DEVCORE DEVELOPMENTS PTY LTD

PLANNING PROPOSAL – ROWAN VILLAGE, 7066 HOLBROOK ROAD, ROWAN

STORMWATER MANAGEMENT STRATEGY

APRIL 2022

101 West Fyans Street
Newtown, VIC, 3220

Tel: (02) 9299 2855
Fax: (02) 9262 6208
Email: wma@wmawater.com.au
Web: www.wmawater.com.au

PLANNING PROPOSAL – ROWAN VILLAGE, 7066 HOLBROOK ROAD, ROWAN

STORMWATER MANAGEMENT STRATEGY

APRIL 2022

Project Planning Proposal – Rowan Village, 7066 Holbrook Road, Rowan	**Project Number** **122013**
Client DevCore Developments Pty Ltd	**Client's Representative** Paul Thompson
Project Manager Mark Colegate	

Revision History

Revision	Description	Distribution	Authors	Reviewed by	Verified by	Date
0	Draft Report	WMAwater	Mark Colegate, Yuan Li			MAR 22
1	Final Report	WMAwater	MC, YL	MC	[signature]	APR 22

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

APPENDICES:

LIST OF DIAGRAMS

LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DEM	Digital Terrain Model
EY	Exceedances per Year
IFD	Intensity, Frequency and Duration (Rainfall)
ILP	Initial Layout Plan
m AHD	meters above Australian Height Datum
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
PMP	Probable Maximum Precipitation
SSMP	Site Stormwater Management Plan
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)
WWCC	Wagga Wagga City Council
XPRAFTS	XP Runoff Analysis and Flow Training Simulator (hydrologic model)

ADOPTED TERMINOLOGY

Australian Rainfall and Runoff (ARR, ed Ball et al, 2016) recommends terminology that is not misleading to the public and stakeholders. Therefore, the use of terms such as “recurrence interval” and “return period” are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example, there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2016 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table below describes how they are subtly different.

For events more frequent than 50% AEP, expressing frequency in terms of Annual Exceedance Probability is not meaningful and misleading particularly in areas with strong seasonality. Therefore, the term Exceedances per Year (EY) is recommended. Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example, an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6-month Average Recurrence Interval where there is no seasonality, or an event that is likely to occur twice in one year.

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore, an AEP is not assigned to the PMF.

This report has adopted the approach recommended by ARR and uses % AEP for all events rarer than the 50 % AEP and EY for all events more frequent than this.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	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
Frequent	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
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	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
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

EXECUTIVE SUMMARY

An Existing Flood Condition Assessment and Site Stormwater Management Plan has been developed using ARR 2019 and current industry best practice for the proposed Rezoning and Subdivision located at 7066 Holbrook Road, Rowan NSW 2650.

The Planning Proposal seeks to rezone the site from RU1 Primary Production and R5 Large Lot Residential to the following mix of land use zones:

- R1 General Residential
- R5 Large Lot Residential
- B2 Local Centre
- RE1 Public Recreation

Based on a dwelling yield of 10 dwellings per hectare, the Planning Proposal master plan will enable the delivery of circa 2,100 dwellings across a 225-hectare site area.

The methodology, results, conclusions, and recommendations are summarised below.

Methodology

A regional distributed hydrological (WBNM) and hydraulic (TUFLOW) model was established based on the MOFFRMS model using rainfall and flood estimation techniques consistent with ARR 2019, to define the existing flood characteristics of the Site for flood events with the probability of 20%, 10%, 5%, 2%, 1%, 0.5%, and 0.2% AEPs with a range of critical storm durations and temporal patterns. Flood depth, height, and hazard categories mapping were produced in accordance with ARR 2019 and the Australian Disaster Resilience Handbook Collection.

A high-level review of existing stormwater treatment strategies, including traditional centralised / end-of-line strategies and WSUD orientated decentralised strategies, was conducted. An end-of-line strategy was designed and assessed through modelling exercises to ensure that the stormwater objectives can be achieved in the design.

The developed site (proposed) was delineated into five (5) sub-catchments in accordance with the site topography and initial layout plan. The end-of-line treatment facilities for each sub-catchment were conceptually designed and optimised through a local water quality model in MUSIC and a local hydrological model in XPRAFTS.

Results

The results of the existing conditions flood modelling provide flood intelligence information to inform the design, including external inflows to be conveyed and the natural flood way to be reserved in the proposed development.

Five (5) wetlands with inlet ponds (200 m^3, 100 m^3, 550 m^3, 255 m^3, 650 m^3) and macrophyte zones (3,700 m^2, 1,450 m^2, 10,000 m^2, 5,100 m^2, 12,200 m^2), have been designed to mitigated contaminant loads within stormwater runoff. The site stormwater quantity objectives can be achieved using five (5) detention basins on top of the wetlands with footprints of 4,212 m^2, 1,754 m^2, 11,387 m^2, 5,624 m^2 and 13,884 m^2, respectively, including freeboard. The required land-takes of the five (5) end-of-line detention basins are denoted in the conceptual plan (Diagram A).

Conclusions and Recommendations

The site stormwater quantity objectives can be achieved through the proposed end-of-line management facilities.

The wetlands and detention basins were designed with the assumption that the entire contributing catchment can be drained to each end-of-line facility. However, it should be noted that the northeast part of C4 (approximately 5.5 ha as hatched in Diagram A) cannot freely drain to Wetland/Basin 4 without significant modification of the surface topography. Functionality needs to be achieved through earthworks and or additional measures, e.g., pumping system to drain the stormwater from the northeast part back to the designated wetland / basin or more decentralised solutions with WSUD principles.

The initial layout plan has been updated in accordance with the results of this study. The revision resulted in slight change in fraction impervious area of the sub-catchments in the site, which might lead to slight change in the modelling results. It is recommended to update the modelling to reflect the revised initial layout plan, which is additional to the initial scope of this study.

Decentralised strategies, which implement innovative WSUD principles and can be more sustainable for the integrated water management perspective, were reviewed in this study. This can be further investigated through detailed analysis. Following the submission of the Planning Proposal before investing more on alternative WSUD opportunities.

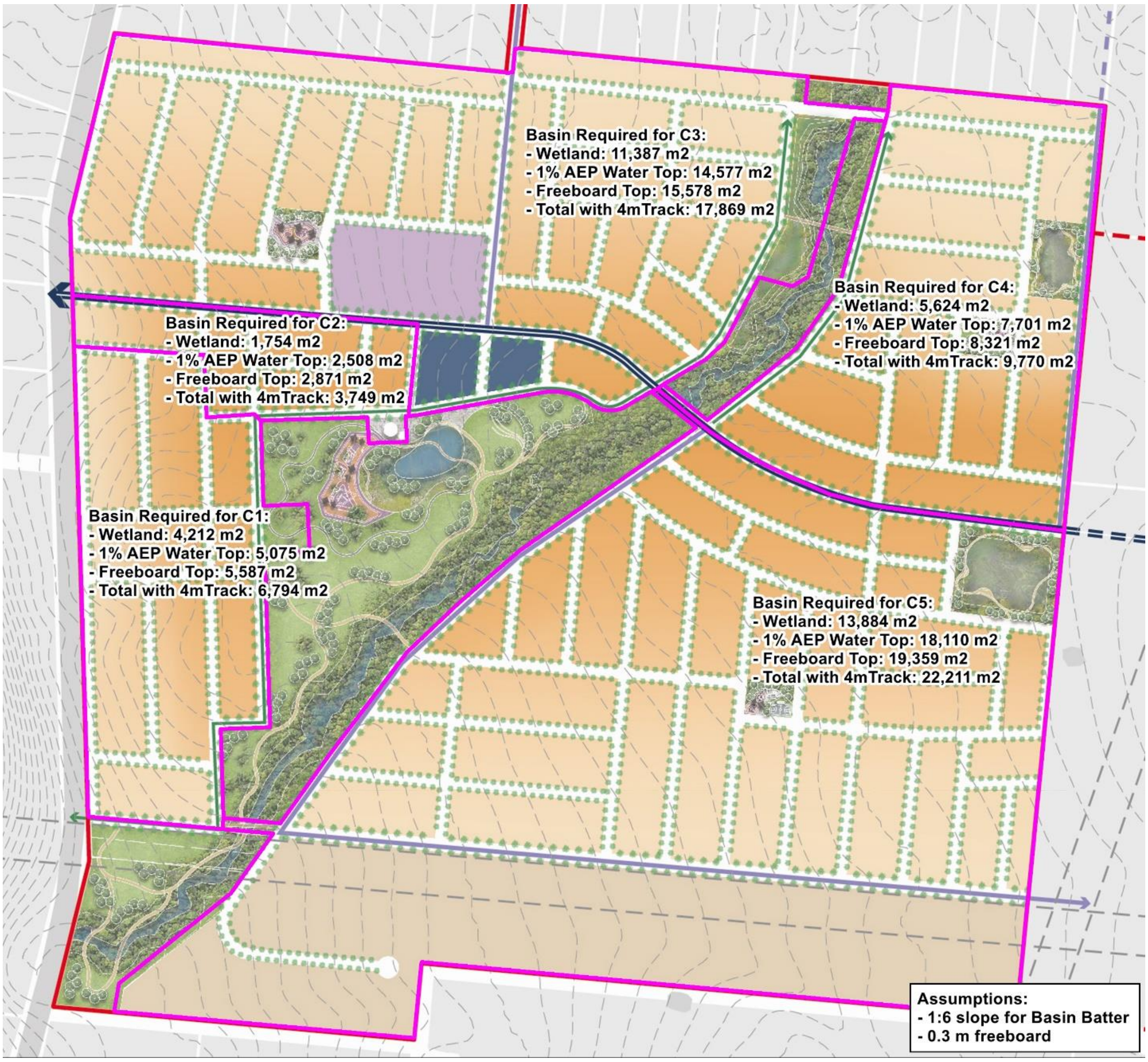


Diagram A: Stormwater Management Conceptual Plan

1. INTRODUCTION

WMAwater was engaged by DevCore Property Group to prepare a Site Stormwater Management Strategy to assist in the planning permit application for the proposed rezoning and circa 2,100 lot subdivision development of a 225.02-hectare land parcel, i.e., approximately 10 lots/ha, located at 7066 Holbrook Road, Rowan NSW 2650 (the Site).

The following report assesses the existing flood characteristics of the Site and details an initial SSMP for the proposed development. The adopted analytical process and modelling outcomes are summarised in following sections, including the development of:

- a regional coupled hydrological (WBNM) and hydraulic (TUFLOW) model based on the model from Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (MOFFRMS) (WMAwater, 2020, Reference 3) and the characteristics of the Site to define existing flood characteristics and inflow required to be conveyed;
- a local hydrological (XPRAFTS) model of the Site for the design of detention facilities to manage site stormwater discharges;
- and a local water quality model (MUSIC) of the Site to design treatment facilities and predict the efficiency of the proposed treatment system in the reduction of contaminants and pollutants.

2. BACKGROUND

The land parcels, known as Rowan Village with a total area of 225 hectares, are being investigated for rezoning and development options with average lot sizes of 540 m^2, 900 m^2 and 8,000 m^2, and an indicative dwelling yield of circa 2,100 including mix of Residential and Seniors Living. The site is currently vacant cropping and grazing land, and is legally described as:

- Lot 18 in DP 1054800
- Lots 24, 26, 43, 65, 66 in DP 757246
- Lot 23 in DP 1063399
- Lots 1 and 2 DP 1171894

An Indicative Layout Plan (ILP, refer to APPENDIX C) has been developed for Planning Proposal submission to Wagga Wagga Shire Council (WWSC) which is supported by a number of technical documents that have been used to achieve relevant design standards. The following document constitutes the assessment of stormwater flooding and drainage and strategy for the adoption of Integrated Water Cycle Management (IWCM) and Water Sensitive Urban Design (WSUD) opportunities to assist a pre-application process and ultimately support a Rezoning and Development Application submission.

2.1. Planning Proposal

The Planning Proposal seeks to rezone the site from RU1 Primary Production and R5 Large Lot Residential to the following mix of land use zones:

- R1 General Residential
- R5 Large Lot Residential
- B2 Local Centre
- RE1 Public Recreation

Based on a dwelling yield of 10 dwellings per hectare, the Planning Proposal master plan will enable the delivery of circa 2,100 dwellings across a 225-hectare site area, which importantly will encompass the delivery of a diverse mix of low density residential housing typologies described as follows:

- **Rural transition residential lots** – These residential lots will be located along the southern boundary of the site and will be the largest residential lot typology. This lot typology will importantly provide an appropriate transition between the site and the adjacent rural context to the south of Rowan Road.

- **Neighbourhood residential lots** – A range of suitable low density residential lots will be accommodated within close proximity to open space provision and the riparian corridor network. This lot typology will provide the appropriate transition between the village residential lots and the rural transition lots. A diversity of lot sizes will be delivered through the neighbourhood residential lot typology.

- **Village residential lots** – These residential lots will leverage off the close proximity to the local centre and its associated amenities and offerings. Fundamentally, these residential lots will still uphold the low-density residential housing charter that the site will deliver, whilst ensuring that an appropriate diversity of housing choice is delivered.

The Planning Proposal will enable the creation of a new amenity-led neighbourhood providing an opportunity for a variety of housing options through a range of residential lot sizes, supported by the timely delivery of resilient utilities and infrastructure that supports and promotes the future growth of Wagga Wagga in an orderly and sustainable way. The delivery of a mix of low-density housing choices will be crucial to attracting a wide range of demographics to the area.

As presented in the Urban Design Study that supports the Planning Proposal, a dense, active, and vibrant local village centre will be located at the heart of the neighbourhood, with a mix of land uses and services for convenience. The local centre will create a focal point for the community and encourages social gathering and interaction.

Future development on the site would be facilitated by a highly connected, and permeable network with convenient access to public transport, public spaces, facilities, and amenities. Cycleways and footpaths will connect across the site to promote a walkable community.

The Planning Proposal will also ensure that the environmental values of the site are preserved through the dedicated retention, and where required rehabilitation, of significant trees and riparian corridors.

2.2. Study Site

The site is located in Rowan, on the southern fringe of Wagga Wagga. The site is bounded by Lloyd Road (north), Holbrook Road (west), Rowan Road (south) and the proposed Sunnyside Estate (east).

The site falls 20 metres from the west boundary to the east boundary. Approximately 30 metres from the south to north boundary. The topography creates three (3) distinct sub catchments and points of discharge –

- an ephemeral waterway which enters at the southwest corner and discharges to the east side of the northern boundary
- across the east boundary into Sunnyside Estate, and
- via the northeast corner of the site into properties fronting Lloyds Road.

The location of the site, sub catchments and overland flow paths can be seen in Figure 1.

2.3. Previous Studies

There have been a number of regional flood studies in this area, including the following recent studies:

- Sunnyside Estate Wagga Wagga Precinct Stormwater Drainage Strategy – WMAwater 2021 (Reference 1)
- Sunnyside Estate Wagga Wagga Site Stormwater Management Plan (SSMP) – WMAwater 2020 (Reference 2)
- Wagga Wagga Major Overland Flow Floodplain Risk Management Study (MOFFRMS) –

Public Exhibition Version, WMAwater, 2020 (Reference 3)
- Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan, WMAwater, 2018 (Reference 4)
- Wagga Wagga Detailed Flood Model Revisions, WMAwater, 2014 (Reference 5)
- Wagga Wagga LGA Murrumbidgee River Flood Modelling, WMAwater, 2012 (Reference 6)
- Wagga Wagga Major Overland Flow Flood Study (MOFFS), 2011 (Reference 7)

The MOFFRMS conducted by WMAwater is the latest flood study covering the Site, which implemented the methodology detailed in the latest best practice guideline, ARR 2019 (Reference 8). The regional model for this study was established based on the refinement of the MOFFRMS model.

3. OBJECTIVES

The objective of the SSMP is to demonstrate that the site can be developed using best practice stormwater management principles and techniques. This will enable the subdivision to meet the stormwater management requirements set in WWCC Development Control Plan (DCP) (Reference 9) and WWCC Engineering Guidelines for Subdivision and Development Standards (Reference 10). The objectives will inform stormwater designs and ensure that stormwater quality and quantity targets are achieved and maintained.

