

Final Draft Report

South Bungendore Stormwater Masterplan



PREPARED FOR QPRC

DOCUMENT CONTROL

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Executive Summary

Calibre was commissioned by Queanbeyan Palerang Regional Council (QPRC) to develop a Stormwater Masterplan for the South Bungendore Township. The area is generally defined as the area within Molonglo Street (Kings Highway), King Street, Trucking Yard Lane and Majara Street / Goulburn Bombala Railway.

The South Bungendore Township does not currently have a coordinated stormwater management plan or strategy. Stormwater management in this area is occurring in an ad-hoc manner. QPRC requires a coordinated stormwater management plan or strategy for current and future developments anticipated within the area.

To mitigate flooding within this area, Option 9-1 was identified as the preferred solution to effectively mitigate flooding to South Bungendore. Option 9-1 requires the following works to be carried out:

- New road graded in between Ellendon Street and Mackay Street adjacent to Trucking Yard Lane with kerb and gutter;
- A 9m wide concrete floodway to the south of the new road. The floodway is proposed to extend through Molonglo Street and discharge directly into Halfway Creek. A new bridge / link slab will be required to be built at Molonglo Street. Alignment to be modified to suit existing infrastructure;
- Ellendon Street regraded with kerb and gutter and a sag point at the intersection with the proposed floodway;
- Extend the existing RCBC under Ellendon Street to convey trapped flows towards the proposed floodway;
- New road alignment to convey local flows towards the 9m wide concrete floodway; and
- Blocks as well as the new road are to be raised a minimum of 1m above the existing surface to provide adequate freeboard to raise building floor levels out of the floodplain. Grading of the blocks generally grade south towards the new road which will convey local flows towards the proposed floodway.

Refer to Appendix D for the location of works and Appendix E for sketches of the proposed works required to be undertaken.

QPRC may choose to undertake all works and recoup the costs under a Section 94 contributions plan, or at a minimum QPRC should construct the floodway while providing individual development constraints to raise blocks above the flood planning area (with adequate freeboard) and associated stormwater infrastructure.

Proposed areas that require to be raised will require to safely convey the 1% AEP flow through their respective parcel of land, with local drainage requiring to comply with the current Palerang Development Control Plan (DCP) 2015. If this constraint is not included in the DCP it could lead to an increase in flooding within the Study Area.

1 Introduction

The Bungendore Township is situated about 40 kilometres north-east of Canberra near the New South Wales / Australian Capital Territory border, and has a population of about 4,178 people (Australian Bureau of Statistics, 2016 Census). Flooding of the Bungendore Township is primarily due to the Township being located on relatively flat topography and at the junction of two tributaries, Halfway Creek and Turallo Creek.

The southern area of Bungendore is developing rapidly and does not have a coordinated stormwater management strategy or plan. Stormwater management is occurring in an ad-hoc manner and is constraining current and future development, leaving Queanbeyan Palerang Regional Council (QPRC) with long-term management issues. Calibre has been engaged by QPRC to undertake a stormwater masterplan for South Bungendore to identify existing flooding issues and provide mitigation options to alleviate flooding.

The Study Area is generally bounded by King Street to the north, the Majura Street / Goulburn Bombala Railway to the east, Trucking Yard Lane to the south and the Molonglo Street (Kings Highway) to the west. Halfway Creek traverses the South West corner of the Study Area. The extents of the Study Area are presented in Figure 1.



Figure 1: Flood Study Area Extents

2 Purpose

The main purpose of this study is to:

- Quantify stormwater flows in the southern areas of Bungendore;
- Develop long-term strategies for the management of stormwater in the southern areas of Bungendore;
- Safely manage stormwater flows along existing drainage paths through residential properties;
- Manage and improve water quality within the catchment;
- Facilitate long-term management of stormwater infrastructure; and
- Provide a basis for the update of Section 94 contributions plans and Development Control Plans.

3 Previous Studies

QPRC has previously undertaken several studies within the Study Area. These studies were provided to Calibre for review and to establish the accuracy of the flooding extents, the studies provided include:

1. *South Bungendore Flood Study*, GHD (2007)
2. *Bungendore Floodplain Risk Management Study (BFRMS)*, WorleyParsons (2014)
3. *King Street Industrial Estate Preliminary Flood Assessment*, SMEC (2016)

The first study was to investigate options for the culvert under the Kings Highway to determine an appropriate culvert upgrade option, and to investigate existing channel geometry modifications, the removal of overland flow paths to determine the minimum floor levels for lots within the Study Area.

The second study focussed on riverine flooding of Halfway Creek, Millpost Creek, and Turallo Creek only and did not consider overland flow through the Study Area, however undertook a validation of the model based on historical flooding within the Bungendore Township.

The third study was to assess the current and future flooding characteristics for the proposed *King Street Industrial Estate* development. This development is bounded by King Street on the North and Majara Street on the East, and is wholly within the Study Area.

A preliminary assessment of the previous studies found the studies in isolation are inadequate for the purpose of developing a Stormwater Masterplan for South Bungendore, however provide relevant information into certain aspects and areas of the Study Area.

4 Data Sources

This section outlines the data used in the development of this Stormwater Masterplan. These sources include previously published studies, inspection of the site, along with data available from government sources.

4.1 Site Inspection

A visual inspection of the Study Area and catchments was undertaken by QPRC and Calibre on Friday 24 April 2018 to confirm the geometry of key hydraulic structures and to gain an appreciation of the characteristics of the catchment. Photographs were obtained at several critical stormwater areas within the Study Area.

4.2 Topographic Data

An Airborne Light Detection and Ranging (LiDAR) survey of the catchment and its immediate surroundings was provided by QPRC. The accuracy of this data can be influenced by the presence of open water or vegetation (tree or shrub canopy) at the time of the survey.

The provided LiDAR shows recently constructed roads within the study not being recorded by the LiDAR data. The following roads contained incomplete LiDAR data and will not provide an accurate flood extent for each respective road:

- Chinnery Close;
- Jacombs Street;
- Road to the north of Jacombs Street;
- Hopkins Street contains a sag between Jacobs Street and Finch Street; and
- Gap in the Kings Highway where an existing stormwater culvert exists, South of Trucking Yard Lane.

A Digital Elevation Model (DEM) was created from the provided LiDAR to form the basis of the two-dimensional hydraulic modelling for the study.

4.3 Infrastructure Data

Stormwater pit and pipe data was provided by QPRC, including channel geometry, pipe and culvert attributes. A thorough review of this data revealed some missing information regarding pipe diameters, invert levels, and locations. Assumptions on missing information was taken from available WAE information or when not available assumptions were made based on adjacent pipe and node data. Driveway culverts have not been included in the infrastructure data, in critical areas driveway culverts have been included and assumptions of pipe attributes made based on site visits carried out.

The extent of the stormwater pipe network used is displayed in Figure 2.



Figure 2: Modelled Stormwater Network

4.4 Proposed Land use

The current land use of the study area contains a mixture of rural residential, residential and industrial land use types. Ultimately the study area will contain mostly residential (R2) zoned land with small areas of industrial (IN2) and roads / rail (SP2). The study area is bound by rural development (RU1). The proposed land use within the Study Area is shown in Figure 3.



Figure 3: Proposed Study Area Land use

The proposed land use information provides an understanding of which design storms are required to be conveyed through each land use type in accordance with the Palerang Development Control Plan (DCP) 2015.

5 Hydrology Modelling

The hydrologic modelling for this investigation was undertaken using the XP-RAFTS software package with parameters reviewed and adopted from the Bungendore Floodplain Risk Management Study (BFRMS) XP-Rafts model. Where parameter values were missing, Calibre made assumptions, which are provided in Appendix A.

5.1 Catchment Mapping

Determining the catchment extents can be a slightly subjective process, particularly in areas where localised features such as kerbs and walls can result in different catchment extents than the natural ground topography would suggest.

For this study, catchments displayed in Figure 4 were delineated taking into consideration the following factors:

- Ground topography data (discussed in Section 4.2);
- Arrangement of street kerb and pit/pipe systems; and
- Observations from a site inspection undertaken on 24 April 2018.

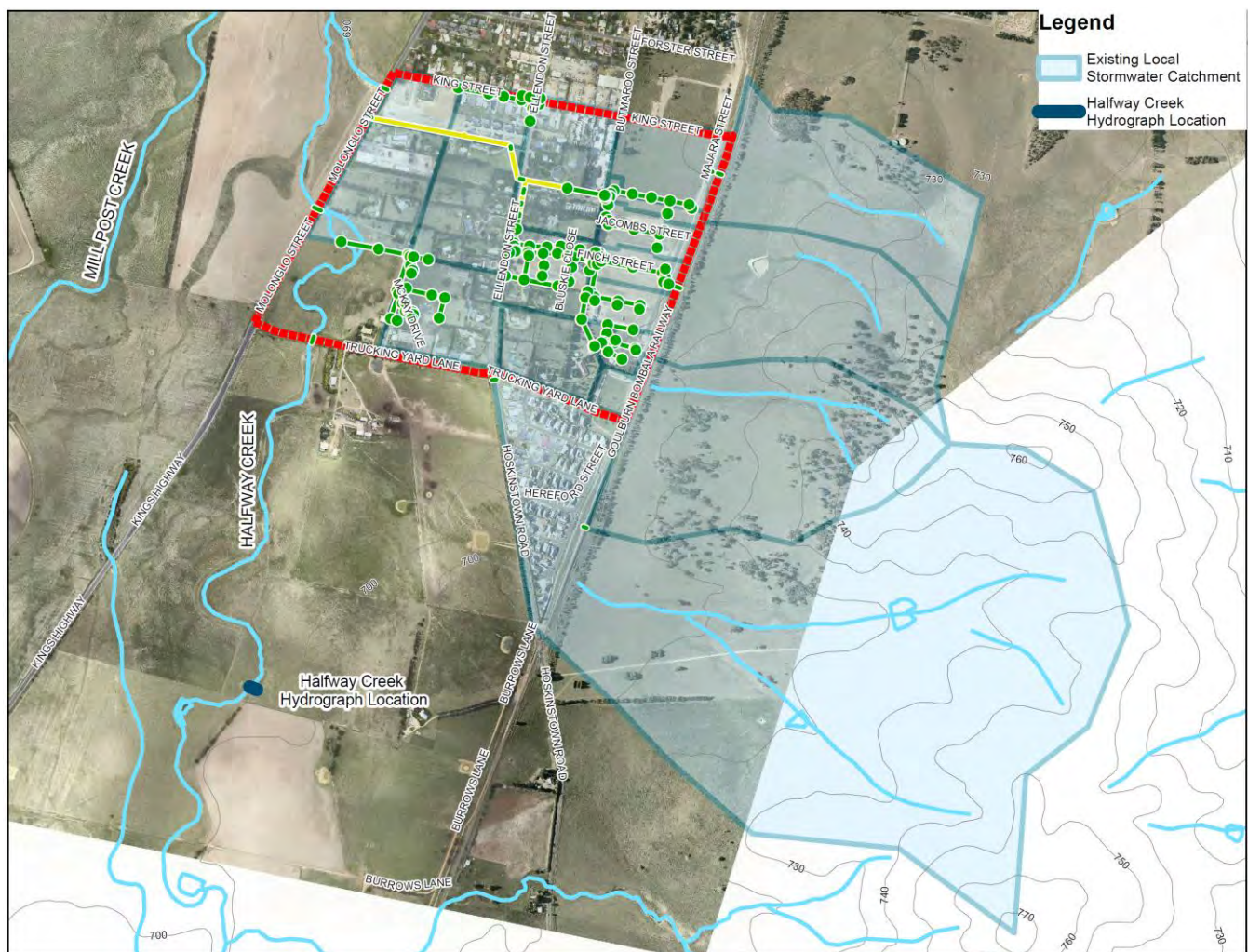


Figure 4: Study Area Existing Stormwater Catchments

The BFRMS contained a small number of nodes representing Halfway Creek with no nodes representing the existing urbanised extent of South Bungendore or the Bungendore Township. Once the existing local stormwater catchments was delineated, the difference in area was subtracted from the BFRMS XP-Rafts Halfway Creek nodes and impervious area assumption applied to represent the South Bungendore Study Area.

The XP-Rafts hydrologic modelling for South Bungendore was then undertaken for the 18.1% AEP, 10% AEP and 1% AEP with each AEP run using several storm durations ranging from 15 minutes to 9 hours.

It was found that the critical storm duration for all AEP events through the Study Area was 15 minutes. The Turallo Creek and subsequent Halfway Creek critical storm was identified to be the 360min event based on the BFRMS. Both durations were applied to the flood model to determine the worst case flood extent for the Study Area. Refer to Appendix A for the modelling summary sheet on hydrology parameters and assumptions made for the South Bungendore.

A comparison between the BFRMS XP-Rafts and Calibre's updated XP-Rafts hydrographs were undertaken to compare their suitability for the South Bungendore Study Area. The differences between the 18.1% and 1% AEP are within an acceptable magnitudes (i.e. <5%) and are suitable for the South Bungendore Stormwater Masterplan, refer the Model Validation (Hydrology).section in Appendix A.

6 Hydraulic Modelling

Two software programs were used for the hydraulic modelling of the Study Area.

- DRAINS was used to model the one dimensional stormwater pipe network urban stormwater drainage systems and catchments. It was used to model the stormwater routing through the stormwater pipe network of South Bungendore to determine the pipe capacity and subsequent overland flows within the Study Area.
- TUFLOW (2016-03-AD-iDP) is a hydrodynamic model used for simulating one-dimensional (1D) and two-dimensional (2D) flows to check the existing flooding conditions and the effectiveness of the proposed mitigation design options. Inputs from the overland flows from DRAINS were applied to simulate the hydrologic response of the catchments affecting South Bungendore. Outputs from the TUFLOW model provided the direction, depth and hazard classification of the overland flow through the Study Area.

7 Existing Flood Extents

The provided LiDAR, stormwater infrastructure and existing and proposed land use types were incorporated into the modelling as well as the Study Area specific hydrology to provide an ultimate unmitigated scenario for the Study Area. Figure 5 below identifies the existing flood prone areas if no stormwater strategy is implemented for the South Bungendore Study Area and development was allowed to continue.

Table 7.1 Existing Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.67	0.21	0.26
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.15	0.46	0.19
C	Ellendon Street at the inlet to the culverts under Ellendon Street	3.44	1.34	0.45
D ¹	Open swale immediately adjacent to Molonglo Street	3.58	0.70	0.71

Note:

- 1 Do the extent of flooding bypasses around Node D have occurred and the values presented may not reflect what occurs on site. Flood Extents however are representative.

