DRAFT

Mungindi *Floodplain Risk Management Plan—*

Mungindi Bridge over Barwon River

FOR / Waterways Consulting Services

CLIENT / Moree Plains Shire Council

DOCUMENT NO / S13162-RPT-002 REV / B DATE / 29/11/2014

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CONTENTS

Appendices

Document *Control*

Revision	Date	Description	Prepared	Reviewed	Approved
A	27/05/14	Issued for Council Review	B Stinton	D Collyer	
B	29/11/14	Incorporated Council Review Comments	B Stinton	D Collyer	

PREFACE

The NSW State Government's *Flood Prone Land Policy* aims to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land. The policy highlights that primary responsibility for floodplain risk management rests with Councils, which are provided with financial and technical support by the State Government.

In 2005 the NSW Government published the *Floodplain Development Manual* (the '*Manual*') which seeks to aid local Councils in managing flood risk. The *Manual* provides guidance to local Councils for the development and implementation of floodplain risk management plans, overseen by the floodplain risk management committee.

The *Mungindi Floodplain Risk Management Plan* (the '*Plan'*) has been prepared by BG&E Consulting Engineers on behalf of the Moree Plains Shire Council. The *Plan* complies with the requirements of the NSW Government's *Flood Prone Land Policy* and the *Manual.* The *Plan* addresses the existing, future and continuing flood problems for Mungindi, detailing how flood prone land within the township is to be managed.

The *Plan* has been prepared in the following structure:

Section 1 provides an overview of the study area and flood environment.

Section 2 lists relevant state and local government legislation and policies to which the *Plan* must integrate.

Section 3 outlines the preceding studies and activities carried out by Council as part of the floodplain risk management process.

Section 4 summarises the results of flood modelling carried out during previous studies to estimate flood behaviour for the study area.

Section 5 describes how flood risk is classified within the Shire and how flood risk categories can be applied to the study area.

Section 6 lists the recommended flood, property, and response modification measures identified during the floodplain risk management study to manage existing, future and continuing flood risk.

Section 7 presents a plan for implementation of the recommended management measures along with funding requirements and responsibilities.

1 BACKGROUND

1.1 Locality

The name Mungindi derives from the language of the indigenous Kamilaroi people who inhabited the area before European settlement. It is thought to mean 'water hole by the river'.

The general area of Mungindi is located within the Border Rivers catchment on the Barwon River floodplain. The town itself lies on the Carnarvon Highway, 120 km north-west of Moree, straddling the Queensland and New South Wales border. The location of the township within the Moree Plains Shire Council boundaries is shown on Figure 1.

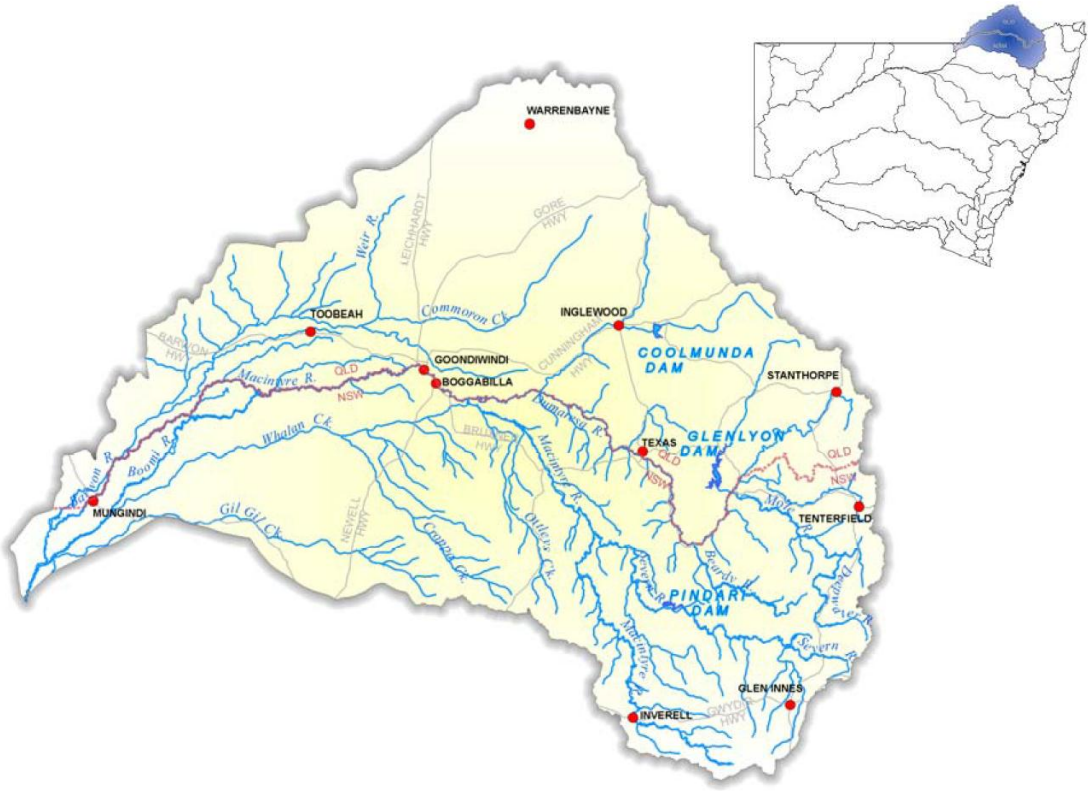


Figure 1 – Border Rivers Catchment Plan
(Source: NSW Office of Water)

Mungindi has a population of approximately 650 people, supporting a strong agricultural industry in cotton, wheat and cattle farming. The township is located immediately adjacent to and mainly on the southern side (NSW side) of the Barwon River. On the northern side of the river (QLD side) there is a small portion of the township of Mungindi, which contains the hospital and a small number of residential properties.

Figure 2 – Mungindi Aerial Photograph

1.2 Flood Environment

The Barwon River forms the state border at the junction of the Weir River and the Macintyre River upstream of Mungindi. The river flows towards the southwest corner of the catchment and continues to eventually join the Culgoa River to form the Darling River. The lower end of the catchment is characterised by a complex series of anabranching channels. The town of Mungundi on the Barwon River marks the downstream end of the Border Rivers catchment.

The south western region of the catchment comprises flat alluvial plains which are drained by a series of intermittent watercourses, the principal ones being Croppa Creek, Whalan Creek and Gil Gil Creek. The elevation across these plains ranges from around 400 metres in the eastern extent to just 150 metres at Mungindi.

The town has been subject to major floods on many occasions over the past 120 years. The largest of these occurred in 1890 and 1976, while the most recent occurred in 1998. Flood waters are reported to remain around the town for a period of approximately 4 to 8 weeks during major flood events.

As a result of historical flooding, a levee system has been progressively developed to protect the township from inundation. Prior to 1976 only a minor levee systems existed around the Mungindi townships. However, following the 1976 flood, the levee banks were upgraded to protect the southern township. The project was completed in 1980. Further works were carried out on the town levee north of the river (within Queensland) in 1999 to raise and strengthen the levee system.

In addition to the township levees, farm levees have also been progressively constructed on the Barwon River floodplain surrounding Mungindi as the agricultural industry has developed over the years. These levees have impacted the distribution of breakout flows from the river systems, both upstream and downstream of Mungindi.

1.3 Area to which this Plan applies

The *Plan* has been prepared for the NSW township of Mungindi or specifically the area surrounded by the current levee and not including nearby farms or properties outside the levee.

2 LEGISLATION AND POLICY

2.1 State Level

The management of the Barwon River floodplain at Mungindi must be undertaken within the current legislative and policy framework. A brief summary of the relevant legislation and policy is presented below. Where possible, potential future changes have also been considered.

The Flood Prone Land Policy

The primary objective of the NSW Government's *Flood Prone Land Policy* is to reduce the impacts of flooding on occupiers of flood prone land and to reduce losses caused by flooding. 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. The *Floodplain Development Manual (2005)* (the '*Manual*') supports the Policy and outlines a merit approach to floodplain management.

Water Act 1912 & Water Management Act 2000

The two key pieces of legislation for the management of water in NSW are the *Water Act 1912* and *Water Management Act 2000*. Floodplain management in rural areas of New South Wales is administered under Part 8 of the *Water Act 1912*. This Act is being progressively phased out and replaced by the *Water Management Act 2000*, but some provisions are still in force.

The object of the *Water Management Act 2000* is the sustainable and integrated management of the state's water for the benefit of both present and future generations. The *Water Management Act 2000* recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land.

Additional Floodplain Management Controls

There are several additional legislative acts and policies that are relevant to floodplain management and the approval process of flood control works. The majority of these relate to floodplain environmental matters such as flora and fauna, wetlands, threatened species, and fish habitat. Of particular importance are the Environmental Planning and Assessment Act 1979 and Environmental Plan and Assessment Regulation Act 2000.

2.2 Local Council Regulatory Framework

The Moree Plains Shire Council has several planning documents that control development in and around Moree. These include (in order of precedence):

Local Environment Plan

A Local Environmental Plan (LEP) is a plan prepared in accordance with the *Environmental Planning and Assessment Act 1979* that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land. The

current LEP for the Moree Plains area is the *Moree Plains Local Environmental Plan 2011* (referred herein as '*LEP (2011)*').

Development Control Plan

A Development Control Plan (DCP) is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act 1979* that provides detailed guidelines for the assessment of development applications. The *Moree Plains Development Control Plan 2013* (referred herein as '*DCP (2013)*') includes a section on floodplain development and management for land within Moree Plains Shire.

Moree and Environs Floodplain Risk Management Plan

The *Moree and Environs Floodplain Risk Management Plan* (referred herein as '*Moree & Environs FRMP'*) was adopted by Council in 2008 to provide a framework for the management of flood risk in the Moree Plains local government area. Recommendations from the *Moree & Environs FRMP* were incorporated into the *LEP (2011)* and *DCP (2013)* for the purpose of assessing development applications in flood prone areas.

3 FLOODPLAIN RISK MANAGEMENT PROCESS

The NSW Stage Government's *Flood Prone Land Policy* aims to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land. The policy highlights that primary responsibility for floodplain risk management rests with Councils, which are provided with financial and technical support by the State Government.

In 2005 the NSW Government published the *Floodplain Development Manual* which seeks to aid local Councils in managing flood risk. The Manual provides guidance to local councils for the development and implementation of floodplain risk management plans, overseen by the floodplain risk management committee.

The floodplain risk management process is summarised below:

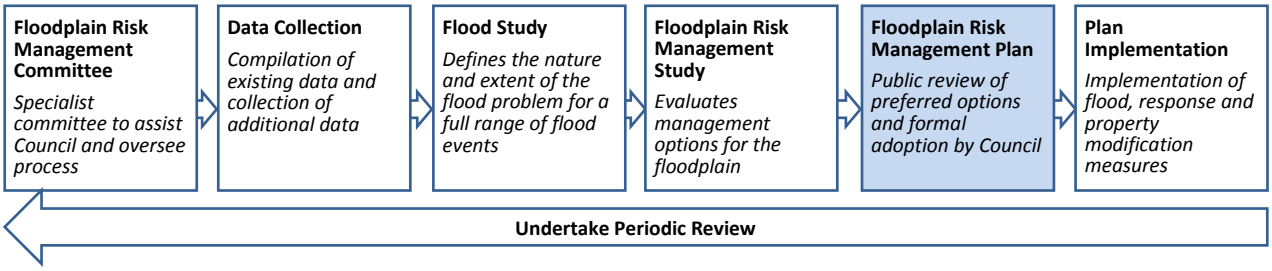


Figure 3 – The Floodplain Risk Management Process

The *Plan* has been prepared to address the existing, future and continuing flood problems for the Mungindi township, detailing how flood prone land within the study areas is to be managed. Details of preceding phases are presented in Section 3.3.