The stormwater management guidelines commonly list the following objectives for stormwater management:

- **Protect natural systems:** protect and enhance natural water systems in settlements
- **Integrate stormwater management into landscapes:** create multi-use corridors in settlements to prevent flood risks whilst providing recreational and visual amenity
- **Protect water quality:** protect the quality of water draining from settlements
- **Reduce stormwater runoff volumes and peak discharges:** mitigate additional stormwater runoff from settlements by use of retention facilities and minimising impervious areas (Zero Impact)
- **Add value whilst minimising infrastructure costs:** minimise the infrastructure costs of settlements by use of systems analysis of strategies across many scales from household to neighbourhood to city to region.

Specific objectives for this study are detailed below.

3.1. Existing Flooding Objectives:

Establishing the existing flood conditions allows an understanding of the availability of developable land and identification of regional stormwater constraints associated with the development of the site. The objectives of existing conditions flood modelling for this study include:

- Prepare existing flood mapping for designated range of storm events;
- Establish the existing flood characteristics for the site;
- Quantify flows into and out of the Site under existing conditions.

3.2. Site Stormwater Quality Objective

There are no specific pollutant reduction targets defined in the DCP (Reference 9) or Engineering Guidelines (Reference 10). However, the Engineering Guidelines (Reference 10) has the following requirement:

- Management of development and urban stormwater within the context of total urban water cycle management in accordance with Australian Runoff Quality: A Guide to Water Sensitive Design, 2006.

For this study, the stormwater quality targets defined by Australian Runoff Quality (ARQ, Reference 11) were adopted, as summarised below:

- 80% reduction in Suspended solids (SS);
- 45% reduction in total nitrogen (TN);

- 45% reduction in total phosphorus (TP);
- 70% reduction in gross pollutants (GP).

3.3. Site Stormwater Quantity Objectives

The Engineering Guidelines (Reference 10) requires on-site detention to be provided to reduce the potential for local flooding and damage to existing properties by mitigating runoff from new developments to pre-developed discharge rates. Therefore, the adopted stormwater quantity objective for this study is:

- No-worsening stormwater peak discharges after development.

4. EXISTING FLOOD CONDITIONS

Establishing the existing flood conditions allows an understanding of the availability of developable land and identification of regional stormwater constraints associated with the development of the site. The defined existing (pre-development) flood characteristics will inform the inflows to the site that are required to be conveyed through the site after development.

The Lake Albert flood model, a subset of the entire model from the MOFFRMS (Reference 1), was used as a base model for this study and minor refinements were carried out to characterise existing flood conditions for the local precinct, including the Rowan Village (subject site) and the Sunnyside Estate (neighbour development on east).

The key features of the Lake Albert flood model are summarised below:
- Hydrological model:

- A network hydrological model was set up in WBNM;
- Probability Neutral Burst Initial Losses (PNBIL) from ARR Data Hub (Reference 12) were adopted;
- Continuous Losses from ARR Data Hub were adjusted by the multiplier 0.4 as suggested by NSW Specific Data Info in ARR Data Hub (Reference 13);
- Areal Reduction Factor (ARF) parameters from ARR Data Hub were adopted;
- A single (average of the whole MOFFRMS catchment) IFD from BOM 2016 IFD (Reference 14) was used for each AEP.

- Hydraulic model:

- A 2D hydraulic model were set up using TUFLOW modelling tool;
- Digital Elevation Model (DEM) with 1 m resolution was used;
- Modelling grid size was set to be 5 m;
- Key stormwater drainage network and hydraulic constraints were incorporated.

For a full description of the Lake Albert flood model, refer to MOFFRMS (Reference 1).

The refinements of the Lake Albert model made for this study are summarised below:
- Hydrological model:

- Sub-catchment delineation around the Site and the Sunnyside Estate on the east was refined according to the boundaries of the Site and Sunnyside Estate, as illustrated in Figure 2;
- Areas were recalculated for those adjusted/new sub-catchments with fraction impervious retained as 0% as per the MOFFRMS;
- The IFD for each AEP was averaged for the study catchment rather than the whole MOFFRMS catchment;
- The ARFs were updated to the catchment area draining to Stringybark Creek, which were previously based on the entire catchment area;
- Two to three (2-3) critical durations and representative temporal patterns for each AEP were selected in accordance with the peak flows from the Site and the ephemeral

waterway through the site.

- *Hydraulic model:*

- TUFLOW model was updated with new inflow locations (2d_sa) for the new WBNM sub-catchments;
- Additional reporting locations/cross-sections (2d_po) were added to extract flow information within/around the Site.

Hydrological modelling was carried out for ten (10) temporal patterns, a range of AEPs (20%, 10%, 5%, 2%, 1%, 0.5%, and 0.2% AEPs), and a range of storm durations (30 min to 12 hr) using the updated WBNM model. The critical duration and representative temporal pattern for each AEP were selected based on the peak flows from the Site and the ephemeral waterway through the site.

The selected events were then modelled through updated TUFLOW to characterise existing flood conditions for the Site. Flood depth and height mapping were produced and are shown in Figure B1 to Figure B7. Flood hazard categories were determined in accordance with the Australian Disaster Resilience Handbook Collection (Reference 15). Hazard categories mapping are illustrated in Figure B8 to Figure B14. A summary of this categorisation is provided in Diagram 1.

Existing flood mapping identifies two (2) stormwater flow paths, entering the site from the west boundary, that convey stormwater generated in the upper catchment. The existing waterway channel is the primary flow path for stormwater runoff generated within the upper catchment. This waterway will be largely reserved to catering the external flow through the site. The secondary flow path enters the site about midway along the west boundary. This inflow will need to be catered for within the developed drainage system to facilitate conveyance back to the main channel alignment.

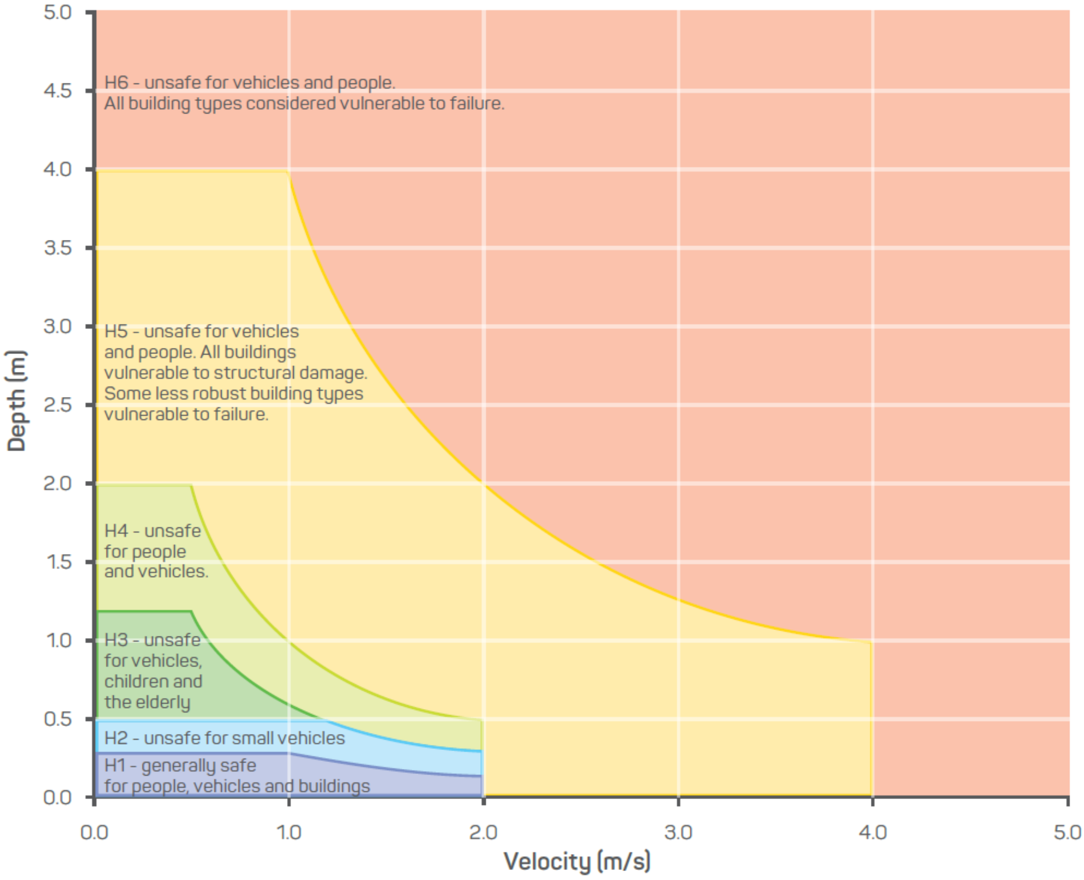


Diagram 1: General Flood Hazard Vulnerability Curves (Reference 15)

5. SITE STORMWATER MANAGEMENT

The objective of the Site Stormwater Management Plan (SSMP) is to mitigate adverse impacts on stormwater discharges resulting from the development of the Site. Site stormwater discharge will meet the conditions and requirements for stormwater management. These requirements ensure that appropriate design and stormwater mitigation is applied to ensure that stormwater quality and quantity targets are achieved and maintained. The specific site stormwater objectives for proposed developments of the Site are detailed in Section 3.

5.1. Stormwater Treatment Strategies

The stormwater objectives can be achieved using the more traditional centralised or end-of-line treatment systems, or by using more decentralised or distributed response.

5.1.1. Centralised (end-of-line)

A centralised treatment system is widely considered to be the Business as Usual (BAU) approach to stormwater management. It involves the collection and conveyance of stormwater runoff generated within the development to dedicated end-of-line treatment facilities, primarily made up of wetlands and detention basins, capable of managing the cumulative stormwater runoff volumes prior to discharging the site.

5.1.2. Decentralised (distributed)

For the pre-application phase of this project a centralised strategy will be developed. However, Rowan Village would most likely adopt, a decentralised or distributed solution that allows the management of stormwater runoff closer to the source. This allows for smaller and more integrated facilities to be adopted which can be multi-dimensional in purpose.

Distributed systems allow the adoption of Integrated Water Cycle Management (IWCM) and Water Sensitive Urban Design (WSUD) approaches to achieve the stormwater objectives and promote more sustainable and resilient settlements.

The central premise of IWCM is the need for a whole-of-system approach to manage the natural, built and service aspects of the urban water cycle to achieve multiple community and environmental outcomes. A key component of IWCM is WSUD, which integrates water cycle management measures into urban planning and design.

IWCM and WSUD strategies look to integrate the following opportunities (or combinations thereof) into the fabric of settlements:

- Retention, rather than rapid conveyance, of stormwater
- Capture and use of rainwater and stormwater as an alternative or supplementary source of water to minimise reliance on centralised supplies drawn from remote catchments
- Use of vegetation for filtering purposes
- Utilisation of water efficient landscaping
- Protection of water related environmental, recreation and cultural values

- Decentralised water harvesting for various applications
- Decentralised wastewater treatment and reuse.

These approaches offer the potential to reduce - the size and cost of infrastructure, loss of developable land, impermeable surfaces, heat island effect, runoff volumes, potable water demand, etc, whilst treating runoff closer to the source.

WSUD elements include –

- Sediment basins
- Bioretention swales
- Bioretention basins
- Sand filters
- Swale and buffer systems
- Constructed wetlands
- Ponds
- Infiltration systems/passive irrigation
- Rainwater tanks
- Reuse applications
- Aquifer storage and recovery

The rest of this section details the modelling and optimisation of a traditional end-of-line stormwater management strategy, including wetlands and detention basins, to show that the stormwater water quality and quantity objectives can be achieved. A more decentralised strategy with more WSUD considerations can be further assessed in the next stages if required.

5.2. Site Catchment Delineation

The developed site, which is anticipated to generate an average of 10 lots/ha, was delineated into stormwater drainage catchments with reference to the proposed ILP and general topography. It is expected that some degree of regrading will occur within the developed site.

The developed site was delineated into five (5) sub-catchments around the central waterway corridor. Drainage catchment delineation is shown in Figure 3.

Existing flood mapping identifies two (2) stormwater flow paths, entering the site from the west boundary, that convey stormwater generated in the upper catchment. The existing waterway channel is the primary flow path for stormwater runoff generated within the upper catchment. The ILP provides a ‘green’ corridor along the waterway alignment, this will allow the regional flows to continue through the site without consideration of the developed site drainage system.

The secondary flow path enters the site about midway along the west boundary. This inflow will need to be catered for within the developed drainage system to facilitate conveyance back to the main channel alignment.

Stormwater management facilities will be designed to mitigate stormwater runoff generated within the developed site, prior to entering the waterway corridor.

An end-of-line combined wetland (for water quality) and detention basin (for water quantity) was conceptually designed for each of the five (5) sub-catchments, as detailed in below sections. The sub-catchment area development breakdown is summarised in Table 1, based on the following fraction impervious assumptions for land use:

- 8% - Rural Transition Residential Lots
- 70% - Neighbourhood Residential Lots
- 80% - Village Residential Lots, Senior Living, Village Centre
- 65% - Road Reserves
- 0% - Open Space, Drainage Reserves

Table 1: Developed Site Breakdown

Sub-catchment	Land use	Sub-catchment Area	Pervious Area	Impervious Area	Increase in FIA
C1 (19.8 ha)	neighbourhood residential lots (10.9 ha)	19.8 ha	6.3 ha	13.5 ha	68%
	village residential lots (2.6 ha)				
	road reserve (5.8 ha)				
	drainage reserve (0.5 ha)				
C2 (7.1 ha)	neighbourhood residential lots (0.2 ha)	7.1 ha	1.9 ha	5.2 ha	74%
	village residential lots (5.2 ha)				
	road reserve (1.7 ha)				
	drainage reserve (0.2 ha)				
C3 (52.1 ha)	neighbourhood residential lots (18.2 ha)	52.1 ha	15.9 ha	36.2 ha	70%
	village residential lots (13.1 ha)				
	village centre (1.6 ha)				
	senior living (3.3 ha)				
	open space (0.5 ha)				
	road reserve (13.9 ha)				
	drainage reserve (1.5 ha)				
C4 (27.5 ha)	neighbourhood residential lots (16.5 ha)	22.0 ha (gravity) 5.5 ha (pumped)	8.7 ha	18.7 ha	68%
	village residential lots (3.1 ha)				
	road reserve (7.3 ha)				
	drainage reserve (0.6 ha)				
C5 (87.9 ha)	rural transition residential lot (26.8 ha)	87.9 ha	44.3 ha	43.6 ha	50%
	neighbourhood residential lot (30.3 ha)				
	village residential lot (10.9 ha)				
	open space (0.3 ha)				
	road reserve (18.0 ha)				
	drainage reserve (1.7 ha)				

5.3. Stormwater Quality

Assessment of the quality of stormwater discharge from the developed Site was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) by eWater. It allows the analysis of stormwater quality and the assessment of the efficiency of the treatment facilities. The operation of MUSIC requires climatic forcing, i.e., rainfall and potential evapotranspiration (PET), and geological parameters.

5.3.1. Climatic Inputs

Wagga Wagga AMO is one of the closest rain gauges to the Site with high quality pluviograph records. Ten (10) years of pluviograph data from 01/01/2000 to 01/01/2010 recorded by Wagga Wagga AMO station were used together with the monthly average PET data at the same location.

5.3.2. Geology

The default soil parameters from MUSIC were adopted as shown in Table 2.

Table 2: Soil Characteristics for the Study Site

Parameter	Urban Residential
Rainfall Threshold (mm/day)	1
Soil Capacity (mm)	120
Initial Storage (%)	25
Field Capacity	80
Infiltration Capacity coefficient a	200
Infiltration Capacity coefficient b	1
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Base flow Rate (%)	5
Daily Deep Seepage Rate (%)	0

5.3.3. Model Structure

A water quality model was set up in MUSIC, as shown in Diagram 2. Each sub-catchment was defined as a source node and connected to an end-of-line wetland. Fraction impervious under developed conditions for each source node were implemented as shown in Table 1.