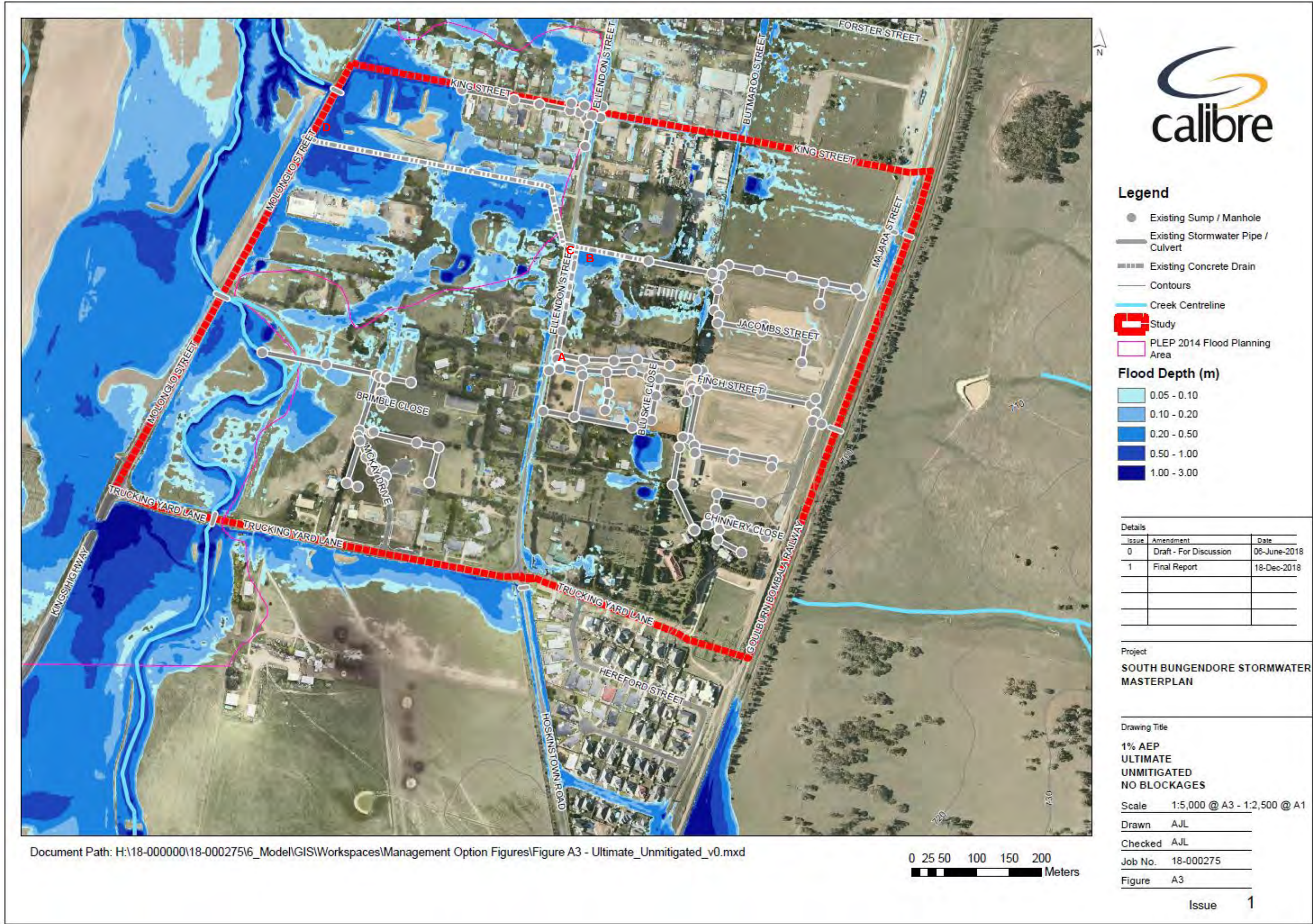


Figure 5: 1% 15min AEP - Ultimate Unmitigated No Blockages

Notes:

Flood Extents upstream of the two railway culverts that discharge directly into the Study Area are not shown.

The flood map shows the recently constructed developments immediately downstream of the Goulburn Bombala Railway are relatively clear of the 1% AEP flood extent with ponding below 50mm occurring on their respective roads. Development infrastructure within the Flood Planning Area such as culverts under Molonglo Street are generally tail water controlled, due to the riverine flood depths from Halfway Creek. This as well as minimum grades within the Study Area (less than 0.2%) limits the ability for stormwater infrastructure to convey the 1% AEP flow from the Study Area below Molonglo Street towards Halfway Creek.

The analysis also concluded that the railway culverts immediately upstream of the Study Area do not have sufficient capacity to convey the 1% AEP flows under the railway line. When the culverts reach their capacity, flows are conveyed north upstream of the railway line towards the Bungendore Township / Turallo Creek.

Flooding was also noted at King Street, where the capacity of the road and drainage network was exceeded. When the capacity of the infrastructure is exceeded flows are conveyed north outside of the Study Area along Majura Street, Butmaroo Street and Ellendon Street towards the Bungendore Township.

8 Mitigation Options Assessed

With an understanding of the critical flood issues, six options were identified which range from upgrading existing roads through to new drainage easements. The description of each option is presented below with subsequent detailed mapping provided in Appendix D

Option 6-1

- King Street regraded to remove existing sag points. Kerb and gutter to replace the existing swale drains and a 1 × 1.8m × 0.9m Reinforced Concrete Box Culvert (RCBC) stormwater pipe and collection pits under King Street;
- New road graded in between Ellendon Street and Molonglo Street with kerb and gutter and a 3 × 3m × 0.6m RCBC stormwater pipe and pits; and
- Extension and widening of the swale downstream of existing Molonglo Street culverts

Table 8.1 Mitigation Option 6-1 Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.67	0.20	0.25
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.15	0.45	0.21
C	Ellendon Street at the inlet to the culverts under Ellendon Street	0.64	0.92	0.15
D	Open swale immediately adjacent to Molonglo Street	2.85	0.75	0.36

Note:

Refer below figure for location of flows.



Figure 6: Option 6-1 - 1% 15min AEP - Ultimate Mitigated No Blockages

Option 6-2

- King Street regraded to remove existing sag points. Kerb and gutter to replace the existing swale drains;
- New road graded in between Ellendon Street and Molonglo Street with kerb and gutter;
- A 9m wide concrete floodway to the south of the new road. The floodway is proposed to extend through Molonglo Street and discharge directly into Halfway Creek. A new bridge / link slab will be required to be built at Molonglo Street. Alignment to be modified to suit existing infrastructure; and
- Extension and widening of the swale downstream of existing Molonglo Street culverts.

Table 8.2 Mitigation Option 6-2 Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.49	0.21	0.26
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.16	0.55	0.17
C	Ellendon Street at the inlet to the culverts under Ellendon Street	1.14	0.51	0.25
D	Open swale immediately adjacent to Molonglo Street	1.15	0.63	0.13

Note:

Refer below figure for location of flows.

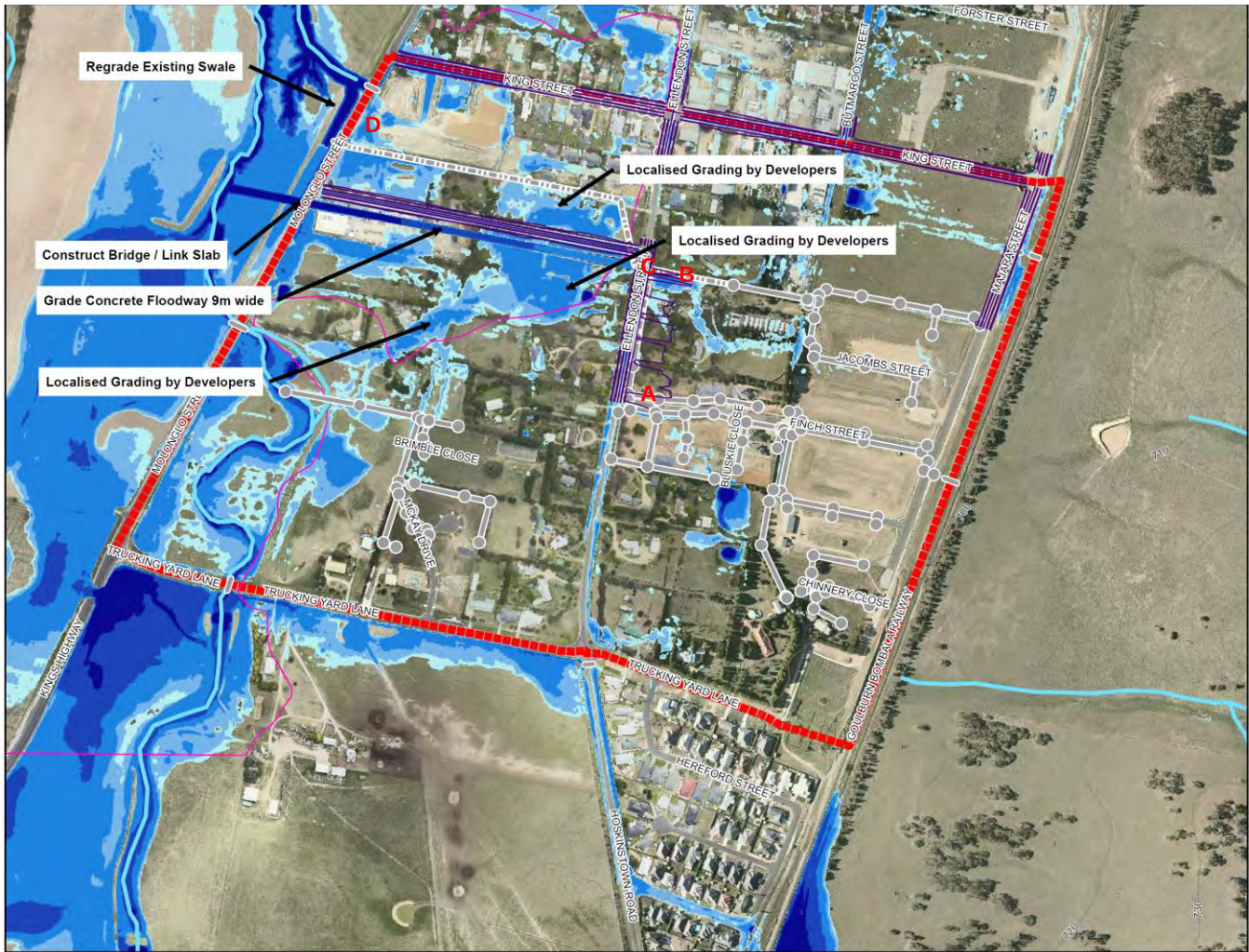


Figure 7: Option 6-2 - 1% 15min AEP - Ultimate Mitigated No Blockages

Option 6-3

- King Street regraded to remove existing sag points; kerb and gutter to replace the existing swale drains;
- A 9m wide concrete floodway from Ellendon Street, extending through Molonglo Street, and discharging directly into Halfway Creek. A new bridge / link slab is required to be built at Molonglo Street. Alignment to be modified to suit existing infrastructure; and
- Extension and widening of the swale downstream of existing Molonglo Street culverts.

Table 8.3 Mitigation Option 6-3 Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.67	0.23	0.23
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.14	0.35	0.27
C	Ellendon Street at the inlet to the culverts under Ellendon Street	2.21	0.69	0.40
D	Open swale immediately adjacent to Molonglo Street	0.97	0.64	0.11

Note:

Refer below figure for location of flows.

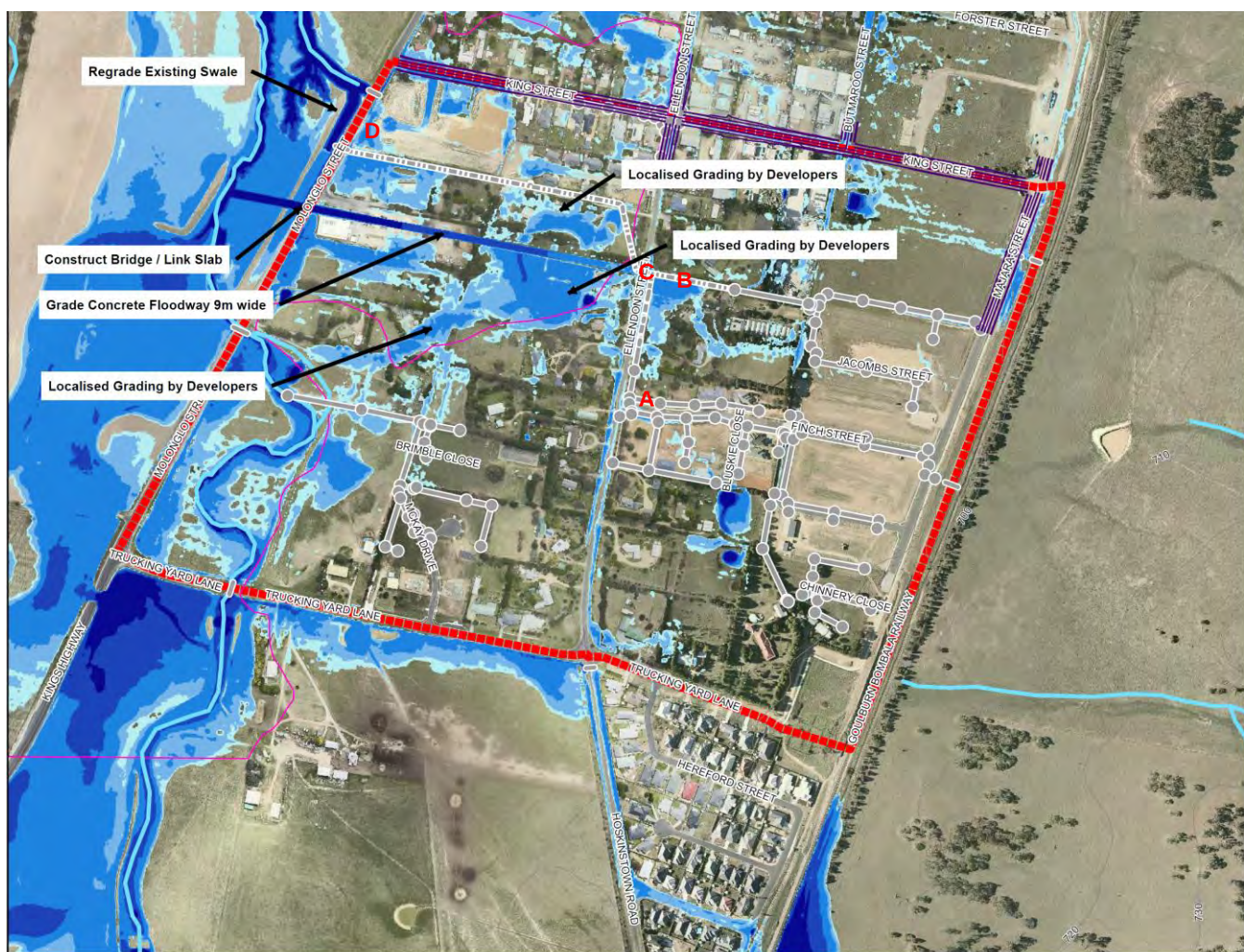


Figure 8: Option 6-3 - 1% 15min AEP - Ultimate Mitigated No Blockages

Option 6-4

- Detention basin upstream of the Goulburn Bombala Railway to attenuate flows prior to entering the Study Area.

Due to the size of the upstream catchment relative to the Study Area, peak flow attenuation will have no effect on the critical storm peak event. No flood mapping was carried out for this option.

Option 7-1

- New road graded in between Ellendon Street and Mackay Street adjacent to Trucking Yard Lane with kerb and gutter;
- Ellendon Street regraded with kerb and gutter and a sag point at the intersection with the new road;
- A 9m wide concrete floodway from the new road to Halfway Creek. The floodway extends through the existing bund on Halfway Creek and the existing stormwater pipes to be exhumed. Alignment can be modified to suit existing infrastructure;
- New road alignment to convey flows from the Ellendon Street sag towards the 9m wide concrete floodway; and
- Blocks either side of the new road are to be raised a minimum 1m above the existing surface to provide adequate freeboard to raise building floor levels out of the floodplain. Grading of the blocks generally grade south towards the proposed floodway.

Table 8.4 Mitigation Option 7-1 Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.67	0.21	0.24
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.17	0.51	0.18
C	3/4 along the new road	5.97	0.62	1.15
D	Open swale immediately adjacent to Molonglo Street	0.52	0.35	0.07

Note:

Refer below figure for location of flows.



Figure 9: Option 7-1 - 1% 15min AEP - Ultimate Mitigated No Blockages

Option 8-2:

- New road graded in between Ellendon Street and Mackay Street adjacent to Trucking Yard Lane with kerb and gutter;
- Ellendon Street regraded with kerb and gutter and a sag point at the intersection with the proposed floodway and Finch Street;
- A 9m wide concrete floodway from the intersection of Ellendon and Finch Street to Halfway Creek. The floodway extends through the existing bund on Halfway Creek;
- Redirect the outlet of the existing Finch Street RCBC to discharge flows under Ellendon Street into the new floodway;
- Extend the existing RCBC under Ellendon Street to convey trapped flows towards the proposed floodway;
- New road alignment to convey local flows towards the 9m wide concrete floodway; and
- Blocks as well as the new road are to be raised a minimum of 1m above the existing surface to provide adequate freeboard to raise building floor levels out of the floodplain. Grading of the blocks generally grade south towards the new road which will convey local flows towards the proposed floodway.

Table 8.5 Mitigation Option 8-2 Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.67	0.23	0.24
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.14	0.43	0.21
C	Ellendon Street at the inlet to the culverts under Ellendon Street	2.51	1.81	0.50
D	Open swale immediately adjacent to Molonglo Street	1.76	0.72	0.17
E	Option 8-2 floodway upstream of the new road	2.96	0.45	1.06

Note:

Refer below figure for location of flows.

