4273 Goulburn Road, Crookwell

(Lot 24 DP1119250)

Flood Impact and Risk Assessment (FIRA)

Revision 1
March 2024

Catchment Simulation Solutions

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Client	Client Representative
	Tina Dodson (Premise)

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1 INTRODUCTION

Upper Lachlan Shire Council, on behalf of Tina Dodson of Premise, is proposing to amend the Upper Lachlan Local Environment Plan (LEP) 2010 by rezoning land located at Lot 24 DP1119250 at Crookwell, NSW (herein referred to as 'the site'). The planning proposal seeks to upzone the site from RU1 (primary production) zoning to R5 (large lot residential) zoning to allow for future subdivision into smaller lots. The areas of the site that will be dedicated to the conveyance and storage of flood water will be rezoned from RU1 to C3 (Environmental Management). The location of the site is shown in **Figure 1**, which is enclosed in **Appendix A**. **Figure 1** shows that the existing site largely comprises of rural pasture and scattered trees, with a single dwelling in the north-western corner of the site.

The planning proposal went through the Department of Planning and Environment (DPE) gateway process which has identified that parts of the site are likely to experience overland flow. Therefore, any potential changes across the site have the potential to alter existing flood behaviour which may adversely impact on nearby properties. Furthermore, rezoning of the existing site to allow intensification of development across flood liable land is potentially inconsistent with Section 9.1 Ministerial Direction 4.1 *Flooding*. As such, any rezoning must manage the flooding to ensure the existing flood risk is not increased.

In recognition of the existing overland flow risk through the site and the potential for any future development to adversely impact on flooding across neighbouring properties, DPE requested a Flood Impact and Risk Assessment be prepared. In this regard, the current report has been prepared and aimed to address the following objectives:

- Define the impact of flooding on the rezoning area, including local overland flows across the range of possible floods up to and including the Probable Maximum Flood (PMF)
- Quantify the impact of the development on flood behaviour, particularly adverse impacts on existing properties downstream of the site
- Quantify the potential impact of flooding on the safety of people within the rezoning area across the full range of possible floods, and
- Quantify the impact of climate change on flooding.

The following report summarises the outcomes of this assessment.

2 Existing Flood Behaviour

2.1 General

In order to understand the potential impact of the rezoning, including the future subdivision and development of the land on flood behaviour, it was first necessary to define flood behaviour for "existing" conditions. *'The Village of Crookwell Flood Study'* (Lyall and Associates, 2014) is the most contemporary representation of flood behaviour in the area. However, the flood model used as part of this study did not include the subject site. Therefore, there is no available flood information for the site. Therefore, it was necessary to develop new hydrologic and hydraulic models of the local catchment to define existing overland flow behaviour.

The hydrologic model, which is used to simulate rainfall-runoff processes, was developed using the XP-RAFTS software. The hydraulic model, which is used to simulate movement of runoff along the various watercourses, was developed using the TUFLOW software.

The following chapter describes the model development process as well as the outcomes of the existing flood assessment.

2.2 XP-RAFTS Modelling

2.2.1 Catchment Delineation

As shown in **Figure 1**, several small tributaries extend through the site. The tributaries form part of the wider Kiamma Creek catchment.

The CatchmentSIM software was used to delineate the contributing catchment draining through the site as far downstream as East Street (located approximately 450 m downstream of the site).

The subcatchment delineation was based on a 2 metre Digital Elevation Model (DEM) that was developed from a mix of 2009 and 2016 LiDAR data obtained from the ELVIS website. The overall catchment was broken up into a number of smaller subcatchments to better define the spatial variation of hydrologic properties across the catchment. The adopted subcatchments are shown on **Figure 2**.

A variety of hydrologic parameters were calculated for each subcatchment to enable the hydrologic model to be parameterised. This included:

- Subcatchment area
- Subcatchment slope
- Percentage impervious
- Roughness (PERN)
- Flow path length

The subcatchment area, subcatchment slope and flow path length were calculated automatically by the CatchmentSIM software based on the underlying DEM.

The percentage impervious and subcatchment roughness were calculated by developing a series of land use polygons representing each major land use across the catchment, and these are shown on **Figure 3**. A representative impervious percentage and roughness was assigned to each of the land use types and is listed in **Table 1**. This information was then used to calculate a weighted average impervious percentage and roughness value for each subcatchment. The adopted subcatchment properties are provided in **Appendix B**.

Table 1 Adopted land use Impervious percentage and Manning's "n" Roughness Values

Material Description	Impervious (%)	Roughness
Grass	0	0.030
Trees	0	0.100
Waterbodies	100	0.030
Roadway	100	0.015
Urban Lots	70	0.070
Open Space (proposed conditions)	0	0.030
Watercourses	0	0.040
Building	100	XP-RAFTS: 0.025 TUFLOW: 1.000

Where possible, the hydrologic parameters shown in **Table 1** are consistent with those adopted as part of the '*The Village of Crookwell Flood Study'* (Lyall and Associates, 2014).

2.2.2 Model Development

The subcatchment information described in the previous sections formed the basis for developing an XP-RAFTS hydrologic model of the catchment. The subcatchment and nodal-link layout is shown on **Figure 2**. Each subcatchment "node" was parameterised based on the information contained in **Appendix B**.

Time delay routing links were adopted to represent the routing of flows between subcatchment "nodes". The Bransby-Williams equation was adopted for the lag calculations with a 0.6 factor applied to convert from time of concentration to a main stream channel lag.

2.2.3 Rainfall

Point rainfall depths were downloaded from the Bureau of Meteorology 2016 IFD website for the 63.2%, 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events. The adopted rainfall depths for each frequency are provided in **Table 2**.

Table 2 Design Rainfall Depths

Duration	Rainfall Depth (mm)									
	63.2% AEP	**50% AEP**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**	**1% AEP**	**0.5% AEP**	**0.2% AEP**	**PMP**
5 mins	4.54	5.02	6.53	7.54	8.53	9.82	10.8	12	13.6	N/A
10 mins	6.98	7.76	10.2	11.9	13.5	15.6	17.3	19.2	21.7	N/A
15 min	8.59	9.55	12.6	14.6	16.6	19.3	21.4	23.7	26.9	150
20 mins	9.8	10.9	14.3	16.6	18.9	21.9	24.2	26.9	30.5	N/A
25 mins	10.8	11.9	15.7	18.2	20.6	23.9	26.4	29.3	33.2	N/A
30 mins	11.6	12.8	16.8	19.5	22.1	25.5	28.2	31.3	35.4	220
45 mins	13.5	14.9	19.4	22.4	25.4	29.3	32.2	35.7	40.5	280
1 hour	15	16.5	21.4	24.7	27.9	32.1	35.3	39.1	44.4	330
1.5 hour	17.3	19.1	24.6	28.3	31.9	36.7	40.3	44.7	50.6	420
2 hours	19.3	21.2	27.3	31.3	35.3	40.6	44.6	49.4	56	490
3 hours	22.5	24.7	31.8	36.5	41.2	47.4	52.2	57.9	65.6	600
4.5 hours	26.4	29.1	37.4	43.2	48.8	56.4	62.2	69	78.3	N/A
6 hours	29.7	32.7	42.3	49	55.5	64.4	71.3	79	89.6	800
9 hours	35.1	38.8	50.6	58.9	67.1	78.3	87	96.5	110	N/A
12 hours	39.4	43.7	57.5	67.2	77	90.2	101	112	127	N/A
18 hours	46.2	51.5	68.6	80.7	93	110	123	136	154	N/A
24 hours	51.3	57.4	77.2	91.2	106	125	140	155	176	N/A
36 hours	58.6	65.8	89.6	107	124	147	164	183	208	N/A
48 hours	63.6	71.7	98.2	117	136	161	181	200	228	N/A
72 hours	70.3	79.4	109	130	152	179	200	222	251	N/A
96 hours	74.7	84.5	116	138	161	190	212	234	264	N/A

Probable Maximum Precipitation

As part of the current study, it was also necessary to define flood characteristics for the Probable Maximum Flood (PMF). The PMF is considered to be the largest flood that could conceivably occur across a particular area and is used to define the extent of the flood liable area. The PMF is estimated by routing the Probable Maximum Precipitation (PMP) through the XP-RAFTS model. The PMP is defined as the greatest depth of rainfall that is meteorologically possible at a specific location.

PMP depths were derived for a range of storm durations up to and including the 6-hour event based on procedures set out in the Bureau of Meteorology's *'Generalised Short Duration Method'* (GSDM) (Bureau of Meteorology, 2003). The GSDM PMP calculations are provided in **Appendix C** and a summary of rainfall depths is included in **Table 2**.

2.2.4 Rainfall Losses

The initial-continuing loss model was applied as part of the design storm simulations to simulate rainfall losses across the catchment. The burst losses for pervious sections of the catchment were assigned using the ARR2019 data hub "probability neutral" burst losses. The pervious continuing loss rates were applied as per the revised New South Wales jurisdictional guidance published on the ARR data hub. This involves applying a 0.4 factor to the published data hub value of 4.30mm/hr (i.e., 0.4 x 4.3mm/hr = 1.72 mm/hr). For impervious surfaces, a burst loss of 0 mm and a continuing loss rate of 0 mm/hr were adopted.

2.2.5 Temporal Patterns

ARR2019 employs 10 different temporal patterns for each AEP/storm duration to define the time variation in rainfall during each storm. The use of a variety of different temporal patterns is intended to reflect the natural variability of a typical rainfall event (i.e., no two storms will be the same).

The temporal patterns for the study area were downloaded from the ARR data hub and were used to simulate the temporal distribution of rainfall for each design storm. In accordance with ARR2019 for catchments with an area less than 75 km^2, the "point" temporal patterns rather than "areal" temporal patterns were selected to describe the temporal variation in rainfall.

ARR2019 groups the temporal patterns into "frequent", "intermediate" and "rare" bins, which were applied to each design storm as follows:

- Frequent temporal patterns: 63.2% AEP, 50% AEP and 20% AEP
- Intermediate temporal patterns: 10% AEP and 5% AEP
- Rare temporal patterns: 2% AEP, 1% AEP, 0.5% AEP and 0.2% AEP

For the PMP, a single temporal pattern was adopted for each PMP storm simulation in line with the approach recommended in the *'Generalised Short Duration Method'* (GSDM) (Bureau of Meteorology, 2003).

2.2.6 Results

Peak discharges were generated for the full range of storm durations and temporal patterns for each subcatchment for the 63.2%, 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events. The critical storm duration for each XP-RAFTS subcatchment was then determined. This involved calculating the average design discharge for each subcatchment (based on consideration of the suite of ten temporal patterns for each storm frequency and duration). The storm duration that produced the highest average discharge was adopted as the critical duration for each subcatchment. The critical duration for each XP-RAFTS model subcatchment is summarised in **Appendix D**.

A representative ARR2019 temporal pattern for each subcatchment was also selected. This was identified as the temporal pattern that generated the next highest peak discharge above the average. The adopted temporal pattern for each subcatchment and the associated peak discharge is also included in **Appendix D**.

The storm duration/temporal pattern combinations that produced the critical flow within the site, for each flood event is presented in **Table 3**. All storm duration/temporal pattern combinations in **Table 3** were adopted as part of all subsequent analysis to define design flood behaviour for this study.

Table 3 Adopted storm duration and temporal patterns.

Adopted Storm Duration	Adopted Storm Temporal Pattern									
	63.2% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMP#
15	3746	3742	3742							N/A
30										N/A
45						3844	3844	3844	3844	
60					3884	3871	3875	3819	3876	N/A
90						3890	3907	3907		N/A
120			3956	3901	3901					
180										
270										
360										
540										
720	4093	4093								
1440	4155	4155								

Only one temporal pattern is provided by the GSDM PMP Method

2.3 TUFLOW Modelling

2.3.1 Model Development

A hydraulic model of the local watercourses draining through the site was developed using the TUFLOW software. Key features of the TUFLOW model are summarised below:

- Model Domain: the TUFLOW hydraulic model area extends across the full extent of the site and areas upstream of the site. The model also extends 450 metres north-west of the site to the crossing of East Street, Crookwell (i.e., well downstream of the site) to ensure the adopted downstream boundary condition did not impact on flood behaviour in the vicinity of the site. The extent of the model is shown on **Figure 3**.
- Grid Size: a 2 metre grid size was used to represent the variation in terrain and hydraulic properties (e.g., hydraulic roughness) across the catchment.
- Topography: A combination of 2009 and 2016 LiDAR data was used to assign elevations to each TUFLOW model grid cell. Minor terrain modifications were also included in area where the LiDAR data provided a less reliable representation of the ground surface, such as along the watercourses and to represent the bottom profile of farm dams.

- Land Use and Hydraulic Roughness: the land use types across the model domain were used within the TUFLOW model to assign hydraulic roughness coefficients to each grid cell. The adopted roughness coefficients are included in **Table 1** and the extent of each land use is shown on **Figure 3**.
- Buildings: Buildings can provide a significant impediment to flow. Therefore, as shown in **Table 1**, buildings were represented in the TUFLOW model using a high roughness value of = 1.0 to reflect this flow impediment.
- Farm Dams: A number of farm dams are located in the site as well as within the upstream catchment. Although these water bodies do have the potential to temporarily store water during rainfall events, none of the storages are explicitly designed to serve as flood detention basins. As a result, these dams were assumed to be "full" at the start of each simulation and provided no formal attenuation of flows.
- Inflow hydrographs: The critical flow hydrographs generated by the XP-RAFTS model (as outlined in **Table 3**) were used to define inflows to the hydraulic model. The local hydrographs were applied to the TUFLOW model at the outlet of each XP-RAFTS model subcatchment.
- Downstream Boundary: The downstream boundary condition was defined using a 'normal depth' (i.e.: Manning's) calculation. A slope of 6% was adopted for the downstream boundary at East St, Crookwell, whilst a 2% slope was used on the boundary near Kiamma Creek based on the available LiDAR at the respective locations.
- Hydraulic Structures: Culverts were included at waterway crossings of major roadways based on field measurements. Although the culvert dimensions are not of a survey standard, they are considered sufficient for the current assessment.
- Hydraulic Structure Blockage: Blockage for all culverts have been calculated based on procedures outlined in *'Australian Rainfall and Runoff – Project 11: Blockage Guidelines for Culverts and Small Bridges'* (Engineers Australia, 2015). The blockage calculations and adopted blockage factors are contained within **Appendix E**. A 'high blockage' sensitivity assessment for the 1% AEP event was also completed and is discussed in Section 3.6.

2.3.2 Results

The TUFLOW model was used to simulate flood behaviour for the 63.2%, 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events as well as the PMF for existing topographic and development conditions.

Flood mapping was prepared for each design flood by enveloping the peak flood behaviour from all duration/temporal pattern combinations for that event, and is presented in **Appendix A** as follows:

- Peak floodwater depths and levels: **Figures 4** to **13**.
- Peak velocity: **Figures 14** to **23**.

Figure 4 through **Figure 13** shows that there are several flow paths that extend through the site. This includes a more significant flow path that enters at the south-eastern corner of the lot and passes through the site in a north-westerly direction, before leaving the site along the western boundary through a culvert under Grange Road.

Two smaller flow paths are also shown to enter the site along the southern boundary and eastern boundary which join the main flow path in roughly the centre of the site. A third smaller flow path is shown to form parallel with the northern site boundary (running adjacent to Goulburn Road before being conveyed through culverts to the northern side of the road and towards Kiamma Creek).

The depth results indicate that:

- Depths along all flow paths are generally less than 0.2 meters in all events up to and including the 0.2% AEP, with small, incised portions reaching up to 0.4 metres. In the PMF, depths along the flow paths more commonly exceed 0.4 metres.
- Depths in farm dams can exceed 1.2 metres.

Figures 14 through **Figure 23** indicate that:

- Peak velocities along all flow paths generally exceed 0.5m/s, with the more incised portions reaching between 1 and 2m/s in events up to and including the 0.2% AEP. In the PMF, peak velocities along a large portion of the main, southern and eastern flow paths can exceed 2m/s.
- Velocities along the northern flow path generally do not exceed 1m/s in any flood event.

Hydraulic Categories

Hydraulic Categories for the 1% AEP flood and PMF were also calculated. This involved subdividing the floodplain into floodway, flood storage and flood fringe categories in accordance with definitions provided in the '*Flood Function – Flood risk management guideline FB02'* (NSW Government, 2023).

Criteria for defining hydraulic categories is not explicitly available as these will typically vary from catchment to catchment. However, *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) established hydraulic categories. Due to the site being situated within the township of Crookwell, the same criteria were applied to the current study.

This included defining floodways based on criteria defined by Howells et al (2004), as follows:

- Velocity x Depth > 0.25m^2/s AND Velocity > 0.25m/s, OR
- Velocity > 1m/s.

Flood storage and flood fringe areas were subsequently defined based on the following:

- Flood Storage: Areas not defined as floodway AND Depth > 0.4m.
- Flood Fringe: Remaining areas.

These criteria were applied to the 1% AEP and PMF results from the flood modelling and the resulting hydraulic categories are presented in **Figure 24** and **25** respectively.

Figure 24 indicates that, within the development site, the majority of inundation within the site in the 1% AEP event is classified as flood fringe, with flood storage defined within farm dams. Floodways are shown to occur along parts of the main flow paths within the site. **Figure 25** shows that in the PMF, large sections of the existing site are classified as floodway areas, which aligns with the main flow paths through the site.

Flood Hazard

To confirm the nature and extent of the existing flood hazard across the site, flood hazard mapping was prepared based upon flood hazard vulnerability curves presented in '*Flood Hazard – Flood risk management guideline FB03'* (NSW Government Department of Planning and Environment, 2023). The hazard curves, which are reproduced in **Plate 1**, assess the potential vulnerability of people, cars and structures based upon the depth and velocity of floodwaters at a particular location. The maximum flood hazard for each design flood are presented in **Figures 26** to **35**.

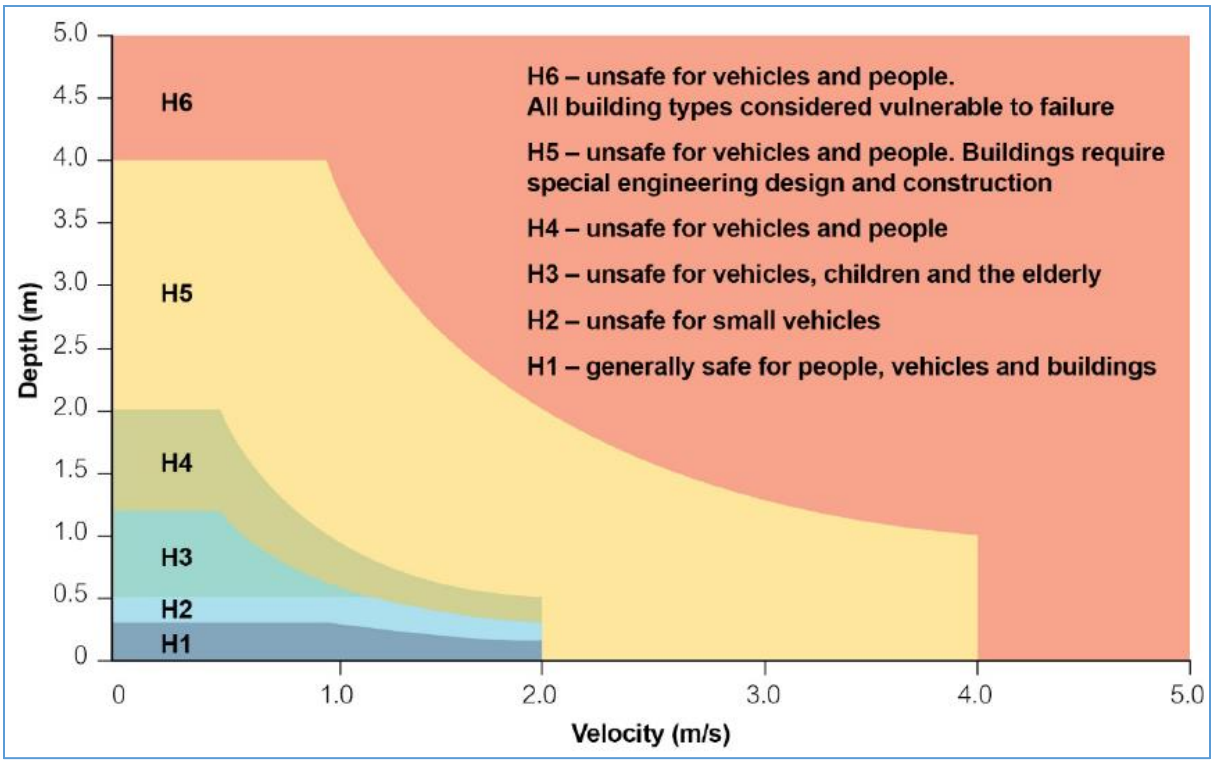

Plate 1 Flood hazard vulnerability curves (NSW Government, 2023)

Figures 26 to **35** show that the flood hazard across most of the site is no higher than H1 in all flood events, up to and including the 0.2% AEP. Areas of H2 form within localised incised sections of the flow paths. The flood hazard within the farm dams can reach up to H5. In the PMF, the majority of the main flow path is classified as H5 hazard, however, the balance of the site generally remains no higher than H2.

These results indicate that the site would generally be safe for people in all events up to the 0.2% AEP. However, the PMF poses a more significant risk to life.

3 Post-Development Flood Behaviour

3.1 Description of the Proposed Development

As previously discussed, Upper Lachlan Shire Council, on behalf of Tina Dodson of Premise intends to rezone the existing site from an RU1 (primary production) zoning to R5 (large lot residential) and C3 (Environmental Management) zoning to allow for future subdivision into smaller lots. A concept design for the future use of the site is provided in **Appendix F** and includes:

- Construction of a new internal roadway network linking to three entry/exit points onto Grange Road. The internal roadway will cross a watercourse at one location and require culverts to convey flow under the roadway.
- Construction of four (4) OSD basins within the site to manage surface runoff and ensure peak discharge from the site is not increased by the proposed works.
- Fill outside of conveyance and storage areas to allow for subdivision to form new residential lots.
- Allocation of open space within the centre of the site (adjacent to the main channel).
- Culverts beneath roadways to convey flows from the OSD basins to the main channel.

The increased impervious surfaces that will occur as part of the subdivision have the potential to increase peak discharges and volumes leaving the site. The placement of fill and construction of the roadway crossing within the site also has the potential to redistribute flows. Both factors could impact on downstream properties.

The following sections describe the assessment that was completed to define "post-development" flood conditions. This includes a discussion on the potential impacts that the proposed works are likely to have on existing flood behaviour.

3.2 Model Updates

3.2.1 XP-RAFTS Model

The XP-RAFTS model that was used to define existing hydrology was updated to include the modified land use anticipated from the proposed subdivision and development of the land. This involved updating the existing land use polygons to account for the following changes:

- The new internal roadways, which were assumed to be 100% impervious.
- The new residential lots, which were assumed to be 70% impervious.
- Flood conveyance and storage areas, assumed to be 0% impervious.

The updated land use polygons that were used to inform the hydrologic model modifications are shown on **Figure 36**. The model parameters for areas located outside of the site were not altered from the "existing" conditions assessment.

3.2.2 TUFLOW Model

To quantify the impact that the proposed development is likely to have on existing flood behaviour, the TUFLOW model that was used to define "existing" flood behaviour was updated to reflect the concept design shown in **Appendix F**. This incorporated the following changes:

- Topographic changes across the site to raise the future lots and roadways to be above the peak 1% AEP flood level, plus 0.5 metres freeboard.
- Topographic changes to form a channel through the centre of the site (roughly diagonal from the south-east corner to the western boundary). The channel was designed to have a trapezoidal shape.
- Topographic modifications to include the OSD basins.
- Inclusion of a 5 x 2.4mW x 0.9mH RCBC culvert through the new roadway to convey flow along the main channel crossing.
- Inclusion of various other culverts from the OSD basins to the main channel (including 2x2.4mWx0.6mH culverts from the southern OSD basin, 3x2.4mWx0.6mH culverts from the eastern OSD basin, and 1x0.9m diameter culvert together with 1x0.3m diameter culvert from the northern OSD basin. 1x0.9mx0.6m culvert was also included at the outlet of the main OSD basin from its western boundary).
- Modifications to the hydraulic roughness within the site to reflect the roadways, residential lots, OSD basins and main channel, as well as areas of open space within the centre of the site (adjacent to the main channel).

3.3 Results

3.3.1 Peak Flows

The updated XP-RAFTS model was used to re-simulate the 63.2%, 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events and PMF for all storm durations and temporal patterns for post-development catchment conditions. A complete listing of XP-RAFTS model outputs for each subcatchment for post-development conditions is provided in **Appendix G.**

A review of the post-development critical durations and temporal patterns showed that they were identical to the critical durations and temporal patterns for existing conditions. Therefore, the critical storms listed in **Table 3** were also retained as part of the post-development flood analysis.

The peak outflows from the local subcatchments incorporating the proposed development were compared against flows under existing conditions to gain an appreciation of the impact of the development on peak discharges. The peak flow comparison is presented in **Table 4** and indicates that peak flows at subcatchment 2 (the subcatchment representing the outflow from the site) under proposed conditions is shown to increase by up to 50% for frequent flood events (63.2% and 50% AEP), but slightly reduce (generally by 3-4%) for the rarer flood events (10% AEP through PMF).

The reduction in peak flow from the site for the rarer flood events is a result of the faster response time of the site due to the greater proportion of impervious surfaces. This allows the peak flow from the site to escape before the peak flow from the upper catchment arrives. However, this does not take into consideration the increase in runoff volume from the site as a result of the additional impervious surfaces.

Table 4 Peak flow comparison from the development site under existing and post-development conditions

Flood Event	Peak Flows for Main Flow Path at Downstream Site Boundary (XP-RAFTS Node 2) (m^3/s)	
	Existing	Proposed
63.2% AEP	0.92	1.42
50% AEP	1.10	1.59
20% AEP	2.05	2.12
10% AEP	2.77	2.61
5% AEP	3.46	3.11
2% AEP	3.77	3.69
1% AEP	4.46	4.28
0.5% AEP	5.05	4.84
0.2% AEP	6.23	5.77
PMP	63.2	61.5

To further confirm whether the change in flows (and volume) generated within the site will alter flood behaviour, a post-development hydraulic assessment was completed, which is discussed below.

3.3.2 Depths, Levels and Velocities

The TUFLOW model was then used to simulate flood behaviour for the 63.2%, 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events and PMF events for the same critical duration and temporal pattern as existing conditions. The flow hydrographs were then applied to the TUFLOW model.

The initial simulations results indicated that the increase in runoff volume from the site, as well as the redistribution of flow from the site resulting from the placement of fill was producing adverse impacts across downstream properties. Therefore, additional areas were included within the site to provide additional storage capacity to offset the increased volumes of runoff and redistribution of flows, and these OSD areas form part of the site design previously discussed.

Flood mapping was prepared from the final post-development simulation and are presented as follows:

- Peak floodwater depths and levels are presented in **Figures 37** to **46**.
- Peak velocity results are presented in **Figures 47** to **56**.

Figure 37 through **46** shows that although floodwater enters the site at the same locations as under existing conditions, the overland flow is constrained to the main channel (running roughly from the south-east of the site in a north-westerly direction). OSD basins on the southern, eastern, and northern extremities of the site contain floodwater that is conveyed through culverts to the main channel. A more significant OSD basin located in the north-western portion of the site contains additional flow within the site. Further details of flood behaviour under proposed conditions are included below:

- Depths within the main channel in events up to and including the 0.2% AEP generally do not exceed 0.4 metres.
- Depths within the main OSD basin can vary from 0.6 metres in the 63.2% AEP to 1.2 metres in the 0.2% AEP event.
- Depths within the smaller OSD basins do not exceed 0.6 metres in events up to the 0.2% AEP.
- In the PMF, depths of up to 0.8 metres are common along the main flow path and can exceed 1.2 metres within the OSD basins.

Figures 47 to **55** indicate that peak velocities along the main channel generally remain below 1.5m/s apart from localised increases in the vicinity of the main culvert crossing, where velocities can exceed 2m/s. **Figure 56** shows that in the PMF, velocities exceeding 2m/s are common along the main flow path, particularly within the south-eastern half of the flow path.

No inundation of residential lots is predicted in any flood event, with internal roadways also remaining flood free with the exception of some shallow, slow-moving inundation adjacent to the main and southern OSD basins.

3.3.3 Hydraulic Categories

Hydraulic categories for the 1% AEP and PMF under proposed conditions were also calculated based on the criteria listed in Section 2.3.2 and are presented on **Figures 57** and **58**.

Figure 57 shows that in the 1% AEP event, a floodway is maintained along the main channel through the site. Flood storage areas would be introduced within the OSD basins, with the remainder of inundation within the site classified as flood fringe.

Figure 58 shows that in the PMF, floodways are contained to the main channel, as well as within part sections of the OSD basins. Flood storages are also prominent within the OSD basins, with the remainder of inundation within the site classified as flood fringe.

All floodways are sited away from any future residential lots. Therefore, the suggested development areas are consistent with the post-development flood behaviour with future development located clear of floodways and flood storage areas.

3.3.4 Flood Hazard

Flood hazard categories were also defined for proposed conditions and are presented on **Figures 59** through **68.**

Figures 59 through **68** shows that the flood hazard:

- Along the main channel generally remains no higher than H2 in events up to and including the 0.2% AEP but reaches H5 in the PMF.

- A localised area of H5 is predicted in flood events up to the 0.2% AEP (and H6 in the PMF) at the outlet of the culverts through the internal roadway, however, this is localised and a result of the higher velocities discussed earlier.
- Hazard within the smaller OSD basins does not exceed H2 apart from in the PMF when H4 hazard is predicted.
- Hazard within the main OSD basin is predicted to reach H3 in events up to and including the 0.2% AEP and H5 in the PMF.

The flood hazard mapping presented on **Figures 59** through **68** provides a valuable understanding of the potential risk to future people, vehicles and property within the development site as a result of flooding. More specifically, the hazard mapping allows identification of areas of the site which would not be safe for people or vehicles to navigate, and areas where construction of dwellings should be avoided. The hazard mapping indicates that:

- In all simulated design floods, the internal roadway is not predicted to exceed H1 hazard, indicating safe movement of vehicles and people within the site, including the entry/exit to the site via the northern most entry on Grange Road (the closest entry/exit when travelling to/from Goulburn Road).
- All lots to be sued for residential purposes (and therefore future development) are flood free,
- The OSD areas present a flood risk to people. Therefore, access to the OSD basins should be prevented (e.g., having the basins fenced off).

Overall, these results confirm that the developable portions of the site are safe for pedestrians and vehicles. All access roads are safe in events up to and including the 0.2% AEP, with the northern most entry on Grange Road (the closest entry/exit when travelling to/from Goulburn Road) safe in the PMF which will be safe to access via the internal road network from all lots.

3.4 Flood Impact Assessment

To gain an understanding of the location and magnitude of changes in flood behaviour because of the proposed works, flood level and velocity difference mapping was prepared. The flood level and velocity differences have been calculated by subtracting the peak flood levels and velocities from 'existing' conditions from that of 'post-development' conditions. The resulting difference maps provide a contour map showing the magnitude and location of changes in flood level and velocity associated with the subdivision and development of the site. The flood level difference maps are provided in **Figures 69** through **78**, and the velocity difference maps are provided in **Figures 79** through **88**.

Figures 69 through **78** indicate that flood levels within the site are predicted to significantly alter relative to existing conditions within the site, with large areas of 'now dry' predicted across the former southern and eastern flow paths which are now captured within OSD basins along the southern and eastern boundary. The south-eastern flow path largely remains; however, the alignment has altered, leading to areas of 'now wet' predicted within part-sections of the channel, which are particularly prevalent at the downstream boundary of the site within the main OSD basin. Further areas of 'now wet' are also predicted along the northern boundary within the northern OSD basin.

Of greater importance is that **Figures 69** through **78** indicate that reductions in flood levels outside of the development site are predicted, with reductions of between 0.05 and 0.15 metres typical within the golf course located to the west of the development site in events up to the 0.2% AEP, and reductions of over 0.25 metres predicted in the PMF. Reductions in peak flood level are also predicted to the north of the development site, however, the magnitude of these reductions are generally no greater than 0.05 metres.

It is noted that an increase in flood level of 0.04 metres is predicted to the west of the site (within the golf course) in the PMF as a result of more concentrated discharge from the development site. However, this is localised and considered minor in nature, and does not impact any infrastructure or buildings. Areas of increased flood extent are also predicted along the western boundary of the site (within the road reserve) as a result of the proposed fill and construction of a more formalised roadside swale in this location, however, this does not extend onto the roadway pavement, and therefore does not adversely impact on traffic movement.

Figures 79 through **88** indicate that both increases and decreases in velocity are predicted along the main channel because of the redistribution and channelisation of flow. Of note is the reduction in peak velocity that are predicted downstream of the site to the west and north as a result of the OSD basins within the site. However, increases in peak velocity of up to 0.2m/s are predicted along the more formalised roadside swale within the road reserve bounding the west of the site, and increases of up to 0.15m/s are also predicted within localised portions of the golf course. These increases are not considered significant, and do not impact any infrastructure or buildings, and could be managed/removed as part of any future detailed design of the site. Further, these occur in locations where a reduction in depth is predicted, and therefore there is no increase in VxD (and therefore hazard).

3.5 Climate Change Assessment

Climate change and, in particular, rainfall increases have the potential to impact on present-day flood behaviour. As such, it was considered important to gain an understanding of the flood behaviour that could be expected under future climate change conditions. In this regard, the 0.5% AEP and 0.2% AEP flood events have been used as proxies for the 1% AEP under future climate change conditions (representing increases in 1% AEP rainfall intensity of 11% and 26% respectively).

Additional XP-RAFTS simulations were completed for the additional 0.2% AEP event (as noted earlier, the 0.5% AEP event had already been defined within the current assessment). This was undertaken by inputting design rainfall from the Bureau of Meteorology 2016 IFD webpage and determining the critical duration and temporal pattern for the site. This yielded critical durations as per **Table 3**. The inflow hydrographs were then applied to the TUFLOW model for proposed conditions.

Flood level and velocity difference mapping was then prepared by subtracting the 1% AEP results from the 0.5% AEP and 0.2% AEP results for proposed conditions. The differences are presented as:

- **Figure 89** – Peak flood level differences between the 0.5% AEP and 1% AEP events as proxy for 11% increase in rainfall intensity
- **Figure 90** – Peak velocity differences between the 0.5% AEP and 1% AEP events as proxy for 11% increase in rainfall intensity
- **Figure 91** – Peak flood level differences between the 0.2% AEP and 1% AEP events as proxy for 26% increase in rainfall intensity
- **Figure 92** – Peak velocity differences between the 0.2% AEP and 1% AEP events as proxy for 26% increase in rainfall intensity

Figure 89 shows that a ~11% increase in 1% AEP rainfall intensity is predicted to increase peak flood levels by generally no more than 0.02 metres within the site, however, areas within the OSD basins (particularly the central and northern basins) are predicted to experience increases of up to 0.09 meters and 0.05 metres respectively. Some isolated areas with increases of less than 0.02 metres as well as areas of 'now wet' are also anticipated, particularly within the farm dam off the south-eastern corner of the site, and on Goulburn Road which may impact trafficability of the roadway. **Figure 90** shows that flood velocities are predicted to typically increase by no more than 0.15m/s along the main channel, and only in localised areas.

Figure 91 shows that a ~26% increase in 1% AEP rainfall intensity produces flood level increases that are generally no greater than 0.06 metres along the main channel, however, flood level increases within the main OSD basin can exceed 0.2 metres and 0.08 metres within the northern basin. Increases in flood level of up to 0.04 metres are predicted downstream of the site (through the golf course) with additional inundation ('now wet') is anticipated on Goulburn Road and towards Kiamma Creek. The results shown on **Figure 92** indicates that an increase in peak velocity of up to 0.2m/s is typical within the main channel.

Although rainfall increases do have the potential to increase flood levels and velocities within the site, as well as on surrounding roadways and properties, the impacts are not sufficiently large to extend into areas where future development is likely to occur. As a result, climate change is not predicted to produce any significant impact on the potential future development areas within the site.

3.6 Blockage Assessment

Blockage of culverts has the potential to impact on flood behaviour in the vicinity of such structures. As such, it was considered important to gain an understanding of how a high level of structure blockage could impact on flooding across the site. In this regard, a blockage sensitivity assessment was completed for the 1% AEP flood event. The sensitivity assessment was undertaken using the following methodology:

- If the blockage applied to a culvert was 0% in the 1% AEP event, it was increased to 50% blocked.
- If the blockage applied to a culvert was more than 0% in the 1% AEP event, it was increased to 100% blocked.

- An exception to these was the outlet pipes from the OSD basins which retained their base 1% AEP blockage characteristics as debris control devices will be utilised (given these are not standard culvert crossings subject to typical debris loadings).

This methodology was adopted as it considers the design blockage applied to a culvert when deciding how much to increase the applied blockage under the sensitivity assessment. This avoids an extremely conservative approach of applying 100% blockage regardless of the size of the culvert and the contributing debris size.

The peak flood depth and level results for the 1% AEP event with higher blockage are presented in **Figure 93** and indicate that flood depths of up to 0.6 metres are predicted on the upstream side of the internal roadway crossing of the main channel, and that depths of over 1 metre are predicted within the main OSD basin.

Peak flood level differences calculated by subtracting the 'design blockage' 1% AEP peak flood levels from the 'blockage' 1% AEP levels are also presented in **Figure 94.** This indicates that the blockage produces increases in flood level of 0.04 metres within the main OSD basin. Localised Increases of over 0.1 metres are predicted on the upstream side of the internal roadway crossing of the main channel. Increases in peak flood level are also predicted at culvert crossings adjacent to Goulburn Road. Small reductions in peak flood level and areas of 'now dry' are shown to occur within the golf course to the west of the site as a result of additional water being held within the site under the blockage scenario. No impacts are predicted within the portion of the site where future residential works are proposed, nor on Grange Road (and therefore there is no impact to emergency response considerations in the 1% AEP event).

Overall, the blockage sensitivity assessment indicates that the increased blockage of culverts will not produce any significant impacts during the 1% AEP event.

3.7 Flood Planning Level/Area

Flood planning levels (FPLs) and the flood planning area (FPA) are important tools in the management of flood risk. The flood planning area is used to define the area where flood-related development controls apply. For those areas contained within the flood planning area, the flood planning levels are frequently used to establish the elevation of key components of a development, such as minimum floor levels.

The flood planning level is typically derived by adding a freeboard to a specific design flood. This specified design flood is frequently referred to as the "planning" flood. The freeboard is intended to account for any uncertainties in the derivation of the planning flood level.

The *'Flood Risk Management Manual'* (NSW Government, 2023) does not explicitly state which design flood event should be used as the "planning" flood, nor the required freeboard amount that should be applied. In this regard, local guidance was sought from *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) which defined a variable flood planning area for different sections of the floodplain, namely:

- Main Stream Flooding (MSF): 1% AEP + 0.5 metres.
- Minor Tributary Flooding (MTF): Areas where depths in the 1% AEP exceed 0.15 metres.
- Major Overland Flow (MOF): Extent of high and low hazard floodways AND areas where depths in the 1% AEP exceed 0.15 metres.

On review of the definitions from *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017), the site would potentially fall within the MTF or MOF categories. This is confirmed by *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) identifying that the main flow path that originates upstream of the site is labelled as the "Cullen Street Overland Flow Path". Therefore, MSF is not considered appropriate for application due to the shallow inundation relative to the wider Kiamma Creek and Crookwell River catchment. Nevertheless, to provide a conservative approach, the definition of MTF has been applied across the entire site.

The flood planning area was subsequently defined using the peak depths for the 1% AEP event shown on **Figure 95** (the FPA is the area where the 1%AEP flood depths exceed 0.15 metres with no lateral extension applied). The flood planning level was then extracted based upon the peak 1% AEP flood level within the flood planning area, and both the flood planning level contours and area are shown in **Figure 95** (note that the flood planning area has been clipped to the development site which is the focus of this assessment). The 1% AEP and PMF extents have also been shown in **Figure 95** to define significant areas of the floodplain (1% AEP extent) and the extent of the floodplain (PMF extent).

As shown on **Figure 95**, although the flood planning area extends across parts of the overall site, they are contained to formal watercourses and OSD areas. Habitable areas and internals roads are predicted to remain outside of the flood planning areas. This includes future dwelling locations.

3.8 Emergency Response Considerations

As discussed in Section 3.3.2, and shown on **Figures 37** to **46**, no inundation of the internal roadways or proposed residential lots is predicted in any 'base' design flood up to and including the 0.2% AEP, with only minor inundation in localised locations on roads in the PMF. Therefore, all future dwellings will be elevated above all potential floods and evacuation from the site will not be necessary. However, emergency access to and from the site may still be necessary (e.g., medical emergency). In this regard, the flood hazard along Grange Road was interrogated between the site and Goulburn Road (and therefore the township proper of Crookwell, as well as the nearby Crookwell showground which remains flood free in all events).

This indicates that in all events less severe than the PMF, Grange Road can be safely traversed via any of the three proposed entry/exit points as flood hazard remains no higher than H1. However, in the PMF event, flood hazard on Grange Road to the south-west of the main OSD basin is predicted to experience a hazard of H5 and would not be safe to traverse by any means. However, the flood hazard to the north of the closest intersection to Goulburn Road remains no greater than H1. Therefore, in the PMF event, access to and egress from the site should only be undertaken via the northern most entry on Grange Road (the closest entry/exit when travelling to/from Goulburn Road) towards Crookwell.

