EDWARD RIVER AT DENILIQUIN FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FINAL REPORT

APRIL 2017

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Project Deniliquin Floodplain Risk Management Study and Plan	**Project Number** 115027
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* Edward River Council was established on 12 May 2016 following the amalgamation of Deniliquin Council and Conargo Shire Council.

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FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. Flood Study
- Determine the nature and extent of the flood problem.

2. Floodplain Risk Management
- Evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan
- Involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan
- Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The current study constitutes the second and third stages of the process.

This Floodplain Risk Management Study and Plan has been prepared for the Study Area encompassing the Edward River at Deniliquin and the Local Government Area of the former Deniliquin Council.

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EXECUTIVE SUMMARY

The Deniliquin Floodplain Risk Management Study which follows on from the Flood Study for the area completed in 2014, has been undertaken in accordance with the NSW Government's Flood Prone Land Policy. A full assessment of the existing flood risk in the catchment has been carried out, including flood hazard across the Study Area, overfloor flooding of residential, commercial and industrial properties, identification of known flooding issues and hotspots, and emergency response during a flood event. A range of measures aimed at managing this flood risk were assessed for their efficacy across a range of criteria, which allows options to be recommended as part of the Floodplain Risk Management Plan for the area.

Background

The Edward River is located in the Riverina region in the south-west of New South Wales. The River is an anabranch of the Murray River, running parallel to it for approximately 380 km before re-joining it at Wakool Junction. This study concerns the section of the Edward River in the Deniliquin Study Area, which is approximately 100 km^2 and has a 19 km long section of the Edward River and its floodplain. The majority of the area is classed as *Primary Production*, with large sections of *General Industrial* and *Large Lot Residential* also outside the town centre. The Deniliquin Township is centred on the Edward River, with the majority of the urban area on the south side of the river. This area is predominantly *General Residential*, with pockets of *Local Centre* and *Public Recreation.* On the north side of the river, the Davidson Street area remains classed as *1(a) General Rural* and *2 (urban)*, while north of Brick Kiln Creek in North Deniliquin there is an area of *General Residential* centred along the Cobb Highway. Adjacent to the urban areas, there are large areas of *National Parks and Nature Reserves, Private Recreation and Public Recreation*.

Existing Flood Environment

Deniliquin has significant flood affectation, with rare flood events completely inundating large sections of both urban and rural area. Flooding in the area results from high rainfall over the Murray River catchment, which stretches into the Snowy Mountains in the Great Dividing Range. Relatively frequent floods (less than 5% AEP) are, compared to larger events, quite benign, with most development located outside the 10% AEP flood extents. Flood events are also characterised by their long warning time, usually with days of warning available, and their long duration, with inundation periods of over a week.

Flood risk in the area relates to the inundation of property, roads and infrastructure, and evacuation constraints in different areas. Inundation in frequent floods (e.g. 10% AEP) is relatively minor, with flood liability concentrated to two caravan parks in the area. In larger events (5% and 2% AEP) the Davidson Street area experiences widespread flooding and the North Deniliquin area must be evacuated. In the 1% AEP event, North Deniliquin is also severely flooded, and the floodplain has a width of several kilometres. There is additional risk arising from the low awareness of flooding in the area.

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Economic Impact of Flooding

A flood damages assessment was carried out for the inundation of residential and commercial properties in the area. The assessment was based on surveyed and estimated flood levels for all properties in the Study Area. The annual average damages for residential and commercial/industrial properties was found to be $3.04M.

Flood Risk Management Options

A number of catchment-wide management options have been recommended. These include a consideration of voluntary purchase in the Davidson Street Area, amendments to Council policies, flood information on S149 certificates and updating the Flood Planning Level and Area to reflect updated design flood levels. Several response modification measures have also been included, most notably the development of a centralised Flood Intelligence Kit. Recommendations have also been made regarding flood warnings, evacuation planning and improving community awareness.

A range of site-specific management options were also investigated for the area. Options were focussed on identified hotspots and drew upon discussion via the community consultation and the floodplain management committee. Twelve options were tested for their effect on flood behaviour in a range of design flood events. Most focussed upon the flood affectation in the Davidson Street area and in North Deniliquin, with options including levee upgrades, levee removal and channel modifications. A summary of recommended options is shown in Table 1.

The completion of this report was delayed due to a flood event in October 2016, which provided an opportunity to undertake data collection for the validation of the design flood model and evaluation of flood management operations. A number of recommendations arose from this investigation, and have been described in detail in Appendix G and included in Table 1.

Table 1 Summary of Recommended Mitigation Options

Ref	Options	Priority
FM01	Development and implementation of Vegetation Management Plan	Low
FM05	South Deniliquin Levee: Revised spillway and freeboard	High
FM07	North Deniliquin Levee: Upgrade to 1% AEP + 0.5 m freeboard	High
FM12	Davidson Street Flow Path Improvement	High
PM01	Revision of Flood Planning Level and Flood Planning Area	High
PM02	Update Planning Policies (DCP and LEP)	Medium
PM03	Amendments to s149 Certificates	Medium
PM04	Investigation of Voluntary Purchase	Low
RM01	Flood Emergency Management	High
RM02	Development of ‘Just in Time’ warning system	Medium
RM03	Evacuation Planning	High
RM04	Community Flood Awareness	High
Oct 16 - R1	Centralised Flood Intel Kit	App G
Oct 16 - R2	Levee Pipe Condition Assessment	App G
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	App G
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	App G
Oct 16 - R5	Collection of flood data following an event	App G

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1. INTRODUCTION

Deniliquin has experienced severe flooding on several occasions since its settlement in the mid-19th century. Large floods have occurred in 1955, 1956 and 1975, and the largest event on record occurred in 1870. A makeshift levee was built in 1955 and has been subsequently modified and upgraded. The main areas of flood affectation are around Davidson Street, which is surrounded by an informal levee, and North Deniliquin, which can be inundated in large floods. It should be noted that no large floods have occurred in recent history, with the last major flood in 1956 and the last moderate flood in 1993.

This floodplain risk management study and plan assesses flood risk for the town and surrounding area and follows the recently completed Edward River at Deniliquin Flood Study (Reference 2). In addition to assessment of flood risk, the current study tests a range of mitigation options aimed at managing the area’s flood risk.

1.1. The Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1) the floodplain risk management process is formed of sequential stages:

- Data Collection;
- Flood Study;
- Floodplain Risk Management Study;
- Floodplain Risk Management Plan; and
- Plan Implementation.

The first key stage of the process has been undertaken with the completion of the recent flood study in 2014 (Reference 2). Following this, the Floodplain Risk Management Study and Plan (FRMS&P) are undertaken for the catchment in two phases:

Phase I – Floodplain Risk Management Study in which the floodplain management issues confronting the Study Area are assessed, management options investigated and recommendations made. The objectives for this phase include:

- Review the recent flood study and update the hydraulic models where required;
- Identify requirement of additional floor level survey;
- Review Council’s existing environmental planning policies and instruments, identify modifications required to current policies;
- Identify residential flood planning levels and flood planning area;
- Identify and assess works, measures and restrictions aimed at reducing the impacts and losses caused by flooding and consider their impacts if implemented, taking into account the potential impacts of climate change;

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- Review the local flood plan, examine the present flood warning system, community flood awareness and emergency response measures (involvement with the NSW State Emergency Service);
- Provide Council with sufficient documentation (including preliminary concept design) to complete a New Works Ranking Form in order to apply to OEH for funding support.

Phase II – Floodplain Risk Management Plan which is developed from the floodplain risk management study and details how flood prone land within the Study Areas is to be managed moving forward. The primary aim of the Plan is to reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk at this time. The FRMS&P will provide sufficient detail (by way of preliminary concept design drawings/ mapping) for Council to pursue funding for the recommended option.

The Plan consists of prioritised and costed measures for implementation.

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2. BACKGROUND

2.1. Study Area

The Edward River is located in the Riverina region in the south-west of New South Wales. The River is an anabranch of the Murray River, breaking off at Picnic Point and then running parallel to it for approximately 380 km before re-joining it at Wakool Junction. This study concerns the section of the Edward River at Deniliquin, which is approximately 100 km^2 and has a 19 km long section of the Edward River and its floodplain, as shown on Figure 1. The river travels in a general north-west direction through the area, which varies in elevation from 80 mAHD to 100 mAHD. The area, like much of the Riverina region, is characterised by its very flat terrain, containing mostly agricultural and pastoral land. The town of Deniliquin (population approximately 8,000) lies on both sides of the Edward River, and has a number of properties in the floodplain itself.

2.2. Land Use

The land use zones as identified in the 2013 LEP (Reference 3) are shown in Figure 2. The majority of the area is classed as *Primary Production*, with large sections of *General Industrial* and *Large Lot Residential* also outside the town centre. The Deniliquin Township is centred on the Edward River, with the majority of the urban area on the south side of the river. This area is predominantly *General Residential*, with pockets of *Local Centre* and *Public Recreation.* On the north side of the river, the Davidson Street area is classed as a Deferred Matter where the former zones of *1(a) General Rural* and *2 (urban)* remain, while north of Brick Kiln Creek in North Deniliquin there is an area of *General Residential* centred along the Cobb Highway. Adjacent to the urban areas, there are large areas of *National Parks and Nature Reserves, Private Recreation and Public Recreation*.

2.3. Social Characteristics

Understanding the social characteristics of the area can help ensure floodplain risk management practices adopted are aligned with the communities at risk. For example, ‘stable’ communities (characterised by a high proportion of home ownership and low frequency of residents moving into or out of the area) are more likely to have a better understanding of the flood risks within the area.

Social characteristic data was obtained from the 2011 census (http://www.abs.gov.au/) for the Study Area. The census data shows that a small number of households speak a language other than English at home (3.7%), for example Italian (0.4%), Cantonese (0.3%) and Afrikaans (0.3%), which should be considered when organising flood awareness education or when issuing evacuation orders. The data also shows that a very small number of people moved to the area within the 10-year period prior to the census at around 0.2% of the residents, but around 26% to 34% of residents are staying in a rented property. This suggests a low frequency of change of residents in the area, which is advantageous for undertaking flood awareness/community education programmes.

The catchment has a small average dwelling size of 2.2 people, and a relatively high portion of single person dwellings (33.7% compared to the NSW average of 24.2%). This may need to be considered in evacuation planning as it may indicate a higher than usual number of properties relative to population. There is a large average number of motor vehicles per dwelling of 1.6 with 85% of residents owning at least one vehicle and 10.0% owning no vehicle (compared to a NSW average of 10.4%). This will assist when considering evacuation routes (i.e. that they should be traversable by foot or be able to gain access to a vehicle due to the high proportion of residents owning at least one vehicle).

Demographically, the catchment has a higher portion of over-65 year olds (21.3% compared to 14.7% for NSW), and the average proportion of under 14 year olds (18.9% compared to 19.2% for the state), which suggests demographics may have a significant impact on evacuation planning.

2.4. Local Environment

The Study Area consists of urbanised and cleared land, as well the Deniliquin State Forest, natural wetlands and riparian zones. Like other towns in the region, mature river red gums are prevalent throughout the riparian zone. The town itself contains a series of parks along a remnant flood runner, which includes habitats for the endangered Southern Pigmy Perch. The remaining natural environment is located along the river system, with intermittent sections of natural vegetation upstream and downstream of the town. Two designated areas are Deniliquin State Forest and the Island Sanctuary.

Deniliquin State Forest and the Island Sanctuary are situated south-east of the main urban area, in the Edward River's riparian zone. The area is home to a large range of avian species including Waders, Crakes, Banded Lapwing, Wood Duck, Royal Spoonbill, Darter, Great Egret and the Superb Parrot (endangered). Platypuses, water rats and kangaroos similarly live within the area. The Island Sanctuary also hosts several shrubs, plants and trees indigenous to the Deniliquin district.

The section of the Edward River in the Study Area is comprised of the river's main channel, anabranches and flood runners along the channel, and oxbow lakes where sections of channel have broken off the main channel and becomes lakes or wetlands. Between these features lie areas of cleared and vegetated land that become inundated in a large flood. The floodplain width is extensive and, as with any river, the alignment of the various channels is in a state of flux. Although large parts of the floodplain are cleared, the vegetated areas contain native vegetation and there is a mix of terrestrial and aquatic fauna in the area.

2.5. Previous Studies

A number of studies have investigated flooding in and around Deniliquin. The studies, categorised as either floodplain management studies or environmental assessments, have been reviewed and summarised in the Flood Study (Reference 2) and include:

Floodplain Management Studies:

- Deniliquin Floodplain management Study – Rankine and Hill, February 1984
- Deniliquin Flood Protection Levee Study – Sinclair Knight Merz, July 1997
- Edward-Wakool Rivers – Stages 1, 2, 3, - Flood Study Report – SMEC, May 2004
- Hydraulics Analysis of the 100 year ARI Flood on South West Deniliquin – NSW Department of Commerce, 2008
- Floodplain Management Plan, Edward and Wakool Rivers Stage 1 Deniliquin to Moama-Moulamein Railway – NSW Department of Climate Change and Water, 2011
- Edward River at Deniliquin Flood Study – WMAwater, November 2014

Environmental Assessments:

- Environmental Impact Statement for the Construction of North Deniliquin Flood Levees (CMPS&F Environmental, 1994)
- South Deniliquin Levee Stage II and North Deniliquin Levee Stage II – Environmental Impact Statement (Kinhill, 1996)
- Deniliquin Floodplain Management – Statement of Environment Effects for the West Deniliquin Levee Bank (GHD, 2005)

2.5.1. Flood Studies

Edward River at Deniliquin Flood Study – WMAwater, November 2014.
A flood study was carried out for the Study Area which included the former Deniliquin Council Local Government Area (LGA) in accordance with the NSW Government's Flood Policy. The Flood Study was aimed at determining design flood behaviour in the area. Design flood behaviour was defined through the use of a flood frequency analysis and a 2D hydrodynamic model. Design flood levels were used to assess the flood behaviour around the town's levee system, as well as give preliminary identification of flooding issues.

Design flood behaviour was determined for events ranging from 20% to 0.5% Annual Exceedance Probability (AEP) as well as the Probable Maximum Flood (PMF). The analysis was made up of two parts: firstly, design discharges were derived from a flood frequency analysis, and secondly, a 2D hydraulic model based on TUFLOW software was used to determine the flood level and velocity corresponding to those discharges. The adopted design discharges determined by the flood frequency analysis are given in Table 2. The PMF was approximated by tripling the 'expected parameter' estimate of the 1% AEP flow. The hydraulic model was calibrated using three historical events (floods of 1956, 1975 and 1993). Design results produced by the calibrated model included peak flood depth and level, as well as hydraulic hazard and hydraulic categories. A preliminary estimate of the 0.2% AEP event and the 1% AEP + 0.5 m extent was made for planning purposes as part of this study. The design flood behaviour produced by the study supersede the previous Study Area-wide assessment, completed in 1984 (Reference 4).

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Table 2 Estimated Design Flows

AEP (%)	Flow (m^3/s)	Flow (Ml/d)
10	998	**86,200**
5	1391	**120,200**
2	1861	**160,800**
1	2204	**190,400**
0.5	2425	**209,500**
0.2	2702	**233,485**
PMF	6499	**561,000**

The current study uses the model established as part of the Flood Study. No revisions or changes to the model were required.

2.5.2. Floodplain Management Studies

Deniliquin Floodplain Management Study - Rankine and Hill, February 1984 (Reference 4)
The study made a comprehensive assessment of flooding behaviour in the area which was used to determine the height of the levee system that was subsequently built and completed in April 2012. The study used a flood frequency analysis to determine design discharges, which were then used to estimated flood levels using a Standard Step Method of Backwater Analysis. The design flood levels were superseded by the recent flood study (Reference 2).

The study recommended the existing levee system be upgraded to provide protection against the 1% AEP design event. This included extending the levees around North and South Deniliquin and raising the existing structure to a height of the 1% AEP flood level plus 1.0 m freeboard. The study included geotechnical investigations and found that some sections of the levee were poorly compacted and may fail during a flood. It also found that a higher levee on Davidson Street would constrict flow and worsen flood affectation for North and South Deniliquin, and that the existing Davidson Street levee should be removed. The Davidson Street levee was found to be structurally inadequate for flood protection and there was risk of failure during an event.

Deniliquin Flood Protection Levee Study - Sinclair Knight Merz, July 1997
The study was undertaken subsequent to a levee upgrade being recommended, and assessed the type and design of levee system necessary, including revising the estimate of the levee's freeboard. The study used the flood frequency analysis undertaken in the previous study (Reference 4) and the design levels determined by that study. The study recommended a freeboard of 0.5 m for South Deniliquin and 0.1 m for North Deniliquin. The freeboard in both locations was assessed in terms of its components (wave action, spillways, levee types etc.), its benefit from an economic viewpoint, and the community's needs. It concluded that the previously recommended 1 m freeboard was too high and should be lowered.

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Edward-Wakool Rivers – Stages 1, 2, 3 – Flood Study Report - SMEC, May 2004
The study modelled the Edward-Wakool Rivers between Deniliquin and Liewah Station (more than 100 km of river), and used MIKE-11, a more advanced 1D hydraulic model than the HEC model previously used. The model was calibrated with the flood events of '93, '75 and '56, and validated using the '96 event. Different model parameters were used to represent the current and pre-developed states of the floodplain. The upstream boundary of the Study Area was the town of Deniliquin and the model used the gauged data from the town as an inflow.

Hydraulics Analysis of the 100 year ARI Flood on South West Deniliquin - NSW Department of Commerce, 2008
Using HEC-RAS and the procedures established in the Rankine and Hill model, the study covered Edward River and its floodplain starting at Stockbridge and ending at Lawson Syphon. It found that if the existing levee is not extended to the Mulwala Canal, south-west Deniliquin would experience Low Hazard flooding during the 100 year ARI event (generally equivalent to the 1% AEP event), with a maximum ponding depth of around 0.28 m. It modified the model used by the 1999 Golf Course Levee Report and used Rankine and Hill (1984) modelling procedures.

Floodplain Management Plan, Edward and Wakool Rivers Stage 1 Deniliquin to Moama-Moulamein Railway – NSW Department of Climate Change and Water, 2011
The Wakool River originates from the Edward River approximately 7 km west (downstream) of Deniliquin. This is beyond the bounds of the Deniliquin Study Area, and the options proposed generally involve the removal of levees, which would be highly unlikely to have any significant adverse impacts on upstream rural properties within the Deniliquin Study Area.

2.5.3. Environmental Assessments

Three environmental assessments undertaken in the area were reviewed. They were:

- Environmental Impact Statement for the Construction of North Deniliquin Flood Levees (CMPS&F Environmental, 1994)
- South Deniliquin Levee Stage II and North Deniliquin Levee Stage II – Environmental Impact Statement (Kinhill, 1996)
- Deniliquin Floodplain Management – Statement of Environment Effects for the West Deniliquin Levee Bank (GHD, 2005)

The studies uniformly concluded that their respective sections of the levee system would have minimal impact on flooding patterns in the area. The Kinhill (1996) report mentions that there would be a minor increase in flood levels upstream of the levee due to its construction, referencing the Rankine and Hill (1984) study. Also, the CMPS&F (1994) report found that the minor relocation of a section of the North Deniliquin Drainage Channel would have no impact on the overall drainage system (Reference 8).

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3. EXISTING FLOOD ENVIRONMENT

Deniliquin has significant flood affectation, with rare flood events completely inundating large sections of both urban and rural area. Flooding in the area results from high rainfall over the Murray River catchment, which extends into the Snowy Mountains in the Great Dividing Range. Relatively frequent floods (less than 5% AEP) are, compared to larger events, quite benign, with most development located outside the 10% AEP flood extents. Flood events are also characterised by their long warning, with typically around one week's warning available. The following section summarises the historical flood events and design flood behaviour determined by the Flood Study (Reference 2).

3.1. Historical Flood Events

Deniliquin has experienced severe flooding on several occasions since its settlement in the mid-19th century. The largest flood on record occurred in 1870, devastating the town and the surrounding land. Large floods then passed through the town in 1917 and 1931, before a makeshift levee was built in 1955 in the weeks leading up to the flood of that year. The levee protected most of the town during that flood and the one of the following year, which was larger than the 1955 event and inundated the Davidson Street area. Subsequent floods have not peaked as high as the 1956 event and the town has been largely flood free, except for the Davidson Street area, which was inundated in the 1975 event.

The following section gives an overview of the historical flood events. Most information has been taken from the stream gauge at Deniliquin (no. 409003, at its new (current) location) and from the book 'Flood History of Deniliquin' (Reference 16), which provided extensive information about past floods in the form of scanned newspaper articles. It should be noted that the gauge was moved in 1981 from the bridge to a point approximately 250 m upstream (see Figure 1) and that all quoted gauge levels refer to the level at the new location. Gauge Zero is 82.43 mAHD. The articles, as well as a series of photos, date back to 1870 and refer to floods as early as 1851. For reference, the SES defines the following categories of flooding based on the gauge level:

- 4.6 m – Minor Flood
- 7.2 m – Moderate Flood
- 9.2 m – Major Flood

Design events and historical flood events, their flow and depth at gauge are shown in Table 3.

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Table 3 Design and Historical Flood Events

Flood Event	Flow (ML/day)	Peak Flood Depth at Gauge[1] (m)
Oct 1993	83,300	8.48
Nov 1975	119,600	9.04
Jul 1956	154,100	9.37
Oct 1917	189,100	9.63
Sept 1955	110,900	8.95
Nov 1870	200,500	9.68
20% AEP	51,800	7.0
10% AEP	86,200	8.6
5% AEP	120,200	9.4
2% AEP	160,800	9.9
1% AEP	190,400	10.1
0.5% AEP	209,500	10.2
PMF	561,500	11.0

[1]Peak flood depths are based on the rating curve produced in the Flood Study and are in reference to the new gauge location.

It should be noted that due to changes in the floodplain, the relationship of flood height and flow has changed significantly since the early flood events and so the events' AEP cannot be determined by comparison to the design event peak levels, instead a comparison of peak flood flow would provide a better indicator.

3.1.1. November 1870

Anecdotal evidence from newspaper articles cited the 1870 flood as 'the highest known here since the occupation of the white man', covering an area of many hundreds of square miles. It was estimated that nearly all of the townspeople were evacuated and found refuge in two hotels on higher ground. The majority of public buildings were inundated including the English and Catholic churches and the public school, with "all of the streets in the south town being submerged". The event is recorded as reaching a peak height of 9.68 m on the gauge (no. 409003).

3.1.2. October 1917

The peak of the 1917 flood was reached on October 30 at 9.63 m on the current gauge. At only 4 inches below the peak of the 1870 flood, it is still the second highest flood in Deniliquin's history. Houses in North and South Deniliquin were inundated, and newspaper articles refer to the main street being inundated (likely Davidson Street or Napier Street). Many roads and footpaths were said to have suffered severe damage, with Taylor's Bridge and Memorial Park inundated. Photos of the flood are shown on Figure 3. There was limited information on effects of the flood.

3.1.3. July 1931

The 1931 flood peaked at a gauge level of 8.99 m (91.42 mAHD). From photos provided in 'Flood History of Deniliquin' (Reference 16) and reproduced in Figure 3, it can be seen that there was widespread flooding with a large number of residential properties, paddocks and roads inundated. The levee system was significantly less developed than it is now, so without further anecdotal evidence it is difficult to define the flood extents and its effects. However, given that the level was so close to the 1975 event the impacts are assumed to be similar, and are listed in Section 3.1.6.

3.1.4. September 1955

The 1955 flood peaked at 9.02 m (91.45 mAHD) on Sunday the 4th September at 1pm. This event is marked by the significant community effort to build '3 to 4 miles' of levee banks up to a height of 12 ft. in approximately five days preceding the flood. Newspaper articles from the time noted approximately 250 people were evacuated, mostly from North Deniliquin but also from End Street West and Russell St (in South Deniliquin). Photos and newspaper articles from the time of the event are included in Reference 16.

3.1.5. July 1956

The 1956 flood at Deniliquin peaked at 8.99 m (91.42 mAHD) on the 17th of July that year. As noted, a makeshift levee was built in 1955 in the weeks leading up to the flood of that year and it was added to in 1956. Five flood marks were available that represent the peak water level of the 1956 event. Photos of the flood are shown on Figure 3. Further knowledge of the event comes from anecdotal evidence and newspaper reports from the time. These sources gave the following information:

- The main part of town (South Deniliquin) was, on the whole, not inundated. The Wyatt Street levee was not overtopped. There was inundation in the vicinity of the golf course, as a rescue was made from a home surrounded by water near Memorial Park.
- The section of land between the Edward River and Brick Kiln Creek was severely flooded. Water was flowing over Davidson Street. There is no record of the depth, beyond that the Edward River Hotel had several feet of inundation, a photo shows a house with water to the roof level and that boating became a necessary means of transport to cross between North Deniliquin and the main part of town. Photos from the time show that the area was extensively flooded but do not give exact dates.
- The extent of flooding in North Deniliquin (north of Brick Kiln Creek) is not well-documented. The newspaper from the time reported that homes in North Deniliquin had been evacuated. The fact that there were crossings between North Deniliquin and the main part of town, as well as reports that emergency shops and a post office were set up in North Deniliquin, suggest the area was only partially inundated, if at all.
- Water spread overland in an easterly direction (opposite to the flow of the river) immediately south of Wakool Road near Racecourse Road and Burton St.
- The house at 215 Waring St in South Deniliquin was inundated with water.

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3.1.6. November 1975

The 1975 flood peaked at 9.04 m (91.47 mAHD) on the 5th and 6th of November, 1975. Twelve flood marks were available that represent the peak water level of the 1975 event. The flood marks cover a 6 km stretch of the river and range from 91.83 to 90.72 mAHD in height. Anecdotal evidence and newspaper reports give several pieces of information:

- Davidson Street experienced some inundation, with the tennis courts near Brick Kiln Creek being covered with water before the flood peaked.
- Water came close to overtopping (or may have overtopped) a makeshift levee at the end of Burton Street.
- A small bridge on Memorial Drive, under construction at the time, was inundated.

3.1.7. October 1993

The 1993 flood peaked at 8.48 m (90.91 mAHD) on the 18th of October, 1993. No floodmarks were available for the 1993 event. Community consultation undertaken as part of the Flood Study (Reference 2) found that little to no flooding of urban area was experienced. From the general response, it was ascertained that the Davidson Street area was not flooded and that the levee was not breached in any location.

Estimated flood extent maps of the 1956, 1975 and 1993 events were presented in the Flood Study (Reference 2)

3.1.8. October 2016

The 2016 flood followed months of higher than average rainfall across the Murray River catchment, and occurred just as the Public Exhibition phase of this report was being held. The flood initially peaked at 7.06 m on the 1st October, then fell briefly before rising to 8.62 m on the 17th October, making it comparable to a 10% AEP design event (8.6 m at the gauge). In this event, a small number of properties upstream of the levee system and further downstream in the Dahwilly area are affected. Within town, water generally stayed within the Edward River channel but affected parts of both the Riverside Caravan Park and McLeans Beach Caravan Park.

Given the timing of the flood with this Floodplain Risk Management Study, the completion of the Study was delayed so as to include a detailed analysis of the flood itself and how it was managed. Appendix G details the data collection and model verification undertaken, and an assessment of the way in which the community’s response was managed. The report includes recommendations for improvement that have been added to the Floodplain Risk Management Plan in Section 9.9.

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3.2. Design Flood Behaviour

Flood levels and extents for a range of design events were determined in the Flood Study (Reference 2) using the hydraulic model in combination with the design discharges determined by the flood frequency analysis. The flood frequency analysis determined estimates of the 20%, 10%, 5%, 2%, 1% and 0.5% AEP events, which were then assessed using the hydraulic model. Flood behaviour was also produced for the PMF event, which used a modified model schematisation, due to the extent of inundation. The 0.2% AEP event was assessed as part of the current study to assist in the assessment of planning measures. Table 4 summarises the peak flood level at seven locations for each of the events. A short description of each event's flow behaviour is given below. Section 4 gives further description of the flood risk across the area and the performance of the existing levee network is discussed in Section 4.5.1.

Table 4 Peak Flood Levels in Study Area for Design Events

	Peak Flood Level mAHD							
Location	*20% AEP*	*10% AEP*	*5% AEP*	*2% AEP*	*1% AEP*	*0.5% AEP*	*0.2% AEP*	*PMF*
National Bridge	89.3	90.9	91.6	92.1	92.3	92.4	92.5	93.1
Gauge Location	89.4	91.0	91.8	92.3	92.5	92.6	92.7	93.4
Brick Kiln Creek Bridge	89.5	91.1	91.8	92.3	92.5	92.7	92.7	93.3
River @ Burton St	88.7	90.2	91.0	91.5	91.6	91.7	91.8	92.2
Tarangle Creek @Ross St	89.7	91.3	92.1	92.6	92.8	92.9	93.0	93.7
River @ Lawson Syphon	90.7	92.1	92.7	93.2	93.4	93.6	93.7	94.7
River @ Boggy Creek Rd	88.3	89.8	90.7	91.1	91.2	91.3	91.3	91.7

Note: Gauge Zero: 82.43 mAHD

- The 20% AEP flood event does not spread far beyond the main channel of the river, except for several flood runners becoming active. For example Brick Kiln Creek transmits flow during the event, as well as Tarangle Creek and other small flowpaths.
- The 10% AEP event covers more of the high flow area (the vegetated areas adjacent to the floodplain), including a large section east of Carew St. The Davidson Street levee is not overtopped, however the caravan parks immediately upstream of the National Bridge and at McLean Beach are inundated.
- The 5% AEP event breaches the Davidson Street levee and spreads over the remaining high flow area, making the inundated area a flowpath running in the north-west direction. The Davidson Street Levee is overtopped by 0.1 m at a single point, where the levee elevation dips slightly. The 5% event also overtops the river banks immediately east of the end of Ochtertyre Street, spreading in a SE direction up until the levee, to a depth of around 0.2 m.
- The 2% AEP event inundates significantly more area than the more frequent events, as the water extends out of the high flow area and slowly spreads over the flat pastoral land, mostly downstream of the township. The Davidson Street levee is overtopped in several areas by up to 0.6 m, and the area is almost completely inundated at the flood peak. Almost all of the North and South Deniliquin levees are withstanding water at the flood peak, except for three localised low points where the North Deniliquin levee is overtopped.

- The 1% AEP flood peaks at 92.3 mAHD at the National Bridge and 92.5 mAHD at the location of the town gauge. The South Deniliquin levee is not overtopped, but much of the Davidson Street area is inundated, and the North Deniliquin levee is breached at several points.
- The 0.5% AEP event has a flood extent not dissimilar to the 1% AEP event, and is around 0.15 m higher across the Study Area. The event inundates a section of land immediately south of the Mulwala Canal, flowing from west of Lawson Syphon up until Wirraway Drive. However, this inundation is dependent on the culverts beneath the Canal and also beneath the Cobb Highway, and as such will be quite different under a scenario where culvert blockage exists.

- The 0.2% AEP event has a very similar flood extent to the 0.5% AEP event, however extends north between Mooney Swamp Road and Conargo Road. In South Deniliquin, the flood extent reaches further west towards the airport. Levels are typically 0.05 m to 0.1 m higher than in the 0.5% AEP.
- The PMF event inundates almost the entire Study Area, as water spreads out from the main channel, including both sides of the Mulwala Canal. At the peak of the event, most of the Study Area is inundated to a depth of between 1 m and 3 m.

3.3. Travel Time

According to the Local Flood Plan (Reference 14), there is one to two weeks' time between a flood-producing flow leaving Hume Dam and the flood peak occurring in Deniliquin. The long warning time is a result of the large catchment area upstream of Deniliquin, and the well-developed system of gauges and flood forecasting systems in the Murray River catchment.

Table 5 below is an excerpt from Table 2 in Annex A of the Deniliquin – Conargo Local Flood Plan (Reference 14) and provides an indication of flood travel times based on past flood events in the area.

Table 5: Indicative Flood Travel Times (Reference 14)

Water Course	From	To	Time Taken	Comments
Murray River	Hume Dam	Tocumwal	4.5 days	
	Tocumwal	Edward River Offtake	5.5 days	
Edward River	Tocumwal	Deniliquin	3.5 – 4.5 days	Via Tuppal and Bullatale Creeks (NOTE: This time was reduced to 31.5 hours in the August 1990 event with forests fully flooded beforehand).
	Tocumwal	Deniliquin	5 days	Via Murray and Edward Rivers
	Deniliquin	Moulamein	8 days	

3.4. Rate of Rise

The rate of rise of floodwaters is typically slow, with a gradual increase in river levels over the weeks preceding the flood peak. As with travel time, the slow rate of rise is a result of the very large catchment upstream of Deniliquin. Analysis of flood events for which data is available shows that the average rate of rise in the two weeks preceding the flood peak is 0.3 m per day, and as low as in 0.1 m for the July 1931 and July 1956 flood events. Table 6 gives the average and maximum rate of rise for the two weeks prior to the flood peak for eight historical events. River water level was taken from gauge no. 409003 ('Edward River @ Deniliquin').

Table 6: Average and Maximum Rates of Rise for Historical Events

Flood Event	Rate of rise (m/day) in lead up to flood peak	
	Average	Maximum
Sep 1889	0.3	0.9
Oct 1917	0.3	0.5
Jul 1931	0.1	0.3
Aug 1939	0.3	0.6
Sep 1955	0.3	0.6
Jul 1956	0.1	0.2
Nov 1975	0.3	0.6
Oct 1993	0.3	0.6

As described in the Flood Study (Reference 2), the rate of rise in design events is based on an idealised hydrograph from a single historical event. The 1993 shape was selected for the Flood Study as it was most representative of the river, being one of the most recent significant events and having a typical shape with a long rising limb leading up to the peak. It should be noted that the actual rate of rise can be faster or slower in actual events. The event the hydrograph shape was based on has an average rate of rise (in flood level) of 0.3 m per day in the 7 days leading up to the peak, and a maximum rate of rise of 0.6 m per day.

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4. ASSESSMENT OF FLOOD RISK

4.1. Overview of Flood Risk

Flooding in the Study Area is characterised by long duration events that inundate large areas of riparian vegetation and spread across the higher, more urbanised areas in large flood events. In a large flood event, the majority of flow is contained in the main channel of the Edward River, with velocities of 1.5 to 2 m/s and depths of 8 to 12 m. Outside of the main channel in the riparian zone, flowpaths are less defined and velocities are around 0.1 to 0.3 m/s, and depths are around 1 to 2 m in a large event. In cleared areas beyond the riparian zone, such as Davidson Street, velocities are generally less than 0.1 m/s and depths less than 1 m (if inundated at all).

Variation in flood risk across the Study Area is dependent on the functioning of the various formal and informal levees. Most urbanised areas are protected by a levee which reduces flood risk in an event that does not overtop the levee, which corresponds to floods of 1% AEP and less for the majority of the town. When an area’s levee is overtopped (or at high risk of overtopping), the effects of flooding are greatly increased, with inundation, isolation and possible destruction of residential properties and other buildings, flooding of roads and significant risk to life. For areas outside the levee system, flood risk is comprised of isolation in small flood events and above-floor inundation and destruction of property, as well as roads and other infrastructure. The long duration of flood events also means that flood risk exists for areas that may not become flooded during the event but must be evacuated due to isolation, such as the Davidson Street area and North Deniliquin.

The following sections describe the different components of the area’s flood risk.

4.2. Hydraulic Hazard

Provisional hazard categories were produced for two design events (5% and 1% AEP) in the Flood Study (Reference 2). The two categories of hazard shown in the figures (high and low hazard) are used to inform the management of flood risk in the Study Area, as they describe the severity of the flood at a certain location in terms of its depth and velocity. The provisional hydraulic hazard categories determined here are based on the method prescribed by the Floodplain Development Manual 2005, Appendix L.

All figures showed that the area of high provisional hazard is fairly continuous, following the main channel and the high flow zone. Areas of low provisional hazard are located on the fringe of the high flow zone in the 5% AEP event, and the wider floodplain in the 1% AEP event. The 1% AEP also contains large areas of high hazard on the floodplain away from the main channel; these correspond to either small flood runners on the floodplain where the water is slightly deeper than surrounding land, or areas where floodwaters have pooled due to the embankments of roads and canals impeding the movement of flow.

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4.3. True Hazard

While the Flood Study (Reference 2) defined the provisional hydraulic hazard, the current study has undertaken an assessment of a range of factors to determine the true flood hazard. The Flood Study (Reference 2) found that in the 1% AEP event, high provisional hydraulic hazard corresponded to virtually all of the riparian zone, as well as most of the Davidson Street area and pockets of deeper inundation away from the riparian zone. However, the hazard categories are limited to considering depth and velocity across the Study Area. To assess the true flood hazard all adverse effects of flooding have to be considered. As well as considering the provisional (hydraulic) hazard it also incorporates other criteria such as threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production and those detailed in Table 7. The true hazard for the 5% AEP event and 1% AEP event are shown on Figure 4 and Figure 5 respectively.

Table 7: Flood Hazard Factors

Criteria	Weight [1]	Comment
Size of the flood	Medium	The size or magnitude of the flood can affect depths and velocities. Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation. In Deniliquin, small events are relatively benign and flooding is contained in the riparian zone. For large floods, flooding occurs outside the levees (e.g. Davidson Street, various caravan parks) and potentially in North Deniliquin. Events much larger than the 1% AEP can cause massive damage as virtually the entire Study Area is inundated.
Depth and velocity of floodwaters	Medium	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event. Generally at Deniliquin, flow in most areas is deep with low velocity. Hazardous depths and velocities are well-represented by the provisional hydraulic hazard.
Rate of rise of floodwaters	Low	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events. At Deniliquin, the rate of rise is quite slow due to the flat topography and very large catchment size. Deniliquin typically experiences an average rate of rise (in flood level) of 0.3 m per day in the 7 days leading up to the peak, with a maximum rate of rise of 0.6 m per day.
Duration of flooding	High	The greater the duration of flooding the more disruption to the community and potential flood damages. A short period of inundation may allow some materials to dry and recover whereas a long duration may cause damages beyond repair. At Deniliquin the flooding duration is relatively long, with flood events typically lasting several days or even weeks. This means timely evacuation is critical, as residents who elect to stay at home and 'wait out the flood' can be left without enough food or water to last the duration of inundation, and often require rescue.
Effective warning and evacuation time	Low	This is dependent on the rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act. With a warning time of 7-10 days, Deniliquin residents are generally given sufficient time to receive a warning, prepare for an evacuation and to safely evacuate, including relocating possessions to minimise damage.

Criteria	Weight [1]	Comment
Flood awareness and readiness of the community	Medium	The community of Deniliquin has a degree of flood awareness but it is likely to be limited to those people aware of the more recent events. Recent flooding events and community consultation undertaken as part of the current flood risk management process (of which this report forms part) has raised awareness of the flood problem. However, sufficient lack of awareness likely exists, due to the time elapsed since the last major flood. The last major flood (greater than 9.2 m at the gauge) was in 1956 and this was approximately a 2% AEP event. Virtually no resident of Deniliquin has experienced a 1% AEP flood in the area. It is likely that the effect of a 1% AEP flood (e.g. flooding in North Deniliquin, overfloor flooding of approximately 400 properties) is not widely known or understood. It should be noted that the levee system may also contribute to an overstated sense of security, which especially in the Davidson Street area may have serious implications for evacuation.
Effective flood access	Medium	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication. Given the long warning times, evacuation generally occurs over a number of days and can be staged so as to minimise the number of road users at any one time. However, where evacuation is required from North Deniliquin, there is a risk that an order will not be heeded until the risk to the area is imminent at which point Davidson Street will be completely flooded. This reliance on Davidson Street as an evacuation route inhibits effective flood access for North Deniliquin.
Evacuation problems	Medium	Evacuation problems could also be exacerbated by the time of day during which flooding occurs. For example flooding overnight may be more difficult for residential areas. The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. Mobility of people, such as the elderly, children or disabled, who are less likely to be able to move through floodwaters and on-going bad weather conditions is a consideration. Despite having a long warning time and evacuation notice, if the flood warning is underestimated residents may not feel the need for or urgency of evacuation, which could complicate evacuation arrangements closer to the flood event. The false sense of security offered by the Davidson Street Levee may also contribute to a lack of urgency felt by residents of the Davidson St area.
Type of development	Medium	The type of flood prone development will to some degree correspond to the level of occupant awareness, mobility of people as well as population density. Longer term home owners would likely have a better level of flood awareness than a guest at a hotel while residents from an residential care home are likely to be less mobile than average. Key concerns in Deniliquin are the caravan parks (McLean Beach and Riverside), which are among the first locations to be inundated and are also home to elderly residents.

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Criteria	Weight [1]	Comment
Additional Concerns	Low/ medium	The impact of debris in overland flow flooding is unlikely to be a significant factor due to the low flood depths and/or velocities. However, there is always concern over floating debris causing injury to wading pedestrians or structural damages to property. This could affect people evacuating homes in the Davidson St Area. Floating debris, vehicles or other items can increase hazard. In the Edward River and Brick Kiln Creek where velocities are high, large debris can block structures, such as the National Bridge, causing damage and increases in flood levels upstream of the blockage.

[1] *Relative weighting in assessing the hazard for Deniliquin determined by interrogation of Reference* 2 *results*

Several minor amendments have been made to increase the hazard classification of provisionally low hazard areas totally surrounded by high hazard areas for the 1% AEP event. The only substantial area upgraded to high hazard is North Deniliquin as it is cut off from South Deniliquin in the 1% AEP event (as Davidson Street is inundated), affecting access and evacuation routes. Other concerns listed in the above table did not warrant any further changes to develop the true hazard classification.

4.4. Hydraulic Categories

Hydraulic categories describe the flood behaviour by categorising areas depending on their function during the flood event, specifically, whether they transmit large quantities of water (floodway), store a significant volume of water (flood storage) or do not play a significant role in either storing or conveying water (flood fringe). As with categories of hazard, hydraulic categories play an important role in informing floodplain risk management in an area. The hydraulic categories determined for the Study Area are shown on Figure 6.

The Flood Study (Reference 2) details the methods used to determine the floodway at Deniliquin. The study used a combination of the method proposed by Howells et al (Reference 12) and consideration with an encroachment analysis. Using different depth and velocity thresholds, different definitions of floodway were tested for the implications of fully developing the corresponding flood storage area. That is, for a particular floodway, the flood storage area was blocked out to approximate development, and if the reduction in conveyance resulted in an increase of greater than 0.1 m on existing flood levels, the floodway area was increased. Once the floodway area was determined, the remaining area was categorised as either flood storage or flood fringe, depending on if the flood depth was greater or less than 0.7 m, respectively.

As a check, the percentage of flow conveyed by the designated floodway was measured at different sections of the floodplain. It was found that at the peak of the 1% AEP event, the area designated as floodway conveyed 97% of the flow at the National Bridge (with 3% of the flow passing outside the floodway, through North Deniliquin and to the north-east. Similarly, the floodway at Lawson Syphon conveyed 99% of the flow, and the floodway at Boggy Creek Road took 92%. Overall, the floodway conveyed more than 90% of the flow passing through the Study Area, and up to 99% in some sections.

The floodway's conveyance of the majority of the flow (in some sections, virtually the entire flow) is indicative of the topography of the floodplain around Deniliquin and the way in which it conveys floodwaters. The area between the established flood runners and the river (which is well approximated by the 5% AEP flood extent) conveys the majority of the flow, even in rare events. This is due to the remaining floodplain being extremely flat and having very few water courses. While 80% (of total flow) has been used to determine floodway in other studies, the floodplain's topography and built environment around Deniliquin allows no selection of a floodway that conveys 80% of total flow, while also satisfying the aforementioned encroachment analysis.

4.5. Existing Floodplain Management

4.5.1. Levees in Deniliquin

The town of Deniliquin is located on either side of the Edward River and is protected on both sides of the river by an extensive levee structure. The location of the levees is shown on Figure 7. With regards to the levee system, there are three separate zones of flood risk in Deniliquin:

1. *North Deniliquin*, located on the north side of the Edward River and Brick Kiln Creek,
2. *Davidson Street*, a developed area of land bounded by the river and Brick Kiln Creek, and
3. *South Deniliquin*, the main part of the town, located on the south side of the Edward River.

4.5.1.1. Levee Overview

The three levees (surrounding the aforementioned three areas of the town) act to confine the floodwaters to the riparian zone between North and South Deniliquin. In addition, the Davidson Street levee acts to keep flows in Brick Kiln Creek and the main channel, until it is overtopped and water flows over Davidson Street. Some development also exists between the levee system and the river, for example Mclean Beach Caravan Park and Memorial Park, and these areas experience more frequent inundation. Both the North and South Deniliquin levees have been recently upgraded and are well maintained; and considered to be structurally sound. The structural quality of the other levees in the Study Area are unknown; particularly the Davidson Street levee which was identified in the 1984 study (Reference 4) to be of low structural quality and ongoing maintenance has not be undertaken since.

The North Deniliquin levee is of concrete wall and earthfill embankment construction and has a design crest level generally equivalent to the 1% AEP event + 0.1 m freeboard based on Reference 4. The suitability of this freeboard is discussed in Section 8. The South Deniliquin levee comprises both earthfill embankment, concrete crib wall and reaches of concrete wall (some removable for visual amenity) and generally has a crest level of the 1% AEP level + 0.5 m freeboard. The Davidson Street levee also comprises both earthfill embankment and sections of concrete wall, and restricts flow through the area for events smaller than a 10% AEP event once an appropriate freeboard is applied. The levee around the Davidson Street area is not an official levee, is not maintained by Council and has been found to be structurally inadequate. A number of mitigation options to address these issues are investigated in Section 9.3.8.

There are minor levees that protect the Deniliquin Riverside Caravan Park and McLean Beach Caravan Park. They are not considered in this section as they only provide protection to small localised areas in relatively frequent events (less than 10% AEP), however they are included as flooding hotspots and considered in the proposed mitigation options in Section 9.4.

4.5.1.2. Levee Freeboard Requirements

A levee freeboard assessment has been conducted in Section 8 and has determined the appropriate freeboard for levees in Deniliquin to be a minimum of 0.5 – 0.6 m. This is the minimum height the levee crest should be above the flood level against which it is designed to protect. Levee freeboard is calculated based on several factors, including model uncertainties, wave action, settlement of earth embankments and defects, as well as anomalies and the effect of climate change. The following sections briefly describe each of the levee systems, its intended design level of protection and its actual current level of protection and the reasons these may differ.

4.5.1.3. South Deniliquin Levee

The upstream end of the South Deniliquin Levee begins at the intersection of Lawson Syphon Road and Carew Street. The earthfill embankment runs parallel to Carew St before heading north through to the golf course. At the rear of Mathews Park the levee becomes a concrete wall and continues until Crispe St, where there is a short segment (41 m) of concrete crib wall (with earth fill). The earth levee continues from here until just before the bulkhead gate at Memorial Drive. At this point the concrete wall begins and continues along Sanctuary Lane. Approximately 150 m upstream of the National Bridge the concrete wall finishes and earth embankment continues to just beyond the bridge, changing to concrete crib wall at Charlotte Street. There is a 225 m section of concrete crib wall until it meets Hardinge St and returns to concrete wall construction. The concrete wall follows Riverside Rd around, and after a 160 m section of crib wall between Macauley St and Tennis Lane, the concrete wall continues behind the McLean Beach Caravan Park along the river until just after Burton Street. Earthfill embankment then continues for another 3.98 km, finishing at the southern end of Wyatt Street.

Figure 8 shows the height of various design flood events compared to the South Deniliquin crest level. To determine the levee's level of protection, the required freeboard is a minimum of 0.5 – 0.6 m (as determined in Section 8) is subtracted from the crest level. This is represented by the 'levee design height' on the figure. As shown, the upstream half of the levee, from Carew Street to around Butler Street, is around 0 to 0.2 m below the 1% AEP level, and has a low point at the east end of Duncan Street with freeboard of only 0.29 m. This is due to minor changes to the design flood level between the 1984 study (Reference 4), which was used for the levee design, and the recent Flood Study (Reference 2). Minor upgrades to rectify these deficiencies have been recommended as part of ongoing levee maintenance in Section 9.4.5. There is a section adjacent to Carew Street and the State Forest which has a design freeboard of 1 m, based on the 1984 study (Reference 4). During construction this freeboard was revised down to 0.5 m for the remainder of the levee. Figure 8 also shows the spillway in the last ~3.2 km is too high, and should be lowered to effectively operate as a spillway. This is also modelled and described in Section 9.4.5.

4.5.1.4. North Deniliquin Levee

The North Deniliquin Levee comprises sections of high ground and three distinct levee sections. The largest levee section is 4.7 km of earthfill embankment construction around the rear of North Deniliquin, beginning at Melon St and heading north to Charles St. It roughly follows Charles St until Hyde Street, where it turns and follows Hyde St northeast before turning to the northwest and running behind properties on the north side of Augustus Street. It then follows Augustus St to April St, where it turns and heads southwest back towards the river. There is a short amount of levee embankment between April St and Smart Street where this section of the levee ends. The section of levee between Coborro and Wanderer Streets has a design freeboard of 1 m. During construction this design freeboard was revised down to 0.1 m for the remainder of the levee.

There is a short (280 m) section of concrete wall starting about 50 m upstream of Short St, running northwest behind the service station on the corner of Victoria and Davidson Streets, then continuing northwest parallel to Victoria St until Boyd St.

The third section is designed to protect waterfront houses along the Edward River. An earthfill embankment starts at the river end of Hyde St, and cuts down to the river to the boundary of 308 River Street. The concrete wall continues through the backyard of number 306, stopping just inside the boundary of 304 River St. The levee returns to earthfill embankment constructions and continues along the river bank until 258 River St, approximately halfway between Yarra St and Coborro St. The levee alignment with its construction type is shown on Figure F2 in Appendix F.

The North Deniliquin crest level is compared to the various design flood levels in Figure 9. Unlike South Deniliquin, the crest level is below the current 1% AEP flood level for large sections, specifically upstream of Brick Kiln Creek on the river side, at Brick Kiln Creek Bridge and near Smart Street on the river side. As discussed in the recent flood study, this is due to three factors:

1. The revision in design flood behaviour had significant changes around Brick Kiln Creek as the high curvature of the river across the floodplain was not previously accounted for in setting the levee design height. This resulted in a higher flood level upstream of Brick Kiln Creek.
2. There are localised dips in the levee where erosion or other degradation has taken place.
3. The low design freeboard used for the majority of the North Deniliquin levee design (0.1 m) means small revisions to the flood level can have large implications for the structure's level of protection. The freeboard assessment (Section 8) has determined a more appropriate minimum freeboard to be 0.5 - 0.6 m.

Assuming the 0.1 m design freeboard, the levee's design height is between 0.1 and 0.3 m below the current 1% AEP flood level on the river side of the structure. If a 0.5 m freeboard is applied, the levee design height is below the 1% AEP flood level by around 0.5 m for much of its length, and 0.2 m-0.3 m below a 2% AEP event. Therefore the level of protection offered by the current levee is less than a 2% AEP. It should be noted however that there was a revision of the levee freeboard during construction (as there was for the South Levee), and there is a stretch of levee with a 1 m design freeboard between Coborro Street and Wanderer St as shown in Figure 9.

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4.5.1.5. Davidson Street Levee

Figure 10 shows the same comparison for the Davidson Street levee, which is an informal levee not maintained by Council. As mentioned previously, the 1984 study (Reference 4) found that the levee was structurally inadequate and that there was risk of failure from slumping and/or piping under flood conditions. Without this occurring, the levee design height is at approximately at the 10% AEP flood level, once a freeboard of 0.5 m is applied. Assuming the levee is not further modified during a flood event, and that there is no structural failure, it will inhibit flow during a 10% AEP event and likely be overtopped in a 5% AEP event.

4.5.1.6. Deniliquin Levee Bank: Levee Owners Manual (October 2014)

The Levee Owners Manual has been prepared by the NSW Department of Public Works for the former Deniliquin Council (now Edward River Council). The Manual contains instruction on levee inspections, maintenance and operation during flooding. It states that it is the responsibility of the Director Technical Services, Deniliquin Council, to implement the requirements of the Inspection and Maintenance aspects of this Manual.

The Manual contains a detailed description of the North and South Levees and the actions required for operation of non-permanent elements during a flood. A summary of those items that need to be “operated” or “closed” in order for the levee to function as designed is provided in Table 8. The flood height at which these actions are required is listed in Appendix B of the Manual.

Table 8 Summary of Levee Elements

Item	Location(s)	Installation Notes
2 x Lift Bulkhead Flood Gates	Butler Street Junction Street	To be installed by forklift or crane.
1 x Sliding Flood Gate	Near intersection of George Street and Edward Street	Winch and Guide Pole are located in the Levee Shed at the Council Depot.
Removable Panels	Several Locations	Stored in the Levee Shed at the Council Depot.
Stormwater gate valves	Numerous Locations	Keys for gate valves (and fence gates) stored at Council Depot.
6 x Earth Stockpiles	**North Deniliquin** 1. Hay Rd and April St 2. Conargo Rd 3. Finley Rd **South Deniliquin** 1. Lawson Syphon Ro and Carew St 2. MaCauley St and Riverside Dr 3. Wakool Rd and Racecourse Rd	Earth stockpiles are to be placed across roads with a crest level approximately at the design flood height (100 year ARI equivalent to 1% AEP).

4.5.2. Flood Warning System

The large catchment area and the long history of flooding mean there is a well-developed warning system in place in Deniliquin. With a warning time of 7-10 days, Deniliquin typically is well prepared for flooding and evacuation. The Deniliquin-Conargo Local Flood Plan (a Subplan of the Deniliquin-Conargo Local Disaster Plan (DISPLAN) June 2009 (Reference 14) describes the emergency response in the lead-up, during and after a flood event. Section 3.10 of this document details the warning system, which coordinates the delivery of warnings to the community by door-knocking, telephone, mobile public address systems, local radio stations and two-way radio, as well as providing confirmation of evacuation actions.

As an example, the first evacuation warnings issued in the former Deniliquin and Conargo Shire Councils are when the Deniliquin gauge is expected to reach the following heights:

- Davidson Street (Central area), Northern Deniliquin and Riverside Caravan Park – 7.00 m Deniliquin gauge.
- McLean Beach Caravan Park – 8.30 m Deniliquin gauge
- Deniliquin proper – 9.20 m Deniliquin gauge

The Deniliquin- Conargo SES Unit also has a Facebook page, on which it posts storm warnings and advice for residents. This is a powerful tool, however relies on residents a) having Facebook and b) regularly checking it for posts from the SES. Further description of the warning system and recommendations is provided in Section 9.3.6.

4.6. Impact of Future Development

There is little development pressure in Deniliquin and future development is unlikely to have any significant adverse impact on broad flood behaviour. Typically, development in a catchment has the effect of increasing the proportion of impervious surface area, which increases runoff rates, and creating new obstructions to flow paths. Given the wide extent of flooding in Deniliquin, the fact that the floodwaters originate far upstream, it is considered that development of currently vacant land with appropriate controls would have minimal impacts on the area's flood behaviour.

It should also be noted that further development may involve filling in the floodplain for the construction of house pads. At the current scale, this is also thought to be negligible in the context of the widespread flooding Deniliquin experiences. While future development may not affect broader flood behaviour, access to newly developed areas during flood events will be a key issue and should be considered during the planning phase especially in regards to evacuation. The Davidson Street area in particular is not suited to future development as it is located in the floodway and hence a high flood risk area. Controls pertaining to this area and wider floodplain development have been recommended in Section 9.3.

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4.7. Flooding Hotspots

Description of the flood affectation is given for identified flooding hotspots across the Study Area, including description of development, affectation in different sized floods including reference to the gauge level, and description of the true hazard and hydraulic category. The hotspots' locations are shown on Figure 11. Note that all references to gauge heights are based on modelling results from the flood study (Reference 2) and are limited by the model accuracy. Small dips or other changes to levees will significantly affect their overtopping behaviour if they are not captured in the survey data used to create the model.

4.7.1. Caravan Park on Davidson Street

The site is located on the north bank of the Edward River just east (upstream) of the National Bridge, and is occupied by Deniliquin Riverside Caravan Park at the time of writing. According to the local flood plan (Reference 14), it has a total occupancy of approximately 360 people (87 sites x 4 people per site), with 37 powered camp sites, 15 unpowered camp sites, 11 cabins, 24 caravans and fixed/rigid annexes.

When water reaches 7.30 m on the Deniliquin gauge, vans occupying annual sites outside the Park levee begin to be affected. Most are elevated but access is soon lost. In the 10% AEP event water moves north from the river through the drainage path between the two caravan park levees. At 7.74 m (90.17 mAHD) water overtops the mid-section of the park just south of the levee. At 8.23 m (90.66 mAHD) the lower part of the caravan park (on the river side) is completely inundated.

True hazard in the hotspot is 'high' in the 5% AEP event and 'high' in the 1% AEP event (see Figure 4 and Figure 5), largely due to the depth of flooding over the site and its proximity to the main channel. It is classified as Floodway in the 1% AEP hydraulic categorisation.

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4.7.2. Caravan Park at McLean Beach

The site is located on the left bank of the Edward River downstream of the National Bridge and is occupied by the McLean Beach Caravan Park at the time of writing. It has a total occupancy of approximately 1500 people (389 sites x 4 people per site), with 218 annual sites, 10 unpowered sites, 11 cabins, 14 permanent sites (caravan and rigid annex) and 126 casual camp sites.

A review of the SES Flood Intelligence Card and the former Deniliquin Council Flood Response Plan (South Levee) noted that at gauge height 4.70 m water enters low lying areas of the park. At gauge height ~5.84 m the McLean Beach sewerage pump station is inundated, and at 7 m the caravan park is to be closed in accordance with lease arrangements. Once inundated, access to and from individual sites within the park may be lost. McLean Beach Caravan Park is partially enclosed by an informal levee with a crest level equivalent to 90.7 mAHD at the gauge, just below the 10% AEP design height. The levee includes a removable gate which is to be closed when flood waters reach Gauge Height 7 m, which may have implications for the evacuation of the park. This is discussed further in Sections 4.7.2 and 9.4.8. The levee is not maintained by Council and its structural integrity is not known. Modelling suggests it was overtopped in the 1993 event but this has not been confirmed.

The flood risk at the site largely arises from the inundation of permanent sites and the lasting effects on the park's residents. It has been noted in the SES Flood Intelligence Card that evacuation of the relocatable cabins would require cranes and take 2-3 hours preparation time each. Inundation of permanent sites will incur an economic cost from structural damage, ranging from damage to the exterior and foundations to complete loss of the structure in a large flood. The impact on the powered and unpowered sites that are not permanently occupied is relatively minimal, and may have greater effect as loss of business for the park. Evacuation issues are also more likely for residents, who would have less desire to leave than holiday-goers, who have less impetus to stay.

True hazard in the hotspot is a mix of 'high' and not flooded in the 5% AEP event and 'high' in the 1% AEP event (see Figure 4 and Figure 5), largely due to the depth of flooding over the site and its proximity to the main channel. It is classified as Floodway in the 1% AEP hydraulic categorisation.

4.7.3. Davidson Street Area

As described in the Flood Study, the Davidson Street area is located north east of the National Bridge and contains around 100 residential and commercial properties. During a flood event, the water initially surrounds the area but is lower than the informal levee which surrounds the area.
Water approaches the Davidson Street area through the Riverside Caravan Park and water moving north from the river towards Davidson St at Herriot St. Davidson St acts as a levee, causing water to build up on the east of the road, inundating properties between Jones Ave and Morris St. Davidson Street itself is overtopped when the gauge reaches 9.62 m, between Evans St and Hodgkins St, and flow inundates the downstream side of Davidson St. Once the water reaches this area, the area becomes part of the floodplain, transmitting the flow of the river.

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In the 1% AEP event, the entire Davidson Street area is inundated at the peak flood level, with approximately 0.75 m of water over Davidson St and between 0.5 – 1.5 m of water depth on properties either side of the main road.

The flood risk in the area relates to the area's use as a thoroughfare for the town, and to the inundation of residential and commercial properties. Davidson Street is the main route for traffic between North and South Deniliquin, as well as a portion of the highway traffic passing through Deniliquin. There is significant risk of a vehicle or pedestrian using the road once the road is overtopped and becoming swept away, possibly due to misjudging the hazard. The street is particularly important if North Deniliquin is ordered to be evacuated, in which case residents may attempt to use the road after it is safe to cross (which would be well after the evacuation order is given). Secondly, properties in the Davidson Street area are at risk of structural damage due to flooding, and of becoming uninhabitable for the weeks or months after a flood. The number of properties estimated to be inundated above floor in a 5% AEP event is 31, while the 1% AEP event has 89.

True hazard in the hotspot is a mixture of 'low' and 'high' in the 5% AEP event and 'high' in the 1% AEP event (see Figure 4 and Figure 5), largely due to the depth of flooding over the site and the hazardous flow over the main thoroughfare (Davidson Street). It is classified as Floodway in the 1% AEP hydraulic categorisation.

4.7.4. North Deniliquin

Located on the north side of the Edward River and Brick Kiln Creek, the North Deniliquin area is defined by the area enclosed by the North Deniliquin levee, as shown on Figure 7.

The levee is first overtopped at Box Street a gauge height of 9.77 m. Subsequently, the levee is overtopped at Davidson St when the gauge reaches 9.85 and thirdly just south of Smart St at gauge height of 9.91 m. The locations of overtopping are shown on Figure 9 and Figure 12. Once overtopped, water spreads to the north east where it is bound by the northern-most levee. At the 1% AEP peak, virtually all of North Deniliquin is inundated save for properties along the west side of Victoria St between Davidson St and Browning St, both sides of Victoria St up to Robinson St, and properties along the east side of Victoria St from Robinson St to just west of Stirling St.

At the time of writing, evacuation is required for North Deniliquin if the area is isolated by floodwaters, which occurs once Davidson Street is overtopped. It is understood that this is due to the cutting of sewerage infrastructure, which makes the area uninhabitable, in addition to the lack of food and supplies. This means that the area may be evacuated even if it is not forecast to be flooded. As described previously, Davidson Street is overtopped at a gauge height of 9.62 m, but this may be less if the Davidson Street levee fails. There is a risk that the dangers associated with remaining in North Deniliquin during isolation are underestimated, and hazardous evacuation is attempted when Davidson Street is inundated, or rescues must be made.

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Asides from the evacuation risk, flood risk in the area is related to the long duration inundation of property and hazardous flow behaviour at levee overtopping points. While the velocity of floodwaters is low (<0.1 m/s in a large flood) the inundation is very widespread if the levee is overtopped for multiple days and the area would not be considered habitable. The number of properties inundated in a 1% AEP event is 166.

The area is not flooded in the 5% AEP event and is classified as a mixture of 'low' and 'high' true hazard in the 1% AEP event (see Figure 4 and Figure 5). Areas of higher hazard are located towards the northwest end, where there is slightly greater accumulation of depth. The high hazard also relates to the evacuation issues for the area. It is classified as Flood Fringe in the 1% AEP hydraulic categorisation.

4.7.5. West Deniliquin

A flooding hotspot exists west of the South Deniliquin levee in the area north of Wakool Rd between the levee and Boundary St. The area is approximately 2 km^2 in size, and is zoned as Large Lot Residential, with approximately 80 properties in the area. In a large flood event, waters first enter the area through a lagoon/low lying area west of Blackett St. At 8.81 m at the gauge, water overtops Blackett St and slowly spreads towards the east. By a gauge level of 9.32 m, the small area between Harfleur Street and Poictiers Street is inundated to a depth of around 1.8 m. At this level, water also breaks over Gough St, and inundates approximately 5 ha to a depth of 0.05 m. By 9.55 m, flow has reached the wet side of the South Deniliquin levee on the eastern boundary of this zone, inundating an area of around 43 ha around Gough Street and a further 12 ha around Blackett Street. From here, water spreads to the south west, covering the entirety of the hotspot, save for a few properties on higher ground.

The flood risk in the area relates to inundation of property and risk of hazardous evacuation. Relative to the caravan park and Davidson Street hotspots, the area has little affectation, with minimal inundation in events smaller than a 2% AEP. However, in a 2% AEP event and larger, there is widespread inundation that gradually cuts off roads and inundates properties above and below floor level. Some properties have elevated floor levels and will be flood free in virtually all flood events. However, a significant duration of inundation (i.e. multiple days or more) will make the area uninhabitable. There is a risk that residents will not heed evacuation orders and only leave once the flood risk is more apparent, at which time roads will be cut and transport hazardous. Awareness of flooding is expected to be low in the area, given the most recent inundation was in the 1975 flood, pre-dating recent development in the area.

True hazard in the hotspot is mostly 'low' and not flooded in the 5% AEP event and a mixture of 'low' and 'high' in the 1% AEP event (see Figure 4 and Figure 5), largely due to the depth of flooding over the area. It is classified as Floodway in the 1% AEP hydraulic categorisation.

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4.7.6. Dahwilly

The ‘Dahwilly’ hotspot is located downstream of the main urban area in the riparian zone, generally north of the ‘West Deniliquin’ hotspot. The area is flood affected once the riparian zone adjacent to the main channel begins to be inundated, which can isolate properties in as low as a 10% AEP event. As described in the Flood Study, access roads are cut at a gauge height of 6.71 m, with increasing inundation and isolation above this height. In a 5% AEP event the riparian zone is completely inundated, with depths of around 0.5 to 1 m.

Development in the area is limited, with around 10 to 20 residential properties sparsely distributed along the river. Houses are generally built up, with some not being inundated above-floor in a PMF event (refer to Figure 13). Two properties are inundated above floor in the 5% AEP event, and six are flooded in the 2% AEP. As with other hotspots, a significant part of the area’s flood risk is evacuation after access roads begin to be cut. This is particularly true given the area has various unsealed roads, and an ad-hoc evacuation may not know which roads are cut or the available routes that are not inundated.

True hazard in the hotspot is mostly ‘high’ in the 5% AEP event and all ‘high’ in the 1% AEP event (see Figure 4 and Figure 5), largely due to the depth of flooding over the area and the evacuation constraints for the area. It is classified as Floodway in the 1% AEP hydraulic categorisation.

4.8. Overtopping of South Deniliquin Levee

Although the South Deniliquin levee is not overtopped in most flood events, it can be overtopped in very large floods and it is important that this risk is understood. In areas with levees, especially when they are recently built or upgraded, there is sometimes a community perception that the levee protects against all possible floods. With levees that protect against rare events, such as the 1% AEP event, it is possible that it will not be flooded to its crest level in a resident’s lifetime. However, the probability of different floods is such that the levee will inevitably be overtopped by a large enough flood. The certainty of this occurrence means the levee’s overtopping must be well understood and planned for.

Uncertainties in the estimate of the design flood level, which are accounted for by the levee’s freeboard (see Section 8), mean it is not possible to know exactly what AEP event will overtop the levee. For example, if a 1% AEP flow occurs, a worst-case combination of wind and wave setup, model uncertainty and levee settlement would result in the South Deniliquin being overtopped. The probability of this occurring is slightly greater for a 0.5% AEP event, and so on. Overtopping behaviour is therefore described for flooding that reaches a particular gauge height, rather than a particular design event. For reference, a comparison of the levee height to the various design flood events is shown on Figure 8.

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Overtopping of the South Deniliquin levee will occur at a gauge height of 10.42 m, at both Crispe Street and Edwardes Street at their north-east ends. The levee gradient is generally similar to the flood profile, and so multiple locations along the length of the levee will be overtopped within the following 24 hours, inundating the majority of the urban area. Flow will then be directed towards the north-west, following the general direction of the floodplain, until it is blocked by the spillway at the north-west end of the levee. This will then be overtopped and flow will be conveyed throughout the majority of the town. As with previous descriptions of overtopping, gauge heights are based on the hydraulic model and assume no unexpected structural failure of the levee.

4.9. Flood Emergency Response Classification of Communities

To assist in the planning and implementation of response strategies, the SES in conjunction with OEH has developed guidelines to classify communities according to the impact that flooding has upon them. These Emergency Response Planning (ERP) classifications consider flood affected communities as those in which the normal functioning of services is altered, either directly or indirectly, because a flood results in the need for external assistance. This impact relates directly to the operational issues of evacuation, resupply and rescue. Based on the guidelines, communities are classified as either; Flood Islands; Road Access Areas; Overland Escape Routes; Trapped Perimeter Areas or Indirectly Affected. The ERP classification can identify the type and scale of information needed by the SES to assist in emergency response planning (refer to Table 9).

Table 9: Emergency Response Planning Classifications of Communities

Classification	Response Required Resupply	Rescue/Medivac	Evacuation
High flood island	Yes	Possibly	Possibly
Low flood island	No	Yes	Yes
Area with rising road access	No	Possibly	Yes
Area with overland escape routes	No	Possibly	Yes
Low trapped perimeter	No	Yes	Yes
High trapped perimeter	Yes	Possibly	Possibly
Indirectly affected areas	Possibly	Possibly	Possibly

Key considerations for flood emergency response planning in these areas include:

- Cutting of external access isolating an area;
- Key internal roads being cut;
- Transport infrastructure being shut down or unable to operate at maximum efficiency;
- Flooding of any key response infrastructure such as hospitals, evacuation centres, emergency services sites;
- Risk of flooding to key public utilities such as gas, power, sewerage; and
- The extent of the area flooded.

Figure 14 shows the emergency response classifications for the Study Area. Further assessment is made as part of the review of the emergency response in the area in Section 9.3.5.

5. STAKEHOLDER CONSULTATION

5.1. Community Consultation

One of the central objectives of the FRMS process is to actively liaise with the community throughout the process, keep them informed about the current study, identify community concerns and gather information from the community on potential management options for the floodplain. The consultation programme consists of:

- Distribution of newsletter and questionnaire survey;
- The Floodplain Risk Management Committee;
- Edward River Council's website; and
- Public meetings

5.1.1. Previous Consultation

As part of the Flood Study (Reference 2), community questionnaire surveys were undertaken during June 2012 to gather historical data for model calibration. There were 124 residents who returned completed questionnaires, with almost all respondents being aware of flooding in Deniliquin, and some having experienced it personally. Approximately 20% of respondents had performed mitigation works on their property, including temporary works such as sandbagging. A handful of residents gave detailed descriptions of the flood extent during the 1956 event, describing the level the flood came to relative to their property, and mitigation measures taken at the time. The events in 1975 and 1993 were also referred to, as well as a general sentiment that no severe flooding had occurred recently. The three respondents who were not aware of flooding can be considered anomalous, with two of the three having lived in Deniliquin for less than ten years.

Out of the residents who responded, the number who experienced inundation was relatively low, given the history of severe flooding in Deniliquin. Two factors may have contributed to this; the low occurrence of extreme flood events in the last 50 years, and the ability of the levee system to mitigate flood events since its construction. The locations of the respondents suggested that the length of residency was a significant factor, with those who experienced flooding and had lived in Deniliquin for a long period, living adjacent to those who had not experienced it and had a shorter period of residency. Although the questionnaire did not refer to specific events, it can be concluded that Deniliquin has not been subject to major floods in the past 10-20 years, at least in the areas surveyed. Generally, respondents who were affected by flooding were in two areas – south-west of the golf course and between Edward River and Brick Kiln Creek.

5.1.2. Consultation as Part of this Study

Further community questionnaire survey work was undertaken during August 2015 to inform residents of the next stage of the floodplain management process as well as to gather flood information and community's preferred options for managing flood risks within the catchment. Copies of the newsletters and questionnaires were printed and delivered to the owners of approximately 4000 properties likely to be aware of flooding issues. In total 47 responses were received constituting a 1% return rate. The results are as shown in Figure 15 and the location of the respondents are shown in Figure 16.

Of those who responded, there was an 80% awareness rate of the Edward River at Deniliquin Flood Study. There were a low number of residents who were aware that their property was identified as being at risk of flooding or near flood areas. Of those residents who responded, only 20% of respondents were aware of their property being classified as flood prone, while a further 22% of respondents were unsure whether their property was flood prone or not. It is expected that results from the study exaggerate the flood awareness in the town, given that past experience indicates that those who are aware of flooding are more likely to engage in the community consultation process.

Among the preferred management options for managing flood risks within the catchment: improved flow paths, planning/development controls, education/awareness and forecasting/ emergency responses were the most popular. Amongst these controls, improving flood flow paths was the most popular. The least desired options were culvert/bridge enlargement, pit/pipe upgrades and levee upgrades. As part of the current study (see Section 9) several of the suggested options were tested for their effectiveness.

5.2. Floodplain Committee Meetings

The Floodplain Management Committee (FMC) oversees and assists with the floodplain risk management process being carried out within the Council Local Government Area. The committee is comprised of representatives from various stakeholder groups and includes local Councillors, emergency services (SES), and community representatives. Progress on the current study has been presented to the committee on three occasions, with further meetings to come. The NSW Office of Environment and Heritage is represented on the FMC and also provides Council with technical and financial support and advice during the course of the Study.

5.3. Public Exhibition

The draft Floodplain Risk Management Study and Plan was placed on public exhibition from the 19th of September 2016 to the 17th October 2016. Copies of the report were available at Council Chambers and the Deniliquin Library, as well as PDFs available online for download either by section or in its entirety. Two formal presentations were given by WMAwater staff at the Deniliquin RSL which were each attended by approximately 30 community members. The presentation covered the FRM process and described all the options that had been recommended in the Plan.

Community drop-in sessions were hosted by WMAwater in the Deniliquin Library during the first week of the public exhibition period. Community members had the opportunity to stop by and peruse the report and discuss proposed options with WMAwater staff. Animations of the modelling aided greatly in demonstrating how water moved through Deniliquin, and especially to demonstrate how Option FM12, Davidson Street Flowpath Improvement, functioned to improve flood levels in the area.

The following general impressions from the community presentations and drop in sessions were noted:

- Strong community support for removing vegetation in Brick Kiln Creek;
- General acceptance of the proposal to decommission the Davidson Street Levee, especially once the animation was shown;
- Interest from individuals regarding flood affectation at their property – these were addressed during the drop-in session;
- A number of drop-in visitors were interested in the historical flood photos, and spent time identifying childhood homes and recalling memories of past floods;
- At the time of public exhibition there was minor flooding in Deniliquin (which later turned into moderate flooding above a 10% AEP level). It is likely this contributed to heightened interest in the Draft FRMS&P.

Three formal submissions were received following public exhibition, described below in

Table 10 Public Exhibition Submissions

Ref	Author/ Organisation	Submission	Response
01	Deniliquin residents	Support for Voluntary House Raising scheme in the Jones Avenue/ Davidson Street area on the basis that it would be more economical than maintaining/raising the existing informal levee.	Voluntary House Raising is not appropriate in high hazard areas or the floodway, and has not been recommended in the FRMS&P. This is explained further in Section 9.2.4
02	NSW Local Land Services	Thanking Council for the opportunity to review the Draft FRMS&P however did not choose to provide a submission on this occasion.	Acknowledged.
03	NSW Department of Primary Industries	Reaffirmation of the need for all works scheduled to be undertaken on Crown land, road or waterway to be directed to the DPI through the Landowner's Consent process, and all required environmental assessments undertaken and consents provided.	Acknowledged.

6. ECONOMIC IMPACT OF FLOODING

Flood impact can be quantified in the calculation of flood damages. Flood damage calculations do not include all impacts or costs associated with flooding. They do, however, provide a basis for assessing the economic loss of flooding and also a non-subjective means of assessing the merit of flood mitigation works such as retarding basins, levees, drainage enhancement etc. The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including:

- The magnitude (depth, velocity and duration) of the flood;
- Land use and susceptibility to damages;
- Awareness of the community to flooding and how to respond;
- Effective warning time;
- The availability of an evacuation plan or damage minimisation program;
- Physical factors such as failure of services (sewerage), flood borne debris, sedimentation; and
- The types of asset and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed.

The assessment of flood damages not only looks at potential costs due to flooding, but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding. Figure 13 shows all properties in the Study Area that are flooded above floor in the PMF, categorised by the event in which they first experience over-floor flooding. This figure has been created based on a no levee failure scenario, while the damages are calculated assuming the levees fail in flood events greater than their design level of protection. This is discussed further overleaf.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis, by taking into account the probability of a flood occurrence. This means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

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6.1. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages. Direct damages are caused by floodwaters wetting goods and possessions thereby damaging them and resulting in either costs to replace or repair or in a reduction to their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees etc.

Given the variability of flooding, and property and content values, the total likely damages in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of little value for absolute economic evaluation. However, damages estimates are useful when studying and comparing the economic effectiveness of proposed mitigation options. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision making process.

In order to quantify the damages caused by inundation for existing development a floor level survey of 132 properties was undertaken in September 2015. The majority were in the Davidson Street area or downstream of town, south of the river. Surveyed areas were based on where properties were situated outside of the levee and therefore more likely to be flood prone. For remaining properties, estimates were made based on a combination of LiDAR data, visual inspection and comparison to nearby surveyed properties. For properties inside the south Deniliquin levee, a standard height above ground was assumed.

Each of these techniques has a different level of accuracy associated with the estimate, which is not quantified in the final estimate of economic damage cost for each property. The level of accuracy is considered suitable for two reasons. Firstly, the estimation of property damage due to flooding is inherently difficult to estimate, given the large variation in building types, their contents, the duration of flooding and other factors, and so the accuracy of floor heights should be in line with this accuracy. Secondly, the economic damages assessment is only intended to be used as an estimate of the Study Area-wide flood affectation, and not on a per-property basis.

The damages were calculated using a number of height-damage curves derived from OEH Guidelines (Reference 15) which relate the depth of water above the floor with tangible damages. These curves included points for the following events: PMF, 0.5%, 1%, 2%, 5%, 10% and 20% AEP events. The 0.2% AEP event was later run for the purposes of FPA assessment (described in Section 9.3.1, however this event was not incorporated into the damages assessment as it was expected to sit well on the existing curve and refine the outcomes of the damages assessment. Each component of tangible damages is allocated a maximum value and a maximum depth at which this value occurs. Any flood depths greater than this allocated value do not incur additional damages as it is assumed that, by this level, all potential damages have already occurred.

As North and South Deniliquin are protected by levee systems, these need to be considered when calculating damages. In accordance with OEH Guidelines, a properly constructed and maintained levee is considered to only offer protection against floods up to the magnitude of the design flood. For events larger than the design flood, the levee may be deemed to have failed, and therefore inundation of the protected area should be assumed. It should be noted that if failure were not to occur, the economic cost of flooding is likely to be much lower, however the purpose of this approach is to provide a conservative estimation of possible damages.

The failure of the two levees was modelled by lowering 100 m segments at both the upstream and downstream ends of each of the North Levee and South Levee to a height halfway between the mean 1% AEP flood level and the existing natural surface behind the levee.

Despite having been designed for a 1% AEP event, the insufficient freeboard and low spots mean the actual design level of the North Levee is below a 2% AEP event. It has therefore been assumed to breach in the 2% AEP event. The South Levee was designed for a 1% AEP event, however the Flood Study (Reference 2) has shown the levee freeboard to be insufficient in some locations (< 0.5 m), and therefore has been assumed to be breached in the 1% AEP event. In smaller events both levees are assumed to be intact.

The design flood information also assumes that the each event will not be affected by wind and wave setup, wave action, and other factors considered in the levee system’s freeboard. Apart from levee settlement or other degradation, the freeboard factors can act to make the flood level either higher or lower. For example, wind setup can cause the design flood to be either higher or lower than predicted as it comes up against the levee, depending on the wind setup. Assuming all factors would act to raise the flood level, which is the equivalent of removing the levee freeboard when making the flood damages calculations, would overestimate the effect of flooding for a particular design event, and therefore has not been included in this assessment.

Damages were calculated for residential and commercial\industrial properties separately and the process and results are described in the following sections. The combined results are provided in Table 11. This flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account flood damages to any basements or cellars, hence where properties have basements damages can be underestimated.

The database compiled for undertaking damages calculations including floor level information and design flood levels will be provided to Council as part of the handover information for this project. Note that the terminology used refers to a property or lot being the land within the ownership boundary. Flooding of a property does not necessarily mean flooding above floor level of a building on that property/lot.

Table 11: Estimated Combined (Residential and Commercial/Industrial) Flood Damages for Deniliquin Study Area

Event	No. Properties Affected[1]	No. Flooded Above Floor Level[2]	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP[3]	0	0	$ -	0	$ -
10% AEP	17	4	$ 694,000	1	$ 41,000
5% AEP	91	51	$ 4,372,000	4	$ 48,000
2% AEP	368	250	$ 23,517,000	14	$ 64,000
1% AEP	1993	1336	$ 100,958,000	20	$ 51,000
0.5% AEP	2505	1870	$ 138,172,000	20	$ 55,000
PMF	3739	3684	$ 359,597,000	41	$ 96,000
Average Annual Damages (AAD)			**$ 3,044,300**	**100**	**$ 810**

[1]'No. Properties Affected': there is flooding above ground level within the property boundary (ie the lot)
[2]'No. Flooded above floor level': there is flooding above the surveyed or estimated floor level of the house.
[3] There is inundation on the south part of a number of lots along the north bank of the Edward River, however the affectation is sufficiently far from the house or garages/sheds to warrant exclusion from the damages calculation.

The AAD estimate of $3.04 M is higher than expected for a large town situated on a major watercourse. This is due to the conservative approach to levee failure used to calculate damages. As described above, OEH recommends modelling a levee-breach scenario in events greater than the levee's design capacity. Therefore the number of properties affected is much greater than one would expect under a no-failure scenario. It is important to note that while the damages figure is highly conservative, it still shows the relative effects of different sized events, and provides a basis for comparing proposed mitigation options and calculating B/C ratios. The jump in flood affectation is shown clearly between the 2% AEP event and the 1% AEP event, with the number of affected properties increasing significantly from 368 to 1993, and over-floor flooding from 250 to 1336. This means that approximately 80% of properties affected in the 1% AEP are not affected in the 2% AEP event, let alone more frequent events.

The following sections provide a more detailed overview of the assessment for residential and commercial/industrial damages.

6.1.1. Residential Properties

Flood damages assessment for residential development was undertaken in accordance with OEH guidelines (Reference 15). For residential properties, external damages (damages caused by flooding below the floor level) were set at $6,700 and additional costs for clean-up as $4,000. For additional accommodation costs or loss of rent a value of $220 per week was allowed assuming that the property would have to be unoccupied for up to three weeks. Internal (contents) damages were allocated a maximum value of $67,500 occurring at a depth of 2 m above the building floor level (and linearly proportioned between the depths of 0 to 2 m). These estimated values are in line with what has been applied in other recent studies in New South Wales.

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Structural damages vary on whether the property is slab/low set or high set. For the purpose of this study, any property with a floor level of 0.5 m or more above ground level was assumed to be high set. For two storey properties, damages (apart from external damages) are reduced by a factor of 70% where only the ground floor is flooded as it is assumed some contents will be on the upper floor and unaffected and that structural damage costs will be less. In some instances external damage may occur even where the property is not inundated above floor level and therefore tangible damages include external damages which may occur with or without house floor inundation.

A summary of the residential flood damages for the Study Area is provided in

Table 12. Overall, for residential properties in the area there is a large difference in the average tangible damages per property between the frequent and rare flood events. This is reflective of the rarer floods, in particular the PMF, having a far wider flood extent than frequent events, and of these rare events being more costly, even after their rarity has been accounted for.

Table 12: Estimated Residential Flood Damages for Deniliquin

Event	No. Properties Affected[1]	No. Flooded Above Floor Level[2]	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP[3]	0	0	$ -	0	$ -
10% AEP	12	0	$ 43,000	0	$ 3,600
5% AEP	81	42	$ 2,930,000	3	$ 36,200
2% AEP	310	192	$ 14,966,000	12	$ 48,300
1% AEP	1791	1192	$ 81,976,000	21	$ 45,800
0.5% AEP	2252	1671	$ 113,175,000	21	$ 50,300
PMF	3289	3238	$ 284,623,000	43	$ 86,500
Average Annual Damages (AAD)			**$ 2,310,000**		**$ 700**

[1]'No. Properties Affected': there is flooding above ground level within the property boundary (ie the lot)
[2]'No. Flooded above floor level': there is flooding above the surveyed or estimated floor level of the house.
[3] There is inundation on the south part of a number of lots along the north bank of the Edward River, however the affectation is sufficiently far from the house or garages/sheds to warrant exclusion from the damages calculation.

6.1.2. Commercial and Industrial Properties

The tangible flood damage to commercial and industrial properties is more difficult to assess. Commercial and industrial damage estimates are more uncertain and larger than residential damages. Commercial and industrial damage estimates can vary significantly depending on:

- Type of business – stock based or not;
- Duration of flooding – affects how long a business (or access to it) may be closed;
- Ability to move stock or assets before onset of flooding - some large machinery will not be able to moved and in other instances there may be no sufficient warning time to move stock to dry locations (which is not the case in Deniliquin); and
- Ability to transfer business to a temporary location.

Costs to business can occur for a range of reasons, some of which will affect some businesses more than others dependent on the magnitude of flooding and the type of businesses. Common flood costs to businesses are:

- Removal and storage of stock before a flood if warning is given;
- Loss of production – caused by damaged stock, assets and availability of staff;
- Loss of stock and/or assets;
- Reduced stock through reduced or no supplies;
- Trade loss – by customers not being able to access the business or through business closure;
- Cost of replacing damages or lost stock or assets; and
- Clean-up costs.

No specific guidance is available for assessing flood damages to non-residential properties. Therefore for this Study, commercial and industrial damages were calculated using the methodology for residential properties but with the costs/damages increased to a value which is consistent with commercial/industrial development. For example, the maximum value of internal (contents) damages was increased to $191,250 since the building contents are generally of higher value whilst loss of rent was set at $1,000 per week to account for the loss of business through having to close for a period. Flooding below floor level uses the same damages curve as the residential properties.

Though the original OEH guidelines for flood damages calculations are not applicable to non-residential properties, they can still be used to create comparable damage figures. The damages value figure should not be taken as an actual likely cost rather it is useful when comparing potential management options and for benefit-cost analysis.

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A summary of the commercial/industrial flood damages for the Study Area is provided in Table 13. AAD for the surveyed commercial/industrial properties is slightly less than that for residential properties but the number of affected commercial/industrial properties is almost an order of magnitude lower than for residential properties. This reflects the higher costs that businesses would incur compared to residential dwellings when flooded above floor level. On a per property basis the AAD is just over twice as high as residential properties.

Table 13: Estimated Commercial and Industrial Flood Damages for Deniliquin

Event	No. Properties Affected[1]	No. Flooded Above Floor Level[2]	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP[3]	0	0	0	0	0
10% AEP	5	4	$ 651,000	4	$ 130,100
5% AEP	10	9	$ 1,442,000	7	$ 144,200
2% AEP	58	58	$ 8,551,000	20	$ 147,400
1% AEP	203	144	$ 18,989,000	19	$ 93,500
0.5% AEP	254	200	$ 25,024,000	15	$ 98,500
PMF	451	447	$ 75,055,000	34	$ 166,400
Average Annual Damages (AAD)			**$ 732,000**	**$ -**	**$ 1,600**

[1]'Properties Affected': there is flooding above ground level within the property boundary (ie the lot)
[2]'No. Flooded above floor level': there is flooding above the surveyed or estimated floor level of the house.
[3] There is inundation on the south part of a number of lots along the north bank of the Edward River, however the affectation is sufficiently far from the house or garages/sheds to warrant exclusion from the damages calculation.

Further details of the flood damages assessment calculation process are provided in Appendix D.

6.1.3. Distribution of Damages

Deniliquin contains three well-defined zones that experience flooding, namely South Deniliquin (inside the levee), North Deniliquin (inside the north levee) and the Davidson Street area. Table 14 below shows the contribution of each of these areas to the Average Annual Damages (AAD) for Deniliquin, which can be used to help allocate resources to appropriate flood mitigation works.

Table 14 Distribution of Damages (Combined Residential and Commercial/Industrial)

Location	% Contribution to AAD	Average Annual Damages (AAD)	No. Properties in 5% AEP	No. Properties in 1% AEP
South Deniliquin	54%	$ 1,652,824	0	968
North Deniliquin	13%	$ 394,667	0	155
Davidson Street	19%	$ 564,971	33	93
Other	14%	$ 429,701	7	149
Total	**100%**	**$ 3,042,162**	**40**	**1365**

The high number of properties affected (25% of total properties) in the Davidson Street Area in the 5% AEP event highlights that this is a high flood risk area. Several options to improve the flood affectation in this area have been investigated in Section 9.4. The table also shows that the relatively frequently flooded areas (i.e. Davidson Street) do not necessarily contribute more than other areas to the AAD. This is due to the large contribution of damages in the PMF to the AAD, and the much larger urban area in South Deniliquin and North Deniliquin compared to Davidson Street. Although a large portion of the damages is contributed by the flooding during extreme events in South Deniliquin, the treatment of flood risk still is typically focussed on flooding in the 1% AEP event (and more frequent events), where there is a greater contribution from Davidson Street and North Deniliquin. Further details of the assumptions used in the calculation of damages are included in Appendix D.

6.2. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed previously, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community.

Post flood damages surveys have linked flooding to stress, ill-health and trauma for the residents. For example the loss of memorabilia, pets, insurance papers and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition flooding may affect personal relationships and lead to stress in domestic and work situations. In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up etc.) many residents who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage. The extent of the stress depends on the individual and although the majority of flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

Option RM04 (Section 9.3.8) seeks to improve community awareness of flooding, and remove any unnecessary stress caused by not understanding the behaviour of flooding in Deniliquin. An example could be that residents believe flooding can happen very quickly and dramatically (as in other catchments), whereas previous events and modelling has shown there is a slow rate of rise and a long warning time for flooding in Deniliquin. Providing better information about this could help residents handle stress and have more confidence in their own safety and preparedness.

During any flood event there is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths the higher the risk. Section 4.7 describes the main areas of high hazard in the Study Area. However, there will always be local high risk (high hazard) areas where flows may be concentrated around buildings or other structures within low hazard areas.

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7. POLICIES AND PLANNING

7.1. State Legislative and Planning Context

It is important to understand the state legislation that overarches all local legislation to enable appropriate floodplain risk management measures to be proposed that are in keeping with both state and local statutory requirements. This section discusses the state legislation that influences planning in relation to flood risk at the local government level.

7.2. Environmental Planning and Assessment Act 1979 – as amended

The NSW Environmental Planning and Assessment Act (1979) (EP&A Act) provides the framework for regulating and protecting the environment and controlling development. Many other Acts relating to the Environment in NSW rely on the EP&A Act to implement their policy.

In relation to flooding, the Act imposes on Council the responsibility to facilitate the implementation of the NSW Government's Flood Prone Land Policy through the preparation of Local Environment Plans (LEPs) and Development Control Plans (DCPs).

Direction No. 4.3 Flood Prone Land

Under the section 117(2) of the EP&A Act, Direction No. 4.3 is specific to managing flood prone land and applies to all Council's that are responsible for flood prone land within their LGA. The objectives of the direction are;

- *To 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*
- *To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of potential flood impacts both on and off the subject land.*

The direction prevents land within flood planning areas being rezoned from lower vulnerability uses such as recreation, rural or environmental protection zones to higher vulnerability uses such as residential, business or industrial. Council should refer to the direction for full details on this. The direction also requires that proposals must not allow development in floodways or that will result in significant impacts to other properties. Furthermore, development should not be allowed that would result in substantially increased requirement for government spending on flood mitigation, infrastructure or services. Flood Planning Levels (FPLs) are required to be consistent with the Floodplain Development Manual 2005.

The choice of FPLs is further described in the *Guideline on development controls on low risk flood areas – Floodplain Development Manual*, a recent guideline to be read as part of the Floodplain Development Manual. The guideline assists councils in determining FPLs for residential development and recommends the 100-year flood (equivalent to 1% AEP or 100 year ARI) as the basis for the FPL.

Model Local Provisions

In December 2010 the Director General advised Councils of model local provisions which had been settled through parliamentary Council. Clause 6.2 relates to Flood Planning and it was recommended that Council adopt this clause where ever possible. The clause introduces the Flood Planning Area and Map and the relevant matters that must be considered when determining development on land subject to the FPA.

7.3. NSW Flood Prone Land Policy

The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property and reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible. The NSW Floodplain Development Manual (Reference 1) relates to the development of flood liable land for the purposes of Section 733 of the Local Government Act 1993 and incorporates this NSW Flood Prone Land Policy.

The Manual outlines a merits approach based on floodplain management. At the strategic level this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk. The Manual recognises differences between urban and rural floodplain issues. Although it maintains that the same overall floodplain management approach should apply to both it recognises that a different emphasis is required to address issues particular to rural floodplains. These issues include;

- The large area of land under investigation;
- The complexity of flood behaviour;
- The impacts of protection works for valuable crops on flood behaviour;
- The period of inundation;
- The uncertainties associated with flood related data; and
- The environmental values associated with flood dependent ecosystems on rural floodplains.

7.4. State Environmental Planning Policy (Exempt and Complying Development Codes) 2008

This State Environmental Planning Policy (SEPP) under the EP&A Act 1979 aims to identify types of development that are of minimal environmental impact that may be carried out without the need for development consent as well as identify types of complying development that may be carried out in accordance with a complying development certificate as defined in the EP&A Act with a state-wide application.

The SEPP identifies a flood control lot as a lot which flood related development controls apply in respect of developments including dwellings, dual occupancies, multi dwelling housing, residential flat buildings, commercial and industrial uses typically within the flood planning area. Table 15 gives further information on exempt and complying development.

Table 15: SEPP 2008 - Exempt and Complying Development

Exempt **Where land is identified as a Flood Control Lot and the development is minor in nature.**	**Complying** **Where land is identified as a Flood Control Lot**
Cl 2.29 specifies that Earthworks including retaining walls are not exempt.	Cl 3.36 applies to dwellings and dwelling additions specified under the General Housing Code (Part 3 of the SEPP) and clause 3A.38 to all development under the Rural Housing Code (Part 3A of the SEPP). Both clauses 3.36C and 3A.38 set out development standards for flood control lots. Certain certification by the council or a professional engineer specialising in hydraulic engineering is required prior to the development being accepted as "Complying"
Cl 2.33 & 2.37 specifies that fences on residential / industrial / business zoned lands are not exempt.	Cl 4.4A applies to other forms of residential accommodation and specifies that these are not complying
Cl 2.36 specifies that fences on rural / environmental protection or large lot residential are exempt as long as they meet standards specified for height and type and do not interrupt the flow of ground water on that lot.	Cl 5.17 & 5.19 applies to carrying out of works, including earthworks, retaining walls ancillary to alterations to industrial or commercial development and is specified as not complying development.
	Cl 5A.30 applies to new and altered business and industrial development sets out development standards for flood control lots. Certain certification by the council or a professional engineer specialising in hydraulic engineering is required prior to the development being accepted as "Complying."

Examples of requirements set for development within a flood planning area are included below;

- All habitable rooms to be no lower than floor levels set by Council;
- Development at or below the FPL to be constructed of flood compatible material;
- Able to withstand the forces of floodwater, debris and buoyancy up to the flood planning level;
- Not increasing flood affectation elsewhere in the floodplain;
- Reliable access for pedestrians and vehicles from development at a minimum level equal to the lowest habitable floor level of the development to a safe refuge;
- Open car parking spaces or ports that are no lower than the 5% AEP event flood level; and
- Driveways between car parking spaces and the connecting public roadway that will not be inundated by a depth of water greater than 0.3 m during a 1% AEP flood event.

A joint report by a professional engineer who specialises in hydraulic engineering and a professional engineer who specialises in civil engineering is required to confirm the development can withstand floodwater up to the flood planning level and will not increase flood affectation elsewhere in the floodplain.

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Generally, aside from rural fencing, any development to be carried out on land subject to flood storage, floodway, flow path or high hazard / high risk requires a development application and is not considered to be complying development.

7.5. Environmental Assessment and Planning Regulation, 2000

The EP&A Act requires, under section 149, that a person may apply to Council for a planning certificate (commonly known as a Section 149 or s149 certificate) with respect to any land within the area of the Council. Council should then issue a certificate specifying matters relating to the land whether under this or any other Act or otherwise. The Environmental Assessment and Planning Regulations 2000 set out a prescribed form and manner for information that should be included within the planning certificate.

Schedule 4 of the Regulations gives requirement for inclusions on s149 certificates under section 149(2) of the Act. In particular Schedule 4, 7A refers to flood related development control information and requires that Council include whether or not development on the land or part of the land is subject to flood related development controls. The current flood related information included by Council on a Section 149 (2) certificate is reproduced below.

(1) Whether or not development on that land or part of the land for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including development for the purposes of group homes or senior housing) is subject to flood related development controls.

(2) Whether or not development on that land or part of the land for any other purposes is subject to flood related development controls.

(3) Words and expressions in this clause have the same meanings as in the instrument set out in the Schedule to the Standard Instrument (Local Environmental Plans) Order 2006.

(a) There are no flood related development controls for this land or part of the land for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including development for the purposes of group homes or seniors housing).

(b) There are no flood related development controls for development on this land or part of this land for any other purpose.

OR

(a) Flood related development controls apply to this land or part of this for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including development for the purposes of group homes or seniors housing).

(b) Flood related development controls apply to this land or part of the land for development for any other purpose.

The second set of clauses indicating that flood related development controls apply would be triggered for properties within the Flood Planning Area as defined as part of the recent Flood Study (Reference 2).

Section 149(5) of the Act provides for Council to include any other information deemed relevant. The S149(5) can be used to provide more detailed information on flood risk. Council does not currently include any information related to flooding on the Section 149 (5) certificate.

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7.6. Murray REP No. 2 – Riverine Land

The Murray Regional Environmental Plan No. 2 – Riverine Land ensures the river and its floodplain are able to support a range of land uses. It aims to provide a consistent and co-ordinated approach to planning and assessment along the River Murray and conserve and promote its environmental management. It promotes consistency between NSW and Victorian planning in relation to the river and its floodplain.

It outlines required consent and consultation for flood control works as follows:
Definition: *Works which change the natural or existing condition or topography of land (such as the construction or alteration of levees, channels and mounds) and which are likely to affect the hydrology of the River Murray system.*
Planning control: Council consent (except work by or for Department of Water Resources (DWR) or RWC (Vic)); Advertised (except work by or for DWR or RWC (Vic)).
Consultation: DWR, MDBC (as co-ordinator of the Interstate Levees Committee) and the appropriate council's Floodplain Management Committee (if any).

Construction of any works requires the following aspects to be considered as part of the approval:

- Access (to the waterway)
- Bank Disturbance
- Flooding
- Land Degradation
- Landscape
- River Related Uses
- Water Quality
- Wetlands

The above considerations will need to be referenced or included in any local flood related policy to ensure that this statutory instrument and its controls are implemented.

7.7. Existing Council Policy

Up to date and relevant planning controls are important in flood risk management. Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages.

An LEP guides land use and development by zoning all land, identifying appropriate land uses that are allowed in each zone, and controlling development through other planning standards and Development Planning Controls (DCPs). LEPs are made under the EP&A Act 1979 which contains mandatory provisions on what they must contain and the steps a Council must go through to prepare them. In 2006 the NSW Government initiated the Standard Instrument LEP program and produced a new standard format which all LEPs should conform to that is Local Government Area (LGA) wide. The current LEP in the Study Area is the Deniliquin Local Environmental Plan 2013.

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Planning instruments can be used as tools to guide new development away from high flood risk locations and ensure that new development does not increase flood risk elsewhere. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population. Councils use Local Environmental Plans (LEPs) and Development Control Plans (DCPs) to govern control on development with regards to flooding.

7.8. Deniliquin Local Environmental Plan 1997 and 2013

The Deniliquin Local Environmental Plan 1997 and 2013 (DLEP) set out the land use for the area and make environmental provisions for the land. The objectives include minimising possible conflict between adjoining land uses and adverse environmental impacts, minimising the cost of isolated development of rural land and to promote ecologically sustainable development.

The zoning of areas within the Davidson Street area were deferred under the DLEP 2013. Their existing zones under the DLEP 1997 apply, 1(a) General Rural and 2 Urban.