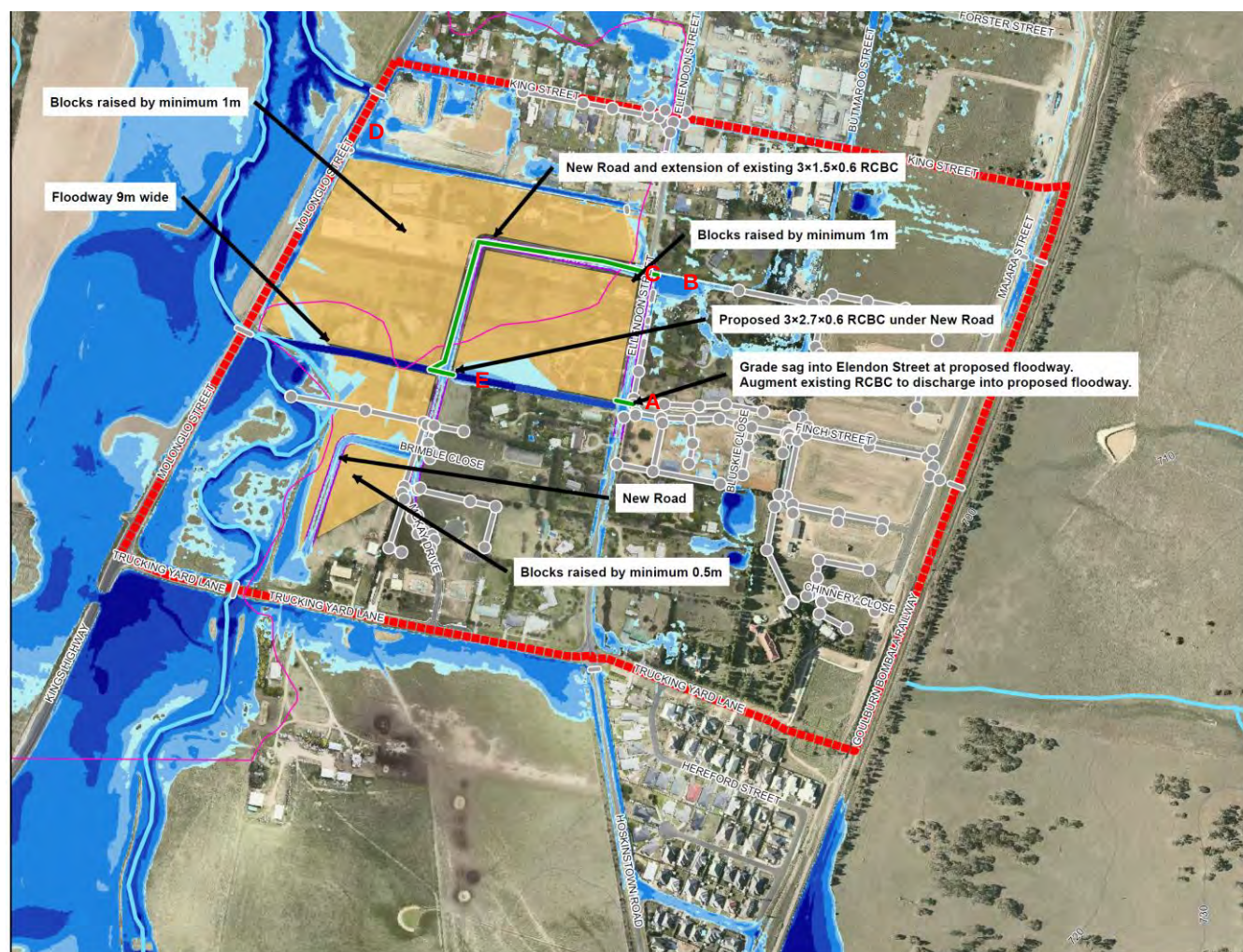


Figure 10: Option 8-2 - 1% 15min AEP - Ultimate Mitigated No Blockages

Option 9-1:

- New road graded in between Ellendon Street and Mackay Street adjacent to Trucking Yard Lane with kerb and gutter;
- A 9m wide concrete floodway to the south of the new road. The floodway is proposed to extend through Molonglo Street and discharge directly into Halfway Creek. A new bridge / link slab will be required to be built at Molonglo Street. Alignment to be modified to suit existing infrastructure;
- Ellendon Street regraded with kerb and gutter and a sag point at the intersection with the proposed floodway;
- Extend the existing RCBC under Ellendon Street to convey trapped flows towards the proposed floodway;
- New road alignment to convey local flows towards the 9m wide concrete floodway; and
- Blocks as well as the new road are to be raised a minimum of 1m above the existing surface to provide adequate freeboard to raise building floor levels out of the floodplain. Grading of the blocks generally grade south towards the new road which will convey local flows towards the proposed floodway.

Table 8.6 Mitigation Option 9-1 Flood Properties

Location	Description	Flow Rate (m ³ /s)	Velocity (m/s)	Depth (m)
A	Finch Street upstream of Ellendon Street	0.67	0.21	0.24
B	Overland flow path on the northern boundary of 124A Ellendon Street upstream of the inverted concrete box culvert on Ellendon Street	2.15	0.54	0.17
C	Ellendon Street at the inlet to the culverts under Ellendon Street	2.55	1.31	0.41
D	Open swale immediately adjacent to Molonglo Street	1.98	0.71	0.17
E	Option 9-1 floodway upstream of the new road	3.32	0.52	1.12

Note:

Refer below figure for location of flows.

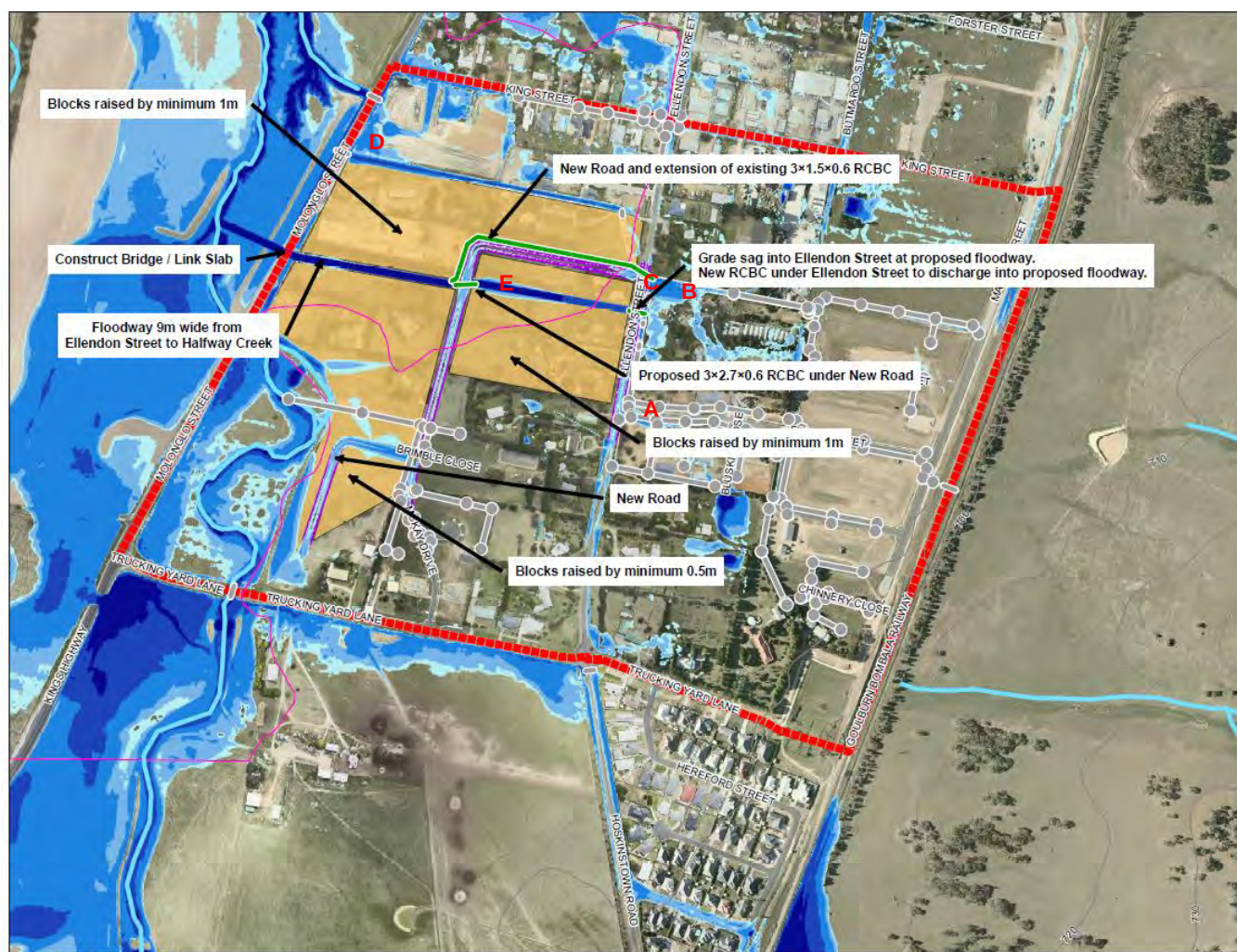


Figure 11: Option 9-1- 1% 15min AEP - Ultimate Mitigated No Blockages

9 Water Quality

Due to the shallow grade of the Study Area (less than 0.2%) and downstream culverts predominately being tail water controlled from Halfway Creek, end of pipe water quality basins such as ponds or wetlands are not recommended as these will likely increase the flooding upstream of the basins within the Study Area. Water quality devices are therefore recommended within each development away from trunk stormwater infrastructure. Water quality devices proposed for South Bungendore would include:

- Rainwater Tanks
- Gross Pollutant Traps
- Swales

10 Discussion

A workshop was held between Calibre and QPRC personal to discuss each option and rank them based on a high level Multi Criteria Analysis (MCA). The criteria adopted and weighting for each option is summarised in Table 10.1.

Table 10.1 Assessment Methodology Criteria

Criteria	Weighting
Capital Cost	15%
Operating Cost	15%
Maintenance Requirements	15%
Effectiveness	25%
Land area required	15%
Constructability	15%

Each option was rated either high, medium or low for each criteria in the MCA. The results of each option are presented in Table 10.2 with the individual criteria scores shown in Appendix B.

Table 10.2 Assessment Methodology Criteria

Option	Score	Ranking
6-1	5.7	5
6-2	7.5	4
6-3	7.9	3
6-4	5.4	7
7-1	5.7	5
8-2	8.1	2
9-1	8.5	1

Option 9-1 was identified as the preferred option primarily due to its effectiveness to mitigate flooding compared to all other options assessed. The preferred option is presented below with the Study Area's critical storm duration of 15min. Additional relevant flood mapping such a comparison of the mitigated to unmitigated flood depth, mitigated flood hazard and a comparison with the Halfway Creek 360min critical storm duration flood depth, are included in Appendix D.

Classification of the flood hazard terminology are detailed in Appendix C as well as proposed sketches of the works proposed for Option 9-1 shown in Appendix E.

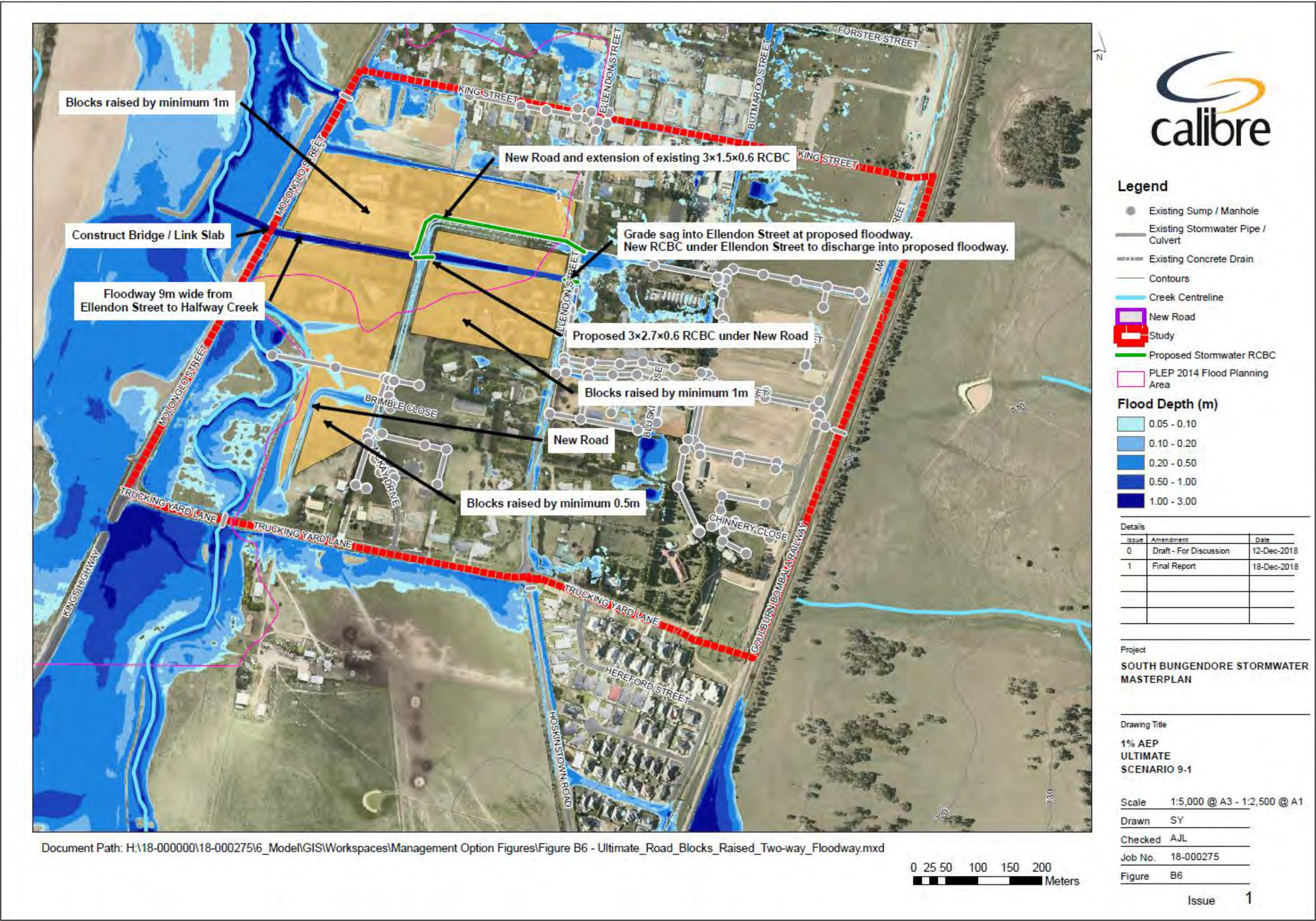


Figure 12: Preferred Option - 1% 15min AEP - Ultimate Mitigated No Blockages

Notes:

Flood Extents upstream of the two railway culverts that discharge directly into the Study Area are not shown.

11 Sensitivity

A sensitivity analysis was undertaken on the existing Study Area infrastructure to assess what impacts changes in assumptions would have on the presented flood extents. The analysis was carried out on the following assumptions:

- Changes to inlet sump assumed blockage rates
- Changes in percentage impervious.

The results show that increasing the percentage blockage on inlet sumps within the Study Area will increase the flood extents, however not drastically.

Increasing the percent impervious of the catchment will improve the flood extents within the Study Area as flows leave the site quicker before the Halfway Creek peak arrives.

Refer to Appendix F for the changes in flood extents with changes in assumptions.

12 Conclusion

The existing flood extents under the ultimate unmitigated option shows the recently constructed developments immediately downstream of the Goulburn Bombala Railway are relatively clear of the 1% AEP flood extent with ponding below 50mm occurring on their respective roads.

Development infrastructure within the Flood Planning Area such as culverts under Molonglo Street are generally tail water controlled, due to the riverine flood depths from Halfway Creek. This as well as minimum grades within the Study Area (less than 0.2%) limits the ability for stormwater infrastructure to convey the 1% AEP flow from the Study Area below Molonglo Street towards Halfway Creek.

To mitigate flooding within this area Option 9-1 was identified as the preferred solution to effectively mitigate flooding to South Bungendore. Option 9-1 requires the following works to be carried out:

- New road graded in between Ellendon Street and Mackay Street adjacent to Trucking Yard Lane with kerb and gutter;
- A 9m wide concrete floodway to the south of the new road. The floodway is proposed to extend through Molonglo Street and discharge directly into Halfway Creek. A new bridge / link slab will be required to be built at Molonglo Street. Alignment to be modified to suit existing infrastructure;
- Ellendon Street regraded with kerb and gutter and a sag point at the intersection with the proposed floodway;
- Extend the existing RCBC under Ellendon Street to convey trapped flows towards the proposed floodway;
- New road alignment to convey local flows towards the 9m wide concrete floodway; and
- Blocks as well as the new road are to be raised a minimum of 1m above the existing surface to provide adequate freeboard to raise building floor levels out of the floodplain. Grading of the blocks generally grade south towards the new road which will convey local flows towards the proposed floodway.