4 REGULATORY REQUIREMENTS

The rezoning of flood liable land requires that the future rezoning and any potential development resulting from it can comply with all local and state government legislation/requirements. These are detailed in the following sections.

4.1 Upper Lachlan Local Environment Plan 2010

The Upper Lachlan Local Environment Plan 2010 (LEP2010) outlines a number of requirements and matters that need consideration when deciding to grant development consent on flood liable land.

Section 5.21(2), 5.21(3) and 5.22(3) of the LEP2010 primarily deals with ways in which the proposed development will interact and impact on existing flood behaviour, and how the flood risk is managed. Details of how the proposed development intends to meet each specific requirement of LEP2010 are summarised in **Table 5**.

Table 5 Upper Lachlan LEP2010 requirements and matters to be considered

Council Requirement	Does Development Meet this Requirement?
Section 5.21(2)	
a) The development is compatible with the flood function and behaviour on the land	The flood function (hydraulic categories) on the land for the 1% AEP and PMF have been defined for existing (**Figures 22-23**) and proposed conditions (**Figures 52-53**). Under existing conditions, the majority of floodways are contained to the main channels through the site. Under proposed conditions, floodway areas are limited to the main channel through the site, as well pas part sections of the OSD basins. The location of the proposed roadways and future residential lots (and therefore future dwellings) are located clear of floodways and flood storage areas, and the proposed works are, therefore, compatible with the flood function in all floods.
b) The development will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties	Flood level and velocity differences have been calculated (**Figures 69-88**) for the full range of flood events and indicate that the proposed works are not predicted to notably impact flood behaviour or increase the flood affectation of other developments or properties in all events up to and including the 0.2% AEP, with small impacts predicted during the PMF which only extend across open space.
c) The development will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of	The subdivision layout proposed as part of the planning proposal has been designed to minimise interaction with floodwater. In this regard, safe occupation and efficient evacuation is facilitated by: - only one crossing of the main channel passing through the site, which is located such that no inundation across

Council Requirement	Does Development Meet this Requirement?
a flood	the roadway surface occurs in any flood event. - all proposed residential lots (and therefore future dwelling locations) are located above the 1 in 100 year ARI (1% AEP) + 0.5 metres level and have flood free access from the dwellings to the internal roadways. - Access to, or egress from the site to the township of Crookwell is available via the northern most entry on Grange Road (the closest entry/exit when travelling to/from Goulburn Road) in all flood events. - Although evacuation is not considered necessary in any flood event, the additional population that will reside in the development site are not considered to exceed the capacity of any evacuation routes given the major arterial nature of Goulburn Road and size and (close) proximity of the Crookwell township. Therefore, the development will not adversely affect the safe occupation or efficient evacuation of people from the site. If evacuation from the site is required, this could be safely completed on foot or by vehicle by exiting the site through the northern most entry on Grange Road (the closest entry/exit when travelling to/from Goulburn Road) and relocating to the Crookwell showground or another location within the township.
d) The development incorporates appropriate measures to manage risk to life in the event of a flood	The subdivision layout proposed as part of the planning proposal has been designed to minimise interaction with floodwater. In this regard, all proposed residential areas are located above the 1 in 100 year ARI (1% AEP) + 0.5 metres level and have flood free access from the dwellings to the internal access roadway, and safe access to Crookwell in any flood event.
e) The development will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses	Flood level and velocity differences have been calculated (**Figures 69-88**) for a range of flood events and indicate that the proposed works are not predicted to have any significant impact on flood levels or velocity outside of the site. Therefore, the development is not predicted to adversely impact the environment or cause erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses in all flood events. Small increases in flood level and velocity are predicted in some events within the golf course to the west of the site, however, these are minor and localised in nature, and do not impact any existing development or buildings. Furthermore, the proposed culvert within the site can be implemented with erosion protection measures at the inlet and outlet to further reduce erosion potential in the vicinity of predicted velocity increases.

Council Requirement	Does Development Meet this Requirement?
Section 5.21(3)	
a) The development needs to consider the impact of the development on projected changes to flood behaviour as a result of climate change	An assessment of the impact on 1% AEP flood behaviour resulting from climate change has been undertaken (see **Section 3.5**) and concluded that flood behaviour within the site does not significantly change due to rainfall increases of 11% and 26%, and, therefore, the impacts of the proposed development on 1% AEP flood behaviour under climate change conditions would not be dissimilar to that documented in this report under existing climatic conditions.
b) The development needs to consider the intended design and scale of buildings resulting from the development	The design and scale of development within the future subdivision is yet to be completed. However, it is expected to be sympathetic to and appropriate for the surrounding natural and built environment, be acceptable to the community and maintain economic feasibility. It also aims to facilitate the development of the subject site in a manner that is consistent with the desired future character of Crookwell and in-line with other similar developments within the Upper Lachlan Shire (e.g.,: within other areas of Crookwell).
c) The development needs to consider whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood	See response to 5.21(2) c) and d)
d) The development needs to consider the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion	The proposed buildings are not predicted to be impacted in any flood event, nor under climate change conditions and are not in a location at risk of coastal erosion. Therefore, modifying, relocating, or removing buildings from their currently proposed locations to reduce the flood risk is not considered necessary.
Section 5.22(2)	
a) This clause applies to sensitive and hazardous development—land between the flood planning area and the probable maximum flood	The planning proposal is for residential purposes and not for sensitive or hazardous development, thus this clause is not applicable.
b) for development that is not sensitive and hazardous development—land the consent authority considers to be land that, in the event of a flood, may— (i) cause a particular risk to life, and (ii) require the evacuation of people or other safety	Parts of the site fall between the flood planning area and probable maximum flood level; however, these areas are dedicated drainage channels or flood storage areas. (i) No particular risk to life has been identified as the sections of the site to be used for future development are not predicted to be inundated in floods up to and including the PMF (ii) Evacuation from the site is not considered necessary,

Council Requirement	Does Development Meet this Requirement?
considerations.	however, can be undertaken by exiting the site through the northern most entry on Grange Road and relocating to the Crookwell showground or other location within the township.
Section 5.22(3)	
a) Development on the land will not affect the safe occupation and efficient evacuation of people in the event of a flood	Although Clause 5.22 is not considered to be applicable to the subject land as it is not for a sensitive land use, the response for 5.21(2) c) can be applied.
b) The development incorporates measures to manage risk to life in the event of a flood	Although Clause 5.22 is not considered to be applicable to the subject land, the response for 5.21(2) d) can be applied.
c) The development will not adversely affect the environment in the event of a flood	Although Clause 5.22 is not considered to be applicable to the subject land, the response for 5.21(2) e) can be applied.

4.2 Upper Lachlan Development Control Plan 2010

Section 4.5.1 of the Upper Lachlan Development Control Plan 2010 (DCP2010) outlines the flood related controls that are applicable to works in areas that are subject to discharge of a 1 in 100-year ARI (1% AEP) mainstream flood event. The controls, together with commentary on how the future development can satisfy the controls are included in **Table 6**.

Table 6 Flood related development controls from the Upper Lachlan Development Control Plan 2010

DCP 2010 Control	Comment
Works cannot involve any physical alteration to waterway or floodway including vegetation clearing	No formal waterway currently exists through the development site, and there is little to no vegetation that will be cleared as part of the site reconfiguration or future dwelling construction. Although some of the works will be undertaken in areas defined as floodways under existing conditions, these will be replaced with a formalised channel and OSD basins which will be zoned appropriately to prevent any future development within them.
Works cannot involve net filling exceeding 50m^3, any reductions of on-site flood storage capacity is avoided and any changes to depth, duration, and velocity of floodwaters of all floods up to and including the 100-year ARI are contained within the site	Although bulk earthworks are proposed which will involve the placement of fill, significant compensatory storage areas will also be provided within the site to manage the flood flows. To demonstrate, the volume of water stored within the site under existing conditions is 10,273m^3, whilst under proposed conditions, 19,512m^3 is stored. This represents a significant increase in flood storage (however, it is noted that additional
Works cannot involve any change in the flood characteristics of the 100-year ARI outside of the subject site that result in:	

- Loss of flood storage, or - Loss of/changes to flow paths, or - Acceleration or retardation of flows, or - Any reduction of warning times elsewhere on the floodplain	runoff is also produced under proposed conditions, therefore requiring some additional compensatory storage volume). **Figures 69-88** indicate that there is some alterations to peak flood level and velocity of floodwaters outside of the site in the 100-year ARI event, however, these are beneficial impacts (lower levels and velocity). Therefore, there is no notable adverse impact to flood behaviour outside of the development site (i.e.: no loss of flood storage, no negative changes to flow paths outside of the site, no acceleration or adverse retardation of flows, and no adverse changes to warning times).
All built form, infrastructure (unless designed to be inundated) and open space must be located on land that would not be subject to flooding during the 100-year ARI flood event	The proposed earthworks ensure that all future development (i.e., habitable areas and roadways) will be located on land that is above the 100-year ARI flood + 0.5 metres level (noting that this exceeds the requirements of the flood planning area definition, and ensures all built form and infrastructure is outside of the flood planning area as well as the 100-year ARI flood + 0.5 metres extent).
Where there is existing development located on land that is subject to inundation during the 100-year ARI flood event, this development /activity must not be intensified through further development	There is no existing development subject to inundation during the 100-year ARI flood event within the site. All areas where increased development are proposed are located clear of the 100 year ARI flood extent.

4.3 NSW Flood Prone Land Policy

The key objectives of the NSW Flood Prone Land Policy are detailed in the *'Flood risk management manual'* (NSW Government, 2023) and are intended to reduce the impacts of flooding and flood liability on communities and individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods.

The proposed development adheres to these objectives by locating all proposed dwellings are located outside of the floodplain and ensuring that internal infrastructure, such as the roadways, are elevated above the peak level of all design floods. This ensures that the future community will not be impacted by flooding. Furthermore, the development is not predicted to increase the flood risk external to the site (small reductions in existing flood levels and velocities are most commonly predicted). As a result, the development will not result in increased private and public losses from flooding.

Overall, it is considered that the proposed proposal for rezoning of this land is in accordance with the objectives of the NSW Flood Prone Land Policy.

4.4 Considering Flooding in Land Use Planning Guideline (2021)

The '*Considering flooding in land use planning guideline'* (DPE, 2021) provides advice to Councils on flood-related land use planning and areas where flood-related development controls should apply. This guideline applies to the current assessment as it is a planning proposal. As such, it is important to ensure that the rezoning and development of the land is consistent with this guideline. The key objectives of the guideline and commentary on how the planning proposal intends to comply with these requirements are outlined in **Table 7**.

Table 7 Summary of the specific guidance provided as part of the gateway determination.

Requirement	Comment
Considering the full range of flood events up to and including the PMF	The current assessment has defined flood behaviour for both existing and proposed conditions for all events, up to and including the PMF.
Considering the key constraints that result from flooding on land, namely: flood function, flood hazard, extent and flood behaviour and risk to life	The current assessment has defined the flood function (hydraulic categories) for the 1% AEP and PMF events, flood hazard, extent and behaviour for the full range of events up to the PMF. All future development will be situated clear of all design floods, ensuring the flood risk is suitably mitigated and that flood function through and downstream of the site will be retained.
Definition of the Flood Planning Area (FPA) based on a Defined Flood Event (DFE)	As discussed in **Section 3.7**, the FPA has been adopted based on the definition provided within *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) which used the 1% AEP event as the DFE.
Adherence to the flood planning clause in the standard instrument (LEP2010)	As per **Section 4.1**, the planning proposal adheres to the requirements of Clause 5.21 and 5.22 of LEP2010

4.5 Specific Guidance

A gateway determination was provided by the Department of Planning and Environment to Upper Lachlan Shire Council on 31 August 2023. As part of this determination, a condition was placed that required the preparation of a Flood Impact and Risk Assessment, and that the planning proposal be updated to reflect the assessment once prepared.

The current report has been prepared in order to meet this requirement. The main outcome of this assessment that required changes to the planning proposal was the need to include areas for the temporary storage of flood water, and that the zoning of land used for the conveyance and storage of flood water be zoned separately to the future residential lots. It is anticipated that the proposal will be updated with these changes in due course.

5 SECTION 9.1: LOCAL PLANNING DIRECTIONS DIRECTION 4.1: FLOODING

Section 9.1(2) of the Environmental Planning and Assessment Act permits the Minister for Planning to issue a direction in relation to the making of local environmental plans. Several of these have been issued including Direction 4.1 which relates to flooding. The direction is outlined below, and commentary has been provided on how the planning proposal plans to meet those requirements.

Objectives

The objectives of this direction are:

(a) ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and

Consistent: It is noted that the *Floodplain Development Manual 2005* has been superseded by the *Flood Risk Management Manual 2023*. Nevertheless, the underlying principles of both documents are consistent.

This FIRA was prepared based on hydrologic procedures outlined within *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (Ball et al, 2019) which reflects modern best practice.

The assessment has shown that the development proposal allows for development within the site that is compatible with the flood behaviour by locating all future residential areas outside of the floodplain. Internal roadways within the site will also be elevated above the PMF.

The works are also not predicted to produce any significant adverse impact on peak flood level or velocity outside of the development site in any flood event. Therefore, the proposal does not increase any public or private losses from flooding.

Furthermore, the development of the site recognises the value of use, occupation, and development of the land.

Each of these outcomes demonstrate that the development proposal meets the key objectives of the NSW Government's Flood Prone Land Policy and Floodplain Development Manual 2005.

(b) ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.

Consistent: The proposed development is considered to provide suitable management of the flood behaviour and flood risk by locating future development areas outside of the floodplain. Consideration of the potential flood impacts for the range of flood events up to the PMF have been assessed and demonstrate that no significant changes in peak flood level or velocity are predicted outside of the development site in any flood event. The development proposal is also consistent with the existing flood-related clauses set out in the Upper Lachlan Local Environment Plan 2010

Application

This direction applies to all relevant planning authorities that are responsible for flood prone land when preparing a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.

> Applies: The planning proposal is located within the Upper Lachlan Shire Council LGA. Upper Lachlan Shire Council are responsible for the management of flood prone land within the Upper Lachlan Shire Council LGA. The planning proposal aims to rezone land that is flood prone.

Direction 4.1

(1) A planning proposal must include provisions that give effect to and are consistent with:

(a) the NSW Flood Prone Land Policy

> Consistent: Detailed discussion on how this proposal has demonstrated compliance with the NSW Flood Prone Land Policy is included in Section 4.3 as well as the previous page of this report.

(b) the principles of the Floodplain Development Manual 2005

> Consistent: As outlined in Section 4.3, the proposal has demonstrated compliance with the NSW Flood Prone Land Policy and has adopted (where possible) hydrologic and hydraulic parameters, hydraulic category definitions and flood planning area definitions from *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) which was prepared in accordance with the NSW Floodplain Development Manual 2005 and is considered to be the best local guidance.

(c) The Considering flooding in land use planning guideline 2021, and

> Consistent: Detailed discussion on how this proposal has demonstrated compliance with the 'Considering Flooding in Land Use Planning Guideline' 2021 is included in Section 4.4 of this report.

(d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.

> Consistent: *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) was prepared in accordance with the NSW Floodplain Development Manual 2005. The proposed development within the site has been prepared to adhere to the flood planning considerations outlined in this study, including but not limited to, the use of the 1% AEP event as the defined flood event, definition of the flood planning area, minimum floor levels at the 1%AEP plus 0.5 metres level.

(2) A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones.

Consistent: Although the areas of the site to be used for future residential development will be rezoned from RU1 (primary production) zoning to R5 (large lot residential) zoning, the areas that will be used for the conveyance or storage of floodwater (which include the flood planning area) will be rezoned to C3 (Environmental Management). All R5 areas will be located outside of the post-development flood planning area.

(3) A planning proposal must not contain provisions that apply to the flood planning area which:

(a) permit development in floodway areas,

Consistent: No habitable development is proposed within any floodway area (under proposed conditions).

(b) permit development that will result in significant flood impacts to other properties,

Consistent: Flood level and velocity impacts have been mapped (**Figures 63-80**) for the 63.2%, 50%,20%, 5%, 1%, 0.5% AEP and PMF events. The mapping shows no significant adverse impacts on flood behaviour across other properties.

(c) permit development for the purposes of residential accommodation in high hazard areas,

Consistent: No residential development is proposed within any high hazard areas during floods up to and including the PMF.

(d) permit a significant increase in the development and/or dwelling density of that land,

Consistent: The rezoning from RU2 to RU5 provides the opportunity for increased development within the site. However, no development or increase in dwelling density is proposed within the floodplain (i.e., PMF extent) under proposed conditions.

(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,

Consistent: The development that would result from the panning proposal does not propose any of these development types, and the development maintains effective evacuation in all flood events.

(f) **permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,**

Consistent: A development application will be lodged seeking consent for the proposed development following the approval of the planning proposal.

(g) **are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or**

Consistent: The proposed rezoning and development will locate all development (other than drainage infrastructure) outside of the flood planning area. This will prevent the need for increased government spending on flood mitigation.

Although evacuation from the site is not considered necessary, safe evacuation in all flood events from the site is available via the internal access roadway by exiting the northern most entry on Grange Road and relocating to the Crookwell showground or other location within the township. Therefore, the proposal will not require increased spending on emergency management services and emergency response measures.

(h) **permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.**

Consistent: The proposed rezoning from RU2 (rural) zoning to RU5 (village) zoning will not permit hazardous industries or hazardous storage establishments as only residential development is proposed. Further, all proposed development (other than infrastructure) will be located outside of the PMF.

(4) **A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:**

(a) **permit development in floodway areas,**

(b) **permit development that will result in significant flood impacts to other properties,**

(c) **permit a significant increase in the dwelling density of that land,**

(d) **permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,**

(e) **are likely to affect the safe occupation of and efficient evacuation of the lot, or**

(f) **are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.**

Consistent: Upper Lachlan Shire Council has adopted the Special Flood Considerations clause (clause 5.22 within the LEP). However, as no sensitive land uses are proposed, the special flood considerations clause does not apply.

(5) For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.

Consistent: Flooding within the development site is considered to be 'Minor Tributary Flooding' as per definitions in the *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) which was undertaken for townships located within the Upper Lachlan Shire (including Crookwell in which the site is located) and is therefore considered to be the best local guidance. A flood planning area was developed for the current site in a manner consistent with this study.

Consistency

(9) A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Planning Secretary (or their nominee) that:

(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or

Consistent: No inconsistencies with this planning direction are considered to occur. However, the planning proposal is considered to be consistent with the principles and guidelines of the Floodplain Development Manual 2005 and has followed consistent procedures to the '*The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan*'.

(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or

Not applicable: No inconsistencies with this planning direction are considered to occur, and an adopted Council floodplain risk management study is applicable.

(c) the planning proposal is supported by a flood impact and risk assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or

Consistent: This report forms the Flood Impact and Risk Assessment that has been prepared on behalf of the Upper Lachlan Shire Council and has been completed consistent with the principles and guidelines of the Floodplain Development Manual 2005 and *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017).

(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.

Not applicable: No inconsistencies with this planning direction are considered to occur.

6 SUMMARY

Upper Lachlan Shire Council, on behalf of Tina Dodson of Premise is proposing to rezone land located at Lot 24 DP1119250 at Crookwell, NSW, with the sites being rezoned from RU2 to RU5 or C3 zoning. This report serves as a flood impact and risk assessment that was completed to quantify the potential impacts of development of the site and the compliance of the proposed rezoning and development of the land with relevant local and state government requirements. It was prepared in response to a gateway determination ruling issued by the Department of Planning and Environment (DPE).

The assessment was completed using an XP-RAFTS hydrologic model to simulate catchment hydrology and a TUFLOW model to simulate flood hydraulics. Both models were developed specifically for the current assessment using current industry bast practice and similar hydrologic/hydraulic parameters to that used in '*The Village of Crookwell Flood Study'* (Lyall and Associates, 2014).

The models were used to simulate a range of design floods from the 63.2% AEP flood through to the PMF for 'existing' conditions. The outcomes of the existing conditions assessment showed that there are multiple flow paths through the site. However, the main flow path travels from the south-eastern corner to the western boundary of the site. In events up to an including the 0.2% AEP, areas of H2 form within localised, incised sections of the flow paths and the flood hazard within the farm dams can reach up to H5. In the PMF, the majority of the main flow path is classified as H5, however, the remainder of the site generally remains no higher than H2.

Updates were then completed to the models to represent the proposed rezoning and development of the land. This included fill for future residential lots and roadways, regrading to form a channel through the centre of the site and OSD basins, and associated drainage infrastructure through the site. The modelling confirmed that all future development areas were situated outside of the flood planning area, as well as the extent of the PMF.

A flood impact assessment was completed and shows that although the proposed works are predicted to produce localised changes in flood behaviour within the site, no significant adverse changes in flood level or velocity are predicted outside of the site in all flood events.

An assessment of climate change impacts was also completed (using the 0.5% and 0.2% AEP events as proxies for increased rainfall intensity) and indicated that future increases in rainfall are not predicted to have a significant impact on present day design flood behaviour.

The flood planning area was mapped based on the definition of 'minor tributary flooding' from *'The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan'* (Lyall & Associates, 2017) which is considered to be the best local guidance. This confirms that all proposed development areas are located outside of the flood planning area.

Emergency response has been considered and although evacuation from the site is not considered necessary (i.e., all future development can be located above the peak level of the PMF), access to and egress from the site can be undertaken towards Crookwell via the northern most entry on Grange Road in all flood events.

Overall, the rezoning and development of the land is considered to adhere to the principles of the Floodplain Development Manual 2005, NSW Government's Flood Prone Land Policy, and Considering Flooding in Land Use Planning Guideline 2021. It also demonstrates compliance with the Upper Lachlan Shire Local Environment Plan 2010 and Upper Lachlan Shire Development Control Plan 2010. All specific guidance provided by the Department of Planning and Environment and Upper Lachlan Shire Council has also been addressed, which includes Ministerial Direction 4.1.

7 REFERENCES

- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2019) *Australian Rainfall and Runoff: A Guide to Flood Estimation*, © Commonwealth of Australia (Geoscience Australia).
- Department of Planning and Environment (2021) *Considering flooding in land use planning guideline*
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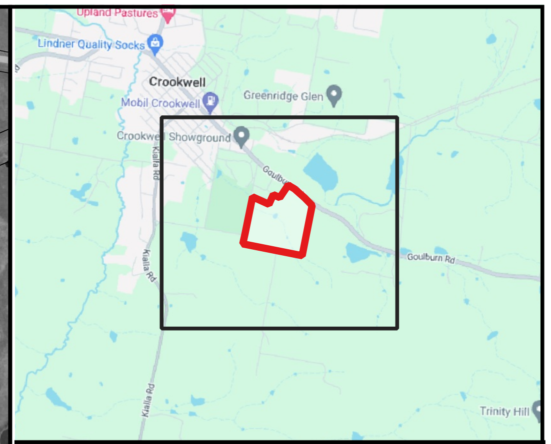
- Lyall & Associates (2014). *The Village of Crookwell Flood Study*. Prepared for Upper Lachlan Shire Council
- Lyall & Associates (2017). *The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan*. Prepared for Upper Lachlan Shire Council
- NSW Government. (2023). *Flood Risk Management Guideline FB02 - Flood Function*
- NSW Government. (2023). *Flood Risk Management Guideline FB03 – Flood Hazard*
- NSW Government. (2023). *Flood Risk Management Manual*
- Upper Lachlan Shire (2010) *Upper Lachlan Shire Development Control Plan*
- Upper Lachlan Shire (2010) *Upper Lachlan Local Environment Plan*

APPENDIX A
FIGURES



LEGEND
Site Location
Main Streams

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:7500 (at A3)

0 90 180 270 360 m

Figure 1 :
Location of Development Site

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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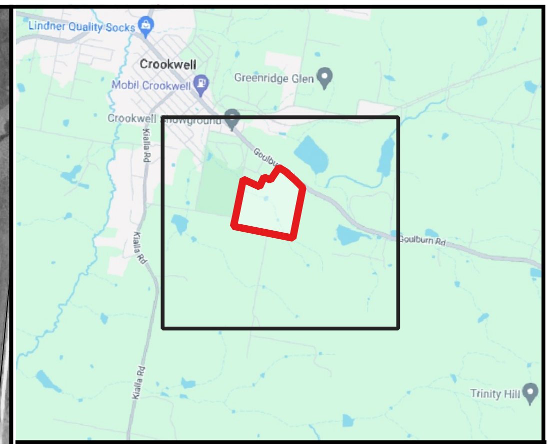

LEGEND
Site Location
Subcatchment Area
Nodal Links

Notes:
Aerial photograph: NSW SIX MAPS

N
Scale: 1:7500 (at A3)
0 90 180 270 360 m

Figure 2 :
XP-RAFTS
Subcatchment Layout

Prepared by:
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Sydney, NSW, 2000

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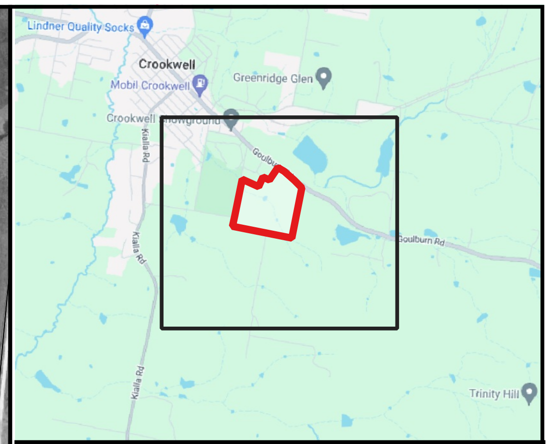

LEGEND

- Site Location
- TUFLOW Model Extent
- Hydrologic Inflow Location
- Culvert
- Stage-Flow Boundary

Materials

- Grass
- Roadways
- Trees
- Buildings
- Waterbodies

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:7500 (at A3)

0 90 180 270 360 m

Figure 3 : Existing TUFLOW Model Layout

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Sydney, NSW, 2000

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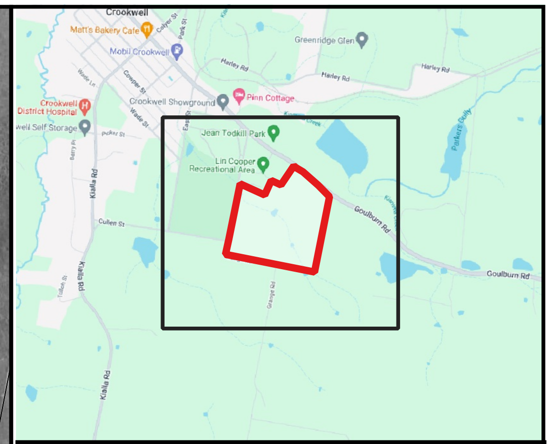

LEGEND

Site Location

Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 4 :
Peak Floodwater Depths and Levels for the 63.2% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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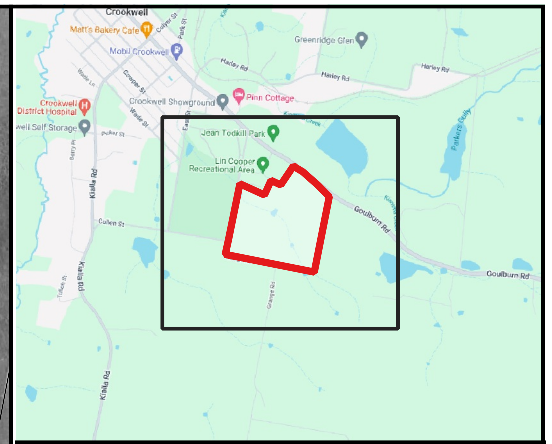

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 5 : Peak Floodwater Depths and Levels for the 50% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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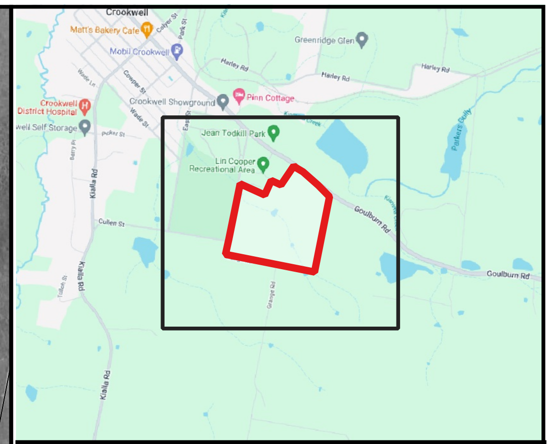

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 6 : Peak Floodwater Depths and Levels for the 20% AEP Flood for Existing Conditions

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Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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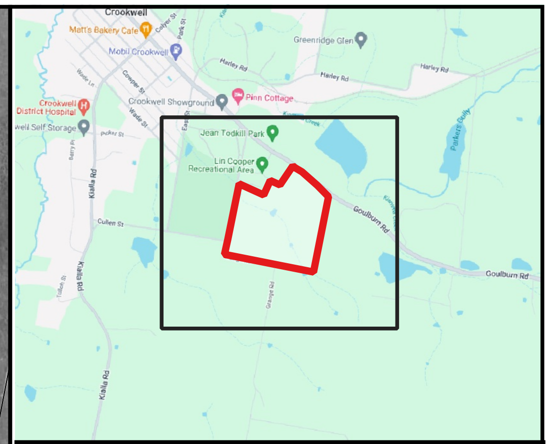

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 7 : Peak Floodwater Depths and Levels for the 10% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 8 :
Peak Floodwater Depths and Levels for the 5% AEP Flood for Existing Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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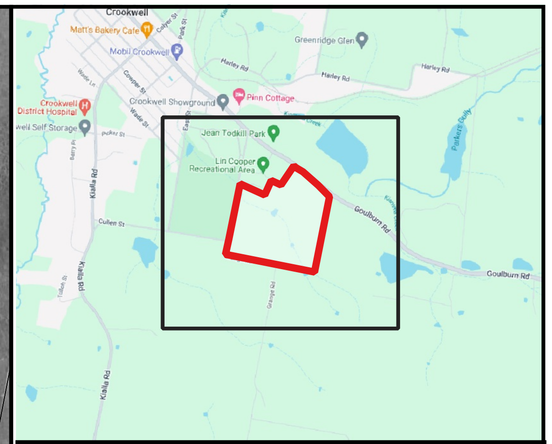

LEGEND
- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)
- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 9 :
Peak Floodwater Depths and Levels for the 2% AEP Flood for Existing Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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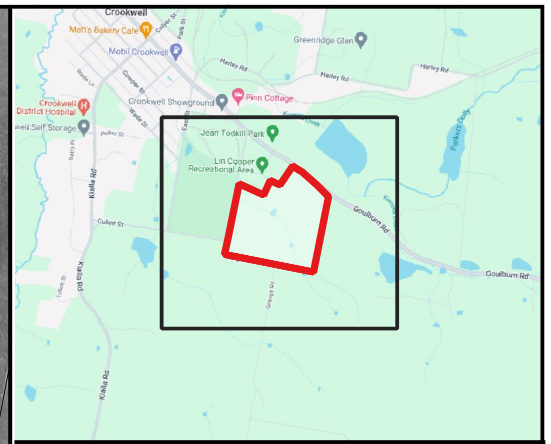

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 10 :
Peak Floodwater Depths and Levels for the 1% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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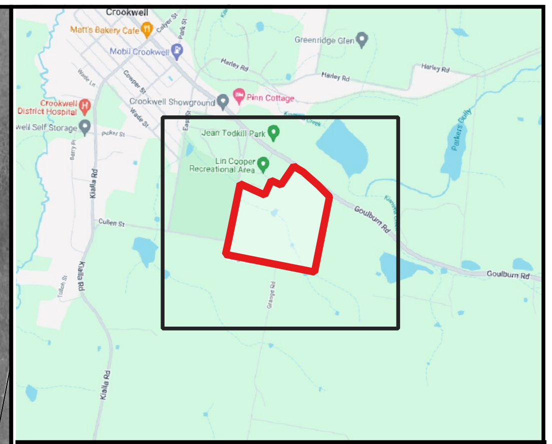

LEGEND

Site Location

Flood Level Contour (0.5m interval)

Depth(m)

0.00 - 0.20
0.20 - 0.40
0.40 - 0.60
0.60 - 0.80
0.80 - 1.00
1.00 - 1.20
> 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 11 :
Peak Floodwater Depths and Levels for the 0.5% AEP Flood for Existing Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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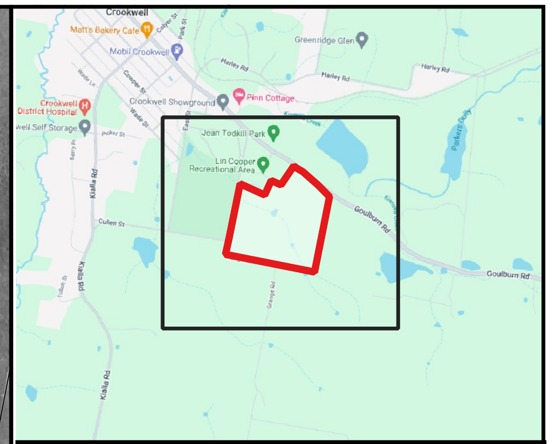

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 12 : Peak Floodwater Depths and Levels for the 0.2% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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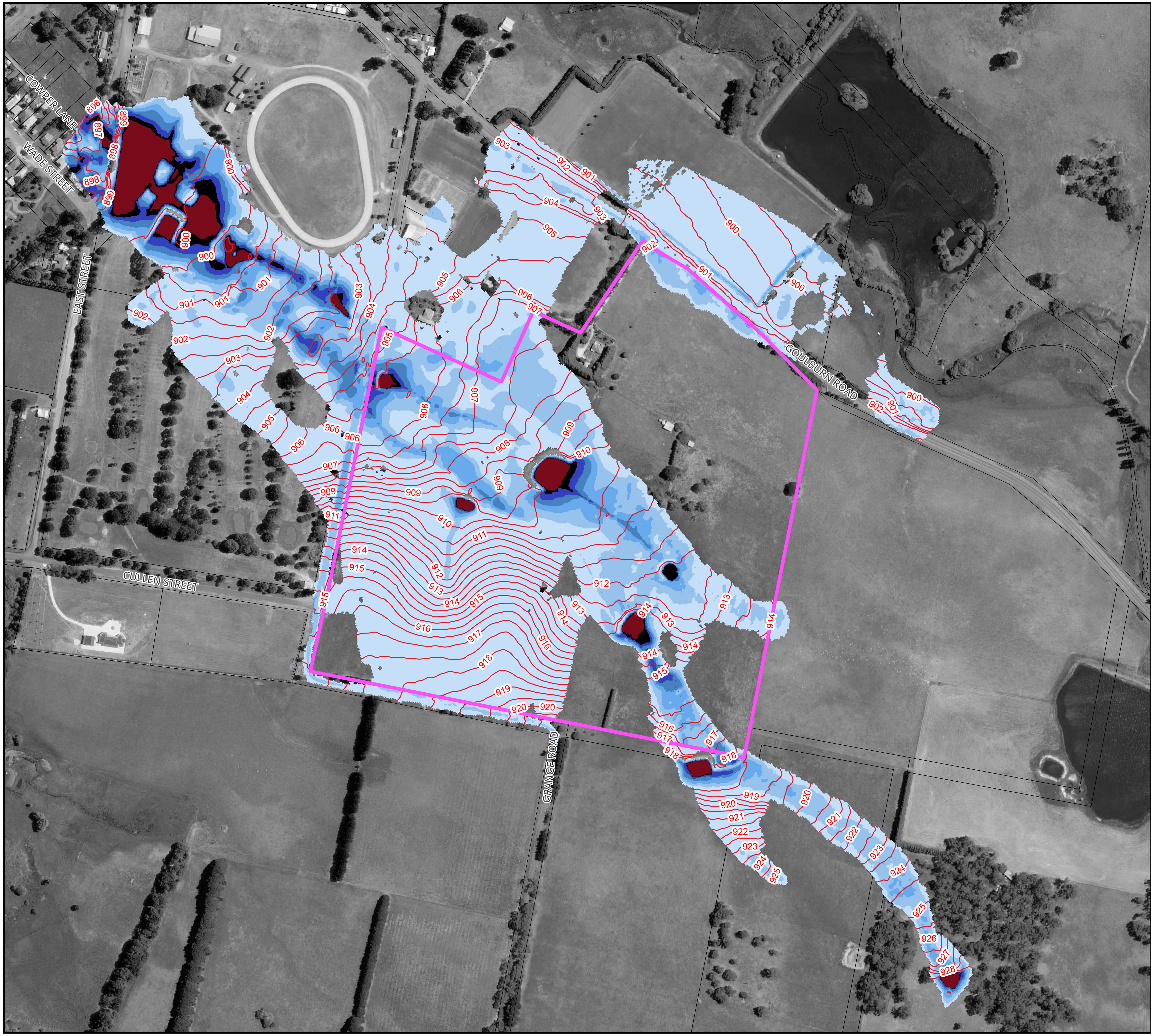

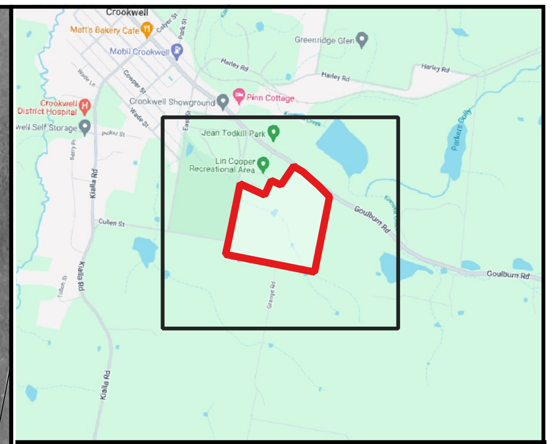

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 13 :
Peak Floodwater Depths and Levels for the PMF for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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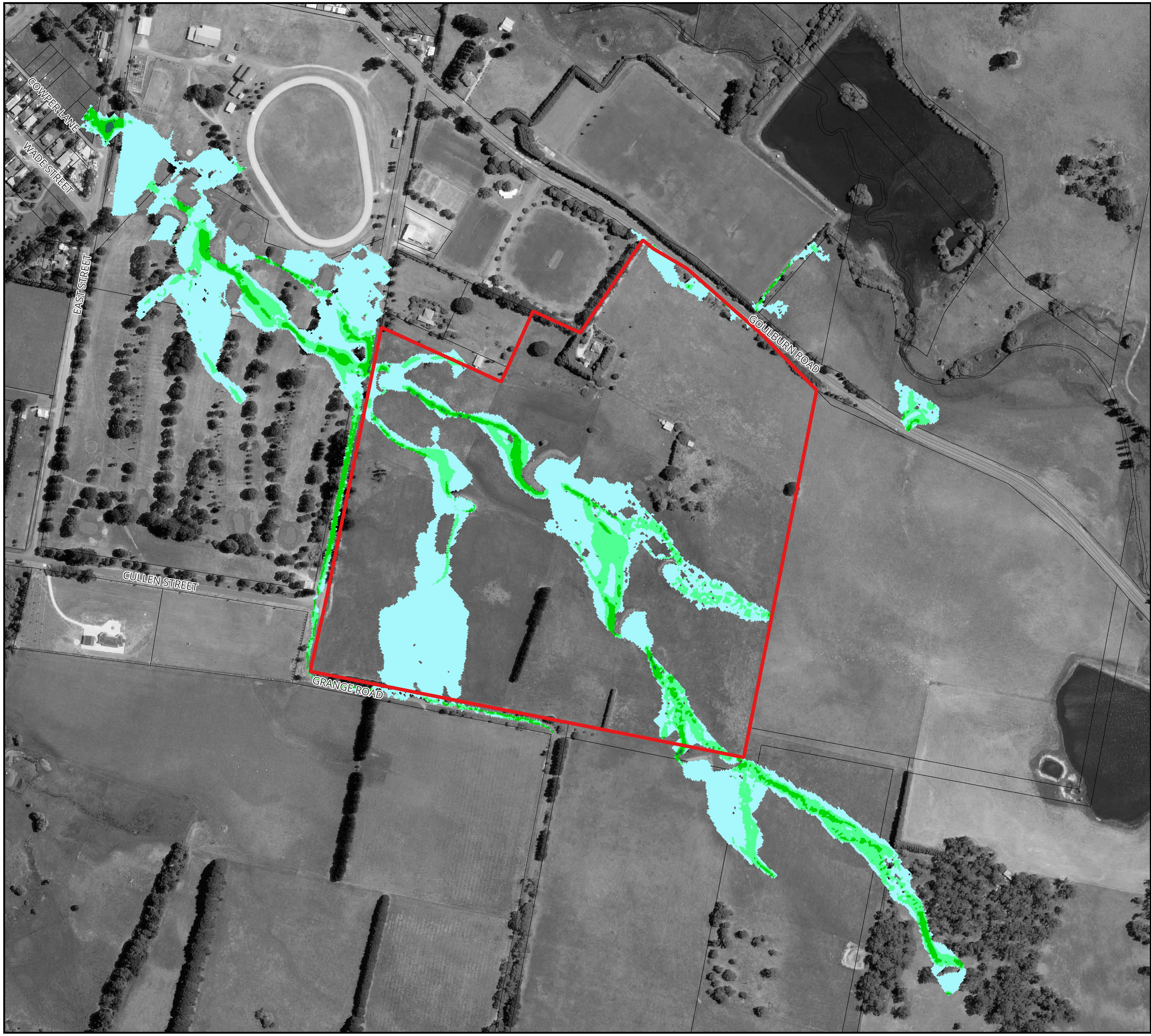