Clause 6.2 DLEP 2013 refers to Flood Planning and is reproduced below.

(1) The objectives of this clause are as follows:
> *(a) to minimise the flood risk to life and property associated with the use of land,*
> *(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,*
> *(c) to avoid significant adverse impacts on flood behaviour and the environment.*

(2) This clause applies to flood liable land.
(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:
> *(a) is compatible with the flood hazard of the land, and*
> *(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and*
> *(c) incorporates appropriate measures to manage risk to life from flood, and*
> *(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and*
> *(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.*

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

Its objectives are to minimise flood risk to life and property, allow development that is compatible with an area's flood hazard, and avoid significant adverse impacts on flood behaviour and the environment. It applies to land that is flood liable, which under the definition in the Floodplain Development Manual is land below the PMF. The clause also states conditions under which development consent must not be granted.

Furthermore, Part 4 of the policy lists 'minimise the intensification of development of flood liable land' as one objective of the minimum subdivision lot size clause.

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Clause 21 of DLEP1997 contains the following clause in relation to flood liable land.

> *(1) A person must not erect a building or carry out a work for any purpose on flood liable land except with the consent of the Council.*
> *(2) The Council must not consent to the erection of a building or the carrying out of a work on flood liable land if the Council is satisfied that the development is likely:*
>> *(a) to impede the flow of floodwater on that land or on adjoining land, or*
>> *(b) to imperil the safety of persons on that land or on adjoining land in the event of those lands being inundated with floodwater, or*
>> *(c) to aggravate the consequences of floodwater flowing on that land or on adjoining land with regard to erosion, siltation and the destruction of vegetation, or*
>> *(d) to have an adverse effect on the watertable of that land or adjoining land.*
>
> *(3) The Council must not grant a consent required by this clause unless it has taken into consideration:*
>> *(a) the cumulative effect of the proposed development and other development on flood behaviour, and*
>> *(b) the risk of pollution to the waterways caused by the proposed development, and*
>> *(c) the availability of flood free access to the proposed development.*

7.9. Deniliquin Development Control Plan 2016

A Development Control Plan (DCP) is a document which supports the requirements of the Local Environmental Plan (LEP) and provides a guide for development. The Deniliquin DCP 2016 contains 14 chapters pertaining to different zones and aspects of development, such as residential zones, industrial zones, environmental zones, hazards and car parking. Chapter 10: Hazards is concerned with bush fire prone land, contaminated land and flood liable land.

Specifically Section 10.3 references the indicative map of the Flood Planning Area (FPA) as produced as part of the Flood Study (Reference 2) while stating that the policy is applicable to flood liable land including the floodplain and floodway areas. That is, the policy is applicable to land within the FPA and up to the extent of the PMF. The policy includes definitions for floodplain, floodway, flood planning level and probable maximum flood.

The objectives of the policy are to minimise the risk to public safety and costs of flood damage; and ensure development is compatible with the flood hazard and undertaken in accordance with the Floodplain Development Manual.

The policy contains controls as set out in Table 10.1 which are consistent with the above objectives as they apply to a range of different land use zonings. The controls relate to:

- minimum floor levels as set out in Council's Policy 5.9 – Flood Planning Levels,
- evacuation access,
- consistency with Clause 6.2 of the LEP,
- Preparation of Flood Risk Management Plans for Commercial, Infrastructure and Industrial Zones.

To allow for redevelopment of properties with existing structures located within the areas defined as floodway a number of additional controls apply that aim to improve or maintain the flood risk at the site. These additional controls include:

- structural requirements in accordance with the flood hazard,
- orientation of development to minimise impact on flood behaviour,
- construction material selection to ensure that flow of flood water is not impeded,
- alteration of existing ground levels is not permitted for Commercial, Infrastructure and Industrial Zones,
- storage of hazardous materials above the flood planning level for Commercial, Infrastructure and Industrial Zones.

Amendments to the Deniliquin LEP and DCP have been investigated and recommended in Section 9.3.1.

7.10. Flood Planning Levels Policy – Town Planning 5.9

Edward River Council has a town planning policy 'Flood Planning Levels' which describes how minimum floor levels for flooding are determined in the Study Area. The policy was developed in October 2010 and revised in February 2015. The objective of the policy is to set flood planning levels (FPLs) in the flood planning area. The policy has requirements for different areas in the Study Area, specifically:

- FPA except Davidson Street area and inside North Deniliquin levee – all finished floor levels of residential accommodation shall be above the FPL. For developments where an addition to existing accommodation is less than 30% by area of the existing habitable floor area, the existing floor level may be used. Additions of greater than 30% shall be above the FPL.
- Davidson Street Area – All finished floor levels shall be above the FPL (Davidson Street Area). Again, additions of less than 30% of the existing habitable area may use the existing floor level.
- Inside North Deniliquin levee – All finished floor levels of residential accommodation shall be 300 mm above the existing ground level. Additions of less than 30% may use existing floor level, while greater than 30% requires 300 mm above the ground level.

The policy defines the FPA as land identified in Figure 32 of the Edward River at Deniliquin Flood Study (Reference 2) or land at or below the flood planning level. The flood planning level is defined as a level of the 1% AEP flood + 0.1 m and the flood planning level (Davidson Street area) is defined as a level of the 1% AEP flood + 0.5 m. The 1% AEP flood levels are defined as those shown on Figure 17 of the Edward River at Deniliquin Flood Study (Reference 2). The suitability of these freeboard values are discussed further in Section 8.

8. FREEBOARD ASSESSMENT FOR DENILIQUIN

Mitigation works and planning measures (such as flood planning levels) are often designed based on protection or capacity for a particular design flood event, such as the 1% AEP event. To provide reasonable certainty that this level of protection is achieved a freeboard is added to the selected design flood level. Freeboard is a factor of safety and can be different for mitigation works and flood planning levels due to the components to be considered. The following components are generally considered:

- Uncertainties in flood level estimates (due to ground survey, design flow accuracy, structure blockage);
- Local variations (surge) in flood level;
- Wind, Wave action and surge;
- Post construction settlement;
- Surface erosion or shrinkage; and
- Changes in the catchment and design estimates over time resulting from climate change, development etc.

The relative level of contribution and likelihood of occurrence for each of these components will vary by measure type and location across the floodplain. For example, surface erosion and shrinkage would not apply to a freeboard for Flood Planning Levels, but would apply to a freeboard for a levee.

This section seeks to identify the various components making up freeboard as they apply to mitigation works (such as levees) and flood planning levels.

8.1. Mitigation Works Freeboard Assessment

A number of levee upgrade options have been proposed in Section 9.3.8, and these have included a recommended allowance of freeboard. This section provides information on how freeboard has been calculated for levees and other mitigation works in the Deniliquin floodplain. The estimate here also allows the level of protection afforded by the existing levees to be determined.

Freeboard is incorporated into the final design height of a levee and is expressed as the incremental difference in height between the level of the flood against which the levee is designed to protect, and the design crest level of the levee. The assessment provided is adequate for concept design, however any recommended upgrade works will require a feasibility study including a review of the assigned freeboard components. It is based on the assessment carried out in 1997 by Sinclair Knight Merz in the *Deniliquin Flood Protection Levee Study* (Reference 5) and the *2010 NSW Dept. of Works Wagga Wagga Levee Upgrade Flood Freeboard* (Reference 19). These previous assessments have been used as a starting point for the current assessment, with components modified for the Deniliquin flood context or updated based on more recent modelling.

8.1.1. Uncertainties in the Estimated Flood Levels

The determination of flood levels comprises a number of factors and parameters, each containing a degree of uncertainty. These factors may include:

- How well the theoretical ARI-Discharge curve fits known flood events;
- Availability of detailed survey and other topographic data;
- Reliability of historical flood data;
- Estimated parameters including afflux, surface roughness, evapotranspiration, rainfall patterns etc.

These uncertainties can have localised or cumulative effects on the accuracy of hydrologic and hydraulic modelling, and hence, the resulting design flood levels produced. A component of the freeboard accounts for this compromise in confidence in the design flood levels. Uncertainties in flood level estimates can be determined through an analysis of the sensitivity of design flood levels to changes in various modelling assumptions. A sensitivity analysis was undertaken as part of the *Edward River at Deniliquin Flood Study 2015* (Reference 2). The results showed that the flood level estimates were relatively insensitive to changes in model assumptions with results generally fluctuating +/- 0.15 m up to a maximum of 0.3 m at isolated locations. A value of **0.15 m** has been assigned to uncertainties in estimated flood levels. This value is also supported by the relative small scale between events of different magnitudes; there is typically 0.1 m between the 1% AEP and 0.2% AEP event and a maximum of 0.9 m between the 1% AEP and the PMF.

8.1.2. Local Water Surge

Local flood water levels can be higher than the general flood level due to local blockages or obstructions in the floodplain, or if the levee alignment is oblique to the direction of the flow. Results of flood modelling can be used to understand the sensitivity of design flood levels to these influences. The impacts of blockage were considered as part of the sensitivity analysis undertaken in Reference 2; the results showed a very minor fluctuation in flood level of less than +/- 0.1 m. A local surge allowance of **0.1 m** (conservatively) has been included in the freeboard calculation to allow for this.

8.1.3. Wave Action

Where the levee is exposed to a large expanse of flood water, significant waves can be generated under windy conditions and may overtop the levee. Design wave actions are a product of:

- Fetch – the distance the wave is assumed to travel;
- Design wind;
- Wave Height;
- Wind Set-up, and
- Wave Run-up – when a wave reaches a sloping embankment (e.g. levee) it will break on the embankment and run up the slope. Run-up would not apply to flood planning levels.

Based on the conditions present in Deniliquin the effect of wave action including wave run-up has been estimated as **0.4 m.**

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8.1.4. Embankment Settlement

The levee settlement component allows for the normal post-construction settlement of earthfill embankment levees. In most cases, earthfill embankment levees are constructed with a reasonable degree of compaction and post-construction settlement may be expected to be in the order of 1% of the height of the levee. A post construction settlement allowance for earthfill embankments is proposed as **0.025 m**. Given the age of levees in Deniliquin it is unlikely that further significant settlement would occur, however any upgraded sections would be susceptible to post construction settlement and compaction under traffic. Concrete sections of a levee are not expected to experience any significant settlement. Embankment settlement would not apply to flood planning levels.

8.1.5. Defects in Mitigation Works

Levees of earthfill embankment construction are prone to defects and require ongoing maintenance. This component allows for the following defects, and may be reduced with a thorough ongoing maintenance schedule:

- Erosion – dependent on condition of the levee, compaction, type of material used, quality of construction and surface protection (gravel crest, grass cover on batters etc.);
- Holes – due to burrowing animals, dispersion cavities etc., holes may foster piping through the levee;
- Low points – caused by concentrated animal, pedestrian and vehicular traffic;
- Cracking – poses a risk of piping depending on levee material, moisture content and maintenance;
- Regular Maintenance – to reduce or eliminate the risk of levee progressive failure from defects and compensate for settlement of embankments; and
- Defect Allowance – allowing for poor ongoing levee maintenance by including a greater design freeboard. The better the maintenance the smaller this component may be.

For a well maintained embankment, a freeboard component of **0.1 m** is considered appropriate. Defects would not apply to flood planning levels.

8.1.6. Climate Change

The Floodplain Development Manual (Reference 1) indicates that climate change should be considered in the development and implementation of floodplain risk management works, to ensure that the level of protection can be maintained under future conditions.

The impacts of climate change on flood producing rainfall events will have a flow on effect on flood behaviour. This may result in key flood levels being reached more frequently, and floods of the same ARI being of a larger magnitude. The freeboard allowance required to cater for climate change is greatly affected by the uncertainties in future model projections, and is therefore somewhat of an estimation. The impacts of climate change projections were assessed as part of Reference 2 and a freeboard component of **0.1 m** is considered appropriate.

8.1.7. Summary of Mitigation Work Freeboard Components

Each of the components described above combine to provide an estimate of the freeboard required. They are however unlikely to occur simultaneously, and therefore a relative probability of occurrence has been included when determining the overall freeboard size in Table 16 overleaf. This preliminary assessment has been undertaken for the purposes of this Floodplain Risk Management Study and the initial identification and assessment of mitigation works. The assigned values may be revised as part of future detailed investigations of individual works.

Table 16 Summary of Mitigation Work Freeboard Components

Component	Allowance (m)	Probability	Final Component (m)
Uncertainties in Flood Model	0.15	1.0	0.15
Local Water Surge	0.1	0.75	0.075
Wave Action	0.4	0.5	0.2
Levee Settlement	0.025	0.5	0.0125
Defects in Embankment	0.1	0.5	0.05
Climate Change	0.1	1	0.1
Total			**0.5875** **(0.5 – 0.6)**

A recommended freeboard for well-constructed and maintained levees in NSW is generally between 0.6 m and 1.0 m and a minimum freeboard of 0.6 m has been adopted across the region for recent levee projects. Consideration of factors specific to Deniliquin in the above assessment has shown that an appropriate freeboard for mitigation works is between 0.5 and 0.6 m, consistent with recent regional levee projects. In addition, given the recent upgrade of the levee system (with an adopted freeboard of 0.5 m) and limited scale between flood events of different magnitudes, a freeboard of 0.5 m has been adopted for the purposes of planning and analysis of mitigation works as part of this Floodplain Risk Management Study. This should be reviewed as part of future detailed design.

8.2. Summary of Flood Planning Level Freeboard Components

A similar approach is taken to determining the freeboard to be included in the Flood Planning Level (FPL). A FPL is assigned to new development, it is the minimum floor level to be built and aims to reduce the likelihood of flood damage occurring to an acceptable level. The freeboard for FPL does not need to include the components related directly to embankment construction (including settlement and defects), however wave action (excluding run up) and local water surge are still applicable. The freeboard components and their relative probability are included in Table 17 below.

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Table 17 Summary of Freeboard Components (FPL)

Component	Allowance (m)	Probability	Final Component (m)
Uncertainties in Flood Model	0.15	1.0	0.15
Local Water Surge	0.1	0.75	0.075
Wave Action (excluding run-up)	0.15	0.5	0.075
Climate Change	0.1	1	0.1
Total			**0.4 (0.3 – 0.4)**

Considering these components as they apply at Deniliquin, the above assessment shows that an appropriate freeboard for flood planning levels is between 0.3 and 0.4 m.

When determining a FPL freeboard for new development, in addition to considering the components described above, a number of other factors such as the extent of the subsequent Flood Planning Area (FPA) should be considered. The extent of the FPA is the land at or below the FPL. The boundaries of this extent are important to ensure flood related planning controls are applied where necessary and not to those lots with minimal or no flood risk. Typically, and as per the Floodplain Development Manual, the FPA will be based on the extent formed by the 1% AEP mainstream flooding event plus freeboard (typically 0.5 m) and, therefore, extended further than the extent of the 1% AEP event. Planning controls may, therefore, be applied to development which is not necessarily within the 1% AEP flood extent but included in the FPA. The inclusion of freeboard provides greater confidence that a 1% AEP level of protection will be maintain accounting for the uncertainties that make up the design flood level. They key is to ensure that this additional extent is appropriate given the flood risk that exists.

The flat topography of the Study Area has a significant impact on the flood behaviour in Deniliquin. Over 80% of the 100 km^2 Study Area is between 89 and 94.5 mAHD, and a section taken laterally across the floodplain generally has a gradient of less than 0.1%. The floodplain does not exhibit the more conventional river valley shape and flow that breaks out of the riparian zone spreads out over a wide area at shallow depth. This results in only slight variations in height (Refer to Table 18) and extent between events of different magnitude and a significantly larger event is required to substantially change the flood extent.

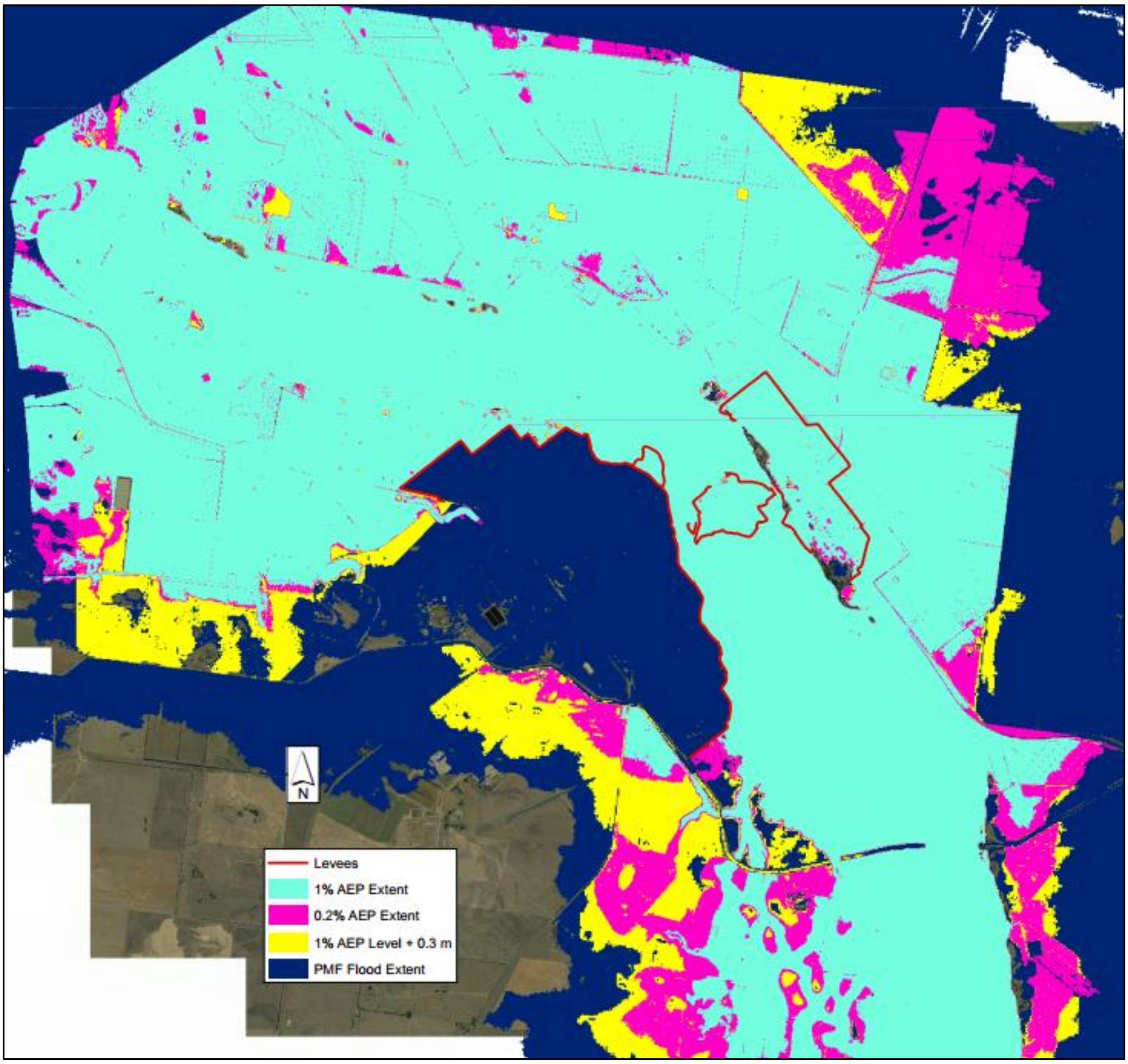
Table 18 Change in Peak Flood Level

	Peak Flood Level (mAHD)	Difference in Peak Flood Level from 1% AEP (m)		
Location	*1% AEP*	*0.5% AEP*	*0.2% AEP*	*PMF*
National Bridge	92.3	0.1	0.2	0.8
Gauge Location	92.5	0.1	0.2	0.9
Brick Kiln Creek Bridge	92.5	0.2	0.2	0.8
River @ Burton St	91.6	0.1	0.2	0.6
Tarangle Creek @Ross St	92.8	0.1	0.2	0.9
River @ Lawson Syphon	93.4	0.2	0.3	1.3
River @ Boggy Creek Rd	91.2	0.1	0.1	0.5

Traditionally, the selected freeboard is added to the 1% AEP extent to slightly stretch the extent to the FPA. Considering the flood behaviour at Deniliquin, applying this method with a 0.5 m freeboard would include a large proportion of the floodplain, an additional 50% area and some areas beyond the extent of the PMF or flood liable land. It is unlikely that the freeboard components discussed in Section 8.1 would combine to generate such a broad extent of inundation without the event being much rarer. The extent generated by the 1% AEP + 0.5 m freeboard therefore does not capture and exaggerates the intended purpose of the freeboard in the FPA. An excessively large FPA would exaggerate the flood risk and potentially restrict development on the edges of the floodplain.

The extent of the FPA should be representative of a real flood extent that could occur considering the freeboard components and the location specific flood behaviour. The 0.2% AEP extent is considered to be a reasonable representation of this extent. The extent of the 0.2% AEP is shown on Diagram 1 compared to the 1% AEP, 1% AEP + 0.3 m and PMF extent.

Diagram 1 Comparison of design event extents and proposed FPA



The 0.2% AEP event is typically 0.2 – 0.3 m higher than the 1% AEP event and additionally the extent is approximated well by the 1% AEP + 0.3 m freeboard. This is shown on Figure 17.

Consideration of the various freeboard components and the flood behaviour at Deniliquin indicates that a freeboard of 0.3 m would be suitable to be used in determining the FPA. Recommendations regarding the FPL and FPA are discussed in Section 9.3.1.

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9. FLOODPLAIN RISK MANAGEMENT OPTIONS

9.1. Background

Floodplain risk management measures are actions which can be undertaken in both the short and long term which manage the risk of flooding. Measures range from flood modification measures such as levees and retarding basins, to response measures such as emergency response planning and property modification measures such as house raising or development controls. These types are described in the following section. The section also describes the management measures that were assessed in detail for the Study Area.

9.1.1. Categories of Floodplain Risk Management Measures

Flood modification measures modify the physical behaviour of a flood including depth, velocity and redirection of flow paths. Typical measures include flood mitigation dams, retarding basins, on-site detention, channel improvements, levees or floodways. Pit and pipe improvement and even pumps may also be considered in some cases.

Property modification measures modify the existing land use and development controls for future development. This is generally accomplished through such means as flood proofing, house raising or sealing entrances, strategic planning such as land use zoning, building regulations such as flood-related development controls, or voluntary purchase.

Response modification measures modify the response of the community to flood hazard by educating flood affected property owners about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Table 19 below provides a summary of floodplain risk management measures that have been considered for the Study Area.

Table 19: Flood Risk Management Measures

Flood Modification	Property Modification	Response Modification
Retarding basins/ Mitigation Dams	Land zoning	Community awareness/preparedness
Drainage Capacity Enhancement	Voluntary purchase	Flood warning
Levees	Building & development controls	Evacuation planning
Temporary defences	Flood proofing	Evacuation access
	House raising	Flood plan / recovery plan
	Flood access	Flood insurance

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9.1.2. Relative Merits of Management Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option enabling the ranking against similar projects in other areas. A B/C ratio is the benefits expressed in monetary terms (as a reduction in flood damage), compared to the actual likely cost of achieving those benefits. It is a standard method for using the time value of money to appraise long-term projects of the reduction in flood damages (benefit) compared to the cost of the works (including ongoing maintenance). Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles such as a reduction in risk to life (as discussed in Section 6.2).

The potential environmental and social impacts, and other intangible benefits of any proposed flood mitigation measure must be considered in the assessment and cannot be evaluated using the classical B/C approach. The approach also does not consider the financial feasibility of works that require a large capital outlay, the impact on emergency services, the political or administrative feasibility of an option, its effect on the risk to life, as well as its long term performance. For this reason a matrix type assessment has been used which enables a value (including non-economic worth) to be assigned to each measure.

Multi-criteria decision matrices are recommended in the Floodplain Development Manual and therefore it is also a recommendation herein that multi-variate decision matrices be developed allowing detailed benefit/cost estimates, community involvement in determining social and other intangible values, and local assessment of environmental impacts. A multi-criteria matrix assessment has been made as part of this report (Section 9.6).

9.2. Options Not Considered Further

9.2.1. Sub-surface Drainage Capacity Enhancement

Increasing the flow conveyance capacity of a sub-surface drainage structure typically involves an increase to the effective flow area of the structure via installation of larger or more pipes/culverts. This generally reduces flood levels upstream of the area where the modifications are made. The resulting increase in flow can cause increases to flood levels and inundation frequency downstream of the modifications if the increased capacity is not matched throughout the downstream drainage system. In this regard, increases to structure conveyance can produce opposite effects to detention basins, which reduce discharge to downstream areas at the expense of increased storage of floodwaters within the basin and potentially surrounding areas.

The current study is concerned with riverine flooding due to the Edward River, and the town's urban drainage system has little influence on this broad flooding. A pit and pipe system is used to manage runoff rates that are orders of magnitude smaller than that experienced in Deniliquin during a riverine flood. For this reason, drainage capacity enhancements have not been considered further.

9.2.2. Retarding/Detention Basins

Retarding basins are often used in developing catchments. These measures are appropriate for use in controlling flooding in small catchments, to retard flow in the upstream reaches of large catchments, or to mitigate the effects of increased runoff caused by development. Retarding basins store runoff temporarily and then release it at a reduced rate. Although they do not reduce the total volume of runoff significantly, they do reduce the rate at which runoff occurs, thus reducing downstream flood levels. They also typically include a spillway on the embankment wall, which is a slightly lower section that allows controlled overtopping if the basin capacity is exceeded. Retarding basins are sometimes used in conjunction with large scale development to allow for communal mitigation of increases to runoff. They can also be used in general urban drainage systems for example, some Councils use playing fields for retention of flows during flood events.

As with sub-surface drainage, retarding basins are used to treat much smaller flow rates than that experienced in Deniliquin due to riverine flooding. Generally speaking, a very large retarding basin may be able to mitigate a flow in the order of 100 m^3/s. As the 1% AEP peak flow in Deniliquin is just over 2000 m^3/s, this makes them not applicable to the Study Area.

9.2.3. Flood Mitigation Dams

Dams and reservoirs are capable of providing flood mitigation by detaining and retarding discharge on the upper part of a catchment. As with retarding basins, a dam located upstream of an area may be able to capture some or all of the runoff volume in a flood event, significantly reducing the peak discharge downstream. The ability of the dam to reduce the downstream flooding depends on the available storage volume in the dam prior to the event occurring, as well as its outlet structures and their ability to pass or retain large volumes of runoff. In turn, the available storage is highly dependent on the dam's primary purpose. For example, a dam used for water supply purposes will retain as much runoff as possible during each year, which may mean the dam is full when a flood occurs.

Some dams and weirs upstream of Deniliquin have secondary uses as flood mitigation dams, including Yarrawonga Weir, Hume Dam and Dartmouth Dam. These dams' primary use is for water supply and flood mitigation is only sometimes possible. If a flood-producing rainfall occurs when one of the dams is full, it will pass the full flow to the downstream area, and not reduce the flood peak. The variability of possible flood-producing rainfall events and the very large catchment area mean there is little certainty about what effect the dams will have in future flood events.

The construction of a dam for flood mitigation purposes at Deniliquin is not appropriate for the scale of flood risk. Furthermore, the reliability of dams used for flood mitigation is less than that of other mitigation works or measures. To maximise the reduction in flood peak, the dam must always have a large part of its storage reserved for potential inflows, which requires constant discharge of inflows and is at odds with the other dam uses (i.e. water supply). There are also often significant environmental impacts which cannot be justified given the scale of risk.

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9.2.4. Voluntary House Raising

Voluntary house raising (VHR) seeks to reduce the frequency of exposure to flood damage of the house and its contents by raising the house above the minimum Flood Planning Level (FPL), and accordingly reduce the frequency of household disruption and associated trauma and anxiety. VHR is eligible for OEH funding based on eligibility criteria set out in the OEH Guidelines for Voluntary House Raising Schemes (Reference 17). VHR was considered for the Davidson Street area as it may be of benefit to some residences, however VHR is inappropriate in a floodway and does not meet the guideline requirements and so was not considered further.

9.3. Catchment-wide Management Options

Catchment-wide management options, include property modification and response modification options. The options considered include:

- Property modification options:
    - Flood planning levels for the area based on review of the current FPL and FPA, flood behaviour (e.g. scaling between events) and freeboard components (PM01);
    - Floodplain management via development control planning, including possible changes to the existing plans based on a review. Possible changes include stipulation of when impact assessment is required, where flood compatible materials should be used, and consideration of study outputs (e.g. PMF extent, hydraulic categories, true hazard) in development of land (PM02);
    - Notification of flood affectation on an individual lot bases via s149 certificates (PM03); and
    - Voluntary Purchase (PM04);
- Response modification options:
    - Amendments to the local flood plan and other emergency response documents based on review of its recommended procedures, including flood warning and evacuation (RM01, RM02 & RM03); and
    - Community awareness program to increase knowledge of flooding and its effects in the area, installation of depth gauge and historical flood markers (RM04).

The report will also make recommendations as to which options should be undertaken and their relative benefits.

9.3.1. Property Modification – Revision of Flood Planning Level and Flood Planning Area (PM01)

Flood Planning Levels (FPLs) are an important tool in floodplain risk management. Appendix K of the Floodplain Development Manual (Reference 1) provides a comprehensive guide to the purpose and determination of FPLs. The FPL provides a development control measure for managing future flood risk and is derived from a combination of a design flood event and a freeboard.

The FPL for planning purposes is generally the height at which new building floor levels should be built to minimise frequency of inundation and associated damage. It may also refer to the height to which flood proofing should be applied to reduce damages to commercial properties. It applies to properties in the Flood Planning Area (FPA), which is typically the land at or below the flood planning level. The Flood Planning Area (FPA) is an area within Council's LGA to which flood planning controls are applied. It is important to define the boundaries of the FPA to ensure flood related planning controls are applied where necessary and not to those lots unaffected by flood risk. It is also important to define the FPA on criteria as per the NSW Floodplain Development Manual (Reference 1).

Due to the mixture of residential and commercial development in the Study Area, a variety of FPLs may be applicable depending on where in the catchment development is being considered and also based on the type of development being proposed.

A variety of factors need to be considered when calculating the FPL for an area. A key consideration is the flood behaviour and resultant risk to life and property. The Floodplain Development Manual identifies the following issues to be considered:

- Risk to life;
- Long term strategic plan for land use near and on the floodplain;
- Existing and potential land use;
- Current flood level used for planning purposes;
- Land availability and its needs;
- FPL for flood modification measures (levee banks etc.);
- Changes in potential flood damages caused by selecting a particular flood planning level;
- Consequences of floods larger than that selected for the FPL;
- Environmental issues along the flood corridor;
- Flood warning, emergency response and evacuation issues;
- Flood readiness of the community (both present and future);
- Possibility of creating a false sense of security within the community;
- Land values and social equity;
- Potential impact of future development on flooding; and
- Duty of care.

As a guide, Table 20 has been reproduced from the NSW Floodplain Development Manual 2005 to indicate the likelihood of the occurrence of an event in an average lifetime to indicate the potential risk to life.

Analysis of the data presented in Table 20 gives a perspective on the frequency of floods being exceeded over an average lifetime. The data indicates that there is a 50% chance of a 100 Year ARI (1% AEP) event occurring at least once in a 70 year period. Given this potential, it is reasonable from a risk management perspective to give further consideration to the adoption of the 1% AEP flood event as the basis for the FPL. Given the social issues associated with a flood event, and the non-tangible effects such as stress and trauma, it is appropriate to limit the exposure of people to floods.

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Note that there still remains a 30% chance of exposure to at least one flood of a 200 Year ARI (0.5% AEP) magnitude over a 70 year period. This gives rise to the consideration of the adoption of a rarer flood event (such as the PMF) as the flood planning level for some types of more vulnerable development.

Table 20: Likelihood of given design events occurring in a period of 70 years

Likelihood of Occurrence in Any Year (ARI)	Probability of Experiencing At Least One Event in 70 Years (%)	Probability of Experiencing At Least Two Events in 70 Years (%)
10	99.9	99.3
20	97	86
50	75	41
100	50	16
200	30	5

The Floodplain Development Manual states that the FPL for standard residential development is the 1% AEP flood event plus a freeboard which is typically 0.5 m. Depending on the nature of the development and the level of flood risk, individual FPLs can be adopted for a local area within a greater floodplain area.

The FPL can be varied depending on the use, and the vulnerability of the building/development to flooding. For example, residential development could be considered more vulnerable due to people being present or its location, whilst commercial development could be considered less vulnerable, or it could be accepted that commercial property owners are willing to take a higher risk. For developments more vulnerable to flooding (hospitals, schools, electricity sub-stations, seniors housing and the like) consideration should be given to events rarer than the 1% AEP when determining their FPL and either consider the PMF or situating those developments outside the floodplain where possible.

For the less vulnerable commercial and industrial developments, flood proofing a building to the FPL can be considered where raising floor levels is not an option or not feasible, but should not be allowed for residential developments or more vulnerable uses. For example, it could be a requirement that residential dwellings are to have floor levels above the FPL, whilst commercial properties could have lower floor levels but be subject to other controls such as flood proofing to the level of the FPL.

More sensitive land uses such as nursing homes, hospitals and childcare centres and the like should ideally be located outside of the FPA and above the PMF.

Weighing up the range of factors discussed above in addition to those described in the freeboard assessment presented in Section 8, an appropriate FPL for Deniliquin would be the 1% AEP flood level plus 0.3 m freeboard for residential development in those areas outside the floodway (Refer to Figure 6). It is also appropriate that a higher freeboard (0.5 m) is applied to the replacement of existing dwellings and the construction of new swellings where an entitlement exists in the floodway including Davidson Street.

The Flood Planning Area (FPA) is an area to which flood planning controls are applied. The FPA should be the extent of the 1% AEP + 0.3m. The level of protection provided by the existing levees affect the extent of the FPA, for example it can be said that the South Deniliquin levee generally provides a 1% AEP level of protection (refer to Section 4.5.1.3 and Section 8) and therefore these areas are not included within the FPA and therefore a FPL will not apply to residential development. At present the North Deniliquin levee does not provide protection in the 1% AEP event and therefore will be included in the FPA. Should the North Deniliquin levee be upgraded to a 1% AEP level of protection (including the recommended freeboard) then it would be excluded from the FPA.

Council's Flood Planning Levels Policy 5.9 provides guidance on flood level controls and is enforced by controls included in the DCP. This policy requires updating in accordance with the recommendations included in this section.

☑ **PM01 Recommendation**

- Mapping should be utilised to inform the FPA and FPLs set for all residential development on land that exists within the FPA.
- Include floor level controls for sensitive uses.
- Allow flood proofing to the FPL for non-residential developments.
- Update the FPA (and related documentation) to reflect the extent of the 1% AEP event + 0.3 m freeboard.
- Update the FPL (and related documentation) for non-floodway areas to be 1% AEP event + 0.3 m freeboard.
- Update the FPL (and related documentation) for replacement of existing dwellings and new dwellings in floodway areas to be 1% AEP event + 0.5 m freeboard.
- Apply a FPL of 1% AEP event + 0.3 m freeboard in the areas protected by the North Deniliquin levee until upgraded.
- These changes will require a Planning Proposal and additional notations included in s149 certificates for properties within the FPA (Refer Section 9.3.3).

9.3.2. Property Modification – Planning Policy Review (PM02)

Appropriate land use planning can reduce future flood risk and associated flood damages by ensuring that development is compatible with flood risk. Planning instruments can be used as tools to:

- Guide new development away from high flood risk locations;
- Prevent inappropriate development from occurring;
- Ensure that new development does not increase flood risk elsewhere; and
- Develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population.

Deniliquin Local Environmental Plan 2013 and 1997

Land use zones are generally governed by a Local Environmental Plan (LEP). The NSW Standard Instrument LEP does not include a specific land use zone classification for flood prone land, rather it permits a Flood Planning Area (FPA) map to be included as a layer imposed across all land use zones. The FPA map is referred to via a number of standard clauses, specifically Clause 6.2.

Clause 6.2 of the Deniliquin LEP 2013 (DLEP2013) and Clause 21 of Deniliquin LEP 1997 (DLEP1997) as discussed in Section 7.8 do not include a reference to a FPA map or Flood Planning Level (FPL) as prescribed in the Standard Instrument LEP clauses, rather stating that they are applied to *flood liable land*. This is inconsistent with the purpose of this clause and should be updated to use one of the Standard Instrument clauses that refer to the FPA map or land below the FPL. The FPL and FPA recommendations are included in Section 9.3.1.

As discussed in Section 4.7.3 and 7.8, the zoning of the Davidson Street area was deferred as part of the DLEP 2013 pending recommendations from this study. The Davidson Street area is located in a floodway and subject to high flood risk. The deferred area is managed under Deniliquin LEP 1997, while the rest of Deniliquin falls under the 2013 LEP.

Ideally the zoning should be compatible with this flood risk to ensure the permissible uses are appropriate. Under current planning legislation existing use rights would remain. Therefore, complete removal of flood risk would require an extensive program of rezoning and voluntary purchase (discussed in Section 9.3.4). This would be an extensive and costly project for Council. The implementation of appropriate zoning that prevents intensification of development or development of facilities that are more sensitive to flood risk; supported by development controls (discussed later in this section), is required. This would aim to reduce risk and property damage over time whilst ensuring that the current risk situation will become no worse.

There is limited development pressure in Deniliquin that would require rezoning of land to higher density uses. When considering possible future rezoning, the outputs from Reference 2 and this study should be considered to ensure the zoning is appropriate to the flood risk and appropriate flood controls are applied.

To make any significant changes to the provisions of an LEP, a planning proposal must be prepared.

Flood Policy/DCP

A potential impact on flooding can arise through the intensification of development on the floodplain, which may either remove flood storage or impact on the conveyance of flows. The Deniliquin LEP 2013 includes a control ('6.2 Flood Planning') that consent must not be granted to any development which adversely impacts the flood behaviour such that affectation on another property or development is worsened. The Deniliquin LEP 1997 also includes a control (Clause 21: Flood Liable Land) that consent should not be granted to development that a) impedes the flow of flood water, imperils the safety of persons, aggravates the consequences of floodwater flowing on that land or on adjoining land with regard to erosion, siltation and the destruction of vegetation, or has an adverse impact on the water table of that land or adjoining land on that land

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or on adjoining land. It is recommended that all references to flooding in the Deniliquin LEP (2013 and 1997) are brought in line with current flood information, especially regarding land use zoning and terminology used, as discussed below. Flood related controls in the LEPs should be supported through the Development Control Plan (DCP).

A Development Control Plan is a document which supports the requirements of the Local Environmental Plan (LEP) and provides a guide for development. Chapter 10 of the Deniliquin DCP 2016 provides guidance in relation to development on flood liable land.

The application of flood controls is essential in areas where a building entitlement exists which cannot be removed by voluntary purchase or rezoning, this will ensure that the risk to life and damage can be minimised over time.

Other recommendations for amendment include the following:

- Mapping from this study should be included to define areas related to the Flood Planning Area and floodway;
- Terminology should be consistent with the Floodplain Development Manual (Reference 1) particularly in relation to the use of the terms ‘floodplain’ and ‘flood liable land’;
- Controls applying to “Floodplain” should be applicable to areas within the Flood Planning Area outside the Floodway;
- The objectives should include “to avoid significant adverse impacts on flood behaviour and the environment”;
- Existing and replacement dwellings cannot exist simultaneously;
- Add “maintained” to clauses related to safe path of travel;
- Clauses Floodway – Residential and Rural Zones 1 and 4 could be combined to avoid repetition;
- Include restrictions for development with sensitive use (for example seniors living facilities, hospitals and child care centres etc); and
- Include requirement for impacts of development to be documented.

☑	**PM02 Recommendation** • The current flood planning Clause 6.2 DLEP2013 and Clause 21 DLEP1997 applies to flood liable land, this should be revised to the FPA and a map included (Refer to Figure 17) in line with the standard instrument. • Apply an appropriate zone to the Davidson Street (Deferred Matter) area. • When reconsidering existing zones do so in line with current flood data and mapping to ensure compatibility with the existing flood risk. • Submit a planning proposal to the Department of Planning and Environment to amend the DLEP 2013 and DLEP 1997. • Introduce flood controls via an updated DCP and Flood Planning Levels Policy (Refer to Recommendations in Section 9.3.1 and Section 9.3.1).

9.3.3. Property Modification – Changes to s149 Certificates (PM03)

Section 149 Planning Certificates are issued in accordance with the Environmental Planning & Assessment Act 1979. They contain information on how a property may be used and the restrictions on development that apply. A person may request a 149 certificate to obtain information about his or her own property, but generally a 149 certificate will be requested when a property is to be redeveloped or sold. When land is bought or sold the Conveyancing Act 1919 requires that a Section 149 Planning Certificate be attached to the Contract for Sale.

Schedule 4 of the Regulations gives requirement for inclusions on s149 certificates under section 149(2) of the Act. In particular Schedule 4, 7A refers to flood related development control information and requires that Council include whether or not development on the land or part of the land is subject to flood related development controls.

Section 149 (5) is a more detailed certificate and could for instance include “notes” on flood risk such as whether the property is above or below the FPL, details of other events including the PMF, percentage of lot affected, potential flood heights and hazard categories. Where only parts of lots are flood affected the 149 certificate may notify either the percentage area of a lot that is affected and / or only include lots that are 15% affected or greater.

Currently Council provides information related to flood related development controls on 149(2) certificates for properties within the Flood Planning Area (FPA) as defined in the recent Flood Study (Reference 2). This is based on a Flood Planning Level of the 1% AEP flood level + 0.1 m. The Section 149 (5) currently does not provide additional details related to flooding.

This report has recommended a change to the current Flood Planning Level and Area (discussed in Section 9.3.1). This will affect the properties subject to flood related development controls and subsequently affect the notification on the 149 (2) certificate.

It is important that the information presented in the planning certificate is clear because although flood controls only apply to land in the FPA, flood risk exists to the PMF. Land outside of the FPA therefore can still flood during rare events and the community can be made aware of this via notes of the 149 (2)/ (5) certificate.

Section 17.2 and 17.3 of Appendix I to the FDM (Reference 1) detail typical examples of information for inclusion in 149 certificates.

This more sophisticated level of data and mapping from this study and Reference 2 will assist in the dissemination of accurate information to the community. A GIS based map can provide useful information to a property owner.

Land owners can be concerned when their property is tagged as ‘flood affected’ particularly when only a portion of the site is actually impacted. The FPA mapping derived from this study allows the identification of flood affectation via a percentage of site area impacted. Land owners can be concerned as to how a notification may impact on their property value or insurance, for example. The Insurance Council of Australia provides detailed fact sheets on how flood information is used

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for insurance pricing. This should be taken into account when developing a consultation strategy for notification of any changes related to s149 planning certificates.

Example of other information that can be included on a 149 (5) certificate include information on flood hazard. Categories of flood hazard can include:

- Low Hazard – trucks able to evacuate people and possessions easily. Able-bodied adults readily able to wade out of danger.
    - Low Hazard: Flood Fringe
    - Low Hazard: Flood Storage
    - Low Hazard: Floodway
- High Hazard – Possible danger to personal safety. Difficult to evacuate by trucks. Able-bodied adults would have difficulty wading out of danger.
    - High Hazard: Flood Fringe
    - High Hazard: Flood Storage
    - High Hazard: Floodway

The following measures are recommended to be incorporated into 149 certificates:

- Whether the land is within the FPA and flood related development controls apply, (149(2));
- Design flood levels/depths specific to the property for the 1% AEP, 5% AEP and PMF events, (149(5));
- Percentages of lots affected by the FPA if not 100%, (149(5));
- Likelihood of flooding (149(5));
- Flood hazard (149(5)).

Land owners will be required to be notified of changes to both the 149 (2) and 149 (5) planning certificates.

☑ **PM02 Recommendation**

- Update properties with a s149(5) notification within the FPA based on recommendations in Section 9.3.1.
- Develop a Template Certificate/Map for information on flood affectation to be included on s149 (5) planning certificates.
- Notify current land owners of changes.

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9.3.4. Property Modification – Voluntary Purchase (PM04)

Voluntary purchase (VP) is recognised as an effective floodplain risk management measure for existing properties in areas where:

- There are highly hazardous flood conditions and the principal objective is to remove people living in these properties and reduce the risk to life of residents and potential rescuers;
- A property is located within a floodway and its removal may contribute to a floodway clearance program that aims to reduce significant impacts of flood behaviour elsewhere in the floodplain by improving the conveyance of the floodway; or
- Purchase of a property enables other flood mitigation works to be implemented (e.g. channel improvements or levee construction).

The NSW Office of Environment and Heritage provides funding to assist councils with the purchase of eligible properties. In the Guidelines for Voluntary Purchase Schemes (Reference 18), eligibility criteria notes that VP will be considered only where no other feasible flood risk management options are available to address the risk to life at the property (5.2), and, that subsidised funding is generally only available for residential properties and not commercial and industrial properties (5.3).

In regards to the Davidson Street area, the business related structures (not eligible for VP) would remain and therefore demolition of residential properties would not effectively clear and improve the conveyance of the floodway. However, while there may not be any hydraulic benefit gained from voluntary purchase of the residential properties, it would still have the benefit of removing occupants from the high hazard area, reducing risk to lives of both residents and potential rescuers and reducing property damage. The removal of 25% of the affected residential properties within the area (14 dwellings) would result in a reduction in Annual Average Damages in the order of $95,900, with a B/C Ratio of 0.4. A VP scheme is often implemented over a long period, sometimes decades as a result of funding availability and prioritisation and ranking of floodplain management works across the state. It is likely that at most one property could be acquired per year, stretching this scheme out to an optimistic minimum of 14 years and likely longer. This is not ideal and complementary measures should also be considered to reduce flood risk through the area, these are discussed in Section 9.3.1. In addition, following discussion with the FMC in March 2016 it was agreed that upgrade of the Davidson Street levee was not feasible, and in the absence of alternative floodplain risk management works for this area, VP warrants further investigation in the form of a feasibility assessment.

☑	**PM04 Recommendation** Voluntary Purchase is recommended for further investigation, especially for residential properties in the Davidson Street area.

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9.3.5. Response Modification - Flood Emergency Management (RM01)

There are a number of documents that contain instructions for emergency response during a flood event in Deniliquin. A review of the following documents has been has been undertaken to identify discrepancies between the available emergency response plans. It is recommended that these discrepancies are addressed and plans amalgamated to ensure consistency between Council and SES actions.

1. Deniliquin Council Flood Response Plan South Levee System (Date unknown)
2. SES Flood Intelligence Card – Deniliquin Gauge-Station Number 409003 (Jan 2000)
3. SES Deniliquin – Conargo Local Flood Plan (June 2009)
4. Deniliquin Levee Bank Levee Owner's Manual (Dept. Public Works, October 2014)

9.3.5.1. Gauge Height Discrepancies (Documents 1 and 2)

Upon review of documents (1) and (2) which referenced heights relative to the gauge at its new (current) location, two discrepancies were noted. As described in Table 21, these discrepancies were 100 mm and 40 mm respectively, and being so small are beyond the capability of the model to confirm with such accuracy. It is recommended that Council and SES agree upon the more conservative (lower) elevation and ensure their plans are consistent rather than undertaking a detailed investigation into which figure is more correct.

Table 21 Council/SES Flood Plan Gauge Height Discrepancies

SES Gauge Height (m)	Council Gauge Height (m)	Consequence	WMAwater Comment	Recommendation
3.62	3.52	Aljoes Creek starts to run.	Due to the nature of the flood model, all creeks start in a 'wet' scenario, and therefore the model cannot identify exactly when Aljoes Creek starts to run. 100 mm is beyond the accuracy of the model.	100 mm not a big enough discrepancy to warrant major investigation. Recommend take conservative approach and be consistent between Council and SES
5.88	5.84	McLean Beach Sewer pump station is inundated	Again, 40 mm discrepancy is beyond the tolerance of model accuracy.	40 mm not a big enough discrepancy to warrant major investigation. Recommend take conservative approach and be consistent between Council and SES

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9.3.5.2. Gauge Height of Design Events

The current flood emergency response documents do not reflect the most recent design flood levels. They may have been based on the 1984 Flood Study (Reference 4), or on the previous gauge location at National Bridge. The documents should be updated with the latest design levels. Design events reach the following gauge heights at the current Deniliquin Gauge (Station No. 409003):

- 20% AEP – 7.0 m
- 10% AEP – 8.6 m
- 5% AEP – 9.4 m
- 2% AEP – 9.9 m
- 1% AEP – 10.1 m

9.3.5.3. Action/ Consequence Discrepancies (Documents 1, 2 and 4)

Given the different roles of Council and SES, the description of consequences at various gauge heights differs between the documents. It is recommended that the plans are amalgamated and consist of ALL consequences/ actions, and perhaps itemise the responsible party. This may help streamline actions prior to and during a flood, and ensure Council and SES are each aware of the other's roles. It may also lend itself to greater efficiencies in the operation of certain tasks. Examples of differing consequences at listed gauge heights is shown in Table 22.

Table 22 Discrepancies in Council/SES Flood Plans

Gauge Reading (m)	SES Consequence	Council Consequence
4.60	Danger height for areas outside levees. Media alert to pump licences and graziers.	Minor Flood
7.30	Riverside Caravan Park, Davidson Street - vans occupying annual sites outside the park's levee begin to be affected; most are elevated but access to this area is lost at 7.4 metres.	Close off Napier Gate Valve and pump from pit outside levee. Top of pit at levee height.
7.40	Riverside Caravan Park access to vans occupying annual sites across floodway lost.	Close off Gate Valve (Behind Lawn Tennis Courts Charlotte Street)
7.80	Floodway commences to run.	Access bridge cut off (Island Sanctuary).
7.95	Ground level between Ovals 2 and 3 at Memorial Park	Close off Gate Valve (End Street at Deni Car-o-tel Caravan Park)
8.21	2/09/81. Peak height (on old bridge gauge). No need to correct by 0.04 metres to align with new gauge unless correcting all historical readings.	Close off Gate Valve (Butler Street at Riverview Motel).
8.50	McLean Beach Caravan Park levee height. Designed to be 8.3 metres (crest height) but in practice so far is 8.5 metres.	Put Bulkhead gate in place (Block off Butler Street at Riverview Motel).

A third version of the gauge height/ consequence table is provided in Document 4, which again contains slightly differing information for the operation of levee components in South Deniliquin. WMAwater recommends amalgamating the three tables to ensure every consequence is accounted for and that actions to be undertaken are clearly listed and easily understood.

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9.3.5.4. General Assessment of Consequences

WMAwater conducted an investigation to check the levels and corresponding consequences provided in each of the Council and the SES Flood Plans by stepping through the results at each available timestep and cross checking the locations and consequences provided. The description of flood behaviour at a given gauge level in each of the Council's and SES' documents were found to be generally consistent with modelled results.

9.3.5.5. Stockpiles

There are six (6) clay stockpiles listed in Section 5.3 of Document 4 for use during a flood to close gaps in the levee across main roads:

A. Lawsons Syphon Road
B. Macauley Street
C. Wakool Road/ Racecourse Road
D. Finley Road
E. Conargo Road
F. Hay Road

Stockpile C is located at the end of the South Deniliquin Levee, which is classified as spillway, and has been omitted from Section 7.1.3 (which describes the operation of levee elements during a flood) and Appendix B – Flood Response Levels. This omission should be corrected, or a note added as to why Stockpile C is not to be used during a flood if this is the case.

Section 7.1.3 of the Levee Owners Manual (Reference 20) notes that earth stockpiles are to be placed across roads with a crest level approximately at the design flood height (100 year ARI flood, equivalent to the 1% AEP event). The stockpiles currently do not allow for any freeboard. Any future changes to the levee operation should also be incorporated.

9.3.5.6. Post Flood Evaluation

Following a flood event it is recommended that a Flood Intelligence Collection and Review is undertaken in Deniliquin. The purpose of this review would be to:

- Identify any gaps or shortcomings of flood-related action plans, especially the installation of temporary levee panels and bulkhead gates;
- Collect data including flood marks, community experience, damage to property;
- Keep track of when roads were overtopped;
- Identify what worked well and opportunities for improvement in flood response actions;
- Any further items deemed relevant at the time.

All of this information is invaluable to the improvement of flood action plans and preparation for the next flood event. Please note that this list is not exhaustive and should be developed further by Council in collaboration with the SES. All emergency response documents should be updated as necessary to reflect findings of the review to ensure they contain the most up to date information available.

9.3.5.7. Summary

A general review of Deniliquin's Emergency Response Plans has shown the documents available to be inconsistent and hard to follow. The documents were written at various times and may not all be up to date with regard to current design flood levels. It is recommended that all actions required in the event of a flood are consolidated into one exhaustive document. It is recommended that this document be developed immediately and include the following:

- Immediate works to Davidson Street Flow Path Improvement (See Section 9.4.12);
- Clear instructions on the gauge heights at which removable levee panels/ gates are to be installed;
- An evacuation plan developed in line with the access available before and after panels/gates are put in place (e.g. at McLean's Beach Caravan Park);
- Map clearly showing the location of required valves/pumps/taps etc;
- Capture local knowledge that is not documented;
- Brief notes on equipment and resources required to complete each action; and
- Confirm usage of Stockpile C, and ensure allowance of sufficient material to provide adequate freeboard above design flood level.

This document should be reviewed every two years (alongside the periodic testing of levee panels) by Council and SES together to ensure consistency of approach and the efficient allocation of resources. It should also be noted that the SES volunteers who are tasked with implementing these actions may not be local to Deniliquin. This should be kept in mind while developing the revised Deniliquin Flood Response Plan to ensure instructions and locations are clear.

☑ **RM01 Recommendation**

- Develop one consolidated, thorough and up to date Flood Emergency Response Plan for Deniliquin to be shared by SES and Council.
- Develop a post-flood event evaluation and review plan to ensure valuable information is captured, and update the Flood Emergency Response Plan accordingly.

9.3.6. Response Modification - Flood Warning (RM02)

Flood warning can significantly reduce damages and risk to life and studies have shown that flood warning systems generally have high benefit/cost ratio if sufficient warning time is provided. Flood warning and the implementation of evacuation procedures by the SES are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BoM) is responsible for flood warnings on major river systems which the SES disseminates to the local community. Adequate warning gives residents time to move goods and cars above the reach of floodwaters and to evacuate from the immediate area to designated evacuation points or flood free ground.

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The effectiveness of a flood warning scheme, known as the effective flood warning time, depends on:

- The maximum potential warning time before the onset of flooding;
- The actual warning time provided before the onset of flooding. This depends on the adequacy of the information gathering network and the skill and knowledge of the operators; and
- The flood awareness of the community responding to a warning.

For overland flow flooding providing a flood warning is more difficult than for area impacted by mainstream floods. Overland flooding usually occurs soon after, or at the same time, as intense rainfall. Spatial differences in the rainfall patterns may go undetected by the sparse rainfall gauge network. However the flooding at Deniliquin is riverine and caused by heavy rainfall much further upstream. For flooding via river systems, predictions of potential peak flood height and timing are possible with a high degree of reliability afforded by upstream gauges.

The Bureau of Meteorology (BoM) provides Flood Warning Services to Deniliquin via the Flood Watch notifications. A Flood Watch is a notification of the potential for a flood to occur as a result of a developing weather situation, and consists of short, generalised statements about the developing weather including forecast rainfall totals, description of catchment conditions and indications of streams at risk. As specified in the Conargo-Deniliquin Local Flood Plan (Reference 14), the BoM will attempt to estimate the magnitude of likely flooding in terms of adopted flood classifications. Continued cooperation between the SES and BoM is supported by this FRMS.

Given the long warning time for flooding in Deniliquin (7-10 days), a 'just in time' approach to flood awareness is deemed to be the most effective form of flood education. This method is currently implemented by the SES and should be continued. Ongoing education or awareness campaigns can bore people or cause complacency and may be forgotten by the time a flood arrives. Instead it is proposed that Deniliquin Council have community information templates that can be readily implemented in case of a flood. These may include a webpage with flood information, warning and instruction in the local paper and community meeting(s) to issue flood warnings, advice and evacuation instructions as necessary.

☑	**RM02 Recommendation** Continuation of current SES Flood Warning System and cooperation with the Bureau of Meteorology is recommended, with flood warning and evacuation templates developed to be readily implemented in case of flood.

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9.3.7. Response Modification – Evacuation (RM03)

A review of the 2009 Deniliquin-Conargo Local Flood Plan has been conducted to identify any gaps or updates required. Significant property inundation in a flood event may force residents to evacuate their homes. Residents will either leave of their own accord, as they feel their property is uninhabitable, or they will be issued an evacuation order. The SES has responsibility for evacuating people due to flooding. The nature of flooding in the Study Area means warning time will generally be 7-10 days. The warning time determines the type of evacuation – the substantial warning time will allow more controlled evacuation prior to property inundation occurring.

The main issues with all flood evacuations are:

- they must be carried out quickly and efficiently;
- they are hazardous for both rescuers and evacuees;
- residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers;
- people do not appreciate the dangers of crossing floodwaters;
- Demographics – high proportion of over-65 year olds (21.3% of Deniliquin's population; and
- Vehicle ownership – 85% of residents own at least one vehicle, however 10% of Deniliquin's residents do not own a vehicle.

Deployment of Levee Gates vs Evacuation/ Access

As discussed in Section 9.3.5, there are a number of levee panels to be installed in event of a flood. The installation of some of these gates and panels will directly affect evacuation routes, and should therefore be considered carefully and included in the Local Flood Plan. Examples of locations include Memorial Drive and McLean Beach Caravan Park.

Evacuation Routes

The Deniliquin-Conargo Local Flood Plan notes that 'Evacuation routes will be dependent upon road closure information at hand during the particular flood event'. As road closures are usually Council's responsibility, clear and open communication between the SES and Council is essential. It is recommended that tentative routes to the listed evacuation centres are mapped out and the gauge levels that would trigger a road closure identified.

Further Information

SES provided a list of hotspots and additional information has been provided in Section 4.7 and the Flood Study (Reference 2) which can be used to further refine the Local Flood Plan. These hotspots include the Davidson St Caravan Park, McLean Beach Caravan Park, Davidson Street area, North Deniliquin, West Deniliquin and Dahwilly.

The evacuation plan should be based upon the most recent design flood levels and take into account access routes affected by the installation of levee panels/gates. The evacuation plan should be refined in collaboration with Council as part of the Revised Deniliquin Flood Emergency Response Plan as described in Section 9.3.5. A range of flood information derived from the flood modelling undertaken in Reference 2 will be provided to Council and SES to assist in the development of an updated evacuation plan.

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☑	**RM03 Recommendation** Develop an updated evacuation plan based on most recent design flood information as part of Option RM01.

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9.3.8. Response Modification – Community Flood Awareness (RM04)

The community of Deniliquin has a degree of flood awareness but it is likely to be limited to those people aware of the more recent events. The last major flood (greater than 9.2 m at the gauge) was in 1956 and this was approximately a 2% AEP event. Virtually no resident of Deniliquin has experienced a 1% AEP flood in the area. It is likely that the effect of a 1% AEP flood (e.g. flooding in North Deniliquin, overfloor flooding of approximately 400 properties) is not widely known or understood. It should be noted that the levee system may also contribute to an overstated sense of security, which especially in the Davidson Street area may have serious implications for evacuation.

Conversely, residents may hold an overstated view of how quickly flooding can occur and be unduly stressed by the thought of flooding in Deniliquin. This could be due to seeing televised footage of flooding in other catchments, and not having a good understanding of the slow rate of rise and long warning time characteristic of Deniliquin flooding.

Typical issues with flood awareness among community members can often involve:

- Misunderstanding of nomenclature (e.g. How a 1% AEP event can occur several times within a short period, for example the 1949 and 1950 events at Kempsey);
- Lack of awareness of how flooding occurs and where water moves;
- Lack of awareness of extent and depth of flooding possible; and
- Lack of understanding and context regarding the size of floods different gauge heights represent.

To combat this it is proposed that community flood awareness be improved in three ways:

1. Provide residents with a fridge magnet that shows the effects of flooding at varying gauge heights and includes general flood risk information;
2. Installation of a depth gauge on the Edward River (near National Bridge); and
3. Installation of one or more historical flood posts at prominent locations in town.

9.3.8.1. Flood Awareness Fridge Magnet

The proposed flyer (in the form of a fridge magnet for example) would serve to provide context of the extent of flooding possible in Deniliquin to aid those who have never experienced a flood. It is expected that this will help residents understand the urgency required if a flood event occurred, appreciate the seriousness of an evacuation notice, but also reduce unnecessary stress regarding flooding. The purpose of this publication would be for floodplain risk management and be Council's responsibility. This is distinct from emergency information provided in response to a real flood event, and typically the responsibility of the SES.

As described in Section 9.3.6 there is generally sufficient warning time to prepare residents for evacuation as well as to disseminate relevant flood information, and an ongoing community education approach has been deemed unsuitable as it would be costly and ineffective as residents become bored or complacent about flooding. The purpose of this flyer however would be to improve baseline awareness of flooding within the community, to allow for better preparedness when a flood event does occur. An example flyer has been provided overleaf.

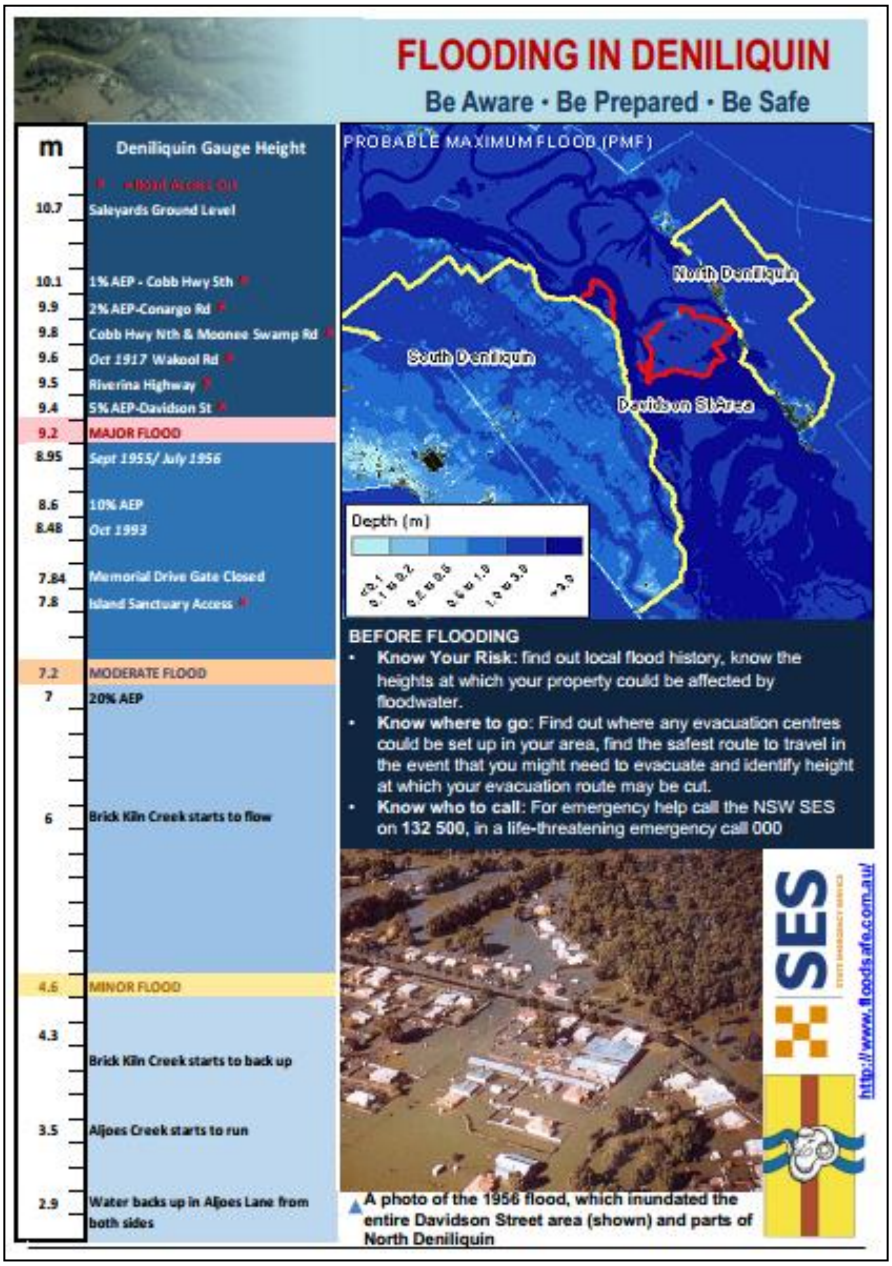

Diagram 2 Example fridge magnet to promote flood awareness in

An easy-to-understand graphical flyer, perhaps in the form of a fridge magnet, would greatly improve the baseline community awareness of flooding, especially as majority of residents have not experienced a major flood event. Improved awareness will be advantageous when a flood event does occur as the community may have a greater appreciation of the danger they may be in. This would make things easier for SES and may improve safety of residents throughout Deniliquin.

Emergency flood information, especially information of what to do in a flood, should be managed by the SES, possibly through use of FloodSAFE brochures either for the Murray Region or specific to Deniliquin.

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9.3.8.2. Installation of Depth Gauge at the National Bridge, Edward River

Flood warnings for Deniliquin are typically given in reference to the 'gauge height', that is, the gauge approximately 200 m upstream of the National Bridge (Gauge No. 409003 ('Edward River @ Deniliquin'). How these heights translate to the amount of water in the river is not generally well understood, and it is thought that a depth gauge could improve understanding and provide some context to flood warnings received. Many riverine towns throughout the world utilise bridge piers or footings for such gauges as they are in highly trafficked areas, structurally sound and highly visible to passers-by. The National Bridge could be a good location in Deniliquin, however other sites may be considered. For example the Katherine Town Community in the Northern Territory utilise the depth markings on the railway bridge pylon to gauge the severity of water levels during flood events (see Photo 1). Once installed, there would be ongoing maintenance required to ensure markings remain clearly visible.

Photo 1 Railway bridge over the Katherine River due for repainting *Photo from Katherinetimes.com.au 2015*

9.3.8.3. Installation of Historical Depth Markers in Deniliquin

As discussed in Section 3.1, Deniliquin has experienced severe flooding on several occasions since its settlement in the mid-19th century. The largest flood on record occurred in 1870, devastating the town and the surrounding land. Large floods then passed through the town in 1917 and 1931, before a makeshift levee was built in 1955 in the weeks leading up to the flood of that year. The levee protected most of the town during that flood and the one of the following year, which was larger than the 1955 event and inundated the Davidson Street area. Subsequent floods have not peaked as high as the 1956 event and the town has been largely flood free, except for the Davidson Street area, which was inundated in the 1975 event.

The extent and depth of such floods is generally not well appreciated by the community, especially as they have not experienced significant flooding themselves. Historical flood depth markers can make real the level that was reached in particular events for such residents. These should be installed at location(s) away from the river so that the magnitude and extent of inundation can be appreciated. In addition to historical events, depths for a range of gauge heights could be included which can be derived from modelling.

There is a number of historical flood markers throughout NSW, for example Maitland in the Hunter Valley has utilised signage on power poles, as shown in Photo 2, while Gunnedah in North Western NSW has a designated 'flood post', with the peak levels of various events marked. A key feature for Deniliquin should be the inclusion of corresponding gauge height references for various historical events, to provide context for the heights quoted in flood warnings and related newspaper articles. The gauge heights should be referenced back to gauge zero (Gauge No. 409003 ('Edward River @ Deniliquin') to minimise confusion.

Photo 2 Historical flood marker in Maitland, NSW
http://familypedia.wikia.com/wiki/Maitland,_New_South_Wales

Photo 3 Flood Height Post, Gunnedah, NSW (*Photo C. Burgess 2016)*

☑

RM04 Recommendation

- Develop a visually clear and concise notice (fridge magnet) to increase flood awareness among residents in Deniliquin.
- Investigate ordering Deniliquin-specific SES FloodSAFE brochures for use in a flood event.
- Install depth gauge for the Edward River, at or near National Bridge.
- Install historic flood markers throughout town, including gauge height reference.

9.3.9. Recommendations Arising from the October 2016 Flood Analysis

Deniliquin experienced a flood in October 2016 that peaked at 8.62 m at the gauge, making it slightly higher than 10% AEP design event (8.6 m). The Edward River began rising during the Public Exhibition period of this FRMS, and the completion of the report was held so as to capture flood intelligence and evaluate how the flood was managed. The recommendations are summarised in Table 23, and described in further detail in Appendix G. The recommendations have also been assessed using the multi-criteria matrix analysis in Section 9.6, and included in the Floodplain Risk Management Plan (Section 9.9).

Table 23 Recommendations based on October 2016 Flood Event

ID	Recommendation	Description
Oct 16 – R1	Centralised Flood Intel Kit	Formation of a "kit" that contains all necessary flood intelligence documentation regarding general flood behaviour, road closures, levee pipe closures and levee management (gates/panel operation) for easy use during a flood.
Oct 16 – R2	Levee Pipe Condition Assessment	Council is to undertake a thorough audit of the condition of all levee stormwater pipes, to ensure that they each are in good condition and fitted with serviceable gates. Upgrades should be made where necessary based on the findings of the assessment.
Oct 16 – R3	Improved Communications During Flood Event: Internal Council Comms	Council's Director of Technical Services to conduct bi-weekly staff briefings before and during a flood event to keep staff informed and manage various tasks to be completed, then conduct post- event evaluation.
Oct 16 – R4	Improved Communications During Flood Event: Council and SES	Brief meeting between the SES and Council to be held as soon as possible following initial flood warning to clarify roles and responsibilities.
Oct 16 – R5	Collection of flood data following an event	Council is to undertake data collection activities in a timely manner following a flood event. This includes collection of flood marks, interviews with staff and asset condition assessment. Community feedback should also be collected.

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9.4. Site Specific Management Options

Site specific management options involve flood modification works aimed at managing the flood risk in a particular part of the Study Area. Given that Deniliquin occupies a very small part of the river's larger catchment, options have been focussed on those that either improve conveyance through the area through channel works and vegetation clearing, or blocking flow from an area, via a levee. The section of the floodplain through the town is already well-developed, with a substantial levee system and urban area on both sides of the river, which limits the structural or flood modifications works that can be undertaken.

An overview of the flood affected areas and assessed mitigation options are provided in Table 24 and shown in Figure 18. These options are discussed in detail in Sections 9.4.1 to 9.4.11. The following sections each include a discussion of modelled impacts, detailed to the nearest 0.01 m. This is beyond the accuracy of the flood model, which, as discussed in Section 8.1.1 vary between +/- 0.15 m and up to 0.3 m, however the number of significant figures has not been reduced so as to not overstate impacts of the investigated mitigation option.

Table 24: Flood Affected Areas and Proposed Mitigation Options

Flood Affected Streets/Areas	Proposed Mitigation Options	Reference
Davidson Street Area and North Deniliquin	Clearing Out and Lowering Brick Kiln Creek	FM01
Davidson Street Area	Davidson Street Levee Raised to 1% AEP	FM02
South Deniliquin, North Deniliquin and Davidson Street Area	Revised North, South Deniliquin Levees and Davidson Levee - all to 1% AEP	FM03
Davidson Street Area	Removed Davidson Street Levee	FM04
South Deniliquin	Revised Spillway and Freeboard for South Deniliquin Levee	FM05
North Deniliquin	Revised North Deniliquin Levee - Minor Upgrade	FM06
North Deniliquin	Revised North Deniliquin Levee - 1% AEP Plus 0.5 m Freeboard Upgrade	FM07
Caravan Park at McLean Beach	Revised Caravan Park Levee - 1% AEP level	FM08
Davidson Street Area	Revised Davidson Street levee	FM09
Davidson Street Area	New Bypass Channel Through Davidson Street	FM10
Davidson Street Area and North Deniliquin	Lower Embankment Downstream and Upstream of the bridge	FM11
Davidson Street Area and North Deniliquin	Davidson Street Flow Path Improvement	FM12

9.4.1. Flood Modification – Clearing Out and Lowering Brick Kiln Creek (FM01)

Option Description

Option FM01 describes a conveyance improvement for Brick Kiln Creek with the goal of improving the Davidson Street and North Deniliquin levees' protection in a range of flood events, and reducing general flood affectation through these areas. Brick Kiln Creek breaks off from the Edward River upstream of the National Bridge, near RJ Edwards Park and conveys a significant magnitude of flow in a flood event. The flow is somewhat limited by the topography at the beginning of the creek, which is not as wide or deep as the rest of the creek, for example at Brick Kiln Creek Bridge. Anecdotal evidence suggests fill has been dumped in the area. Furthermore, there is medium-density vegetation, including established trees, in the creek bed, which can impede the flow. By changing the creek shape, more flow could be distributed through the creek, away from the main channel, which may be able to reduce the peak flood level against the Davidson Street and North Deniliquin levees.

The location of the works is shown on Figure 19. In the hatched area, the creek has been lowered to just below 87 mAHD, which is up to 1 m lower than what currently exists. The channel has also been widened from 40 m to 60 m. Topographic changes have been made to the limit of what is possible given property ownership constraints. Similarly, the creek has been modelled with a smoother hydraulic roughness (Manning's 'n' of 0.04) to represent the removal of vegetation.

Modelled Impacts

The mitigation option achieves minimal reduction in flood level for the area, as lowering and widening does not significantly increase flow in a large flood. The impact of the proposed works on the 1% AEP flood level is shown on Figure 19, while Figure 20 shows the impact in the 5% AEP. The figures show that in both events there is a small increase in flood level downstream of Brick Kiln Creek Bridge (6 mm in 1% AEP, 15 mm in 5% AEP) while there is negligible decrease upstream of the bridge (6 mm in 1% AEP, 4 mm in 5% AEP).

The minimal impact caused by the large-scale channel clearing is a result of the relative changes to flow behaviour in the larger system. Brick Kiln Creek is small relative to the Edward River, with around 15% of its flow in a large flood (1,178 m^3/s in river vs. 179 m^3/s in creek for the 5% AEP event, 1,564 m^3/s vs. 184 m^3/s in the 1% AEP event). The creek's topography is quite confined due to the levee on either side of it, which limits the amount of flow it can carry in large floods. The relatively small flow in Brick Kiln Creek means that any changes to its flow will be small compared to the overall system. Secondly, increasing the creek's cross-section can reduce the watercourse's velocity, reducing the overall conveyance through the creek. For this option, the creek flow area was increased from around 175 m^2 to 220 m^2. However, the velocity in the channel drops from 1.36 m/s to 1.14 m/s in the 1% AEP, which meant the flow increased only by 14 m^3/s. In a smaller system, 14m^3/s would result in a significant change in peak flood level, however, as the total 1% AEP flow is over 2000 m^3/s, it is relatively small and does not result in a significant reduction in level.

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Vegetation Management Requirements

Advice from the NSW Office of Environment and Heritage highlighted the difficulties associated with vegetation management stemming from the competing objectives of flood risk reduction, erosion control and ecological conservation, and the importance of developing and submitting a formal Vegetation Management Plan (VMP) for approval prior to any works being undertaken. When considering vegetation management for flood risk reduction it is important to note that the removal of vegetation can have detrimental impacts, including:

- Hydrologic Impacts – Flood problems downstream can be accentuated due to the decreased travel time for the flood hydrograph where upstream roughness is reduced;
- Hydraulic/Geomorphic Impacts – Flow velocities will increase, which, together with the loss of protection offered by vegetation, can significantly increase channel bank and bed erosion;
- Ecological Impacts – Destruction of riverine habitat particularly if river banks are not revegetated with more appropriate, endemic native vegetation; and
- Maintenance Issues – The need for regular maintenance which may not be practical to achieve.

In order to limit damage to riverine and/or floodplain health the following conditions may be placed upon the removal of any vegetation:

- The types of vegetation that may be removed, and allowable area of removal;
- Extent to which vegetation may be removed (stem densities to remain);
- Staging of the main phase of the work (both spatially and temporally), and methodologies and equipment used;
- Precautions to be observed to avoid damage/disturbance to remaining vegetation, and any necessary 'offset areas' and their maintenance.

The NSW OEH has set out a 5 Stage process in developing and implementing a VMP for floodplain risk management (FRM) as outlined below:

1. Feasibility Assessment – Assessment of the potential hydraulic benefits, cost effectiveness and practicality of vegetation management as a FRM measure – see Evaluation below.
2. Adoption by Council of vegetation management as an element in Council's adopted FRMP.
3. Preparation of a formal VMP (including maintenance requirements) in consultation with relevant authorities for approval under relevant legislation.
4. Relevant authorities consider formal VMP which may be approved, with or without conditions.
5. If approved, VMP implementation considering associated conditions and on-going maintenance.

Given that vegetation management can improve floodplain risk, funding is available from OEH for both the development of the plan and the initial implementation of management works (i.e. clearing vegetation and establishing offset zones). However continued funding is dependent upon the receipt of all relevant environmental approvals, and ongoing maintenance is Council's responsibility. The cost of gaining the necessary approvals and ongoing implementation could be substantial and depending on the flood risk benefits the management provides, this option may not be feasible.

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Evaluation

The proposed clearing of Brick Kiln Creek would not provide significant benefit to Davidson Street or North Deniliquin and would involve large-scale earthworks and vegetation clearing. Although modifying the channel would increase peak flow through it, the change in peak flood level is less than 0.01 m. It was found that the increase in flow area and conveyance only resulted in an increase of 14 m^3/s in the creek for the 1% AEP; not enough to significantly lower the flood level. Furthermore, the large-scale nature of the required works, which would require excavating by around 1 m over a 350 m section of the creek as well as removal of mature river red gums, would have a significant environmental impact and would only be justified by a much larger benefit to the flood risk.

Separate to earthworks being carried out, the young trees in the creek and other flood runners throughout the study area may be managed to ensure the creeks do not become more densely vegetated. A number of young trees were identified in the area upstream of Brick Kiln Creek Bridge. If the trees grow further, they have the potential to block the creek to the extent that its hydraulic roughness will change, raising flood levels by a small amount. A vegetation management plan would ensure trees and other vegetation can continue to grow in the area while removing a portion to preserve the hydraulic roughness of the waterway.

FM01 Recommendation

☒ The excavation and large scale clearing of Brick Kiln Creek is not recommended.

☑ The development and implementation of a Vegetation Management Plan for all creeks and rivers in Deniliquin is recommended.

9.4.2. Davidson Street Levee Raised to 1% AEP (FM02)

Option Description

Option FM02 involves raising the informal levee around Davidson Street to a 1% AEP level with the goal of increasing the Davidson Street area's flood protection. The area is currently inundated in around a 5% AEP event and experiences widespread inundation of property and roads, which can act as evacuation routes. The previous study to assess the effect of a levee in the area was the 1984 study (Reference 4), which concluded that the levee should be removed, so as to not constrain the river by blocking a part of the floodplain, and to not exaggerate the protection of the informal levee. In addition, the condition of the levee is unknown but is expected to be poor. Option FM02 re-assesses this analysis based on the revised modelling approach established by the recent Flood Study (Reference 2) which better represents flow behaviour around Davidson Street. The option takes the existing levee alignment and raises it to above the 1% AEP level. Freeboard was not considered as it was a general feasibility test of the option to confirm the previous recommendation.

Modelled Impacts

The raised levee protects the Davidson Street area in flood events up to the 1% AEP, but causes significant impacts in the upstream area. Figure 21 shows the location of the levee upgrade and the impact in the 1% AEP event. As shown, the Davidson Street area is no longer flooded. However, there is an impact of between 0.02 and 0.05 m in a large area upstream of the upgrade. The impacted area includes properties that would experience more frequent flooding as a result of the upgrade. Analysis of above floor flooding found that the upgrade would cause above-floor flooding of four properties in the 1% AEP event that are not flooded in the 1% AEP event under existing conditions. The impact also reduces the level of protection of both the South and North Deniliquin levees.

Evaluation

A levee upgrade for Davidson Street is not considered feasible as it results in significant adverse impacts in the area upstream. Although an upgrade would likely reduce overall flood damages in Deniliquin, the reduction in one area at the expense of another is not considered reasonable and is not sanctioned under the NSW floodplain management program. As recognized in the previous analysis and during large flood events, the Davidson Street area lies in the centre of the floodplain in a large flood, conveys a large percentage of flow, for example, 15% of total flow in the 1% AEP event and is classified as floodway. Given this function, it cannot be further leveed without causing widespread adverse impacts upstream. Further the cost associated with an upgrade of this nature would be substantial and cannot be justified by the benefits and impacts.

☒	**FM02 Recommendation** The raising of the Davidson Street Levee is not recommended due to the adverse impacts caused upstream and its floodway location.

9.4.3. Revised North, South Deniliquin Levees and Davidson Levee - all to 1% AEP (FM03)

Option Description

Option FM03 involves a combination of levee upgrades to the North, South and Davidson Street Levees. The option is aimed at improving the flood affectation in Davidson Street and North Deniliquin and maintaining the level of protection in South Deniliquin as levee upgrades in the other two areas will reduce the level of protection for the South Deniliquin levee. The option has been tested to determine what impact will occur at properties outside the levees and how much the levees would have to be raised to achieve 1% AEP + 0.5 m freeboard protection in all three areas. As stated previously, Davidson Street forms a significant floodway area in the 1% AEP event and its obstruction via a levee will cause adverse impacts upstream and is not likely to be considered further.

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Modelled Impacts

The upgrades cause widespread adverse impacts upstream of Davidson Street but significantly improve flood affectation in Davidson Street and North Deniliquin. Figure 22 shows the locations of the raised levees as well as the impact in the 1% AEP event. Figure 23 shows the impact in the 5% AEP event. As shown in the 1% AEP event, the adverse impact includes Memorial Park and surrounding area, populated areas north and east of the North Deniliquin levee, and populated areas between Carew Street and Lawson Syphon Road. The adverse impacts are between 0.01 and 0.1 m over the area. This increase corresponds to a required raising of approximately 0.2 m for half of the South Deniliquin levee, and 0.3 to 0.6 m for the North Deniliquin levee. The impact is caused by the flow which previously passed over Davidson Street, and also into North Deniliquin in a 1% AEP event now having to flow through Brick Kiln Creek or the river, which causes an afflux upstream.

The impact corresponds to a reduction in the overall number of properties flooded above floor, but at the cost of properties that are newly flooded under the option. In the 5% AEP event, the total number flooded decreases from 51 to 11. In the 1% AEP event, there are four properties newly flooded above floor under the option, while the total number decreases from 399 to 98.

Evaluation

The upgraded levees provide significant benefit to Davidson Street and North Deniliquin but would require additional mitigation works to manage the widespread adverse impact. The majority of properties outside the levee system upstream of the town would be more frequently flooded as a result of the upgrade, which is considered to be unacceptable when choosing flood mitigation works. Every property impacted would require additional mitigation works if the work were to be considered feasible, such as additional levees or channel conveyance improvements. Given the scope of works required (approximately 10 km of levee to upgrade, not including supplementary works to affected properties) and the level of development in the area, the option is not considered feasible. The flood affectation in Davidson Street would more appropriately be managed by property and response measures.

☒	**FM03 Recommendation** The revision of the North, South and Davidson Street Levees is not recommended due to the adverse impacts caused upstream.

9.4.4. Removed Davidson Street Levee (FM04)

Option Description

Option FM04 involves the removal of the Davidson Street levee with the goal of reducing flood affectation at North Deniliquin. As described previously, the Davidson Street area conveys a significant portion of flow in a large flood event due to its location in the natural floodplain of the river. This function has been recognised during large floods in Deniliquin, where the constricting effect of the area can be observed. Furthermore, the condition of the levee is unknown, but is expected to be poor. The levee's removal was tested to determine the extent to which it raises water levels against the North and South Deniliquin levees in a 1% AEP event. Although the levee was removed in the scenario, Davidson Street was unaltered, which is close in height to the levee

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(around 91.5 – 92.0 mAHD), and therefore also can obstruct flow during a large flood. The option was also tested for its effect in the 5% and 2% AEP events.

Modelled Impacts

The option results in a small reduction in peak flood level in a large area upstream of Davidson Street, but also leads to increased affectation in Davidson Street in some events. The impact on flood behaviour for the 1%, 2% and 5% AEP is shown on Figure 24, Figure 25 and Figure 26, respectively. The impacts are summarised as follows:

- 1% AEP event: Reduction of up to 0.1 m in large area upstream of the levee, including within North Deniliquin levee. Similar to 2% AEP event, mix of adverse and beneficial impacts in Davidson Street. The overall number of properties flooded above floor decreases from 399 to 374.
- 2% AEP event: Reduction of up to 0.1 m in large area upstream of the levee, which benefits flood protection of North Deniliquin levee. At Davidson Street, minor increases adjacent to the removed levee location of up to 0.1 m, and reduction for the majority of Davidson Street area of around 0.1 m, due to improved conveyance over the area. The overall number of properties flooded above floor decreases from 185 to 179.
- 5% AEP: Minor reduction upstream of the Davidson Street levee, no significant benefit to flood affectation. Significant adverse impacts within the Davidson Street area including newly flooded areas and more than a 0.2 m increase in peak flood depth. The number of properties flooded above floor increases from 51 to 95.

Overall, the levee's removal would benefit some properties in North Deniliquin that are currently flood affected, but would adversely impact the majority of properties in Davidson Street, which would experience worse inundation in a 5% AEP event. This corresponds to an increase in the number of properties flooded above floor in a 5% AEP, while the total number decreases in a 2% and 1% AEP event. The magnitude of the impacts shows that while the levee is obstructing flow, the afflux is generally 0.1 m or less. This suggests the remainder of the Davidson Street area obstructs the flow, particularly the roads itself, which is slightly raised above the natural ground height.

Evaluation

Removal of the Davidson Street Levee would reduce flood affectation in the upstream area, particularly in North Deniliquin, but not by enough to justify the adverse impact on Davidson Street properties. The impact in North Deniliquin is a reduction of around 0.06 m in the 1% AEP, for properties that are affected by the levee overtopping. Under this scenario, the area would still be severely affected in a 1% AEP event and residents would be evacuated. This would be at the cost of a significant increase in flooding (up to 0.2 m) and more properties flooded above floor in the Davidson Street area in a 5% AEP event, a much more frequent occurrence than the 1% AEP. Given that with the levee removed flow is still obstructed by Davidson Street itself, the levees removal does not appear to be justified.

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As has been observed in previous assessments of the area, there is no straightforward management option for flood liability at the Davidson Street area. It is apparent that the risk of failure of the levee is central to any action, as there is large uncertainty about how the levee functions in different events. A quality audit of the levee would provide details on the condition of the levee, but is a costly exercise and it is unlikely that a substantial levee could remain in this floodway location. A separate measure to mitigate the uncertainty around the levee would be to base Davidson Street area's flood planning level (FPL) on a scenario where the levee is removed (i.e. assume it fails). This will be assessed as part of the FPA/FPL determination.

Following on from this, another mitigation option is proposed (FM12) which will involve lowering a portion of the Davidson Street levee on the downstream end to improve the efficiency of the flow path through the area and effectively decommission the levee. This option is investigated Section 9.4.12.

☒	**FM04 Recommendation** This option is not recommended, refer to Option FM12 for recommended works regarding Davidson Street Levee.

9.4.5. Revised Spillway and Freeboard for South Deniliquin Levee (FM05)

Option Description

Option FM05 describes a revision to the crest level of the South Deniliquin levee to align its design flood level with the updated design results (Reference 2) and to improve its spillway function. The upgrade would confirm its protection against the 1% AEP event and improve the spillway function if the levee is overtopped in a rare event (approximately 0.2% AEP or rarer). The design of the levee was based on the design flood levels produced by the 1984 study (Reference 4) with a freeboard of 0.5 m. As described in the Flood Study (Reference 2), the 2D hydraulic model improved the estimate of design flood levels along the length of the levee, with some sections around 0.1 m higher under revised results. As described in Section 4.5.1, the levee now has a freeboard of 0.4 m in some sections, slightly lower than its design freeboard, and as low as 0.29 m at the east end of Duncan Street (just to the east (upstream) of Crispe Street. A freeboard of 0.5 m has been confirmed as the minimum acceptable freeboard for levees at Deniliquin in the assessment undertaken in Section 8.

The option also involves changing the height of the north-west end of the South Deniliquin levee to improve the spillway function. The spillway is a section of the levee with a lower freeboard that allows for controlled overtopping of the levee if a flood exceeding the levee's design event occurs. As described in the Flood Study, modelling found the spillway was too high for much of its length. The revised option has a 400 m spillway beginning where the current spillway begins, before raising the levee back to the 1% AEP + 0.5 m freeboard for the remaining 2.8 km of the levee to the west of the spillway.

Modelled Impacts

The revised spillway was preliminarily designed in accordance with the OEH Guideline on spillway design and iteratively modelled by lowering and widening a downstream section of the existing crest level by an appropriate amount to allow it to function in larger events. The lowered height was determined by reviewing the levee profile in Figure 8 to provide approximately 0.2 m freeboard. The levee upgrade was modelled with reference to the levee failure scenario adopted for the initial calculation of damages as discussed in Section 6, which following the freeboard assessment in Section 8 identified that the South Deniliquin Levee has an actual level of protection below the 1% AEP. Although designed for the 1% AEP event + 0.5 m freeboard, variations in flood levels since the 1984 study (Reference 4), as well as some low spots in the levee due to normal erosion and defects mean its level of protection is actually lower than originally designed. According to OEH guidelines it was assumed therefore that the South Deniliquin Levee would fail in the 1% AEP event (and greater events), which resulted in inundation of the majority of properties in South Deniliquin. The South Deniliquin Levee Upgrade therefore prevents this from happening in the 1% AEP event, though it is still assumed to fail in the 0.5% AEP event and PMF. The resulting impacts in the 1% AEP event (See Figure 27) show that the area behind the South Deniliquin Levee is no longer flooded, and there are associated minor increases in peak flood levels of the adjacent areas. In events greater than the 1% AEP the revised spillway will provide improved flood risk management by allowing for controlled overtopping, and prevent the levee from retaining water excessively within the South Deniliquin residential area.

Evaluation

The increased freeboard will improve the confidence in the levee's ability to protect against the 1% AEP event, for which the levee is designed, while the revised spillway will improve the levee's operation during events greater than the 1% AEP. The works required are relatively minor and while detailed design would be required, they could be undertaken in line with the existing ongoing maintenance program for the levee. A preliminary concept design and costing for this option has been included in Appendix F.

☑	**FM05 Recommendation** This option to revise the existing spillway and reinstate 0.5 m freeboard for the South Deniliquin Levee is recommended for implementation.

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9.4.6. Revised North Deniliquin Levee – Minor Upgrade (FM06)

Option Description

As described in Section 4.5.1, the area's levee does not currently protect against a 1% AEP flood and has a relatively small design freeboard of 0.1 m. Previous studies found that a 0.1 m freeboard achieved a compromise between the community expectations and the identified freeboard components. The current study recognises that a significantly higher levee (e.g. based on 1% AEP + 0.5 m) may not be accepted due to its impact on visual amenity and access to river. However, the level of protection of the levee is overstated if a 0.1 m freeboard is used, as it can be easily overtopped by a slight variation in the predicted flood level. Two options have therefore been assessed, FM06 which involves a minor upgrade to the levee by filling in gaps to achieve an approximate level of protection of 2% AEP + 0.3 m, and FM07 which raises it to the level of protection to be equivalent to that of the South Deniliquin levee (1% + 0.5 m). Option FM06 is essentially the "do nothing" option.

It should be noted that a freeboard of 0.3 m will still not achieve complete protection against the 2% AEP event. A freeboard assessment of the area in Section 8 has found the required minimum freeboard is 0.5 m. A freeboard of 0.3 m would not ensure protection against the 2% AEP event.

Modelled Impacts

Under the levee-failure approach all levees are assumed to fail in events greater than their design level of protection. Following the freeboard assessment in Section 8 it was found that the North Deniliquin Levee has an actual level of protection below the 2% AEP event, and that the appropriate freeboard required for levees is 0.5 m. Therefore, the impact of this minor upgrade would still not protect against the 2% AEP event as it does not have the appropriate freeboard as determined in Section 8. With only 300 mm freeboard, the levee cannot be confidently relied upon to protect against the range of levels at which a 2% AEP event can occur. It should be noted also that a levee upgrade to the 2% AEP + 0.3 m will only have 0.1 m freeboard against a 1% AEP event flow (which is generally 0.2 m higher), and there is fair chance the levee will be overtopped.

There would be minor adverse impacts in the adjacent area due to the localised gaps being filled, however they would be deemed acceptable given they are minimal. This is due to the flow that previously overtopped the levee being re-distributed towards Davidson Street. It would be expected that these gaps would be filled if an imminent flood was due to overtop the levee, without consideration of the impact on Davidson Street, as they are not part of the levee's design.

Evaluation

Despite filling in small localised gaps in the levee, this option should only be considered a minor upgrade and is not recommended. The upgrade would afford the levee a level of protection of approximately the 2% AEP plus a freeboard of 0.3 m, which does not ensure protection against the range of heights at which the 2% AEP event can occur. The area protected by the North Deniliquin Levee would still be included in the Flood Planning Area and therefore would still require floor level controls as well as s149 notation.

☒ **FM06 Recommendation**
This option is not recommended as it does not provide an adequate level of protection in either the 2% AEP event or the 1% AEP event.

9.4.7. Revised North Deniliquin Levee – 1% AEP + 0.5 m Freeboard Upgrade (FM07)

Option Description

The option consists of the same upgrade described by FM06, but to around 0.4 m higher, which achieves a level of protection at the 1% AEP with an allowance of 0.5 m freeboard. This level would raise the North Deniliquin levee to have the same level of protection as that in South Deniliquin. A freeboard assessment undertaken in Section 8 has determined 0.5 m to be the minimum acceptable level of freeboard for levees at Deniliquin. To raise the levee to a level of 1% AEP + 0.5 m, the section upstream of Davidson Street would be raised around 0.6 m, as would the section near Brick Kiln Creek Bridge. The section near Smart Street would be between 0.3 - 0.7 m higher, while the remainder would need an increase of around 0.1 m or less. A mixture of methods could be applied and are discussed in Appendix F.

A preliminary assessment has been conducted in accordance with the OEH Guideline on spillway design to determine an appropriate location for the spillway section of the North Deniliquin Levee. This was iteratively modelled by removing the levee elevation and observing the way water would move through North Deniliquin. This revealed a low lying area in the north-west corner of the levee, around the intersection of April Street and Augustus Street. This has been identified in Figure G2 in Appendix F. The spillway is generally recommended to have freeboard of approximately 200 mm, however the exact location and length should be determined with detailed modelling in conjunction with the upgraded levee design.

Modelled Impacts

The levee upgrade scenario was modelled and compared with the levee failure scenario as a base case, as discussed in Section 8. The levee upgrade has the effect of raising the levee's actual level of protection, and preventing it from being breached in the 2% AEP and the 1% AEP events. The impacts of this upgrade in the 1% and 2% AEP event are shown on Figure 28 and Figure 29 respectively, which show the area inside the North Deniliquin Levee to be no longer flooded, while the peak flood levels in the area outside of the levee to the northeast are raised slightly (less than 0.05 m). Peak flood levels north of the corner of April and Augustus Streets are slightly reduced, as water no longer spills over the levee at this location. In the 1% AEP event, peak flood levels are exacerbated in the Davidson Street Area (up to 0.05 m) as the water is kept out of North

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Deniliquin. This option has demonstrate an improved confidence that the levee will protect against the 1% AEP event as a result of having the appropriate freeboard (0.5 m) as determined in Section 8.

Evaluation

The option would achieve a significant benefit to North Deniliquin's flood risk. The levee would provide the same level of protection as offered in South Deniliquin against flooding of property and infrastructure. The 1% AEP event is widely used in NSW as the design event for levees, as it achieves a balance between the community's expectation of protection against an event that is likely to happen at least once in a lifetime, and not building to an extreme flood that may not be experienced, with an unacceptable financial cost. The adverse impacts are acceptable for the reason discussed in the previous section.

It is understood that the levee in North Deniliquin was originally designed with a 0.5 m freeboard but that this had unacceptable impacts on visual amenity and river access for the community. Second to this, if a forecast flood were to surround the area, an evacuation order will likely be issued as the area cannot sustain an isolated population for more than a few days. The primary purpose of a levee is however, to protect property and reduce flood damage, rather than to protect people. The reality is that the freeboard cannot be 'lowered' and that a 0.1 m freeboard does not provide adequate assurance of protection against the 1% AEP event. A minimum freeboard of 0.5 m will ensure that property damages in North Deniliquin is minimised. If the upgrade is implemented, North Deniliquin will not be subject to flood related development controls and the area behind the levee will be excluded from the Flood Planning Area (FPA). This will have subsequent impacts on flood insurance for residential and commercial properties. The community concerns will need to be considered in regards to the various consequences of the level of protection when deciding which levee upgrade is required for North Deniliquin. A preliminary concept design and costing for this option has been included in Appendix F, including a brief investigation of alternative temporary flood barrier options to ameliorate community opposition and assist with restrictive easement issues.

☑ **FM07 Recommendation**

- This option is recommended, and temporary barriers to ensure continued visual amenity and access to the waterfront should be investigated.
- It is recommended that an extensive feasibility study be undertaken as a first step.

9.4.8. Revised McLean Beach Levee (FM08)

Option Description

Option FM08 describes a levee upgrade to the informal levee around the caravan park at McLean Beach. As described in Section 4.7.2, the caravan park is flood affected in relatively frequent flood events and is enclosed by an informal levee, with a crest level equivalent to 90.7 mAHD at the gauge, just below the 10% AEP design height. FM08 assesses the impacts of upgrading the informal levee to a 1% AEP level to reduce the effect of flooding at the caravan park. This corresponds to a level of approximately 92.0 mAHD plus freeboard.

Modelled Impacts

The upgrade achieves significant benefit for the caravan park in a range of events but also adversely impacts the upstream area. Figure 30 shows the location of the upgrade and the impact in the 1% AEP event. The figure shows that the caravan park is no longer flooded in the 1% AEP (and smaller events by extension). The adverse impact shown is around 0.07 m along the South Deniliquin levee and 0.03 m in the Davidson Street area. This corresponds to worsened flooding for the 89 properties flooded above floor in the area in a 1% AEP event, and will also slightly reduce the level of protection of the Davidson Street levee. The impacts are caused by the removal of the flowpath that forms over the caravan park in a large flood. As shown, the park sits on a 180° bend in the river, which forces flow around the levee structure when raised.

Evaluation

The adverse impacts resulting from the upgraded levee are too high to justify the additional protection it gives the park. As described, the caravan park and the rest of the McLean Beach area form a significant flowpath in a large flood, that when blocked, increases the peak flood level over a large area upstream. This would reduce the level of protection of the North and South Deniliquin levees, and worsen property flooding in the Davidson Street area. As described, the caravan park's location means it must be inundated in a large flood, lest there may be an impact in the upstream area.

One possible further option for the park would be relocate some caravan/cabin lots south so as to allow the north side of the levee to be shifted south, with the levee enclosing a smaller area. With a larger area outside the levee and the corresponding increasing in flow area, it may be possible the levee could then be slightly raised (e.g. to between the 10% and 5% AEP levels) without causing an adverse impact upstream. This could be the subject of a separate feasibility study.

The levee currently provides protection in the 5 year ARI event and is first overtopped at gauge height 8.35 m in the 10% AEP event. Upgrading the levee to achieve protection in the 10% AEP event would require raising it in parts by approximately 300 mm. Given the variable height of the levee the areas requiring upgrade will need to be confirmed in a further investigation. This upgrade could delay inundation by about 14 hours for a relatively limited amount of earthworks. It should also be noted that access to the caravan park is cut off when the levee is closed at the Butler Street bulkhead floodgate.

☒ **FM08 Recommendation**

This option is not recommended, however benefits could be achieved by upgrading the levee to the 10% AEP event level.