Refer to Appendix D for the location of works and Appendix E for sketches of the proposed works required to be undertaken.

Under both unmitigated and mitigated options, the analysis concluded that the railway culverts immediately upstream of the Study Area do not have sufficient capacity to convey the 1% AEP flows under the railway line. When the culverts reach their capacity, flows are conveyed north upstream of the railway line towards the Bungendore Township / Turallo Creek.

Flooding was also noted at King Street where the capacity of the road and drainage network was exceed, however when the capacity of the infrastructure is exceed flows are conveyed north outside of the Study Area along Majura Street, Butmaroo Street and Ellendon Street towards the Bungendore Township

If either the railway culverts or the King Street stormwater infrastructure capacity is to be increased, this could lead to increase flooding within South Bungendore, however potential less flooding north of the Study Area.

Due to the shallow grade of the study area water quality treatment is proposed to be undertaken away from critical stormwater infrastructure and include:

- Rainwater Tanks
- Gross Pollutant Traps
- Swales

12.1 Section 94 Contributions and Development Control Plans

Option 9-1 was identified as the preferred option to ensure flows are safely managed through the Study Area and improved known flooding hotspot locations. QPRC may choose to undertake all works and recoup the costs under a Section 94 contributions plan, or at a minimum QPRC should construct the floodway while providing individual development constraints to raise blocks above the flood planning area (with adequate freeboard) and associated stormwater infrastructure.

Proposed areas that require to be raised will require to safely convey the 1% AEP flow through their respective parcel of land, with local drainage requiring to comply with the current Palerang Development Control Plan (DCP) 2015. If this constraint is not included in the DCP it could lead to an increase in flooding within the Study Area.

12.2 Further Assessment

It is recommended that the TUFLOW model be re-run with updated LiDAR data with the recently constructed roads noted in Section 4-2, as well as a detailed survey of Molonglo Street including the culverts under Kings Highway south of Trucking Yard Lane. This will be required to provide more accurate flood levels to inform building floor levels for future development and assess if any additional flooding exists.

Sizing of stormwater infrastructure is preliminary only and will need to be verified once proposed development grading and reticulation stormwater is confirmed. Changes in flow direction from future development will have some impact on the sizing of infrastructure and potential flood depths and hazards within the Study Area.

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Appendix A Modelling Summary

QPRC

18-000275 – SOUTH BUNGENDORE STORMWATER MASTERPALN MODEL SUMMARY SHEET – 24 SEPTEMBER 2018

Date: 24 September 2018

Distribution: Queanbeyan-Palerang Regional Council

Calibre

Criteria/Parameter/ Type	Value/Description	Source/link	Comments/departures
Models used			
<i>TUFLOW</i>	Control Parameters: GIS Format = SHP Origin = 720288, 6093445 Orientation = 720290, 6093445 Cell Size = 2 m Grid Size (X,Y) = 4000, 3000 Start Time = 0 hr End Time = 5 hr Timestep = 0.5 (2D) Timestep = 0.25 (1D) Number Iterations = 4 Map Output Interval = 60	Created by Calibre	Run using Version: TUFLOW_iDP_w64.exe
<i>XP-RAFTS</i>		Created by Calibre	Run using Version: Jul 2016
<i>DRAINS</i>		Created by Calibre	Run using Version: 2018.05
Topography			
Ground survey	.asc, .dwg and .pdf files provided WAE files provided	Provided by QPRC	Refer to mapping
Proposed surface	Existing terrain and design TIN for the proposed surface was created and assembled in 12d and exported as .12da files to be read into TUFLOW	Created by Calibre	Refer to mapping
Recurrence Interval			
IFD Data	2yr 1hr , 23.5 mm/hr 2yr 12hr , 4.4 mm/hr 2yr 72hr , 1.19 mm/hr 50yr 1hr , 43.4 mm/hr 50yr 12hr , 7.85 mm/hr 50yr 72hr , 2.39 mm/hr Skew, 0.20 F2, 4.28 F50 , 15.56 Zone 2	Bungendore Floodplain Risk Management Study provided XP-Rafts models	-
Design AEP	18.1%; 10%;1%	XP-RAFTS inputs Drains inputs	-

18-000275 – SOUTH BUNGENDORE STORMWATER MASTERPALN MODEL SUMMARY SHEET – 24 SEPTEMBER 2018

Criteria/Parameter/ Type	Value/Description	Source/link	Comments/departures
Durations modelled			
Storm events	10min 15min 20min 25min 30min 45min 60min 120min 360min 540min	XP-RAFTS outputs Drains Outputs TUFLOW inputs	-
Roughness			
XP-Rafts / Drains Manning	Pervious = 0.06 Impervious = 0.015	-	
XP-Rafts / Drains % Impervious	Rural = 5% Rural Residential = 40% Residential = 60% Industrial = 60%	Rural - Bungendore Floodplain Risk Management Study provided XP-Rafts models All others previous experience	
TUFLOW One dimensional roughness	n = 0.011	-	
TUFLOW Two dimensional roughness	Urban 0.025 Asphalt/Road 0.012 Concrete 0.015 Grass/Reserve 0.06 Creek Bed 0.08	-	
Losses			
	Initial Loss = 1.7mm Continual Loss = 1.7 mm/hr	Bungendore Floodplain Risk Management Study provided XP- Rafts models	
Aerial photography			
QPRC Supplied Aerial	-	-	Refer to mapping
Site Inspections			
24/06/2018	-	Performed by Calibre with QPRC	-
Land Use categorisation			
	-	QPRC provided Shape file	-
Obstructions			

18-000275 – SOUTH BUNGENDORE STORMWATER MASTERPALN MODEL SUMMARY SHEET – 24 SEPTEMBER 2018

TUFLOW Culverts	Type – C Manning's n – 0.011 US Invert – 691.1 DS Invert – 690.7 Width – 0.9 Number – 3 Type – R Manning's n – 0.011 US Invert – 691.3 DS Invert – 691.25 Width – 1.5 Height – 0.6 Number – 1 Type – R Manning's n – 0.011 US Invert – 692 DS Invert – 691.77 Width – 2.1 Height – 1.2 Number – 4 Type – R Manning's n – 0.011 US Invert – 693.3 DS Invert – 693.3 Width – 1.8 Height – 1.2 Number – 2 Type – R Manning's n – 0.011 US Invert – 696.75 DS Invert – 696.65 Width – 1.53 Height – 0.72 Number – 3 Type – C Manning's n – 0.011 US Invert – 703 DS Invert – 703 Width – 1.65 Number – 1	QPRC supplied data, survey data, existing study data, and WAE drawings	Refer to mapping
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18-000275 – SOUTH BUNGENDORE STORMWATER MASTERPALN MODEL SUMMARY SHEET – 24 SEPTEMBER 2018

	Type – C Manning's n – 0.011 US Invert – 702 DS Invert – 701.6 Width – 0.75 Number – 1 Type – C Manning's n – 0.011 US Invert – 701.45 DS Invert – 701.25 Width – 1.05 Number – 1 Type – R Manning's n – 0.011 US Invert – 701.1 DS Invert – 701 Width – 1.2 Height – 0.3 Number – 3 Type – R Manning's n – 0.011 US Invert – 693.3 DS Invert – 692.95 Width – 1.53 Height – 0.72 Number – 3 Type – R Manning's n – 0.011 US Invert – 691.95 DS Invert – 691.91 Width – 1.5 Height – 0.6 Number – 2 Type – R Manning's n – 0.011 US Invert – 692.8 DS Invert – 692.777 Width – 2.7 Height – 0.6 Number – 3		
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18-000275 – SOUTH BUNGENDORE STORMWATER MASTERPALN MODEL SUMMARY SHEET – 24 SEPTEMBER 2018

Criteria/Parameter/ Type	Value/Description	Source/link	Comments/departures
Boundary conditions			
Upstream	Inflow Hydrographs exported from XP-RAFTS and DRAINS	XP-RAFTS and DRAINS	Applied via 2d_bc_Hydrograph_L.shp and 2d_bc_Hydrograph_P.shp layer created in QGIS
Downstream	Type – HQ b – 0.01	-	-
Coordinate system			
Model coordinate system	EPSG:7855, GDA2020 / MGA zone 55	-	-
Hazard Categorisation			
<i>TUFLOW</i>	Z0 – Velocity x Depth product Z1 – Flood hazard category based on the Australian NSW Floodplain Management Manual (NSWG, 2005).	-	Refer to mapping

18-000275 – SOUTH BUNGENDORE STORMWATER MASTERPALN MODEL SUMMARY SHEET – 24 SEPTEMBER 2018

Model Validation (Hydrology)

No validation points or measuring instrumentation exists within the Study Area making a comparison with existing flood extents difficult. However the BFRMS was identified to have been validated based on comparison with historical rainfall events downstream of the Study Area. To provide a minimum comparison against actual rainfall events Calibre compared the BFRMS Halfway Creek critical 360min duration hydrograph against the Calibre modified Halfway Creek 360min hydrograph. The differences between hydrographs are shown below.

Table A-1 Comparison between BFRMS and Calibre Peak flows

Storm	Model	Time to Peak	Peak Flow	Difference to BFRMS
18.1% - 360min	BFRMS	3h 59min	82.48	0.0%
18.1% - 360min	Calibre	3h 59min	78.568	4.7%
1% - 360min	BFRMS	3h 58min	161.384	0.0%
1% - 360min	Calibre	3h 58min	155.902	3.4%

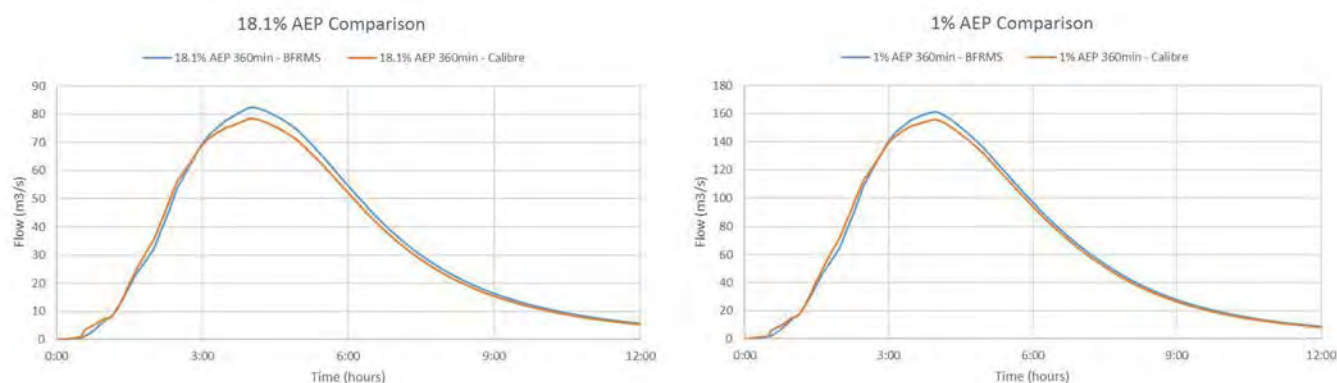


Figure 1: Comparison between BFRMS and South Bungendore Hydrographs

The reduction in peak flow estimates as shown above has been attributed to no impervious parameters being adopted in the BFRMS modelling. The inclusion of an impervious catchment will allow that portion of the catchment to leave the site faster than a pervious catchment, reducing the peak. The differences between the 18.1% and 1% AEP are within an acceptable magnitude and are suitable for comparison with the BFRMS.

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Appendix B Multi Criteria Analysis

QPRC

Weighting		15.00%	15.00%	15.00%	25.00%	15.00%	15.00%	100.00%	
Option	Description	Capital Cost	Operating Cost	Maintenance Requirements	Effectiveness	Land area required	Construct-ability	Score	Ranking
6-1	King Street regraded and new road from Ellendon Street to Kings Highway; SW pipe and pit network from Trucking Yard Lane to Halfway Creek and from Ellendon Street to Halfway Creek	High	Medium	High	Low	Low	High		
		0.5	1.1	0.5	0.8	1.5	1.5	5.7	5
6-2	Channel from Ellendon St to Halfway Creek; King Street regraded and new road from Ellendon Street to Kings Highway	Medium	Low	Medium	Medium	Medium	Medium		
		1.1	1.5	1.1	1.8	1.1	1.1	7.5	4
6-3	Channel from Ellendon St to Halfway Creek; King Street regraded only	Low	Low	Medium	Medium	Medium	Medium		
		1.5	1.5	1.1	1.8	1.1	1.1	7.9	3
6-4	Detention Basin Eastern side of Railway	Medium	High	Medium	Low	Medium	Medium		
		1.1	0.5	1.1	0.8	1.1	1.1	5.4	7
7-1	Raise blocks and use new road to drain area	High	Low	Low	Low	Medium	Low		
		0.5	1.5	1.5	0.8	1.1	0.5	5.7	5
8-2	New floodway off Finch Street to Halfway Creek and raise blocks	High	Low	Low	High	Medium	Medium		
		0.5	1.5	1.5	2.5	1.1	1.1	8.1	2
9-1	New floodway off Ellendon Street to Halfway Creek and raise blocks	High	Low	Low	High	Medium	High		
		0.5	1.5	1.5	2.5	1.1	1.5	8.5	1

Criteria

High

3

Medium

7

Low

10

Effectiveness Criteria

High

10

Medium

7

Low

3

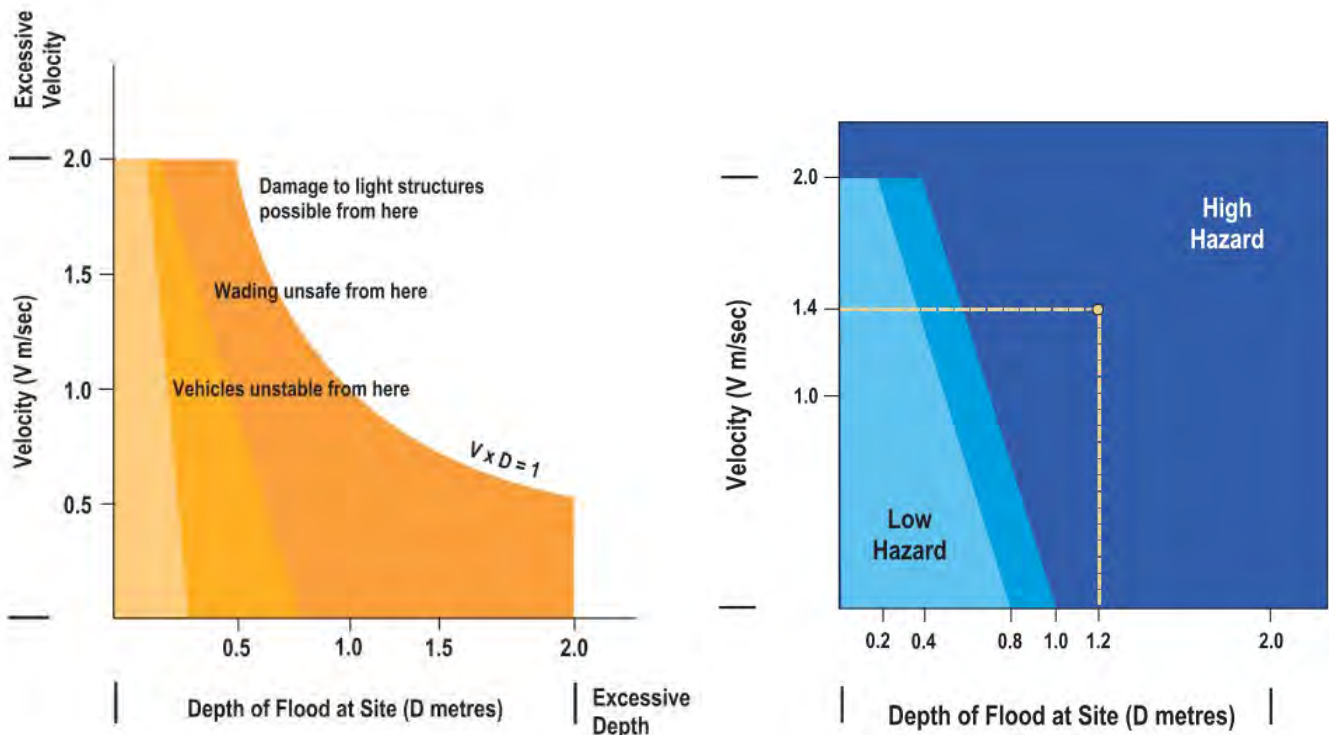
SOUTH BUNGENDORE STORMWATER MASTERPLAN

Appendix C Flood Hazard Classification

QPRC

The personal danger and physical property damage caused by flood waters varies both in time and location across the floodplain, and is measured by the flood hazard classification. The flood hazard classification is a measure of the degree to difficulty that pedestrians, cars and other vehicles will have in egressing flooded areas, and the likely damage to properties and infrastructure. The flood hazard classification at a particular location within the floodplain is a function of the velocity and depth of the flood waters at that location.

