the East Leppington Precinct is anticipated to be delivered by the developer of particular sites. This will include:

- Rainwater tanks
- Gross pollutant traps
- Bio-retention areas
- Stormwater harvesting infrastructure

Stormwater drainage pit and pipe network will be delivered as part of the road infrastructure.

2.4.3 Road Infrastructure

The upgrade of arterial roads are to be funded by Roads and Maritime Services (RMS) or through the State Infrastructure Contribution (SIC), a levy paid by landowners and developers in the Growth Centres to fund major infrastructure. The SIC is collected to ensure that key infrastructure, in particular roads can be delivered generally in line with the rate of development as demand for this infrastructure increases. These roads will be delivered by either the RMS or Council.

Sub-arterial and essential collector roads, bridges, associated intersections will generally be undertaken by Council and funded under Section 94 contributions.

Development of local roads under normal circumstances is the responsibility of the developer of each particular site and will be ultimately dedicated to Council through conditions of development consent.

3.0 Proposed Development Staging

Based on existing infrastructure availability and the pattern of land ownership within the East Leppington Precinct, a proposed development staging plan has been produced and is presented as Figure 3 (Cardno, 2012). Cardno developed the development staging plan based on information provided by the major landowner in Cambelltown LGA, along with associated development projections.

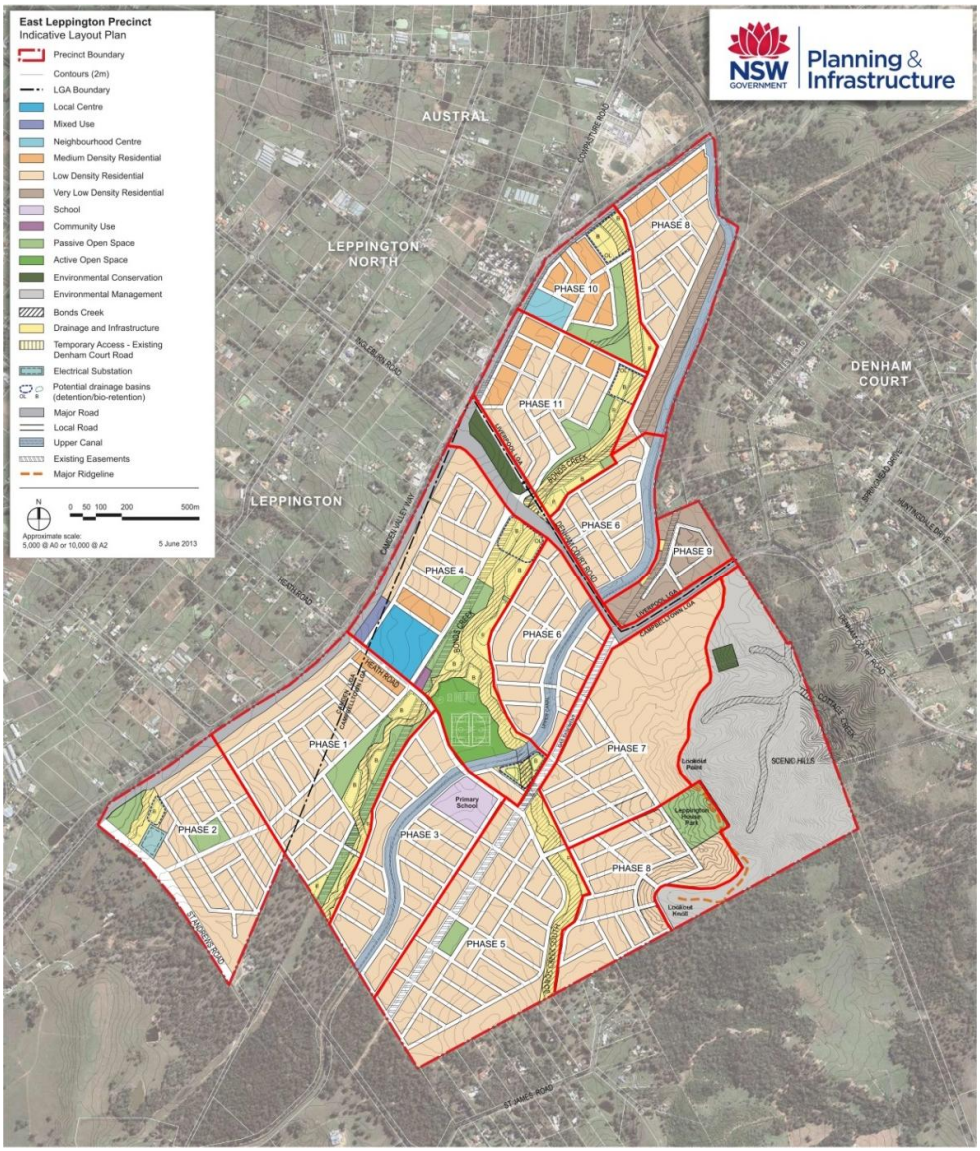


Figure 3 Development Staging Plan (Cardno 2012)

The development staging plan proposes 11 separate development stages, commencing in the south west corner of the Precinct and progressing to the north and east.

Construction of first lots is anticipated to commence in the southern parts of the precinct, as advised by the major landowner, with the release program thereafter consisting of approximately 250 lots per annum. Full delivery of development within the Precinct is likely to be achieved over approximately 16 years, with development complete in approximately 2029.

The following sections provide guidance as to the delivery of services infrastructure in the Precinct based on the proposed development staging.

4.0 Existing Infrastructure and Interim Servicing Strategy

Existing infrastructure services networks in the East Leppington Precinct are generally limited, supplying only the existing semi-rural development in the Precinct.

Advice has been sought from the relevant utility agencies to determine existing capacity of infrastructure either in the Precinct or within close proximity that could be augmented to allow initial development to occur within the Precinct.

A set of interim servicing strategies has been proposed by the utility agencies to provide for initial stages of development in the Precinct. A summary of these potential interim servicing arrangements is presented in Figure 4 and the proposals for each infrastructure type is discussed below.

The staging of delivery of the water cycle infrastructure and road infrastructure will not require establishment of interim strategies. This is discussed further in Sections 5.2 and 5.3.

The interim servicing strategy is preliminary, and further confirmation from the relevant agencies will be required during the development application phase by the relevant landowner/s to confirm the infrastructure provision for the initial stages of development in the Precinct.