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9.4.9. Revised Davidson Street Levee (FM09)

Option Description

Option FM09 describes a revision to the height of the Davidson Street levee to improve its function during a flood without reducing its level of protection. As shown in Figure 31, the Davidson Street levee has a high part on the north-west side, which is up to 93.0 mAHD. The raised area is likely to be from fill placed in the area. While providing protection to flooding from Brick Kiln Creek, the raised area is surrounded in a large flood and does not offer any additional protection to the rest of the Davidson Street levee. Lowering the area to 92.0 mAHD will not reduce the overall level of protection for Davidson Street, and may reduce the area's inundation by increasing the conveyance as flow leaves the area into Brick Kiln Creek.

Modelled Impacts

The option achieves minor benefit for Davidson Street in the 1% AEP event, and negligible benefit in the 5% AEP event. The impact on peak flood level in the 1% AEP event is shown in Figure 31, while Figure 32 shows the 5% AEP impact. Both figures show the area to be lowered to 92 mAHD. The 5% AEP event shows negligible impact, likely because there is relatively little flow through Davidson Street (34 m^3/s compared to 1356 m^3/s in the river and Brick Kiln Creek). The impact in the 1% AEP event is a reduction of 0.02 m across the Davidson Street area. This indicates that the lowered area is obstructing flow and causing an afflux in the existing case, but that the afflux is generally small. The reduced level would correspond to a minor benefit to property flooding in the Davidson Street area.

Evaluation

Lowering the raised area on the northwest side of Davidson Street will not result in significant benefit in most flood events. As described, the impact in the 5% AEP event in negligible, while the 1% AEP event has around 0.02 m reduction, which will have a minor effect on flood affectation. Given that affectation in the 1% AEP is quite severe in Davidson Street, with over 1 m of water in some areas, the benefit is minor and the cost of the works would not be justified.

☒	**FM09 Recommendation** This option is not recommended due to the high cost of works without substantial benefit in the Davidson Street Area.

9.4.10. New Bypass Channel through Davidson Street (FM10)

Option Description

Option FM10 describes an artificial channel through the Davidson Street area aimed at reducing the flood affectation for Davidson Street and North Deniliquin. This option was suggested by members of the community. The channel would be constructed perpendicular to Davidson Street somewhere along the length of Davidson Street (depending on constraints around property ownership). It would involve construction of a spillway within the existing levee, which would then flow into the channel, before exiting at the downstream end through a pipe and spillway. The channel invert would be approximately 3 m below Davidson Street and it would have a width of approximately 40 m.

Modelled Impacts

The artificial channel causes significant adverse impacts in the Davidson Street area and minimal reduction in flood level. Figure 33 and Figure 34 show the impact in the 2% and 5% AEP event, respectively, as well as a possible location of the channel. In the 5% AEP event, the channel redistributes more flow along it, and when its capacity is exceeded there is increased flooding on the downstream half of the area. The re-distribution favours the upstream side of the street, a part of which is no longer flooded. In the 2% AEP event, there is a decrease of up to 0.1 m in most of Davidson Street, due to the increased conveyance through the area provided by the channel. There is also slightly less overtopping of the North Deniliquin levee which results in a reduction of around 0.1 m in one area. The reduction does not extend upstream of Davidson Street and therefore provides limited widespread benefit.

Evaluation

Although a channel would provide significant benefit in large flood events, it would adversely impact properties in a 5% AEP event, and would have significant constraints relating to property ownership, environmental impacts and additional concentrated flood risk at the channel. As described, the re-distribution of flow to a channel through the area results in adverse impacts for properties adjacent to the channel once it is overtopped. For the option to have more consistent benefit, it would have to block flow in relatively small floods, and then change to allowing a large flow into the channel in larger events. Although this type of dynamic system is used in irrigation channels and similar features, it is not considered practical for controlling flood behaviour. In addition, any channel would require purchase of at least several properties in the areas, which would be prohibitively expensive and not guaranteed to work. The option would need to produce a greater benefit for the scope to be justified.

☒ **FM10 Recommendation**

This option is not recommended due to the adverse impacts in a 5% AEP event, as well as the environmental impacts caused by the excavation works.

9.4.11. Lower Embankment Downstream and Upstream of the Bridge (FM11)

Option Description

Option FM11 involves large-scale earthworks and vegetation removal on the upstream and downstream sides of the National Bridge, aimed at improving conveyance through the area. The area to be lowered consists of the land between the river and the Davidson Street caravan park (approximately 80 m wide), continuing under the bridge, widening to lower Edward River Oval and connecting into the low ground approximately 250 m north of the oval. The mature vegetation between the oval and the river would not be affected. The entire area to be lowered is approximately 6 hectares, and it is to be lowered to 87 mAHD (at south end) grading down to 86 mAHD (north end) (existing elevation is between 88 and 90 mAHD). The lowered ground is aimed at increasing the conveyance through the section of river and lowering the level against Davidson Street (and possibly North Deniliquin levee) as a result. Residents' knowledge of the area suggests the oval and surrounding area has been artificially raised as the town has grown, and the option would be approximating the original flowpath.

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Modelled Impacts

The option achieves widespread reduction in the peak flood level but does not significantly change the flood affectation at Davidson Street or North Deniliquin in the 1% AEP event. The impact in the 1%, 2% and 5% AEP events is shown on Figure 35, Figure 36 and Figure 37 respectively, as is the location of the lowered ground. The results show that the most benefit is had in the 5% AEP event, where a large part of the Davidson Street area is no longer flooded, however Davidson Street itself is still overtopped. The benefit in the larger events consists of around 0.05 m decrease in a large area upstream of the option. This corresponds to a slight increase in the level of protection for the North and South Deniliquin levees.

Based on the design events modelled (5%, 2% and 1% AEP) the option reduces the AAD from $1,957k to $1,869k. The reduction of $88k is equivalent to a benefit of $1,294k (assuming lifetime of 50 years, 7% inflation rate).

Evaluation

The option achieves improved flood liability in the Davidson Street area for frequent events but has significant environmental and cultural impacts. The benefit largely relates to reduced property and road flooding in the Davidson Street area in the 5% AEP event. There is some benefit to North and South Deniliquin as the flood level against the levee system is reduced. As described, the lowered area extends over a large area (approximately 6 hectares) and would involve large scale excavation. Iterative testing of the option found that lesser excavation, such as only beneath National Bridge, or only upstream or downstream of the bridge, did not achieve a significant reduction. The required excavation would involve removal of a number of trees on the river bank upstream of National Bridge, as well as some around the oval (but not those on the river bank adjacent to the oval). There would also be cultural impacts associated with loss of the usability of the oval. The impacts associated with this option cannot be justified by the relatively small benefit.

☒ **FM11 Recommendation**

This option is not recommended due to the large scale environmental and cultural impacts with relatively small benefits.

9.4.12. Davidson Street Flow Path Improvement

Option Description

The Davidson Street levee is an informal levee not maintained by Council. The 1984 study (Reference 4) found that the levee was structurally inadequate and that there was risk of failure from slumping and/or piping under flood conditions. Upgrade of the levee is not appropriate given its current structural integrity, its location in the floodway, and the adverse impacts a higher levee would cause to North and South Deniliquin (as investigated in Option FM02). Removal of the levee has also been shown to be inappropriate due to the minimal hydraulic benefit to the surrounding floodplain, as a result of the embankment formed by Davidson Street, and the substantial negative impacts to the Davidson Street area. Upgrade or removal of the levee would be an extensive and costly project for Council. In view of these factors Option FM12 involves improvement of the flow path through the Davidson Street area effectively decommissioning the Davidson Street levee. The works involve the removal; to ground level; of a 250 m section of the levee at its downstream side.

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This would involve the removal of approximately 6,000 m^3 of earth, which could be used on the proposed North Deniliquin Levee upgrade if suitable. The spoil location must be considered carefully to not cause further impacts within the floodway. The removal of the proposed section of levee would also allow water to escape from the Davidson Street Area and thus reduce flood levels through the area as well as North Deniliquin, as described below. In addition decommissioning the Davidson Street Levee will assist in reducing the false sense of security it affords to residents, as discussed in Section 4.3.

Modelled Impacts

The breach was modelled by lowering a 250 m stretch of the levee at its downstream end. Water enters the Davidson Street area via overtopping at the front (upstream side) of the levee at gauge height 9.2 m (91.63 mAHD). In the 5%, 2% and 1% AEP events, the main cause of inundation is from water overtopping the front of the levee at Jones Street and Davidson Street between Evans Street and Hodgkins Street, moving from east to west through the Davidson Street Area. However, the lowered levee section also allows water ingress from west to east, causing some areas to be inundated slightly earlier than they would have been. A benefit of this scenario however is that the peak flood levels are reduced as water is allowed to escape through the removed section at the downstream end of the area. The levee at this downstream end in its current state acts to retain water and increase peak flood levels in the Davidson Street Area.

The particular impacts of this scenario on flood behaviour depends on the magnitude of the flood event. The option achieves widespread reduction in flood levels and slightly reduces flood affectation in Davidson Street and North Deniliquin in the 1% AEP event. Results show the most benefit is had in the 2% AEP event with significant reductions in peak flood levels occurring in a small area of North Deniliquin, and widespread reduction in flood levels across the Davidson Street area. Modelling of the 5% AEP event however does not show this widespread reduction, instead there is a localised newly flooded area in the vicinity of the works and minimal impacts across the Davidson Street area, with slightly increased flood levels on the undeveloped area west of Herriot Street. The impact in the 1%, 2% and 5% AEP events is shown on Figure 38, Figure 39 and Figure 40 respectively, as is the location of the proposed works.

Evaluation

As discussed previously, Davidson Street levee is an informal levee not maintained by Council. The 1984 study (Reference 4) found that the levee was structurally inadequate and that there was risk of failure from slumping and/or piping under flood conditions. Removal of the levee was recommended, however there are significant costs associated with this in addition to other feasibility issues. An improvement in the safety of Davidson Street residents could therefore be achieved by effectively decommissioning the levee and removing the false impression of the protection it provides by improving the flow path through the area. This option reduces flood levels both in the Davidson Street Area and North Deniliquin, and is recommended for further investigation. It should however be noted that spoil from this site must be removed (possibly used to upgrade the North Deniliquin Levee if suitable) as local spoiling would impact flood behaviour. With the high B/C ratio of 1.5, this option is economically feasible and has been included in the Plan for implementation. A preliminary concept design and costing for this option has been included in Appendix F.

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☑ **FM12 Recommendation**
This option is recommended.

9.5. Economic Assessment of Recommended Measures

The cost effectiveness of the flood modification management options in reducing flood liability within the catchment was determined using the benefit/cost (B/C) approach. Options were only assessed if they had a significant effect on property affectation. These included FM05 – Revised Spillway and Freeboard for South Deniliquin Levee, FM07 – Revised North Deniliquin Levee and FM12 –Davidson Street Flow Path Improvement. Further details on costing is provided in Appendix F. Although the option is recommended, an assessment of FM01 – Development of a Vegetation Management Plan is not possible at this stage as further advice regarding the extent and location of appropriate vegetation management is required. A brief economic analysis of Option PM04 – Voluntary Purchase was also undertaken to examine the economic benefits associated with the purchase of a number of properties in the Davidson Street Area.

9.5.1. Damages Assessment Approach

The damages were calculated using a number of height-damage curves derived from OEH Guidelines (Reference 15) which relate the depth of water above the floor with tangible damages. Each component of tangible damages is allocated a maximum value and a maximum depth at which this value occurs. Any flood depths greater than this allocated value do not incur additional damages as it is assumed that, by this level, all potential damages have already occurred.

As discussed in Section 6.1, North and South Deniliquin are protected by levee systems which need to be considered when calculating damages. In accordance with OEH Guidelines, a properly constructed and maintained levee is considered to only offer protection against floods up to its design level of protection. For events larger than the design flood, the levee may be deemed to have failed, and therefore inundation of the protected area should be assumed. The calculation of damages for Options FM05 and FM07 reflect this approach. The base case was calculated by simulating a failure scenario in events including and greater than the 2% AEP for the North Deniliquin Levee, and events including and above the 1% AEP for the South Deniliquin Levee. These actual levels of protection were determined by subtracting the appropriate freeboard (0.5 m for levees, refer to Section 8) from the existing levee elevation data available. The upgraded options are therefore set to fail only in events greater than the 1% AEP event, thus significantly reducing the damages incurred in the 1% AEP event and below.

Option FM12 however pertains directly to the Davidson Street Area, and the levee-failure scenario approach was not deemed necessary for the comparison of pre- and post-decommissioning damages. The benefits of the decommissioned option were compared with the as-is scenario to produce an indication of reduction in benefits, and hence B/C ratio.

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The same approach was applied to PM04 which investigates Voluntary Purchase within the Davidson Street Area. Through consultation with Council and the FMC it appears that residents would be largely unwilling to participate in voluntary purchase, however the effect of removing 25% of residential properties was investigated for completeness. Again it was thought that the levee failure scenario was not required to show the indicative expected benefits within the Davidson Street Area.

9.5.2. Base Case Damages

This section provides a re-cap of the base-case damages assessed in Section 6 for ease of comparison with the damages found following the modelled implementation of each option. While commercial and residential damage estimates were calculated separately, they have been presented here as a combined figure for simplicity. Table 25 shows the combined residential and commercial base case damages assessment for Deniliquin.

Table 25 Deniliquin Base-Case Damages: Combined Residential and Commercial Damages

Event	No. Properties Affected	No. Flooded Above Floor Level	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP	0	0	$ -	0	$ -
10% AEP	17	4	$ 694,000	1	$ 41,000
5% AEP	91	51	$ 4,372,000	4	$ 48,000
2% AEP	368	250	$ 23,517,000	14	$ 64,000
1% AEP	1994	1336	$ 100,965,000	20	$ 51,000
0.5% AEP	2506	1871	$ 138,199,000	20	$ 55,000
PMF	3740	3685	$ 359,678,000	41	$ 96,000
Average Annual Damages (AAD)			$ 3,044,700	100	
Average annual Damage (AAD) per dwelling					$ 810
Net Present Value of Damages (20 year economic life)					$ 35,300,295

9.5.3. Comparison of Proposed Options

As discussed above, four options were assessed for their cost effectiveness: FM05, FM07, FM12 and PM04. The flood modification options (FM) were shown to lower flood levels in areas of property affectation, and will therefore have some reduction in the economic cost of flooding in Deniliquin. Option PM04 removes 14 houses (25% of the worst-affected residential properties in the Davidson Street Area), and the economic impact of this is also shown below.

B/C ratios were calculated by comparing the Net Present Values (NPV) of the benefits (i.e. the difference in NPV of base case damages less the NPV of the damages post-option implantation) over the economic life of the structure (assumed to be 20 years in accordance with NSW Treasury Guidelines, with a 7% discount rate) to the capital cost of the works. No provision has been made for ongoing maintenance costs as these are not eligible for funding under the FRMP and it is assumed the costs will not be significantly extra to Council's existing maintenance schedule.

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Table 26 presents the reduction in AAD offered by each option, and the B/C ratio of the proposed works.

Table 26 Economic Assessment of Options

Option	Reduction in AAD	B/C Ratio
FM05 – Revised Spillway and Freeboard for South Deniliquin Levee	$529,300	16.4
FM07 – Revised North Deniliquin Levee – 1% AEP + 0.5 m Freeboard	$203,500	1.3
FM12 – Davidson Street Flow Path Improvement	$77,000	1.5
PM04 – Voluntary Purchase (Removal of 25% of residences)	$95,900	0.4

9.5.4. FM05 Economic Assessment

The economic assessment of the upgrade to the South Deniliquin Levee (Option FM05) is shown in Table 27. Note that this assessment is across the entire Study Area, not just the area protected by the South Deniliquin Levee.

Table 27 FM05 Economic Assessment

Event	No. Properties Affected	No. Flooded Above Floor Level	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP	**0**	**0**	**$ -**	**0**	**$ -**
10% AEP	**17**	**4**	**$ 694,000**	**1**	**$ 41,000**
5% AEP	**91**	**51**	**$ 4,372,000**	**5**	**$ 48,000**
2% AEP	**368**	**250**	**$ 23,517,000**	**17**	**$ 64,000**
1% AEP	**538**	**384**	**$ 35,710,000**	**5**	**$ 66,000**
0.5% AEP	**2468**	**1820**	**$ 135,347,000**	**17**	**$ 55,000**
PMF	**3733**	**3676**	**$ 349,431,000**	**48**	**$ 94,000**
Average Annual Damages (AAD)			**$ 2,515,408**	**93**	
Average annual Damage (AAD) per dwelling					**$ 670**
Base Case Study Area-Wide AAD (before option implementation)					**$ 3,044,700**
Reduction in Study Area-Wide AAD (after option implementation)					**$ 529,300**
% Reduction in AAD per dwelling					**17%**
Net Present Value of Damages (20 year economic life)					**$ 29,163,700**
Estimated Cost of works					**$ 374,700**
B/C Ratio					**16.4**

NOTE: 'Properties Affected': there is flooding above ground level within the property boundary (ie the lot)
'No. Flooded above floor level': there is flooding above the surveyed or estimated floor level of the house.

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The increased freeboard improves the confidence in the levee's ability to protect against the 1% AEP event, for which the levee is designed, while the revised spillway will improve the levee's operation during events greater than the 1% AEP. The high B/C ratio and significant benefits of this option the inundation that could occur if the levee were to fail at the 1% AEP event. This scenario assumes hundreds of properties would be inundated in a 1% AEP event, whereas with the upgrade, the number of properties affected within the South Deniliquin Levee are greatly reduced, resulting in a significant reduction in damages. It is acknowledged that in reality, the upgrades to the levee are relatively minor, however they would provide assured protection in the 1% AEP event as the requisite minimum freeboard (calculated to be 0.5 m in Section 8) would be provided by the upgraded levee.

9.5.5. FM07 Economic Assessment

The economic assessment of the upgrade to the North Deniliquin Levee (Option FM07) is shown in Table 28.

Table 28 FM07 Economic Assessment

Event	No. Properties Affected	No. Flooded Above Floor Level	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP	**0**	**0**	**$ -**	**0**	**$ -**
10% AEP	**17**	**4**	**$ 694,000**	**1**	**$ 41,000**
5% AEP	**91**	**51**	**$ 4,372,000**	**4**	**$ 48,000**
2% AEP	**260**	**179**	**$ 18,184,000**	**12**	**$ 70,000**
1% AEP	**1805**	**1216**	**$ 91,057,000**	**19**	**$ 50,000**
0.5% AEP	**2472**	**1811**	**$ 133,447,000**	**20**	**$ 54,000**
PMF	**3737**	**3685**	**$ 360,163,000**	**43**	**$ 96,000**
Average Annual Damages (AAD)			**$ 2,841,180**	**100**	
Average annual Damage (AAD) per dwelling					**760**
Base Case Study Area-wide AAD (before option implementation)					**$ 3,044,700**
Reduction in Study Area-wide AAD (after option implementation)					**$ 203,500**
% Reduction in AAD per dwelling					**6%**
Net Present Value of Damages (20 year economic life)					**$ 32,940,700**
Estimated Cost of works					**$ 1,855,100**
B/C Ratio					**1.3**

NOTE: 'No. Properties Affected': there is flooding above ground level within the property boundary (ie the lot)
'No. Flooded above floor level': there is flooding above the surveyed or estimated floor level of the house.

As for Option FM05, the benefits of this option could be considered to be overstated due to the conservative approach used in the base case damages calculations. However the costs associated with this option are much higher (~$1.9 M) and so the overall financial efficiency is not as high.

9.5.6. FM12 Economic Assessment

As discussed in Section 6, the damages assessment for Option FM12, the Davidson Street Flow Path Improvement was undertaken without the application of the North and South Deniliquin Levee failure scenario. The levee failure scenario was not deemed necessary to assess the difference that the option would make to affectation of properties within the Davidson Street area. The economic assessment of the Davidson Street Flow Path Improvement (Option FM12) is shown in Table 29.

Table 29 Option FM12 Economic Assessment

Event	No. Properties Affected	No. Flooded Above Floor Level	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP	**0**	**0**	**$ -**	**0**	**$ -**
10% AEP	**17**	**4**	**$ 694,000**	**2**	**$ 41,000**
5% AEP	**58**	**30**	**$ 2,985,000**	**5**	**$ 51,000**
2% AEP	**261**	**179**	**$ 17,712,000**	**17**	**$ 68,000**
1% AEP	**520**	**383**	**$ 35,594,000**	**14**	**$ 68,000**
0.5% AEP	**611**	**480**	**$ 44,001,000**	**11**	**$ 72,000**
PMF	**3719**	**3653**	**$ 345,592,000**	**52**	**$ 93,000**
Average Annual Damages (AAD)			**$ 1,876,630**	**100**	
Average annual Damage (AAD) per dwelling					**$ 500**
Base Case Study Area-wide AAD (no levee failure scenario)					**$ 1,958,698**
Reduction in Study Area-wide AAD (after option implementation)					**$ 82,100**
% Reduction in AAD per dwelling					**7%**
Net Present Value of Damages (Base Case)					**$ 22,650,820**
Net Present Value of Damages (Option Implemented)					**$ 21,757,675**
Estimated Cost of works					**$ 580,200**
B/C Ratio					**1.5**

NOTE: 'Properties Affected': there is flooding above ground level within the property boundary (ie the lot)
'No. Flooded above floor level': there is flooding above the surveyed or estimated floor level of the house.

As indicated in the table, the flow path improvement reduces the flood affectation and results in a substantial economic benefit with a B/C Ratio of 1.5 due to the cost of the option being significantly less than the net present value of the reduction in AAD. It is expected that the implementation of this option with adequate publicity will also remove the false sense of security held by residents, and aid the SES by ensuring residents have a more realistic understanding of the danger flooding poses to them and their homes.

9.6. Assessment Matrix

9.6.1. Background

Multi-variate decision matrices are recommended in the Floodplain Development Manual (Reference 1) and therefore it is also a recommendation of this report that multi-variate decision matrices be developed for specific management options, allowing benefit/cost estimates, community involvement in determining social and other intangible values, and local assessment of environmental impacts.

The criteria assigned a value in the management matrix are:

- Risk to life;
- Impact on flood behaviour (reduction in flood level, hazard or hydraulic categorisation) over the range of flood events;
- Number of properties benefited by measure;
- Compliance with EP&A Act 1979 (whether the work adversely impacts existing development, involves development in the floodway, or encourages development which increases spending on flood mitigation, infrastructure or services)
- Technical feasibility (design considerations, construction constraints, long-term performance);
- Community acceptance and social impacts;
- Economic merits (capital and recurring costs versus reduction in flood damages);
- Financial feasibility to fund the measure;
- Long term performance;
- Environmental and ecological benefits;
- Impacts on the State Emergency Services;
- Political and/or administrative issues; and
- Long-term performance given the potential impacts of climate change.

The scoring system for the above criteria is provided in Table 30. Tangible costs and damages are also used as the basis of B/C analysis for some measures.

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Table 30: Matrix Scoring System

SCORE:	-3	-2	-1	0	1	2	3
Impact on Flood Behaviour	>100 mm increase	50 to 100 mm increase	<50 mm increase	no change	<50 mm decrease	50 to 100 mm decrease	>100 mm decrease
Number of Properties Benefited	>5 adversely affected	2-5 adversely affected	<2 adversely affected	none	<2	2 to 5	>5
Compliance with EP&A Act 1979	major issues	moderate issues	minor issues	neutral	moderately straight-forward	Straight-forward	no issues
Technical Feasibility	major issues	moderate issues	minor issues	neutral	moderately straight-forward	Straight-forward	no issues
Community Acceptance	majority against	most against	some against	neutral	minor	most	majority
Economic Merits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Financial Feasibility	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Environmental & Ecological Benefits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Impacts on SES	major disbenefit	moderate disbenefit	minor disbenefit	neutral	minor benefit	moderate benefit	major benefit
Political / administrative Issues	major negative	moderate negative	minor negative	neutral	few	very few	none
Long Term Performance	major disbenefit	moderate disbenefit	minor disbenefit	neutral	positive	good	excellent
Risk to Life	major increase	moderate increase	minor increase	neutral	minor benefit	moderate benefit	major benefit

9.6.2. Results

The assessment matrix is given in Table 31 with each of the assessed management options scored against the range of criteria. ‘Community Acceptance’ has been allocated a draft score at this time, as the community information session is yet to be held (the matrix will be updated when the information is available). The draft score is based on initial consultation undertaken at the commencement of the Study. It is important to note that the approach undertaken does not provide an absolute “right” answer as to what should be included in the Management Plan but is rather for the purpose of providing an easy framework for comparing the various options on an issue by issue basis which stakeholders can then use to make a decision. For the same reason, the total score given to each option, and the subsequent rank, is only an indicator to be used for general comparison.

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Table 31 Multi-Criteria Matrix Assessment

Ref	Option	Section in Report	Impact on Flood Behaviour	Number of Properties Benefited	Compliance with EP&A Act 1979	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental/Ecological Benefits	Impact on SES	Political/Admin Issues	Long Term Performance	Risk to Life	0	Total Score	Ran
FM01	Clearing Out and Lowering Brick Kiln Creek	9.4.1	0	0	0	1	1	0	-1	-3	0	-2	0	0		-4	22
FM02	Davidson Street Levee Raised to 1% AEP	9.4.2	-2	3	-3	-1	2	1	-1	-2	2	-2	1	2		0	20
FM03	Revised North, South Deniliquin Levees and Davidson Levee -all to 1% AEP	9.4.3	-2	3	-3	-2	-1	1	-2	-2	3	-3	1	2		-5	=17
FM04	Removed Davidson Street Levee	9.4.4	1	-3	0	1	-3	2	2	-1	2	-3	2	2		2	19
FM05	Revised Spillway and Freeboard for South Deniliquin Levee	9.4.5	1	1	0	1	3	1	1	0	1	-1	1	1		10	15
FM06	Revised North Deniliquin Levee - 2% AEP Plus 0.3 m Freeboard	9.4.6	2	3	0	1	0	1	0	0	2	-2	1	1		9	16
FM07	Revised North Deniliquin Levee - 1% AEP Plus 0.5 m Freeboard	9.4.7	3	3	0	1	3	2	0	0	3	-2	1	2		16	12
FM08	Revised Caravan Park Levee - 1% AEP level	9.4.8	-2	-2	-2	1	1	-1	1	-1	1	-2	1	0		-5	=17
FM09	Revised Davidson Street levee	9.4.9	1	1	0	1	1	1	1	0	0	-1	1	0		6	17
FM10	New Bypass Channel Through Davidson Street	9.4.10	-3	-3	-2	-2	-3	-1	-2	-2	-2	-3	-1	-2		-26	26
FM11	Lower Embankment Downstream and Upstream of the bridge	9.4.11	1	2	0	-1	-3	1	-1	-3	0	-3	-1	0		-8	25
FM12	Davidson Street Flow Path Improvement	9.4.12	1	3	3	2	-1	3	3	0	3	-1	2	2		20	=3
																0	20
PM01	Revision of FPL and FPA	9.3.1	0		3		-2	0	1	1	2	-3	2	1		5	18
PM02	Planning Policy Review	9.3.2	0	0	3	3	0	0	1	1	2	-2	2	1		11	=8
PM03	Changes to s149 Certificates	9.3.3	0	3	3	3	2	0	1	1	2	-1	2	1		17	11
PM04	Voluntary Purchase	9.3.4	1	0	2	-1	-2	2	1	1	3	-2	3	3		11	=8
RM01	Flood Emergency Management Review	9.3.5	0	0	3	3	3	3	3	0	3	0	3	1		22	6
RM02	Flood Warning	9.3.6	0	0	3	2	2	2	3	0	3	0	3	2		20	=3
RM03	Evacuation	9.3.7	0	0	3	2	2	2	3	0	3	0	3	3		21	7
RM04	Community Flood Awareness	9.3.8	0	0	3	3	3	1	3	0	3	0	3	1		20	=3
Oct 16 - R1	Centralised Flood Intel Kit	App G	0	0	3	3	3	3	3	0	3	3	3	3		27	2
Oct 16 - R2	Levee Pipe Condition Assessment	App G	0	0	3	3	3	3	2	1	3	2	3	3		26	3
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	App G	0	0	3	3	3	3	3	0	2	2	3	2		24	5
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	App G	0	0	3	3	3	3	3	0	3	2	3	3		26	3
Oct 16 - R5	Collection of flood data following an event	App G	0	0	3	3	3	3	3	1	3	3	3	3		28	1

Recommended in Draft Floodplain Risk Management Plan

As shown in the matrix, most options have a range of positive and negative effects, making comparison of the options more difficult. The features of note are:

- Impact on flood behaviour is mixed, with some options having beneficial impacts but this being offset by adverse impacts in other areas. The upgrade to the North Deniliquin levee (FM07) has the most beneficial impact. Similarly, some options both benefitted and worsened impacts on properties across the area.
- Most options have negative environmental impacts as they involve removal of mature trees and other vegetation.
- Most options benefit the SES, as they either improve certainty by formalising the Davidson Street levee functioning, or improve the protection in North Deniliquin.
- All options are likely to have some political or administrative issues. Previous studies have shown significant community engagement on management options that has factored into the political process. Furthermore, options generally involve crown lands, private property and Council property.
- Similarly to the SES benefit, most options improve risk to life by formalising Davidson Street's functioning or improving protection in North Deniliquin.
- The recommendations made in the October 16 Flood Review are high scoring due to the benefits they cause and the low cost of implementation.

9.7. Summary of Recommendations

A number of mitigation options have been investigated as part of this FRMS. Table 32 summarises the measures that have been assessed and are deemed worthy to either be implemented immediately, or warrant further investigation.

Table 32 Summary of Recommendations

Study Area Wide – Recommended Measures		
Option	**Description**	**Ref**
PM01	Revision of FPL/ FPA	9.3.1
PM02	Amendments to Planning Policies	9.3.2
PM03	Changes to s149(2) and (5) Certificates	9.3.3
PM04	Investigation of Voluntary Purchase	9.3.4
RM01	Flood Emergency Response Management	9.3.5
RM02	Improvement of Flood Warning System	9.3.6
RM03	Evacuation	9.3.7
RM04	Community Flood Awareness	9.3.8
Oct 16 - R1	Centralised Flood Intel Kit	App G
Oct 16 - R2	Levee Pipe Condition Assessment	App G
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	App G
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	App G
Oct 16 - R5	Collection of flood data following an event	App G

South Deniliquin – Recommended Measures		
FM05	Amendments to spillway and freeboard (as ongoing maintenance)	9.4.5
PM01	Revision of FPL/ FPA	9.3.1
PM02	Amendments to Planning Policies	9.3.2
PM03	Changes to s149(2) and (5) Certificates	9.3.3
RM01	Flood Emergency Response Management	9.3.5
RM02	Improvement of Flood Warning System	9.3.6
RM03	Evacuation	9.3.7
RM04	Community Flood Awareness	9.3.8
Oct 16 - R1	Centralised Flood Intel Kit	App G
Oct 16 - R2	Levee Pipe Condition Assessment	App G
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	App G
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	App G
Oct 16 - R5	Collection of flood data following an event	App G

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North Deniliquin – Recommended Measures		
FM07	Levee Upgrade to 1% AEP + 0.5 m Freeboard	9.4.7
PM01	Revision of FPL/ FPA	9.3.1
PM02	Amendments to Planning Policies	9.3.2
PM03	Changes to s149(2) and (5) Certificates	9.3.3
RM01	Flood Emergency Response Management	9.3.5
RM02	Improvement of Flood Warning System	9.3.6
RM03	Evacuation	9.3.7
RM04	Community Flood Awareness	9.3.8
Oct 16 - R1	Centralised Flood Intel Kit	App G
Oct 16 - R2	Levee Pipe Condition Assessment	App G
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	App G
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	App G
Oct 16 - R5	Collection of flood data following an event	App G

Davidson Street Area – Recommended Measures		
FM12	Davidson Street Flow Path Improvement	9.4.12
PM01	Revision of FPL/ FPA	9.3.1
PM02	Amendments to Planning Policies	9.3.2
PM03	Changes to s149(2) and (5) Certificates	9.3.3
PM04	Investigation of Voluntary Purchase	9.3.4
RM01	Flood Emergency Response Management	9.3.5
RM02	Improvement of Flood Warning System	9.3.6
RM03	Evacuation	9.3.7
RM04	Community Flood Awareness	9.3.8
Oct 16 - R1	Centralised Flood Intel Kit	App G
Oct 16 - R2	Levee Pipe Condition Assessment	App G
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	App G
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	App G
Oct 16 - R5	Collection of flood data following an event	App G

9.8. Combined Floodplain Risk Management Scheme

The upgrades to the North Deniliquin Levee and South Deniliquin Levee, and the Davidson Street Flow Path Improvements would ideally be implemented as part of a combined flood risk mitigation scheme. The two levee upgrades have been modelled as a combined option and no adverse impacts were found to occur. They have been addressed and assessed separately in this report to better facilitate staged implementation as funding becomes available. It is also envisaged that the planning and response measures recommended are also implemented as part of this scheme.

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9.9. Floodplain Risk Management Plan

This Plan summarises the recommended works investigated by the Deniliquin Floodplain Risk Management Study. The Study made an assessment of flood risk across the Deniliquin Study Area, and follows on from the Edward River at Deniliquin Flood Study (Reference 2). Flood risk is varied across the township, with North and South Deniliquin protected to some degree by an extensive levee system, and the central Davidson Street area experiencing high flood risk due to its location in the floodway.

The Floodplain Development Manual (Reference 1) notes that ‘An implementation program is to be included in the management plan. This is to be prioritised based upon how soon the management measures can be implemented, what constraints exist, and how effective the measures are. Measures with little cost that can readily be implemented and which are effective in reducing damage or personal danger should have high priority.

Table 33 and Table 34 lists the mitigation measures assessed by the Deniliquin Floodplain Risk Management Study that have been recommended for implementation. The table describes the purpose of the measure, as well as its priority, cost, timeframe and the party responsible for its implementation. Detailed description of each recommendation is provided in Section 9 of the Study, which also contains measures that were assessed but were not viable for recommendation.

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Table 33 Deniliquin Floodplain Risk Management Plan (Sheet 1 of 2)

Reference	Option	Description	Benefits	Concerns	Responsibility	Funding	Cost	B/C Ratio	Priority
FLOOD MODIFICATION MEASURES									
FM01	Develop and implement vegetation management plan	Management of young trees in the Edward River, Brick Kiln Creek and other watercourses could prevent over-vegetation and increased hydraulic roughness of the waterways.	This is a preventative measure designed to maintain the hydraulic roughness of the creek by managing vegetation, which may prevent an unwanted increase in peak flood levels.	Ecological impacts (possible destruction of riverine habitat) and erosion due to increased water velocities.	Council would be responsible for development of the VMP in accordance with OEH guidelines - Funding available?	OEH Funding available for development of VMP and initial implementation. Ongoing work is at Council's own cost.	$50,000 (Development) + Ongoing Costs	N/A	Low
FM05[1]	South Deniliquin Levee: Revised spillway and freeboard	Improve function of the spillway and upgrade parts of the levee that have less than 0.5 m freeboard in the 1% AEP event.	Improved spillway will allow for controlled overtopping of the levee if a flood event larger than design level occurs. Upgrades will ensure a 1% AEP level of protection.	Raising concrete sections or removable panels may be costly and difficult.	Council would be responsible for construction and maintenance.	OEH Funding available for feasibility, detailed design and construction	$ 374,700	>>1	High
FM07[1]	North Deniliquin Levee: Upgraded to 1% AEP event + 0.5 m freeboard	Upgrades to much of the levee to ensure protection in the 1% AEP event.	Upgrades will provide protection in the 1% AEP event with the determined 0.5 m freeboard.	Importance of visual amenity and significant works required.	Council would be responsible for construction and maintenance.	OEH Funding available for feasibility, detailed design and construction	$ 1,855,150	1.6	High
FM12	Davidson Street Flow Path Improvement	Permanently lowering a 220 m length at the downstream end of the Davidson Street Levee.	Reduction of flood levels in events greater than a 2% AEP as water is no longer retained, removal of 'false sense of security' provided by the existing levee.	Community response to the measure.	Council would be responsible for excavation.	OEH Funding available for feasibility, detailed design and construction	$ 580,180	2.0	High
PROPERTY MODIFICATION MEASURES									
PM01	Revision of Flood Planning Level and Flood Planning Area	The FPL defines land subject to flood planning controls. The proposed level and extent is that of the 1% AEP + 0.3 m freeboard.	Update FPL and FPA in line with findings from FRMS including appropriate application of freeboard to ensure future development is protected in the 1% AEP event.	Community acceptance of 0.3 m freeboard	Council - and to be clearly communicated to residents	No funding available	Minimal	Significan ongoing benefit as house renewal removes damages at 1% AEP.	High
PM02	Planning Policy Review	Reconsider existing zones against current flood data and mapping, and introduce flood controls via an updated DCP and Flood Planning Levels Policy.	Appropriate land use planning can reduce future flood risk and associated damages by ensuring that development is compatible with flood risk.	Existing building entitlements in floodway areas cannot be removed under current planning legislation.	Council - and to be clearly communicated to residents	No funding available	Minimal - Council Work Hours	N/A	High
PM03	Amendments to s149 Certificates	Section 149 Certificates provide property owners with a brief (149(2)) or detailed (149(5)) description of flood affectation (if any) and whether development controls at their property.	Additional details provided on 149(5) can improve flood risk awareness in the community.	None	Council - and to be clearly communicated to residents	No funding available	Setup Costs $10,000 and minimal ongoing costs	N/A	Medium
PM04[2]	Voluntary Purchase	Properties located within a floodway may be eligible for voluntary purchase, which aims to remove residents from high flood risk areas.	Removal of residents from high flood risk areas provides benefits to the residents themselves, the SES and rescuers during a flood and may also allow for other mitigation works to be undertaken in the area.	Residents may not want to leave their homes, and not all properties would be eligibla for Voluntary Purchase.	Council in consultation with property owners.	OEH Funding available for voluntary purchase	Scheme $50,000 House Purchase ~$200,000	0.5	Low

Table 34 Deniliquin Floodplain Risk Management Plan (Sheet 2 of 2)

RESPONSE MODIFICATION MEASURES									
Reference	**Option**	**Description**	**Benefits**	**Concerns**	**Responsibility**	**Funding**	**Cost**	**B/C Ratio**	**Priority**
RM01	Flood Emergency Management	Review and amalgamate current Council and SES emergency flood response documents.	One thorough, easy to follow emergency response plan will make flood response safer and more efficient in the event of a flood.	High level of detail required to ensure no action is accidentally omitted from the plan.	SES and Council in cooperation	Possible OEH Funding available under 'integrated schemes' or 'projects to improve evacuation management only'	Minimal	N/A	High
RM02	Develop 'Just in Time' Flood Warning system	The long warning time for flooding in Deniliquin (typically 7-10 days) means a 'Just in Time' approach to flood warning would be appropriate.	Having flood warning templates in place will aid efficiency of preparing and issuing flood warnings to residents.	None	SES and Council in cooperation	OEH Funding Available under 'Projects to improve flood warning'	Minimal Initial (to save time in implementation).	N/A	Medium
RM03	Evacuation Planning	An evacuation plan should be based on the latest available design flood information and take into accout location and demographics of residents.	Improved and updated information available regarding flooding in Deniliquin should be used to improve existing evacuation plans as part of RM01 Emergency Management.	The evacuation plan should account for mobility of residents (especially aged over 65) and be cogniscent of road closures due to flooding or installation of temporary levees.	SES and Council in cooperation	OEH Funding Available under 'Projects to improve evacuation management'	Minimal Initial (to save time in implementation).	N/A	Medium
RM04	Community Flood Awareness	Development of a fridge-magnet style flyer to improve baseline awareness of flooding in Deniliquin, installation of depth gauge at National Bridge and installation of historic flood markers.	Improved community awareness of flooding and greater appreciation of the flood risk for residents in Deniliquin, better understanding of "gauge height".	Information may be ignored or forgotten by residents, ongoing maintenance of depth markers and flood posts required	SES and Council in cooperation	OEH Funding Available under 'Projects to improve flood warning'	Minimal	N/A	Medium
Oct 16 - R1[3]	Centralised Flood Intel Kit	Formation of a "kit" that contains all necessary flood intelligence documentation regarding general flood behaviour, road closures, levee pipe closures and levee management (gates/panel operation) for easy use during a flood.	Having necessary information on hand is key to the effective and timely management of flood related operations, such as locating and closing levee pipes, installing bulkhead gates or levee panels.	The Flood Intel Kit contains up to date, useful information. The main concern is ensuring that it is actually used and not forgotten or ignored by Council staff in favour of old documents. Revisions to the kit should be made following future flood events to capture lessons learnt and problems encountered, or address deficiencies in the data.	Council	Not Applicable. The Flood Intel Kit has been provided in the FRMS&P.	Minimal - Council Work Hours to update following flood events	N/A	High
Oct 16 - R2	Levee Pipe Condition Assessment	Council is to undertake a thorough audit of the condition of all levee stormwater pipes, to ensure that they each are in good condition and fitted with serviceable gates. Upgrades should be made where necessary based on the findings of the assessment.	Significant reduction in the time taken for Council staff to close levee pipes, and improved safety thereof, would drastically increase the resources available during a flood event.	Commitment from Council required to include levee pipe upgrades in budget and ongoing maintenance schedule to ensure serviceability.	Council	Possible OEH Funding available	Minimal	N/A	High
Oct 16 - R3	Improved Communications During Flood Event: Internal Council Comms	Council's Director of Technical Services to conduct bi-weekly staff briefings before and during a flood event to keep staff informed and manage various tasks to be completed, then conduct post- event evaluation.	Keeping staff informed is vital to the smooth running of flood management activities, and means that more council staff are able to respond to community queries accurately. Evaluation of the flood management following an event can reveal important lessons to be taken away from the event to improve future management.	Flood events can be chaotic, and meetings must be brief and concise so as to minimise the time staff are not fulfilling their particular roles. Evaluation of the event may be forgotten or delayed, and the quality of recollections declines with time.	Council	Not applicable.	Minimal	N/A	High
Oct 16 - R4	Improved Communications During Flood Event: Council and SES	Brief meeting between the SES and Council to be held as soon as possible following initial flood warning to clarify roles and responsibilities.	Staff that have not worked during a flood may not understand the different roles Council and SES play. A brief meeting may help reduce miscommunication and confusion surrounding road closures and leveeing activities.	Both SES and Council will have to make time for such a meeting, which may be difficult in the lead up to a flood.	SES and Council in cooperation	Not applicable.	None	N/A	High
Oct 16 - R5	Collection of flood data following an event	Council is to undertake data collection activities in a timely manner following a flood event. This includes collection of photographs, flood marks, interviews with staff and asset condition assessment. Community feedback should also be collected.	Data collection provides invaluable information that can be used for future flood modelling activities or to improve the management of flood events as they occur.	Data collection should be undertaken as soon as possible following a flood event to ensure flood marks are not lost and staff/ community experiences are not forgotten or inflated over time.	Council	Possible OEH Funding available	None	N/A	High

Notes		
	1	Options FM05 and FM07 should be undertaken together. They have a combined B/C ratio of 4.7
	2	Cost based on 25% of residential properties in the Davidson St Area (i.e. 14 houses valuated at $195,000 each)
	3	Oct 16- R1-R5: Recommendations made following analysis of the October 2016 Flood Event in Deniliquin, addressed in Appendix G of the FRMS.

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Figures

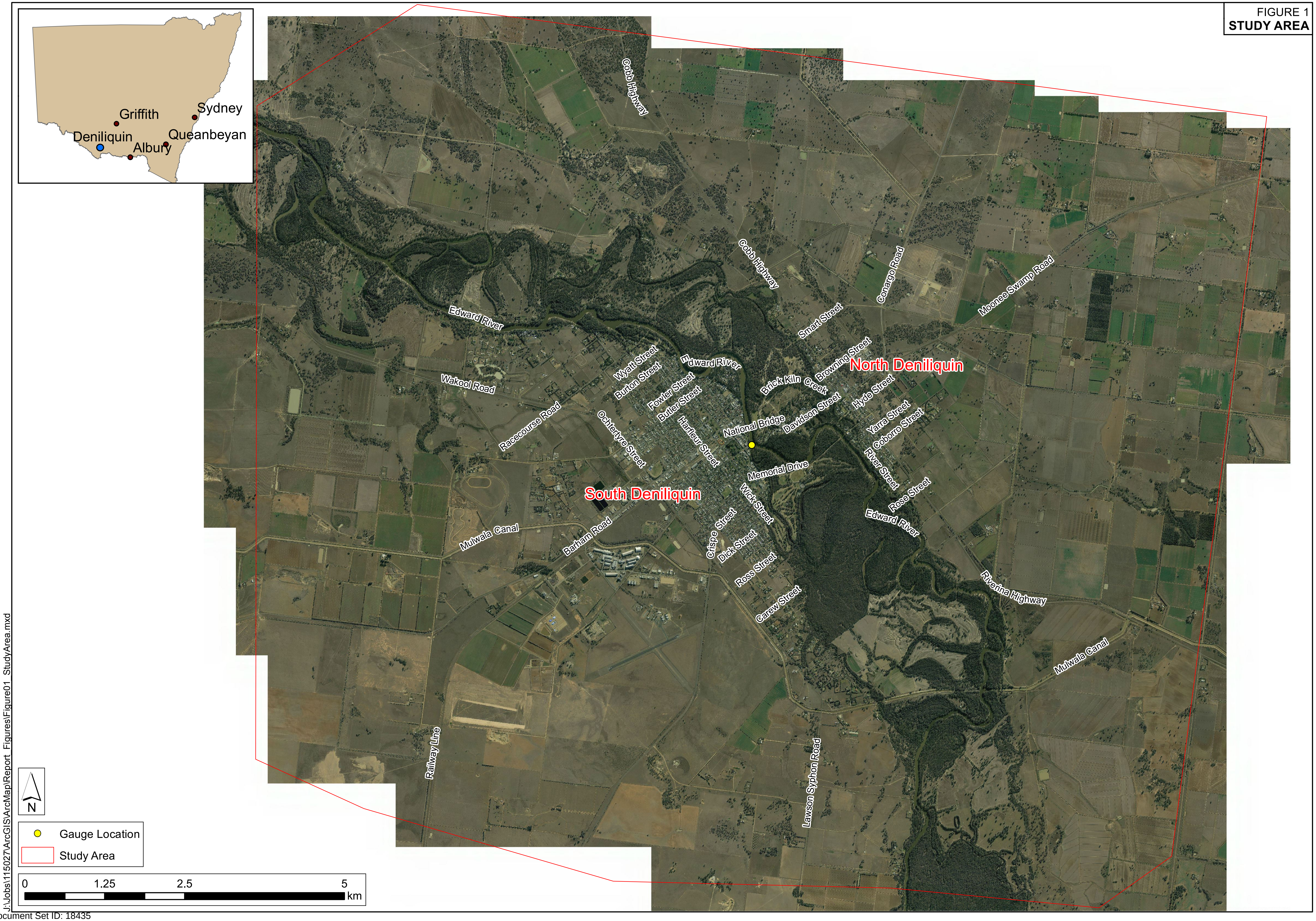

FIGURE 1
STUDY AREA

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FIGURE 2
DENILIQUIN LEP 2013
LAND USE

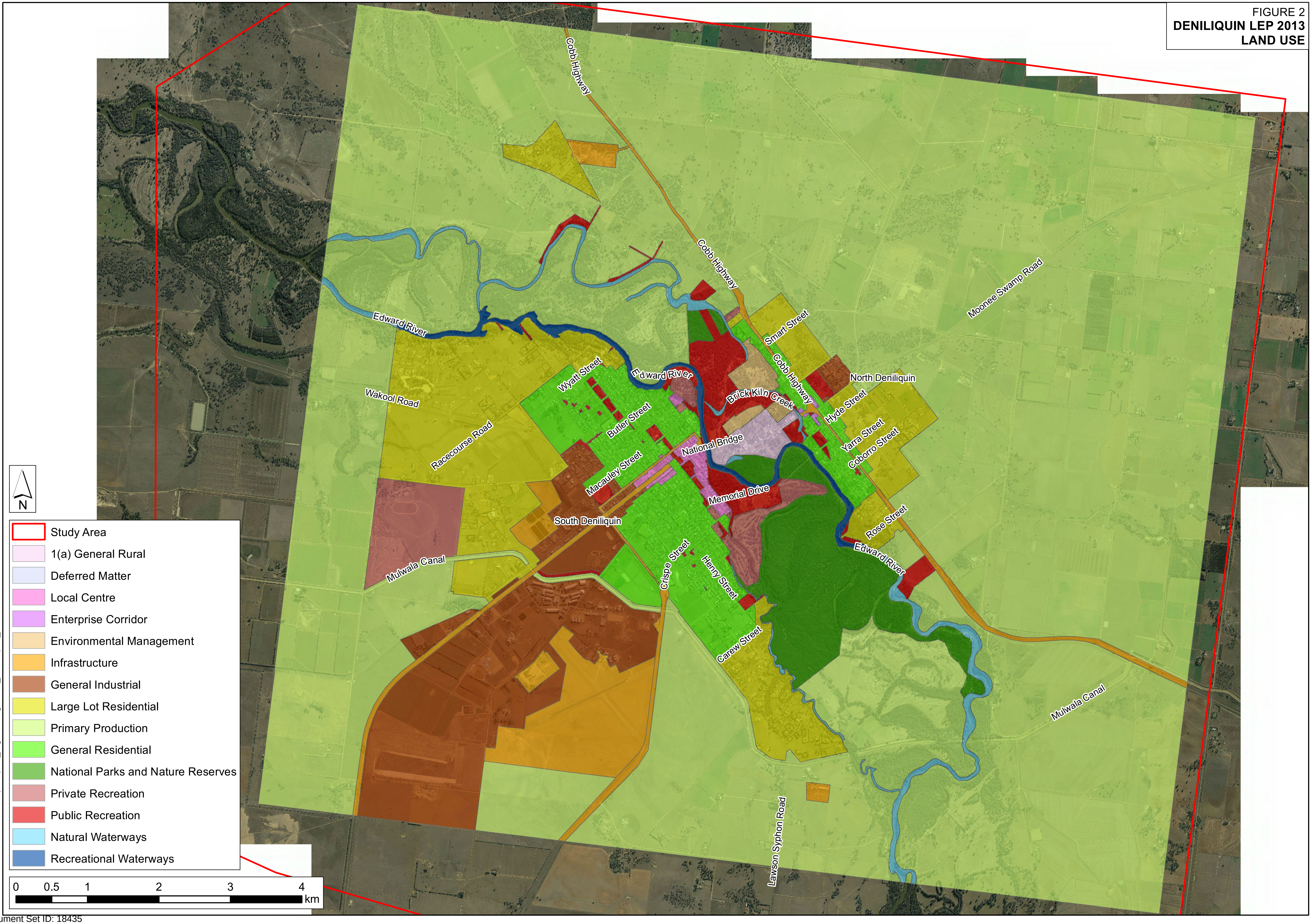

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FIGURE 3
EXISTING MITIGATION WORKS

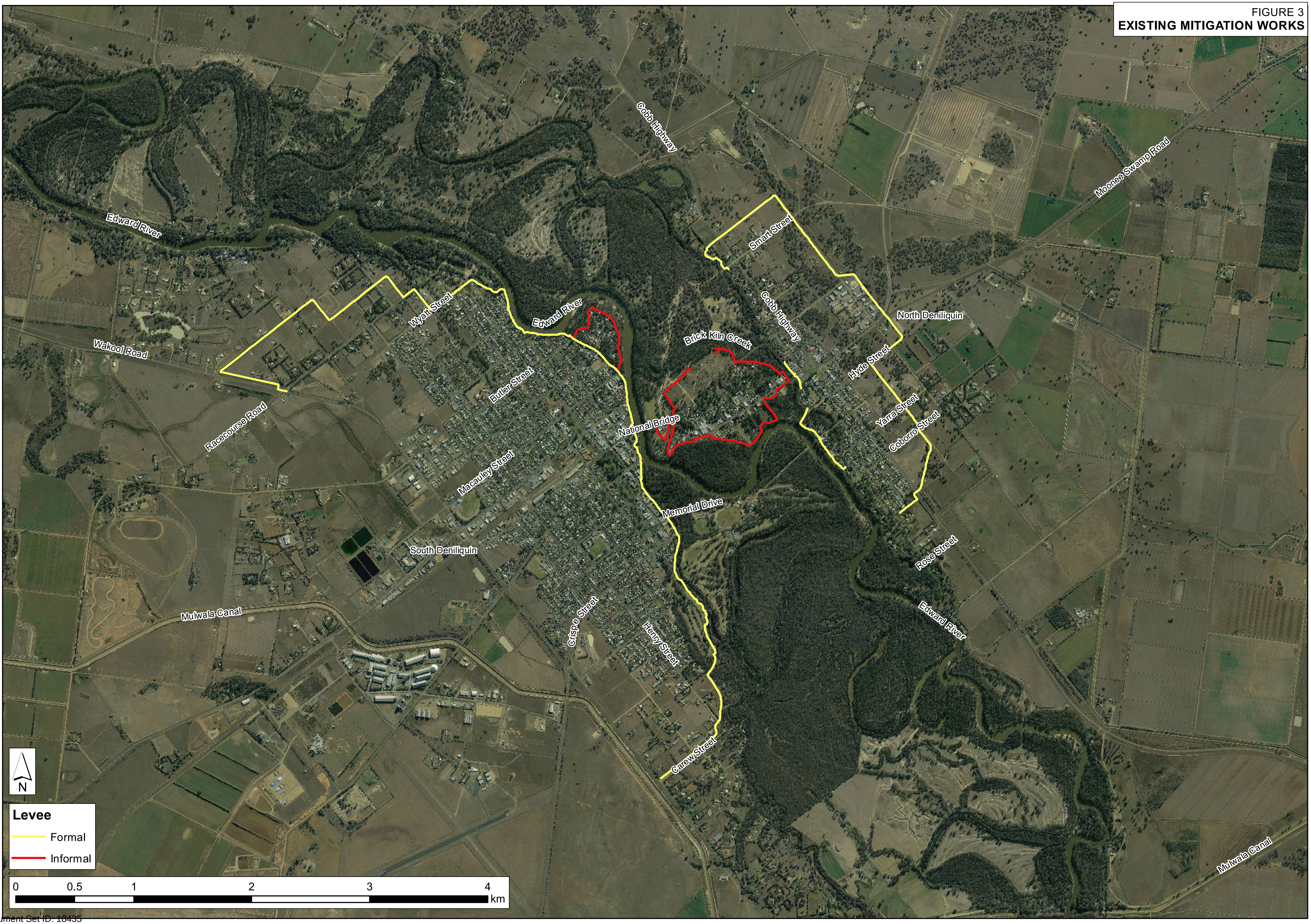

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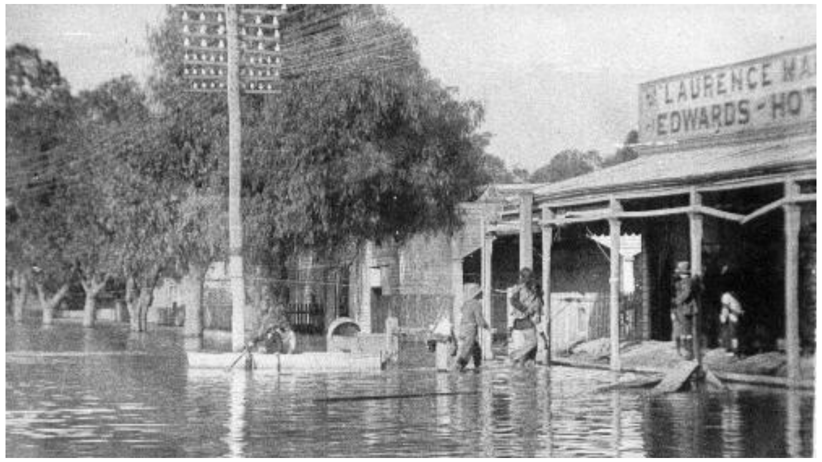
FIGURE 4
HISTORICAL PHOTOS

Corner Cressy St and Edwardes St, 1917

Corner Junction/Poictiers Streets, 1917

Davidson Street, Edward River Hotel front, 1917



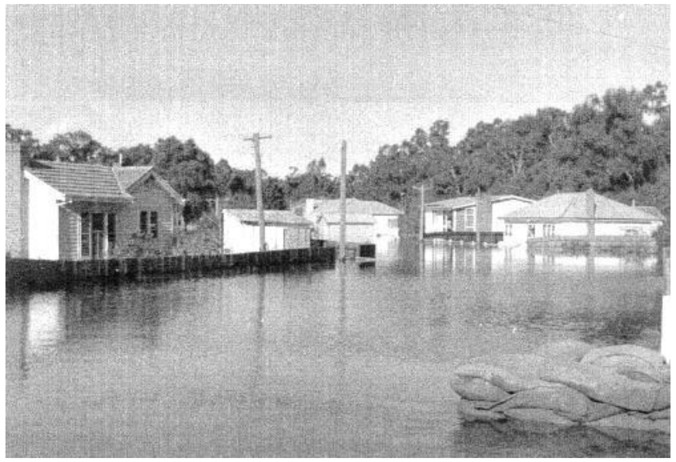
Hodgkins Street houses, 1931

66 Davidson Street, 1956

26 Davidson Street, 1956

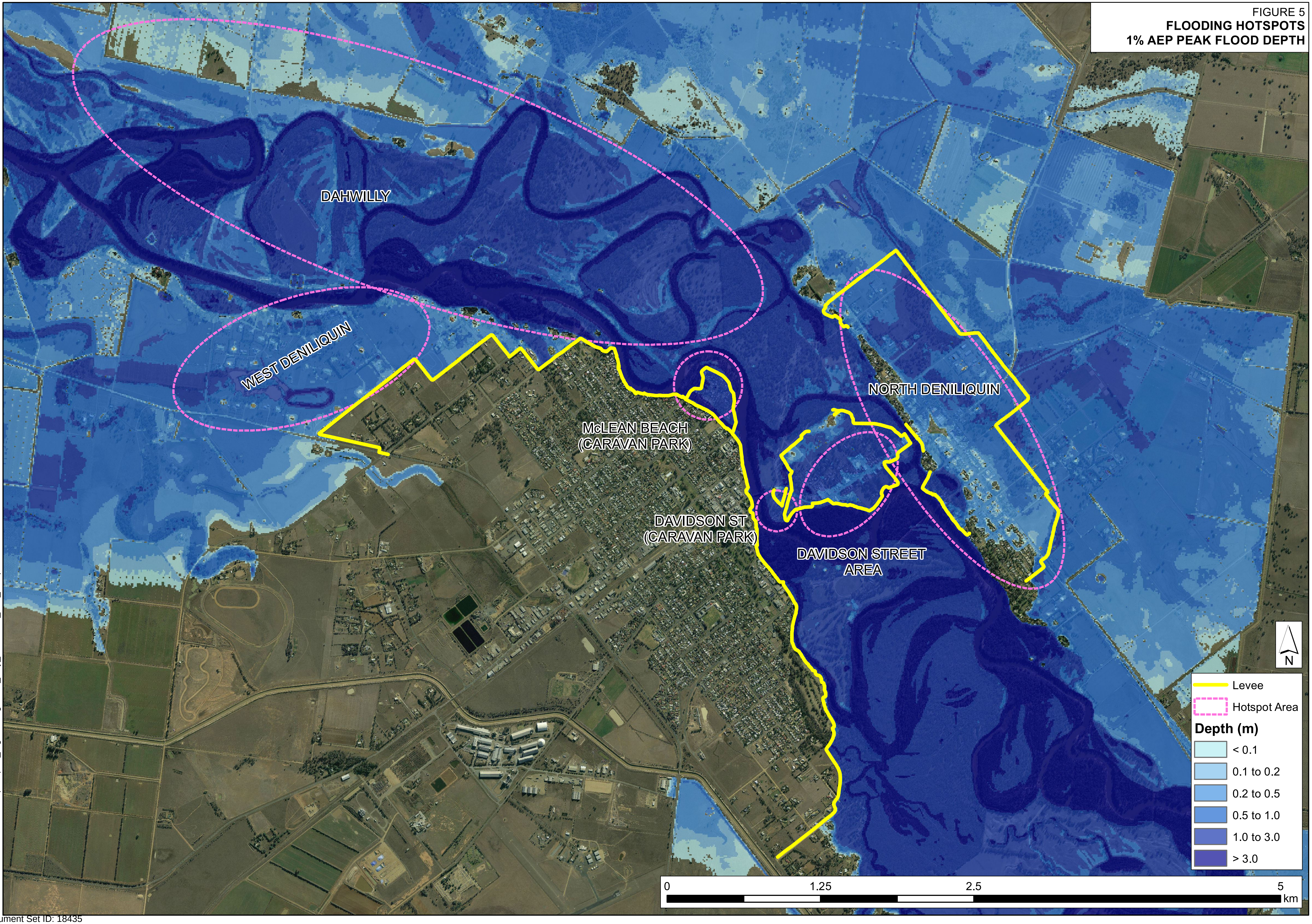
North Deniliquin, 1956

North Deniliquin, brickworks in foreground, 1956



Jones Avenue from Davidson St, 1956

J:\Jobs\115027\Data\HistoricalPhotos\Figure 4 Historical Photos.pptx



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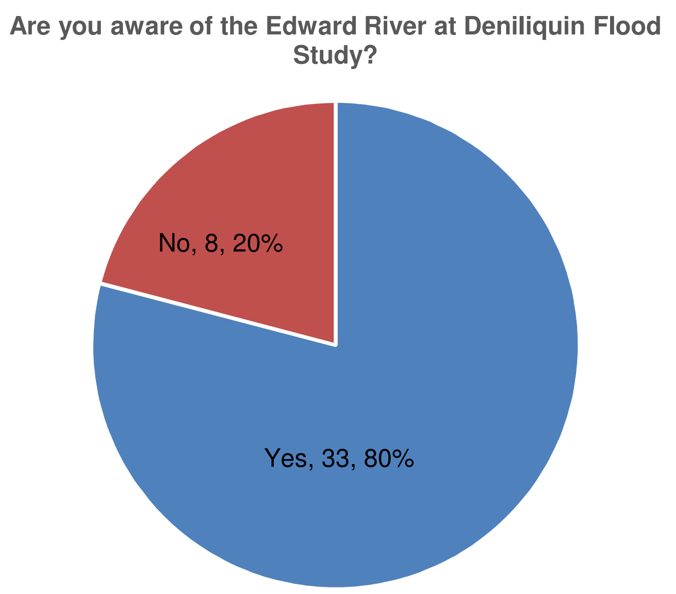

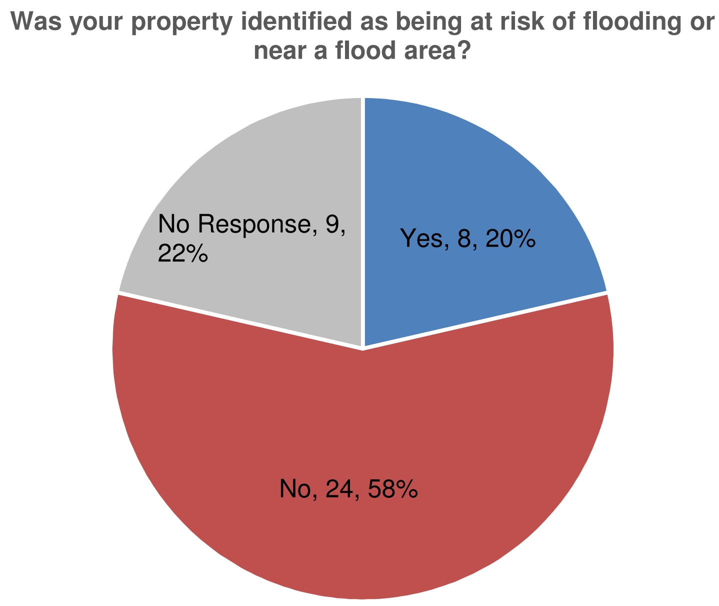

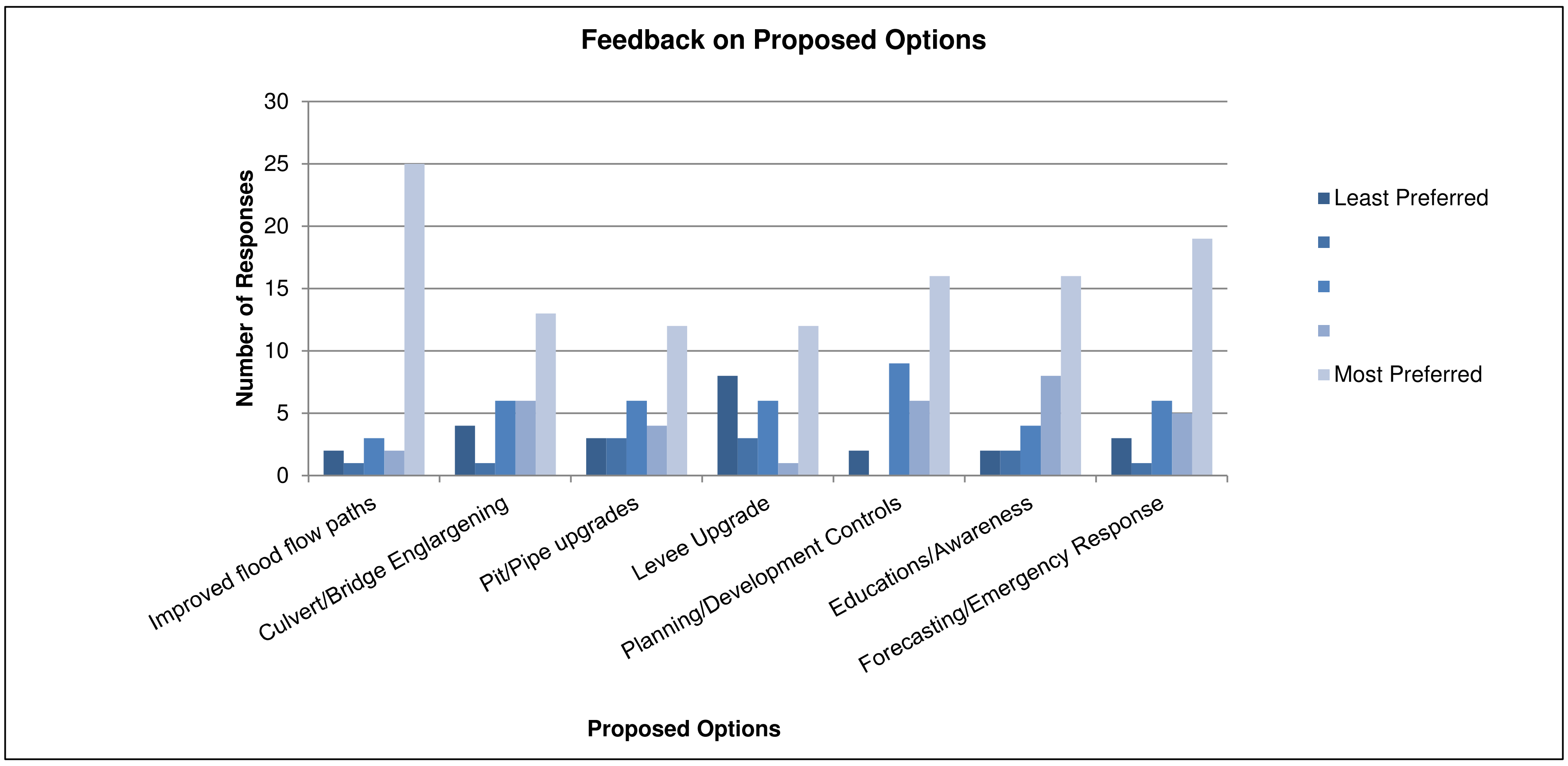

Structural Works	No. Respondents
Clearing Brick Kiln Creek	9
Lengthen BKC bridge	2
Clear channel/creeks of obstructions	5
Improved coneyance near National Bridge	1
Backup watercourses for bottleneck	1
Use irrigation channels	1
Raise North Deni levee	1
Upgrade Davidson Street levee	1
Deepen channel near Caravan Park	1
Remove Davidson Street levee	1
Dam operations	1

Response Measures	No. Respondents
Website with maps	1
Warning systems	1
Emergency response - sandbagging properties	1
Customized awareness/education mailout	2
Practice closing the levee	1
Property Measures	
Don't allow small lot sub-divisions	1

J:\Jobs\115027\Admin\CommunityConsultation\Aug15_Responses\Responses_Tabulated

FIGURE 7
COMMUNITY CONSULTATION RESPONSES
AWARENESS OF FLOOD STUDY AND
PROPERTY INNUNDATION

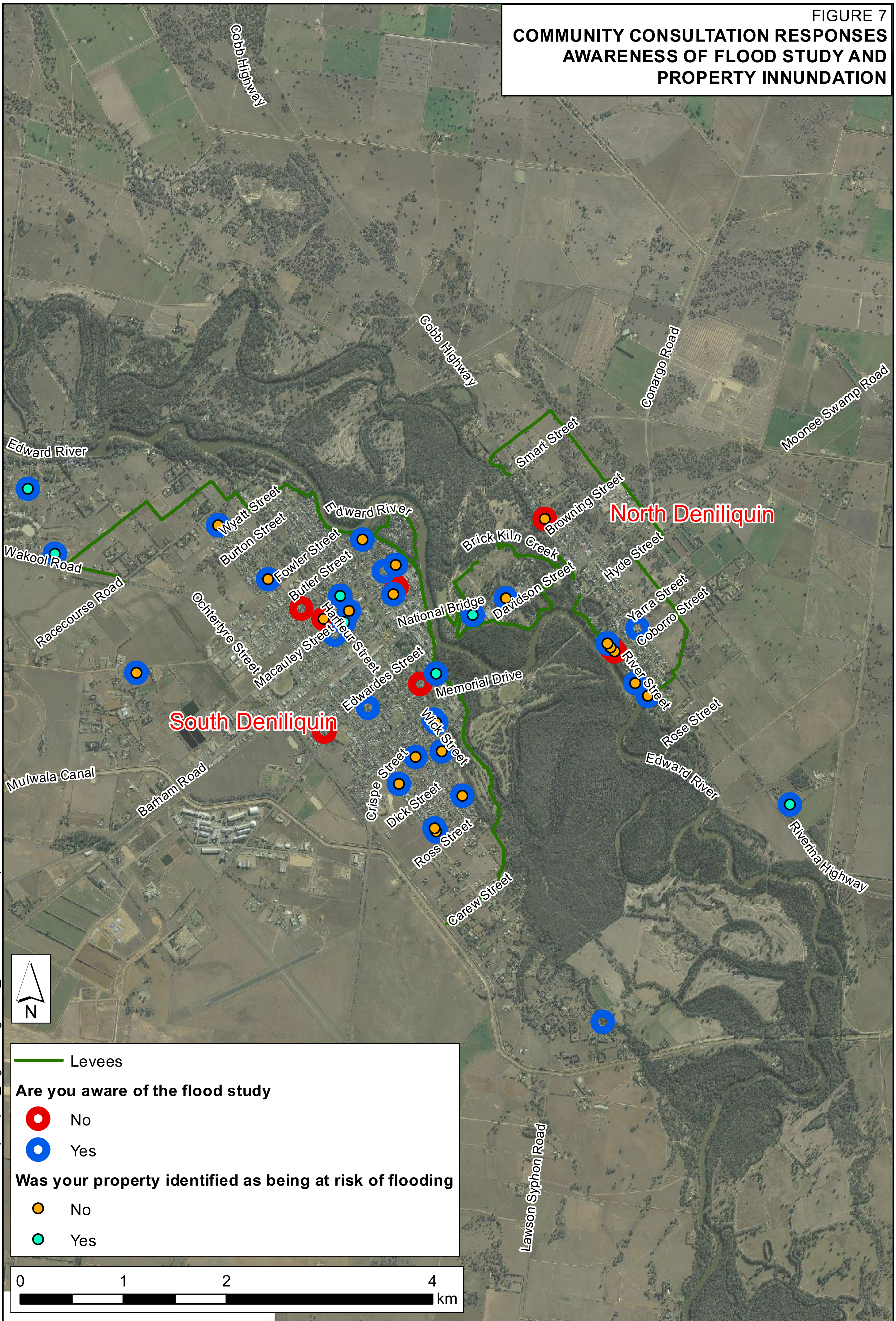

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FIGURE 8
TRUE HYDRAULIC HAZARD
5% AEP DESIGN EVENT

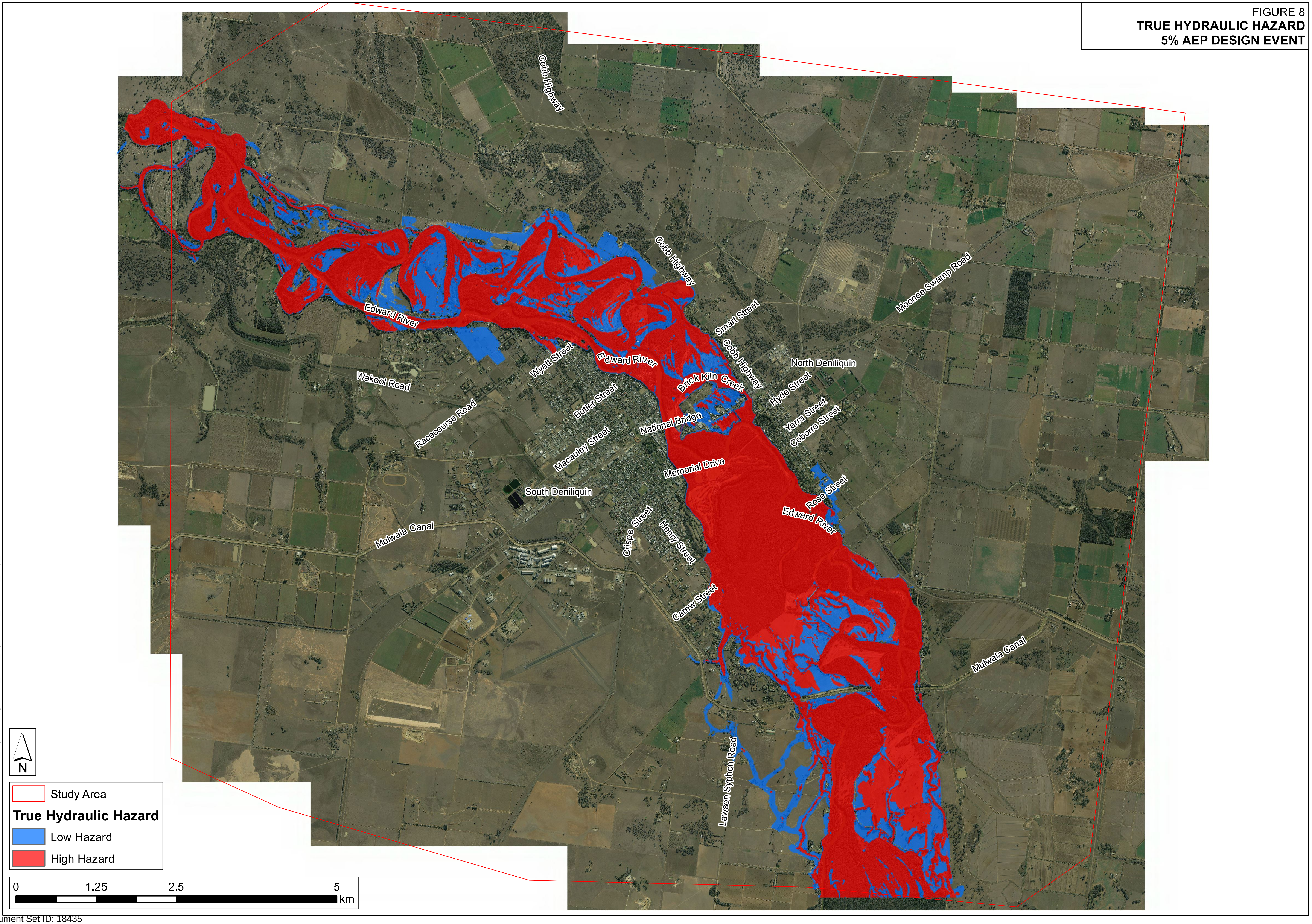

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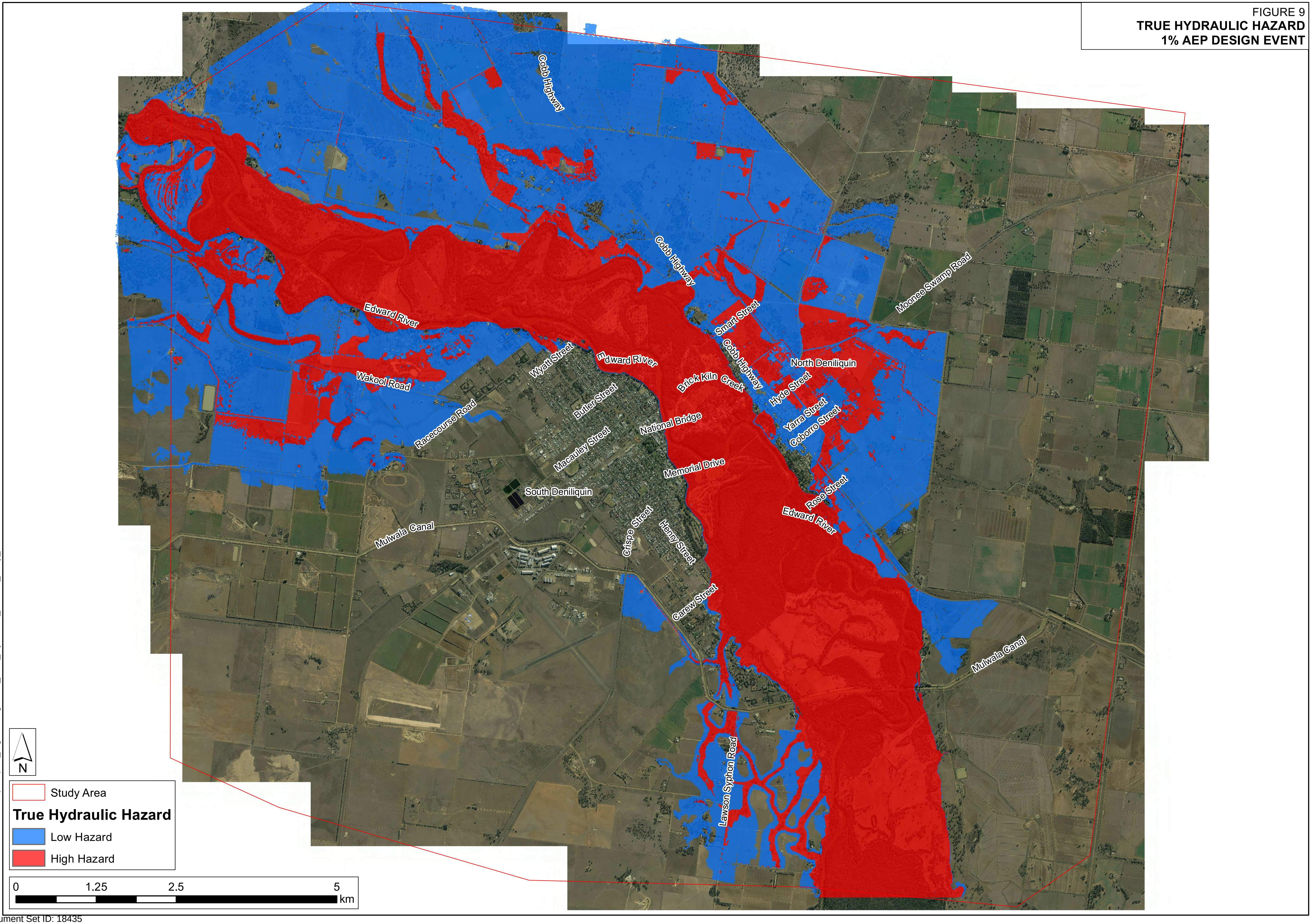
FIGURE 9
TRUE HYDRAULIC HAZARD
1% AEP DESIGN EVENT



J:\Jobs\115027\ArcGIS\ArcMap\Report_Figures\Figure09_True_Hydraulic_Hazard_100y_ARI.mxd

Document Set ID: 18435
Version: 1, Version Date: 01/05/2017

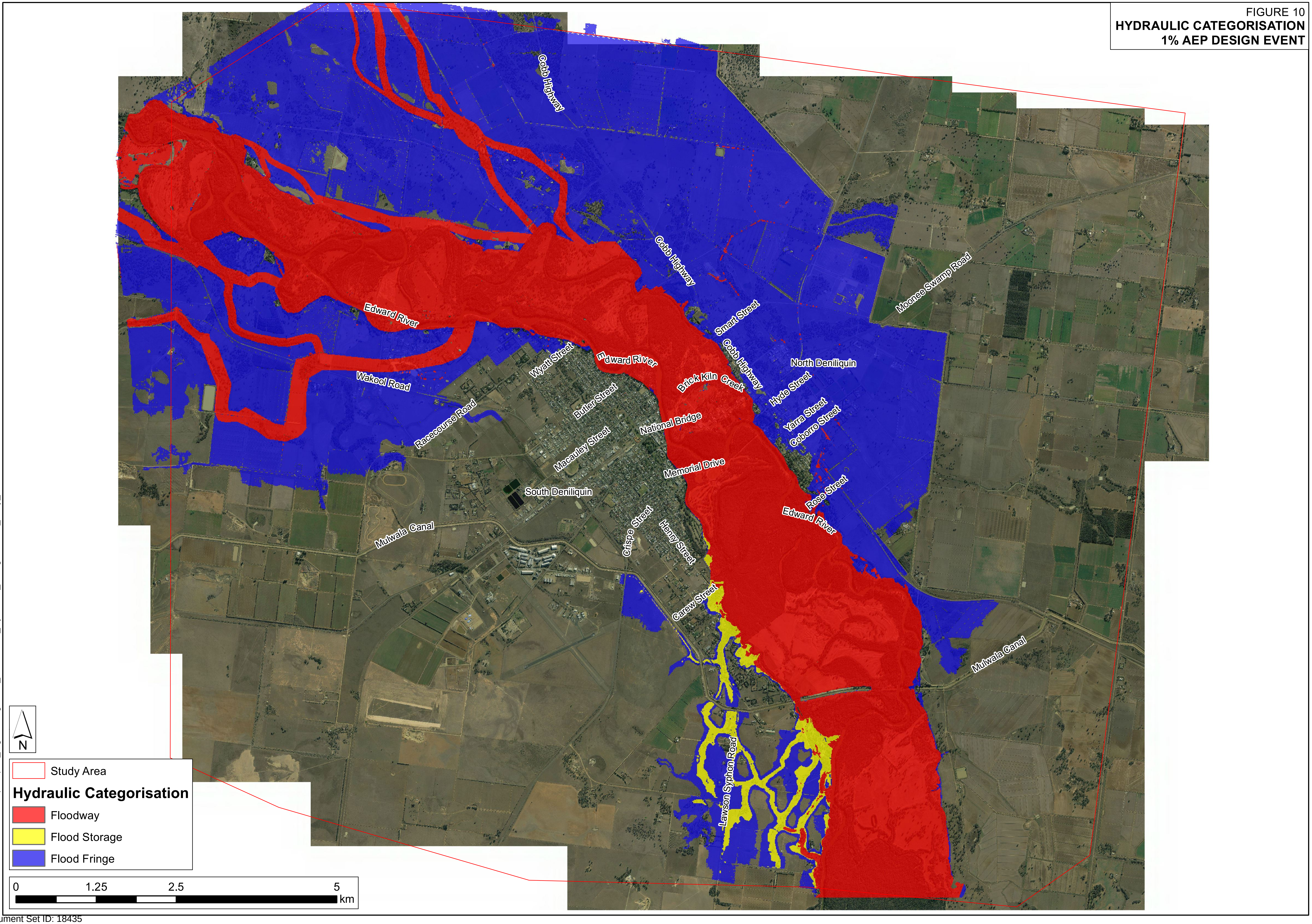


FIGURE 10
HYDRAULIC CATEGORISATION
1% AEP DESIGN EVENT

J:\Jobs\115027\ArcGIS\ArcMap\Report_Figures\Figure10_Provisional_Hydraulic_Categorisation_100y_ARI.mxd

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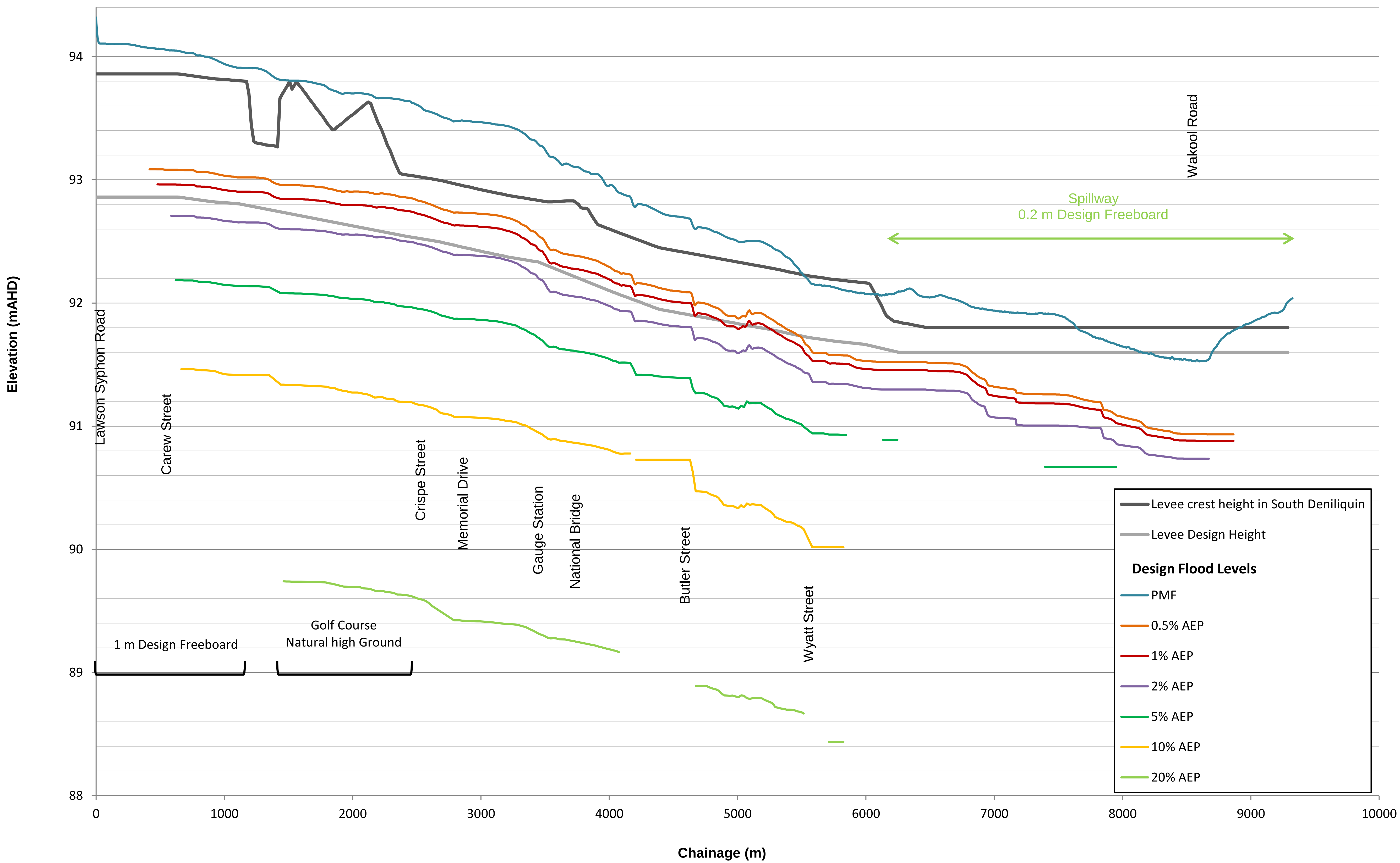
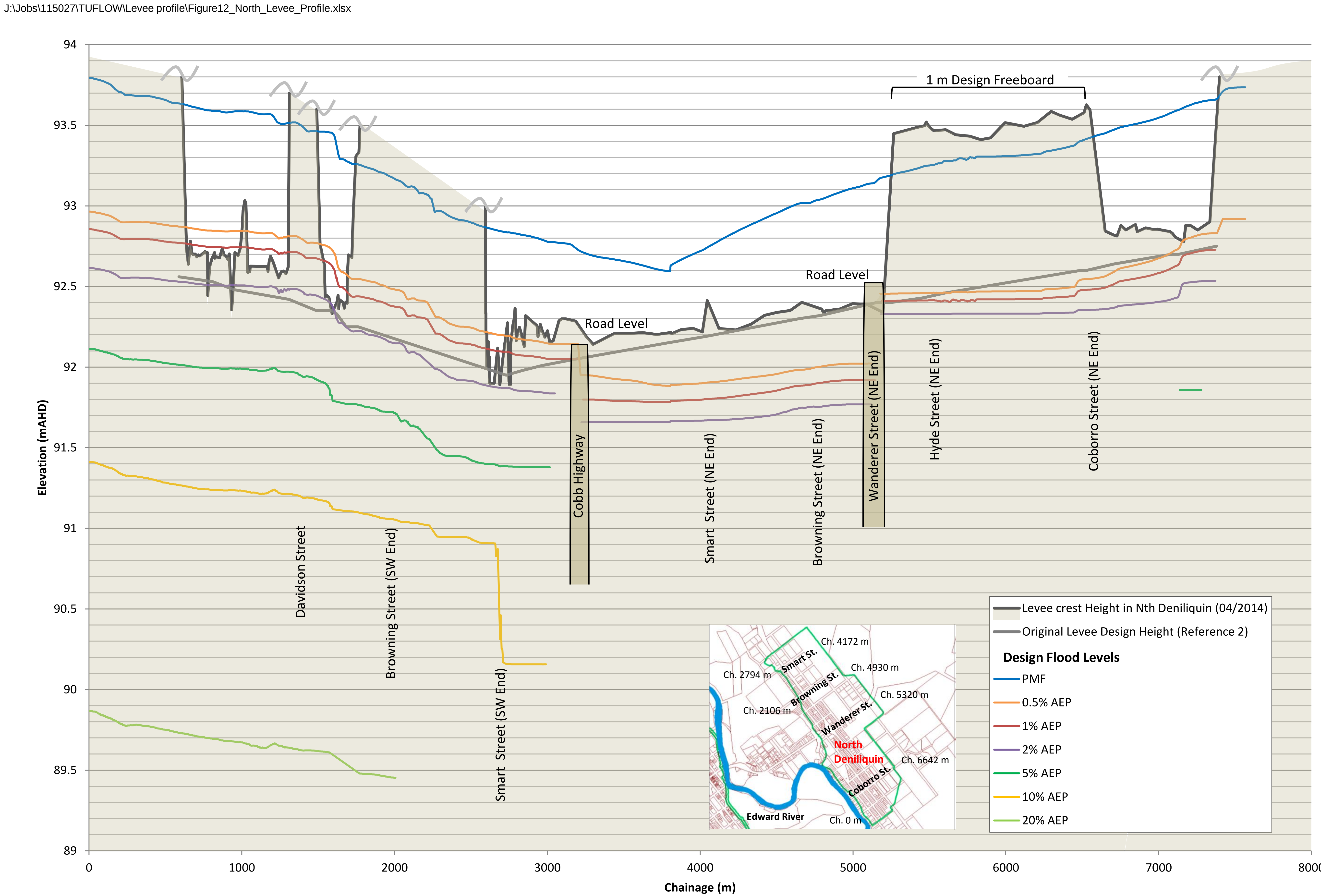
J:\Jobs\115027\TUFLOW\Levee profile\FIGURE 11_1%AEP_LeveeComparison.xlsx



NOTE: The remainder of the levee has a 0.5 m design freeboard.

FIGURE 11
SOUTH DENILIQUIN LEVEE DESIGN FLOOD EVENT PROFILE



NOTE: - Levee elevations above 94 mAHD are sections of natural high ground in North Deniliquin that form part of the levee structure.
- All other sections of the levee have a design freeboard of 0.1 m, except where shown above between chainages 5200 m and 6500 m.

FIGURE 12
NORTH DENILIQUIN LEVEE
DESIGN FLOOD EVENT PROFILE

J:\Jobs\115027\TUFLOW\Levee Profile\Levee

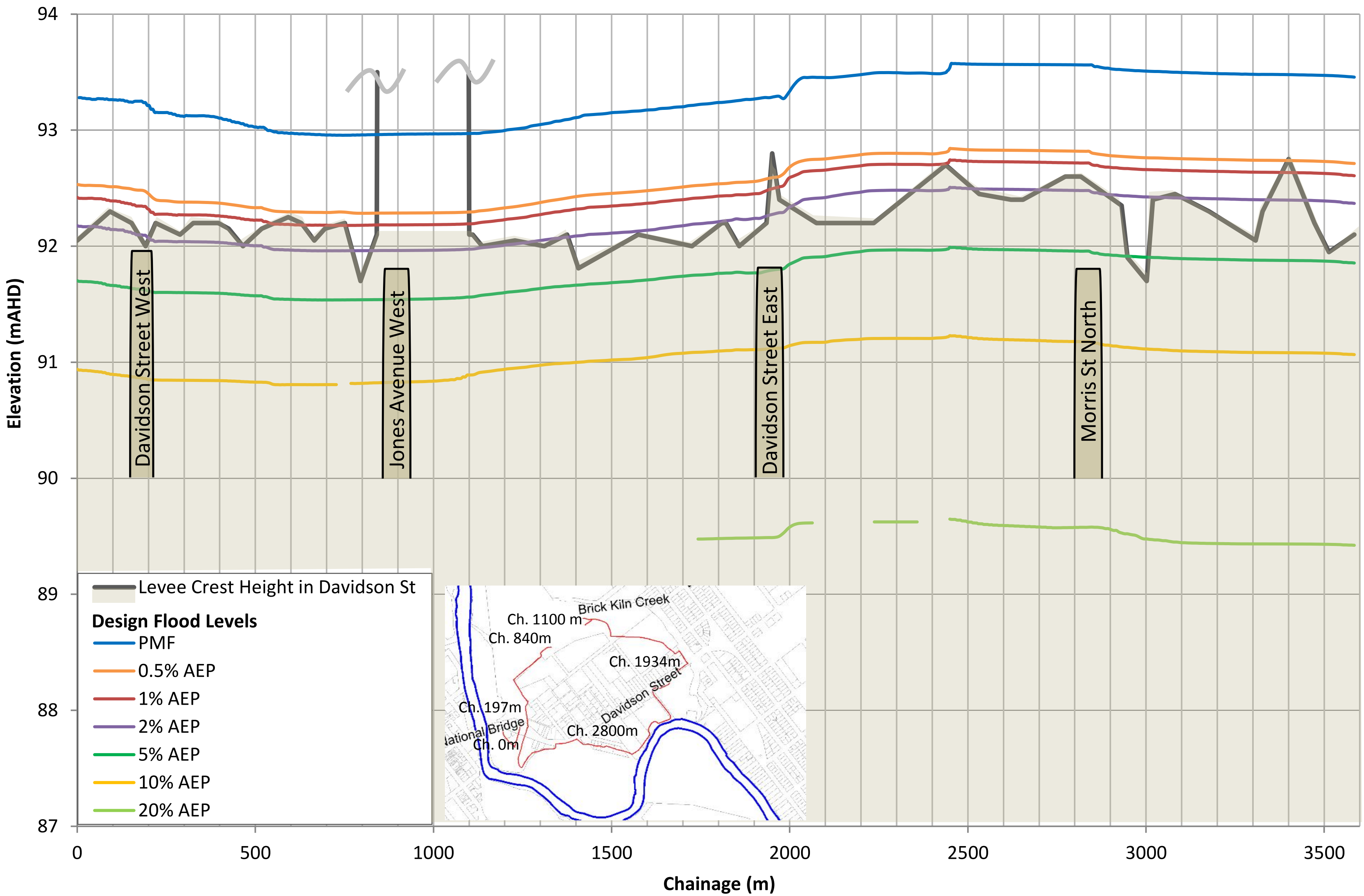


FIGURE 13
DAVIDSON STREET LEVEE
DESIGN FLOOD EVENT PROFILE

Document Set ID: 18435
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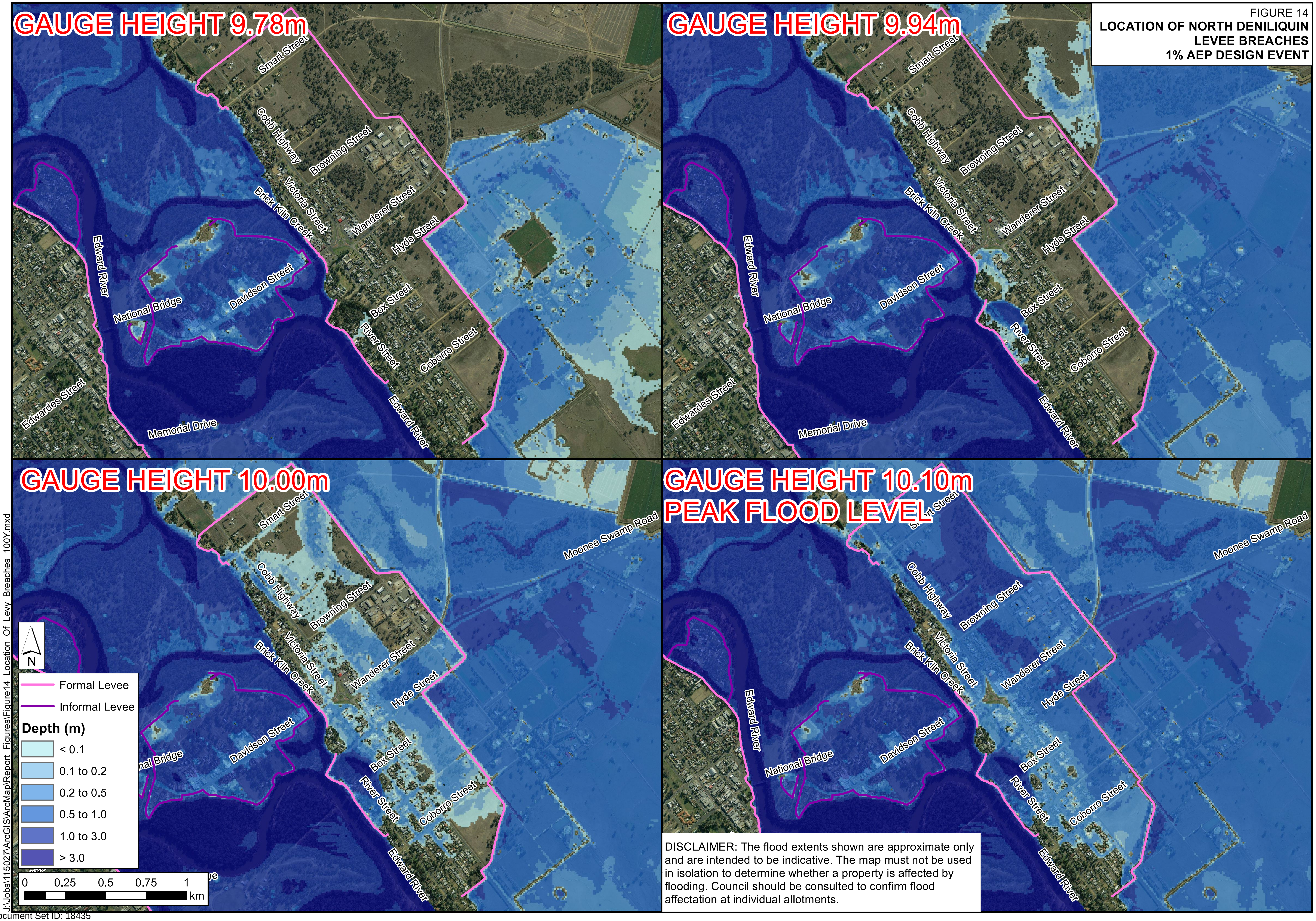

DISCLAIMER: The flood extents shown are approximate only and are intended to be indicative. The map must not be used in isolation to determine whether a property is affected by flooding. Council should be consulted to confirm flood affectation at individual allotments.