3.1 Purpose of the Plan

The purpose of the *Plan* is to provide Council with a range of strategic and statutory planning management measures for addressing the risks associated with flooding in Mungindi, with the objective of minimising financial and personal loss in the event of flooding. This document aims to:

- Recommend a coordinated mix of management measures that address existing, future and continuing flood risk within the Mungindi township;
- Establish a program for implementation and funding for the management plan including priorities, staging, funding, responsibilities, constraints and monitoring;
- Propose modifications to existing Council policies to ensure that the future development of flood affected land is undertaken so as to be compatible with the flood risk;
- Be consistent with local emergency management planning;
- Ensure actions arising out of the management plan are sustainable in social, environmental, cultural and economic terms;

- Be supported by the local community;
- Meet Council's obligations under Section 733 of the *Local Government Act 1993*.

3.2 Floodplain Management Committee

The Mungindi Floodplain Risk Management Committee (the '*Committee*') included representatives of government agencies, landholder groups and individuals. It was formed to assist with the preparation of the floodplain management study for Mungindi.

The Committee was responsible for providing advice on milestone documents (e.g. Flood study report, FRMS report) and on assessment principles and criteria. All members were invited to attend meetings held during the floodplain risk management process. However, attendance at the meetings was generally limited to members with a significant interest in issues associated with the FMPs.

3.3 Preceding Studies

The following studies relating to flooding for Mungindi were completed by Council prior to the preparation of the *Plan:*

Data Collection and Flood Study for Mungindi (2004)

The Mungindi flood study was prepared for Moree Plains Shire Council by Lawson and Treloar to investigate the nature and extent of the flood behaviour in the vicinity of the Mungindi township. As part of the study a flood frequency analysis was carried out on stream gauging data for Barwon River at Mungindi to determine design event flood flows. A SOBEK 2-dimensional hydraulic model was established to define the flow regime in the vicinity of the Mungindi township. Flood behaviour for the study area is discussed further in Section 4.

Mungindi Flood Level Geotechnical Investigation and Assessment Report (2004)

Coffey Geosciences conducted a geotechnical investigation and assessment for the existing flood levee surrounding Mungindi, NSW. Based on the outcomes of the investigation it was considered that the levee would have factors of safety consistent with those typically adopted for civil engineering structures.

Draft Mungindi Levee Rehabilitation Project Flood Study (2005)

In conjunction with the *Mungindi Flood Level Geotechnical Investigation and Assessment Report* (2004) Coffey Geosciences undertook preliminary flood modelling for the Mungindi area which was presented in a Draft Flood Study report.

Mungindi Levee Flood Analysis (2009)

WMAwater undertook further hydraulic analysis to assess the performance of the existing flood levee system and identify levee works required to achieve the preferred level of flood protection. The flood assessment estimated 1% AEP design flood levels for Mungindi along the levee profile. It was found that the existing levee around the township provides no freeboard in some sections above the 1% AEP flood event. Flood behaviour for the study area is discussed further in Section Flood behaviour for the study area is discussed further in Section 4.

Mungindi Floodplain Risk Management Study (2011)

This floodplain risk management study for Mungindi was prepared by Coffey Geotechnics to identify and evaluate the costs and benefits of an integrated mix of measures and options to manage the existing, future and continuing flood risks for Mungindi. The floodplain risk management option which was calculated to be of the most benefit to the township involves raising the levee to 1% AEP plus 1 m. This option was recommended to be adopted by Council to reduce the existing flood risk.

Other management measures were also recommended such as development controls on new building floor levels, new levees and location of new development. The report also recommended improving community preparedness and better interpretive information on expected floods and post event response. Further details on are given in Section 6.

Levee Failure Flood Investigation (2013)

Cardno undertook additional hydraulic modelling to predict flood levels within the Mungindi township in the event of levee failure.

Mungindi Rural Hotspot Flood Investigation (2013)

Water Technology was commissioned by the NSW Government Office of Environment and Heritage to prepare a 2-dimensional hydraulic model for the township of Mungindi. The existing SOBEK model used for previous studies was updated to a TUFLOW model based on 1 m LiDAR survey. The updated model is intended to be used to assess the influence of rural levees on flooding in Mungindi.

3.4 Other Relevant Studies

Other studies which are relevant to the preparation of the FRMP include:

- *Moree Plains Flood Mapping* (Parsons Brinkerhoff, 2007)
- *MacIntyre Valley Flood Plain Management Study* (Laurie, Montgomerie and Pettit, 1981)
- *Border Rivers Floodplain Hydraulic Analysis Study* (Lawson and Treloar, 2002)

3.5 Community Consultation

Community consultation has been a key component throughout the floodplain risk management process to provide and gather historical flood information and enable participation in the decision making process.

Specifically the following consultation activities were undertaken:

- Inclusion of Moree Plains community members in the *Committee*;
- Preparation of a consultation program during the *Mungindi FRMS*;
- Distribution of project information pamphlet to Mungindi residents including survey relating to historical flood information (October 2004). Three detailed responses were received.
- Meeting with survey respondents at SES Mungindi to obtain more detailed feedback on flooding problems (December 2004);
- Committee meeting at Council offices to discuss Mungindi planning issues (December 2004);
- Committee meeting at Council offices to discuss engineering issues (December 2004);

Additionally, the *Mungindi FRMS* was publicly exhibited from 1 March 2010 to 9 April 2010 and ten submissions were received. The issues raised in the submissions have been addressed and, where appropriate the FRMS was amended.

4 FLOOD BEHAVIOUR

Two-dimensional hydraulic models have been developed as part of the floodplain risk management process to define flood behaviour for Mungindi. The models were used to prepare figures showing peak flood depths, velocities and hazard categories for historical and design event simulations.

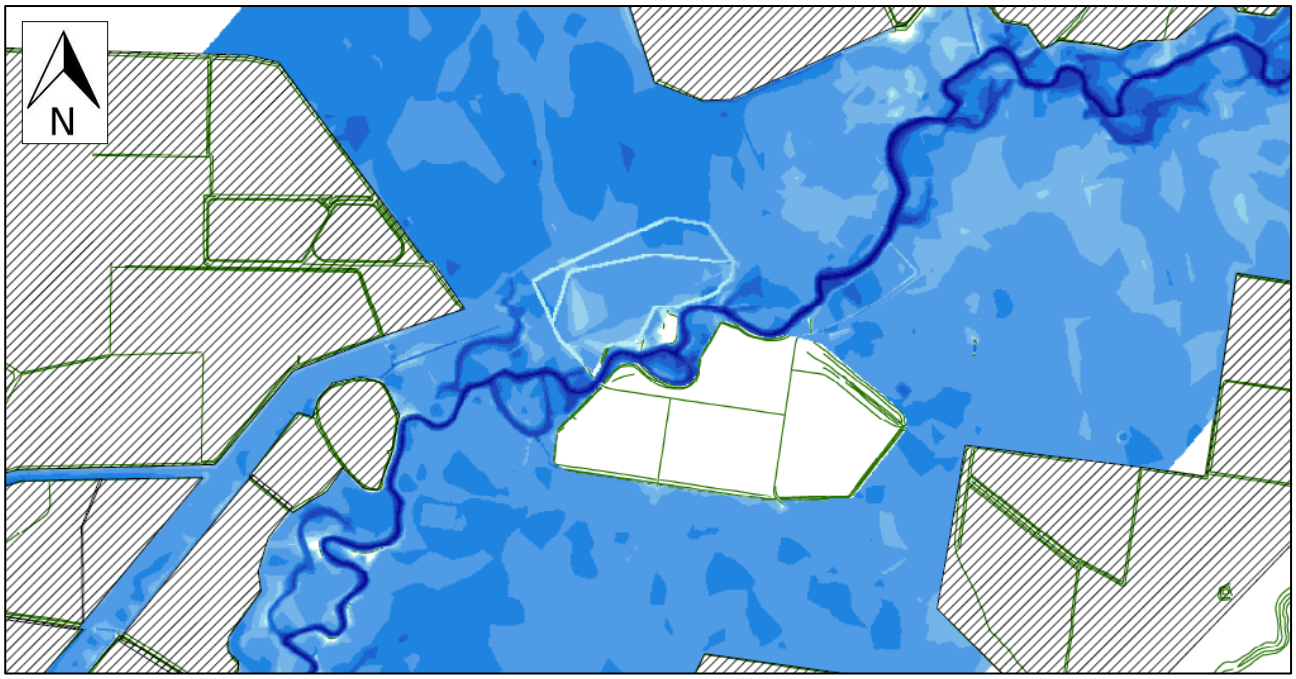


Figure 4 – Hydraulic model results for Mungindi (refer Appendix A)

The primary model used to assess flood behaviour for Mungindi was developed during the *Flood Study for Mungindi* using the SOBEK two-dimensional hydraulic model. The Mungindi model was calibrated to the January 1996 and September 1998 historical flood events. Calibration was based on reported peak flows, water levels and tailwater conditions obtained from a regional MIKE11 model of the Barwon River. The Mungindi model was updated as part of the *Mungindi Levee Flood Analysis* with improved survey and hydrologic data. Relevant figures from these studies are attached in Appendix A.

4.1 Flood Depths

Figures were produced as part of the *Flood Study for Mungindi* showing peak flood depths for the 1976 and 1996 events as well as the 20%, 10% and 1% AEP design events. Updated flood depth mapping was included as part of the *Mungindi Levee Flood Analysis* for the 2% and 1% AEP design events. Flood depths of up to 10 m are shown in the Barwon River during the 1% AEP flood. Along the southern and eastern sections of levee depths of between 1 and 2 m generally occur. The crest of the existing levee was shown to be at or above the 1% AEP flood level (zero freeboard in some areas).

4.2 Flood Velocities

Vector arrows showing flood velocities were reported for the 1996 and 1998 historical flood events. A maximum scale of 0.5 m/s was adopted. It is likely flow velocities in the Barwon River channel and along parts of the levee exceed 0.5 m/s. Flood velocities for design events were not reported.

4.3 Flood Levels

In order to estimate flood levels within the town during a levee failure the current levee was removed from the hydraulic model as part of the *Levee Failure Flood Investigation* (Appendix A). Generally flood levels within the township under this scenario were shown to range from 161.8 mAHD to 162 mAHD. It is understood this information is currently used for development planning within the township.

4.4 Flood Hazard

Provisional hazard maps for the 20%, 10%, 2% and 1% AEP design events were presented using high, transition/medium and low categories. The majority of the area surrounding the existing levee is classified as high hazard during the 1% AEP event. Hazard information is used to help determine areas suitable for development.

5 FLOOD RISK CONSIDERATION

The *Manual* defines flood risk as the potential danger to personal safety and potential damage to property resulting from flooding. The *Moree and Environs FRMP* devised a system of risk classification which seeks to categorise flood risk within the Shire of Moree, including Mungindi. Flood risk for a given area is based on:

- **Flood impact** – potential impact future development would have to flood behaviour (Section 5.1);
- **Frequency hazard** – how often flooding is expected to occur (Section 5.2);
- **Property hazard** – potential for property damage due to flooding (Section 5.3).

