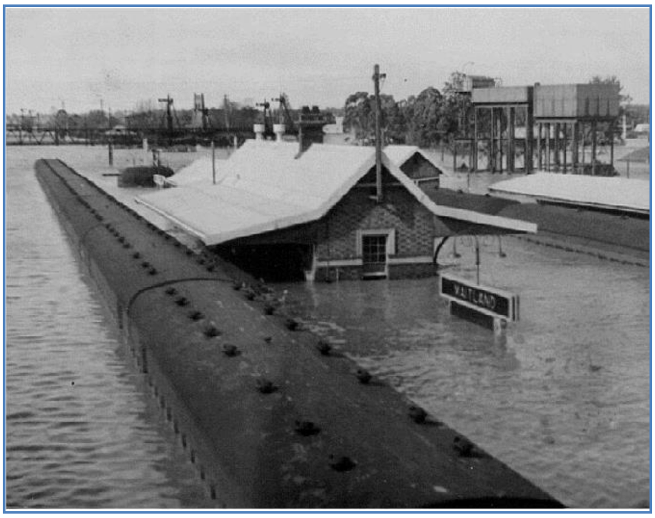
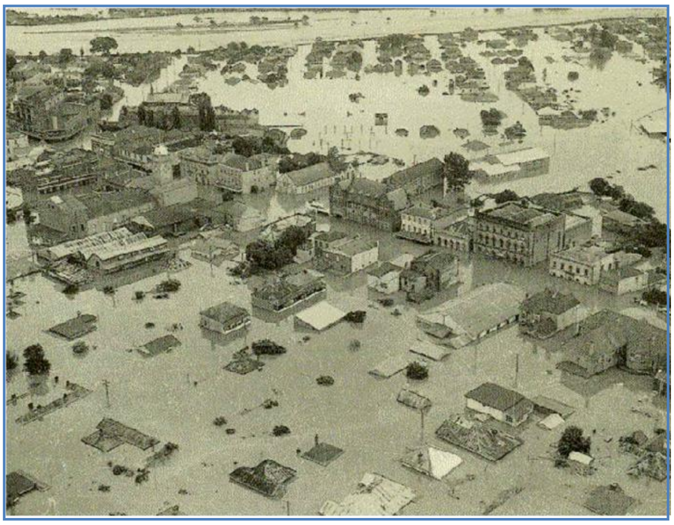
MAITLAND CITY COUNCIL

Hunter River

Floodplain Risk Management Study and Plan

FINAL





November 2015

Level 2, 160 Clarence Street
Sydney, NSW, 2000

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

HUNTER RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FINAL

NOVEMBER 2015

Project **Hunter River Floodplain Risk Management Study and Plan**	**Project Number** **112006**
Client Maitland City Council	**Client's Representative** Josh Ford Ian Shillington
Authors Rhys Hardwick Jones Richard Dewar	**Prepared by**
Date NOVEMBER 2015	**Verified by**

Revision	Description	Date
1	Working Draft for Technical Committee Review	1 February 2013
2	Draft	13 June 2013
3	Draft	14 October 2013
4	Draft for Public Exhibition	31 March 2014
5	Final Draft	10 November 2015
6	Final	November 2015

HUNTER RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

TABLE OF CONTENTS

PAGE

LIST OF APPENDICES

LIST OF PHOTOGRAPHS

LIST OF DIAGRAMS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
ARI	Average Recurrence Interval
ALERT	Automated Local Evaluation in Real Time flood warning software
ALS	Airborne Laser Scanning (ALS and LIDAR are synonymous)
BOM	Bureau of Meteorology
CMA	Catchment Management Authority
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	Development Approval
DCP	Development Control Plan
EPA	Environmental Planning and Assessment
FERP	Flood Emergency Response Plan
FPL	Flood Planning Level
IPCC	Intergovernmental Panel on Climate Change
IPO	Indian Pacific Oscillation
LEP	Local Environmental Plan
LGA	Local Government Area
m	metre
m^3/s	cubic metres per second
Mike11	One Dimensional hydraulic computer model
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
RMS	Roads and Maritime Services (formerly the RTA)
SEPP	State Environmental Planning Policy
SES	State Emergency Service
TUFLOW	Flood simulation software program (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)
WSUD	Water Sensitive Urban Design
1D	One Dimensional hydraulic computer model
2D	Two Dimensional hydraulic computer model

1. 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 Hunter River (Branxton to Green Rocks) Flood Study was completed in September 2010, and constituted the first stage of the management process. The possible effects of a climate change induced increase in design rainfall intensities were also analysed. The flood study supersedes the previous flood study completed in two parts in 1990 and 1998.

The Hunter River Floodplain Risk Management Study and Plan constitutes the second and third stages of the management process for the Maitland Local Government Area (LGA), from the upstream extent of the LGA boundary to Green Rocks. The study is focused on Hunter River floods rather than local catchment flooding and overland flows.

Together these reports provide the basis for the future management of flood liable lands within Maitland and surrounds. Funding was provided from the NSW State Government's Floodplain Risk Management Program and Maitland City Council. The study and plan have been developed for the Maitland Floodplain Risk Management Committee by WMAwater for the future management of flood liable lands in the study area.

2. INTRODUCTION

2.1. Study Area

The study is focused on Hunter River flooding in the Maitland Local Government Area (LGA), including the historic township of Maitland, where the majority of flood-affected properties are located. Maitland is located approximately 30km north-west of Newcastle in New South Wales (Figure 1). The population of the Maitland LGA was 69,646 in the 2011 census, up 23% from 56,492 in 2001. This population is primarily concentrated in two areas either side of Central Maitland along the New England Highway corridor. The first, to the south-east comprises the suburbs of East Maitland, Tenambit, Metford, Thornton and Ashtonfield. The second, to the north-west, comprises Telarah, Rutherford, Anambah and Aberglasslyn. The majority of these urban areas are located on high ground and are not susceptible to inundation from Hunter River flooding. The study area and key locations are shown on Figure 2.

In contrast to the strong population growth of these areas, the population of Central Maitland has been in decline since 1955, primarily as a result of the record flood that occurred in February that year. The population has steadily declined from over 5,500 people prior to the flood in 1954, to less than 2,000 people in 2011. This decline was steepest in the five years immediately following the flood. The population of Lorn has remained relatively steady, declining slightly from 1,447 in 1976 to 1,264 in the 2011 Census.[1]

Maitland has a history of flooding problems, with several recorded instances of major floods resulting in damages and death since European settlement. Very large floods in the Hunter Valley occurred in 1820, 1826, 1832 (seven killed), 1857 (twenty-six killed), 1893 (nine killed), 1913, 1930, 1949, 1952 and 1955 (twenty-four killed, 2,180 homes inundated)[2]. In the years following repeated flooding from 1949 to 1952, the Lower Hunter Valley Flood Mitigation Scheme was planned and constructed to mitigate flood risk and provide some flood protection to Central Maitland and Lorn. The scheme was completed following the devastating 1955 flood.

However this series of levees and flood control banks is not sufficient to protect against a flood of the magnitude of those that occurred in 1955, 1952, and possibly 1930, 1857 and 1820. Maitland has been fortunate that the floods occurring since the full construction of the scheme have been relatively moderate, with the floods of 1971, 1977 and 2007 overtopping the spillways at Bolwarra and Oakhampton but not causing inundation of urban areas. The levee scheme is therefore yet to be tested in a major flood (i.e. larger than a 2% AEP or 1% AEP flood).

2.2. Background

WMAwater was engaged by Maitland City Council to undertake this Floodplain Risk Management Study and Plan. The study includes a review of the 2010 Hunter River Flood Study and other relevant studies, and assessment of floodplain risk management measures for Maitland. The study also includes an assessment of the potential impacts of sea level rise and

[1] From http://profile.id.com.au/maitland/ last accessed 29/01/2013
[2] From "Making Communities Safer in Times of Flood," Chas Keys ISBN 9780646486123

rainfall increases due to climate change on flood behaviour and flood risk in Maitland.

The study also includes a community consultation program, as public participation is a vital component of developing a realistic and practical risk management plan for the community.

2.3. Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), the Floodplain Risk Management Process entails four sequential stages:

Stage 1: *Data Compilation & Flood Study.*
Stage 2: *Floodplain Risk Management Study.*
Stage 3: *Floodplain Risk Management Plan.*
Stage 4: *Implementation of the Plan.*

The Hunter River Floodplain Risk Management Study and Plan constitutes the second and third stages of the management process. The Flood Study stage was completed in December 2010 with publication of the Hunter River (Branxton to Green Rocks) Flood Study (Reference 2). A combination of hydrologic and hydraulic models was used in that study to determine design flood levels resulting from Hunter River floods, although taking into consideration coincident inflows from tributaries such as Wallis and Fishery Creeks, Black Creek and the Paterson River.

The process is recurring, and has previously been undertaken for the Hunter River at Maitland. The studies should be reviewed on a regular basis or when significant new information becomes available. Design flood behaviour from Oakhampton to Green Rocks was previously assessed in the 1998 Supplementary Flood Study (Reference 3), and options to mitigate the risk at Central Maitland from Hunter River flooding were previously assessed in the 1998 Floodplain Management Study (Reference 4). A previous Floodplain Management Plan for the City of Maitland was adopted in 2007 (Reference 5).

2.4. Study Objectives

The objectives of the Floodplain Risk Management Study are to identify and compare various management options, including an assessment of their social, economic and environmental impacts. 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.

The study includes consideration of flood risk at this time and as a result of climate change (due to sea level rise and potentially rainfall intensity increases). This Study and Plan will update the previous Hunter River Floodplain Risk Management Study (1998 – Reference 4) and Plan (1997 – Reference 5) for Maitland.

A glossary of flood related terminology is provided in Appendix A.

3. EXISTING FLOODPLAIN MANAGEMENT

3.1. Catchment Characteristics

The Hunter River is over 300 km long, with headwaters in the Liverpool Range north-east of Scone near Barrington Tops. Glenbawn Dam, located 14 km east of Scone, has a dual role of flood mitigation and regulation of irrigation water supply, with a catchment area of approximately 1,300 km^2. Downstream of Glenbawn Dam, the Hunter River is joined by several major tributaries including the Pages River, the Goulburn River, Wollombi Brook and Glennies Creek before reaching Singleton (see Figure 1). Downstream of Singleton, Glendon Brook and Black Creek are significant tributaries. At the upstream extent of the Maitland LGA, the total Hunter River catchment area is some 17,000 km^2.

Downstream of Maitland, the major tributaries are the Paterson and Williams Rivers, which join the Hunter River between Morpeth and Raymond Terrace. Fishery Creek (Wentworth Swamp) and Wallis Creek (Dagworth Swamp), which join just south of Maitland and flow into the Hunter River via flood gates just east of Horseshoe Bend, have a total catchment area of approximately 400 km^2. The total catchment area of the Hunter River system to the Pacific Ocean at Port Newcastle is approximately 22,000 km^2.

Land-use in the Upper Hunter Valley is a mixture of agriculture (including stock grazing, horse breeding, and farming), and mining. There are a number of underground and open-cut coal mines, particularly in the region between Singleton and Muswellbrook. The Hunter catchment also contains several environmental conservation areas, including the Goulburn River National Park, Barrington Tops National Park, Werakata National Park, Watagan National Park, Mount Royal National Park, Pokolbin State Forest, and Yengo National Park. The south-western part of the catchment in particular consists of conservation areas that are primarily forested.

3.2. Lower Hunter River Floodplain

Within the Maitland LGA, the upstream reach of the Hunter River from Lambs Creek to Oakhampton is relatively confined, with the floodplain in a 1% AEP event less than 300 m wide at several locations. The channel has an average fall of 1 m every 3 km and exhibits extensive meandering, taking 50 km to travel a direct distance of 14 km. Land use in this reach is almost entirely rural agricultural, apart from the growing commercial/residential area of Rutherford-Anambah.

Downstream of Oakhampton, just upstream of the tidal limit, the floodplain widens considerably, with a width of up to 4 km in the 1% AEP event. The channel alignment has changed significantly in the reach from Oakhampton to Green Rocks since European settlement, with relatively sudden changes occurring as a result of extreme flood events. The channel length from Belmore Bridge to Morpeth is at present approximately 9 km, shortened from 26 km when European settlement began.

There are extensive low-lying swamp and marsh areas along the reach from Oakhampton to

Green Rocks, including the confluences of the tributaries that join the Hunter River, such as:

- Wentworth Swamp (Fishery/Swamp Creek);
- Wallis Creek;
- McClymonts Swamp (Barties Creek);
- the Paterson River; and
- the Williams River

The areas comprising the expansive Hunter River floodplain in this reach include:

- the Bolwarra Flats;
- Kings Island;
- Louth Park;
- Pitnacree;
- Raworth;
- Phoenix Park;
- Duckenfield;
- Millers Forest;
- Wallalong and
- Woodville.

3.3. Historical Development

The colonial NSW government established what is now known as East Maitland in the early 19th century. The towns of West Maitland (now Central Maitland) and Morpeth were established by private settlers at a similar time. Development of these two private towns immediately on the banks of the river reflects the importance of river traffic for establishing a trade link to the Hunter Valley at that time.

Maitland is positioned at the upstream tidal limit of the Hunter River and could be reached by vessels with a shallow draft, while Morpeth was at the limit for larger boats. Historically therefore these towns were a major link for goods distribution and transport, accounting for the construction of several large warehouses in Central Maitland, some of which remain today. For approximately 20 years prior to the commencement of the Victorian Gold Rush in the 1850s, Maitland was the second-most populous settlement in Australia.

Flooding has shaped the town development. The two settlements of Lorn and West Maitland were placed on opposite sides of the river, and were not linked by a bridge until the construction of the original Belmore Bridge in 1869. The relatively small patches of high ground in this area led to repeated patterns of development spilling into lower lying areas, such as Horseshoe Bend, despite frequent inundation and loss in these areas throughout the 19th and early 20th century.

Until 1955, the prevailing response to flooding at Maitland was to attempt to manage the flood behaviour through construction of levees and dams, and major river engineering works (refer to Section 6.2 and Appendix B). After the repeated flooding that occurred between 1949 and 1952, and the catastrophic flood of 1955, attitudes shifted towards restricting development in flood-liable areas. The declining importance of the river for trade relative to road and rail networks contributed to an increasing preference to develop the higher ground of East Maitland and Telarah/Rutherford.

3.4. Existing Flood Mitigation Structures

3.4.1. Dams

The two major dams on the Hunter River system are Glenbawn Dam on the Upper Hunter River near Scone and Lake St Clair on Glennies Creek. The primary purpose of both dams is to regulate downstream flow to meet water supply requirements for stock, domestic, irrigation and environmental purposes. Glenbawn Dam also has some hydro-electricity generation capability. Depending on the water level within these lakes prior to a flood, these dams will reduce the peak flow in the Hunter River to some degree during a flood. The amount of attenuation of the peak flow compared to what would occur without the dams in place depends on the available capacity within the dams at the time of the flood, as well as the timing and distribution of rainfall over the broader catchment.

Lake St Clair, constructed between 1980 and 1983, has a capacity of 283 GL, with no reserve for flood mitigation. Glenbawn Dam was partially constructed when the February 1955 flood occurred, and was completed in 1958, then subsequently enlarged in 1987. Glenbawn Dam has a water supply capacity 750 GL, with an additional capacity of 120 GL reserved for flood mitigation purposes. Both dams have un-gated spillways, and spilling from of these dams is therefore unregulated when full capacity is exceeded during a flood.

While the capacity of these dams is significant, it is difficult to assess with accuracy the effect of the dams on flood peaks for the Lower Hunter River. The combined catchment area to Glenbawn Dam and Lake St Clair (Glennies Creek Dam) is less than 1,600 km^2, or approximately 9% of the total Hunter River catchment area to Maitland. As the dams will only partially mitigate the peak flow from these areas in a major flood, the impact on the total Hunter River peak flow at Maitland is likely to be relatively small except in minor flood events. Previous studies at Singleton (Reference 6) and Maitland (References 2 and 3) have ignored the impact of the dams on the flood record, and the same methodology has been adopted for this Floodplain Risk Management Study.

Further discussion about the future use of dams for mitigation of Hunter River flooding at Maitland is provided in Section 6.4.1.

3.4.2. Lower Hunter Flood Mitigation Scheme

The Lower Hunter Flood Mitigation Scheme was largely constructed in the aftermath of the February 1955 flood, although many levees had previously been constructed in an ad-hoc fashion over many years. The scheme involved repair or raising of many of these existing levees, as well as construction of new elements including levees, spillways, control banks and floodgates.

Key features of the scheme relating to Hunter River floods in the vicinity of Maitland include:

- Levee banks along the Hunter River banks, with protection levels generally ranging from the 5% AEP to the 1% AEP;
- The Oakhampton and Bolwarra spillways, which are designed to overtop before the levees protecting the more densely developed areas of Maitland and Lorn, diverting floodwaters around Maitland via the Oakhampton and Bolwarra Floodways. The Oakhampton Floodway directs water into the Wentworth Swamp and Louth Park areas, and eventually back into the Hunter River via Wallis Creek and the Pitnacree area. The Bolwarra Floodway bypasses Lorn to the north, re-joining the Hunter River near Kings Island Road, north of Raworth;
- Floodgates at Wallis Creek to prevent backwater flooding into Louth Park from the Hunter River up to the 5% AEP Hunter River flood event;
- The Maitland Ring Levee, which provides protection to Central Maitland from backwater flooding rising in Wentworth Swamp and Louth Park, up to the 2% AEP level; and
- Floodgates just west of the Maitland railway station, which form part of the Ring Levee.

A map of the major levees comprised by the scheme is given in Figure 3. A database of recognised elements of the scheme is maintained by OEH, and administration of the scheme is undertaken by the Hunter-Central Rivers Catchment Management Authority.

It should be noted that the design standards and construction quality of many structures comprising the scheme are not well understood. A thorough audit and geotechnical investigation of key levee and control embankments around Maitland is a high priority recommendation of this report.

3.5. Flood Policy and Planning Instruments

Within New South Wales, land use planning and development follows the following hierarchy, in decreasing order of seniority:

- Environmental Planning and Assessment Act (EPA Act);
- State Environmental Planning Policies (SEPP);
- Local Environmental Plans (LEPs);
- Development Control Plans (DCPs);

Outside of this hierarchy, the Water Management Act 2000 contains important provisions relating to floodplain management.

Broadly, LEPs deal with land use zoning with permissible and prohibited development, while DCPs deal with more specific detail for particular areas. The instruments of specific relevance to this study are discussed in detail below.

3.5.1. Local Environment Plan 2011

The Maitland Local Environment Plan 2011 (Reference 7), gazetted in December 2011, provides a framework for development of land and land use in the City of Maitland LGA. It contains some specific provisions relating to flood planning, particularly in Section 7.3, which states the following objectives:

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.

These objectives are consistent with those defined in the Floodplain Development Manual (Reference 1). The LEP states that development consent must not be granted unless the consent authority is satisfied that the development:

a) is compatible with the flood hazard of the land; and
b) is not likely to 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) is not likely to 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.

Land using zoning as defined in the LEP is shown on Figure 4. Land to which these flood-related provisions apply is defined as land shown as "Flood Planning Area" on the Flood Planning Maps which are published with the LEP, and "*other land at or below the flood planning level, defined as the 1:100 ARI flood event plus 0.5 metre freeboard*".