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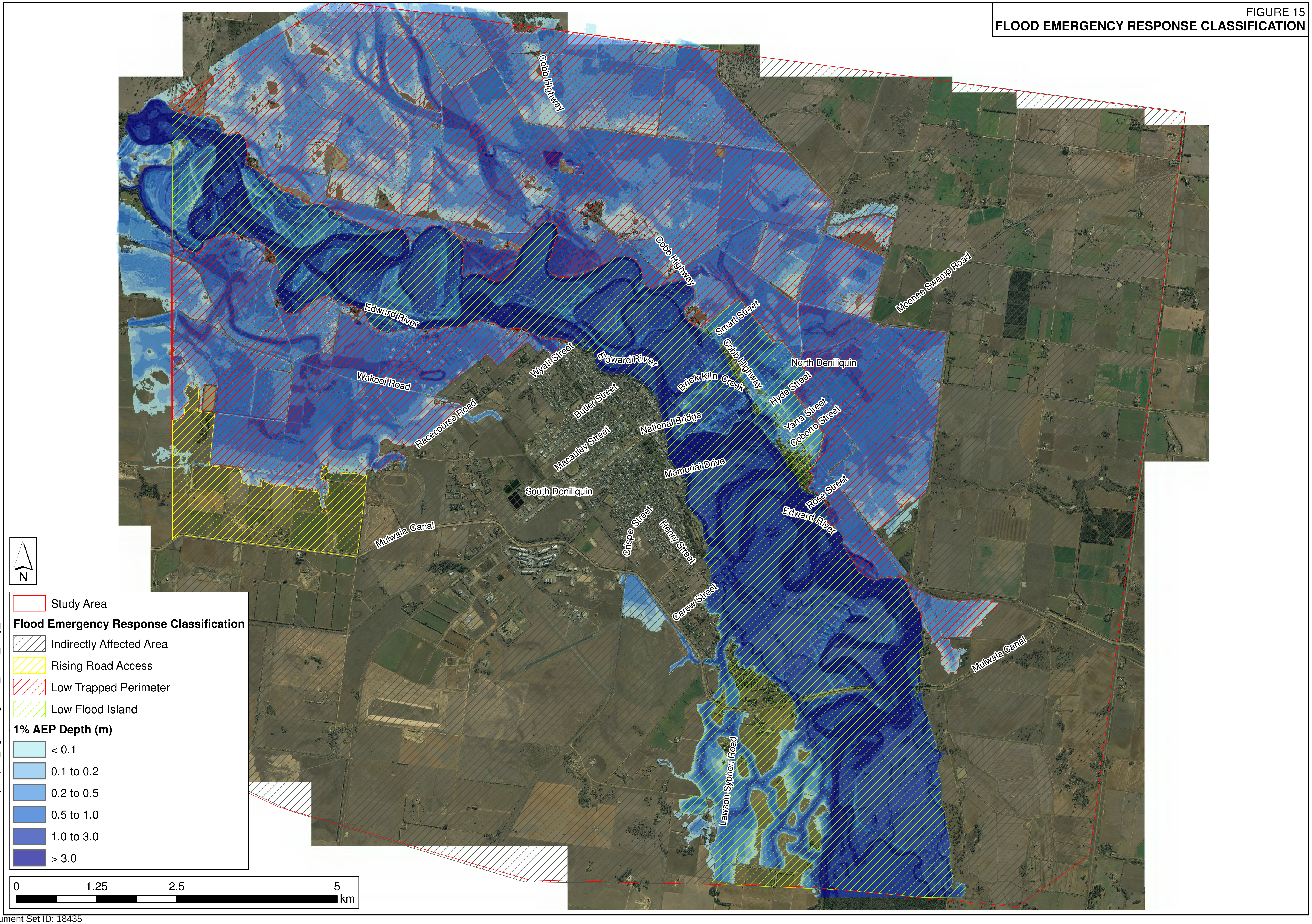
FIGURE 15
FLOOD EMERGENCY RESPONSE CLASSIFICATION



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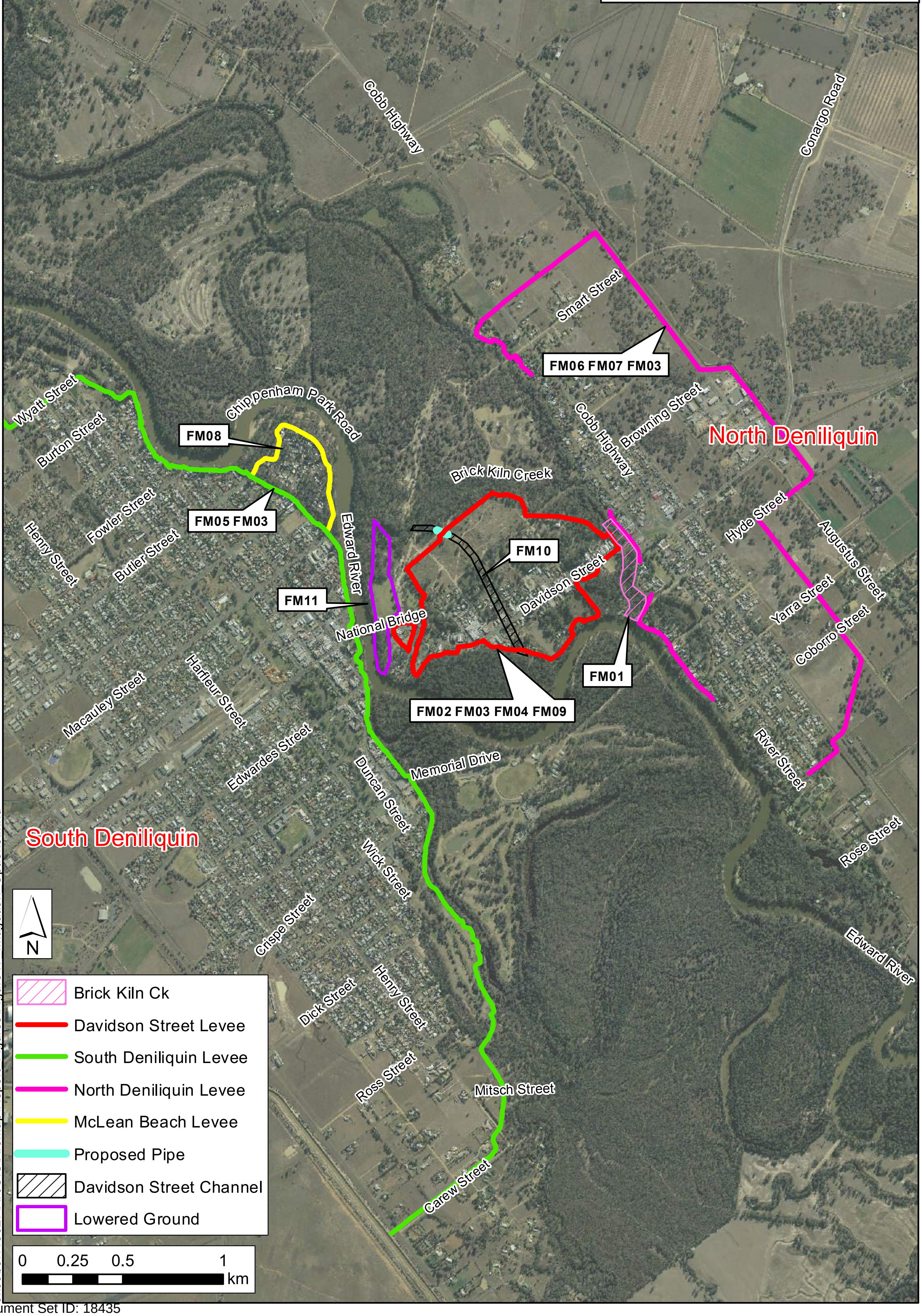
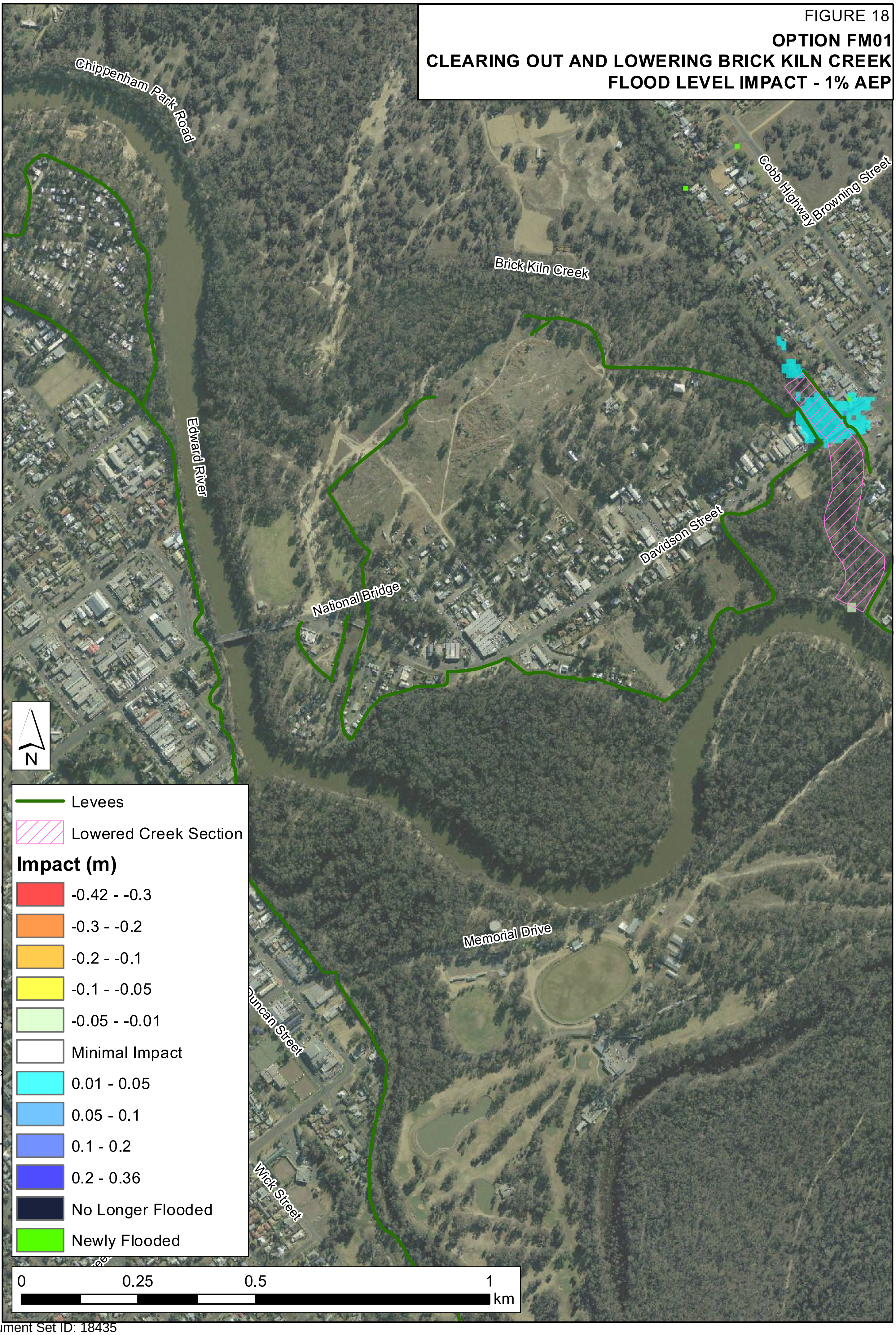
Version: 1, Version Date: 01/05/2017

FIGURE 17
MITIGATION OPTION LOCATIONS



Document Set ID: 18435
Version: 1, Version Date: 01/05/2017



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Version: 1, Version Date: 01/05/2017

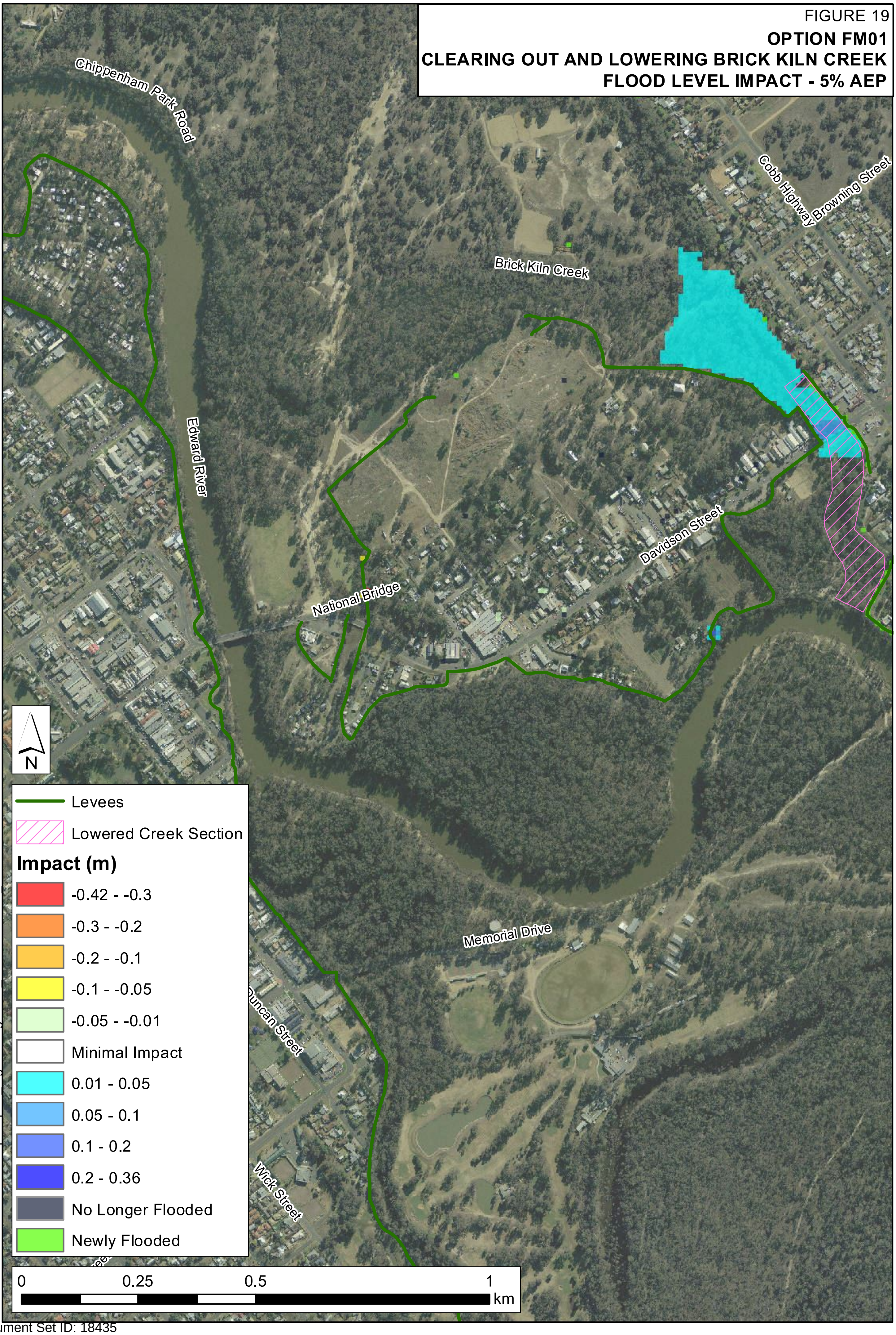
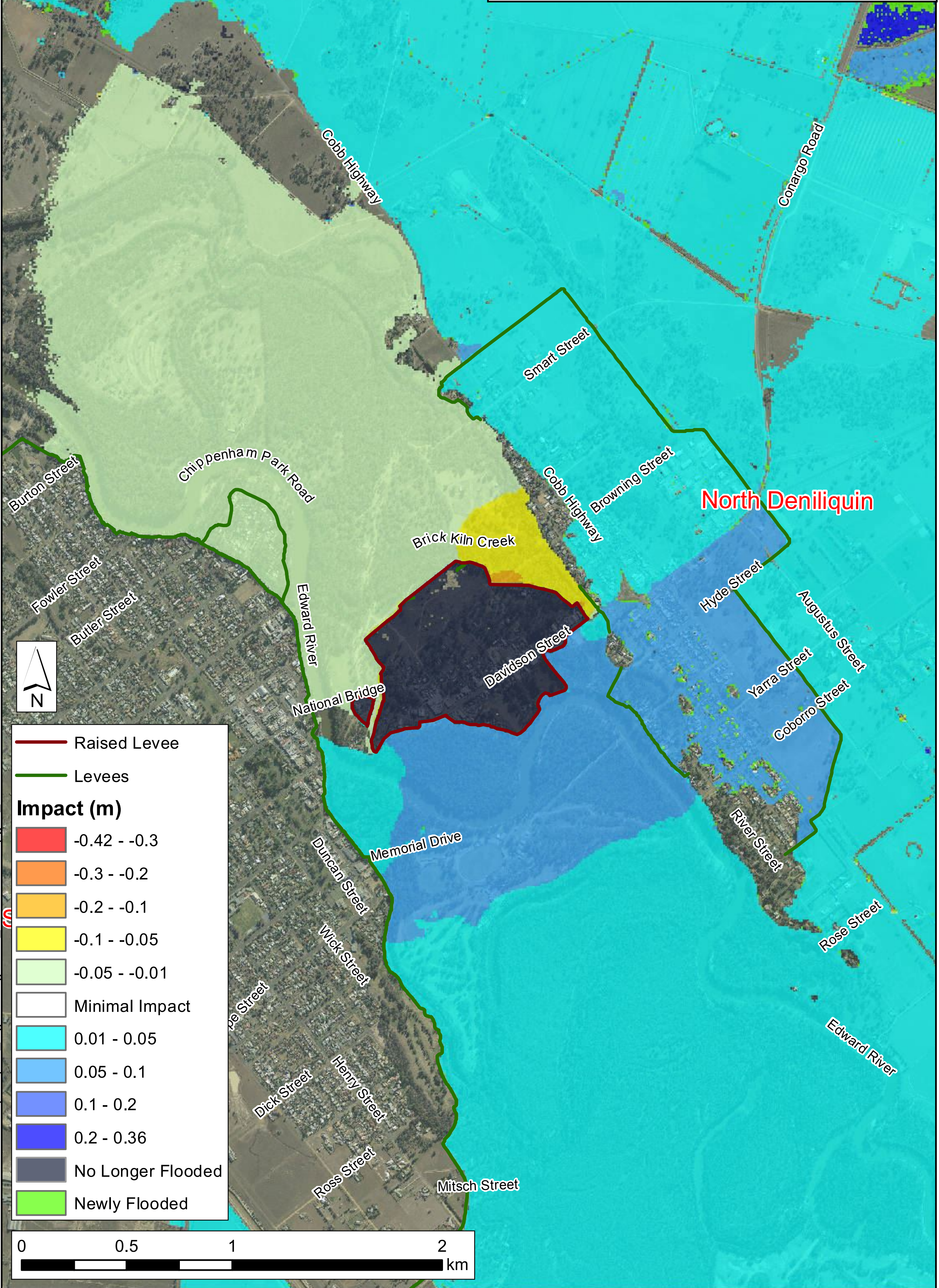


FIGURE 19
OPTION FM01
CLEARING OUT AND LOWERING BRICK KILN CREEK
FLOOD LEVEL IMPACT - 5% AEP
Chippenham Park Road
Cobb Highway
Browning Street
Brick Kiln Creek
Edward River
Davidson Street
National Bridge
Memorial Drive
Duncan Street
Wick Street
N
Levees
Lowered Creek Section
Impact (m)
-0.42 - -0.3
-0.3 - -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
Minimal Impact
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.36
No Longer Flooded
Newly Flooded
0
0.25
0.5
1
km
J:Jobs\115027\ArcGIS\ArcMap\Report_Figures\Figure19_BckKlnSmooth_5%.mxd

FIGURE 20
OPTION FM02
DAVIDSON STREET LEVEE RAISED TO 1% AEP
FLOOD LEVEL IMPACT - 1% AEP



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Version: 1, Version Date: 01/05/2017

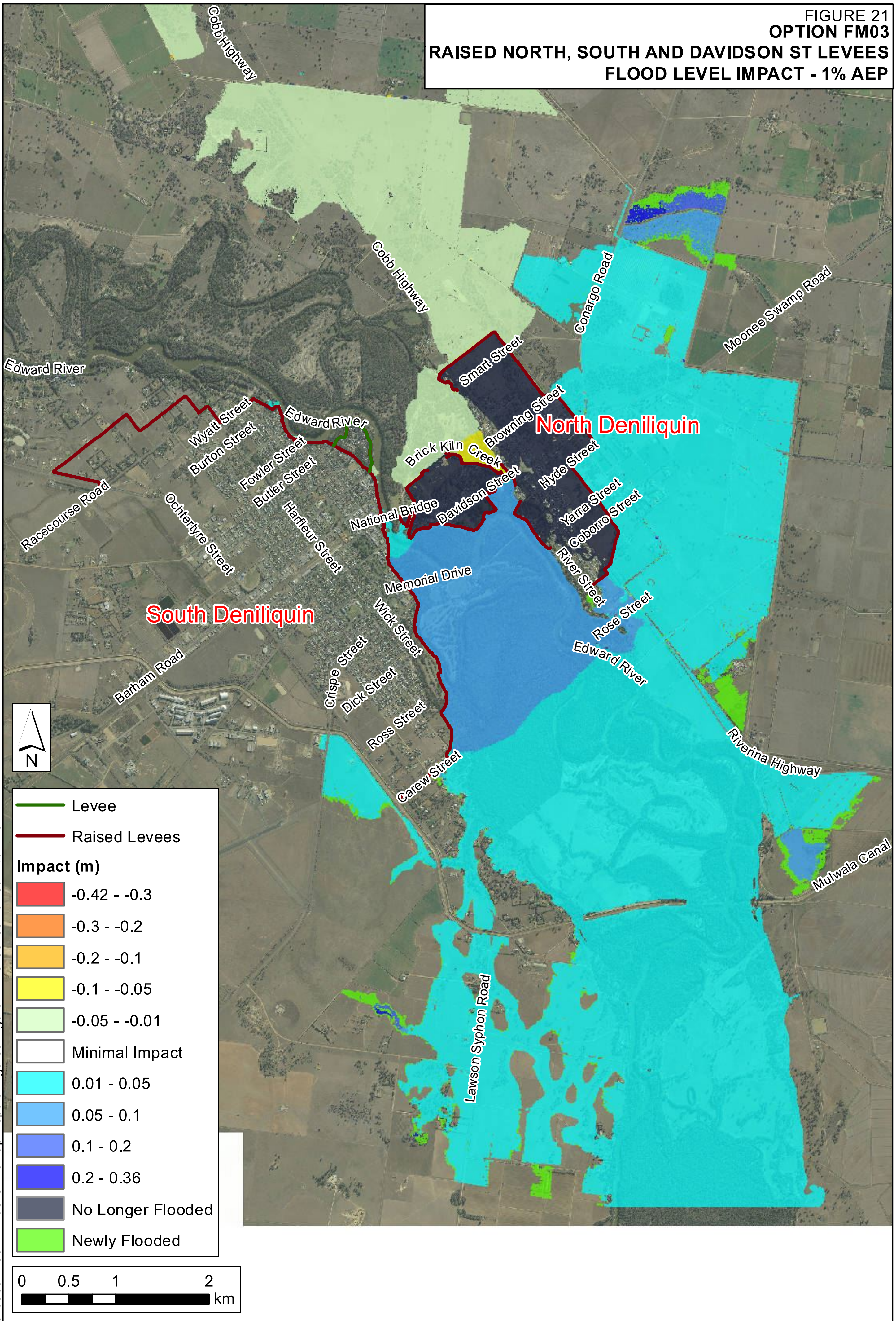

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FIGURE 22

RAISED NORTH, SOUTH AND DAVIDSON STREET LEVEE FLOOD LEVEL IMPACT - 5% AEP

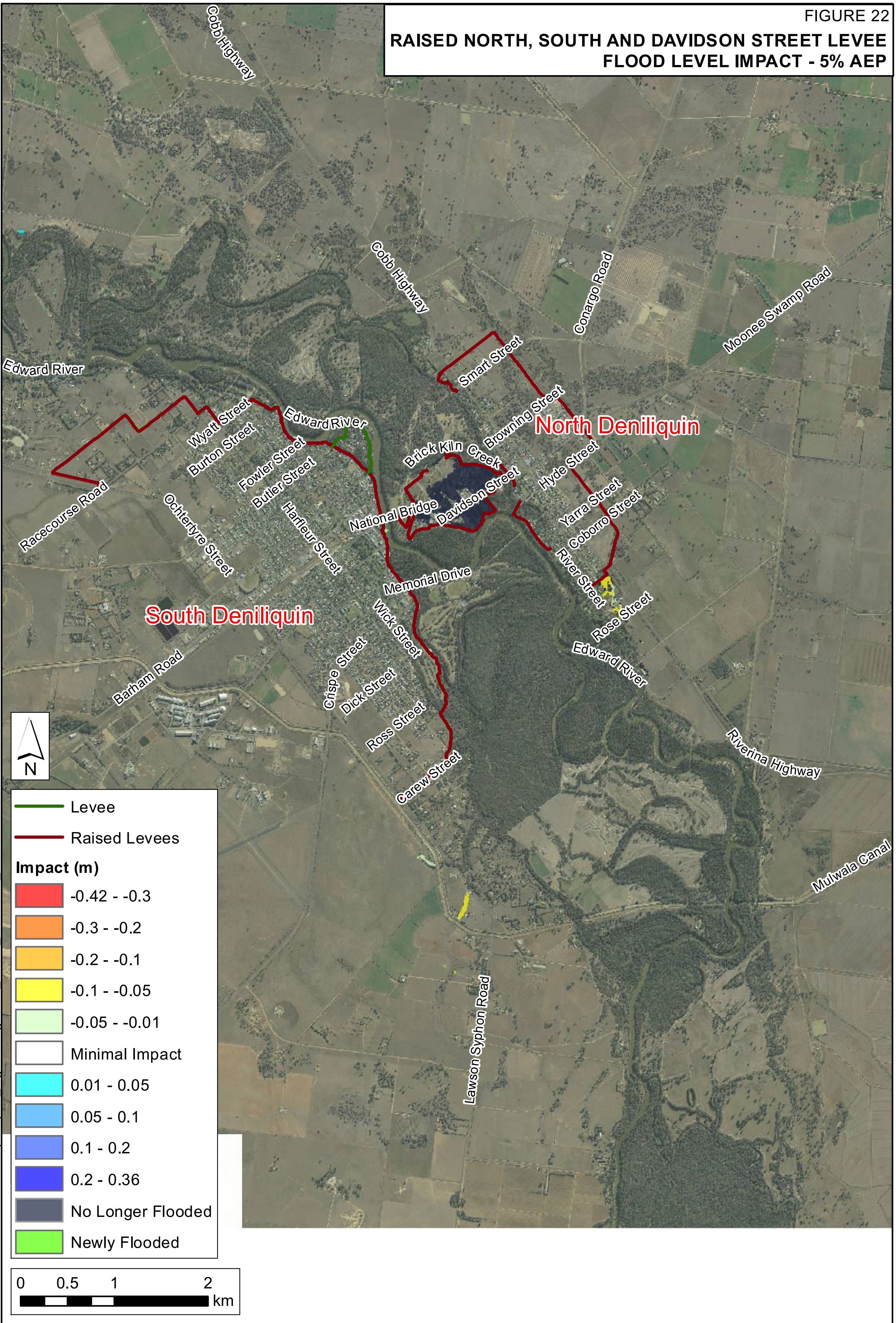

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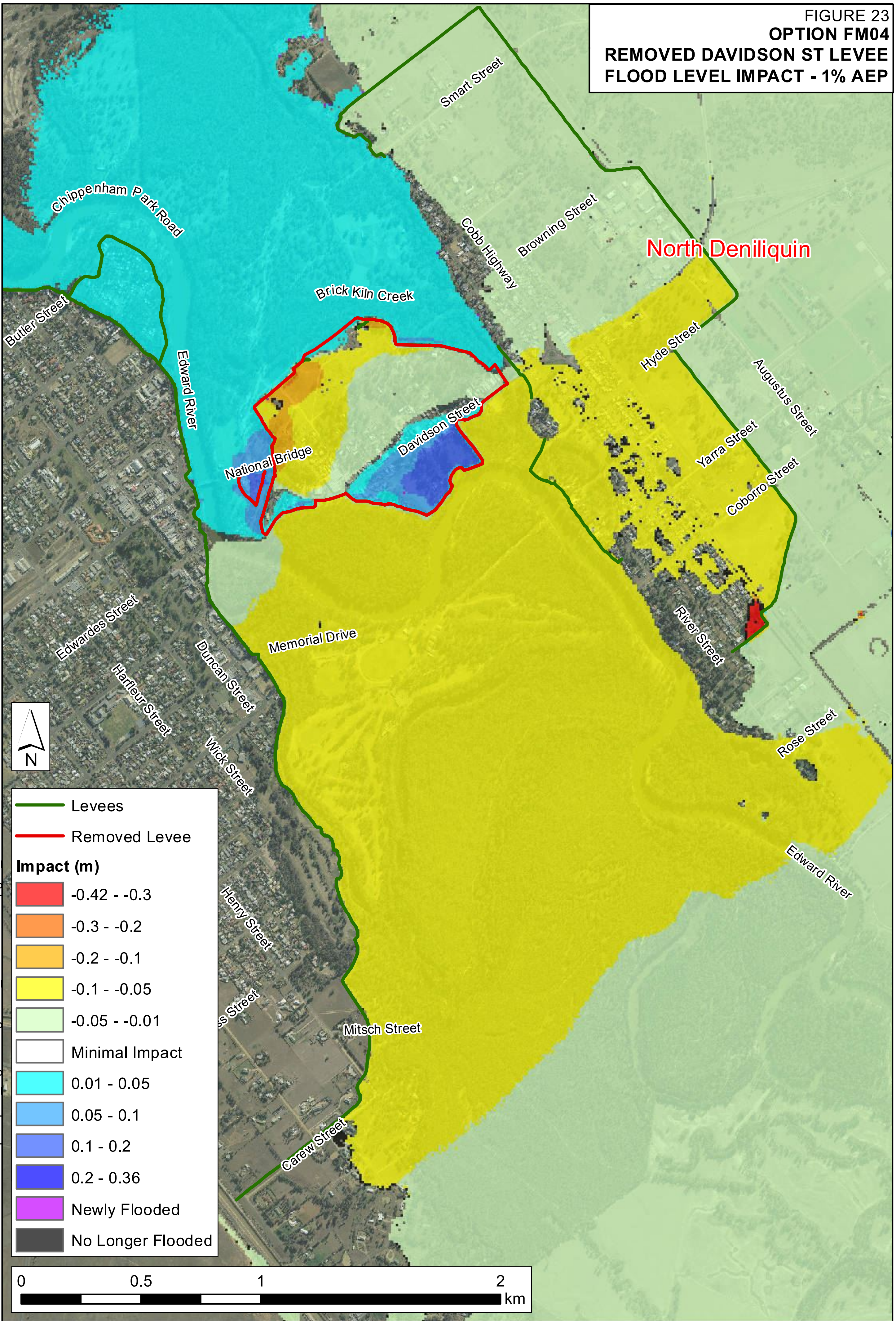
FIGURE 23
OPTION FM04
REMOVED DAVIDSON ST LEVEE
FLOOD LEVEL IMPACT - 1% AEP



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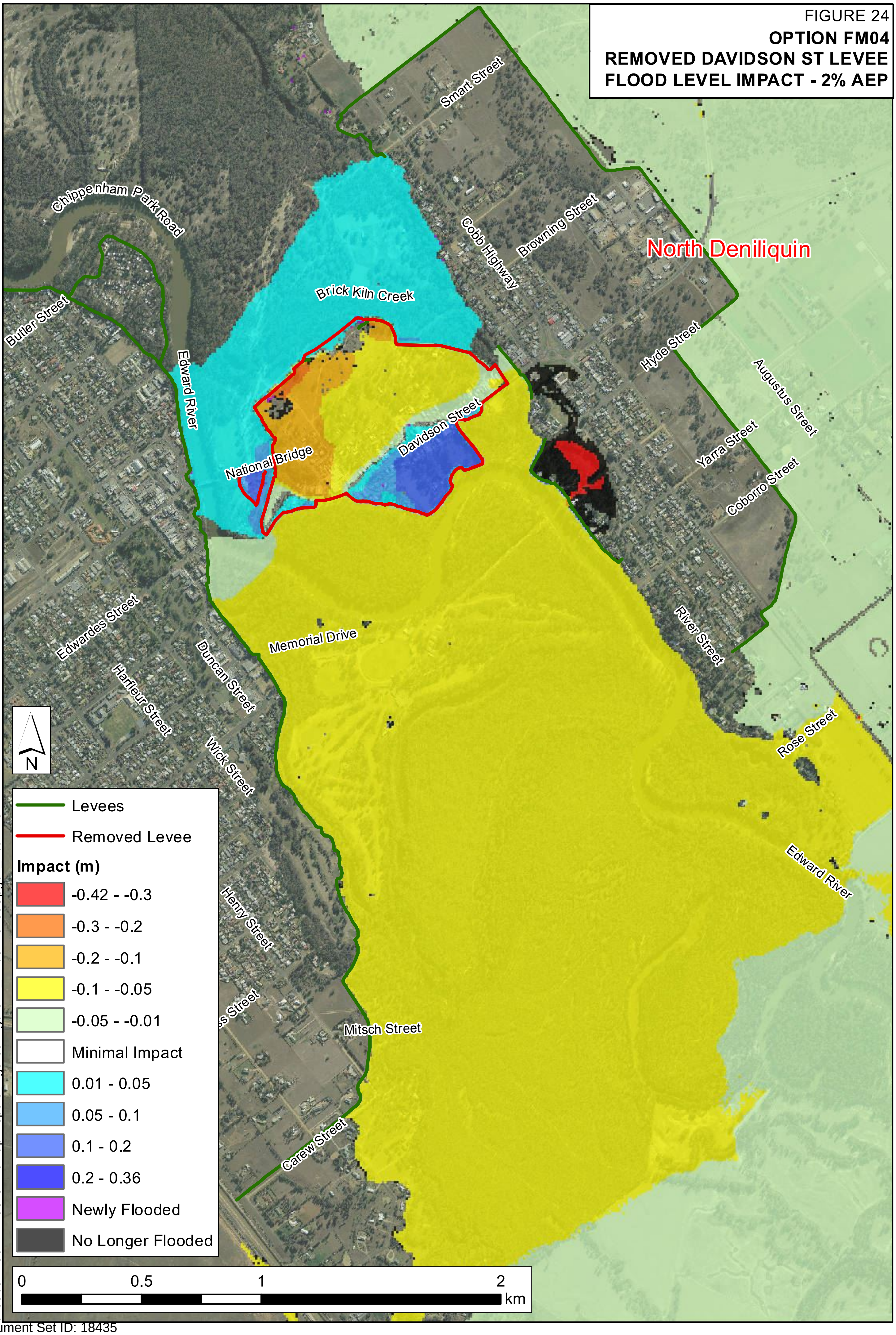

Document Set ID: 18435
Version: 1, Version Date: 01/05/2017

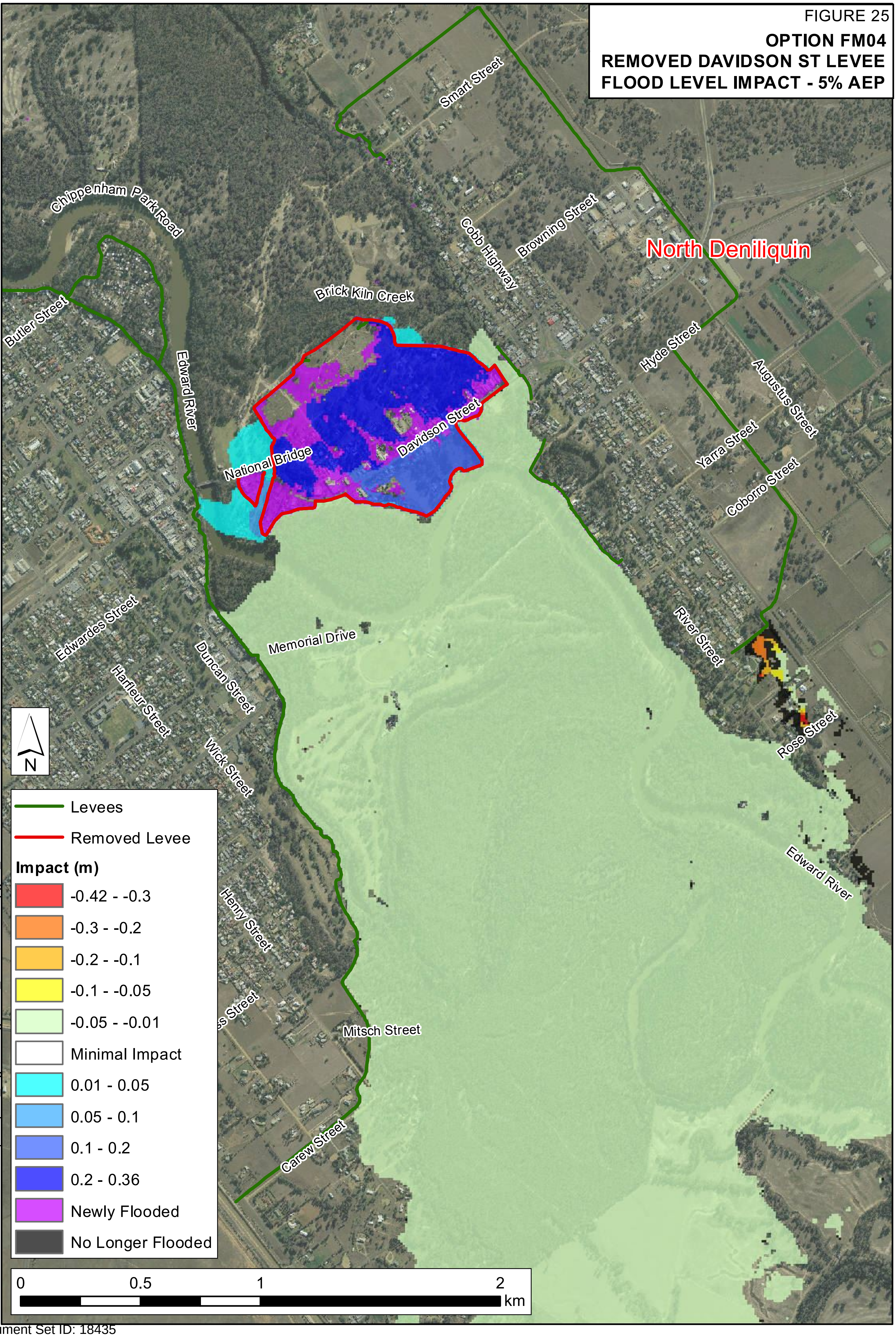

FIGURE 25
OPTION FM04
REMOVED DAVIDSON ST LEVEE
FLOOD LEVEL IMPACT - 5% AEP
North Deniliquin
Smart Street
Chippenham Park Road
Browning Street
Cobb Highway
Brick Kiln Creek
Butler Street
Edward River
Hyde Street
Augustus Street
Davidson Street
National Bridge
Yarra Street
Coborro Street
Memorial Drive
River Street
Edwardes Street
Duncan Street
Harfleur Street
Wick Street
Rose Street
Edward River
Henry Street
Mitsch Street
Carew Street
N
Levees
Removed Levee
Impact (m)
-0.42 - -0.3
-0.3 - -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
Minimal Impact
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.36
Newly Flooded
No Longer Flooded
0 0.5 1 2 km
J:\Jobs\115027\ArcGIS\ArcMap\Report_Figures\Figure25_DvdsnLeveeUpg04_5%.mxd

FIGURE 26
OPTION FM06
REVISED NORTH DENILIQUIN LEVEE 2% AEP + 0.3m
FLOOD LEVEL IMPACT - 1% AEP

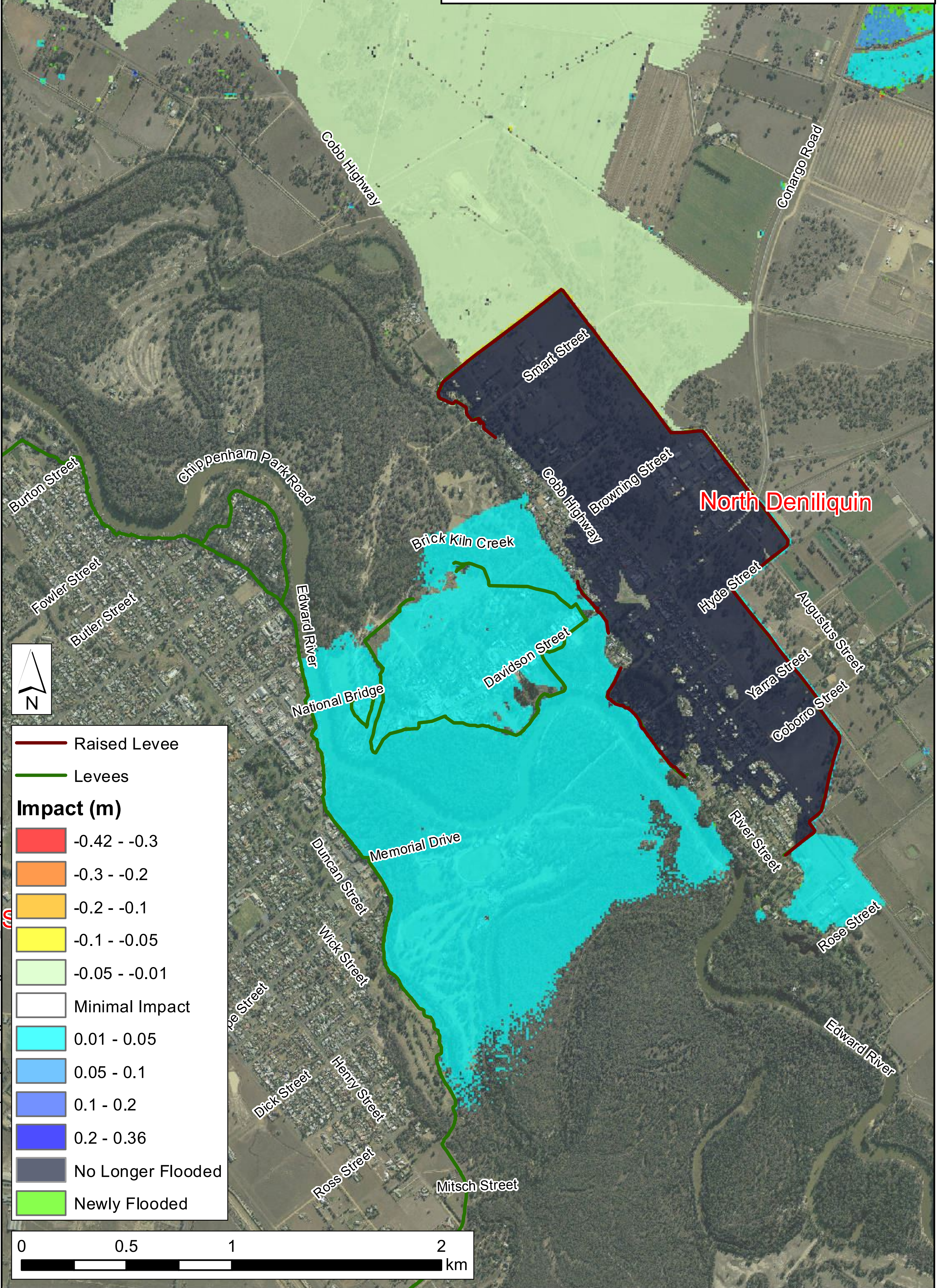

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FIGURE 27
OPTION FM08
REVISED MCLEAN BEACH LEVEE
FLOOD LEVEL IMPACT - 1% AEP

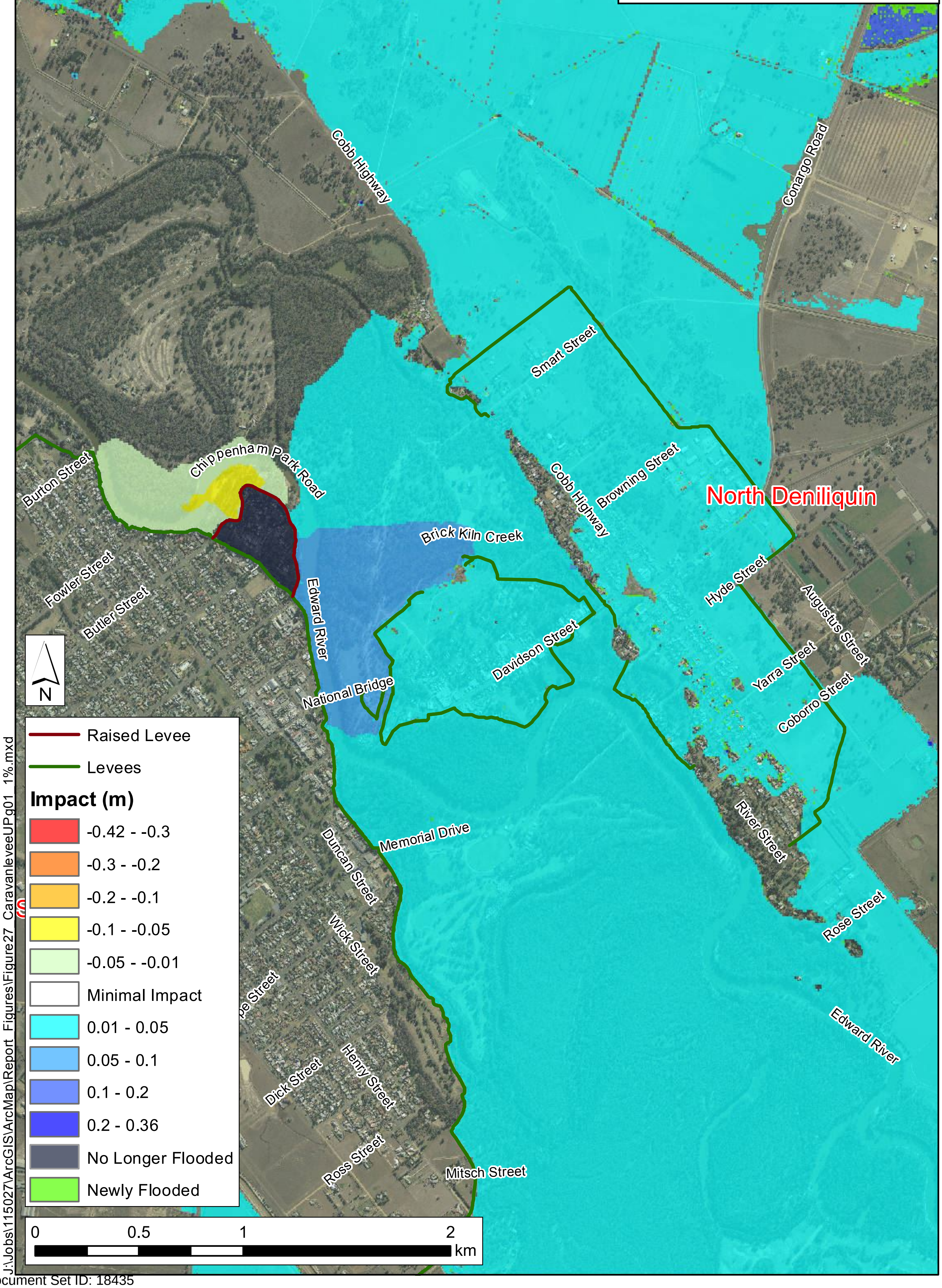
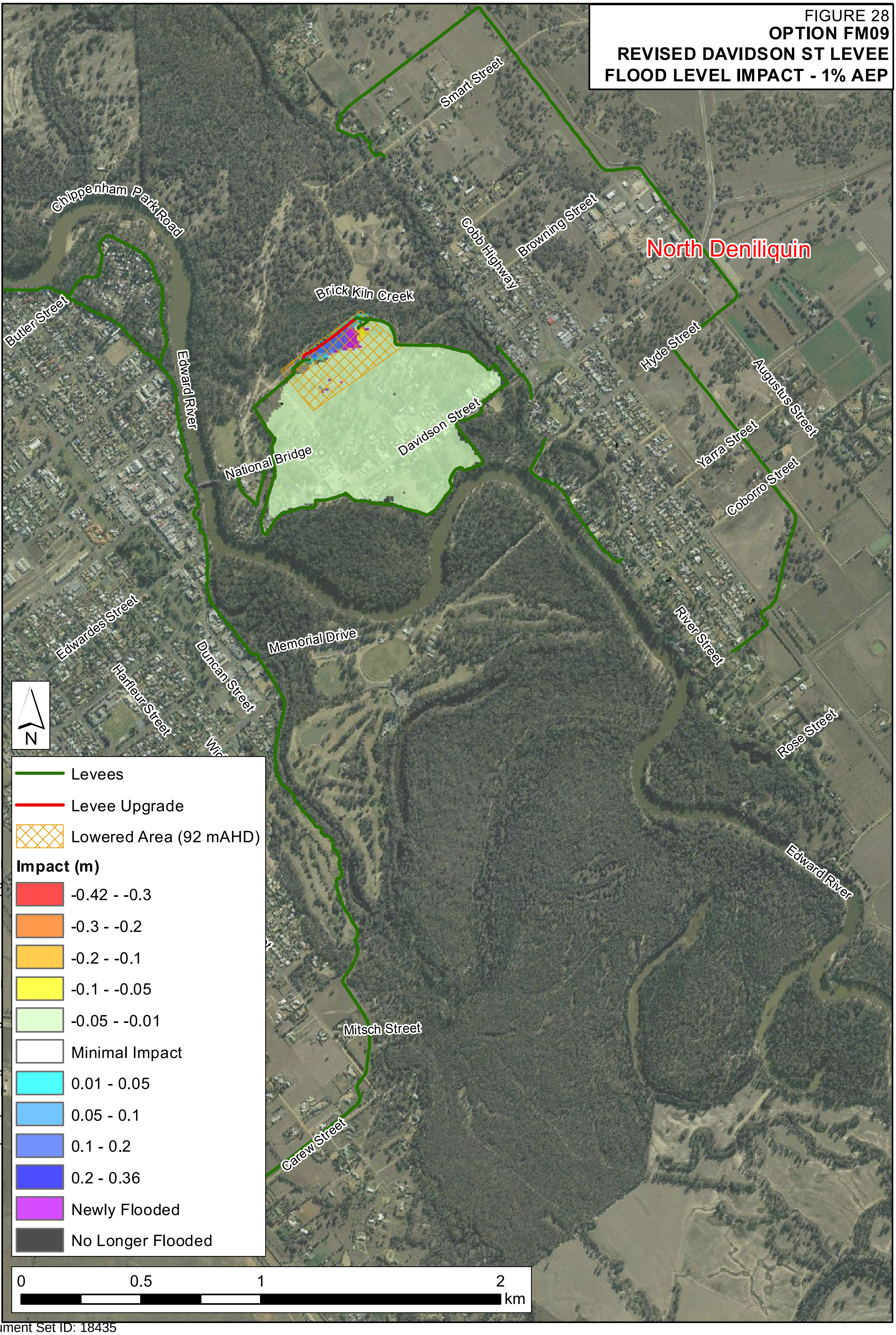


FIGURE 28
OPTION FM09
REVISED DAVIDSON ST LEVEE
FLOOD LEVEL IMPACT - 1% AEP



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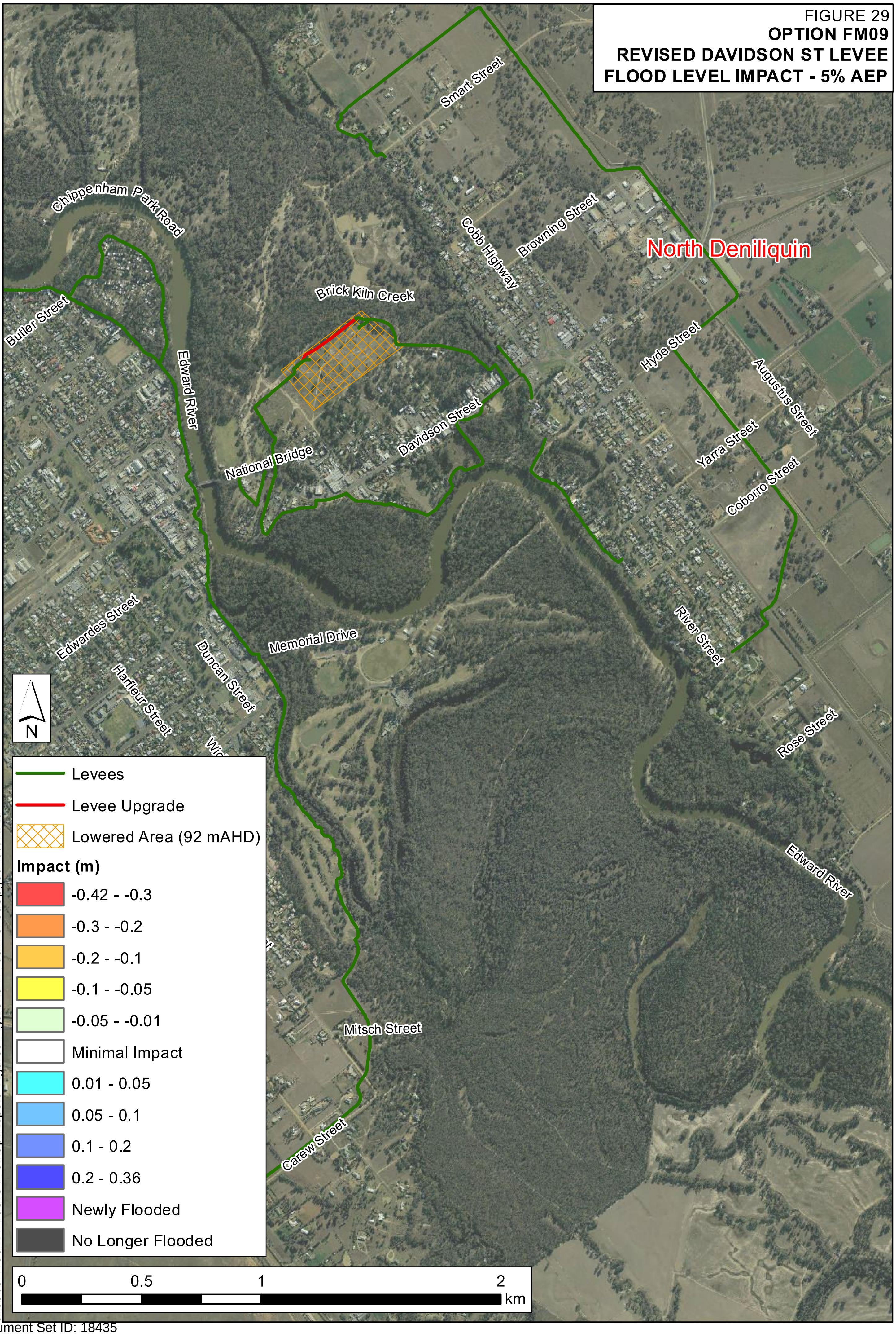

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FIGURE 30
OPTION FM10
NEW CHANNEL THROUGH DAVIDSON STREET
FLOOD LEVEL IMPACT - 2% AEP

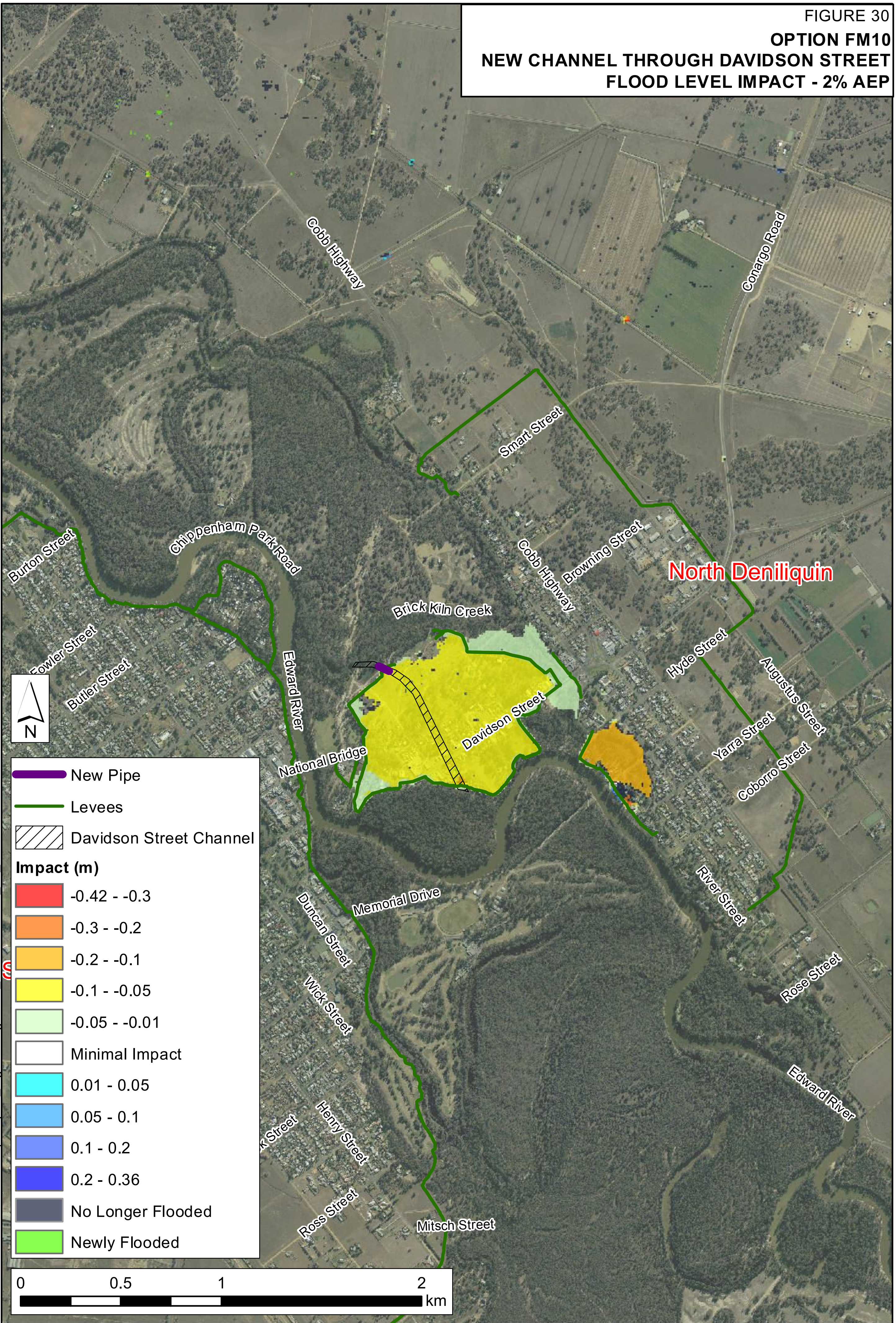

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FIGURE 31
OPTION FM10
NEW CHANNEL THROUGH DAVIDSON STREET
FLOOD LEVEL IMPACT - 5% AEP

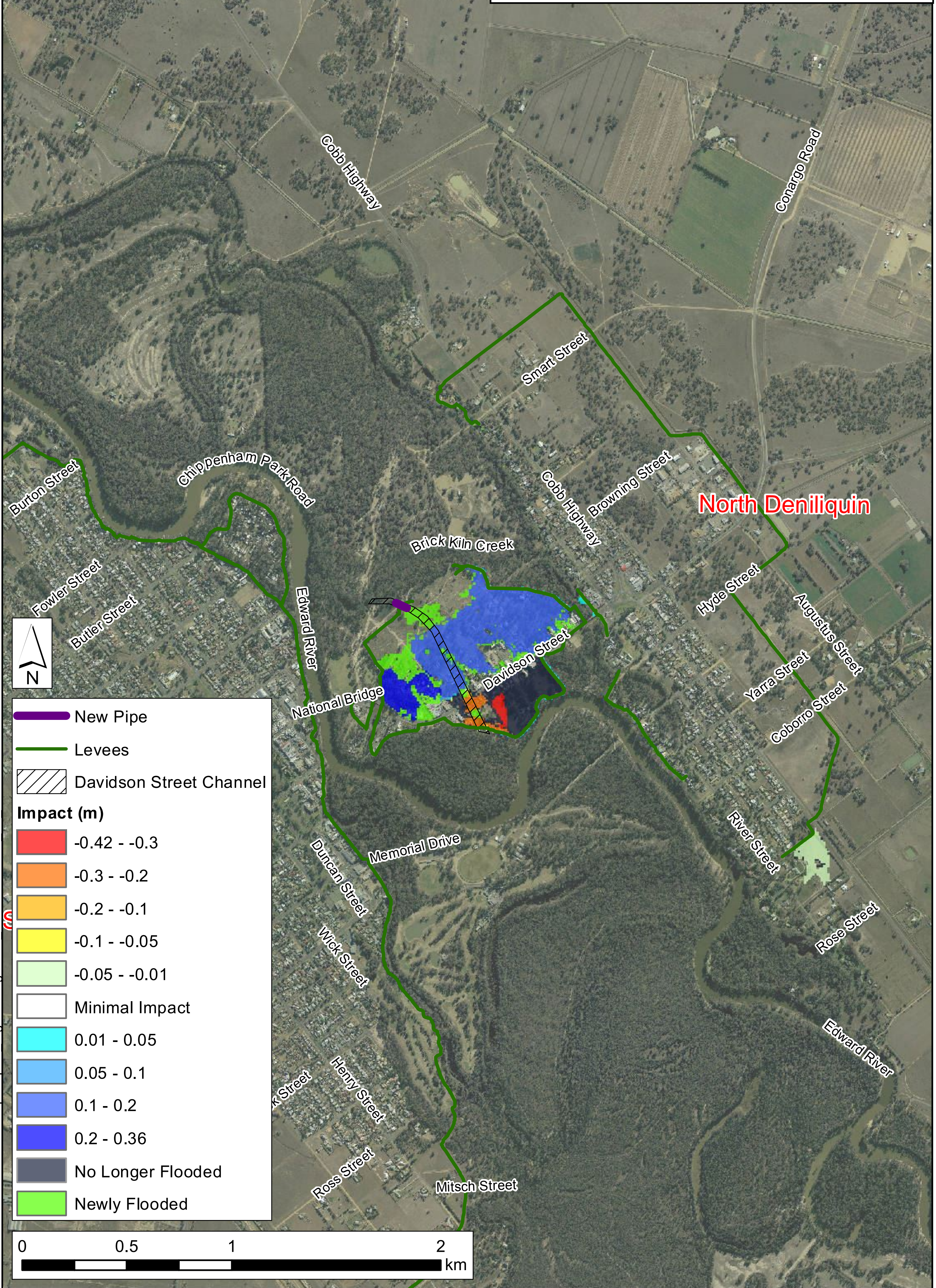

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FIGURE 32
OPTION FM11
LOWER EMBANKMENT NEAR NATIONAL BRIDGE
FLOOD LEVEL IMPACT - 1% AEP

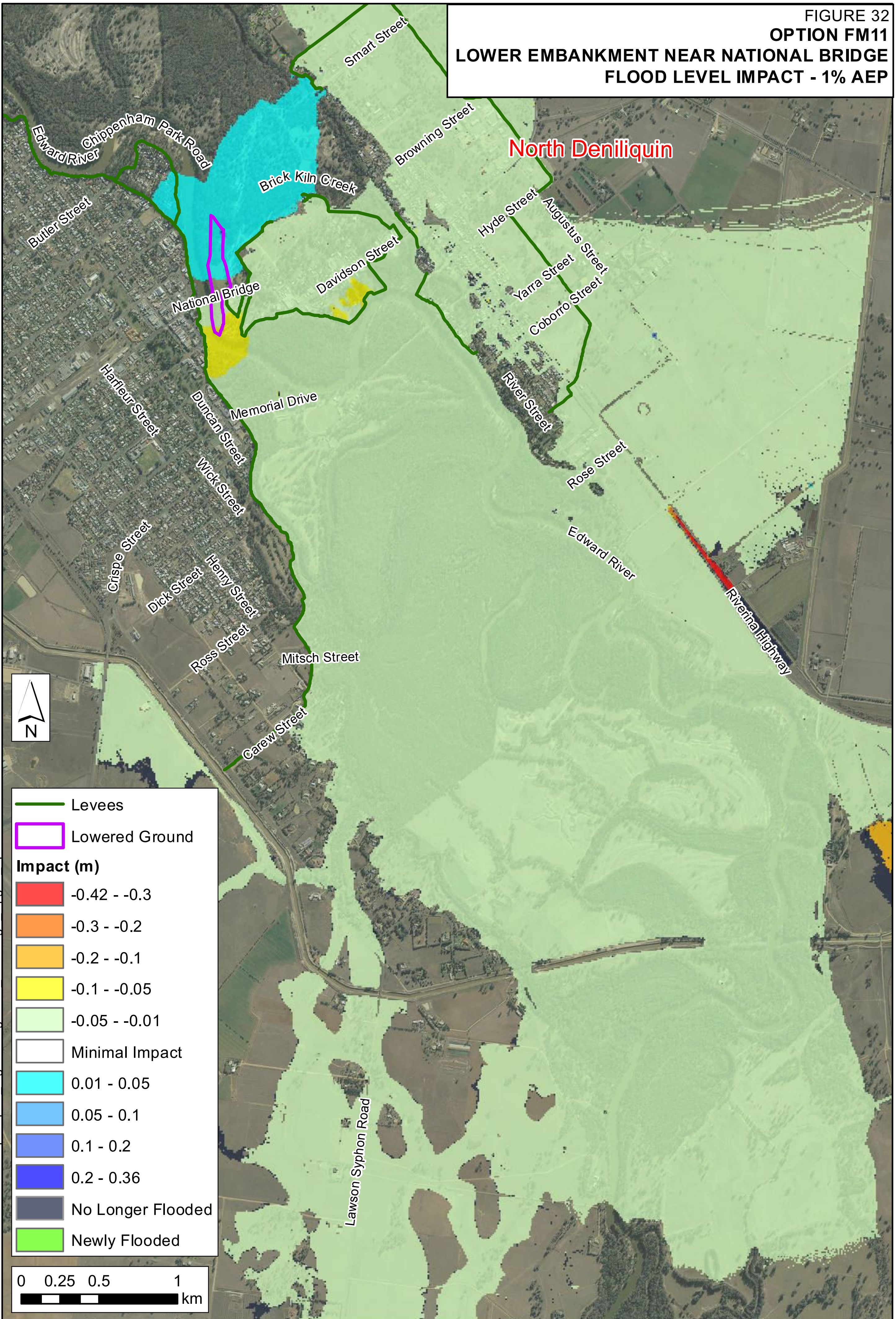

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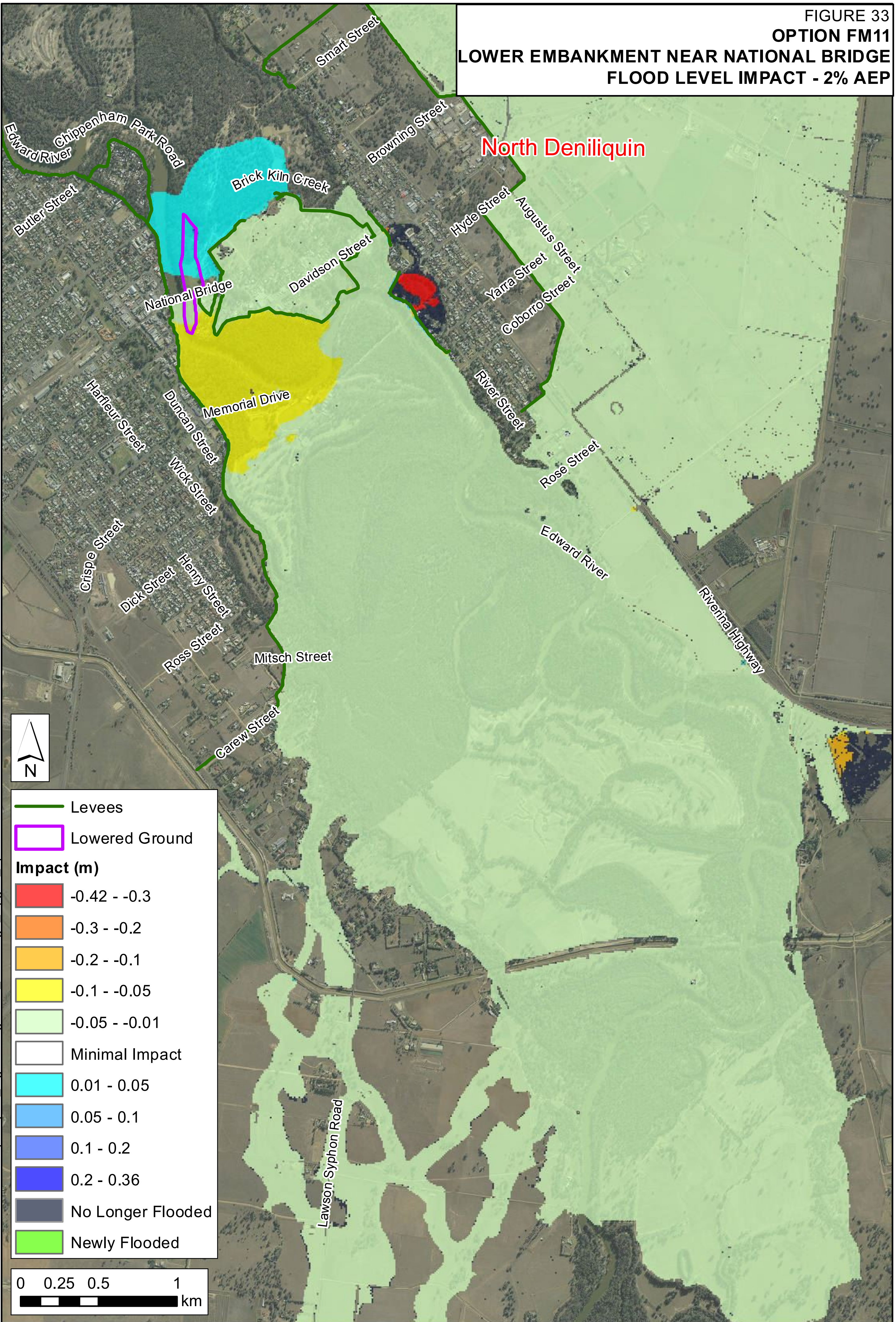
FIGURE 33
OPTION FM11
LOWER EMBANKMENT NEAR NATIONAL BRIDGE
FLOOD LEVEL IMPACT - 2% AEP



Document Set ID: 18435
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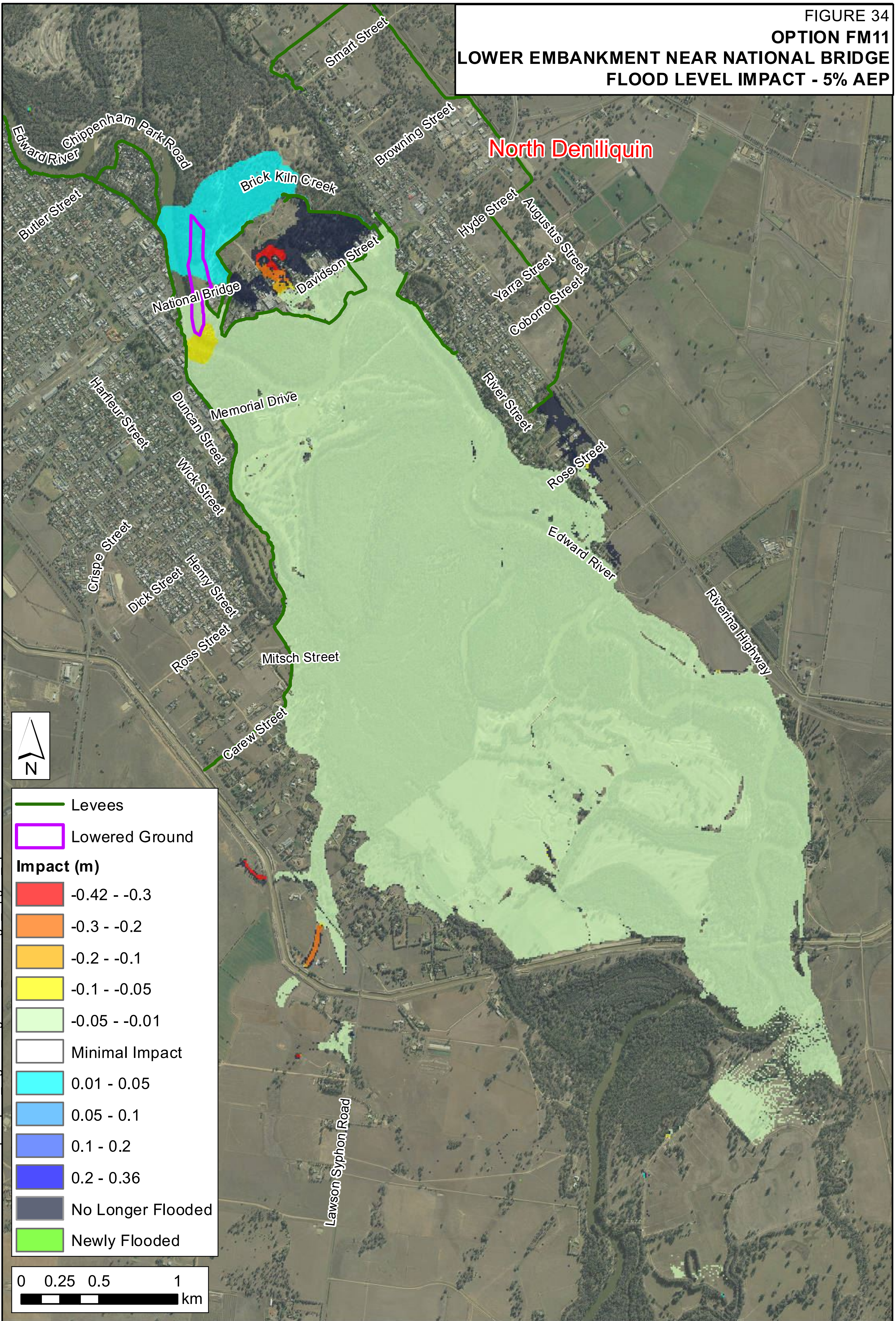
FIGURE 34
OPTION FM11
LOWER EMBANKMENT NEAR NATIONAL BRIDGE
FLOOD LEVEL IMPACT - 5% AEP
North Deniliquin
Smart Street
Browning Street
Edward River
Chippenham Park Road
Butler Street
Brick Kiln Creek
Hyde Street
Augustus Street
Yarra Street
Coborro Street
Davidson Street
National Bridge
Harfleur Street
Duncan Street
Memorial Drive
River Street
Rose Street
Wick Street
Crispe Street
Dick Street
Henry Street
Edward River
Riverina Highway
Ross Street
Mitsch Street
Carew Street
Lawson Syphon Road
N
Levees
Lowered Ground
Impact (m)
-0.42 - -0.3
-0.3 - -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
Minimal Impact
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.36
No Longer Flooded
Newly Flooded
0 0.25 0.5 1
km
J:\Jobs\115027\ArcGIS\ArcMap\Report_Figures\Figure34_NatBridge_Upg04_5pc.mxd

Appendix A

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

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

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

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

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	storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:
	$ the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
	
	$ water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

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

mathematical/computer models

The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach

The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding

Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures

Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

peak discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)

The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP)

The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

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

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Appendix B

FLOOR LEVEL SURVEY FOR DENILIQUIN LGA

1. BACKGROUND

WMAwater are undertaking a floodplain management study for the Deniliquin LGA on behalf of Deniliquin Council. Part of this work involves obtaining floor levels of potentially flood liable buildings (habitable or commercial buildings but not sheds or garages) within the study area. The precise number of building floor levels to be surveyed is unknown but two estimates have been made: 'Option 1' and 'Option 2'. Option 1 consists of 45 properties and is shown in Figure 1, while Option 2 consists of 170 properties and is shown on Figure 2. Note that the properties highlighted will be refined once the option is decided upon. You are invited to provide a per property price and a lump sum fee for each of the two options. Note that the actual number of properties may vary and final budget will be based on a pro-rated amount.

You are invited to provide an email with an attached letter quote, detailing your proposal and timeframe for completion to undertake the works as described above.

We have provided the following information to assist with your quotation:

- Figure 1 and Figure 2 showing approximately what properties are to be surveyed (two options),
- Spreadsheet for format of floor level information (Table 1), and
- Sample photograph of each building to be provided.

Should you require further clarification please do not hesitate to contact the undersigned.

Felix Taaffe – Project Engineer
WMAwater, Level 2, 160 Clarence Street, SYDNEY NSW 2000
Telephone: (02) 9299 2855 **Email:** taaffe@wmater.com.au

2. FLOOR LEVEL SURVEY

We require floor level information for all buildings (as per the format in Table 1) within the area (indicated on Figure 1) this documentation can be made available in GIS format if required. At each location a digital photograph (suggested max size of photo 500kb) of each building is required (refer to the attached Photo.pdf for details of the required format). A GIS layer (either ArcGIS shapefile or MapInfo .tab file) is also required with a point indicating where the ground and floor level has been taken on the property, in MGA55. A single point can be used to represent the ground level and floor level location, even if they are 1-2 metres apart. Each point must have a unique attribute linking it to the completed spreadsheet.

The deliverables from this commission would include:

- Completed Table 1 in a spreadsheet,
- Two hard copy sets of photographs (4 photos per page),
- One digital set of photographs.
- One GIS layer (.shp or .tab) in MGA55 with a point for each property

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FIGURE 01
PROPERTIES TO BE SURVEYED
OPTION 1

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FIGURE 02
**PROPERTIES TO BE SURVEYED
OPTION 2**

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Table 1 - Format for Provision of Floor Level Data

						RESIDENTIAL BUILDINGS						NON RESIDENTIAL BUILDINGS					
Property Tag as on Council cadastre (GIS Tag)	Photograph name	Total number of buildings	Street Number	Street Name	Indicative Ground Level (m AHD)	Lowest Habitable Floor Level (m AHD)	Single (S) or Double storey (D)	Do people live on the Ground Floor (Y or N)	**House Size** - Small (S), Medium (M), Large (L)	**Floor Construction** Pier (P) or Slab (S) Other - describe	**Wall Construction** Brick stone or rendered (B), Clad (C) , Mixed (M)	Type (commercial = C, industrial = I, public = P)	Name and Nature of Use/Business	Lowest Floor Level (m AHD)	Approximate Floor Area (m^2)	**Floor Construction** Pier (P) or Slab (S) Other - describe	**Wall Construction** Brick stone or rendered (B), Clad (C) , Mixed (M)
7879	16JohnSt1, 2, 3	3	16	John St	5.25	6.25	S	Y	M	S	B						
												C	Bobs Nursery	6.16	36	S	B
												C	Bobs Fish Stor	6.2	50	S	B
78880	20JohnSt	1	20	John St	5.25	6.56	D	Y	L	S	B						
7671	22JohnSt	1	22	John St	5.25							P	Toilet Block	5.05	50	S	B

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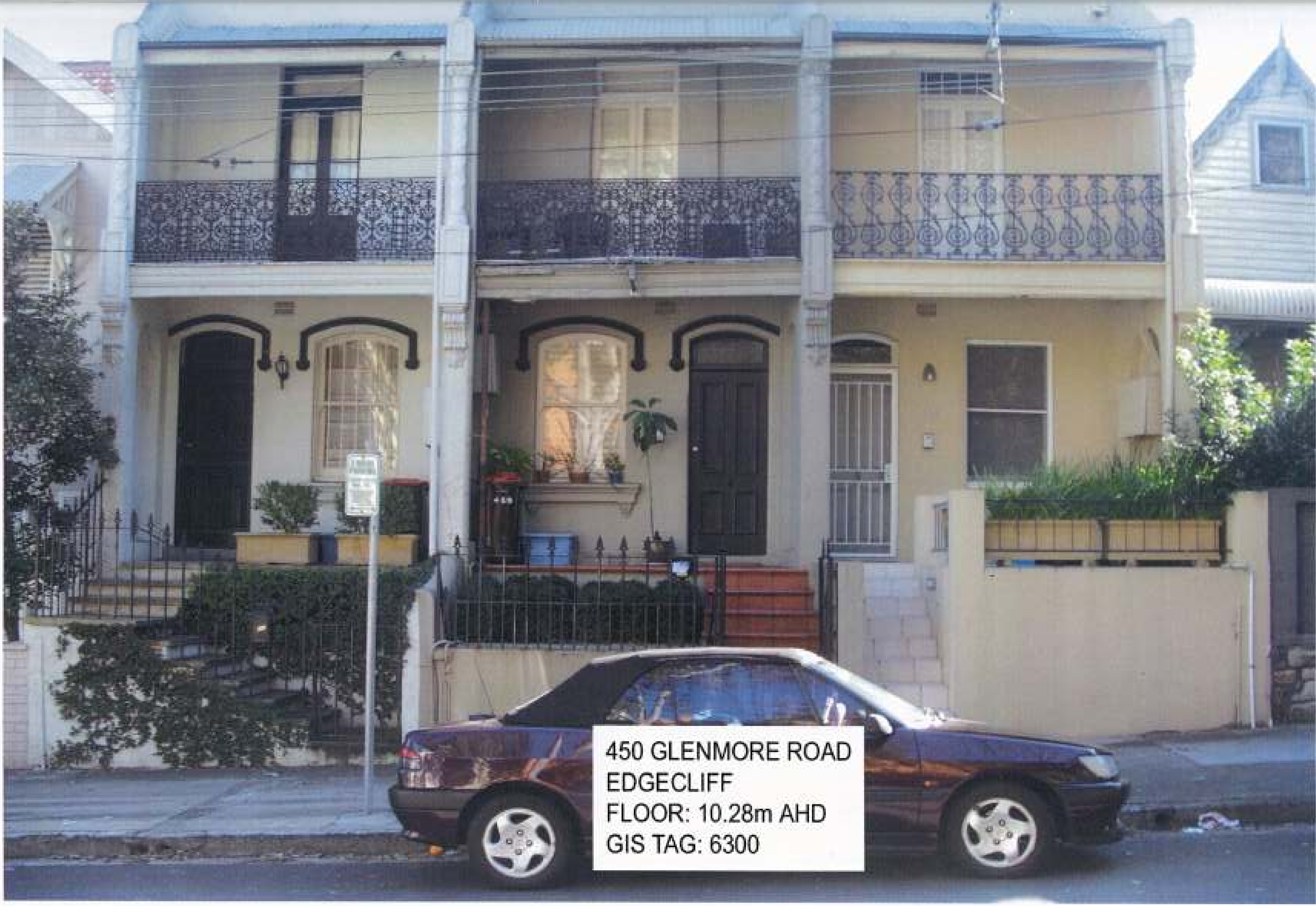
450 GLENMORE ROAD
EDGECLIFF
FLOOR: 10.28m AHD
GIS TAG: 6300

JR

31 August 2015

THE RESIDENT

DENILIQUIN COUNCIL
Achievement through Action

Dear Sir/Madam

FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN FOR THE DENILIQUIN LOCAL GOVERNMENT AREA

Deniliquin Council is currently undertaking a Floodplain Risk Management Study and Plan for our local government area. As your property may be within a flood risk area, Council is required to carry out a floor level survey of buildings within the area as part of the study. WMAwater is carrying out the Floodplain Risk Management Study and Plan on behalf of Council, while Brian Mitsch and Associates is undertaking the floor level survey.

Whilst it is unlikely, there may be a requirement for the surveyors to enter private property. Council would appreciate if property owners would permit the surveyors to enter the property upon request. In the event that property owners are absent Council would appreciate if the surveyors could enter the property by any reasonable means. Under no circumstances would the surveyor be required to enter any buildings on the property.

Should you require any further information, please do not hesitate to contact me on (03) 5898 3111.

Yours sincerely

Julie Rogers

Julie Rogers
MANAGER ENVIRONMENTAL SERVICES

All correspondence to be directed to the General Manager

Civic Centre
Civic Place
PO Box 270
DENILIQUIN NSW 2710

Telephone
03 5898 3000

Facsimile
03 5898 3029

Email
council@deniliquin.nsw.gov.au

Website
www.deniliquin.nsw.gov.au

ABN 90 513 847 629

DENILIQUIN

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Appendix C

Edward River at Deniliquin Floodplain Risk Management Study

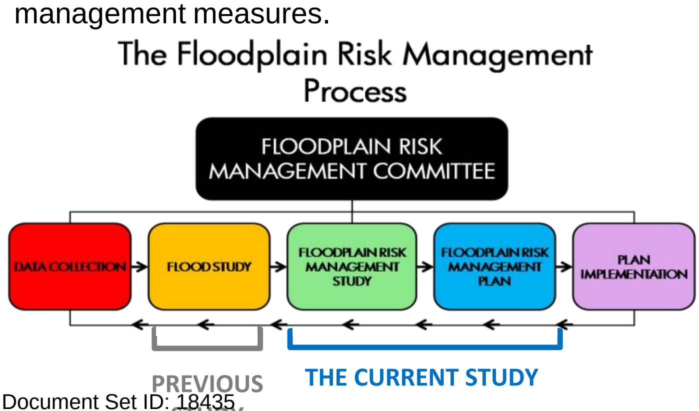
Community Information Newsletter August 2015

Deniliquin Council has recently begun the Edward River at Deniliquin Floodplain Risk Management Study, following completion of the area's flood study in late 2014. The Risk Management Study will assess the flood risk across the LGA, based on the flood behaviour defined by the Flood Study. The current study will also assess a range of possible mitigation measures, aimed at managing the current and future flood risk in Deniliquin. This newsletter provides an overview of the study, including opportunity for community involvement.

▲ **A photo of the 1956 flood, which inundated the entire Davidson Street area (shown) and parts of North Deniliquin**

Background

The Floodplain Risk Management Study is a part of the Floodplain Risk Management Process (see below) for the Deniliquin Council Area (LGA). The process, which is set out by the NSW Government's Flood Policy, involves a series of stages, of which the current study forms the third and fourth. The flood study defined the flood behaviour in the LGA, while the current stage makes a complete assessment of flood risk, including identification and assessment of management measures.



Range of Flooding

Floods in Deniliquin come in a range of sizes, ranging from low flow contained in the river and surrounding flood runners to extreme flooding that may overtop the levee system and cause significant damage. The flood study categorised each potential flood according to its peak flood flow. The corresponding depth at the gauge is recorded at the river gauge near Edwardes Street.

The completed flood study determined the probability of a particular peak flood occurring in any year. The study found that the 1% (or 1 in 100) Annual Exceedance Probability (AEP) flood has a flow of 190,400 ML/day which equates to a depth of 10.1 m at the gauge, or 92.5 mAHD. The 1% AEP flood has a 1% chance of occurring or being exceeded in any given year. This is known as a design flood. The study assessed various design floods, including those of 20%, 10%, 5%, 2%, 1% and 0.5% AEP. Flood risk is then assessed by the current study by looking at the consequences of the range of design flood events.

Flood Event	Flow (ML/day)	Peak Flood Depth at Gauge (m)
Oct 1993	83,300	8.48
Nov 1975	119,600	9.04
Jul 1956	154,100	9.37
Oct 1917	189,100	9.63
Sep1955	110,900	8.95
Nov 1870	200,500	9.68
20% AEP	51,800	7.0
10% AEP	86,200	8.6
5% AEP	120,200	9.4
2% AEP	160,800	9.9
1% AEP	190,400	10.1
0.5% AEP	209,500	10.2
PMF	561,500	11.0

▲ **The flow and peak flood depth of historical floods, as compared to the design floods assessed by the flood study**

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Types of Flood Risk

Floods can cause loss of life and injury, costly damage to houses and other buildings, and destruction of infrastructure such as roads, bridges, water supply, electricity and sewerage. Following a large flood, further effects include economic hardship during the recovery period, and psychological damage to those affected. For example, flooding in Victoria in 2011 caused the death of two people, flooded 1,700 properties and cost of up to $2 billion from agriculture damage alone.

Super – Human Effort Beat Flood in South Deni.

"River Near Peak:" Engineer

TODAY THE EDWARD RIVER at the National Bridge reached 30ft. 9in. district engineer (Mr. Ian Bolton) reported, and he said it has now reached somewhere in the vicinity of its peak. There may be a slight rise of an inch or two, after which he expects it to remain steady for a couple of days before starting to fall slowly.

Nearly 6 Miles Levee Banks

LAST YEAR'S MARATHON effort to combat the flood, when the river reached 29ft. 6in., was surpassed this week-end in another tremendous community effort when 20,000 yards of earth was moved to surround South Deniliquin with 5½ miles of levee banks.

Upwards of 80 trucks, tippers and tray body vehicles, were filled at the Echuca Road pit by giant earth moving equipment and smaller tractors with front end loaders, and they left the pit at the rate of nearly two a minute.

Work continued for 24 hours, and Army personnel and newspapermen who visited the town agreed that the organisation here was the most colossal they had ever witnessed.

cases up to date.

The Billabong Creek at Puckawidgee (Conargo) reached its peak of 17ft. 2ins. on July 13, and has now fallen to 16ft. 9ins., but will rise again later. The peak of 17ft. 2ins. was 11ins. higher than in 1931 and 1952.

The Billabong Creek is still rising at Jerilderie and it is expected that the Forest Creek will also likewise.

Moulamein is 19ft. 6ins. being only 2ins. below the record 1931 flood level of 19ft. 8ins. It is ex-

ESTABLISHED 1859

Pastoral Times

PUBLISHED AT DENILIQUIN
TUESDAYS & FRIDAYS

Registered at the G.P.O. for transmission by Post as a Newspaper

TUESDAY, JULY 17, 1956 Vol. XCVI. No. 6532 4d. per copy, 39/- per annum

EMERGENCY POST OFFICE

An emergency Post Office has been established at Hardman's woodyard at North Deniliquin, and the Postmaster (Mr. F. C. Grant) yesterday assured the mayor that if the mails were transported by civic authorities to North Deniliquin, all would be delivered.

It is also reported that 50 cable pairs of the telephone line are irreplacable due to the flood waters.

However, an emergency service is being given where ever possible to North Deniliquin, Finley, Tocumwal and Conargo Roads through spare trunk cables.

Mr. Peter Gill, telephone line engineer from Narrandera, has been in Deniliquin ever since the flood emergency started.

He was joined yesterday by Mr. A. S. Bundle, supervising engineer for southern region, Sydney, Mr. K. Douglas, trunks

No stock losses by Flood

Agents Claim

Although there were cases of stock stranded on islands and sandhills, so far no losses have been caused by flooding, representatives of stock and station agencies said yesterday.

A spokesman for Dalgety's said that landholders had moved stock before the floods hit the district.

However some rams from Boonoke and ewes from Mundiwa had to be transported through flood waters to grazing properties in the Mathoura district.

GOVERNMENT SHOULD FINANCE

The mayor (Ald. J. P. Burchfield), and other heads of shires and municipalities affected by flood in the Murray Electorate, have constantly been in touch with Mr. J. A. Lawson, M.L.A., reporting on the flood position.

As a result, Mr. Lawson has given the following notice of motion, to be moved today in the Legislative Assembly in general business:

That in the opinion of this House—

▲ **A July 1956 article describing preparations for the impending flood *(c/o Deniliquin Historical Society)***

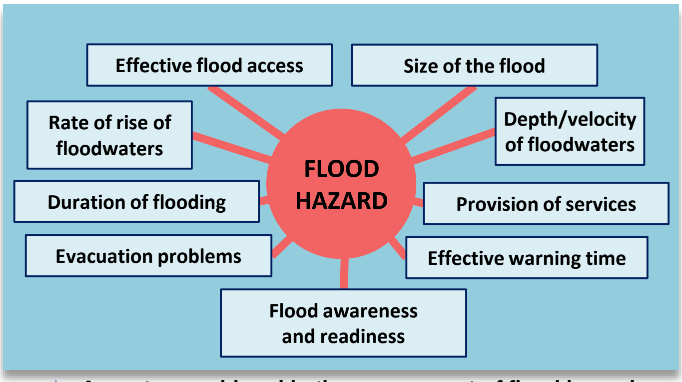
Flood Risk in Deniliquin

Flooding in Deniliquin is characterised by its very long warning time (more than one week), and the long duration of flooding (also weeks). This gives Deniliquin a warning period that is essential for preparing the levee and evacuating at-risk properties. The long duration means that areas can be cut off from essential services for a long time, and that residents in affected areas who attempt to wait out the flood place themselves and emergency services personnel in great risk. The floodwaters themselves tend to be slow moving, except for in existing creeks and channels.

▲ **A house is completely submerged during the 1956 flood *(c/o Deniliquin Historical Society)***

Flood Mitigation Measures

Deniliquin has a variety of measures in place to mitigate the effect of flooding, and the current study will examine these works and other possible measures. The largest structural work in Deniliquin is the levee, which surrounds the main part of town and part of North Deniliquin. The levee protects the town against a range of floods, but can still be overtopped by a large flood. Some of the most important measures are planning measures that guide where new development occurs through Council's Local Environment Plan and Development Control Plan. These include managing development in areas of high flood risk, and setting a minimum floor level for any redevelopment, or new development, in a flood prone area.



▲ **Aspects considered in the assessment of flood hazard**

The current study will assess both structural and planning measures, as well as 'response' measures, which improve the community's response during a flood event. Council has identified several measures to be assessed, including clearing of Brick Kiln Creek and improving the performance of the levee system. The community is invited to provide further suggestions using the attached questionnaire.

What Happens Next?

Over the next several months, the current study will assess flood risk in detail and identify and test various flood mitigation measures, including those identified by the community, where appropriate. The results of the assessment will be published in a draft report, that will go on public exhibition. At that point in time the community will be invited to give feedback on the results.

Deniliquin Council

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Edward River at Deniliquin Floodplain Risk Management Study

Response Form **August 2015**

The floodplain risk management study is currently assessing options for managing flooding in Deniliquin. Please use the following form to give any feedback you may have on possible options, including options which may improve flooding.

Please return the completed form to Deniliquin Council (mail, email or fax) by __28th August 2015.__
Mail: PO Box 270, Civic Place Deniliquin NSW 2710
Email: council@deniliquin.nsw.gov.au
Fax: (03) 5898 3029

Name : .... Phone: ....

Address : ....

Email : ....

Are you aware of the Edward River at Deniliquin Flood Study? ☐Yes ☐ No

If yes, was your property identified as being at risk of flooding or near a flood area? ☐Yes ☐ No

As a local resident who may have witnessed flooding, you may have your own ideas about how to reduce flood risk. Which of the following do you prefer? (1=least preferred, 5=most preferred)

Proposed Option	**Preference**
Improved flood flow paths – Suggested location/other comments:	1 2 3 4 5
Culvert/bridge enlarging – Suggested location/other comments:	1 2 3 4 5
Pit and pipe upgrades – Suggested location/other comments:	1 2 3 4 5
Levee Upgrade – Suggested location/other comments:	1 2 3 4 5
Strategic planning and flood related development controls – Suggested location/other comments:	1 2 3 4 5
Education of the community, providing greater awareness of potential hazards– Suggested location/other comments:	1 2 3 4 5
Flood forecasting/warning, evacuation planning and emergency response– Suggested location/other comments:	1 2 3 4 5

Other (please specify any options you think are suitable): ....

....

....

Privacy Notice The information supplied will be used by Deniliquin Council and its consultants to consider flooding matters within the local government area. Personal information will remain confidential, however responses may be accessed by third parties through the Government Information (Public Access) Act 2009

Appendix D

APPENDIX D: FLOOD DAMAGES ASSESSMENT

D.1. Quantification of Damages

The quantification of flood damages is an important part of the floodplain risk management process. Flood damages can be defined as actual or potential where actual damage refers to the damage incurred during known flood events while potential damage is an estimation of the damage that could occur. Calculating potential flood damages gives a potential value of damage per property per design flood event, and an overall average annual damages value which is the average cost to property owners per year owing to flood damages. By quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including;

- The magnitude (depth, velocity and duration) of the flood;
- Land use and susceptibility to damages;
- Awareness of the community to flooding;
- Effective warning time;
- The availability of an evacuation plan or damage minimisation program;
- Physical factors such as failure of services (sewerage), flood borne debris; and
- The types of asset and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment and can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. Types of flood damages are shown on Diagram D1 overleaf.

To undertake the damages assessment floor level data is required. Floor level survey was undertaken for 132 properties was undertaken in September 2015. The majority were in the Davidson Street area or downstream of town, south of the river. Surveyed areas were based on where properties were situated outside of the levee and therefore more likely to be flood prone. For remaining properties, estimates were made based on a combination of LiDAR data, visual inspection and comparison to nearby surveyed properties. For properties inside the south Deniliquin levee, a standard height above ground was assumed.

The non-residential damages are more complex than residential damages and have different damages associated with flooding. Damages for commercial properties have been assessed using separate damage curves to residential damages.

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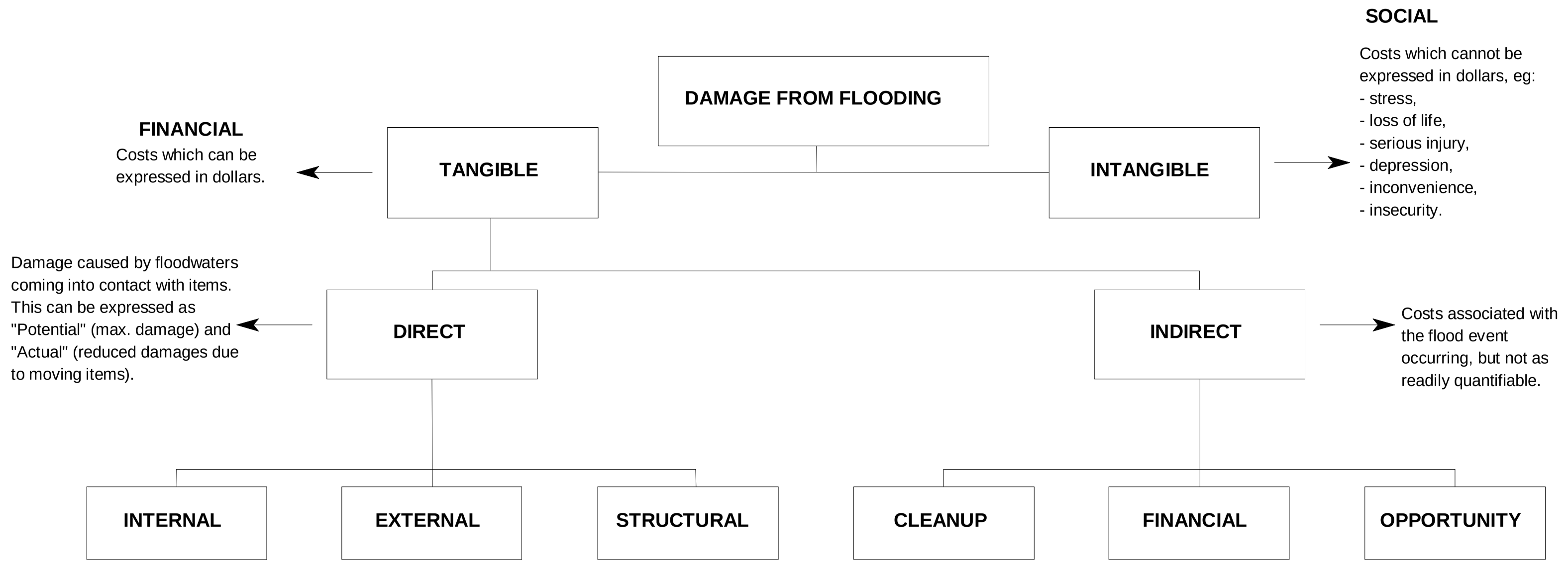
Diagram D1: Flood Damage Categories



	INTERNAL	EXTERNAL	STRUCTURAL	CLEANUP	FINANCIAL	OPPORTUNITY
RESIDENTIAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences	Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings)	Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris	Loss of wages, Living costs (temporary accommodation and food), Time to repair/replace damaged items	Not Applicable
RURAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Sheds (stables/barns), Machinery, Tools, Fences, Feed storage, Saddles, Crops &/or Stock, Irrigation Systems	Physical Damage to Structures: Damage to Homestead, Sheds, Access tracks, Protection levees	Clean Homestead and Out-buildings; Remove Debris; Dispose of affected crops &/or stock	Loss of Farm Production and Income, Re-instatement of Pastures, Supplementary feeding of stock (by hand or outside agistment), Stock movement/ transport, Living costs (temporary accommodation and food)	Sowing or harvesting of Crops, Sale of Stock (at depreciated value or dependent on market influences)
COMMERCIAL	Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials	External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences	Physical Damage to Buildings	Dispose of damaged products, stock, materials; Cleaning and Re-instatement	Loss of Productivity and Income, Bank Interest Charges	Loss of existing &/or Potential Trade
PUBLIC AUTHORITIES	Contents of Public Buildings and Facilities	Public Property and Facilities: Parks, Signs, Machinery, Equipment	Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links	Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent)	Disruption of Services, Community Service Relief Grants	Provision of Public Service

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D.2. Identifying Flood Affected Properties

The damages assessment does not only look at potential costs due to flooding but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding.