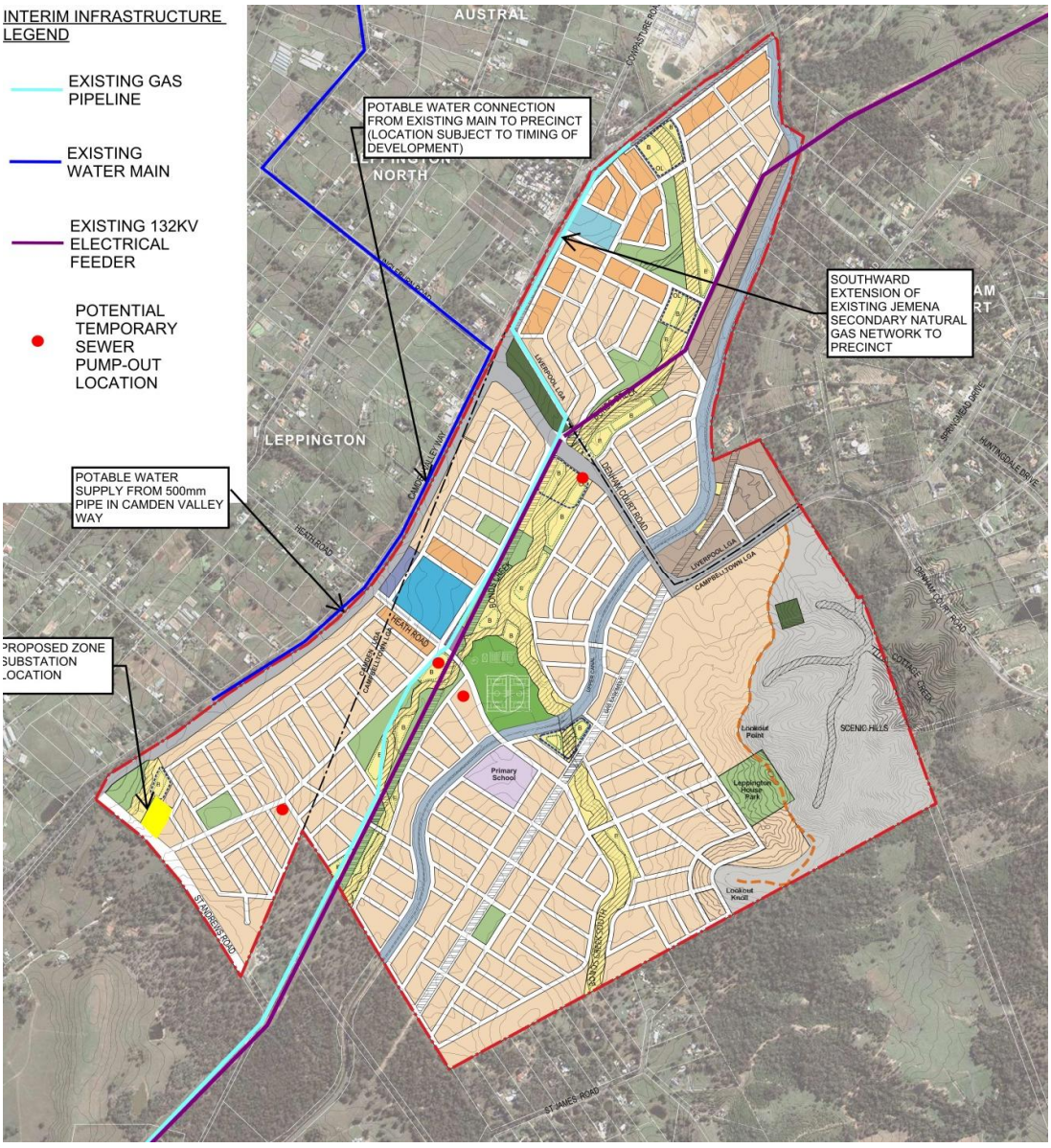


Figure 4 Interim Servicing Strategy

4.1 Water

The East Leppington Precinct is in close proximity to three water reservoirs and intersected by multiple trunk water mains. This existing infrastructure includes:

1. The Raby reservoirs and pumping stations located above the water supply canal in Denham Court;
2. The Leppington reservoirs and pumping stations located in Woolglen Park Road Leppington;
3. The Denham Court reservoirs located north of the site in Fox Valley Road Denham Court;
4. A 450mm main crossing the northern portion of the Precinct, a 500mm main crossing the western part of the Precinct and various mains between 200 and 500mm on Camden Valley Way (Cardno, 2012).

Sydney Water has advised that the existing 500mm diameter main located in Camden Valley Way will be capable of servicing up to 1,400 dwellings, up until approximately 2017, and will permit connection of the East Leppington development to the 500mm diameter main.

Sydney Water has made a preliminary commitment to deliver upgrades to the external potable water network upstream of the precinct by mid-2015, to provide further capacity to the existing 500mm diameter main to facilitate the servicing of the remainder of the East Leppington Precinct.

4.2 Sewer

The East Leppington Precinct does not currently have any connections to the Sydney Water sewer network and it is anticipated that the existing semi-rural development is served by on-site disposal systems. The closest existing Sydney Water sewer infrastructure is located on Camden Valley Way approximately 3 km north of the Precinct and has limited capacity.

Substantial upgrades to the sewer infrastructure throughout the South West Growth Centre are currently being investigated by Sydney Water.

Sydney Water has advised that interim sewer servicing for the East Leppington Precinct will consist of a pump-out system, consisting of a wet-well that is regularly pumped-out and trucked to an STP.

Potential locations for wet wells (pump-out tanks) are identified in Figure 4. These have not been confirmed with Sydney Water and will need to consider the staging of developments within the Precinct. It is understood that appropriate locations for wet wells have been identified for the development within the Campbelltown and Camden areas as part of discussions between Sydney Water and the major land owner in these areas.

Similarly, other early developers within the precinct, particularly in the Liverpool area, will be required to engage with Sydney Water to determine details of the temporary pump-out system as appropriate. The location of the wet-well(s) will need to be considered in relation to future trunk servicing layouts and the associated truck movements.

It is likely that each individual pump-out systems will be limited to serving 150 dwellings due to restrictions on the acceptable amount of truck movements. As such, if this interim arrangement is to service additional dwellings, alternative truck access arrangements and construction controls to minimise wet weather infiltration will need to be considered during design development.

Sydney Water may seek to incorporate tank storage into the ultimate servicing strategy as a wet well or wet weather storage. Cost of any tanks and pump-out delivered as part of Sydney Water's servicing strategy will be borne by Sydney Water.

This interim measure will be employed until such time as the ultimate servicing scheme is initiated by Sydney Water. Sydney Water has made a preliminary commitment to deliver ultimate wastewater infrastructure for the precinct by mid-2015. Based on the development staging discussed in Section 3.0, this interim arrangement will potentially be required to service Stage 1 and part of Stage 2, which represent development within the Campbelltown and Camden areas. Given the cost of establishing and maintaining pump-out systems and that the sewer infrastructure for the whole East Leppington Precinct is planned to be delivered by mid-2015, it may not be necessary for development within the Liverpool part of the precinct to be part of the interim servicing arrangement. However, this may not be the case if development within the Liverpool LGA precedes earlier than expected.

4.3 Electricity

There is currently limited electrical infrastructure within the East Leppington Precinct and Endeavour Energy has advised that upgrades will be required to supply the proposed development.

Endeavour Energy has committed to upgrade works to supply the Precinct, and the required infrastructure, including zone substation, is scheduled for delivery in mid-2014.