It should be noted that the Flood Planning Maps currently published with the Maitland LEP are inconsistent with the definition provided above. The current maps are a composite of two sets of information:

- Downstream of Oakhampton – approximate 1% AEP flood extents based on the 1998 Supplementary Flood Study (Reference 3); and
- Upstream of Oakhampton – approximate February 1955 flood extents (source uncertain – Reference 13 is the likely source).

The extents shown on these maps are identical to the extent shown previously in the August 2000 DCP mapping (Reference 8), do not include an allowance for a 0.5 m freeboard, and are therefore inconsistent with the definition provided in the LEP. The inclusion of "*other land at or below the flood planning level*" in Section 7.3 provides a mechanism to include land not necessarily shown on the maps (including land that may be affected by flooding from sources other than the Hunter River, such as local creek catchments). However, the maps should be updated to reflect Council's current best estimate of the Flood Planning Area based on the most recent December 2010 Flood Study (Reference 2) results (see Figure 5).

3.5.2. Development Control Plan 2011

The Maitland City Wide Development Control Plan (DCP, Reference 9) is divided into 6 parts, namely:

Part A. Administration;
Part B. Environmental Guidelines;
Part C. Design Guidelines;
Part D. Locality Plans;
Part E. Special Precincts;
Part F. Urban Release Areas.

Part B contains sections relating to stormwater, wastewater, vegetation and flood management. Section B.3 specifically addresses flood risk management for the Hunter River floodplain, and is divided into sections covering the following:

- Introduction and statement of objectives;
- Identification of constraints on development;
- Requirements for development applications;
- Additional guidelines for specific land-use zones, including:
  - Rural or environmental zones;
  - Residential zones;
  - House raising or flood proofing works;
  - Commercial zones (B1, B2, B3 and B4);
  - B5 business and B6 enterprise and industrial zones;
- Flood proofing guidelines; and
- Definitions of flood-related terms.

The DCP discourages development within a floodway, but does not preclude it if there is some specific planning merit satisfying community needs. It is stated that an analysis requiring a fully dynamic computer model may be required for such an application.

The DCP requires that new development on the floodplain will require Council consent via a development application, and recommends pre-application meetings with Council officers to identify the extent and type of information that is likely to be required for the submission. Typically Council will require a Statement of Environmental Effects, addressing, illustrating or confirming that:

a) the proposed development will not increase the flood hazard or flood damage to other properties (mostly adjacent) or adversely affect them in any way during floods;
b) the design of the proposed development is such that the risks of structural failure or damage in the event of flooding, including damage to other property up to the Flood Standard level, or as otherwise nominated in Clause 3.7(b), would be minimal;
c) the proposed development has been designed to withstand the effects of inundation of floodwaters in the Flood Standard event, with activities, contents or fittings susceptible to flood damage being located at a level above the Flood Standard, i.e. "flood proofed";
d) if levees are proposed to protect a development, the impact of the levees on flood behaviour must be assessed and the habitable floor level of the proposed development behind the levee must still be set at or above the Design Floor Level;
e) the incorporation of permanent maintenance free measures to allow the timely, orderly and safe evacuation of people from the site should a flood occur. Similarly, the measures proposed to safeguard goods, material, plant and equipment in a flood. These

measures should be compatible with the Maitland Local Disaster Plan;

f) in rural areas, the proposals for the evacuation of any livestock in a flood;
g) the measures to reduce the risks to people, animals and goods likely to utilise the development;
h) the measures to reduce the risks that the development will allow the accumulation and build-up of debris being carried by floodwaters;
i) the design has full regard to the Flood Proofing Guidelines in Part 5 of this chapter;
j) all other relevant matters normally addressed in a Statement of Environmental Effects to cover relevant heads of consideration listed in Section 79(c) of the Act;
k) the potential impacts on the significance of heritage items and heritage conservation areas.

The Flood Standard is defined in the DCP as the 1% AEP flood event, as estimated in the October 1998 Supplementary Flood Study (Reference 3). The Design Floor Level is defined as being 0.5 m above the Flood Standard. These two terms are now not in general usage.

The DCP generally requires that development in the floodplain has the following characteristics:

- all habitable room floor levels of a new development be at or above the Design Floor Level;
- be capable of withstanding the effects of flooding (including immersion, structural stability and impact from debris);
- not adversely affect the flow of floodwaters;
- habitable floor levels on additions or alterations to existing buildings be at or above the Design Floor Level unless it can be demonstrated to Council that it is impractical to achieve that level;
- a development application must be submitted for any filling in flood liable land.

3.5.3. Water Management Act 2000

Part 2 of the *Water Management Act 2000* relates to Hunter Valley flood mitigation works, and contains several provisions of the repealed *Hunter Valley Flood Mitigation Act 1956*. Section 256 states that a person must not do the following except with Ministerial consent:

a) construct any building, fence or structure in, on, or adjacent to a levee bank, or
b) construct a flood work on a floodplain.

The responsible Ministers under the act are jointly the Minister for Regional Infrastructure and Services and the Minister for Primary Industries.

For the purposes of the Act, levee banks are defined as "*a levee bank designed or intended for the purpose of or that could or might have the effect of excluding or partially excluding the waters of the Hunter River or waters overflowing from the Hunter River from any land*". This includes all tributaries of the Hunter River and the estuary. The Act refers to areas of "Declared Floodplain" as established by the Section 16 of the *Hunter Valley Flood Mitigation Act 1956*.

3.5.4. Exempt and Complying Development

The State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 aims to "*provide streamlined assessment processes for development that complies with specific development standards*".

This SEPP document describes types of development that may be undertaken in flood liable areas under the Exempt and Complying Development classification. The requirements are identical for new and existing dwellings. Exempt and Complying Development must satisfy the following criteria:

- The development be constructed or installed outside of any floodway; and
- All habitable rooms be at least 500mm above the 1 in 100 year flood height; and
- Any part of the building below the 1 in 100 year flood height be constructed of flood compatible material; and
- A civil engineer and a hydraulic engineer jointly certify that the development will be able to withstand the force of any flood waters, debris and buoyancy in a 1 in 100 year flood event,
- and that the development will not increase flood affectation elsewhere within the floodplain; and
- Reliable pedestrian and vehicle access from the development, at a minimum level equal to the lowest habitable floor level of the development, be available to a safe refuge; and
- Open car parking or carports be no lower than the 1 in 20 year flood height; and
- There be a driveway connecting any car parking space and a public roadway that will not be inundated by more than 0.3m of water during a 1 in 100 year flood event.

It is noted that the final criterion is likely to preclude the majority of lots affected by flooding in the 1% AEP event from qualifying as exempt or complying development.

3.5.5. Section 149 Planning Certificates

Maitland City Council currently has a notation which it places on Section 149(2) Planning Certificates which identifies whether the subject land is subject to flood-related development controls. Example wording for a rural property is:

> *"Development on this land or part of this 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)* ***is*** *subject to flood related development controls contained within cl. 7.3 of the Maitland Local Environmental Plan 2011 and s. B3 of the Maitland Development Control Plan 2011."*

> *"Development on this land or part of this land for any other purpose* ***is*** *subject to flood related development controls contained within cl. 7.3 of the Maitland Local Environmental Plan 2011 and s. B3 of the Maitland Development Control plan 2011."*

> *"Information given in relation to flooding is based upon Councils adopted 1:100 ARI (Average Recurrent Interval) flood event."*
>
> *"The Maitland Local Environmental Plan 2011 identifies the flood planning level (FPL) as the level of a 1:100 ARI flood event plus 0.5m freeboard."*
>
> *"The subject land **is** within a Declared Flood Plain within the meaning of the Water Management Act 2000. Development on this land **is** subject to flood related development control contained in Section 256 of the Water management Act 2000."*

Maitland City Council does not currently provide additional flood information on Section 149(5) Planning Certificates.

3.6. Flood Planning Levels

Under the LEP (Reference 7) the 1% AEP flood (100 year ARI) is adopted as the design flood standard for planning and general risk management purposes. This policy also sets the extent for flood-related planning controls (the Flood Planning Area) as the land below the 1% AEP flood level plus a freeboard allowance of 0.5 m (defined as the Flood Planning Level or FPL). Section 7.3 of the DCP requires that the minimum floor level for habitable rooms be set above the FPL, although the terminology used in the DCP is "Design Floor Level," which has the potential to be confusing.

For additions or alterations to existing buildings, the DCP requires habitable room floor level to be above the FPL "*unless it can be demonstrated to Council that it is impractical to achieve that level*". This clause is likely to negate floor level controls from some addition/alteration works where existing floor levels are substantially below the FPL.

Floor level requirements for commercial and industrial development are not specified in the DCP, although structures are required to be certified as capable of withstanding the effects of flooding, including immersion, structural stability and impact from debris. For commercial development the DCP requires that "*the premises should be designed to ensure that plant, equipment, storage or other fixtures or fittings liable to damage by floods are located within the building above the Flood Standard or be movable to levels above the Flood Standard*". This requirement is compulsory for B1 Neighbourhood Centre, B2 Local Centre and B4 Mixed Use zonings, and encouraged for B3 Commercial Core zoning wherever possible. For B5 Business Development, B6 Enterprise Corridor and Industrial Zones there are no specific flood controls beyond the general provisions described in the LEP and DCP.

3.7. Flood Warning

The Bureau of Meteorology (BOM) operates a flood forecasting system for the Hunter River. The system is similar to that implemented for most of the major river systems in Australia. The BOM issues Flood Watches in advance of possible floods, if forecasts indicate that flood-producing rain is expected. Severe Thunderstorm and Severe Weather Warnings are also issued when localised intense storms are expected that may produce flash flooding for smaller catchments.

The BOM monitors the Hunter River catchment via a network of ALERT rainfall gauges and river height gauges. The density of this gauge network is relatively high compared with other east coast river systems, and the size of the catchment results in reasonably long warning times being provided for Maitland. The NSW State Flood Plan (Reference 10) stipulates that the BOM will provide 12 hours notice for flood heights from 5.9 m to 7.1 m AHD at the Belmore Bridge gauge. 24 hours notice is required for heights above 7.1 m AHD at the gauge, which encompasses the full range of Major and Moderate flood classifications, and much of the Minor flood classification.

The Flood Warning system allows SES personnel to monitor flooding developments on the Hunter River, through real-time water level sensing as well as guidance on anticipated flood severity. The system is generally based on stations which automatically record rainfall or river levels at upstream locations and telemeter the information to a central location. Consideration is also given to ocean storm surge and tidal anomalies (where applicable) by the use of a simple tidal algorithm. Analysis is then undertaken to determine the expected time and height of the flood peak. At present there is a relatively comprehensive system for the Hunter River, with its major tributaries all being monitored.

The BOM also provides Flood Warnings at several locations upstream of Maitland, including Singleton, Denman, Muswellbrook, and a flash flood alert system at Scone. The observed flooding at these locations can be used to refine the predicted flood peaks at Maitland as the flood progresses. This system was "tested" in the June 2007 event and subsequently minor revisions were incorporated.

3.8. Flood Response Planning

Flood response planning for Maitland is addressed as part of the Maitland City Local Flood Plan (Reference 11), which is a sub-plan of the Maitland Local Disaster Plan. The Local Flood Plan, dated June 2013, covers the entire Maitland City Council LGA, and encompasses preparedness measures, direction of response operations, and co-ordination of recovery efforts after flooding has subsided. Specifically, the plan covers the following issues:

- allocation of responsibilities and duties for Maitland City Council, the Maitland SES Local Controller and Unit Members, the BOM, Local Area Police Force and Fire Brigades, NSW state government departments, utility providers, road and rail authorities and others;
- a requirement that the plan be reviewed no less frequently than every five years;
- sources of flood intelligence and flood warnings;
- deployment, activation, liaison and communication protocols for SES personnel and other response organisations during flood operations;
- operational details for road closures, flood rescue, evacuation, and logistics (including resupply); and
- guidance for recovery and debriefing.

There are several annexes to the Local Flood Plan containing:

- Annex A – general information about flood mechanisms at Maitland, flood producing weather systems, flood history, and descriptions of flood mitigation structures such as levees and dams.
- Annex B – typical flood behaviour and timing for various key gauge levels, and identification of specific risk areas in various rural, urban and village areas, including public institutions that may require closure or evacuation.
- Annex C – a summary of flood level gauges in the area that are monitored by the SES.
- Annex D – a distribution list for dissemination of SES flood bulletins including media outlets and government agencies.
- Annex E – a template evacuation warning message.
- Annex F – operational details for evacuation, including responsibilities, evacuation trigger levels, helicopter landing zones, and potential sites for evacuation centres.
- Annex G to Annex O – specific operational details and evacuation information for each of the nine operational sectors within the Maitland City LGA.
- Annex P – arrangement for the evacuation of caravan parks and relocation of caravans.
- Annex Q – details of the dam failure warning and evacuation system for Glennies Creek and Chichester Dam.

The Flood Plan notes that for most floods occurring within the Maitland LGA, evacuation is not likely to be required. However it is identified that for large floods approaching the magnitude of the February 1955 flood, large-scale evacuations will be required, concentrated in the Lorn, Central Maitland and South Maitland areas. Rural communities in the floodplain would also become isolated. It is estimated that an extreme flood, sufficient to almost entirely inundate Central Maitland and Lorn, would require evacuations of up to 12,000 people.

Evacuation routes identified from the Lorn-Maitland sector include:

- Les Darcy Drive (New England Highway) to East Maitland and Metford;
- New England Highway to Rutherford and Telarah;
- Long Bridge to Rutherford and Telarah;
- Belmore Road to Bolwarra;
- Rail from Maitland Station to Telarah Station or Victoria St Station, with bus transport to nearby schools.

Each of these evacuation routes would be cut in a Hunter River flood greater than a 5% AEP event. In a 5% AEP flood, the Oakhampton and Bolwarra spillways would both be overtopped, cutting Belmore Road, the New England Highway to Telarah, and requiring the railway flood gate to be closed. In slightly larger events, or with major coincident flooding of Wallis/Fishery Creeks, Les Darcy Drive and the railway line to East Maitland would also be cut.

While Long Bridge may not necessarily be overtopped in a 5% AEP event, a structural assessment of the bridge has determined that it should be closed to traffic once water begins to flow in the Oakhampton floodway, due to the risk of failure from flood debris and hydrodynamic loadings (Reference 12). During the exhibition and review stage of this report, Council and OEH indicated that RMS had advised the bridge can remain operational when there is flow under the deck in the Oakhampton floodway. RMS did not respond to requests from Council for a written report to verify this statement.

In events great than a 5% AEP, all evacuation routes from Central/South Maitland and Lorn are likely to be cut before the flood peak at Belmore Bridge, and possibly 24 hours or more before the flood peak in South Maitland, Louth Park and Horseshoe Bend. Evacuation considerations for Maitland are discussed in further detail in Section 7.2.

Review of the Local Flood Plan is required every 5 years, and was therefore due in 2008. The SES has indicated that a substantial review and revision of the Maitland Local Flood Plan has been completed, but a draft was not available for review as part of this study. The revised draft flood plan has not been finalised due to changes to the adopted SES format and methodology for producing flood plans.

This review did not identify any significant omissions or errors in the February 2003 version of the plan. The SES indicated that the revised draft plan includes updates based on new information obtained during the June 2007 flood, and observations of the efficacy of the existing plan by operational crews during that event.

The 2003 plan refers primarily to Oakhampton Railway Bridge gauge flood levels, in conjunction with Belmore Bridge levels. According to the NSW State Flood Plan, the BOM produces flood warnings for Belmore Bridge but not Oakhampton Railway, although forecasts for Oakhampton Railway gauge may be available to the SES in practice.

There is some merit in using forecast levels at Oakhampton Railway Bridge for emergency planning as this gauge is upstream of the main Oakhampton and Bolwarra spillways, and probably provides a better indication of the likely extent of overtopping of those spillways. However the record length at Belmore Bridge is significantly longer, and the public are more likely to be able to relate flood levels at this gauge with flood risk at various locations, and this is the height that tends to be more widely reported in the media. The flood predictions at Oakhampton are also possibly subject to more uncertainty due to the shorter record length used to obtain empirical relationships with other gauges. These are factors for the SES to consider in future reviews of the Maitland Flood Plan.

The revised draft Local Flood Plan should also be checked to ensure consistency with the most recent modelled flood behaviour from the December 2010 Flood Study (Reference 2). Emergency Response Planning Categorisation, documented in Section 4.5 of this study, may also be useful in revising the plan.

3.9. Previous Studies and Planning Documents

A summary of key reports relating to floodplain management over the last thirty years is provided below. The studies are presented in chronological order to illustrate changes in policy or mitigation strategies that have occurred over time.

Some additional discussion of historical attitudes and investigations for flood mitigation in earlier periods is provided in Section 6.2.

3.9.1. Lower Hunter River Floodplain Atlas (1983)

Produced by Public Works, the atlas contained mapping showing flood extents for 1% AEP, 2% AEP and 5% AEP design floods (Reference 13). The estimated extents were based on results of scaled physical modelling undertaken in the late 1960s with extent mapping based on 1:4000 scale mapping undertaken by the government mapping authority.

The study estimated the 1955 flood as approximately a 1% AEP event, and in many locations the 1% AEP estimates were similar to the observed 1955 flood data. The main exceptions were areas now protected by the Lower Hunter Flood Mitigation Scheme, which was estimated to reduce the 1955 flood level by 0.9 m to 10.0 mAHD at Maitland Railway Station, and by 1.4 m to 7.8 mAHD at Lorn.

The availability of ALS survey has meant that these maps should now not be used.

3.9.2. Hunter Valley Floodplain Management Study (1981)

Sinclair Knight & Partners developed a program of floodplain management works based on available data (Reference 14). Within the Maitland LGA, it was recommended that:

- a detailed engineering and planning study of Central Maitland be undertaken to establish development control policies compatible with its inherent flood hazard;
- implement building regulations including:
  - require all businesses to provide storage at a sufficiently high level to ensure that stock normally kept at ground level could be protected from flood damage;
  - introduce flood proofing regulations for alterations, additions and new development;
  - formulate emergency evacuation and post-flood procedures;
- maintain the existing policy of no infill development for Lorn;
- floodway zones be progressively cleared though an acquisition programme which required removal of some 184 houses valued at $5.5 million (indicative estimate at the time – equivalent to about $20 million in 2012 based on CPI).

3.9.3. Hunter Valley Flood Mitigation – Central Maitland Land Use Study (1982)

Undertaken by Public Works, this study (Reference 15) formed the basis for the planning policies subsequently implemented in the Central Maitland Development Control Plan No. 8 (Reference 16).

The objectives of the study were oriented towards land use zoning, and the identification of appropriate land uses for flood prone areas. A specific objective of the study was the limitation of residential land use so that the total population on the floodplain did not increase.

3.9.4. Central Maitland Development Control Plan No. 8 (1986)

The DCP No. 8 (Reference 16) was implemented by Council in June 1986. The stated objectives of the plan were to:

a) encourage the development of non-residential development able to withstand the effects of flooding;
b) provide opportunities for housing on land generally above the 1% AEP flood level, to allow replacement of flood affected housing turned over to other uses, subject to flood proofing measures in new housing, and limits on the amount of new housing to ensure the overall numbers of people exposed to flood risk do not increase; and
c) recognise and aim to strengthen Central Maitland's regional, commercial, entertainment, historical, tourism and recreation roles and functions.