D.3. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages (Diagram D1). Direct damages are caused by floodwaters wetting goods and possessions resulting in cost of replacement or repair, or in a reduction of their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees etc.

Given the variability of flooding and property and content values, the total likely damages figure in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of little value for absolute economic evaluation. However, considering damages estimates is useful when studying the economic effectiveness of proposed mitigation options. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision making process.

D.4. Expressing Flood Damages

Average Annual Damages (AAD) is equal to the damage caused by all floods over a period of time divided by the number of years in that period, and represents the equivalent average damages that would be experienced by the community on an annual basis. This means that the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods. Total potential damage refers to the total damage estimated for a given flood event. Average damage per property is the total damage estimated for a particular flood event divided by the number of properties flood affected in this event; either by flooding on the yard and/or above floor level of a building.

D.5. Calculating Tangible Flood Damages

The flood damages assessment was undertaken for existing development in accordance with current OEH guidelines (Reference 9) and the Floodplain Development Manual (Reference 8). Potential flood damages were calculated with the use of height-damage curves which relate the depth of water above the floor with tangible damages. The height-damage curves were established in accordance with OEH guidelines (Reference 9)

For residential damages the values used are based on the recommendations in the guidance with a post late 2001 adjustment factor applied to increase damage values according to changes in Average Weekly Earnings (AWE) since 2001. Separate curves were established

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for non-residential damages.

Structural damages vary on whether the property is slab/low set or high set. For the purpose of this study, any property with a floor level of 0.5 m or more above ground level was assumed to be high set.

In calculating AAD, it was assumed that there would be no flood damages in events smaller than the 5-year ARI event.

Commercial and industrial damages are typically higher than residential damages, and as such a multiplier was applied to the total damage per property for each event by adjusting the typical building size value within the curve development calculations. Other factors, including the clean-up costs and external damages, were adjusted to reflect the differences between commercial and residential properties.

To adjust the residential damage curve to be applicable to non-residential development, the average contents damages for a business was estimated to be $150,000 and the clean-up costs have been estimated at $4,000. This was done to take into account the higher costs that businesses would incur compared to residential dwellings when flooded above floor level. The commercial damages curves were also amended to reduce the bench height based on the assumption that many commercial premises would have stock from floor level. External damage was set at $1,250 as per residential properties. The parameters assumed in the stage-damages curves are presented in Table D 1, and the resultant curves are shown in Diagram D2 and D3. The Rock and Lockhart FRMS&P investigated a range of methods for the assessment of commercial damages in consultation with OEH, the preferred method is that which has been adopted for this study. The adopted values for the residential damages assessment are listed below.

Table D 1 Stage-Damage Curve Parameters

SITE SPECIFIC INFORMATION FOR RESIDENTIAL DAMAGE CURVE DEVELOPMENT			
Version 3.01 June 2011			
PROJECT	**DETAILS**	**DATE**	**JOB No.**
Deniliquin FRMS	**Residential Only**	**June 2016**	**115027**
BUILDINGS			
Regional Cost Variation Factor	1.00	*From Rawlinsons*	
Post late 2001 adjustments	1.50	*Changes in AWE see AWE Stats Worksheet*	
Post Flood Inflation Factor *Multiply overall structural costs by this factor*	1.00	*1.0 to 1.5* *Judgement to be used. Some suggestions below*	
	Regional City Houses Affected	*Factor*	*Regional Town Houses Affected Factor*

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Small scale impact	*<*	*50*	*1.00*		*<*	*10*	*1.00*
Medium scale impacts in Regional City		*100*	*1.20*			*30*	*1.30*
Large scale impacts in Regional City	*>*	*150*	*1.40*		*>*	*50*	*1.50*
Typical Duration of Immersion	2 to 10	hours					
Building Damage Repair Limitation Factor	0.85	*due to no insurance*		*short duration*			*long duration*
		Suggested range		*0.85*		*to*	*1.00*
Typical House Size	240	m^2	*240*	*m^2 is Base*			
Building Size Adjustment	1.0						
Total Building Adjustment Factor	**1.28**						
CONTENTS							
Average Contents Relevant to Site	$ 60,000		*Base for 240 m^2 house*		*$ 60,000*		
Post late 2001 adjustments	1.50	*From above*					
Contents Damage Repair Limitation Factor	0.90	*due to no insurance*		*short duration*			*long duration*
Sub-Total Adjustment Factor	1.35	*Suggested range*		*0.75*		*to*	*0.90*
Level of Flood Awareness	low	*low or high only. Low default unless otherwise justifiable.*					
Effective Warning Time	0	hour					
Interpolated DRF adjustment (Awareness/Time)	1.00	IDRF = Interpolated Damage Reduction Factor					
Typical Table/Bench Height (TTBH)	0.90	*0.9m is typical height. If typical is 2 storey house use 2.6m.*					
Total Contents Adjustment Factor AFD <= TTBH	**1.35**	AFD = Above Floor Depth					
Total Contents Adjustment Factor AFD > TTBH	**1.35**						
Most recent advice from Victorian Rapid Assessment Method							
Low level of awareness is expected norm (long term average) any deviation needs to be justified.							
Basic contents damages are based upon a DRF of	*0.9*						
Effective Warning time (hours)	***0***	***3***	***6***	***12***	***24***		
RAM Average IDRF Inexperienced (Low awareness)	*0.90*	*0.80*	*0.80*	*0.80*	*0.70*		
DRF (ARF/0.9)	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*		
RAM AIDF Experienced (High awareness)	*0.80*	*0.80*	*0.60*	*0.40*	*0.40*		
DRF (ARF/0.9)	*0.89*	*0.89*	*0.67*	*0.44*	*0.44*		
Site Specific DRF (DRF/0.9) for Awareness level for iteration	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*		
Effective Warning time (hours)	*0*	*3*	*0*				
Site Specific iterations	*1.00*	*0.89*	*1.00*				
ADDITIONAL FACTORS							
Post late 2001 adjustments	1.50	*From above*					
External Damage	$ 6,700	*$6,700 recommended without justification*					
Clean Up Costs	$ 4,000	*$4,000 recommended without justification*					

Likely Time in Alternate Accommodation	3	weeks			
Additional accommodation costs /Loss of Rent	$ 220	*$220 per week recommended without justification*			
TWO STOREY HOUSE BUILDING & CONTENTS FACTORS					
Up to Second Floor Level, less than	2.6	m	70%	Single Storey Slab on Ground	
From Second Storey up, greater than	2.6	m	115 %	Single Storey Slab on Ground	
Base Curves		AFD = Above Floor Depth			
Single Storey Slab/Low Set	13164	+	4871	x	AFD in metres
Structure with GST	AFD	greater than	0.0	m	
Validity Limits	AFD	less than or equal to		6	m
Single Storey High Set	16586	+	7454	x	AFD
Structure with GST	AFD	greater than	-0.001	m	
Validity Limits	AFD	less than or equal to		6	m
Contents	20000	+	20000	x	AFD
Contents with GST	AFD	greater than		0	
Validity Limits	AFD	less than or equal to		2	

Diagram D2: Flood Damages Curves – Residential Property

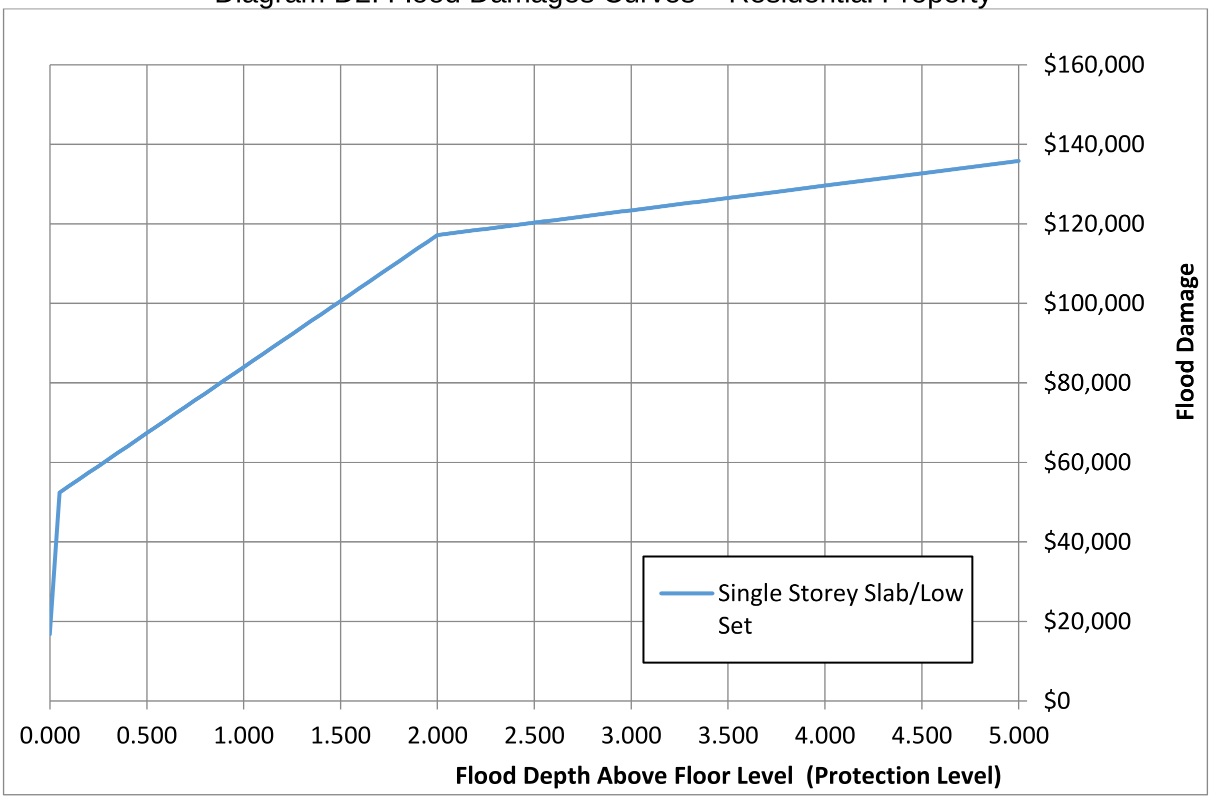
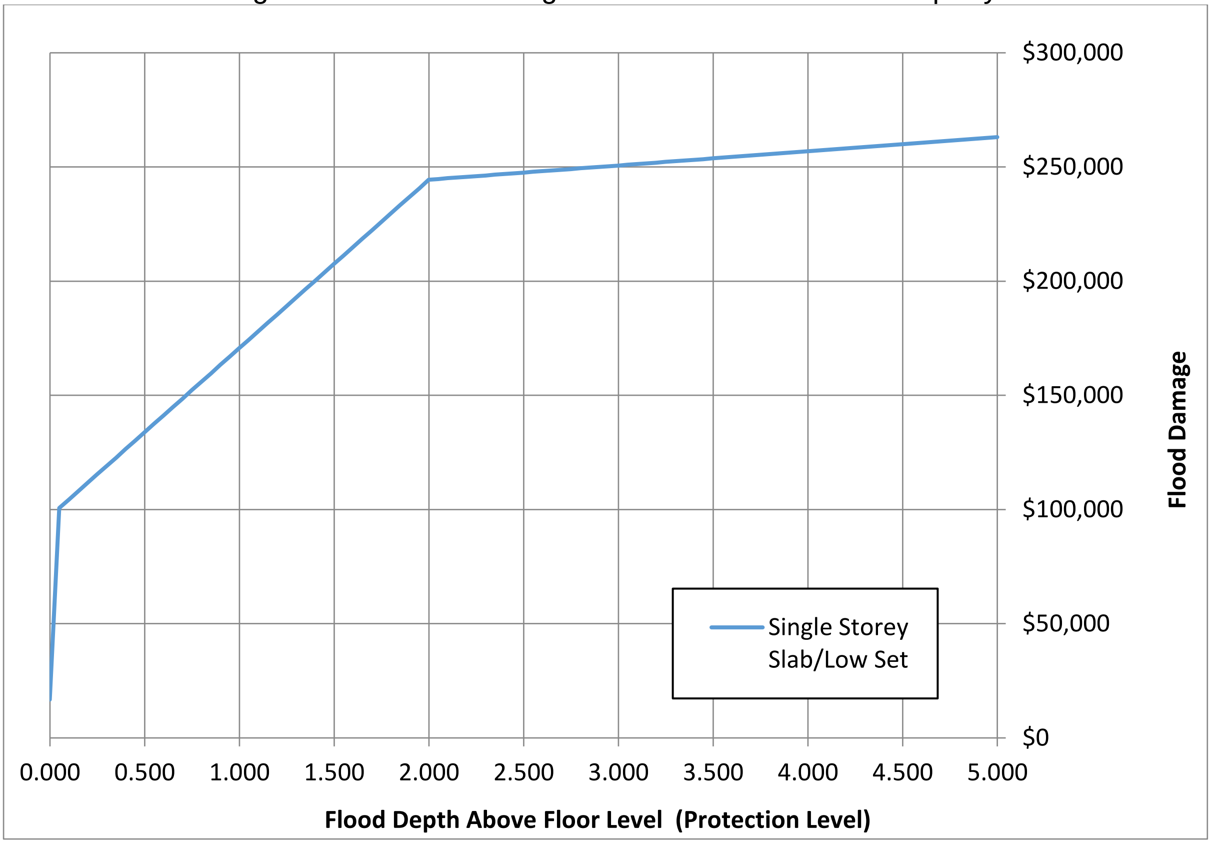


Diagram D3: Flood Damages Curves – Commercial Property



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The OEH guidelines suggest a protection level be applied when calculating damages. This effectively reduces the floor level by the given amount (usually 0.5 m). This level of protection is considered overly conservative and has not been applied in this instance. Given the extensive levee system at Deniliquin, a levee failure scenario has been applied in accordance with OEH guidelines which assumes a levee will fail in events greater than its design service level. This achieves a conservative estimate of damages, and it was deemed unnecessary to both breach levees and lower floor levels significantly. Incorporating this 0.5 m 'level of protection' would lead to Council financing flood management measures that provide little benefit. The adopted approach is described in Section 6 of the FRMS.

D.6. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community.

Post flood damages surveys have linked flooding to stress, ill-health and trauma for residents. For example the loss of memorabilia, pets, insurance papers and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition flooding may affect personal relationships and lead to stress in domestic and work situations. In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up etc.) many residents who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage. The extent of the stress depends on the individual and although the majority of flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

During any flood event there is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths the higher the risk. The Deniliquin study area generally is classified as high hazard for areas along the Edward River and other waterways, however the hazard farther from the river and in built-up urban areas is generally catergorised as low hazard.

D.7. Benefit/Cost Analyses for Management Options

To assess the full monetary benefits, including taking into account costs of construction and maintenance, Net Present Value (NPV) calculations were used and a B/C ratio established. The B/C approach is used to quantify the economic worth of each option enabling the ranking against other options. A B/C ratio is the benefits expressed in monetary terms, i.e. the

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reduction in AAD, compared to the actual likely cost of achieving those benefits, i.e. construction and maintenance costs.

The AAD per annum in today's monetary terms was assumed to apply for each year of the NPV damage calculation and was established for each year based on a discount rate of 7% as per the recommendation in the Residential Flood Damages FRM Guidelines (Reference 9). A construction cost was estimated and, using the NPV of the AAD assuming lifetime of 50-years, the B/C ratio was established for each of the options.

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Appendix E

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DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
2.90	Aljoes Creek.	Water comences to back up Aljoes Creek				
3		from both sides.				
3.52	Aljoes Creek.	Aljoes Creek comences to run.				
3.90	Golf Course. (Inside levee **5.80** see consequences)	Close flood Gate. But monitor water levels	2x1350mm	Gate Valve	Pump from pit or	1
3.90	MCLEANS BEACH TOILETS (if height is expected above 4.5)	on inside of levee because this outlet is for			pump over levee	
		most of the area east of Napier Street.			with special pump.	
4.60		**"Minor Flood".**				
4.66	Island Sanctuary.	Water starts to enter Island Sanctuary				
		near footbridge.				
5.00	Under Butler Street 30m outside levee..	Close off pipe under local levee.	500mm	Pipe only	Pump over local	2
					levee	
5.70	Butler Street at Riverview Motel.	Close off Gate Valve.	525mm	Pipe and wingwall	Pump from pit	3
5.84	McLean Beach.	Sewer pump station is inundated.				
6.40	Wyatt Street between Poictiers & Harfleur Streets.	Close off pipes at wing wall but monitor water	2x1220mm	Wingwall bolts & door	Pump over road	4
		levels on inside of levee because this outlet		and drop boards	special pump.	
		is for most of the area west of Napier Street.				
6.88	Crispe Street near Deni Car-o-tel Caravan Park.	Close off Gate Valve.	375mm	Gate Valve	Pump from pit	6
6.96	Crispe Street behind Middy's.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	7
7.20		**"Moderate Flood".**				
7.30	Napier Street down stream side of National Bridge.	Close off Napier Gate Valve and pump from	2x610mm	Gate Valve in pit		8
		pit outside levee. Top of pit at levee height.	900mm	Pump from this pit		
7.40	Behind Lawn Tennis Courts Charlotte Street.	Close off Gate Valve.	525mm	Gate Valve and	Pump from pit	9
				wingwall		
7.43	Hardinge Street opposite Police Station.	Close off Gate Valve.	525mm	Gate Valve in pit	Pump from pit	10
7.48	Burton Street west side near No. 57.	Close off pipe.	300mm	Pipe only	Pump from pit	11
7.50	200m north of Henry Street. East end of town.	Close off Gate Valve	375mm	Gate Valve	Pump over levee.	12
7.50	Fowler Street at Edward River in park area.	Close off Gate Valve	450mm	Pipe only	Pump from pit	13
7.50	George Street west end at Edward River.	Close off Gate Valve.	225mm	Pipe only	Pump from pit	14
7.50	Riverside Drive behind Hospital.	Close off Gate Valve.	525mm	Gate Valve	Pump from pit	15
7.50	George Street east end opposite Men's Club.	Close off George Street Gate Valve.	375mm	Pipe only	Pump from pit	16
7.64?	Memorial Drive behind Coach House Hotel Motel.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	17
7.80	Island Sanctuary.	Access bridge cut off.				
7.84	Memorial Drive at Tarangle Creek Bridge.	Put Bulkhead gate in place.			Pump over levee.	
		Access to Showgrounds, Golf Club and				
		Golf Leisure Resort lost. **Units at 9.82m.**				
7.95	End Street at Deni Car-o-tel Caravan Park.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	18
8.10	Carew and Henry Streets intersection.	Prepare to close Carew and Henry Streets.				
		water over intersection.				
8.10?	300m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	19

Different gauge readings
Different descriptions
Does not exist on SES database

06/05/2016 WMAwater Comments

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

8.21	Butler Street at Riverview Motel.	Close off Gate Valve.		Pipe only	Pump from pit	
GAUGE READING	**LOCATION**	**CONSEQUENCES**	**SIZE OF PIPES**	**DOWNSTREAM.**	**UPSTREAM.**	**No.**
8.30	Mclean Beach Caravan Park.	Estimated crest height of levee protecting.				
		McLean Beach Caravan Park.				
8.30	Gate Valve on outside of levee behind Dept of Ag.	Close off Gate Valve.	300mm	Gate and wingwall	Pump from pit	20
	Charlotte Street.					
8.36?	North side of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	21
8.50	Block off Butler Street at Riverview Motel.	Put Bulkhead gate in place.			Pump over levee.	22
8.80	Block off Macauley Street at back entrance to McLean					
	Beach caravan park.					
8.95	Wellington Plaza behind Salvation Army building.	Close off pipe.	225mm	Pipe only	Pump from pit	23
9.12	Carew Street 100m north of Syphon Road.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	24
9.20		**" Major Flood".**				
9.32	Panels to be put in between Burton Street and	**Panels stored at Council Depot in**				
	Department of Agriculture.	**Hardinge Street. In shed in back cnr.**				
9.50	Memorial Drive to George - Edwardes inters.	Top up levees that have not yet been raised.				
	Burton Street to the west.	Varying alignments and heights.				
9.82	1:100 year flood at National bridge is **92.25 AHD.**	**1 : 100 year flood level.**				
10.06	Carew Street at Hetherington Street inters.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	25
10.32	Packenham Street to Duncan - Hughes inters.	Height of levee bank.				
10.32	George - Edwardes inters. To Burton Street.	Height of levee bank.				
10.82	Lawson Syphon road to Packenham Street.	Height of levee bank.				
	EXTRA INFORMATION.					
	St Michael Sreet Area.					
	Burton Street to Fowler Street most houses have					
	90mm stormwater pipes through the levee but all are					
	close to 1:100 flood level (9.8).					
	Wenburn Court Area.					
	Two 90mm stormwater pipes go through levee in this					
	area but are also at about 9.8.					
	No levee yet constructed at ????? St Michael St next to Wenburn Motel.					
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- The panels for the levee are stored in a shed in the back left hand corner of the Deniliquin Council Depot.					
	Note:- The panels for the levee are to be placed before 9.32 if flood prediction to be near 1:100 year flood level.					
	Note:- Levee is built to 1:100 year flood level with 0.5m free board for wave action only.					

same gauge reading

Different gauge readings

Different descriptions

Does not exist on SES database

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SES

Different gauge readings

Different descriptions

Does not exist on other database

FLOOD INTELLIGENCE CARD

DENILIQUIN GAUGE - STATION NUMBER: 409003

Monday, 24 January 2000

ACCURACY:

Use this information as a guide to the possible effects of a flood. The card is based on estimates of flood behaviour and particular effects may occur at heights different from those indicated here. They may also occur at slightly different heights in different floods.

CONFIDENTIALITY:

This card may contain sensitive information about the effects of flooding on private property. Specific reference to private addresses or business must be made directly to owners or other emergency services and NOT via broadcast or print media.

Stream: Edward River | **Gauge Zero:** 82.429m

Location: Rear of DWR Office | **Datum Type:** AHD

Minor: 5.50 **Moderate:** 7.20 **Major:** 9.20 | **Levee Height:** 9.4

Class	Height (m)	Consequences
	Note:	The town levee is currently being upgraded to protect Deniliquin against a 1% AEP flood level (plus one metre). For planning and warning purposes in the event of levee failure or overtopping there are lists of surveyed heights of areas inside the town levees are attached as Annexes A, B and C to this card. Historically, flood height predictions have varied over the first few days but settle down and become more reliable after about three to five days after the flood producing rain. The eventual predicted peak may be reduced as the result of upstream levee banks failing as occurred in the 1993 flood.
	✓ 2.90	Water commences to back up Aljoes Lane from both sides.
	3.62	Aljoes Creek commences to run. Gauge height: 3.52 on council's.
	4.30	Brick Kiln Creek commences to back up.
	4.60	Danger height for areas outside levees. Media alert to pump licensees and graziers.
	✓ 4.66	Water starts to enter the Island Sanctuary (nature reserve) near the footbridge.
	4.70	Water enters the low-lying area of McLeans Beach Caravan Park. This area is used for tourist vans and as a camping area There are 40 powered sites; power has to be disconnected.
	4.76	The footbridge to the Island Sanctuary is closed. This is the normal pedestrian access to the sanctuary; vehicular access to the rear of the sanctuary is still available via the Memorial Park Bridge.
	5.10	The Edward River Oval pump has to be removed by this height.
MIN	5.60	

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Different gauge reading

Different description

Does not exist on council's database

Class	Height (m)	Consequences
		Water at foot of McLeans Beach Caravan Park levee, on old road levee. Consider closing gap in levee at park entrance if it has been lowered for ease of access by patrons.
MIN	5.63	Brick Kiln Creek crosses causeway on Chippenham Park access road near Edward River Oval, close road. Stock route affected.
MIN	5.80	Approximate level of causeway at Sandhurst Island Estate to McMillan, Vesty, Dick Lee and 3 non-resident properties off Dahwilly Lane.
MIN	5.88	McLeans Beach sewerage pump station inundated. Height: 5.84 on other.
MIN	6.00	Brick Kiln Creek commences to flow.
MIN	6.06	Council MRS DRIVER. Cut out and weld in new plate in floor and sills on drivers side. Close storm drain outlet, 1050 mm dia, cut out and weld in new plate in floor and sills on drivers side at Wick Street. Progressive closure of other drains as the river rises.
MIN	6.10	Boggy Creek causeway level; alternative access to Chippingham Park area from Dahwilly Road. Access from Dahwilly Road closes at 6.3 m (or earlier if damaged). Cut out and weld in new plate in floor and sills on drivers side.
MIN	✓ 6.40	In previous floods, water backed up to Wyatt Street levee.
MIN	6.67	Footbridge at Golf Links cut.
MIN	7.00	McLeans Beach Caravan Park closed in accordance with lease arrangements.
MOD	✓ 7.20	Moderate flood level exceeded at an average frequency of 4 years, but varying to 1 to 8 years. Floor of lavatory at Edward River Oval flooded. Floor of lavatory at Edward Street Oval flooded.
MOD	7.30	Riverside Caravan Park, Davidson Street - vans occupying annual sites outside the park's levee begin to be affected; most are elevated but access to this area is lost at 7.4 metres.
MOD	7.40	Riverside Caravan Park access to vans occupying annual sites across floodway lost.
MOD	7.49	31/08/90. Peak height.
MOD	7.66	Water commences to back up from western end of floodway near National Bridge.
MOD	7.70	Island Sanctuary flooded; native fauna to be relocated by this height; all road access to this area is lost at 7.84 metres.
MOD	7.80	Floodway commences to run.
MOD	✓ 7.84	Memorial Park Drive closed; access to showgrounds, Golf Club and the Golf Leisure Resort lost. The resort contains about 24 motel style units above the 1% AEP flood level (9.82 metres).
MOD	7.95	Ground level between Ovals 2 and 3 at Memorial Park.
MOD	7.96	15/10/96. The house in 4 Post Reserve area belonging to Mr Desie Grieves evacuated (Map DENILIQUIN 7826-I and IV, GR 811331). Other houses along river in the same area are progressively threatened; two were evacuated and one sandbagged in the flood of October 1993 which peaked at 8.48 metres.
MOD	8.00	Boggy Creek causeway at Sandhurst Island Estate off Dahwilly Lane to Sibley, Ward, Cunningham and Bullock (non-residential) properties. Likely to wash out when inundated.

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Different gauge readings
Different descriptions
Does not exist on council's database

Class	Height (m)	Consequences
		Water across Memorial Park Drive bridge. NB: For predicted peaks above this level, consider using a sandbagging machine to build up a stockpile of 2/3 filled untied bags placed on pallets and stored undercover. Especially if the peak is expected to exceed 8.3 metres.
MOD	✓ 8.10	Water across Carew and Henry streets intersection.
MOD	8.11	30/10/92. Peak height.
MOD	8.21	2/09/81. Peak height (on old bridge gauge). No need to correct by 0.04 metres to align with new gauge unless correcting all historical readings.
MOD	✓ 8.30	Estimated crest height of the levee protecting the McLeans Beach Caravan Park. The park has a capacity of 450 sites. There are 26 relocatable cabins (on skids and/or wheels) which would require cranes and take about 2-3 hours preparation time each. There are also about 250 semi-permanent vans (50% hard annexes) which would require about 1.5 hours each to prepare for relocation. The remaining sites are reserved for tourist vans. NB: Depending on the conditions for individual floods, the levee may not inundate until 8.5 metres.
MOD	8.48	17/10/93. Peak height. In this event, north Deniliquin tennis courts were flooded and approximately six riverside houses were threatened upstream in Lawson Siphon and Four Post areas (some were sandbagged). At this height in future floods there may be more houses at risk in this area due to development. Three houses were sanbagged for protection in the Dahwilly area. The predicted peak height was 9-9.1 metres however this was not achieved due to a farm levee giving way upstream on the Tuppal Creek Floodway causing a diversion of some of the flow. Monitor and inspect the Central Levee.
MOD	8.50	McLean Beach Caravan Park levee height. Designed to be 8.3 metres but in practice so far is 8.5 metres.
MOD	8.53	Main oval at Memorial Park flooded.
MOD	9.05	5/11/75. Peak height (old bridge gauge).
MAJ	✓ 9.20	This is considered to be the critical height for Deniliquin. Evacuations should be considered if is predicted that this height is to be exceeded. Only referred to as "Major flood" in council's.
MAJ	9.40	Levee height; Central levee (Davidson Street); actual height in 1993. Consider temporary raising slightly further if other levees will not be endangered. Evacuate Central area, approx 270 people (includes some elderly people). This should be commenced two days prior to this height occuring.
MAJ	9.42	16/07/56. Peak height (Note: Height taken on old gauge - some conflicting reports of actual height between 9.37 and 9.42). During this flood the Central levee in Davidson Street was breached before overtopping to relieve pressure on the weaknesses in the South levee; houses were flooded as a result. Davidson Street level and existing levee top at Davidson Street, if overtopped; close northern sewerage system. Water enters top section of the Riverside Caravan Park. The park has about seven motel style cabins and 14 semi-permanent caravans which require a crane and/or a low-loader to relocate. It

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Different gauge readings

Different descriptions

Does not exist on council's database

Class	Height (m)	Consequences
		would take between 3 to five days to relocate these assets.
		Approx 1 in 40 ARI.
MAJ	✓ 9.50	North and South levees topped up in 1993 to this height. At this level, the whole town is threatened. Raise levees with earthmoving machinery and sandbag where access is difficult. Preposition pallets of sandbags for emergency use. Low mobility and non-essential personnel should be evacuated before this level is reached.
MAJ	9.62	Wenbern Motel; top of floor slab on wing extending beyond levee.
MAJ	9.63	30/10/1917. Peak height. In this event flood water inundated town. This was before the construction of the current levee system.
MAJ	9.68	1/11/1870. Flood of record.
MAJ	✓ 9.82	Estimated 1% AEP flood level.
MAJ	9.90	Sewerage Treatment Plant - approximate ground level. Much of the plant is above the surrounding flood level. However, consider construction of a temporary levee if this height or greater is anticipated to prevent overloading by flood water or contamination of the flood water. From this point on there exists the potential for a progressive closedown. The humus tank and outlet channel may be inundated but the sewage is mostly treated by this stage. If the plant continues to operate, treated effluent is pumped into lagoons. There is considerable storage capacity but it may be prudent to partly draw the final lagoon down before the flood water arrives to increase storage capacity. Council Engineering staff and Health Surveyors need to monitor and assess the situation.
MAJ	10.70	Ground level at Sale yards; protected by Mulwala Canal and high ground surrounding them.
MAJ	10.86	Future south levee (Planned to be 1 metre above 1% AEP flood level). Surveyed floor levels of some properties inside the levee are attached as Annex A to this card.
MAJ	11.27	Mulwala Canal Bank, Cemetery Road.
MAJ	11.29	Water Treatment Plant - approximate ground level at pumps.
MAJ	11.62	Mulwala Canal bank, Echuca Road Bridge (centre line) at Barham Road and aerodrome terminal area.
MAJ	11.69	Mulwala Canal bank at Barham Road and aerodrome terminal area.

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Appendix F

APPENDIX F: CONCEPT DESIGN AND COSTING

Three flood modification works have been selected for recommendation in the Deniliquin Floodplain Risk Management Plan. A brief description of works, concept design sketches and preliminary bill of quantities has been provided for each of these options (listed below). It should be noted that any pricing and design work is at a conceptual stage only and is designed to provide indicative figures for the purposes of a cost-benefit analysis, and to assist in Council's completion of a New Works Ranking Form. Further detailed design is required to fully determine construction and maintenance requirements, and hence a more refined estimate of the costs involved.

The measures for which concept design and preliminary costing have been prepared include:

- Option FM05 – Revised Spillway and Freeboard for South Deniliquin Levee
- Option FM07 – North Deniliquin Levee Upgrade
- Option FM12 – Decommissioning of Davidson St Levee

1. Revised Spillway and Freeboard for South Deniliquin Levee (FM05)

1.1. Introduction

The South Deniliquin Levee is located to the south of the Edward River (left bank) with a total length of 9623 m and protects the main part of town. It comprises both earthfill embankment (6537 m), reaches of concrete wall, some with removable panels/ sliding bulkhead gates (2663 m) and concrete crib wall construction (424 m).

The most recent freeboard assessment, undertaken in Section 7.11 of the Deniliquin Floodplain Risk Management Study confirms that 0.5 m freeboard to be appropriate for earthen sections of the levee.

The design of the levee was based on the design flood levels produced by the 1984 study (Reference 1) with a freeboard of 0.5 m and up to 1 m in some sections. As described in the Flood Study (Reference 2), the 2D hydraulic model improved the estimate of design flood levels along the length of the levee, with some sections around 0.1 m higher under revised results. As a result, the available freeboard is now lower than that determined as being required to maintain the design level of protection (Refer to Section 7.11 of the FRMS), with freeboard as low as 0.29 m in some sections.

The option also involves changing the height of the north-west end of the South Deniliquin levee to improve the spillway function. The spillway is a section of the levee with a lower freeboard (usually 200 mm freeboard) that allows for controlled overtopping of the levee if a flood exceeding the levee's design event occurs. As described in the Flood Study, modelling found the spillway was much greater than the 1% AEP design height for much of its length. The revised option has a 400 m spillway beginning where the current spillway begins at the corner of Wyatt and Poictiers Streets, before raising the levee back to the 1% AEP + 0.5 m freeboard for the remaining 2.8 km of the levee to the west of the spillway. The location of proposed works is shown in Figure F1.

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1.2. Levee Upgrade

1.2.1. Locations Requiring Upgrade

To ensure the South Deniliquin Levee has the requisite 0.5 m freeboard, the existing crest level needs to be raised in a number of areas. A comprehensive design study including survey and geotechnical investigation would be required to confirm all locations requiring upgrade, however a preliminary identification of locations has been undertaken based on the levee profile shown in Figure F1 South Deniliquin Levee Upgrade Works and the design crest elevations provided in *Deniliquin Flood Plain Management: Deniliquin Levees – Operation and Maintenance Manual Plans (Dec 2011)* and are listed below (with current freeboard shown):

- End of Duncan Street at the golf course (0.29 m);
- Earth embankment section east of Memorial Drive (0.34 m);
- Concrete Wall near Illington Plaza/ End St (0.30 m);
- Earth section just next to the Cressy St concrete wall (0.30 m);
- Earth section near the Visitors Information Centre (0.48 m);
- Section along Riverside Rd from Cobb Hwy to Butler Street (~ 0.40 mm).

1.2.2. Scope of Works

Earthfill embankment levees require ongoing maintenance due to post-construction settlement, defects caused by traffic, tree roots or burrowing animals, and erosion. It is therefore proposed that the upgrades be undertaken as part of the ongoing maintenance of the levee.

In locations where the levee is to be ‘topped up’, the following works are required:

- Removal of ~150 mm topsoil;
- Excavation of a cut-off trench (to be designed);
- Deposition of earth (with appropriate clay content) in layers of 150 mm and compacted;
- Continued layering and compaction until the crest reaches design height;
- Crest to be finished with the original topsoil and seeded with native grasses to hinder erosion.

Sections of concrete wall requiring more than 150 mm to be raised will require further engineering design, as the addition of permanent or temporary panels may compromise the existing structure. An alternative may be the use of temporary flood barriers as discussed in Section 2.4.1.

1.3. Spillway Revision

Figure F1 also shows how the nominated spillway from CH 6960 (Corner Wyatt St and Poictiers Street) to the end of the levee is currently too high and hence would not function as a spillway in case of a flood event. The revised option has a 400 m spillway beginning where the current spillway begins at the corner of Wyatt Street and Poictiers Street, before raising the levee back to the 1% AEP + 0.5 m freeboard for the remaining 2.8 km of the levee to the west of the spillway.

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1.3.1. Scope of Works

The spillway revision works would involve:

- Detailed design and modelling to optimise height, length and location of the spillway;
- Excavation to just above the design level (currently 1% AEP + 0.2 m);
- Compaction to ensure stability of the newly lowered crest.
- Removal of spoil offsite (used in upgrade works if suitable).

1.4. Preliminary Costing

A **preliminary** bill of quantities has been included in Attachment F1 and is based on current estimates of the extent of works required and associated rates. The nature of levee upgrades in NSW is that materials can be found to be of variable quality and that initial estimates may change significantly between concept and detailed design, especially as these processes may take several years and rates may change over time. At this stage a 20% contingency has been included in the price, however this bill of quantities is designed to give an indicative cost only and provide an overview of the stages of work involved.

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2. Revised North Deniliquin Levee – 1% AEP + 0.5 m Freeboard (FM07)

2.1. Introduction

The North Deniliquin Levee in its three sections covers a total length of 5683 m. The longest section wraps around the north side of North Deniliquin and is of earthfill embankment construction and has a length of 4698 m. There is a concrete wall either side of Davidson Street with a total length of 276 m, and a waterfront section comprising 102 m of concrete wall and 607 m of earthfill embankment.

The North Deniliquin Levee in its current state does not provide protection in the 1% AEP event due to its limited freeboard. Levee freeboard is an amount in addition to the levee design level to ensure that the levee provides protection in the design event selected, allowing for variations in flood level and other aspects that may affect levee height. The appropriate freeboard considering these factors as determined in Section 7.11 is 0.5 m. Option FM07 therefore consists of an upgrade to the North Deniliquin Levee that will achieve a level of protection at the 1% AEP by ensuring the freeboard meets the required minimum of 0.5 m above the design flood level. This would provide the same protection as that in South Deniliquin. To raise the levee to a level of 1% AEP + 0.5 m, the section upstream of Davidson Street would be raised around 0.6 m, as would the section near Brick Kiln Creek Bridge. The section near Smart Street would be between 0.3 - 0.7 m higher, while the remainder would need an increase of around 0.1 m or less.

For the purpose of this concept design the levee has been split into two sections; the rear section that runs around the northern perimeter of North Deniliquin for approximately 4.7 km, and the shorter 'waterfront' sections that are subject to easement constraints due to private property and visual amenity. Different approaches to the upgrade will need to be taken to suit the two sections of levee, and while it is expected that earthfill embankment upgrade would be appropriate for the rear levee section, this may not be feasible in the waterfront sections.

2.2. Earthfill Embankment Upgrade

The current alignment of the North Deniliquin Levee is shown in Figure F2 and a long section of its elevation in Figure F3. Proposed additions to the existing levee should designed in accordance with the dimensions recommended in the *Levee Owners Guideline (*Reference 19), which has a cross section typical of earthfill embankment levees in NSW and has been used in preliminary estimates for works in Deniliquin. A typical cross section is shown in Diagram 1. The Guideline describes a 3 - 4 m wide crest with a 3H:1V batter on the wet side and a 2H:1V batter on the dry side with an impermeable clay core. A well compacted, impermeable foundation is essential to prevent piping beneath the levee.

The height of the existing levee can be increased by building up the earth embankment. This involves excavating a cut-off trench approximately 1m wide and 0.25 m deep to ensure new material is adequately keyed into the existing core. New material is deposited in layers and compacted before the next layer is placed. Any height increase to the embankment has an

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associated increase in the total levee footprint as fill must also be added to either the wet or dry side batter. For this reason, this solution is only appropriate where the existing easement is not constrained by buildings or large trees and has sufficient distance to the existing waterway.

Road crossings are currently managed by constructing a temporary levee embankment using material from a nearby stockpile (reserved for this purpose). Levee upgrade therefore would also require topping up existing stockpiles for road crossings at Cobb Highway, Wanderer Street and Hay Road. Detailed survey and design is recommended to determine the volume currently available, the condition of the current material and volume required to be added to provide sufficient material for the temporary embankment (including allowance for a compaction factor) and freeboard. Alternatively, temporary flood barriers may be a more appropriate solution for road crossings. A selection of barriers have been discussed in Section 2.4.1.

Diagram 1 Typical NSW earth embankment levee cross section (from *the Levee Owners Guideline*)

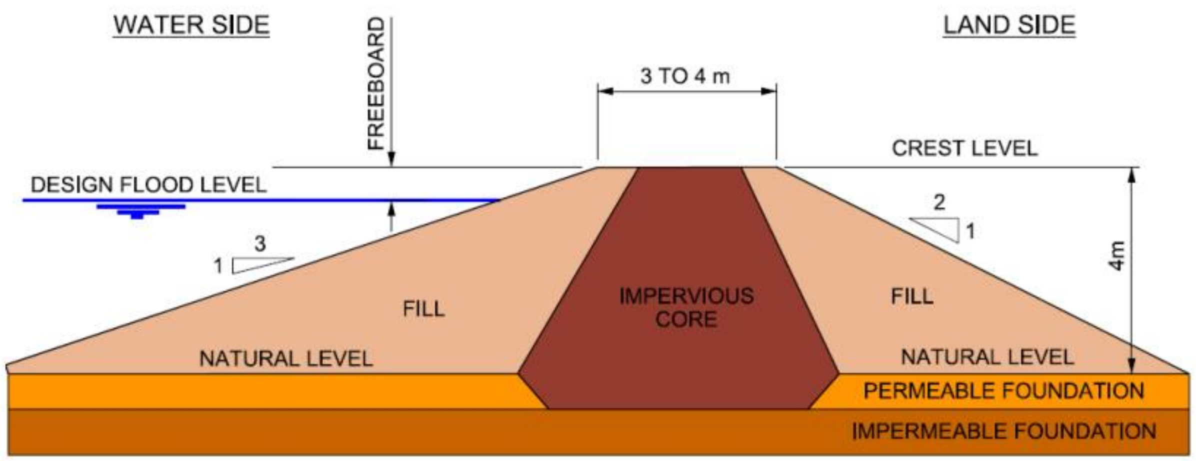

Figure 4.1 Typical NSW earth embankment levee cross section

2.3. Spillway

A preliminary spillway location has been determined through modelling a scenario in which the North Deniliquin Levee elevation was removed. This showed how water would move naturally through North Deniliquin, and revealed a low lying area in the north west at the corner of April Street and Augustus Street. The spillway is generally recommended to have a freeboard of approximately 200 mm to allow for controlled overtopping in a flood event greater than the design level of protection. The exact location and length of spillway should be determined with more detailed modelling with the finalised levee upgrade model.

2.4. Waterfront Sections

As shown on Figure F2, there are two sections of the levee that exist to protect property along the river front between lengths of existing high ground (up to 5 m above the design 1% AEP level). In the past, visual amenity has been a ruling factor in setting the levee crest height and has

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contributed to the adoption of an insufficient freeboard allowance. As discussed in Section 7.11 of the report, the freeboard exists to allow for uncertainties in the modelled flood levels, account for wave action, wave run up and wind set up as well as physical defects in the levee including settlement, holes (due to animals or tree roots) and erosion. It is therefore necessary to upgrade the levee to provide sufficient freeboard to protect against the 1% AEP event, and methods to do so should duly consider the visual amenity of residents.

A detailed profile of the levee should be determined prior to works with detailed cross section survey to ensure no low spots are missed and that existing high spots are adequately captured and excluded from upgrade works. The feasibility of upgrading the earth embankment should be confirmed as a first stage, though it is expected that the constraints posed by existing buildings may be prohibitive. If this is the case, a temporary flood barriers may be a suitable option. These are discussed below.

2.4.1. Temporary Flood Barriers

Temporary barriers are intended to provide temporary flood risk reduction. These barriers are generally set up just prior to a flood event, and are generally removed immediately after the flood threat has passed. Deniliquin has a long flood warning time, which allows time for these structures to be installed, however would create more work for the Council and SES in event of a flood. If properly managed through emergency response plans, temporary barriers could provide a solution to some sections of the required upgrade in North Deniliquin without sacrificing visual amenity. Sections of the South Deniliquin Levee are removable panels, and there are a number of sliding bulkhead gates that provide protection without permanently affecting the view or blocking access roads.

There is a broad range of removable flood barrier technologies and products available that could be considered for use in North Deniliquin. Table 1 shows a number of products available including a fold out fence and three stacked panel systems. Fold-out fences are stored flat (stacked on pallets) while not in use, and in event of a flood are laid on the ground and opened out. Diagonal props are put in place and act as a retaining wall against floodwaters. Further investigation is required as to whether these would be suitable to the uneven ground along residences in North Deniliquin. They offer a wall height of minimum 1.2 m, so may be considered excessive for the upgrade, which requires a maximum height increase of 700 mm above the existing crest level.

Alternatively, stacked panel systems involve the permanent installation of a flat concrete flooring to ensure a good seal at the base of the panel, and for this reason may not be viable in North Deniliquin. In the event of a flood, vertical stanchions are affixed to the base and panels slotted in and secured. As for the fold-out wall, the height may be excessive for what is required to bring the levee up to an acceptable level, and as components are generally imported can be an expensive set up, with the system costing between $1000 and $1500 per linear metre.

However it should be noted that the technology in this field is evolving rapidly, and Picture 4 shows an Australian designed and made removable structure with a flexible plastic membrane designed specifically for use in rural settings with uneven ground. This type of product may be suitable for

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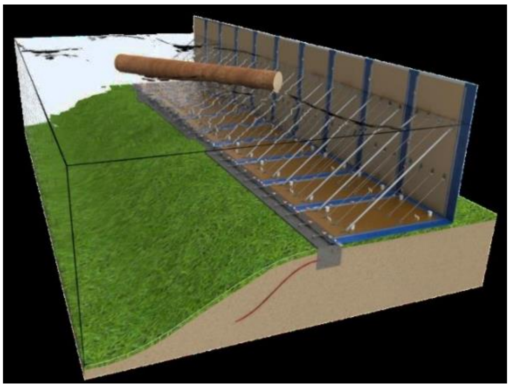
application in parts of Deniliquin where visual amenity or easement access are key constraints. It is recommended that further research be undertaken to determine the most suitable and economic solution for North Deniliquin. Appropriate design and modelling of the use of temporary barriers is also required, in accordance with OEH guidelines.

Table 1 Temporary Flood Barriers

1 	2 
3 	4 

[1] **Fold-out Fence mobile flood barrier** *(http://www.bluemont.com.au/flood-prevention/aquafence-mobile-flood-barriers-fold-out-fence/)*

2 **Stacked Panel System** *(http://www.floodingsolutions.com.au/floodplank)*

[3] **Stacked Panel System** *http://www.floodcontrolinternational.com.au/PRODUCTS/FLOOD-BARRIERS/demountables.php*

[4] **Membrane and Support Structure** *Flooding Solutions (Patent Pending)*

2.5. Upgrade of existing concrete wall

There is a short section of concrete wall along both upstream and downstream of Davidson Street. Following preliminary investigation it appears the crest of the wall is requires raising in the order of 0.3 m to 0.7 m. Structural modification of any existing concrete structure would require detailed review of the original wall designs and proposed upgrades, ensuring the new loads against the original levee are able to be supported.

2.6. Preliminary Costing

A preliminary bill of quantities has been included in **Attachment F2** to give an indication of expected cost. It should be noted that this is an estimate only, and historically NSW levee

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upgrades have cost more than initial estimates due to the presence of unsuitable material or lack of readily available suitable source material. A contingency of 20% has therefore been included, though with detailed design could be refined further.

3. Davidson Street Levee Decommissioning (FM12)

3.1. Introduction

Davidson Street levee is an informal levee not maintained by Council. The 1984 study (Reference 1) found that the levee was structurally inadequate and that there was risk of failure from slumping and/or piping under flood conditions. Leaving the levee as it is poses a risk to the community as its protection level is overstated, and the false sense of security it affords residents could be dangerous as the urgency of evacuation may not be appreciated. The decommissioning of this levee is therefore proposed and is to be implemented by breaching a section of the embankment permanently.

3.2. Description of Works

An area measuring approximately 250 m by 70 m has been selected as a preliminary area to be lowered at the back (downstream) of the Davidson Street area, effectively removing the levee along that length. This area is shown in Figure F4, and amounts to a volume of approximately 6,000 m^3 of cut. The cut is to be spoiled offsite so as not to cause further impacts on flood levels. It is noted that depending on its suitability, the excavated material could be used in the North Deniliquin Levee Upgrade earthworks.

Before any works are carried out further investigation is required to:

- Refine the location, size and depth of excavation;
- Geotechnical investigation to determine the suitability of material for use in North Deniliquin Levee Upgrade; and
- An appropriate location for spoil if not suitable for re-use in North Deniliquin Levee.

The construction process would involve:

- Site establishment;
- Clearing topsoil and stockpiling locally; and
- Excavation to design level (either spoiling in a stockpile for North Deniliquin Levee Works or offsite).

Community members should be made aware of the decommissioning by various forms of promotion including newspaper articles, letters to residents and TV/ Radio discussion of the works. This is key to residents understanding their flood risk and the protection the levee would or would not provide.

3.3. Preliminary Costing

A preliminary costing of the works involved in the decommissioning of Davidson Street Levee has been provided in Attachment F3. Again, this bill of quantities is preliminary only and is based on

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earth moving rates that may not be current at the time of implementation.

4. Figures and Attachments

5. References

Reference 1 Rankine & Hill Pty Limited
Deniliquin Flood Plain Management Study
February, 1984.

Reference 2 Deniliquin Council
Edward River at Deniliquin Flood Study
WMAwater, November 2014

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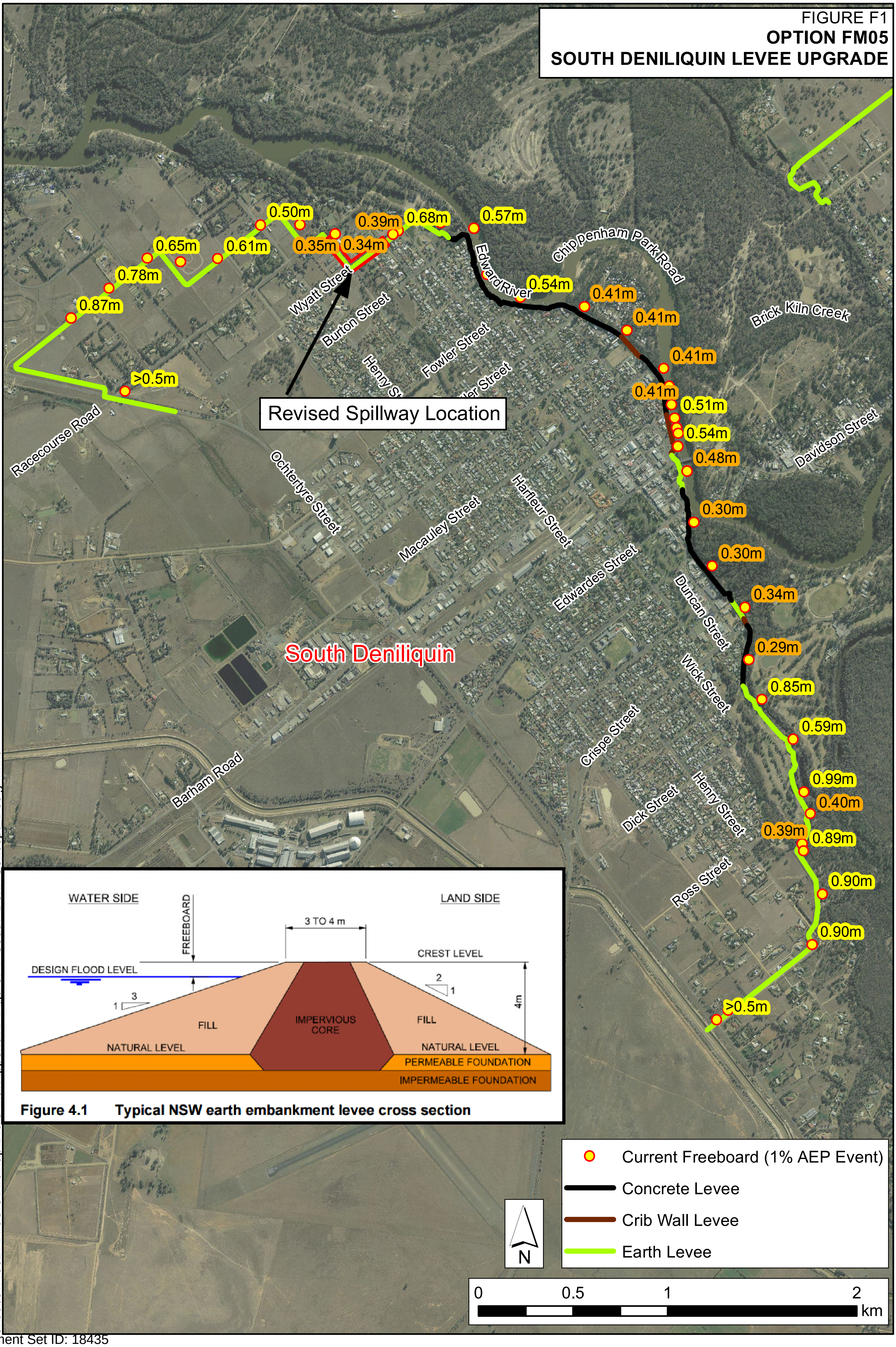

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FIGURE F2
OPTION FM07
NORTH DENILIQUIN LEVEE UPGRADE

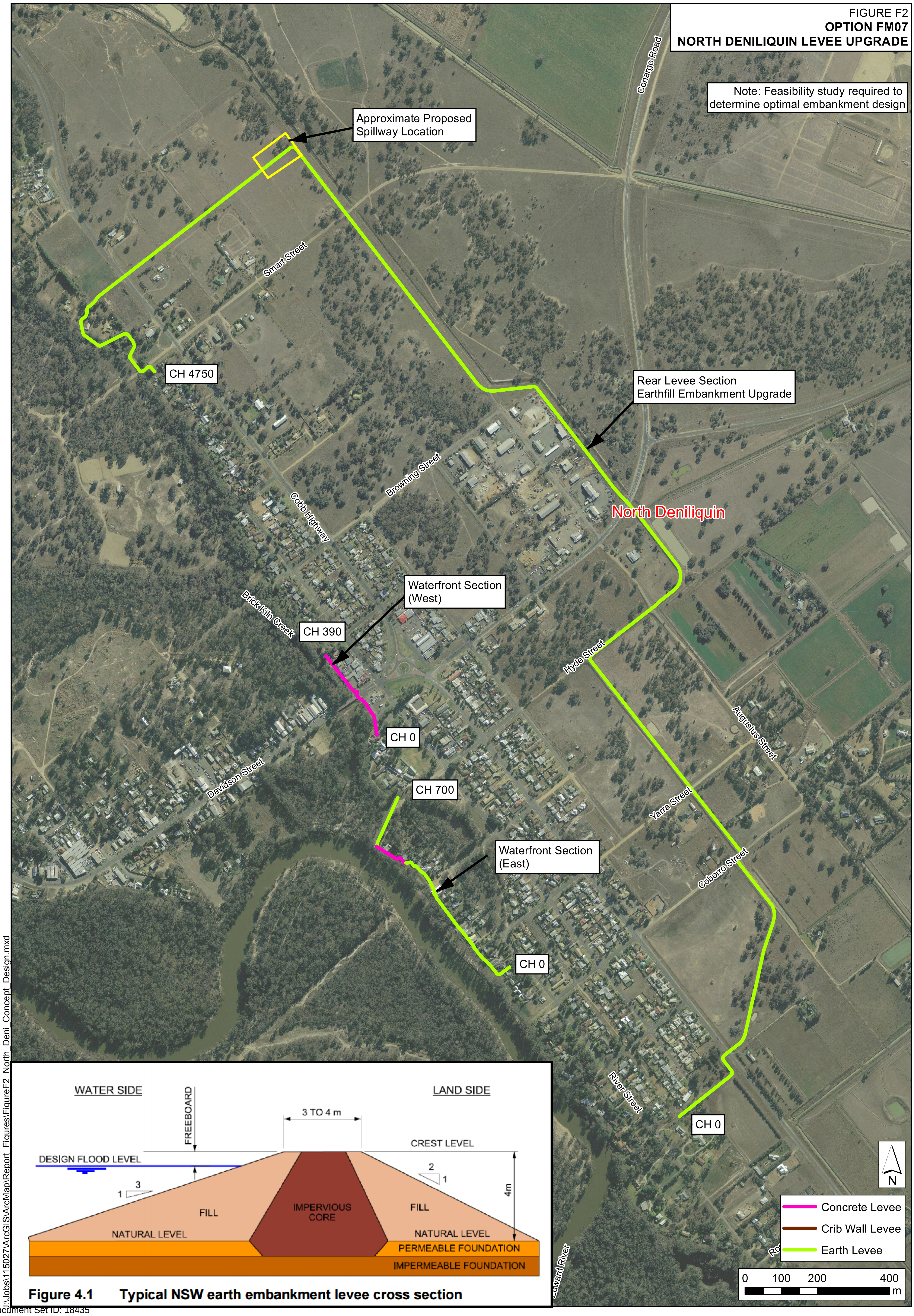

Figure 4.1 Typical NSW earth embankment levee cross section

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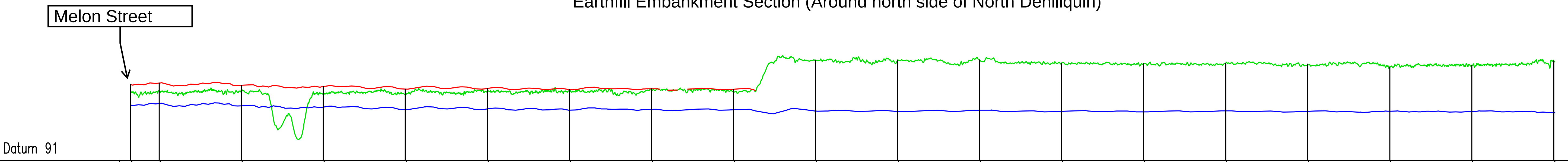
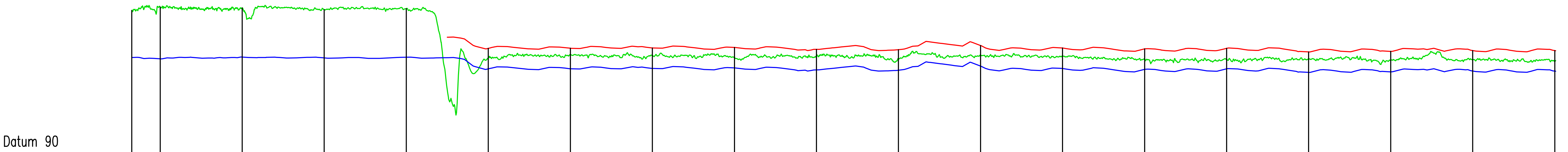
FIGURE F3
OPTION FM07: NORTH DENILIQUIN
LEVEE UPGRADE
LONG SECTION

Earthfill Embankment Section (Around north side of North Deniliquin)



Chainage	65	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
Design Levee Crest		93.038	92.982	92.952	92.890	92.907	92.878	92.898	92.886										
1% AEP Flood level	92.503	92.538	92.482	92.452	92.390	92.407	92.378	92.398	92.386	92.354	92.342	92.375	92.347	92.335	92.360	92.349	92.352	92.344	92.162
Existing Ground	92.816	92.845	92.833	92.757	92.767	92.830	92.869	92.888	92.823	93.597	93.598	93.600	93.526	93.509	93.522	93.497	93.427	93.472	93.428
Height	0.187	0.194	0.149	0.195	0.123	0.077	0.009	0.009	0.063										



Chainage	1765	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500
Design Levee Crest						92.570	92.573	92.580	92.593	92.545	92.537	92.639	92.578	92.557	92.572	92.482	92.497	92.516	92.516
1% AEP Flood level	92.346	92.314	92.356	92.338	92.352	92.070	92.073	92.080	92.093	92.045	92.037	92.139	92.078	92.057	92.072	91.982	91.997	92.016	92.016
Existing Ground	93.495	93.578	93.556	93.515	93.540	92.333	92.417	92.396	92.340	92.394	92.312	92.408	92.382	92.308	92.296	92.318	92.279	92.287	92.287
Height	0.650	0.764	0.701	0.677	0.688	0.238	0.156	0.184	0.253	0.151	0.225	0.231	0.196	0.249	0.275	0.164	0.218	0.229	0.229

SCALE: HORIZONTAL 1:5000, VERTICAL 1:100
EXISTING GROUND LEVEL
DESIGN LEVEE CREST LEVEL
1% AEP EVENT LEVEL

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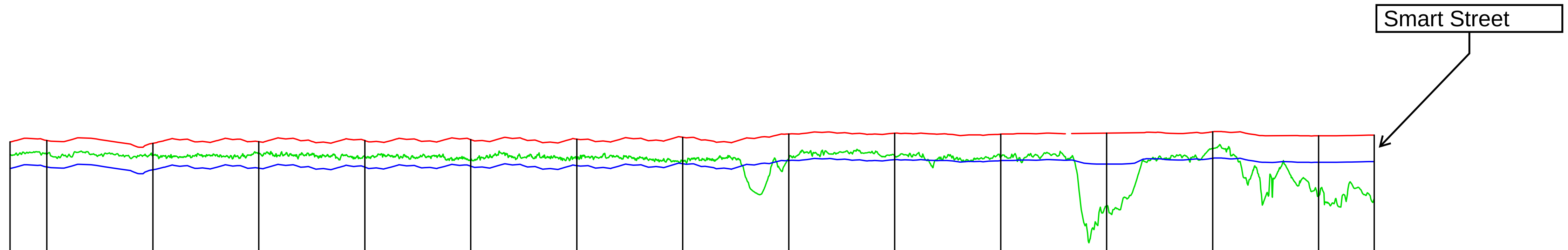
FIGURE F3
OPTION FM07: NORTH DENILIQUIN
LEVEE UPGRADE
LONG SECTION



Datum 90

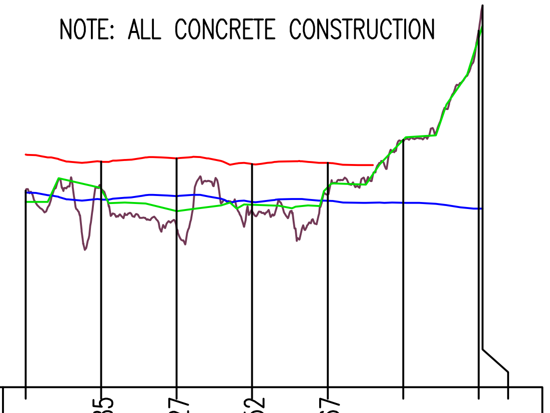
Design Levee Crest	92.486	92.514	92.459	92.491	92.511	92.529	92.539	92.574	92.637	92.650	92.633	92.652	92.678	92.600	
1% AEP Flood level	91.986	92.014	91.959	91.991	92.011	92.029	92.039	92.074	92.137	92.150	92.133	92.069	92.178	92.100	92.115
Existing Ground	92.248	92.249	92.223	92.282	92.206	92.158	92.151	92.104	92.171	92.220	92.193	91.281	92.362	91.456	91.418
Height	0.239	0.265	0.236	0.209	0.306	0.371	0.388	0.470	0.465	0.430	0.440	1.370	0.316	1.144	1.198
Chainage	3465	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4752

SCALE: HORIZONTAL 1:5000, VERTICAL 1:100
EXISTING GROUND LEVEL
DESIGN LEVEE CREST LEVEL
1% AEP EVENT LEVEL

FIGURE F3
OPTION FM07: NORTH DENILIQUIN
LEVEE UPGRADE
LONG SECTION

NORTH DENILIQUIN LEVEE: RIVERSIDE SECTIONS

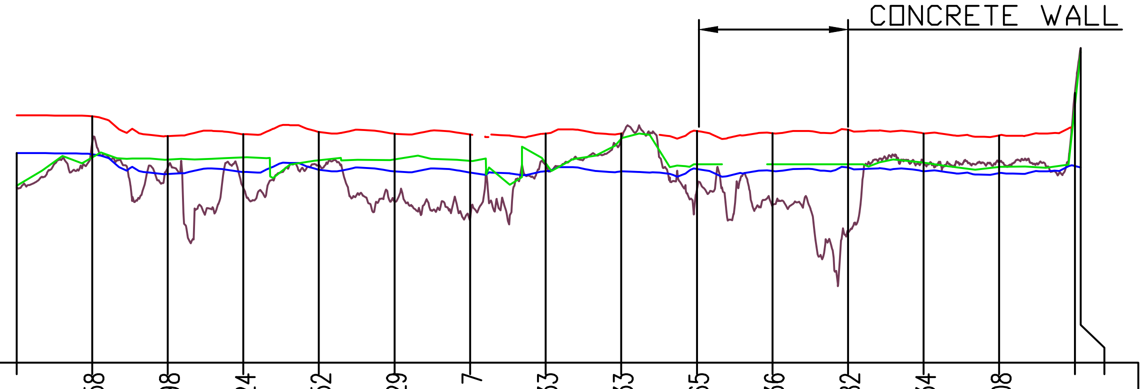
UPSTREAM AND DOWNSTREAM OF DAVIDSON STREET



Datum 90

Design Levee Crest		92.985	93.027	92.952	92.967			
Existing Levee Crest	92.450	92.621	92.331	92.414	92.646	93.272	94.624	94.783
Depth		0.363	0.696	0.538	0.321			
Chainages	0	50	100	150	200	250	300	303

WATERFRONT SECTION



Datum 90

Design Levee Crest		93.258	92.998	93.024	93.052	93.029	93.017	93.033	93.033	93.065	93.036	93.082	93.034	93.008		
Existing Levee Crest	92.341	92.715	92.686	92.715	92.678	92.688	92.671	92.639	92.962	92.626	92.626	92.625	92.646	92.591	93.386	94.112
Depth		0.543	0.312	0.309	0.373	0.341	0.347	0.395	0.070	0.439	0.410	0.456	0.388	0.417		
Chainages	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	704

SCALE: HORIZONTAL 1:5000, VERTICAL 1:100
EXISTING GROUND LEVEL
EXISTING LEVEE CREST
DESIGN LEVEE CREST LEVEL
1% AEP EVENT LEVEL

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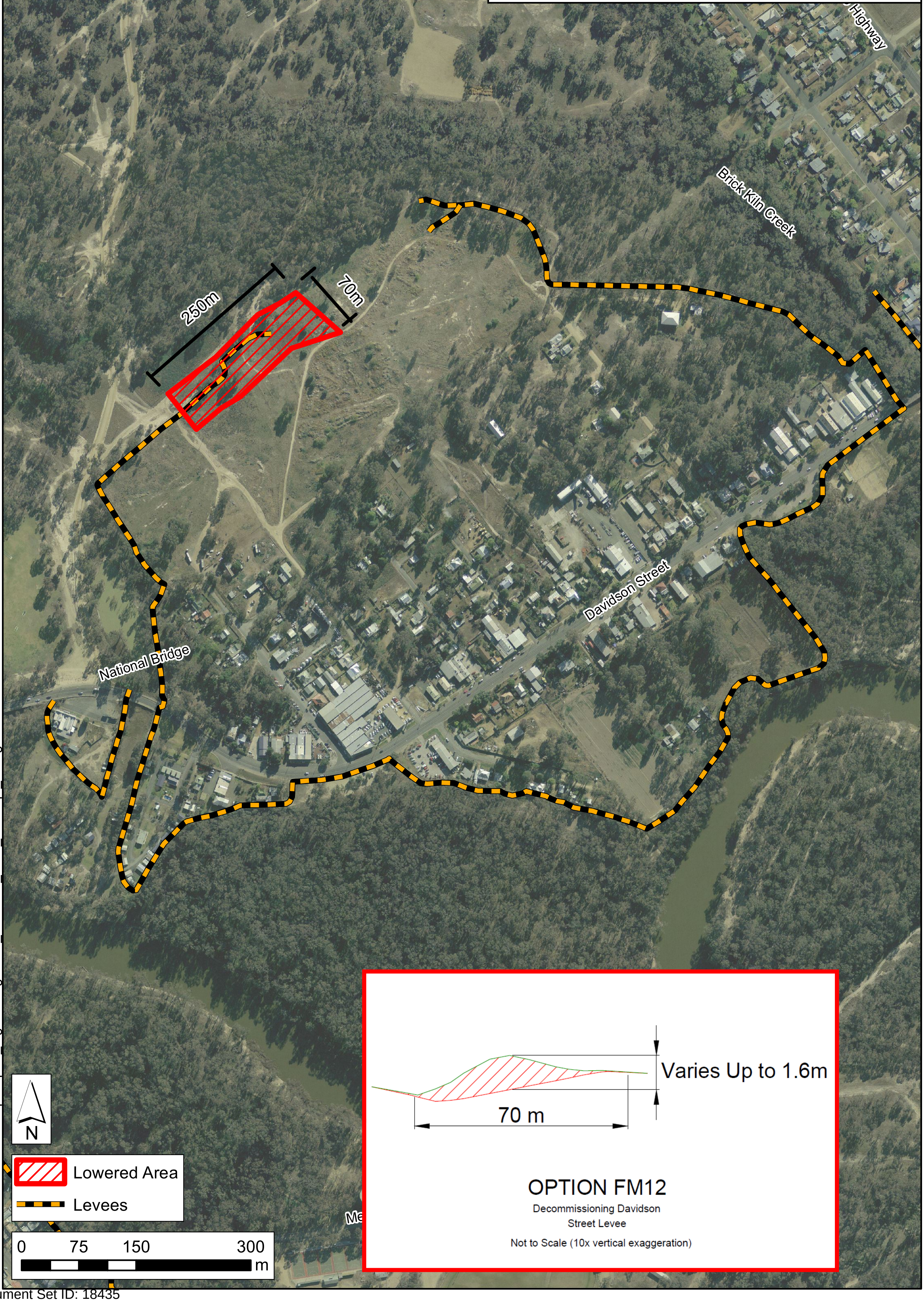
FIGURE F4
OPTION FM12
DAVIDSON STREET LEVEE DECOMMISSIONED



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Option FM05

Revised Spillway and Freeboard for South Deniliquin Levee

Preliminary Bill of Quantities

Fixed Costs	UNIT	QUANTITY	Rate (ex GST)	COST
Detailed Design Study (including optimisation of design levels and locations of works)	item	1	$ 50,000.00	$ 50,000.00
Planning and approvals/ easement requirements	m	400	$ 10.00	$ 4,000.00
Detailed Survey	X-sections	20	$ 600.00	$ 12,000.00
Contractor Establishment	item	1	$ 5,000.00	$ 5,000.00
WHS Compliance	item	1	$ 10,000.00	$ 10,000.00
Project Management	hrs	40	$ 200.00	$ 8,000.00
Total				**$ 89,000.00**

Levee Upgrade (Earth Sections)	UNIT	QUANTITY	2014 RATE (ex GST)	COST
			RURAL NSW	
Removal of top soil and vegetation (100 mm)	m^3	813	$ 5.00	$ 4,063.50
Fill in embankment (could be supplied from spillway excavation if suitable)	m^3	406	$ 10.00	$ 4,063.50
Fuel	l/m^3	406	$ 0.50	$ 203.18
Compaction of new material	m^3	406	$ 2.50	$ 1,015.88
Allowance for removal of unsuitable material (10%)	m^3	81.3	$ 8.00	$ 650.16
Construction Management (10% of fill and compaction cost)	hrs	1	$ 528.26	$ 528.26
Top soil placement	m^2	406	$ 8.00	$ 3,250.80
Top soil seeding	m^2	406	$ 7.00	$ 2,844.45
Total				**$ 16,619.72**

Spillway Revision	UNIT	QUANTITY	2014 RATE (ex GST)	COST
			RURAL NSW	
Removal of top soil and vegetation (100 mm)	m^3	120	$ 5.00	$ 600.00
Excavation of embankment (assume 300 mm removed from existing crest)	m^3	240	$ 10.00	$ 2,400.00
Compaction of new crest	m^2	1,200	$ 2.50	$ 3,000.00
Allowance for removal of unsuitable material (10%)	m^3	12.0	$ 8.00	$ 96.00
Construction Management (10% of fill and compaction cost)	hrs	1	$ 540.00	$ 540.00
Total				**$ 6,636.00**

Levee Upgrade (Concrete Sections)	UNIT	QUANTITY	2014 RATE (ex GST)	COST
			RURAL NSW	
Estimation for concrete/ removable panel sections	m	1	$ 200,000.00	$ 200,000.00
Total				**$ 200,000.00**

Maintenance	UNIT	QUANTITY	Rate (ex GST)	COST
Continuation of existing Council maintenance schedule	item	N/A	N/A	
Total				**$ -**

Overall Project Cost (Ex GST)	**$ 312,256**
20% Contingency	$ 62,451.14
Total cost including contingency (ex GST)	**$ 374,707**

Option FM07
North Deniliquin Levee Upgrade

Preliminary Bill of Quantities

Fixed Costs	UNIT	QUANTITY	Rate (ex GST)	COST
Detailed Design Study (including flood optimisation modelling, geotechnical investigation)	item	1	$ 150,000.00	$ 150,000.00
Planning and approvals/ easement requirements	m	1,000	$ 15.00	$ 15,000.00
Detailed Survey	X-sections	40	$ 600.00	$ 24,000.00
Detailed Removable Levee Research and Design	hrs	120	$ 200.00	$ 24,000.00
Contractor Establishment	item	1	$ 5,000.00	$ 5,000.00
WHS Compliance	item	1	$ 10,000.00	$ 10,000.00
Project Management	hrs	24	$ 200.00	$ 4,800.00
Total				**$ 232,800.00**

Levee Upgrade (Unconstrained areas)	UNIT	QUANTITY	RATE (ex GST)	COST
Removal of top soil and vegetation	m³	2,156	$ 5.00	$ 10,777.50
Excavation of cut-off trench	m³	1,437	$ 2.50	$ 3,592.50
Fill in levee embankment (including compaction factor) [1]	m³	9,120	$ 3.60	$ 32,832.00
Fuel	l/m³	9,120	$ 0.50	$ 4,560.00
Allowance for removal of unsuitable material (10%)	m³	912	$ 8.00	$ 7,296.00
Construction Management (10% of excavation, fill and fuel)	hrs	1	$ 4,098.45	$ 4,098.45
Topping up stockpiles (to be determined)	m³	500	$ 2.50	$ 1,250.00
Total				**$ 63,156.45**

Levee Upgrade (Waterfront areas)	UNIT	QUANTITY	RATE (ex GST)	COST
Removable panel system	m	1,000	$ 1,200.00	$ 1,200,000.00
Preparation of foundation and permanent footing components	m	1,000	$ 50.00	$ 50,000.00
Total				**$ 1,250,000.00**

Operation & Maintenance	UNIT	QUANTITY	Rate (ex GST)	COST
Updating Emergency Response Plans and O&M Manuals to include installation of temporary barriers and updated design levels for road crossings.	item	N/A	N/A	
Total				**$ -**

Overall Project Cost (Ex GST)	**$ 1,545,956**
20% Contingency	$ 309,191.29
Total cost including contingency (ex GST)	**$ 1,855,148**

[1] May be offset with spoil from Davidson Levee Decommissioning (~ 6,000 m^3)

Option FM12
Decommissioning Davidson Street Levee

Preliminary Bill of Quantities

Fixed Costs	UNIT	QUANTITY	Rate (ex GST)	COST
Detailed Feasibility Study (including Flood Impact Study and geotechnical investigation)	item	1	$ 60,000.00	$ 60,000.00
Detailed Survey	hrs	160	$ 600.00	$ 96,000.00
Contractor Establishment	item	1	$ 5,000.00	$ 5,000.00
WHS Compliance	item	1	$ 10,000.00	$ 10,000.00
Project Management (10% of Fixed Costs)	item	1	$ 9,600.00	$ 9,600.00
Total				**$ 180,600.00**

Excavation of Davidson Street Levee	UNIT	QUANTITY	2014 RATE (ex GST) RURAL NSW	COST
Excavation of Davidson Street Levee	m³	6,000	$ 3.60	$ 21,600.00
Removal of Spoil	m³	6,000	$ 3.00	$ 18,000.00
Compaction of design surface	m²	17,500	$ 2.50	$ 43,750.00
Fuel	l/m³	6,000	$ 0.50	$ 3,000.00
Top soil placement/ seeding with native grass	m²	17,500	$ 12.00	$ 210,000.00
Construction Management (10% of Excavation and Compaction Cost)	item	1	$ 6,535.00	$ 6,535.00
Total				**$ 302,885.00**

Overall Project Cost (Ex GST)	**$ 483,485**
20% Contingency	$ 96,697.00
Total cost including contingency (ex GST)	**$ 580,182**

Appendix G

EDWARD RIVER AT DENILIQUIN

OCTOBER 2016 FLOOD EVENT

DATA COLLECTION, MODEL VALIDATION AND FLOOD INTELLIGENCE REPORT

Sloane St boat ramp 23rd September 2016

APRIL 2017

Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: 9299 2855
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DENILIQUIN OCTOBER 2016 FLOOD EVENT ANALYSIS

FINAL REPORT

APRIL 2017

Project Deniliquin October 2016 Flood Event Analysis	**Project Number** 115027
Client Edward River Council	**Client's Representative** Julie Rogers
Authors Catherine Goonan Kieran Smith	**Prepared by**
Date 26 April 2017	**Verified by**

Revision	Description	Date
3	Final	Apr 17
2	Draft Final	Mar 17
1	Draft	21/12/16

Note: This report is included in the Edward River at Deniliquin Floodplain Risk Management Study and Plan as Appendix G

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DENILIQUIN OCTOBER 2016 FLOOD EVENT ANALYSIS

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1. INTRODUCTION

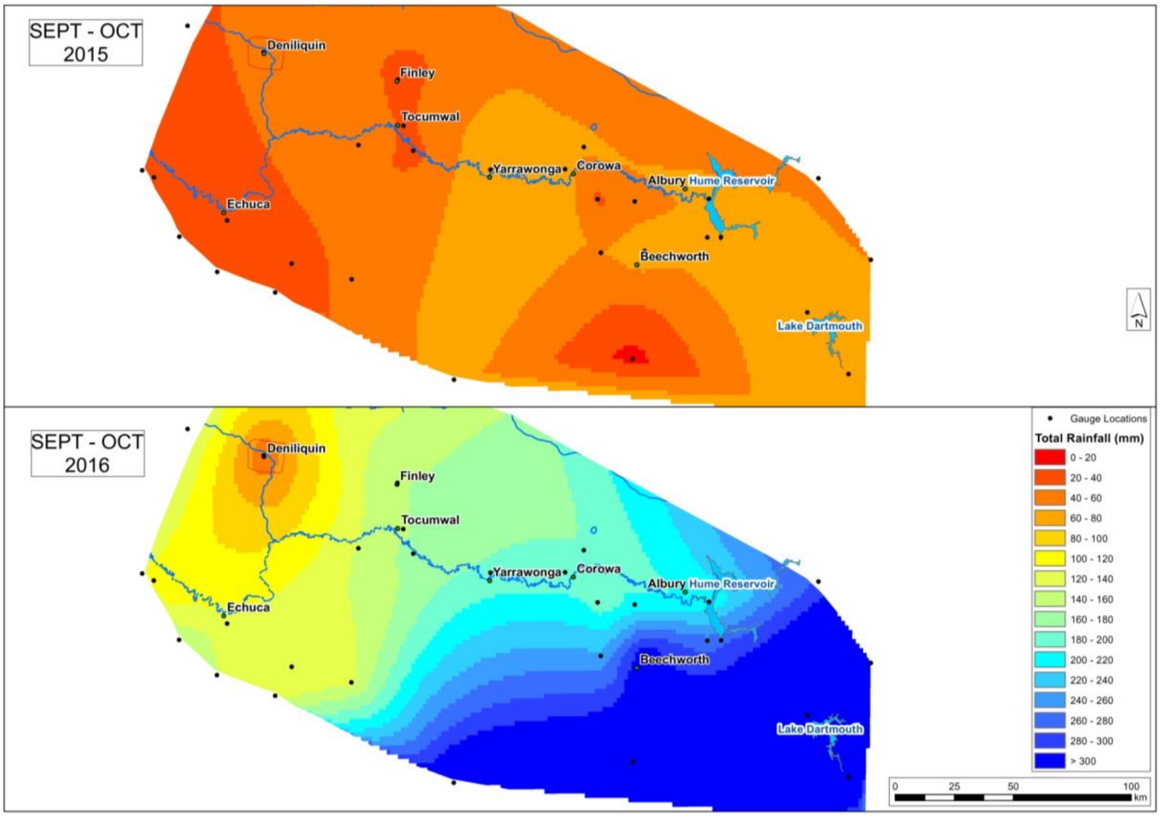
In October 2016, the township of Deniliquin experienced a flood event. The Edward River initially peaked at 7.06 m on the 1st of October, then fell briefly before rising to 8.62 m at the Deniliquin Gauge. At this height, the 2016 flood event was comparable to a 10% AEP event (8.6 m) and an event in October 1993 (8.48 m). In this size event, a small number of properties upstream of the levee system and further downstream in the Dahwilly area are affected. Within town, water generally stays within the Edward River channel but affects parts of both the Riverside Caravan Park and McLeans Beach Caravan Park.

Flooding in Deniliquin results from high rainfall over the Murray River catchment, which stretches into the Snowy Mountains in the Great Dividing Range. This area received considerably more rainfall in the months preceding the flooding than in the previous year. This is illustrated in Diagram 1, which compares total rainfalls in September and October of 2015 and 2016. Furthermore, Deniliquin itself received significantly higher than average rain, creating saturated conditions primed for a flood event. The long term average rainfalls are compared with the 2016 total rainfall in Table 1.

Table 1: Long term average rainfalls at Deniliquin

Month	Long Term Average Rainfall (mm)	2016 Total Rainfall (mm)
August	33.3	61.8
September	37.5	103.6

Diagram 1: Rainfall Comparison



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The flood event on the Edward River at Deniliquin in October 2016, occurred just as the Public Exhibition period of the *Edward River at Deniliquin Floodplain Risk Management Study and Plan* (FRMS&P) was coming to a close. One of the recommendations coming out of the Plan was to synthesise and improve Council's existing flood intelligence so as to better prepare for future flood events. The timing of the October flood event has presented Council with an opportunity to start implementing this recommendation.

This report is presented in four sections. Section 2 presents data collected and compiled by hydrology specialists WMAwater. WMAwater had been previously involved in the *Edward River at Deniliquin Flood Study (Reference 2),* and at the time of writing were engaged to assist as Council completed the Floodplain Risk Management Study and Plan, to which this report is appended. WMAwater's investigation included interviews with Council staff, presentation at public meetings, drop-in sessions for the community, field visits, and compilation of provided data in the form of photos, GIS mapping, aerial imagery and surveyed marks.

Section 3 presents how this data was used to validate the flood model used in the Flood Study and FRMS and to model the October 2016 event. Data from the NSW Office of Water was used to provide the inflow hydrograph, and the topography around McLeans Beach Caravan Park was raised to reflect the sandbagging on the levee during the event.

Section 4 provides the materials required to update Council's flood intelligence. It is based on data previously held by Council, however is supplemented by information from a variety of sources, not least of which are the accounts from outdoor Council staff. It is divided into Flood Behaviour, Road Closures and Levee Pipes and each makes use of GIS mapping for ease of operation. A usable spreadsheet format will be provided to Council for ongoing revision following flood events.

The final chapter (Section 5) details the recommendations for Council based on the findings of the data collection and modelling activities. These recommendations are intended to improve flood management practices where possible, and reduce some of the difficulty and general chaos that typically occurs during flood events.

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2. DATA COLLECTION

2.1. Community Newsletter

A community newsletter was designed by WMAwater and Edward River Council and distributed to residents within the catchment with the aim of collecting flood data to be utilised in model validation and verification. The newsletter provided information on how the 2016 event compared to historical and design events, and details about public meetings and drop-in sessions. The newsletter also detailed what information would be useful for model confirmation and how to record flood marks. A copy of the newsletter is included as Appendix A.

2.2. Online Survey

An online data collection survey was set up using *Survey Monkey* to allow residents to answer questions about their experiences of the flood event and to provide an important source of information for both flood modelling and to improve flood management for future flood events. The survey asked residents to supply:

- Photographs and flood level marks;
- Descriptions of flow paths;
- Road inundation information;
- Details of property affectation and damage; and
- Details of sandbagging or other temporary protection works;

A printout of the online survey is included as Appendix B. As of March 2017 no responses had been received. It is thought that this may be due to the following factors:

- Relatively small number of residents/ business owners were directly affected;
- There were other avenues available for reporting/ recording their experience (e.g. going to Council directly);
- The survey was only advertised a couple of weeks following the flood peak, so residents may have moved on by this time; and
- The residents affected varied in age, and the older of these are generally less comfortable using computers and the internet. Fortunately many of these residents attended the public meetings and drop-in sessions as discussed in 2.5.2 and 2.5.3.

2.3. Photo Collection

WMAwater has compiled photographs of the flood from the following sources:

- WMAwater site visits;
- *Deniliquin History in Photos* Facebook Page;
- Photos provided by residents;
- Photos provided by Council staff; and
- Online news articles.

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Many of these photos have been geo-referenced in GoogleEarth to provide an interactive presentation of the flood at various locations and dates throughout the event. A KMZ file of the photo compilation has been included as Attachment 1. Appendix C contains a selection of key locations and a comparison of photos taken on different dates, showing how various gauge levels match inundation extents.

2.4. Newspaper Catalogue

WMAwater catalogued flood information recorded in the local Deniliquin newspaper *The Pastoral Times* from the 27th September 2016 to the 4th November 2016. Key features noted include actual gauged river levels, predicted river levels, road closures and dam releases, as well as public opinion and comments regarding the flooding. The results have been provided in Attachment 2, containing scanned articles and the information log in spreadsheet format.

2.5. Data Collection Trip – November 2016

WMAwater staff visited Deniliquin from the 23rd to 25th of November 2016 to undertake various data collection exercises. These included interviews with Council and SES staff, presenting at public meetings, hosting drop-in sessions and visiting a number of flood affected sites.

2.5.1. Interviews with Edward River Council Staff

WMAwater staff interviewed Edward River Council (Council) staff to gather information on how the October 2016 flood was managed and the actions undertaken. The aim of these interviews was to talk to a range of personnel across management, supervisory and field positions to acknowledge aspects of the event that worked well, and identify areas of improvement for future flood event management. Notes from the interviews are included in Appendix D, with findings summarised below.

Overall, the work and preparations required of council staff directed by the Director Technical Services, Mark Dalzell, was well understood. Staff noted that meetings conducted by Mr Dalzell were beneficial for the coordination of operations and teams. The Flood Update Reports distributed by Mr Dalzell throughout the event have been included in Appendix E.

The *Deniliquin Council Flood Response Plans* were used by both management and outdoor staff alike. Several staff mentioned that while the tables were very helpful and generally correct, there were some deficiencies to be addressed:

- A number of levee pipes were not listed on the tables, compilation of complete levee pipe asset register with GIS mapping is recommended;
- The time taken to close pipes was extended due to faulty or missing gates, requiring temporary gates, bungs or plastic and dirt to seal them. This took several man hours to complete;
- A systematic upgrade of a number of pipes and gates is requested by a number of staff and thought to be essential to reducing the time and resources required at each pipe closure; and

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- Ongoing and regular maintenance (opening and closing) of gates would help ensure all gates are in good working order.

The original Flood Response Plans for both South Deniliquin and North Deniliquin Levees and SES requirements have been included in Appendix F for reference. Proposed revised versions of these tables are described in Section 4.

In regards to the community, if not unconcerned, most members of the community seemed supportive and appreciative of the actions of Council staff during their preparations.

Aside from management issues during the flood event, the interviews revealed a disparity in understanding on a number of topics between different levels of Council staff, including:

- The approach regarding “Decommissioning” the Davidson Street Levee (From FRMP); and
- The role of the SES during floods, and improving communication between Council, the SES and the public, especially regarding decisions about sandbagging and evacuation.

Generally it was commented that the Edward River Council managed the October 2016 Flood well, however several staff noted that if it had been any larger they would have needed additional resources to cope. The flood peaked at 8.62 m at the gauge, and required actions were generally limited to closing levee gates and pipes and sandbagging at McLeans Beach and a couple of residential properties. With a higher peak, levee panels would need to have been installed in the South Deniliquin levee, several road crossings blocked with fill, and many more roads in the Davidson Street area would have been overtopped. The findings of this report indicate several opportunities for improvement to flood management in Deniliquin that will assist Council in facing future flood events.

2.5.2. Public Meetings

Two public meetings were held at the Deniliquin RSL at 7pm on the 23rd and 24th November 2016. The aims of these meetings were to promote the various opportunities for residents to contribute information about their flood experiences, and describe what the information would be used for. A presentation was given by WMAwater providing rainfall and river flow data for the flood event, an overview of the actions taken by Council, and preliminary modelling results. The presentation has been provided in Appendix G.

The public meetings were attended by 5 residents on the Wednesday night, and 3 on the Thursday night. The attendees had generally been directly affected or had property inundated during the flood, and without a large crowd were able to speak directly with WMAwater staff and have their experiences and comments recorded. These have been presented along with notes from the Drop-in Sessions in Figure 1.

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2.5.3. Drop-in Sessions

Two drop-in sessions were hosted by WMAwater staff at Central Murray Regional Library at the following times:

- Thursday 24th November: 10 am – 4 pm
- Friday 25th November: 9.30 am – 11 am

Attendance was generally low, however a number of residents called in and described inundation around their property, which is useful for hydraulic model validation. Community members were generally very happy with Council and SES efforts during the flood event. These were noted and have been presented in Figure 1 and included in KMZ format as Attachment 3.

2.5.4. Site Visits

Whilst in Deniliquin, WMAwater staff walked from Edwardes Street to McLeans Beach Caravan Park along the Beach to Beach Walk, and visited the Riverside Caravan Park.

Key features noted include:

- Height of sandbagging around McLeans Beach Caravan Park (up to 4 sandbags high, ~800 mm);
- Location of water marks and debris marks on trees and fences;
- Extent of bank erosion on the right bank around McLeans Beach Caravan Park
- Location and condition of pipes at and near the Riverside Caravan Park;

Photos from these site visits are shown on Figure 2 and a selection have been included in the KMZ (GoogleEarth) Photo Compilation in Attachment 1.

2.6. Sandbagging of Levee at McLeans Beach Caravan Park

McLeans Beach Caravan Park is located on the left bank of the Edward River downstream of National Bridge in the floodway. At the time of writing, the park had a total potential occupancy of approximately 1500 people (389 sites x 4 people per site), with 218 annual sites, 10 unpowered sites, 11 cabins, 14 permanent sites (caravan and rigid annex) and 126 casual camp sites.

Part of the caravan park is protected by an earth levee, with an approximate service level just below the 10% AEP event. The height of the levee was validated by survey early in the flood event, and the first peak came close to overtopping the levee, therefore the levee was topped up with sandbags. However as predictions of the second flood peak rose, there was a huge effort to raise the service level of the levee to protect property within the levee by approximately 800 mm. This was achieved using sandbags and compacted earth fill, and undertaken by residents along with SES and Council staff.

Generally, it is accespted Floodplain Management practice that sandbagging a levee should only be undertaken to fill in gaps or low points (that would normally be addressed in routine

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maintenance). Raising a levee by 800 mm and increasing its level of protection is not appropriate as the higher levee could increase flood levels elsewhere, and resources should be used equitably across the floodplain as needed.

Had the flood been slightly higher, all sandbagging efforts would have been in vain as the McLeans Beach levee would have been overtopped even at its higher level. Furthermore, the manhours, equipment and material resources spent on the levee would not have been available to the broader floodplain.

In future flood events, the design service level of all levees in town must be accepted and not raised as the flood progresses. Maintenance of existing earth levees should be undertaken regularly by the levee owners to ensure defects such as low spots due to pedestrian/ vehicle traffic are addressed.

Photo 1 Sandbagging at McLeans Beach Caravan Park

3. FLOOD MODEL VALIDATION

3.1. Modelling Approach

WMAwater modelled the October 2016 flood event utilising the existing flood model created for the 2014 Edward River at Deniliquin Flood Study (Reference 1) and data obtained from the 2016 flood event. Recorded gauge height data from Gauge 409003 – Edward River at Deniliquin, was used as the basis for the flow input into the TUFLOW model. The rating curve used to convert recorded gauge heights into flow is described below.

The 2016 peak gauge height of 8.62 m is comparable to the 10% AEP design event (peak: 8.6 m) as defined in the Flood Study, and the relatively recent 1993 event (peak: 8.48 m). The 2016 event model was therefore based on the model files and various parameters for these two events.

The 2016 event model was initially calibrated to survey data collected by Council during the flood, a georeferenced aerial image of the flood at its peak, and photography provided by Council, residents and WMAwater staff. This 2016 modelled event then allowed validation of the existing model developed in the 2014 Edward River at Deniliquin Flood Study for the 10% AEP design event.

3.2. Model Inflow Data

3.2.1. Rating Curve Selection

The NSW Department of Primary Industries (DPI) operates Gauge No. 409003 ‘Edward River at Deniliquin’ which records stream water level (in metres gauge height). This stage data is converted into flow data based on a relationship of height to flow (rating curve). The rating curves produced by DPI are typically built from a series of gaugings during flood events, and then extrapolated beyond the highest gauged event. The recorded gauge height and produced flow data (in ML/day) for the October 2016 event was obtained from DPI in 15 minute time intervals.

During the 2014 Flood Study, the TUFLOW hydraulic model was calibrated to a range of historical events. This model produced its own rating curve from a range of flows and historical events, and generally provides a more accurate representation of higher flows as it can better represent out-of-bank flow behaviour than the DPI rating curve extrapolation. At low flows, the DPI and TUFLOW rating curves are very similar, but have subtle differences due to the different methods used. This can be seen in Chart 1.

The TUFLOW-produced rating curve was selected to convert recorded gauge heights to flow for use in modelling the 2016 event to ensure the model correctly reproduced recorded gauge heights for given inflows at the gauge site. The DPI recorded gauge heights were converted to flows using interpolation of the TUFLOW rating curve, and this flow hydrograph was applied at the upstream inflow boundary of the model, described further in Section 3.2.2.

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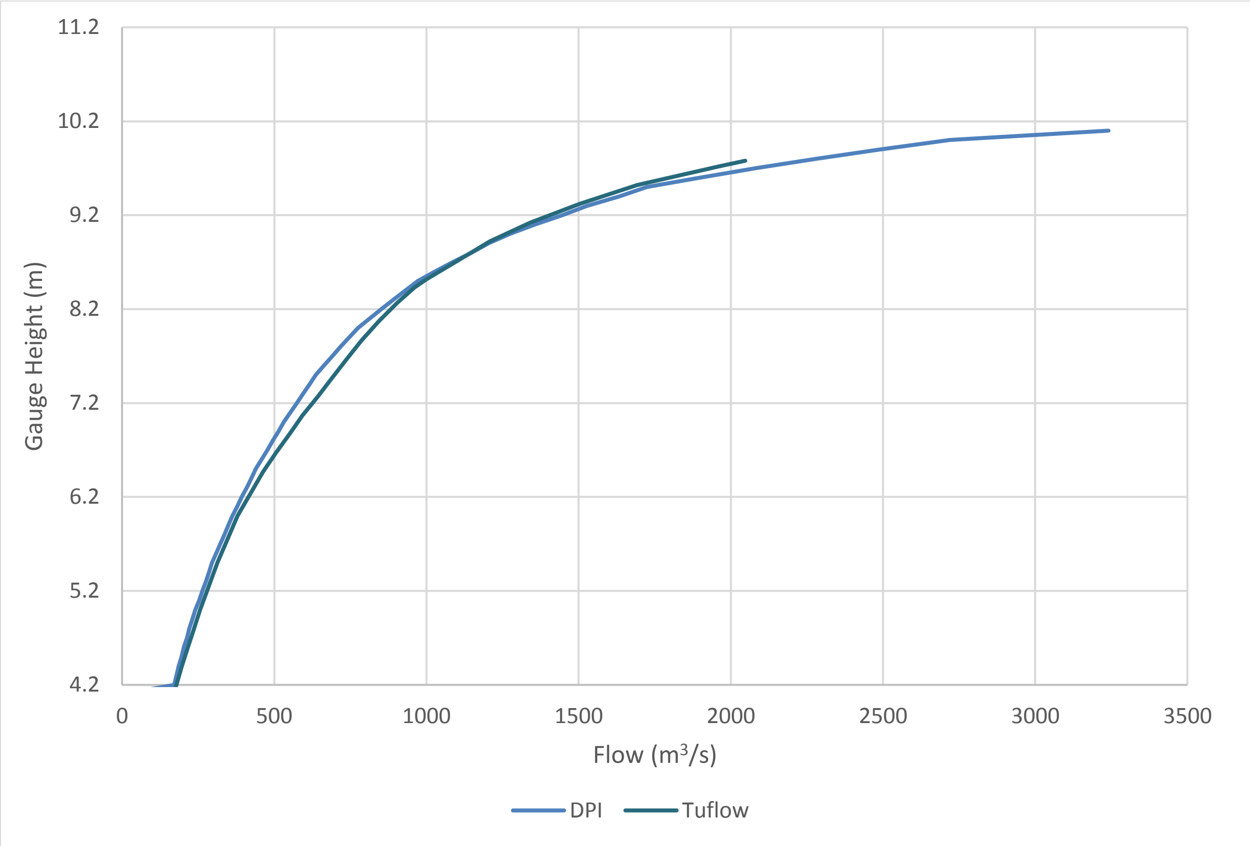
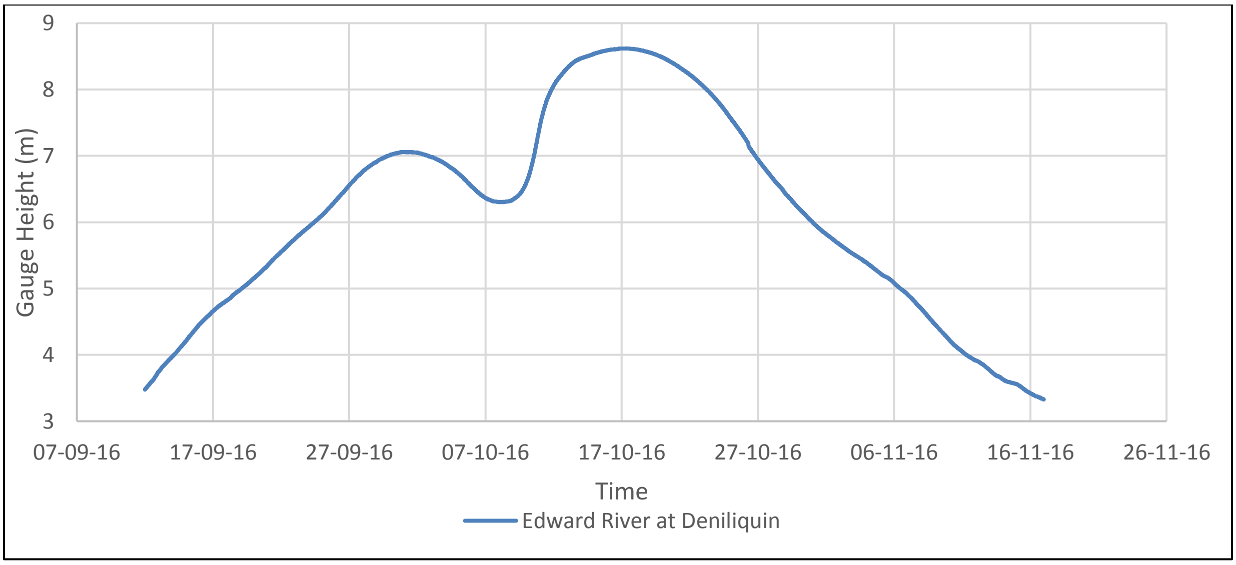
Chart 1: Comparison of Department of Primary Industries (DPI) and TUFLOW rating curves



3.2.2. 2016 Event Hydrograph

Between the 14th of September and 25th of October the Edward River at Deniliquin was elevated above 4 m (and stayed elevated above normal levels into November.) The stage hydrograph for the period is shown in Chart 2 below. As can be seen in the chart, the stage hydrograph shows a dual peak flood event with an initial rise to a peak of 7.06 m, a brief recession and then a steeper rise to the peak water level of 8.62 m recorded on the 17th of October 2016.