Each of these categories has been implemented within Council's *DCP (2013)* in order to assess the suitability of future development based on flood risk. In addition to the above categories, the following planning controls also need to be applied:

- **Flood planning level** - combination of flood levels and appropriate freeboard used to nominate development levels (Section 5.4);
- **Evacuation and access –** criteria for ensuring a continuous link between habitable areas and the likely location of a flood evacuation centre (Section 5.5).

5.1 Flood Impact

Flood impact categories (referred to in the *Manual* as hydraulic categories) represent the potential for development at a particular location to affect flood behaviour, thereby causing adverse impacts elsewhere. There are three flood impact categories:

- **Floodway** areas where a significant volume of water flows during floods. Even partial blockage of these areas would result in an increase to flood levels in other areas or significant redistribution of flood flows;
- **Flood storage** areas that are important for the temporary storage of floodwaters during the passage of a flood. A reduction in available storage volume can increase flood levels downstream or redistribute flood flows;
- **Flood fringe** areas which are affected by flooding, however development in these areas would have little effect on flood behaviour elsewhere.

Council's *DCP (2013)* incorporates specific controls for new development based on the above flood impact categories. Further information relating to each of these categories is presented in Section 3 of the *Moree and Environs FRMP*.

To date flood impact categories for Mungindi have not been formally identified. To ensure consistency with the requirements of the *DCP (2013)* it is recommended that these categories are determined based on the results of previous studies (Section 7.2).

5.2 Frequency Hazard

The frequency hazard category describes how often a particular location is likely to be flooded, providing a basis for determining whether or not land is suitable for development. For instance, land that is flooded regularly will afford the occupiers an unacceptable exposure to flood risk and associated impacts (frequent evacuation, clean up etc). The *Moree & Environs FRMP* recommends the following frequency hazard categories:

- **High frequency hazard (F3)** areas that have a probability of flooding annually greater than 10% (AEP > 10%);
- **Moderate frequency hazard (F2)** areas that have a probability of flooding annually of between 10% and 1% (10% ≥ AEP ≥ 1%);
- **Low frequency hazard (F1)** areas that have a probability of flooding annually less than 1% (AEP < 1%).

The *Moree & Environs FRMP* recommends incorporating an additional 500 mm of flood depth when estimating flood extents to account for uncertainty. The above categories also apply to land that is isolated due to flooding (for instance if a primary road access is cut off).

Council's *DCP (2013)* requires an estimate of the frequency hazard category be provided as part of the development application. Further information relating to each of these categories is presented in Section 4.2.1 of the *Moree & Environs FRMP*.

Frequency hazard categories for the township should be reviewed following upgrade of the existing levee.

5.3 Property Hazard

While frequency hazard seeks to classify how often land will be flooded, property hazard is based on the hydraulic properties of the flood itself and the potential for damage to property. The *Moree Plains & Environs FRMP* nominates the following categories for property hazard:

- **High property hazard (P3)** areas where there is a potential for significant structural damage to buildings, particularly light framed buildings which are considered unstable;
- **Moderate property hazard (P2)** areas where manufactured homes and shipping containers are considered unstable;
- **Low property hazard (P1)** areas where the potential for structural damage is sufficiently low.

Property hazard is assessed using the depth and velocity of floodwaters during the 1% AEP event. Further information relating to each of these categories is presented in Section 4.2.2 of the *Moree and Environs FRMP* and Appendix L of the *Manual*.

Previous studies for Mungindi classified the area surrounding the township levee as being high hazard (refer Section 4.4). In addition, Parsons Brinkerhoff prepared a Flood Atlas for Moree and surrounds in 2007. The Atlas includes maps of flood hazards for various areas. Sheet 6 refers to Mungindi and denotes the areas within the levee as 'no hazard' and the areas outside the levee as 'high hazard'. The high hazard areas are those below 1% AEP.

5.4 Flood Planning Levels

Flood planning levels (FPLs) are an important tool in the management of flood risk. They are derived from a combination of a flood event (historic flood or flood of certain AEP) and a freeboard. Freeboard is a factor of safety that accounts for the inherent uncertainties in flood level estimation, as well as local factors such as wave action.

The nominated FPL for the Moree Plains Shire is defined in the *LEP (2011)* as the level of a 1% AEP flood event plus 500 mm freeboard. According to the *Manual*, this method of calculating the FPL is typical for new residential development in NSW, and should only be varied in exceptional circumstances. The *DCP (2013)* requires floor levels for residential developments to be at or above the FPL.

It is important to note that freeboard can vary depending on the type of land use and potential risk associated with development. For instance, Councils *DCP (2013)* applies a minimum floor level of 350 mm below the FPL for commercial, industrial and other building developments (this equates to the 1% AEP flood event plus 150 mm freeboard).

Alternatively additional freeboard may be required for mitigation works which are exposed to greater risk. In the case of the Mungindi township levee a higher freeboard of 1.0 m to the levee crest is recommended by the *FRMS* to allow for:

- Wind and wave action during flooding, given the significant time frame and duration of flooding;
- Allowance for uncertain effects of climate change, with up to 0.7 m increase in the 1% AEP flood level expected;
- Variations in flood behaviour from that modelled;
- Variations between the modelled levels and actual floods due to the effects of rural levees that are not accounted for with precision in *the Mungindi Levee Flood Analysis*;
- The consideration that flooding of Mungindi within the levee during a significant flood will lead to a very high cost to the community, which is exacerbated by the long duration of floods in the area.

Based on a freeboard of 1 m the existing levee is estimated to provide a level of protection of less than 5% AEP. Additionally there is potential that the existing levee could suffer from structural failure during a flood, allowing floodwaters to enter the township. For this reason current planning considers the township area inside the levee as flood prone and requires new development to comply with the FPLs in Table 5.1.

Development Type	Flood Planning Level (FPL)
Commercial/Industrial/Other	1% AEP plus 0.15 m freeboard
Residential	1% AEP plus 0.5 m freeboard
Township levee	1% AEP plus 1.0 m freeboard

Table 5.1 – Mungindi Flood Planning Levels

1% AEP flood levels within the township were estimated as part of the *Mungindi Flood Investigation – Levee Failure* (Cardno, 2013) assuming failure of the levee. Additional work is currently being undertaken by OEH to confirm 1% AEP flood levels based on various rural levee scenarios. It is recommended that FPLs within the townsite be reviewed by Council following the proposed upgrade of the existing levee and the rural levee assessment.

5.5 Evacuation and Access

Evacuation from flooded areas and ease of access for emergency service personnel needs to be considered as part of the flood risk management process. The *Moree & Environs FRMP* recommends that properties should not be isolated for longer than 24 hours during the 1% AEP flood. Roads are considered inaccessible by a standard car if the depth of flooding exceeds 300 mm.

The response time for flooding at Mungindi is in the order of a few days. Flood waters are reported to remain around the town for several weeks during major flood events, causing isolation. It is recommended a local flood plan be prepared to improve emergency response during flood events. The local flood plan should describe various measures to be undertaken before, during and after a flood including evacuation, resupply and other procedures. The local flood plan is typically prepared by the SES in association with other agencies and the community.

6 FLOODPLAIN RISK MANAGEMENT MEASURES

Various risk management options for Mungindi were identified during the *Mungindi FRMS*. Strategic assessments were undertaken to review existing, future and continuing flood risk and anticipated social, economic and ecological impacts. Recommended risk management measures for Mungindi are summarised in this chapter. Further details of the assessment can be found in Section 5 of the *Mungindi FRMS*.

6.1 Flood Modification Measures

Flood modification measures aim to modify the behaviour of the flood itself by reducing flood levels or velocities or excluding floodwaters from areas under threat. This is particularly relevant to the Mungindi township which is surrounded by an existing levee.

The floodplain risk management option which had the highest weighted score was that of raising the levee crest height to the 1% AEP flood level plus 1 m freeboard. This option was recommended for adoption in the *FRMS* to reduce existing flood risk. Other flood modification measures such as house raising or voluntary purchase were not recommended given the associated social and economic impacts and low benefit to cost ratio.

Levees are a common and proven means of reducing damages to existing properties under threat from flooding, however they are restricted to addressing existing flood risk. Further measures must be considered to address future and continuing flood risk.

6.2 Property Modification Measures

Property modification measures include development controls on existing and future development to manage future flood risk. The following options were recommended for adoption in the FRMS:

- Development controls on new building floor levels;
- Development controls on new levees or filling outside the township levee;
- Development controls on new residential development outside the township levee.

6.3 Response Modification Measures

Response modification measures help authorities and the population at risk better cope with a flood event. The following options were recommended in the *FRMS* to manage continuing flood risk:

- Further educate community about flood risk, including annual community flood review meetings and interpretive advice on gauge levels and anticipated flooding effects;
- Prepare local flood plan for study area and ensure properties are prepared for flooding;
- Compile list of residents with specialist skills and resources which may be of use during flood events.

An implementation plan for the adopted floodplain risk management measures is presented in Section 7.

7 IMPLEMENTATION AND REVIEW

7.1 Implementation

Objectives and strategies for each of the adopted floodplain management measures from the *Mungindi FRMS* are shown in Table 7.1. Estimated implementation costs were provided in the *Mungindi FRMS* which was published in 2011.

7.2 Other Recommendations

- Development controls within the township (including flood planning levels and hazard categories) should be reviewed following upgrade of the existing levee and completion of the rural levee assessment.
- Council's *DCP (2013)* requires development areas to be classified as being 'high' or 'low' hazard. The *Moree & Environs FRMP* recommends developments be classified for both property and frequency hazard. The meaning of hazard in the *DCP (2013)* and how it relates to the hazard categories in the *Moree & Environs FRMP* should be clarified.
- Previous studies estimate flood levels during the probable maximum flood (PMF) to be above the crest level of the proposed levee upgrade (1% AEP plus 1 m). In accordance with the *Manual* it is recommended the extent, nature and potential consequences of flooding for events up to and including the PMF be considered during future works.