Endeavour Energy will work with developers to determine appropriate interim servicing solutions in the event that any dwellings are constructed prior to the commissioning of the zone substation.

4.4 Natural Gas

Jemena has advised that natural gas is available via an existing off-site high pressure secondary network adjacent to the precinct, which can be extended to supply any proposed development within the East Leppington Precinct, subject to commercial viability being achieved.

The details and timing of delivery of the natural gas supply will be determined by Jemena following a review of the commercial viability. This would require Jemena to review whether the proposed network expansion will generate sufficient patronage to its services to justify the capital cost of servicing the site. In the event that commercial viability is not justified, Jemena will request contributions from the developers.

Where Jemena's commercial viability review is satisfied, Jemena will be responsible for installation of all lead in and reticulation works.

4.5 Telecommunications

NBN Co. has advised that they can service the initial stages of development as part of their overall strategy for the Precinct.

5.0 Ultimate Infrastructure Strategy

A description of the proposed ultimate servicing arrangements for the East Leppington Precinct is presented in the following Sections.

5.1 Services Infrastructure

A summary of the proposed trunk services infrastructure arrangements for the East Leppington Precinct is presented in Figure 5 and discussed in the following Sections.

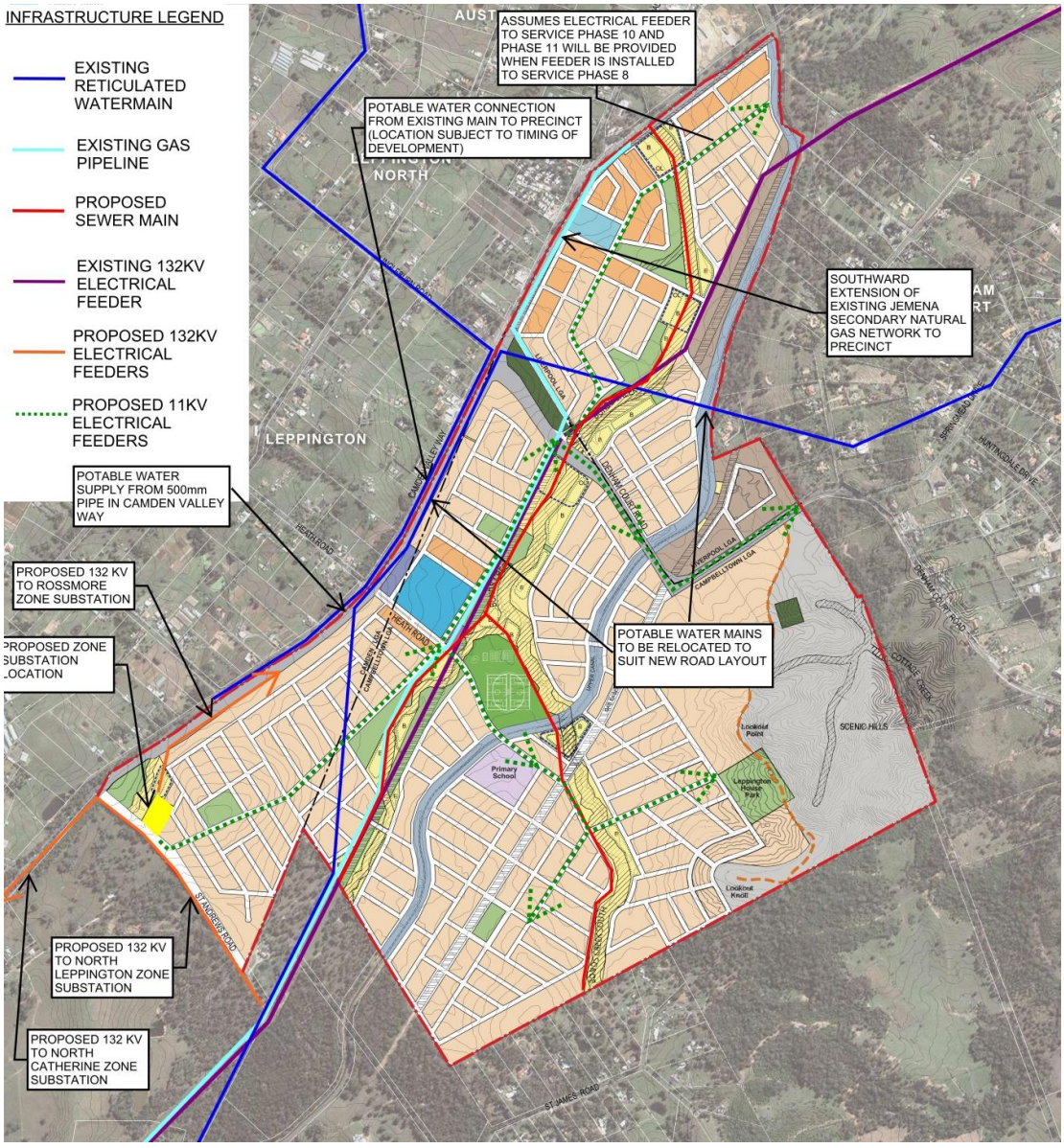


Figure 5 Ultimate Trunk Services Infrastructure Plan (Source: Cardno 2012)

5.1.1 Water

Sydney Water is currently reviewing their strategy for delivery of water infrastructure to the South West Growth Centre. It is anticipated that this overall strategy will require upgrades to existing Sydney Water infrastructure external to the East Leppington Precinct, which will service development within the overall South West Growth Centre.

A part of its long term servicing strategy, Sydney Water has advised that it will provide upgrades to the external potable water network upstream of the precinct to facilitate the servicing of the remainder of the East Leppington Precinct. These off-site infrastructure works will provide further capacity at the existing 500 mm main located in Camden Valley Way, providing sufficient capacity for this main to service the whole East Leppington Precinct.

Sydney Water has made a preliminary commitment to deliver ultimate water infrastructure for the precinct by mid-2015.

Developers will be responsible for provision of potable water reticulation throughout the Precinct under the Section 73 process. These water mains will be dedicated back to Sydney Water once constructed.

Sydney Water's amended recycled water servicing strategy to the North and South-West Growth Centres does not propose that the Precinct be serviced by recycled water.

5.1.2 Sewer

Sydney Water has made a preliminary commitment to deliver ultimate sewer infrastructure for the precinct by mid-2015.

Sydney Water is currently reviewing their strategy for delivery of sewer infrastructure to the South West Growth Centre.

Sydney Water has previously identified a number of options for providing sewage servicing to the East Leppington Precinct as follows:

1. Connection via pump station and rising main discharging to the Liverpool STP, which currently has sufficient capacity to service the Precinct. The discharge point would likely be to the existing trunk system on Camden Valley Way in the vicinity of Edmonson Park.
2. Connection via pump station and rising main discharging to the Oran Park / Turner Road system. Sydney Water has advised that this is unlikely to be feasible.
3. Localised treatment and re-use for irrigation. This was considered not to be feasible on a Precinct level, due to limited available land for irrigation within the Precinct.
4. A combination of the above.