An interpretation of the hazard at a particular location can be established from graphs from the NSW Governments *Floodplain Management Manual* (2005). These graphs show the relationship between the depth and velocity of flood waters



The criteria presented in the graphs were used to determine the provisional flood and hazard levels within the study area for the proposed mitigated option. The criteria used is an integer number from 1 to 3.

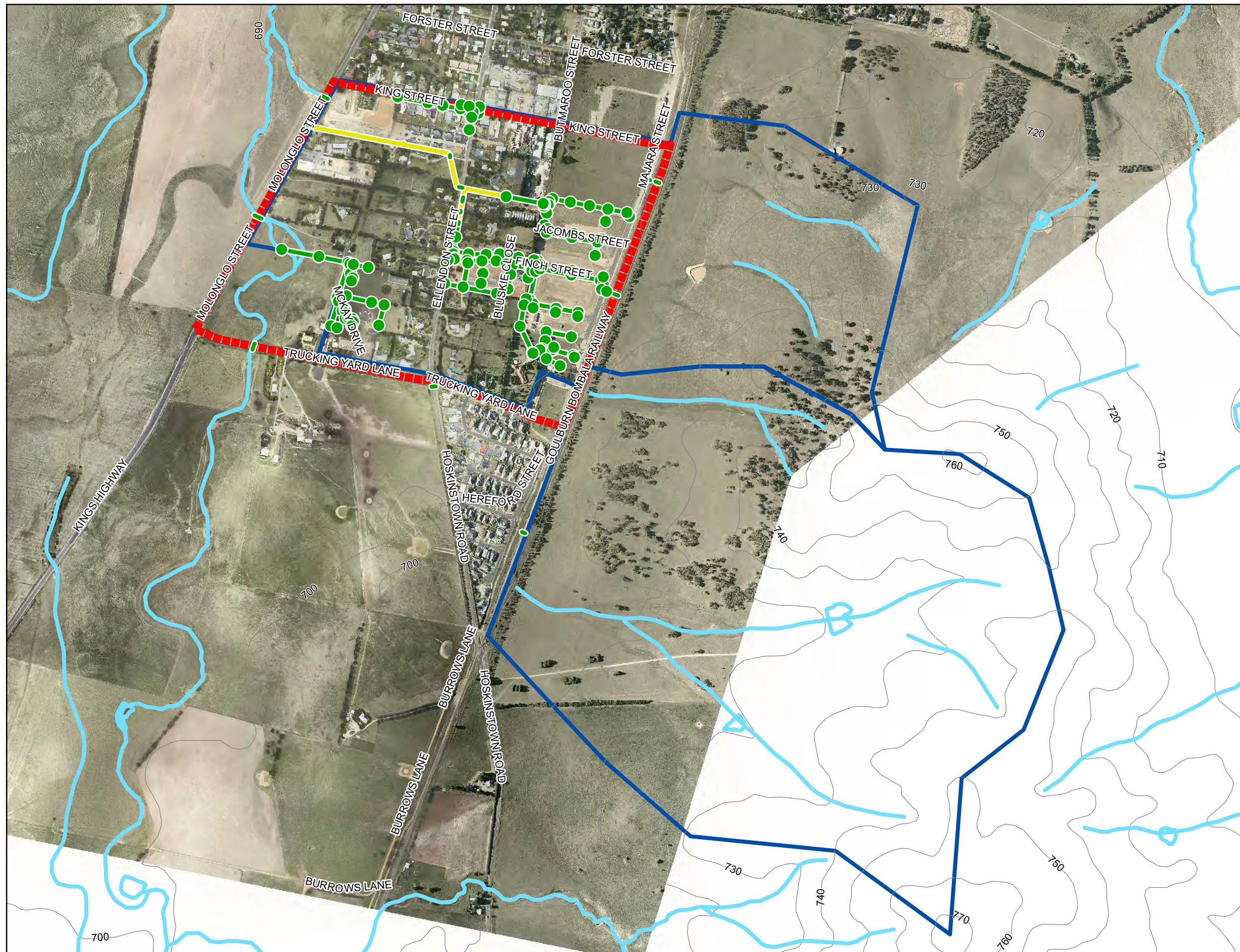
1. Low Hazard (The limit of the low hazard areas effectively defines the flood extent)
2. Intermediate Hazard (dependent on site conditions)
3. High Hazard (The maximum hazard value is not necessarily when the maximum water level occurs)

The hazard represented in this mapping is provisional only as it is based on an interpretation of the flood hydraulics and does not reflect the effects of other factors that may influence the flood hazard. The impacts associated with a high hazard may be reduced if an effective local flood plan is developed, implemented and maintained. As a result, the flood hazard should be further reviewed and refined during the investigations required to develop a Floodplain Risk Management Plan for the area.

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Appendix D Flood Maps

QPRC



Legend

- Modelled Sump / Manhole
- Modelled Stormwater Pipe / Culvert
- Modelled Concrete Drain
- Contours
- Creek Centreline
- ▭ Study Area
- ▭ Catchment Extent

Notes:

Details

Issue	Amendment	Date
0	Draft - For Discussion	23-Dec-2016

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

MODELLING EXTENT

Scale 1:10,000 @ A3 - 1:5,000 @ A1

Drawn AJL

Checked AJL

Job No. 18-000275

Figure A0

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure A0 - Data_v0.mxd

0 65130 260 390 520
Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details		
Issue	Amendment	Date
0	Draft - For Discussion	06-Jun-2018
1	Final Report	18-Dec-2018

Project
SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title
**1% AEP
EXISTING
UNMITIGATED
SUMPS 100% BLOCKED**

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Drawn AJL
Checked AJL
Job No. 18-000275
Figure A1

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure A1 - Existing_Retic_Blocked_v0.mxd

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Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study Area
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details		
Issue	Amendment	Date
0	Draft - For Discussion	06-Jun-2018
1	Final Report	18-Dec-2018

Project
SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title
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EXISTING
UNMITIGATED
NO BLOCKAGES**

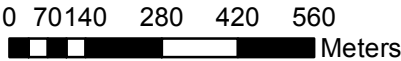
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Drawn AJL

Checked AJL

Job No. 18-000275

Figure A2





Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	06-June-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
UNMITIGATED
NO BLOCKAGES**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn AJL

Checked AJL

Job No. 18-000275

Figure A3

Issue 1

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0 25 50 100 150 200
Meters



Legend

- Existing Sump /
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study
- Proposed Stormwater
- Proposed Road
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	08-June-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 6-1
NO BLOCKAGES**

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Drawn AJL

Checked AJL

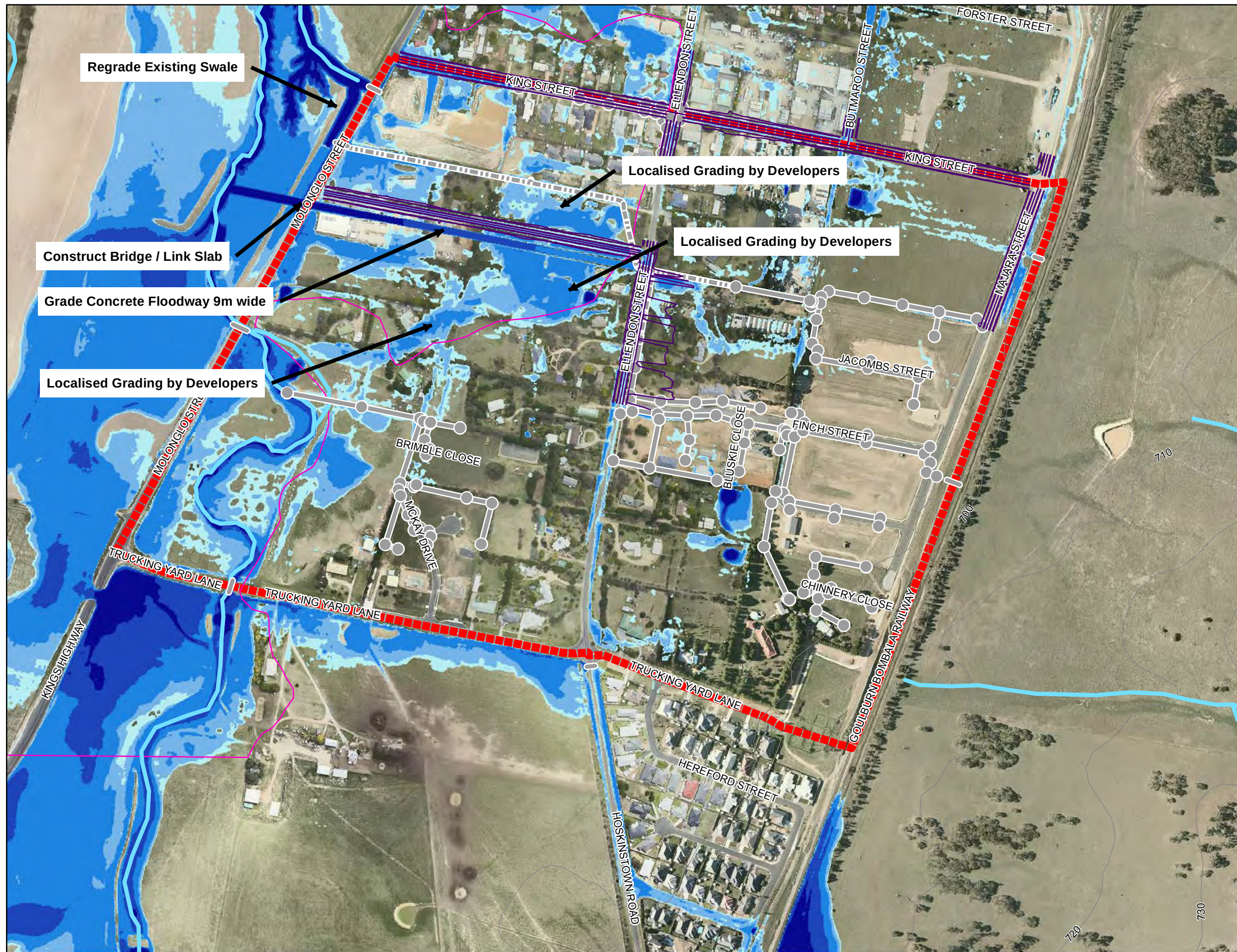
Job No. 18-000275

Figure B1

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure B1 - Ultimate_Road_RCBCx2_v0.mxd

0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study Area
- Proposed Stormwater RCBC
- Proposed Road Regrading
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	08-June-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 6-2
NO BLOCKAGES**

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Drawn AJL

Checked AJL

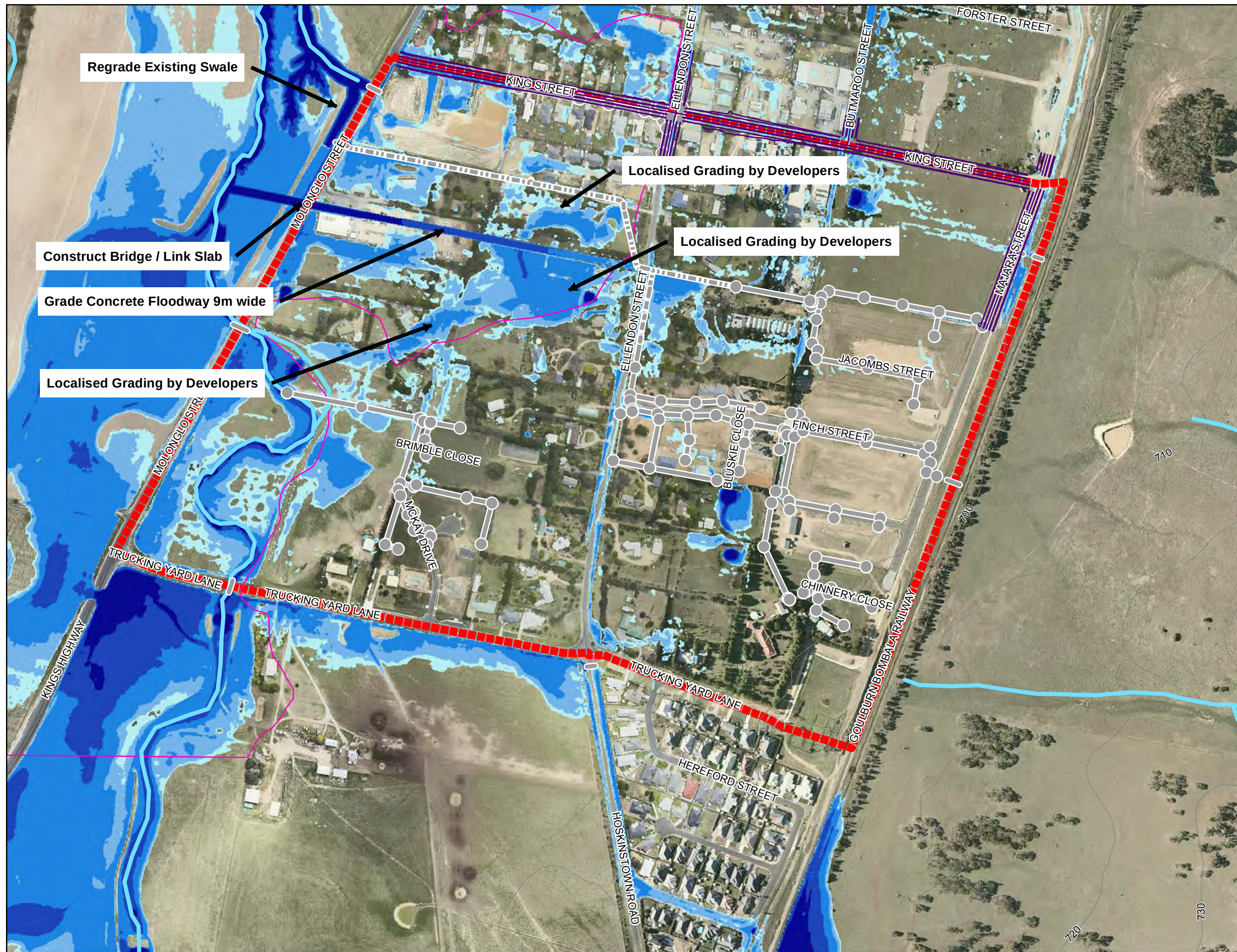
Job No. 18-000275

Figure B2

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure B2 - Ultimate_Road_Floodway_v0.mxd

0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study
- Proposed Road Regrading
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	08-June-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 6-3
NO BLOCKAGES**

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Drawn AJL

Checked AJL

Job No. 18-000275

Figure B3

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure B3 - Ultimate_Floodway_Only_v1.mxd

0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
 - Existing Stormwater Pipe / Culvert
 - Existing Concrete Drain
 - Contours
 - Creek Centreline
 - New Road
 - Raised Blocks by Developers
 - Study
- Flood Depth (m)**
- 0.05 - 0.10
 - 0.10 - 0.20
 - 0.20 - 0.50
 - 0.50 - 1.00
 - 1.00 - 3.00
- PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	03-July-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 7-1**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