The general principles of the DCP No. 8 were similar to those outlined in the current DCP (refer to Section 3.5.2). The main point of difference from current planning documents was the specification of several special residential zonings for existing flood affected residential development, such as 2(b) "Flood Liable", 2(c) "No Infill", and 2(d) "Living Area" zones. The purpose of these zones was explicitly to limit the expansion of urban development on flood-prone areas, and to encourage the development of non-residential uses instead.

The plan gave Council the power to purchase land in 2(c) "No Infill" areas if the existing dwelling was destroyed by fire. Additionally, limits were placed on works that increased the floor area or extending the life of existing dwellings in this zone.

3.9.5. Maitland Local Environment Plan (1993)

The 1993 LEP (Reference 17) effectively repealed some of the previous flood-related planning controls as stated in the DCP No. 8. Residential 2(c) and 2(d) zonings, which contained relatively strict provisions preventing infill development or renewal in flood-liable areas, were removed.

The 2(b) "Flood Liable" Residential zoning was retained, and encompassed areas of Horseshoe Bend and South Maitland. Development of new dwellings was not permitted in the 2(b) zoning.

3.9.6. Lower Hunter Valley Supplementary Flood Study (1998)

This study (Reference 3) was undertaken by Webb McKeown & Associates (now WMAwater). Flood frequency analysis was undertaken to determine peak flow rates for a range of design floods using historical flood records at Belmore Bridge. Hydraulic modelling of the Hunter River reach from Oakhampton to Green Rocks was undertaken using the Mike11 Package, and was calibrated to the 1955, 1971, 1972, 1977, 1978 and 1985 flood events. Design event modelling used the hydrograph shape from the 1955 event.

The major differences with the previous design flood information from the Floodplain Atlas (Reference 13) were:

- the re-assessment of the February 1955 flood as close to a rarer 0.5% AEP flood rather than a 1% AEP flood;

- increases to 1% AEP flood levels in urban areas such as Maitland railway station and Lorn;
- decreases to some 1% AEP flood levels in rural areas.

3.9.7. Lower Hunter Valley Floodplain Management Study (1998)

This study (Reference 4), undertaken by Webb McKeown & Associates (now WMAwater) investigated a range of floodplain management measures. Following several stages of assessment and refinement of the measures, and consultation with the community, a range of mitigation measures were recommended, as summarised in Table 1 below:

Table 1: Mitigation Measures Previously Assessed in Reference 4

TYPE OF MEASURE	RECOMMENDATION	PRIORITY
STRUCTURAL		
Dams	Not viable on economic grounds	-
Retarding Basins	Not applicable – insufficient flood storage volume	-
River Works	Limited benefit, environmental impacts, high costs	-
Levees	Establish a rural land users committee to investigate minor works in rural areas, with potentially significant benefits	High
	Raise the Maitland Ring Levee to a uniform level in conjunction with other works in the area	Medium
	Undertake a detailed study to examine the feasibility and benefit of constructing a levee at Sharkies Lane to protect Lorn	Medium
NON-STRUCTURAL		
House raising or flood proofing	Council to discuss implementation of flood proofing / house raising scheme with state government authority	High
Planning controls	Update planning instruments to include current state of knowledge regarding flooding at Maitland, including Section 149 certificates.	High
Voluntary Purchase	Council to discuss continuation of the existing voluntary purchase scheme with state government authority	High
Flood Warning	Improve the existing flood warning system	High
Information/Education	Improve the dissemination of flood information to the public	High
Flood Response	Periodically review the SES disaster management plan	High
Flood Insurance	Not available for residential mainstream flooding	-

The study also recommended that proposals for future development on the floodplain should be subject to the following considerations:

- filling within a Floodway (as defined in the study) is not recommended;
- a reasonable amount of filling, preferable by a cut and fill approach, is acceptable within a Flood Storage or a Flood Fringe areas (as defined in the study);

- the erosion and sedimentation regime of the river should not be adversely affected;
- development should include measures to further improve water quality of the Hunter River and its tributaries;
- potential impacts of climate change should be monitored;
- consideration should be given to potential impacts on the integrity of existing flood mitigation works, or causing a significant re-distribution of flow.

3.9.8. Hunter River Floodplain Management DCP No. 29 (2000)

This iteration of the DCP (Reference 8) superseded DCP No. 8 (1986), and contained some clarifications to improve consistency with the LEP (1993), as well as new mapping based on design flood modelling information from the 1998 Flood Study (Reference 3) as well as several changes to flood-related development controls in Maitland.

The DCP enabled replacement of destroyed dwellings in Residential 2(b) zones subject to Council's approval of a merits-based application. Renovations and additions to existing dwellings were permitted subject to approval by Council, based on a range of criteria including heritage and streetscape aspects.

The DCP No. 29 also included guidelines for house raising and flood proofing of existing dwellings, in accordance with the recommendations of the 1998 Floodplain Risk Management Study (Reference 4).

The general requirement for developments in the floodplain were very similar to those in the current DCP (refer to Section 3.5.2), including the requirement for habitable room floor levels of new developments to be at or above the Flood Standard level plus 0.5 m freeboard.

3.9.9. Maitland Urban Settlement Strategy (2000)

The Strategy (Reference 18) identified areas with the potential to be used for sustainable residential purposes, to accommodate forecast urban population growth within the Maitland LGA. It examined the wider implications of new urban development at several investigation sites, including effects on servicing, existing land uses, environmental values and the historic and rural character of the City.

The Strategy included flood affectation of land as a "hard constraint" on the identification of appropriate investigation sites, and consequently did not include flood liable areas on the shortlist of investigation sites. This reinforced the existing policy of limiting urban expansion or infill residential development in flood liable areas.

3.9.10. City of Maitland Floodplain Risk Management Plan (2007)

This study (Reference 5) involved refinement of measures identified in the 1998 Floodplain Risk Management Study (Reference 4), and selection of a preferred strategy for implementation of floodplain management. The mitigation measures recommended as part of the Plan are summarised in Table 2 below.

Table 2: Mitigation Measures Previously Recommended in Reference 5

Action	Economic Cost	Indicative Benefit/ Cost Ratio	Period of Implementation				
			Year 1	Year 2	Year 3	Year 4	Year 5
HIGH PRIORITY							
Initiate changes to the Rural Flood Mitigation Scheme	Unknown	-	ONGOING				
Review Existing Voluntary Purchase Scheme	Up to $200k per house	-	ONGOING				
Improve the existing flood warning system	Low	High	✓			✓	
Periodically review the SES Local Flood Plan	Low	High	✓			✓	
Improve dissemination of flood information/education to public	Low	High	ONGOING				
Prepare a Floodplain Risk Management Policy	Low		✓				
Adopt a Flood Planning Level	Low		✓				
Update and review wording of s149 certificate.	Low		✓				
Identify properties affected by flood related development controls	Low		ONGOING				
Amend LEP 1993	Low						
Flooding assessment to be included as criterion in identifying release areas	Low		ONGOING				
Amend floodplain management provisions of DCP	Low		✓	✓			
Obtain advice on climate change biennially	Low			✓		✓	
Ensure development controls address future development in upper catchments	Low		ONGOING				
MEDIUM PRIORITY							
Investigate feasibility of levee at Lorn	Several $million			✓		✓	
Raise Maitland Ring Levee	$100,000				✓		
Initiate scheme to promote house raising and flood proofing	$60,000 per house			✓		✓	✓
Obtain data from future floods	Low		WHEN APPROPRIATE				

Most of the recommended high priority measures have been implemented to some degree, while less progress has been made with the medium priority measures. The outstanding measures have been reviewed as part of the present study.

3.9.11. Central Maitland Structure Plan (2009)

The Structure Plan (Reference 19) was prepared for Council by City Plan Urban Design, and is intended to provide a framework for planning and development in Central Maitland. The Structure Plan was developed in response to population growth targets set by the NSW State Government in the Lower Hunter Regional Strategy.

The Plan sets an explicit target of increasing the population of Central Maitland back to the levels of 1954 (about 5,500 people) by 2030. Since the 1955 flood, population levels have steadily declined to below 2,000 in the 2006 census. It is identified that there has been a trend of leaving the town centre observed in many Australian towns, and this trend has been exacerbated by planning restrictions on flood-liable residential land at Maitland. The goal of population growth as stated in the Structure Plan is primarily aimed at reversing the trend of urban decay, and increasing prosperity and economic activity through renewed development of the area.

On the issue of flood risk, the Structure Plan states:

> *"Flood mitigation measures, flood warning systems, building design and construction technology and evacuation processes are all much improved since the devastating flood of 1955. As such it is considered that it is time to reverse the trend of abandoning the historic and attractive Centre of Maitland in favour of renewal and activation."*

The Structure Plan also notes:

> *"There are many ways to respond to the risk of flood. It is anticipated that the city will develop an integrated plan for ways to respond to flooding. The plan may include such elements as: an early warning system; households and businesses prepare a 'flood ready plan'; an evacuation plan and a recovery plan. Public education and a special attitude to be taken by all households and businesses within the flood zone will be important elements. Design strategies for flooding relate to infrastructure design & escape routes. Other design elements include building design that incorporates upper level storage; elevated homes 'Queenslander' style; 'Floodable finishes' in lower levels and; buildings to have appropriate structural integrity. Many of these strategies have a long history in Maitland, the structure plan requires they are renewed and integrated to allow the centre to grow"*

The measures identified above are discussed in detail later in this report.

It should be noted that reduction of population in high flood risk areas was a stated objective of flood planning policies implemented after the 1955 flood, and in the Development Control Policies in place since 1986. There are therefore inconsistencies between the Structure Plan and the Development Control Policies for Maitland.

In addition there has been no construction of mitigation measures since 1955 that have reduced flood levels in an event of magnitude of the 1955 event. Whilst flood warning systems and evacuation processes have been improved since 1955 these systems cannot be relied upon to evacuate the entire population of Maitland. This is largely because residents are reluctant to leave until the last possible moment. This is a common phenomenon with evacuation from floods and bushfires.

3.9.12. Hunter River Branxton to Green Rocks Flood Study (2010)

This study (Reference 2), undertaken by WMAwater, determined Hunter River design flood levels for the entire Maitland City LGA, and superseded the 1998 Flood Study (Reference 3). Reasons for initiating the study and updating the design flood levels included:

- The use of a two-dimensional (2D) model to simulate flood behaviour, an advancement over one-dimensional (1D) techniques used in the previous study;
- The availability of detailed topographic data from Airborne Laser Scanning (ALS) has enabled the use of 2D models, an accurate definition of topographic features in the floodplain and the ability to provide accurate flood extent and depth mapping;
- The need to obtain design flood level estimates upstream of Oakhampton (not previously available);
- Advancements in flood frequency estimation, used to determine design flow rates on the Hunter River;
- The June 2007 flood was the third largest flood since February 1955 and over 30 peak levels were recorded by residents as well as at thirteen automatic water levels recorders within the study area. This event therefore provided suitable data for model calibration;
- The June 2007 event equalled the January 1971 event at Singleton, exceeded the 1971 peak at Greta (by 0.7m) but was 0.4m lower than 1971 at Maitland (Belmore Bridge). This apparent "anomaly" together with the relatively "slow" travel time of the flood peak from Singleton in 2007 was not well re-produced by existing models and required some further investigation; and
- There was a general need to review the results of the October 1998 Flood Study (Reference 3) and establish a computer model for use in the evaluation of climate change scenarios as well as to investigate potential development options.

The following tasks were undertaken in the Flood Study:

- collection of historical flood data;
- flood frequency analysis for Oakhampton/Belmore Bridge;
- development of hydrologic (WBNM) and hydraulic (TUFLOW) models, calibrated against historical flood behaviour (June 2007, February 1971 and February 1955);
- design flood estimation (including the 50% AEP, 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.2% AEP, and 0.5% AEP events as well as the PMF);
- assessment of provisional flood hazard (for the PMF and 1% AEP events).

The 2010 Flood Study provides the foundation for this present study to consider management of flood risk at Maitland from Hunter River flood mechanisms.

3.10. Environmental Considerations

The action plan developed by the CMA (Reference 20) outlines a comprehensive action plan for the Hunter River catchment, including guiding principles for a wide range of catchment management activities. Of particular relevance to this study are the guiding principles relating to rivers and freshwater wetlands, including:

- maintaining and increasing vegetation cover in the catchment to improve water quality. This may also have the effect of reversing increased runoff flows resulting from past clearing in the upper catchment;
- protecting and rehabilitating riparian vegetation. This practice can influence flood behaviour, and it appears that the effects of policies to reinstate riparian vegetation were evident in the altered Hunter River flood behaviour observed in June 2007 compared to the floods in the 1970s, when riparian vegetation was relatively degraded compared to current conditions. These factors were discussed in the 2010 Flood Study (Reference 2);
- maintaining/improving aquatic habitat, including:
    - in-stream engineering works should consider stream habitat and geomorphic processes;
    - snags and obstructions should not be removed from the river where possible, and should be relocated if causing safety hazards or inappropriate river processes;
    - sand and gravel extraction and dredging activities should consider impacts on aquatic habitat.
- maintaining/improving floodplain connectivity, removing levees where appropriate to restore wetland connectivity to the river. Floodplain management plans should be developed, with consistent approaches between Councils in the same catchment.

These guiding principles are largely consistent with modern floodplain management practices in NSW, where channel engineering works in major rivers (such as channel re-alignment/straightening, channel clearing, or major dredging) are generally regarded as an inappropriate flood management response. This is due to the relatively low benefit-cost ratio of such works for lowering flood damages and other flood risks, and also the loss of environmental assets through habitat destruction and reduced biodiversity and water quality.

While policies to rehabilitate riparian vegetation undoubtedly have some effect on flood behaviour, the effect is not inherently “good” or “bad” in terms of reducing or increasing flood levels. Increased vegetation can reduce channel conveyance and slow the passage of floodwaters, causing greater attenuation of the flood wave as it moves downstream. While localised flood levels may be slightly higher, particularly in the upper catchment, the attenuation effect may reduce peak flood levels in the lower catchment. This appears to have occurred to some extent in the June 2007 Hunter River flood.

Physical flood mitigation measures are discussed further in Section 8. The recommendations of this study are consistent with the guiding principles of the Hunter-Central River Catchment Action Plan, and conservation of environmental assets in Maitland.

3.11. Cultural and Heritage Considerations

The Maitland City Council area includes significant sites of indigenous and non-indigenous heritage, resulting from the City's importance as one of the major population and trade centres for European settlers prior to Federation. The Central Maitland Structure Plan (Reference 19) provides a comprehensive overview of key heritage items in the area. A high proportion of existing buildings within Central Maitland are identified as Heritage, Potential Heritage, or Contributory Heritage Items. Efforts to revitalise Central Maitland, despite the flood risks, are largely related to these heritage values.

A basic search of the Aboriginal Heritage Information Management System (AHIMS), maintained by the NSW OEH, indicates there are nil recorded sites in Central Maitland in the vicinity of physical works assessed in this study. Implementation of any physical works which disturb the natural ground surface or require clearing of vegetation should incorporate a more detailed review of the AHIMS database to determine whether an archaeological survey is required.

4. EXISTING FLOOD PROBLEM

4.1. Flooding Mechanisms

The Maitland City LGA covers some 400 km^2. Flooding in Maitland City may occur as a result of:

- elevated flows from runoff in the Hunter River catchment and its tributaries;
- elevated flows from local creek catchment runoff;
- flow along roads and through private property as a result of intense rainfall over urbanised areas; or
- local runoff that accumulates (ponds) in low-lying areas, such as sags on roads or areas where overland flow paths are blocked. This type of flooding may be exacerbated by inadequate or blocked local drainage, and/or restricted overland flow paths.

These factors may occur in isolation or in combination with each other. Elevated water levels in the Hunter River would typically result from long duration broad-scale rainfall systems, which may or may not occur in conjunction with intense rainfall that causes significant flooding in the local creek catchments.

Hunter River flooding is the most significant flood risk for large parts of the Maitland City LGA. Most of the flood damages and flood-related deaths within Maitland (within the last 200 years) have been primarily a result of Hunter River or major tributary flooding. A collection of historical flood photographs from various sources is provided in Appendix C.

Tidal mechanisms are not a cause of flooding in the Maitland City LGA.

4.2. Flood Behaviour

4.2.1. Design

The Hunter River (Branxton to Green Rocks) Flood Study (Reference 2) reported design flood data for current catchment conditions. Modelling results from Reference 2 indicate flow is primarily in-bank for the 50% AEP event (the most frequent event modelled), with some shallow overbank flooding of low-lying areas on the Lower Paterson River and downstream of Morpeth. The 50% AEP event is large enough for the formation of an anabranch flow-path from Porters Hollow (just downstream of Harry Boyle Bridge), through Howes Lagoon, and re-joining the Hunter River immediately upstream of Morpeth.

From the 20% AEP to 10% AEP event, widespread overbank flooding of low-lying rural areas upstream of Oakhampton occurs. Downstream of Oakhampton, flows are primarily contained in-bank as far downstream as Harry Boyle bridge, with the Oakhampton and Bolwarra Spillways being just overtopped in the 10% AEP event (with only inconsequential impacts). In the 10% AEP event, the majority of rural floodplain areas downstream of Harry Boyle bridge are inundated, including Raworth, Largs/Kings Island, Phoenix Park, Woodville, Wallalong, Duckenfield, Millers Forest, and McClymonts Swamp.

Up to the 10% AEP event, modelling indicates all major evacuation routes from Maitland (including Long Bridge, New England Highway, Les Darcy Drive, and Belmore Road) would be flood-free, although all of these routes would be cut (by high hazard flow) in events larger than 5% AEP. Closure of Cessnock Road is dependent on the extent of flooding in Fishery and Wallis Creeks. Historically, the low-point at Testers Hollow has been inundated relatively frequently so it is unlikely that Cessnock Road would be flood-free for a 10% AEP event. At Branxton, events greater than the 10% AEP will result in isolated overtopping of the New England Highway from backwater flooding (as occurred in June 2007).

In events between 5% AEP and 2% AEP magnitude, significant overtopping of the Oakhampton and Bolwarra Spillways will occur, with high hazard flow occurring in each of the respective floodways, resulting in widespread inundation throughout Louth Park and the Bolwarra Flats. The deck level of Long Bridge is overtopped between a 5% and 2% AEP flood. Wyburns Levee, which extends eastwards from the Wallis Creek floodgates to Morpeth Road near Reid Street, is overtopped in floods greater than the 5% AEP, resulting in flooding of the Pitnacree area.

The Maitland Ring Levee, including the flood gates at Maitland Railway Station, provides protection for South and Central Maitland up to the 2% AEP event. In larger floods (approximately 1.4% AEP or 70 year ARI), the Ring Levee is overtopped and widespread inundation occurs in urban areas of Maitland and low-lying parts of East Maitland along Melbourne Street.

In the 1% AEP event, most of South and Central Maitland is inundated, with depths exceeding 2.5 m in large areas of Horseshoe Bend, and along the railway corridor including Maitland railway station. The extent of inundation is up to 4 km wide at some points. While Lorn is protected from inundation by levees along the Hunter River, the flood level in the river is up to 3 m higher than average ground levels in the area. Low-lying areas at the east of Lorn are inundated by backwater flooding from the Bolwarra Flats. Each of the evacuation routes from Lorn and South/Central Maitland is inundated by flood depths exceeding 2.5 m.