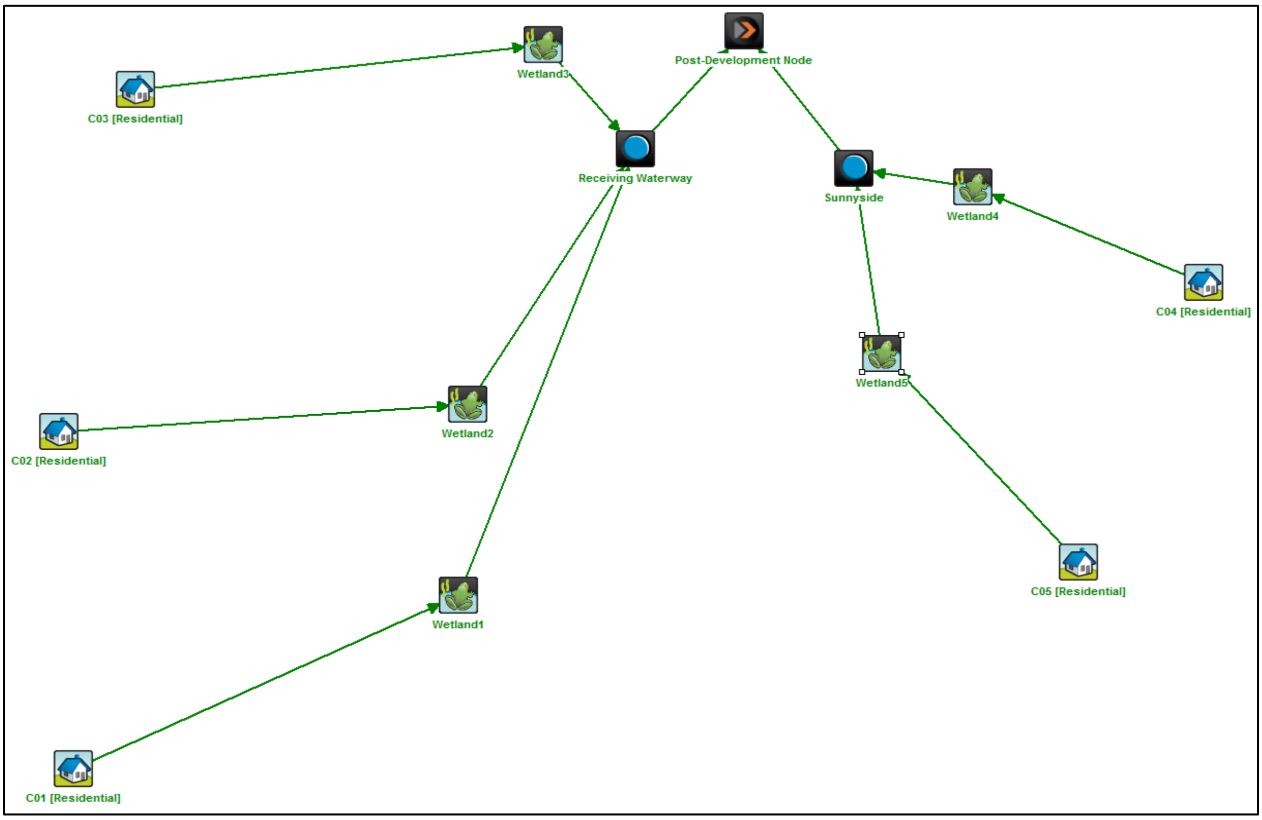


Diagram 2: MUSIC Network Schematic

5.3.4. Modelling Results

Each wetland was optimised to ensure that water quality from the developed Site meets stormwater quality objectives (Section 3). The following rules as suggested by WaterNSW (Reference 16) were applied while optimising the wetlands:

- The constructed wetland should then be modelled with an inlet pond with a volume more than 10% of the wetland's permanent pool volume.
- Extended detention should not exceed 0.5 m unless it can be shown that a higher depth is achievable without flooding impacts.
- The permanent pool volume in the constructed wetland should not exceed the surface area (at permanent pool level) multiplied by one metre unless more detailed information is provided of the wetland configuration.
- Exfiltration shall be 0 mm per hour unless 'lost' water is returned to the model via a secondary drainage link or it can be demonstrated that infiltrated runoff would not contribute to observed flows downstream either through surface runoff, seepage into drainage lines, interflow or groundwater (for example deep sandy soils).
- The evaporative loss shall be the default value of 125% of the relevant potential evapotranspiration (PET) value.
- The notional detention time of the wetland should typically be between 48 to 72 hr to ensure optimal treatment of nutrients.

The proposed wetland configurations and the stormwater quality treatment efficiencies are summarised in Table 3 and Table 4, respectively.

Table 3: Wetland Requirements

Parameter	Wetland 1 (C1)	Wetland 2 (C2)	Wetland 3 (C3)	Wetland 4 (C4)	Wetland 5 (C5)
Low Flow By-pass (m^3/s)	0	0	0	0	0
High Flow By-pass (m^3/s)	100	100	100	100	100
Inlet Pond Volume (m^3)	200	100	550	255	650
Surface Area (m^2)	3,700	1,450	10,000	5,100	12,200
Extended Detention Depth (m)	0.5	0.5	0.5	0.5	0.5
Permanent Pool Volume (m^3)	1,850	725	5,000	2,550	6,100
Initial Volume (m^3)	1,850	725	5,000	2,550	6,100
Exfiltration Rate (mm/hr)	0	0	0	0	0
Evaporative Loss as % of PET	125	125	125	125	125
Equivalent Diameter (mm)	70	45	110	90	130
Overflow Weir Width (m)	3	3	5	3	5
Notional Detention Time (hr)	63.7	60.4	69.7	53.1	60.9

Table 4: Stormwater Quality Treatment Efficiency

Parameter	Reduction (%)					Objective (%)
	Wetland 1	Wetland 2	Wetland 3	Wetland 4	Wetland 5	
Total Suspended Solids (kg/yr)	81	81.1	81.7	83.2	82.3	80
Total Phosphorus (kg/yr)	67.5	68.1	67.6	68.5	69	45
Total Nitrogen (kg/yr)	45.3	45.7	45.5	45.1	45.3	45
Gross Pollutants (kg/yr)	100.0	100.0	100.0	100.0	100.0	70

5.4. Stormwater Quantity

Assessment of the quantity of stormwater discharge from the developed Site was undertaken by establishing a local hydrological model in XPRAFTS. It allows the quantification of Permissible Site Discharges (PSD) and the optimisation of the detention basins. The following sections summarises the model establishment, PSD estimation, detention basin optimization and mitigation results.

5.4.1. XPRAFTS Parameters

The XPRAFTS parameter identification for the local area was carried out in the Sunnyside Stormwater Management Strategy (Reference 2), through the calibration of a local XPRAFTS model against the Lake Albert WBNM from MOFFRMS (Reference 3). The calibration model presented in Reference 2 covers part of Sunnyside Estate and part of Rowan Village. Therefore, the parameter values identified through the calibration process in Reference 2 are deemed to represent the hydrological characteristics in the local region and were directly adopted for this study.

For details of the parameters and calibration process, refer to Reference 2.

5.4.2. Existing Site Conditions

A site based local XPRAFTS model was established, as shown in Diagram 3. The fraction impervious for each sub-site was set to 0% to represent the existing conditions. The C2 to C5 are standalone sub-catchments, while C1 receives and conveys stormwater from external catchment LA_111 to the discharge point.

An ensemble of storm events was used to simulate 20% to 1% AEP events and evaluate the stormwater peak discharges generated by the contributing catchment areas.

The critical duration for each design event probability and each sub-catchment may vary depending on a number of conditions. Therefore, to ascertain the critical storm duration impacting the site, the consideration of a number of storm durations is important. For this study, the ten (10) temporal patterns from 30 min to12 hr durations for each AEP were analysed.

The PSD for each AEP was determined by the critical duration, which produces the highest mean peak flows of the ten temporal patterns. The PSDs are tabulated in Table 5.

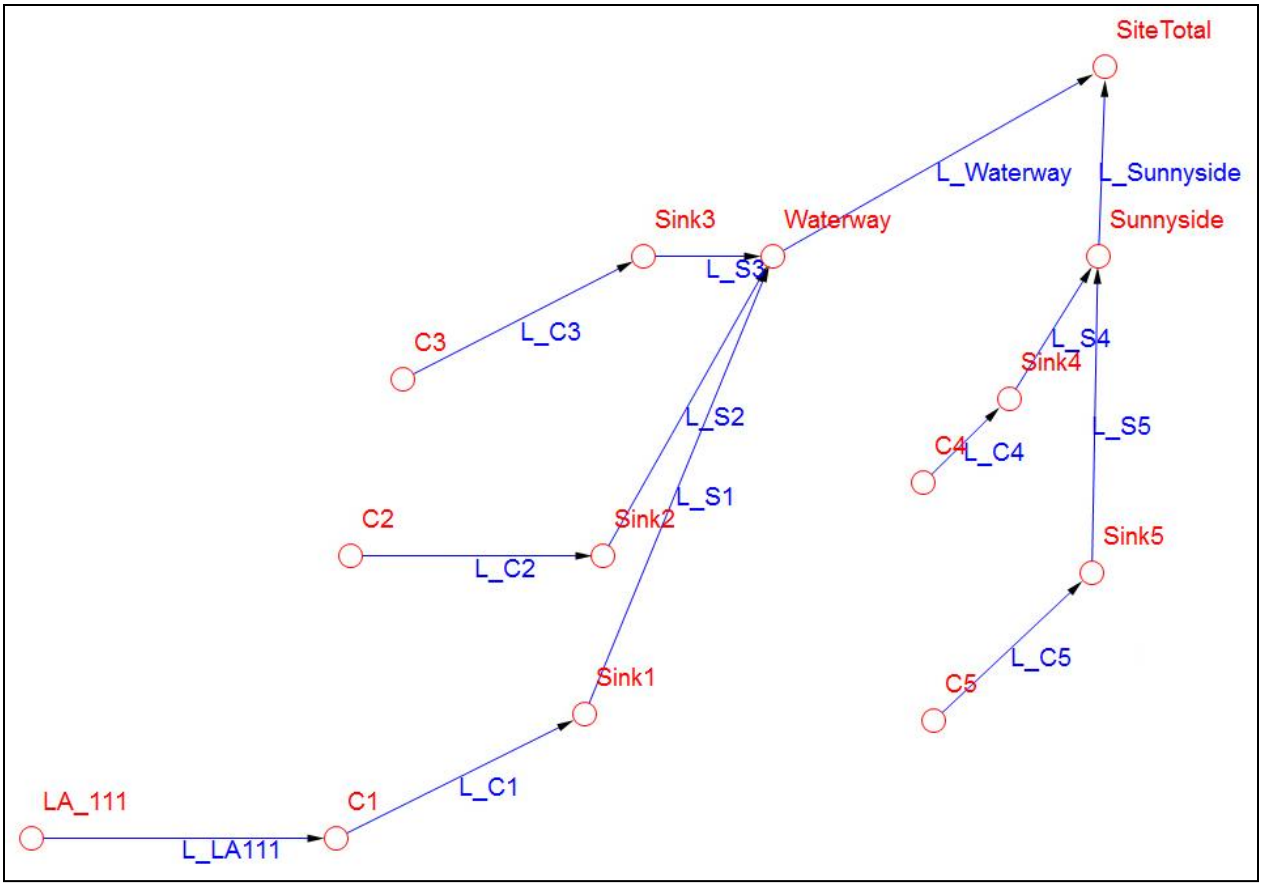


Diagram 3: The Local Site-based XPRAFTS Model Schematic for Existing Conditions

Table 5: Permissible Site Discharges

	C1		C2		C3		C4		C5	
AEP	Peak Q (m^3/s)	Duration	Peak Q (m^3/s)	Duration	Peak Q (m^3/s)	Duration	Peak Q (m^3/s)	Duration	Peak Q (m^3/s)	Duration
1%	4.27	1 hr	0.88	45 min	4.28	1.5 hr	1.98	1.5 hr	5.96	1.5 hr
2%	3.42	1 hr	0.71	1 hr	3.49	1.5 hr	1.57	1.5 hr	4.76	2 hr
5%	2.75	2 hr	0.57	1 hr	2.70	2 hr	1.22	2 hr	3.68	2 hr
10%	2.25	2 hr	0.45	2 hr	2.17	2 hr	0.98	2 hr	2.93	2 hr
20%	1.59	2 hr	0.32	2 hr	1.55	2 hr	0.71	3 hr	2.15	3 hr

5.4.3. Developed Site Conditions

The site based local XPRAFTS model was revised by incorporating five (5) on-site detention basins, as shown in Diagram 4. The pervious and impervious areas for each sub-site were set according to the values in Table 1 to represent the developed conditions.

A detention basin was designed on top of each wetland for each site-based sub-catchment. The conceptual footprint (assumed to be the surface area plus inlet pond area) of each wetland was used as the bottom area for the detention basin. Basin stage-storage relationships were conceptually designed based on the assumed bottom footprints and 1:6 side slope. The basin outlet configurations were adjusted to minimize the requirement for the total footprint of each basin and to ensure that a 'no worsening' of discharge from the developed Site is achieved.

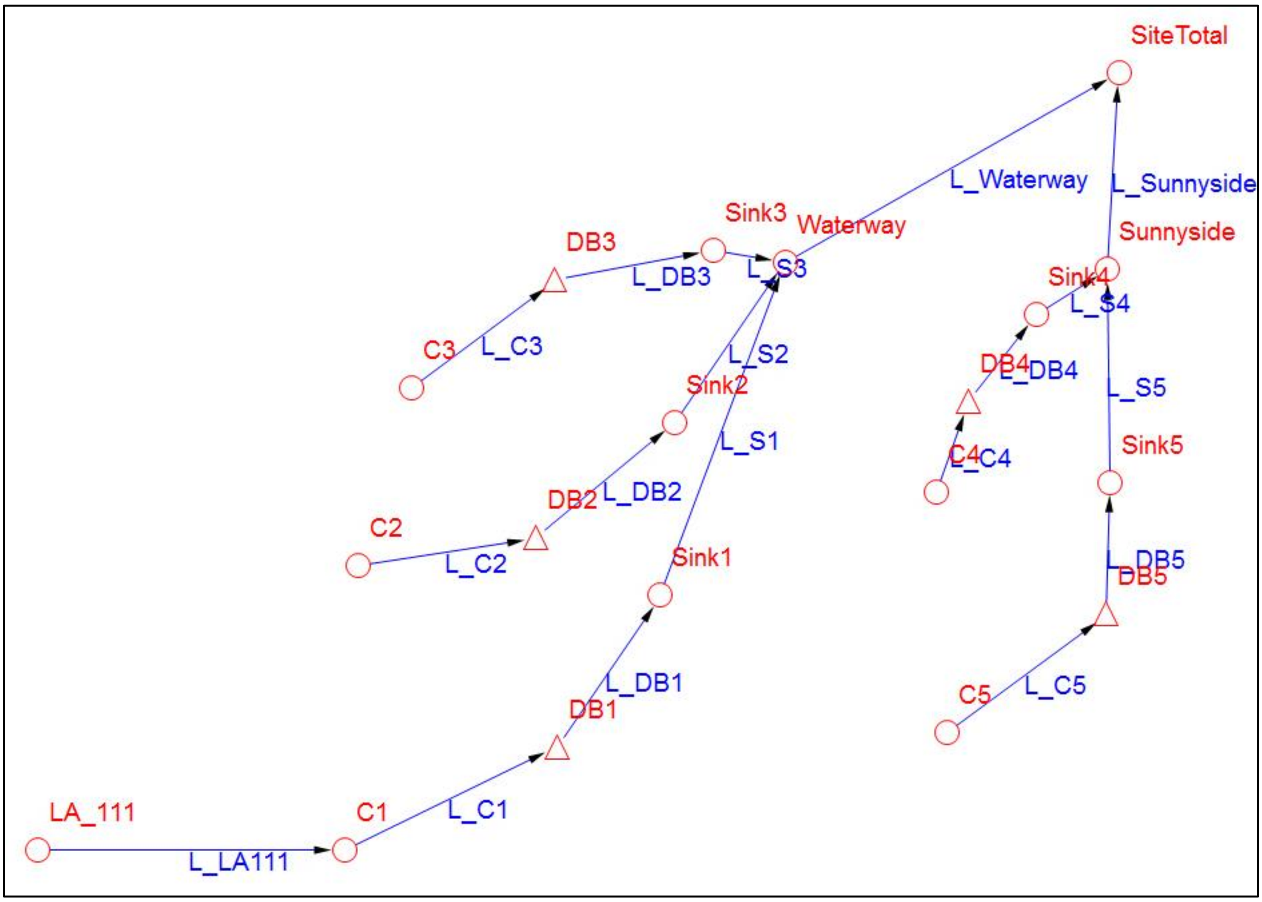


Diagram 4: The Local Site-based XPRAFTS Model Schematic for Developed Conditions

The peak discharges from sub-catchments under the existing, unmitigated(developed), and mitigated(developed) conditions and the final modelled configurations of the three detention basins are summarised in Table 6 to Table 10.