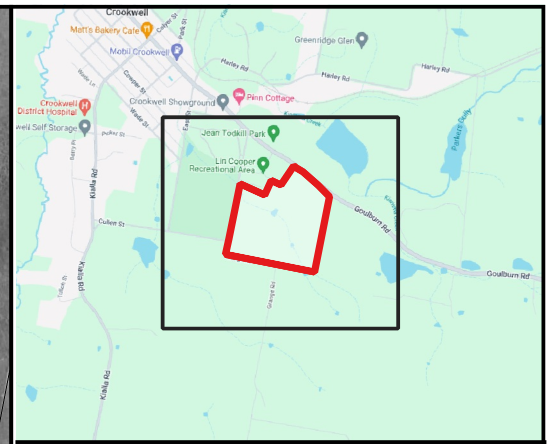

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 14 :
Peak Flood Velocity for the 63.2% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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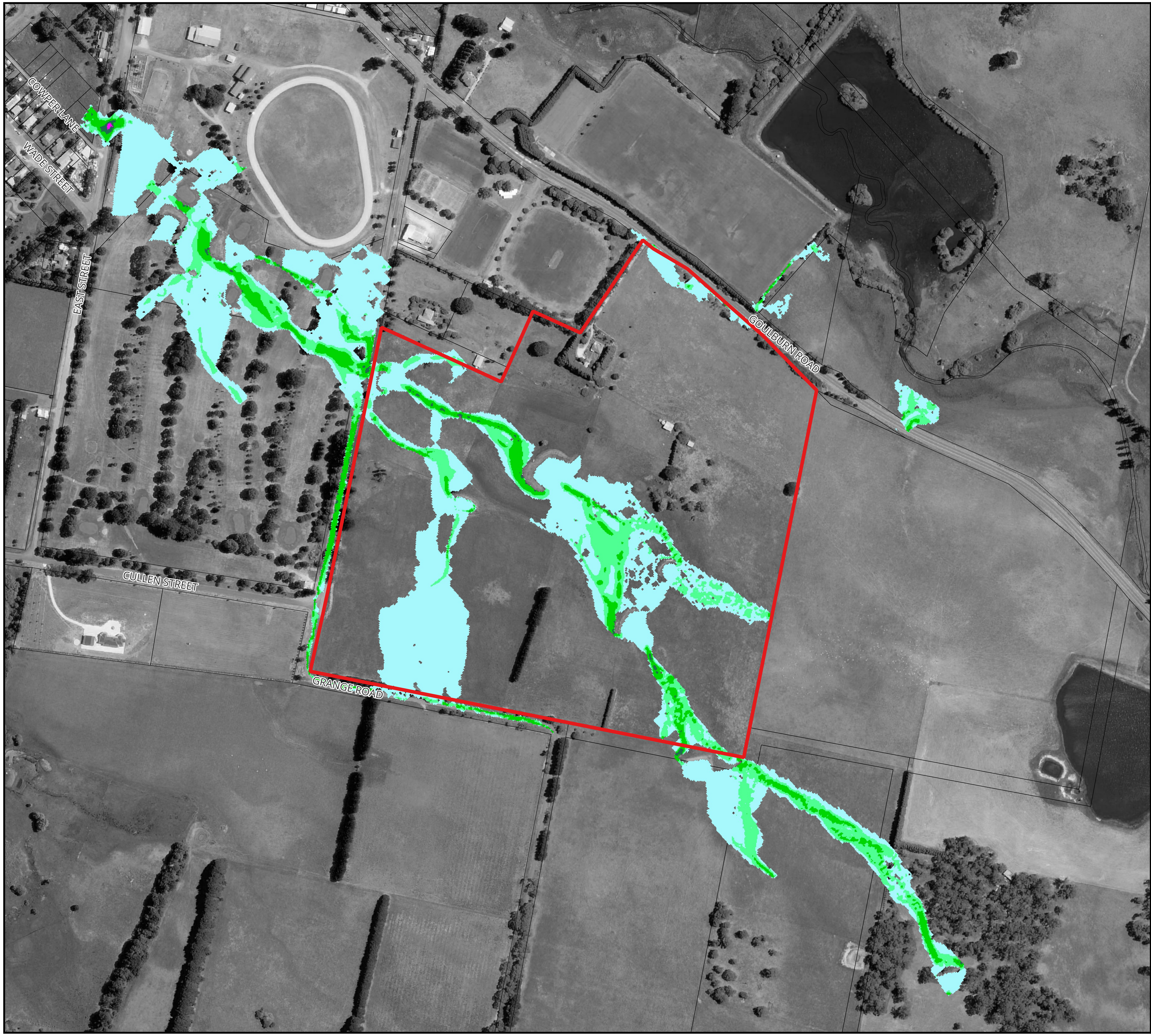

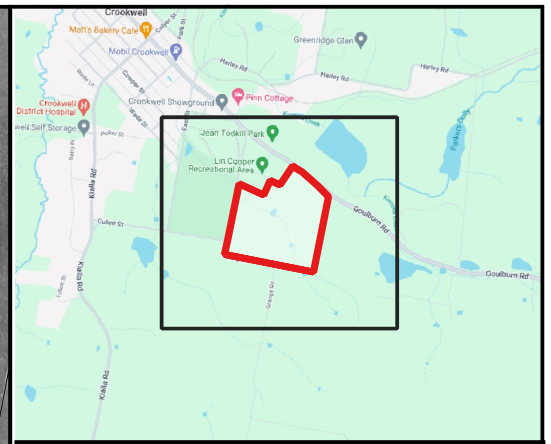

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 15 :
Peak Flood Velocity for the 50% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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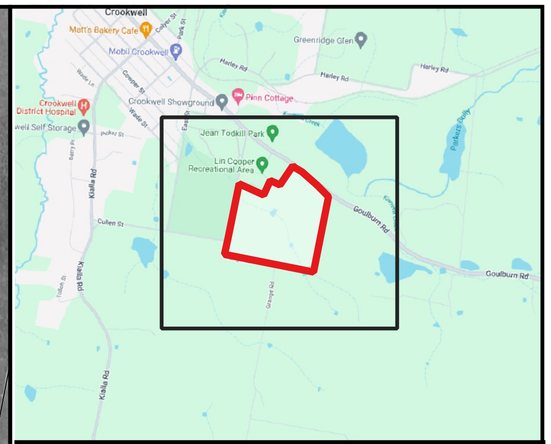

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 16 :
Peak Flood Velocity for the 20% AEP Flood for Existing Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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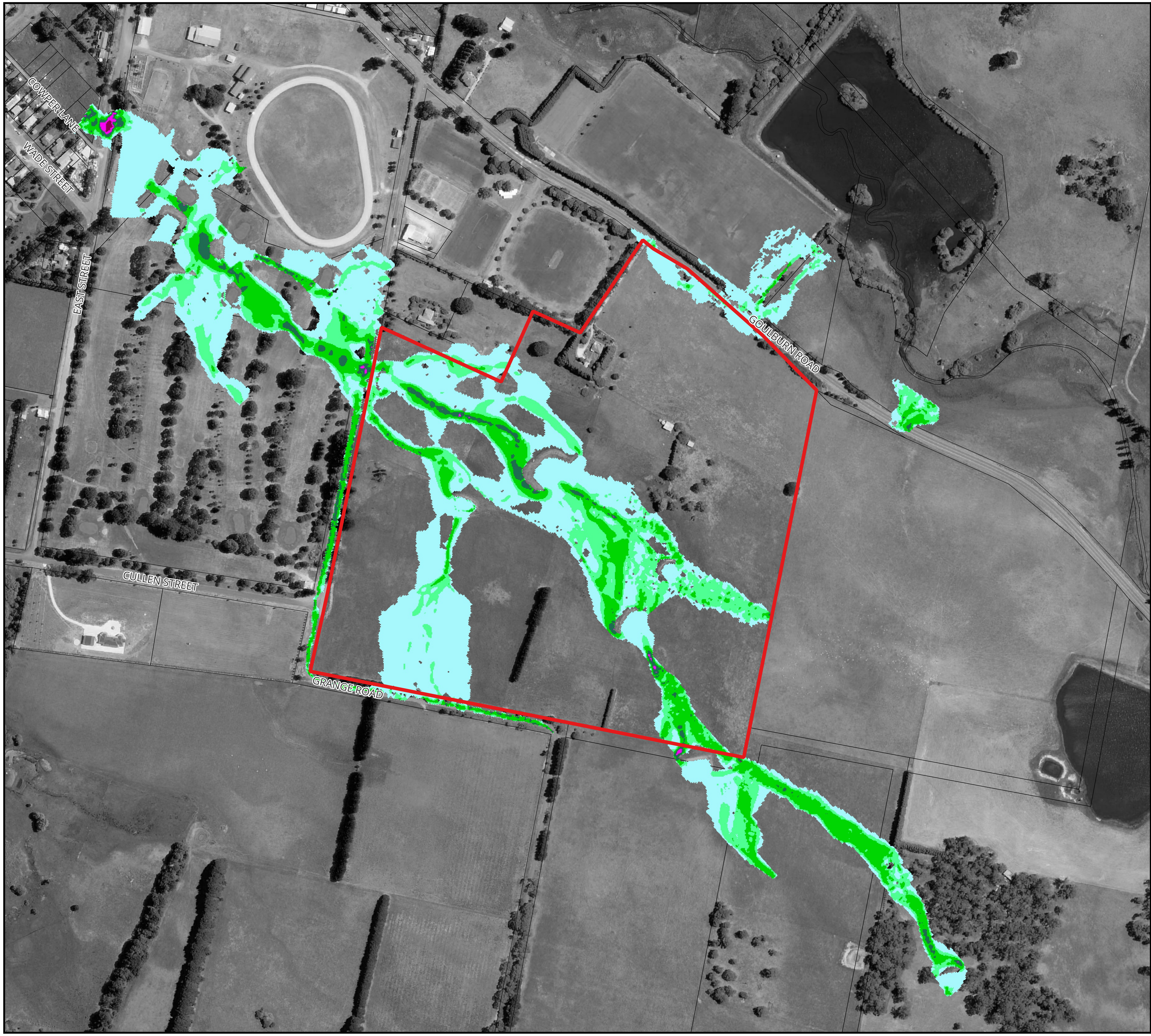

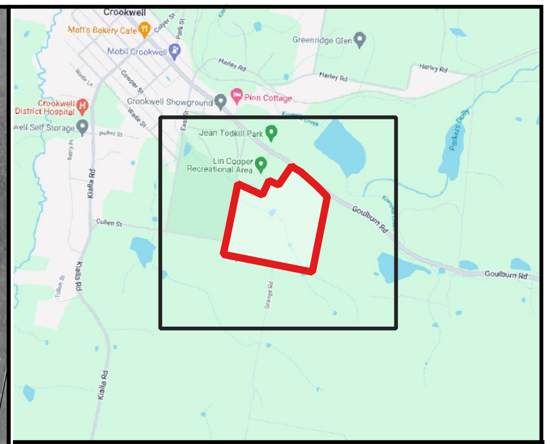

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 17 :
Peak Flood Velocity for the 10% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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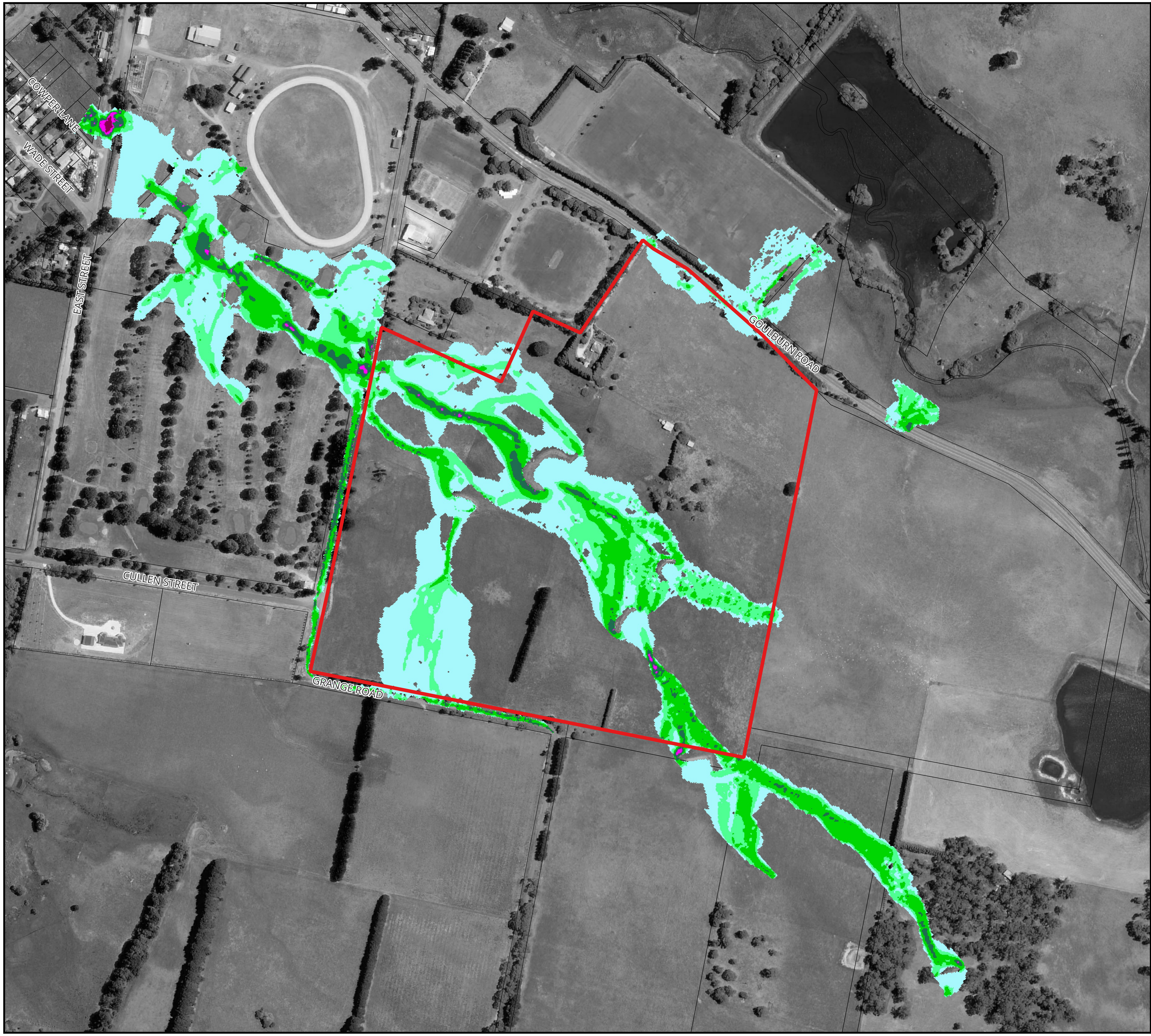

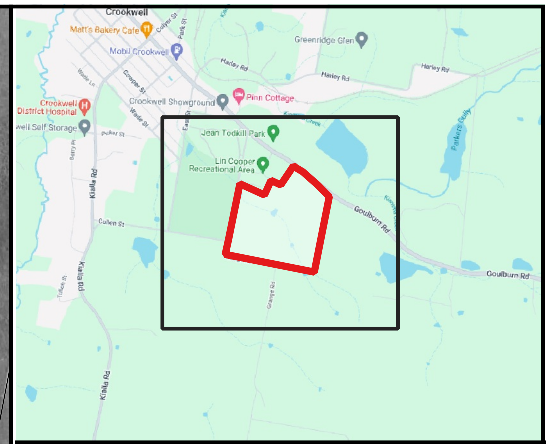

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 18 :
Peak Flood Velocity for
the 5% AEP Flood for
Existing Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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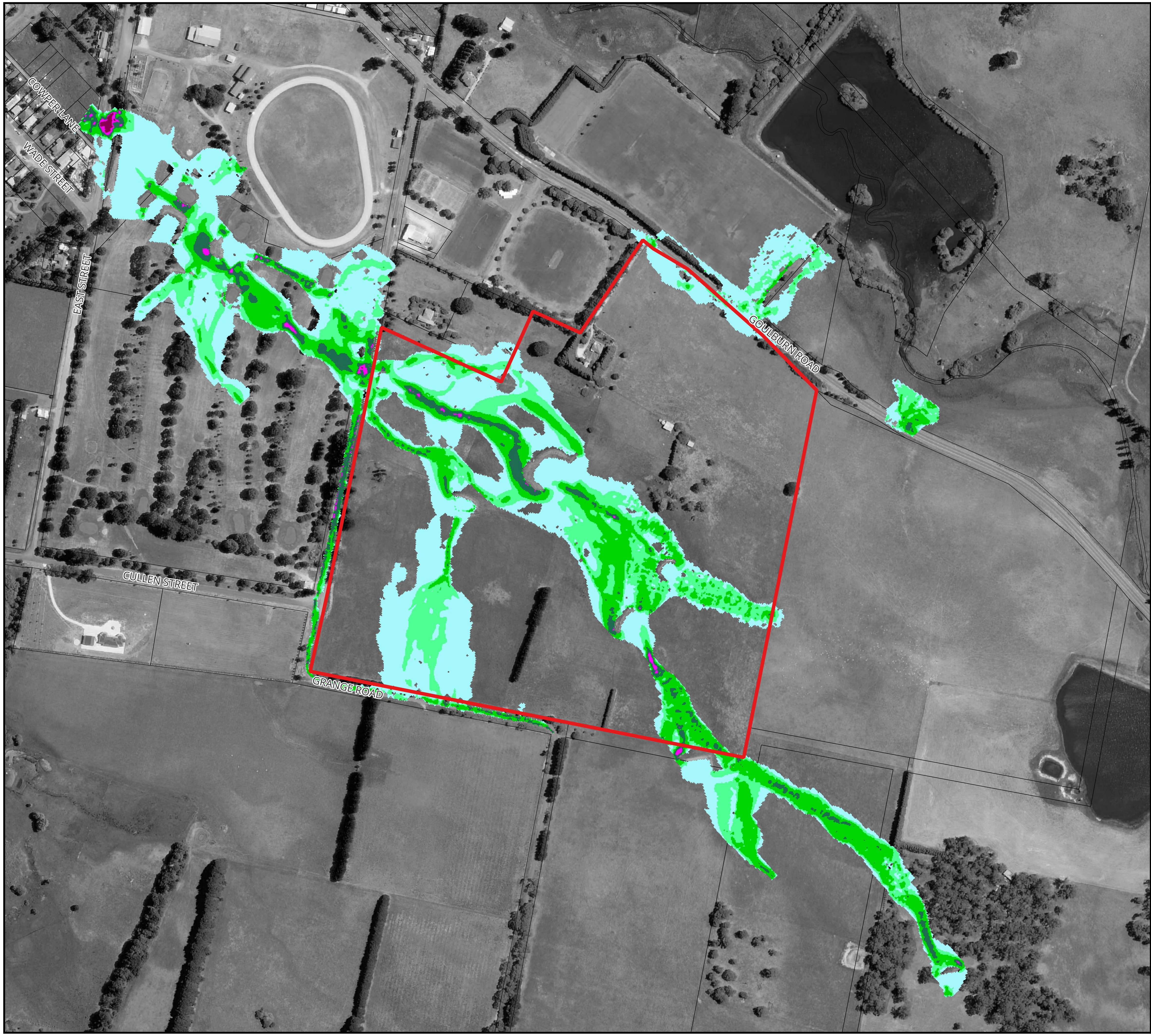

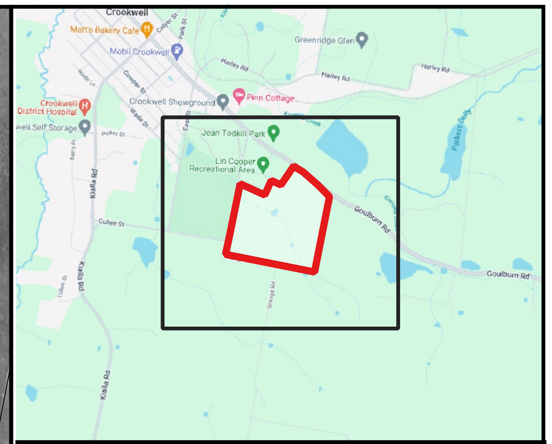

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 19 :
Peak Flood Velocity for the 2% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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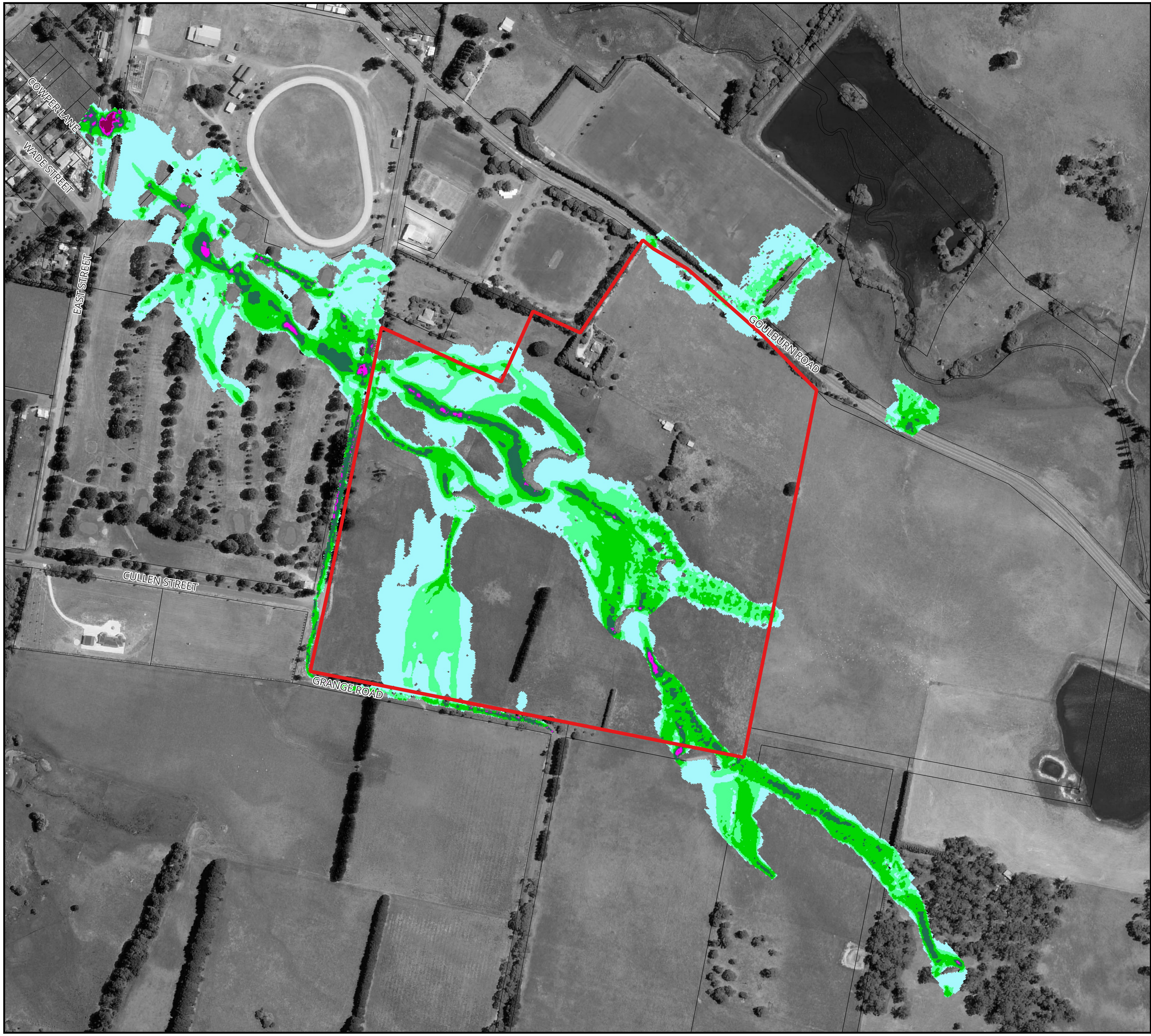

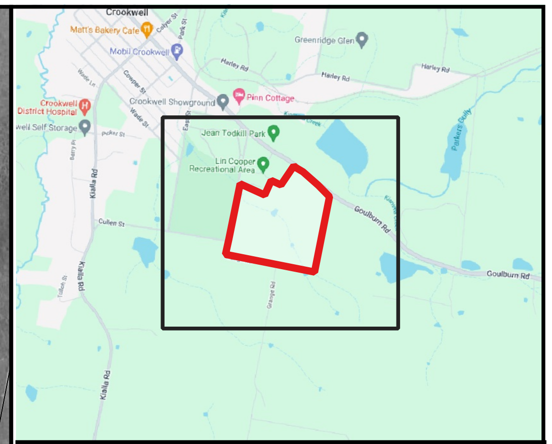

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 20 :
Peak Flood Velocity for the 1% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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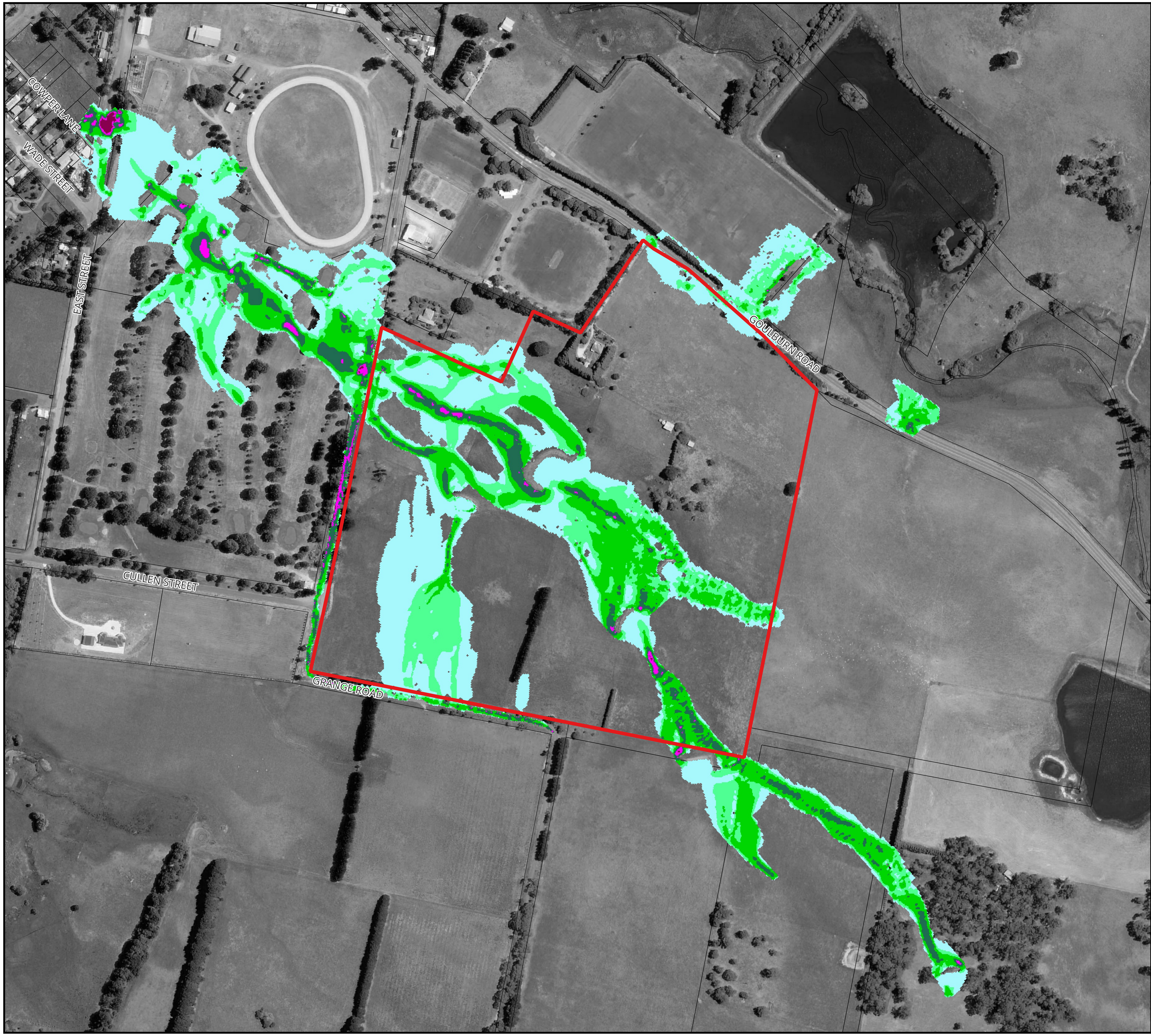

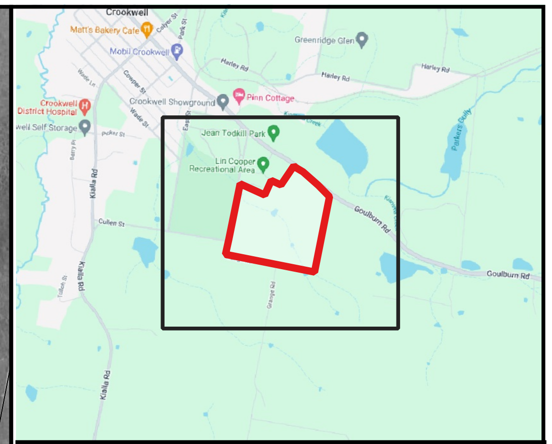

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 21 :
Peak Flood Velocity for the 0.5% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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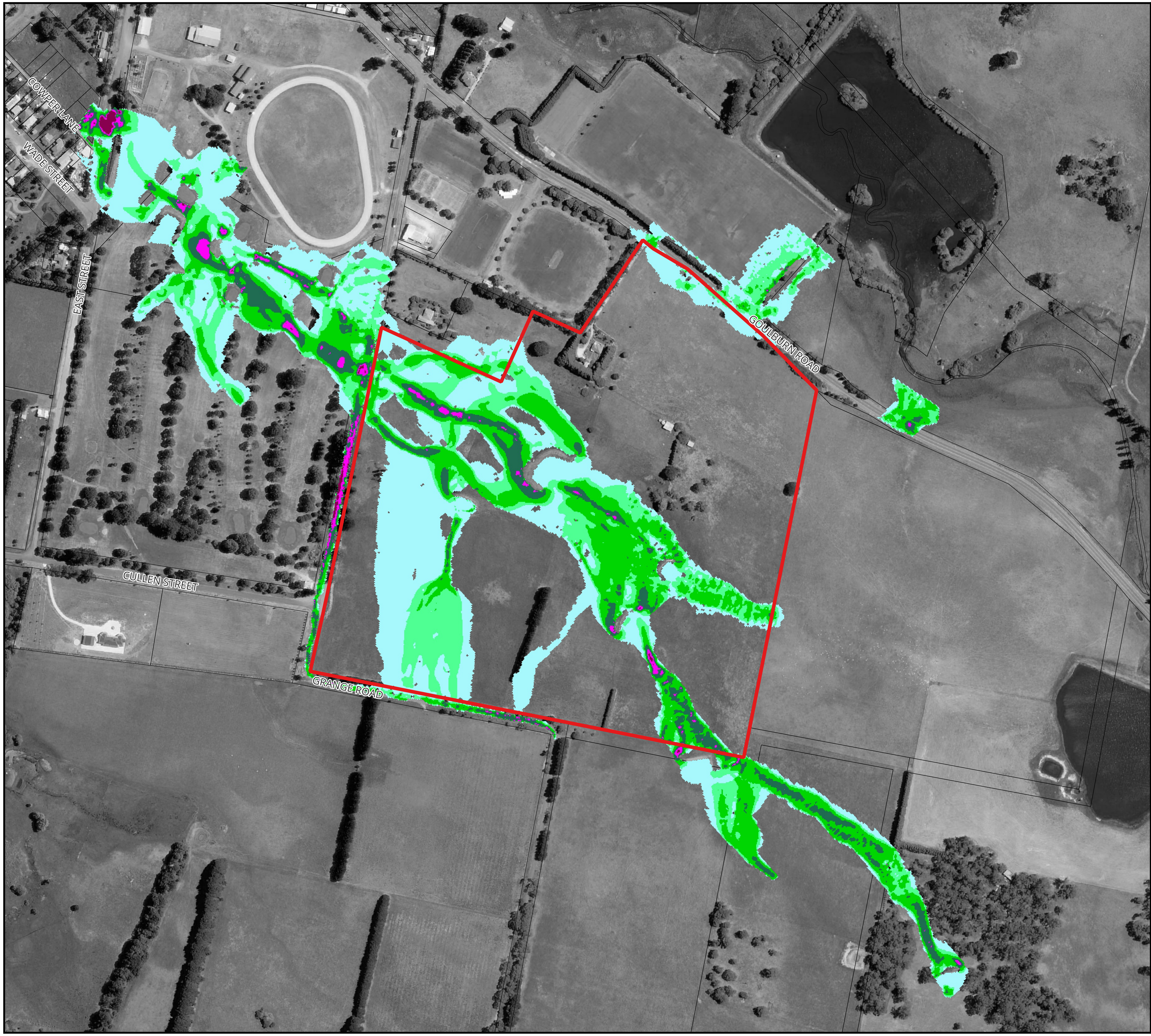

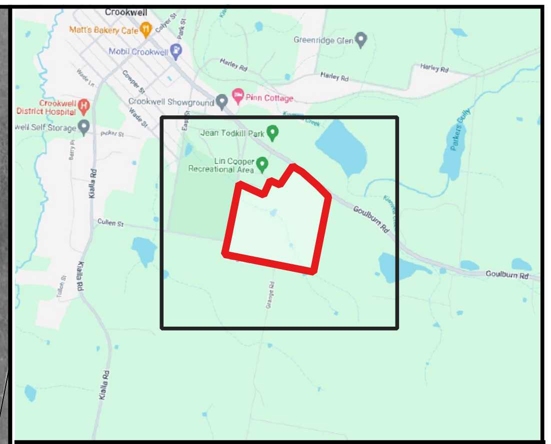

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 22 :
Peak Flood Velocity for the 0.2% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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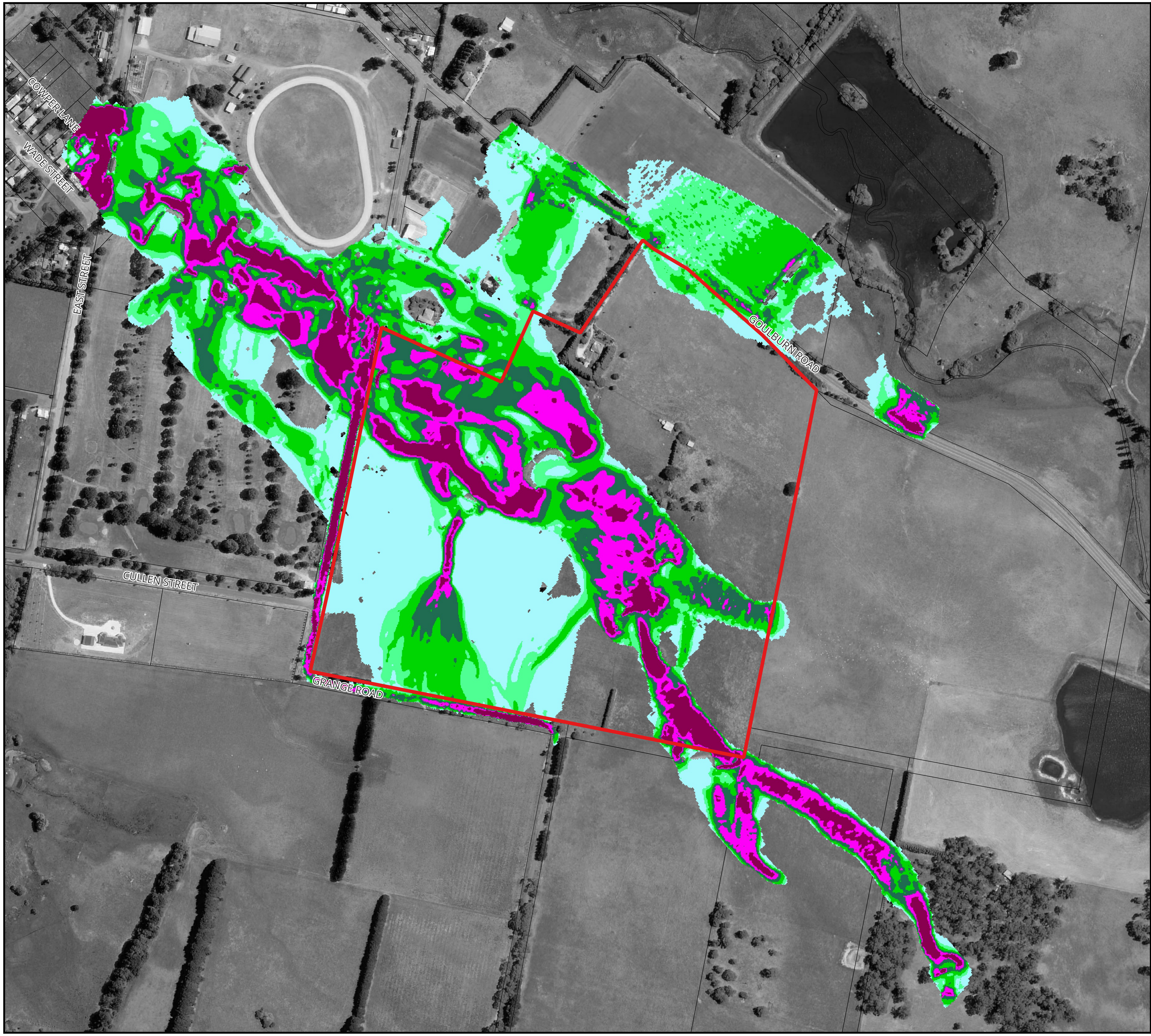
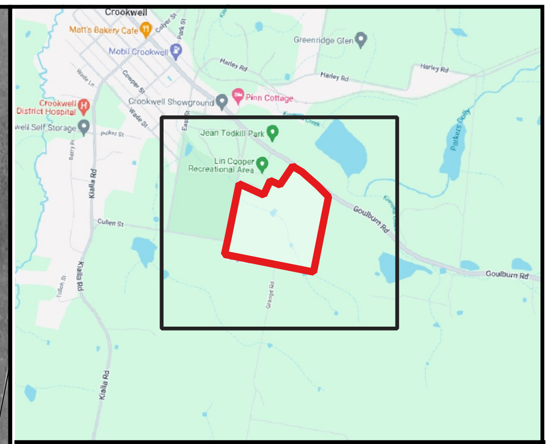




LEGEND
Site Location
Velocity (m/s)
<= 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00

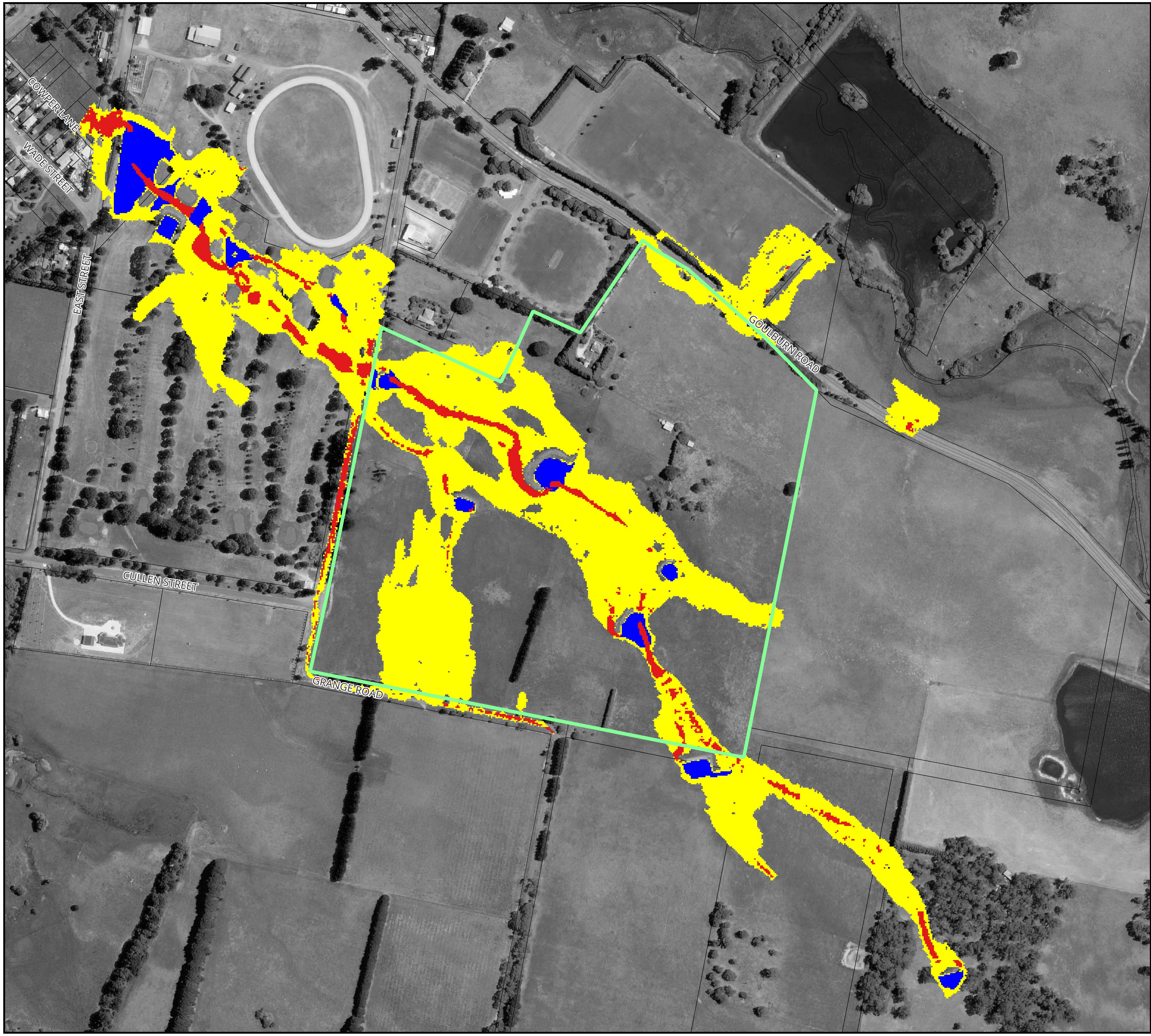
Notes:
Aerial photograph: NSW SIX MAPS

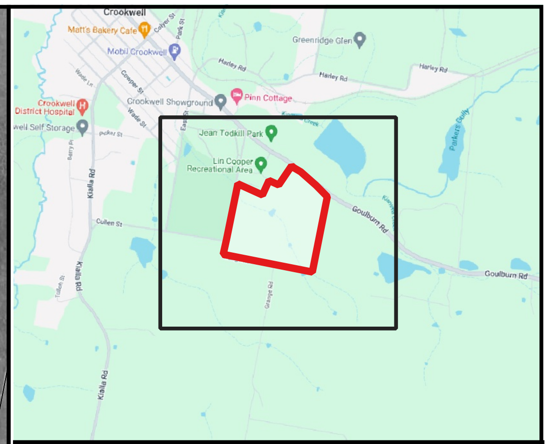
N
Scale: 1:5000 (at A3)
0 60 120 180 240 m