Checked AJL

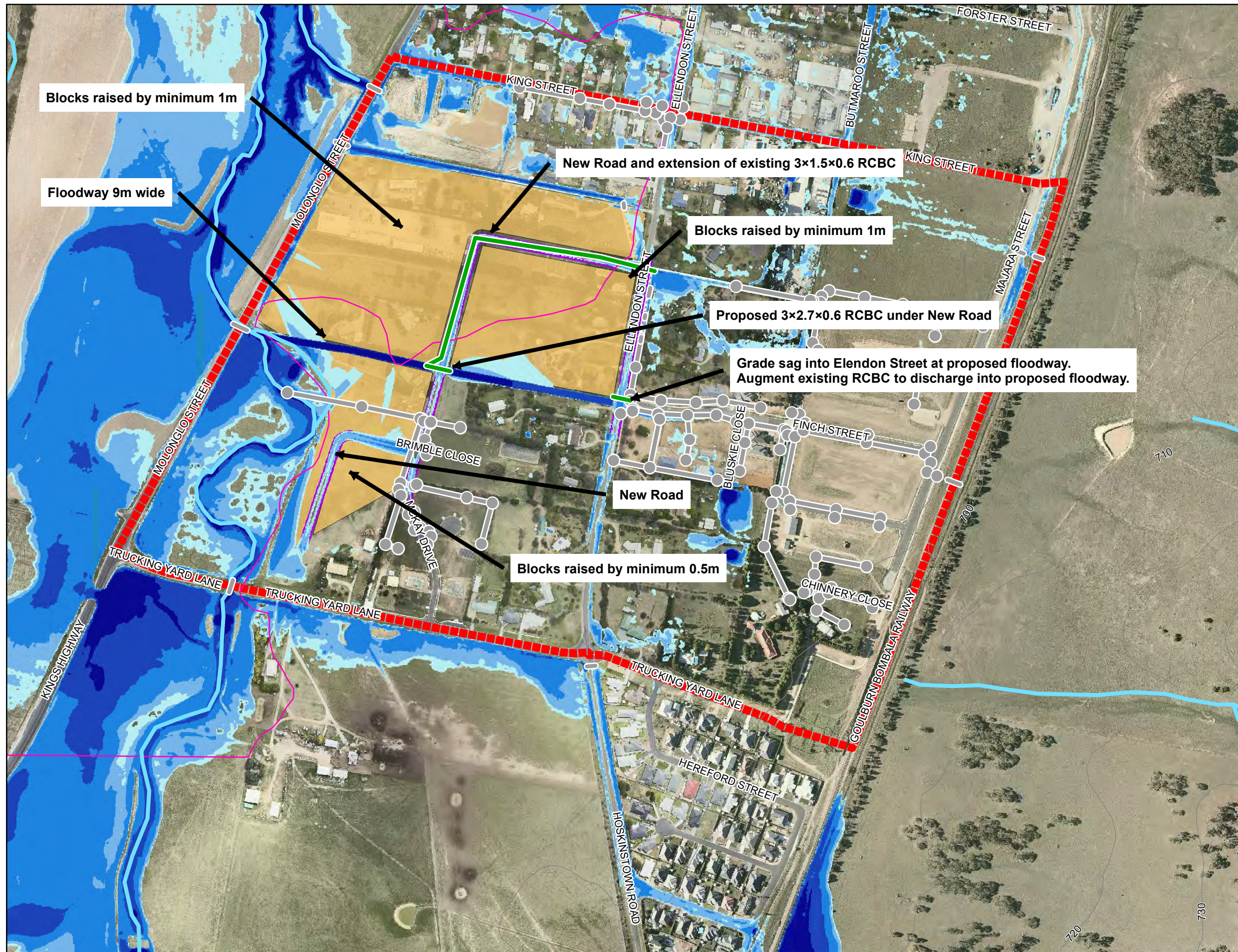
Job No. 18-000275

Figure B4

Issue 1

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0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
 - Existing Stormwater Pipe / Culvert
 - Existing Concrete Drain
 - Contours
 - Creek Centreline
 - New Road
 - Raised Blocks
 - Study Area
- Flood Depth (m)**
- 0.05 - 0.10
 - 0.10 - 0.20
 - 0.20 - 0.50
 - 0.50 - 1.00
 - 1.00 - 3.00
 - Flood Planning Area

Details

Issue	Amendment	Date
1	Draft - For Discussion	06-Sept-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 8-2**

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Drawn SY

Checked AJL

Job No. 18-000275

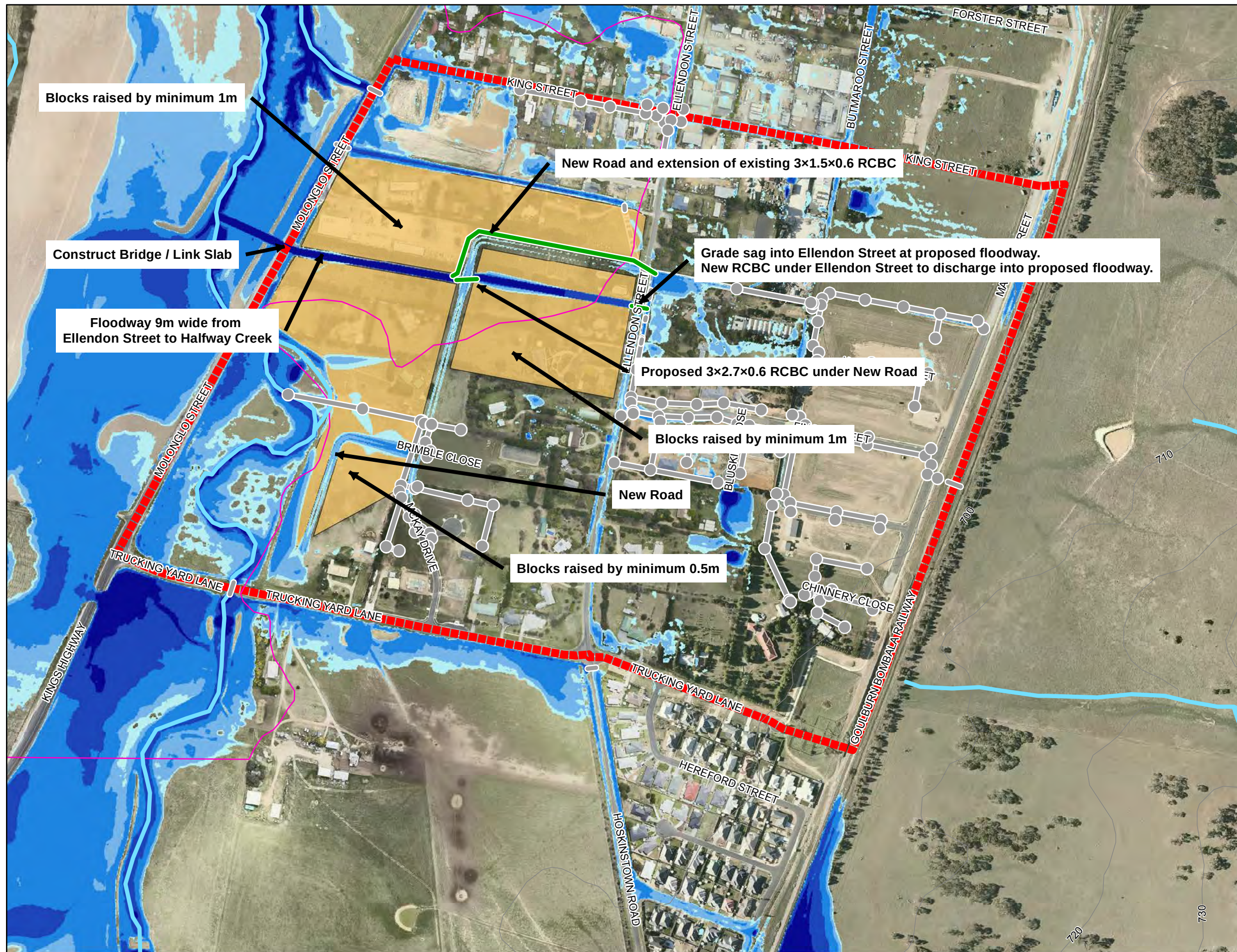
Figure B5

Issue

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0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- New Road
- Study
- Proposed Stormwater RCBC
- PLEP 2014 Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	12-Dec-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 9-1**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

Checked AJL

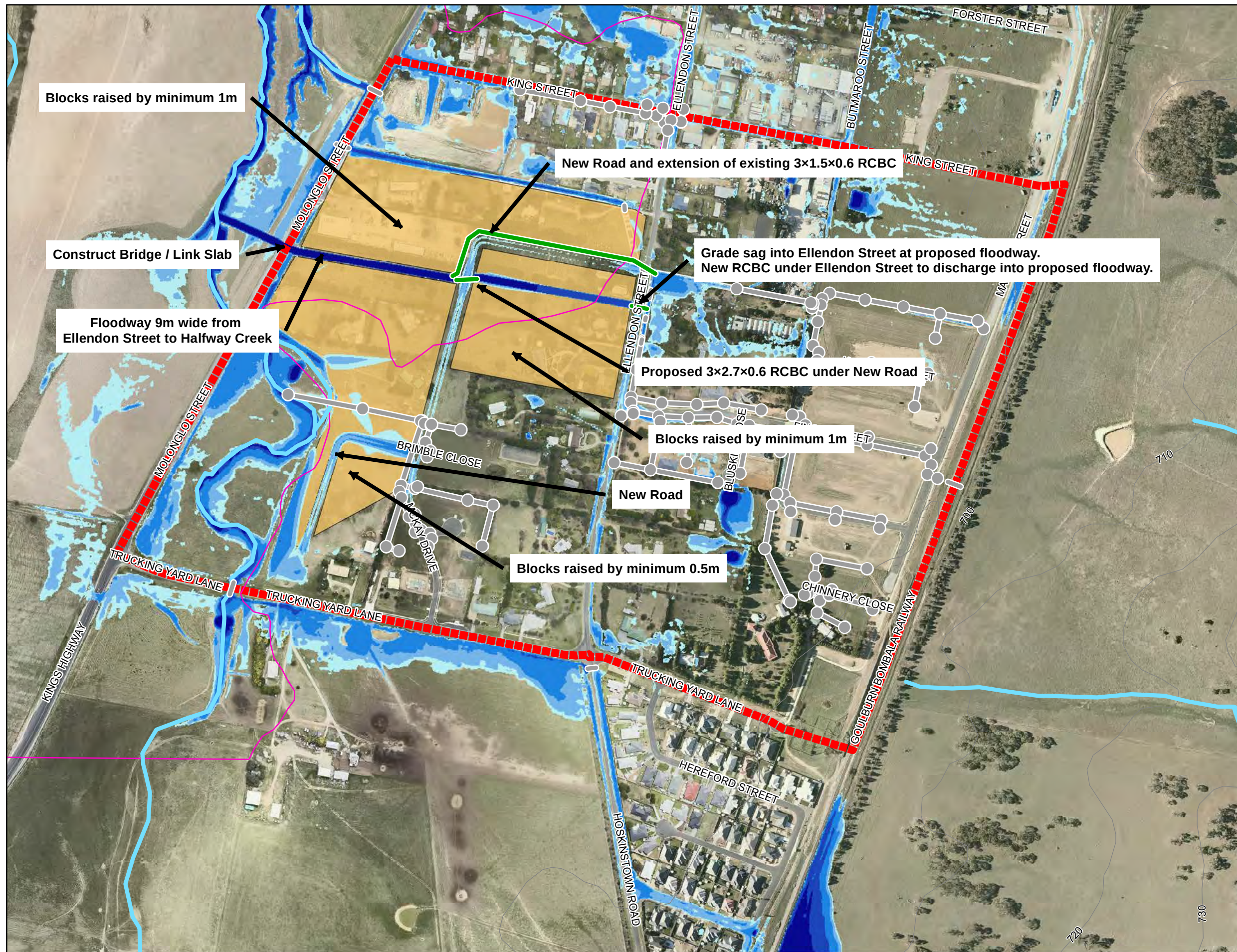
Job No. 18-000275

Figure B6

Issue 1

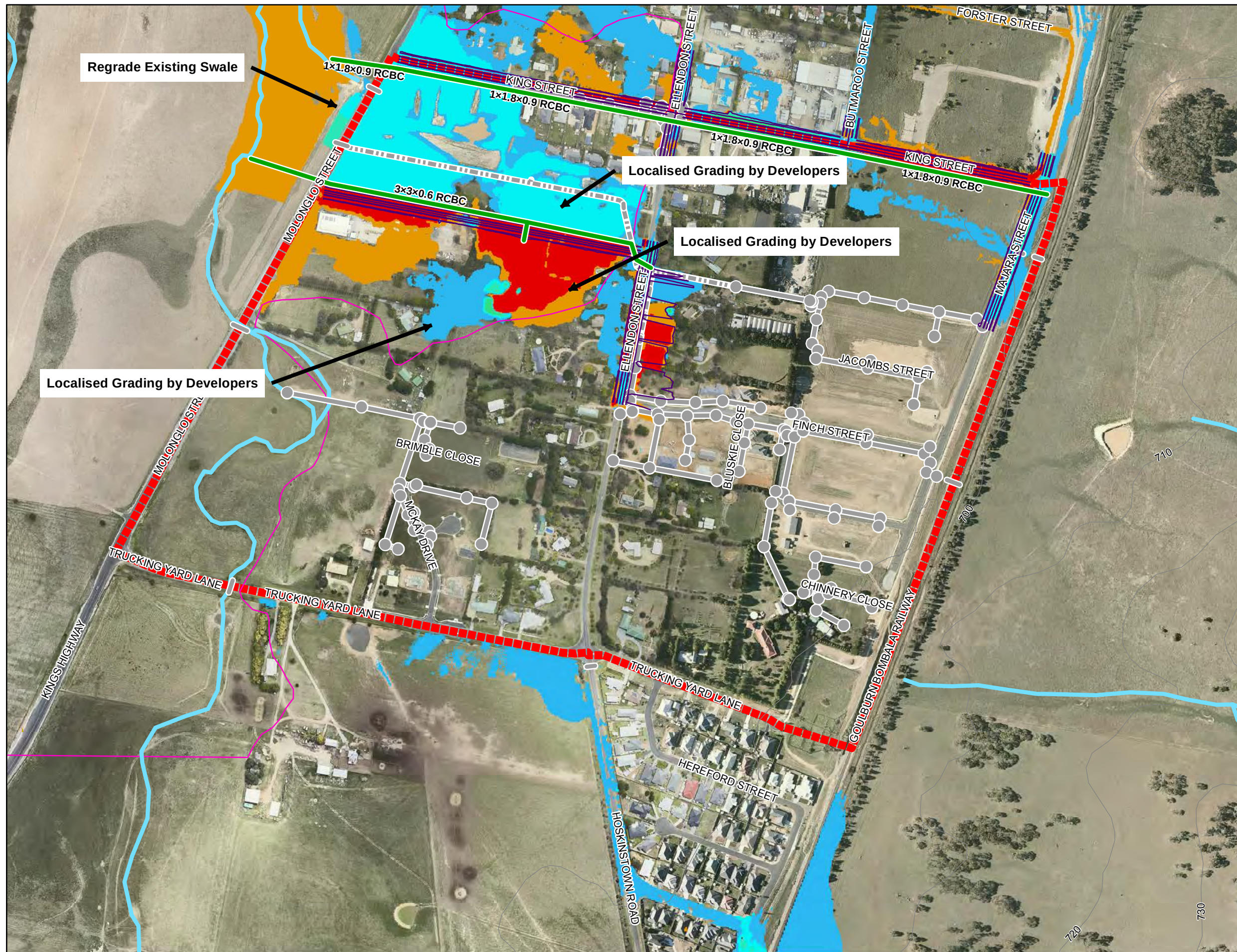
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Meters



Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure B6.1 - Ultimate_Road_Blocks_Raised_Two-way_Floodway.mxd

0 25 50 100 150 200
Meters



Legend

- Contours
- Creek Centreline
- Study
- Proposed Stormwater RCBC
- Proposed Road Regrading
- PLEP 2014 Flood Planning Area

Flood Depth

Difference

- < -3.0
- 3.0 to -1.0
- 1.0 to -0.50
- 0.50 to -0.30
- 0.30 to -0.10
- 0.10 to -0.01
- 0.01 to 0.01
- 0.01 to 0.10
- 0.10 to 0.30

Details

Issue	Amendment	Date
0	Draft - For Discussion	14-June-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
SCENARIO 6-1
FLOOD DIFFERENCE COMPARISON
TO ULTIMATE EXISTING**