Table 6: Basin Requirements and Peak Discharges from Basin1 (C1)

AEP	Stage (m)	Area (m^2)	Outlet Configuration		Mitigated Flow (m^3/s)	Unmitigated Flow (m^3/s)	PSD (m^3/s)
			IL (m)	Dimension			
Bottom	0	4,212					
20%	0.34	4,758	0	2 × 3 m W × 0.35 m H (twin culverts)	1.58	2.55	1.59
10%	0.37	4,805			2.18	3.26	2.25
5%	0.42	4,883	0.4	12 m W (spillway)	2.63	3.84	2.75
2%	0.47	4,974			3.32	4.46	3.42
1%	0.53	5,075			4.20	5.26	4.27
Freeboard	0.83	5,587					

* Information will be extracted from the model and presented in the final report (similarly hereinafter).

Table 7: Basin Requirements and Peak Discharges from Basin2 (C2)

AEP	Stage (m)	Area (m^2)	Outlet Configuration		Mitigated Flow (m^3/s)	Unmitigated Flow (m^3/s)	PSD (m^3/s)
			IL (m)	Dimension			
Bottom	0	1,754					
20%	0.42	2,200	0	0.95 m W × 0.48 m H (culvert)	0.32	0.99	0.32
10%	0.49	2,283			0.45	1.25	0.45
5%	0.56	2,365	0.53	1.7 m W (spillway)	0.57	1.46	0.57
2%	0.62	2,430			0.71	1.67	0.71
1%	0.68	2,508			0.88	1.91	0.88
Freeboard	0.98	2,871					

Table 8: Basin Requirements and Peak Discharges from Basin3 (C3)

AEP	Stage (m)	Area (m^2)	Outlet Configuration		Mitigated Flow (m^3/s)	Unmitigated Flow (m^3/s)	PSD (m^3/s)
			IL (m)	Dimension			
Bottom	0	11,387					
20%	0.60	13,259	0	2.3 m W × 0.65 m H (culvert)	1.54	6.78	1.55
10%	0.73	13,706			2.02	8.54	2.17
5%	0.81	13,942	0.7	4.5 m W (spillway)	2.58	9.97	2.70
2%	0.89	14,213			3.44	11.30	3.49
1%	1.00	14,578			4.28	12.84	4.28
Freeboard	1.30	15,578					

Table 9: Basin Requirements and Peak Discharges from Basin4 (C4)

AEP	Stage (m)	Area (m^2)	Outlet Configuration		Mitigated Flow (m^3/s)	Unmitigated Flow (m^3/s)	PSD (m^3/s)
			IL (m)	Dimension			
Bottom	0	5,624					
20%	0.64	6,813	0	1.1 m W × 0.7 m H (culvert)	0.71	3.46	0.71
10%	0.75	7,040			0.96	4.37	0.98
5%	0.86	7,244	0.78	1.2 m W (spillway)	1.21	5.10	1.22
2%	0.97	7,470			1.57	5.80	1.57
1%	1.08	7,702			1.90	6.59	1.98
Freeboard	1.38	8,322					

Table 10: Basin Requirements and Peak Discharges from Basin5 (C5)

AEP	Stage (m)	Area (m^2)	Outlet Configuration		Mitigated Flow (m^3/s)	Unmitigated Flow (m^3/s)	PSD (m^3/s)
			IL (m)	Dimension			
Bottom	0	13,884					
20%	0.62	16,337	0	2.95 m W × 0.7 m H (twin culverts)	2.15	8.10	2.15
10%	0.77	16,938			2.74	10.30	2.93
5%	0.84	17,259	0.75	4.8 m W (spillway)	3.51	12.06	3.68
2%	0.95	17,709			4.76	13.74	4.76
1%	1.05	18,110			5.91	15.70	5.96
Freeboard	1.35	19,359					

6. CONCLUSIONS

An Existing Flood Condition Assessment and Site Stormwater Management Strategy has been developed using ARR 2019 current industry best practice for the proposed Rezoning and Subdivision of the subject site, known as Rowan Village, Rowan NSW 2650.

A regional distributed hydrological (WBNM) and hydraulic (TUFLOW) model has been set up based on the WMAwater MOFFRMS model using rainfall and flood estimation techniques consistent with ARR 2019, to define the existing flood characteristics of the Site for flood events with the probability of 20%, 10%, 5%, 2%, 1%, 0.5%, and 0.2% AEPs with a range of critical storm durations. The results of the existing conditions flood modelling provide flood intelligence information to inform the design, including external inflows to be conveyed and the natural flood way to be reserved in the proposed development.

A local water quality model for the developed site has been set up with MUSIC. Five (5) wetlands have been designed using the MUSIC model to ensure the site discharge meeting the stormwater quality objectives. A local hydrological model for the developable site has been set up with XPRAFTS. Five (5) detention basins have been designed on top of the wetlands to ensure "no-worsening" stormwater peak discharges due to proposed development.

The site stormwater quality objectives for the proposed development can be achieved using the five wetlands for the five sub-catchments as denoted in the conceptual plan (Diagram 5) with inlet ponds (200 m^3, 100 m^3, 550 m^3, 255 m^3, 650 m^3) and macrophyte zones (3,700 m^2, 1,450 m^2, 10,000 m^2, 5,100 m^2, 12,200 m^2) as suggested by MUSIC modelling results. It should be noted that batters are not parameterised in MUSIC, which will need to be accounted during the functional design.

The site stormwater quantity objectives can be achieved using five detention basins on top of the wetlands with footprints of 5,587 m^2, 2,871 m^2, 15,578 m^2, 8,321 m^2, and 19,359 m^2, respectively, including freeboard, based on the XPRAFTS modelling results.

Basin 1 was designed to convey both flows generated by both C1 (site) and external sub-catchment on the west. The other four basins were designed to detain stormwater generated within the site. The external flow entering from the southwest will be conveyed through existing waterway with appropriate drainage design where required.

The wetlands and detention basins were designed with the assumption that the entire contributing catchment can be drained to each end-of-line facility. However, it should be noted that the northeast part of C4 (approximately 5.5 ha as hatched in Diagram 5) cannot be drained to Wetland/Basin 4 without significant modification of the topography. Pumping system may be required to drain the stormwater from the northeast part back to the designated wetland / basin. Alternatively, more decentralised solutions with WSUD principles can be further investigated.

In conclusion, the analysis undertaken in this study has demonstrated that the site stormwater requirements and objectives can be achieved through proposed stormwater management measures. The modelling exercise and management plan are conceptual only and the functionality need to be further tested during functional design stage.

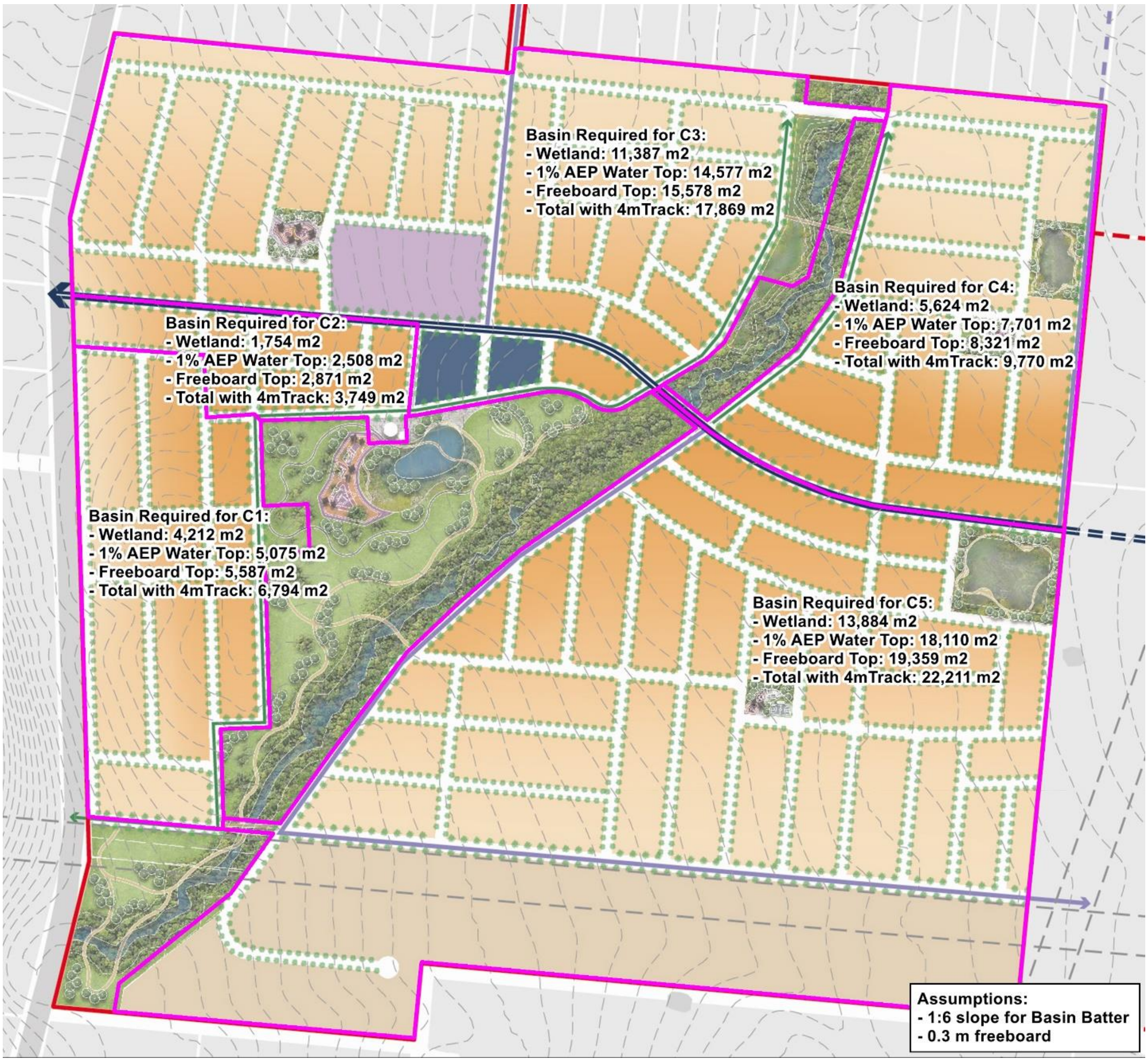


Diagram 5: Stormwater Management Conceptual Plan

7. REFERENCES

1. Colegate, M. & Li, Y.
Sunnyside Estate Wagga Wagga – Precinct Stormwater Drainage Strategy
WMAwater, Australia, 2021

2. Colegate, M. & Li, Y.
Sunnyside Estate Wagga Wagga – Site Stormwater Management Plan
WMAwater, Australia, 2020

3. Joly, F. & Goonan, C.
Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan – Report 01: Data Collection and Model Review
WMAwater, Australia, 2020

4. Goonan C.
Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan
WMAwater, Australia, 2018

5. Richards, Z., Conway, P., & Gray, S.
Wagga Wagga Detailed Flood Model Revision
WMAwater, Australia, 2014

6. Varga, I., Richards, Z., & Gray, S.
Wagga Wagga LGA Murrumbidgee River Flood Modelling
WMAwater, Australia, 2012

7. Gray, S. & Hicks, B.
Wagga Wagga Major Overland Flow Flood Study
WMAwater, Australia, 2011

8. Ball J., Babister M., Nathan R., Weeks W., Weinmann E., Retallick M., & Testoni I. (Editors)
Australian Rainfall and Runoff: A Guide to Flood Estimation
Commonwealth of Australia, Australia, 2019

9. Wagga Wagga City Council
Wagga Wagga Development Control Plan
Wagga Wagga City Council, NSW, Australia, 2010

10. Wagga Wagga City Council
Wagga Wagga Engineering Guidelines for Subdivision and Development Standards
Wagga Wagga City Council, NSW, Australia, 2017

11. Wong T. (Editor-in-Chief)

Australian Rainfall Quality – A guide to Water Sensitive Urban Design
Engineer Australia, 2006

12. Babister, M., Trim, A., Testoni, I., & Retallick, M.
The Australian Rainfall & Runoff Datahub
37th Hydrology and Water Resources Symposium Queenstown NZ, 2016
http://data.arr-software.org/

13. Podger, S., Babister, M., Trim, A., Retallick, M., & Adam, M.
Review of ARR Design Inputs for NSW
WMAwater, Australia, 2019
http://data.arr-software.org/nsw_specific

14. Bureau of Meterology
http://www.bom.gov.au/water/designRainfalls/revised-ifd/

15. Commonwealth of Australia
Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia
Australian Institute for Disaster Resilience, Australia, 2017

16. WaterNSW
Using MUSIC in Sydney Drinking Water Catchment
WaterNSW, NSW, Australia, 2019

Figures


FIGURE 01
SITE LOCATION
Catchment 1
Catchment 2
Catchment 3
Site Boundary
Creeks
Sub-catchments
0
125
250
500
m
N
J:\Jobs\122013\ArcGIS\ArcMap\Main_Figures\Figure01_Site_Location.mxd