Figure 23 :
Peak Flood Velocity for the PMF for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\J760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz





LEGEND
Site Location
Hydraulic Categories
Flood Fringe
Flood Storage
Floodway

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 24 :
Hydraulic Categories for the 1% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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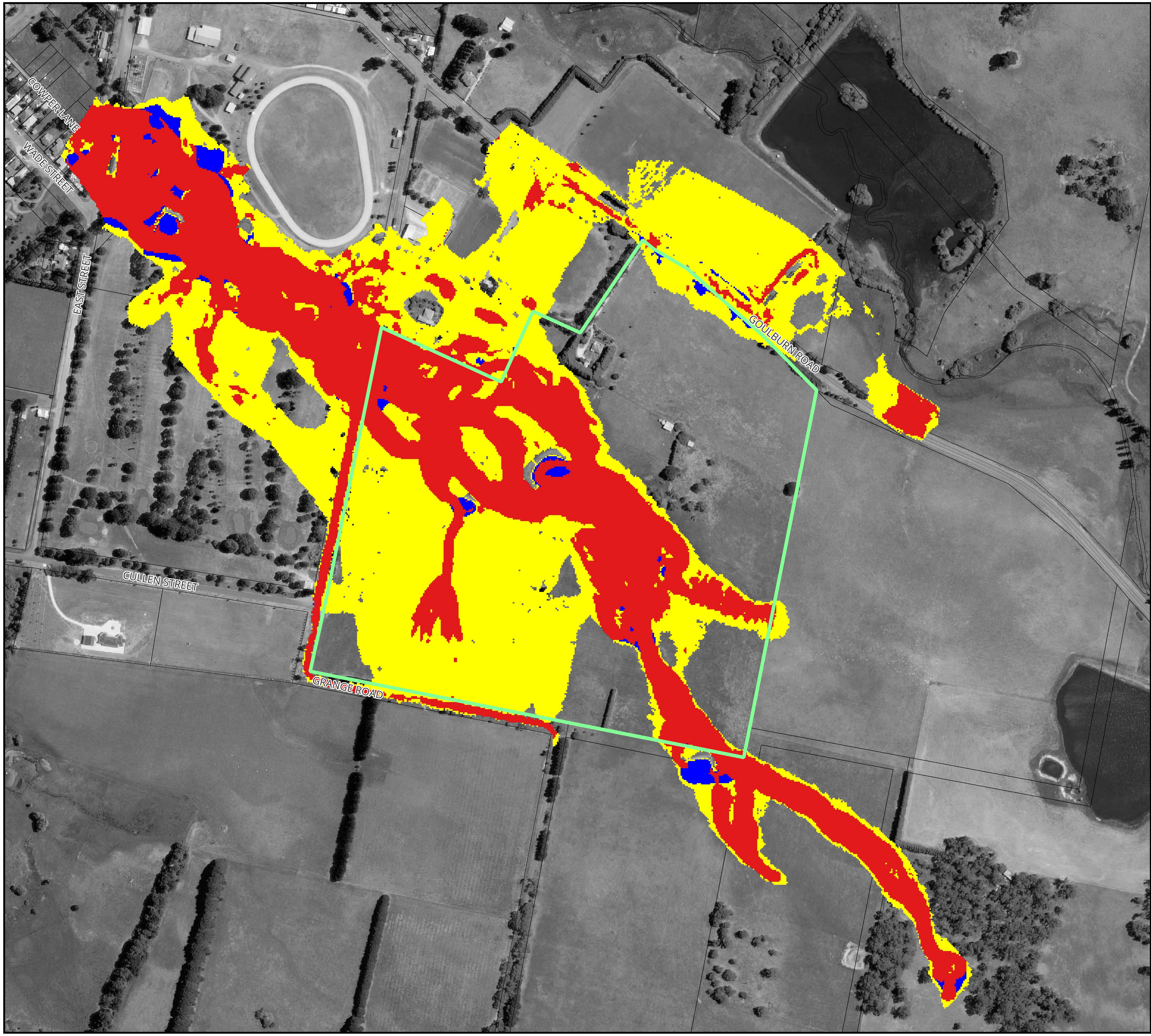

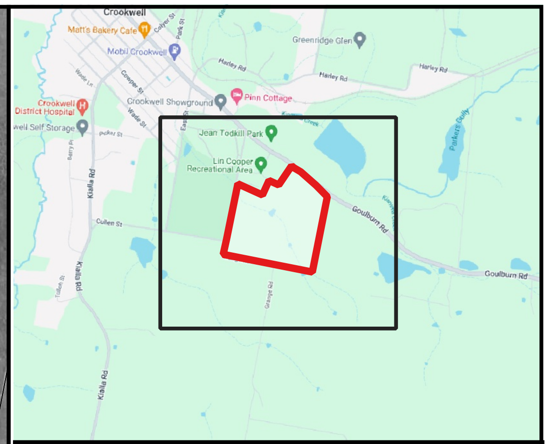

LEGEND
Site Location
Hydraulic Categories
Flood Fringe
Flood Storage
Floodway

Notes:
Aerial photograph: NSW SIX MAPS

N
Scale: 1:5000 (at A3)
0 60 120 180 240 m

Figure 25 :
Hydraulic Categories for the PMF for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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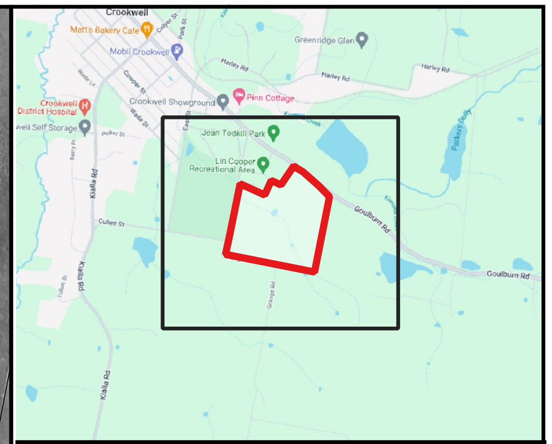

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 26 :
Flood Hazard for the 63.2% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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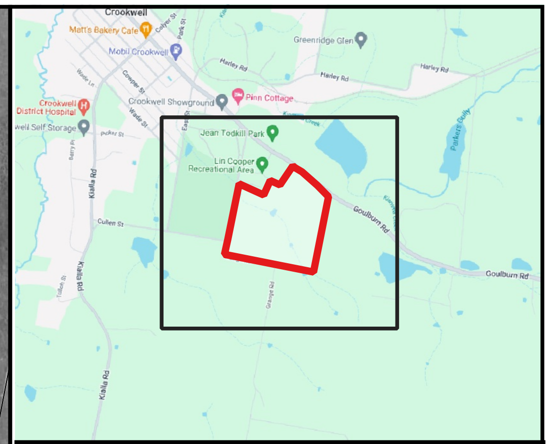

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 27 : Flood Hazard for the 50% AEP Flood for Existing Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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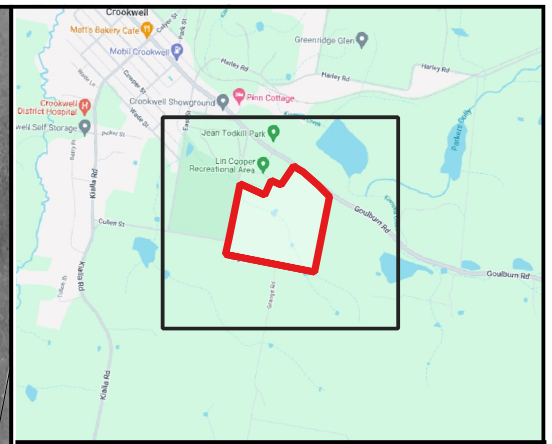

LEGEND

- Site Location
- Hazard Categories
  - H1 - Generally safe
  - H2 - Unsafe for small vehicles
  - H3 - Unsafe for vehicles, childrenand elderly
  - H4 - Unsafe for people and vehicles
  - H5 - Unsafe for people and vehicles Buildings require special design
  - H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 28 :
Flood Hazard for the 20% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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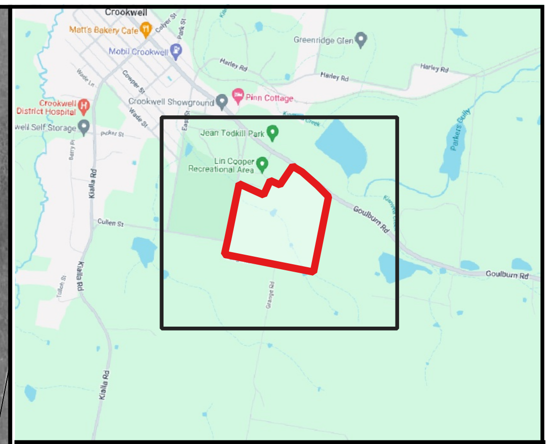

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 29 :
Flood Hazard for the 10% AEP Flood for Existing Conditions**

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz

LEGEND

- Site Location
- Hazard Categories
  - H1 - Generally safe
  - H2 - Unsafe for small vehicles
  - H3 - Unsafe for vehicles, childrenand elderly
  - H4 - Unsafe for people and vehicles
  - H5 - Unsafe for people and vehicles Buildings require special design
  - H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 30 :
Flood Hazard for the 5% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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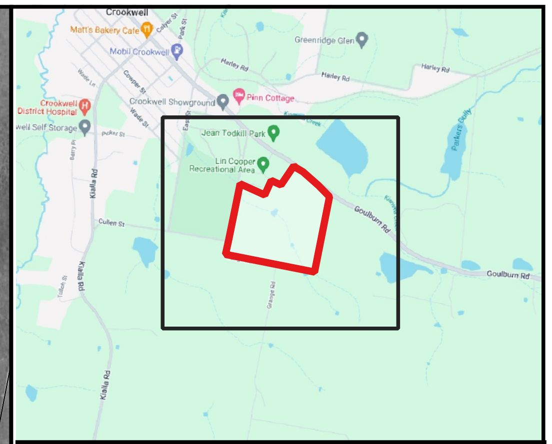

LEGEND

- Site Location
- Hazard Categories
- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 31 :
Flood Hazard for the 2% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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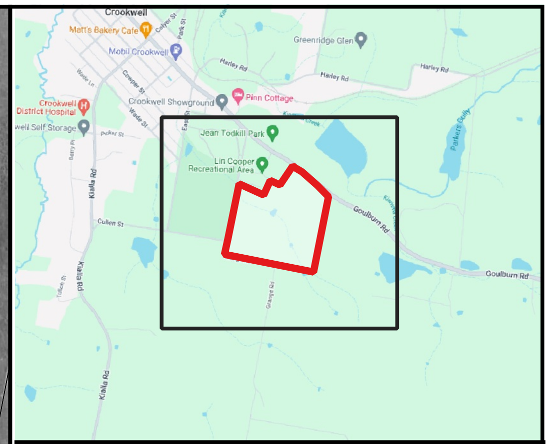

LEGEND

- Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 32 :
Flood Hazard for the 1% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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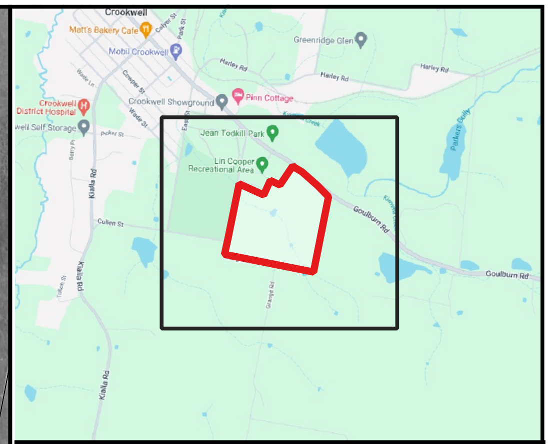


LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

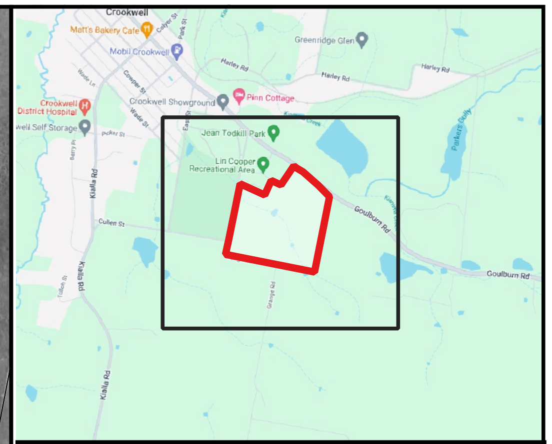
Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 33 :
Flood Hazard for the 0.5% AEP Flood for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

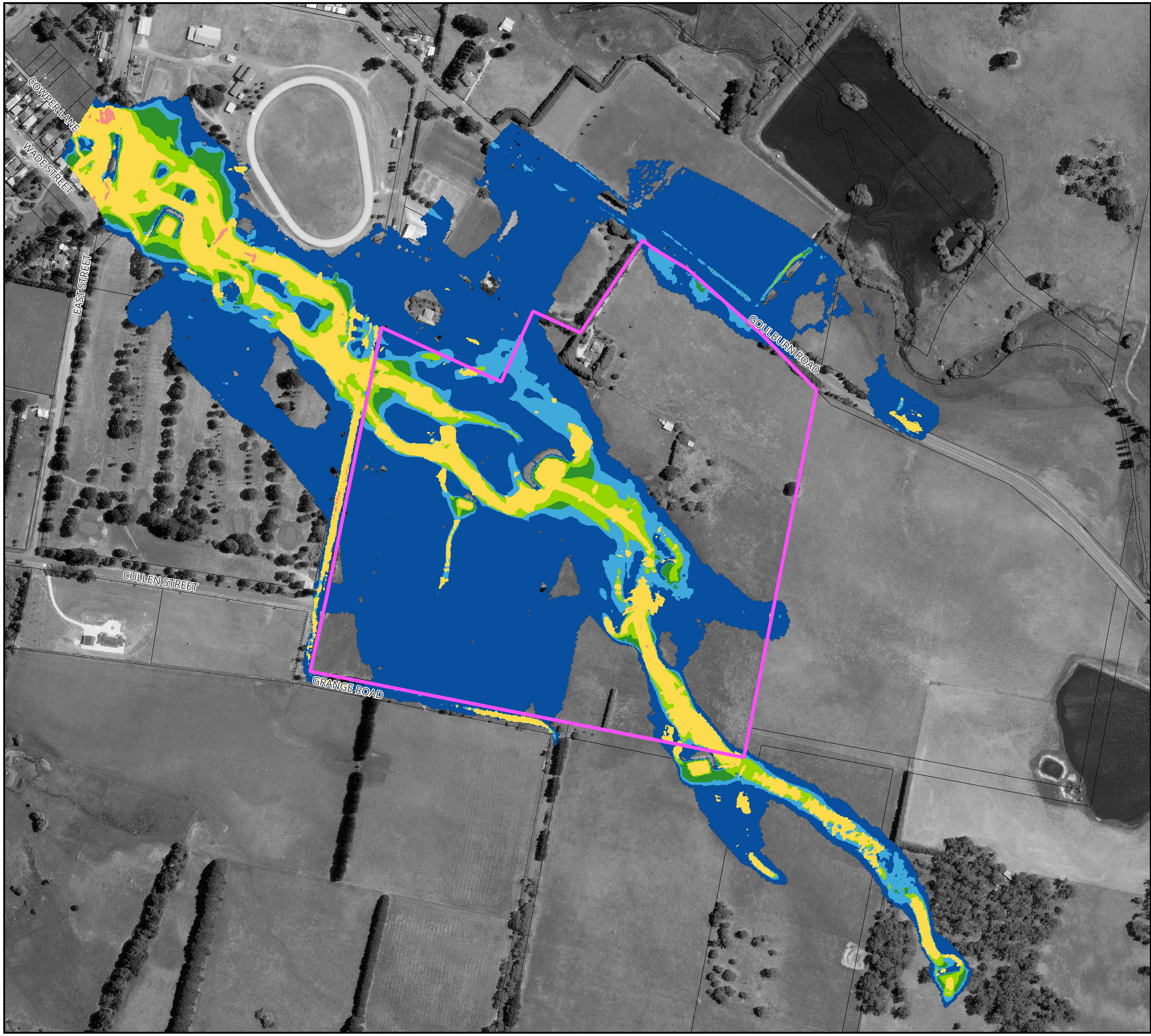
0 60 120 180 240 m

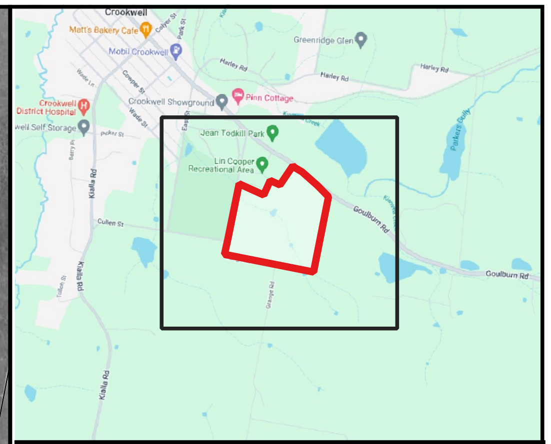
**Figure 34 :
Flood Hazard for the 0.2% AEP Flood for Existing Conditions**

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz





LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

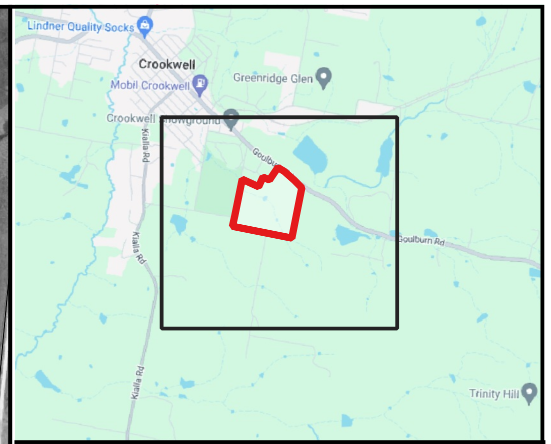
Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 35 :
Flood Hazard for the PMF for Existing Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

- Site Location
- TUFLOW Model Extent
- Hydrologic Inflow Location
- Culvert
- Stage-Flow Boundary

Materials

- Grass
- Roadways
- Trees
- Buildings
- Waterbodies
- Proposed Watercourse with Plantations
- Proposed Lots
- Natural space with trees/shrubs

Notes:
Aerial photograph: NSW SIX MAPS

N

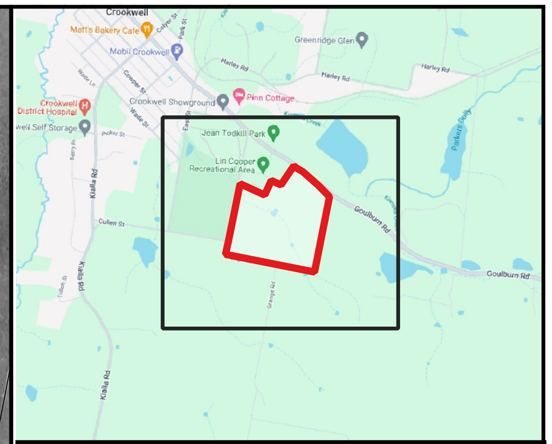
Scale: 1:7500 (at A3)

0 90 180 270 360 m

Figure 36 :
Post-Development TUFLOW Model Layout

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\J760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 37 :
Peak Floodwater Depths and Levels for the 63.2% AEP Flood for Proposed Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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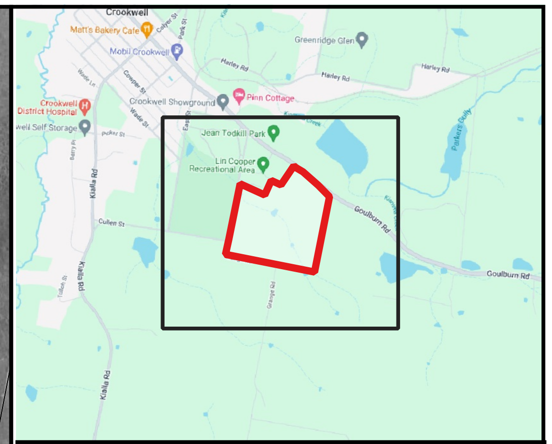


LEGEND
Site Location
Flood Level Contour (0.5m interval)
Depth(m)
0.00 - 0.20
0.20 - 0.40
0.40 - 0.60
0.60 - 0.80
0.80 - 1.00
1.00 - 1.20
> 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

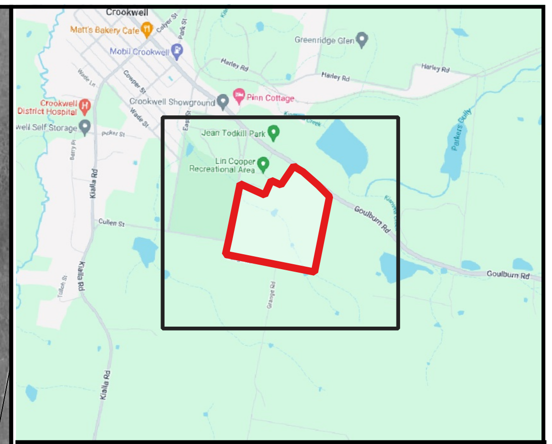
Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 38 :
Peak Floodwater Depths and Levels for the 50% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 39 : Peak Floodwater Depths and Levels for the 20% AEP Flood for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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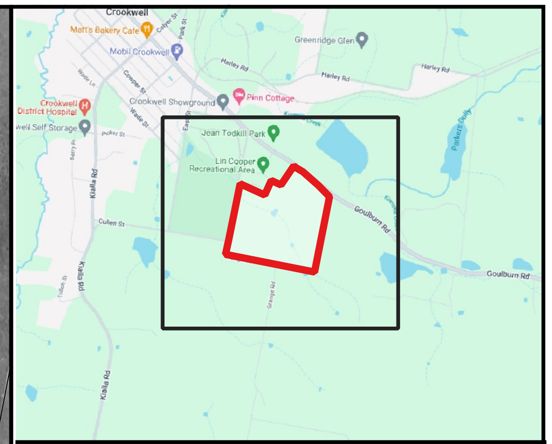

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 40 : Peak Floodwater Depths and Levels for the 10% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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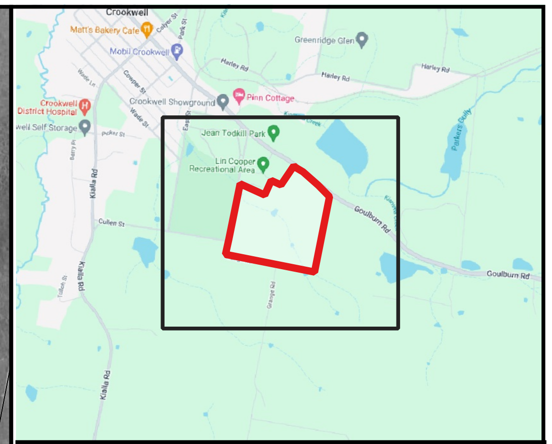

LEGEND

Site Location

Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 41 : Peak Floodwater Depths and Levels for the 5% AEP Flood for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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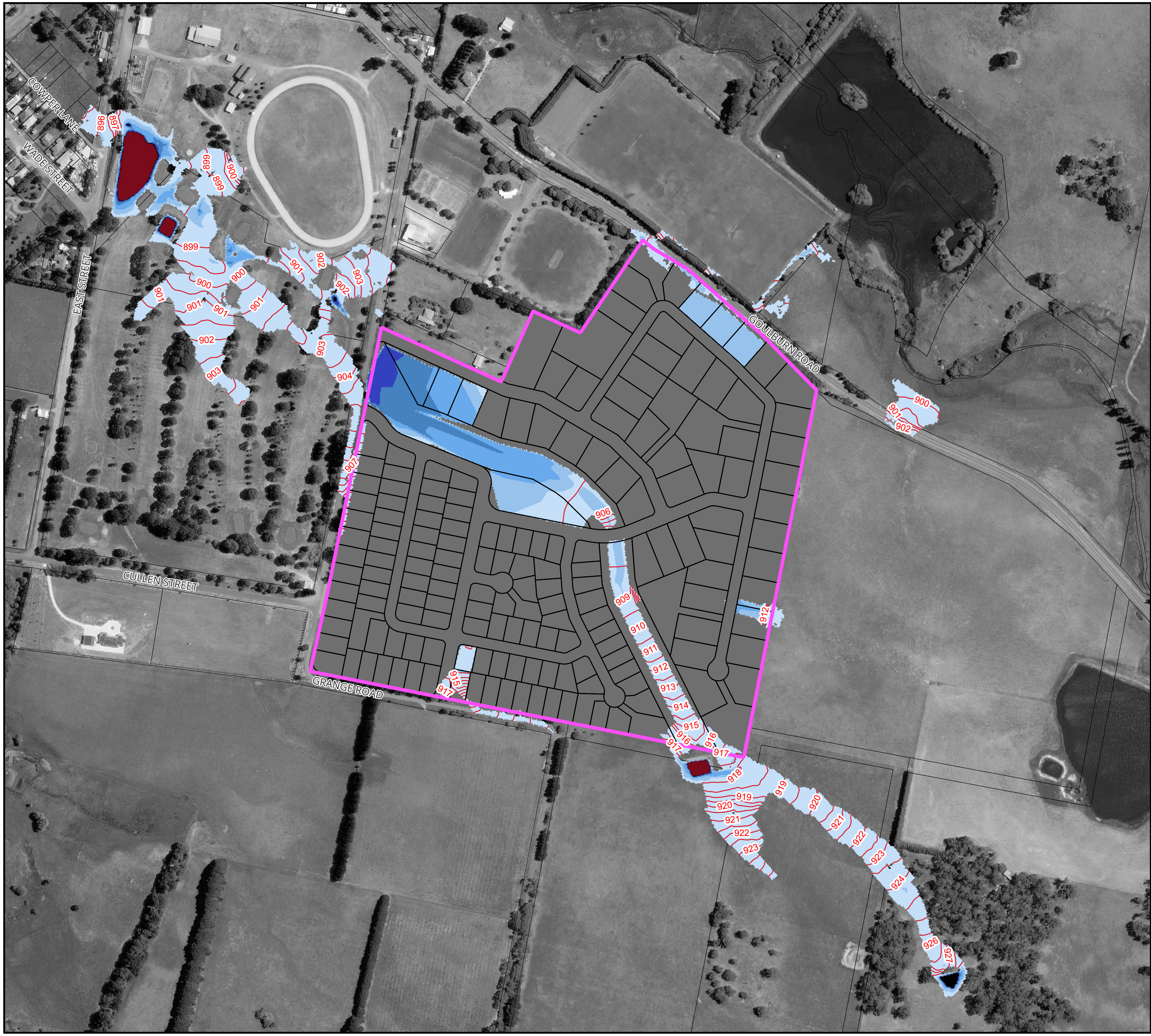

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 42 : Peak Floodwater Depths and Levels for the 2% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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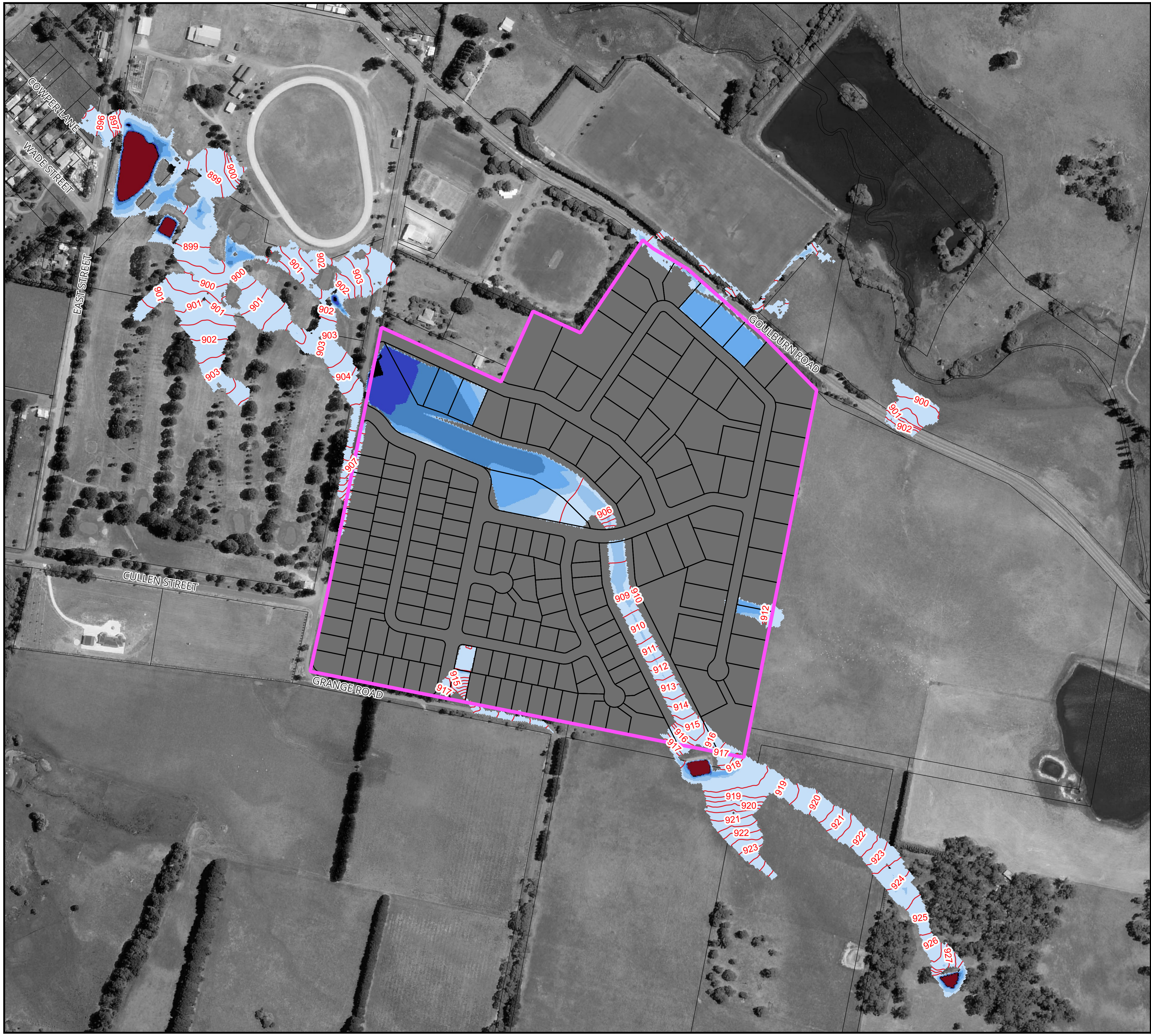

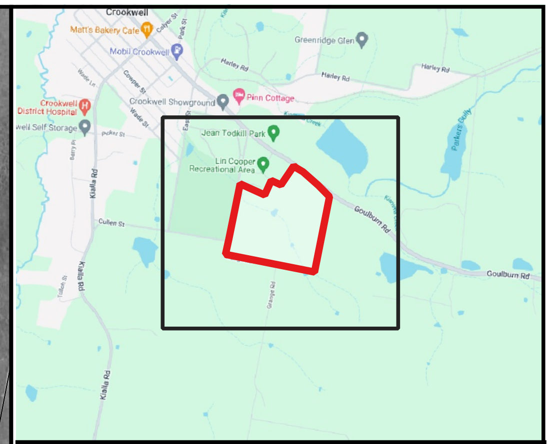

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 43 :
Peak Floodwater Depths and Levels for the 1% AEP Flood for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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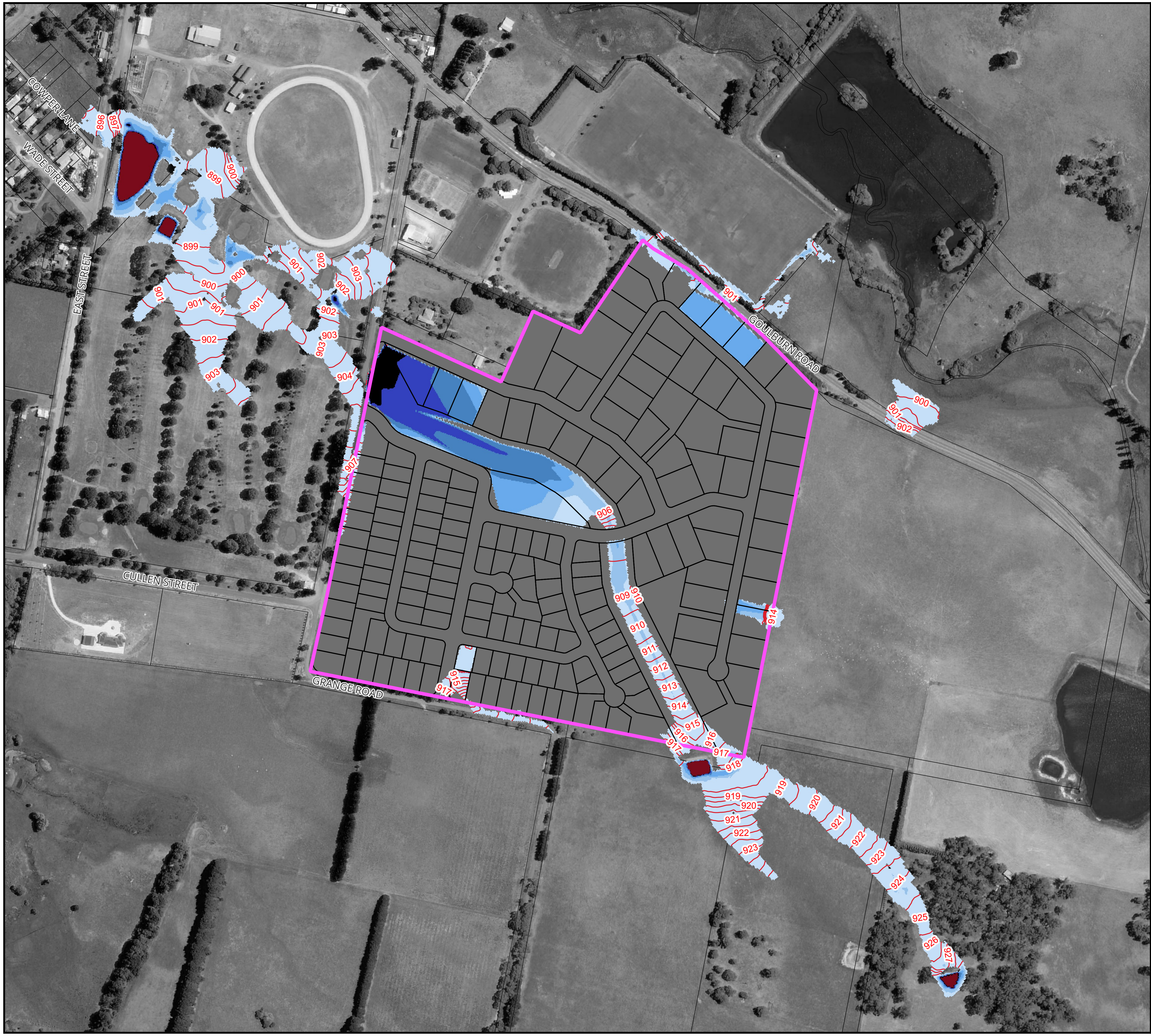

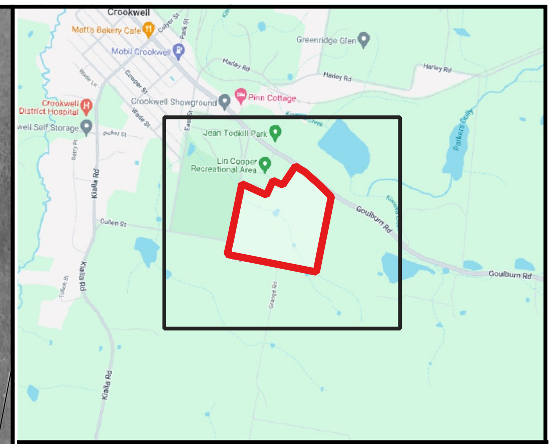

LEGEND

Site Location

Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 44 : Peak Floodwater Depths and Levels for the 0.5% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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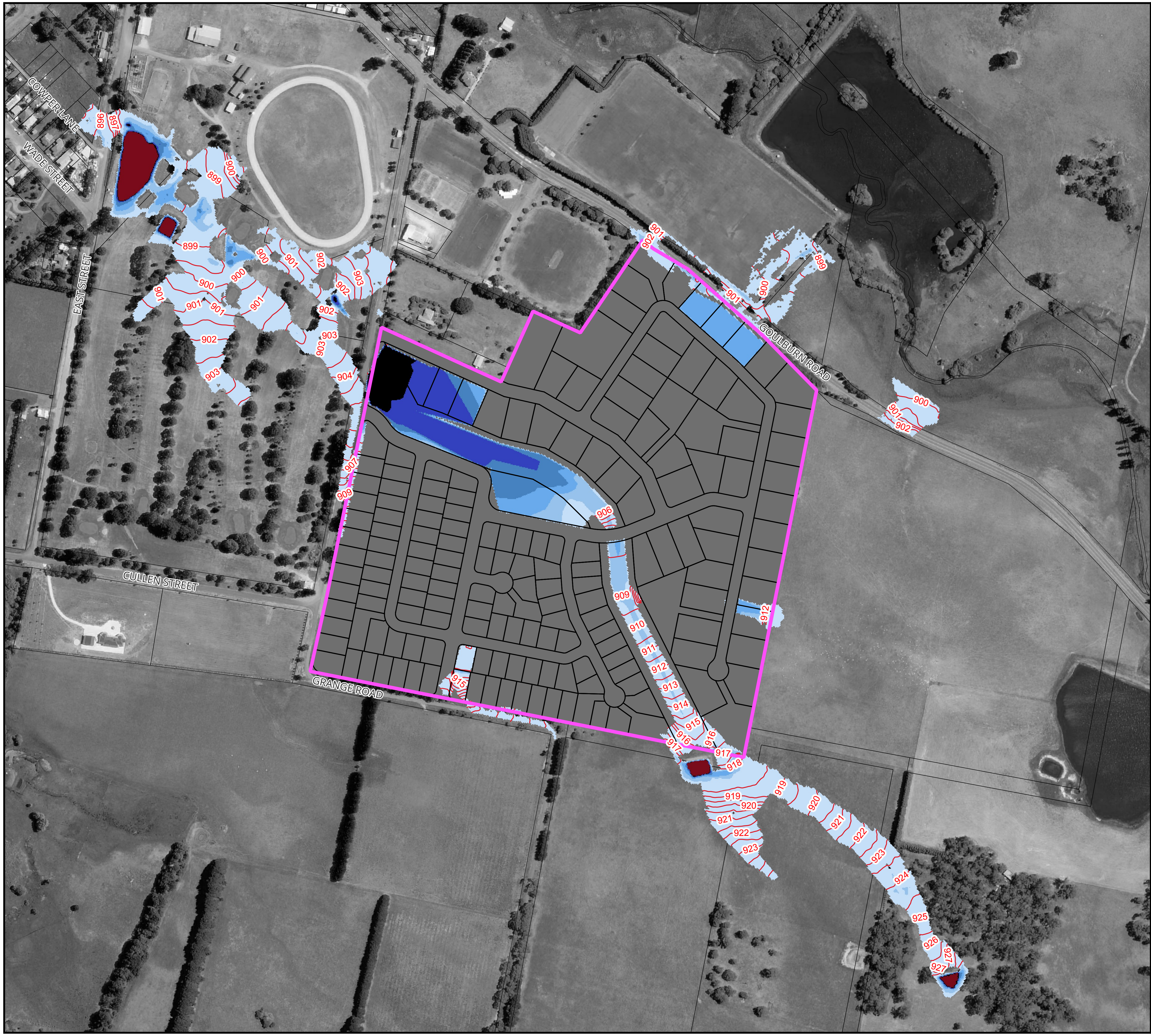