Upstream of Oakhampton, flooding up to the 1% AEP primarily affects rural areas. Low-lying urban areas in Rutherford may be affected by some flooding, with inundation reaching but not overtopping the New England Highway to the east of Maitland Airport. In floods larger than the 1% AEP, a flow-path forms from the Hunter River through Rutherford flowing south through Heritage Green golf course, and across the railway line and Wollombi Road into Wentworth Swamp.

In a 0.2% AEP flood all the levees forming the Lower Hunter Flood Mitigation Scheme are overtopped, and Lorn and Central Maitland are completely inundated by floodwaters. The flood level will exceed the second storey floor level in many parts of Central Maitland in a flood of this magnitude.

Details of flood behaviour at specific locations, including peak height profiles, design flood contours, depths, velocities and provisional hazard classification maps, are provided in Reference 3.

4.2.2. Historic

Historic flood behaviour (since completion of the Lower Hunter Flood Mitigation Scheme in the 1950s) has largely been in accordance with the design flood behaviour described above, although there have been relatively few major floods since 1955, compared to prior periods. Table 3 summarises key characteristics of the flood behaviour during major historical floods since 1955.

Table 3: Summary of Historical Flood Behaviour at Maitland

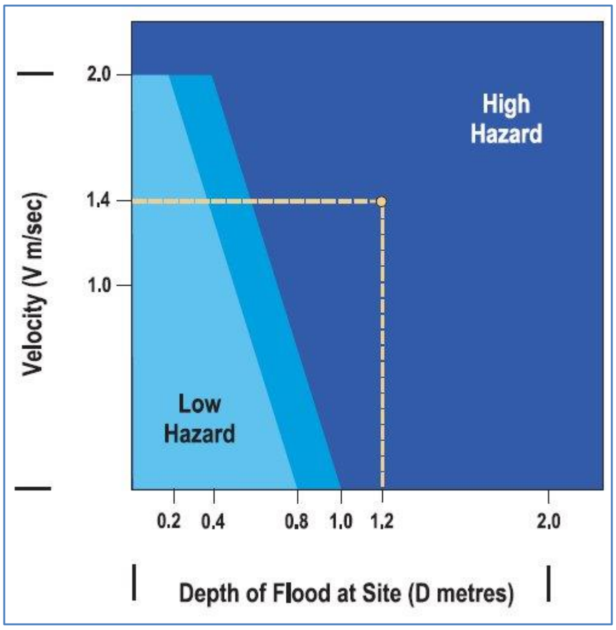
Flood Event	February 1955	February 1971	March 1977	June 2007
Belmore Bridge Flood Level	12.1 mAHD	11.1 mAHD	10.8 mAHD	10.7 mAHD
Bolwarra Spillway Overtopped?	Yes	Yes	Yes	No (leakage through rock mattress)
Oakhampton Spillways Overtopped?	Yes	Yes	Yes	Yes
Central Maitland Inundated?	Yes	No	No	No
Lorn Inundated?	Yes	No	No	No
Travel Time of Flood Peak – Singleton to Greta	n/a	15 hours	n/a	19 hours
Travel Time of Flood Peak – Singleton to Maitland	n/a	18 hours	11 hours	28 hours
Estimated Flood Magnitude at Belmore Bridge	0.5% AEP (200 year ARI)	5% AEP (20 year ARI)	7% AEP (15 year ARI)	10% AEP (10 year ARI)

A selection of photographs from historical floods is provided in Appendix C.

4.3. Flood Hazard Classification

The provisional hazard categorisation for the study area was quantitatively determined using depth and velocity for each design event in accordance with the provisional hydraulic hazard categorisation (Appendix L, Reference 1).

Diagram 1: Provisional Flood Hazard Definition from Reference 1



Notes

The degree of hazard may be either -

- reduced by establishment of an effective flood evacuation procedure.
- increased if evacuation difficulties exist.

In the transition zone highlight by the median colour, the degree of hazard is dependant on site conditions and the nature of the proposed development.

Example:

If the depth of flood water is **1.2 m**
and the velocity of floodwater is **1.4 m/sec**
then the provisional hazard is **high**

FIGURE L2 - Provisional Hydraulic Hazard Categories

The transition zone (the band from Diagram 1 between high and low hazard) was classified as high hazard. These hazard categories are not yet finalised, and may change as part of the Floodplain Risk Management Study, according to the provisions described in the “Notes” from Figure L2, or from other considerations.

As per the “Notes” in Diagram 1, the provisional hazards were reviewed in this study to consider other factors such as rate of rise of floodwaters, duration, threat to life, evacuation difficulties and the potential for damage, social disruption and loss of production. These factors and related comments are summarised in Table 4.

The main issues influencing the true hazard assessment relate to evacuation difficulties. While warning times are relatively long and effective evacuation procedures are in place, these considerations are outweighed by the lack of a suitable evacuation route for floods greater than the 5% AEP level. These issues are discussed in detail in Section 7.2.

Due to the reasonably large number of people affected by these evacuation difficulties, the true hazard of Central Maitland and Lorn is assessed to be greater than the provisional classification undertaken in Reference 2. Without high level evacuation up to the 1% AEP level, these areas are considered to be low hazard for 1% AEP event, and high true hazard for larger floods. The assessed true hazard in shown on Figure 7 and Figure 8.

Table 4: Weightings for Assessment of True Hazard

Criteria	Weight (1)	Comment
Rate of Rise of Floodwaters	Medium	The rate of rise in the Hunter River and onset of flow along roads would be relatively slow, which would allow time for residents to react once inundation of an area begins to occur, although the evacuation distance is significant in some areas such as Phoenix Park. An important exception to this is if levee failure were to occur. In some areas such as Horseshoe Bend and Lorn, levee failure would resemble a dam break with potentially catastrophic consequences.
Duration of Flooding	Medium	The duration for local catchment flooding will generally exceed one to two days, potentially lasting up to a week in some areas, and depending on flood magnitude. This can increase the true hazard due to problems arising from isolation such as restricted access to food, supplies and medical care.
Size of the Flood	Low	The hazard can change significantly with the magnitude of the flood, particularly for Hunter River floods greater than the 1% AEP. However, these higher hazard areas are generally captured by the provisional hazard criteria.
Effective Warning and Evacuation Times	High	Effective warning time is likely to exceed 12 hours at a minimum, and possibly exceed 24 hours. This can lower true hazard if effective and proven evacuation procedures are in place.
Additional Concerns such as Bank Erosion, Debris, Wind Wave Action	High	In major events, bank erosion has the potential to alter the course of major flow-paths during an event, or to cause levee failure, creating confusion and potentially compromising evacuation plans. Wind wave action is unlikely to be a major issue but waves from traffic may be, due to the proximity of flood prone properties to main traffic routes.
Evacuation Difficulties	Very High	Existing evacuation routes from South/Central Maitland and Lorn are cut in floods larger than a 10% AEP magnitude. There is a risk that if people do not evacuate early prior to the onset of flooding, when the perceived risk may be lower, there will be no chance for conventional evacuation later.
Flood Awareness of the Community	Medium	The flood awareness of the community is quite high due to the educational and publicity efforts of the SES and CMA, and the flood event of June 2007. However, as a long period has elapsed since urban areas were flooded, there is some evidence of complacency about the level of protection offered by the flood mitigation scheme. This may cause people to ignore evacuation directions.
Depth and Velocity of Floodwaters	Low	In areas of overland flow roads are subject to fast flowing water. In the main creek channels velocities and depth would be high. There is always a risk of a car or pedestrian being swept into the open channel while attempting to cross swiftly flowing waters at major creek crossings or even within some of the urban areas. However this factor is largely included in the provisional hydraulic hazard calculation metrics.

Note: (1) Relative weighting in assessing the true hazard.

For the remainder of the study area catchment the factors in Table 4 do not significantly alter the provisional hazard classifications for the 1% AEP and PMF events. In general it was found that areas where a high flood hazard would be justified based on consideration of the high-weight criteria in Table 4, the area was already designated high hazard as a result of the depth/velocity criteria used to develop the provisional hazard.

Hazard mapping for various climate change scenarios is shown in Appendix D.

4.4. Hydraulic Categories

The Floodplain Development Manual (Reference 1) defines three hydraulic categorises which can be applied to define different areas of the floodplain. The hydraulic categories of flood prone land include:

> "***Floodways*** are those areas 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 flow or a significant increase in flood levels."
>
> "***Flood storage areas*** are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood."
>
> "***Flood fringe*** is the remaining area of flood prone land after floodway and flood storage areas have been defined."

There is no technical definition of hydraulic categorisation that would be suitable for all catchments, and different approaches are used by different consultants and authorities, based on the specific features of the study catchment in question.

For this study, preliminary hydraulic categories were defined by the following criteria:

- Floodway is defined as areas where:
  - the peak value of velocity multiplied by depth (V*D) > 1.0 m^2/s **AND** peak velocity > 0.1 m/s, **OR**
  - peak velocity > 0.8 m/s.

  The remainder of the floodplain is either Flood Storage or Flood Fringe,
- Flood Storage comprises areas outside the Floodway where peak depth > 1.5 m; and
- Flood Fringe comprises areas outside the Floodway where peak depth < 1.5 m.

These preliminary categories were further refined by removing relatively small or isolated patches of floodway, where it was apparent that local features were responsible for isolated estimates of higher velocity, but the area clearly did not meet the definition of Floodway from Reference 1.

The above hydraulic classifications have been applied to the Maitland City study area based on available hydraulic model results together with knowledge of the catchment and experience in other catchments.

The preliminary floodways were also augmented by adding areas that lie:

- within 15m of the centre of a defined waterway channel; or
- within 5m of the edge of a flood mitigation structure.

Hydraulic category mapping for current conditions is shown on Figure 9 and Figure 10, and for various climate change scenarios in Appendix D.

4.5. Flood ERP Classification of Communities

WMAwater undertook delineation of floodplain communities into Flood Emergency Response Planning (FERP) categories, in accordance with the guidelines in Reference 21. Classifications were undertaken only for Hunter River flooding, and do not consider scenarios where flooding from tributaries such as Wallis Creek may occur without major flooding in the Hunter River.

FERP mapping for Hunter River flooding is provided in Figure 11 and Figure 12. The response categories are presented in conjunction with a range of flood magnitudes, including the 5% AEP, 1% AEP and PMF extents, to assist emergency services personnel in preparing response strategies for a range of forecasted flood magnitudes. However it should be recognised that the PMF behaviour is the primary consideration for determination of many of the flood categories. For example, this is the primary reason why Central Maitland and Lorn are classified as “Low Flood Island” for the 5% AEP and 1% AEP events, even though in these events there are parts of these areas above the modelled inundation level.

Vehicular access is one of the most important features of Maitland with regards to the FERP classification. Evacuation routes from South/Central Maitland and Lorn are discussed in detail in Section 7.2. All evacuation routes from these areas are cut in events larger than a 10% AEP flood. While Long Bridge is not overtopped in a 5% AEP flood or smaller, structural assessments have been undertaken that recommend the bridge should not be used when significant water is flowing in the Oakhampton floodway (i.e. larger than a 10% AEP flood), due to the risk of structural failure from the impact of flood-borne debris (Reference 12). These areas are completely inundated in the PMF, but evacuation by vehicle or foot will not be possible once flooding exceeds the 10% AEP level. This characteristic results in the entire area of Louth Park, South/Central Maitland and Lorn being classified as Low Flood Island.

Most of the other urban areas within the Maitland LGA generally have rising road access, are only indirectly affected, or are within large high trapped perimeter areas and are therefore less likely to require emergency evacuation, resupply or rescue.

The main urban areas that are flood free in the PMF, and have sufficient facilities to provide refuge and shelter for flood evacuees, are:

1. Telarah, and connected high-ground portions of Rutherford and Aberglasslyn;
2. East Maitland/Tenambit; and
3. Morpeth.

A list of potential evacuation centres is detailed in the Maitland Local Flood Plan (Reference 11).

It should be noted that detailed information about rural homesteads was not available for this study. For some individual rural properties it may be possible to remain at the property for minor to moderate floods, but in major floods the chance to evacuate by vehicle or foot may pass prior to inundation of the house. These properties would meet the criteria of High or Low Flood

Island. These isolated rural properties have not been identified as part of the FERP classification mapping in this study.

4.6. Flood Damages Assessment

The costs of flood damages and the extent of the disruption to the community depend upon many factors including:

- the magnitude (depth, velocity and duration) of the flood,
- land usage and susceptibility to damage,
- awareness of the community with regards to flooding risks,
- effective warning time,
- the availability of an evacuation plan or damage minimisation program,
- physical factors such as erosion of the river banks, flood borne debris, sedimentation.

In order to quantify the effect of inundation on existing development, detailed survey of floor levels was obtained for properties within flood liable areas (see Figure 6). The floor level survey was undertaken by Rennie Golledge surveyors, and included:

- 2225 residences; and
- 471 commercial and public buildings.

The survey targeted properties in residential areas of Maitland, Lorn, East Maitland, Telarah, Aberglasslyn, Rutherford, Bolwarra Heights, and the rural/residential areas of South Maitland and Louth Park. Floor levels for more isolated rural properties in Pitnacree, Raworth, Phoenix Park, Bolwarra, and other areas upstream of Oakhampton were not surveyed due to the high incremental cost of obtaining these levels. Approximately 250 rural properties in these areas were identified as potentially having residences in a flood liable area. Many of these properties are likely to be raised above ground level. The flood damages assessment therefore captures the majority of flood affected properties in the study area, but is likely to be a slight underestimate as a result of the rural properties for which floor levels were not obtained.

Flood damages can be defined as being "tangible" or "intangible". Tangible damages are those for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value (stress and anxiety, injury, loss of life, etc.). A summary of the types of flood damages is provided as Table 5.

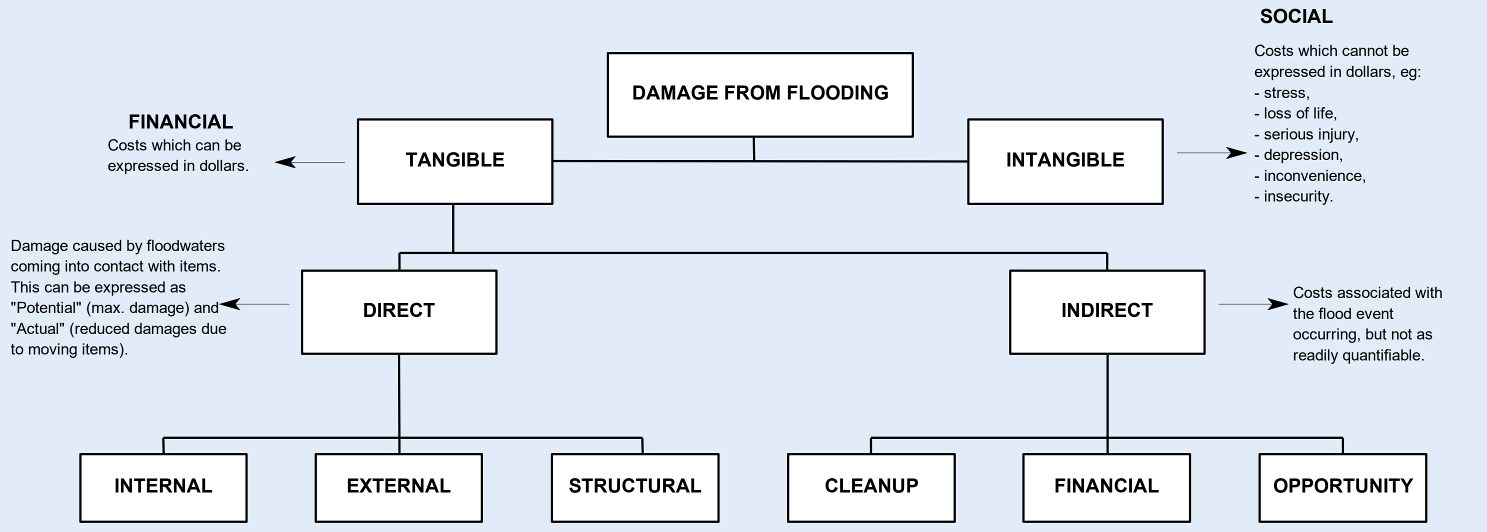
4.6.1. Tangible Flood Damages

Tangible flood damages comprise 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 a reduction in 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, gardens). Indirect damages are the additional financial losses caused by the flood including the cost of temporary accommodation, loss of wages by employees etc.

While the total likely damages in a given flood are useful to get a “feel” for the magnitude of the flood problem, it is of little value for absolute economic evaluation. When considering the economic effectiveness of a proposed mitigation option, the key question is what are the total damages prevented over the life of the option? This is a function not only of the high damages which occur in large floods but also of the lesser but more frequent damages which occur in small floods.

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. By this means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods. For the calculation of AAD for the City of Maitland it was assumed that there are no flood damages in the 20% AEP flood event, as the flood extent is largely confined to the river channel and low-lying rural areas not protected by the flood mitigation scheme.

Table 5: Breakdown of Flood Damages 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 accomodation 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 accomodation 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

The outcomes of the flood damages assessment for existing development are summarised in Table 6 and Table 7.

Table 6: Flood Damages Assessment – Number of Properties Inundated

	EVENT						
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
ABOVE GROUND FLOODING							
Residential	17	73	320	1219	1616	2122	2149
Commercial	0	2	37	268	361	451	446
Public	0	0	1	10	12	13	13
Total	**17**	**75**	**358**	**1497**	**1989**	**2586**	**2608**
ABOVE FLOOR FLOODING							
Residential	13	38	205	1011	1410	2053	2093
Commercial	0	2	35	266	355	446	446
Public	0	0	1	10	12	13	12
Total	**13**	**40**	**241**	**1287**	**1777**	**2512**	**2551**

Table 7: Flood Damages Assessment – Tangible Damages

Event	Damage Per Property Affected	Total Damages
PMF	$113,000	$296,000,000
0.2% AEP	$101,000	$260,000,000
0.5% AEP	$87,400	$174,000,000
1% AEP	$81,800	$123,000,000
2% AEP	$49,100	$17,600,000
5% AEP	$42,100	$2,990,000
10% AEP	$68,400	$889,000
Average Annual Damages	$1,190	$3,090,000

Table 7 shows a significant increase in tangible damages between the 2% AEP and 1% AEP events from $17M to $123M, reflecting overtopping of the Ring Levee and inundation of large parts of South/Central Maitland and Horseshoe Bend in events greater than about 1.4% AEP (or 70 year ARI). Due to the flood mitigation scheme, the flood damages in events up to the 5% AEP magnitude (11.1 mAHD at Belmore Bridge) are relatively low in comparison to the 1% AEP damages. However there would be some potentially significant damage to rural properties that is not included this analysis, such as erosion and fencing damage. In the June 2007 flood, some properties lost significant arable land area due to river bank erosion.

4.6.2. Intangible Flood Damages

The intangible damages associated with flooding are inherently more difficult to estimate. In addition to the direct and indirect damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as ongoing stress and anxiety, loss of life, injury 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 substantially greater than the tangible damages) and depend on a range of factors including the size of flood, the individuals affected, community preparedness, etc. However, it is important that the consideration of intangible damages is included when considering the impacts of flooding on a community. An overview of the types of intangible damages likely to occur from Hunter River floods in the Maitland LGA is discussed below.

Isolation

Isolation (the ability to freely exit and enter your house) during flood events will become a significant factor for rural residents. Often there is a high level of community support and spirit, which can to some extent negate the effects of isolation and can assist in a flood. Long periods between floods can lead to some residents being unprepared for long periods of isolation. Isolation is of significant concern if a medical emergency arises during a flood.