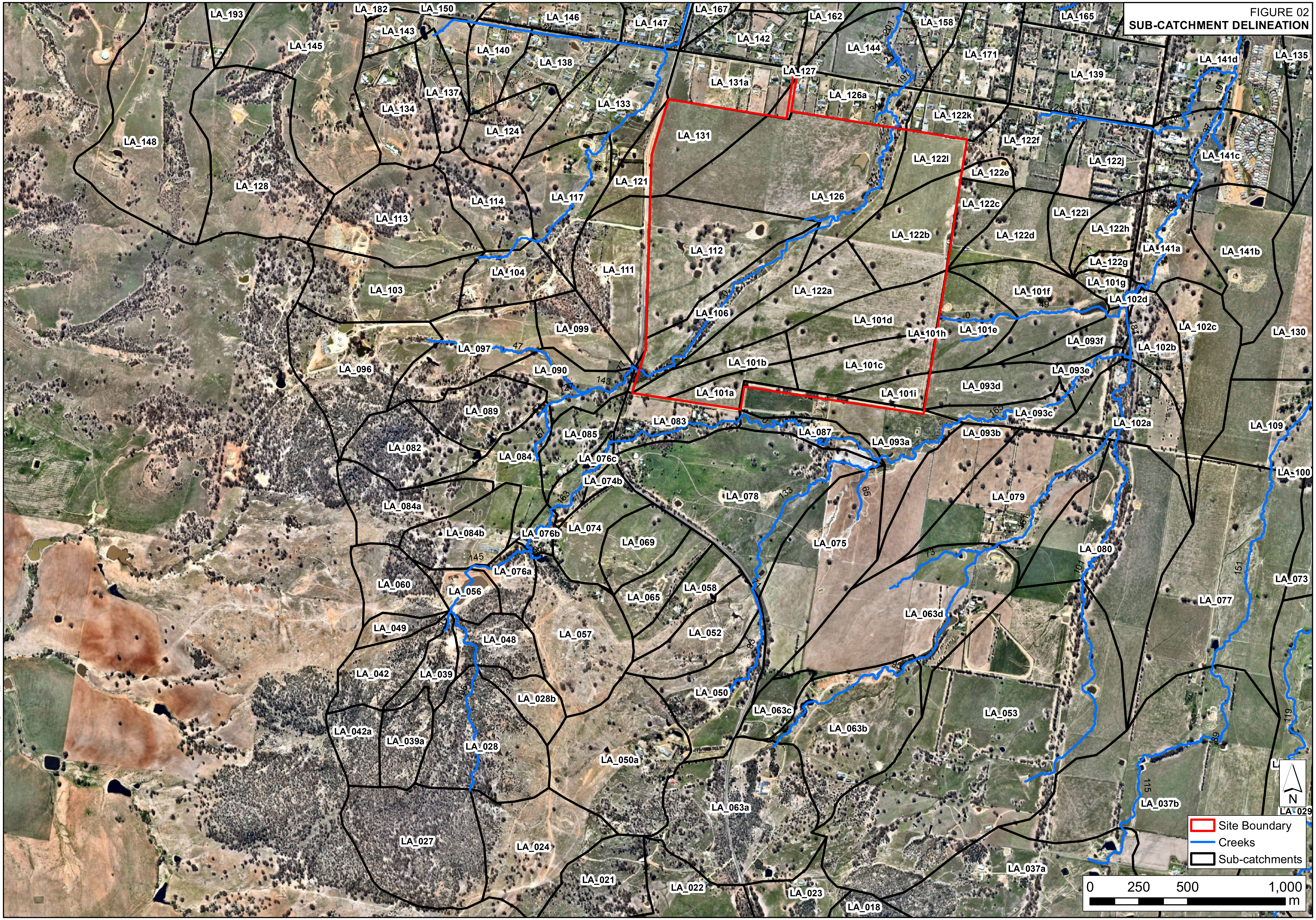


FIGURE 02
SUB-CATCHMENT DELINEATION

J:\Jobs\122013\ArcGIS\ArcMap\Main_Figures\Figure02_Sub-Catchment_Delineation.mxd

FIGURE 03
SITE DELINEATION

Appendix A

APPENDIX A. GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

	redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	

	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood

	storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: - the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or - water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

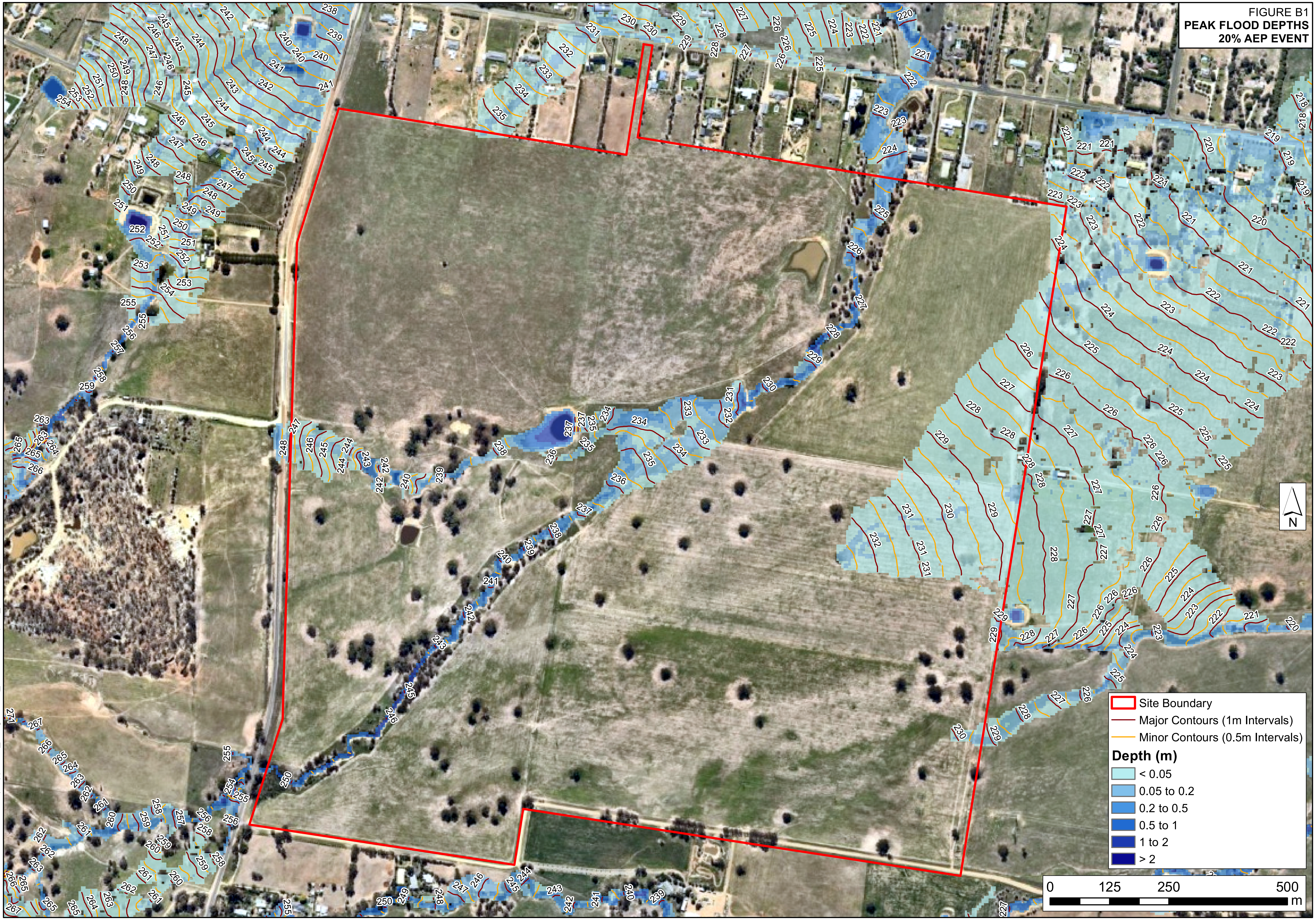
- major overland flow paths through developed areas outside of defined drainage reserves; and/or
- the potential to affect a number of buildings along the major flow path.

mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State=s rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

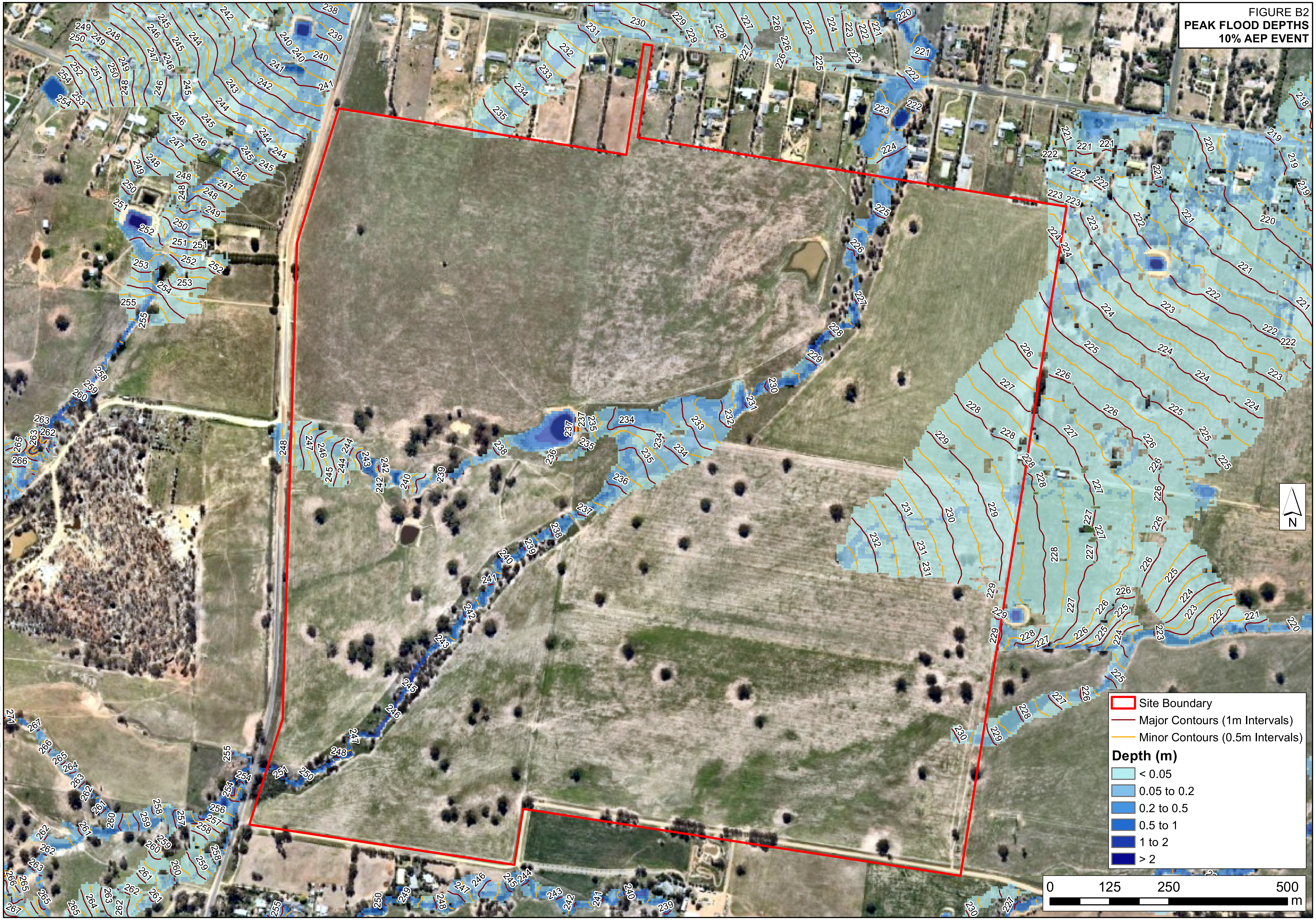
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to Awater level@. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B

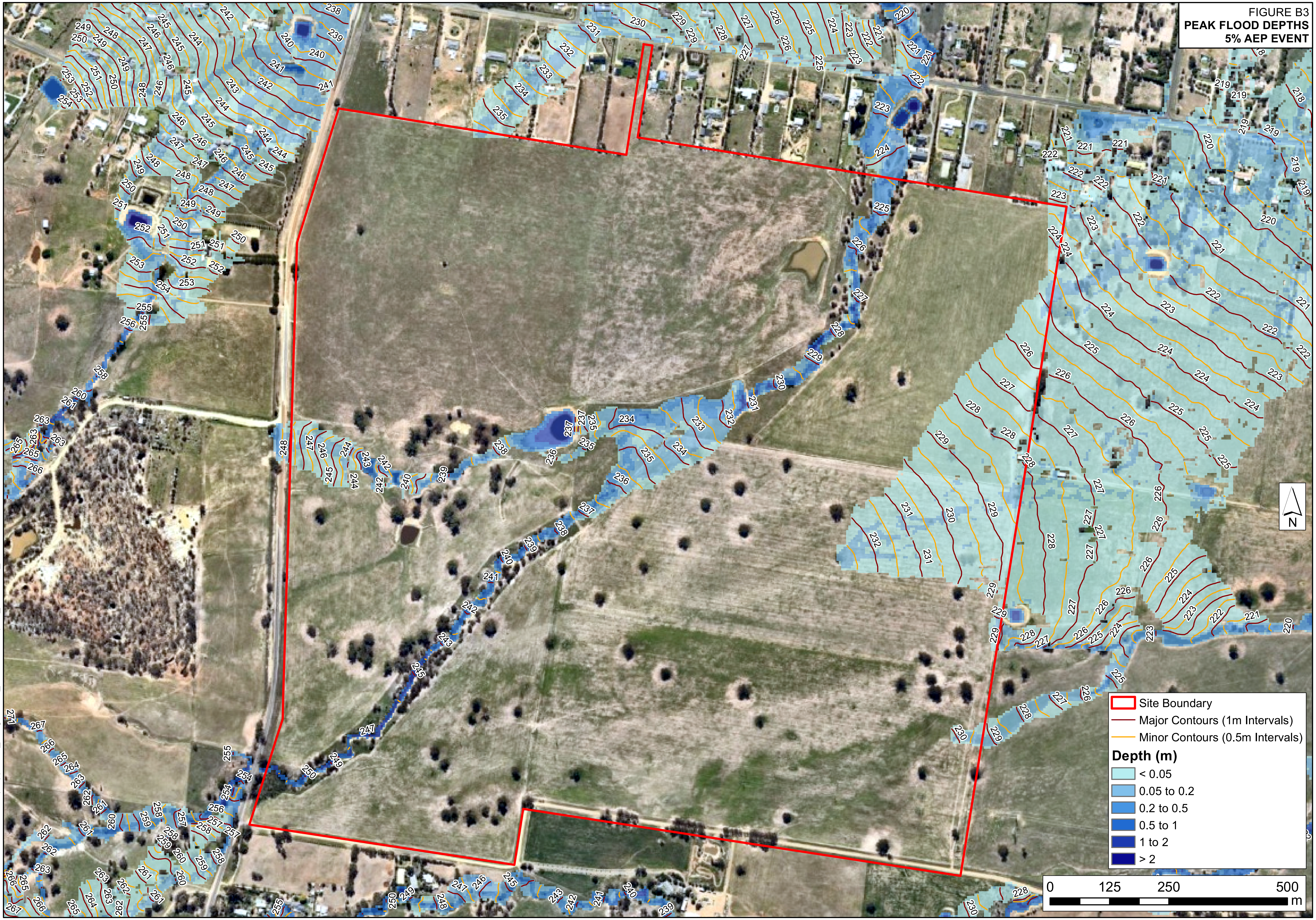
APPENDIX B. FLOOD MAPPING FOR EXISTING CONDITIONS



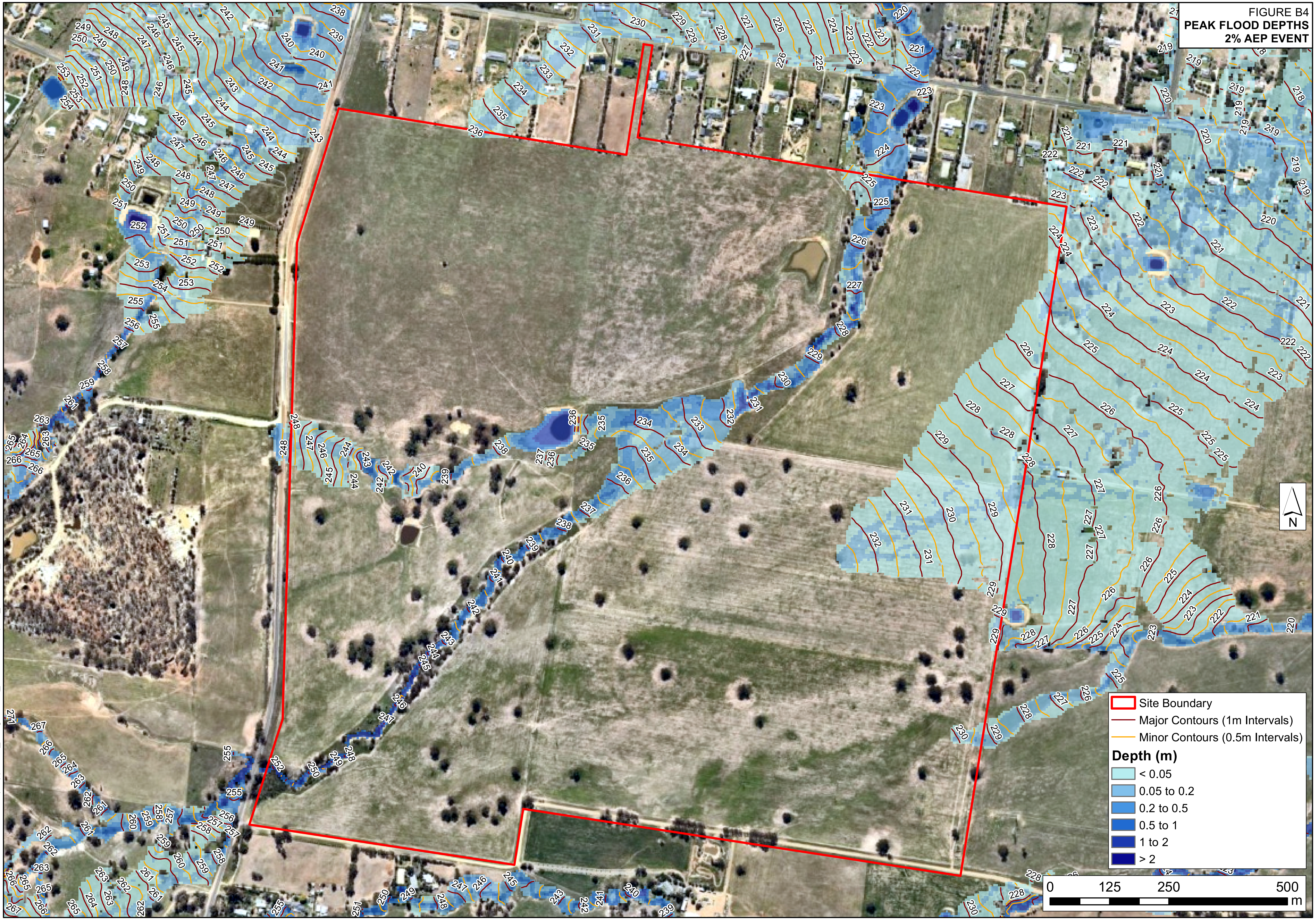
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB01_PeakFloodDepths_005YAEP_Event.mxd