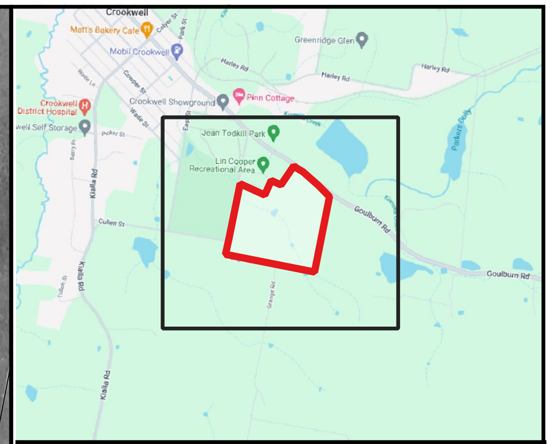

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 45 : Peak Floodwater Depths and Levels for the 0.2% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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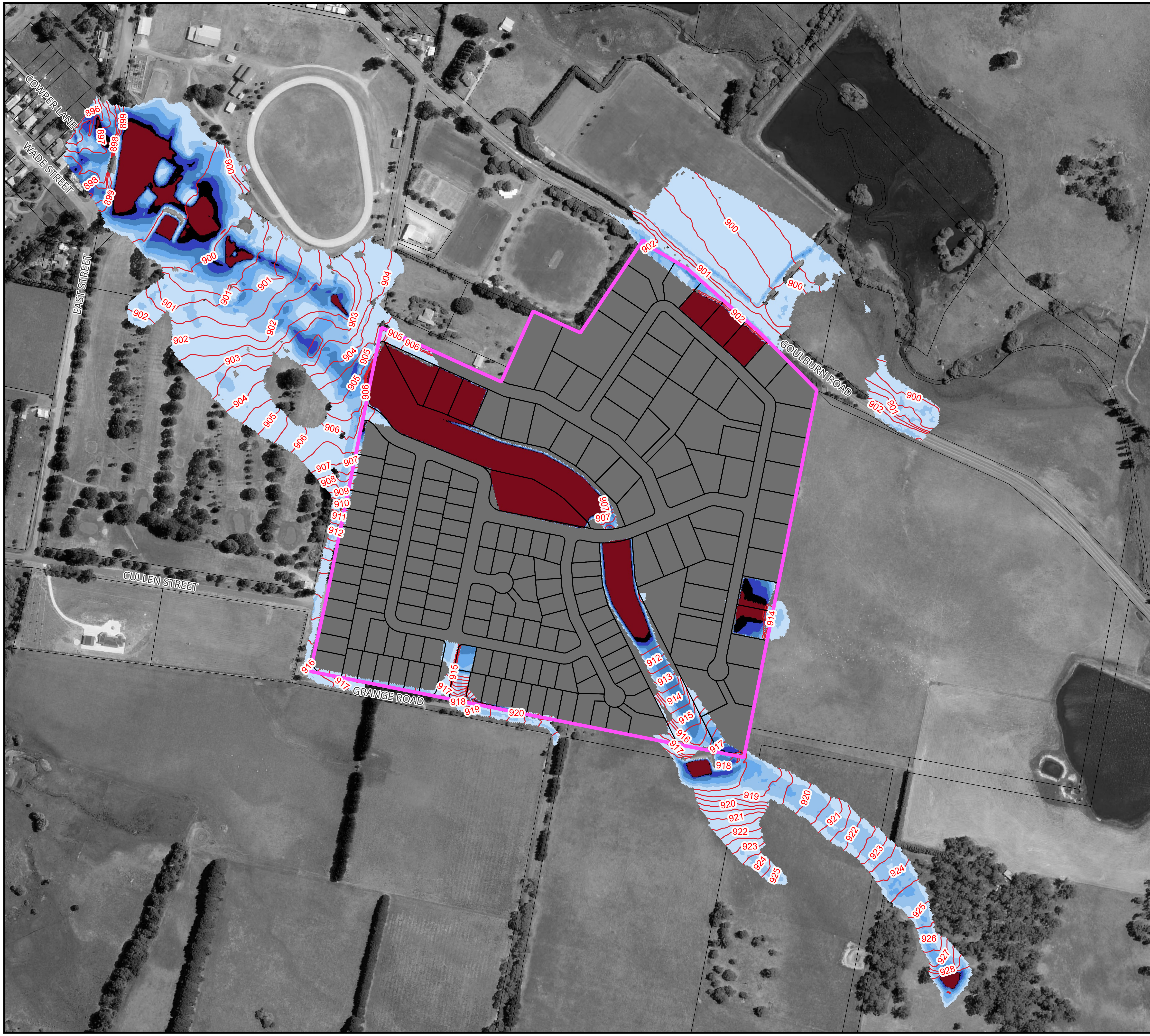

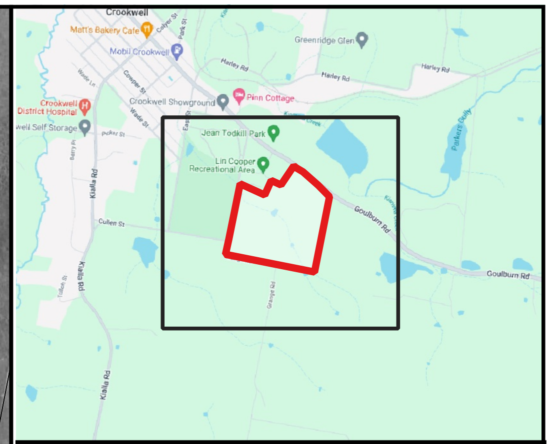

LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 46 :
Peak Floodwater Depths and Levels for the PMF for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 47 :
Peak Flood Velocity for the 63.2% AEP Flood for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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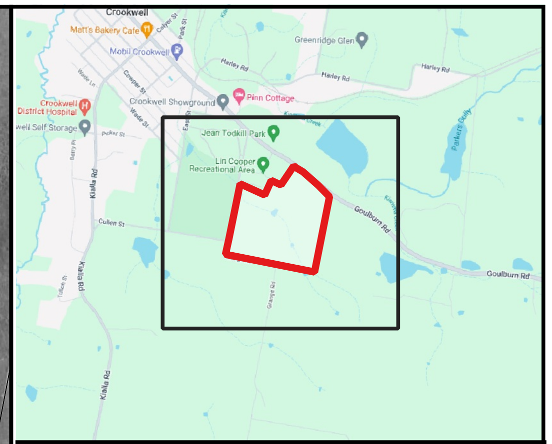

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 48 :
Peak Flood Velocity for the 50% AEP Flood for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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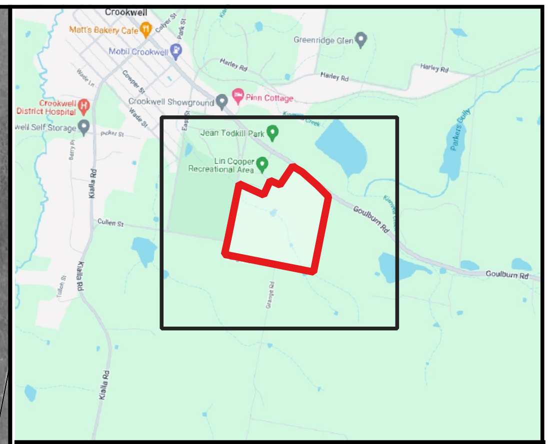

LEGEND
Site Location
Velocity (m/s)
<= 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 49 :
Peak Flood Velocity for the 20% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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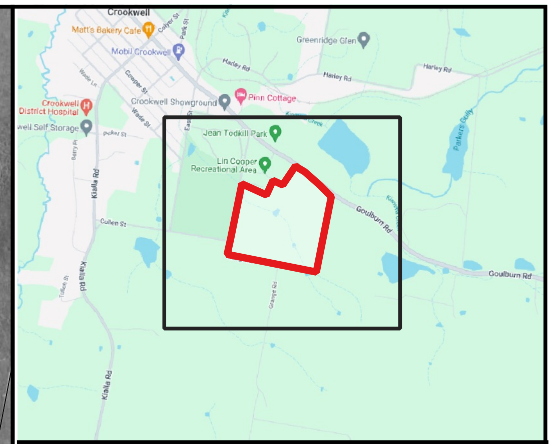

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 50 :
Peak Flood Velocity for the 10% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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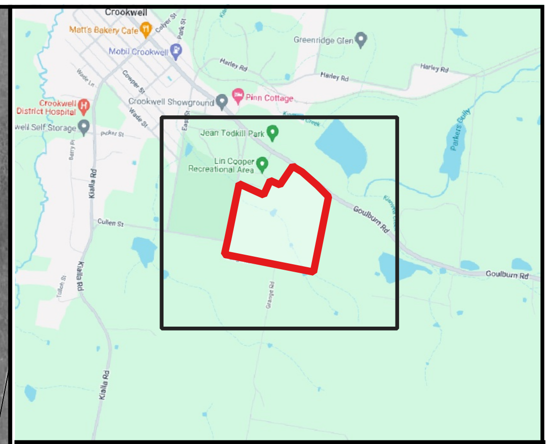

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 51 :
Peak Flood Velocity for the 5% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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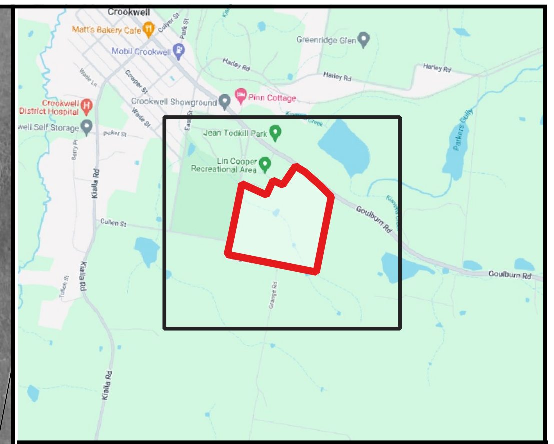

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 52 :
Peak Flood Velocity for the 2% AEP Flood for Proposed Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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Figure 53 : Peak Flood Velocity for the 1% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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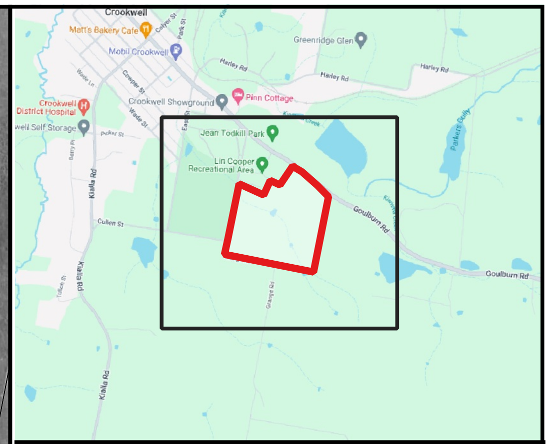

LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 54 :
Peak Flood Velocity for the 0.5% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
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Sydney, NSW, 2000

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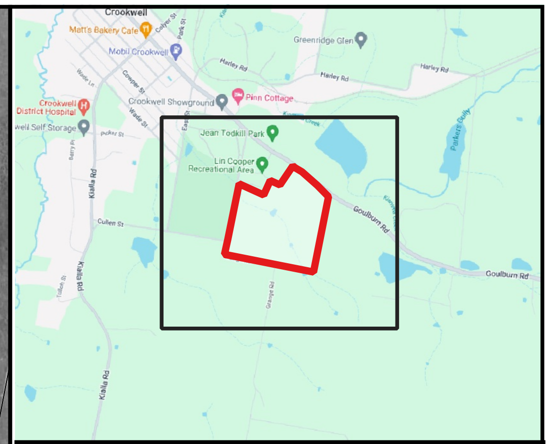

LEGEND

- Site Location
- Velocity (m/s)
  - <= 0.25
  - 0.25 - 0.50
  - 0.50 - 1.00
  - 1.00 - 1.50
  - 1.50 - 2.00
  - > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 55 :
Peak Flood Velocity for the 0.2% AEP Flood for Proposed Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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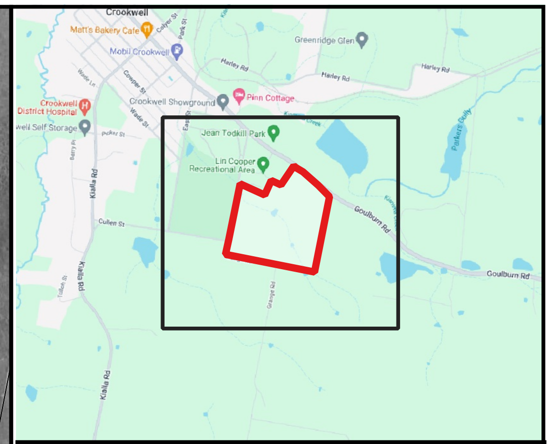


LEGEND

Site Location

Velocity (m/s)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

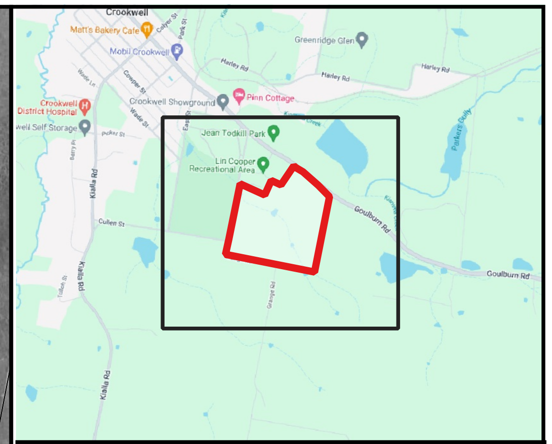
0 60 120 180 240 m

Figure 56 :
Peak Flood Velocity for the PMF for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

Site Location

Hydraulic Categories

Flood Fringe

Flood Storage

Floodway

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

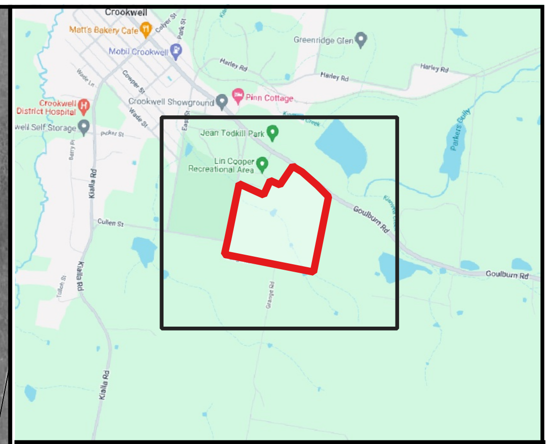
0 60 120 180 240 m

Figure 57 :
Hydraulic Categories for the 1% AEP Flood for Proposed Conditions

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

Site Location

Hydraulic Categories

Flood Fringe

Flood Storage

Floodway

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

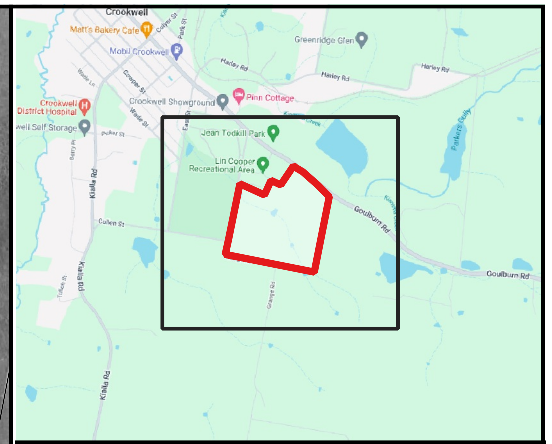
0 60 120 180 240 m

**Figure 58 :
Hydraulic Categories for
the PMF for Proposed
Conditions**

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\J760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

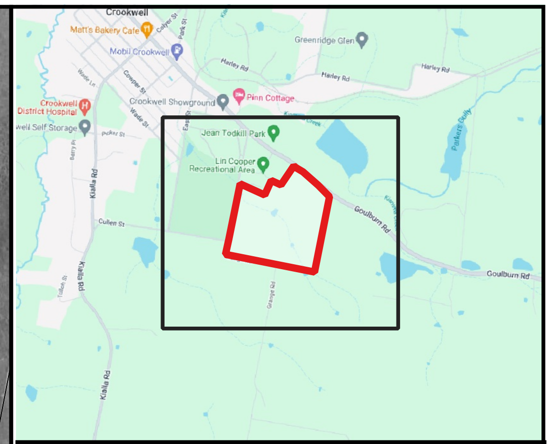
Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 59 :
Flood Hazard for the
63.2% AEP Flood for
Proposed Conditions**

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

- Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

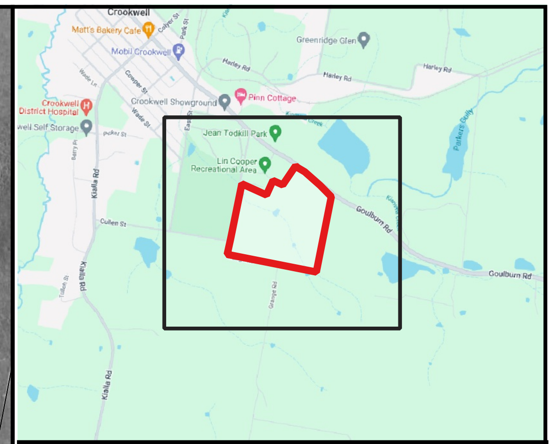
Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 60 :
Flood Hazard for the 50% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\J760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

- Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 61 :
Flood Hazard for the 20% AEP Flood for Proposed Conditions**

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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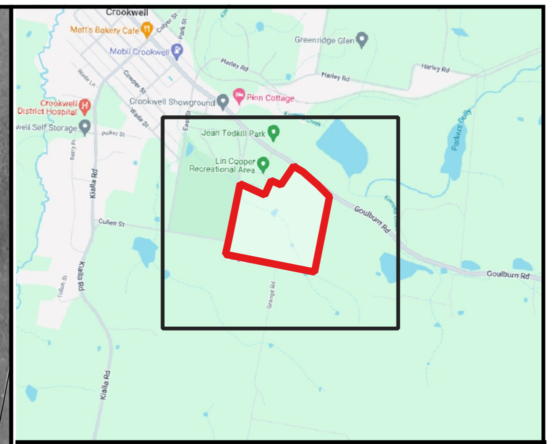

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 62 : Flood Hazard for the 10% AEP Flood for Proposed Conditions

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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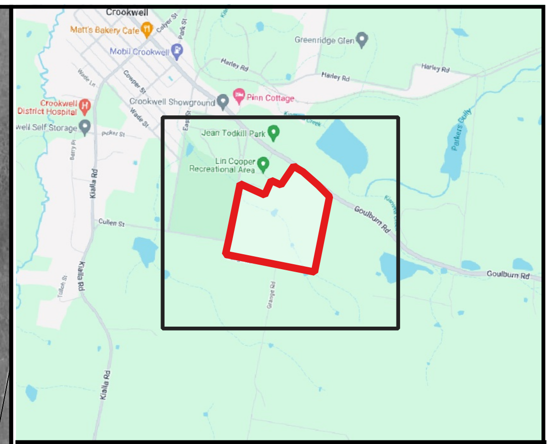

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 63 :
Flood Hazard for the 5% AEP Flood for Proposed Conditions

Prepared by:
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Sydney, NSW, 2000

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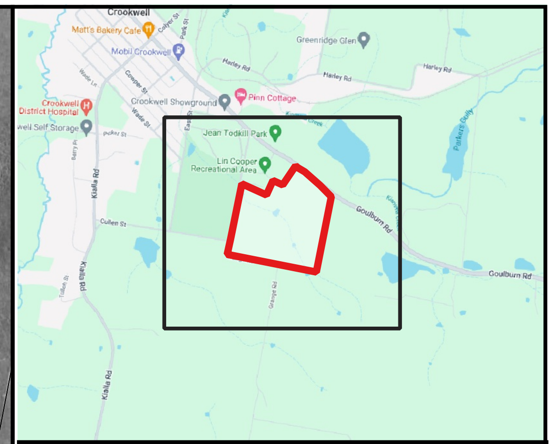

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 64 :
Flood Hazard for the 2% AEP Flood for Proposed Conditions**

Prepared by:

Catchment Simulation Solutions
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Sydney, NSW, 2000

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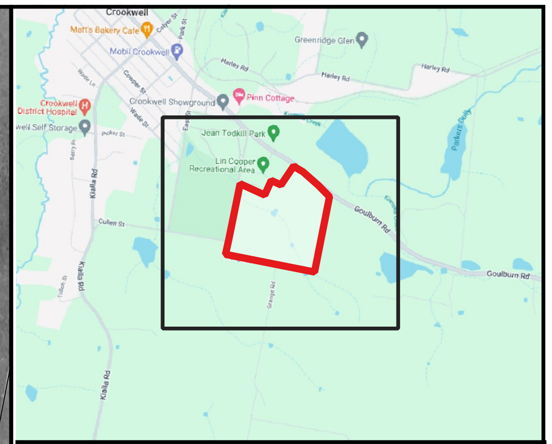

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 65 :
Flood Hazard for the 1% AEP Flood for Proposed Conditions

Prepared by:
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Sydney, NSW, 2000

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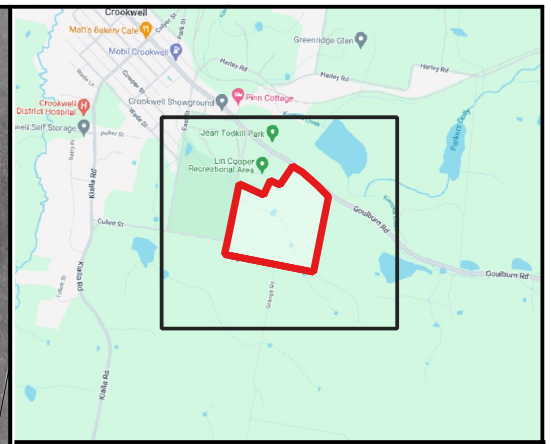

LEGEND

- Site Location
- Hazard Categories
- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 66 :
Flood Hazard for the 0.5% AEP Flood for Proposed Conditions

Prepared by:
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Sydney, NSW, 2000

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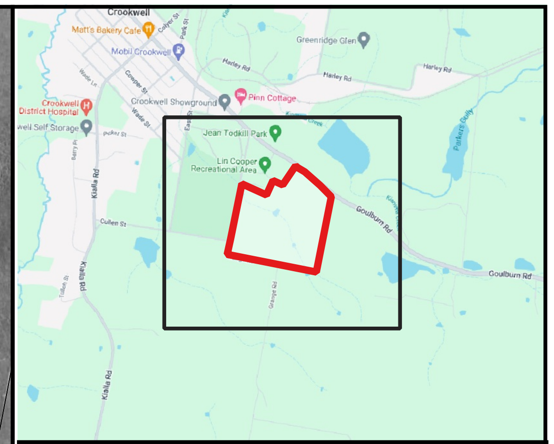

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 67 :
Flood Hazard for the 0.2% AEP Flood for Proposed Conditions

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Sydney, NSW, 2000

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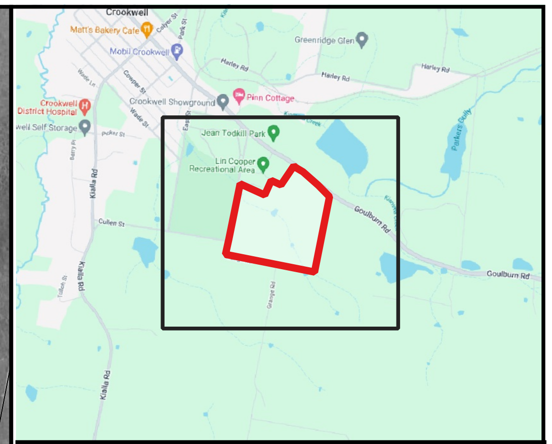

LEGEND

Site Location

Hazard Categories

- H1 - Generally safe
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, childrenand elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people and vehicles Buildings require special design
- H6 - Unsafe for people and vehicles. All buildings vulnerable to failure

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 68 : Flood Hazard for the PMF for Proposed Conditions

Prepared by:

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Sydney, NSW, 2000

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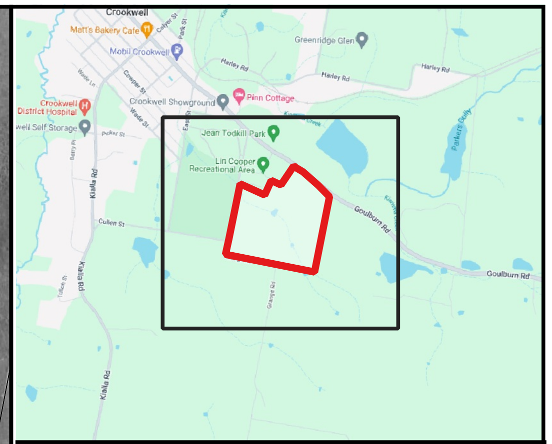

LEGEND
Site Location
Flood Level Difference (m)
-0.50
-0.25
-0.15
-0.10
-0.05
-0.02
Differences less than ±0.02m
0.02
0.05
0.10
0.15
0.25
0.50
Was wet, now dry
Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 69 : Predicted Change in Peak 63.2% AEP Flood Levels

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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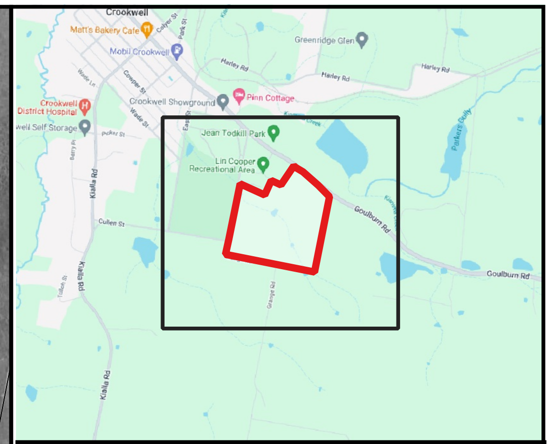

LEGEND
Site Location
Flood Level Difference (m)
-0.50
-0.25
-0.15
-0.10
-0.05
-0.02
Differences less than ±0.02m
0.02
0.05
0.10
0.15
0.25
0.50
Was wet, now dry
Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N
Scale: 1:5000 (at A3)
0 60 120 180 240 m

Figure 70 : Predicted Change in Peak 50% AEP Flood Levels

Prepared by:
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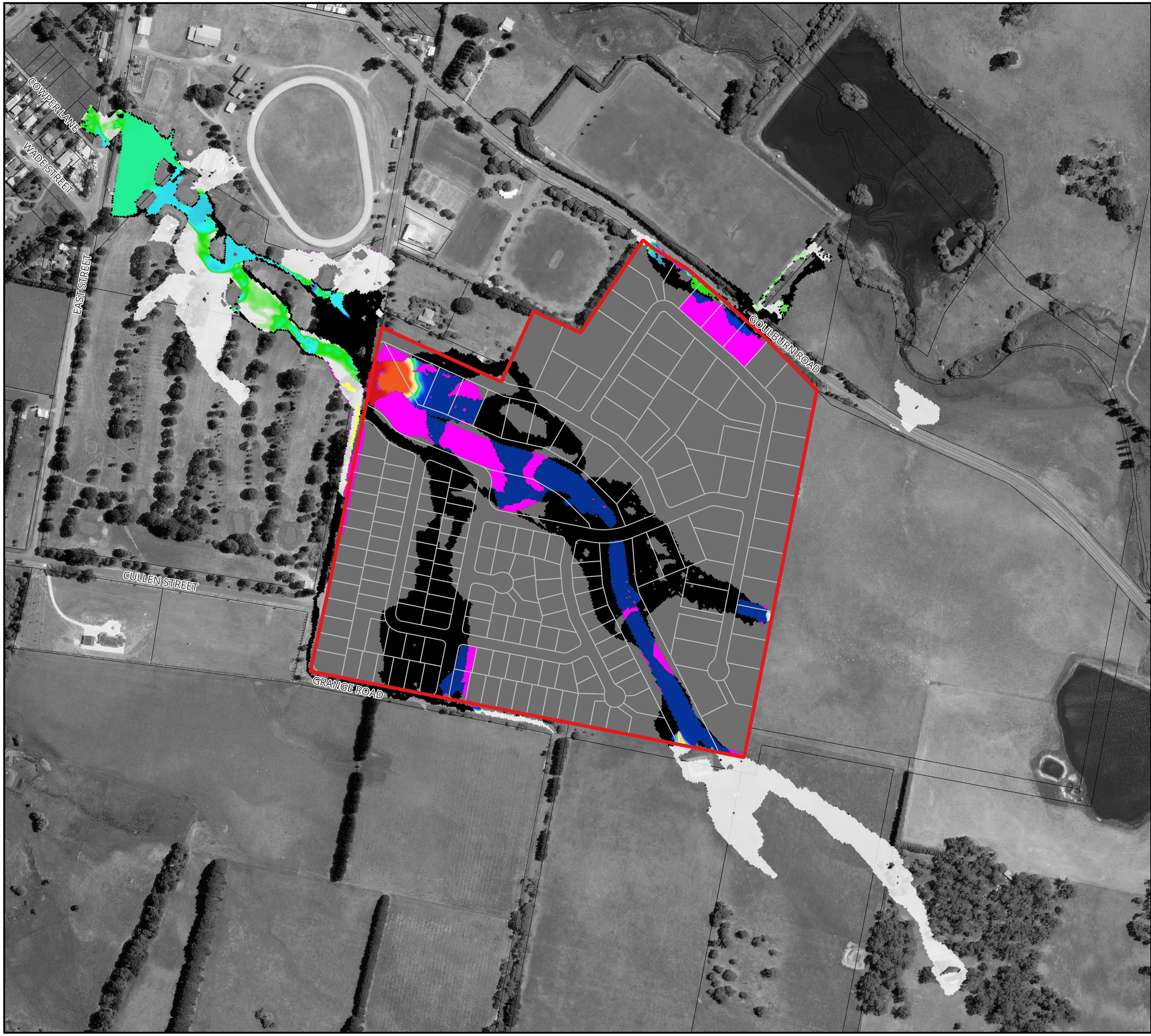

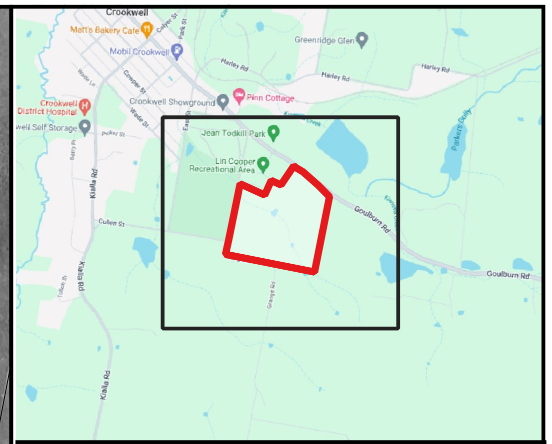

LEGEND

Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 71 : Predicted Change in Peak 20% AEP Flood Levels

Prepared by:

Catchment Simulation Solutions
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Sydney, NSW, 2000

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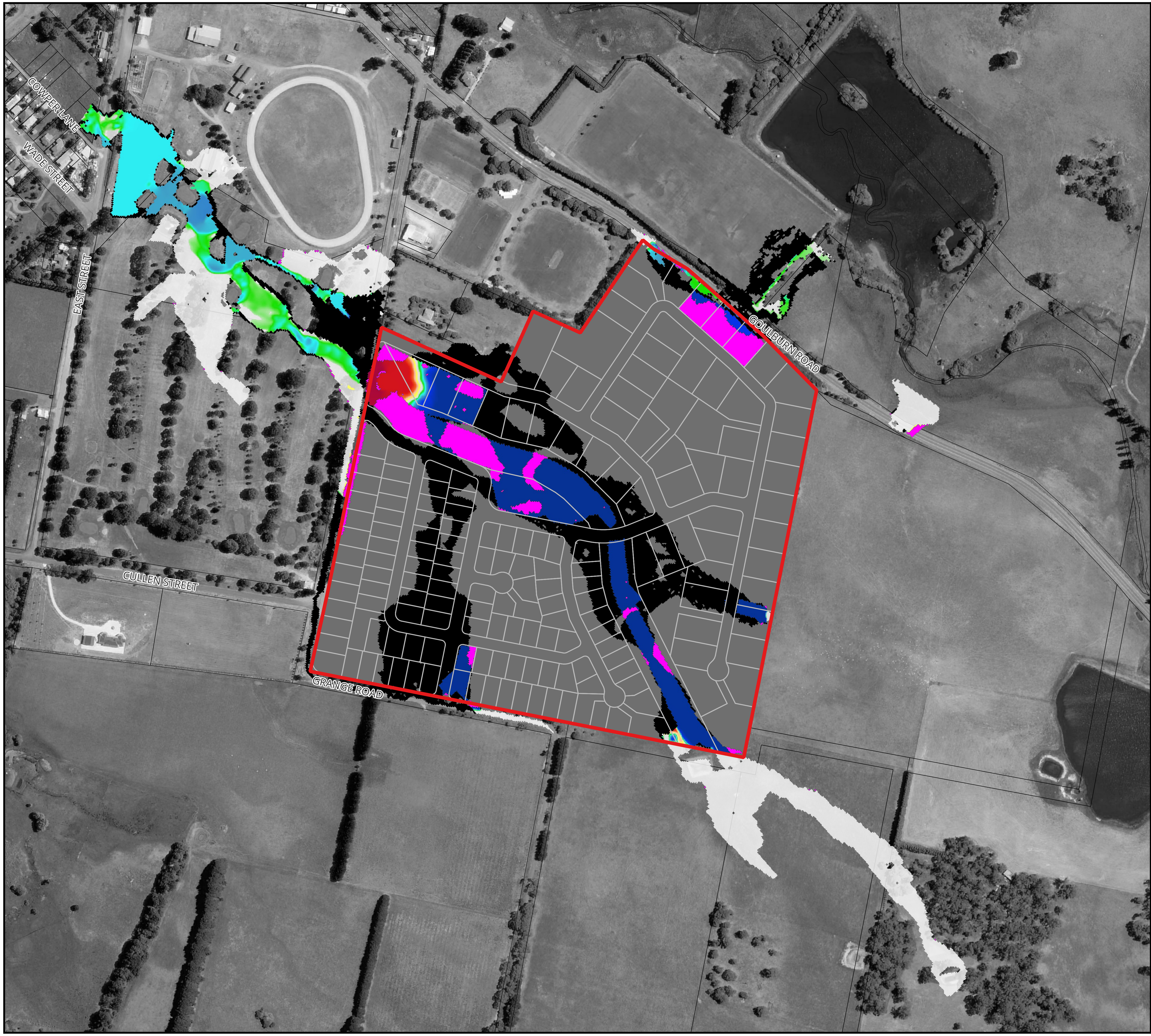

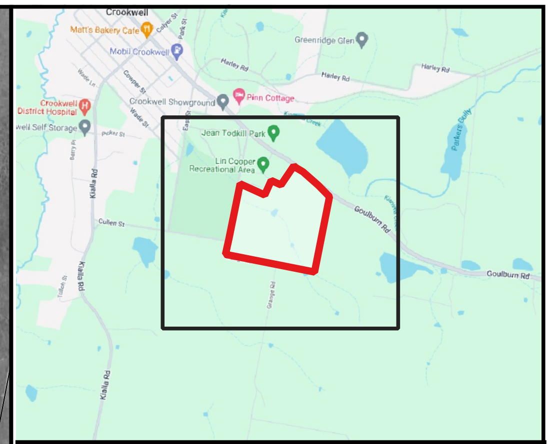

LEGEND

Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 72 : Predicted Change in Peak 10% AEP Flood Levels

Prepared by:
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Sydney, NSW, 2000

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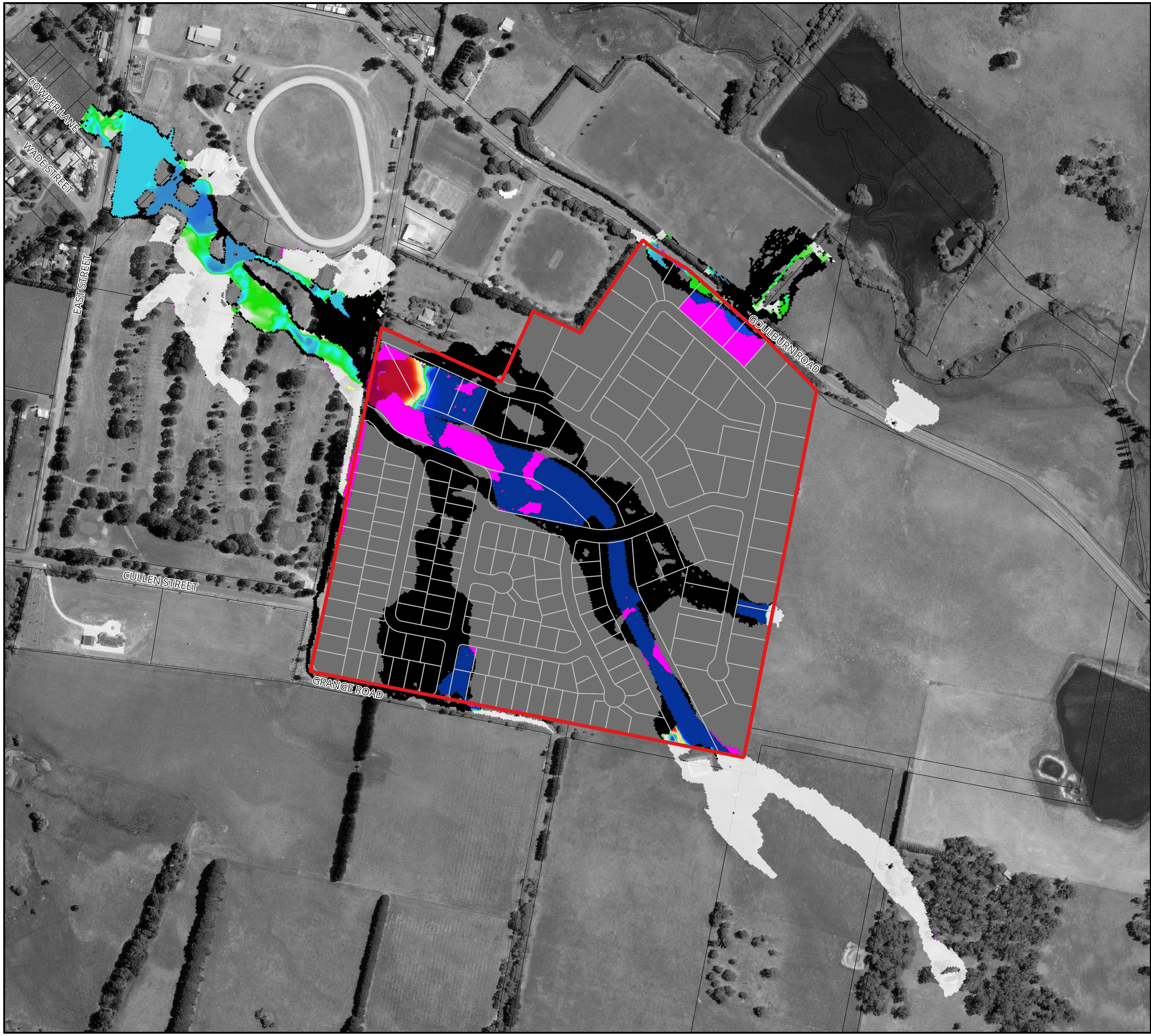

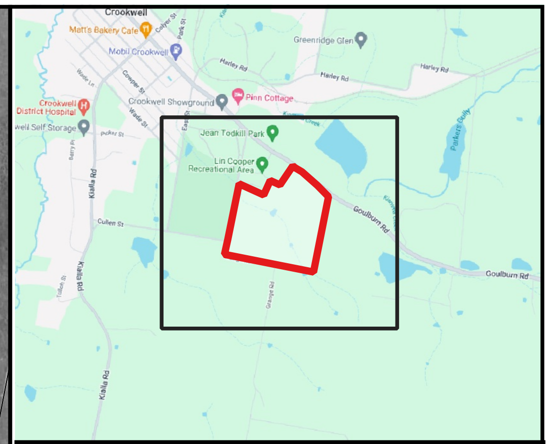

LEGEND
Site Location
Flood Level Difference (m)
-0.50
-0.25
-0.15
-0.10
-0.05
-0.02
Differences less than ±0.02m
0.02
0.05
0.10
0.15
0.25
0.50
Was wet, now dry
Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N
Scale: 1:5000 (at A3)
0 60 120 180 240 m