Recent advice from Sydney Water indicates that the ultimate servicing strategy for the East Leppington Precinct will most likely consist of a new trunk gravity carrier main falling in a northerly direction, following the alignment of Bonds Creek. There is potential for this carrier main to discharge to the existing Liverpool STP via a pump station or to connect to the Kemps Creek STP by gravity. These options are currently being reviewed by Sydney Water.

Developers will be responsible for provision of sewer reticulation throughout the Precinct under the Section 73 process. These sewer mains will be dedicated back to Sydney Water once constructed.

5.1.3 Electricity

Endeavour Energy is currently progressing planning for the installation of a new zone substation fronting St Andrews Road, near the corner of Camden Valley Way, to service the East Leppington Precinct. The site location has been agreed and it is understood that Endeavour Energy currently anticipates that this zone substation will be operational by mid-2014.

The agreed location of the zone substation allows for the installation of 132 kV feeders along St Andrews Road to the south and to the existing 132kV feeders which run through the Precinct, as well as in both directions along Camden Valley Way. These feeders will form connections to other zone substations in the South West Growth Centre. As such, this zone substation will form an important strategic role in the supply for the wider area, providing redundancy in the network.

Endeavour Energy has also advised that as part of its system upgrades, it intends to upgrade the 132 kV overhead conductors running through the easement in the Precinct.

It will be the responsibility of the developers to run 11kV high voltage feeders from the zone substation to the respective parts of the precinct. This includes all lead in works for Stages remote from the substation. This could either be via below ground feeders or temporary aboveground services, which will be determined and agreed as part of the detailed electrical design process with Endeavour Energy. All high and low voltage, reticulation conductors for the Precinct will ultimately be required to be located underground to improve urban amenity and provide extreme weather protection in accordance with Endeavour Energy guidelines. Figure 5 provides a preliminary indication as to where it may be appropriate to install connecting feeders from the proposed new zone substation to each development area based on the indicative development staging provided in Section 3.0. However, these should be considered as indicative only, and developers should consult Endeavour Energy as part of the agreement process.

5.1.4 Natural Gas

Jemena has advised that the High Pressure Secondary Network (HPSN) which currently terminates on Camden Valley Way approximately 200m south of the Cowpasture Rd intersection would need to be extended to service the Precinct and that a pressure reducing station would be required to be installed by Jemena to reduce pressure suitably for reticulation purposes (Cardno, 2012).

The details and timing of delivery of the ultimate natural gas supply will be determined by Jemena following a review of the commercial viability. This would require Jemena to review whether the proposed network expansion will generate sufficient patronage to its services to justify the capital cost of servicing the site. In the event that commercial viability is not justified, Jemena will request contributions from the developers.

Where Jemena's commercial viability review is satisfied, Jemena will be responsible for installation of all lead in and reticulation works.

5.1.5 Telecommunications

NBN Co has confirmed that it would be able to provide telecommunication services to the Precinct within the proposed timing of the development works. This is based on the assumption that the development program will deliver stages in greater than 100 new lots.

Developers will be responsible for the cost and implementation of a pit and pipe network, while NBN Co. will be responsible for funding and installation of fibre optic infrastructure, including backhaul to a point of interconnect.

5.2 Water Cycle Management Infrastructure

The Water Cycle Management Report prepared by Cardno (May 2013) evaluates the flood behaviour within the East Leppington Precinct and proposes various infrastructure components to manage the stormwater quantity and quality. A summary of the key water cycle management infrastructure to be delivered is presented in Table 2.

Table 2 Summary of Proposed Water Cycle Management Infrastructure

Stormwater Measure	Proposed Infrastructure
Riparian Corridor Widths	• 25m on the tributary of Scalibrini Creek • 25m on Bonds Creek upstream of the confluence point • 45m on the Bonds Creek tributary • 45m on Bonds Creek downstream of the confluence point
Retarding Basins	• On-line basins x3 for Bonds Creek • On-line basins x1 for South Bonds Creek • Off-line basins x1 for tributary of Scalibrini Creek (combined with bio-retention)
Floodplain Management	• Channelisation of the reach between Denham Court Road and Camden Valley Way.
Stormwater Quality Management	• Rainwater tanks • Gross pollutant traps • Bio-retention areas • Stormwater harvesting

The preliminary water cycle management infrastructure plan is presented as Figure 6. The key infrastructure, as presented in Table 2 has been graphically presented alongside the development stage in which they are anticipated to be delivered. This proposed development staging also reflects what is outlined in Section 3.0. The retarding basins are identified in the earliest development stage that will contribute flow to that basin.