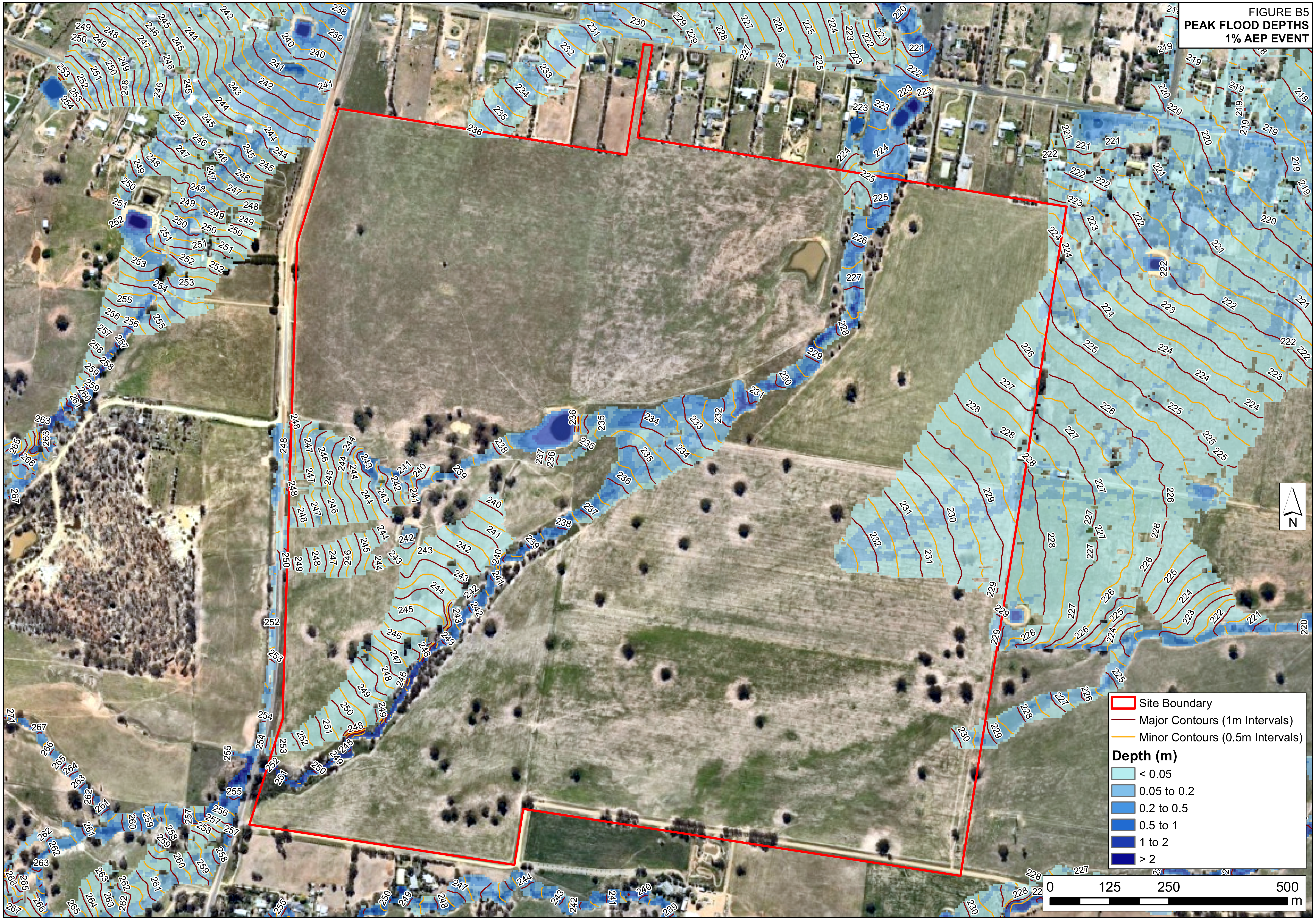
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB02_PeakFloodDepths_010YAEP_Event.mxd



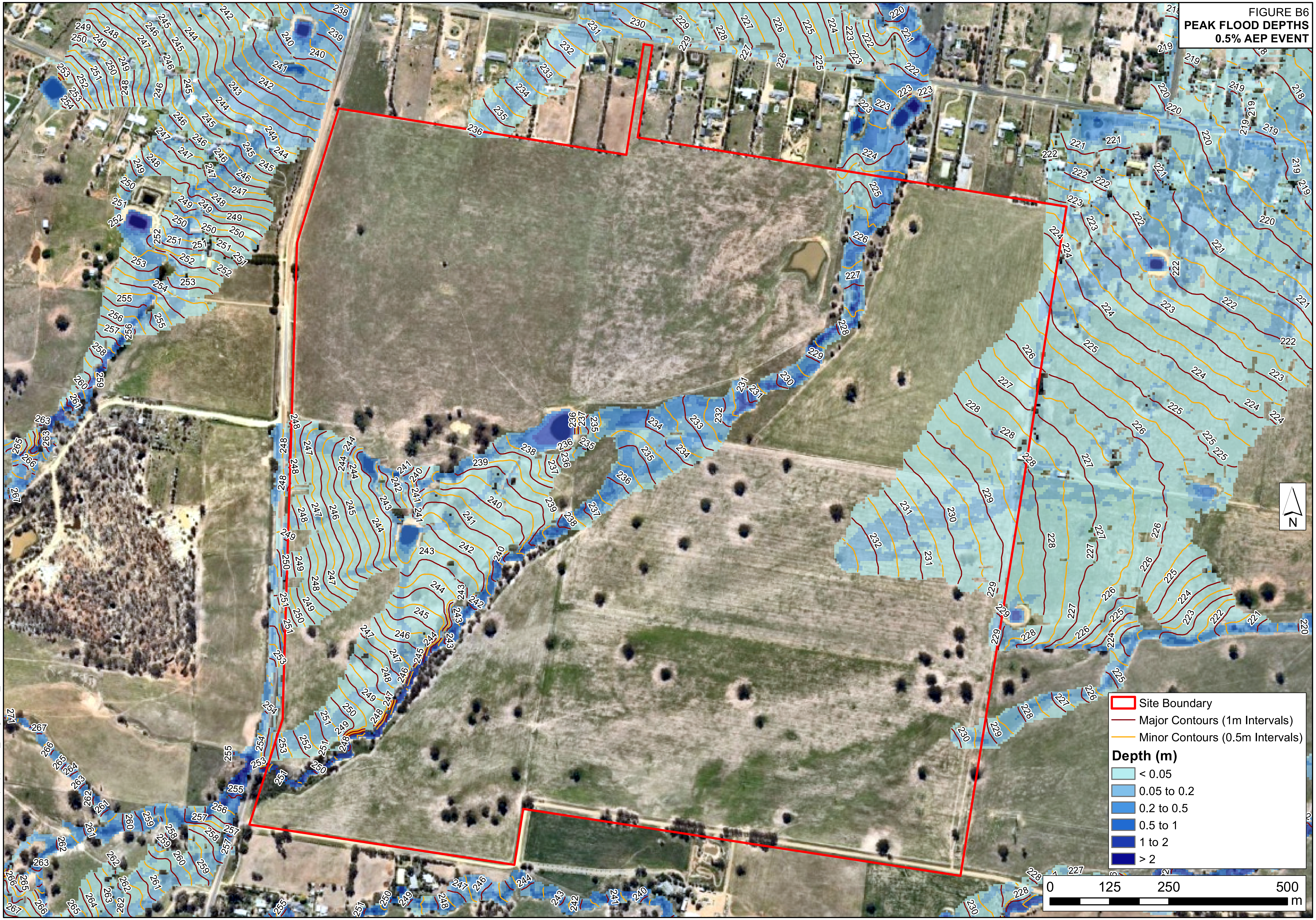
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB03_PeakFloodDepths_020YAEP_Event.mxd



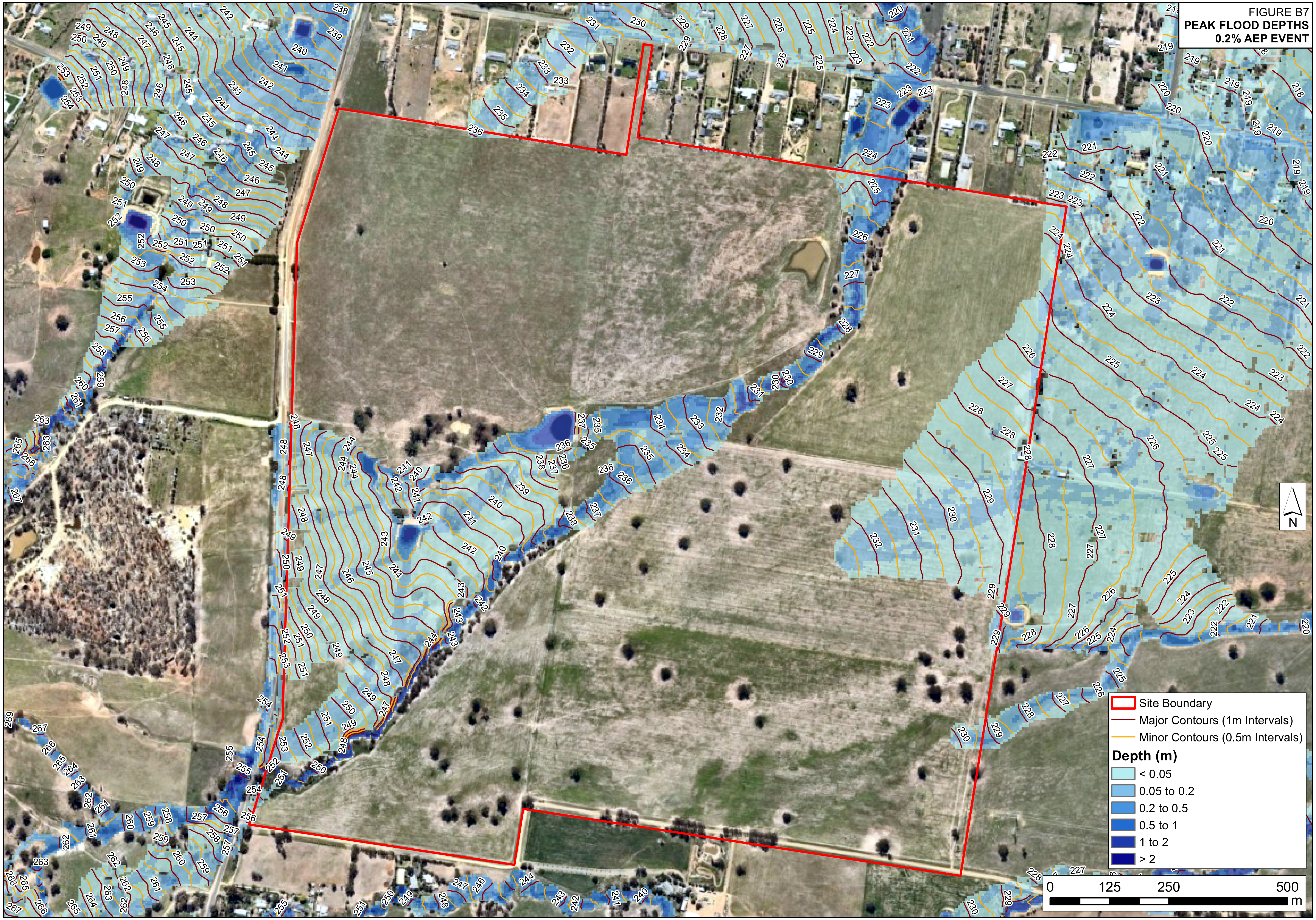
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB04_PeakFloodDepths_050YAEP_Event.mxd



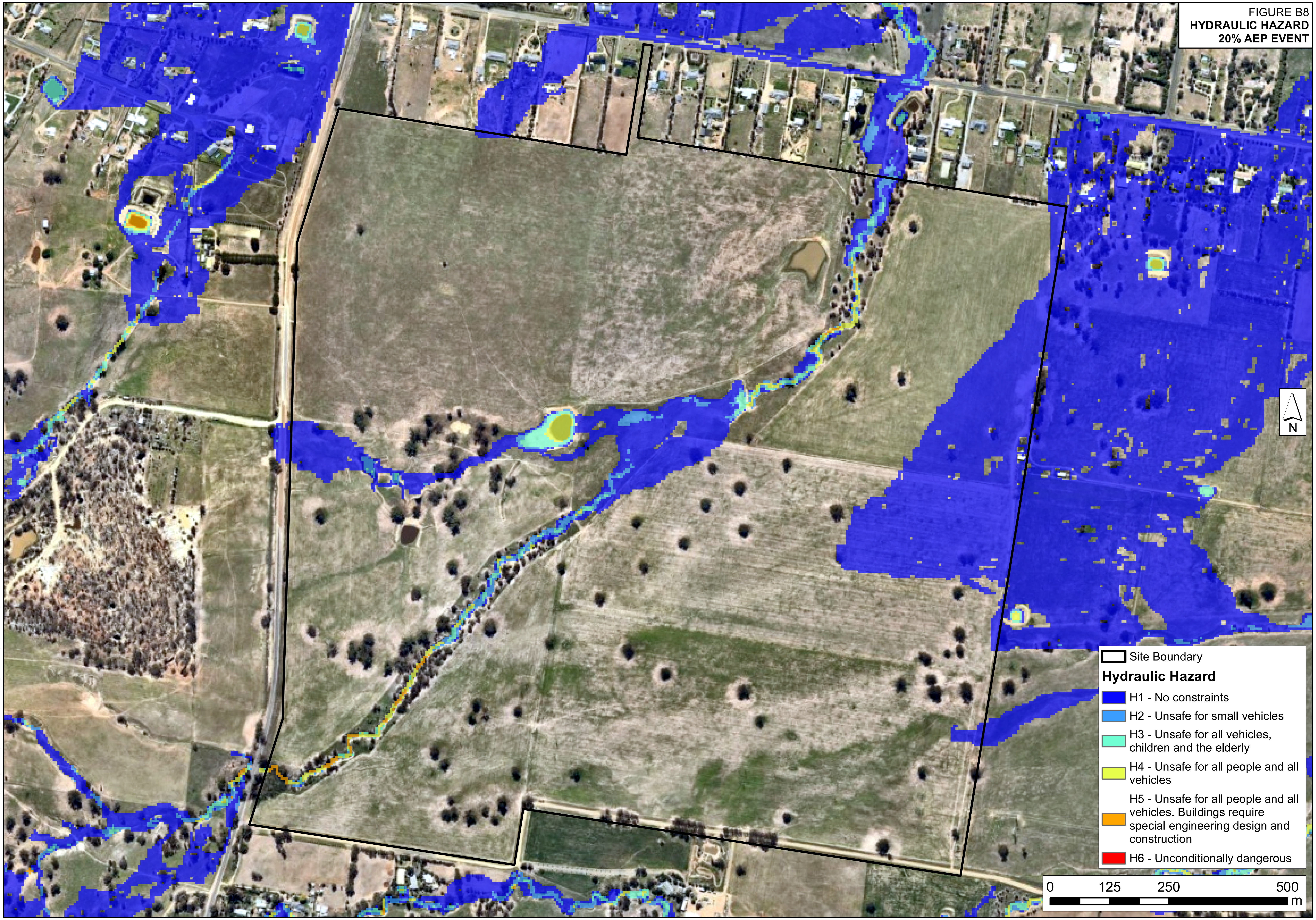
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB05_PeakFloodDepths_100YAEP_Event.mxd