Population Demographics

Analysis of the 2006 Census data indicates that there are some particular features of the population demographics of the community in Central Maitland that may contribute to additional intangible damages, particularly community resilience.

These include age and income population characteristics. The population in some of the suburbs most vulnerable to flood inundation are older than the Australian average. For example, the proportion of residents aged over 60 years of age is 23.5% compared to 20.3% for the whole of NSW.

While some households in flood-liable communities enjoy high incomes, many people living in vulnerable communities are living on incomes that are significantly lower than the Hunter Region average. For example, 25.2% of households earn less than $600 per week compared to a Hunter Region average of 23.6%.

Unemployment levels in flood-liable communities of Maitland are generally higher than the Hunter Region, with the unemployment level in Central Maitland/Lorn being 7.3% compared to the Hunter Region level of 5.2% in 2011.

These age, income and unemployment statistics indicate the possibility of lower resilience of flood-liable communities to adapt to change, therefore requiring local adaptation plans that acknowledge and respond to specific local challenges. Well-developed emergency preparedness, response and recovery programs are also required.

Stress

In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, loss of work, clean up etc.) many residents who have experienced a major flood are fearful of the occurrence of another flood event and its associated damage. For example, the following quote is from a resident of nearby Cessnock who was affected by the June 2007 flood (Reference 22):

> *"Until people go through this sort of situation, many people do not realise how much it can affect your life. Ever since last June long weekend, we and all the other people who suffered through this terrible ordeal are terrified every time we get heavy rain or bad storms, as we worry that this could happen again."*

The extent of the stress depends on the individual. This is like to be a significant issue in Maitland for the next flood greater that the 2% AEP level, due to length of time that has elapsed since this level was exceeded (over 55 years), and the number of people that would therefore be affected that have not previously experienced a major flood.

Risk to Life and Injury

During any flood event there is the potential for injury as well as loss of life. The likelihood of loss of life is relatively high for events greater than the 1% AEP level at Maitland, whether directly or indirectly as a result of flooding, due to several factors including:

- the lack of a high level evacuation route from Central Maitland and Lorn;
- the large number of properties affected by high hazard flooding;
- the duration of inundation and potential for isolation;
- a relatively high proportion of aged residents living in flood affected properties.

4.6.3. Limitations of the Flood Damages Assessment

Aside from intangible costs, significant tangible costs can be expected for Maitland that were not included in the flood damages assessment due to the lack of suitable data. These costs include:

- inundation of properties for which floor level data were not obtained, such as rural/agricultural homesteads;
- loss of livestock (for example up to 100,000 animals were estimated to be lost in the 1955 flood);
- damage to public infrastructure such as roads, railways and power lines. Extensive road repairs may be required after a major Hunter River flood due to the relatively long inundation periods;
- loss of crops;
- other agricultural damages such as erosion of arable land and damage to equipment/fences; and
- costs of emergency management operations, such as helicopter rescue.

4.6.4. Summary of Flood Affectation by Area

A summary of damages and above floor inundation for various areas in the LGA is shown in Table 8 and Table 9 below.

Figure 20 shows the design flood event for which above floor inundation is first expected to occur in Central Maitland, Bolwarra and Anambah.

Table 8: Flood Damages ($millions) by Area

Location	Event							AAD ($)
	PMF	0.2% AEP	0.5% AEP	1% AEP	2% AEP	5% AEP	10% AEP	
Central Maitland & Horseshoe Bend	112	106	92.0	72.3	9.73	1.76	0.38	$1,580,000
Lorn	73.6	54.5	6.19	2.08	1.00	0	0	$269,000
Bolwarra, Oakhampton & Telarah	13.0	11.4	8.28	5.11	1.66	0.81	0.39	$208,000
Aberglasslyn, Anambah & Rutherford	38.1	31.7	16.8	3.32	0.11	0	0	$211,000
Louth Park, South Maitland, East Maitland, & Pitnacree	58.7	56.1	50.4	39.6	5.07	0.41	0.12	$824,000
Total	296	260	174	123	17.6	2.99	0.89	$3,090,000

The results indicate that the bulk of AAD from Hunter River flooding in the Maitland occur in the following areas:

- Central and South Maitland;
- Horseshoe Bend;
- Louth Park; and
- Pitnacree.

This is particularly apparent in the estimate for tangible damages from the 1% AEP, which exceeds $100M for these areas out of a total of $123M.

Table 9: Properties Inundated above Floor Level

Location	Event						
	PMF	0.2% AEP	0.5% AEP	1% AEP	2% AEP	5% AEP	10% AEP
Central Maitland & Horseshoe Bend	1080	1070	930	770	124	22	4
Lorn	568	562	73	27	14	0	0
Bolwarra, Oakhampton & Telarah	110	103	78	49	19	10	4
Aberglasslyn, Anambah & Rutherford	314	299	245	53	2	0	0
Louth Park, South Maitland, East Maitland, & Pitnacree	480	476	449	386	82	4	2
Total	2552	2510	1775	1285	241	36	10

4.7. Previous Flood Mitigation Measures Considered

A summary of previous flood mitigation measures considered is provided as part of the review of the 1998 Hunter River Floodplain Risk Management Study (Reference 4) and 2007 Plan (Reference 5) in Sections 3.9.7 and 3.9.10. Further context is provided in Section 6.2 as part of the discussion of historical floodplain management approaches.

5. POTENTIAL IMPACTS OF CLIMATE CHANGE

5.1. Flood Study Review

The hydrologic and hydraulic models previously developed for the study area were reviewed in this study, to assess their suitability for:

- defining flood behaviour;
- estimating the extent of existing flood problems;
- evaluating risk management options;
- identifying potential impacts of climate change.

The models from the 2010 Flood Study (Reference 3, refer to Section 3.9.12) were found to be suitable for undertaking modelling work required for this study, including assessment of potential climate change impacts and floodplain risk management measures.

5.2. Review of Flood Planning Levels at Branxton

As part of the design investigations for the Hunter Expressway, Hunter River flood levels at Branxton were reviewed to determine required road levels to satisfy flood immunity requirements of the project. As part of this review, additional historical flood levels from 1955 were obtained, and additional modelling was undertaken by the project alliance. WMAwater also undertook a review of design flood levels, and determined that based on the new available data, the model calibration from Reference 2 was slightly high at Branxton for the 1955 flood event (see Reference 24).

Based on the review findings, it was determined that design flood levels at Branxton (within the Cessnock LGA) should be re-calibrated using local historical data, resulting in a lower 1% AEP flood level than that estimated in Reference 2. It was also recommended that a higher freeboard than 0.5 m be adopted for setting Flood Planning Levels at Branxton, in light of the large range of flood levels and uncertainty about historical levels at this location. The revised level was adopted by Cessnock City Council for the Branxton area.

The review recognised that the calibration within the Maitland LGA produced a good match across a range of flood events. This is because the calibration process was primarily focussed on the Maitland LGA parts of the Hunter River for which significantly more historical flood data were available. The review of Flood Planning Levels at Branxton therefore does not affect the design flood levels or assessment of floodplain risk management measures within the Maitland LGA.

5.3. Climate Change Modelling

5.3.1. Background

Intensive scientific investigation is ongoing to estimate the effects that increasing amounts of greenhouse gases (water vapour, carbon dioxide, methane, nitrous oxide, ozone) may be having on the average earth surface temperature. Changes to surface and atmospheric temperatures may affect climate and sea levels. The extent of any permanent climatic or sea level change can only be established through scientific observations over several decades. Nevertheless, it is prudent to consider the possible range of impacts with regard to flooding and the level of flood protection provided by any mitigation works.

Based on the latest research by the United Nations Intergovernmental Panel on Climate Change (IPCC) evidence is emerging on the likelihood of climate change and sea level rise as a result of increasing greenhouse gasses. In this regard, the following points can be made:

- greenhouse gas concentrations continue to increase;
- the balance of evidence suggests human activity has resulted in climate change over the past century;
- global sea level has risen about 0.1 m to 0.25 m in the past century;
- many uncertainties limit the accuracy to which future climate change and sea level rises can be projected and predicted.

5.3.2. Sea Level Rise

In October 2009 the NSW State Government released a policy statement (Reference 25) which sought to address how sea level rise should be dealt with in studies seeking to define flood risk in those areas likely to be impacted by sea level rise. This document superseded the NSW Governments “Practical Consideration of Climate Change” which was released in 2007 (Reference 26). From this policy statement document ensued further draft guideline documents one of which (Reference 27) addresses how sea level rise associated with climate change should be incorporated into flood risk assessments.

Reference 25 states that:

- The following sea level rise projection benchmarks should be adopted:
  - A sea level rise of 0.4 m by 2050; and
  - A sea level rise of 0.9 m by 2100.
- any flood study for a site likely to be impacted by sea level rise should utilise the 2100 sea level rise benchmark of 0.9 m; and
- Any sea level rise must not be accounted for in the 0.5 m freeboard.

This policy was rescinded in 2012, with the NSW government determining that each Council should be responsible for developing planning policies relating to climate change (Reference 28). In the absence of revised guidance from leading Australian climate research organisations such as CSIRO, it is recommended that Maitland Council retain the policy outlined in Reference 25.

Any change in the sea level will have an immediate impact but this will largely only affect Hunter River flood levels closer to Newcastle Harbour. The reach from Maitland to Green Rocks is located in the upper reaches of the Hunter River estuary, and tidal influences in the study area are significantly weaker than in lower parts of the estuary closer to the coast. Sea level rise will raise the normal water level in the Hunter River at Maitland but will not impact on design flood levels (unless sea level rises of several metres occur).

The effect of the projected sea level increase by 2100 was assessed by altering the downstream boundary of the TUFLOW model to reflect mean sea level increases of 0.4 m and 0.9m. Modelling results confirm that the projected increases in sea level by 2100 would not have a significant influence on Hunter River flood behaviour within the Maitland LGA.

5.3.3. Design Rainfall Intensities

The BOM has indicated that while revisions to design rainfalls to take account of potential for climate change may be required, there is insufficient information at present to define appropriate adjustments, as the implications of temperature changes on extreme rainfall intensities are presently unclear. There is no certainty that a warming global climate would in fact increase design rainfalls for major flood producing storms, particularly on larger catchments (such as the Hunter River). There is some recent literature by CSIRO that suggests extreme rainfalls may increase by up to 30% in parts of NSW (in other places the projected increases are much less or even decrease); however this information is not of sufficient accuracy for use as yet (Reference 26).

Any change in design flood rainfall intensities will increase the frequency, depth and extent of inundation across the catchment. It has also been suggested that the cyclone belt may move further southwards. The possible impacts of this on design rainfalls cannot be ascertained at this time as little is known about the mechanisms that determine the movement of cyclones under existing conditions.

Projected increases to evaporation are also an important consideration because increased evaporation in a warmer climate would lead to generally dryer catchment conditions, resulting in lower runoff from rainfall. Daily evaporation rates for eastern NSW are projected to increase by up to 40% by 2070 (Reference 26). Mean annual rainfall is projected to decrease, which will also result in generally dryer catchment conditions. The influence of dry catchment conditions on river runoff is observable in climate variability using the Indian Pacific Oscillation (IPO) index (Reference 29). Although mean daily rainfall intensity is not observed to differ significantly between IPO phases, runoff is significantly reduced during periods with fewer rain days.

The combination of uncertainty about projected changes in rainfall and evaporation makes it extremely difficult to predict with confidence the likely changes to peak flows for large Hunter River flood events under warmer climate scenarios.

In light of this uncertainty, the NSW State Government advice (Reference 26) recommends sensitivity analysis on flood modelling should be undertaken to develop an understanding of the effect of various levels of change in the hydrologic regime. Specifically, it is suggested that increases of 10%, 20% and 30% to rainfall intensity be considered.

5.3.4. Effect of Rainfall Increases on Peak Design Flow Rates

A 10% increase in catchment average rainfall does not translate directly into an equivalent increase in peak flow rate, with the actual increase dependent on several characteristics of the catchment and river channel. The 2010 Flood Study (Reference 2) used a flood frequency approach to model design flood levels at Maitland, meaning that modelling of the rainfall-runoff process was not undertaken, and models are not available to directly determine the effect of a 10%, 20%, 30% rainfall increase on peak flow rates.

Clarification of this issue can be obtained by looking at results from similar catchment where rainfall-runoff modelling has been undertaken, such as the Macleay River on the NSW north coast. Table 10 below shows the increase in peak flow rates at Kempsey for various combinations of rainfall intensity and evaporation increases compared to current conditions, for the 1% AEP design flood (Reference 30). The catchment area of the Macleay River upstream of Kempsey (11,500 km^2) is smaller than the Hunter River catchment to Maitland (17,000 km^2), but the 1% AEP peak flow is higher due to higher catchment average rainfalls.

Table 10: Modelled 1% AEP Peak Flow Increases - Macleay River at Kempsey for Climate Change Scenarios

	Increase in Infiltration Losses due to Dry Conditions		
	0%	**10%**	**20%**
Increase in Rainfall Intensity	**Percentage Increase in Peak Discharge at Kempsey**		
10%	16%	13%	9%
20%	33%	29%	25%
30%	52%	46%	42%

A 20% increase to evaporation is the mid-range of projected increases by 2070 (Reference 26). The right-hand column of Table 10 indicates that each 10% increase in rainfall produces approximately a proportionally similar increase in peak flow rate. For the purposes of this study, a 10%/20%/30% increase in rainfall was assumed to produce an equivalent 10%/20%/30% increase in peak flow rates at Oakhampton.

To put these increases in perspective for design flood estimates under current conditions, a 30% increase to the 1% AEP (100 year ARI) peak flow of 8,000 m^3/s gives a peak flow very similar to the current 0.5% AEP (200 year ARI) peak flow of 10,300 m^3/s. That is, the current 1% AEP flood level for the Central Maitland (9.7 mAHD at the railway station), would increase by 1.0m (to 10.7 mAHD, equivalent to the current 0.5% AEP flood level) if runoff was to increase by 30%. By the same reasoning, the 10% AEP (10 year ARI) flood magnitude would increase to be roughly equivalent to the current 6.7% AEP (15 year ARI) flood magnitude with an increase in runoff of 30%.

5.3.5. Climate Change Modelling Scenarios

The Flood Study TUFLOW models were used to undertake a range of model scenarios to investigate the potential impacts of climate change of flood behaviour in the study area. Table 11 indicates the combination of climate change scenarios that were modelled, and for which maps of hydraulic hazard and hydraulic categories were prepared (Appendix D).

Table 11: Matrix of Climate Change Model Scenarios for 1% AEP flood

	Sea Level Rise Scenario		
Rainfall Scenario	**Year 2010 (+0.0 m)**	**Year 2050 (+0.4 m)**	**Year 2100 (+0.9 m)**
Current rainfall	✓ † ‡		
+10%	✓ † ‡		
+20%	✓ † ‡		
+30%	✓ † ‡		

✓ Flood depths and velocities modelled
† Flood hazard classification mapping undertaken
‡ Hydraulic categories mapping undertaken

5.4. Implications of Potential Climate Change

Modelling indicated that projected sea level rise benchmarks will have a negligible impact on Hunter River flood behaviour in the Maitland LGA, in terms of peak flood levels, extents and flood hazard.

For the 1% AEP event incorporating a 0.9 m sea level rise increase, estimated impacts on peak flood levels were not significant.

The effect of increasing the design flows by 10%, 20% and 30% was evaluated for the 1% AEP flood, resulting in a relatively significant impact on peak flood levels compared to sea level rise. Table 12 shows impacts on peak flood levels for each scenario (see Figure 3 for comparison locations).

Generally speaking, each incremental 10% increase in flow results in a 0.4 m increase in peak flood levels upstream of Oakhampton, and a 0.2 m increase in flood levels downstream of Oakhampton, with localised increases in peak flood level of approximately twice that amount.

Maps of flood hazard and hydraulic categories for increased rainfall intensity scenarios are provided in Appendix D.

Table 12: Climate Change Rainfall Sensitivity – Peak Flood Level Impacts

ID	Type	Location	1% AEP Peak Level (mAHD)	Impact +10% Runoff (m)	Impact +20% Runoff (m)	Impact +30% Runoff (m)
A	Hunter River	U/S Oakhampton No. 2	13.0	0.18	0.36	0.53
B	Hunter River	Adjacent to Bolwarra Spillway	12.5	0.12	0.24	0.36
C	Hunter River	Belmore Bridge	11.7	0.06	0.14	0.22
D	Floodway	Powerhouse Control	12.2	0.17	0.37	0.55
E	Floodway	Mount Pleasant St	11.8	0.16	0.36	0.56
F	Floodway	Long Bridge	11.5	0.15	0.35	0.53
G	Floodplain	Dagworth Bridge	9.7	0.21	0.51	0.76
H	Floodplain	Victoria Bridge	9.7	0.20	0.48	0.71
I	Floodway	Pitnacree Rd	9.6	0.16	0.37	0.52
J	Floodplain	Lorn	7.5	0.18	0.38	0.56
K	Floodplain	Belmore/Paterson Rd	9.2	0.16	0.34	0.52
L	Floodplain	U/S Howes Lagoon	9.6	0.15	0.34	0.48
M	Floodplain	D/S Howes Lagoon	8.0	0.12	0.25	0.35
N	Floodplain	Pitnacree	8.1	0.09	0.19	0.27
O	Hunter River	Kings Island	7.3	0.14	0.30	0.43
P	Hunter River	Morpeth Bridge	7.2	0.03	0.11	0.15
Q	Hunter River	Green Rocks Gauge	5.7	0.07	0.15	0.27

5.5. Selection of Flood Planning Levels

Application of a 1% AEP flood level with a 0.5m freeboard as the FPL for residential property is generally consistent with the recommendations of the Floodplain Development Manual (Appendix K, Reference 1) and the 2007 Maitland Floodplain Risk Management Plan (Reference 5). However, the FPL policy should be revised to include consideration of extreme flood events up to the PMF for flood awareness and emergency management, and for developments such as aged care facilities with particular evacuation issues, or critical public infrastructure (such as hospitals, transformers, substations, SES buildings, etc.).

It is also recommended that a default FPL for the commercial and industrial development be specified (possibly the 1% AEP flood level without freeboard), with lower FPLs to be allowable on a merits-based approach taking into account the nature of the development and appropriate level of flood risk.

Development controls on extensions/renovations to existing dwellings should be tightened to remove loopholes allowing development below the residential FPL where it is impractical to build to required levels.

6. FLOODPLAIN RISK MANAGEMENT MEASURES

6.1. Introduction

The NSW Government's Floodplain Development Manual (Reference 1) identifies three categories of flood risk to be managed via the implementation of a Floodplain Risk Management Plan. The broad risk categories are:

> **Existing flood risk,** relating to risks of damage and personal danger for existing flood-affected communities and properties.
>
> **Future flood risk,** associated with any new development on flood prone land.
>
> **Continuing flood risk,** or the remaining risk to current and future flood-affected communities after implementing floodplain risk management measures. This includes risk of larger floods than those directly managed by physical works or development controls, and the risk of failure of mitigation works such as levees.

The manual also separates floodplain management measures into three broad categories:

> **Flood modification measures** modify the flood's physical behaviour (depth, velocity) and include flood mitigation dams, retarding basins, on-site detention, channel modifications, diversions, levees, floodways, flood gates or catchment treatment.
>
> **Property modification measures** modify land use including development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), planning and building regulations (zoning) or voluntary purchase.
>
> **Response modification measures** modify the community's response to flood hazard by informing flood affected property owners about the nature of flooding so that they can make 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.