Figure 73 : Predicted Change in Peak 5% AEP Flood Levels

Prepared by:
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Sydney, NSW, 2000

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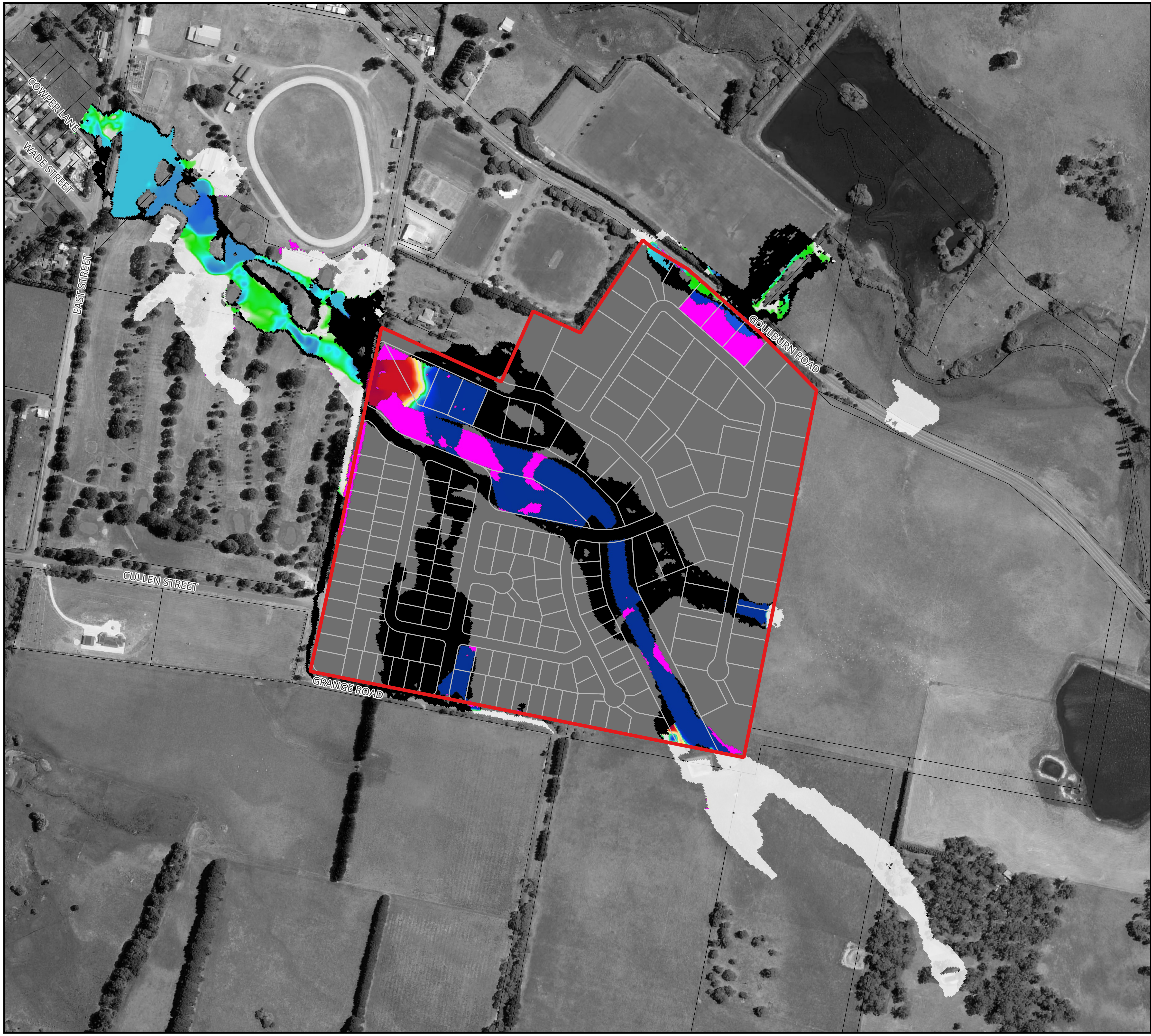

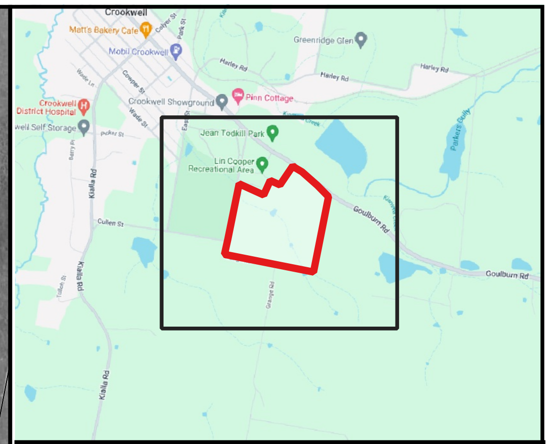

LEGEND

- Site Location
- Flood Level Difference (m)
- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 74 : Predicted Change in Peak 2% AEP Flood Levels

Prepared by:

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Sydney, NSW, 2000

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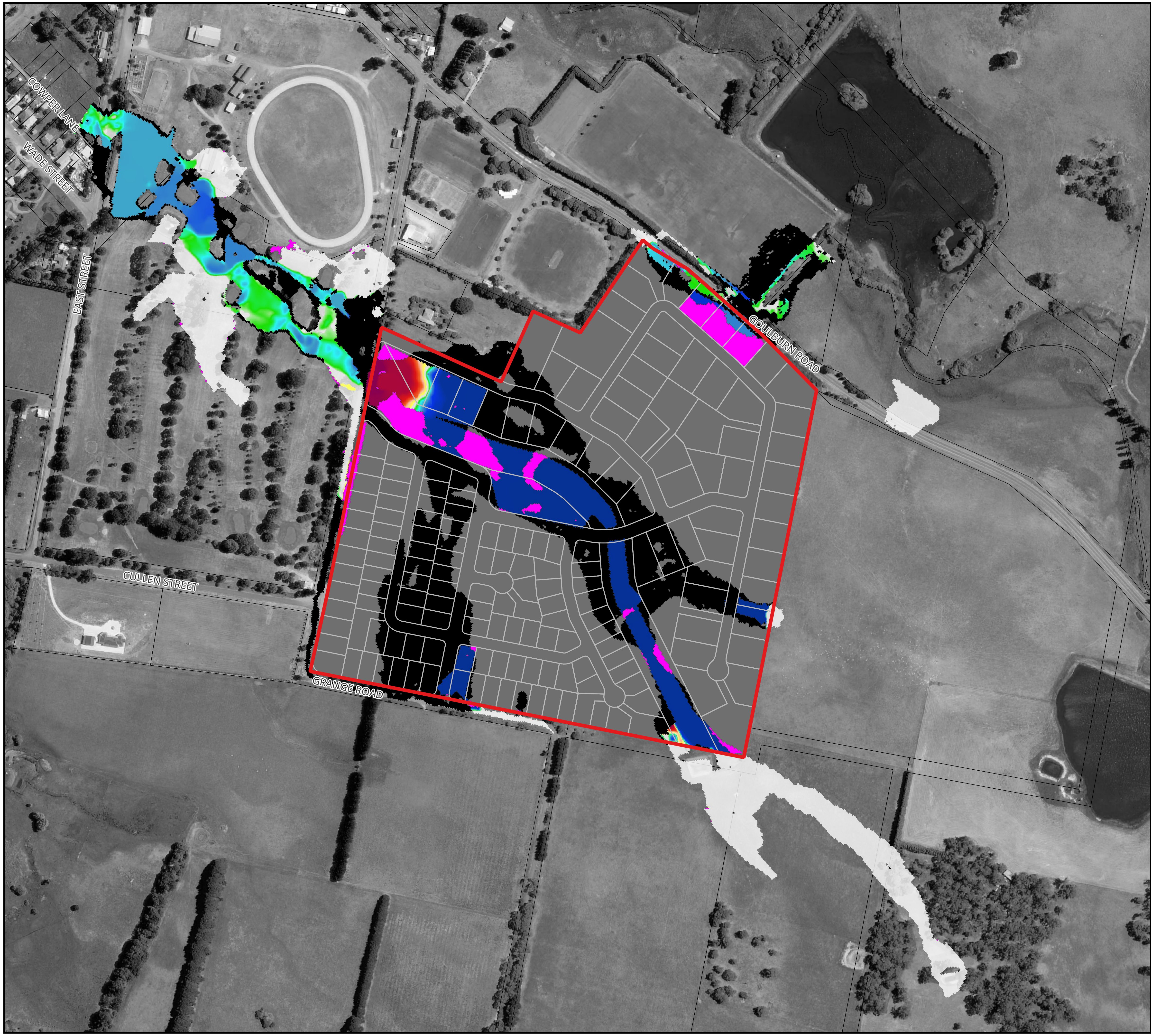

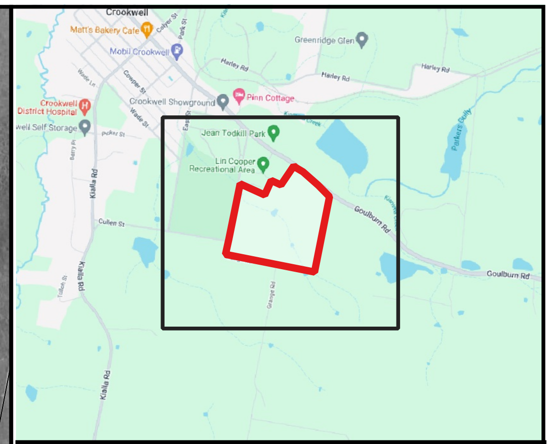

LEGEND

- Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

**Figure 75 :
Predicted Change in
Peak 1% AEP Flood
Levels**

Prepared by:
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Sydney, NSW, 2000

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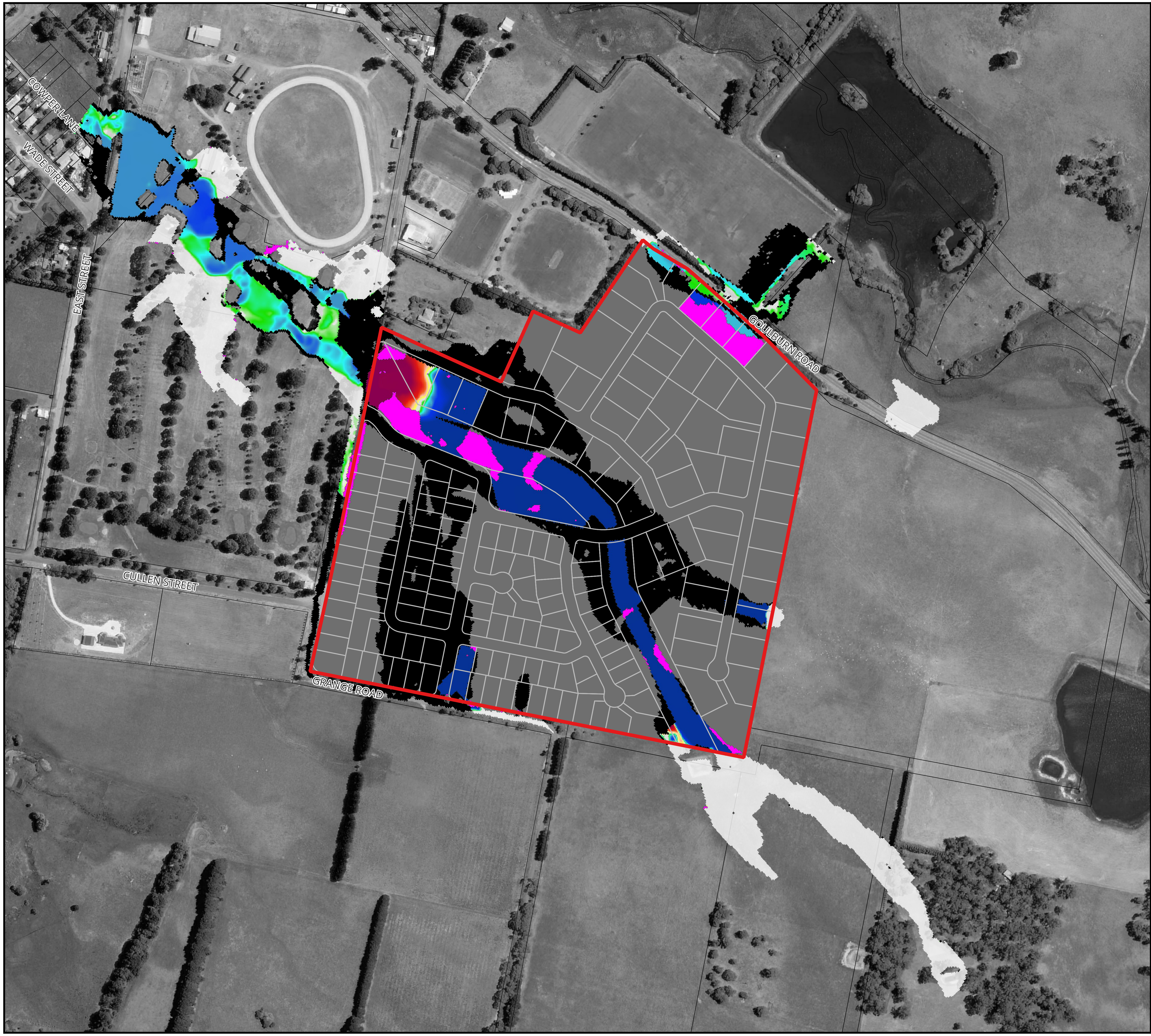

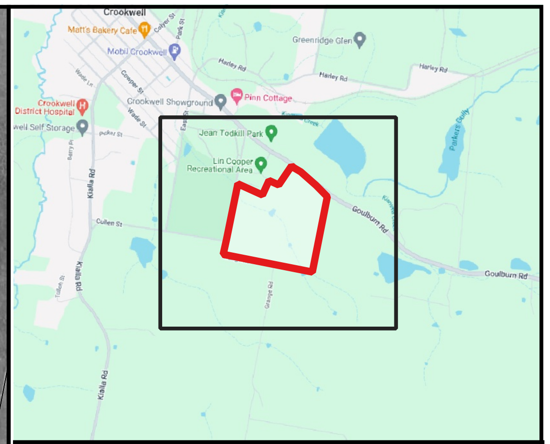

LEGEND

Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 76 : Predicted Change in Peak 0.5% AEP Flood Levels

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Sydney, NSW, 2000

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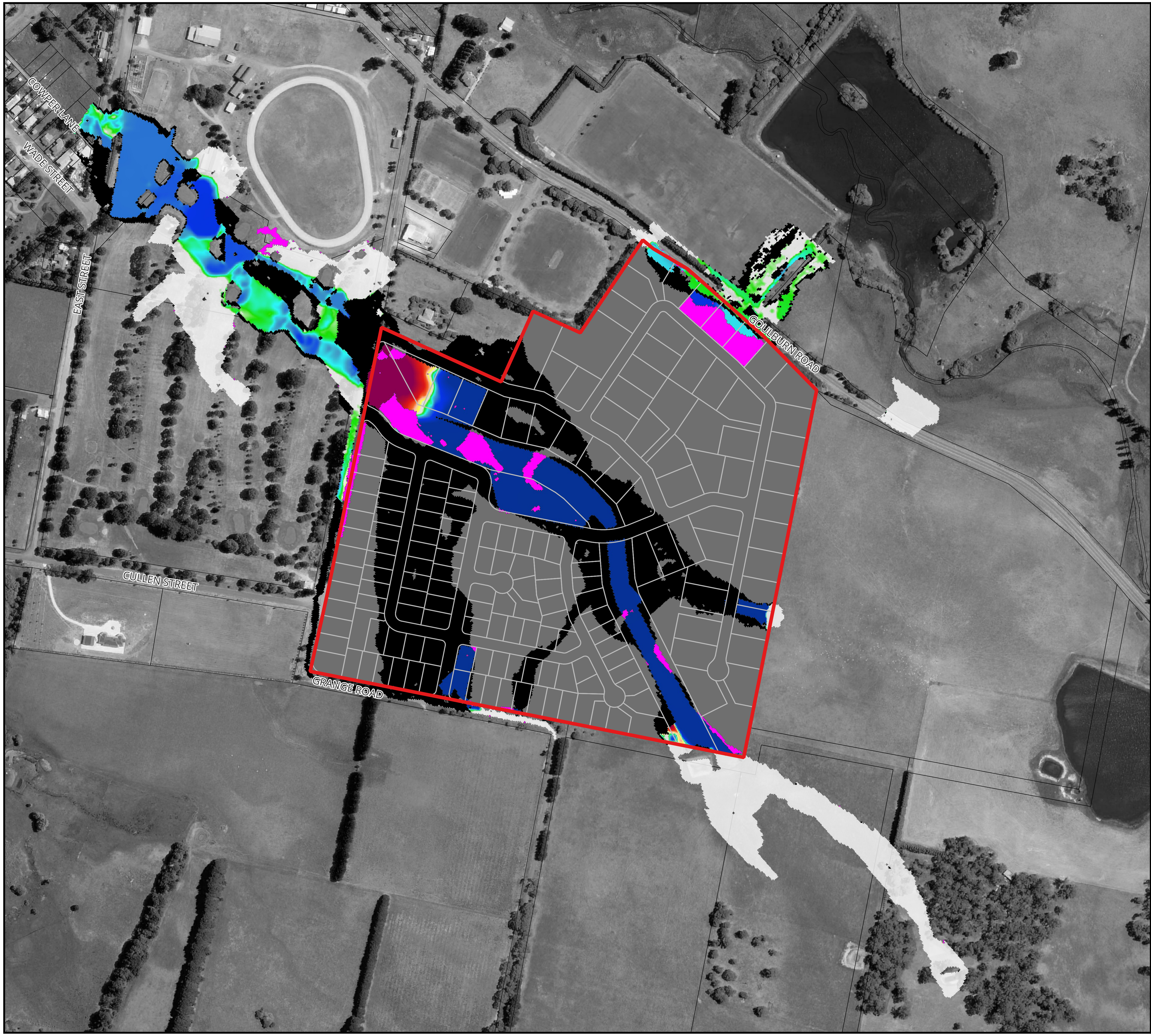

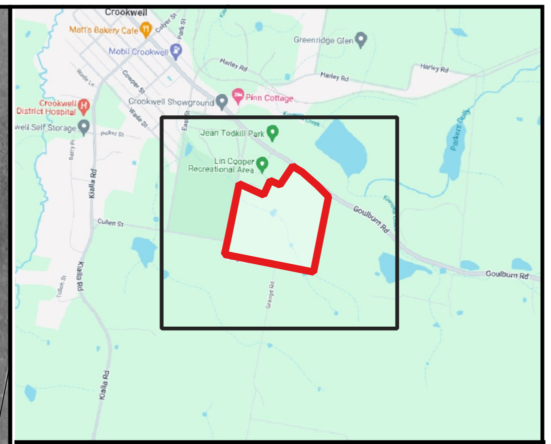

LEGEND

- Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 77 : Predicted Change in Peak 0.2% AEP Flood Levels

Prepared by:
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Sydney, NSW, 2000

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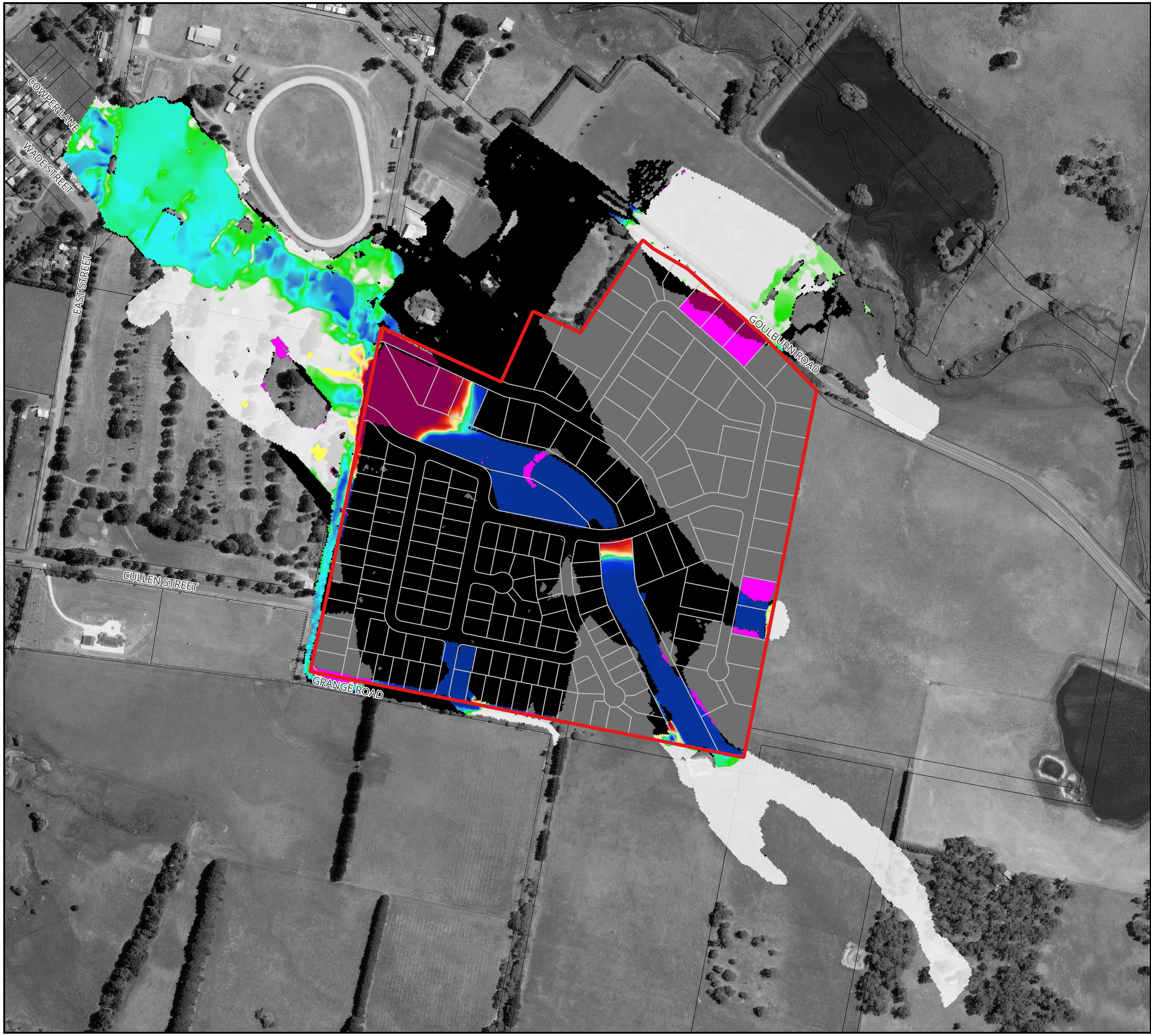

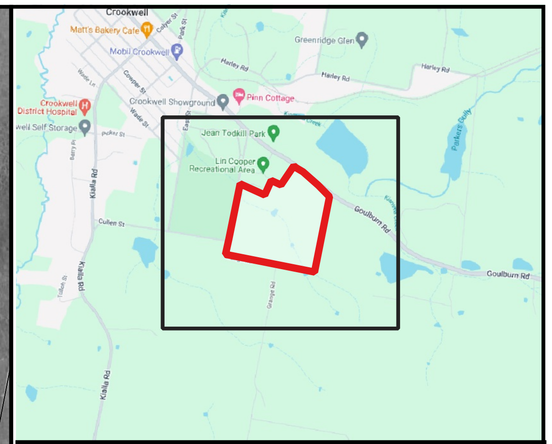

LEGEND

Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 78 :
Predicted Change in Peak PMF Flood Levels

Prepared by:
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Sydney, NSW, 2000

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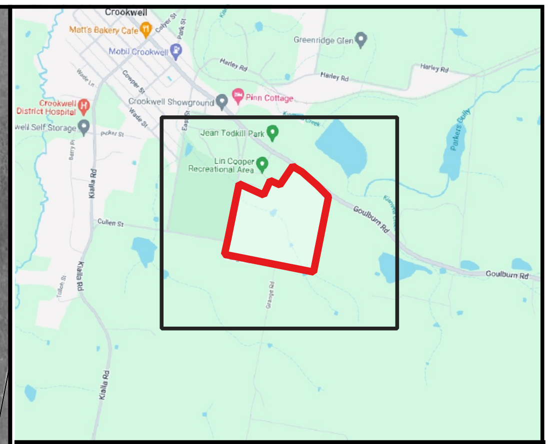

LEGEND

- Site Location
- Flood Velocity Difference (m/s)
- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 79 : Predicted Change in Peak 63.2% AEP Flood Velocity

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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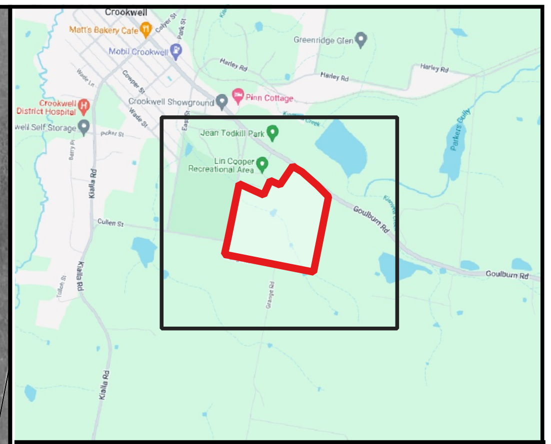

LEGEND

- Site Location

Flood Velocity Difference (m/s)

- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 80 : Predicted Change in Peak 50% AEP Flood Velocity

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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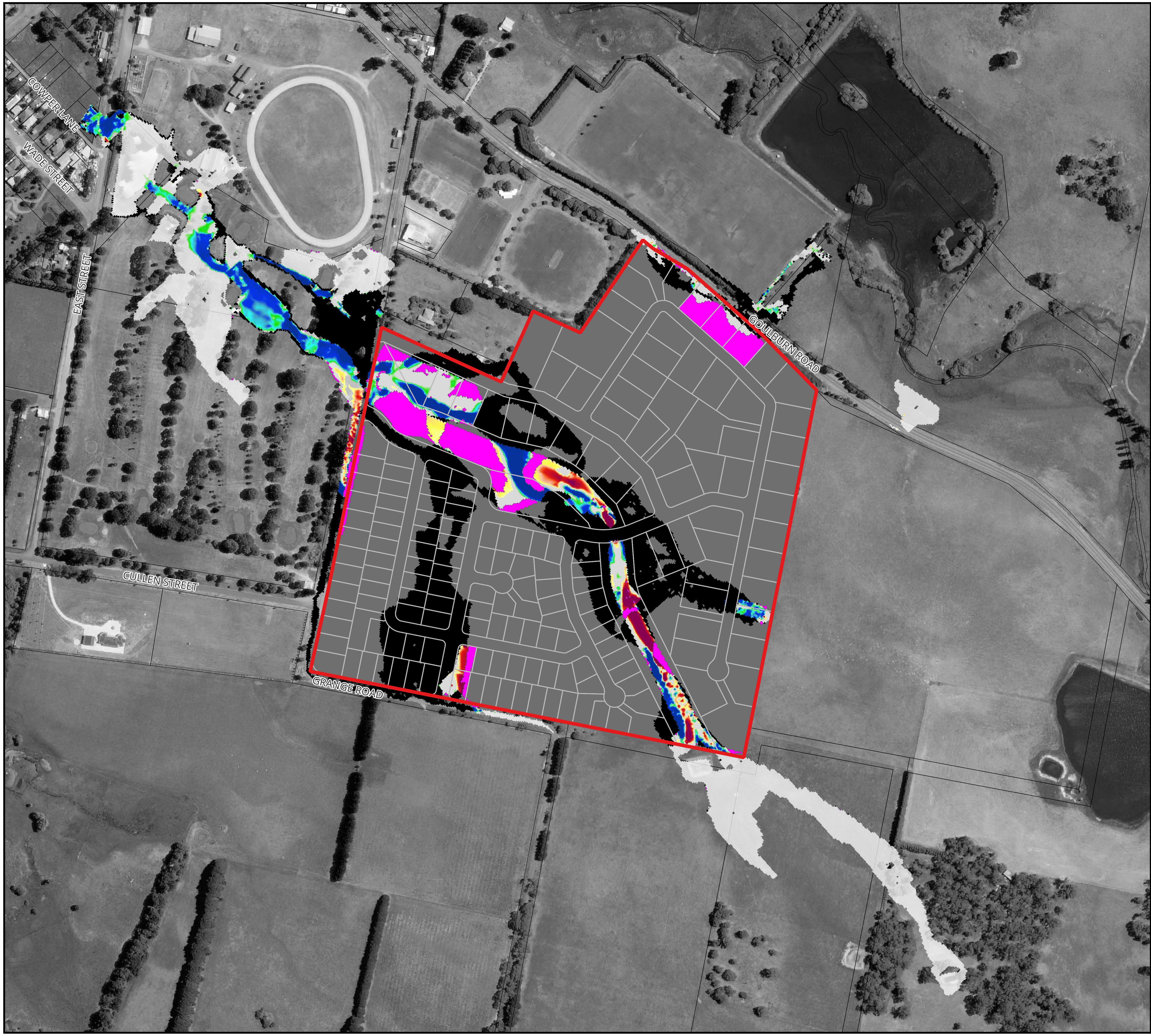

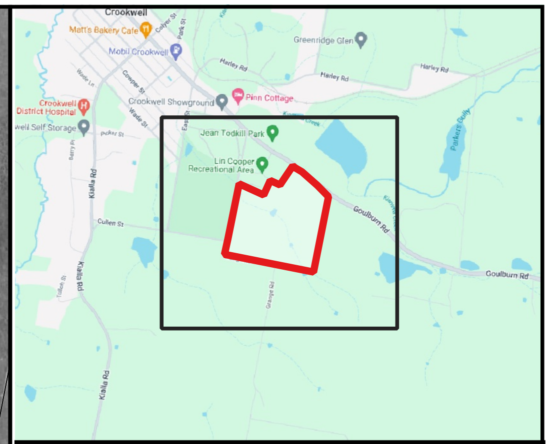

LEGEND

Site Location

Flood Velocity Difference (m/s)

-0.50
-0.30
-0.25
-0.20
-0.15
-0.10
Differences less than ±0.10m
0.10
0.15
0.20
0.25
0.30
0.50
Was wet, now dry
Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 81 : Predicted Change in Peak 20% AEP Flood Velocity

Prepared by:
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Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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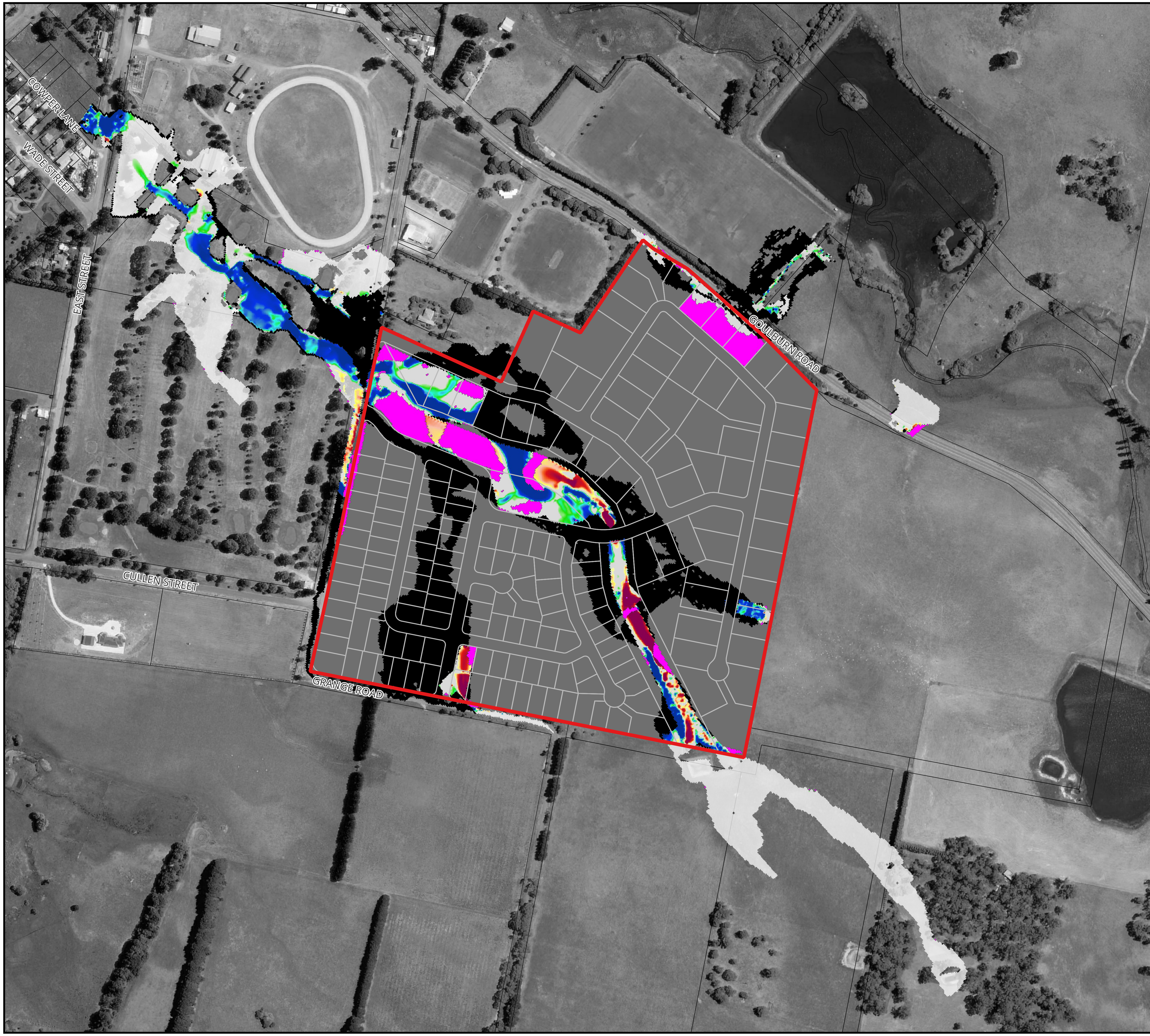

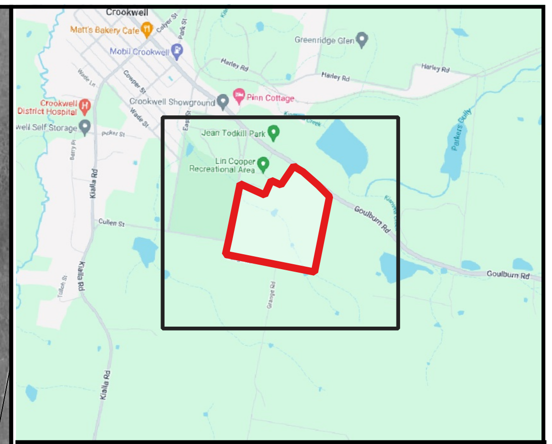

LEGEND
Site Location
Flood Velocity Difference (m/s)
-0.50
-0.30
-0.25
-0.20
-0.15
-0.10
Differences less than ±0.10m
0.10
0.15
0.20
0.25
0.30
0.50
Was wet, now dry
Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N
Scale: 1:5000 (at A3)
0 60 120 180 240 m

Figure 82 :
Predicted Change in Peak 10% AEP Flood Velocity

Prepared by:
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Sydney, NSW, 2000

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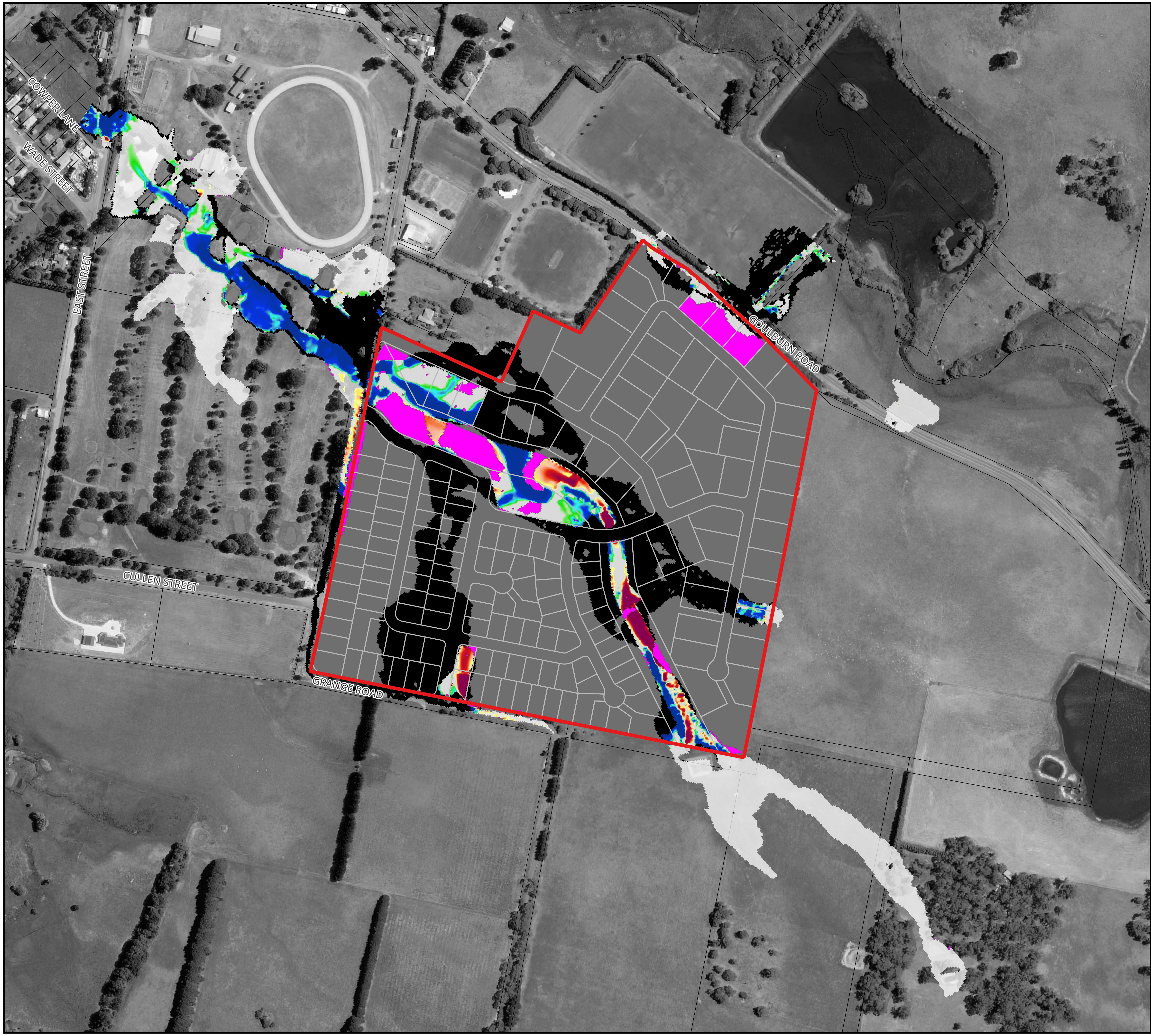
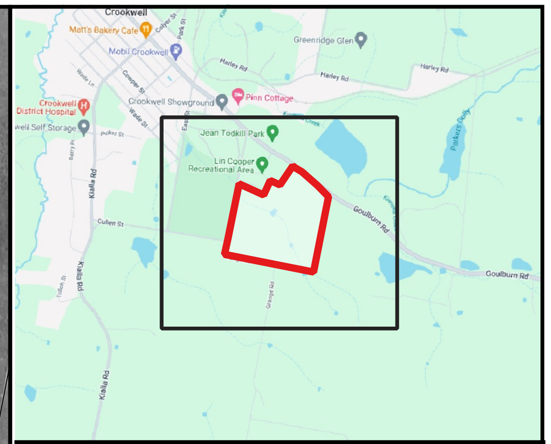




LEGEND

- Site Location
- Flood Velocity Difference (m/s)
- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