Chart 2: Edward River at Deniliquin Gauge Height



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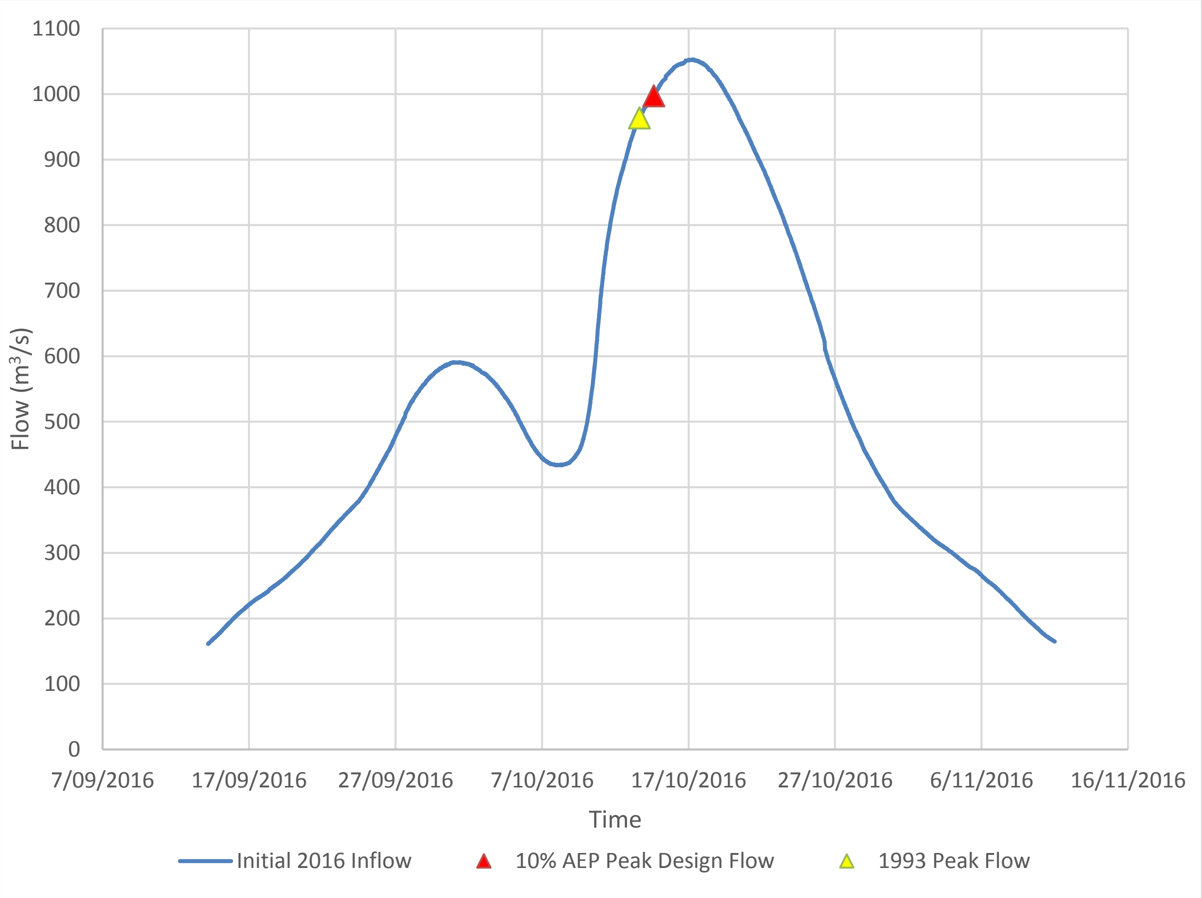
3.3. Initial Model Run

The gauge height information was converted to a model inflow hydrograph using the TUFLOW rating curve described in Section 3.2.1. This initial model inflow is shown below in Chart 3. Peak model inflows for the 10% AEP design flood and the 1993 flood event are included as reference points.

Chart 3: Initial 2016 Inflow Hydrograph



Two initial model runs were undertaken with inputs listed in Table 2:

Table 2 Initial Model Inputs

Inflow	Tailwater Level	Initial Water Levels
2016 inflow	1993 level	1993 level
2016 inflow	1993 level	10% AEP design level

The model was run for 1000 hours to cover the period from the 14th of September to the 25th of October 2016. This period coincided with a starting point at which the Edward River was at a gauge height above 4 m. This developed a set of initial water level conditions which represented the key flood behaviour early in the event (the dual peak) while allowing an acceptable model run time for the second larger peak.

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3.4. Model Calibration

3.4.1. Calibration Data

Data collection undertaken by Edward River Council during the 2016 event included surveyed flood marks along the length of the Edward River at Deniliquin and a georeferenced aerial of the flood event at the peak. These data sources were utilised to calibrate the 2016 flood model and are included as Figure 3.

A range of photos provided by Council, residents, media and WMAwater staff also contributed to calibration of model results. A selection of such photos is provided in Appendix C.

3.4.1.1. Raising of McLeans Beach Levee

As discussed in Section 2.6 the McLeans Beach levee was raised by between 500 mm – 1000 mm during the 2016 event to prevent flooding of the McLeans Beach Caravan Park. This represents the only key change to model topography for this event.

3.4.2. Initial Results and Discrepancies

Comparisons between preliminary model results, aerial photos and recorded flood level readings found that the initial model did not accurately match the real flood event in a number of areas. In the downstream area of the catchment (the area west of the township), modelled flood levels were lower than surveyed levels and the modelled flood extent smaller than the peak shown in the aerial imagery. Flood levels and extents in the upstream area of the catchment were found to be generally accurate, although some modelled flood levels along Brick Kiln Creek were higher than surveyed levels. A comparison of the modelled and photographed flood extent highlighted a discrepancy around a private elevated driveway near Blackett Street, where the driveway was restricting the modelled extent. On investigation a private bridge structure exists in the driveway which had previously not been included in the model. This structure was estimated and added which resolved the extent discrepany in this area. The driveway is overtopped in a 5% AEP event.

3.4.3. Model Variations

The model was altered and iterated with several variations in an attempt to produce a more accurate calibration. To reduce model run-times (which were previously upwards of 100 hours) the grid cell-size was increased from 10 m to 20 m with final simulations completed on the 10 m grid. The tested variables included:

1. Taking an approximate average of the water levels at the Edward River at Deniliquin and Stevens Weir (409023) gauges during the flood event and overlaying the Stevens Weir profile at that average as a tailwater;
2. Increasing the hydraulic roughness in the area west of Deniliquin by varying Mannings “n” values;
3. Raising the road along the bank of the Edward River to remove a flood runner;
4. Raising the tailwater adopted in variation 1 (above) by 500 mm;
5. Increasing the hydraulic roughness in the downstream section of the Edward River;

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6. Changing the model tailwater to be a weighted interpolation of the Edward River and Stevens Weir Gauges. This weighted interpolation was based on the distance of both gauges from the downstream model boundary and the shape of both hydrographs (See Section 3.4.4); and
7. Scaling the inflow data (See Section 3.4.5).

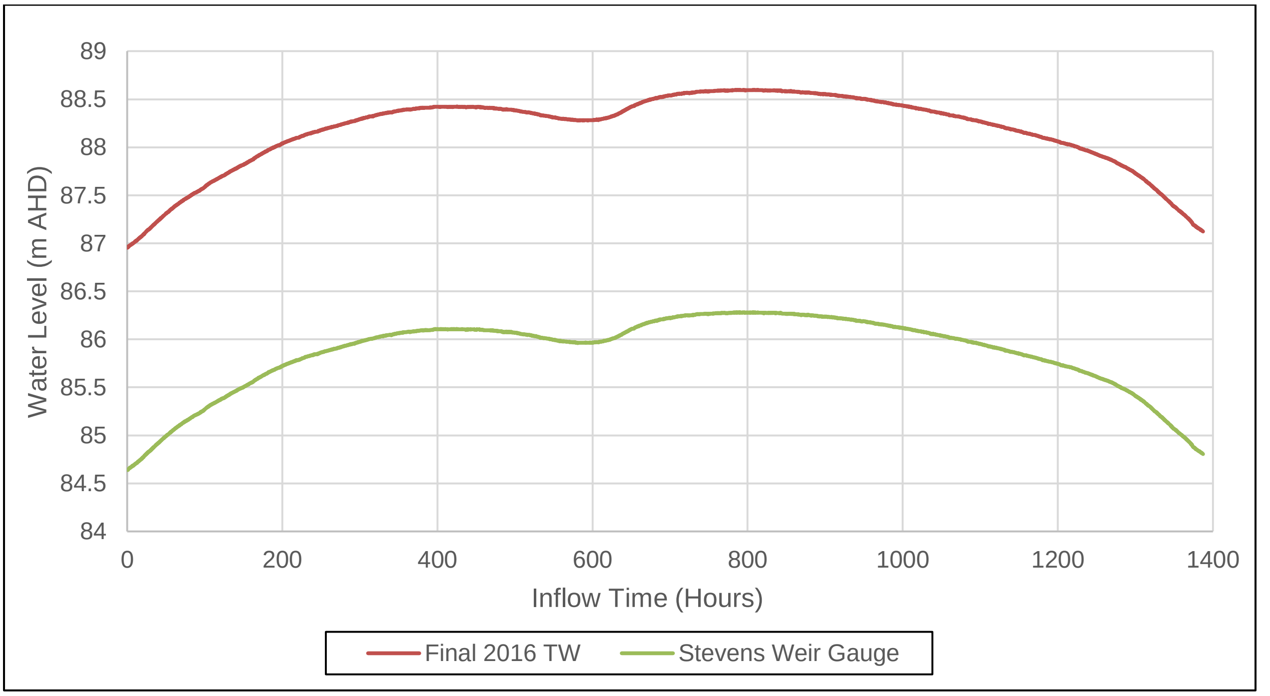
The location of each of the variations is shown in Figure 4.

3.4.4. Tailwater Estimation

The flatter Stevens Weir profile was adopted as the tailwater shape to provide a more consistent output estimate of probable levels at the downstream boundary. Thus, the following estimate was adopted, and shown in Chart 4:

1. The average of the two peaks from the interpolated tailwater (variation 6) was calculated.
2. The Stevens Weir profile was adjusted to match that average peak.

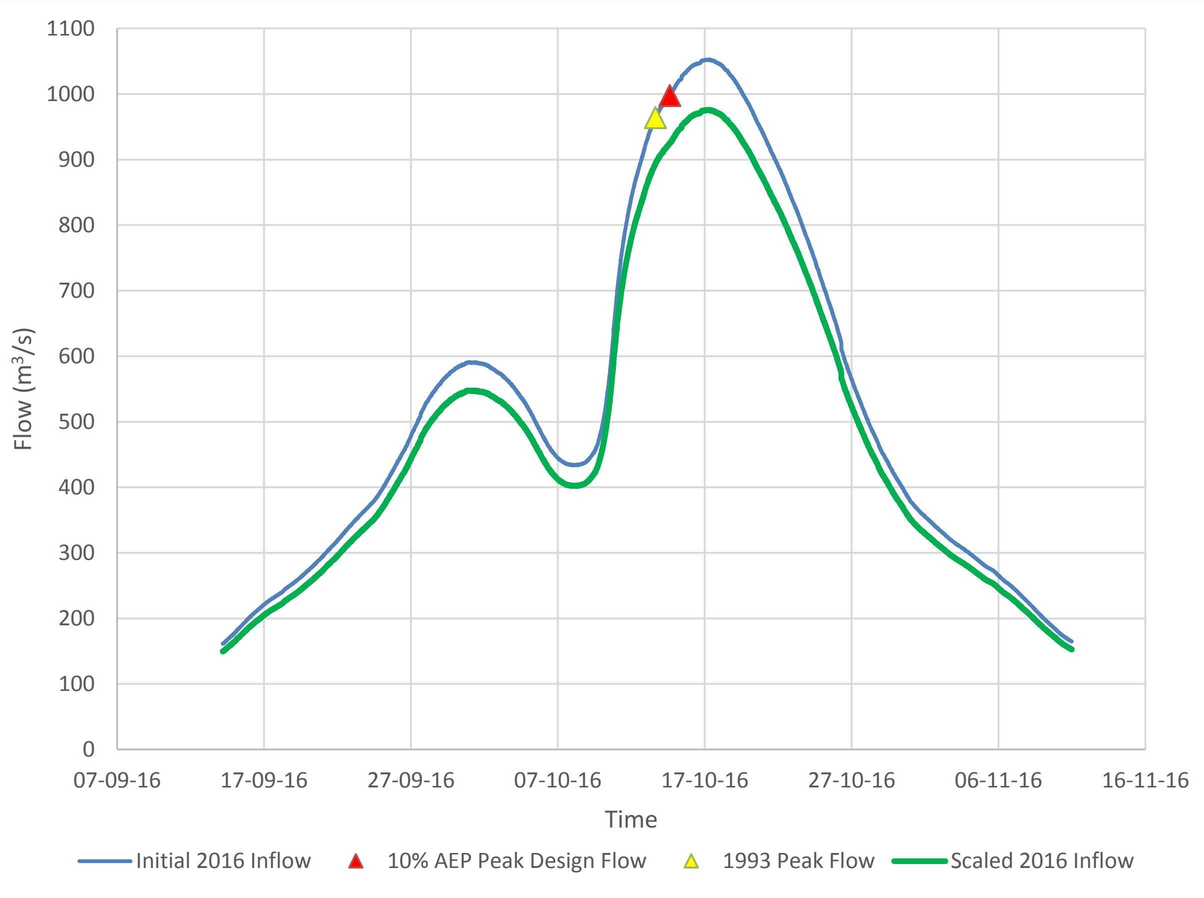
Chart 4: Estimated 2016 Tailwater Level



3.4.5. Revised Model Inflow

A comparison of the stage hydrographs for the modelled and recorded 2016 flood events found that the model initially overestimated peak flood behaviour at the gauge. To produce a more accurate flood level at the gauge, the model inflow was scaled to 93% of its initial value. A comparison between the original and scaled model inflows is shown in Chart 5 below. The model was re-run with the scaled inflow and the results are described below.

Chart 5: Revised 2016 Inflow Hydrograph



3.5. Comparison of October 2016 Model and Actual Event

A comparison of the final October 2016 flood model and the actual flood event is included as Figure 5. It can be seen from the figure that across the study area the model was able to achieve a high level of accuracy, with nearly all of the modelled flood levels being within +/- 150mm of the recorded flood levels (considered an acceptable tolerance for calibration.)

A comparison of the stage hydrographs for the final modelled and recorded 2016 flood events is included in Chart 6 below. It can be seen in the chart that the modelled event accurately replicates the recorded peak as well as the shape and timing of the event.

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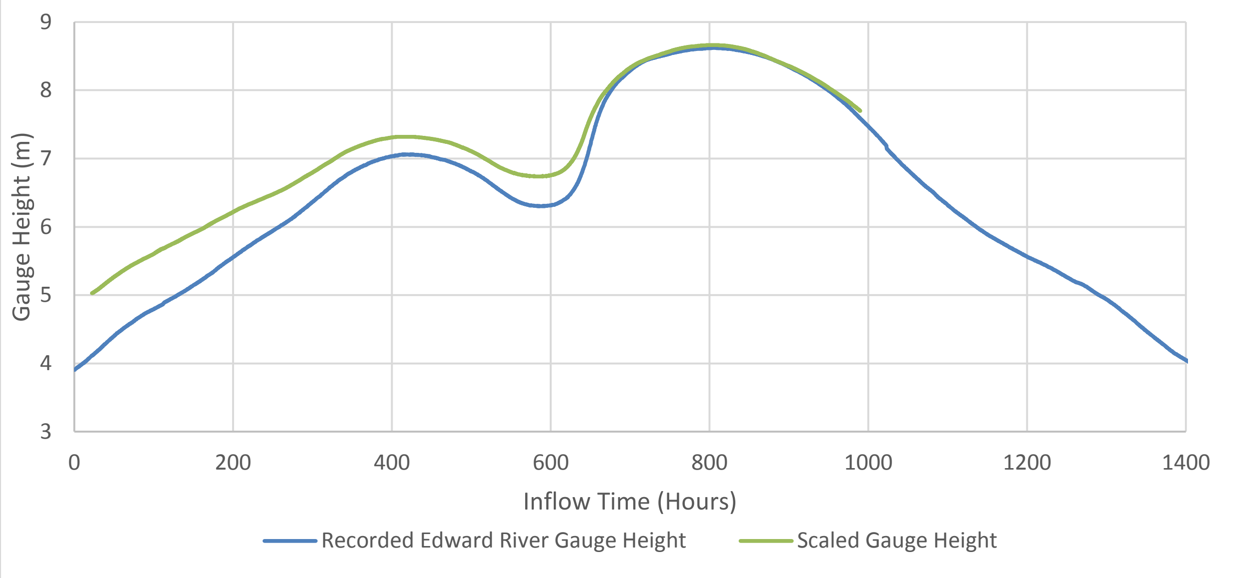
Chart 6: Final Edward River Gauge Level Comparison



It is noted that there is a single location just downstream of the town where the modelled flood level is not within +/- 150 mm of the recorded level. However, the point is in close proximity to points with accepted tolerances. Recorded flood levels that are not within the extent of the modelled 2016 event are considered to be areas that are affected by localised or overland flow flooding as a result of intense local rainfalls (and are denoted as null with a value of '-999').

There are a number of factors that may contribute to discrepancies between recorded and modelled flood levels, including but not limited to the recording of flood levels outside of the flood peak or the use of a relatively large 10 m model grid cell size. Recorded spot heights also have a level of uncertainty regarding the time they were recorded or if they are subject to localised influences. Detailed information was not provided to WMAwater. Despite this, aside from a single point outside of the acceptable +/- 150 mm tolerance, the modelled flood event accurately matches the recorded flood event across the study area including at both the upstream and downstream boundaries. In addition, the extent of the actual flood event is well matched in the model as can be seen in Appendix H and Appendix I. For these reasons it is considered that the model calibration was successful and the October 2016 flood model is an accurate representation of the real October 2016 flood event.

3.6. Model Validation: Comparison to 1993 and 10% AEP Design Event

The October 2016 flood event produced a peak flood level of 8.62 m at the Edward River gauge. This is very similar to the estimated 10% AEP design level of 8.6 m determined by the 2014 Flood Study and the recorded peak of the 1993 event of 8.48m. As the 2016 flood model has been calibrated to the recorded flood levels collected during the flood event, and given the similar gauge levels, it is useful in validating the 10% AEP model.

Figure 6 shows a flood level comparison of the 2016 and 10% AEP flood models. It is clear from the figure that the 2016 flood model has notably higher flood levels and a larger flood extent than the 10% AEP model; in parts considerably higher than would be expected given the similar levels

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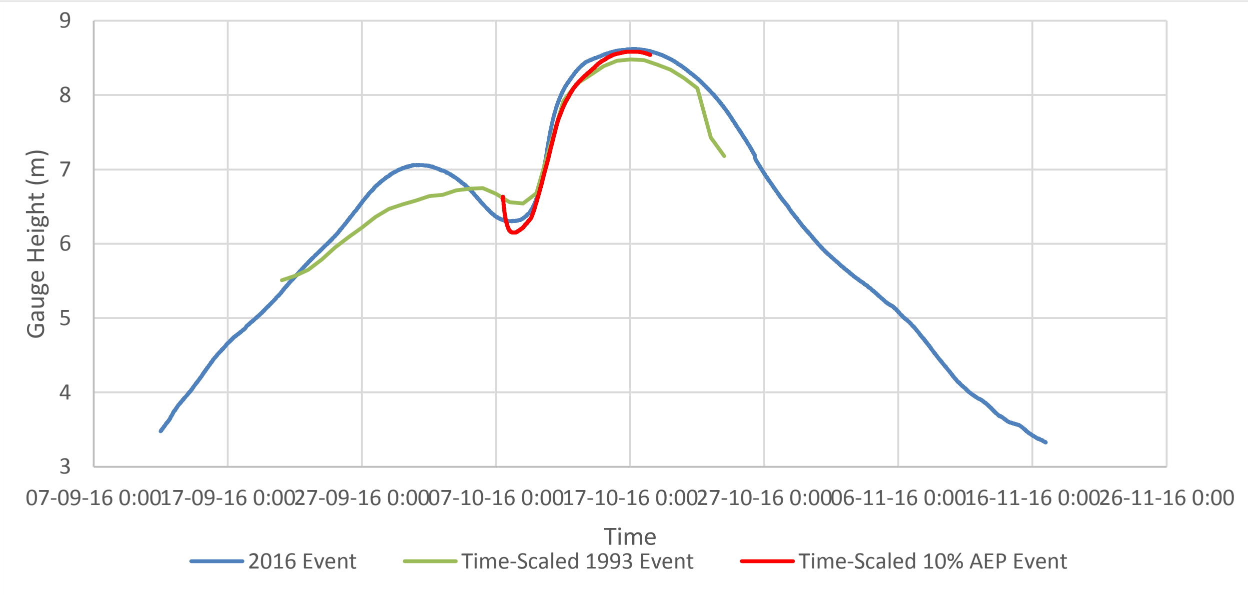
at the Edward River gauge. Figure 7 and Figure 8 show peak flood extent comparisons for the 2016 event and the 10% AEP Design Event and 1993 events respectively.

Some of the discrepancies between the two models are easily accounted for. The raising of the McLeans Beach levee during the 2016 event meant that it was not flooded as expected in a flood of that magnitude. Similarly the inclusion of the bridge structure on the Blackett Street driveway meant it was flooded in the 2016 model.

However, in areas upstream and downstream of the gauge, the 2016 flood model accurately produces recorded flood levels and extents surveyed during the flood event. In these areas the 10% AEP and the 1993 models are considerably lower than the 2016 model, with more than 300 mm difference in some cases along with significantly less flooded areas.

A comparison of the recorded gauge height for 1993 and 2016 and the modelled gauge height for the 10% AEP event is shown below on Chart 7.

Chart 7: Gauge Height Comparisons

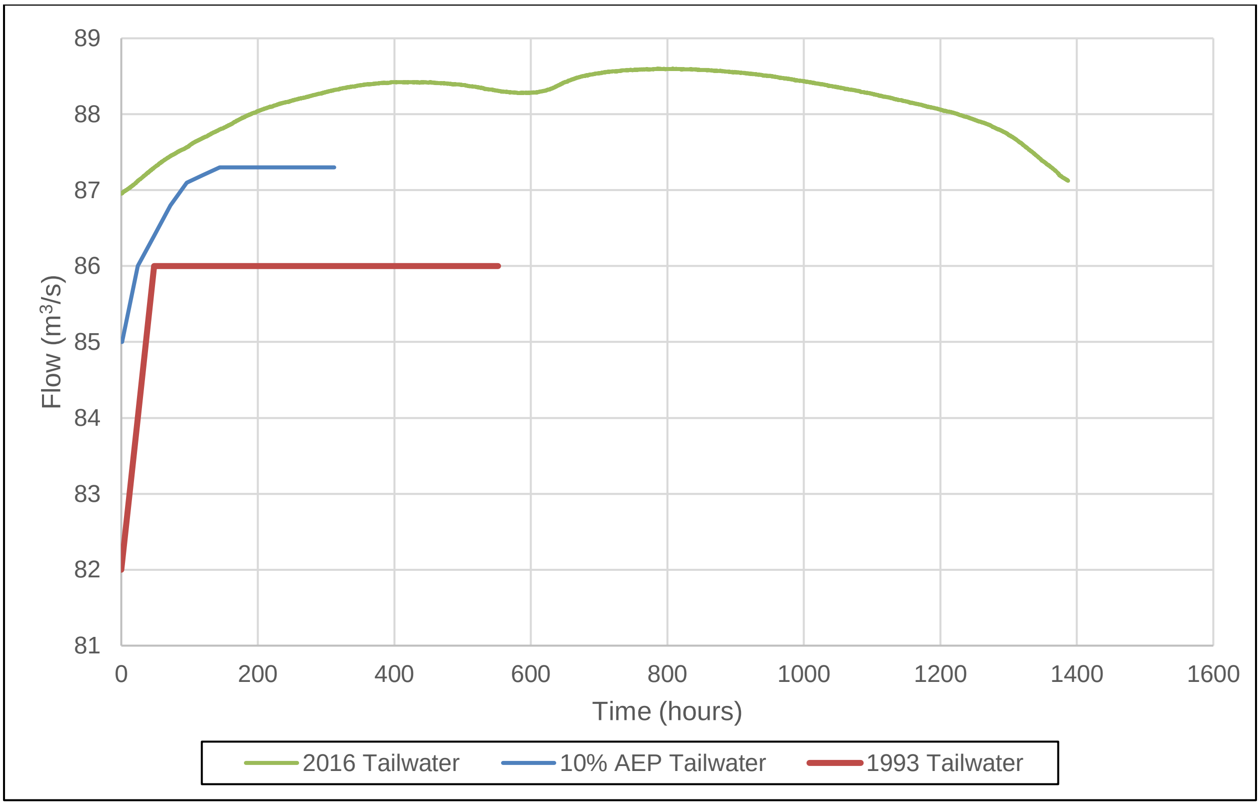


Recorded/modelled gauge height for the 2016, 1993 events and 10% AEP design event follow a similar shape and have similar peaks as can be seen in Chart 7. A significant difference between the three models is that the 2016 flood has a much more pronounced initial peak than both the 10% AEP and 1993 events. The initial peak of the 2016 flood allows a significant amount of water to build up over the floowplain before the arrival of the larger peak.

During the 2014 Flood Study there was limited calibration or anecdotal information for the 1993 event. Given the similar shape to 2016, albeit with a smaller initial peak, it may be possible that the modelled 1993 flood extent is underestimating the actual event and wider inundation was experienced (similar to 2016).

The large flood level differences at the upstream and downstream catchment boundaries come as a result of the highly varied inflow and tailwater conditions of the three models. The tailwater conditions are shown below in Chart 8.

Chart 8: Model Tailwater Comparison



The modelled tailwater conditions for the 2016 event are significantly higher than those utilised in the other models with a peak value 1 m higher than the 10% AEP event and over 2 m higher than the 1993 event as can be seen in Chart 8. The higher tailwater allows a significant amount of water to remain in the flood model particularly in the downstream end of the catchment, contributing to the difference in flood levels and extent. The combination of recorded extent information and comprehensive flood levels across the study area has allowed a more accurate estimate of the 2016 event tailwater conditions.

This combination of longer model run times, a more pronounced dual peak inflow hydrograph and high tailwater levels lead to higher flood levels in the 2016 event when compared to the 1993 and 10% AEP design events.

4. FLOOD INTELLIGENCE

Flood intelligence for the Edward River at Deniliquin is currently available in a number of documents. The following documents record flood behaviour and actions required at corresponding river levels (gauge heights):

- Deniliquin Council Flood Response Plan – South Levee System *(Council)*
- Deniliquin Council Flood Response Plan – North and Central Levee System *(Council)*
- Flood Intelligence Card – Deniliquin Gauge (Station No. 409003) *(SES)*

The documents have some overlaps, gaps and discrepancies, and as evidenced in the October 2016 flood event, omit several items to be actioned during a flood event, including a number of levee pipes to be closed.

Additional sources of flood intelligence include:

- Deniliquin Council Flood Response Plan South Levee System *(Council, date unknown)*
- Deniliquin Council Flood Response Plan North and Central Levee System *(Council, date unknown)*
- Council Flood Reports (During Event) *(Council, October 2016)*
- Deniliquin – Conargo Local Flood Plan *(SES, 2009)*
- Flood Modelling *(WMAwater, 2014-2017)*
- Interviews with residents and Council staff *(WMAwater, Nov 2016).*

WMAwater has addressed flood intelligence for Council purposes in three categories designed to update the above noted documents. The three categories are:

1. **Flood Behaviour** – noting where water is likely to flow at various (approximate) gauge heights;
2. **Road Closures** – noting roads commonly overtopped during flood events and the approximate gauge height at which access is cut; and
3. **Levee Pipe Closures –** noting the approximate gauge height at which each levee pipe is to be closed to prevent backwatering of stormwater systems;

The documents are designed to be held and used by Council. Sections 1 and 2 (flood behaviour and road closures) are to be supplied to the SES to supplement their flood intelligence.

Note: the new flood intelligence documents are based on a reconciliation of the current documents, interviews with residents and Council staff regarding operations during the October 2016 event, and flood modelling carried out by WMAwater. They will require ongoing revision as infrastructure is developed and after every flood as new lessons are learnt. Such a recommendation will be included in the Floodplain Risk Management Plan.

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4.1. Flood Behaviour

Information regarding flood behaviour in the Edward River and smaller creeks such as Aljoes Creek and Brick Kiln Creek has been recorded in the existing intelligence cards/ flood response plans, noted in the Council Flood reports and recorded as anecdotes during WMAwater's data collection interviews. Understanding the way in which floodwater moves through town is an important aspect of being prepared for flooding and the actions required (such as closing levee gates, providing warning for evacuation).

The flood behaviour intelligence card has been included in the Flood Intel Kit (Attachment 4) as described in Section 5.1.

4.2. Road Closures

The major cause of death during floods is by people entering floodwater. This includes driving, riding and walking through floodwater, and playing in floodwater. Driving through floodwaters is very dangerous for reasons including but not limited to:

- Floodwaters may be deeper and faster flowing than it appears;
- Floodwaters often contains hidden snags and debris;
- Condition of road beneath water is unknown - floodwater can erode and wash away surfaces leaving deep holes and uneven surfaces which cannot be seen;
- Cars can break down due to water ingress, or can be swept away with flood waters; and
- Drivers and passengers can become trapped in vehicles.

Council generally takes responsibility for closing roads that are affected by flood waters. Communication with SES is especially important when closing roads during a flood to ensure appropriate access (for evacuation etc.) is maintained.

A map and list of roads commonly affected during flooding due to their location in the floodplain is provided in the updated Flood Intel Kit (Attachment 4) as described in Section 5.1.

Notes:

- There is more certainty regarding roads cut in frequent events (up to approximately the 10% AEP event) and these have been validated with records from October 2016. Road closures in greater events are based on current flood intelligence data made available by Council and model results;
- The list provided focuses on roads affected by mainstream flooding only. Direct rainfall may also cause access on some roads to have water over them – these roads are not addressed in this report.
- The Deniliquin Levee Bank – Levee Owner's Manual contains notes on road closures required to close gaps in the levees using clay stockpiles. Note that other temporary flood barriers may be appropriate in the future, and clay stockpiles must be maintained in the interim.

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4.3. Levee Pipe Closure

The stormwater systems in North Deniliquin, Central Deniliquin (Davidson St Area) and South Deniliquin generally drain to the Edward river via pipes through the levee bank. When the water level in the river rises, water can enter these pipes from the river side and backwater through the stormwater drainage system, causing inundation of private properties and roads.

In the event of flooding, the gate valves on each levee pipe are to be closed. The pipes are at varying elevations, and the time of closure is determined by the predicted river peak water level (in metres gauge height).

A table and accompanying map showing the location of each levee pipe (for each North, Central and South Deniliquin), and the gauge height at which they are to be closed is supplied in the Flood Intel Kit (Attachment 4) as described in 5.1

Notes:

- Gates should be closed as soon as possible after receiving a peak flood level prediction of up to 500 mm higher than the given gauge height;
- The given gauge heights in Attachment 4 assumes that all levee pipes are fitted with gate valves and gates are in good working order (and therefore can be closed in a timely manner). Condition assessments and ongoing maintenance and upgrades are required under the *Deniliquin Levee Bank – Levee Owner's Maintenance Manual (October 2014);*
- The time taken to close each pipe is dependent on the condition of the gate valve. Missing gates can require several manhours and resources to block the pipe via other means. Ongoing condition assessment and gate maintenance will greatly reduce the time taken by Council staff to close levees, and allow staff to do so when water levels are lower and therefore with greater safety.
- As quoted in the Levee Owner's Manual (p. 104), *"There may not be enough resources available at the time to close off valves etc. "later". If resources could be limited at that "later" time, it may be wise to not only close off the valves required for now but to close more of those valves at a higher level, thus freeing up resources later. While there may be plenty of warning of a flood event, when the flood does arrive it may rise relatively quickly (as seen during the October 2016 event).*

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5. KEY RECOMMENDATIONS

5.1. R1: Centralised Flood Intel Kit

Key to efficient operation during a flood is having all necessary resources readily available. It is recommended that a Centralised Flood Intel Kit is prepared as soon as possible and regularly checked.

The kit should contain:

- Hardcopies of all flood intelligence documentation provided in this report (lists in table format and mapping):
    - General flood behaviour;
    - Road closures;
    - Levee pipe closures
- *Deniliquin Levee Bank – Levee Owner's Maintenance Manual (October 2014),* which contains procedure for the installation of Lift Bulkhead Gates, Slide Bulkhead Gates, earth stockpiles and removable panels;

PDF versions of the above have been provided in Attachment 4*, and a hardcopy should be stored with:*

- Any tools specifically required for the installation of bulkhead gates and removable panels;
- Keys to padlocks on levee pipe gate valves;
- Spare inflatable bungs in the events that levee pipe gates are not serviceable (see condition assessment below);
- Anything else deemed useful by Council staff based on experiences in the October 2016 event.

An electronic version of the kit should be kept on the Council network containing soft copies of all the above documents, and GoogleEarth KML files containing levee pipe locations and common road closure points. Training on use of the GoogleEarth files should be provided to outdoor staff particularly as soon as it is received so that staff can become familiar and identify any issues. The condition assessment described below provides the idea opportunity for using testing the GoogleEarth files in the field.

The kit (both electronic and physical) should be reviewed and revised following all future flood events to ensure data is up to date and gaps in the data are filled.

This recommendation has been included in the Floodplain Risk Management Study and Plan.

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5.2. R2: Levee Pipe Condition Assessment

As described in Section 2.5.1, aside from sandbagging, the works undertaken by the Edward River Council were largely centred around closing levee pipes. There were a number of difficulties encountered by field staff in locating pipes, finding that pipes had no gates or that gates would not close effectively. A number of pipes were not on the Flood Response Plans at all. The poor condition of a number of levee pipes and their gate valves had a direct impact on the time taken to seal the levee in North, South and Central Deniliquin during the October 2016 flood event. The drain on resources would have been catastrophic if the peak level had been any higher as resources would be neeed on other flood response measures such as levee panel installation, and during interviews Council staff described themselves as ‘chasing their tails’ and ‘playing catch-up’ as it was.

The Deniliquin Levee Owners Manual (Section 7.1.5) notes that the time and resources required are as follows:
Time:

- *South Deniliquin – Approximately 1 day to close off all valves (approximately 40 off)*
- *North and Central Deniliquin – Approximately 1 day to close off all valves (approximately 40 off)*

Resources:

- *Two (2) off labourers;*
- *One (1) off 1 tonne truck/ute;*
- *Keys to gates and padlocks*

These times and resources were significantly exceeded during the October 2016 event. Completing the gate closures in a timely manner relies on having up to date intelligence on the exact location of pipes, and that all gates are in good working condition. To this end, further to the flood intelligence proposed in Section 4.3, an urgent basic condition assessment is recommended. Materials to carry out such an assessment are provided in Attachment 5 and include an assessment table and mapping of the pipe locations (as PDF and usable GIS layers). The condition assessment is required by the *Deniliquin Levee Bank – Levee Owner’s Maintenance Manual (October 2014),* and will assist in the prioritisation of funding for upgrades and repairs where required.

A pro-forma for the condition assessment is included in Attachment 5, and requires the following four factors to be completed:

- Basic condition classification as described below (failed – excellent);
- Comment specifying issues (e.g. gate missing/ broken, pipe cracked etc.);
- Pipe diameter and material;
- Photograph (with date stamp and preferably georeferenced).

The condition assessment should be based on the current function and defects of the components based on five categories as observed during the inspections.

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The condition classifications are as follows:

- Excellent – as new condition, no damage, gate working well.
- Good – no significant damage, gate working.
- Fair – some damage, gate in serviceable condition.
- Poor – significant damage, gate not in adequate serviceable condition.
- Failed – missing or severely damaged, not serviceable or repairable, no gate or gate not serviceable.

The focus of the condition classification is on the presence and serviceability of gate valves, and as such each gate valve must be fully closed and reopened during inspection. Ongoing maintenance and upgrades for the pipes themselves, and pits and headwalls should be undertaken as per the *Levee Owner's Maintenance Manual* maintenance log.

The timely closing of levee pipes is imperative to being prepared for a larger flood, where further actions are required and additional demand is placed on the outdoor Council staff. As such, an immediate and ongoing condition assessment schedule has been added to the Floodplain Risk Management Plan.

5.3. Improved Communications

This is a general recommendation pertaining to the communication both within Council and between Council and the SES. It reflects an ideal situation, however acknowledges the general chaos that can occur during a flood event.

5.3.1. R3: Internal Council Communications

Several Council staff commented that the briefings held by Mark Dalzell, the then Director Technical Services, during the flood event were very useful for informing staff of the situation and unifying the approach required.

An evaluation meeting following each future flood event would provide an opportunity for Council to improve on its flood management and address any issues before the next flood. Specifically, much value could be gained from engaging with the outdoor staff after a flood and update asset maintenance/upgrade schedules as required. As discussed in Section 4, all flood intelligence documents are to be revised following all flood events to maintain currency. Of particular interest are the location and timing of response measures that are required.

5.3.2. R4: Council and SES Communications

A number of Council staff interviewees acknowledged the confusion experienced during the October 2016 flood event, especially in regards to sandbagging McLean's Beach Caravan Park. It would be worthwhile having the relevant SES controller address Council staff (both management and outdoor staff) during a non-emergency time, to describe the role and goals of the SES during flood events and how the organisation interacts and cooperates with Council.

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It is envisaged that if Council staff have better understanding of these key flood issues, questions from the public can be addressed with the most current information to minimise confusion and minimise ill-founded rumours from spreading, especially regarding topics like sandbagging and evacuation.

The Flood Intelligence as provided in Attachment 4 and Attachment 5 should be made available to the Deniliquin-Conargo SES unit.

A recommendation about the improved communications is included in the Floodplain Risk Management Plan.

5.4. R5: Flood Data Collection

It is recommended that Council undertakes data collection activities in a timely manner during and immediately following a flood event. This includes but is not limited to the commissioning of aerial photography at the flood peak, survey of flood marks and high water levels, interviews with staff and asset condition assessment. Community feedback should be recorded through written submissions and photographs, or interviews where appropriate, and if there are flood marks (debris lines on fences/ high water marks on trees etc.) shown on private properties after the flood recedes, these should be recorded and surveyed before they fade or disappear.

Peak flood levels captured using RTK GPS survey during the October 2016 flood event were useful in the calibration of the flood model, however there were some unresolved discrepancies between the recorded and modelled flood levels resulting from uncertainity with the recorded survey marks. In future flood events, every effort should be taken to assign a relative accuracy/confidence to survey marks recorded at the time of (or following) the flood event as this would greatly assist in the model calibration/validation process.

Such data is invaluable in the future development of flood modelling and also for the preparation of flood management. Furthermore, as data is collected and lessons learned, the Flood Intel Kit should be updated to include anything that was found to be missing or deficient during the flood event.

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Figures

ID	Category	Description
E01	Inundation	All wet
E02	Flow Path	Flow Path
E03	Flow Path	Flow Path
E04	Flow Path	Overland Flow Path
E05	Flow Path	Flow from Edward River
E06	Erosion	Bank Erosion (Decommissioned powerpole and pump gone due to bank erosion into the river, about 1m). Warning/ Max speed sign was also washed in (close to pump station). Bank erosion is encroaching current road, detour will be necessary in subsequent events. Suggest re-routing road permanently away from the bank.
E07	Erosion	Bank Erosion - Right on the water where serious bank dropped away (503 and 505) and the jetty at 505 damaged. Communicated with Council and felt secure in Council's actions during the event. Had a good sense of how high above the river they were, although floor levels are unknown. There was still 8-10 foot until innundation and the house is situated well within levee. Concrete levee, concerns about the earth embankment erosion.
E08	Erosion	Jetty and walkway were undermined and dislodged. the willow tree from 497 was washed into the back yard. Vegetation lost in backyard which had previously survived other events. Bank stability is a concern with waterskiing over Christmas. There was major bank slump at 503 as flood receeded.
E09	Inundation	Neighbour had installed flood markers for the 1975 Flood (Peak 9.04 m), but these were exceeded. Water depths of up to 3-4 m deep on property (though land falls away quickly). The bridge over gully is 150 cm high, with a guard rail 1m higher. At 7.2 m the water was at the top of the bridge, guard rails hidden.
E10	Inundation	Water still in low lying area (38 days after peak)
E11	General Experience	Had to boat through this paddock to stay over on Hay Road. 17 days of no access, a week not staying at home. Lived there 13 years and neighbour has been there for 18 years, with no issues until now.
E12	Erosion	Hole here caused by lots of erosion of the road width, erosion occurred along a 20 m long stretch, and is about 0.5 m deep, still water in most of it. In other areas water was more like 'sweeping' over road and grass, roads still intact. Occurring on dirt roads, no gravel/ bitumen.
E13	General Experience	Cars were parked here, and had to boat to the house
E14	Inundation	Local inundation (about a foot through chook yard).
E15	General Experience	Water coming from east (down in gully). Pipe closed at McLeans Beach caravan park driveway

FIGURE 1
COMMUNITY CONSULTATION COMMENTS

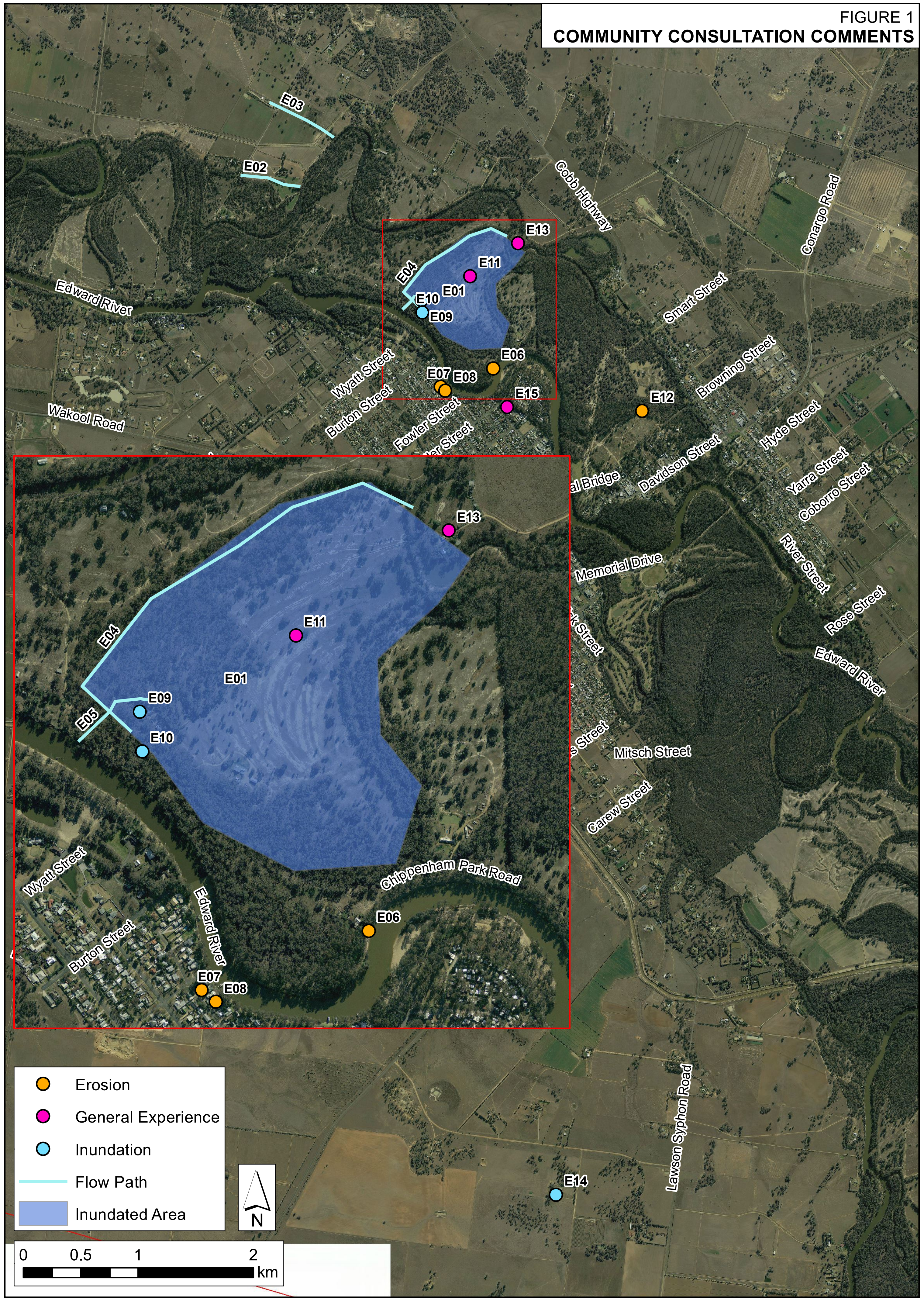

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FIGURE 2
WMAWATER SITE VISIT
NOVEMBER 24, 2016

Canoe Club (McLeans Beach)

McLeans Beach Caravan Park

National Bridge from left bank

Right bank taken from Beach to Beach Walk


McLeans Beach Caravan Park Levee


McLeans Beach Caravan Park Levee

McLeans Beach Caravan Park


McLeans Beach Caravan Park Levee


Pipe through South Deniliquin Levee

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FIGURE 3
RECORDED FLOOD LEVELS AND FLOOD EXTENT
DENILIQUIN
OCTOBER 2016 EVENT

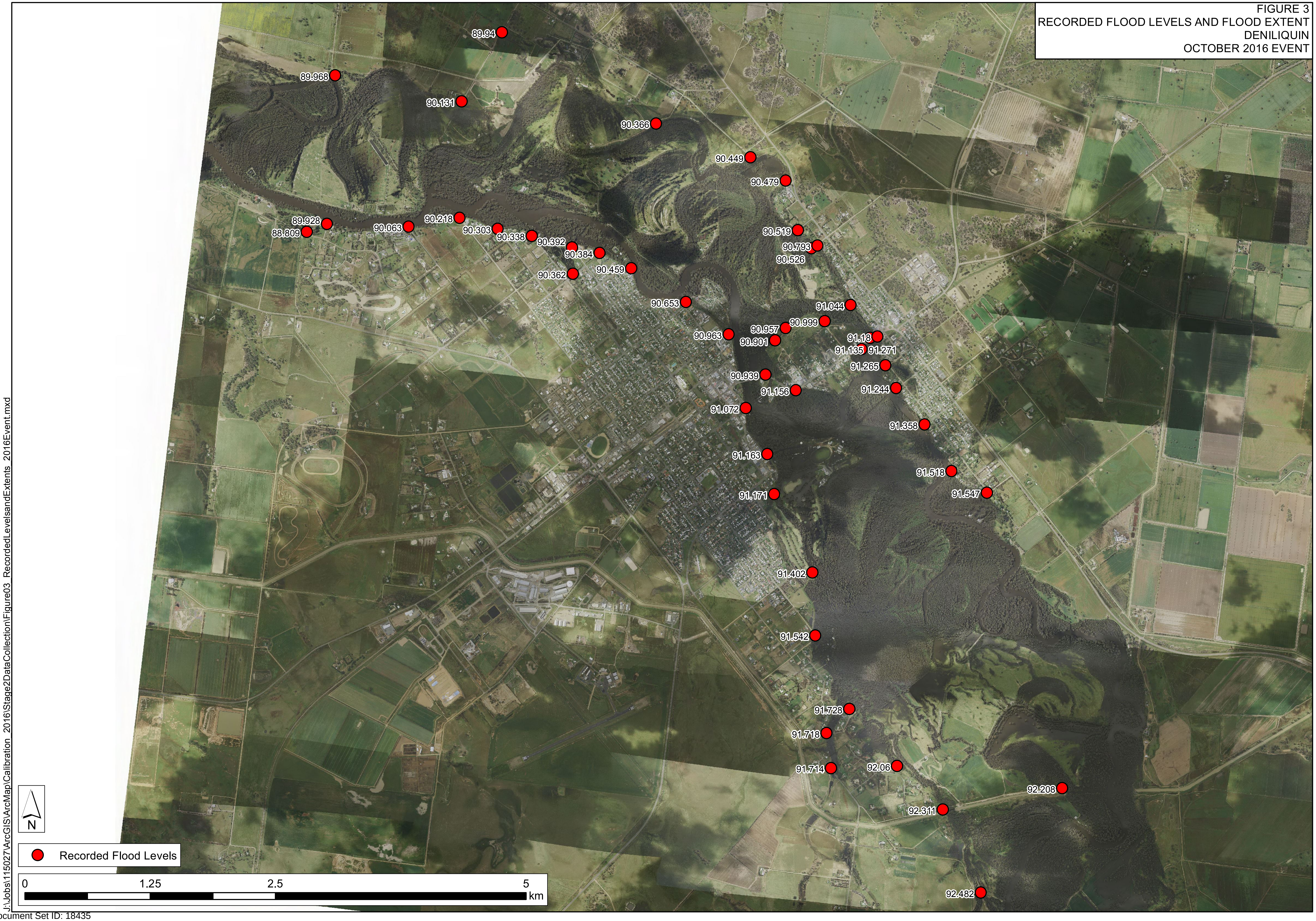

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FIGURE 4
MODEL VARIATIONS
DENILIQUIN
OCTOBER 2016 EVENT

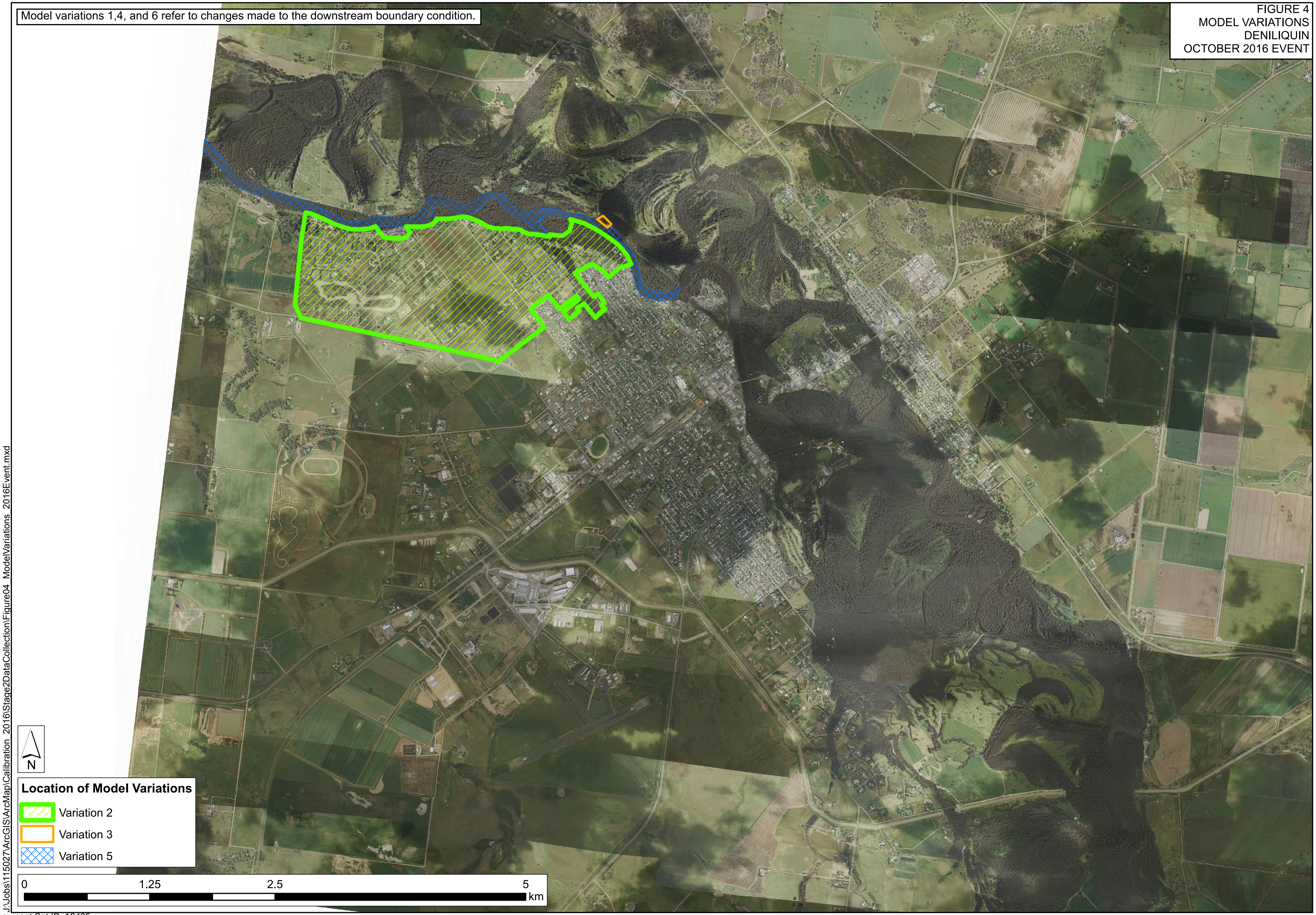

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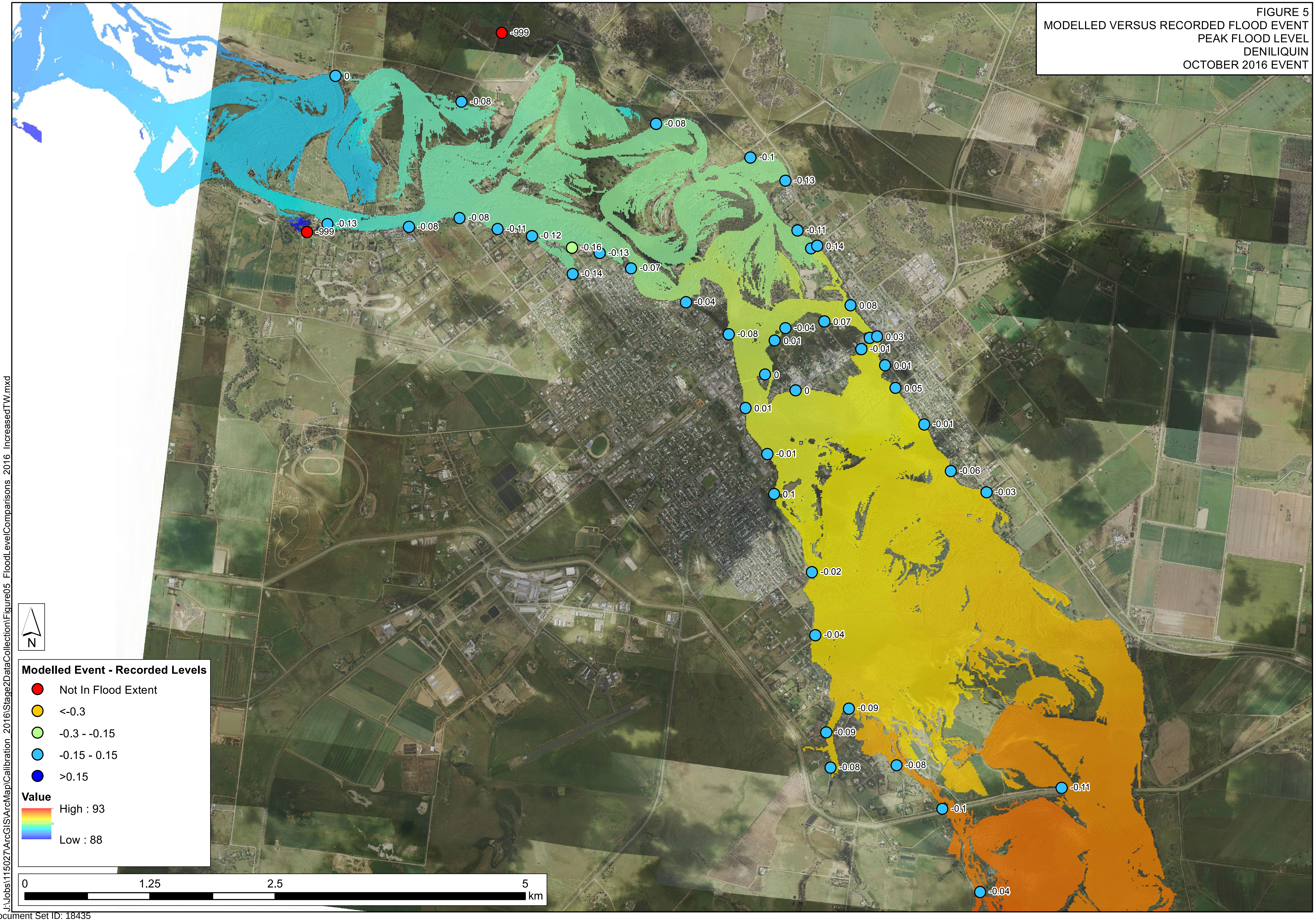
FIGURE 5
MODELLED VERSUS RECORDED FLOOD EVENT
PEAK FLOOD LEVEL
DENILIQUIN
OCTOBER 2016 EVENT



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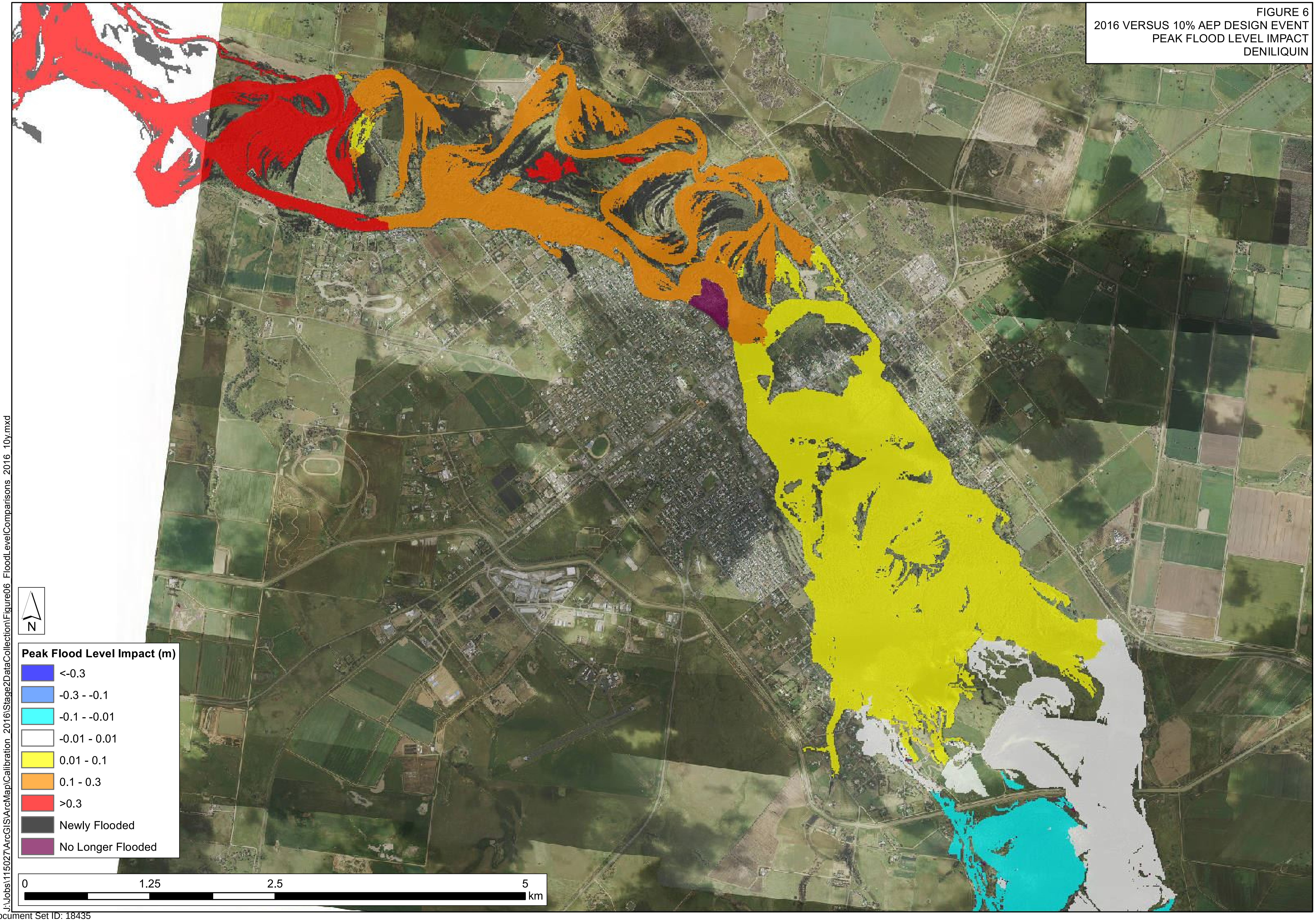

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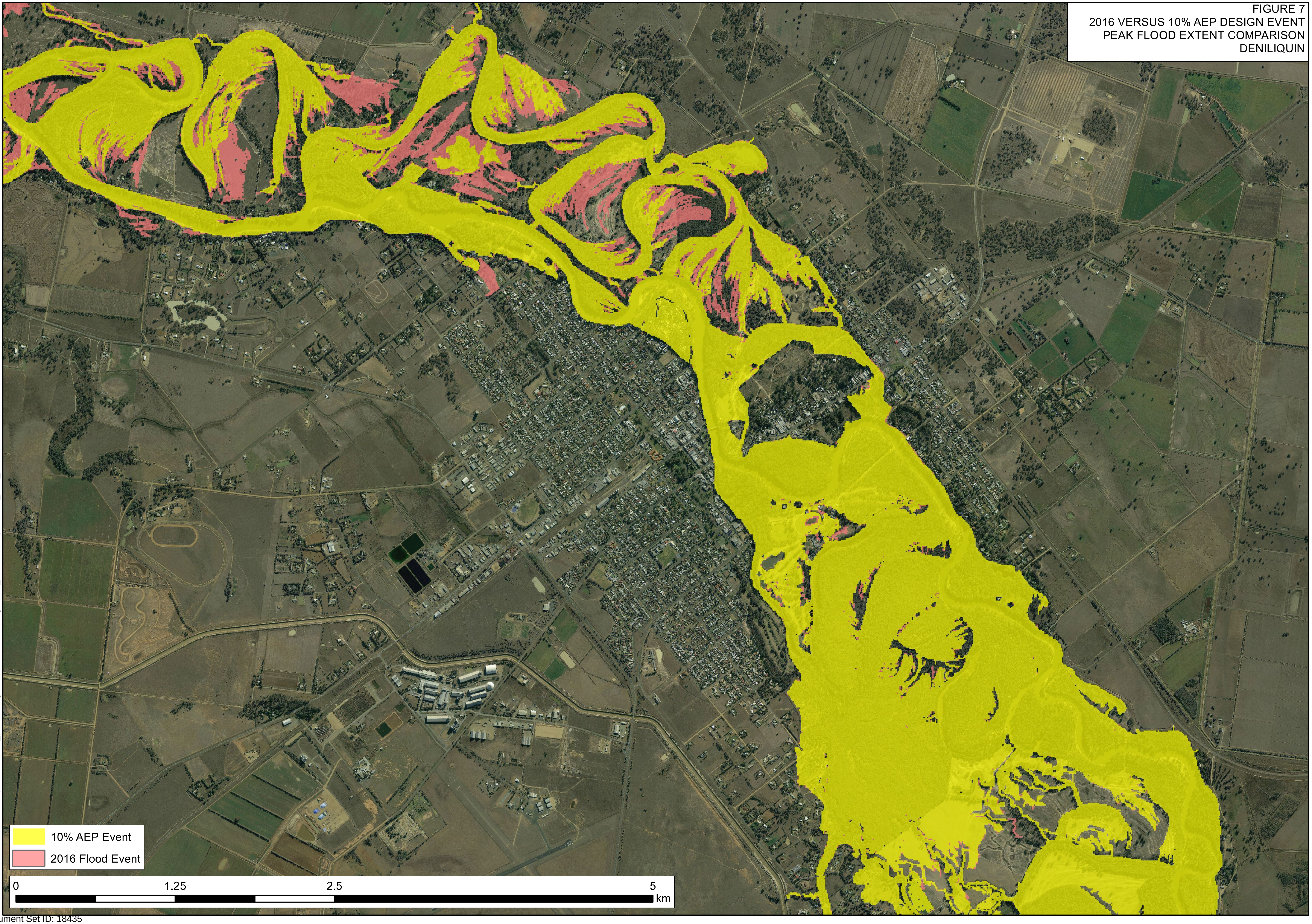

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Document Set ID: 18435
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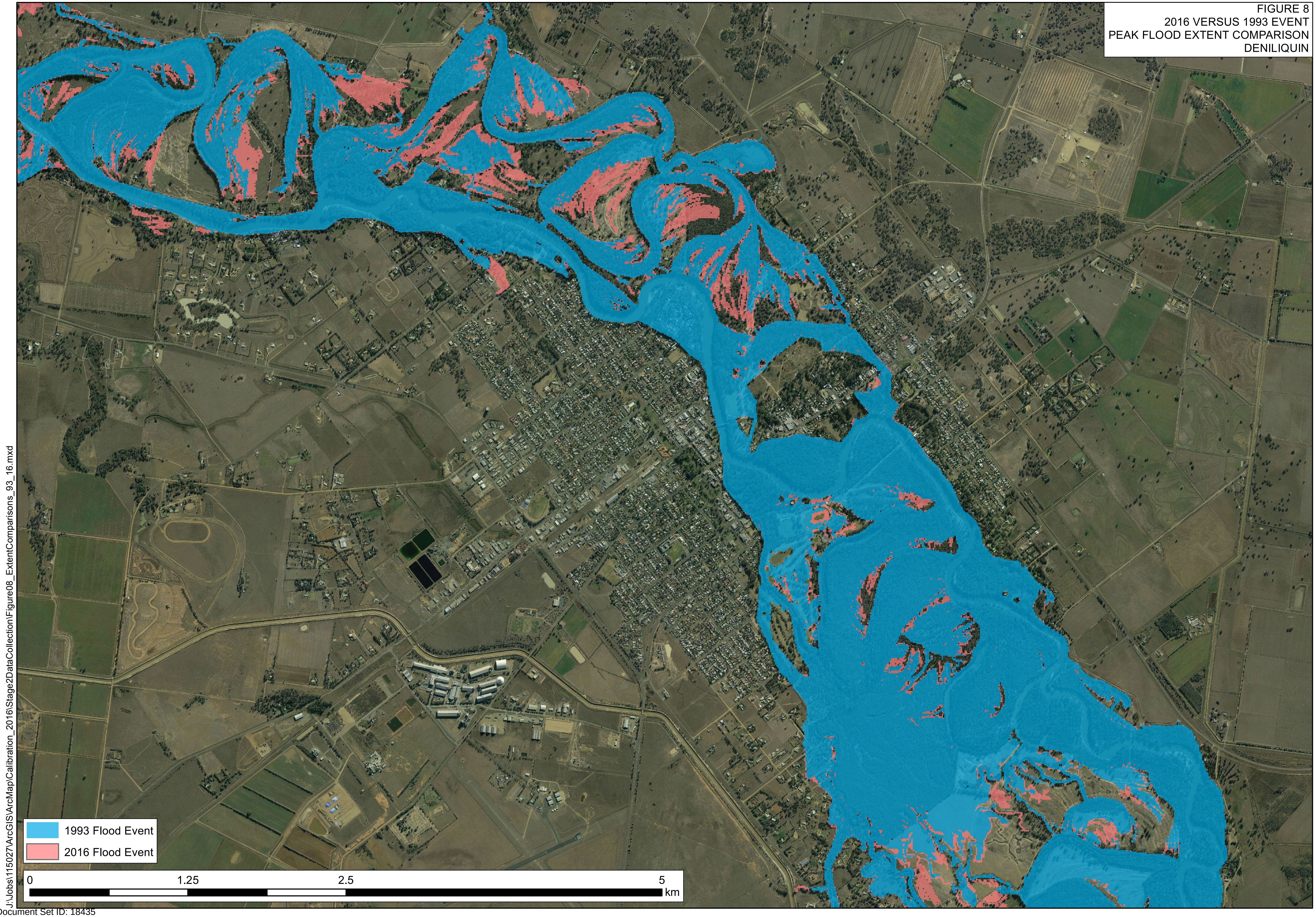

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Appendix A

Edward River COUNCIL

Current Flooding in Deniliquin
Community Information Collection
November 2016

Have you been impacted by flooding? We want to hear from you!

Edward River Council and the New South Wales State Emergency Service (SES) recorded the recent flood as it developed, and we need your input to ensure all information is effectively captured.

This data will be used to better prepare for future flood events, and confirm modelling produced in the 2014 Edward River at Deniliquin Flood Study.

What sort of information will be useful?

- Photos and videos (with time, date and location noted);
- Flood Marks (see overleaf);
- Description of where water went, e.g. where and when it overtopped a road or levee, if it flowed from the Edward River, Brick Kiln Creek, Aljoes Creek, or some other creek;
- Water depths around your home;
- If water went inside your house or any building on your property (depth and description of damage); and
- Whether you did any sandbagging or other temporary works around your property or a neighbour's.

Submissions must be received by Friday, 16 December 2016 and can be made by:

Post PO Box 270
Deniliquin NSW 2710

Email: Julie.rogers@edwardriver.nsw.gov.au

In-person: Julie Rogers, Edward River Council
Civic Place, Deniliquin or
122 End Street, Deniliquin

Website: www.edwardriver.nsw.gov.au

Public Meetings and Drop-In Sessions

Public meetings will be held on Wednesday, 23 and Thursday, 24 November 2016 at the Mountbatten Room, Deniliquin RSL. The meetings will run from 7.00pm - 9.00pm.

Two Drop-In Sessions will be held at the Central Murray Regional Library in Deniliquin. The first session will be held on Thursday, 24 November 2016 from 10.00am - 4.00pm, and the second will be held on Friday, 25 November 2016 and run from 9.30am - 11.00am.

Flood Event	Flow (ML/day)	Peak Flood Depth at Gauge (m)
20% AEP	51,800	7.0
October 1993	83,300	8.48
10% AEP	86,200	8.6
October 2016*	89,423*	8.62*
September 1955	110,900	8.95
November 1975	119,600	9.04
July 1956	154,100	9.37
5% AEP	120,200	9.4
October 1917	189,100	9.63
November 1870	200,500	9.68
2% AEP	160,800	9.9
1% AEP	190,400	10.1
0.5% AEP	209,500	10.2
PMF	561,500	11

ABOVE: The flow and peak flood depth of historical floods, as compared to the design floods assessed by the 2014 Flood Study.

* Recorded at 17/10/2016, not at peak.

ABOVE: Sandbagging at McLean Beach Caravan Park.

Flood Information and Images

Flood information and photos can be found on the following Facebook pages:

NSW SES Murray Region

The Deniliquin-Conargo SES Unit

Deniliquin History in Photos

Edward River COUNCIL

Current Flooding in Deniliquin
Community Information Collection
October 2016

How to record flood marks

Flood marks play a vital role in recording a flood event, marking the peak water levels at various locations. Flood marks are also used to validate hydraulic flood models. Flood marks from this flood will be used to confirm the model developed in the 2014 Flood Study.

The most useful thing to do is mark water levels or debris lines more permanently, so they can be surveyed in the future (possibly four weeks after debris has been cleaned up). This can be done by:

- Hammering a nail into a fence post, tree or telegraph poles at the peak flood levels; or
- Marking peak levels on houses with spray paint or duct tape.

If you can take photos:

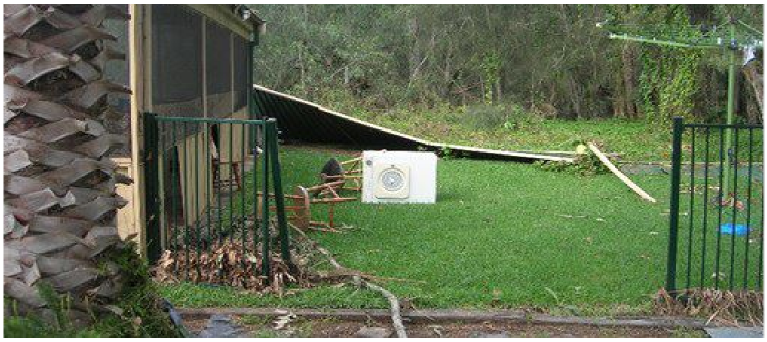
- Take photos of the depth of flooding (see Photo 1)
- Take photos showing the **exact depth above ground** using a tape measure (see Photo 2)
- Record the **location(s)** at which the flood mark is observed, e.g. mark on a map or GoogleEarth.
- Take photos of the extent of flooding and any damage on your property (see Photo 3).

Send your recorded flood marks and your contact details to Council.

PHOTO 1 (Above): Zoomed out photo showing extent of inundation. Include address, the side of the building, and date of the flood.

PHOTO 2 (Right): Zoomed in photo showing maximum water depth.

PHOTO 3 (Below): Flood extent and damage shown.



Enquiries and further information:

Julie Rogers
Manager Environmental Services
T: 03 5898 3000
E: julie.rogers@edwardriver.nsw.gov.au

Edward River Council
Civic Place (PO Box 270)
Deniliquin NSW 2710
council@edwardriver.nsw.gov.au
www.edwardriver.nsw.gov.au

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Appendix B

Deniliquin October 2016 Community Information Collection

The local knowledge of residents and business operators, and their personal experiences of flooding are an important source of information. In the aftermath of the October 2016 flood event, it is essential to collect accurate data about the extent, magnitude, and timing of the floods. This information is vital for understanding the flood risk, and for developing strategies for mitigating this risk in the future. Please provide any information you have about your experiences of the recent flooding in the following questions.

Council and SES have been recording the current flood as it develops, and need your input to ensure all information is captured. This will be used to better prepare for future flood events, and confirm modelling produced in the 2014 Flood Study.

Beach to Beach Walk from walkway at the corner of George St and Edwardes St (Photo taken 28th September 2016)

Deniliquin October 2016 Community Information Collection

All information provided is optional. Personal information will be stored by WMAwater and will not be disclosed to a third party. Respondents who wish to retract information can contact WMAwater, who will delete the relevant response.

1. Contact Information

Please note your contact details are optional, and will only be used to contact you for more information regarding this study.

Name:

Address:

Telephone:

Email:

2. Can we contact you directly for more information? It is very helpful if we can follow up to clarify the information provided (for example to obtain photographs).

- Yes
- No

3. How long have you lived at your current address?

- Less than 5 years
- 5 -10 years
- 10 - 15 years
- 15 - 30 years
- More than 30 years

4. How long have you lived in the area?

- Less than 5 years
- 5 -10 years
- 10 - 15 years
- 15 - 30 years
- More than 30 years

Deniliquin October 2016 Community Information Collection

This section is about any general flooding you observed in the most recent, October 2016 flood event. More specific questions about inundation of property will follow.

5. Where and when did you observe the October 2016 flooding? Please be as specific as you can about the time and the location.

6. Do you have any records of the October 2016 flooding, such as photographs or flood level marks on buildings, trees, posts, sheds which can be used to identify the height of the flooding? Tick all boxes which apply.

- [ ] Photographs during the flood (preferably with the time the photograph was taken)
- [ ] Photographs after the flood
- [ ] Flood level marks on buildings
- [ ] Flood level marks on trees, fences, signs or other semi-permanent structures

Other (please specify)

7. If you responded to Q6, please upload any records of the October 2016 flooding here:

If you have multiple images, please group them in a .doc or .pdf format and upload as one document. Alternatively, you can send them to the email or postal addresses provided at the end of the survey.

Choose File No file chosen

8. Can you describe where the water went? e.g where and when it overtopped a road or a levee, if it flowed from the Edward River, Brick Kiln Ck, Aljoes Ck or other creek.

◯ Yes

◯ No

If “Yes”, please include a specific location & description of where and when it was observed.

9. Did you observe inundation of roadways?

◯ Yes

◯ No

If yes, please provide details. Be as specific as possible about the location, the time, and the depth of inundation

Edward River COUNCIL

Deniliquin October 2016 Community Information Collection

This page relates to inundation of property from the most recent, October 2016 flood event. If the flooding did not affect your property or neighbouring properties on this event, please proceed to the next page.

10. Was your property affected by the October 2016 flooding?

- [ ] No
- [ ] Yes, above floor
- [ ] Yes, above garage/shed floor
- [ ] Yes, within backyard

If yes, please provide details below regarding the location, date and time of the flooding. Please be as specific as possible.

11. What type of property was affected?

- House
- Commercial Building
- Farm Land

Other (please specify)

12. Was any damage caused to the property?

◯ Yes

◯ No

Please give a brief description, including approximate depth of water and cost of damages.

13. In the most recent floods, have you done any sandbagging or other temporary works around your property or a neighbour's?

◯ Yes

◯ No

If "Yes", please include a specific location and description of what temporary works were completed.

Edward River COUNCIL

Deniliquin October 2016 Community Information Collection

Thank you for taking the time to complete this questionnaire.

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Additional records of the October 2016 flood event, including photos and videos, can be directly **uploaded** through the link below at **Question 15** of this survey.

Alternatively, they can also be sent to this email or postal address by 30th November 2016.

julie.rogers@edwardriver.nsw.gov.au

The General Manager, Edward River Council
PO Box 270, Deniliquin

If you would like to have items returned, please note this and the items will be returned at the conclusion of the data collection. Supplied photographs or other data may be reproduced in future flood study reports prepared for Council and/or the NSW state government. Please indicate whether you wish to receive credit for information supplied.

14. Please provide any other information you feel may be relevant to the October 2016 flood event.

15. If you have additional records of the October 2016 flooding, you can upload them here:

If you have multiple images, please group them in a .doc or .pdf format and upload as one document.

Choose File   No file chosen

Appendix C

PHOTO – LOCATION COMPARISONS

How to read this document:

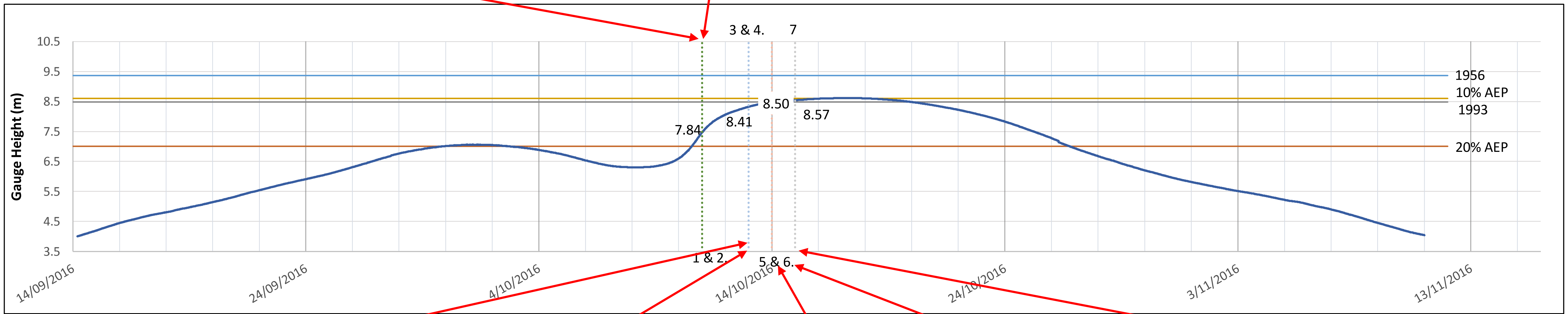
Aerial image: zoomed in over the area where the photos were taken

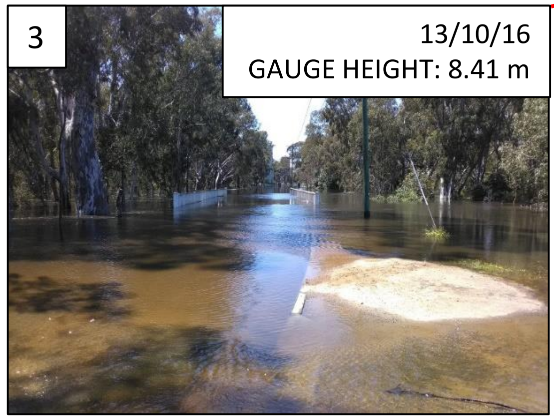
Hydrograph: shows how the river level changes during the flood. The dates when the images were taken are included.

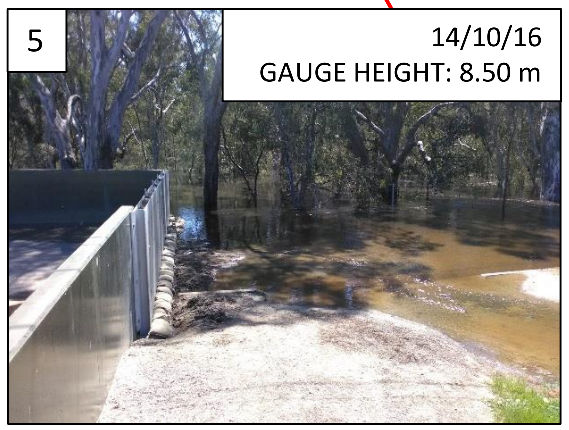
Images of the same location taken over different dates of the flood

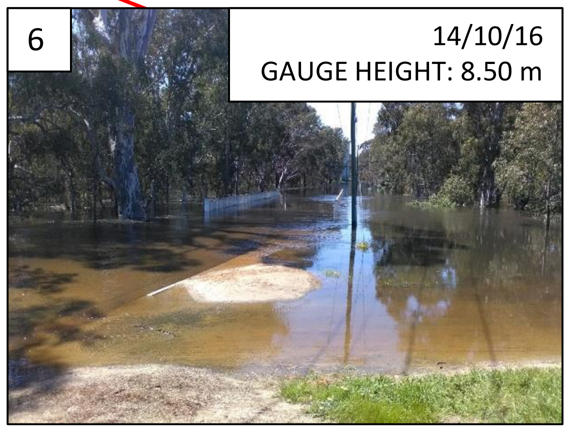
Aerial image of Deniliquin. Taken 30/07/2012

LOCATION: Memorial Drive Bridge near Sanctuary Lane







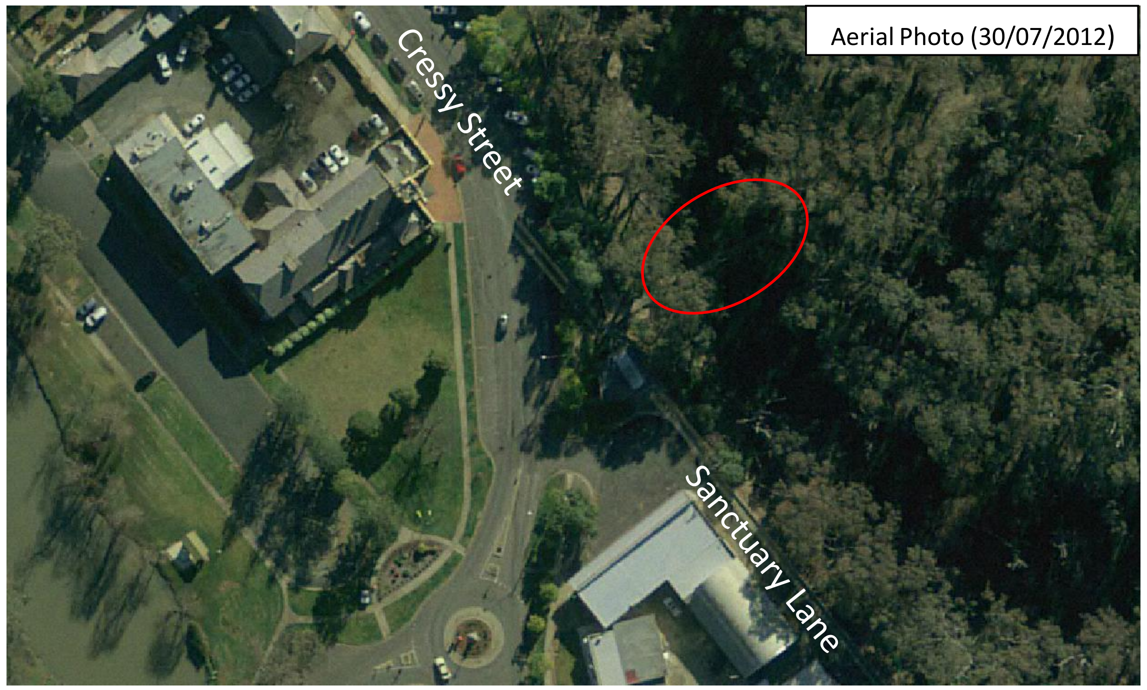


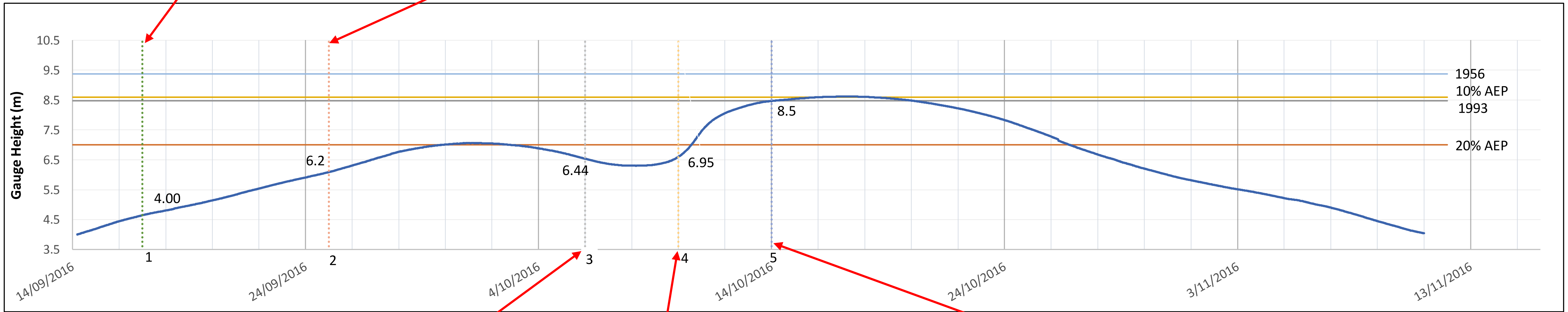
Edward River Hydrograph Gauge at Deniliquin (Gauge No. 409003). Gauge zero= 82.43 mAHD, for example 6m at the gauge equates to 88.43 mAHD

LOCATION: Island Sanctuary Footbridge near Cressy Street

1 13/9/16- 20/9/16 GAUGE HEIGHT: 4.003-5.23 m

2 25/09/16 GAUGE HEIGHT: 6.20 m





3 06/10/16 GAUGE HEIGHT: 6.44 m

4 10/10/16 GAUGE LEVEL: 6.95 m

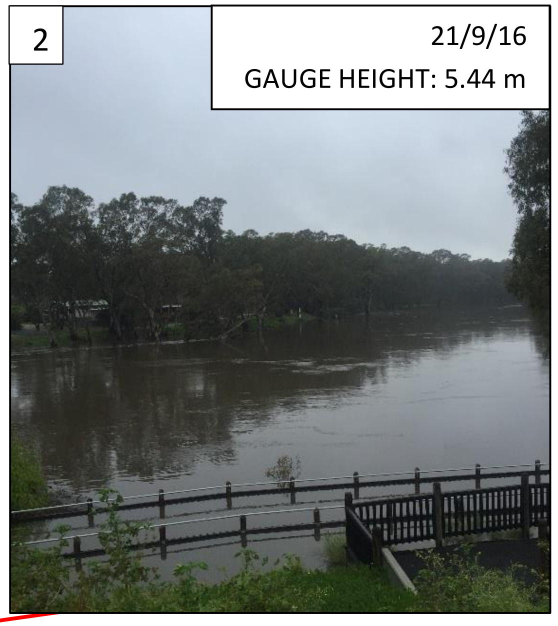
5 14/10/16 GAUGE LEVEL: 8.50 m

Edward River Hydrograph Gauge at Deniliquin (Gauge No. 409003). Gauge zero= 82.43 mAHD, for example 6m at the gauge equates to 88.43 mAHD

LOCATION: Edward River Beach to Beach Walk, corner of George Street and Edwardes Street

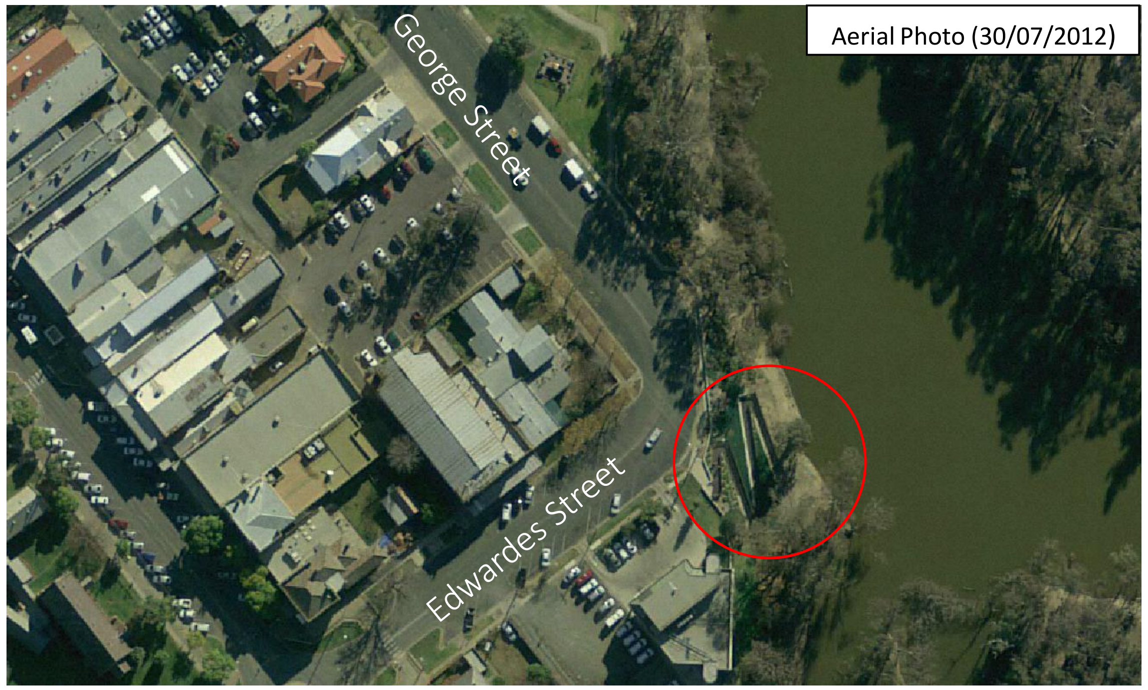
1

21/09/16
GAUGE HEIGHT: 5.44 m

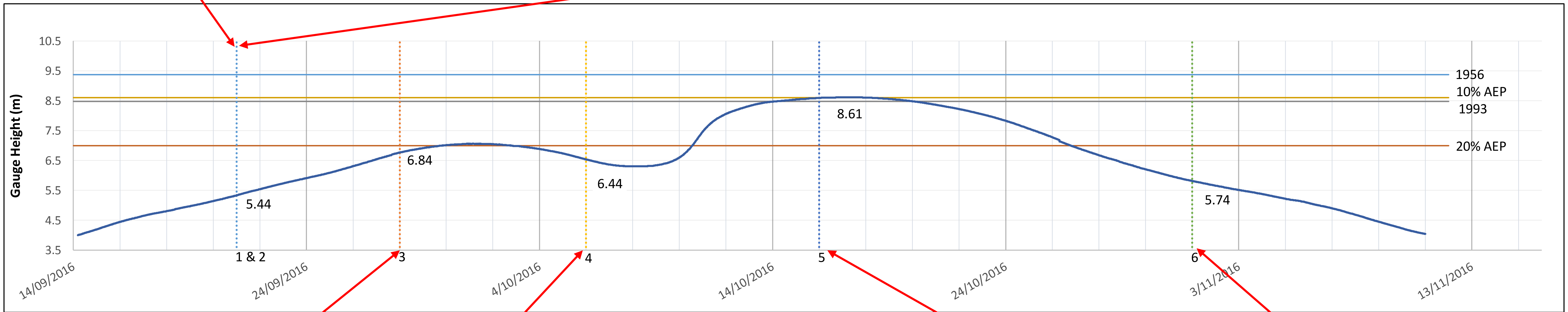


2

21/9/16
GAUGE HEIGHT: 5.44 m

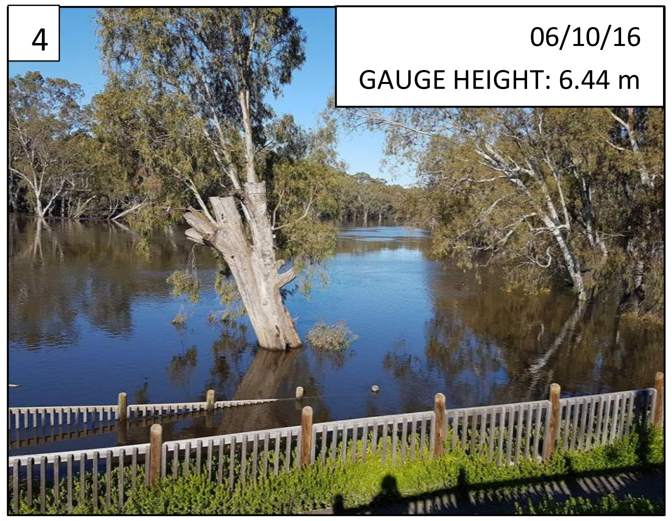


Aerial Photo (30/07/2012)



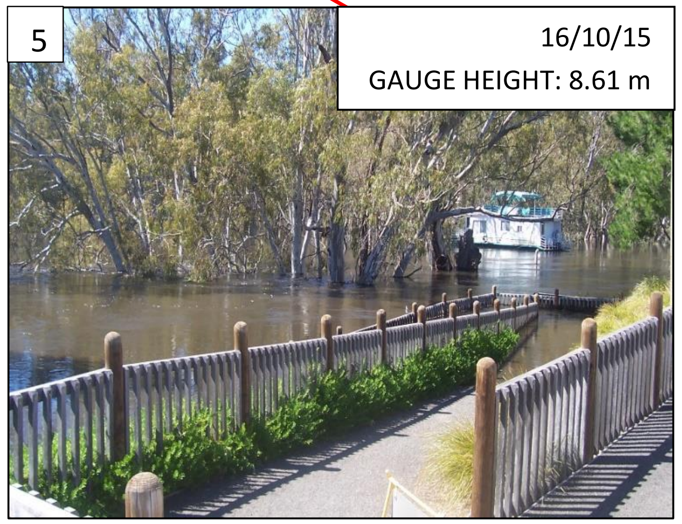
3

28/09/16
GAUGE HEIGHT: 6.84 m



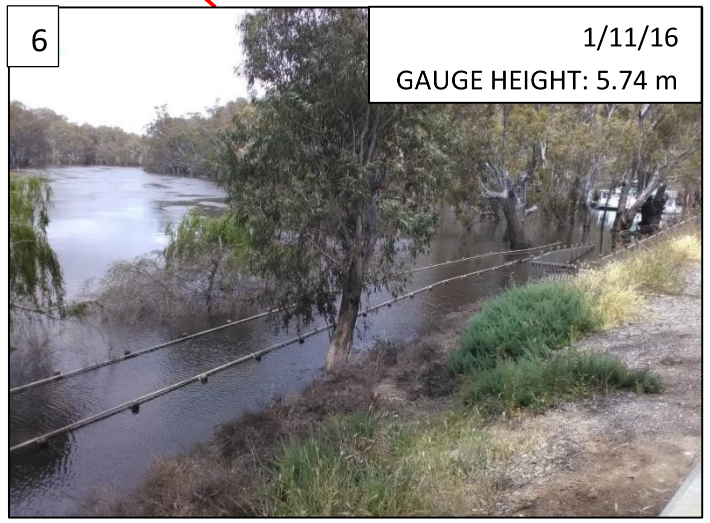
4

06/10/16
GAUGE HEIGHT: 6.44 m



5

16/10/15
GAUGE HEIGHT: 8.61 m

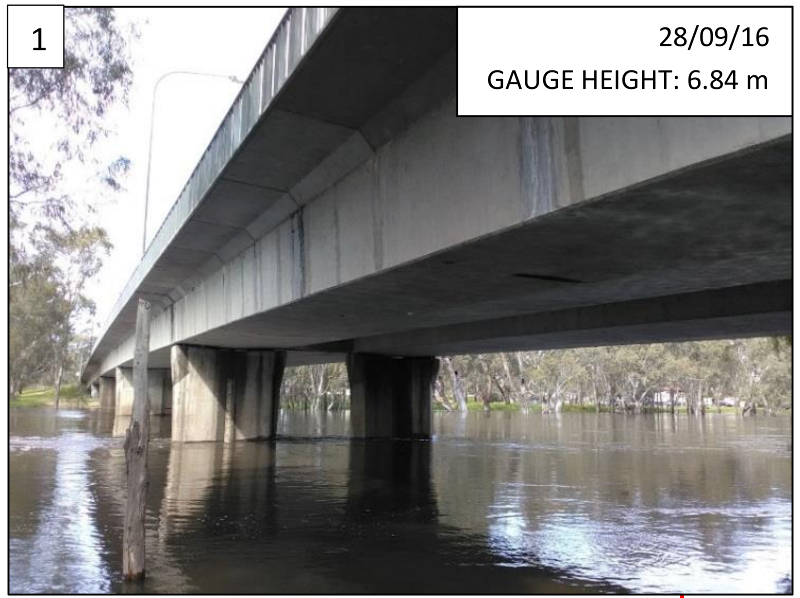


6

1/11/16
GAUGE HEIGHT: 5.74 m

Edward River Hydrograph Gauge at Deniliquin (Gauge No. 409003). Gauge zero= 82.43 mAHD, for example 6m at the gauge equates to 88.43 mAHD

LOCATION: Edward River at National Bridge, Cobb Highway

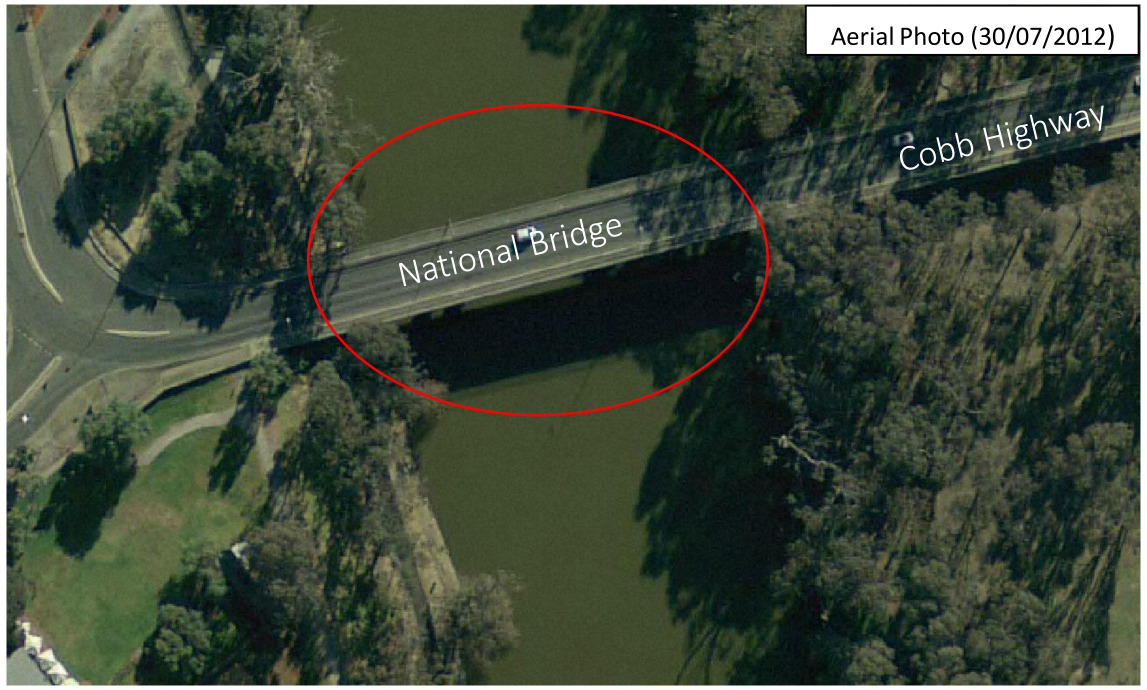


1

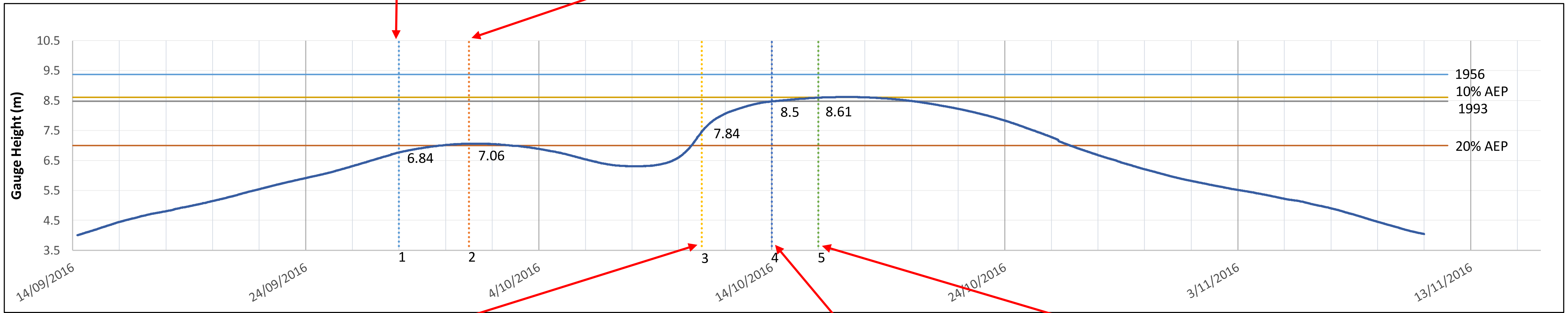
28/09/16
GAUGE HEIGHT: 6.84 m

2

01/10/16
GAUGE HEIGHT: 7.06 m



Aerial Photo (30/07/2012)



3

11/10/16
GAUGE HEIGHT: 7.84 m

4

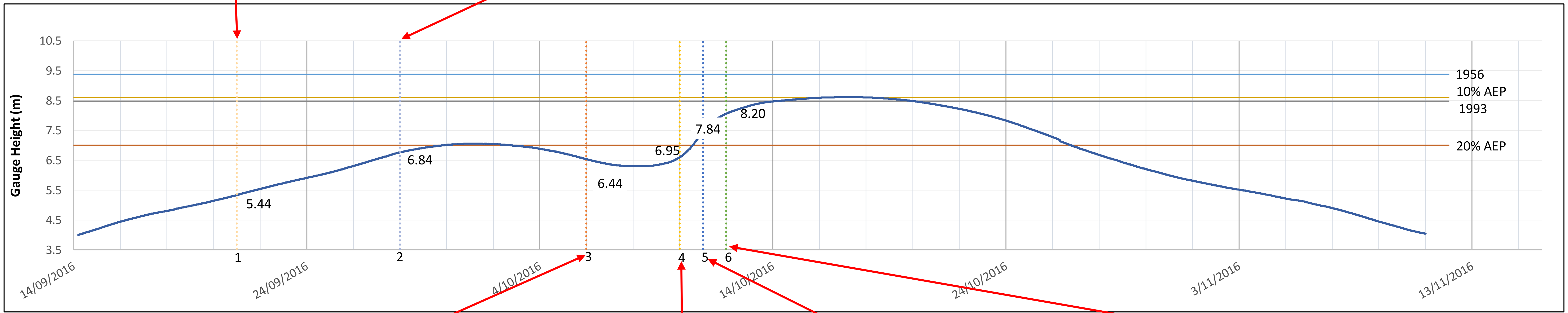
14/10/16
GAUGE HEIGHT: 8.50 m

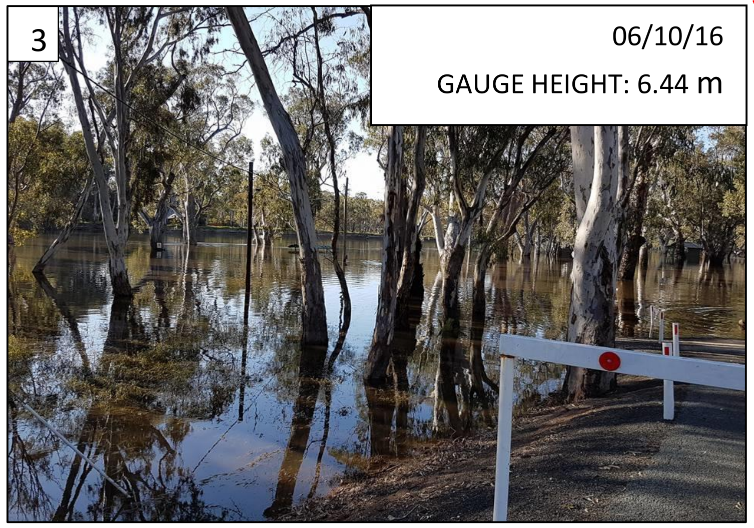
5

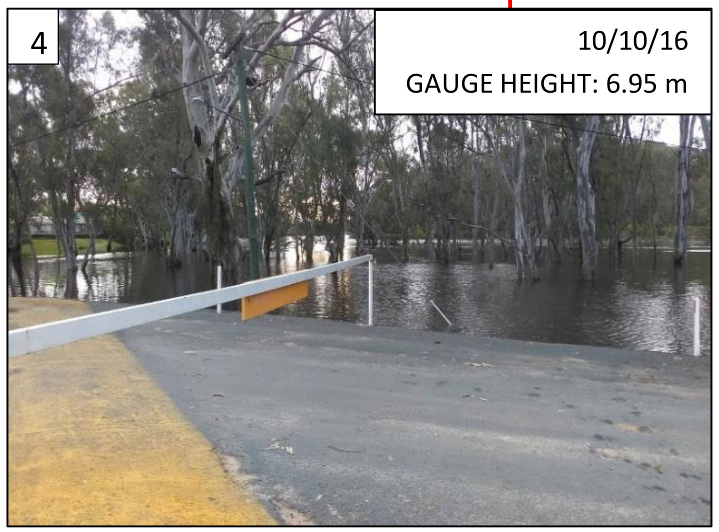
16/10/15
GAUGE HEIGHT: 8.61 m

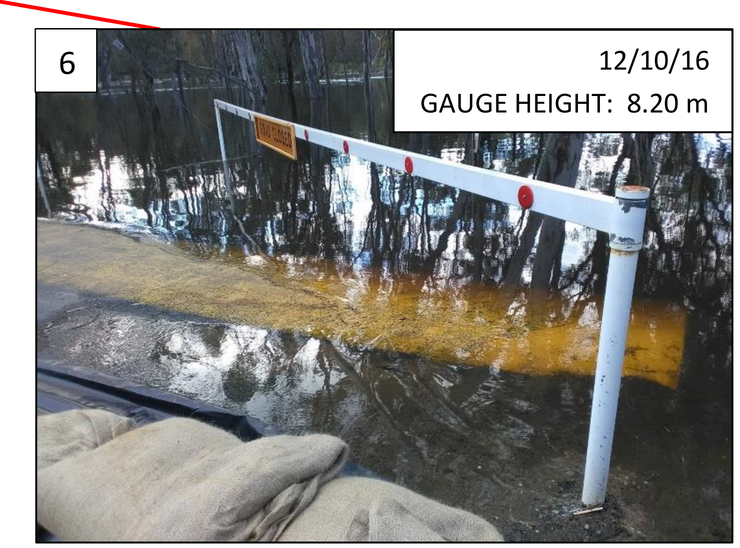
Edward River Hydrograph Gauge at Deniliquin (Gauge No. 409003). Gauge zero= 82.43 mAHD, for example 6m at the gauge equates to 88.43 mAHD

LOCATION: McLeans Beach Caravan Park Entry on Butler Street



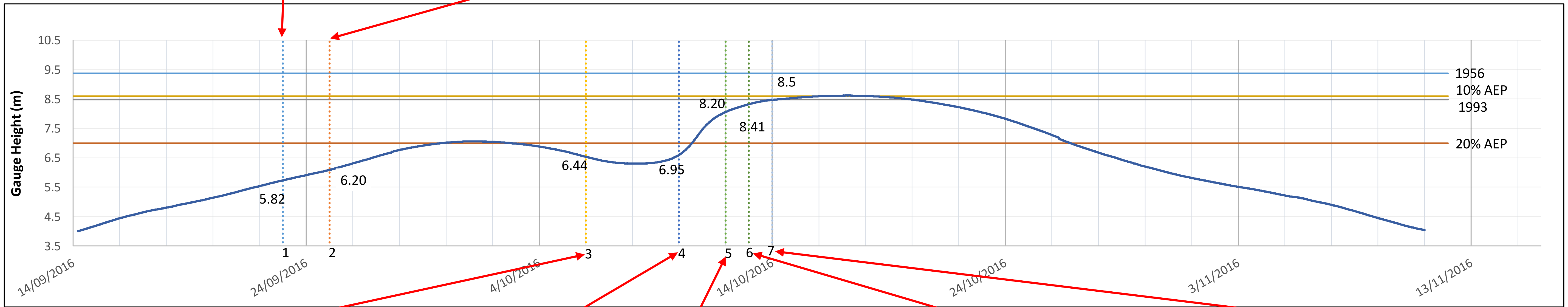


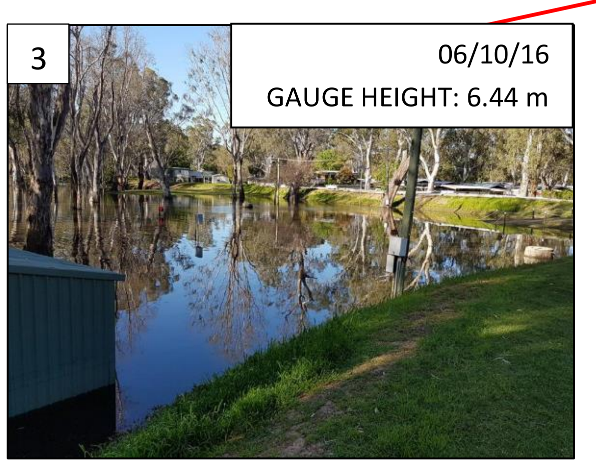


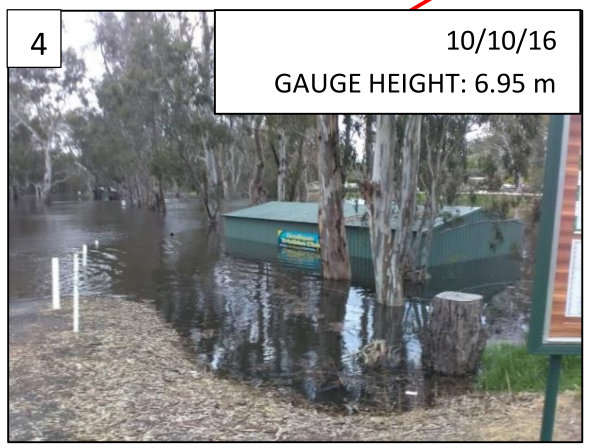


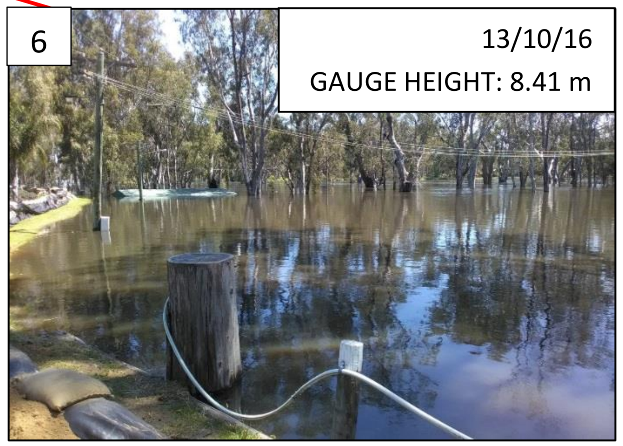
Edward River Hydrograph Gauge at Deniliquin (Gauge No. 409003). Gauge zero= 82.43 mAHD, for example 6m at the gauge equates to 88.43 mAHD

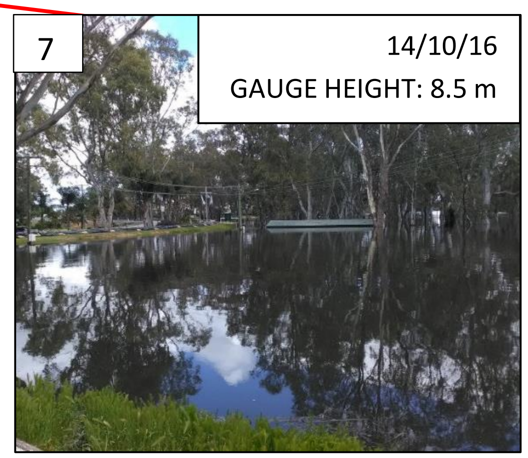
LOCATION: McLeans Beach Canoe Shed near Butler Street











Edward River Hydrograph Gauge at Deniliquin (Gauge No. 409003). Gauge zero= 82.43 mAHD, for example 6m at the gauge equates to 88.43 mAHD

APPENDIX D. INTRODUCTION

This appendix records the notes made during interviews between WMAwater and Council staff regarding the October 2016 Flood Event.