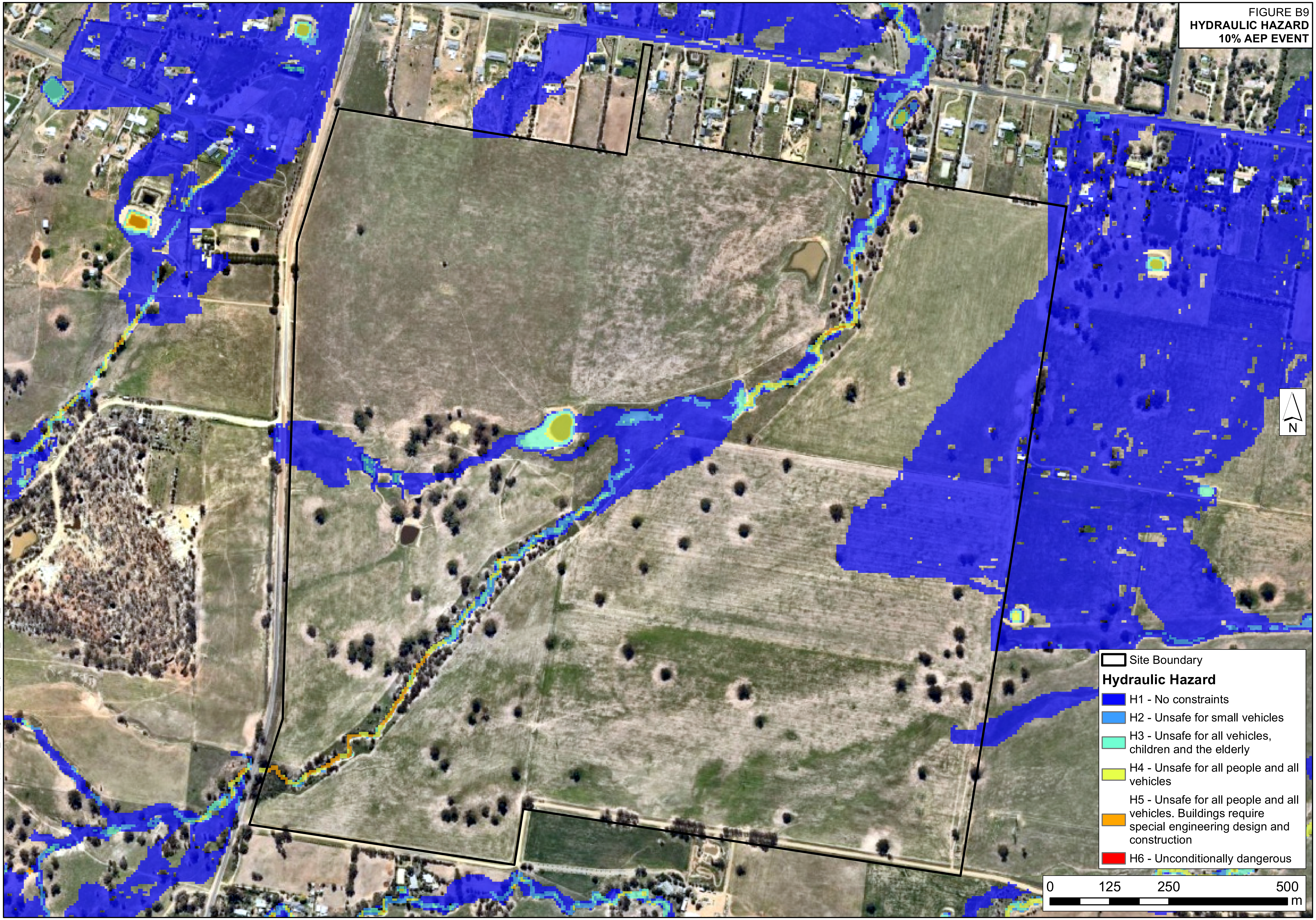
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB06_PeakFloodDepths_200YAEP_Event.mxd



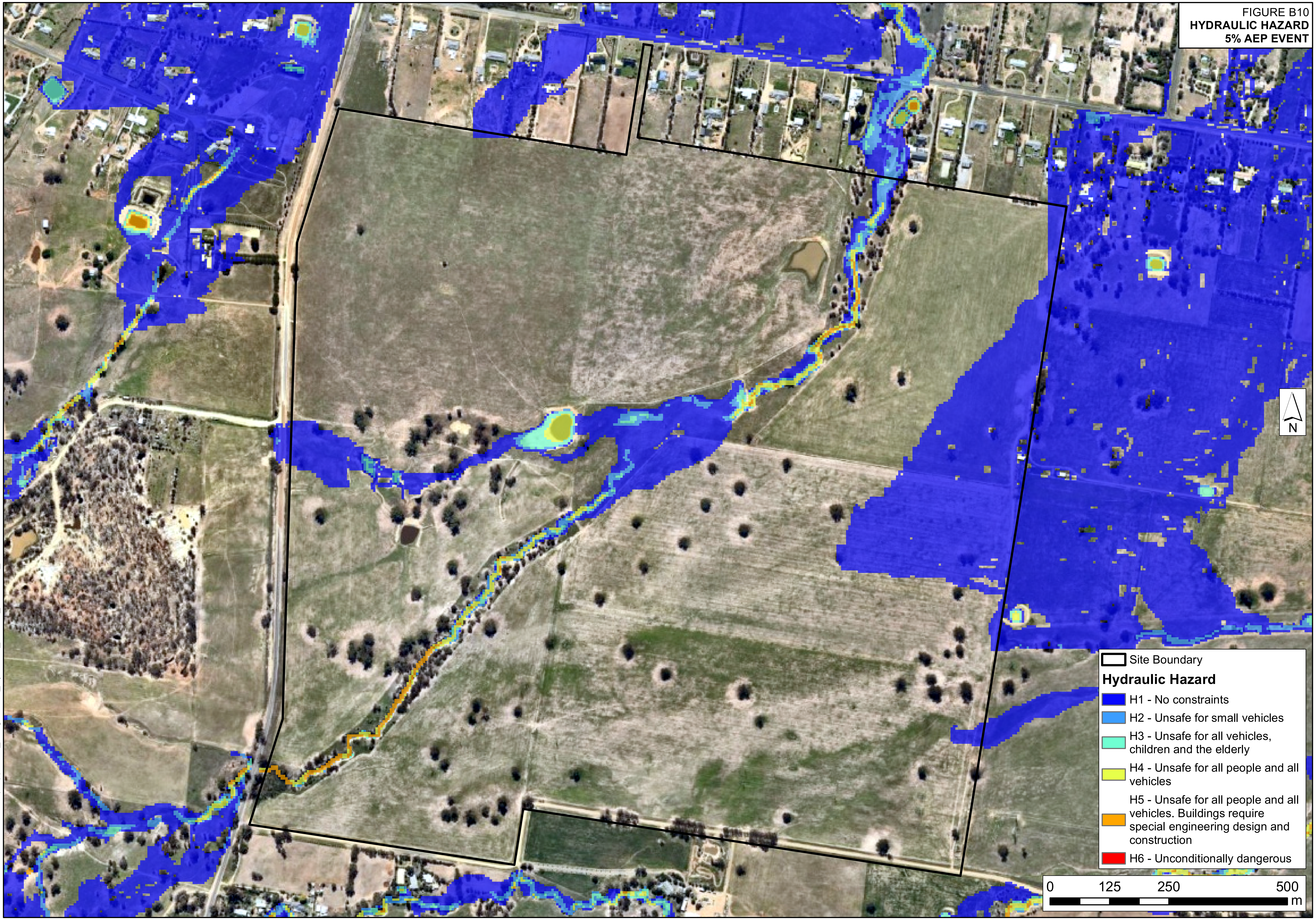
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB07_PeakFloodDepths_500YAEP_Event.mxd



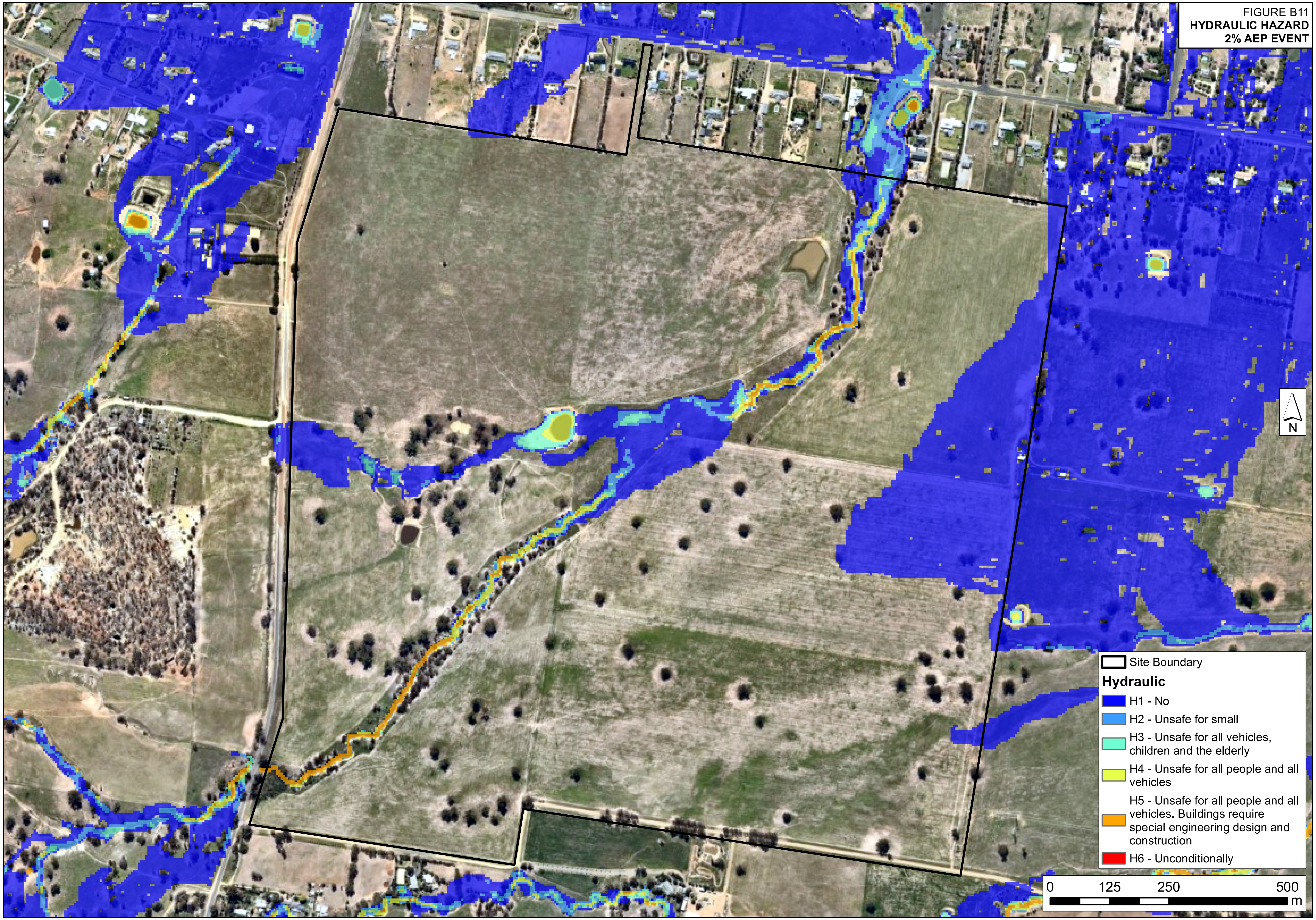
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB08_Hydraulic_Hazard_005YAEP_Event.mxd



J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB09_Hydraulic_Hazard_010YAEP_Event.mxd



J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB10_Hydraulic_Hazard_020YAEP_Event.mxd