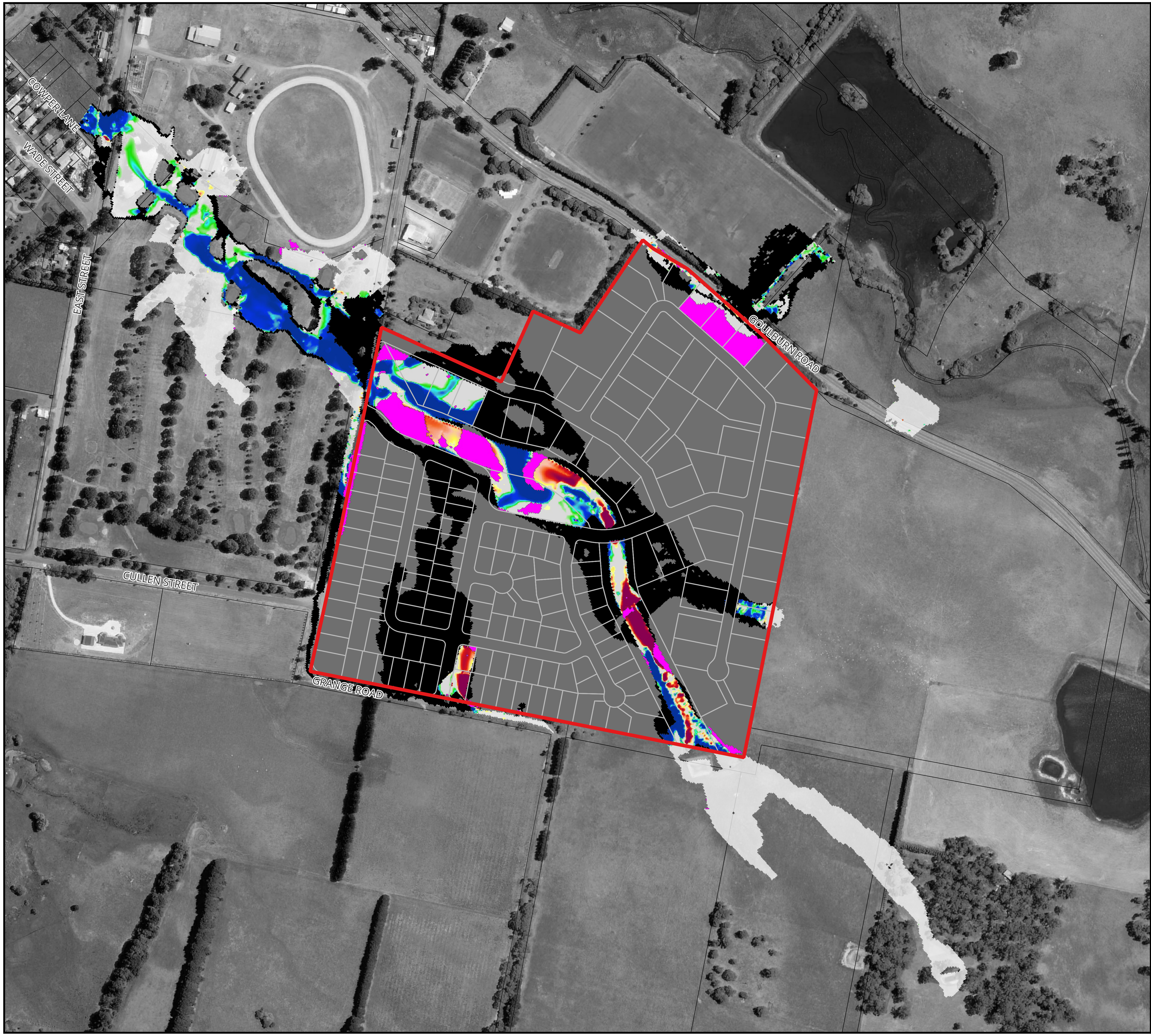
Scale: 1:5000 (at A3)

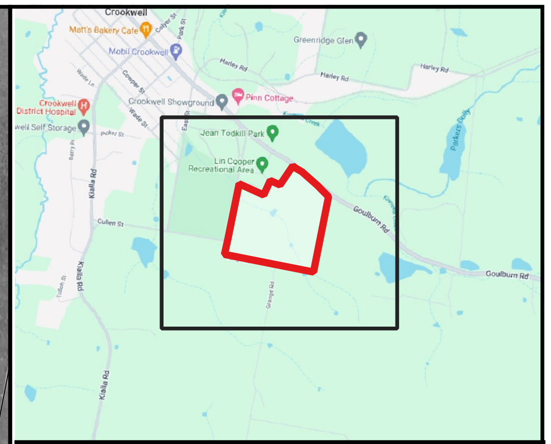
0 60 120 180 240 m

Figure 83 : Predicted Change in Peak 5% AEP Flood Velocity

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz





LEGEND

- Site Location
- Flood Velocity Difference (m/s)
- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 84 : Predicted Change in Peak 2% AEP Flood Velocity

Prepared by:
Catchment Simulation Solutions
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Sydney, NSW, 2000

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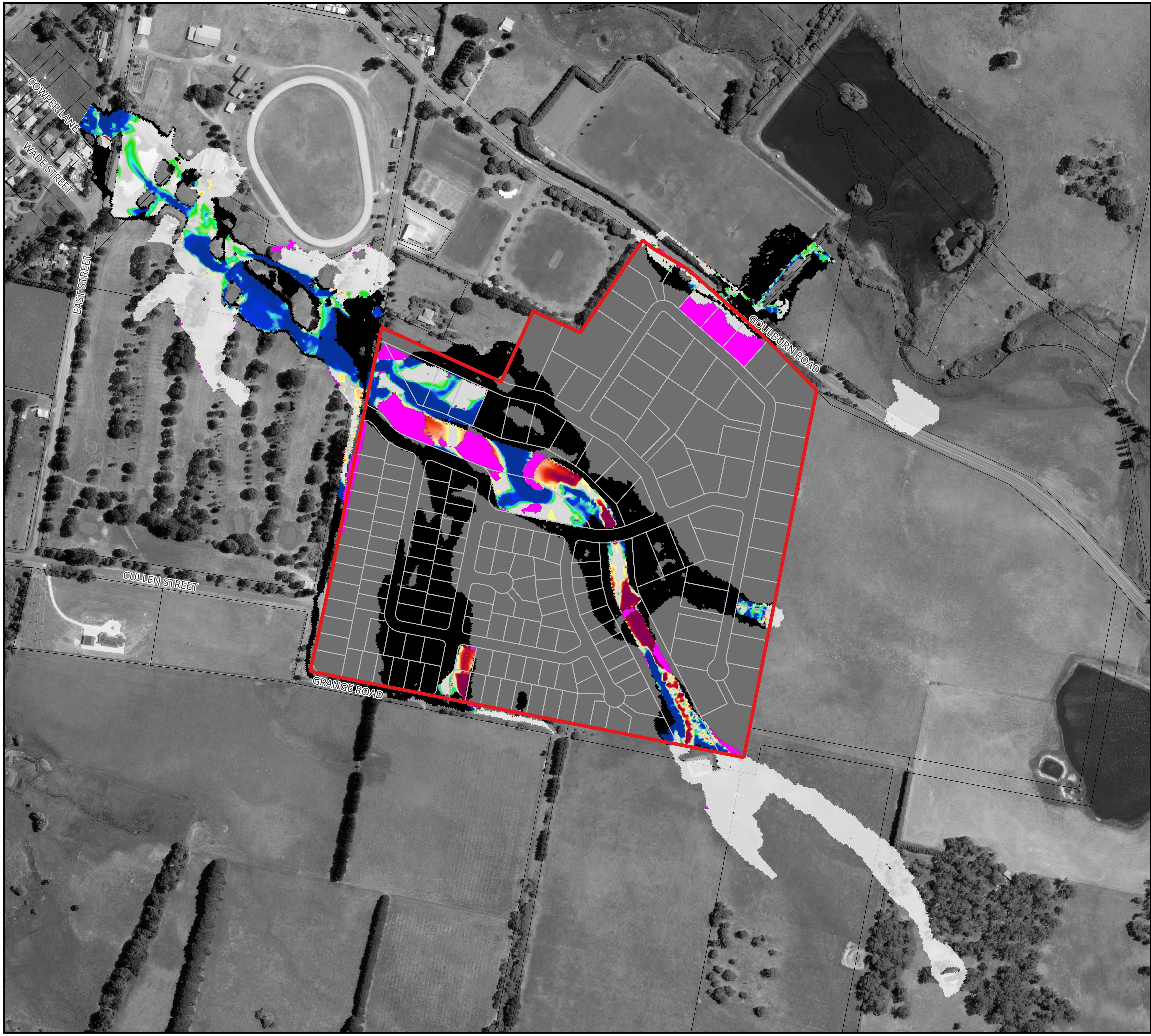

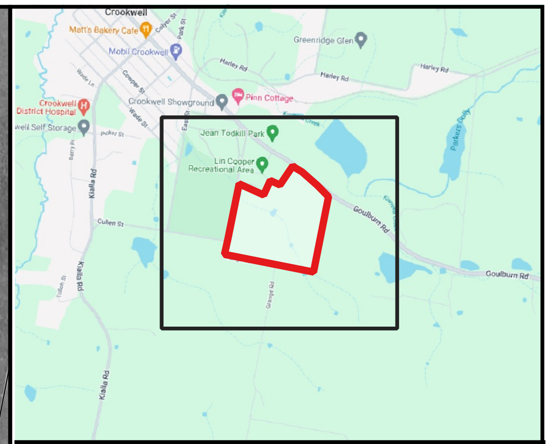

LEGEND

- Site Location

Flood Velocity Difference (m/s)

- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 85 : Predicted Change in Peak 1% AEP Flood Velocity

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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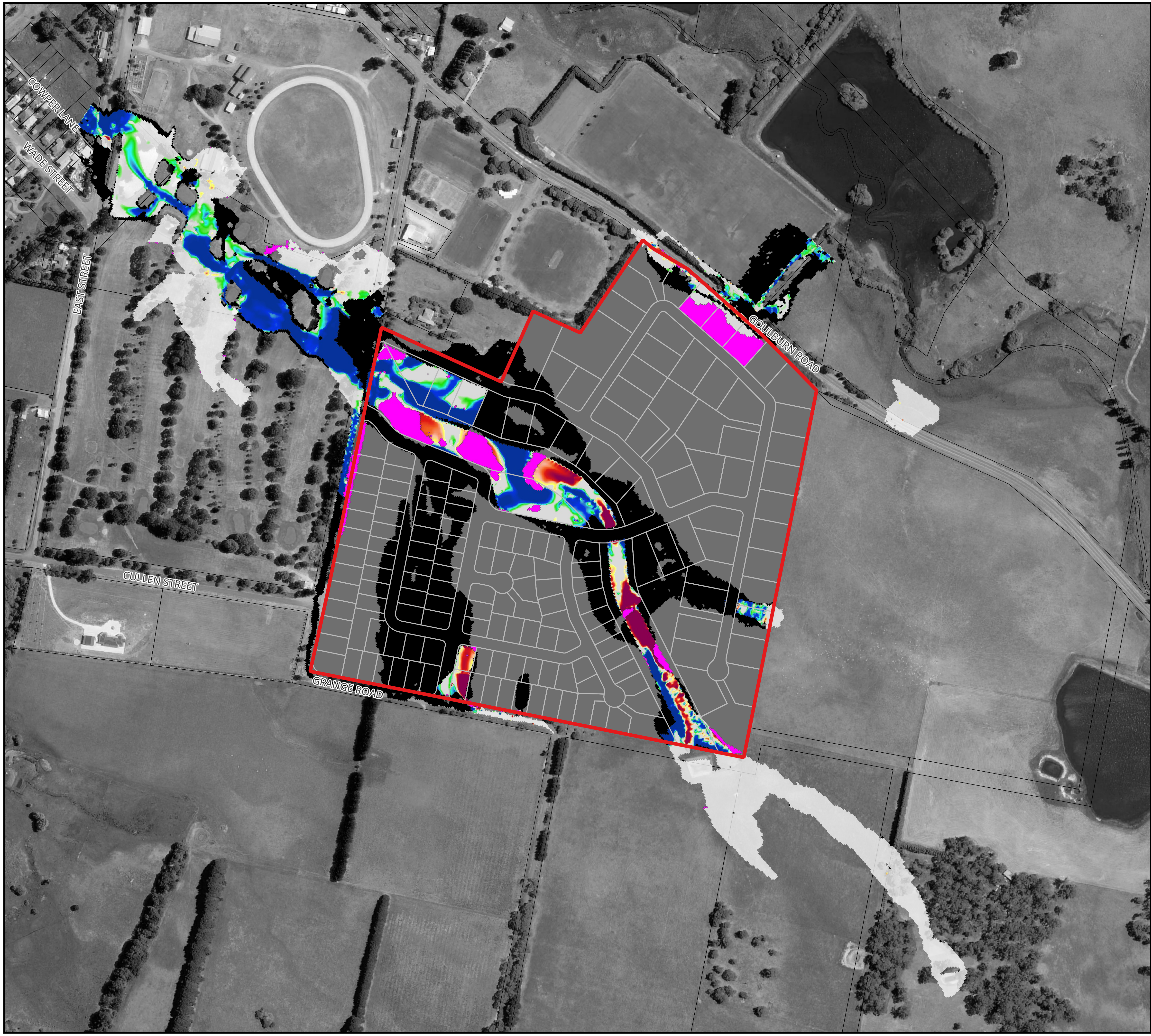

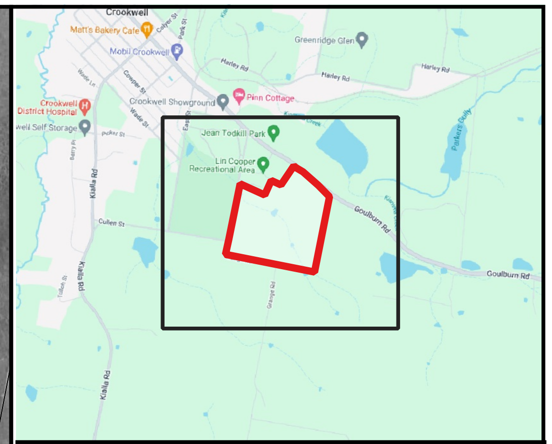

LEGEND

Site Location

Flood Velocity Difference (m/s)

- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 86 :
Predicted Change in Peak 0.5% AEP Flood Velocity

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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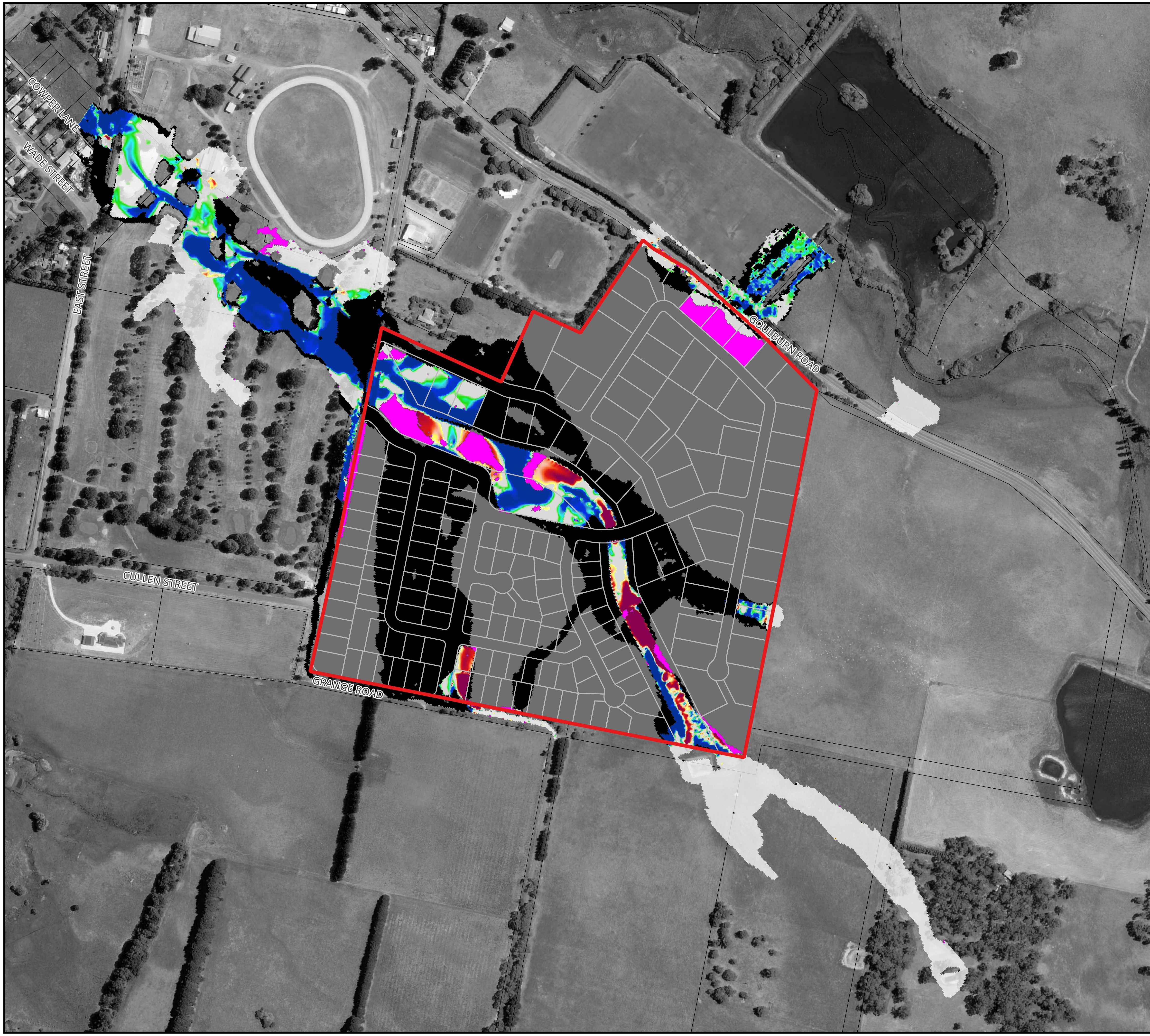

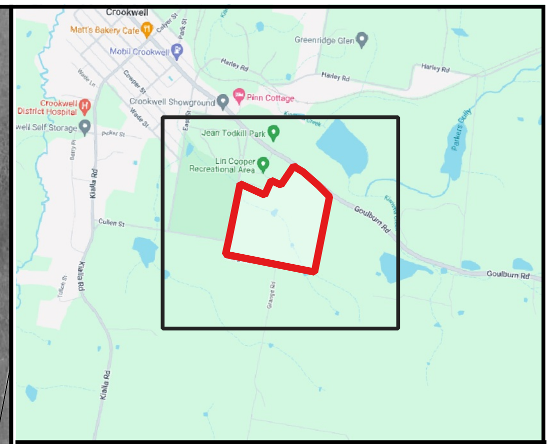

LEGEND

Site Location

Flood Velocity Difference (m/s)

- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 87 : Predicted Change in Peak 0.2% AEP Flood Velocity

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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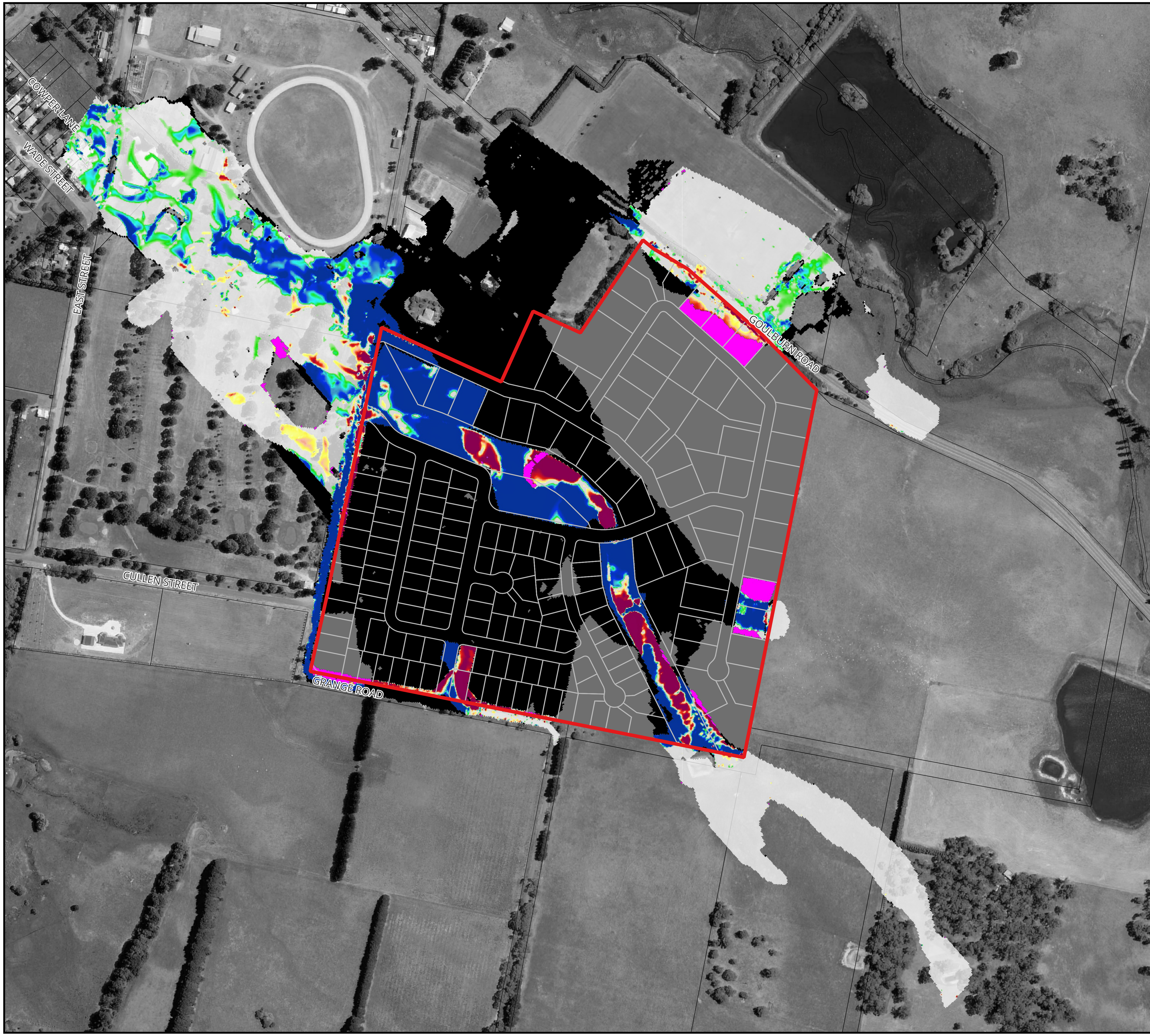

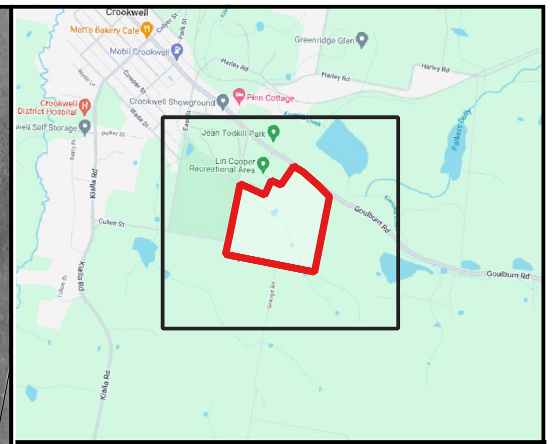

LEGEND

- Site Location
- Flood Velocity Difference (m/s)
- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 88 :
Predicted Change in
Peak PMF Flood Velocity

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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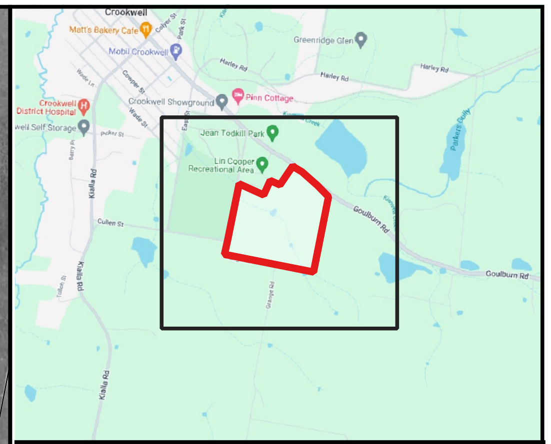


LEGEND

- Site Location
- Flood Level Difference (m)
- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

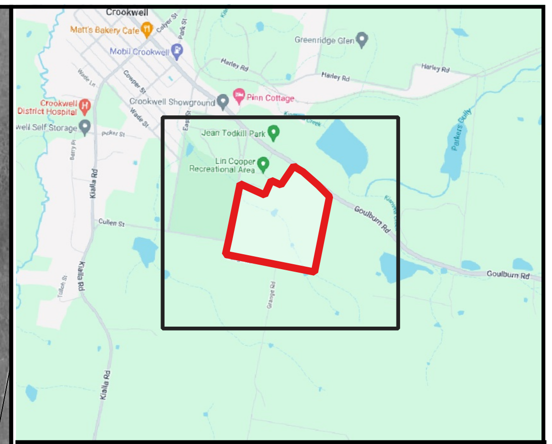
Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 89 : Predicted Change in Peak 1% AEP Flood Levels as a result of Climate Change using the 0.5% AEP Event as a Proxy

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\J760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND
- Site Location
- Flood Velocity Difference (m/s)
- -0.50
- -0.30
- -0.25
- -0.20
- -0.15
- -0.10
- Differences less than ±0.10m
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 90 : Predicted Change in Peak 1% AEP Flood Velocity as a result of Climate Change using the 0.5% AEP Event as a Proxy

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

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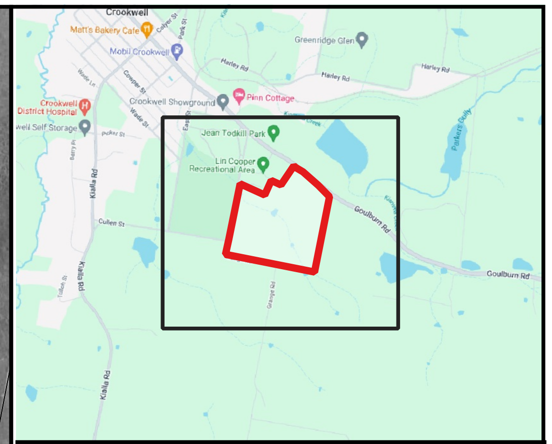


LEGEND

Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 91 : Predicted Change in Peak 1% AEP Flood Levels as a result of Climate Change using the 0.2% AEP Event as a Proxy

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz

LEGEND

Site Location

Flood Velocity Difference (m/s)

-0.50
-0.30
-0.25
-0.20
-0.15
-0.10
Differences less than ±0.10m
0.10
0.15
0.20
0.25
0.30
0.50
Was wet, now dry
Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

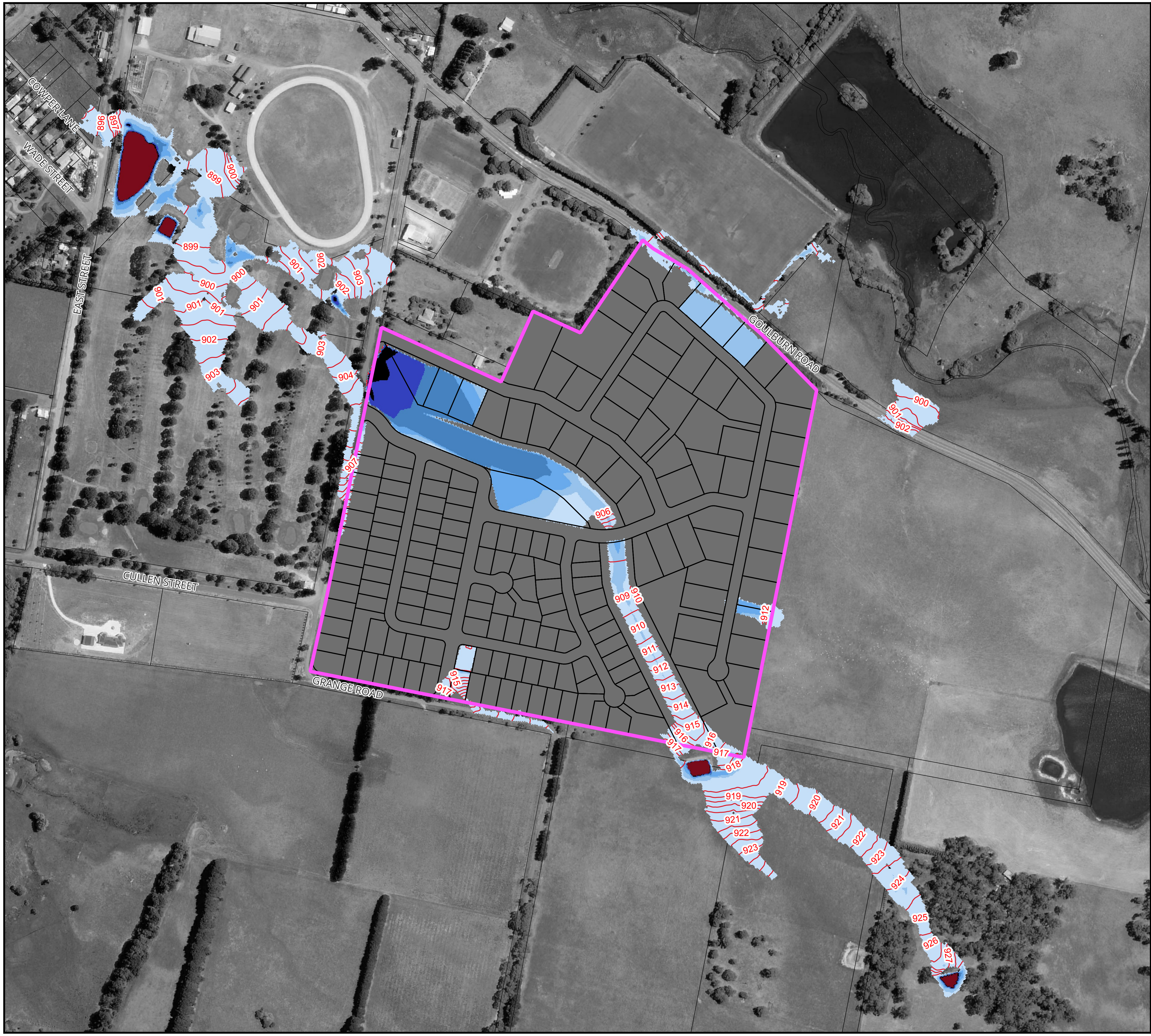
0 60 120 180 240 m

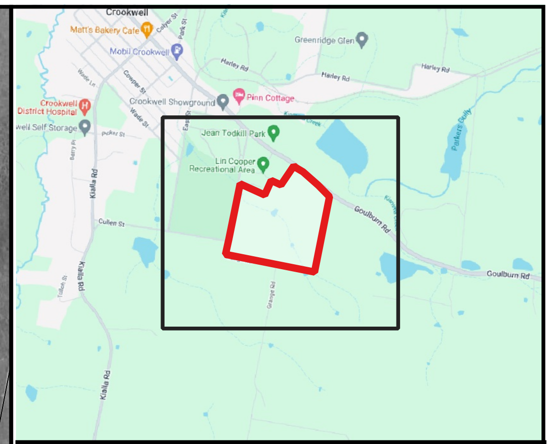
Figure 92 : Predicted Change in Peak 1% AEP Flood Velocity as a result of Climate Change using the 0.2% AEP Event as a Proxy

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz





LEGEND

- Site Location
- Flood Level Contour (0.5m interval)

Depth(m)

- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.20
- > 1.20

Notes:
Aerial photograph: NSW SIX MAPS

N

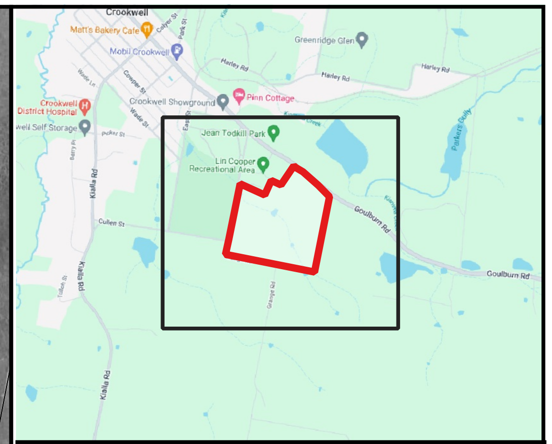
Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 93 : Peak Floodwater Depths and Levels for the 1% AEP Flood for Proposed Conditions with High Culvert Blockage

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND

Site Location

Flood Level Difference (m)

- -0.50
- -0.25
- -0.15
- -0.10
- -0.05
- -0.02
- Differences less than ±0.02m
- 0.02
- 0.05
- 0.10
- 0.15
- 0.25
- 0.50
- Was wet, now dry
- Was dry, now wet

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

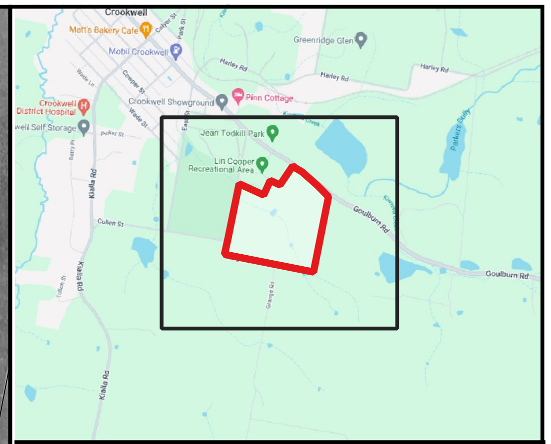
0 60 120 180 240 m

Figure 94 : Predicted Change in Peak 1% AEP Flood Levels as a result High Culvert Blockage

Prepared by:

Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\J760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz



LEGEND
- Site Location
- Flood Planning Level (mAHD)
- Flood Planning Area
- 1%AEP Flood Extent
- PMF Extent

Notes:
Aerial photograph: NSW SIX MAPS

N

Scale: 1:5000 (at A3)

0 60 120 180 240 m

Figure 95 :
Flood Planning Area and Levels

Prepared by:
Catchment Simulation Solutions
Suite 1, Level 10, 70 Phillip St
Sydney, NSW, 2000

File Path: T:\~Projects\U760 - 4273 Goulburn Road, Crookwell FIRA\Figures\QGIS\GoulburnRd_Figures.qgz

Appendix B
XP-RAFTS Subcatchment Parameters

Existing XP-RAFTS Subcatchment Parameters						
Subcatchment ID	Subcatchment Area (ha)	Total Upstream Area (ha)	Subcatchment Slope (%)	Impervious Area (ha)	Impervious Prop (%)	Main Stream Length (km)
1	2.33	8.23	3.9	0.03	1.24	2.19
2	0.04	61.72	4.19	0	4.49	0.07
3	2.61	2.61	8.43	0	0	7.4
4	1.15	1.15	1.81	0.29	24.84	1.42
5	1.16	1.16	3.03	0.29	24.85	3.41
6	2.77	2.77	1.77	0.32	11.45	1.4
7	3.13	5.9	1.82	0.1	3.1	0.02
8	4.96	9.81	3.47	0.08	1.59	1.25
9	7.42	16.43	2.28	0	0.01	2.03
10	9.02	9.02	4.8	0	0	4.4
11	4.85	4.85	3.66	0.08	1.56	3.07
12	1.98	85.99	0.57	0.4	20.04	0
13	1.62	29.65	2.49	0.01	0.49	1.45
14	1.6	1.6	2.76	0.25	15.83	2.7
15	0.35	1.95	1.21	0.16	46.42	1.29
16	4.89	4.89	2.89	0	0	2.64
17	2.54	32.19	2.08	0.02	0.87	1.1
18	3.76	44.99	2.27	0.16	4.3	2.1
19	3.56	3.56	1.49	0.04	1.01	1.77
20	5.6	7.56	2.9	0	0	3.03
21	4.15	9.03	1.6	0	0	1.08
22	2.38	9.94	2.18	0	0	1.36
23	0.05	51.74	1.69	0	0	0.05
24	2.63	47.62	1.93	0	0	1.79
25	0.51	4.07	1.3	0.04	8.7	1.19
26	0.76	0.76	1.51	0.03	3.44	1.62
27	0.37	0.37	1.84	0.06	16.92	1.73
28	0.24	0.24	1.78	0.05	19.27	2.71
29	1.84	1.84	2.64	0	0	3.23
30	3.08	4.92	2.27	0	0	2.17
31	0.8	2.41	2.33	0	0	2.27
32	2.65	4.02	1.74	0.34	12.68	1.55
33	2.07	64.95	2.06	0.03	1.56	1.9
34	0.77	0.77	2.46	0	0	2.52
35	0.84	0.84	2.22	0	0	2.08
36	3.1	3.1	0.39	0	0	0.26
37	1.28	1.28	2.43	0.27	21.29	2.08
38	0.67	3.77	1.78	0.15	22.5	1.87
39	2.65	78.96	1.59	0.08	2.99	1.3
40	1.79	1.79	5.26	0	0	3.81
41	240.03	342.64	0.94	23.46	9.77	1.49
42	4.62	4.62	5.9	0.08	1.73	6.01

Post-Development XP-RAFTS Subcatchment Parameters						
Subcatchment ID	Subcatchment Area (ha)	Total Upstream Area (ha)	Subcatchment Slope (%)	Impervious Area (ha)	Impervious Prop (%)	Main Stream Length (km)
1	2.33	8.23	3.9	1.65	70.8	2.19
2	0.04	61.72	4.19	0	0	0.07
3	2.61	2.61	8.43	0.24	9.29	7.4
4	1.15	1.15	1.81	0.71	61.87	1.42
5	1.16	1.16	3.03	0.67	57.45	3.41
6	2.77	2.77	1.77	0.46	16.46	1.4
7	3.13	5.9	1.82	2.24	71.51	0.02
8	4.96	9.81	3.47	0.08	1.59	1.25
9	7.42	16.43	2.28	0.02	0.34	2.03
10	9.02	9.02	4.8	0	0	4.4
11	4.85	4.85	3.66	0.08	1.56	3.07
12	1.98	85.99	0.57	0.4	20.04	0
13	1.62	29.65	2.49	0.61	37.76	1.45
14	1.6	1.6	2.76	0.25	15.83	2.7
15	0.35	1.95	1.21	0.17	48.12	1.29
16	4.89	4.89	2.89	0.01	0.22	2.64
17	2.54	32.19	2.08	1.47	57.66	1.1
18	3.76	44.99	2.27	2.04	54.18	2.1
19	3.56	3.56	1.49	2.53	71.03	1.77
20	5.6	7.56	2.9	4.15	74	3.03
21	4.15	9.03	1.6	2.85	68.72	1.08
22	2.38	9.94	2.18	1.65	69.23	1.36
23	0.05	51.74	1.69	0	1.6	0.05
24	2.63	47.62	1.93	1.05	39.73	1.79
25	0.51	4.07	1.3	0.27	52.92	1.19
26	0.76	0.76	1.51	0.03	3.44	1.62
27	0.37	0.37	1.84	0.18	48.73	1.73
28	0.24	0.24	1.78	0.05	19.27	2.71
29	1.84	1.84	2.64	0	0	3.23
30	3.08	4.92	2.27	0	0	2.17
31	0.8	2.41	2.33	0	0	2.27
32	2.65	4.02	1.74	0.34	12.69	1.55
33	2.07	64.95	2.06	0.03	1.41	1.9
34	0.77	0.77	2.46	0	0	2.52
35	0.84	0.84	2.22	0	0	2.08
36	3.1	3.1	0.39	0	0	0.26
37	1.28	1.28	2.43	0.27	21.29	2.08
38	0.67	3.77	1.78	0.15	22.5	1.87
39	2.65	78.96	1.59	0.08	2.99	1.3
40	1.79	1.79	5.26	0.01	0.49	3.81
41	240.03	342.64	0.94	23.46	9.77	1.49
42	4.62	4.62	5.9	0.08	1.73	6.01

Appendix C
PMP Calculations

GSDM CALCULATION SHEET

LOCATION INFORMATION

Catchment Goulburn Rd, Crookwell   Area 3.43 km^2

State New South Wales   Duration Limit 6.0 hrs

Latitude 34.4702^{0}S   Longitude 149.4846^{0}E

Portion of Area Considered:

Smooth, **S** = 0.00 (0.0 - 1.0)   Rough, **R** = 1.00 (0.0 - 1.0)

ELEVATION ADJUSTMENT FACTOR (EAF)

Mean Elevation 914 m

Adjustment for Elevation (-0.05 per 300m above 1500m) 0.00

EAF = **1.00** (0.85 – 1.00)

MOISTURE ADJUSTMENT FACTOR (MAF)

MAF = **0.67** (0.40-1.00)