7.3 Plan Review

Floodplain risk management plans are required to be reviewed regularly to ensure that their provisions remain appropriate. Typically plans are reviewed every 5 years or so, or following a major flood or change in circumstances that impact on the relevance of the plan, under the direction of the *Committee.*

Management Measure	Objectives	Implementation Strategy	Responsibility	Priority	FRMS Reference	Estimated Cost (2011)
Flood Modification						
Perform maintenance on existing levee flood gates	- Ensure flood gates close during flood to prevent floodwaters entering the township	- Schedule into maintenance program	MPSC	1	5.1.1	
Upgrade existing levee	- Increase level of protection to 1% AEP flood level plus 1.0 m freeboard to comply with OEH recommendations - Incorporate spillway into levee upgrade to control water ingress in the event of levee overtopping	- Undertake detailed investigation and design for levee upgrade and spillway - Resolve land acquisition requirements for levee upgrade	MPSC MPSC	1	5.1.2	$1M
Property Modification						
Review development controls for areas within township	- Ensure future development has adequate flood immunity	- Review flood planning levels within township following levee upgrade	MPSC	2	5.2.1	
Establish development controls for areas outside of township	- Ensure future development outside of the township (buildings, levees, filling etc) does not have a detrimental impact to flood behaviour	- Undertake hydraulic assessment to confirm impact of rural development including cumulative impacts	OEH	1	5.2.2 & 5.2.3	$50k
Response Modification						
Provide interpretive advice on gauge levels and anticipated flooding effects	- Increase community awareness of how river heights translate to flood potential within the township	- Construct interpretive signage in prominent public places such as post office, shops and other locations	MPSC	1	5.3.1	$20k
Annual community flood review meetings	- Increase community awareness to flood risk and increase involvement to flood planning	- Organise annual community evening to review flood measures, preparation and responses	MPSC	2	5.3.2 (1)	$12k

Management Measure	Objectives	Implementation Strategy	Responsibility	Priority	FRMS Reference	Estimated Cost (2011)
Further educate community about flood risk	- Increase flood readiness of community and response to flooding	- Issue reminders of flood risk in newspapers and at community meetings - Display historical flood photographs and newspaper articles at post office and local shops in Mungindi and Moree - Prepare and disseminate flood information leaflets to residents - Prepare video documentary of historic flood events in the area and present at community meeting - Erect signage showing flood levels of previous significant floods - Promote projects on floods and flood management within schools - Arrange commemorative events to reflect on significant historical floods	MPSC / SES	2	5.3.2 (2)	$30k
Develop a system to disseminate flood information to the community	- Increase the likelihood of flood information being accessed by community to raise awareness of flood risk	- Develop website and text messaging service to inform residents of updates to flood information	SES	3	5.3.2 (3)	$20k
Prepare local flood plan for study area	- Assist agencies with tasks to perform during flood events to meet their responsibilities - Inform and educate flood liable communities about flood problems to mitigate property losses and improve safety during flooding	- Assign SES local controller for Moree - SES to work with Council to develop local flood plan	SES SES/MPSC	1	5.3.2 (4)	$30k

Management Measure	Objectives	Implementation Strategy	Responsibility	Priority	FRMS Reference	Estimated Cost (2011)
Compile list of residents with specialist skills and resources which may be of use during flood events	- Improve flood response by utilising readily available resources	- Identify residents with specialists skills relevant to flood management (medical, able to operate heavy machinery, radio operators, pilots, engineers, electricians etc) - Identify residents with access to buildings that could be used to shelter evacuees and other resources useful for evacuation such as tractors and boats	MPSC MPSC	1	5.3.2 (5)	$7k
Ensure properties are prepared for flooding	- Minimise property damage	- Inform residents of relevant FPL - Ensure personal valuables can be stored above the FPL or higher in the event of a flood - Review family emergency procedures, replace batteries in torches and radios and refresh long term supplies	MPSC Community SES	3	5.3.2 (6)	

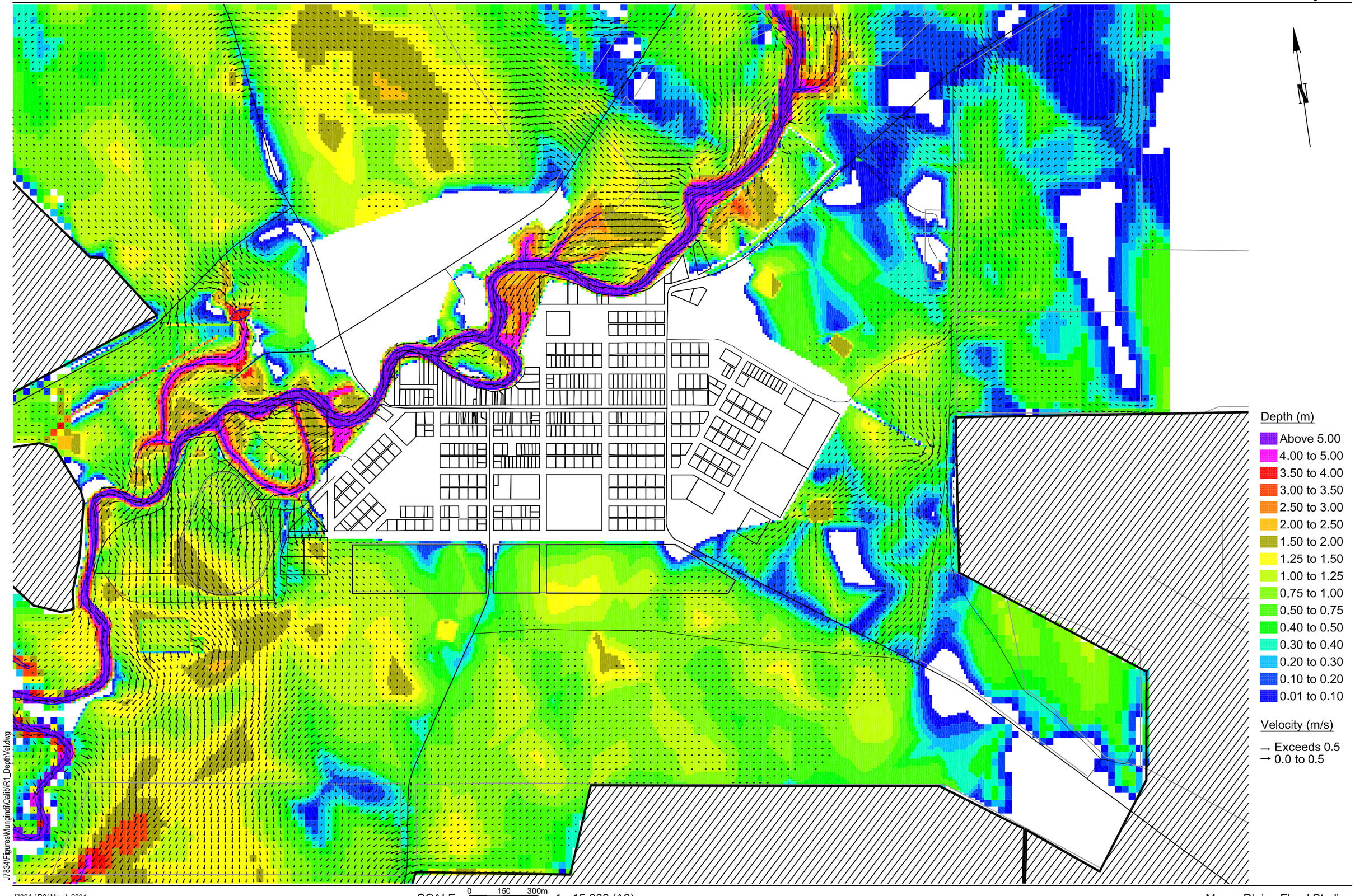
Table 7.1 – Floodplain Risk Management Measures Implementation Plan

Note: The community education management measures should increase in priority as the years since a flood event increases.

APPENDIX A

Hydraulic Modelling Outputs

Source:	***Flood Study for Mungindi (2004)***	***Figures 4.1 to 6.3***
	Mungindi Levee Flood Analysis (2009)	***Figures 15 to 20***
	Levee Failure Flood Investigation (2013)	***Figures 3 to 5***

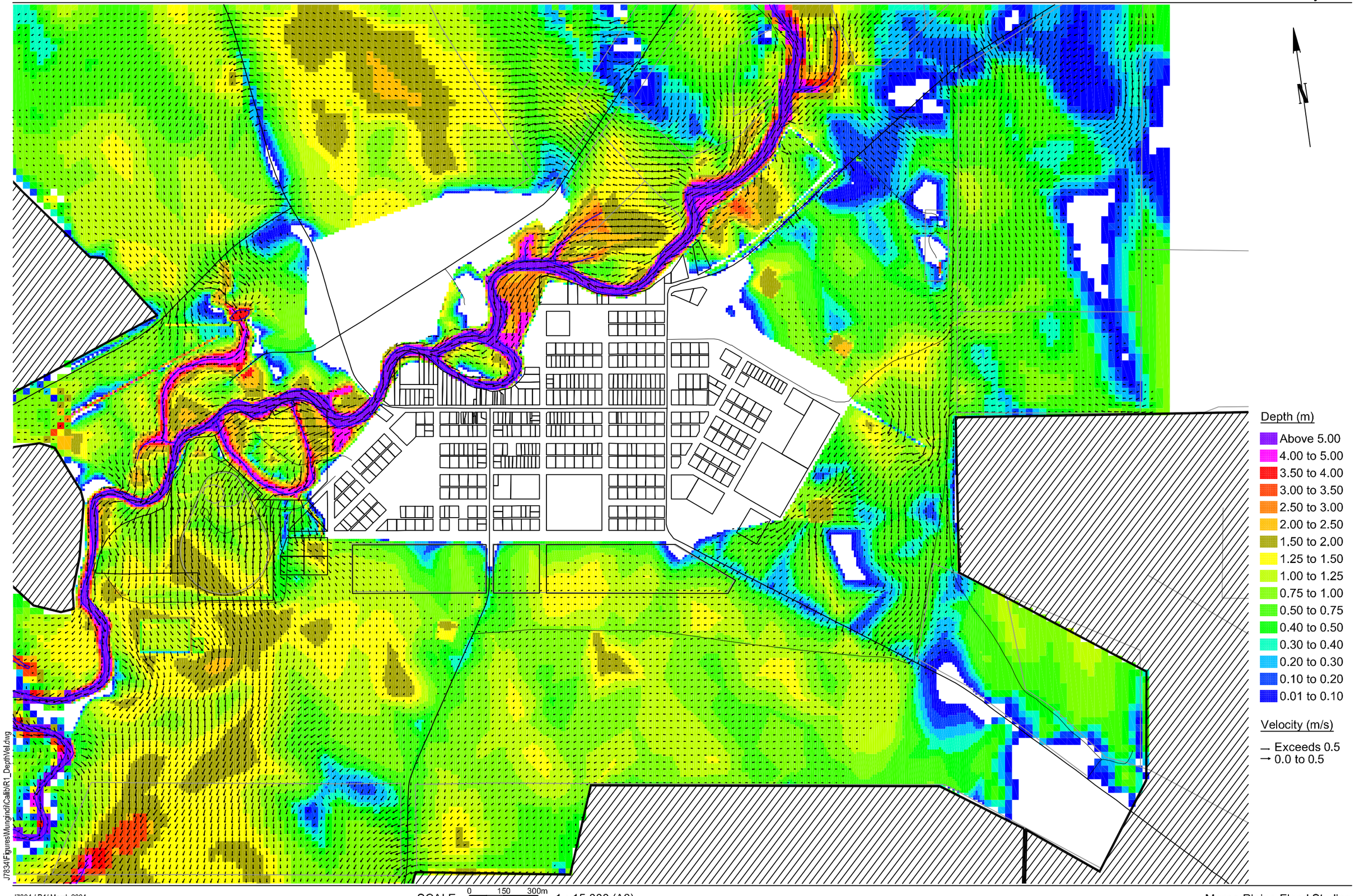


J7834 / R2/ March 2004

SCALE 0 150 300m 1 : 15,000 (A3)