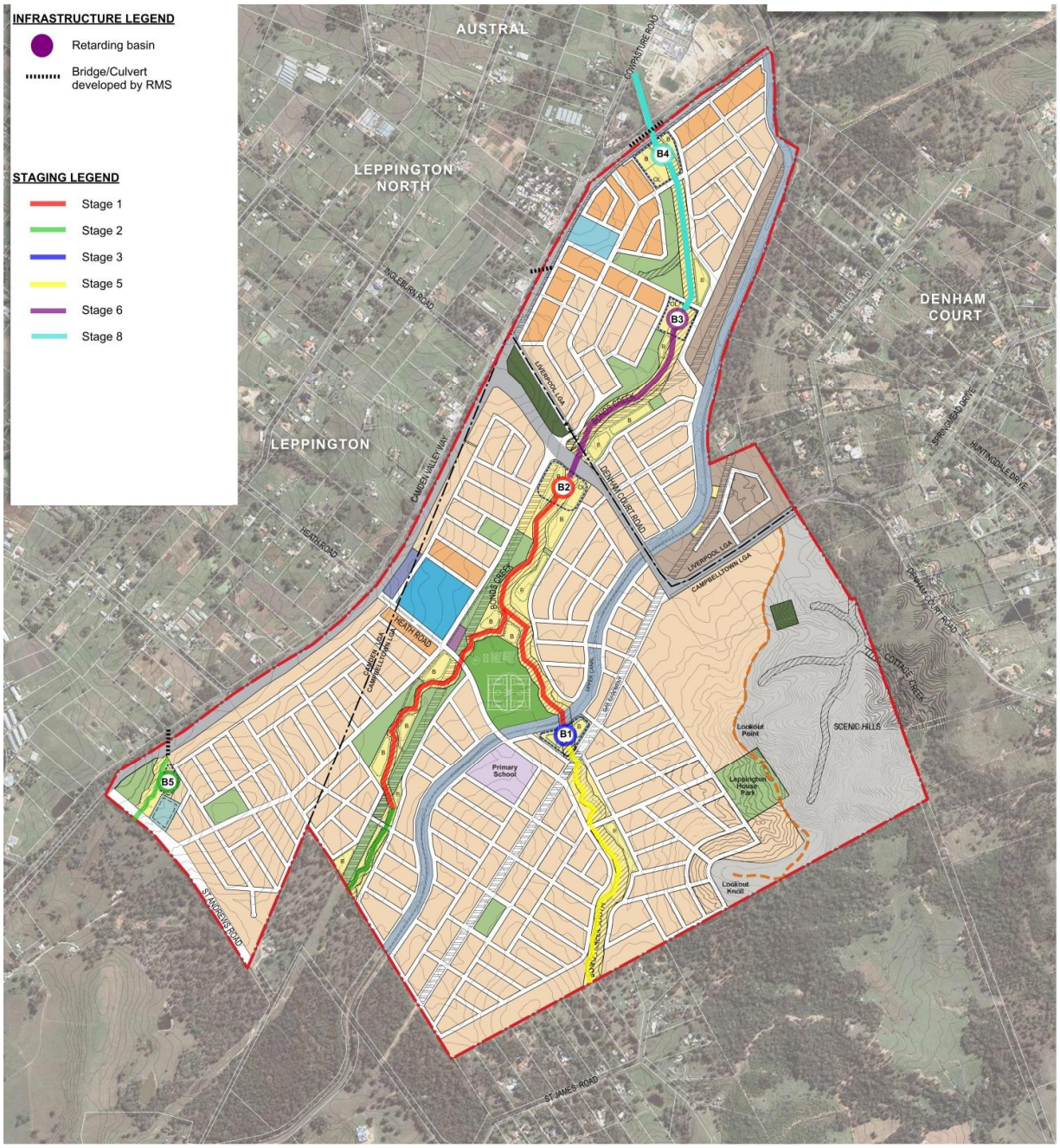


Figure 6 Preliminary Water Cycle Infrastructure Plan (Source: Cardno 2013)

The water cycle management infrastructure proposed within the Liverpool LGA part of the precinct for the relevant development stages is presented in Table 3.

Table 3 Proposed Water Cycle Management Infrastructure for Liverpool LGA by Development Stage

Development Stage	Liverpool LGA	Campbelltown LGA	Camden LGA
1	-	• On-line Retarding Basin - Bonds Creek (B2) • Riparian Corridor - Bonds Creek and Bonds Creek South	-
2	-	• Riparian Corridor - Bonds Creek	• Off-line Retarding Basin - tributary of Scalibrini Creek (B5) • Riparian Corridor - Tributary of Scalibrini Creek
3	-	• On-line Retarding Basin - Bonds Creek South (B1) • Riparian Corridor - Bonds Creek South	-
5	-	• Riparian Corridor - Bonds Creek South	-
6	• On-line Retarding Basin - Bonds Creek (B3) • Riparian Corridor - Bonds Creek • Channelisation between basins B2 and B3	• Riparian Corridor - Bonds Creek • Channelisation between basins B2 and B3	-
8	• On-line Retarding Basin - Bonds Creek (B4) • Riparian Corridor - Bonds Creek • Channelisation between basins B3 and B4	-	-

5.3 Transport Infrastructure

5.3.1 Roads

The East Leppington Precinct is serviced by a number of existing regional and sub-arterial roads, as well as a limited number of existing collector and local roads. Major existing roads serving the Precinct include:

- Arterial and sub-arterial roads:
  - Camden Valley Way – Arterial, provides a link between Hoxton Park and Narellan;
  - Denham Court Road – Sub-arterial function, links Denham Court, Ingleburn and Leppington; and
  - Cowpasture Road – Sub-arterial function, linking road between Camden Valley Way and Bringelly Road (not within the East Leppington Precinct, but provides service to the Precinct boundary).
- Collector and local roads:
  - Ingleburn Road – Collector road, serves the suburb of Leppington by connecting local roads to Camden Valley Way, intersection with Denham Court Road will be re-aligned as part of the

Camden Valley Way upgrade by RMS (not within the East Leppington Precinct, but provides service to the Precinct boundary) ;

- Heath Road – Collector road, serves the suburb of Leppington and connects to Camden Valley Way (not within the East Leppington Precinct, but provides service to the Precinct boundary); and
- St Andrew's Road – Local no-through road, serves a number of rural properties to the south of the proposed development.

The East Leppington Precinct ILP does not propose any new arterial or sub-arterial roads to be delivered as part of the development, however upgrades of the existing roads will be required.

Roads and Maritime Services (RMS) is currently managing the detailed design and construction of the Camden Valley Way upgrade, which involves expanding from the existing two lane road to a four lane dual carriageway road, and signalised junctions at various intersections on Camden Valley Way. It is understood that RMS has made provision for a further two lanes within the Camden Valley Way median strip for potential future expansion of the road to six lanes. Yield figures produced as part of the Traffic Assessment prepared for the Precinct (Cardno 2013) indicate a possible future upgrade being required in 2026.

The section to be constructed between Cowpasture Road and Cobbitty Road forms the western boundary of the East Leppington Precinct. There is a commitment to complete this section of the upgrade in 2016.

The following upgrades are also planned for Denham Court Road:

- Re-alignment of Denham Court Road between Camden Valley Way and Bonds Creek Bridge to align with Ingleburn Road – subject to RMS approval;
- Signalised connections along Denham Court Road to provide full access between the northern and southern areas of the precinct – subject to RMS approval; and
- Upgrade of Denham Court Road between Bonds Creek Bridge and eastern border of the Precinct – subject to Section 94 for land acquisition and works.

Yield figures produced as part of the Traffic Assessment prepared for the Precinct (Cardno 2013) indicate a potential need to upgrade Denham Court Road to a four lane road within the East Leppington Precinct boundary in 2026.

New collector and local roads will be delivered throughout the Precinct to service the proposed development. Roundabouts at collector road intersections and internal vehicular bridges have also been identified for delivery to ensure satisfactory traffic operations and connectivity within the precinct (Cardno 2013).

The preliminary road infrastructure plan is presented as Figure 7. It is anticipated that road works for each development stage will be limited to works within that stage boundary.

5.3.2 Rail

The South West Rail Link, when completed, will connect the Precinct's population with the regional passenger rail network. Leppington Railway Station will be located around 1.7 kilometres from the northern tip of the East Leppington site and will initially be served by 4 trains per hour with the potential for more in peak periods.

The South West Rail Link project includes:

- A new 11.4-kilometre rail line from Glenfield to Leppington;
- Two new stations located at Edmondson Park and Leppington, including commuter car parking;
- A train stabling facility at Rossmore;
- An upgrade of the existing Glenfield Station and bus/rail interchange, including new commuter car parking; and
- Construction of Glenfield North and Glenfield South rail flyovers. Construction of the rail link to Leppington Major Centre is proposed to be completed by 2016.