J:\Jobs\122013\ArcMap\Appendix_B\FigureB11_Hydraulic_Hazard_050YAEP_Event.mxd

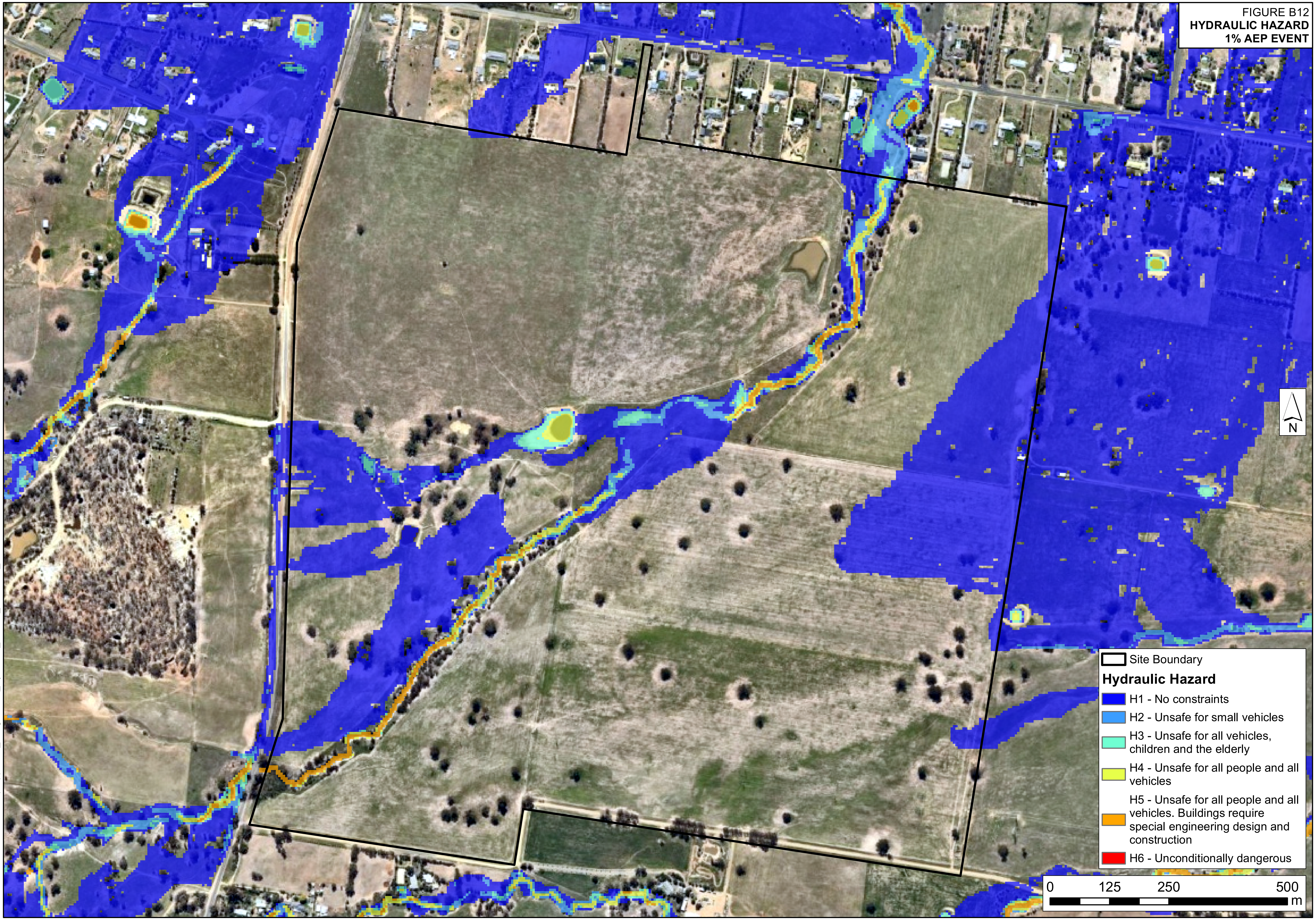
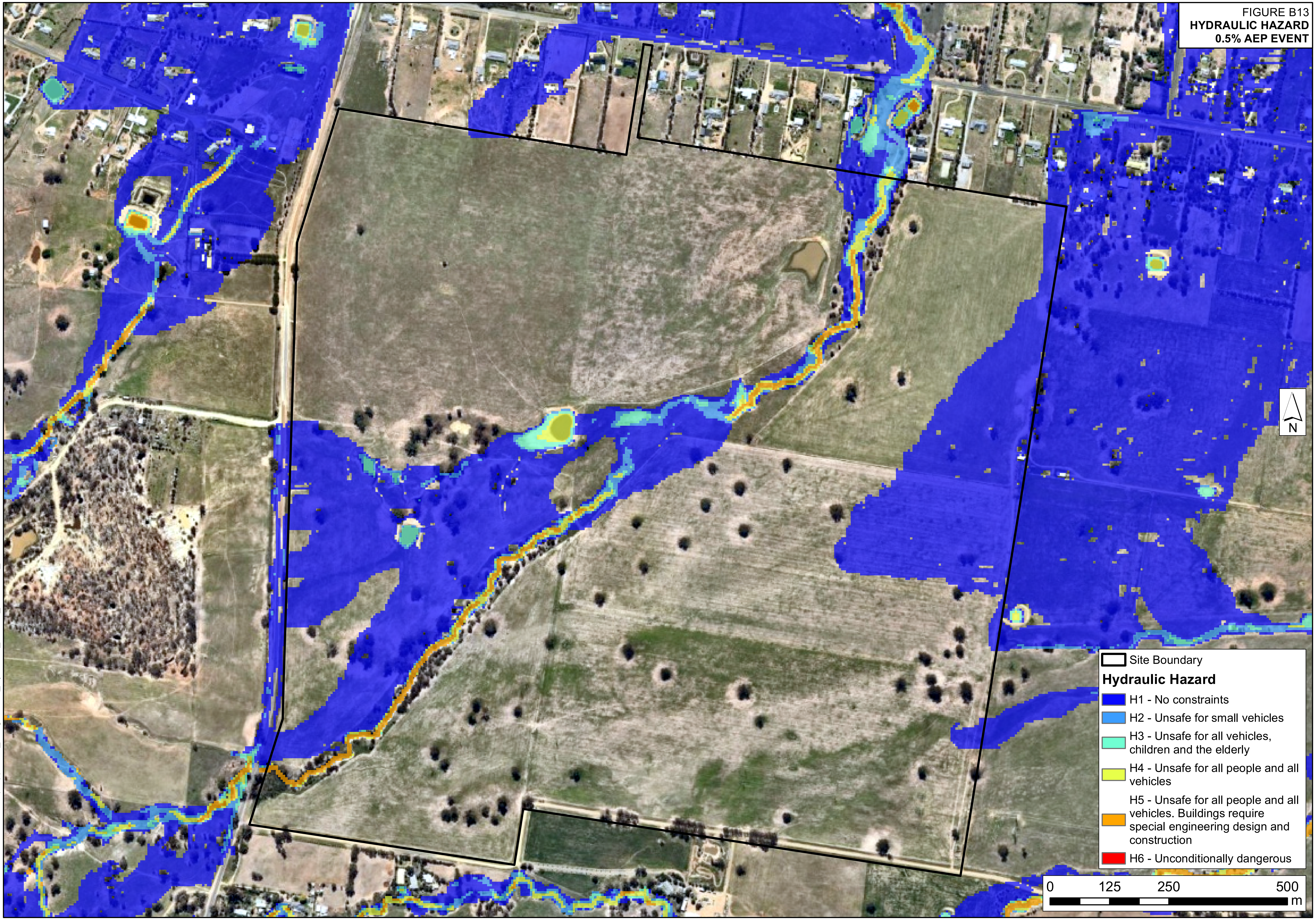
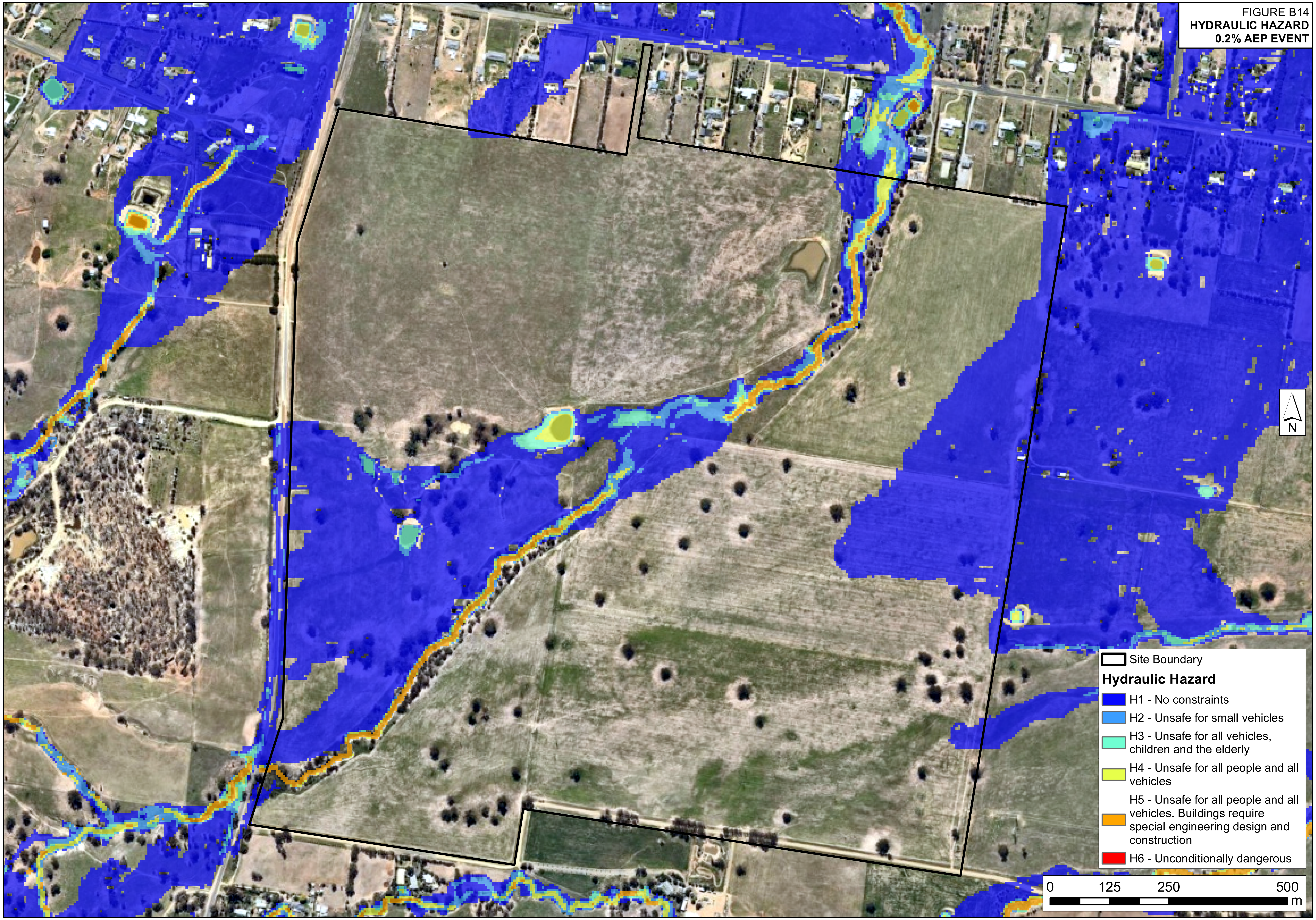


FIGURE B12
HYDRAULIC HAZARD
1% AEP EVENT
N
Site Boundary
Hydraulic Hazard
H1 - No constraints
H2 - Unsafe for small vehicles
H3 - Unsafe for all vehicles, children and the elderly
H4 - Unsafe for all people and all vehicles
H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction
H6 - Unconditionally dangerous
0
125
250
500
m
J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB12_Hydraulic_Hazard_100YAEP_Event.mxd

FIGURE B13
HYDRAULIC HAZARD
0.5% AEP EVENT



J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB13_Hydraulic_Hazard_200YAEP_Event.mxd



J:\Jobs\122013\ArcGIS\ArcMap\Appendix_B\FigureB14_Hydraulic_Hazard_500YAEP_Event.mxd

Appendix C

APPENDIX C. INITIAL LAYOUT PLAN

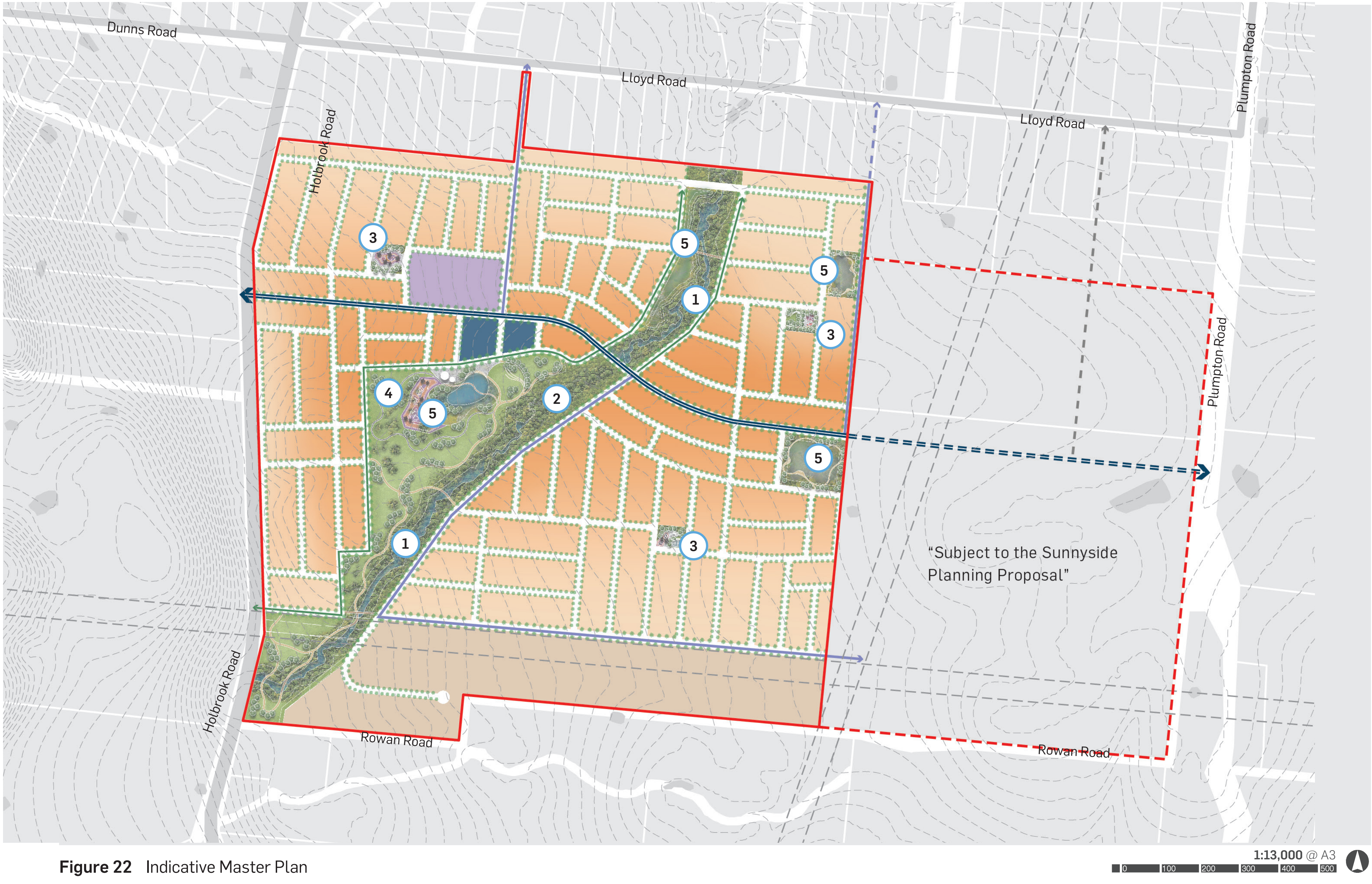


Figure 22 Indicative Master Plan

LEGEND

Rowan Village (The site)

The site has a total area of 225.02 Ha.

Sunnyside Planning Proposal- Indicative

1 **Primary Watercourse**

The primary watercourse of the riparian corridor is categorised as Strahler stream order 2 and 3.

Easements

The existing electricity transmission line is located on the southern side of the site.

2 **Riparian Corridor**

The Riparian Corridor includes a high order water course and allows for a buffer of 20-30m from the top of bank on each side. It runs through the centre of the site and is integrated wholly into the open space network.

3 **Local Parks**

Parks are planned to deliver quality open space within a 400m radius. In combination with passive open spaces along the riparian corridor, they create a connected network of open spaces across the site.

Village Centre

The local Village Centre will support approximately 2700m² of retail floorspace by 2045. This will include c. 1500m² supermarket and 1200m² of retail specialties and additional non-retail convenience based facilities

The Village Centre also supports a 2300m² childcare centre and a 500m² Medical Centre

4 **Open space integrated with the riparian corridor**

This open space corridor is integrated with the riparian corridor and provides recreational amenity for the community. It also provides opportunities to accommodate active open spaces and playgrounds.

5 **Drainage Basin**

Five (5) drainage basins have been proposed to appropriately manage water flows. Three (3) of these are integrated with the riparian corridor, with two (2) others located at the north-east and east of the site.

These are designed with both inaccessible wet basins and dry basins with limited accessibility, including landscape buffer's and walking pathways.

Collector Road

The East-West collector road is proposed at the central location of the site. It provides connection from Holbrook Road through the site and is intended to connect through to Plumpton Rd through the Sunnyside Project to the East. The major project connection creates a network with off-road active transport and public transport options included.

Collector Road - Potential extension towards Sunnyside site

Primary Local Street

Primary roads will provide the main access routes connecting from Lloyd Road and internally to the collector road. This will further support the active transport network.

Potential primary Local Street in Sunnyside Site

Proposed road to wider street network

An opportunity to extend the primary roads in future to the north and east to connect to Lloyd Road and the surrounding context.

Park Road

Park Road is located at the interface with the riparian corridor. It is a green road with tree canopies and active transport routes and provides recreational purpose in addition to accessibility.

Rural Transition Residential Area

These residential lots will be located along the southern boundary of the site and will be the largest residential lot typology. This lot typology will importantly provide an appropriate transition between the site and the adjacent rural context to the south of Rowan Road.

Neighbourhood Residential Area

A range of suitable low density residential lots will be accommodated within close proximity to open space provision and the riparian corridor network. This lot typology will provide the appropriate transition between the village residential lots and the rural transition lots. A diversity of lot sizes will be delivered through the neighbourhood residential lot typology.

Village Residential Area

These residential lots will leverage off the close proximity to the local centre and its associated amenities and offerings. Fundamentally, these residential lots will still uphold the low density residential housing charter that the site will deliver, whilst ensuring that an appropriate diversity of housing choice is delivered.

Seniors Living

The senior living component is located adjacent to the collector road, the village centre and the local open space to take advantage of the high amenity and accessibility.