Moree Plains Flood Studies

Figure 4.1 - Mungindi 1996 Event Peak Depths & Velocities

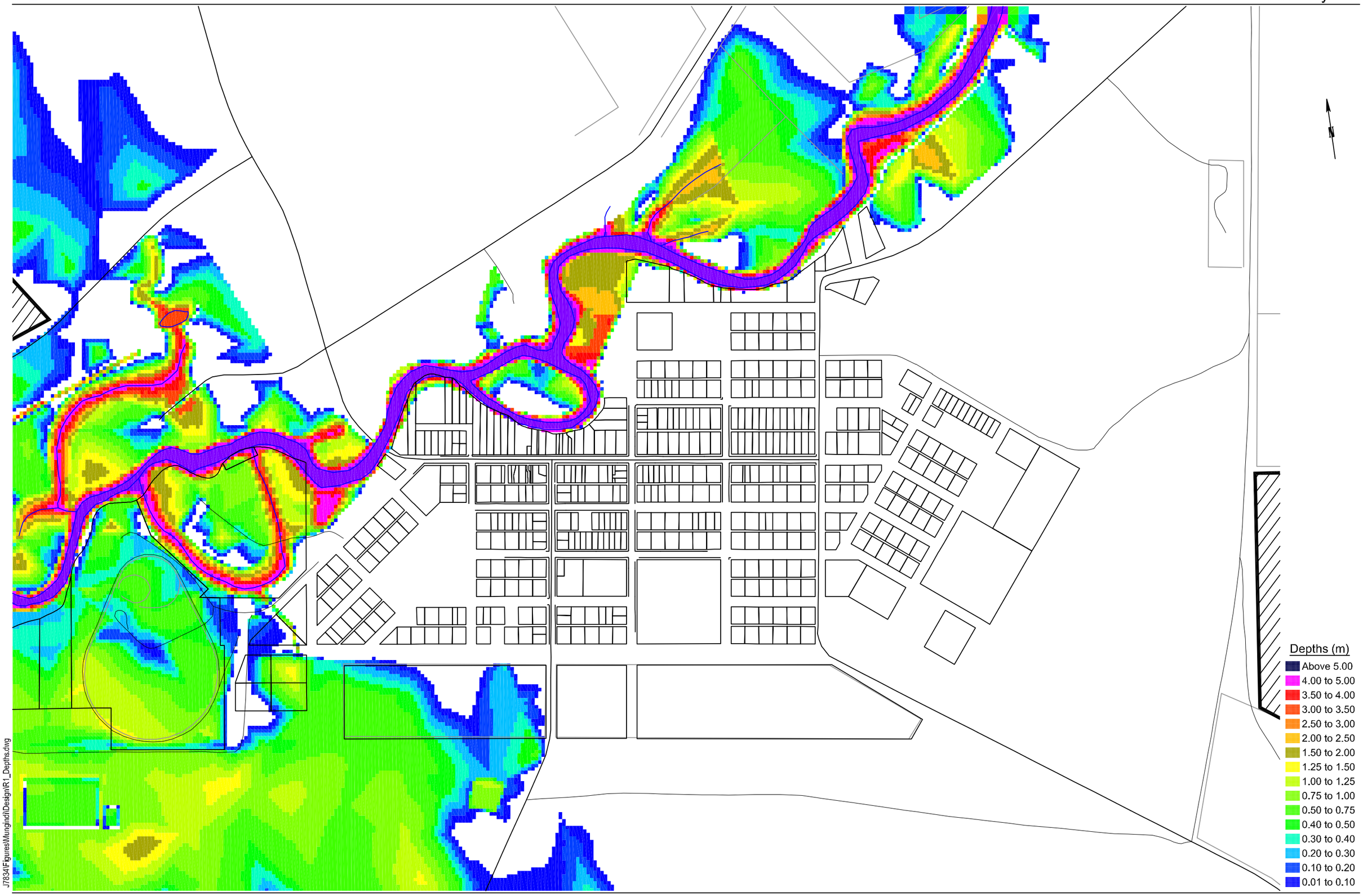


J7834 / R1/ March 2004

SCALE 0 150 300m 1 : 15,000 (A3)

Moree Plains Flood Studies

Figure 4.2 - Mungindi 1998 Event Peak Depths & Velocities



J7834\Figures\Mungindi\Design\R1_Depths.dwg

J7834 / R2/ March 2004

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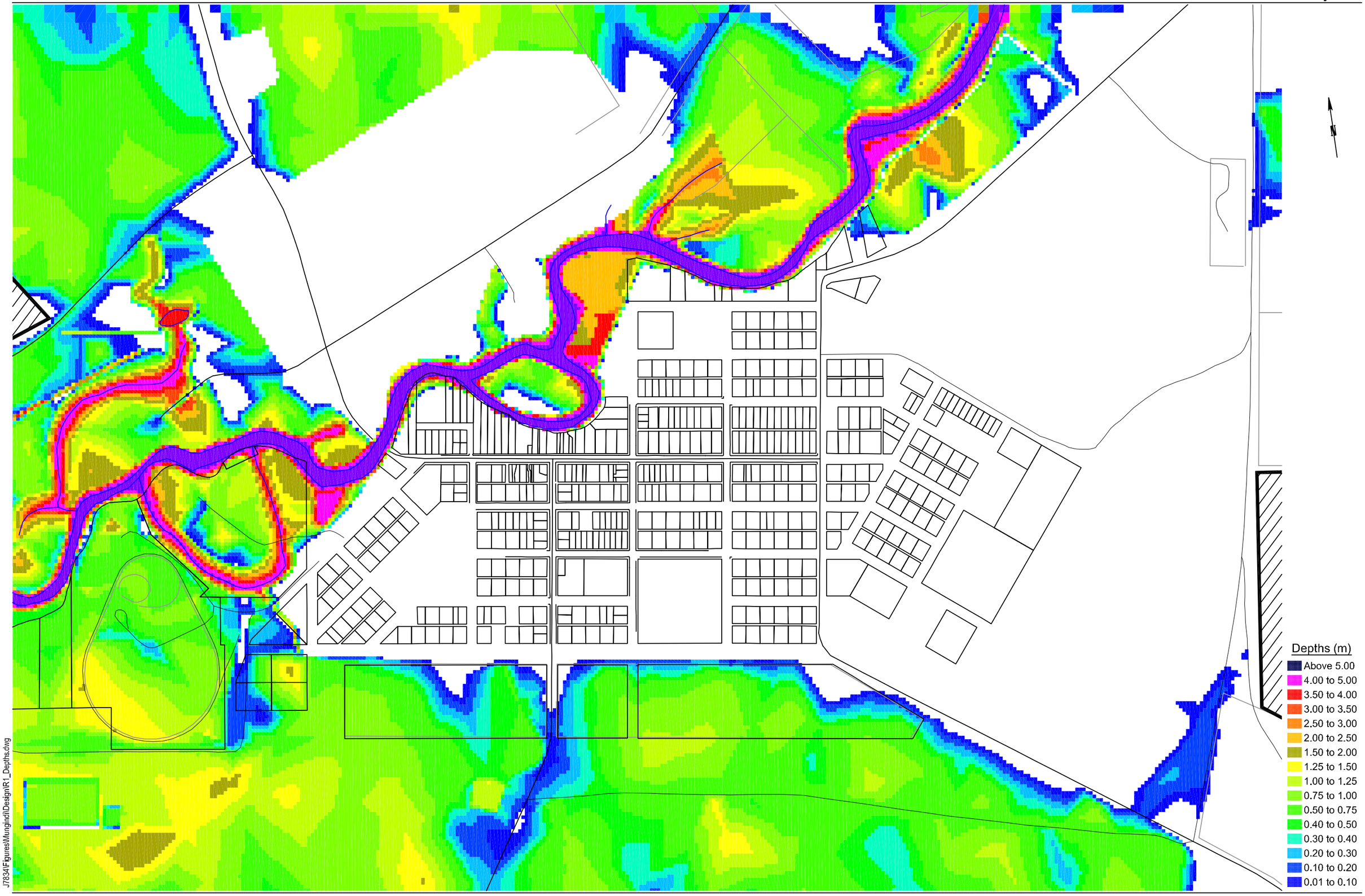
Moree Plains Flood Studies

Figure 5.1 - Mungindi Peak Depths - 20% AEP Event



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J7834 / R1/ March 2004

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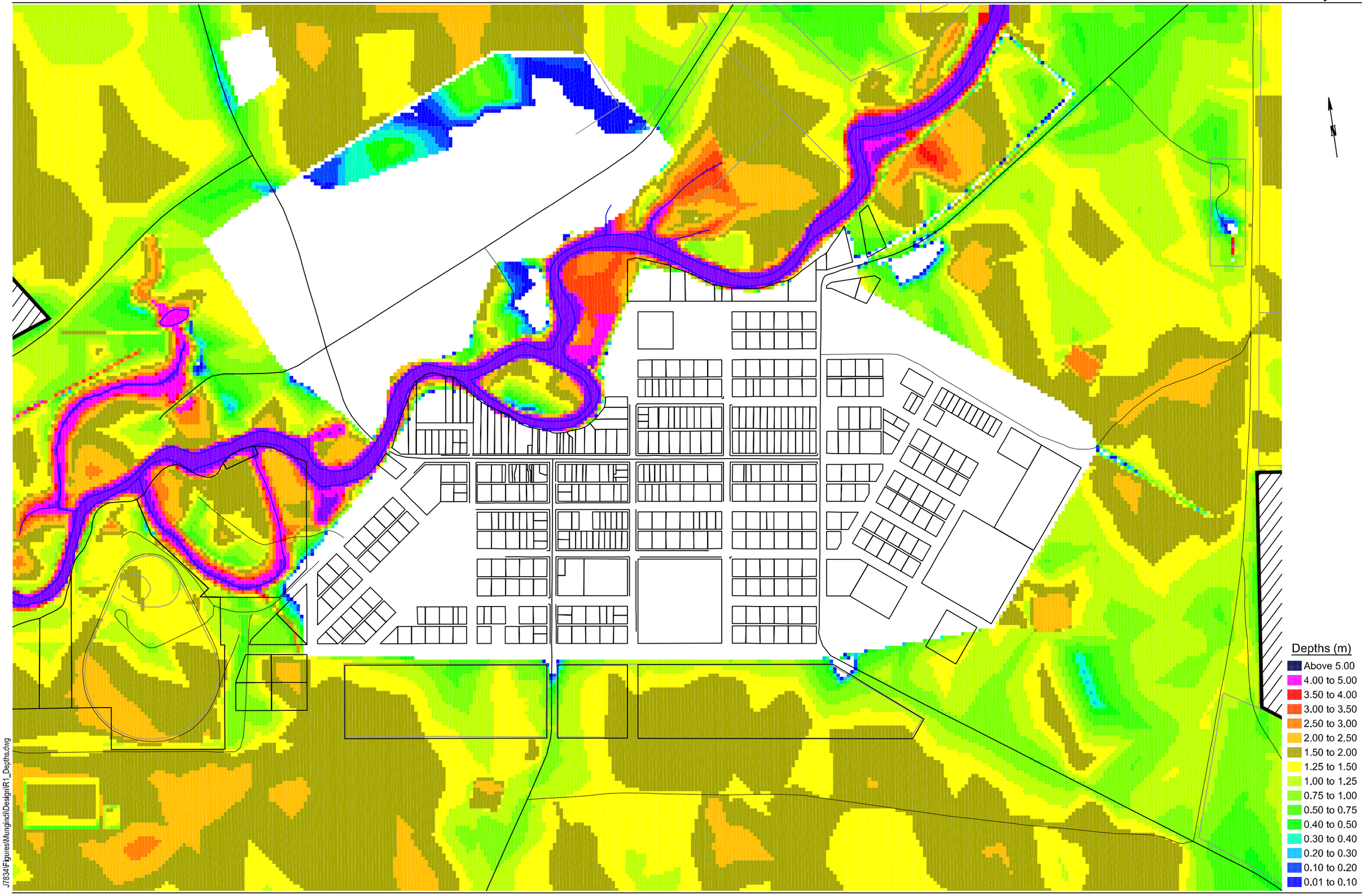
Moree Plains Flood Studies