In previous studies the terminology of structural/non-structural measures was adopted rather than the above.

6.2. Maitland Flood Management History

Many of the floodplain risk management measures that have been implemented in Maitland pre-date the Floodplain Development Manual (Reference 1). The February 1955 flood provided significant impetus for the development of current floodplain management practices in Australia. A brief summary of historical attitudes to floodplain management at Maitland is provided below.

6.2.1. Settlement and early 20th Century

Archived newspaper articles provide an insight into attitudes to flood management during the early periods of European settlement in Maitland. A selection of articles from the National Library of Australia archives is provided in Appendix B. For much of the 19th century, debate focussed largely on the increased catchment runoff resulting from deforestation, and it was broadly perceived that major channel works would help prevent flooding at Maitland.

After the flood of 1893, public debate was polarised between two camps as to the appropriate engineering response – a report by consulting engineer Mr C. Napier Bell recommended channel straightening and clearing works between Belmore Bridge and Green Rocks, while another report undertaken by Public Works endorsed the construction of a large dam upstream near Singleton (what would have been one of the largest dams in the world at the time). Both schemes were estimated to cost around £800,000 to £1 million, or close to $135 million in current terms.[3] The difficulties and risks in undertaking such major works, particularly the construction of dams, were identified by the authors, as well as the reality that only a moderate benefit would be achieved for major floods like that of 1893 (i.e. significant flooding would still occur). The fact that such proposals were considered is probably more of a reflection of the importance of Maitland as an economic and trade centre at the time.

In 1952, after major floods were experienced at Maitland in four consecutive years, an article in the Sydney Morning Herald documented that at least ten reports had been prepared addressing flood mitigation in the Hunter River between 1868 and 1913. In 1948, a report prepared by Mr. G. Huddleston from the Water Conservation and Irrigation Commission, recommended a 20-year program with an estimated cost of £8.5 million (more than $400 million today). The program included construction of three flood control dams, relocation of two other dams, levee bank realignment, and major channel realignment, clearing and dredging works between Maitland and Green Rocks.

6.2.2. Post-1955 Flood

The 1955 flood in the Hunter Valley had a shaping influence on floodplain management practice in NSW. The losses incurred during that event were enough to force an acceptance that major engineering works such as channel realignment/dredging or dam construction would not be sufficient in isolation to produce a level of flood risk acceptable to the community, and that the costs of such works were prohibitive. The flood brought increased recognition that development control would also be required. Evidence of this change in mindset can be obtained from an article in the Canberra Times, published shortly after the flood, which indicates the Mayor and Council of Maitland of the time endorsed wholesale removal of the main business centre of Maitland to higher ground, at an estimated cost of £15 million including compensation for affected businesses.

While construction of the Lower Hunter Valley Flood Mitigation Scheme and Glenbawn Dam

[3] Conversion based on CPI calculator tools provided by the Reserve Bank of Australia.

was not completed until after the 1955 flood, both sets of works were the culmination of many years of investigation into measures for mitigating flooding in the Hunter Valley. Many recommended works were never undertaken, including major dams on the Hunter River and Wollombi Brook near Singleton, and channel works downstream of Oakhampton, most likely due to the significant costs. Nonetheless, as a result of the long history of flooding, over time several measures have been implemented to mitigate flooding at Maitland and along the Hunter River, including:

- construction of the Lower Hunter Valley Flood Mitigation Scheme comprising a broad network of levees, spillways, and floodgates;
- construction of Glenbawn Dam;
- implementation of development controls consistent with estimated 1% AEP flood levels;
- limitations on infill development in flood prone areas such as Central and South Maitland, Louth Park, Horseshoe Bend and Lorn.

These measures have been successful in that the level of existing flood risk at Maitland is probably less today than in the 1940s and 1950s, as a result of both physical flood modification works, improvements in communication and management of flood warnings, and a reduction of development density in high flood risk areas. However, this study has identified several areas where improvements can be made for the management of future and ongoing flood risk, particularly in the areas of evacuation and planning controls.

6.3. Methodology for Assessment of Potential Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost approach has often been used to quantify the economic worth of works on a relative basis enabling ranking against similar projects in other areas. The benefit/cost ratio is the ratio of the Net Present Worth of the reduction in flood damage (benefit) compared to the cost of the works. Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles such as anxiety, risk to life, ill health and other social and environmental effects. In this study the reduction in tangible damages to public utilities as a result of implementation of a floodplain management measure has not been included.

The potential environmental or social impacts of any proposed flood mitigation measure are of great concern to society and these cannot be evaluated using the classical benefit/cost approach. The public consultation program carried out as part of this study (Section 11) was designed to ensure that identifiable social and environmental factors were considered in the decision making process.

6.4. Measures Not Considered in Detail

A preliminary assessment of a wide range of typical measures was undertaken, where the measures were classified with regard to likely reduction in flood level, social effect, environmental impact, cost to implement and benefit/cost ratio.

A number of measures were identified that did not warrant detailed consideration and these are summarised in Table 13, with some discussion provided below. Measures which were given more detailed consideration are discussed in the subsequent sections of this report.

Table 13: Summary of Mitigation Measures Not Considered in Detail

Measure	Impact				
	Reduction in Flood Levels	**Social Effect**	**Environmental Impact**	**Cost to Implement**	**Benefit/ Cost Ratio**
FLOOD MODIFICATION MEASURES:					
Flood Mitigation Dams	Yes	Variable*	Very High	Very High	Low
Retarding Basins, On-site Detention	Minimal	Low	High	Very High	Very Low
Channel Modifications	Yes	Variable	High	Very High	Very Low
Flow path Diversion	Variable#	Variable	High	Very High	Very Low
Catchment Treatment	Yes - variable	High	High	Very High	Very Low
PROPERTY MODIFICATION MEASURES:					
Voluntary Purchase of ALL Flood Liable Buildings (as opposed to selected high risk buildings – see Section 9.5 for more discussion)	Nil	High	Nil	High per building	Very Low
RESPONSE MODIFICATION MEASURES:					
Flood Insurance	Nil	Moderate	Nil	Very high (when including cost of any subsidies).	Low

* Social impact of dam construction and channel modification varies with site location depending on the number of people displaced.

\# Flow path diversion causes redistribution of floodwaters, with localised increases/decreases.

6.4.1. Flood Mitigation Dams

Flood mitigation dams have frequently been used in rural areas of NSW to reduce peak flows downstream. Glenbawn Dam has a dedicated flood mitigation component of the total dam storage. Various historical assessments have advocated the building of several dams in addition to Glenbawn to mitigate flooding in the Hunter Valley, although most were never built. Settlement and development of the upper catchment areas has rendered many of the proposed sites unsuitable now.

Dams have several characteristics that can make them unsuitable in certain situations. Factors to be considered include:

- high cost of construction, requiring funding primarily by state and federal governments;
- high environmental damage caused by the construction;
- possible sterilisation of land within the dam area;
- potentially high cost of land purchase;

- displacement of existing residents;
- risk of failure of the dam wall;
- generally low benefit/cost ratio, and
- general lack of suitable sites. A considerable volume of water needs to be impounded by the dam in order to achieve a significant reduction in flood level downstream. Generally a dam site requires a narrowing of the floodplain at a location that captures a suitable portion of the upstream catchment and favourable geotechnical conditions.

One of the previously proposed dam sites, on Wollombi Brook upstream of Broke, may still be feasible depending on the social, environmental and geotechnical factors listed above. However it is unlikely that the cost would be justifiable based purely on flood mitigation benefits. In the future, if a dam is required for other reasons such as regulation for irrigation or potable water supply, then the inclusion of additional capacity for flood mitigation should be considered by the relevant authorities. However taking into account the factors above, dams have not been assessed in detail as a core flood mitigation strategy for Maitland City.

6.4.2. Retarding Basins, On-Site Detention

Retarding basins are small-scale flood mitigation dams commonly used in residential catchments for the purposes of mitigating peak flows by retaining runoff from intense storms and releasing it at a relatively sustained rate. One of the major impediments in their use as a flood mitigation measure for existing development is the lack of suitable sites. For new “green-fields” developments there is the opportunity to incorporate the retarding basins into site design which is not possible for existing development. Retarding basins can also provide significant water quality benefits, though in a heavily built up urban environment it is difficult to maintain these systems for this purpose.

Retarding basins may be suitable for compensating the effects of new development on local catchment runoff in urban release areas, but they are not of sufficient scale to make a significant difference to Hunter River flood risk in Maitland LGA.

6.4.3. Channel Modifications

Channel modifications are usually undertaken to either increase the capacity of the channel and/or improve the conveyance of floodwaters, which in turn can reduce peak flood levels. Channel modifications encompass a broad range of measures and include amplification, straightening, concrete lining, removal of structures or natural obstructions, dredging and vegetation clearing.

Amplification and Dredging

Channel amplification involves increasing the capacity of the creek or drainage system, thereby reducing the frequency with which floodwaters overtop the banks. The main problem with channel amplification in natural creeks is that the channel often tends to return to its original state via accumulation of sediment in the dredged or widened reach of the channel.

This study did not identify any areas where channel amplification is likely to provide a significant reduction in flood risk. Generally, constrictions in channel capacity in the local creeks are due to bridge and culvert structures, or vegetation, rather than the channel dimensions. It is considered that measures which address these issues would be more effective, and less expensive, than widespread channel amplification works.

Straightening

These measures are generally undertaken in order to shorten and steepen the flow path, thereby increasing the conveyance of water through the channel system. However, they are relatively expensive and have significant impacts on the environment and visual amenity, and carry significant risk that the channel will revert to its previous path during a large flood. The Hunter River between Belmore Bridge and Green Rocks has historically been geomorphologically active, and the river length has shortened from 26 km to 9 km between Maitland and Morpeth since settlement.

Vegetation Clearing

Removal of vegetation from the channel and banks can lower flood levels in a localised area around the works. The main problem with this approach is that the vegetation can quickly regrow in the cleared section of channel, and routine maintenance programs to keep the channel clear are often untenable with the resources typically available to Council for such works. Removal of vegetation often has undesirable follow-on effects, such as increased erosion, and loss of habitat and biodiversity. As discussed in Section 3.10, maintaining a healthy native riparian zone has many environmental benefits, and also generally has a benefit on flood levels for downstream areas. Maitland has likely benefited from programs to rehabilitate riparian vegetation in upstream areas of the Hunter Valley catchment.

CONCLUSION

Recent flooding experiences on the Mississippi River, which has been highly engineered with large scale channel modification works, have highlighted the risks of pursuing such strategies for floodplain management of major rivers. Such works are not considered a viable measure for providing balanced environmentally sensitive flood mitigation benefits on the Hunter River.

6.4.4. Flow Path Diversion

Diversion of catchment runoff along an alternative flow path can reduce or prevent flow through a particular area and considerably reduce flood risk. This approach is often not feasible due to physical constraints of the system, as the existing creek or flow path typically follows the lowest path through the catchment, and there is a lack of alternative flow paths without resorting to pumping or diversion channels with very shallow grade. When diversion of flow away from a given area is possible, care must be taken not to cause adverse flood impacts on the area to which the flow is redirected.

Historically there have been proposals for radical diversion of the Hunter River, for example a diversion from upstream of Belmore Bridge eastwards through the Bolwarra area (via the current Bolwarra spillway), re-joining the existing river alignment at Kings Island/McKimms Corner. The

Lower Hunter Valley Flood Mitigation Scheme formalises the split of flood flows into overbank floodplain areas downstream of Oakhampton, which would have naturally occurred to some extent prior to levee construction.

Such measures would have a very high cost, as well as a very high environmental and social impacts, and any benefits in flood risk are likely to be outweighed by the risk of the works failing during a large flood (e.g. the river reverting to its previous alignment, or along an entirely new alignment). Diversion measures have therefore not been considered in detail.

6.4.5. Catchment Treatment

Catchment treatment modifies the runoff characteristics of the catchment to reduce the amount of runoff to downstream areas. For a rural catchment, this involves limiting deforestation or contour ploughing of hill slopes. These measures can reduce the volumes of run-off in relatively small, frequent rainfall events, typically up to about 20% AEP. They have less effect in larger, less frequent events, above say a 5% AEP.

Catchment treatment is practically unlikely to significantly change flood behaviour in the Hunter River unless applied to extreme levels, and enforcement of catchment treatment policies in the upper Hunter River catchment areas is beyond the authority of Maitland City Council. The guiding principles outlined in the Catchment Action Plan developed by the Hunter-Central Rivers CMA (Reference 20) provide an appropriate framework for catchment treatment that is consistent with the floodplain management objectives for Maitland City.

6.4.6. Flood Insurance

Flood insurance does not reduce flood damages but transforms the random sequence of large infrequent losses into a regular series of payments (premiums) for an individual or a community. In the last five years the provision of flood insurance has changed and now it is available for all residential, commercial and industrial properties. However some insurance companies will not insure high risk properties. The types of flood damage that are covered, and premiums for flood cover, vary significantly between providers. The issue of flood insurance and its appropriateness as a flood mitigation measure was examined by the NSW Government and by the Insurance Council of Australia, with the issue being brought into particular focus by the widespread residential flooding in Queensland in January 2011.

Due to the relative predictability of flooding compared to other natural disasters, and improved mapping from recent developments in modelling techniques, insurance companies can develop a reasonably accurate quantification of flood risk for an individual property. High annual premiums may be required to adequately cover properties that are known to be at relatively high risk of flooding, unless non-flood-liable properties are also required to pay for flood insurance, thereby subsidising flood-liable properties. The high premiums mean that property owners are likely to “take the risk” that a flood will not occur (i.e. self-insure).

Another issue with flood insurance is that it can diminish restraint in capital investment on flood-liable land. A property owner may be more likely to develop/renovate if potential losses from flooding are perceived to be covered. These circumstances may actually result in an increase in gross economic damages.

Due to these inconsistencies between available flood cover, types of flood cover, and potential to change perceived flood risk, flood insurance is not recommended as an appropriate flood mitigation measure for Maitland. However when requested by a property owner, Council should provide available information about flood levels, depths, and floor levels for individual properties to enable residents to make informed decisions about insurance cover.

Council should also make detailed property-based flood information, assessed as part of the flood damages component of this study, available to insurance agencies when requested to enable rigorous and informed assessment of risk to be undertaken, as flood damages can vary significantly between two neighbouring properties depending on factors such as foundation type, floor level, number of storeys, etc.

7. RESPONSE MODIFICATION MEASURES

7.1. Overview

As stated in the Maitland Local Flood Plan (Reference 11), the SES has the responsibility to control flood response operations, and to direct the activities of other supporting government agencies. This authority is legislated in the State Emergency and Rescue Management Act 1989 and the State Emergency Service Act 1989.

In order that the expectations of the community can be met in regards to emergency response, adequate information and resources must be available. There is therefore a need as part of this Floodplain Risk Management Study to identify potential issues relating to emergency management, such as the adequacy of:

- flood data collection networks;
- design flood information;
- evacuation routes; and
- flood warning capability.

7.2. Evacuation Routes

7.2.1. Background

The majority of the Maitland City LGA has rising access to high ground above the Hunter River PMF level. The notable exceptions are the areas of Central and South Maitland, Horseshoe Bend, Louth Park and Lorn. These areas are surrounded by high hazard floodways in floods equivalent to the 5% AEP or greater. As discussed in Section 7.2, existing evacuation routes from these areas are likely to be cut several hours before the flood peak occurs (Figure 14). The higher ground in Central Maitland CBD and in Lorn will provide refuge for a 1% AEP flood, but this area will diminish in larger floods. This flood behaviour creates a risk that in a flood greater than the 1% AEP, a very large number of people could become stranded in Central Maitland and Lorn, and require mass evacuation by boat or helicopter.

Warning times for major flooding are generally expected to exceed 24 hours, giving sufficient time for most residents to evacuate to nearby facilities in Telarah/Rutherford, Bolwarra Heights, or East Maitland. However, experience in the 2007 flood has shown that not all residents who are instructed to evacuate will do so immediately. The long period since the floods of the 1950s and 1970s, including the drought period of the 1990s, has resulted in a high level of complacency about the flood risks at Maitland, with a perception that the levee scheme protects against all floods.

During a flood event of 1% AEP magnitude or greater, it will be necessary for several thousand residents in Maitland to evacuate their homes. In some locations the depth of inundation will exceed 3 m or even 4 m above floor level, resulting in a significant risk to life to these residents if they remain in their house. In the February 1955 flood, numerous people were evacuated by helicopter or boat from the roof or attic of their property. Three men on board an amphibious army boat were electrocuted when their radio antenna struck powerlines, and two navy personnel were fortunate to survive after their helicopter crashed during a rescue attempt (Reference 23), although the two men they were attempting to rescue were killed. Such rescues are risky for the emergency services personnel involved, and the equipment required is expensive and may not be readily available. If a mass evacuation was required due to rising floodwaters threatening to inundate the high ground in Central Maitland, locally available helicopter resources would be stretched and evacuation assistance from army helicopters would probably be required.

There are also accounts of people evacuating by foot along the railway embankment towards East Maitland during large floods. More secure fencing of railway corridors in recent decades is likely to prevent this route being accessible to pedestrians for emergency flood evacuation. Railway corridors may also present an electrocution hazard during a flood.

A similar situation to that described above at Maitland occurred in Bundaberg, Queensland in January 2013 as a result of flooding from ex-tropical cyclone Oswald. The Bureau of Meteorology provides 12 to 24 hours warning for major floods of the Burnett River at Bundaberg (same as for the Hunter River at Maitland). Despite these warnings and national television coverage as cyclone Oswald approached and made landfall, many residents either did not evacuate in time or only did so when their houses started to flood. The Sydney Morning Herald reported: [4]

> *"When the water got up to her knees, Sharon Hills knew it was time to flee her rental property in a low-lying new estate in Bundaberg's western suburbs. At 1.30am, with her four children in tow, the single mother got in the car and drove nervously down a 30 centimetre-deep creek that had been her concrete driveway."*

1,300 people were isolated by floodwaters at Bundaberg with surface based emergency crews unable to reach them (out of a total of approximately 7,500 evacuated).[5] A mandatory evacuation order was issued and army Black Hawk helicopters were used to pluck people from the roofs of their homes. This situation resulted from residents ignoring advice to leave prior to the flood peak and placed rescuers and residents at significant risk.

Continuously rising access along evacuation routes provides a significant benefit, as residents who are not aware of directions to evacuate, or who choose not to heed such directions, will still have a chance to evacuate once floodwaters overtop levees or begin to inundate their homes, reducing the pressure and risk for emergency air and water-based evacuation teams.

7.2.2. Need for Improved Evacuation

Implementation of controls such as minimum floor levels and flood-compatible structural requirements (which are already largely in place via the LEP and DCP) can reduce the tangible damages resulting from flooding, but do not address risk to life. An increase in the population in

[4] Sydney Morning Herald, *"After the flood comes deluge of damages bills"* 2 Feb 2013.
[5] Herald Sun, *"Bundaberg's flood clean-up begins"* 29 Jan 2013

flood liable areas of Central Maitland, as per the objectives of the Central Maitland Structure Plan (Reference 19), will result in some incremental increase in risk to life in this area. This increase in risk must be considered in light of:

- the current DCP 2011 (Reference 9), which aims "*to contain the spread of urban development in flood liable areas and to encourage the contraction of areas of residential development in flood liable areas;"* and
- the current LEP 2011 (Reference 7), which prohibits consent of development that is "*likely to result in unsustainable social and economic costs to the community as a consequence of flooding*", or does not "*incorporate appropriate measures to manage risk to life from flood."*

Any proposal to increase population in flood liable areas of Central Maitland should therefore address these considerations, including evacuation limitations.