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Drawn AJL

Checked AJL

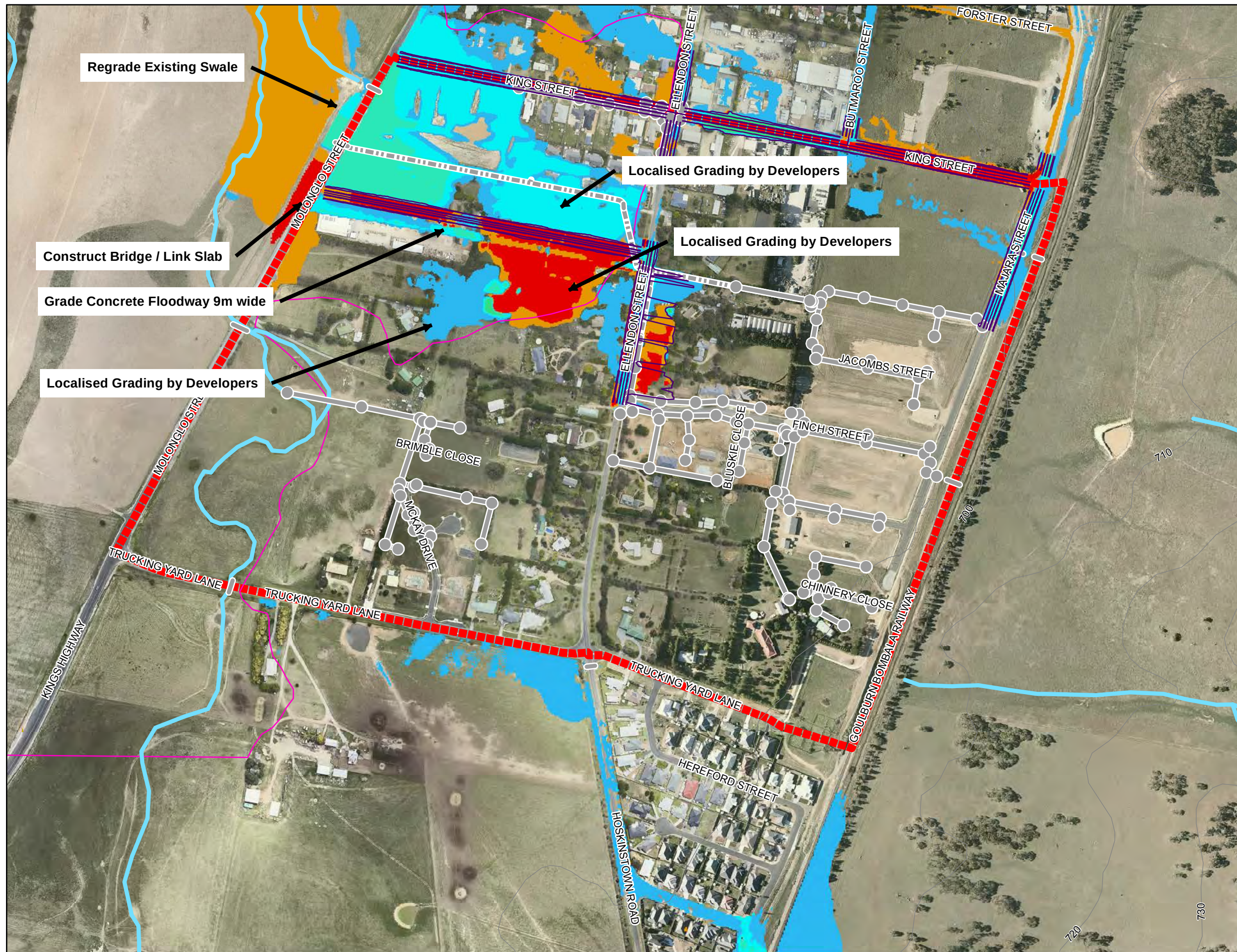
Job No. 18-000275

Figure D1

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure D1 - Ultimate_Road_RCBCx2_v1.mxd

0 25 50 100 150 200
Meters



Legend

- Contours
- Creek Centreline
- Study
- Proposed Stormwater RCBC
- Proposed Road Regrading
- PLEP 2014 Flood Planning Area

Flood Depth

Difference

- < -3.0
- 3.0 to -1.0
- 1.0 to -0.50
- 0.50 to -0.30
- 0.30 to -0.10
- 0.10 to -0.01
- 0.01 to 0.01
- 0.01 to 0.10
- 0.10 to 0.30

Details

Issue	Amendment	Date
0	Draft - For Discussion	14-June-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
SCENARIO 6-2
FLOOD DIFFERENCE COMPARISON
TO ULTIMATE EXISTING**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn AJL

Checked AJL

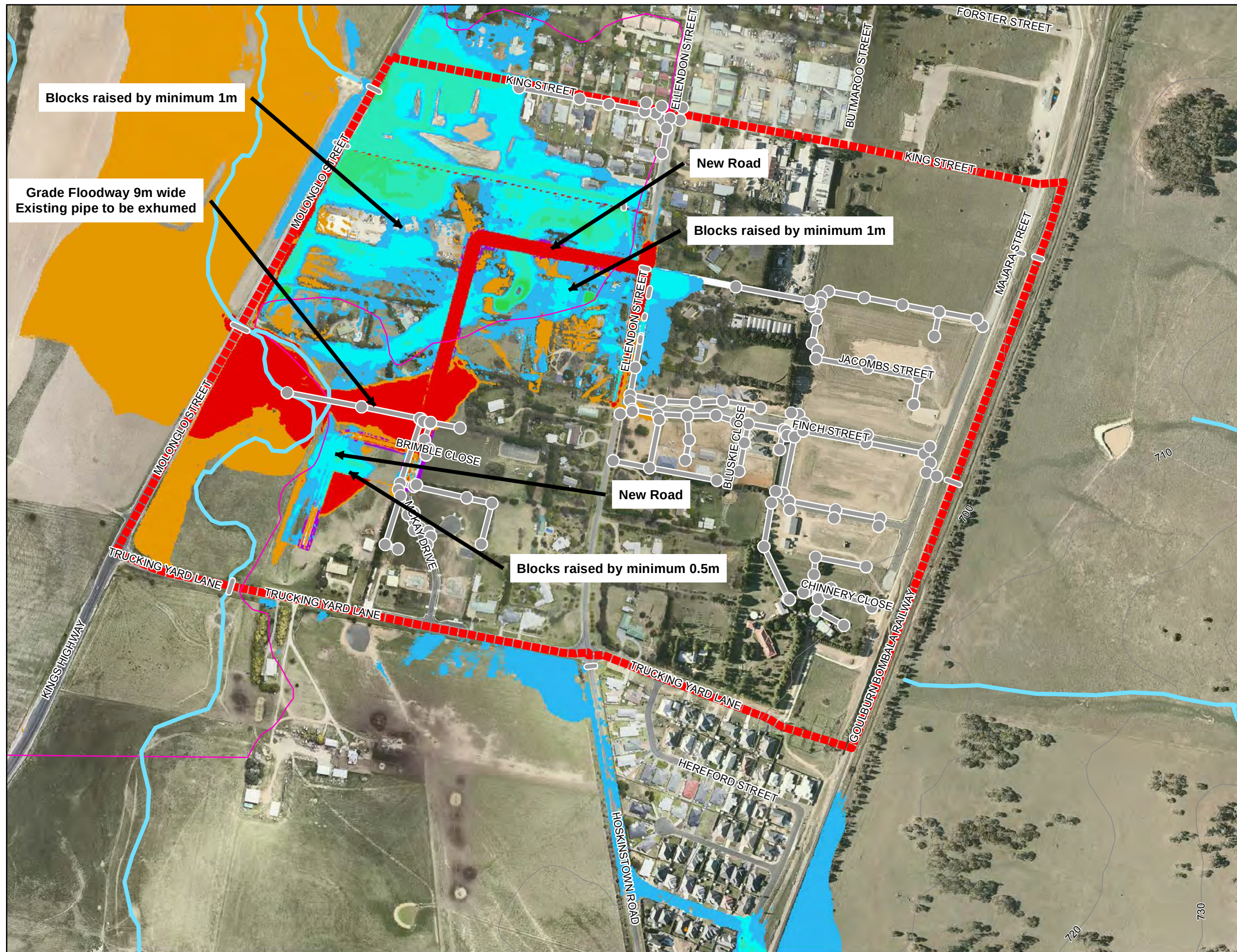
Job No. 18-000275

Figure D2

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure D2 - Ultimate_Road_Floodway_v0.mxd

0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study Area
- < -3.0
- 3.0 to -1.0
- 1.0 to -0.50
- 0.50 to -0.30
- 0.30 to -0.10
- 0.10 to -0.01
- 0.01 to 0.01
- 0.01 to 0.10
- 0.10 to 1.0
- PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	03-July-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 7-1
FLOOD DIFFERENCE COMPARISON
TO ULTIMATE EXISTING**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

Checked AJL

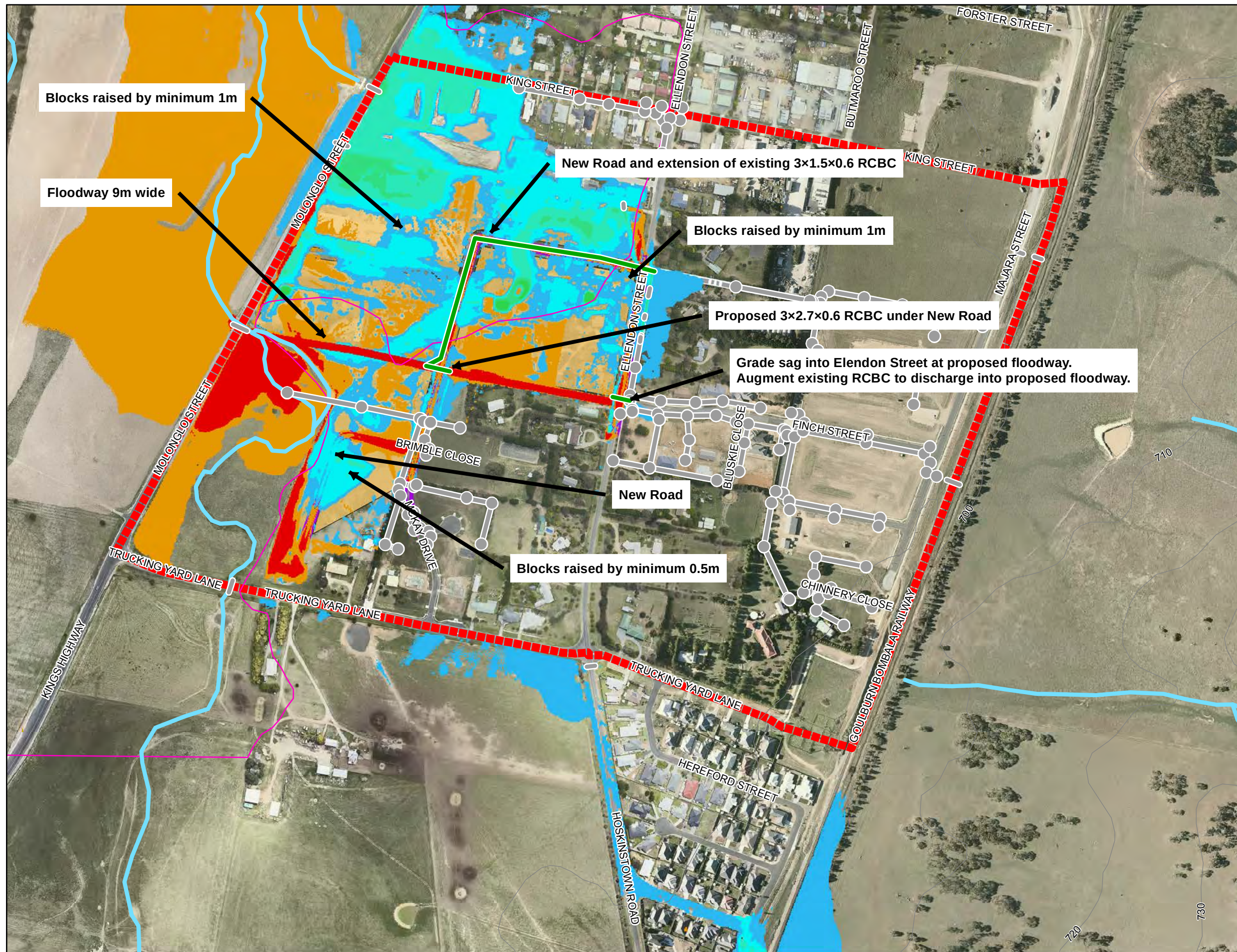
Job No. 18-000275

Figure D4

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure D4 - Ultimate_Road_Blocks_Raised_Two-way_Floodway - Comparison_v0.mxd

0 25 50 100 150 200 Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study
- < -3.0
- 3.0 to -1.0
- 1.0 to -0.50
- 0.50 to -0.30
- 0.30 to -0.10
- 0.10 to -0.01
- 0.01 to 0.01
- 0.01 to 0.10
- 0.10 to 1.0
- PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	06-Sept-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 8-2
FLOOD DIFFERENCE COMPARISON**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

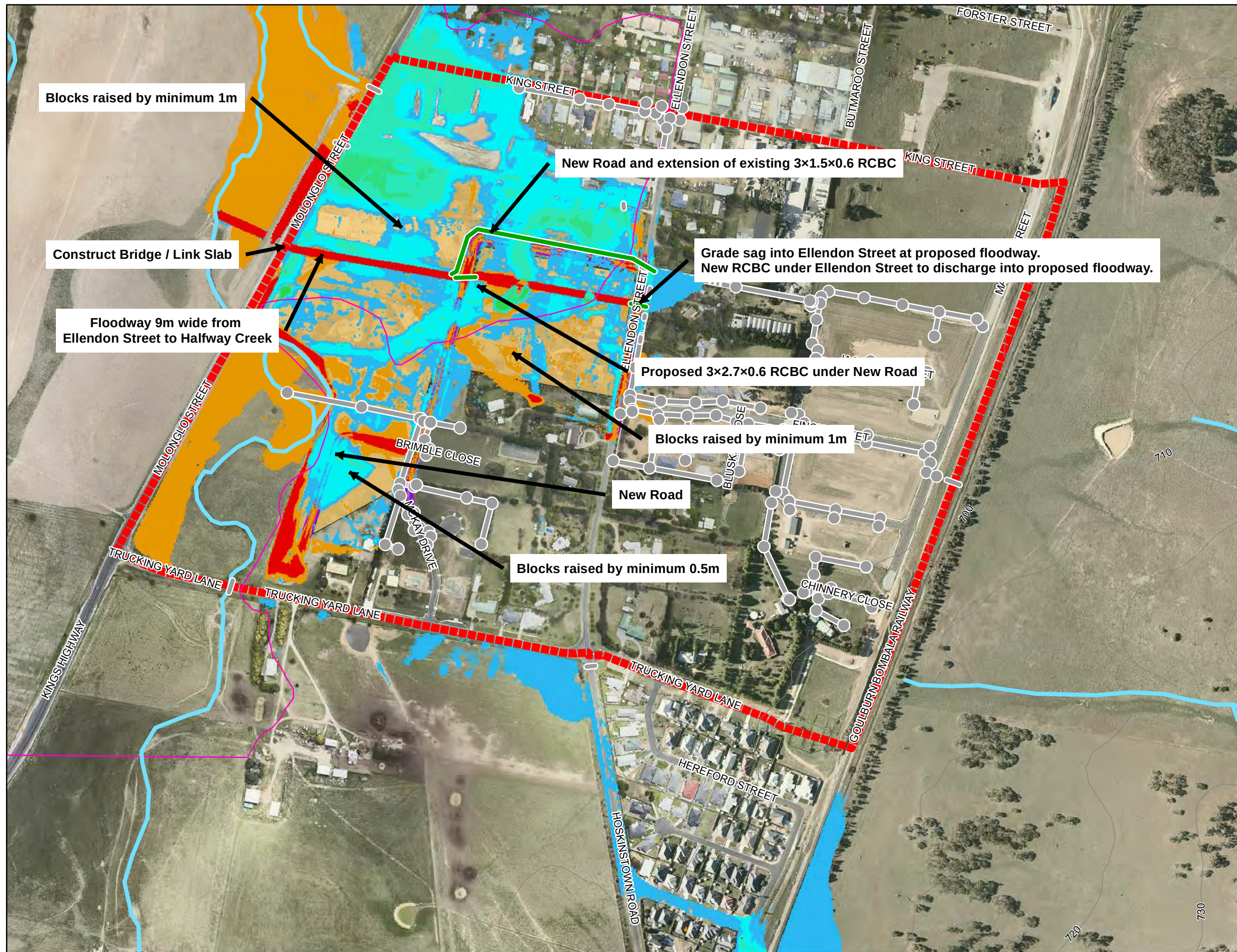
Checked AJL

Job No. 18-000275

Figure D5

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure D5 - Ultimate_Road_Blocks_Raised_Two-way_Floodway Extended - Comparison_v0.mxd
0 25 50 100 150 200 Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study
- < -3.0
- 3.0 to -1.0
- 1.0 to -0.50
- 0.50 to -0.30
- 0.30 to -0.10
- 0.10 to -0.01
- 0.01 to 0.01
- 0.01 to 0.10
- 0.10 to 1.0
- Proposed Stormwater RCBC
- PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	12-Dec-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 9-1
FLOOD DIFFERENCE COMPARISON**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