Figure 5.2 - Mungindi Peak Depths - 10% AEP Event



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J7834 / R2/ March 2004

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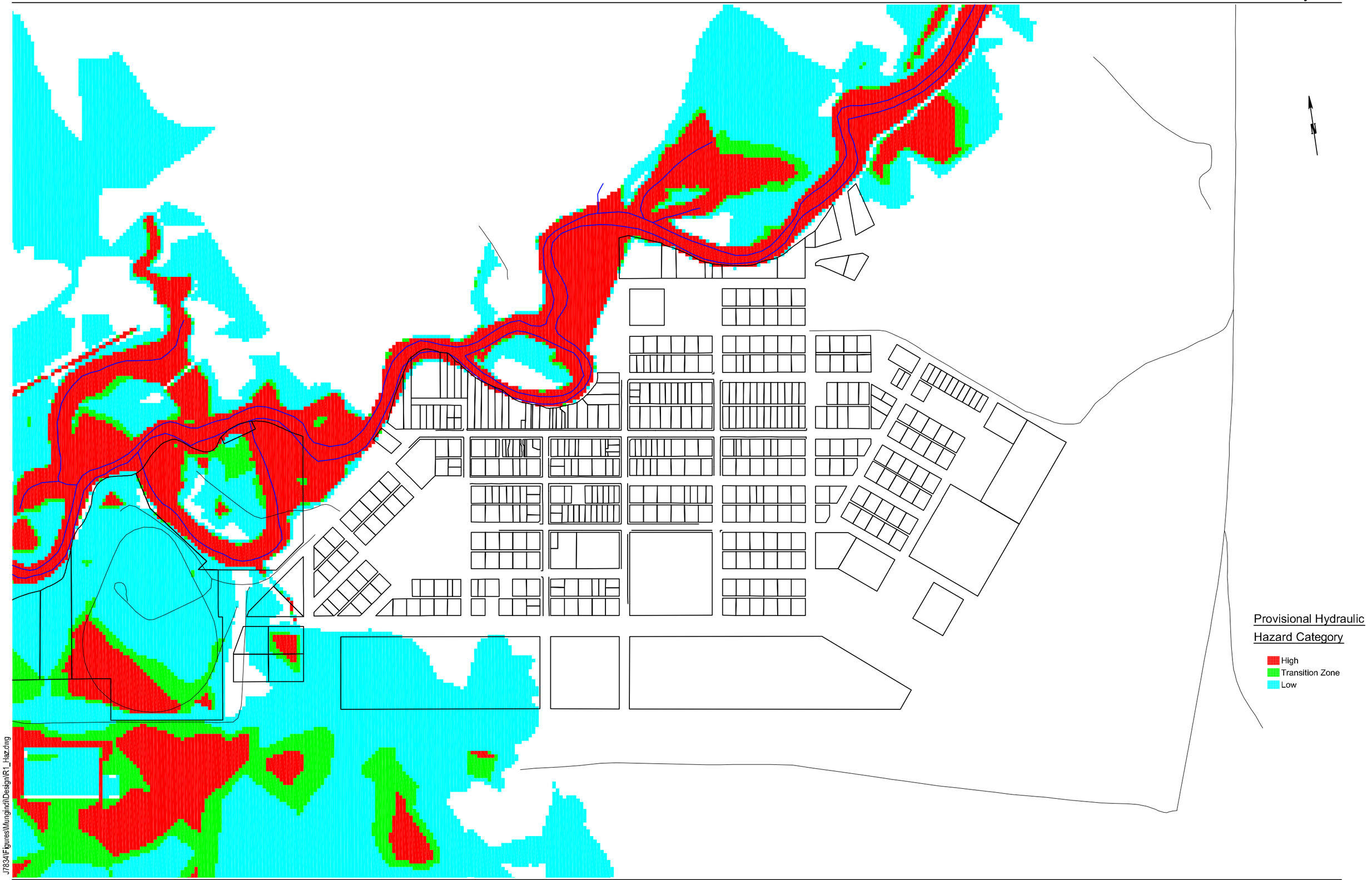
Moree Plains Flood Studies

Figure 5.3 - Mungindi Peak Depths - 1% AEP Event



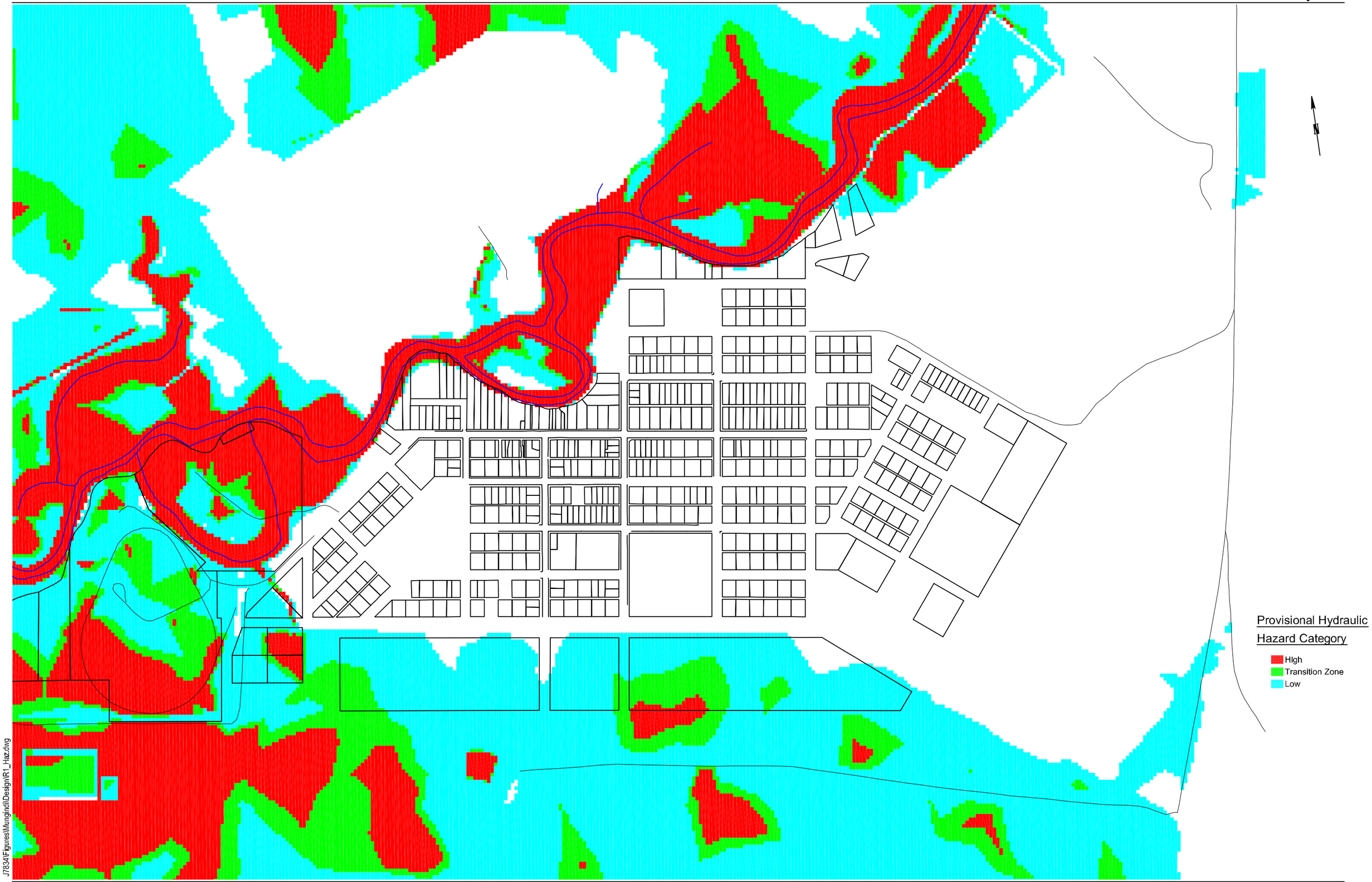
J7834\Figures\Mungindi\Design\R1_Haz.dwg

J7834 / R2/ March 2004

SCALE 0 100 200m 1:10,000(A3)

Moree Plains Flood Studies

Figure 6.1 - Mungindi Peak Hazard - 20% AEP Event



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J7834 / R1/ March 2004

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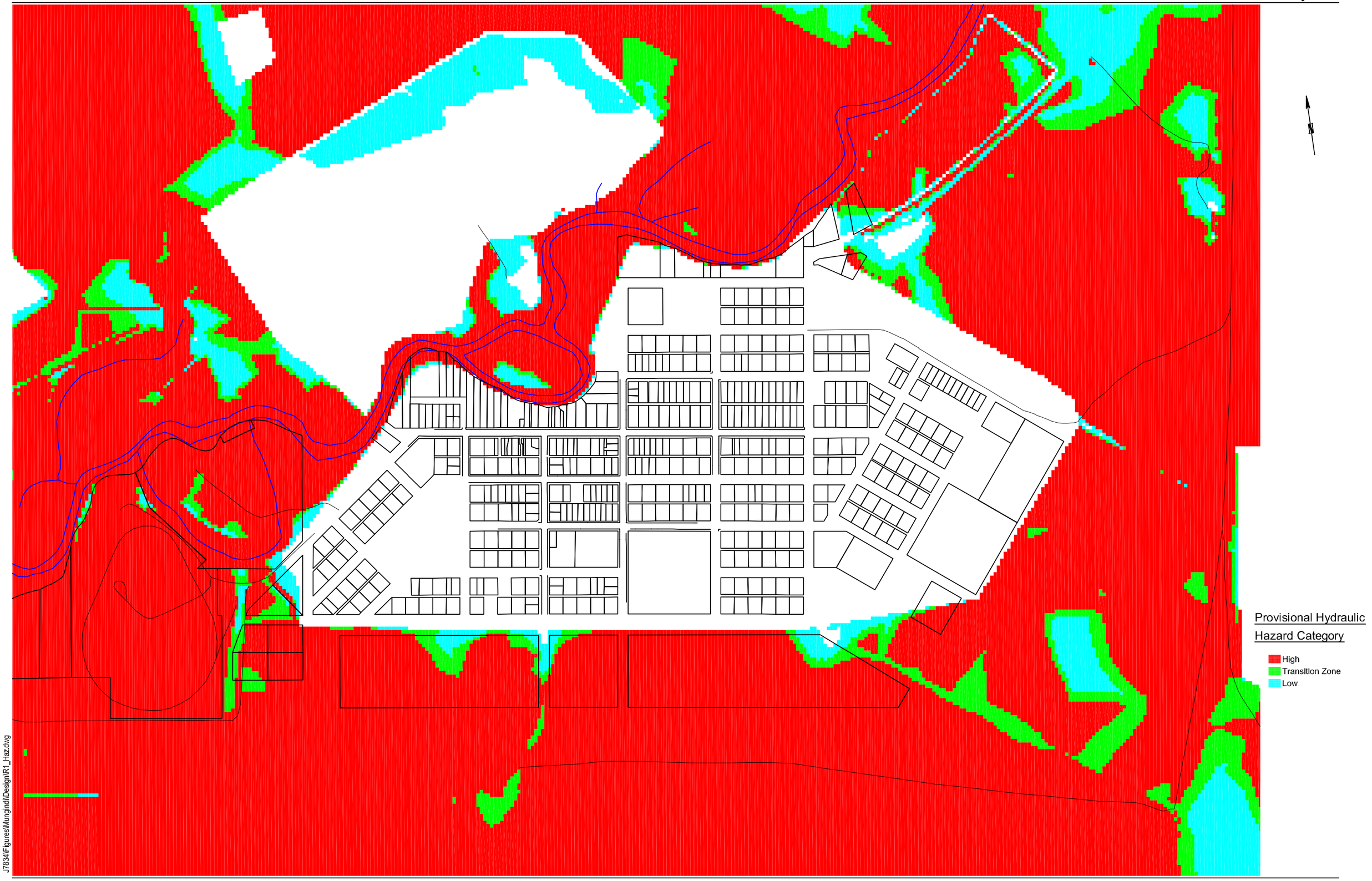
Moree Plains Flood Studies