D.1. John Stammers

Name	Jon Stammers	Date of Interview	23/11/16
Usual Role	Water and Sewer Engineer (2.5 years with Deniliquin Council)		
Role during flood	Water and Sewer Engineer, with instructions from Mark Dalzell Recorded river levels from BOM in an Excel spreadsheet Self-Directed checks of sewer pump stations		
General Comments	All went fairly well McLeans Beach was evacuated and sewer pump station was switched off. Mark Dalzell guided all operations.		
Comments regarding Community Members	There were some complaints from community, with a few concerned that they would be inundated. Lots of ‘rubberneckers’ (especially at McLeans Beach) Community responded well to evacuation notices issued by SES. Council did not issue evacuation notices. Outside staff knew problem areas and low spots and swung into action		
Most impacted areas	McLeans Beach, McLeans Beach Caravan Park, Memorial Park and Golf course Some properties in the Wakool Road area impacted		
Sandbagging	McLeans Beach Levee (along the whole levee) along with volunteers, SES and Council staff.		

D.2. Steve Wilson

Name	Steve Wilson	Date of Interview	23/11/16
Usual Role	Projects and Assets Officer (Survey and Design)		
Role during flood	Minimal role in the lead up Recorded levels around caravan park levee (survey) using RTK GPS with the CORSnet in town. Organised the flying of aerial photography and ECW – Flew on Sunday but too cloudy, flew again on Monday. Instructions were taken from Mark Dalzell.		
General Comments	Catchment primed since March Sandbagging around McLeans Beach because the predicted peak was 'borderline' – they had the opportunity and resources to save the caravan park and reduce damages, insurance issues and clean-up costs. Flood intelligence sheets worked well. When the water level rose from 8 m to 8.5 m this caused the most change in landscape and covered a larger area, for example at the end of Henry St and Carew St. There was a fair bit of seepage through levee, though no levee audit is proposed at this stage. Seepage noted across the road from RSL near Memorial Park and McLeans Beach Levee.		
Comments regarding Community Members	Steve had minimal interaction with community. Community perception of the flood: blasé, disbelief about predicted gauge heights, doubtful. Some confusion regarding "gauge height" and how it was different upstream and downstream. Better understanding of RL (mAHD) as floor levels were generally known in mAHD, and RLs could be correlated to an actual place (e.g. their property).		
Impacted areas	The corner of Rose and River St (North Deniliquin) culvert was sealed (with dirt and plastic) as the table drain was found to be backwatering. Design underway to replace with a proper pipe with floodgate. Lots of flowpaths down through Dahwilly Road and Boggy Creek Road, there is possibly a missing culvert in the model. Pipe blowout in the Davidson Street Levee		
Sandbagging	McLeans Beach levee raised up to 300 mm with clay fill, then sandbagged on top (up to 500 mm). The McLeans beach levee was constructed in 1992 and had settled/ slumped from the original design level.		
Data Provided	ECW (Aerial imagery at peak – 17/10/16) Tab file of flood levels, including where there was water on the road around Boggy Creek Road, Dahwilly Road, and Phylands Lane. Some points added to GoogleEarth layer		

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D.3. Shannon Williams and Mick Maher

Name	Shannon Williams and Mick Maher	Date of Interview	23/11/16
Usual Role	Water and Sewer Leader and Operator (Outdoor Team)		
Role during flood	Whatever needed to be done. Instructions from Macca (Tony Oddy) Work through Flood Intelligence Card, respond to public requests		
General Comments	Initially not very well organised, about a week late, chasing tails Made a list of extra actions (provided to WMAwater) Lots of open drainage pipes Gates needed – current infrastructure was either not working or hadn't been tested Blow-up bungs used in a number of drainage pipes with missing/ non-functional gates (in Riverside Caravan Park) Council infrastructure needs improvement and upgrades - A "Massive Overhaul" of flood gates is needed. Tracking predicted flood levels was undertaken. Mark Dalzell called 4-5 meetings of everyone from managers to supervisors, which were helpful. Temporary levee walls would have been useful in preference to sandbags (lots of man hours, some seepage). The manual/paperwork for the flood gate installation was missing, some issues with installation If the flood had been much higher they would've lost McLeans Beach and the east end of town. It got close to the level that would have required much more effort and extra resources would have been needed. Lots of lost time – 6-7 blokes, few hours on each drainage pipe to be closed (at least 4 phone calls if gate was missing or did not close properly). Shortage of blowup bungs. Suggest ongoing maintenance/ upgrade of all drainage pipes.		
Comments regarding Community Members	Community were generally positive, could see the Council efforts, and were really happy. However there were several issues not on list (flood intelligence card) or that Council thought had been addressed (e.g. a gate not fully closing) Some people were inconvenienced, but did not experience major impacts. One lady was however very stressed and they appeased her concerns by sandbagging her house.		
Sandbagging	Outside staff generally hung around after their normal work hours to help out.		
Data Provided	Annotated Council Flood Intelligence cards, notes of extra actions (these have been added to intel card).		

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D.4. Tony Oddy

Name	Tony Oddy	Date of Interview	19/12/16
Usual Role	Civil Works Supervisor		
Role during flood	Supervising the outside team, Mark Dalzell giving direction with input from outside team. Frequent briefing meetings with Mark and other council staff.		
General Comments	• ‘Flood Response Plan’ table worked well; • Rapid rate of rise overnight meant they fell behind schedule; • Some issues with older pipe gates not sealing properly, taking extra time and resources to close effectively – 4 or 5 upgrades required urgently; •		
Comments regarding Community Members	• Only had direct interaction with McLeans Beach caravan park owners, especially during sandbagging efforts. They were happy with his efforts.		
Impacted areas	• Caravan parks; • East end of town (outside levee).		
Sandbagging	• Made their own sandbagging machine; • No sandbags initially supplied by the SES;		
Data Provided	*N/A*		
Other comments	Confusion about ‘unauthorised sandbagging’ according to SES, whereas Council has better local knowledge and knows what needs protecting better than SES (often) from out of town. The event was completely different to that of 1993, especially that the SES took a much more active role. Confusion about “decommissioned” state of Davidson Street Levee. Commented on the tennis courts constructed on Jones Avenue which took 0.5 m off the levee in that area.		

Appendix E

EDWARD RIVER COUNCIL

DENILIQUIN FLOOD UPDATE # 1

Date: Tuesday, 27 September 2016

Time: 9:00 am

FLOOD CONDITIONS

	Time & Date	River Height (gauge height)	Flood Status
Current River Height	7am, Tuesday, 27/09/16	6.61m	Minor
Expected River Height	Friday, 20/09/16	7.5m	Moderate

Latest Bureau of Meteorology flood warning information is attached.

LOCAL EMERGENCY MANAGEMENT OPERATIONS AND EMERGENCY OPERATIONS

The Emergency Operations Centre for Deniliquin has not been activated. LEOCONs and LEMOs have been requested to remain contactable.

SES are currently reviewing flood information and are on stand by.

FLOOD ISSUES – DENILIQUIN

McLean Beach Caravan Park

27/09/16 - Lease for caravan park notes that park to be closed once the river reaches a level of 7.0m (anticipated by Thursday, 29/09/16). Survey of the existing levee on 23/09/16 shows minimum height of levee to be 8.2m.

Based on a levee height of 8.2m, Council has determined that evacuation of the caravan park shall commence once the river height reaches 7.7m. Any evacuations shall be done in conjunction with SES.

Pumping of local drainage water has been undertaken in the low gully area between the caravan park and Charlotte Street.

Action: (Mark Dalzell) Contact SES and caravan park owners regarding the revised river level for evacuation of the park.

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Riverside Caravan Park

27/09/16 - SES flood intelligence notes that access to areas within the park are cut-off at a river height of 7.4m

Action: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert.

Lagoon Culvert behind Bowling Club (Eastern end of system) – Close @ 5.8m

27/09/16 – Water is not entering culvert from the river. Currently being monitored.

Action: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert.

Lagoon Culvert along Wyatt Street (Western end of system) – Close @ 6.4m

27/09/16 – Water is not entering culvert from the river. Currently being monitored. Anticipated closure on 27/09/16.

Action: (Tony Oddy) Continue monitoring water levels.

Culverts through Levee – South Deniliquin

27/09/16 – The following culverts have been closed:

- Butler Street, 30m outside levee. Drainage pump currently in place for local run-off.

Culverts through Levee – Davidson Street area

27/09/16 – The following culverts have been closed:

- Nil.

Culverts through Levee – North Deniliquin

27/09/16 – The following culverts have been closed:

- Boyd Street at Brick Kiln Creek;
- Hyde Street at River Street.

ROAD CLOSURES

The following roads have been closed due to flooding or local rainfall events:

- Lawson Syphon Road at # 494;
- Smart Street / Chippenham Park Road, between Edward River Oval and intersection of Chippenham Park Road and Smart Street;
- Poictier Street, river end;

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- Harfleur Street, river end;
- McLean Beach; and
- All public boat ramps

COMMUNITY ADVICE AND INFORMATION

Media Releases

27/09/16 - No media releases have been issued by Council regarding this incident.

Action: (Mark Dalzell) Prepare media release, in conjunction with SES, for approval and publication.

Website

27/09/16 - Website currently has no information relating to the current event.

Action: (Mark Dalzell/Cian Middleton) Update website once media release has been approved.

Facebook and Social Media

27/09/16 - No post have been made on Facebook regarding the event.

Action: (Mark Dalzell/Cian Middleton) Update Facebook once media release has been approved.

SES Updates

Latest SES Update is attached.

ANTICIPATED ISSUES

It is anticipated that the following actions shall be required during the next 48 hours (based on an anticipated river height of 7.2m on Thursday, 29/09/16):

- Review of status of McLean Beach caravan park in relation to closure of the park;
- Close off culverts at the following locations:
    - Herriott Street near old brick works (6.68m);
    - Wanderer Street near Shell service station (6.70m);
    - Crispe Street near Deni Car-o-tel park (6.88m);
    - Crispe Street behind Middies Electrical; (corner of End Street and Crispe Street) (6.98m);
    - 278 River Street (7.18m)

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- o Davidson Street opposite Herriott Street (7.18m).

GENERAL ISSUES

Material and Stores

27/09/16 - Discussion by staff regarding Councils readiness for flood action. This includes stores of sand bags, sand, plastic, drainage pumps and signs.

Action: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs.

Action: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company.

Financial Task Numbers

27/09/16 - All costs incurred Council staff relating to the flood event, including labour, plant and materials, shall be booked to the following Operational Task Number

- OP1869.

NEXT MEETING

The next meeting shall be at 2pm on Thursday, 29/09/16.

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Australian Government
Bureau of Meteorology

IDN36629

Australian Government Bureau of Meteorology **New South Wales**

MINOR TO MODERATE FLOOD WARNING FOR THE MURRAY AND EDWARD RIVERS

Issued at 6:03 pm EST on Monday 26 September 2016

Flood Warning Number: 39

Minor rural flooding is easing around Corowa and minor flooding at Tocumwal.

The Murray River at Barham is rising slowly and moderate flooding continues.

Minor flooding continues along the Edward River at Deniliquin and moderate flooding at Stevens Weir.

Predicted River Heights/Flows:

Torrumbarry

- reach 7.5 metres around Wednesday [28/09/16] with minor flooding

Barham

- reach 5.9 metres around Wednesday [28/09/16] with moderate flooding

Deniliquin

- reach 7.5 metres around Friday [30/09/16] with moderate flooding.

Stevens Weir

- reach 6.5 metres around Saturday [01/10/16] with moderate flooding.

Moulamein

-reach 5.0 metres around 06/10/16 with minor flooding

FloodSafe advice is available at www.ses.nsw.gov.au

For emergency assistance call the SES on telephone number 132 500.

For life threatening emergencies, call 000 immediately.

Weather Forecast:

For the latest weather forecast see www.bom.gov.au/nsw/forecasts/

Next Issue:

The next warning will be issued by 11am Tuesday [27/09/16].

Latest River Heights:

Location	Height of River	Date/Time of Observation
Murray R at Albury	3.46m steady	05:00 PM MON 26/09/16
Murray R. at Corowa	5.75m steady	05:00 PM MON 26/09/16
Murray R at Yarrawonga Weir D/S	6.05m steady	05:00 PM MON 26/09/16

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Location	Height of River	Date/Time of Observation
Murray R at Tocumwal	6.49m steady	02:45 PM MON 26/09/16
Edward R at Deniliquin	6.47m steady	05:00 PM MON 26/09/16
Edward R D/S Stevens Weir	6.2m steady	05:00 PM MON 26/09/16
Edward R at Moulamein	4.33m steady	05:00 PM MON 26/09/16
Murray R. at Echuca Wharf	91.76m steady	02:30 PM MON 26/09/16
Murray R at Barham	5.83m steady	05:00 PM MON 26/09/16
Murray R at Swan Hill	3.77m steady	02:30 PM MON 26/09/16
Murray R. at Wakool Junction	7.29m steady	02:30 PM MON 26/09/16
Murray R. at Boundary Bend	6.07m steady	02:30 PM MON 26/09/16
Murray R at Wentworth Lock 10	29.65m steady	05:00 PM MON 26/09/16

For latest rainfall and river level information see

www.bom.gov.au/nsw/flood/

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Mark Dalzell

From: Owen Plowman <plow1owe@police.nsw.gov.au>
Sent: Monday, September 26, 2016 4:08 PM
To: Scott Fullerton; abutler@urana.nsw.gov.au; adrenovski@balranald.nsw.gov.au; ajardine@carrathool.nsw.gov.au; along@ambulance.nsw.gov.au; Andrew Robertson; Andrew Spliet; anne.roser@griffith.nsw.gov.au; Anthony Reneker; barryh@leeton.nsw.gov.au; bartonw@junee.nsw.gov.au; Benjamin Clavel; Bernard Nix; Bernard.kates@one.ses.nsw.gov.au; bpurves@ambulance.nsw.gov.au; Bradie Logue; Brett Roden; bruce.mcbean@narrandera.nsw.gov.au; cdore@blandshire.nsw.gov.au; Craig Johnson; Craig N Middleton; craig.bretherton@epa.nsw.gov.au; craig.mcintyre@one.ses.nsw.gov.au; David Noble; David.buchtmann@ses.nsw.gov.au; Debbie.bickerton@gwahs.health.nsw.gov.au; Denise.garner@gsahs.health.nsw.gov.au; denis.gelle@jerilderie.nsw.gov.au; Dennis.shrimpton@facs.nsw.gov.au; Des Bilske; dts@murrumbidgeeshire.com.au; dwebb@lockhart.nsw.gov.au; -M-MDL-EMU; epurcell@ambulance.nsw.gov.au; Evan Quarmby; few1sha@; frede@berriganshire.nsw.gov.au; fred.hammer@narrandera.nsw.gov.au; Fred.spain@finance.nsw.gov.au; Garry.tye@fire.nsw.gov.au; Gary Worboys; gblackie@greaterhume.nsw.gov.au; Giles.butler@dpi.nsw.gov.au; gm@murrumbidgeeshire.com.au; gmcgrath@tumbashire.nsw.gov.au; gneyland@blandshire.nsw.gov.au; Jakeb Ellis; jgregory@hay.nsw.gov.au; Jodie Marshall; John Wadsworth; jon.gregory1 @one.ses.nsw.gov.au; Juay Brown; Karen.cairney@gsahs.health.nsw.gov.au; kell3dar@police.nsw.gov.au; Kenneth Dale; Kenneth.murphy@fire.nsw.gov.au; Ken.hall@rfs.nsw.gov.au; Kevin.adams@rfs.nsw.gov.au; Kim Sorensen; Kim Traynor; Kristie Ryan; Leslie Hyne; Lindsay.lashbrook@rfs.nsw.gov.au; longmores@junee.nsw.gov.au; manjit.chugha@griffith.nsw.gov.au; Mark Wall; Mark Dalzell; Michael Rowan; Michael Strachan; moliver@greaterhume.nsw.gov.au; mylesh@berriganshire.nsw.gov.au; Narelle Tucker; Narelle.Wren@transport.nsw.gov.au; Nicholas Seddon; nichole.richardson@one.ses.nsw.gov.au; Nick.turner@rfs.nsw.gov.au; nigel.sutton@corowa.nsw.gov.au; nogilvie@temora.nsw.gov.au; Patrick.westwood@rfs.nsw.gov.au; Paul Condon; Paul Lloyd; Paul W Jones; Paul.harding@facs.nsw.gov.au; paul.hogan@mpes.nsw.gov.au; Peter 1 Robertson; Peter M McLaughlin; Peter Mclay; pmullins@snowyvalleys.nsw.gov.au; rblazejak@ambulance.nsw.gov.au; rc.mon@marinerescuensw.com.au; revell.peter@wagga.nsw.gov.au; Roger.orr@rfs.nsw.gov.au; schalmers@alburycity.nsw.gov.au; Scott J Russell; secretary@rescue.org.au; sitrep@seoc.nsw.gov.au; sjones@lockhart.nsw.gov.au; smillett@alburycity.nsw.gov.au; Stanley Wall; steve.holden@rfs.nsw.gov.au; swilson@carrathool.nsw.gov.au; tkelly@coolamon.nsw.gov.au; Tony.burns@gsahs.health.nsw.gov.au; Tracey.oakman@gsahs.health.nsw.gov.au; trish.malone@one.ses.nsw.gov.au; Trudi.mcdonald@dpc.nsw.gov.au; Wendy.McPherson@dpc.nsw.gov.au; William.sayer@fire.nsw.gov.au; "youm1ian@police.nsw.gov.au, wood1win@police.nsw.gov.au, <youm1ian"@PHQDVIMS1.police.nsw.gov.au
Cc: Craig Bowra
Subject: Re: EM Update 26/09/2016 - Riverina Murray EM Region Rainfall Event & NSW SES Operations [DLM=For-Official-Use-Only]

EM Update - Riverina Murray EM Region 26/09/2016 Rainfall Event & NSW SES Operations

EM Notification: - For Information Only - Combat Agency controlled event

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As at: 16:00hrs Monday 26/9/16

Combat Agency: NSW SES
NSW SES Actions: Murrumbidgee SES Region IMT (Day Ops - Monitoring Overnight) at Wagga.
NSW SES Actions: Lachlan SES Region IMT (24 Hr Ops) at Parkes.
NSW SES Actions: Murray SES Region IMT (Day Ops - Monitoring Overnight) at Albury.

Situation: A widespread Flood event continues to impact the Riverina Murray EM Region catchments with many local areas experiencing minor to moderate flooding. Current river heights remain near or at minor to moderate Flood Level with another rainfall event has forecast for 29 & 30 Sept. Ongoing rainfall events are predicted for the remainder of September and for the month of October. The catchments remain saturated across the Riverina Murray EM Region. River levels will remain high, near or at Minor or Moderate Flood levels as the Major Storages manage releases through coming days and weeks.

Lachlan NSW SES Region
An “All Clear” for Evacuees has been issued for the village of Ungarie on the Humbug Creek system in Bland Shire. The impact of forecast rainfall that is expected in the area later in the week is being assessed.

Flooding on the Lachlan River continues to cause concerns for towns (Forbes) within the Central West EM Region (info not covered in this EM Update).

Murrumbidgee NSW SES Region (includes the Mirool Creek system)
Focus remains on Minor/Moderate flooding in the LGAs of Narrandera, Griffith, Murrumbidgee, Leeton, Carrathool and Hay, the forecast rainfall implications for later this week across the region are being assessed. The NSW SES recommend that people in the Griffith area monitor the Griffith City Council Facebook page for regular updates on the East Mirrool Regulator. https://www.facebook.com/griffithcitycouncil/

Murray NSW SES Region (includes the Edwards River & Billabong Creek Systems)
Murray Region currently has Minor to Moderate Flood warnings for the Murray and Edwards Rivers. There is a flood advice for the Billabong Creek at Conargo and downstream to Moulamein. Predicted rainfall for Southwest Slopes has the potential to cause renewed flooding on the Upper Murray and Billabong Creeks. Murray catchment and inflows from Victorian flooding on the Goulburn, Broken and NE Catchments may cause some concern in to the coming week.
· All forested areas adjacent to the Edward and Murray rivers have been inundated and most areas have been closed to the public.
· A number of isolated properties at Morundah and Moonacullah Aboriginal community near Deniliquin have been evacuated and alternate accommodation has been sourced through FACS

Impact Issues:
· The catchments remain saturated across the Riverina Murray EM Region. River levels are expected to remain high at minor or moderate Flood levels as Major Storages manage releases through coming days and weeks.
· **Transport Disruption Road:** NEWELL HWY CLOSURE: possible long term closure of Newell Hwy due to water damage between West Wyalong and Forbes. Please refer to RMS live traffic for updates. Localised flooding has resulted numerous other road closures, refer to NSW RMS Live Traffic for impacts to major roads: See Website: https://www.livetraffic.com/desktop.html
· **Transport Disruption Rail:** Widespread and numerous closures of Branch Lines across the John Holland Riverina Area

Current Activity/Control Structure:
NSW SES Lachlan, Murray & Murrumbidgee IMT are managing Flood Operations and related Public Information.

Partially activation of **AASFA LCC** at Albury and Wagga with the Murray and Riverina **Local Land Services (LLS)** monitoring issues associated with stranded livestock, this is being done in consultation with the Combat Agency (NSW SES).

Griffith EOC remains at **Stand By** (Yellow Status – unmanned but ready).
Wagga EOC remains at **Stand By** (Yellow Status – unmanned but ready).

Agencies have reported that they are conducting forward/contingency planning regarding personnel and resource support arrangements for this protracted event.

FRNSW have pre-staged a "High Trans" high volume water pump at Wagga Wagga that can be deployed anywhere within the region if required.

EM Actions Required:

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LEOCONs, LEMOs, REMC ESOs and F/Area Coordinators should to remain contactable.

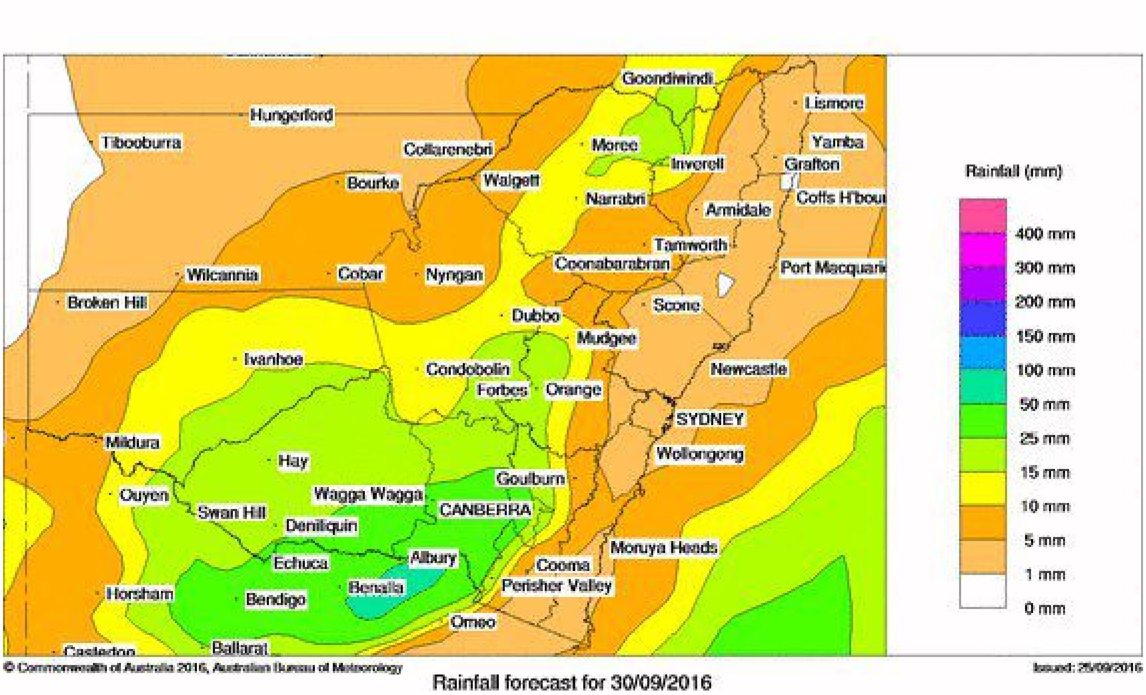
EM Actions Outstanding:
Nil

Future EM Considerations:
Forecast rainfall implications for later this week across the region are being assessed. See BoM Forecast maps for 29 & 30 Sept below.

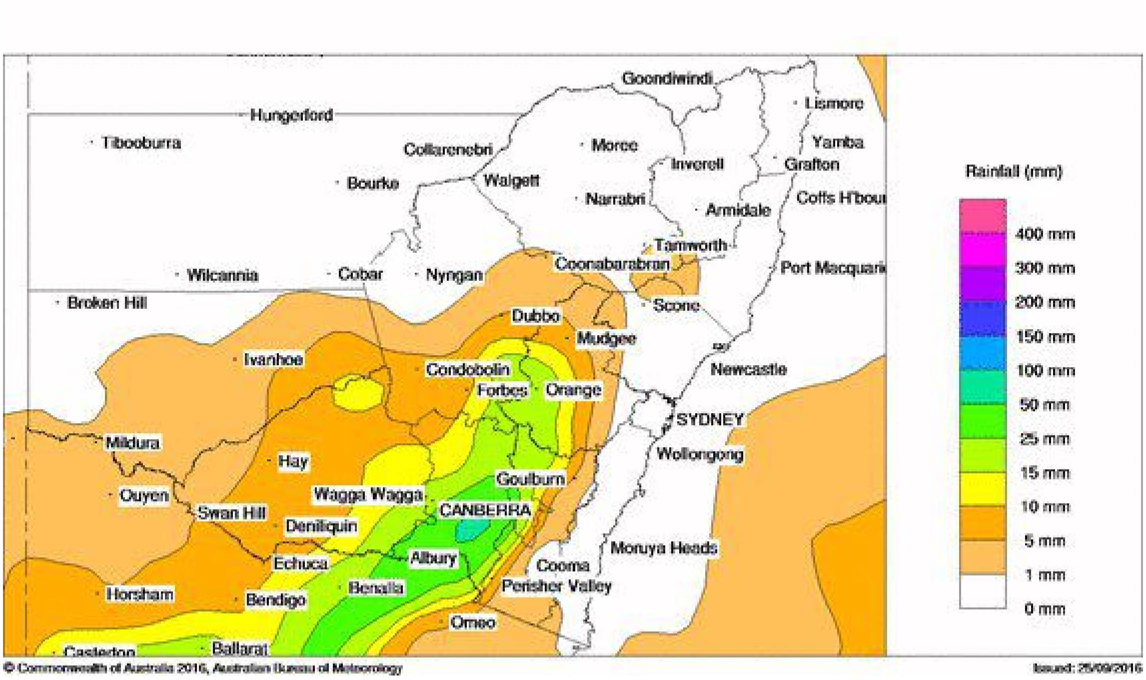
Prepared By:
REMO Owen Plowman Mob 0429 154 619 Email: plow1owe@police.nsw.gov.au

Note: REMO Scott Fullerton is on leave until Mon 10th Oct.
REMO Scott Fullerton Mob 0429 819 745 Email: full1sco@police.nsw.gov.au

Rainfall forecast for 29/09/2016



Rainfall forecast for 30/09/2016



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ALL HEIGHTS SHOWN RELATIVE TO RIVER GAUGE LEVELS.

RIVER GAUGE LEVEL	AHD	
0.00m	82.43m	
4.60m	87.03m	MINOR FLOOD LEVEL
7.20m	89.63m	MODERATE FLOOD LEVEL
8.00m	90.43m	
8.20m	90.63m	
8.40m	90.83m	
8.60m	91.03m	
9.20m	91.63m	MAJOR FLOOD LEVEL

SURVEY UNDERTAKEN BY EDWARD RIVER COUNCIL ON 23 SEPTEMBER 2016 USING GPS ROVER.

No.	DESCRIPTION	DATE	INIT

AMENDMENTS

DRAWN
DATE
DESIGNED
DATE
SUPERVISING ENG.
DATE
CHECKED
DATE
PROJECT OFFICER
DATE
FILE NO.

Edward River Council
Civic Centre
Civic Place
PO Box 270
Deniliquin, NSW, 2710
Phone 03 5898 3000
Fax 03 5898 3029

McLEAN BEACH CARAVAN PARK

LEVEE HEIGHTS - SEPTEMBER 2016

SCALE	SHEET No.	DRAWING No.	AMEND	SHEET SIZE
1:2000 (A3)	1 OF 1			A1

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
4.30	Brick Kiln Creek.	Brick Kiln Creek comences to back up.				
4.60		**"Minor Flood".**				
5.10	Edward River Oval	Irrigation pump to be removed.				
5.63	Chippenham Park Road.	Prepare to close access to Chippenham				
		Park via Edward River Oval.				
5.80	Dahwilly Lane.	Prepare to close access to Sandhurst				
		Island on Dahwilly Lane.				
6.00	Brick Kiln Creek.	Brick Kiln Creek comences to run.				
6.14	Boyd Street at Brick Kiln Creek.	Close off pipe at wingwall.	1070mm	Headwall bolts & door	Sump	**26**
6.14	Hyde Street at River Street.	Close off Gate Valve in pit.	300mm	Gate Valve in pit	Pump over levee	**27**
6.19	Davidson - Morris Street near old Butter Factory.	Close off pipe.	375mm	Pipe only	Pump over levee.	**28**
6.68	Herriott Street near old brick works.	Close off pipe.	375mm	Headwall bolts & door	Pump from drain	**29**
6.70	Wanderer Street near Shell Sevice Station.	Close off Gate Valve.	750mm	Wingwall & Gate Valve	Pump from pit 20m	**30**
7.18	River Street. No. 278.	Close off pipe.	300mm	Pipe only	Pump from pit	**31**
7.18	Davidson Street opposite Herriott Street.	Close off pipe.	460mm	Pipe only	Pump from pit	**32**
7.20		**"Moderate Flood".**				
7.20	Edward River Oval.	Sewer pump inundated.				
7.25	Brick Kiln Creek. Downstream of Sportsman's Hotel.	Close off valve in pit.	150mm	Pipe only	Pump from pit	**33**
7.30	Riverside Caravan Park.	Prepare to evacuate Riverside Caravan				
		Park outside the park's levee.				
7.47	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	3x100mm	Pipe only ????	Pump from pit ???	**34**
7.50	River Street. No. 270.	Close off pipe.	225mm	Pipe only	Pump from pit	**35**
7.62	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	460mm	Pipe only ????	Pump from pit ???	**36**
7.65	Davidson Street. East side of Brick Kiln Creek Bridge.	Close off Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	**37**
	at Shell Service Station.					
7.65	River Street. No. 306.	Close off pipe.	100mm	Pipe only	????????	**38**
7.70	Davidson Street in Floodway. (east side).	Close off pipe.	300mm	Pipe only	Pump from drain	**39**
7.71	Jones Avenue	Close off pipe.	375mm	Headwall bolts & door	Pump from pit	**40**
7.73	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	????????	????????	**41**
7.76	Davidson Street behind Fred's 4WD. (No. 28).	Close off pipe.	300mm	Headwall bolts & door	Pump from pit	**42**
7.80	Floodway in Davidson Street.	Floodway comences to run.				
7.82	Davidson Street at south side Brick Kiln Creek Bridge.	Close off pipe.	225mm	Pipe only	Pump from pit	**43**
7.85	Davidson Street near Sporties Hotel.	Close off Davidson Street Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	**44**
8.10	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	Pipe only	Pump from pit	**45**
8.34	Davidson Street in Floodway. (west side).	Close off pipe.	300mm	Pipe only	Pump from drain	**46**
8.35	Davidson Street in Floodway. (east side nature strip).	Close off pipe.	300mm	Pipe only	Pump from pit	**47**
8.38	Melon Street at Edward River.	Close off pipe.	460mm	Pipe only	Pump from pit	**48**
8.50	Between National and Brick Kiln Creek bridges.	Monitor and inspect the Central Levee.				

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
8.70	River Street No.308. House at Hyde Street corner.	Close off pipe.	100mm	Pipe only		**49**
8.71	Davidson - Morris Street near old Butter Factory.	Close off pipe.	300mm	Pipe only	Pump from drain.	**50**
8.78	River Street. No. 284.	Close off pipe.	300mm	Pipe only	Pump from pit	**51**
8.95	River Street. No. 268.	Close off pipe.	100mm	Pipe only	Pump from pit	**52**
9.20		**" Major Flood".**				
9.40	Central Levee.	Height of levee. Consider temporary raising				
		slghtly further if other levees will not be				
		endangered.				
		Evacuate Central area, approx 270 people				
		(includes some elderly people). This should				
		be commenced two days before this height				
		occuring.				
9.42	Davidson Street.	Height of road. If water goes over close off				
		north Deni sewer system.				
		Water enters main part of Riverside Caravan				
		Park.				
9.82		**1 : 100 year flood level.**				
	EXTRA INFORMATION.					
	North of Finley Road opposite Melon Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**53**
	Yarra Street at Charles Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**54**
	Augustus Street north of Hyde Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**55**
	Augustus Street behind DLS Engineering.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**56**
	Augustus Street north of Browning Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**57**
	Augustus Street at Smart Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**58**
	Close off Finley Road near Melon Street.					
	Close off Conargo Road near Augustus Street.					
	Close off Hay Road at April Street.					
9.92	Melon Street to Robinson Street along Edward River	Height of constructed levee bank and the				
	and Brick Kiln Creek.	rest in this area above this height.				
9.92	Melon Street to Coborro Street.	Height of levee bank.				
9.92	Conargo Road to April Street to Hay Road.	Height of levee bank.				
10.82	Coborro Street to Conargo Road.	Height of levee bank.				
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- North Levee is built to 1:100 year flood level with 0.1m free board only.					

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
2.90	Aljoes Creek.	Water comences to back up Aljoes Creek				
		from both sides.				
3.52	Aljoes Creek.	Aljoes Creek comences to run.				
3.90	Golf Course. (Inside levee **5.80** see consequences)	Close flood Gate. But monitor water levels	2x1350mm	Gate Valve	Pump from pit or	**1**
		on inside of levee because this outlet is for			pump over levee	
		most of the area east of Napier Street.			with special pump.	
4.60		**"Minor Flood".**				
4.66	Island Sanctuary.	Water starts to enter Island Sanctuary				
		near footbridge.				
5.00	Under Butler Street 30m outside levee..	Close off pipe under local levee.	500mm	Pipe only	Pump over local	**2**
					levee	
5.70	Butler Street at Riverview Motel.	Close off Gate Valve.	525mm	Pipe and wingwall	Pump from pit	**3**
5.84	McLean Beach.	Sewer pump station is inundated.				
6.40	Wyatt Street between Poictiers & Harfleur Streets.	Close off pipes at wing wall but monitor water	2x1220mm	Wingwall bolts & door	Pump over road	**4**
		levels on inside of levee because this outlet		and drop boards	special pump.	
		is for most of the area west of Napier Street.				
6.88	Crispe Street near Deni Car-o-tel Caravan Park.	Close off Gate Valve.	375mm	Gate Valve	Pump from pit	**6**
6.96	Crispe Street behind Middy's.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	**7**
7.20		**"Moderate Flood".**				
7.30	Napier Street down stream side of National Bridge.	Close off Napier Gate Valve and pump from	2x610mm	Gate Valve in pit		**8**
		pit outside levee. Top of pit at levee height.	900mm	Pump from this pit		
7.40	Behind Lawn Tennis Courts Charlotte Street.	Close off Gate Valve.	525mm	Gate Valve and	Pump from pit	**9**
				wingwall		
7.43	Hardinge Street opposite Police Station.	Close off Gate Valve.	525mm	Gate Valve in pit	Pump from pit	**10**
7.48	Burton Street west side near No. 57.	Close off pipe.	300mm	Pipe only	Pump from pit	**11**
7.50	200m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**12**
7.50	Fowler Street at Edward River in park area.	Close off Gate Valve.	450mm	Pipe only	Pump from pit	**13**
7.50	George Street west end at Edward River.	Close off Gate Valve.	225mm	Pipe only	Pump from pit	**14**
7.50	Riverside Drive behind Hospital.	Close off Gate Valve.	525mm	Gate Valve	Pump from pit	**15**
7.50	George Street east end opposite Men's Club.	Close off George Street Gate Valve.	375mm	Pipe only	Pump from pit	**16**
7.64?	Memorial Drive behind Coach House Hotel Motel.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	**17**
7.80	Island Sanctuary.	Access bridge cut off.				
7.84	Memorial Drive at Tarangle Creek Bridge.	Put Bulkhead gate in place.			Pump over levee.	
		Access to Showgrounds, Golf Club and				
		Golf Leisure Resort lost. **Units at 9.82m**.				
7.95	End Street at Deni Car-o-tel Caravan Park.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	**18**
8.10	Carew and Henry Streets intersection.	Prepare to close Carew and Henry Streets.				
		water over intersection.				
8.10?	300m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**19**

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

8.21	Butler Street at Riverview Motel.	Close off Gate Valve.		Pipe only	Pump from pit	
GAUGE READING	**LOCATION**	**CONSEQUENCES**	**SIZE OF PIPES**	**DOWNSTREAM.**	**UPSTREAM.**	**No.**
8.30	Mclean Beach Caravan Park.	Estimated crest height of levee protecting.				
		McLean Beach Caravan Park.				
8.30	Gate Valve on outside of levee behind Dept of Ag.	Close off Gate Valve.	300mm	Gate and wingwall	Pump from pit	**20**
	Charlotte Street.					
8.36?	North side of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**21**
8.50	Block off Butler Street at Riverview Motel.	Put Bulkhead gate in place.			Pump over levee.	**22**
8.80	Block off Macauley Street at back entrance to McLean					
	Beach caravan park.					
8.95	Wellington Plaza behind Salvation Army building.	Close off pipe.	225mm	Pipe only	Pump from pit	**23**
9.12	Carew Street 100m north of Syphon Road.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**24**
9.20		**" Major Flood".**				
9.32	Panels to be put in between Burton Street and	**Panels stored at Council Depot in**				
	Department of Agriculture.	**Hardinge Street. In shed in back cnr.**				
9.50	Memorial Drive to George - Edwardes inters.	Top up levees that have not yet been raised.				
	Burton Street to the west.	Varying alignments and heights.				
9.82	1:100 year flood at National bridge is **92.25 AHD.**	**1 : 100 year flood level.**				
10.06	Carew Street at Hetherington Street inters.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**25**
10.32	Packenham Street to Duncan - Hughes inters.	Height of levee bank.				
10.32	George - Edwardes inters. To Burton Street.	Height of levee bank.				
10.82	Lawson Syphon road to Packenham Street.	Height of levee bank.				
	EXTRA INFORMATION.					
	St Michael Sreet Area.					
	Burton Street to Fowler Street most houses have					
	90mm stormwater pipes through the levee but all are					
	close to 1:100 flood level (9.8).					
	Wenburn Court Area.					
	Two 90mm stormwater pipes go through levee in this					
	area but are also at about 9.8.					
	No levee yet constructed at ????? St Michael St next to Wenburn Motel.					
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- The panels for the levee are stored in a shed in the back left hand corner of the Deniliquin Council Depot.					
	Note:- The panels for the levee are to be placed before 9.32 if flood prediction to be near 1:100 year flood level.					
	Note:- Levee is built to 1:100 year flood level with 0.5m free board for wave action only.					

EDWARD RIVER COUNCIL

DENILIQUIN FLOOD UPDATE # 2

Date: Thursday, 29 September 2016

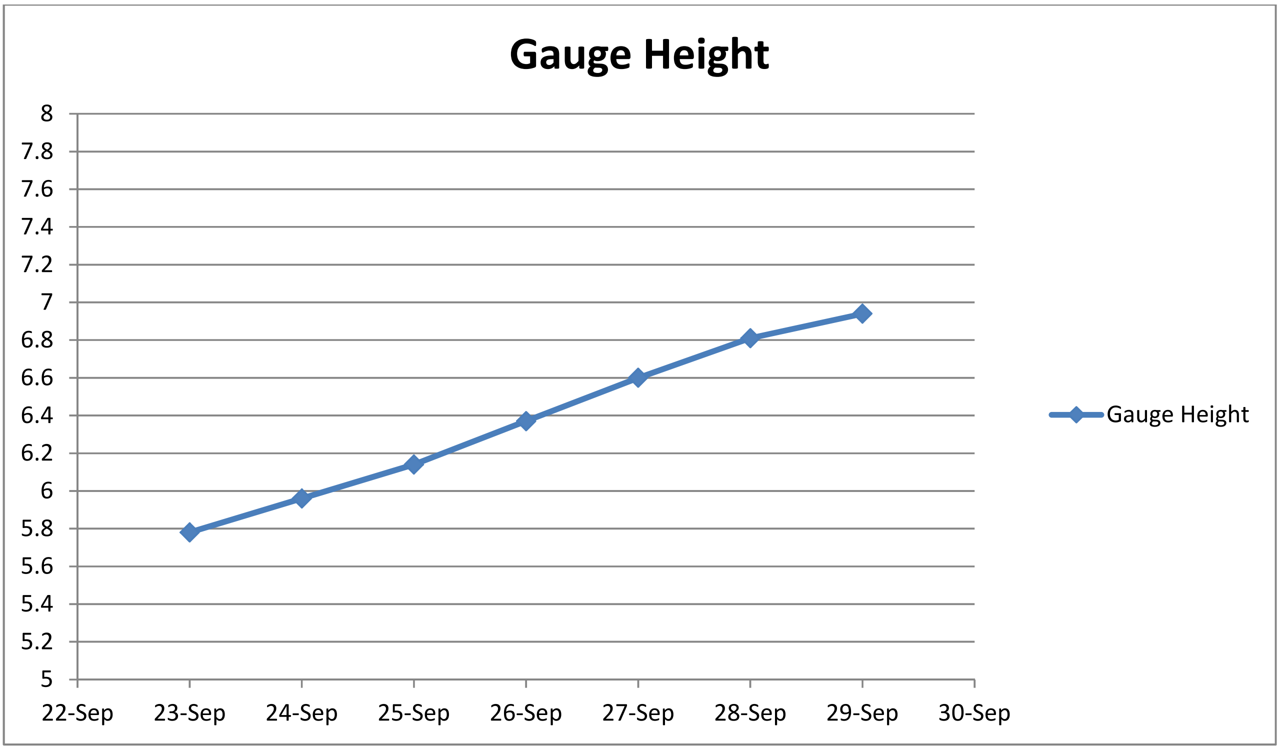
Time: 2.00 pm

FLOOD CONDITIONS

	Time & Date	**River Height (gauge height)**	**Flood Status**
Current River Height	6am, Thursday, 28/09/16	6.94m	Minor
Expected River Height	Saturday, 1/10/16	7.5m	Moderate

Latest Bureau of Meteorology flood warning information is attached.

7 – day river height trend



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LOCAL EMERGENCY MANAGEMENT OPERATIONS AND EMERGENCY OPERATIONS

The Emergency Operations Centre for Deniliquin has not been activated. LEOCONs and LEMOs have been requested to remain contactable.

SES are currently reviewing flood information and are on stand by.

FLOOD ISSUES – DENILIQUIN

McLean Beach Caravan Park

29/09/16 - Discussion with Park Managers regarding a new closure river level for the park of 7.7m, based on survey information. Council staff to investigate temporary measures for raising the levee to 8.5m.

The gully area between the caravan park and Charlotte Street continues to fill with water and is starting to back up to low lying areas within the park. Council need to continue monitoring this and look at more pumps.

Action: (Tony Oddy) Continue to monitor water levels in gully and source additional pumps.

Action from 27/09/16: (Mark Dalzell) Contact SES and caravan park owners regarding the revised river level for evacuation of the park. COMPLETE.

27/09/16 - Lease for caravan park notes that park to be closed once the river reaches a level of 7.0m (anticipated by Thursday, 29/09/16). Survey of the existing levee on 23/09/16 shows minimum height of levee to be 8.2m.

Based on a levee height of 8.2m, Council has determined that evacuation of the caravan park shall commence once the river height reaches 7.7m. Any evacuations shall be done in conjunction with SES.

Pumping of local drainage water has been undertaken in the low gully area between the caravan park and Charlotte Street.

Action: (Mark Dalzell) Contact SES and caravan park owners regarding the revised river level for evacuation of the park.

Riverside Caravan Park

29/09/16 - Low lying areas in the park are closed with camping and units having been moved to higher ground or off-site. Park managers are in discussions with SES regarding flooding.

27/09/16 - SES flood intelligence notes that access to areas within the park are cut-off at a river height of 7.4m.

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Lagoon Culvert behind Bowling Club (Eastern end of system) – Close @ 5.8m

29/09/16 - Culvert between dam near 12th tee and Tarangle Creek closed on Monday, 26 September 2016. Golf club are pumping out of the dam to the creek. Details of culvert to be included in flood intelligence information following the flood.

Action from 27/09/16: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert. REQUIRED CHANGES TO FLOOD INTELLIGENCE HAVE BEEN NOTED.

27/09/16 – Water is not entering culvert from the river. Currently being monitored.

Action: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert.

Lagoon Culvert along Wyatt Street (Western end of system) – Close @ 6.4m

29/09/16 - Culvert still open but being monitored.

Action: (Tony Oddy) Continue monitoring water levels.

Action from 27/09/16: (Tony Oddy) Continue monitoring water levels. COMPLETE.

27/09/16 – Water is not entering culvert from the river. Currently being monitored. Anticipated closure on 27/09/16.

Action: (Tony Oddy) Continue monitoring water levels.

Culverts through Levee – South Deniliquin

29/09/16 – The following culverts have been closed:

- Butler Street, 30m outside levee. Drainage pump currently in place for local run-off (27/09/16)

Culverts through Levee – Davidson Street area

29/09/16 – The following culverts have been closed:

- Morris Street, southeast of Davidson Street, leading to the forest area.

Culverts through Levee – North Deniliquin

29/09/16 – The following culverts have been closed:

- 278 River Street (Murray's);
- 270 River Street;
- Boyd Street at Brick Kiln Creek (27/09/16);

- Hyde Street at River Street (27/09/16).

ROAD CLOSURES

The following roads have been closed due to flooding or local rainfall events:

- Lawson Syphon Road at # 494;
- Smart Street / Chippenham Park Road, between Edward River Oval and intersection of Chippenham Park Road and Smart Street;
- Poictier Street, river end after Blackett Street;
- Harfleur Street, river end after Blackett Street;
- Twin Rivers Road;
- McLean Beach; and
- All public boat ramps

COMMUNITY ADVICE AND INFORMATION

Media Releases

29/09/16 - Media release issued on 28/09/16.

27/09/16 - No media releases have been issued by Council regarding this incident.

Action: (Mark Dalzell) Prepare media release, in conjunction with SES, for approval and publication.

Website

29/09/16 - Media release included on website.

27/09/16 - Website currently has no information relating to the current event.

Action: (Mark Dalzell/Cian Middleton) Update website once media release has been approved.

Facebook and Social Media

29/09/16 - Facebook site has been updated.

27/09/16 - No post have been made on Facebook regarding the event.

Action: (Mark Dalzell/Cian Middleton) Update Facebook once media release has been approved.

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SES Updates

Latest SES Update is attached.

ANTICIPATED ISSUES

It is anticipated that the following actions shall be required during the next 48 hours (based on an anticipated river height of 7.2m on Thursday, 29/09/16):

- Review of status of McLean Beach caravan park in relation to closure of the park;

- Close off culverts at the following locations:

    - Herriott Street near old brick works (6.68m);

    - Wanderer Street near Shell service station (6.70m);

    - Crispe Street near Deni Car-o-tel park (6.88m);

    - Crispe Street behind Middies Electrical; (corner of End Street and Crispe Street) (6.98m);

    - Davidson Street opposite Herriott Street (7.18m).

Memorial Drive

Council's flood intelligence notes that Memorial Drive is cut-off at the bridge near the Island Sanctuary at a level of 7.8m.

GENERAL ISSUES

Flood Records

29/09/16 - The keeping of records and taking of photos was discussed. It was noted that it would be good to take aerial photos, utilising Murray Constructions helicopter, as well as photos and records of river heights.

Council staff and SES have been recording the flood as it has come up and shall compile the information into a single record at the end of the event.

Action from: (Mark Dalzell) organise flight with Murray Constructions for aerial photography.

Staff Availability

29/09/16 - Staff availability for the weekend was discussed, as well as contact for senior staff to assist in the co-ordination of flood related matters. Mark Dalzell, Barry Barlow and Des Bilske shall be available if call-out staff require any assistance. Supervisors

Action from: (Paul Hussey/Tony Oddy/Shanon Williams/Ray Hussey) Supervisors are to provide information regarding staff availability for the upcoming weekend.

Material and Stores

29/09/16 - Council and SES have approximately 29,000 sandbags in Deniliquin, though the SES reserve (24,000) is a strategic reserve and may be used at other places. New rolls of plastic have been purchased and an audit of existing signs has been completed.

Sand bag machine has been located near F&RNSW building at the airport with sand nearby.

Action from 27/09/16: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs. COMPLETE.

Action from 27/09/16: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company. STAFF CURRENTLY DISCUSSING THIS WITH LOCAL SIGN WRITER.

27/09/16 - Discussion by staff regarding Councils readiness for flood action. This includes stores of sand bags, sand, plastic, drainage pumps and signs.

Action: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs.

Action: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company.

Financial Task Numbers

27/09/16 - All costs incurred Council staff relating to the flood event, including labour, plant and materials, shall be booked to the following Operational Task Number

- OP1869.

NEXT MEETING

The next meeting shall be at 2pm on Tuesday, 4 October 2016.

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Australian Government
Bureau of Meteorology

IDN36629

Australian Government Bureau of Meteorology **New South Wales**

MINOR TO MODERATE FLOOD WARNING FOR THE MURRAY AND EDWARD RIVERS

Issued at 10:08 am EST on Thursday 29 September 2016

Flood Warning Number: 43 (reissue)

The Murray River at Albury is expected to reach minor flood level on Thursday [29/09/16]. Further rises are possible depending o Kiewa River.

Renewed rises are expected along the Murray River at Corowa with minor flooding.

The Murray River at Torrumbarry has peaked near 7.46 metres on Wednesday [28/09/16] with minor flooding.

Moderate flooding continues at Barham and is rising slowly.

Minor flooding continues along the Edward River at Deniliquin and moderate flooding at Stevens Weir.

Predicted River Heights/Flows:

Albury

- reach minor flood level (4.3 metres) on Thursday [29/09/16]

Barham

- reach 5.9 metres around Thursday [29/09/16] with moderate flooding

Deniliquin

- reach 7.5 metres around Saturday [01/10/16] with moderate flooding

Stevens Weir

- reach 6.5 metres around Sunday [02/10/16] with moderate flooding

Moulamein

- exceed minor flood level (4.6 metres) around Friday [30/09/16]

- reach moderate flood level (5.2 metres) around next Monday [10/10/16]

FloodSafe advice is available at www.ses.nsw.gov.au

For emergency assistance call the SES on telephone number 132 500.

For life threatening emergencies, call 000 immediately.

Weather Forecast:

For the latest weather forecast see www.bom.gov.au/nsw/forecasts/

Next Issue:

The next warning will be issued by 10 am Friday [30/09/16].

Latest River Heights:

Location	Height of River	Date/Time of Observation
Murray R at Albury	4.19m rising	09:00 AM THU 29/09/16

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Location	Height of River	Date/Time of Observation
Murray R. at Corowa	5.23m steady	09:00 AM THU 29/09/16
Murray R at Yarrawonga Weir D/S	5.47m falling	09:00 AM THU 29/09/16
Murray R at Tocumwal	6.29m falling	08:45 AM THU 29/09/16
Edward R at Deniliquin	6.96m rising	09:00 AM THU 29/09/16
Edward R D/S Stevens Weir	6.31m rising	09:00 AM THU 29/09/16
Edward R at Moulamein	4.53m rising	09:00 AM THU 29/09/16
Murray R. at Echuca Wharf	91.69m falling	08:45 AM THU 29/09/16
Murray R at Barham	5.87m rising	10:00 AM THU 29/09/16
Murray R at Swan Hill	3.84m steady	08:45 AM THU 29/09/16
Murray R. at Wakool Junction	7.55m rising	08:45 AM THU 29/09/16
Murray R. at Boundary Bend	6.24m rising	08:45 AM THU 29/09/16
Murray R at Wentworth Lock 10	29.83m steady	09:00 AM THU 29/09/16

For latest rainfall and river level information see

www.bom.gov.au/nsw/flood/

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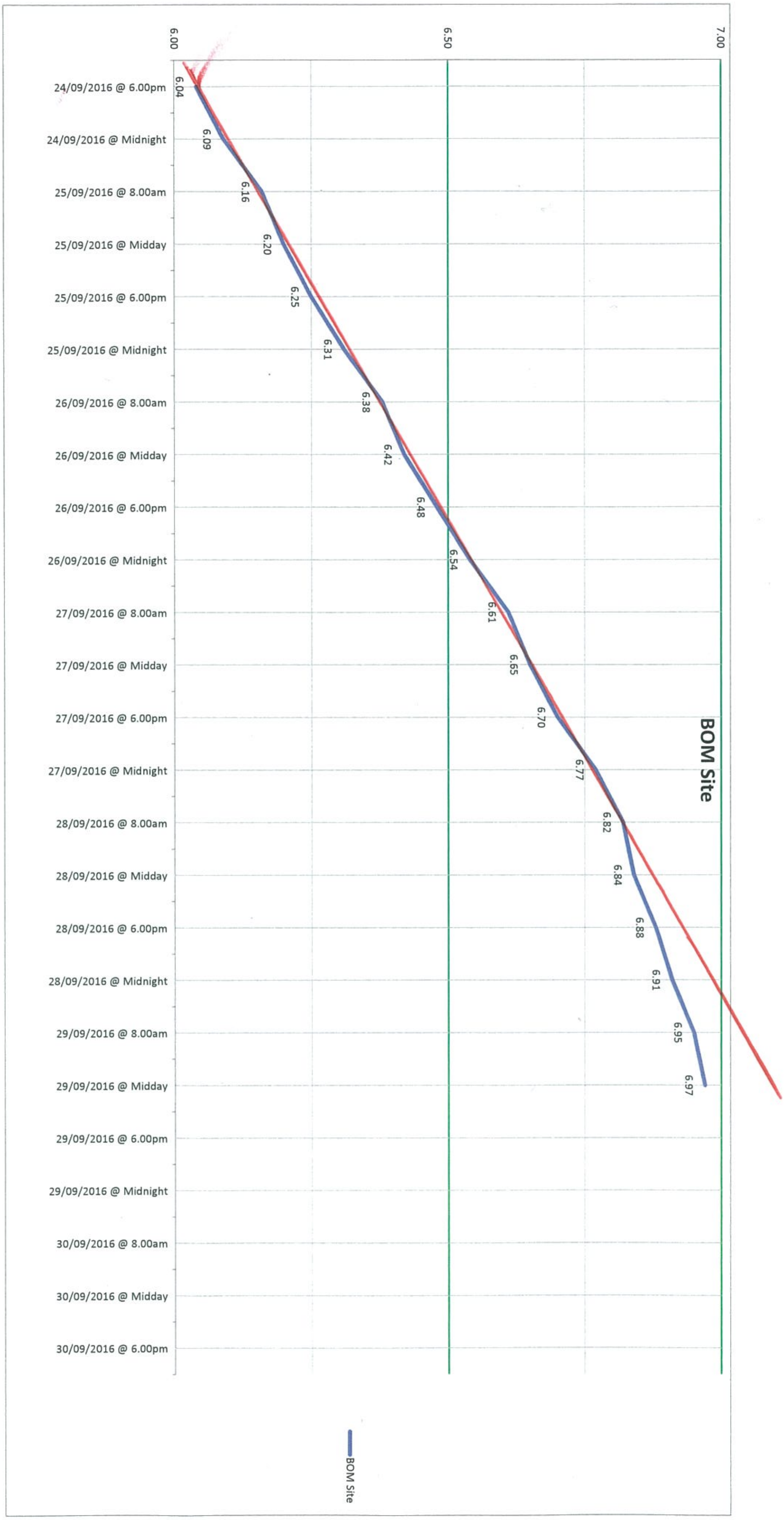

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Mark Dalzell

From:	Owen Plowman <plow1owe@police.nsw.gov.au>
Sent:	Thursday, September 29, 2016 3:59 PM
To:	Owen Plowman; abutler@urana.nsw.gov.au; adrenovski@balranald.nsw.gov.au; ajardine@carrathool.nsw.gov.au; along@ambulance.nsw.gov.au; Andrew Robertson; Andrew Spliet; anne.roser@griffith.nsw.gov.au; Anthony Reneker; barryh@leeton.nsw.gov.au; bartonw@junee.nsw.gov.au; Benjamin Clavel; Bernard Nix; Bernard.kates@one.ses.nsw.gov.au; bpurves@ambulance.nsw.gov.au; Bradie Logue; Brett Roden; bruce.mcbean@narrandera.nsw.gov.au; LEMO Bland Shire Colleen Dore; Craig Johnson; Craig N Middleton; EPA Craig Bretherton; craig.mcintyre@one.ses.nsw.gov.au; David Noble; David Buchtmann; Debbie.bickerton@gwahs.health.nsw.gov.au; Denise.garner@gsahs.health.nsw.gov.au; denis.gelle@jerilderie.nsw.gov.au; Dennis.shrimpton@facs.nsw.gov.au; Des Bilske; dts@murrumbidgeeshire.com.au; dwebb@lockhart.nsw.gov.au; -M-MDL-EMU; Ambulance Eamonn Purcell; Evan Quarmby; frede@berriganshire.nsw.gov.au; fred.hammer@narrandera.nsw.gov.au; Fred.spain@finance.nsw.gov.au; Garry.tye@fire.nsw.gov.au; Gary Worboys; gblackie@greaterhume.nsw.gov.au; Giles.butler@dpi.nsw.gov.au; gm@murrumbidgeeshire.com.au; gmcgrath@tumbashire.nsw.gov.au; gneyland@blandshire.nsw.gov.au; Jakeb Ellis; jgregory@hay.nsw.gov.au; Jodie Marshall; John Wadsworth; jon.gregory1@one.ses.nsw.gov.au; Juay Brown; Karen.cairney@gsahs.health.nsw.gov.au; Darren Kelly; Kenneth Dale; Ken Murphy; Ken.hall@rfs.nsw.gov.au; Kevin.adams@rfs.nsw.gov.au; Kim Sorensen; Kim Traynor; Kristie Ryan; Leslie Hyne; Lindsay.lashbrook@rfs.nsw.gov.au; longmores@junee.nsw.gov.au; manjit.chugha@griffith.nsw.gov.au; Mark Wall; Mark Dalzell; Michael Rowan; Michael Strachan; moliver@greaterhume.nsw.gov.au; mylesh@berriganshire.nsw.gov.au; Narelle Tucker; Narelle.Wren@transport.nsw.gov.au; Nicholas Seddon; nichole.richardson@one.ses.nsw.gov.au; Nick.turner@rfs.nsw.gov.au; nigel.sutton@corowa.nsw.gov.au; nogilvie@temora.nsw.gov.au; Patrick.westwood@rfs.nsw.gov.au; Paul Condon; Paul Lloyd; Paul W Jones; Paul.harding@facs.nsw.gov.au; paul.hogan@mpes.nsw.gov.au; Peter 1 Robertson; Peter M McLaughlin; Peter Mclay; pmullins@snowyvalleys.nsw.gov.au; rblazejak@ambulance.nsw.gov.au; rc.mon@marinerescuensw.com.au; revell.peter@wagga.nsw.gov.au; Roger.orr@rfs.nsw.gov.au; schalmers@alburycity.nsw.gov.au; Scott Fullerton; Scott J Russell; secretary@rescue.org.au; sitrep@seoc.nsw.gov.au; sjones@lockhart.nsw.gov.au; smillett@alburycity.nsw.gov.au; Stanley Wall; steve.holden@rfs.nsw.gov.au; swilson@carrathool.nsw.gov.au; tennille.west@member.ses.nsw.gov.au; tkelly@coolamon.nsw.gov.au; Tony.burns@gsahs.health.nsw.gov.au; Tracey.oakman@gsahs.health.nsw.gov.au; trish.malone@one.ses.nsw.gov.au; Trudi.mcdonald@dpc.nsw.gov.au; Wendy.McPherson@dpc.nsw.gov.au; William.sayer@fire.nsw.gov.au; "youm1ian@police.nsw.gov.au, wood1win@police.nsw.gov.au, <youm1ian, wood1win@police.nsw.gov.au, joss.actsnsw@defence.gov.au, Phillip Malligan <mall1phi@police.nsw.gov.au>, Warren Goodall <good1war@police.nsw.gov.au>, Craig Bowra <bowr1cra@police.nsw.gov.au>"@PHQDVIMS1.police.nsw.gov.au
Subject:	Riverina Murray EM Update as at 16:00 hrs 29/09/2016 [DLM=For-Official-Use-Only]

EM Update - Riverina Murray EM Region Rainfall Event & NSW SES Operations

EM Notification: - For Information Only - Combat Agency controlled event

Document Set ID: 18435
Version: 1, Version Date: 01/05/2017

As at: 16:00 hrs Thursday 29/09/2016

Combat Agency: NSW SES
NSW SES Actions: Murrumbidgee SES Region IMT (Day Ops - Monitoring Overnight) at Wagga.
NSW SES Actions: Lachlan SES Region IMT (24 Hr Ops) at Parkes.
NSW SES Actions: Murray SES Region IMT (Day Ops - Monitoring Overnight) at Albury.

Situation: Conditions remain stable, weather impacts from last night and throughout the day today have been minimal, however the prolonged and widespread flood event continues to impact the Riverina Murray EM Region catchments with many local areas experiencing minor to moderate flooding. With ongoing rainfall events predicted for the month of October river levels will remain high, near or at Minor or Moderate Flood levels as the Major Storages manage releases through coming days and weeks.

Lachlan NSW SES Region
The current forecast Rainfall & Storm event has **not** caused further flooding at Ungarie in Bland Shire. The NSW SES Lachlan IMT is monitoring this location in consultation with Bland Shire Council and other local resources. Flooding on the Lachlan River system continues to cause concerns for communities within the Central West EM Region (not covered in this EM Update).

Murrumbidgee NSW SES Region (includes the Mirool Creek system)
Monitoring of Minor/Moderate flooding in the LGAs of Narrandera, Griffith, Murrumbidgee, Leeton, Carrathool. Flood conditions at Hay are being closely monitored, t he NSW SES recommend that people in the Griffith area monitor the Griffith City Council Facebook page for regular updates on the East Mirool Regulator: https :// www.facebook.com/griffithcitycouncil/

Temora SES IMT conducted a preplanning briefing with Temora LEMC yesterday afternoon and have agreed on control structure and multi agency supporting arrangements for coming days, the situation at Temora remains well controlled.

Murray NSW SES Region (includes the Edwards River & Billabong Creek Systems)
Murray Region currently has Minor to Moderate Flood warnings for the Murray and Edwards Rivers. There is a flood advice for the Billabong Creek at Conargo and downstream to Moulamein. Predicted rainfall for Southwest Slopes has the potential to cause renewed flooding on the Upper Murray and Billabong Creeks. Murray catchment and inflows from Victorian flooding on the Goulburn, Broken and NE Catchments may cause some concern into next week.
· All forested areas adjacent to the Edward and Murray rivers have been inundated and most areas have been closed to the public.
· A number of isolated properties at Morundah and Moonacullah Aboriginal community near Deniliquin have been evacuated and alternate accommodation has been sourced through FACS

Impact Issues:
· The catchments remain saturated across the Riverina Murray EM Region. River levels are expected to remain high at minor or moderate Flood levels as Major Storages manage releases through coming days and weeks.
· **Transport Disruption Road: NEWELL HWY CLOSURE**: possible long term closure of Newell Hwy due to water damage between West Wyalong and Forbes. The Newell Hwy is also closed to all traffic at Gillenbah south of Narrandera. Please refer to RMS live traffic for updates and diversions. Localised flooding has resulted numerous other road closures, also refer to NSW RMS Live Traffic for impacts to major roads: See Website: https://www.livetraffic.com/desktop.html , for local roads refer to the respective LGA websites.
· **Transport Disruption Rail:** Widespread and numerous closures of Branch Lines across the John Holland controlled Riverina Area.

Current Activity/Control Structure:
- NSW SES Lachlan, Murray & Murrumbidgee IMTs are managing Flood Operations and related Public Information.

- Partial activation of **AASFA LCC** at Albury and Wagga with the Murray and Riverina **Local Land Services (LLS)** monitoring issues associated with stranded livestock, this is being done in consultation with the Combat Agency (NSW SES).

Griffith EOC remains at **Stand By** (Yellow Status – unmanned but ready). The Griffith EOC may to activate Operational status for Storm activity if required.
Wagga EOC remains at **Stand By** (Yellow Status– unmanned but ready) Wagga EOC may be activated to Operational status for Storm activity forecast for later in the day and into tomorrow.

EMOS (the NSW Emergency Management Operations System) as of today includes REMO issued Riverina Murray EM Updates.

Agencies have reported that they have conducted forward/contingency planning regarding personnel and resource support arrangements for this protracted event.

FRNSW have pre-staged a "High Trans" high volume water pump at Wagga Wagga that can be deployed anywhere within the region if required.

EM Actions Required:
LEOCONs, LEMOs, REMC ESOs and F/Area Coordinators should to remain contactable.

EM Actions Outstanding:
Nil

Future EM Considerations:
The NSW SES Murrumbidgee IMT IC will conduct a Public Information Meeting with residents from North Wagga Wagga at the North Wagga Hall at 18:30 hrs Friday September 30th.

Prepared By:
REMO Owen Plowman Mob 0429 154 619 Email: plow1owe@police.nsw.gov.au

Note: REMO Scott Fullerton is on leave until Mon 10th Oct.
REMO Scott Fullerton Mob 0429 819 745 Email: full1sco@police.nsw.gov.au

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Edward River flood update

Wednesday, 28 September 2016

Edward River Council is advising residents that the Edward River is expected to exceed moderate flood level this Friday, 30 September 2016.

Council's Manager Technical Services Mark Dalzell said the Bureau of Services has predicted the Edward River will reach a height at Deniliquin on Friday of 7.5 metres.

This is considered to be above the moderate flood height for Deniliquin.

Mr Dalzell said the impact of the flood will be to low lying areas, and property owners are encouraged to remove or raise pumps and other infrastructure near the river.

He said some road closures have been put in place, including roads which lead to boat ramps. A full list of road closures can be found by contacting Council, or visiting Council's website at www.edwardriver.nsw.gov.au.

Mr Dalzell said residents and visitors are reminded that flood water is very dangerous.

All public boat ramps are closed and people are encouraged not to enter, walk through, drive through or operate boats on flood water or flooding rivers.

"There is a lot of debris moving down the river, much of it below the surface level of the water, that presents danger which cannot be seen," he said.

Anyone who requires assistance in regard to flooding on their property is encouraged to contact the SES on 132 500 or visit www.ses.nsw.gov.au.

For information regarding roads and access to properties, please contact Edward River Council on (03) 5898 3000 or visit www.edwardriver.nsw.gov.au.

Further information on river heights can be found at the Bureau of Meteorology website at www.bom.gov.au.

ENDS.

ALL HEIGHTS SHOWN RELATIVE TO RIVER GAUGE LEVELS.

RIVER GAUGE LEVEL	AHD	
0.00m	82.43m	
4.60m	87.03m	MINOR FLOOD LEVEL
7.20m	89.63m	MODERATE FLOOD LEVEL
8.00m	90.43m	
8.20m	90.63m	
8.40m	90.83m	
8.60m	91.03m	
9.20m	91.63m	MAJOR FLOOD LEVEL

SURVEY UNDERTAKEN BY EDWARD RIVER COUNCIL ON 23 SEPTEMBER 2016 USING GPS ROVER.

No.	DESCRIPTION	DATE	INIT
AMENDMENTS			

DRAWN
DATE
CHECKED
DATE
DESIGNED
DATE
PROJECT OFFICER
DATE
SUPERVISING ENG.
DATE
FILE NO.

Edward River Council
Civic Centre
Civic Place
PO Box 270
Deniliquin, NSW, 2710
Phone 03 5898 3000
Fax 03 5898 3029

McLEAN BEACH CARAVAN PARK

LEVEE HEIGHTS - SEPTEMBER 2016

SCALE	SHEET No.	DRAWING No.	AMEND	SHEET SIZE
1:2000 (A3)	1 OF 1			A1

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
2.90	Aljoes Creek.	Water comences to back up Aljoes Creek				
		from both sides.				
3.52	Aljoes Creek.	Aljoes Creek comences to run.				
3.90	Golf Course. (Inside levee **5.80** see consequences)	Close flood Gate. But monitor water levels	2x1350mm	Gate Valve	Pump from pit or	**1**
		on inside of levee because this outlet is for			pump over levee	
		most of the area east of Napier Street.			with special pump.	
4.60		**"Minor Flood".**				
4.66	Island Sanctuary.	Water starts to enter Island Sanctuary				
		near footbridge.				
5.00	Under Butler Street 30m outside levee..	Close off pipe under local levee.	500mm	Pipe only	Pump over local	**2**
					levee	
5.70	Butler Street at Riverview Motel.	Close off Gate Valve.	525mm	Pipe and wingwall	Pump from pit	**3**
5.84	McLean Beach.	Sewer pump station is inundated.				
6.40	Wyatt Street between Poictiers & Harfleur Streets.	Close off pipes at wing wall but monitor water	2x1220mm	Wingwall bolts & door	Pump over road	**4**
		levels on inside of levee because this outlet		and drop boards	special pump.	
		is for most of the area west of Napier Street.				
6.88	Crispe Street near Deni Car-o-tel Caravan Park.	Close off Gate Valve.	375mm	Gate Valve	Pump from pit	**6**
6.96	Crispe Street behind Middy's.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	**7**
7.20		**"Moderate Flood".**				
7.30	Napier Street down stream side of National Bridge.	Close off Napier Gate Valve and pump from	2x610mm	Gate Valve in pit		**8**
		pit outside levee. Top of pit at levee height.	900mm	Pump from this pit		
7.40	Behind Lawn Tennis Courts Charlotte Street.	Close off Gate Valve.	525mm	Gate Valve and	Pump from pit	**9**
				wingwall		
7.43	Hardinge Street opposite Police Station.	Close off Gate Valve.	525mm	Gate Valve in pit	Pump from pit	**10**
7.48	Burton Street west side near No. 57.	Close off pipe.	300mm	Pipe only	Pump from pit	**11**
7.50	200m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**12**
7.50	Fowler Street at Edward River in park area.	Close off Gate Valve.	450mm	Pipe only	Pump from pit	**13**
7.50	George Street west end at Edward River.	Close off Gate Valve.	225mm	Pipe only	Pump from pit	**14**
7.50	Riverside Drive behind Hospital.	Close off Gate Valve.	525mm	Gate Valve	Pump from pit	**15**
7.50	George Street east end opposite Men's Club.	Close off George Street Gate Valve.	375mm	Pipe only	Pump from pit	**16**
7.64?	Memorial Drive behind Coach House Hotel Motel.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	**17**
7.80	Island Sanctuary.	Access bridge cut off.				
7.84	Memorial Drive at Tarangle Creek Bridge.	Put Bulkhead gate in place.			Pump over levee.	
		Access to Showgrounds, Golf Club and				
		Golf Leisure Resort lost. **Units at 9.82m**.				
7.95	End Street at Deni Car-o-tel Caravan Park.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	**18**
8.10	Carew and Henry Streets intersection.	Prepare to close Carew and Henry Streets.				
		water over intersection.				
8.10?	300m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**19**

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

8.21	Butler Street at Riverview Motel.	Close off Gate Valve.		Pipe only	Pump from pit	
GAUGE READING	**LOCATION**	**CONSEQUENCES**	**SIZE OF PIPES**	**DOWNSTREAM.**	**UPSTREAM.**	**No.**
8.30	Mclean Beach Caravan Park.	Estimated crest height of levee protecting.				
		McLean Beach Caravan Park.				
8.30	Gate Valve on outside of levee behind Dept of Ag.	Close off Gate Valve.	300mm	Gate and wingwall	Pump from pit	**20**
	Charlotte Street.					
8.36?	North side of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**21**
8.50	Block off Butler Street at Riverview Motel.	Put Bulkhead gate in place.			Pump over levee.	**22**
8.80	Block off Macauley Street at back entrance to McLean					
	Beach caravan park.					
8.95	Wellington Plaza behind Salvation Army building.	Close off pipe.	225mm	Pipe only	Pump from pit	**23**
9.12	Carew Street 100m north of Syphon Road.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**24**
9.20		**" Major Flood".**				
9.32	Panels to be put in between Burton Street and	**Panels stored at Council Depot in**				
	Department of Agriculture.	**Hardinge Street. In shed in back cnr.**				
9.50	Memorial Drive to George - Edwardes inters.	Top up levees that have not yet been raised.				
	Burton Street to the west.	Varying alignments and heights.				
9.82	1:100 year flood at National bridge is **92.25 AHD.**	**1 : 100 year flood level.**				
10.06	Carew Street at Hetherington Street inters.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**25**
10.32	Packenham Street to Duncan - Hughes inters.	Height of levee bank.				
10.32	George - Edwardes inters. To Burton Street.	Height of levee bank.				
10.82	Lawson Syphon road to Packenham Street.	Height of levee bank.				
	EXTRA INFORMATION.					
	St Michael Sreet Area.					
	Burton Street to Fowler Street most houses have					
	90mm stormwater pipes through the levee but all are					
	close to 1:100 flood level (9.8).					
	Wenburn Court Area.					
	Two 90mm stormwater pipes go through levee in this					
	area but are also at about 9.8.					
	No levee yet constructed at ????? St Michael St next to Wenburn Motel.					
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- The panels for the levee are stored in a shed in the back left hand corner of the Deniliquin Council Depot.					
	Note:- The panels for the levee are to be placed before 9.32 if flood prediction to be near 1:100 year flood level.					
	Note:- Levee is built to 1:100 year flood level with 0.5m free board for wave action only.					

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
4.30	Brick Kiln Creek.	Brick Kiln Creek comences to back up.				
4.60		**"Minor Flood".**				
5.10	Edward River Oval	Irrigation pump to be removed.				
5.63	Chippenham Park Road.	Prepare to close access to Chippenham				
		Park via Edward River Oval.				
5.80	Dahwilly Lane.	Prepare to close access to Sandhurst				
		Island on Dahwilly Lane.				
6.00	Brick Kiln Creek.	Brick Kiln Creek comences to run.				
6.14	Boyd Street at Brick Kiln Creek.	Close off pipe at wingwall.	1070mm	Headwall bolts & door	Sump	**26**
6.14	Hyde Street at River Street.	Close off Gate Valve in pit.	300mm	Gate Valve in pit	Pump over levee	**27**
6.19	Davidson - Morris Street near old Butter Factory.	Close off pipe.	375mm	Pipe only	Pump over levee.	**28**
6.68	Herriott Street near old brick works.	Close off pipe.	375mm	Headwall bolts & door	Pump from drain	**29**
6.70	Wanderer Street near Shell Sevice Station.	Close off Gate Valve.	750mm	Wingwall & Gate Valve	Pump from pit 20m	**30**
7.18	River Street. No. 278.	Close off pipe.	300mm	Pipe only	Pump from pit	**31**
7.18	Davidson Street opposite Herriott Street.	Close off pipe.	460mm	Pipe only	Pump from pit	**32**
7.20		**"Moderate Flood".**				
7.20	Edward River Oval.	Sewer pump inundated.				
7.25	Brick Kiln Creek. Downstream of Sportsman's Hotel.	Close off valve in pit.	150mm	Pipe only	Pump from pit	**33**
7.30	Riverside Caravan Park.	Prepare to evacuate Riverside Caravan				
		Park outside the park's levee.				
7.47	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	3x100mm	Pipe only ????	Pump from pit ???	**34**
7.50	River Street. No. 270.	Close off pipe.	225mm	Pipe only	Pump from pit	**35**
7.62	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	460mm	Pipe only ????	Pump from pit ???	**36**
7.65	Davidson Street. East side of Brick Kiln Creek Bridge.	Close off Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	**37**
	at Shell Service Station.					
7.65	River Street. No. 306.	Close off pipe.	100mm	Pipe only	????????	**38**
7.70	Davidson Street in Floodway. (east side).	Close off pipe.	300mm	Pipe only	Pump from drain	**39**
7.71	Jones Avenue	Close off pipe.	375mm	Headwall bolts & door	Pump from pit	**40**
7.73	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	????????	????????	**41**
7.76	Davidson Street behind Fred's 4WD. (No. 28).	Close off pipe.	300mm	Headwall bolts & door	Pump from pit	**42**
7.80	Floodway in Davidson Street.	Floodway comences to run.				
7.82	Davidson Street at south side Brick Kiln Creek Bridge.	Close off pipe.	225mm	Pipe only	Pump from pit	**43**
7.85	Davidson Street near Sporties Hotel.	Close off Davidson Street Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	**44**
8.10	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	Pipe only	Pump from pit	**45**
8.34	Davidson Street in Floodway. (west side).	Close off pipe.	300mm	Pipe only	Pump from drain	**46**
8.35	Davidson Street in Floodway. (east side nature strip).	Close off pipe.	300mm	Pipe only	Pump from pit	**47**
8.38	Melon Street at Edward River.	Close off pipe.	460mm	Pipe only	Pump from pit	**48**
8.50	Between National and Brick Kiln Creek bridges.	Monitor and inspect the Central Levee.				

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
8.70	River Street No.308. House at Hyde Street corner.	Close off pipe.	100mm	Pipe only		**49**
8.71	Davidson - Morris Street near old Butter Factory.	Close off pipe.	300mm	Pipe only	Pump from drain.	**50**
8.78	River Street. No. 284.	Close off pipe.	300mm	Pipe only	Pump from pit	**51**
8.95	River Street. No. 268.	Close off pipe.	100mm	Pipe only	Pump from pit	**52**
9.20		**" Major Flood".**				
9.40	Central Levee.	Height of levee. Consider temporary raising				
		slghtly further if other levees will not be				
		endangered.				
		Evacuate Central area, approx 270 people				
		(includes some elderly people). This should				
		be commenced two days before this height				
		occuring.				
9.42	Davidson Street.	Height of road. If water goes over close off				
		north Deni sewer system.				
		Water enters main part of Riverside Caravan				
		Park.				
9.82		**1 : 100 year flood level.**				
	EXTRA INFORMATION.					
	North of Finley Road opposite Melon Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**53**
	Yarra Street at Charles Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**54**
	Augustus Street north of Hyde Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**55**
	Augustus Street behind DLS Engineering.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**56**
	Augustus Street north of Browning Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**57**
	Augustus Street at Smart Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**58**
	Close off Finley Road near Melon Street.					
	Close off Conargo Road near Augustus Street.					
	Close off Hay Road at April Street.					
9.92	Melon Street to Robinson Street along Edward River	Height of constructed levee bank and the				
	and Brick Kiln Creek.	rest in this area above this height.				
9.92	Melon Street to Coborro Street.	Height of levee bank.				
9.92	Conargo Road to April Street to Hay Road.	Height of levee bank.				
10.82	Coborro Street to Conargo Road.	Height of levee bank.				
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- North Levee is built to 1:100 year flood level with 0.1m free board only.					

EDWARD RIVER COUNCIL

DENILIQUIN FLOOD UPDATE # 3

Date: Tuesday, 4 October 2016

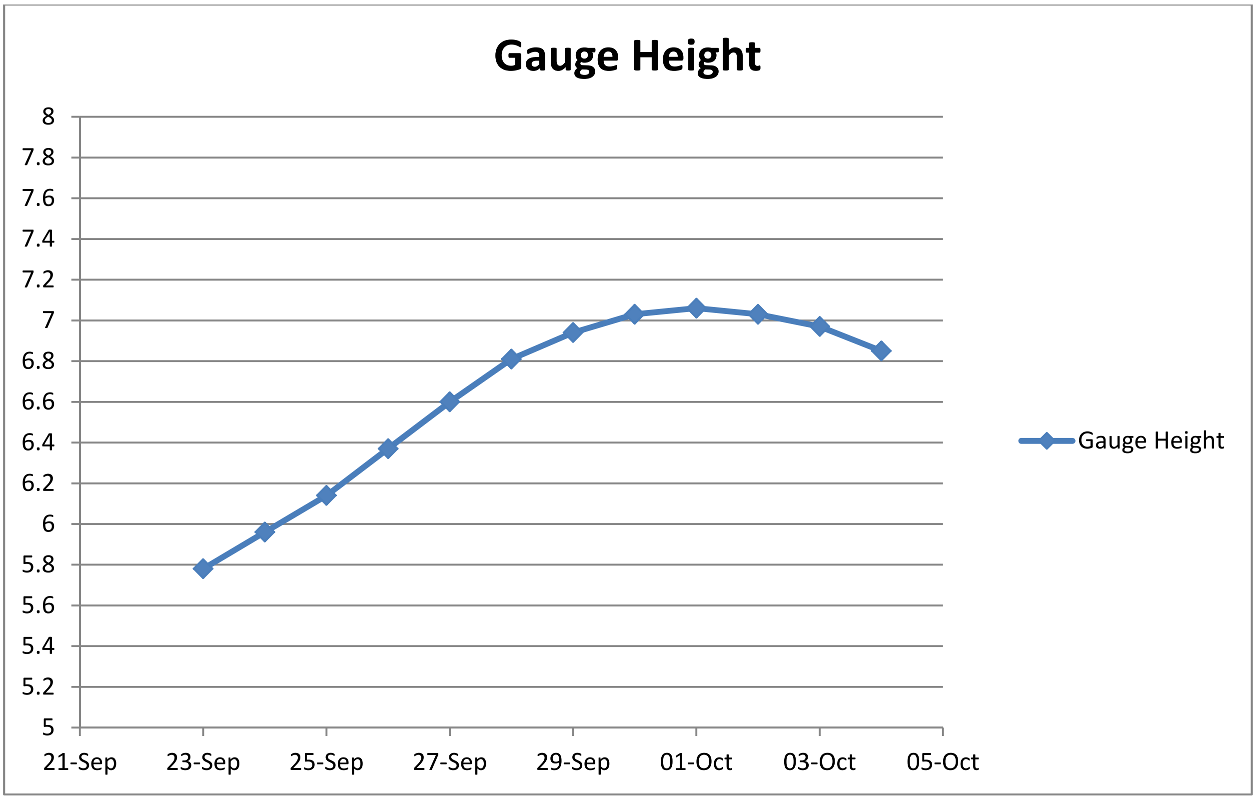
Time: 2.00 pm

FLOOD CONDITIONS

	Time & Date	River Height (gauge height)	Flood Status
Current River Height	10am, Tuesday, 4 October 2016	6.83m	Minor
Expected River Height	Friday, 14/10/16	7.5m	Moderate

Latest Bureau of Meteorology flood warning information is attached.

River Height Trend



LOCAL EMERGENCY MANAGEMENT OPERATIONS AND EMERGENCY OPERATIONS

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The Emergency Operations Centre for Deniliquin has not been activated. LEOCONs and LEMOs have been requested to remain contactable.

SES are currently reviewing flood information and are on stand by.

FLOOD ISSUES – DENILIQUIN

McLean Beach Caravan Park

4/10/16 - Pumping of gully between park and Charlotte Street continuing.

Action from 29/09/16: (Tony Oddy) Continue to monitor water levels in gully and source additional pumps. COMPLETE.

29/09/16 - Discussion with Park Managers regarding a new closure river level for the park of 7.7m, based on survey information. Council staff to investigate temporary measures for raising the levee to 8.5m.

The gully area between the caravan park and Charlotte Street continues to fill with water and is starting to back up to low lying areas within the park. Council need to continue monitoring this and look at more pumps.

Action: (Tony Oddy) Continue to monitor water levels in gully and source additional pumps.

Action from 27/09/16: (Mark Dalzell) Contact SES and caravan park owners regarding the revised river level for evacuation of the park. COMPLETE.

27/09/16 - Lease for caravan park notes that park to be closed once the river reaches a level of 7.0m (anticipated by Thursday, 29/09/16). Survey of the existing levee on 23/09/16 shows minimum height of levee to be 8.2m.

Based on a levee height of 8.2m, Council has determined that evacuation of the caravan park shall commence once the river height reaches 7.7m. Any evacuations shall be done in conjunction with SES.

Pumping of local drainage water has been undertaken in the low gully area between the caravan park and Charlotte Street.

Action: (Mark Dalzell) Contact SES and caravan park owners regarding the revised river level for evacuation of the park.

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Riverside Caravan Park

4/10/16 - Situation is being monitored by SES.

29/09/16 - Low lying areas in the park are closed with camping and units having been moved to higher ground or off-site. Park managers are in discussions with SES regarding flooding.

27/09/16 - SES flood intelligence notes that access to areas within the park are cut-off at a river height of 7.4m.

Lagoon Culvert behind Bowling Club (Eastern end of system) – Close @ 5.8m

4/10/16 - Situation is being monitored by Council staff.