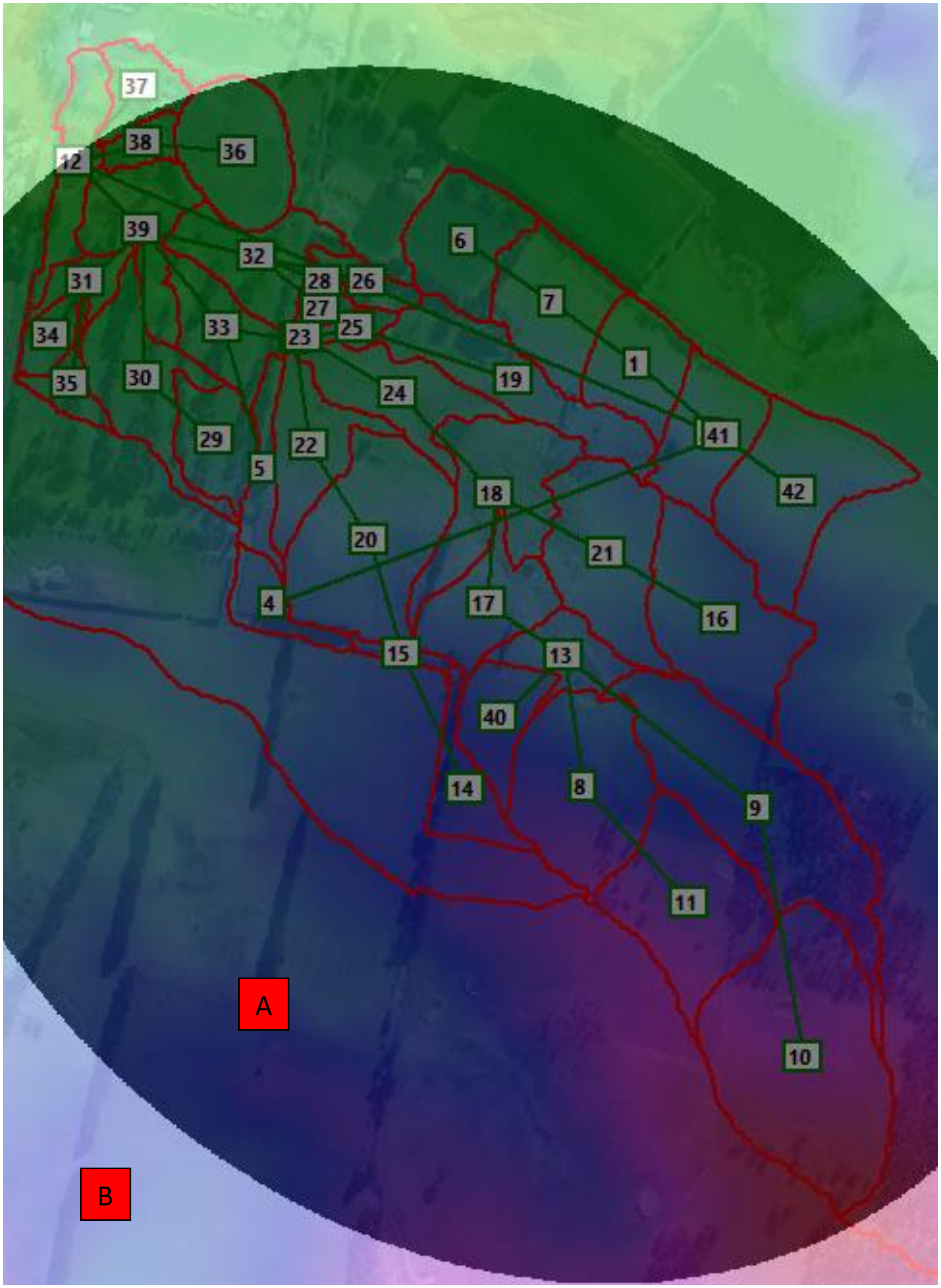
PMP VALUES (mm)

Duration (hours)	Initial Depth -Smooth (D_S)	Initial Depth -Rough (D_R)	PMP Estimate = (D_SxS + D_RxR) x MAF x EAF	Rounded PMP Estimate (nearest 10 mm)
0.25	228	228	153	150
0.50	332	332	222	220
0.75	420	420	282	280
1.00	487	487	327	330
1.50	557	630	422	420
2.00	622	735	493	490
2.50	662	811	544	540
3.00	698	890	596	600
4.00	764	1018	682	680
5.00	824	1121	751	750
6.00	871	1187	795	800

Prepared By Daniel Fedczyna   Date 23/01/2024

Checked By David Tetley   Date 25/01/2024

GSDM ELLIPSES



GSDM SPATIAL DISTRIBUTION

DURATION = 0.25 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	236	158	297	297	158
B	1.55	3.43	228	153	524	227	147
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

DURATION = 0.50 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	341	229	429	429	229
B	1.55	3.43	332	222	762	333	215
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

GSDM SPATIAL DISTRIBUTION (continued)

DURATION = 0.75 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	430	288	541	541	288
B	1.55	3.43	420	282	965	424	274
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

DURATION = 1.0 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	499	335	628	628	335
B	1.55	3.43	487	327	1119	491	317
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

GSDM SPATIAL DISTRIBUTION (continued)

DURATION = 1.5 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	644	432	810	810	432
B	1.55	3.43	630	422	1446	635	410
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

DURATION = 2.0 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	754	505	948	948	505
B	1.55	3.43	735	493	1688	740	477
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

GSDM SPATIAL DISTRIBUTION (continued)

DURATION = 2.5 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	833	558	1048	1048	558
B	1.55	3.43	811	544	1863	815	526
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

DURATION = 3.0 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	914	613	1150	1150	613
B	1.55	3.43	890	596	2043	893	576
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

GSDM SPATIAL DISTRIBUTION (continued)

DURATION = 4.0 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	1043	699	1311	1311	699
B	1.55	3.43	1018	682	2338	1027	662
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

DURATION = 5.0 Hours							
Ellipse	Catchment Area Between Ellipse (km^2)	Catchment Area Enclosed by Ellipse (km^2)	Initial Mean Rainfall Depth (mm)	Adjusted Mean Rainfall Depth (mm)	Rainfall Volume enclosed by Ellipse ($mm.km^2$)	Rainfall Volume between Ellipses ($mm.km^2$)	Mean Rainfall Depth between ellipses (mm)
A	1.88	1.88	1152	772	1448	1448	772
B	1.55	3.43	1121	751	2574	1126	726
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

GSDM SPATIAL DISTRIBUTION (continued)

DURATION = 6.0 Hours							
Ellipse	**Catchment Area Between Ellipse (km^2)**	**Catchment Area Enclosed by Ellipse (km^2)**	**Initial Mean Rainfall Depth (mm)**	**Adjusted Mean Rainfall Depth (mm)**	**Rainfall Volume enclosed by Ellipse ($mm.km^2$)**	**Rainfall Volume between Ellipses ($mm.km^2$)**	**Mean Rainfall Depth between ellipses (mm)**
A	1.88	1.88	1217	815	1530	1530	815
B	1.55	3.43	1187	795	2724	1194	771
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A
F	N/A	N/A	N/A	N/A	N/A	N/A	N/A
G	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix D
XP-RAFTS Subcatchment Outputs for Existing Conditions

Existing XP-RAFTS Outputs

Subcatchment ID	63.2% AEP Average Discharge (m3/s)	63.2% AEP Critical Discharge (m3/s)	63.2% AEP Critical Duration (mins)	63.2% AEP Critical Temporal Pattern	50% AEP Average Discharge (m3/s)	50% AEP Critical Discharge (m3/s)	50% AEP Critical Duration (mins)	50% AEP Critical Temporal Pattern
GR-1	0.13	0.14	1440	4155	0.15	0.17	720	4102
GR-2	0.88	0.92	1440	4155	1.05	1.1	720	4102
GR-3	0.06	0.07	720	4102	0.07	0.07	180	3985
GR-4	0.04	0.04	5	5	0.05	0.05	5	5
GR-5	0.04	0.04	5	5	0.05	0.05	5	5
GR-6	0.05	0.05	5	5	0.05	0.05	5	5
GR-7	0.09	0.1	1440	4155	0.11	0.12	1440	4155
GR-8	0.16	0.17	720	4093	0.2	0.2	720	4093
GR-9	0.24	0.26	1440	4155	0.29	0.3	720	4100
GR-10	0.15	0.16	720	4093	0.18	0.19	720	4093
GR-11	0.08	0.08	720	4093	0.1	0.1	720	4093
GR-12	1.15	1.25	720	4102	1.37	1.45	720	4102
GR-13	0.45	0.49	1440	4155	0.53	0.54	720	4100
GR-14	0.04	0.04	5	5	0.04	0.04	5	5
GR-15	0.05	0.05	10	3710	0.05	0.05	10	3710
GR-16	0.08	0.09	720	4093	0.1	0.1	720	4093
GR-17	0.48	0.52	1440	4155	0.57	0.58	720	4100
GR-18	0.67	0.72	1440	4155	0.79	0.82	720	4100
GR-19	0.05	0.05	1440	4155	0.06	0.06	1440	4155
GR-20	0.13	0.13	720	4093	0.15	0.16	720	4102
GR-21	0.14	0.16	1440	4154	0.17	0.18	720	4102
GR-22	0.17	0.17	720	4093	0.2	0.21	720	4102
GR-23	0.74	0.79	1440	4155	0.89	0.93	720	4100
GR-24	0.7	0.75	1440	4155	0.83	0.86	720	4100
GR-25	0.06	0.06	1440	4155	0.07	0.07	1440	4155
GR-26	0.01	0.01	720	4093	0.02	0.02	720	4093
GR-27	0.01	0.01	5	5	0.01	0.01	5	5
GR-28	0.01	0.01	5	5	0.01	0.01	5	5
GR-29	0.03	0.03	1440	4155	0.03	0.04	1440	4154
GR-30	0.07	0.08	1440	4155	0.09	0.09	1440	4155
GR-31	0.04	0.04	720	4093	0.05	0.05	720	4093
GR-32	0.06	0.07	1440	4155	0.08	0.08	1440	4155
GR-33	0.91	0.99	720	4102	1.09	1.15	720	4102
GR-34	0.01	0.01	720	4093	0.02	0.02	720	4093
GR-35	0.01	0.01	1440	4154	0.02	0.02	1440	4154
GR-36	0.03	0.03	1440	4154	0.04	0.04	1440	4158
GR-37	0.04	0.04	5	5	0.05	0.05	5	5
GR-38	0.04	0.04	1440	4158	0.05	0.05	1440	4158
GR-39	1.08	1.17	720	4102	1.29	1.36	720	4102
GR-40	0.04	0.04	720	4102	0.05	0.05	180	3985
GR-41	3.5	3.5	5	5	3.88	3.88	5	5
GR-42	0.1	0.11	720	4102	0.11	0.13	720	4102

Subcatchment ID	20% AEP Average Discharge (m3/s)	20% AEP Critical Discharge (m3/s)	20% AEP Critical Duration (mins)	20% AEP Critical Temporal Pattern	10% AEP Average Discharge (m3/s)	10% AEP Critical Discharge (m3/s)	10% AEP Critical Duration (mins)	10% AEP Critical Temporal Pattern
GR-1	0.33	0.35	120	3956	0.45	0.48	120	3947
GR-2	1.98	2.05	120	3955	2.77	2.77	120	3913
GR-3	0.17	0.18	120	3952	0.23	0.23	60	3884
GR-4	0.06	0.06	5	5	0.09	0.09	120	3945
GR-5	0.06	0.08	120	3952	0.09	0.1	120	3945
GR-6	0.11	0.11	120	3951	0.14	0.15	120	3947
GR-7	0.22	0.24	120	3956	0.3	0.33	120	3947
GR-8	0.41	0.43	120	3956	0.57	0.6	120	3901
GR-9	0.59	0.63	120	3956	0.83	0.86	120	3901
GR-10	0.39	0.41	120	3956	0.54	0.6	60	3885
GR-11	0.21	0.22	120	3956	0.29	0.31	60	3885
GR-12	2.47	2.49	120	3956	3.43	3.54	120	3913
GR-13	1.06	1.12	120	3956	1.49	1.67	120	3947
GR-14	0.08	0.09	120	3956	0.11	0.11	60	3883
GR-15	0.1	0.1	120	3956	0.13	0.14	120	3947
GR-16	0.21	0.22	120	3956	0.29	0.32	60	3885
GR-17	1.13	1.18	120	3956	1.59	1.6	120	3901
GR-18	1.55	1.56	120	3955	2.19	2.22	120	3901
GR-19	0.12	0.12	180	3982	0.16	0.16	120	3913
GR-20	0.32	0.33	120	3956	0.44	0.49	120	3901
GR-21	0.35	0.37	120	3956	0.49	0.51	120	3901
GR-22	0.41	0.42	120	3956	0.57	0.62	120	3901
GR-23	1.71	1.74	120	3955	2.41	2.47	120	3901
GR-24	1.61	1.62	120	3955	2.26	2.31	120	3901
GR-25	0.13	0.14	120	3955	0.19	0.2	120	3944
GR-26	0.03	0.03	120	3956	0.04	0.05	60	3885
GR-27	0.02	0.03	120	3952	0.03	0.03	60	3888
GR-28	0.01	0.02	120	3952	0.02	0.02	120	3947
GR-29	0.07	0.07	120	3956	0.1	0.11	120	3947
GR-30	0.17	0.17	120	3955	0.24	0.27	120	3944
GR-31	0.1	0.1	120	3956	0.14	0.14	120	3901
GR-32	0.15	0.16	120	3956	0.21	0.23	120	3947
GR-33	2.04	2.12	120	3956	2.86	2.87	120	3913
GR-34	0.03	0.03	120	3956	0.05	0.05	60	3885
GR-35	0.03	0.03	120	3956	0.04	0.05	120	3947
GR-36	0.07	0.08	180	3982	0.09	0.1	540	4067
GR-37	0.07	0.07	120	3956	0.09	0.1	120	3945
GR-38	0.09	0.1	180	3982	0.12	0.13	540	4067
GR-39	2.35	2.39	120	3956	3.26	3.36	120	3913
GR-40	0.11	0.12	120	3952	0.15	0.15	60	3884
GR-41	6.04	6.13	720	4093	7.86	9.1	540	4067
GR-42	0.26	0.29	120	3952	0.35	0.36	60	3884

Subcatchment ID	5% AEP Average Discharge (m3/s)	5% AEP Critical Discharge (m3/s)	5% AEP Critical Duration (mins)	5% AEP Critical Temporal Pattern	2% AEP Average Discharge (m3/s)	2% AEP Critical Discharge (m3/s)	2% AEP Critical Duration (mins)	2% AEP Critical Temporal Pattern
GR-1	0.54	0.55	60	3883	0.66	0.7	45	3844
GR-2	3.27	3.46	120	3901	3.77	3.77	60	3871
GR-3	0.3	0.3	30	3829	0.36	0.37	20	3691
GR-4	0.1	0.11	120	3945	0.12	0.13	45	3842
GR-5	0.1	0.11	120	3945	0.13	0.13	45	3842
GR-6	0.18	0.19	60	3889	0.22	0.23	60	3872
GR-7	0.36	0.37	60	3883	0.44	0.5	60	3877
GR-8	0.69	0.71	60	3884	0.85	0.89	45	3844
GR-9	1	1.02	60	3884	1.2	1.26	45	3844
GR-10	0.68	0.69	60	3884	0.83	0.88	45	3844
GR-11	0.36	0.36	60	3884	0.44	0.47	45	3844
GR-12	4.04	4.21	120	3913	4.7	5.45	360	3941
GR-13	1.77	1.86	120	3901	2.09	2.1	60	3873
GR-14	0.14	0.14	45	3854	0.17	0.17	45	3844
GR-15	0.16	0.16	60	3884	0.2	0.2	45	3844
GR-16	0.36	0.37	60	3884	0.44	0.47	45	3844
GR-17	1.89	1.99	120	3901	2.22	2.22	60	3875
GR-18	2.59	2.74	120	3901	3	3.13	60	3875
GR-19	0.19	0.21	120	3947	0.24	0.26	60	3877
GR-20	0.53	0.54	60	3885	0.66	0.69	45	3844
GR-21	0.6	0.61	60	3884	0.73	0.76	45	3844
GR-22	0.69	0.71	60	3884	0.84	0.88	45	3844
GR-23	2.85	3.03	120	3901	3.26	3.42	60	3875
GR-24	2.68	2.84	120	3901	3.09	3.23	60	3875
GR-25	0.22	0.24	120	3947	0.27	0.3	60	3877
GR-26	0.06	0.06	60	3885	0.07	0.07	45	3844
GR-27	0.04	0.04	30	3828	0.04	0.05	30	3815
GR-28	0.02	0.02	30	3824	0.03	0.03	30	3815
GR-29	0.12	0.12	60	3885	0.14	0.14	45	3845
GR-30	0.29	0.29	120	3901	0.35	0.35	60	3876
GR-31	0.17	0.17	60	3884	0.2	0.22	45	3844
GR-32	0.26	0.27	60	3885	0.31	0.33	45	3844
GR-33	3.37	3.39	120	3913	3.87	3.89	60	3871
GR-34	0.06	0.06	60	3884	0.07	0.08	45	3844
GR-35	0.05	0.06	60	3885	0.07	0.07	45	3844
GR-36	0.11	0.12	120	3944	0.14	0.15	180	3964
GR-37	0.11	0.11	45	3812	0.14	0.15	45	3843
GR-38	0.14	0.15	120	3913	0.18	0.19	360	3862
GR-39	3.84	3.98	120	3913	4.44	5.12	360	3941
GR-40	0.18	0.19	30	3829	0.23	0.24	25	3704
GR-41	9.54	10.87	540	4067	12.21	12.76	360	3862
GR-42	0.43	0.45	30	3827	0.55	0.55	30	3815

Subcatchment ID	1% AEP Average Discharge (m3/s)	1% AEP Critical Discharge (m3/s)	1% AEP Critical Duration (mins)	1% AEP Critical Temporal Pattern	1 in 200 Average Discharge (m3/s)	1 in 200 Critical Discharge (m3/s)	1 in 200 Critical Duration (mins)	1 in 200 Critical Temporal Pattern
GR-1	0.78	0.82	45	3844	0.91	0.95	45	3844
GR-2	4.41	4.46	60	3875	5.06	5.14	60	3819
GR-3	0.44	0.45	20	3751	0.52	0.52	20	3703
GR-4	0.15	0.15	30	3815	0.17	0.18	20	3753
GR-5	0.15	0.16	30	3815	0.18	0.19	20	3753
GR-6	0.25	0.26	45	3843	0.3	0.3	45	3844
GR-7	0.52	0.55	45	3844	0.61	0.65	45	3844
GR-8	1	1.06	45	3844	1.16	1.23	45	3844
GR-9	1.43	1.49	45	3844	1.68	1.74	45	3844
GR-10	0.98	1.03	45	3844	1.14	1.24	30	3789
GR-11	0.52	0.54	45	3844	0.6	0.64	30	3789
GR-12	5.46	5.72	360	4023	6.18	6.57	90	3905
GR-13	2.49	2.5	45	3717	2.91	2.92	45	3717
GR-14	0.21	0.21	30	3815	0.24	0.25	30	3815
GR-15	0.23	0.24	30	3815	0.27	0.28	30	3815
GR-16	0.52	0.55	45	3844	0.61	0.66	30	3789
GR-17	2.63	2.63	45	3717	3.07	3.08	45	3717
GR-18	3.52	3.65	45	3844	4.1	4.26	45	3844
GR-19	0.28	0.3	60	3877	0.33	0.35	60	3877
GR-20	0.77	0.82	45	3844	0.89	0.95	45	3844
GR-21	0.87	0.91	45	3844	1.02	1.07	45	3844
GR-22	0.98	1.04	45	3844	1.14	1.19	45	3844
GR-23	3.82	3.96	45	3844	4.44	4.61	45	3844
GR-24	3.61	3.74	45	3844	4.21	4.37	45	3844
GR-25	0.32	0.32	60	3873	0.37	0.39	45	3844
GR-26	0.08	0.08	45	3844	0.09	0.1	45	3844
GR-27	0.05	0.05	20	3703	0.06	0.06	20	3703
GR-28	0.03	0.03	20	3703	0.04	0.04	20	3703
GR-29	0.17	0.18	45	3844	0.2	0.21	45	3844
GR-30	0.41	0.43	45	3844	0.49	0.51	45	3844
GR-31	0.24	0.26	45	3844	0.28	0.3	45	3844
GR-32	0.37	0.39	45	3844	0.43	0.46	45	3844
GR-33	4.52	4.55	60	3875	5.2	5.28	60	3819
GR-34	0.08	0.09	45	3844	0.1	0.11	30	3789
GR-35	0.08	0.08	45	3844	0.09	0.1	45	3844
GR-36	0.17	0.18	180	3960	0.2	0.2	90	3890
GR-37	0.16	0.17	30	3815	0.19	0.2	30	3815
GR-38	0.21	0.22	180	3960	0.24	0.26	180	3960
GR-39	5.17	5.44	360	4023	5.89	5.93	60	3819
GR-40	0.27	0.28	25	3704	0.32	0.33	20	3703
GR-41	14.4	15.04	360	3862	16.45	16.5	360	4024
GR-42	0.66	0.68	25	3704	0.77	0.79	25	3704

Subcatchment ID	1 in 500 Average Discharge (m3/s)	1 in 500 Critical Discharge (m3/s)	1 in 500 Critical Duration (mins)	1 in 500 Critical Temporal Pattern	PMF Average Discharge (m3/s)	PMF Critical Discharge (m3/s)	PMF Critical Duration (mins)	PMF Critical Temporal Pattern
GR-1	1.08	1.13	45	3844	11.18	11.18	30	2
GR-2	6.01	6.23	45	3844	63.22	63.22	60	4
GR-3	0.61	0.62	20	3691	5.35	5.35	15	1
GR-4	0.21	0.22	20	3753	2.02	2.02	15	1
GR-5	0.22	0.23	20	3753	2.07	2.07	15	1
GR-6	0.36	0.36	45	3844	3.86	3.86	30	2
GR-7	0.74	0.79	45	3844	7.9	7.9	30	2
GR-8	1.38	1.45	45	3844	13.93	13.93	30	2
GR-9	2.01	2.08	45	3844	21.7	21.7	30	2
GR-10	1.39	1.52	30	3789	14.07	14.07	15	1
GR-11	0.73	0.79	30	3789	7.37	7.37	15	1
GR-12	7.3	7.31	60	3819	82.04	82.04	90	5
GR-13	3.49	3.51	45	3717	37.26	37.26	45	3
GR-14	0.29	0.29	20	3703	2.89	2.89	15	1
GR-15	0.32	0.33	30	3815	3.12	3.12	15	1
GR-16	0.74	0.81	30	3789	7.52	7.52	15	1
GR-17	3.67	3.67	45	3717	39.32	39.32	45	3
GR-18	4.91	5.11	45	3844	51.43	51.43	45	3
GR-19	0.4	0.42	45	3844	4.61	4.61	30	2
GR-20	1.06	1.12	45	3844	10.22	10.22	30	2
GR-21	1.22	1.28	45	3844	12.98	12.98	30	2
GR-22	1.36	1.42	45	3844	13.1	13.1	30	2
GR-23	5.3	5.52	45	3844	55.01	55.01	45	3
GR-24	5.03	5.24	45	3844	52.42	52.42	45	3
GR-25	0.45	0.48	45	3844	5.24	5.24	30	2
GR-26	0.11	0.12	30	3789	1.13	1.13	30	2
GR-27	0.08	0.08	20	3703	0.72	0.72	15	1
GR-28	0.05	0.05	20	3703	0.46	0.46	15	1
GR-29	0.24	0.26	45	3844	2.63	2.63	30	2
GR-30	0.59	0.62	45	3844	6.59	6.59	30	2
GR-31	0.34	0.34	30	3815	3.51	3.51	30	2
GR-32	0.52	0.55	45	3844	5.61	5.61	30	2
GR-33	6.14	6.35	45	3844	65.18	65.18	90	5
GR-34	0.12	0.13	30	3789	1.2	1.2	15	1
GR-35	0.11	0.12	45	3844	1.21	1.21	30	2
GR-36	0.23	0.24	90	3890	3.18	3.18	45	3
GR-37	0.23	0.23	20	3703	2.07	2.07	15	1
GR-38	0.28	0.3	90	3890	3.75	3.75	60	4
GR-39	6.95	6.99	60	3819	76.68	76.68	90	5
GR-40	0.39	0.39	20	3703	3.62	3.62	15	1
GR-41	19.31	19.8	360	4024	260.18	260.18	120	6
GR-42	0.93	0.94	20	3703	9.1	9.1	15	1

Appendix E
Blockage Assessment

STRUCTURE BLOCKAGE ASSESSMENT

Goulburn Road, Crookwell Flood Assessment

Structure ID		Structure Type	Structure Dimensions			Land Use Across Upstream Catchment	Max. L10 (m)	Control Dimension	Main Stream Slope (%)	Debris Availability (L, M, H)	Debris Mobility (L, M, H)	Debris Transportability (L, M, H)	Debris Potential	Debris Potential at Structure	Adjustment for AEP			Design Blockage Level		
			Dia/Width /Span	Height	Cells / Spans										AEP >5%	AEP 5%-0.5%	AEP < 0.5%	AEP >5%	AEP 5%-0.5%	AEP < 0.5%
Pipe1	C	Pipe Culvert	0.375	0	1	98% Grass, 2% Trees	0.50	W<L	1.93	L	M	M	**LMM**	Low	Low	Low	Medium	25%	25%	50%
Pipe2	C	Pipe Culvert	0.375	0	1	98% Grass, 2% Trees	0.50	W<L	3.77	L	M	H	**LMH**	Medium	Low	Medium	High	25%	50%	100%
Pipe3	C	Pipe Culvert	0.375	0	1	98% Grass, 2% Trees	0.50	W<L	3.43	L	M	H	**LMH**	Medium	Low	Medium	High	25%	50%	100%
Pipe4	C	Pipe Culvert	0.45	0	1	98% Grass, 2% Trees	0.50	W<L	2.9	L	M	M	**LMM**	Low	Low	Low	Medium	25%	25%	50%
Pipe5	C	Pipe Culvert	0.45	0	1	98% Grass, 2% Trees	0.50	W<L	3	L	M	M	**LMM**	Low	Low	Low	Medium	25%	25%	50%
Pipe1_D01	R	Box Culvert	0.9	0.6	1	98% Grass, 2% Trees	0.50	L<W<3L	1.93	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	10%
Pipe1_D01a	R	Box Culvert	2.4	0.6	1	98% Grass, 2% Trees	0.50	W>3L	1.93	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD01	R	Box Culvert	2.4	0.9	6	98% Grass, 2% Trees	0.50	W>3L	2.27	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD02	R	Box Culvert	1.2	0.6	3	98% Grass, 2% Trees	0.50	L<W<3L	2.9	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	10%
PipeD03	R	Box Culvert	2.4	0.6	2	98% Grass, 2% Trees	0.50	W>3L	2.18	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD03a	R	Box Culvert	2.4	0.6	2	98% Grass, 2% Trees	0.50	W>3L	2.18	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD04	R	Box Culvert	2.4	0.75	6	98% Grass, 2% Trees	0.50	W>3L	2.18	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD05	R	Box Culvert	2.4	0.6	4	98% Grass, 2% Trees	0.50	W>3L	1.6	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD05a	R	Box Culvert	2.4	0.6	4	98% Grass, 2% Trees	0.50	W>3L	1.6	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	0%
PipeD06	c	Pipe Culvert	1.2	0	6	98% Grass, 2% Trees	0.50	L<W<3L	2.9	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	10%
PipeD07	c	Pipe Culvert	0.9	0	1	98% Grass, 2% Trees	0.50	L<W<3L	1.82	L	M	M	**LMM**	Low	Low	Low	Medium	0%	0%	10%
PipeD08	c	Pipe Culvert	0.3	0	1	98% Grass, 2% Trees	0.50	W<L	3.9	L	M	H	**LMH**	Low	Low	Low	Medium	25%	25%	50%

Appendix F
Concept Design

Appendix G

XP-RAFTS Subcatchment Outputs for Post-Development Conditions

Post Development XP-RAFTS Outputs

Subcatchment ID	63.2% AEP				50% AEP				20% AEP			
	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern
GR-1	0.59	0.59	5	5	0.65	0.65	5	5	0.85	0.85	5	5
GR-2	1.42	1.42	15	3746	1.58	1.59	15	3742	2.1	2.12	15	3742
GR-3	0.06	0.07	720	4102	0.07	0.07	180	3985	0.16	0.18	120	3952
GR-4	0.11	0.11	5	5	0.12	0.12	5	5	0.16	0.16	5	5
GR-5	0.1	0.1	5	5	0.11	0.11	5	5	0.15	0.15	5	5
GR-6	0.07	0.07	5	5	0.08	0.08	5	5	0.11	0.12	120	3951
GR-7	0.34	0.34	5	5	0.37	0.37	5	5	0.49	0.49	5	5
GR-8	0.16	0.17	720	4093	0.2	0.2	720	4093	0.41	0.43	120	3956
GR-9	0.24	0.26	1440	4155	0.29	0.3	720	4100	0.59	0.63	120	3956
GR-10	0.15	0.16	720	4093	0.18	0.19	720	4093	0.39	0.41	120	3956
GR-11	0.08	0.08	720	4093	0.1	0.1	720	4093	0.21	0.22	120	3956
GR-12	1.45	1.47	20	3775	1.62	1.63	20	3775	2.63	2.65	120	3955
GR-13	0.45	0.48	1440	4155	0.53	0.54	720	4100	1.05	1.09	120	3956
GR-14	0.04	0.04	5	5	0.04	0.04	5	5	0.08	0.09	120	3956
GR-15	0.05	0.05	10	3710	0.05	0.05	10	3710	0.1	0.1	120	3956
GR-16	0.08	0.09	720	4093	0.1	0.1	720	4093	0.21	0.22	120	3956
GR-17	0.47	0.49	1440	4155	0.57	0.59	720	4100	1.1	1.11	120	3955
GR-18	0.76	0.76	10	3712	0.84	0.84	10	3715	1.48	1.51	120	3955
GR-19	0.38	0.38	5	5	0.42	0.42	5	5	0.55	0.55	5	5
GR-20	0.63	0.63	5	5	0.69	0.69	5	5	0.9	0.9	5	5
GR-21	0.43	0.43	5	5	0.48	0.48	5	5	0.62	0.62	5	5
GR-22	0.66	0.67	10	3710	0.74	0.75	10	3710	0.97	0.98	10	3710
GR-23	0.94	0.94	15	3747	1.05	1.05	15	3748	1.6	1.65	120	3955
GR-24	0.76	0.76	10	3712	0.84	0.84	10	3715	1.52	1.55	120	3955
GR-25	0.4	0.4	5	5	0.44	0.44	5	5	0.59	0.59	5	5
GR-26	0.01	0.01	720	4093	0.02	0.02	720	4093	0.03	0.03	120	3956
GR-27	0.03	0.03	5	5	0.03	0.03	5	5	0.04	0.04	5	5
GR-28	0.01	0.01	5	5	0.01	0.01	5	5	0.01	0.02	120	3952
GR-29	0.03	0.03	1440	4155	0.03	0.04	1440	4154	0.07	0.07	120	3956
GR-30	0.07	0.08	1440	4155	0.09	0.09	1440	4155	0.17	0.17	120	3955
GR-31	0.04	0.04	720	4093	0.05	0.05	720	4102	0.1	0.1	120	3956
GR-32	0.07	0.07	10	3711	0.08	0.08	10	3711	0.16	0.16	120	3956
GR-33	1.44	1.46	20	3770	1.6	1.63	20	3770	2.13	2.16	20	3770
GR-34	0.01	0.01	720	4093	0.02	0.02	720	4093	0.03	0.03	120	3956
GR-35	0.01	0.01	1440	4154	0.02	0.02	1440	4154	0.03	0.03	120	3956
GR-36	0.03	0.03	1440	4154	0.04	0.04	1440	4158	0.07	0.08	180	3982
GR-37	0.04	0.04	5	5	0.05	0.05	5	5	0.07	0.07	120	3956
GR-38	0.04	0.04	1440	4158	0.05	0.05	1440	4158	0.09	0.1	180	3982
GR-39	1.45	1.47	20	3775	1.62	1.63	20	3775	2.48	2.51	120	3955
GR-40	0.04	0.04	720	4102	0.05	0.05	180	3985	0.11	0.12	120	3952
GR-41	3.5	3.5	5	5	3.88	3.88	5	5	6.06	6.1	720	4093
GR-42	0.1	0.11	720	4102	0.11	0.13	720	4102	0.26	0.29	120	3952

Subcatchment ID	10% AEP				5% AEP				2% AEP			
	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern
GR-1	0.98	0.98	5	5	1.11	1.11	5	5	1.27	1.27	5	5
GR-2	2.59	2.61	120	3943	3.06	3.11	120	3943	3.65	3.69	90	3890
GR-3	0.22	0.22	60	3884	0.29	0.29	30	3825	0.35	0.36	20	3703
GR-4	0.18	0.18	5	5	0.2	0.2	5	5	0.23	0.23	5	5
GR-5	0.17	0.17	5	5	0.19	0.19	5	5	0.22	0.22	5	5
GR-6	0.16	0.16	120	3943	0.19	0.19	120	3901	0.22	0.24	60	3877
GR-7	0.56	0.56	5	5	0.64	0.64	5	5	0.74	0.75	10	3692
GR-8	0.57	0.6	120	3901	0.69	0.71	60	3884	0.85	0.89	45	3844
GR-9	0.83	0.86	120	3901	1	1.02	60	3884	1.2	1.26	45	3844
GR-10	0.54	0.6	60	3885	0.68	0.69	60	3884	0.83	0.88	45	3844
GR-11	0.29	0.31	60	3885	0.36	0.36	60	3884	0.44	0.47	45	3844
GR-12	3.45	3.47	120	3947	4.1	4.18	120	3913	4.85	4.87	120	3931
GR-13	1.48	1.66	120	3947	1.76	1.85	120	3901	2.07	2.11	60	3875
GR-14	0.11	0.11	60	3883	0.14	0.14	45	3854	0.17	0.17	45	3844
GR-15	0.13	0.14	120	3947	0.16	0.16	60	3884	0.2	0.2	45	3844
GR-16	0.29	0.32	60	3885	0.36	0.37	60	3884	0.44	0.47	45	3844
GR-17	1.55	1.59	120	3901	1.84	1.94	120	3901	2.15	2.18	60	3819
GR-18	2.02	2.07	120	3913	2.4	2.43	120	3913	2.81	2.82	60	3819
GR-19	0.64	0.64	5	5	0.72	0.72	5	5	0.83	0.83	5	5
GR-20	1.04	1.04	5	5	1.18	1.18	5	5	1.36	1.36	5	5
GR-21	0.72	0.72	5	5	0.81	0.81	5	5	0.93	0.93	5	5
GR-22	1.14	1.16	10	3695	1.3	1.32	10	3695	1.55	1.58	10	3690
GR-23	2.19	2.27	120	3913	2.6	2.69	120	3913	3.03	3.09	90	3874
GR-24	2.1	2.14	120	3913	2.49	2.52	120	3913	2.89	2.89	60	3819
GR-25	0.68	0.68	5	5	0.77	0.77	5	5	0.9	0.9	5	5
GR-26	0.04	0.05	60	3885	0.06	0.06	60	3885	0.07	0.07	45	3844
GR-27	0.05	0.05	5	5	0.05	0.05	5	5	0.06	0.06	20	3750
GR-28	0.02	0.02	120	3947	0.02	0.02	30	3824	0.03	0.03	30	3815
GR-29	0.1	0.11	120	3947	0.12	0.12	60	3885	0.14	0.14	45	3845
GR-30	0.24	0.27	120	3944	0.29	0.29	120	3901	0.35	0.35	60	3876
GR-31	0.14	0.14	120	3901	0.17	0.17	60	3884	0.2	0.22	45	3844
GR-32	0.22	0.23	120	3947	0.26	0.28	60	3888	0.31	0.33	45	3843
GR-33	2.71	2.76	120	3943	3.2	3.29	120	3943	3.79	3.86	90	3794
GR-34	0.05	0.05	60	3885	0.06	0.06	60	3884	0.07	0.08	45	3844
GR-35	0.04	0.05	120	3947	0.05	0.06	60	3885	0.07	0.07	45	3844
GR-36	0.09	0.1	540	4067	0.11	0.12	120	3944	0.14	0.15	180	3964
GR-37	0.09	0.1	120	3945	0.11	0.11	45	3812	0.14	0.15	45	3843
GR-38	0.12	0.13	540	4067	0.14	0.15	120	3913	0.18	0.19	360	3862
GR-39	3.25	3.33	120	3913	3.86	3.94	120	3913	4.56	4.61	120	3931
GR-40	0.15	0.15	60	3884	0.18	0.19	30	3829	0.23	0.24	25	3704
GR-41	7.95	8.8	540	4067	9.62	10.54	540	4067	12.44	13.48	360	3862
GR-42	0.35	0.36	60	3884	0.43	0.45	30	3827	0.55	0.55	30	3815

Subcatchment ID	1% AEP				1 in 200				1 in 500				PMF			
	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern	Average Discharge (m3/s)	Critical Discharge (m3/s)	Critical Duration (mins)	Critical Temporal Pattern
GR-1	1.41	1.41	5	5	1.57	1.57	5	5	1.78	1.78	5	5	11.57	11.57	15	1
GR-2	4.21	4.28	90	3907	4.8	4.84	90	3907	5.66	5.77	60	3876	61.49	61.49	90	5
GR-3	0.43	0.43	20	3691	0.5	0.51	20	3691	0.6	0.6	20	3691	5.3	5.3	15	1
GR-4	0.26	0.26	5	5	0.29	0.29	5	5	0.33	0.33	5	5	2.02	2.02	15	1
GR-5	0.25	0.25	5	5	0.27	0.27	5	5	0.31	0.31	5	5	2.2	2.2	15	1
GR-6	0.26	0.31	45	3848	0.31	0.31	45	3843	0.37	0.38	45	3843	3.87	3.87	30	2
GR-7	0.82	0.85	15	3719	0.92	0.92	10	3692	1.05	1.08	15	3719	7.71	7.71	30	2
GR-8	1	1.06	45	3844	1.16	1.23	45	3844	1.38	1.45	45	3844	13.93	13.93	30	2
GR-9	1.43	1.49	45	3844	1.67	1.74	45	3844	2.01	2.08	45	3844	21.68	21.68	30	2
GR-10	0.98	1.03	45	3844	1.14	1.24	30	3789	1.39	1.52	30	3789	14.07	14.07	15	1
GR-11	0.52	0.54	45	3844	0.6	0.64	30	3789	0.73	0.79	30	3789	7.37	7.37	15	1
GR-12	5.56	5.73	90	3890	6.36	6.55	60	3878	7.53	7.77	60	3878	81.33	81.33	90	5
GR-13	2.46	2.47	45	3717	2.88	2.89	45	3717	3.45	3.46	45	3717	37.22	37.22	45	3
GR-14	0.21	0.21	30	3815	0.24	0.25	30	3815	0.29	0.29	20	3703	2.89	2.89	15	1
GR-15	0.23	0.24	30	3815	0.27	0.28	30	3815	0.32	0.33	30	3815	3.12	3.12	15	1
GR-16	0.52	0.55	45	3844	0.61	0.66	30	3789	0.74	0.81	30	3789	7.52	7.52	15	1
GR-17	2.54	2.58	45	3844	2.97	3.02	45	3844	3.56	3.64	45	3844	38.96	38.96	45	3
GR-18	3.32	3.32	60	3819	3.84	3.84	60	3819	4.57	4.59	60	3819	49.47	49.47	45	3
GR-19	0.91	0.91	5	5	1.02	1.02	5	5	1.16	1.16	5	5	6.18	6.18	15	1
GR-20	1.5	1.5	5	5	1.67	1.67	5	5	1.9	1.9	5	5	10.53	10.53	15	1
GR-21	1.03	1.03	5	5	1.15	1.15	5	5	1.3	1.3	5	5	12.26	12.26	30	2
GR-22	1.72	1.76	10	3690	1.92	1.96	10	3690	2.19	2.2	15	3718	14.53	14.53	15	1
GR-23	3.52	3.59	90	3907	4.05	4.09	60	3872	4.83	4.89	60	3872	53.44	53.44	60	4
GR-24	3.41	3.47	60	3877	3.94	3.95	60	3819	4.69	4.72	60	3872	50.87	50.87	60	4
GR-25	0.99	0.99	5	5	1.11	1.11	5	5	1.26	1.26	5	5	7.07	7.07	15	1
GR-26	0.08	0.08	45	3844	0.09	0.1	45	3844	0.11	0.12	30	3789	1.13	1.13	30	2
GR-27	0.07	0.07	20	3753	0.08	0.08	20	3753	0.1	0.11	15	3723	0.74	0.74	15	1
GR-28	0.03	0.03	20	3703	0.04	0.04	20	3703	0.05	0.05	20	3703	0.46	0.46	15	1
GR-29	0.17	0.18	45	3844	0.2	0.21	45	3844	0.24	0.26	45	3844	2.63	2.63	30	2
GR-30	0.41	0.43	45	3844	0.49	0.51	45	3844	0.59	0.62	45	3844	6.59	6.59	30	2
GR-31	0.24	0.26	45	3844	0.28	0.3	45	3844	0.34	0.34	30	3815	3.51	3.51	30	2
GR-32	0.37	0.39	45	3844	0.43	0.46	45	3844	0.52	0.55	45	3844	5.6	5.6	30	2
GR-33	4.38	4.41	90	3890	5	5.03	90	3907	5.89	5.91	60	3876	64.19	64.19	90	5
GR-34	0.08	0.09	45	3844	0.1	0.11	30	3789	0.12	0.13	30	3789	1.2	1.2	15	1
GR-35	0.08	0.08	45	3844	0.09	0.1	45	3844	0.11	0.12	45	3844	1.21	1.21	30	2
GR-36	0.17	0.18	180	3960	0.2	0.2	90	3890	0.23	0.24	90	3890	3.18	3.18	45	3
GR-37	0.16	0.17	30	3815	0.19	0.2	30	3815	0.23	0.23	20	3703	2.07	2.07	15	1
GR-38	0.21	0.22	180	3960	0.24	0.26	180	3960	0.28	0.3	90	3890	3.75	3.75	60	4
GR-39	5.24	5.26	90	3874	6.01	6.18	60	3878	7.12	7.33	60	3878	75.9	75.9	90	5
GR-40	0.27	0.28	25	3704	0.32	0.33	20	3703	0.39	0.39	20	3703	3.62	3.62	15	1
GR-41	14.66	14.91	360	4024	16.72	17.23	360	4024	19.58	20.5	360	4024	259.2	259.2	120	6
GR-42	0.66	0.68	25	3704	0.77	0.79	25	3704	0.93	0.94	20	3703	9.1	9.1	15	1