Figure 6.2 - Mungindi Peak Hazard - 10% AEP Event



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J7834 / R1/ March 2004

SCALE 0 100 200m 1:10,000(A3)

Moree Plains Flood Studies

Figure 6.3 - Mungindi Peak Hazard - 1% AEP Event

FIGURE 15
FLOOD EXTENTS AND DEPTHS
1996 HISTORICAL EVENT

Model Inflow Boundary

162.34
162.29

161.95
162.32

161.64
161.63

161.93
161.88

161.45
161.45

161.30
161.39

N

Flood Depth (m)

- 0 - 0.2
- 0.21 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 6
- 6.01 - 8
- 8.01 - 10

Recorded Flood Level (mAHD)
Modelled Flood Level (mAHD)

km
0 0.5 1 2

Downstream Model Boundary

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FIGURE 16
FLOOD EXTENTS AND DEPTHS
2% AEP EVENT

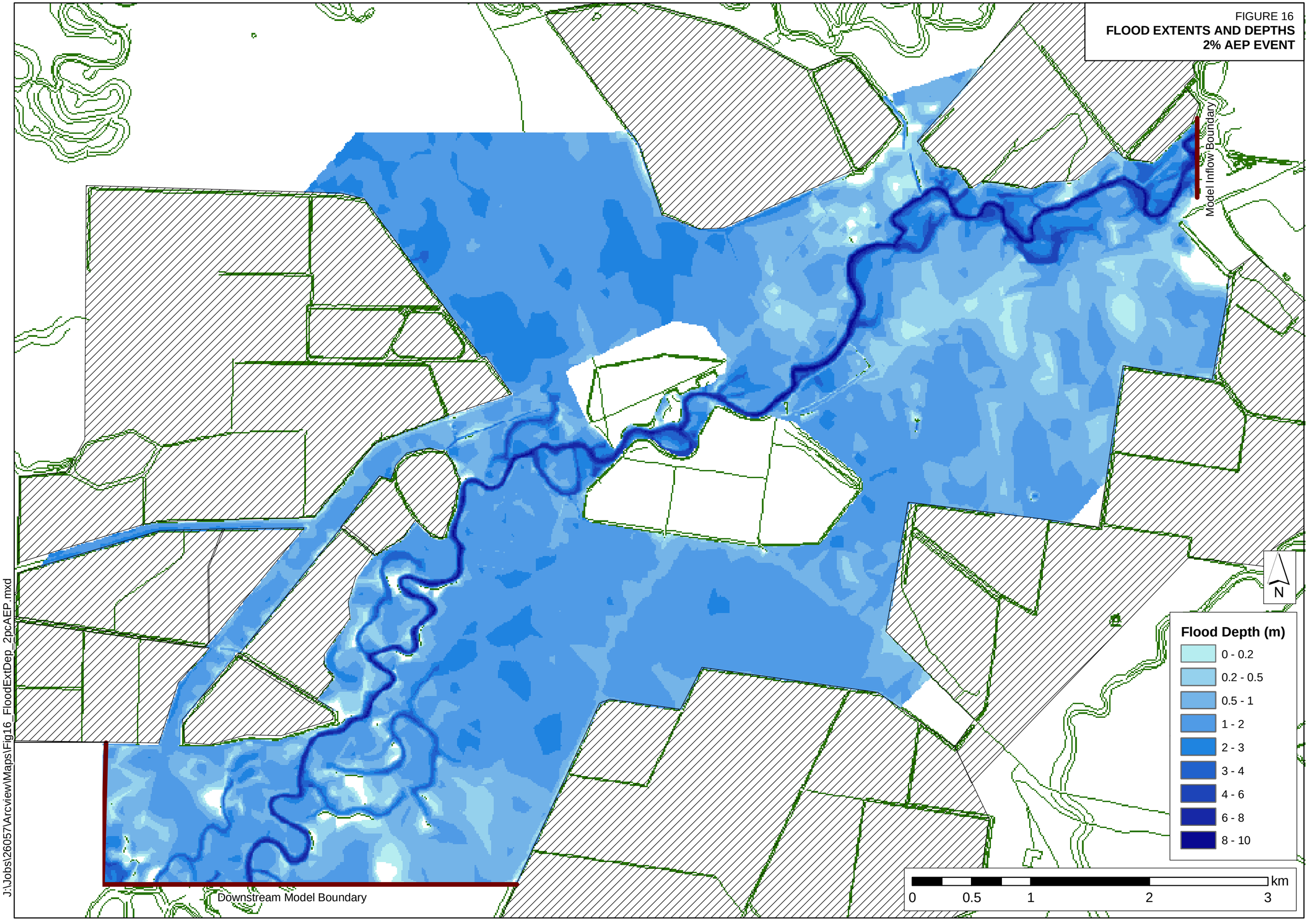

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FIGURE 17
FLOOD EXTENTS AND DEPTHS
1% AEP EVENT

Model Inflow Boundary

N

Flood Depth (m)

- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 6
- 6 - 8
- 8 - 10

0 0.5 1 2 3 km

Downstream Model Boundary

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FIGURE 18

PROVISIONAL HAZARD CATEGORISATION
2% AEP EVENT

Model Inflow Boundary

Downstream Model Boundary

N

2%AEP Event Hazard

- Low
- Medium
- High

0 0.5 1 2 3 km

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FIGURE 19
PROVISIONAL HAZARD CATEGORISATION
1% AEP EVENT

Model Inflow Boundary

Downstream Model Boundary

N

1%AEP Event Hazard
- Low
- Medium
- High

0 0.5 1 2 3 km

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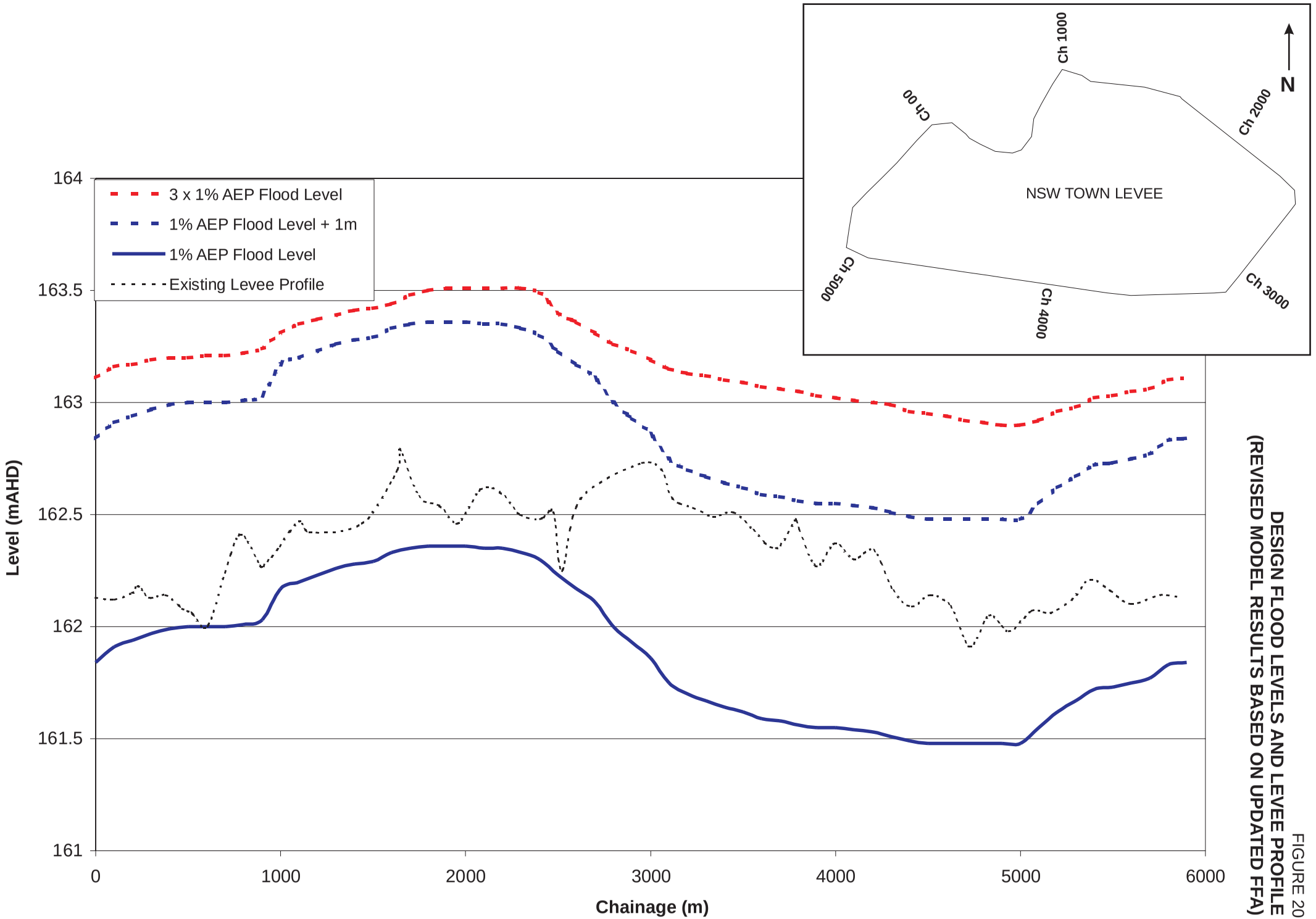

DESIGN FLOOD LEVELS AND LEVEE PROFILE
(REVISED MODEL RESULTS BASED ON UPDATED FFA)