While the likelihood of a flood large enough to inundate all of Central Maitland and Lorn is very low in any given year, the consequences in terms of loss of life would potentially be dire. The probability of such a flood becomes non-trivial over reasonable planning horizons. The probability of a 0.2% AEP flood, sufficient to inundate all of Lorn and most of Central Maitland with high hazard flooding, and probably causing failure of levee banks at some locations, is approximately 10% over the next 50 years and about 18% over the next 100 years. One way to mitigate this risk is to provide a rising evacuation route.

Given that an increase in population as part of the Structure Plan is a reversal of the existing strategy for managing risk to life under previous DCPs, it will be necessary to mitigate the risk by augmenting other parts of the risk management strategy. One area where significant gains can be made is providing improvements to the flood immunity and reliability of evacuation access from Central Maitland.

Under current circumstances, when the Maitland Ring Levee is overtopped there are no safe vehicular or pedestrian evacuation routes from Central Maitland or Lorn. There is therefore a pressing need for a rising egress route that can provide increased safety for evacuees **after** the levees have been overtopped. A preliminary consideration of potential routes and evacuation issues has been undertaken below. A detailed route feasibility study is required to further clarify the relative benefits and disadvantages of various routes, particularly with regard to cost, traffic considerations, land requirements, environmental impacts, and potential for real improvement to the flood risk profile across a range of events.

7.2.3. Potential High Level Evacuation Routes

As the levees provide protection up to the 2% AEP level, a higher evacuation route (for example at the 1% AEP level) would provide the most incremental improvement to evacuation safety. Evacuation is currently possible along Les Darcy Drive for the 5% AEP event and possibly larger, but not in a 2% AEP event. There is therefore no benefit to providing new routes that are cut in the 5% AEP event, and only marginal benefit to providing a 2% AEP flood immunity route. This preliminary review has therefore focussed on routes potentially providing rising egress in a

1% AEP event.

Several possible routes for high level evacuation were considered. Once overtopping of the Maitland Ring Levee occurs, and floodwaters rise, people remaining within the levee extent will likely either remain in upper floors of dwellings, or evacuate towards the higher ground along Church Street and the northern end of High Street, near Belmore Bridge. The high level evacuation route therefore should preferably be accessible from this area.

An overview of possible routes is given below with indicative costs and other information summarised in Table 14. The considerations outlined below include input from discussion paper prepared by Maitland City Council.

Table 14: Summary of High Level Evacuation Route Options

Route	**(1) Long Bridge – current alignment**	**(2,3,4) Long Bridge – revised alignment**	**(5) New England Highway Oakhampton floodway**	**(6) Les Darcy Drive – High St to Melbourne St**	**(7) Belmore Road Bolwarra floodway**
Potential Flood Immunity	2% AEP (full), or 1% AEP (partial)	1% AEP	1% AEP	2% AEP	1% AEP
Bridge Length	300 m	350 m (Route 2) 750 m (Route 3) 550 m (Route 4)	700 m	No bridge	800 m
Embankment Length	n/a	200 m (Route 2) n/a (Route 3) n/a (Route 4)	n/a	1400 m	n/a
Indicative Cost	**$25M**	**$40M (Route 2)** **$80M (Route 3)** **$60M (Route 4)**	**$75M**	**$10M**	**$65M**
Other Comments		Significant traffic issues. Some property acquisition required.	Major traffic flow issues.	Route already provides close to 2% AEP level evacuation, but is closed prior to Ring Levee overtopping.	Does not provide access to major hospital/evacuation centre facilities.

Possible routes include:

1) Existing Long Bridge – the current alignment (see Figure 13) comprises approximately 300 m of bridge with a deck level of approximately 9.3 mAHD. On the Maitland side there is a 350 m stretch of High Street with a level of between 8.8 mAHD and 9.3 mAHD, before rising up to over 10 mAHD at the intersection with Ken Tubman Drive and

Belmore Road. On the Telarah side, High Street rises quickly above the PMF level (refer to Figure 14A for existing ground and flood level profiles along the route).

The bridge deck could be raised above the 1% AEP level, but it is unlikely that the grade of High Street between the bridge and the Belmore Road intersection could be altered due to existing development. This option would provide 1% AEP evacuation over the most hazardous part of the route over the Oakhampton Floodway, but would probably require boat evacuation between Belmore Road and the bridge (approximately 300 m).

The maximum flood immunity of this route would therefore be between 5% AEP and 2% AEP, with high hazard inundation occurring in the 1% AEP event. The current flood immunity level of this alignment is around 5% AEP, or possibly less if the bridge is closed when significant flow in the Oakhampton floodway occurs and the water level approaches the bridge deck.

Note that in combination with the levee discussed in Section 8.2.3, this route could potentially be kept flood-free in a 1% AEP flood, although the total cost of construction might end up being comparable to alternative 1% AEP routes discussed below.

2) Re-aligned Long Bridge – The goal of re-aligning Long Bridge would be to provide direct high-level connectivity to the High Street / Belmore Road intersection and Lorn (via Belmore Bridge). For example, the alignment illustrated on Figure 13 would require approximately 350 m of bridge and approximately 200 m of new high level road embankment. This alignment would require some major changes to the High Street /Belmore Road intersection, and there would be design challenges with integration of the vertical road geometry. There would also be traffic flow challenges for the Ken Tubman Drive connection. Some acquisition of private property would likely be required.

   This route would provide flood free evacuation from the high ground in Central Maitland for events greater than the 2% AEP or 1% AEP (refer to Figure 14B for existing ground and flood level profiles along the route). The marginal cost of constructing this route to provide 1% AEP immunity (instead of 2% AEP) is unlikely to be prohibitive, as the area of the bridge span (length x width) is the most significant component of the cost, with height being secondary. For example, if the pile depth required is 20 m below ground, and 5 m above ground, an incremental increase of 1 m to the pile height does not significantly increase costs.

3) Re-aligned Long Bridge – This route would provide direct high-level connectivity from High St at Telarah to the intersection of Ken Tubman and Allan Walsh Drive (currently a roundabout). Advantages compared to Route 2 would be easier integration with existing vertical road geometry, and fewer land-take issues. The major disadvantages are that Route 3 is longer and road embankment cannot be substituted to reduce the bridge length. It requires over twice the bridge length (750 m bridge) compared to 300 m bridge and 200 m embankment for Route 2). Unless Route 2 is rendered completely infeasible due to difficulties integrating with existing roads, the additional expense of Route 3

means it is unlikely to be the most cost-effective option.

This route would provide flood free evacuation from the high ground in Central Maitland for events greater than the 1% AEP (refer to Figure 14C for existing ground and flood level profiles along the route).

4) Re-aligned Long Bridge – This route would provide direct high-level connectivity from the southern extent of Regent St at Telarah to the intersection of Allan Walsh Drive and Church St (currently a roundabout). An elevated roadway option as presented in the Council discussion paper, as the embankment would need to be approximately 5 m above existing ground levels to reach the 2% AEP flood level, and 6 m for the 1% AEP flood level. The embankment would be nearly 3 m higher than the railway embankment which currently acts as the hydraulic control in Oakhampton Floodway, and would therefore increase flood levels and cause flooding of additional properties in Telarah and Maitland.

   Advantages of a bridge across the Oakhampton Floodway along Route 4 compared to Route 2 would be slightly easier integration with existing vertical road geometry, and fewer land-take issues (as with Route 3). A shorter bridge would be required compared with Route 3, but traffic issues would be worse and potentially invoke resistance from residents on Regents St due to extra through traffic. Route 4 therefore potentially offers a compromise between Routes 2 and 3.

   This route could provide flood free evacuation from the high ground in Central Maitland for events greater than the 1% AEP (refer to Figure 14D for existing ground and flood level profiles along the route).

5) Church Street to Telarah via New England Highway – An alternative evacuation route would be to connect the southern end of Church Street, near Maitland railway station, to the high ground at Telarah, via the existing New England Highway alignment. This would require a bridge across the Oakhampton floodway (with a length of approximately 700 m), connecting the roundabout and railway overpass at Church St to the existing Private Trzecinski Memorial Bridge.

   This route would involve significant difficulties for traffic flow, due to the intersection of the New England Highway and Cessnock Road (which connects to the under-construction Hunter Expressway). Roads & Maritime Services (RMS) is currently planning an upgrade to this intersection, which may potentially involve flyovers that will preclude a high level connection to Church Street. RMS has indicated it is not investigating options to improve flood immunity of the route or to build a bridge across the floodway as part of this project.

   This route would provide high level flood free evacuation from the high ground in Central Maitland and Lorn for events up to the 1% AEP, as Church Street has a minimum level of approximately 10.0 mAHD at the southern end (with a 1% AEP level of 9.73 mAHD –

refer to Figure 14E). However this route would not provide rising evacuation access for larger events, when Church Street would be overtopped and the high ground on High Street would be cut off from the route.

The relatively long bridge length and difficulties for traffic flow make this option less viable than other alternatives. Refer to Figure 14E for existing ground and flood level profiles along the route.

6) High Street to East Maitland via Les Darcy Drive– Under current conditions, the Les Darcy Drive connection from Maitland to East Maitland will be inundated in between a 5% AEP and 2% AEP event.

   Council's discussion paper identifies the possibility of raising Route 6 to be at the 2% AEP level. This would require raising one 800 m section by 1.0 m between High Street and the Wallis Creek bridge, and another 400 m section between Wallis Creek and Melbourne Street by between 0.5 m and 1.0 (refer to Figure 14E for existing ground and flood level profiles along the route). The expense of this option (including the economic costs of closing the New England Highway to complete the upgrade) would potentially be comparable to the bridge options for other routes discussed above. Raising the road would potentially have adverse flood impacts on surrounding areas during larger floods, such as a reduced level of protection from the Ring Levee for South Maitland, as the embankment would present a greater impediment to flow. Finally, this option would not provide appreciable safety improvements for flood evacuation from Central Maitland, as the road would still be cut around the same time that the Ring Levee is overtopped.

   As the distance from the higher ground in Central Maitland to flood-free areas of East Maitland exceeds 3 km, upgrading this route for high level flood evacuation is not feasible, due to the required length of embankment/bridging and associated costs (refer to Figure 14F for existing ground and flood level profiles along the route).

7) Lorn to Bolwarra via Belmore Road – Belmore Road connects Lorn to Bolwarra via the Bolwarra floodway. The route is currently inundated in approximately an 8% AEP event. Making this route suitable for high level evacuation would require the construction of a bridge across the floodway for a length of approximately 800 m, with an average deck height of approximately 3 m above the current road level (refer to Figure 14D).

   This route would provide evacuation from Lorn and the high ground in Central Maitland for events greater than the 1% AEP.

   This route would not require changes to traffic patterns, but the longer bridge length and associated costs make this option less viable than other alternatives. Additionally, although this route provides access to high ground, it is to a relatively isolated area without the accommodation and health care facilities available in either Telarah/Rutherford or East Maitland.

ACTIONS

A comprehensive feasibility and route selection study for a high level evacuation route should be undertaken as a matter of priority, with consideration of the preliminary route assessment undertaken above. On the basis of this preliminary assessment, Route 2 or Route 1 appear to be the most promising.

7.3. Flood Warning and Evacuation Planning

DESCRIPTION

Flood warning and the implementation of evacuation procedures by the SES are widely used throughout NSW to reduce flood damages and protect lives. The BOM is responsible for flood warnings on major river systems.

Providing sufficient warning time has the potential to reduce the social impacts of the flood as well as reducing the strain on emergency services. Adequate flood warning gives residents time to move goods and vehicles above the reach of floodwaters and to evacuate from the immediate area. The effectiveness of a flood warning scheme 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;
- the flood awareness of the community responding to a warning.

DISCUSSION

The flood warning system currently in place for the Hunter River is discussed in Section 3.7.

Due to the relatively long warning time available for Hunter River flooding, it is unlikely that residents will be "caught complete unaware". It will therefore usually be possible to reduce damages by moving items such as furniture, electronics, personal items, rugs, clothing and cars as long as residents take action in response to warning advice.

Although Council monitors the situation during flood events the responsibility for preparing regional flood warning rests with the BOM. The SES issues community-level warnings based on this information. Council does not issue warnings but assists the SES with road closures and evacuations, and operation of some mitigation structures such as flood gates. The SES has a Local Flood Plan for the Maitland City Council Area, the main features of which are discussed in Section 3.8.

The main problems with all flood evacuations are:

- they must be carried out quickly and efficiently;
- they are hazardous for both the rescuers and the evacuees;
- the primary purpose of evacuation is to reduce personal danger, so that people behind levees are often instructed to evacuate due to the risk of levee failure, even when

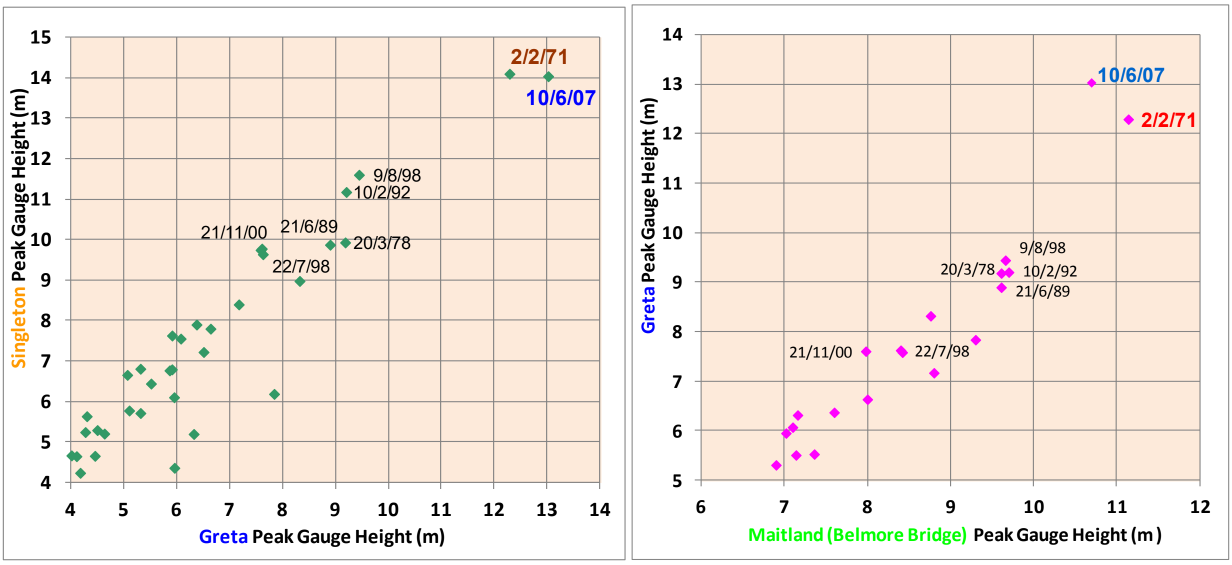
flooding is not expected to overtop the levee and inundate their home;

- residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers;
- evacuation routes may be cut some distance from their houses and people do not often appreciate the dangers of driving or walking through flood waters.

In Central Maitland and Lorn there is the additional pressure that key evacuation routes can be cut well before the flood peak as discussed in Section 7.2.

The only major test of the current warning system occurred in June 2007, as this was the first time since 1977 that the Major flood height of 10.5 mAHD was exceeded. In June 2007 the forecast peak flood level for Belmore Bridge was significantly higher than the actual peak, due largely to the reliance on observed levels at Singleton and Greta, which were relatively high by historical standards. The June 2007 flood was higher than the 1971 flood at Singleton and Greta, but lower at Belmore Bridge (10.7 mAHD compared to 11.1 mAHD in 1971). Diagram 2 illustrates the slightly different June 2007 behaviour compared to previous events.

Diagram 2: Peak Flood Level Gauge Comparisons with Singleton and Greta



The June 2007 prediction of the flood peak at Belmore Bridge led to evacuation of several thousand residents. Fortunately, very few homes were inundated on that occasion, although many properties would have been inundated in the absence of the levee system or if levee failure occurred. The primary purpose of the levee system is to protect property, and early evacuation of residents is the preferred strategy to mitigate against the risk of levee failure, even in events when overtopping of the levee is not expected. In future similar instances, it is likely the SES would issue the same evacuation instructions. This policy is further justified in light of the potential for evacuation routes to be cut as discussed in Sections 4.2 and 7.2.

However as the June 2007 flood warning turned out to be an over prediction, there may be some confusion from the public as to why the evacuation occurred – there is a perception that it was due to the over-prediction rather than a reasoned policy by the SES to reduce risk to life.

As a consequence of the perceived “false alarm”, some residents may feel less inclined to follow instructions to evacuate in the next flood. Improved flood warning performance can only help increase public understanding and confidence in the SES evacuation strategy. The education initiatives discussed in Section 7.4 are also relevant for this issue, particularly signage on evacuation routes.

Because of the issues above, it is important that timely and accurate flood predictions are available, so that informed decisions about evacuation can be made, and to increase levels of compliance with those decisions. The current warning system is adequate, but there may be opportunities for improvement. It is therefore warranted to explore opportunities to upgrade the flood warning system for the Hunter River, using more advanced modelling techniques than are currently utilised for the majority of Australian river systems.

ACTIONS

The response of the community during an event is critical in reducing the flood damages and risk to life. A Local Flood Plan (Reference 11) for the whole Maitland City Council LGA has been developed, but is due for revision to ensure consistency with new design flood information from the most recent 2010 Flood Study (Reference 2), and to reflect new flood intelligence and experience gained from operational response to the June 2007 flood.

The SES has indicated a draft revision of the Local Flood Plan is complete, but has not been finalised due to broad changes in how flood plans are structured and reviewed. This review of the Local Flood Plan should be finalised by the SES, preferably in collaboration with the local SES headquarters at Rutherford. The SES should continue its focus on community education and communicating the importance of early “safety first” evacuation, even if there is only a slim chance of property inundation for affected residents.

Council, in consultation with the BOM, should explore possible methods for upgrading flood prediction capability for the Hunter River. A feasibility study should be undertaken to assess available methods, including:

- updating of the current forecasting methodology using available flood models and flood data from the 2010 Flood Study (Reference 2);
- development of a thorough statistical regression model, exploring the correlation of peak flood heights at Maitland with other data, such as recorded peak flood heights at Singleton, recorded rainfalls, and travel time of the flood peak in the upper catchment; and/or
- development of more sophisticated real-time hydrologic or hydrodynamic modelling tools, and whether such tools can be used within the operational framework of the BOM.

7.4. Public Information and Raising Flood Awareness

DESCRIPTION

The success of any flood warning system and the evacuation process depends on:

- *Flood Awareness*: How aware is the community to the threat of flooding? Has it been adequately informed and educated?

- *Flood Preparedness*: How prepared is the community to react to the threat? Do they (or the SES) have damage minimisation strategies (such as sand bags, the ability to raise possessions above likely inundation levels) which can be implemented?
- *Flood Evacuation*: How prepared are the authorities and the residents to evacuate households to minimise damages and the potential risk to life? How will the evacuation be done, where will the evacuees be moved to?