29/09/16 - Culvert between dam near 12th tee and Tarangle Creek closed on Monday, 26 September 2016. Golf club are pumping out of the dam to the creek. Details of culvert to be included in flood intelligence information following the flood.

Action from 27/09/16: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert. REQUIRED CHANGES TO FLOOD INTELLIGENCE HAVE BEEN NOTED.

27/09/16 – Water is not entering culvert from the river. Currently being monitored.

Action: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert.

Lagoon Culvert along Wyatt Street (Western end of system) – Close @ 6.4m

4/10/16 - Culvert still open but being monitored.

Action: (Tony Oddy) Continue monitoring water levels.

29/09/16 - Culvert still open but being monitored.

Action: (Tony Oddy) Continue monitoring water levels.

Action from 27/09/16: (Tony Oddy) Continue monitoring water levels. COMPLETE.

27/09/16 – Water is not entering culvert from the river. Currently being monitored. Anticipated closure on 27/09/16.

Action: (Tony Oddy) Continue monitoring water levels.

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Memorial Drive

4/10/16 - Renewed peak of 7.5m on 14/10/16 has been noted. Flood intelligence notes that Memorial Drive shall be cut off at the bridge at a height of 7.8m. Memorial Park users, golf club and leisure resort to be advised.

Action: (Mark Dalzell) Notify Memorial Park users, golf club and leisure resort of current status of river and predicted river heights.

Culverts through Levee – South Deniliquin

29/09/16 – The following culverts have been closed:

- Butler Street, 30m outside levee. Drainage pump currently in place for local run-off (27/09/16)

Culverts through Levee – Davidson Street area

29/09/16 – The following culverts have been closed:

- Morris Street, southeast of Davidson Street, leading to the forest area.

Culverts through Levee – North Deniliquin

29/09/16 – The following culverts have been closed:

- 278 River Street (Murray's);
- 270 River Street;
- Boyd Street at Brick Kiln Creek (27/09/16);
- Hyde Street at River Street (27/09/16).

ROAD CLOSURES

The following roads have been closed due to flooding or local rainfall events:

- Lawson Syphon Road at # 494;
- Smart Street / Chippenham Park Road, between Edward River Oval and intersection of Chippenham Park Road and Smart Street;
- Poictiers Street, river end after Blackett Street;
- Harfleur Street, river end after Blackett Street;
- Twin Rivers Road;
- McLean Beach; and
- All public boat ramps

COMMUNITY ADVICE AND INFORMATION

Media Releases

29/09/16 - Media release issued on 28/09/16.

27/09/16 - No media releases have been issued by Council regarding this incident.

Action: (Mark Dalzell) Prepare media release, in conjunction with SES, for approval and publication.

Website

29/09/16 - Media release included on website.

27/09/16 - Website currently has no information relating to the current event.

Action: (Mark Dalzell/Cian Middleton) Update website once media release has been approved.

Facebook and Social Media

29/09/16 - Facebook site has been updated.

27/09/16 - No post have been made on Facebook regarding the event.

Action: (Mark Dalzell/Cian Middleton) Update Facebook once media release has been approved.

SES Updates

Latest SES Update is attached.

ANTICIPATED ISSUES

It is anticipated that the following actions shall be required during the next 48 hours (based on an anticipated river height of 7.2m on Thursday, 29/09/16):

- Review of status of McLean Beach caravan park in relation to closure of the park;
- Close off culverts at the following locations:
    - Herriott Street near old brick works (6.68m);
    - Wanderer Street near Shell service station (6.70m);
    - Crispe Street near Deni Car-o-tel park (6.88m);
    - Crispe Street behind Middies Electrical; (corner of End Street and Crispe Street) (6.98m);
    - Davidson Street opposite Herriott Street (7.18m).

GENERAL ISSUES

Flood Records

4/10/16 - Flight for aerial photography of flooding is being organised.

Action from 29/09/16: (Mark Dalzell) organise flight with Murray Constructions for aerial photography. ONGOING.

29/09/16 - The keeping of records and taking of photos was discussed. It was noted that it would be good to take aerial photos, utilising Murray Constructions helicopter, as well as photos and records of river heights.

Council staff and SES have been recording the flood as it has come up and shall compile the information into a single record at the end of the event.

Action: (Mark Dalzell) organise flight with Murray Constructions for aerial photography.

Staff Availability

29/09/16 - Staff availability for the weekend was discussed, as well as contact for senior staff to assist in the co-ordination of flood related matters. Mark Dalzell, Barry Barlow and Des Bilske shall be available if call-out staff require any assistance.

Action from: (Paul Hussey/Tony Oddy/Shanon Williams/Ray Hussey) Supervisors are to provide information regarding staff availability for the upcoming weekend.

Material and Stores

4/10/16 - Additional sand bags are being sourced should they be required for McLean Beach Caravan Park. Following the completion of the Ute Muster an audit of road signage

Action: (Paul Hussey/ Simone Tonkin) Sand bags to be sourced for McLean Beach

Action from 27/09/16: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company. STAFF CURRENTLY DISCUSSING THIS WITH LOCAL SIGN WRITER.

29/09/16 - Council and SES have approximately 29,000 sandbags in Deniliquin, though the SES reserve (24,000) is a strategic reserve and may be used at other places. New rolls of plastic have been purchased and an audit of existing signs has been completed.

Sand bag machine has been located near F&RNSW building at the airport with sand nearby.

Action from 27/09/16: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs. COMPLETE.

Action from 27/09/16: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company. STAFF CURRENTLY DISCUSSING THIS WITH LOCAL SIGN WRITER.

27/09/16 - Discussion by staff regarding Councils readiness for flood action. This includes stores of sand bags, sand, plastic, drainage pumps and signs.

Action: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs.

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Action: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company.

Financial Task Numbers

27/09/16 - All costs incurred Council staff relating to the flood event, including labour, plant and materials, shall be booked to the following Operational Task Number

- OP1869.

NEXT MEETING

The next meeting shall be at 2pm on Monday, 10 October 2016.

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Australian Government
Bureau of Meteorology

IDN36629

Australian Government Bureau of Meteorology **New South Wales**

MINOR TO MODERATE FLOOD WARNING FOR THE MURRAY AND EDWARD RIVERS

Issued at 10:05 am EDT on Tuesday 4 October 2016

Flood Warning Number: 55

Moderate flooding is occurring along the Murray River at Albury, Corrowa, Yarrawonga and Barham, and along the Edward River

Minor flooding is occuring along the Murray River at Torrumbarry, and along the Edward River at Deniliquin and Moulamein.

Further rainfall is forecast for the next 24 hours. Increased inflows into Hume Dam and from the Kiewa River may cause additiona being closely monitored and revised predictions will be issued if and when necessary.

Predicted River Heights/Flows:

Albury

- remain around the current level (5.28 metres) during Tuesday [04/10/16] into Wednesday [05/10/16] with moderate flooding

Corowa

- reach around 7.7 metres on Wednesday [05/10/16] with moderate flooding

Yarrawonga

- reach 7.3 metres around Wednesday [05/10/16] with moderate flooding

Tocumwal

- reach near 7.0 metres around Thursday [06/10/16] or Friday [07/10/16] with moderate flooding

Barham

- remain near the current level (5.94 metres) during Tuesday [04/10/16] with moderate flooding

Deniliquin

- fall slowly below the current level (6.84 metres) during Tuesday [04/10/16] with minor flooding

- renewed rises to 7.5 metres around 14/10/16 with moderate flooding.

Stevens Weir

- fall slowly below the current level (6.31 metres) during Tuesday [04/10/16] with moderate flooding

Moulamein

- reach 5.0 metres around 09/10/16 with minor flooding

Wakool Junction

- exceed minor flood level (8.8 metres) around 12/10/16.

- reach 10.3 metres around 17/10/16 with minor flooding

FloodSafe advice is available at www.ses.nsw.gov.au

For emergency assistance call the SES on telephone number 132 500.

For life threatening emergencies, call 000 immediately.

Location Height of River Date/Time of Observation

Weather Forecast:

For the latest weather forecast see www.bom.gov.au/nsw/forecasts/

Next Issue:

The next warning will be issued by 5pm Tuesday [04/10/16].

Latest River Heights:

Location	Height of River	Date/Time of Observation
Murray R at Albury	5.28m steady	09:00 AM TUE 04/10/16
Murray R. at Corowa	6.48m rising	09:00 AM TUE 04/10/16
Murray R at Yarrawonga Weir D/S	6.83m steady	09:00 AM TUE 04/10/16
Murray R at Tocumwal	6.1m rising	08:45 AM TUE 04/10/16
Edward R at Deniliquin	6.84m falling	09:00 AM TUE 04/10/16
Edward R D/S Stevens Weir	6.31m falling	09:00 AM TUE 04/10/16
Edward R at Moulamein	4.84m rising	09:00 AM TUE 04/10/16
Murray R. at Echuca Wharf	91.81m rising	08:45 AM TUE 04/10/16
Murray R at Barham	5.94m steady	09:00 AM TUE 04/10/16
Murray R at Swan Hill	3.98m steady	08:45 AM TUE 04/10/16
Murray R. at Wakool Junction	7.25m rising	08:30 AM TUE 04/10/16
Murray R. at Boundary Bend	6.58m steady	08:45 AM TUE 04/10/16
Murray R at Wentworth Lock 10	29.91m steady	09:00 AM TUE 04/10/16

For latest rainfall and river level information see

www.bom.gov.au/nsw/flood/

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Mark Dalzell

From: Owen Plowman <plow1owe@police.nsw.gov.au>
Sent: Friday, September 30, 2016 10:37 AM
To: Owen Plowman
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Subject: Re: Riverina Murray EM Update as at 10:00 Friday 30/09//09/2016 [DLM=For-Official-Use-Only]

EM Update: Riverina Murray EM Region Rainfall Event & NSW SES Operations

EM Notification: - For Information Only - NSW SES (Combat Agency) controlled event: Conditions Remain Stable

As at: 10:00 hrs Friday 30/09/2016

Combat Agency: NSW SES
NSW SES Actions: Murrumbidgee SES Region IMT (Day Ops - Monitoring Overnight) at Wagga.
NSW SES Actions: Lachlan SES Region IMT (24 Hr Ops) at Parkes.
NSW SES Actions: Murray SES Region IMT (Day Ops - Monitoring Overnight) at Albury.
Situation: Conditions remain Stable, rainfall totals and wind speeds across the reporting area have been below forecast, however the prolonged and widespread flood event continues to impact the Riverina Murray EM Region catchments with many local areas experiencing minor to moderate and in some case near major flood Levels. With ongoing rainfall events predicted for the month of October river levels will remain high as the Major Storages manage releases through coming days and weeks.

Lachlan NSW SES Region
Conditions are Stable in the Ungarie area in Bland Shire, NSW SES Lachlan IMT is monitoring this location in consultation with Bland Shire Council and other local resources. Flooding on the Lachlan River system continues to

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cause concerns for communities within the Central West EM Region (not covered in this EM Update).

Murrumbidgee NSW SES Region (includes the Mirool Creek system)
Monitoring flooding in the LGAs of Narrandera, Griffith, Murrumbidgee, Leeton, Carrathool and Hay. NSW SES recommends that people in the Griffith area monitor the Griffith City Council Facebook page for regular updates on the East Mirrool Regulator: https :// www.facebook.com/griffithcitycouncil/

Murray NSW SES Region (includes the Edwards River & Billabong Creek Systems)
Monitoring flooding across the Murray SES Murray Region on the Murray and Edwards Rivers and on the Billabong Creek system. Predicted rainfall for Southwest Slopes has the potential to cause renewed flooding on the Upper Murray and Billabong Creeks. Murray catchment and inflows from Victorian flooding on the Goulburn, Broken and NE Catchments may cause some concern into next week.
Note; Unrelated to the flood event at Deniliquin on the Edwards River the Deniliquin Ute Muster is going ahead as scheduled this weekend, agencies report heavy traffic volumes in the Deniliquin town area.

Impact Issues:
· The catchments remain saturated across the Riverina Murray EM Region. River levels are expected to remain high at minor or moderate Flood levels as Major Storages manage releases through coming days and weeks.
· **Transport Disruption Road: NEWELL HWY CLOSURE**: there is possible long term closure of Newell Hwy due to water damage between West Wyalong and Forbes. The Newell Hwy is also closed to all traffic at Gillenbah south of Narrandera. Please refer to RMS live traffic for updates and diversions. Localised flooding has resulted numerous other road closures, also refer to NSW RMS Live Traffic for impacts to major roads: See Website: https://www.livetraffic.com/desktop.html , for local roads refer to the respective LGA websites.
· **Transport Disruption Rail:** Widespread and numerous closures of branch lines across the John Holland controlled Riverina Area rail network.

Current Activity/Control Structure: NSW SES Lachlan, Murray & Murrumbidgee IMTs are managing Flood Operations and related Public Information.
- Partial activation of **AASFA LCC** at Albury and Wagga with the Murray and Riverina **Local Land Services (LLS)** monitoring issues associated with stranded livestock, this is being done in consultation with the Combat Agency (NSW SES).
Griffith EOC remains at **Stand By** (Yellow Status – unmanned but ready). The Griffith EOC may to activate Operational status for Storm activity if required.
Wagga EOC remains at **Stand By** (Yellow Status– unmanned but ready) Wagga EOC may be activated to Operational status for Storm activity forecast for later in the day and into tomorrow.

EMOS (the NSW Emergency Management Operations System) as of Thursday 29/09/2016 includes REMO issued Riverina Murray EM Updates.

EM Actions Required:
LEOCONs , LEMOs, REMC ESOs and F/Area Coordinators should to remain contactable.

EM Actions Outstanding: Nil

Future EM Considerations:
The NSW SES Murrumbidgee IMT IC will conduct a Public Information Meeting with residents from North Wagga Wagga at the North Wagga Hall at 18:30 hrs tonight, Friday September 30th.

Prepared By:
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DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

8.21	Butler Street at Riverview Motel.	Close off Gate Valve.		Pipe only	Pump from pit	
GAUGE READING	**LOCATION**	**CONSEQUENCES**	**SIZE OF PIPES**	**DOWNSTREAM.**	**UPSTREAM.**	**No.**
8.30	Mclean Beach Caravan Park.	Estimated crest height of levee protecting.				
		McLean Beach Caravan Park.				
8.30	Gate Valve on outside of levee behind Dept of Ag.	Close off Gate Valve.	300mm	Gate and wingwall	Pump from pit	**20**
	Charlotte Street.					
8.36?	North side of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**21**
8.50	Block off Butler Street at Riverview Motel.	Put Bulkhead gate in place.			Pump over levee.	**22**
8.80	Block off Macauley Street at back entrance to McLean					
	Beach caravan park.					
8.95	Wellington Plaza behind Salvation Army building.	Close off pipe.	225mm	Pipe only	Pump from pit	**23**
9.12	Carew Street 100m north of Syphon Road.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**24**
9.20		**" Major Flood".**				
9.32	Panels to be put in between Burton Street and	**Panels stored at Council Depot in**				
	Department of Agriculture.	**Hardinge Street. In shed in back cnr.**				
9.50	Memorial Drive to George - Edwardes inters.	Top up levees that have not yet been raised.				
	Burton Street to the west.	Varying alignments and heights.				
9.82	1:100 year flood at National bridge is **92.25 AHD.**	**1 : 100 year flood level.**				
10.06	Carew Street at Hetherington Street inters.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**25**
10.32	Packenham Street to Duncan - Hughes inters.	Height of levee bank.				
10.32	George - Edwardes inters. To Burton Street.	Height of levee bank.				
10.82	Lawson Syphon road to Packenham Street.	Height of levee bank.				
	EXTRA INFORMATION.					
	St Michael Sreet Area.					
	Burton Street to Fowler Street most houses have					
	90mm stormwater pipes through the levee but all are					
	close to 1:100 flood level (9.8).					
	Wenburn Court Area.					
	Two 90mm stormwater pipes go through levee in this					
	area but are also at about 9.8.					
	No levee yet constructed at ????? St Michael St next to Wenburn Motel.					
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- The panels for the levee are stored in a shed in the back left hand corner of the Deniliquin Council Depot.					
	Note:- The panels for the levee are to be placed before 9.32 if flood prediction to be near 1:100 year flood level.					
	Note:- Levee is built to 1:100 year flood level with 0.5m free board for wave action only.					

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
4.30	Brick Kiln Creek.	Brick Kiln Creek comences to back up.				
4.60		**"Minor Flood".**				
5.10	Edward River Oval	Irrigation pump to be removed.				
5.63	Chippenham Park Road.	Prepare to close access to Chippenham				
		Park via Edward River Oval.				
5.80	Dahwilly Lane.	Prepare to close access to Sandhurst				
		Island on Dahwilly Lane.				
6.00	Brick Kiln Creek.	Brick Kiln Creek comences to run.				
6.14	Boyd Street at Brick Kiln Creek.	Close off pipe at wingwall.	1070mm	Headwall bolts & door	Sump	**26**
6.14	Hyde Street at River Street.	Close off Gate Valve in pit.	300mm	Gate Valve in pit	Pump over levee	**27**
6.19	Davidson - Morris Street near old Butter Factory.	Close off pipe.	375mm	Pipe only	Pump over levee.	**28**
6.68	Herriott Street near old brick works.	Close off pipe.	375mm	Headwall bolts & door	Pump from drain	**29**
6.70	Wanderer Street near Shell Sevice Station.	Close off Gate Valve.	750mm	Wingwall & Gate Valve	Pump from pit 20m	**30**
7.18	River Street. No. 278.	Close off pipe.	300mm	Pipe only	Pump from pit	**31**
7.18	Davidson Street opposite Herriott Street.	Close off pipe.	460mm	Pipe only	Pump from pit	**32**
7.20		**"Moderate Flood".**				
7.20	Edward River Oval.	Sewer pump inundated.				
7.25	Brick Kiln Creek. Downstream of Sportsman's Hotel.	Close off valve in pit.	150mm	Pipe only	Pump from pit	**33**
7.30	Riverside Caravan Park.	Prepare to evacuate Riverside Caravan				
		Park outside the park's levee.				
7.47	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	3x100mm	Pipe only ????	Pump from pit ???	**34**
7.50	River Street. No. 270.	Close off pipe.	225mm	Pipe only	Pump from pit	**35**
7.62	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	460mm	Pipe only ????	Pump from pit ???	**36**
7.65	Davidson Street. East side of Brick Kiln Creek Bridge.	Close off Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	**37**
	at Shell Service Station.					
7.65	River Street. No. 306.	Close off pipe.	100mm	Pipe only	????????	**38**
7.70	Davidson Street in Floodway. (east side).	Close off pipe.	300mm	Pipe only	Pump from drain	**39**
7.71	Jones Avenue	Close off pipe.	375mm	Headwall bolts & door	Pump from pit	**40**
7.73	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	????????	????????	**41**
7.76	Davidson Street behind Fred's 4WD. (No. 28).	Close off pipe.	300mm	Headwall bolts & door	Pump from pit	**42**
7.80	Floodway in Davidson Street.	Floodway comences to run.				
7.82	Davidson Street at south side Brick Kiln Creek Bridge.	Close off pipe.	225mm	Pipe only	Pump from pit	**43**
7.85	Davidson Street near Sporties Hotel.	Close off Davidson Street Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	**44**
8.10	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	Pipe only	Pump from pit	**45**
8.34	Davidson Street in Floodway. (west side).	Close off pipe.	300mm	Pipe only	Pump from drain	**46**
8.35	Davidson Street in Floodway. (east side nature strip).	Close off pipe.	300mm	Pipe only	Pump from pit	**47**
8.38	Melon Street at Edward River.	Close off pipe.	460mm	Pipe only	Pump from pit	**48**
8.50	Between National and Brick Kiln Creek bridges.	Monitor and inspect the Central Levee.				

DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
8.70	River Street No.308. House at Hyde Street corner.	Close off pipe.	100mm	Pipe only		**49**
8.71	Davidson - Morris Street near old Butter Factory.	Close off pipe.	300mm	Pipe only	Pump from drain.	**50**
8.78	River Street. No. 284.	Close off pipe.	300mm	Pipe only	Pump from pit	**51**
8.95	River Street. No. 268.	Close off pipe.	100mm	Pipe only	Pump from pit	**52**
9.20		**" Major Flood".**				
9.40	Central Levee.	Height of levee. Consider temporary raising				
		slghtly further if other levees will not be				
		endangered.				
		Evacuate Central area, approx 270 people				
		(includes some elderly people). This should				
		be commenced two days before this height				
		occuring.				
9.42	Davidson Street.	Height of road. If water goes over close off				
		north Deni sewer system.				
		Water enters main part of Riverside Caravan				
		Park.				
9.82		**1 : 100 year flood level.**				
	EXTRA INFORMATION.					
	North of Finley Road opposite Melon Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**53**
	Yarra Street at Charles Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**54**
	Augustus Street north of Hyde Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**55**
	Augustus Street behind DLS Engineering.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**56**
	Augustus Street north of Browning Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**57**
	Augustus Street at Smart Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**58**
	Close off Finley Road near Melon Street.					
	Close off Conargo Road near Augustus Street.					
	Close off Hay Road at April Street.					
9.92	Melon Street to Robinson Street along Edward River	Height of constructed levee bank and the				
	and Brick Kiln Creek.	rest in this area above this height.				
9.92	Melon Street to Coborro Street.	Height of levee bank.				
9.92	Conargo Road to April Street to Hay Road.	Height of levee bank.				
10.82	Coborro Street to Conargo Road.	Height of levee bank.				
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- North Levee is built to 1:100 year flood level with 0.1m free board only.					

EDWARD RIVER COUNCIL

DENILIQUIN FLOOD UPDATE # 4

Date: Monday, 10 October 2016

Time: 9.00 am

FLOOD CONDITIONS

Billabong Creek @ Conargo

	Time & Date	**River Height (gauge height)**	**Flood Status**
Current River Height	5am, Monday, 10 October 2016	3.87m	
Expected River Height			

Billabong Creek @ Wanganella

	Time & Date	**River Height (gauge height)**	**Flood Status**
Current River Height	5am, Monday, 10 October 2016	3.24m	
Expected River Height			

Edward River @ Deniliquin

	Time & Date	**River Height (gauge height)**	**Flood Status**
Current River Height	5am, Monday, 10 October 2016	6.72m	Minor
Expected River Height	Monday, 17/10/16	8.4m	Moderate

Latest Bureau of Meteorology flood warning information is attached.

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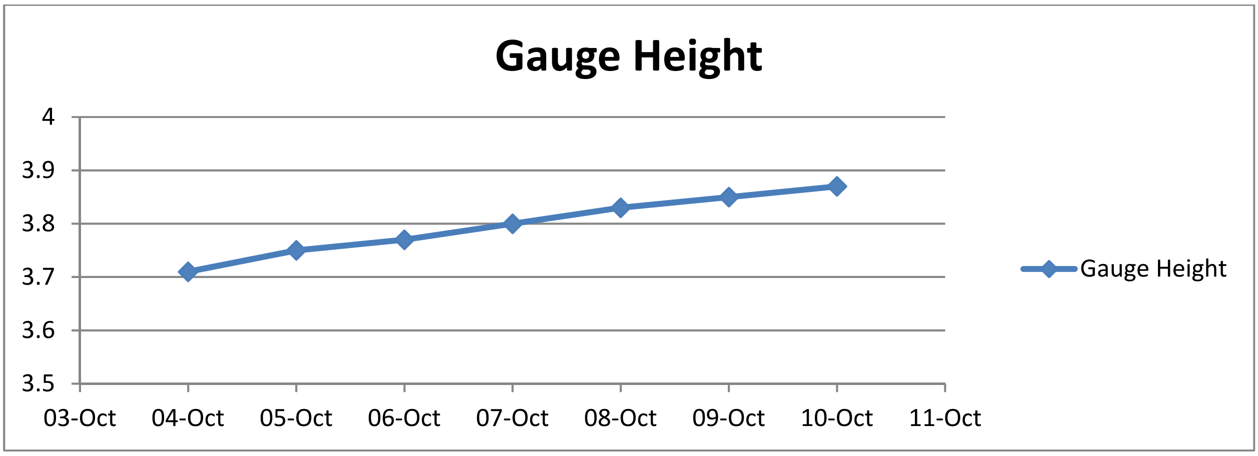
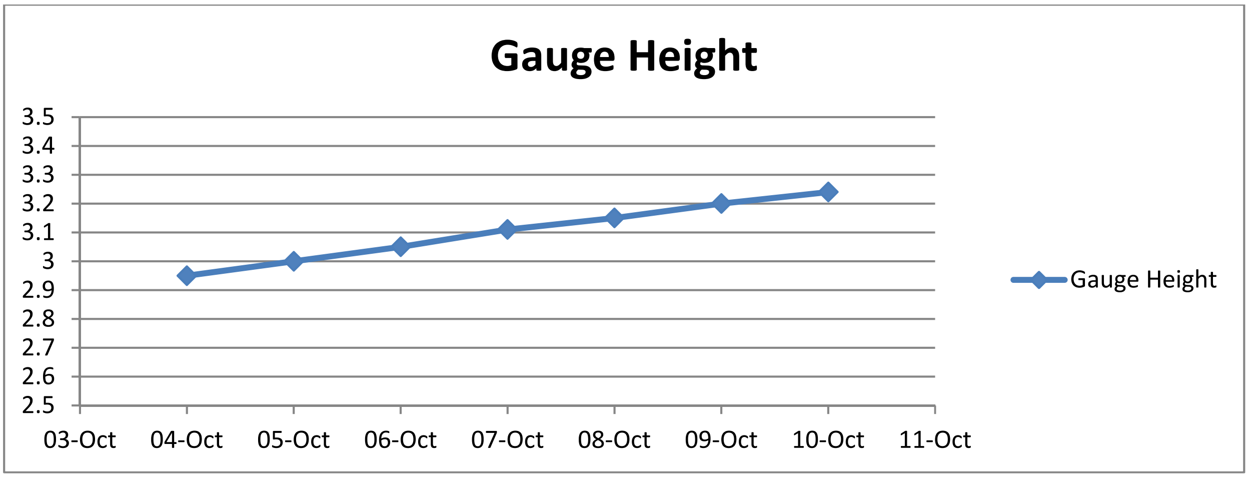
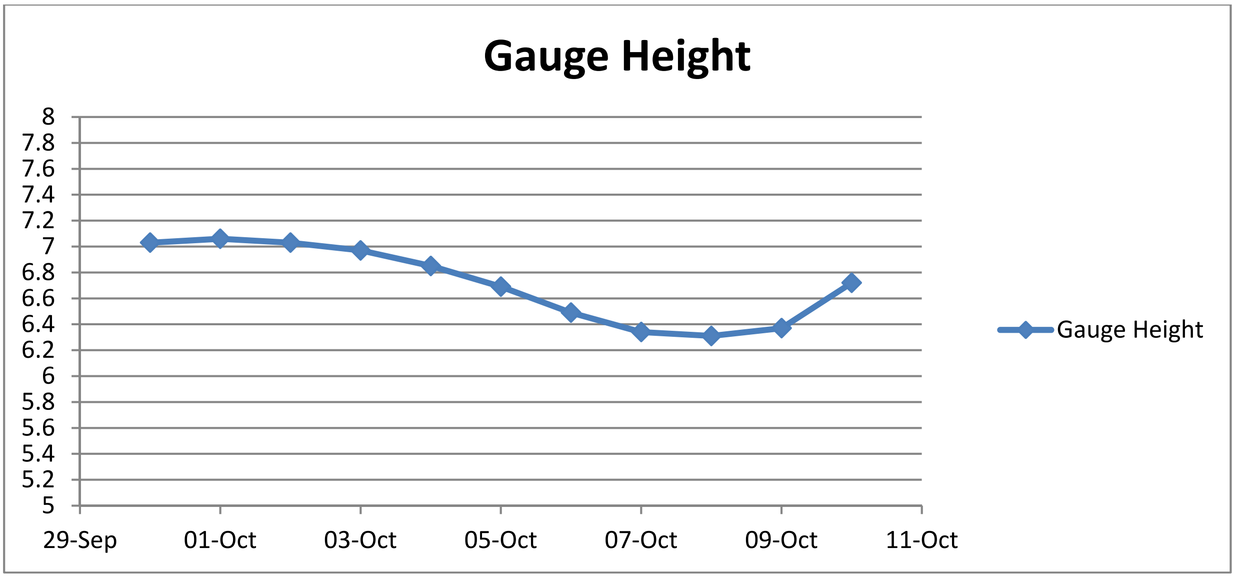
Billabong Creek @ Conargo



Billabong Creek @ Wanganella



Edward River @ Deniliquin



LOCAL EMERGENCY MANAGEMENT OPERATIONS AND EMERGENCY OPERATIONS

An LEMC meeting has been called by SES for Monday, 10 October 2016.

SES have undertaken the following activities:

Conargo and Wanganella

SES have contact property owners in the area and have provided sand and sand bags in each village for residents to use. Some work on levees protecting properties has been undertaken.

Deniliquin

SES has commenced contacting property owners, including caravan park owners and operators, in regard flood protection for properties.

SES commenced stockpiling of filled sand bags on Saturday, 8 October 2016 in preparation for anticipated works.

SES Murray have advised that they shall be bringing in up to two strike teams on Sunday, 9 October 2016 to assist with sand bagging and flood protection.

FLOOD ISSUES – CONARGO

10/10/16 - Works on property levees has been undertaken by property owners. SES has provided sand and sand bags near the Conargo Store.

Concerns with Conargo – Jerilderie Road as Forest Creek may cut off access along the road. Council staff are working on additional drainage adjacent to the road.

FLOOD ISSUES – WANGANELLA

10/10/16 - SES has provided sand and sand bags near the Wanganella Store.

FLOOD ISSUES – DENILIQUIN

McLean Beach Caravan Park

10/10/16 - Council has discussed flood issues with the operators of the caravan park and advised that an order shall be given to them to evacuate the park once the river reaches 7.7m and that access to the park shall be closed once the river reaches 8.0m. This is anticipated to occur on Friday, 14 October 2016.

Council has delivered sand and sandbags to the caravan park so that they may undertake their own sandbagging activities.

Council staff shall need to place sand bags along the top of the levee near the entrance to the park where the access track to the lower camping area crosses over the top of the levee. The current levee height in this area is 8.0m and it must be brought up to 8.2m. Council is not required to undertake any other sandbagging activities at the caravan park at this point in time.

Council shall assist in the moving of caravans to Council's stockpile site area is requested.

Pumping of gully between park and Charlotte Street continuing due to local rainfall.

Action: (Tony Oddy) Organise for sand bagging of the access to the lower camping area so that the minimum levee height is 8.2m.

4/10/16 - Pumping of gully between park and Charlotte Street continuing.

Action from 29/09/16: (Tony Oddy) Continue to monitor water levels in gully and source additional pumps. COMPLETE.

29/09/16 - Discussion with Park Managers regarding a new closure river level for the park of 7.7m, based on survey information. Council staff to investigate temporary measures for raising the levee to 8.5m.

The gully area between the caravan park and Charlotte Street continues to fill with water and is starting to back up to low lying areas within the park. Council need to continue monitoring this and look at more pumps.

Action: (Tony Oddy) Continue to monitor water levels in gully and source additional pumps.

Action from 27/09/16: (Mark Dalzell) Contact SES and caravan park owners regarding the revised river level for evacuation of the park. COMPLETE.

Riverside Caravan Park

10/10/16 - Situation is being monitored by SES and park owners.

29/09/16 - Low lying areas in the park are closed with camping and units having been moved to higher ground or off-site. Park managers are in discussions with SES regarding flooding.

27/09/16 - SES flood intelligence notes that access to areas within the park are cut-off at a river height of 7.4m.

Big 4 Caravan Park

10/10/16 - Council staff have discussed the anticipated flood peak with caravan park owners and it is predicted that the flood waters shall not impact the main park area. Units in lower areas near the river have been moved to higher ground.

Situation is being monitored by SES and park owners.

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Lagoon Culvert behind Bowling Club (Eastern end of system) – Close @ 5.8m

4/10/16 - Situation is being monitored by Council staff.

29/09/16 - Culvert between dam near 12th tee and Tarangle Creek closed on Monday, 26 September 2016. Golf club are pumping out of the dam to the creek. Details of culvert to be included in flood intelligence information following the flood.

Action from 27/09/16: (Mark Dalzell) Update flood intelligence regarding river level for closure of culvert. REQUIRED CHANGES TO FLOOD INTELLIGENCE HAVE BEEN NOTED.

Lagoon Culvert along Wyatt Street (Western end of system) – Close @ 6.4m

4/10/16 - Culvert still open but being monitored.

Action: (Tony Oddy) Continue monitoring water levels.

29/09/16 - Culvert still open but being monitored.

Action: (Tony Oddy) Continue monitoring water levels.

Action from 27/09/16: (Tony Oddy) Continue monitoring water levels. COMPLETE.

27/09/16 – Water is not entering culvert from the river. Currently being monitored. Anticipated closure on 27/09/16.

Action: (Tony Oddy) Continue monitoring water levels.

Memorial Drive

10/10/16 - It is anticipated that access to Memorial Park shall be cut off by Wednesday or Thursday this week. All user groups have been advised.

Action: (Tony Oddy) Organise and place concrete gate at entrance to Memorial Park once river level reaches 7.8m.

Action from 4/10/16: (Mark Dalzell) Notify Memorial Park users, golf club and leisure resort of current status of river and predicted river heights. COMPLETE.

4/10/16 - Renewed peak of 7.5m on 14/10/16 has been noted. Flood intelligence notes that Memorial Drive shall be cut off at the bridge at a height of 7.8m. Memorial Park users, golf club and leisure resort to be advised.

Action: (Mark Dalzell) Notify Memorial Park users, golf club and leisure resort of current status of river and predicted river heights.

Culverts through Levee – South Deniliquin

29/09/16 – The following culverts have been closed:

- Butler Street, 30m outside levee. Drainage pump currently in place for local run-off (27/09/16)

Culverts through Levee – Davidson Street area

29/09/16 – The following culverts have been closed:

- Morris Street, southeast of Davidson Street, leading to the forest area.

Culverts through Levee – North Deniliquin

29/09/16 – The following culverts have been closed:

- 278 River Street (Murray's);
- 270 River Street;
- Boyd Street at Brick Kiln Creek (27/09/16);
- Hyde Street at River Street (27/09/16).

ROAD CLOSURES

The following roads have been closed due to flooding or local rainfall events:

- Boggy Creek Road near intersection with Dahwilly Lane;
- Lawson Syphon Road at # 494;
- Smart Street / Chippenham Park Road, between Edward River Oval and intersection of Chippenham Park Road and Smart Street;
- Poictiers Street, river end after Blackett Street;
- Harfleur Street, river end after Blackett Street;
- Twin Rivers Road;
- McLean Beach; and
- All public boat ramps.

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COMMUNITY ADVICE AND INFORMATION

Media Releases

10/10/16 - Updated media release shall be required based on new predicted flood height for Deniliquin.

Action: (Mark Dalzell) Prepare media release, in conjunction with SES, for approval and publication.

29/09/16 - Media release issued on 28/09/16.

27/09/16 - No media releases have been issued by Council regarding this incident.

Action: (Mark Dalzell) Prepare media release, in conjunction with SES, for approval and publication.

Website

10/10/16 - Website to be continually updated with current information.

Action: (Mark Dalzell/Cian Middleton) Update website once media release has been approved.

29/09/16 - Media release included on website.

27/09/16 - Website currently has no information relating to the current event.

Action: (Mark Dalzell/Cian Middleton) Update website once media release has been approved.

Facebook and Social Media

10/10/16 - Link to SES Murray Facebook site has been provided on Edward River Facebook site.

Action: (Mark Dalzell/Cian Middleton) Update Facebook once media release has been approved.

29/09/16 - Facebook site has been updated.

27/09/16 - No post have been made on Facebook regarding the event.

Action: (Mark Dalzell/Cian Middleton) Update Facebook once media release has been approved.

SES Updates

Latest SES Update is attached.

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ANTICIPATED ISSUES

It is anticipated that the following actions shall be required during the next 48 hours:

- Review of status of McLean Beach caravan park in relation to closure of the park;
- Review of status of access to Memorial Park;
- Monitor road access to Dahwilly Lane area and provides signage as required;
- Monitor road access to the Chippenham Park area and provide advice and road signage as required;
- Close off culverts as per Council's and SES flood information.

GENERAL ISSUES

Flood Records

4/10/16 - Flight for aerial photography of flooding is being organised.

Action from 29/09/16: (Mark Dalzell) organise flight with Murray Constructions for aerial photography. ONGOING.

29/09/16 - The keeping of records and taking of photos was discussed. It was noted that it would be good to take aerial photos, utilising Murray Constructions helicopter, as well as photos and records of river heights.

Council staff and SES have been recording the flood as it has come up and shall compile the information into a single record at the end of the event.

Action: (Mark Dalzell) organise flight with Murray Constructions for aerial photography.

Staff Availability

29/09/16 - Staff availability for the weekend was discussed, as well as contact for senior staff to assist in the co-ordination of flood related matters. Mark Dalzell, Barry Barlow and Des Bilske shall be available if call-out staff require any assistance.

Action from: (Paul Hussey/Tony Oddy/Shanon Williams/Ray Hussey) Supervisors are to provide information regarding staff availability for the upcoming weekend.

Material and Stores

10/10/16 - Additional sand bags have been ordered and should arrive on Monday, 10 October 2016. A self serve sand bag area shall be required to be set-up for Deniliquin.

Action: (Mark Dalzell/Paul Hussey/ Simone Tonkin) Determine location for self serve sand bagging station and set -up station.

Action from 4/10/16: (Paul Hussey/ Simone Tonkin) Sand bags to be sourced for McLean Beach. COMPLETE.

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4/10/16 - Additional sand bags are being sourced should they be required for McLean Beach Caravan Park. Following the completion of the Ute Muster an audit of road signage

Action: (Paul Hussey/ Simone Tonkin) Sand bags to be sourced for McLean Beach

Action from 27/09/16: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company. STAFF CURRENTLY DISCUSSING THIS WITH LOCAL SIGN WRITER.

29/09/16 - Council and SES have approximately 29,000 sandbags in Deniliquin, though the SES reserve (24,000) is a strategic reserve and may be used at other places. New rolls of plastic have been purchased and an audit of existing signs has been completed.

Sand bag machine has been located near F&RNSW building at the airport with sand nearby.

Action from 27/09/16: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs. COMPLETE.

Action from 27/09/16: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company. STAFF CURRENTLY DISCUSSING THIS WITH LOCAL SIGN WRITER.

27/09/16 - Discussion by staff regarding Councils readiness for flood action. This includes stores of sand bags, sand, plastic, drainage pumps and signs.

Action: (Paul Hussey/Tony Oddy) Staff to undertake a stocktake on current store levels of sand bags, sand, plastic, signs.

Action: (Simone Tonkin) Discuss the fabrication of new warning signs, such as Road Closed and Water over Road, by local sign company.

Financial Task Numbers

27/09/16 - All costs incurred Council staff relating to the flood event, including labour, plant and materials, shall be booked to the following Operational Task Number

- OP1869.

NEXT MEETING

The next meeting shall be at 2pm on Wednesday, 12 October 2016.

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Australian Government
Bureau of Meteorology

IDN36629

Australian Government Bureau of Meteorology **New South Wales**

MODERATE TO MAJOR FLOOD WARNING FOR THE MURRAY AND EDWARD RIVERS

Issued at 12:50 pm EDT on Monday 10 October 2016

Flood Warning Number: 66 [reissue]

Moderate flooding is now current and easing at Tocumwal.

Moderate flooding is current at Albury, Corowa, Yarrawonga, Torrumbarry and Barham, and along the Edward River

Minor flooding is occurring along Edward River at Deniliquin.

Predicted River Heights/Flows:

Deniliquin

- reach 8.4 metres around 17/10/16 with moderate flooding.

Stevens Weir

- reach 6.5 metres around 18/10/16 with moderate flooding.

Moulamein

- may reach 5.5 metres last week of October with moderate flooding

Echuca - Moama

- reach 93.7 metres around Friday 14/10/16 with minor flooding

Torrumbarry Weir

- reach major flood level (7.8 metres) around 17/10/16

Barham

- reach 6.0 metres around 21/10/16 with moderate flooding

Swan Hill

- reach 4.5 metres around 23/10/16

Wakool Junction

- exceed minor flood level (8.8 metres) Monday 10/10/16.

- reach 10.3 metres around 17/10/16 with minor flooding

- may reach moderate flood level [10.5 metres] early November

Forecasts for locations downstream of Wakool Junction will be made once upstream peaks are observed

FloodSafe advice is available at www.ses.nsw.gov.au

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For emergency assistance call the SES on telephone number 132 500.

For life threatening emergencies, call 000 immediately.

Weather Forecast:

For the latest weather forecast see www.bom.gov.au/nsw/forecasts/

Next Issue:

The next warning will be issued by 12pm Tuesday [11/10/16].

Latest River Heights:

Location	Height of River	Date/Time of Observation
Murray R at Albury	5.05m steady	12:00 PM MON 10/10/16
Murray R. at Corowa	7.45m rising	12:30 PM MON 10/10/16
Murray R at Yarrawonga Weir D/S	7.25m falling	12:00 PM MON 10/10/16
Murray R at Tocumwal	7.21m falling	11:45 AM MON 10/10/16
Edward R at Deniliquin	6.9m rising	12:00 PM MON 10/10/16
Edward R D/S Stevens Weir	6.25m rising	12:00 PM MON 10/10/16
Edward R at Moulamein	5.2m steady	12:00 PM MON 10/10/16
Murray R. at Echuca Wharf	92.84m rising	12:00 PM MON 10/10/16
Murray R at Barham	5.97m steady	12:00 PM MON 10/10/16
Murray R at Swan Hill	4.11m rising	05:45 AM MON 10/10/16
Murray R. at Wakool Junction	8.85m rising	11:45 AM MON 10/10/16
Murray R. at Boundary Bend	7.02m rising	12:00 PM MON 10/10/16
Murray R at Wentworth Lock 10	30.07m steady	12:00 PM MON 10/10/16

For latest rainfall and river level information see

www.bom.gov.au/nsw/flood/

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Appendix F

06/05/2016

Different gauge readings

SES

Different descriptions

Does not exist on other database

FLOOD INTELLIGENCE CARD

DENILIQUIN GAUGE - STATION NUMBER: 409003

Monday, 24 January 2000

ACCURACY:

Use this information as a guide to the possible effects of a flood. The card is based on estimates of flood behaviour and particular effects may occur at heights different from those indicated here. They may also occur at slightly different heights in different floods.

CONFIDENTIALITY:

This card may contain sensitive information about the effects of flooding on private property. Specific reference to private addresses or business must be made directly to owners or other emergency services and NOT via broadcast or print media.

Stream: Edward River | **Gauge Zero:** 82.429m

Location: Rear of DWR Office | **Datum Type:** AHD

Minor: 5.50 **Moderate:** 7.20 **Major:** 9.20 | **Levee Height:** 9.4

Class	Height (m)	Consequences
	Note:	The town levee is currently being upgraded to protect Deniliquin against a 1% AEP flood level (plus one metre). For planning and warning purposes in the event of levee failure or overtopping there are lists of surveyed heights of areas inside the town levees are attached as Annexes A, B and C to this card. Historically, flood height predictions have varied over the first few days but settle down and become more reliable after about three to five days after the flood producing rain. The eventual predicted peak may be reduced as the result of upstream levee banks failing as occurred in the 1993 flood.
	✓2.90	Water commences to back up Aljoes Lane from both sides.
	3.62	Aljoes Creek commences to run. Gauge height: 3.52 on council's.
	4.30	Brick Kiln Creek commences to back up.
	4.60	Danger height for areas outside levees. Media alert to pump licensees and graziers.
	✓4.66	Water starts to enter the Island Sanctuary (nature reserve) near the footbridge.
	4.70	Water enters the low-lying area of McLeans Beach Caravan Park. This area is used for tourist vans and as a camping area There are 40 powered sites; power has to be disconnected.
	4.76	The footbridge to the Island Sanctuary is closed. This is the normal pedestrian access to the sanctuary; vehicular access to the rear of the sanctuary is still available via the Memorial Park Bridge.
	5.10	The Edward River Oval pump has to be removed by this height.
MIN	5.60	

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Different gauge reading

Different description

Does not exist on council's database

Class	Height (m)	Consequences
		Water at foot of McLeans Beach Caravan Park levee, on old road levee. Consider closing gap in levee at park entrance if it has been lowered for ease of access by patrons.
MIN	5.63	Brick Kiln Creek crosses causeway on Chippenham Park access road near Edward River Oval, close road. Stock route affected.
MIN	5.80	Approximate level of causeway at Sandhurst Island Estate to McMillan, Vesty, Dick Lee and 3 non-resident properties off Dahwilly Lane.
MIN	5.88	McLeans Beach sewerage pump station inundated. Height: 5.84 on other.
MIN	6.00	Brick Kiln Creek commences to flow.
MIN	6.06	Council: Cut out and weld in new plate in floor and sills on drivers side. Close storm drain outlet, 1050 mm dia, cut out and weld in new plate in floor and sills on drivers side at Wick Street. Progressive closure of other drains as the river rises. MRS DRIVER.
MIN	6.10	Boggy Creek causeway level; alternative access to Chippingham Park area from Dahwilly Road. Access from Dahwilly Road closes at 6.3 m (or earlier if damaged). Cut out and weld in new plate in floor and sills on drivers side.
MIN	✓ 6.40	In previous floods, water backed up to Wyatt Street levee.
MIN	6.67	Footbridge at Golf Links cut.
MIN	7.00	McLeans Beach Caravan Park closed in accordance with lease arrangements.
MOD	✓ 7.20	Moderate flood level exceeded at an average frequency of 4 years, but varying to 1 to 8 years. Floor of lavatory at Edward River Oval flooded. Floor of lavatory at Edward Street Oval flooded.
MOD	7.30	Riverside Caravan Park, Davidson Street - vans occupying annual sites outside the park's levee begin to be affected; most are elevated but access to this area is lost at 7.4 metres.
MOD	7.40	Riverside Caravan Park access to vans occupying annual sites across floodway lost.
MOD	7.49	31/08/90. Peak height.
MOD	7.66	Water commences to back up from western end of floodway near National Bridge.
MOD	7.70	Island Sanctuary flooded; native fauna to be relocated by this height; all road access to this area is lost at 7.84 metres.
MOD	7.80	Floodway commences to run.
MOD	✓ 7.84	Memorial Park Drive closed; access to showgrounds, Golf Club and the Golf Leisure Resort lost. The resort contains about 24 motel style units above the 1% AEP flood level (9.82 metres).
MOD	7.95	Ground level between Ovals 2 and 3 at Memorial Park.
MOD	7.96	15/10/96. The house in 4 Post Reserve area belonging to Mr Desie Grieves evacuated (Map DENILIQUIN 7826-I and IV, GR 811331). Other houses along river in the same area are progressively threatened; two were evacuated and one sandbagged in the flood of October 1993 which peaked at 8.48 metres.
MOD	8.00	Boggy Creek causeway at Sandhurst Island Estate off Dahwilly Lane to Sibley, Ward, Cunningham and Bullock (non-residential) properties. Likely to wash out when inundated.

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06/05/2016 WMAwater comments

Different gauge reading

Different descriptions

Does not exist on council's database

Class	Height (m)	Consequences
		Water across Memorial Park Drive bridge.
		NB: For predicted peaks above this level, consider using a sandbagging machine to build up a stockpile of 2/3 filled untied bags placed on pallets and stored undercover. Especially if the peak is expected to exceed 8.3 metres.
MOD	8.10	Water across Carew and Henry streets intersection.
MOD	8.11	30/10/92. Peak height.
MOD	8.21	2/09/81. Peak height (on old bridge gauge). No need to correct by 0.04 metres to align with new gauge unless correcting all historical readings.
MOD	8.30	Estimated crest height of the levee protecting the McLeans Beach Caravan Park. The park has a capacity of 450 sites. There are 26 relocatable cabins (on skids and/or wheels) which would require cranes and take about 2-3 hours preparation time each. There are also about 250 semi-permanent vans (50% hard annexes) which would require about 1.5 hours each to prepare for relocation. The remaining sites are reserved for tourist vans. NB: Depending on the conditions for individual floods, the levee may not inundate until 8.5 metres.
MOD	8.48	17/10/93. Peak height. In this event, north Deniliquin tennis courts were flooded and approximately six riverside houses were threatened upstream in Lawson Siphon and Four Post areas (some were sandbagged). At this height in future floods there may be more houses at risk in this area due to development. Three houses were sanbagged for protection in the Dahwilly area.
		The predicted peak height was 9-9.1 metres however this was not achieved due to a farm levee giving way upstream on the Tuppal Creek Floodway causing a diversion of some of the flow.
		Monitor and inspect the Central Levee.
MOD	8.50	McLean Beach Caravan Park levee height. Designed to be 8.3 metres but in practice so far is 8.5 metres.
MOD	8.53	Main oval at Memorial Park flooded.
MOD	9.05	5/11/75. Peak height (old bridge gauge).
MAJ	9.20	This is considered to be the critical height for Deniliquin. Evacuations should be considered if is predicted that this height is to be exceeded. Only referred to as "Major flood" in council's.
MAJ	9.40	Levee height; Central levee (Davidson Street); actual height in 1993. Consider temporary raising slightly further if other levees will not be endangered.
		Evacuate Central area, approx 270 people (includes some elderly people). This should be commenced two days prior to this height occuring.
MAJ	9.42	16/07/56. Peak height (Note: Height taken on old gauge - some conflicting reports of actual height between 9.37 and 9.42). During this flood the Central levee in Davidson Street was breached before overtopping to relieve pressure on the weaknesses in the South levee; houses were flooded as a result.
		Davidson Street level and existing levee top at Davidson Street, if overtopped; close northern sewerage system. Water enters top section of the Riverside Caravan Park. The park has about seven motel style cabins and 14 semi-permanent caravans which require a crane and/or a low-loader to relocate. It

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Different gauge readings

Different descriptions

Does not exist on council's database

Class	Height (m)	Consequences
		would take between 3 to five days to relocate these assets.
MAJ	✓ 9.50	Approx 1 in 40 ARI. North and South levees topped up in 1993 to this height. At this level, the whole town is threatened. Raise levees with earthmoving machinery and sandbag where access is difficult. Preposition pallets of sandbags for emergency use. Low mobility and non-essential personnel should be evacuated before this level is reached.
MAJ	9.62	Wenbern Motel; top of floor slab on wing extending beyond levee.
MAJ	9.63	30/10/1917. Peak height. In this event flood water inundated town. This was before the construction of the current levee system.
MAJ	9.68	1/11/1870. Flood of record.
MAJ	✓ 9.82	Estimated 1% AEP flood level.
MAJ	9.90	Sewerage Treatment Plant - approximate ground level. Much of the plant is above the surrounding flood level. However, consider construction of a temporary levee if this height or greater is anticipated to prevent overloading by flood water or contamination of the flood water. From this point on there exists the potential for a progressive closedown. The humus tank and outlet channel may be inundated but the sewage is mostly treated by this stage. If the plant continues to operate, treated effluent is pumped into lagoons. There is considerable storage capacity but it may be prudent to partly draw the final lagoon down before the flood water arrives to increase storage capacity. Council Engineering staff and Health Surveyors need to monitor and assess the situation.
MAJ	10.70	Ground level at Sale yards; protected by Mulwala Canal and high ground surrounding them.
MAJ	10.86	Future south levee (Planned to be 1 metre above 1% AEP flood level). Surveyed floor levels of some properties inside the levee are attached as Annex A to this card.
MAJ	11.27	Mulwala Canal Bank, Cemetery Road.
MAJ	11.29	Water Treatment Plant - approximate ground level at pumps.
MAJ	11.62	Mulwala Canal bank, Echuca Road Bridge (centre line) at Barham Road and aerodrome terminal area.
MAJ	11.69	Mulwala Canal bank at Barham Road and aerodrome terminal area.

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DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
4.30	Brick Kiln Creek.	Brick Kiln Creek comences to back up.				
4.60		**"Minor Flood".**				
5.10	Edward River Oval	Irrigation pump to be removed.				
5.63	Chippenham Park Road.	Prepare to close access to Chippenham				
		Park via Edward River Oval.				
5.80	Dahwilly Lane.	Prepare to close access to Sandhurst				
		Island on Dahwilly Lane.				
6.00	Brick Kiln Creek.	Brick Kiln Creek comences to run.				
6.14	Boyd Street at Brick Kiln Creek.	Close off pipe at wingwall.	1070mm	Headwall bolts & door	Sump	26
6.14	Hyde Street at River Street.	Close off Gate Valve in pit.	300mm	Gate Valve in pit	Pump over levee	27
6.19	Davidson - Morris Street near old Butter Factory.	Close off pipe.	375mm	Pipe only	Pump over levee.	28
6.68	Herriott Street near old brick works.	Close off pipe.	375mm	Headwall bolts & door	Pump from drain	29
6.70	Wanderer Street near Shell Sevice Station.	Close off Gate Valve.	750mm	Wingwall & Gate Valve	Pump from pit 20m	30
7.18	River Street. No. 278.	Close off pipe.	300mm	Pipe only	Pump from pit	31
7.18	Davidson Street opposite Herriott Street.	Close off pipe.	460mm	Pipe only	Pump from pit	32
7.20		**"Moderate Flood".**				
7.20	Edward River Oval.	Sewer pump inundated.				
7.25	Brick Kiln Creek. Downstream of Sportsman's Hotel.	Close off valve in pit.	150mm	Pipe only	Pump from pit	33
7.30	Riverside Caravan Park.	Prepare to evacuate Riverside Caravan				
		Park outside the park's levee.				
7.47	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	3x100mm	Pipe only ????	Pump from pit ???	34
7.50	River Street. No. 270.	Close off pipe.	225mm	Pipe only	Pump from pit	35
7.62	Davidson Street Mrs Marks No. 32. ?	Close off pipe.	460mm	Pipe only ????	Pump from pit ???	36
7.65	Davidson Street. East side of Brick Kiln Creek Bridge.	Close off Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	37
	at Shell Service Station.					
7.65	River Street. No. 306.	Close off pipe.	100mm	Pipe only	????????	38
7.70	Davidson Street in Floodway. (east side).	Close off pipe.	300mm	Pipe only	Pump from drain	39
7.71	Jones Avenue	Close off pipe.	375mm	Headwall bolts & door	Pump from pit	40
7.73	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	????????	????????	41
7.76	Davidson Street behind Fred's 4WD. (No. 28).	Close off pipe.	300mm	Headwall bolts & door	Pump from pit	42
7.80	Floodway in Davidson Street.	Floodway comences to run.				
7.82	Davidson Street at south side Brick Kiln Creek Bridge.	Close off pipe.	225mm	Pipe only	Pump from pit	43
7.85	Davidson Street near Sporties Hotel.	Close off Davidson Street Gate Valve.	300mm	Wingwall & Gate Valve	Pump from pit	44
8.10	Hyde Street raw water pump station at Edward River.	Close off pipe in pump station.	100mm	Pipe only	Pump from pit	45
8.34	Davidson Street in Floodway. (west side).	Close off pipe.	300mm	Pipe only	Pump from drain	46
8.35	Davidson Street in Floodway. (east side nature strip).	Close off pipe.	300mm	Pipe only	Pump from pit	47
8.38	Melon Street at Edward River.	Close off pipe.	300mm	Pipe only	Pump from pit	48
8.50	Between National and Brick Kiln Creek bridges.	Monitor and inspect the Central Levee.				

272 River off 8mms — 270 River St o RD 8 mts

286 River off 8mms

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DENILIQUIN COUNCIL FLOOD RESPONSE PLAN NORTH and CENTRAL LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
8.70	River Street No.308. House at Hyde Street corner.	Close off pipe.	100mm	Pipe only		**49**
8.71	Davidson - Morris Street near old Butter Factory.	Close off pipe.	300mm	Pipe only	Pump from drain.	**50**
8.78	River Street. No. 284. Kms	Close off pipe.	300mm	Pipe only	Pump from pit	**51**
8.95	River Street. No. 268.	Close off pipe.	100mm	Pipe only	Pump from pit	**52**
9.20		**" Major Flood".**				
9.40	Central Levee.	Height of levee. Consider temporary raising slghtly further if other levees will not be endangered.				
		Evacuate Central area, approx 270 people (includes some elderly people). This should be commenced two days before this height occuring.				
9.42	Davidson Street.	Height of road. If water goes over close off north Deni sewer system.				
		Water enters main part of Riverside Caravan Park.				
9.82		**1 : 100 year flood level.**				
	EXTRA INFORMATION.					
	North of Finley Road opposite Melon Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**53**
	Yarra Street at Charles Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**54**
	Augustus Street north of Hyde Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**55**
	Augustus Street behind DLS Engineering.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**56**
	Augustus Street north of Browning Street.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**57**
	Augustus Street at Smart Street intersection.	Close off Gate Valve.		Wingwall & Gate Valve	Pump from drain	**58**
	Close off Finley Road near Melon Street.					
	Close off Conargo Road near Augustus Street.					
	Close off Hay Road at April Street.					
9.92	Melon Street to Robinson Street along Edward River and Brick Kiln Creek.	Height of constructed levee bank and the rest in this area above this height.				
9.92	Melon Street to Coborro Street.	Height of levee bank.				
9.92	Conargo Road to April Street to Hay Road.	Height of levee bank.				
10.82	Coborro Street to Conargo Road.	Height of levee bank.				
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- North Levee is built to 1:100 year flood level with 0.1m free board only.					

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DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

GAUGE READING	LOCATION	CONSEQUENCES and ACTIONS	SIZE OF PIPES	DOWNSTREAM.	UPSTREAM.	No.
2.90	Aljoes Creek.	Water comences to back up Aljoes Creek				
		from both sides.				
3.52	Aljoes Creek.	Aljoes Creek comences to run.				
3.90	Golf Course. (Inside levee **5.80** see consequences)	Close flood Gate. But monitor water levels	2x1350mm	Gate Valve	Pump from pit or	1
		on inside of levee because this outlet is for			pump over levee	
		most of the area east of Napier Street.			with special pump.	
4.60		**"Minor Flood".**				
4.66	Island Sanctuary.	Water starts to enter Island Sanctuary				
		near footbridge.				
5.00	Under Butler Street 30m outside levee..	Close off pipe under local levee.	500mm	Pipe only	Pump over local	2
					levee	
~~5.70~~	Butler Street at Riverview Motel.	Close off Gate Valve.	525mm	Pipe and wingwall	Pump from pit	3
5.84	McLean Beach.	Sewer pump station is inundated.				
6.40	Wyatt Street between Poictiers & Harfleur Streets.	Close off pipes at wing wall but monitor water	2x1220mm	Wingwall bolts & door	Pump over road	4
		levels on inside of levee because this outlet		and drop boards	special pump.	
	crispstreet back of car o tel.	is for most of the area west of Napier Street.				
~~6.88~~	Crispe Street near Deni Car-o-tel Caravan Park.	Close off Gate Valve.	375mm	Gate Valve	Pump from pit	6
~~6.96~~	~~Crispe~~ Street behind Middy's.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	7
~~7.20~~	@ End st opposite RSL Club	**"Moderate Flood".**				
7.30	Napier Street down stream side of National Bridge.	Close off Napier Gate Valve and pump from	2x610mm	Gate Valve in pit		8
		pit outside levee. Top of pit at levee height.	900mm	Pump from this pit		
7.40	Behind Lawn Tennis Courts Charlotte Street.	Close off Gate Valve.	525mm	Gate Valve and	Pump from pit	9
				wingwall		
7.43	Hardinge Street opposite Police Station.	Close off Gate Valve.	525mm	Gate Valve in pit	Pump from pit	10
7.48	Burton Street west side near No. 57.	Close off pipe.	300mm	Pipe only	Pump from pit	11
7.50	200m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	12
7.50	Fowler Street at Edward River in park area.	Close off Gate Valve.	450mm	Pipe only	Pump from pit	13
7.50	George Street west end at Edward River.	Close off Gate Valve.	225mm	Pipe only	Pump from pit	14
7.50	Riverside Drive behind Hospital.	Close off Gate Valve.	525mm	Gate Valve	Pump from pit	15
7.50	George Street east end opposite Men's Club.	Close off George Street Gate Valve.	375mm	Pipe only	Pump from pit	16
~~7.64?~~	Memorial Drive behind Coach House Hotel Motel.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	17
7.80	Island Sanctuary.	Access bridge cut off.				
7.84	Memorial Drive at Tarangle Creek Bridge.	Put Bulkhead gate in place.			Pump over levee.	
		Access to Showgrounds, Golf Club and				
		Golf Leisure Resort lost. **Units at 9.82m.**				
~~7.95~~	~~End~~ Street at Deni Car-o-tel Caravan Park.	Close off Gate Valve.	300mm	Gate Valve	Pump from pit	18
~~8.10~~	Carew and Henry Streets intersection.	Prepare to close Carew and Henry Streets.				
		water over intersection.				
8.10?	300m north of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	19

sanctuary lane near lilte trap. 8mts

* close 300mm Poly pive valve Nature st north side caravan park

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DENILIQUIN COUNCIL FLOOD RESPONSE PLAN SOUTH LEVEE SYSTEM.

8.21	Butler Street at Riverview Motel.	Close off Gate Valve.		Pipe only	Pump from pit	
GAUGE READING	**LOCATION**	**CONSEQUENCES**	**SIZE OF PIPES**	**DOWNSTREAM.**	**UPSTREAM.**	**No.**
8.30	Mclean Beach Caravan Park.	Estimated crest height of levee protecting.				
		McLean Beach Caravan Park.				
8.30	Gate Valve on outside of levee behind Dept of Ag.	Close off Gate Valve.	300mm	Gate and wingwall	Pump from pit	**20**
	Charlotte Street.					
8.36?	North side of Henry Street. East end of town.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**21**
8.50	Block off Butler Street at Riverview Motel.	Put Bulkhead gate in place.			Pump over levee.	**22**
8.80	Block off Macauley Street at back entrance to McLean					
	Beach caravan park.					
8.95	Wellington Plaza behind Salvation Army building.	Close off pipe.	225mm	Pipe only	Pump from pit	**23**
9.12	Carew Street 100m north of Syphon Road.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**24**
9.20		**" Major Flood".**				
9.32	Panels to be put in between Burton Street and	**Panels stored at Council Depot in**				
	Department of Agriculture.	**Hardinge Street. In shed in back cnr.**				
9.50	Memorial Drive to George - Edwardes inters.	Top up levees that have not yet been raised.				
	Burton Street to the west.	Varying alignments and heights.				
9.82	1:100 year flood at National bridge is **92.25 AHD.**	**1 : 100 year flood level.**				
10.06	Carew Street at Hetherington Street inters.	Close off Gate Valve.	375mm	Gate Valve	Pump over levee.	**25**
10.32	Packenham Street to Duncan - Hughes inters.	Height of levee bank.				
10.32	George - Edwardes inters. To Burton Street.	Height of levee bank.				
10.82	Lawson Syphon road to Packenham Street.	Height of levee bank.				
	EXTRA INFORMATION.					
	St Michael Sreet Area.					
	Burton Street to Fowler Street most houses have					
	90mm stormwater pipes through the levee but all are					
	close to 1:100 flood level (9.8).					
	Wenburn Court Area.					
	Two 90mm stormwater pipes go through levee in this					
	area but are also at about 9.8.					
	No levee yet constructed at ????? St Michael St next to Wenburn Motel.					
	Note:- Keys for vehicle gates and Gate Valves and also Handles for Gate Valves are at the Deniliquin Council Depot.					
	Note:- The panels for the levee are stored in a shed in the back left hand corner of the Deniliquin Council Depot.					
	Note:- The panels for the levee are to be placed before 9.32 if flood prediction to be near 1:100 year flood level.					
	Note:- Levee is built to 1:100 year flood level with 0.5m free board for wave action only.					

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Appendix G

Edward River at Deniliquin October 2016 Flood Event

Public Meeting

wma water

Edward River COUNCIL

Overview

- Introduction – Who are we, why are we here?
- October 2016 Event Description
- Model Description, results and limitations
- Data Collection
- Contacts, Uploading links, Drop in Sessions

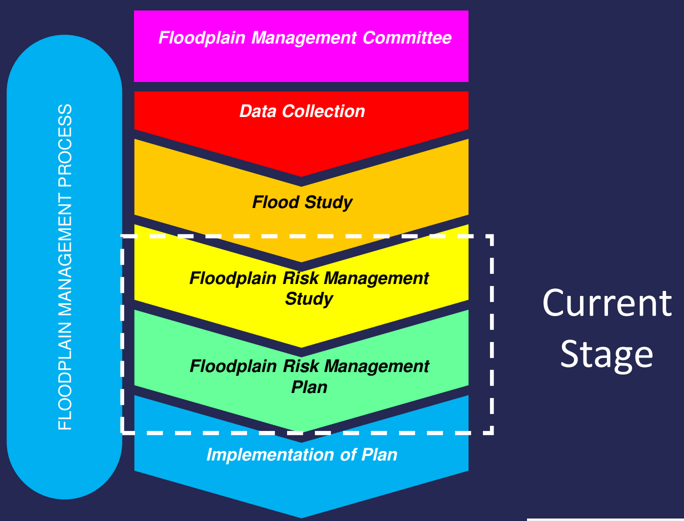
wma water

Edward River COUNCIL

Introduction

- WMAwater is an engineering consultancy specialising in hydrology, hydraulics and floodplain management
- We have been working on the Edwards River at Deniliquin Floodplain Risk Management Study and Plan
- Just finished the Public Exhibition Stage

Study Context



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Why are we having this meeting?

- To collect information about the October Event to validate WMAwater's flood model
- Key recommendation of the Plan: to synthesise and improve Council and SES flood intelligence and action plans
- Gather information to improve how future floods are managed
- Great opportunity to record experiences and lessons learnt

Have Your Say

- Community Newsletter (PDF) available for download:
  http://www.edwardriver.nsw.gov.au/october-2016-flood
- Online Survey https://www.surveymonkey.com/r/DeniFlood2016
- Public Meetings (Mountbatten Room, RSL)
  - Wednesday 23rd Nov, 7pm
  - Thursday 24th Nov, 7pm
- Drop in Sessions at Central Murray Regional Library in Deniliquin:
  - Thursday 24th Nov, 10am – 4pm
  - Friday 25th Nov, 9:30am – 11am
- Written Submissions are preferred
  - Submissions can be lodged online at above website
  - Submissions can also be made to Council, addressed to:

The General Manager
Edward River Council
PO Box 270
Deniliquin, NSW 2710

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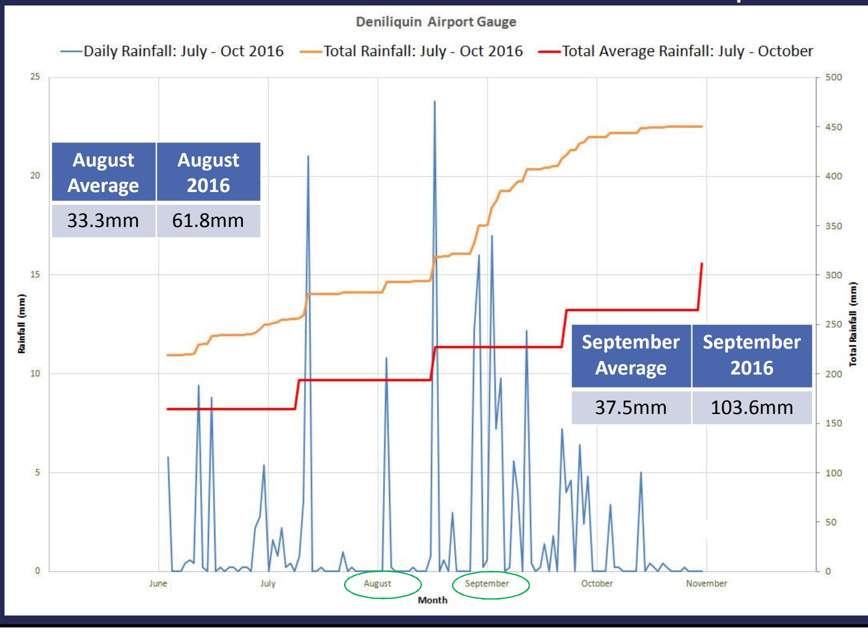
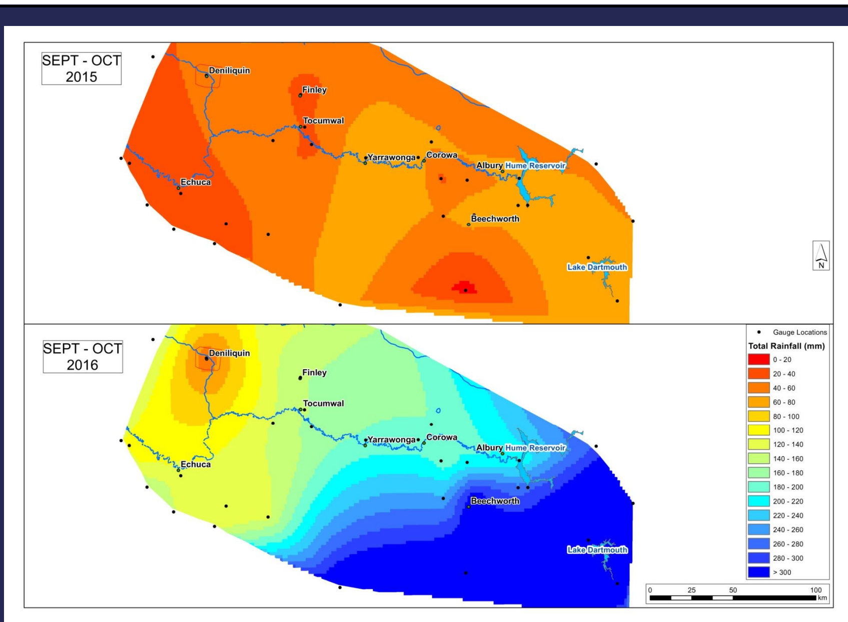
October 2016 Flood: Rainfall Comparison





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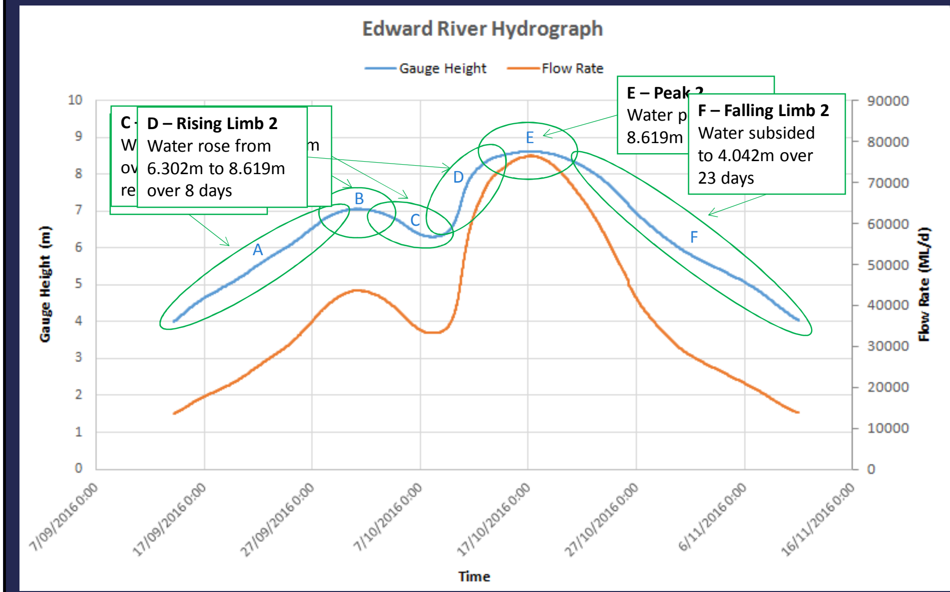
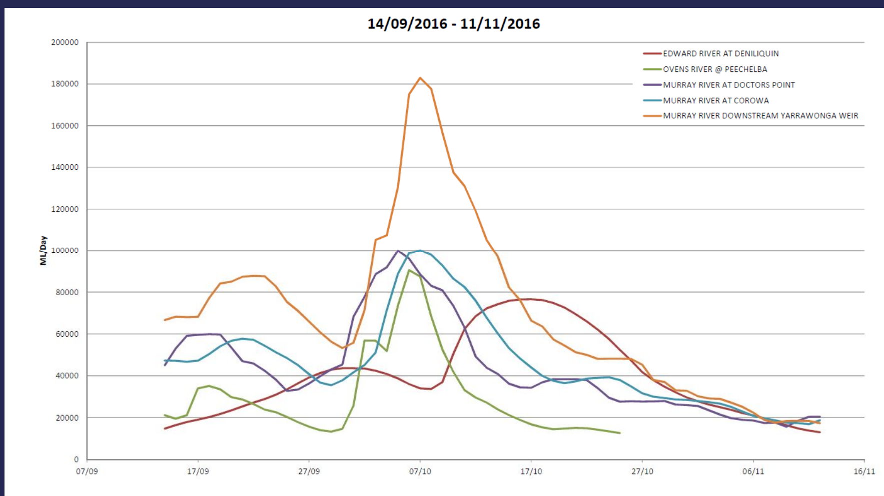


October 2016 Flood Event: River Flows

2016 October Flood: Hydrograph



October 2016 Event

<u>Flood Gates</u>

Memorial Drive closed 10th October

McLeans Beach closed 10th October

<u>Sandbagging</u>

- Flood Gate at Memorial Park
- Properties surrounding Bullatale and Tuppal Creek
- McLeans Beach Caravan Park

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Flood Model

- Originally built for the Edward River at Deniliquin Flood Study (Completed 2014)
- Based on LiDAR data (topography) (2012)
- Simulates big-picture flooding
- Used to define Flood Planning Area and aids understanding of flood risk across the area

Limitations:

- Rivers naturally change over time
- Development in Deniliquin – minor, localised changes in topography
- Focuses on broader scale flooding

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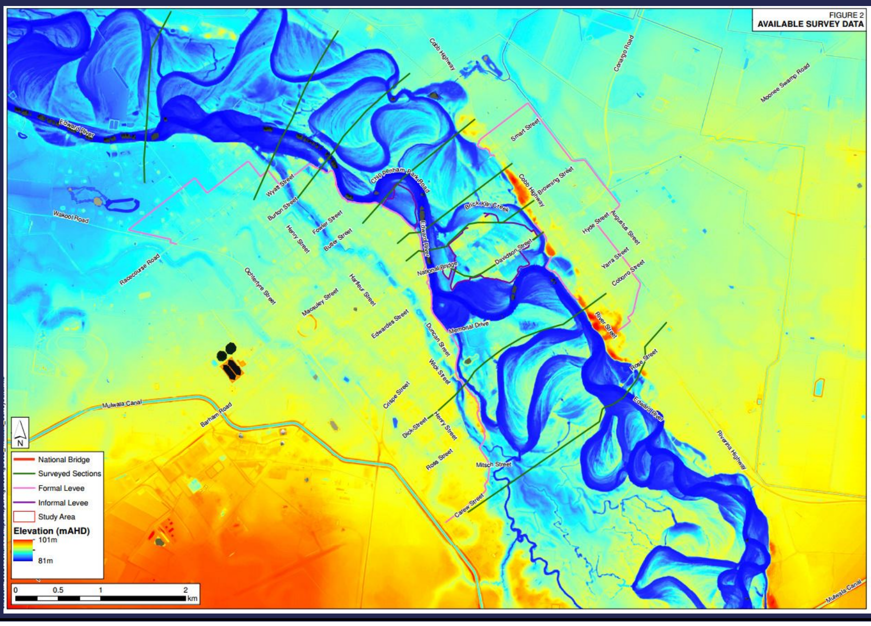
Topography



Draft Model Results

- Based on Hydrograph recorded by Office of Water
- Close to 1993 event
- Draft only – we need YOUR input to refine and validate the localised effects

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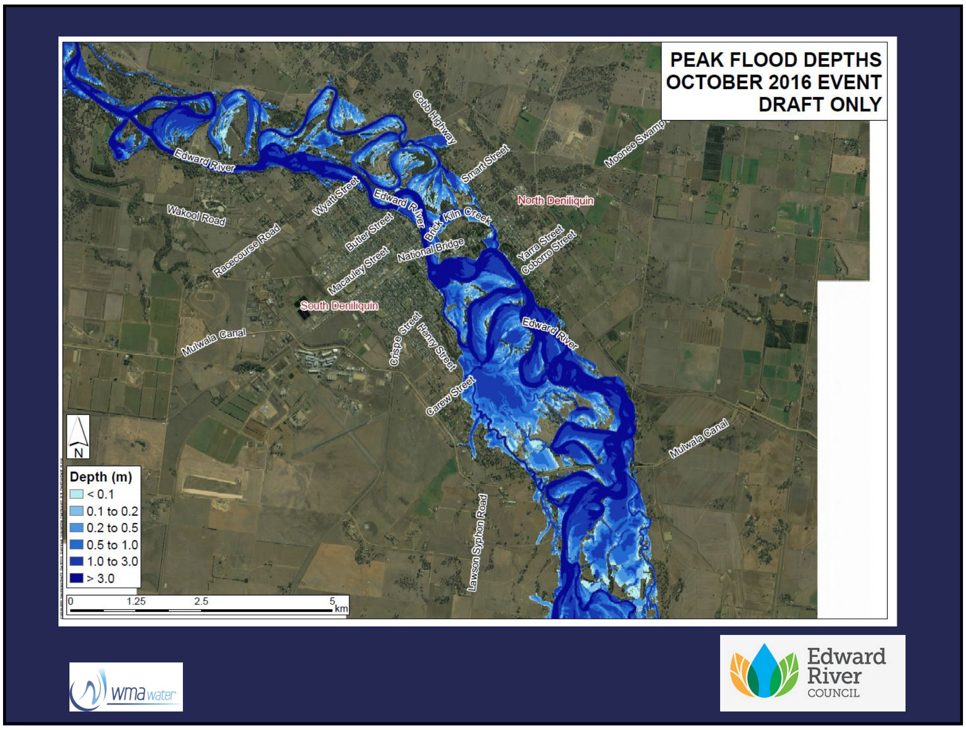

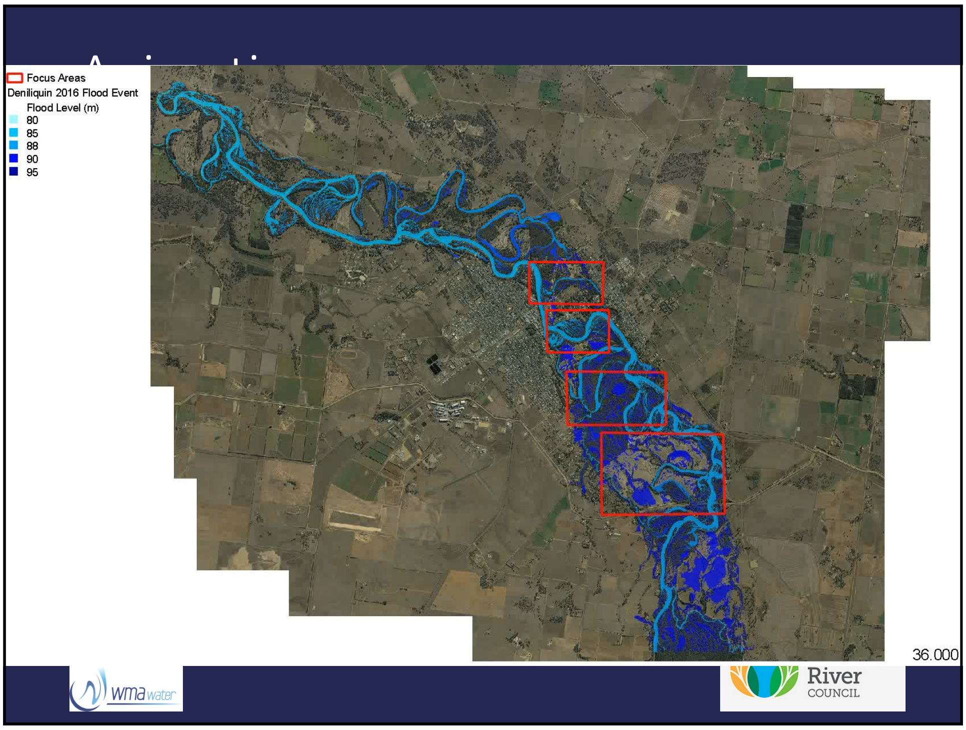

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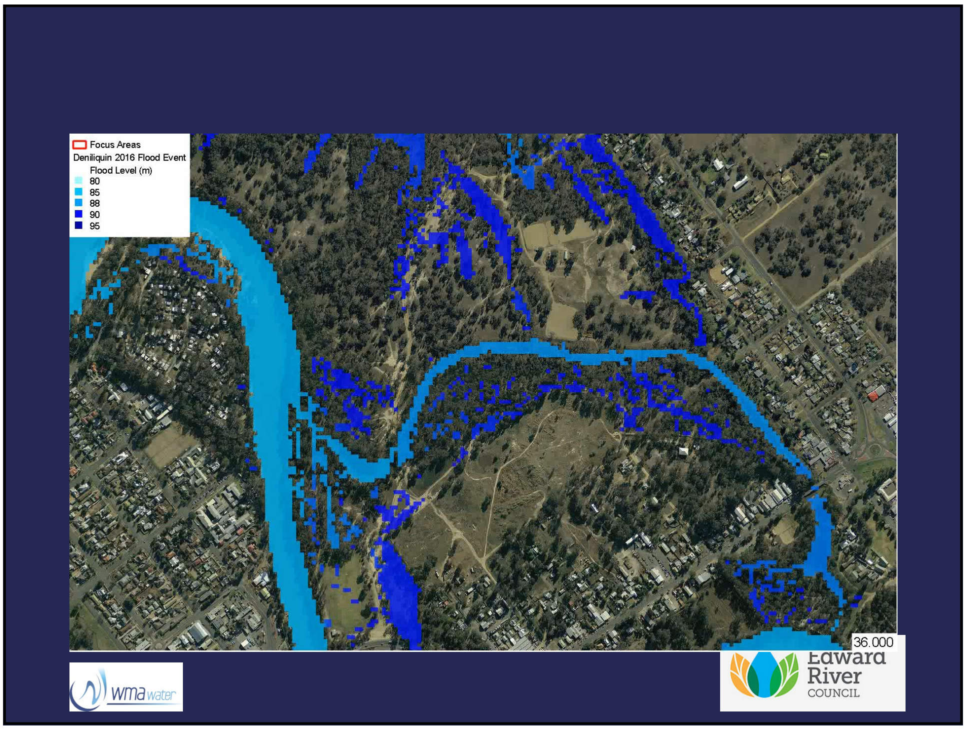
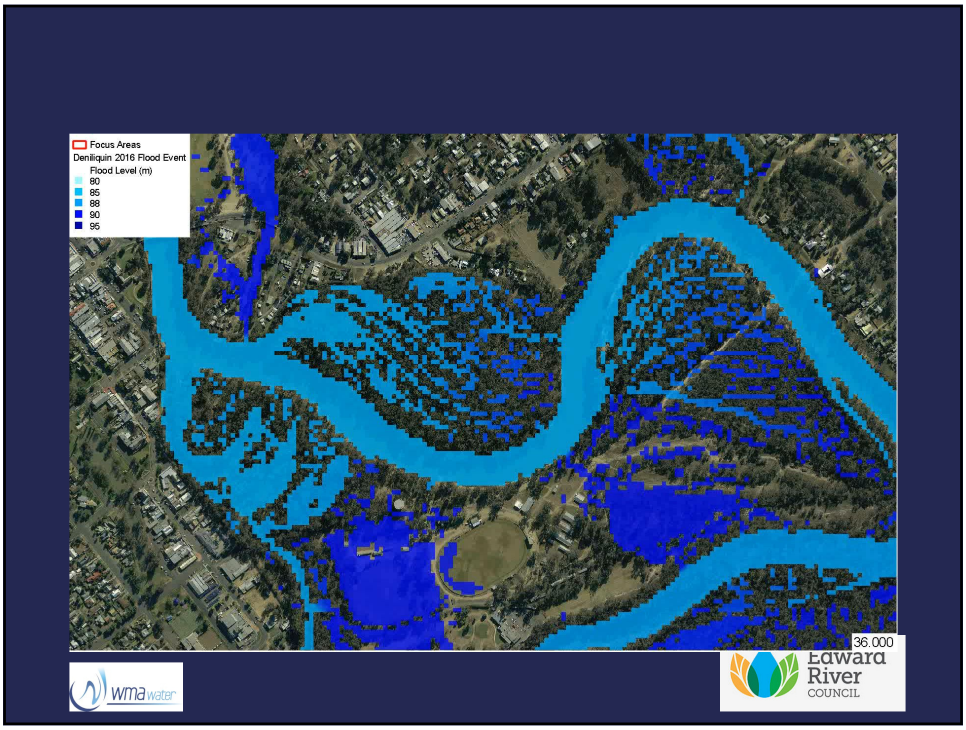

Focus Areas
Deniliquin 2016 Flood Event
Flood Level (m)
80
85
88
90
95
36.000
wma water
Edward River COUNCIL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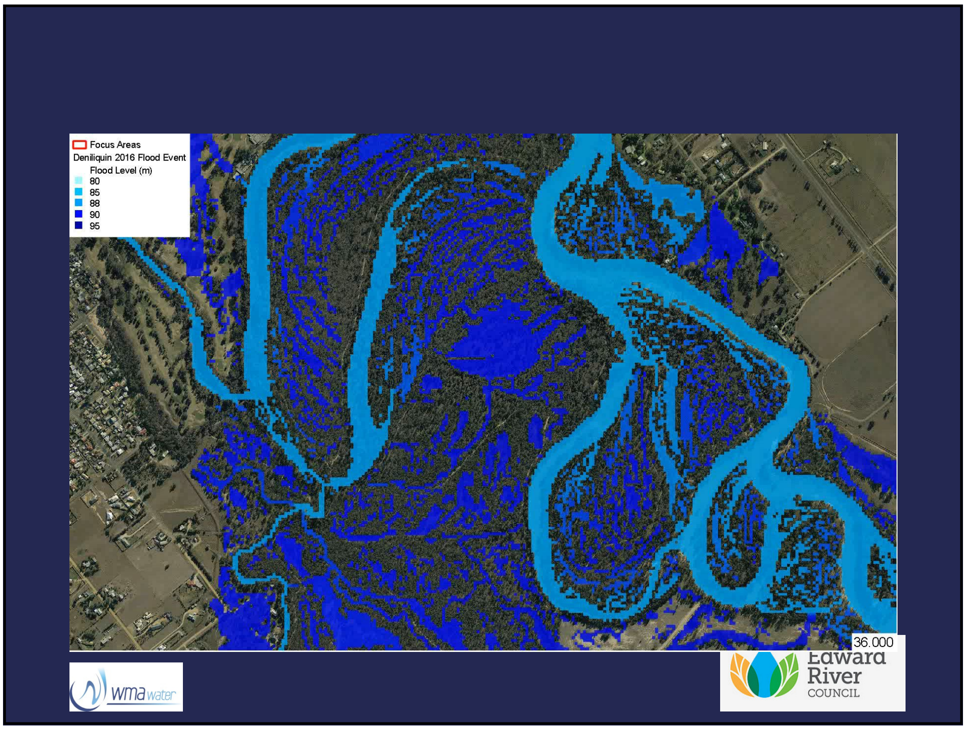
Edward River COUNCIL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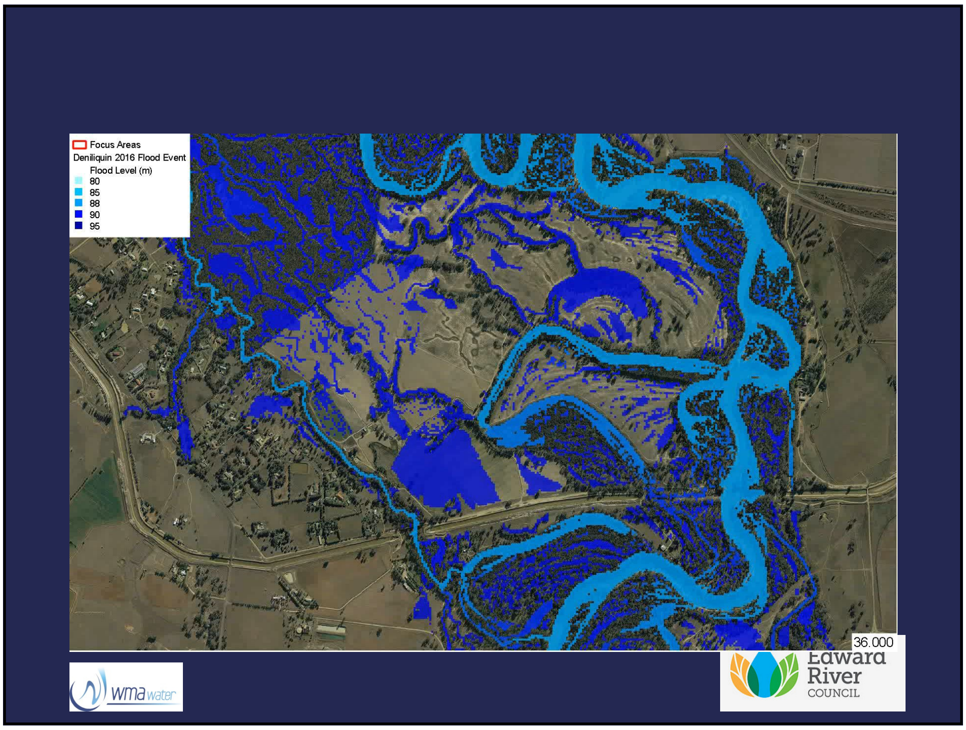
Focus Areas
Deniliquin 2016 Flood Event
Flood Level (m)
80
85
88
90
95
36.000
wma water
Edward River COUNCIL

What do we need from you?

Data from residents is needed to both validate the model and improve future flood management.

Data may include:

- Photos (with date and location)
- Dates/Times of inundation (roads, driveways, properties etc)
- Describe flooding around your property
- What would you like to happen differently next time? (more communication from SES, Council etc?)
- Sandbags carried into properties via boat

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Flood Marks

- Photos with context & location

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Appendix H

AERIAL OVER MEMORIAL PARK, DENILIQUIN

Aerial Image: CAF Consulting 17/10/2016

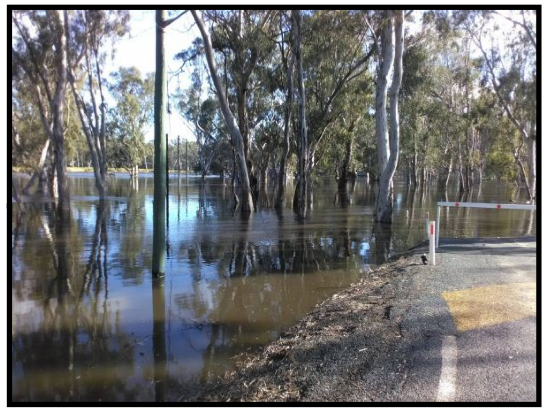
WMA Depth Model for 2016 Flood Event

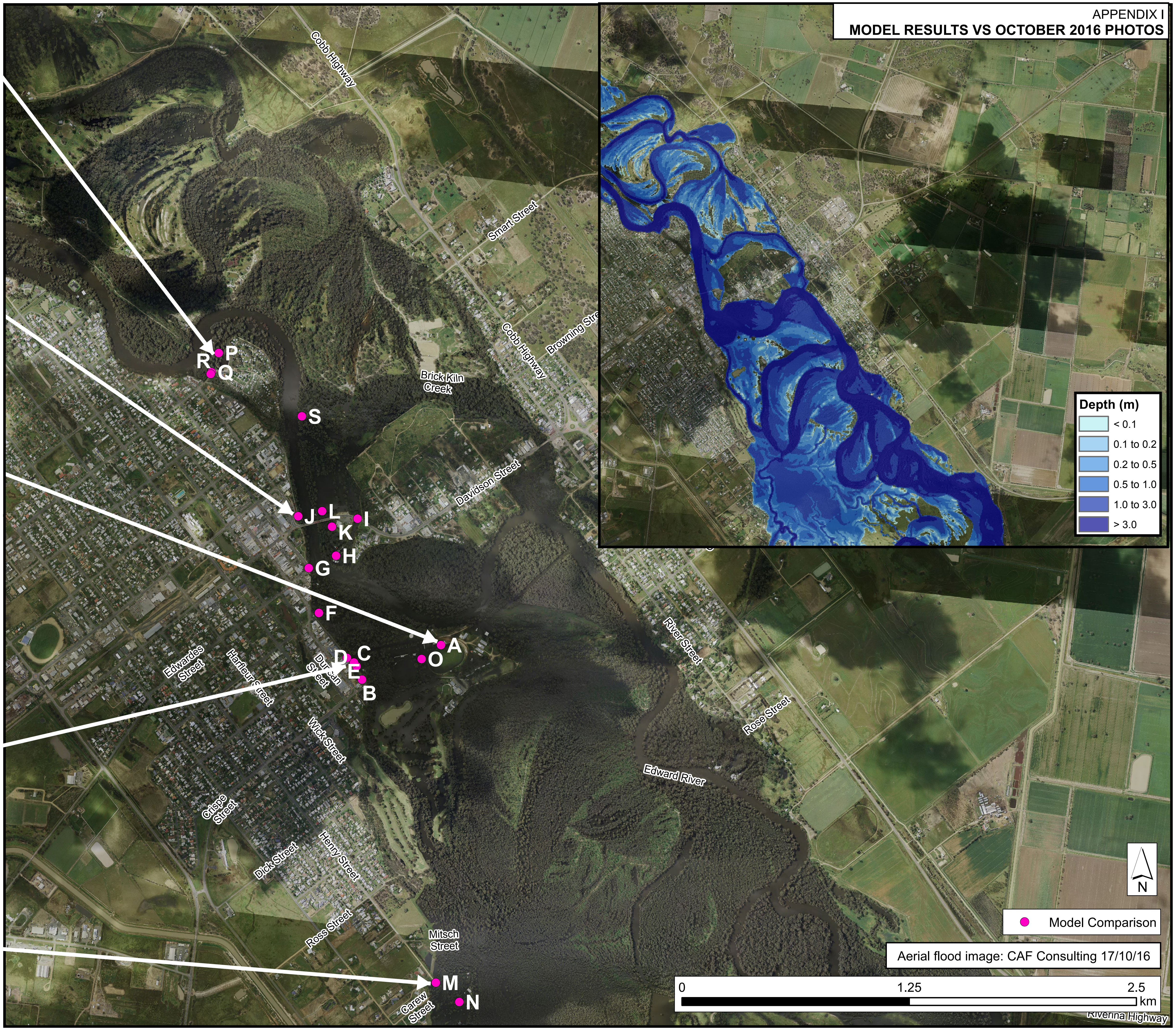
AERIAL OVER DENILIQUIN NATIONAL BRIDGE

Aerial image: CAF Consulting 17/10/2016

WMA Depth Model for 2016 Flood Event

Appendix I





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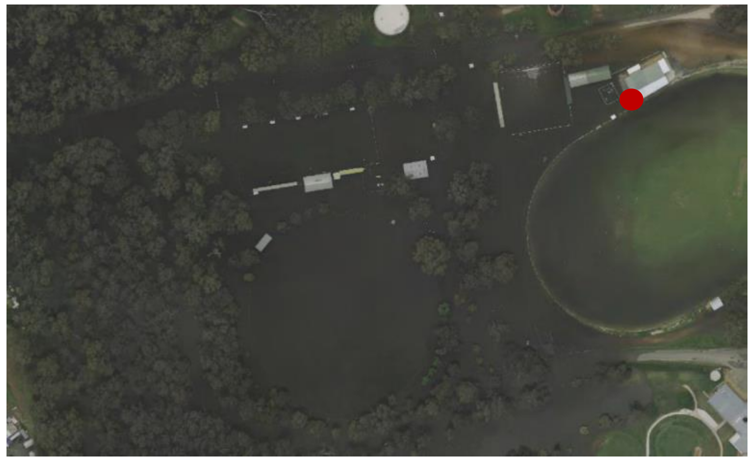
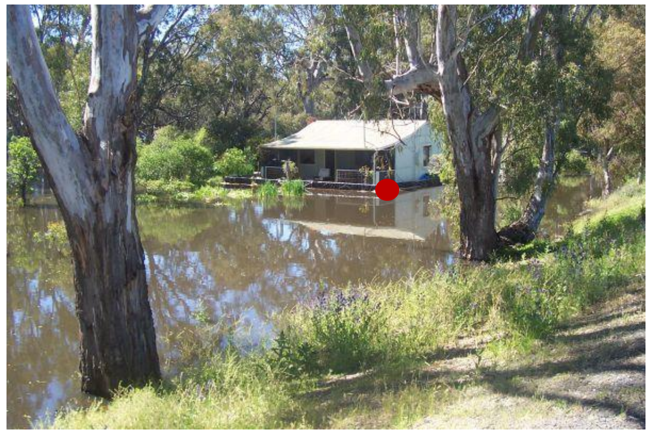
Shed in Memorial Park (A)



House near Memorial Drive (B)

House near Memorial Drive(C)



Tarangle Creek Bridge on Memorial Drive (D)	Tarangle Creek Bridge on Memorial Drive (E)	Island Sanctuary Footbridge (F)
		
		
		

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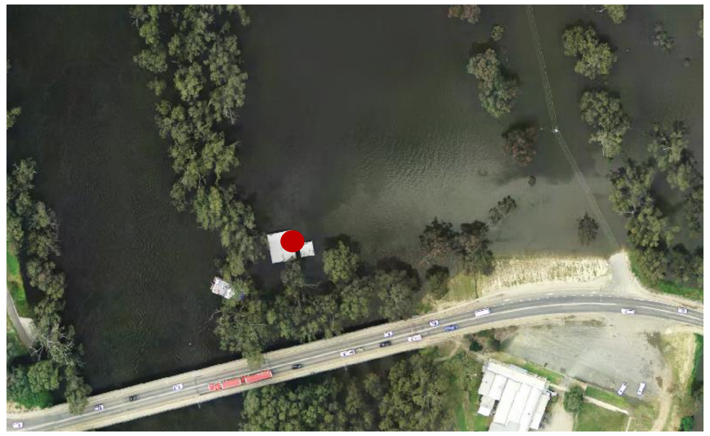
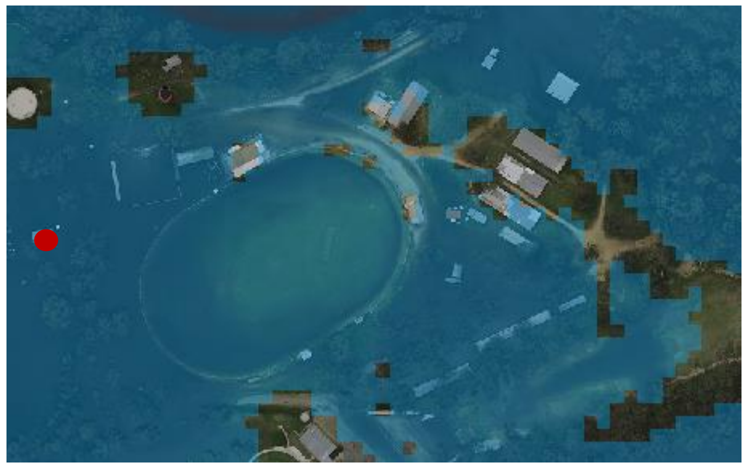
Intersection of Edwardes Street and George Street (G)	Riverside Caravan Park (H)	Cobb Highway near Pony Club Road (I)
		
		
		

West side of Edward River near Cobb Highway (J)	East side of Edward River near Cobb Highway (K)	Deniliquin Oval sheds (L)
		
		
		

Intersection of Henry street and Carew Street (M)

Shed near Carew Street (N)

Shed in Memorial Park (O)



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McLeans Beach with floodmark (P)	Shed at McLeans Beach (Q)	McLeans Beach Caravan Park Entry (R)
		
		
		

Watermark on East side of Edward River (S)

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