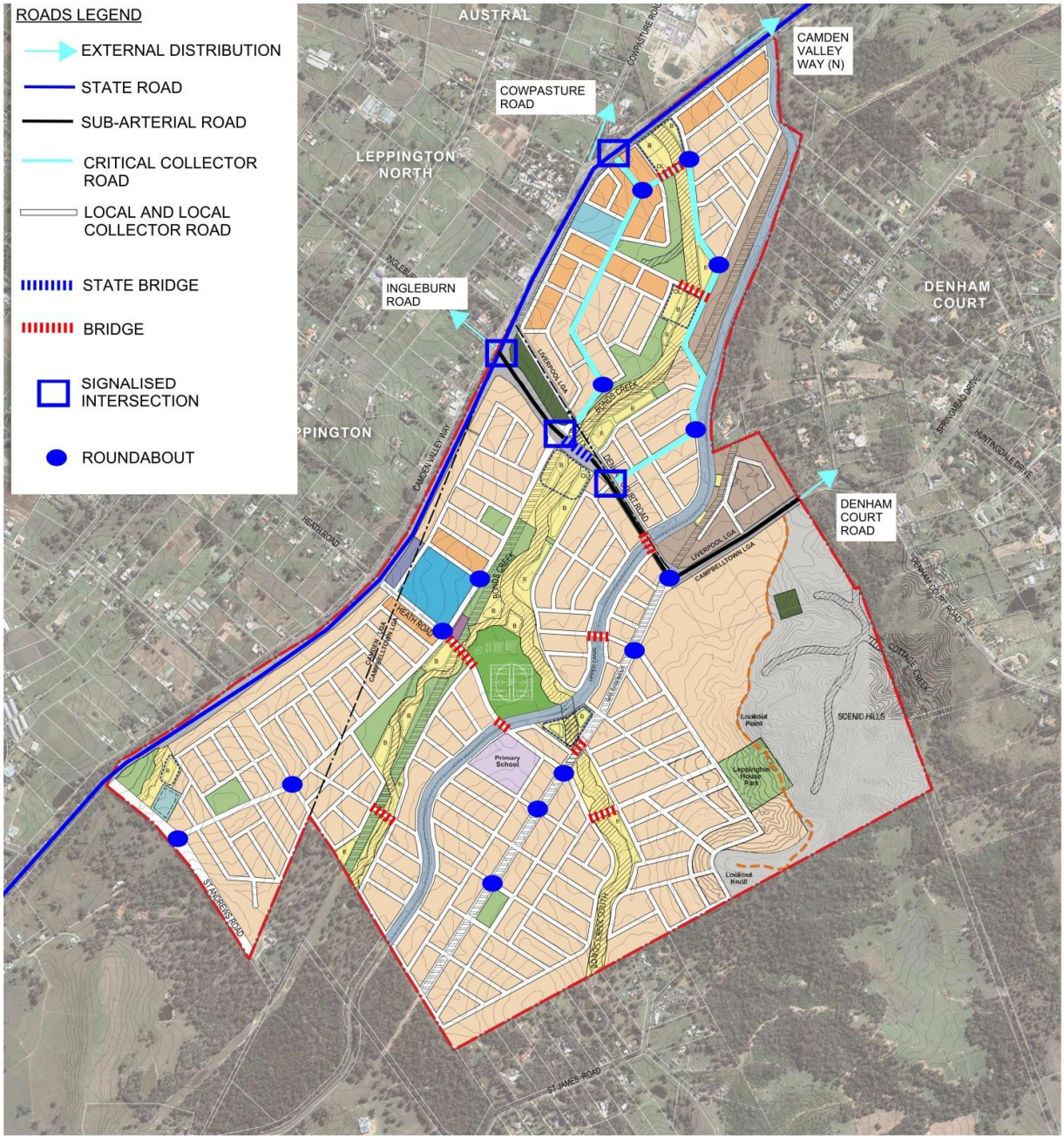


Figure 7 Indicative Road Infrastructure Plan (Source: Cardno 2013)

5.4 Social Infrastructure and Open Space

The Precinct's social infrastructure and open space requirements are described in the report Social Infrastructure and Open Space Assessment – East Leppington Precinct, prepared by Elton Consulting (2012).

Currently, the existing population that lives within the East Leppington Precinct boundary relies on local and district facilities such as schools, community centres, medical services, childcare centres and places of worship in Leppington to the west, the established suburbs of Kearns, Raby, and St Andrews to the south, Ingleburn to the east and Horningsea Park and Prestons to the north.

These local and district level facilities which exist in adjoining suburbs have been built to meet the needs of their immediate populations.

There is little spare capacity within existing social infrastructure in the area to meet the needs of the projected new population of the East Leppington Precinct. While a range of services and facilities are likely to be provided in the surrounding areas of Leppington North, Leppington and Austral to meet some additional needs of East Leppington residents:

- These are not within local walking distance for the future East Leppington Precinct population;
- They have been provided to meet the needs of their local catchments and generally will not have capacity to also meet the needs of the future East Leppington Precinct population;
- While there is reported to be some spare capacity within sporting facilities in Campbelltown LGA, these will not be conveniently accessible to the East Leppington Precinct population, especially for local level activities;
- Existing facilities in adjacent Growth Centre precincts are likely to be redeveloped to meet the needs of their future populations and will not be available in the future to also address demand from East Leppington Precinct; and
- Any spare capacity which currently exists in facilities and open space within Liverpool LGA is likely to be taken up by population growth in other release areas already approved.

The current proposals for social infrastructure and open space are presented in the East Leppington Precinct Indicative Layout Plan presented in Figure 2.

Further details on the required additional local infrastructure to support the proposed Precinct development is outlined further below. Specified infrastructure requirements have been largely based on standard and benchmark rates for provision of social infrastructure on population set by DP&I (Growth Centres Development Code) and Liverpool Council.

5.4.1 Community Facilities

The following community facilities will be required to serve the Precinct's local needs:

- A neighbourhood level multi-purpose community centre, as a base for local community activities and services, to be owned and managed by Campbelltown Council;
- One local centre – intersection of Camden Valley Way and Heath Road providing access to shopping and other commercial services; and
- Private and non-government sector child care, entertainment and leisure facilities, and places of worship.

The Precinct's district and regional needs will be served by the Leppington Major Centre – South West Growth Centre's planned regional centre, which is expected to serve a broader surrounding population of around 120,000.

Infrastructure that has been identified for the proposed Leppington Major Centre include:

- Spaces for large community events, gatherings, celebrations and civic functions;
- Meeting spaces for community organisations and groups and for human services that have a district or regional focus;
- Large spaces for private functions, such as weddings, conventions, conferences;

- Spaces for adult education, workplace training and community learning programs;
- A central library; and
- Spaces for staging major entertainment events or performing arts, spaces for visual arts, and spaces to display and celebrate the cultural heritage of the area

The design and timing of development of these facilities has yet to be finalised and will depend upon a variety of factors, including the availability of funds, and rate of growth of the surrounding population.

5.4.2 Health

The Precinct population will be too small to warrant community health facilities in its own right. These needs will be met by facilities outside the precinct.

Commercially zoned areas within the local mixed-use areas and centre will provide spaces suitable for privately operated GP medical centres and allied health services such as dentists and physiotherapists. Anticipated demand for health services within the East Leppington Precinct is likely to require:

- Local medical centre / GPs, according to market demand and accommodated in commercial premises; and
- Residential aged care facilities, with sites to be acquired through the market.