Checked AJL

Job No. 18-000275

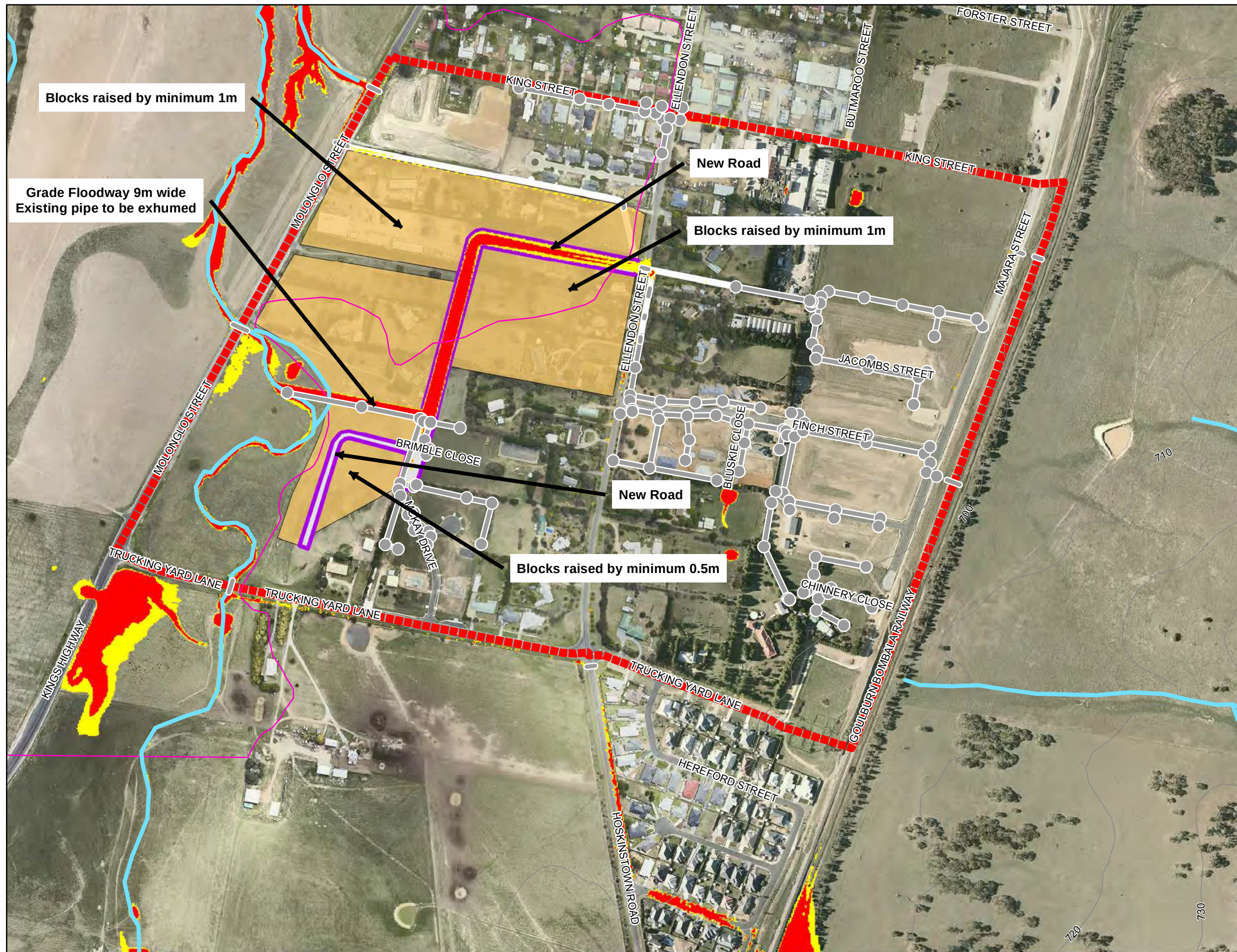
Figure D6

Issue

1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure D6 - Ultimate_Road_Blocks_Raised_Two-way_Floodway Extended - Comparison_v0.mxd

0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
 - Existing Stormwater Pipe / Culvert
 - Existing Concrete Drain
 - Contours
 - Creek Centreline
 - New Road
 - Raised Blocks by Developers
 - Study
- ### Hazard Categorisation
- 1 - LOW
 - 2 - MEDIUM
 - 3 - HIGH
 - PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	03-July-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 7-1
HAZARD CATEGORISATION**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

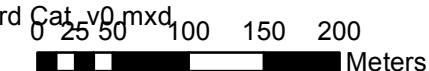
Checked AJL

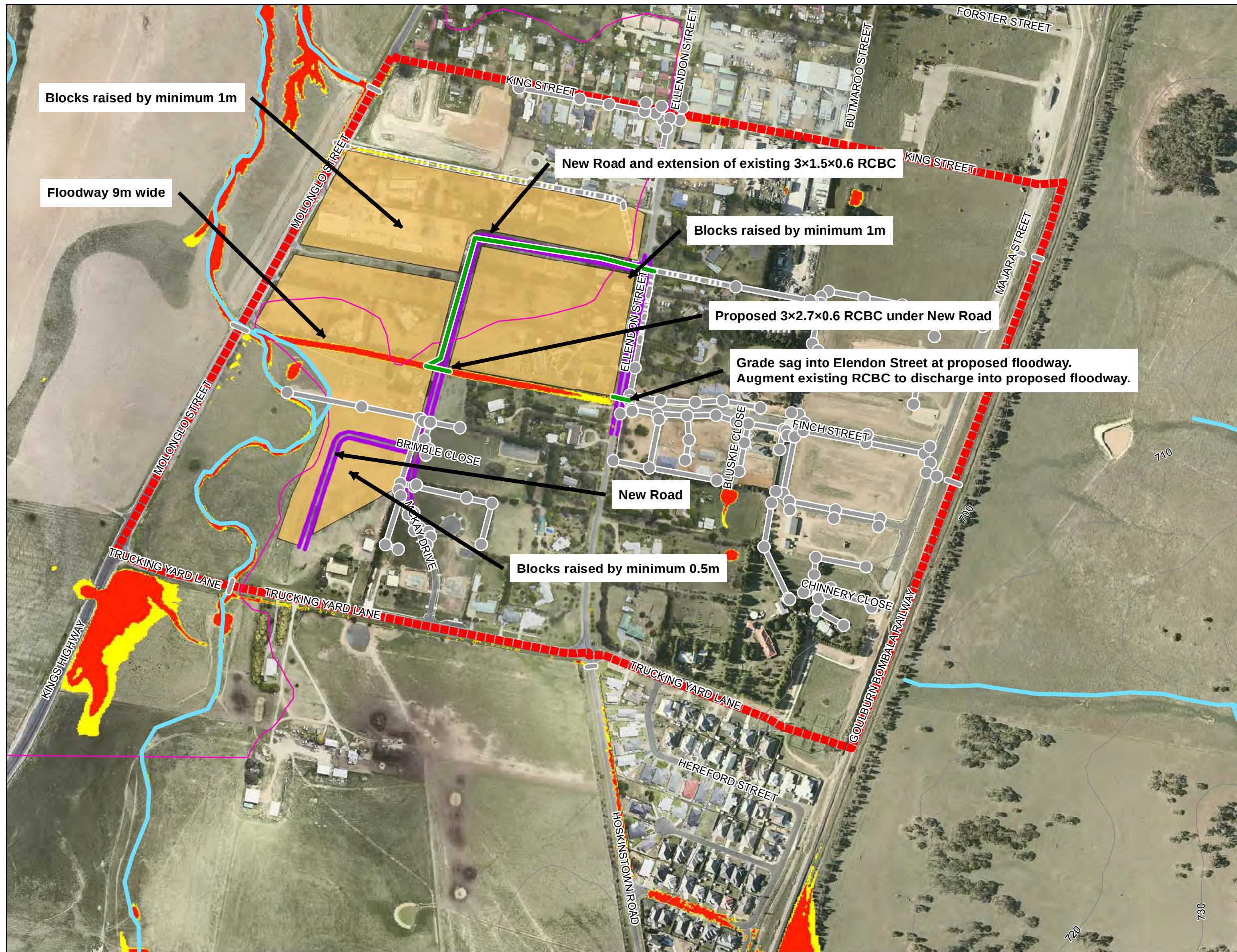
Job No. 18-000275

Figure E4

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure E4 - Ultimate_Road_Blocks_Raised_Two-way_Floodway - Hazard Cat_v0.mxd





Legend

- Existing Sump / Manhole
 - Existing Stormwater Pipe / Culvert
 - Existing Concrete Drain
 - Contours
 - Creek Centreline
 - New Road
 - Raised Blocks
 - Study Area
- ### Hazard Categorisation
- 1 - LOW
 - 2 - MEDIUM
 - 3 - HIGH
 - Proposed Stormwater RCBC
 - PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	06-Sept-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 8-2
HAZARD CATEGORISATION**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

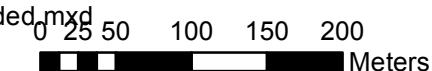
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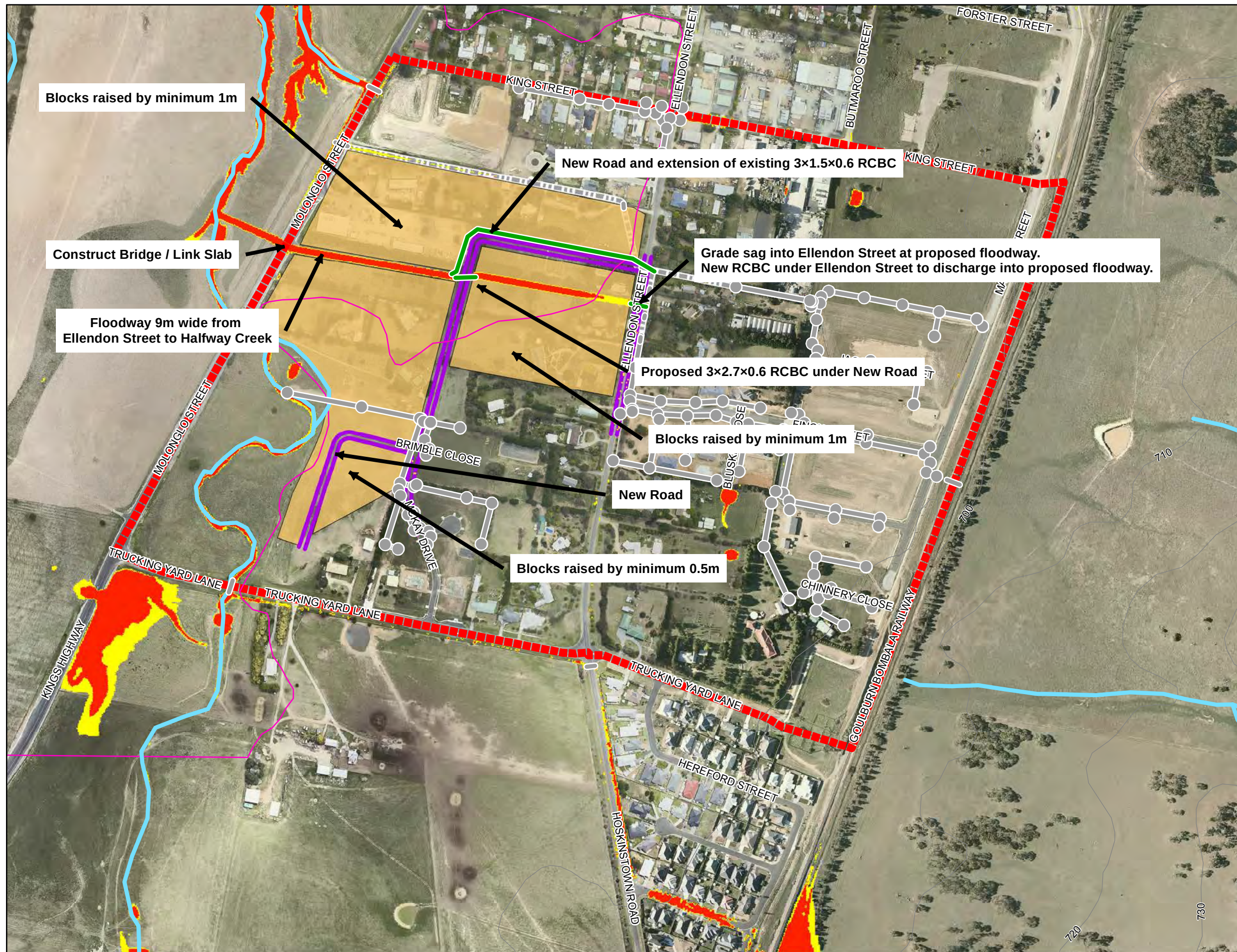
Job No. 18-000275

Figure E5

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure E5 - Ultimate_Road_Blocks_Raised_Two-way_Floodway Extended.mxd





Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- New Road
- Raised Blocks
- Study
- Hazard Categorisation**
 - 1 - LOW
 - 2 - MEDIUM
 - 3 - HIGH
- Proposed Stormwater RCBC
- PLEP 2014 Flood Planning Area

Details

Issue	Amendment	Date
0	Draft - For Discussion	12-Dec-2018
1	Final Report	18-Dec-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
SCENARIO 9-1
HAZARD CATEGORISATION**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn SY

Checked AJL

Job No. 18-000275

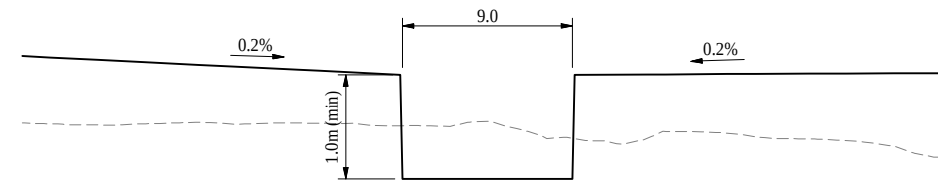
Figure E6

Issue 1

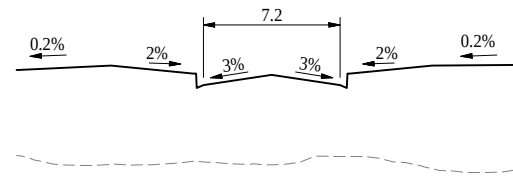
SOUTH BUNGENDORE STORMWATER MASTERPLAN

Appendix E Sketch Plans

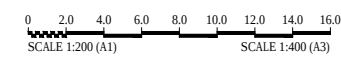
QPRC



TYPICAL FLOODWAY



TYPICAL ROAD



©



SOUTH BUNGENDORE
PROPOSED MITIGATION SECTIONS
For Discussion Purposes Only

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Appendix F Sensitivity Analysis

QPRC



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study Area
- Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	06-June-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
EXISTING
UNMITIGATED
SUMPS 100% BLOCKED**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn AJL

Checked AJL

Job No. 18-000275

Figure A1

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure A1 - Existing_Retic_Blocked_v0.mxd

0 25 50 100 150 200
Meters



Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study Area
- Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	06-June-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
EXISTING
UNMITIGATED
NO BLOCKAGES**

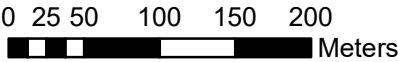
Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn AJL

Checked AJL

Job No. 18-000275

Figure A2





Legend

- Existing Sump / Manhole
- Existing Stormwater Pipe / Culvert
- Existing Concrete Drain
- Contours
- Creek Centreline
- Study Area
- Flood Planning Area

Flood Depth (m)

- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 3.00

Details

Issue	Amendment	Date
0	Draft - For Discussion	06-June-2018

Project

SOUTH BUNGENDORE STORMWATER MASTERPLAN

Drawing Title

**1% AEP
ULTIMATE
UNMITIGATED
NO BLOCKAGES**

Scale 1:5,000 @ A3 - 1:2,500 @ A1

Drawn AJL

Checked AJL

Job No. 18-000275

Figure A3

Issue 1

Document Path: H:\18-000000\18-000275\6_Model\GIS\Workspaces\Management Option Figures\Figure A3 - Ultimate_Unmitigated_v0.mxd

0 25 50 100 150 200
Meters



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