FIGURE 20

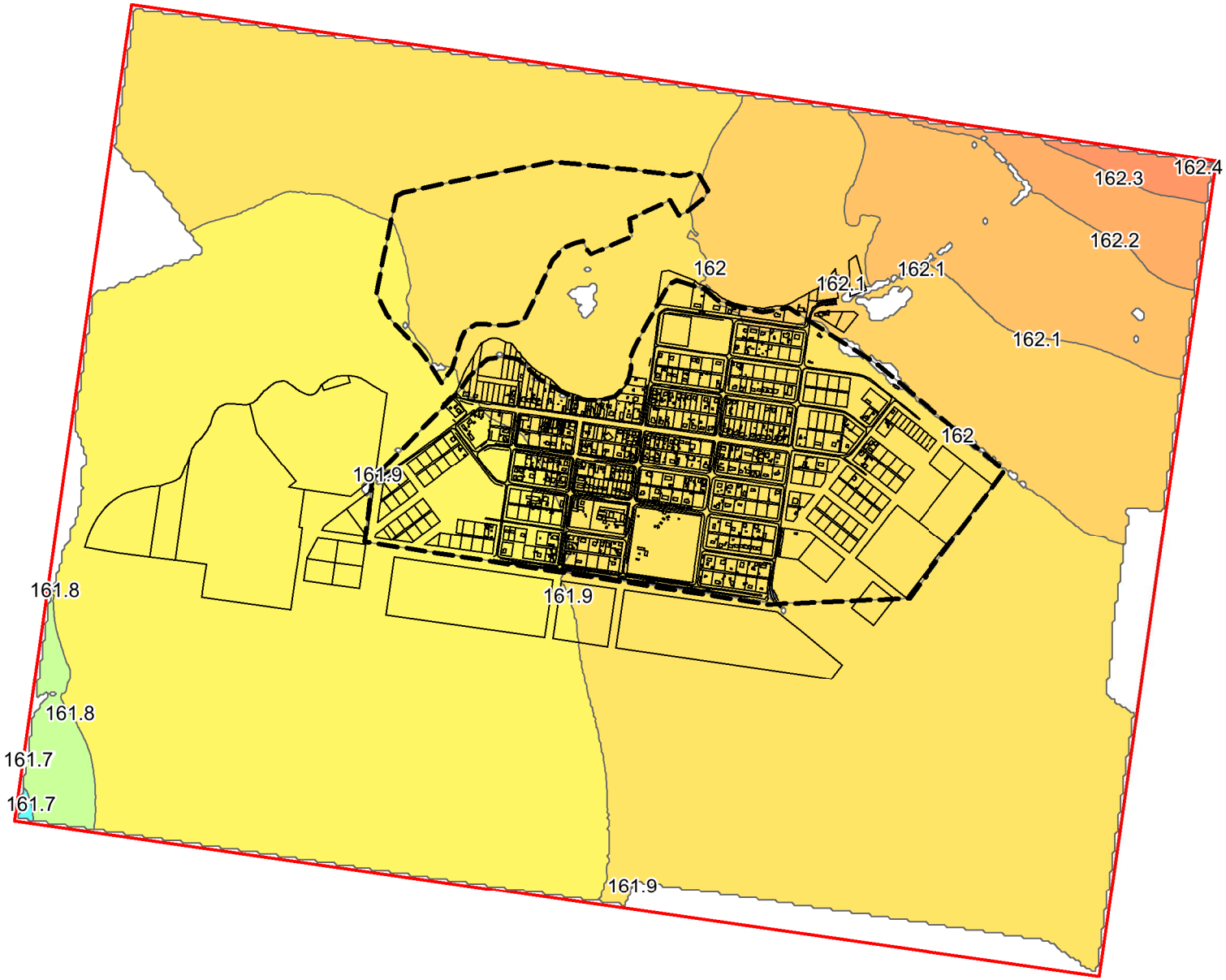

Figure 3

Mungindi Flood Investigation
1% AEP Peak Water Levels
10m Child Grid

LEGEND

N
W E
S

Water Level (mAHD)

- Below 161.60
- 161.60 to 161.70
- 161.70 to 161.80
- 161.80 to 161.90
- 161.90 to 162.00
- 162.00 to 162.10
- 162.10 to 162.20
- 162.20 to 162.30
- 162.30 to 162.40
- Above 162.40

0 100 200
Metres
Scale: 1:10,000

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Cardno (QLD) Pty Ltd | ABN 57 051 074 992
Level 11, North Tower, 515 St Pauls Terrace
Locked Bag 4006, Fortitude Valley QLD 4006
Tel: 07 3369 9822 Fax: 07 3369 9722

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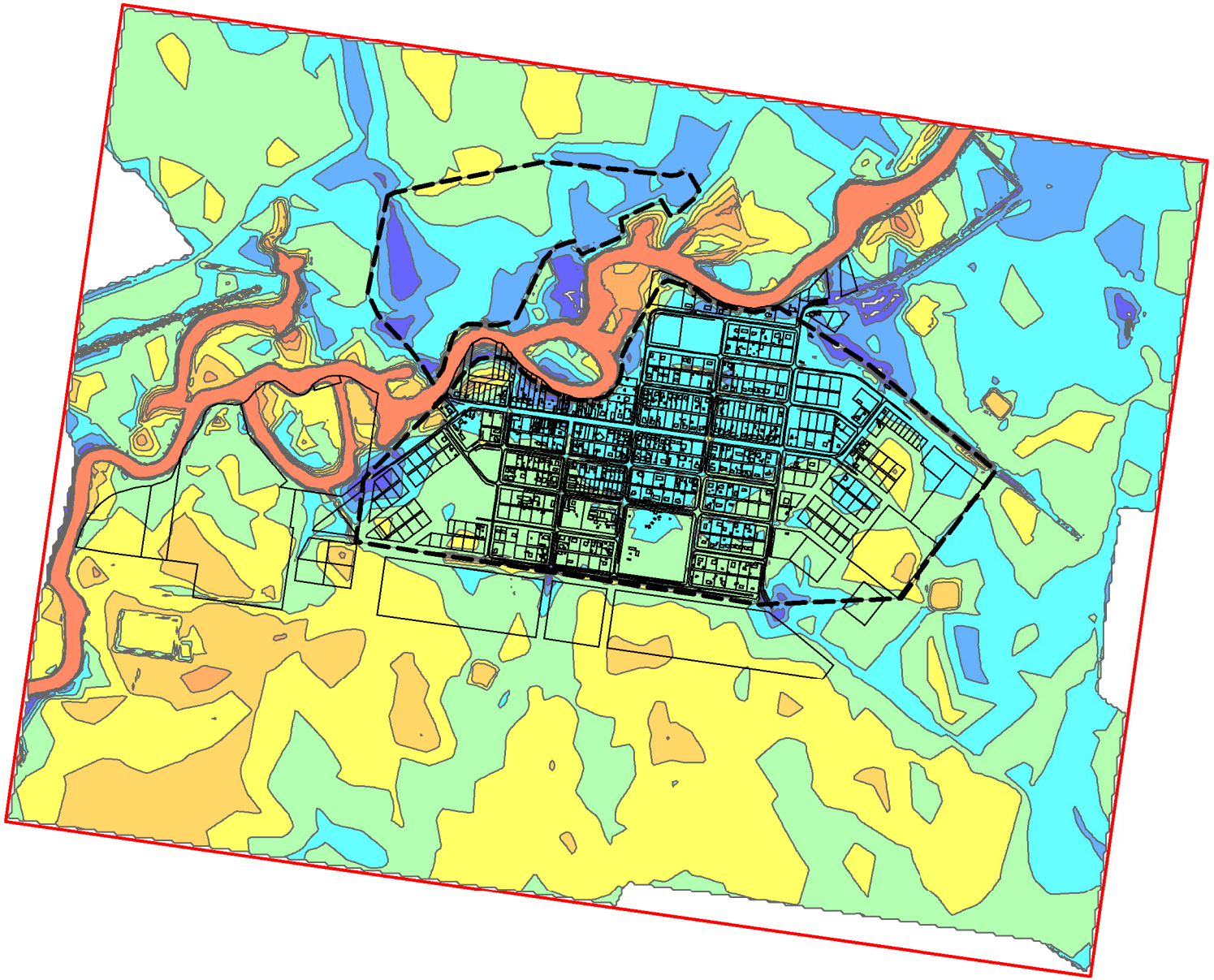

Figure 4

Mungindi Flood Investigation
1% AEP Peak Water Depth
10m Child Grid

LEGEND

N
W E
S

Depth (m)

- Below 0.50
- 0.50 to 1.00
- 1.00 to 1.50
- 1.50 to 2.00
- 2.00 to 2.50
- 2.50 to 3.00
- 3.00 to 3.50
- Above 3.50

0 100 200
Metres
Scale: 1:10,000

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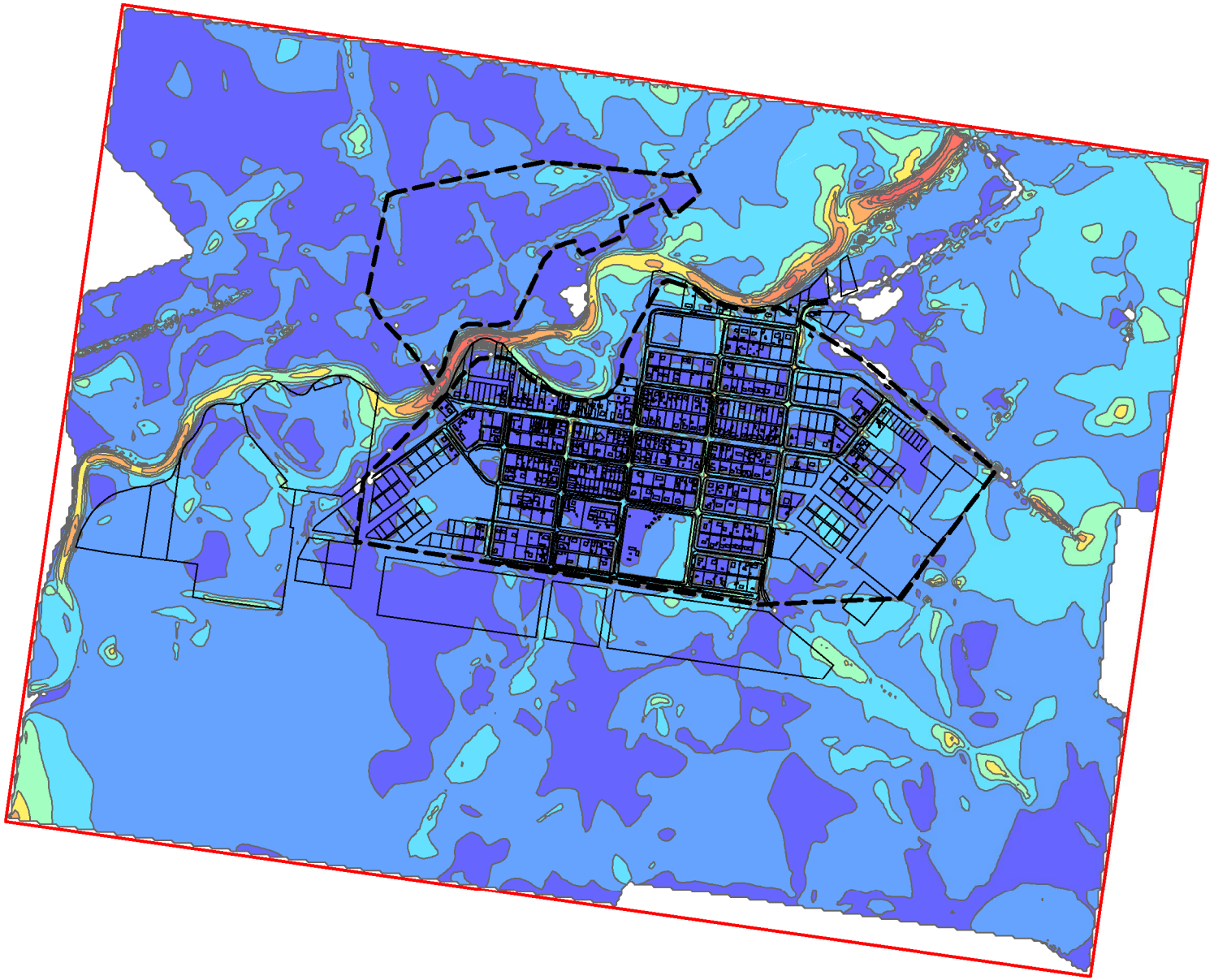

Figure 5

Mungindi Flood Investigation
1% AEP Peak Water Velocity
10m Child Grid

LEGEND

N
W E
S

Velocity (m/s)

- Below 0.20
- 0.20 to 0.40
- 0.40 to 0.60
- 0.60 to 0.80
- 0.80 to 1.00
- 1.00 to 1.20
- 1.20 to 1.40
- 1.40 to 1.60
- 1.60 to 1.80
- Above 1.80

0 100 200
Metres
Scale: 1:10,000

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