The proposed multi-purpose community centre will provide spaces for the delivery of support services and programs for a range of target groups, including families, children, young people, older people and people with a disability. These services are likely to be provided by non-government and community based organisations, perhaps on a sessional or outreach basis.

Other community services are predominantly provided at district, sub-regional and regional levels, rather than at a local level. The bulk of these services will be located within the Leppington Major Centre.

The capacity of major existing hospital facilities within the region, namely Liverpool, Campbelltown and Camden Hospitals will need to be increased to provide for the increased regional population.

The health development strategy recommends provision of a hierarchy of integrated primary and community care centres (IPCC) across the South West Growth Centre. An IPCC contains multidisciplinary and specialist medical ambulatory care that will potentially include a day surgery with attached or incorporated primary care clinics.

These IPCCs are proposed for Leppington, Oran Park and Bringelly. The largest and most comprehensive IPCC in the South West Growth Centre is envisaged for the Leppington Major Centre with a projected catchment population of approximately 150,000. The South Western Sydney Local Health Network has indicated to the Department that it will commit to acquisition of land for the future construction of the Leppington IPCC.

Location of this centre in the Major Centre is important for access to other amenities including childcare, public transport and car parking.

5.4.3 Education

The NSW Department of Education and Communities (DEC, formerly Department of Education and Training) is responsible for public primary and secondary schools and TAFE colleges.

Based on a DEC standard of 1 primary school for 2,500 dwellings, there is likely to be demand for at least one new primary school within the Precinct. A site for the proposed school is proposed in the southern portion of the Precinct, within 200 metres of the proposed sports field. DEC have agreed to be listed as the acquisition authority for this site.

With around 4,400 dwellings proposed for East Leppington Precinct, it is likely that not all of the future demand will be accommodated within one new primary school. Part of the future demand will need to be met by another school.

At this stage, the location of a second school to accommodate part of the East Leppington Precinct student demand has not been determined.

DEC advises that demand for a new primary school is generally reached with the sale of around new 400 lots, although this is dependent on the capacity of schools in surrounding areas and State government approval processes.

East Leppington Precinct will not be large enough by itself to warrant the provision of a new high school. However, it will contribute significantly to high school demand in the wider area. At this stage, it has been assumed that high school needs in East Leppington Precinct will be met by either existing high schools in surrounding areas or those to be located within adjoining precincts.

Private schools will be established to reflect demand from the future socio-economic, cultural and religious profile of the population, and will acquire sites as needed through market processes.

Short term demand for TAFE facilities from the South West Growth Centre will be met regionally, through the four existing TAFE colleges in Liverpool and Campbelltown. The University of Western Sydney, Campbelltown has sufficient spare capacity to accommodate increased demand from East Leppington Precinct.

5.4.4 Open Space and Recreation

In terms of local and district open space and recreation facilities, the study has identified a need for:

- 40 hectares of local and district open space (approx. 2.95 ha per 1,000 people). This open space would be owned and maintained by Liverpool, Camden and Campbelltown Councils
- An approximate 35:65 split between active and passive open space
- Two key suburb parks, focused on the elevated areas in the south-east of the Precinct
- Local parks within walking distance of most dwellings
- Local sports parks with playing fields and multi-purpose courts
- Playgrounds for young children
- A network of walking and cycling trails along the creek line and linking to the wider network, particularly to the Leppington Major Centre

Across the whole East Leppington Precinct, passive open space will comprise 80% of the proposed open space, while active open space will comprise the remaining 20% of open space. This compares with a recommended 35:65 split between active and passive open space.

However, Elton Consulting has noted that the open space provision in the Liverpool Council component of the precinct equates to a rate of 1.7 ha per 1,000 people, which is below the Growth Centres Development Code and Council standard of 2.83 ha per 1,000 people (Elton Consulting 2013). To provide for the active recreational needs of the population within the Liverpool Council area, a recommendation has been put forward that the proposed open space be embellished in ways that encourage as much as possible informal physical activity and an active lifestyle, to help make up for the notional shortfall in the quantum of open space. Suggested embellishments include:

- Off-road cycling paths and “learn to cycle” circuits for young children
- A network of paths and trails for walking and jogging
- Fitness equipment located along the trails
- A large “kick about” area for informal ball games and practice
- A half court with basketball hoop for practice
- Playgrounds that encourage active play and more challenging activities.

East Leppington’s regional open space and recreation needs will be met by the proposed Leppington Major Centre, to be situated in the adjacent Leppington North Precinct. Additional proposed recreation facilities include:

- A regional stadium and sporting facility (possibly in the Western Sydney Parklands in the Bringelly Precinct) to serve the entire Growth Centre population of around 300,000.
- An indoor sports and aquatic centre on a 4 hectare site in the Major Centre.

- Open space in the Major Centre to cater for the needs of residents, workers and visitors, including a town square, informal recreation space for children and youth, areas for lunchtime use, a network of cycling and walking paths, informal water play park, and regional private sector recreation facilities (e.g. tenpin bowling).

6.0 Conclusions

6.1 Infrastructure Delivery Coordination

The East Leppington Precinct ILP makes allowance for the major service infrastructure requirements identified through this report. Key requirements include:

- Allocation of a site for the proposed Zone Substation, completed on 15th March 2013;
- Allowances and appropriate land uses within existing easements of the two underground gas pipelines (Eastern Gas Pipeline and Moomba Sydney Gas Pipeline), electricity transmission lines and the Bonds Creek system; and
- A proposed road network that will facilitate installation of the primary and secondary reticulation infrastructure.

In accordance with the Growth Centres Development Code, service infrastructure distribution networks other than trunk lines should be installed in shared trenches within the road reserve, typically within the footpaths, except at road crossings. The use of shared trenches can often result in lower total costs, particularly in areas of new development such as the East Leppington Precinct (NSW SOC, 2009).

Alignment of services within the shared trench should be in accordance with the Guide to Codes and Practices for Street Opening, Conference 2009 (Department of Planning, 2006). The Streets Opening Conference seeks to promote the concept of shared trenches for the provision of services subject to arrangements that ensure suitable protection, support and access throughout the life of the Services (NSW SOC, 2009).

6.2 Local Essential Infrastructure Delivery Strategy

The East Leppington Precinct presents a unique challenge in that the land is divided between three local Councils. This means that local infrastructure procurement and delivery methodology applied by one Council may be different to that in another area. These issues have been considered by DPI and the three Councils as part of the precinct planning process.

The DPI are preparing draft Section 94 contributions plans for the three LGA's to provide a mechanism to provide for the local infrastructure requirements for the Precincts. These plans will include essential and non-essential infrastructure. Campbelltown Council are currently proposing to enter a Voluntary Planning Agreement (VPA) with the major landowner for land within its LGA.

Each Council will need to update its community strategic plan and associated resourcing strategy, delivery plan and operational plan to address the delivery of local infrastructure to the Precincts. As part of this strategy it may be appropriate or necessary for the Councils to enter into discussions on staging arrangements for key community facilities serving a regional catchment.

The Councils, with assistance from the State Government, should consider preparing infrastructure strategies, oriented toward making it easier for developers and other parties to deliver local infrastructure to a satisfactory standard on behalf of the future communities without unduly burdening the future communities with significant costs.

6.3 Next Steps in Infrastructure Delivery

It is intended that the process for infrastructure delivery in the East Leppington Precinct is clear, open and informative and supports its timely development in accordance with the ILP.

To assist with the further planning, detailed design and delivery of the proposed infrastructure identified within this IDP, it is crucial that the staging plan for the proposed development across the entire precinct be finalised. Infrastructure agencies identified within this IDP will need to be engaged as part of confirmation of the staging plan to enable the finalisation of the respective ultimate servicing strategies; the targeted planning and detailed design of infrastructure to specific timeframes; and preparation of preliminary costs for the works.

Appendix H – Pre-lodgement meeting advice

camden council

Council Reference: SC3084
Record Number: 19/285998

11 October 2019

Jeremy Swan & Mairead Hawes
The Planning Hub
Suite 4, Level 4
35 Buckingham Street
Surry Hills 2010

Re: Pre-lodgement Meeting for Planning Proposal
Property: Tidapa (220, 300, 350 & 360 Chittick Lane, Cobbitty)

Dear Jeremy and Mairead,

Thank you for attending the pre-lodgement meeting for the property held on 19 September 2019, attended by Dea Kandasamy and Geoff Leyland (Strategic Planners), Jeremy Swan and Mairead Hawes (The Planning Hub). Please find the summary of the meeting below outlining key concerns, the requirements for lodgement and current fees.

The pre-lodgement meeting was arranged in response to the proponent's request to discuss a Planning Proposal for potential rezoning of rural land to large lot residential, and supporting land uses, for lands known as Tidapa.

Planning Proposals submitted to Council will be assessed against a range of local and state plans and strategies. These include, but are not restricted to, the Greater Sydney Region Plan (Region Plan), Western City District Plan (District Plan), Camden Community Strategic Plan (CSP), the Rural Lands Strategy (RLS), and the draft Local Strategic Planning Statement (LSPS).

Council officers advised that any Planning Proposal submitted would be reported to the Camden Local Planning Panel (CLPP) for advice prior to being reported to Council. The CLPP comprises of three independent experts and a member of the community, with a rotating chair.

The Planning Proposal should follow the Department of Planning, Industry and Environment's (DPIE) A Guide to Preparing Planning Proposals. This guide can be accessed on DPIE's website.

Camden Local Environmental Plan 2010 (LEP)

Under the Camden LEP 2010, the site is approximately 147Ha of RU1 Primary Production zoned land, with a minimum lot size of 40Ha and a maximum building height of 9.5m. The eastern boundary of the site adjoins the state listed heritage item, Denbigh homestead.

Key Concerns

Protection of Camden's Rural Land (Outside the South West Growth Area)

The principal policy issue relating to the proposal is the rezoning of rural zoned land to urban zone(s). As reiterated at the pre-lodgement meeting, Council has made several decisions that have reinforced the protection of Camden's remaining rural zoned land (outside of the South West Growth Area). Council continues to advocate for the protection of rural land, consistent with the Rural Lands Strategy 2018 (RLS). Previously, Council has not supported a number of Planning Proposals that could impact scenic landscapes, vistas, ridgelines, or heritage values.

The RLS guiding criteria for the assessment of Planning Proposal's must be addressed in any Planning Proposal submitted to Council.

In addition to the RLS, consideration of the Region Plan should also be given. An objective of the Region Plan is that environmental, social and economic values in rural areas are protected and enhanced. The District Plan actions include:

- Maintain or enhance the values of the Metropolitan Rural Area using place-based planning to deliver targeted environmental, social and economic outcomes; and
- Limit urban development to within the Urban Area, except for the specified investigation areas.

These matters must be addressed in any Planning Proposal submitted to Council.

Council can meet its five-year housing supply of land for 11,800 homes as prescribed by the District Plan. Justification for the rezoning of rural lands to provide housing will therefore hold limited weight. Council officers also have concern that rezoning of the site to residential could set a precedent for other rural landholders and the further loss of rural lands.

South West Growth Area (SWGA)

It is understood that the proponent may be seeking to amend the Camden LEP. However, it is recommended that the proponent liaises with the Department of Planning, Industry and Environment regarding the boundary of the SWGA.

Heritage and Visual Impacts

The eastern boundary of the site adjoins the state heritage listed Denbigh estate. The proponent was advised to consider all potential impacts with this heritage item.

Council is preparing a Visual and Scenic View analysis of key sites across Camden. It was recommended the proponent await the outcome of this study.

Outer Sydney Orbital (OSO)

The site lies between the proposed OSO and the existing South West Growth Area. The OSO currently remains proposed with an indicative corridor.

It is premature to assume the final alignment of the OSO at this stage, which is understood to form the principal justification for the rezoning of the site. It is recommended that proponent liaises with Transport for NSW regarding the final alignment of the OSO.

Initial Assessment

Should you proceed with this Planning Proposal, the following documents will be required at lodgement:

- Planning Proposal Lodgement Checklist;
- Application Form (includes owners' consent); and
- Declaration of Interest and /or any gifts or political donations.

The Planning Proposal should include commentary (without necessarily completing a supporting specialist study), for the following matters:

- Economic and retail assessment;
- Commentary on air quality of adjoining land holders; and
- Potential acoustic impacts.

The Planning Proposal should be submitted with the specialist studies listed in the table below:

Reports and supporting studies	Additional information to include
Biodiversity Assessment	Impacts on adjoining lands, in particular beyond the Growth Centre Boundary
Bushfire Assessment	
European and Indigenous Heritage Assessment	Analysis on potential impacts on Denbigh Estate Visual and Scenic Impacts
Housing Analysis	
Land Use Conflict Risk Assessment	
Services and infrastructure delivery strategy	Utility provision to the site from the existing network
Land Capability Assessment	Site Survey (topographical)
Social and community infrastructure Assessment	
Traffic and Transport Assessment	Site access and egress from the Northern Road
Water Cycle Management Assessment	Flooding Drainage Impacts on local waterway

As discussed, further studies may be required if a Gateway Determination to proceed is received.

Fees and Charges

An initial processing fee of **$4,900.00** is required to be paid when submitting a Planning Proposal to Council. This fee is non-refundable.

A further processing fee is required if Council resolves to send the proposal for Gateway Determination. Depending on whether Council officers deem the proposal as minor or major, the second processing fee will be **$10,300.00** or **$27,600.00**.

Additionally, all studies required for the proposal must be funded by the proponent. All fees are current as of 11 October 2019.

If you have any queries regarding this matter, please do not hesitate to contact me on 4654 7606 or Martin Cooper, Manager Strategic Planning, on 4654 7620.

Yours sincerely,



Deaelle Kandasamy
Strategic Planner