The above can be improved upon through implementation of an effective Council or SES run flood awareness program. The extent of the program can vary from year to year depending upon the circumstances.

A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential risks of the situation. During a period of frequent flooding, the residents may develop an unofficial warning network to effectively respond to imminent danger by raising goods, moving cars, lifting carpets, etc. Photographs and other non-replaceable items are generally put in safe places. Often residents in rural areas have developed storage facilities, buildings, etc., which are flood compatible. The level of trauma or anxiety may be reduced as people have “survived” previous floods and know how to handle both the immediate emergency and the post flood rehabilitation phase in a calm and efficient manner.

DISCUSSION

The level of flood awareness within a community is difficult to evaluate. It will vary over time and depends on a number of factors including:

- frequency and impact of previous floods;
- whether an effective public awareness program has been implemented;
- history of residence.

Directly experiencing a major flood is the single most important factor in the level of flood awareness for an individual. In this regard, residents of Maitland are relatively inexperienced due to the long period that has elapsed since major flooding occurred. The 5% AEP level of 11.1 mAHD at Belmore Bridge has not been reached since 1971, a period of more than 40 years. This was an improbable but not particularly unusual dry sequence. Decadal cycles are often observed in flooding patterns throughout NSW, and very wet periods can also occur. Between 1949 and 1955, five floods greater than the 10% AEP level occurred, and two above the 5% AEP level.

June 2007 was the first time since February 1971 that the “Major” flood level of 10.5 mAHD (as defined by the BOM) at Belmore Bridge has been exceeded. On that occasion, the peak of 10.7 mAHD was insufficient to cause significant inundation of property, with only slight overtopping of the Oakhampton spillway and no overtopping of the Bolwarra spillway. This event may therefore have reinforced the perception of many residents that flooding does not pose a major risk to their life or livelihood.

Despite this lack of recent flooding, there are multiple flood education and awareness programs in place in Maitland, mainly due to the seminal influence of the February 1955 flood. Various education initiatives have been put in place by the Hunter-Central Rivers CMA, the SES, and Council, including:

- Fact sheets – the CMA produces fact sheets covering several topics including the Lower Hunter Valley Flood Mitigation Scheme, flood history on the Hunter, Paterson and Williams Rivers, and specific information about the 1955 and 2007 floods.
- Educational DVD – Contains footage and photographs of historical floods, and an informational video about flood behaviour at Maitland (including animated computer flood simulations) produced by the CMA.
- Book "Maitland, City on the Hunter: Fighting floods or living with them" – details the major floods that have occurred in the Lower Hunter over the past 200 years, and documents the influence of the 1955 flood on the development of an integrated approach to flood management in NSW. Written by Dr Chas Keys and produced by the CMA.
- Guided Historical Tours – the CMA and SES developed a 5-part "Walk & Talk" flood tour, including photographs and first-hand accounts of residents and rescue personnel, relating their personal anecdotes from the 1955 flood. The tours are very popular and are typically fully booked.
- FloodSafe guides – prepared by the SES, include informational brochures and fridge magnets about how to prepare and respond to flooding. Guides with information specific to Maitland are available for residential, commercial and rural properties.
- Newspaper articles – the Maitland Mercury frequently publishes articles relating to historical floods and remembrance of the anniversary of past events, and other flood issues.
- "Are You FloodSafe?" kit – a bundled package of fact sheets, educational DVDs and FloodSafe guides prepared by the CMA and provided to school children and participants in walking tours.
- Flood Mark Signs – Council has posted signs indicating the 1955 flood level at several telegraph poles and buildings around Central Maitland, although they are unpopular with some residents and are sometimes removed or vandalised. OEH replaced several of the removed signs at the request of the SES as part of the 60th anniversary commemorations.

These programs are commendable, particularly those run by the CMA which employs a dedicated flood and wetland education officer. Some additional educational methods which could be employed by Council are outlined in Table 15 below.

Table 15: Additional Flood Awareness Methods

Method	Comment
Letter/Pamphlet from Council	These may be sent (annually or biannually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of subsidies, changes to flood levels or any other relevant information.
School Projects	This provides an excellent means of informing the younger generation about flooding, and can lead to infiltration of flood awareness to parents. The CMA already undertakes school visits.
Displays at Council Offices, Library, Schools, Shopping Centres, Local Fairs	This is an inexpensive way of informing the community and may be combined with related displays.
Historical Flood Markers or Depth Indicators on Roads	Signs or marks can be prominently displayed in parks, on telegraph poles or buildings to indicate the level reached in previous floods. Depth indicators on roads advise drivers of potential hazards. These signs are already implemented in Maitland but some have been removed or damaged and require replacement. OEH replaced several of the removed signs at the request of the SES as part of the 60th anniversary commemorations. Large road signs on major evacuation routes showing historical flood depths are also recommended.
Collection of Data from Future Floods	Collection of data assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible.
Establishment of a Flood Affectation Database	A database would provide information on (for example) which houses require evacuation, which roads will be affected (or damaged) and cannot be used for rescue vehicles, which public structures will be affected (e.g. sewage pumps to be switched off, telephone or power cuts). This database should be reviewed after each flood event. It could be developed by various authorities (SES, Police, Council).
Flood Preparedness Program	Providing information to the community regarding flooding helps to inform it of the problem and associated implications. However, it does not necessarily adequately prepare people to react effectively to the problem. A Flood Preparedness Program can assist the community to be adequately prepared, including the distribution of a FloodSafe kit to flood-affected residents. Council should work with the SES to prepare a tailored template with information specific for Maitland, and distribute to all flood-affected households. The template should include basic information about potential evacuation centres, and sources of flood warning information, and prompt residents to determine evacuation routes, storage locations for valuables, etc.

It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the relatively low costs. The perceived value of the information and the level of awareness will diminish as the time since the last flood increases. A major hurdle is often convincing residents large floods will occur in the future. Some residents may oppose an awareness program because they consider it reduces the value of their property. However this should not hinder the continued need to inform and receive feedback from the community.

A key issue that requires constant reinforcement is to ensure that the community prioritises personal safety over other concerns during floods, and walking or driving through flood waters should be strongly discouraged, as this is where most emergency flood rescues occur.

ACTIONS

A flood awareness program should be implemented by Council as part of the Floodplain Management Plan, with a focus on aspects of personal safety and flood preparedness (including evacuation planning).

Council should distribute a FloodSafe guide (see Appendix E) to all flood-affected properties, along with local flood risk information for each property where available (such as floor levels and design flood levels), and information about evacuation routes.

Council should erect large road signs on major evacuation routes, indicating the estimated level for selected historical and design flood events.

8. FLOOD MODIFICATION MEASURES

8.1. Overview

Levee banks are a means of excluding floodwaters from previously inundated areas up to a designated level, and have been widely used for this purpose historically throughout the Maitland City LGA. The banks are generally made of compacted earth and can usually be successfully landscaped to produce minimal visual impact. The Lower Hunter Valley Flood Mitigation Scheme comprises several kilometres of levee banks, and there are numerous informal levee banks that pre-date the construction of the scheme. Because of the piecemeal construction of several of the levee banks, the geotechnical characteristics of the embankments are not well documented.

Flood gates can be constructed as a separate modification measure or as part of the levee design, generally to allow local drainage through the levee, or infrastructure access such as a railway line. There are several existing flood gates in Maitland, including:

- Wallis Creek at Hunter River;
- Fishery Creek at Oakhampton Floodway;
- Wyburns Levee at Howes Lagoon;
- Kings Island/Largs Lagoon at Hunter River;
- Howes Lagoon at Hunter River.

Pumps are also often associated with levee designs. They can be installed to remove local floodwaters behind levees when flood gates are closed or there are no flood gates. They are generally only suitable where there is a small contributory catchment upstream of the areas contained by the levee, and thus only a small volume of water needs to be discharged.

Important negative aspects of levees and associated structures include:

- High cost, due to the requirement for large amounts of good quality compacted fill, and associated earthworks;
- potentially engendering a false sense of security and make residents less flood aware;
- loss of visual amenity for properties behind the levee;
- potentially encouraging intensified development or investment in areas protected by the levee, resulting in greater losses for floods above the level of protection;
- risk of embankment failure, resulting in a high hazard flood wave entering the area behind the levee, possibly in areas that were not expected to be inundated.

The Lower Hunter Valley Flood Mitigation Scheme already provides a comprehensive levee system that protects the majority of existing flood-liable urban development to some degree. In 1971, 1977, and 2007, the levee scheme operated as designed, with inundation generally confined to the designated floodway areas, and minimal inundation of urban and residential areas. The role of this study is to investigate whether any modifications or additions can be made to the existing scheme to improve the level of protection, and to assess the flood impact and cost effectiveness of these modifications.

8.2. New Levee Banks

Potential locations where construction of additional levee banks could further reduce flood damages for localised areas were identified. Detailed assessment of selected locations is provided below.

Construction of new levees, or raising existing levees, would require Council to seek funding via the State Floodplain Management Program fund, and therefore the relative merit of any levee proposals would need to compare favourably against other proposals around NSW. New levees would also be deemed to be owned by Council (in contrast to the existing Lower Hunter Valley Mitigation Scheme), and future maintenance activities would be Council's responsibility. These maintenance costs must be considered as part of any proposal.

OEH has advised that any works to change the crest height of an existing levee would result in OEH transferring ownership and on-going maintenance responsibility of that section of the levee to council.

8.2.1. Private Trzecinski Memorial Bridge Levee – Fishery Creek

The June 2007 Hunter River flood was accompanied by significant flooding of Fishery/Swamp and Wallis Creeks, which filled up a large portion of the flood storage areas in Wentworth Swamp to the south-west of Central Maitland. Overtopping of the Oakhampton spillways from the Hunter River caused inundation of the New England Highway between Church Street and Private Trzecinski Bridge for approximately five days (see Photo 1). The road closure caused major traffic disruptions as all traffic was diverted through Central Maitland and across Long Bridge.

Photo 1: Inundation of New England Highway (at right) on 12th June 2007

RMS directed WMAwater to investigate the cause of the flooding, and possible measures to mitigate the duration of road closure in the future. Information from the SES indicated that in 2007 the cause of inundation was primarily from Hunter River flow down the Oakhampton Floodway. However the review also identified that the protection from the levee to the south of the Oakhampton floodway, which prevents flooding of the New England Highway from Fishery Creek, has been reduced by construction of the Private Trzecinski Bridge. The levee crest is typically between 6.25 and 6.5 mAHD, but there are low points in the vicinity of the bridge, and across the road surface itself, between 5.0 mAHD and 5.5 mAHD (see Figure 15 for details). These gaps allow inundation of the New England Highway bypass, which has a minimum level of 5.4 mAHD, from Wentworth Swamp to the west.

Construction of additional earthen levee embankment, along the alignment shown on Figure 15, would potentially increase the flood protection level of the road from Fishery Creek flooding, and would potentially allow the road to remain open, or re-opened earlier, for major flood events in Fishery and Wallis Creek. The levee would require two embankments:

- north of Private Trzecinski Bridge, with a length of 200 m and a height of between 0.2mAHD and 1.5 mAHD above existing ground levels; and
- south of Private Trzecinski Bridge, with a length of 150 m and a height of between 1.5 mAHD and 2.0 mAHD.

Additionally, construction of a floodgate or penstock on the culvert at Mount Pleasant Street could potentially delay inundation of the area, or prevent inundation for events which overtop the Oakhampton Spillways but without sufficient volume to overtop the Mount Pleasant Street control.

The levee and penstock would primarily produce economic benefits by reducing traffic disruption, rather than a reduction in tangible flood damages, and therefore a detailed benefit/cost assessment has not been undertaken. However, the ratio is likely to be relatively high, particularly if the levee is constructed in conjunction with other major road-works in the area, such as the Church Street roundabout upgrade currently being proposed by RMS. The incremental costs of the earthworks in this situation could potentially be very low.

ACTIONS

Council should engage with RMS to undertake a detailed investigation to construct a levee at Fishery Creek in the vicinity of Private Trzecinski Bridge (Figure 15), in combination with a penstock at the Mount Pleasant Street culvert.

8.2.2. Sharkies Lane Levee – Lorn

Lorn is protected by a levee from direct flooding from the Hunter River for events up to and including the 1% AEP flood. In events where a large amount of flow occurs over the Bolwarra spillway, backwater flooding of Lorn can occur across Sharkies Lane from rising water levels in the Bolwarra flats. Due to the relatively flat terrain, a small increase in flood level can produce a large increase in inundation area through Lorn.

A levee constructed along the eastern side of Sharkies Lane could potentially increase the level of protection for flood affected properties in Lorn up to the 1% or 0.5% AEP level. The levee would need to be approximately 1,000 m in length, with an average height of approximately 1.5 m above existing ground levels, and an indicative alignment as shown on Figure 17. Table 16 gives a summary of the flood affectation for Lorn for a range of events, showing the effect of a levee with 0.5% AEP flood protection.

Table 16: Sharkies Lane Levee – Effect on Property Inundation

	Event					
CURRENT	**5% AEP**	**2% AEP**	**1% AEP**	**0.5% AEP**	**0.2% AEP**	**PMF**
Above ground flooding only	0	27	47	93	6	-
Above floor flooding	0	14	27	73	562	568
Total	**0**	**41**	**74**	**166**	**568**	**568**
WITH SHARKIES LANE LEVEE (Crest Level 8.5 mAHD)						
Above ground flooding only	0	0	0	0	6	-
Above floor flooding	0	0	0	0	562	568
Total	**0**	**0**	**0**	**0**	**568**	**568**

The estimated flood damages for each scenario (with and without a levee) are shown in Table 17. A levee with a 0.5% AEP protection level would reduce AAD by $60,000. The benefit of building the levee now is equivalent to the Net Present Value of the reduction in damages, which is $890,000 using a 50 year design life with a discount factor of 7%. The cost of the levee is estimated at between $1M and $1.5M, depending on availability of materials, and costs of land acquisition if required. The benefit/cost ratio of this option is therefore estimated to be between approximately 0.6 and 0.9.

Table 17: Sharkies Lane Levee – Effect on Flood Damages

AEP	Damages Current Conditions	Damages Sharkies Lane Levee
0.001%	$73,555,974	$73,555,974
0.2%	$54,453,842	$54,453,842
0.5%	$6,192,565	$0
1%	$2,084,137	$0
2%	$996,417	$0
5%	$0	$0
Average Annual Damages	**$269,380**	**$209,051**
Net Present Value of Damages (7% Discount Factor)	**$3,978,000**	**$3,087,000**

Negative impacts associated with levee construction would include:

- Local drainage issues for the catchment enclosed by the levee, which would be exacerbated by the relatively flat topography;
- Access and visual impacts; and
- A heightened sense of security against flooding for property owners behind the levee, potentially leading to increased investment in the protected area and consequently higher damages for events that overtop the levee, as well as potentially increased reluctance to evacuate.

ACTIONS

Given the issues raised above, construction of a levee at Sharkies Lane is considered a relatively ineffective flood risk mitigation measure and further investigation is not recommended at this time. Although the cost/benefit ratio is reasonable for a levee of this type, other measures such as house raising (existing development) and minimum floor level controls (new development) are likely to be more cost effective for this area.

8.2.3. Long Bridge to Mount Pleasant St Levee – Oakhampton Floodway

There are several properties on the eastern side of the Oakhampton floodway which are subject to flooding for events around the 5% AEP level and higher (see Figure 19). This area is bounded to the east by a levee with a crest at approximately 12.3 mAHD, giving a protection level of about the 1% AEP from direct Hunter River flooding.

The area could potentially be protected up to the 1% AEP level by a levee along the eastern edge of the floodway between Long Bridge and Mount Pleasant Street (see indicative alignment on Figure 19). The levee would need to be approximately 800 m long, with an average height of approximately 3.5 m above existing ground levels.

Table 18: Oakhampton Floodway Levee – Effect on Flood Damages

AEP	Damages Current Conditions	Damages with Levee
0.001%	$10,269,644	$10,269,644
0.2%	$9,870,805	$9,870,805
0.5%	$9,259,835	$9,259,835
1%	$8,473,385	$0
2%	$4,753,952	$0
5%	$773,709	$0
Average Annual Damages	**$261,463**	**$71,885**
Net Present Value of Damages (7% Discount Factor)	**$3,860,973**	**$1,061,516**

The estimated flood damages for each scenario (with and without a levee) are shown in Table 18. A levee with a 1% AEP protection level would reduce AAD by $190,000. The benefit of building the levee now is equivalent to the Net Present Value of the reduction in damages, which is $2.8M using a 50 year design life with a discount factor of 7%. The cost of the levee is estimated at between $2.5M and $3.5M, depending on availability of materials, and costs of land acquisition if required. The benefit/cost ratio of this option is therefore estimated to be between approximately 0.8 and 1.1.

Possible issues associated with levee construction at this location would include:

- Incongruity with the land use zoning for the area, which is presently zoned RU1 Rural;
- Increased incentive to allow development for commercial/residential purposes in the area, which would be a reversal of previous flood risk management policies in the area, and potentially lead to increased investment in the protected area and consequently higher damages for events that overtop the levee, as well as potentially increased reluctance to evacuate when instructed;
- The levee is likely to cause increases to flood levels and velocities within the floodway;
- Access and visual impacts; and
- A heightened sense of security for property owners behind the levee.

ACTIONS

Although the benefit cost ratio is relatively high compared to other levee options assessed, given the issues raised above construction of a levee within the Oakhampton floodway is considered a relatively ineffective flood risk mitigation measure and further investigation is not recommended at this time.

8.3. Alterations to Existing Levees/Spillways

8.3.1. Oakhampton Spillways

The two Oakhampton Spillways are grass covered earthen banks which are the primary controls for the distribution of Hunter River flow that enters the Oakhampton Floodway. The No. 1 Spillway is approximately 350 m long with a crest level ranging from 11.6 to 11.8 mAHD. The No. 2 Spillway is approximately 700 m long a crest level ranging from 11.4 to 11.6 mAHD.

During the June 2007 event both the Oakhampton Spillways were overtopped, but the Bolwarra Spillway was not, although some leakage occurred through the upper rock mattress section. It is not clear whether the original design intention was for the Bolwarra and Oakhampton Floodways to be overtopped simultaneously, although there have been suggestions that the original concept was to produce a roughly even three-way split of flows between the two floodways and the Hunter River main channel (Reference 4).

Altering the level of the Oakhampton Spillways would have the effect of altering the flow distribution between these flow paths. Raising the spillways would reduce the proportion of floodwaters through the Oakhampton floodway, and eventually threatening the areas of Central/South Maitland, Louth Park and Pitnacree, while increasing flood flows and levels in the Hunter River main channel and in the areas of Bolwarra and Lorn.

Two scenarios were investigated as part of this study:

- raising the Oakhampton Spillways by 0.5 m; and
- raising the Oakhampton Spillways by 1.0 m.

The impacts of these two scenarios on peak flood levels for the 1% AEP flood event are shown on Figure F1 and Figure F2 in Appendix F.

The cost of raising the Oakhampton Spillways is estimated to be from $900,000 to $1.5M depending on the change in level. Issues arising from a proposal to raise the Oakhampton Spillways include:

- any adjustment to spillway dimensions would create winners and losers compared to the current arrangement. Raising the Oakhampton Spillways would primarily advantage urban landholders at a cost to rural landholders. While there may be a net economic benefit to certain options, there is no clear argument that this would justify the losses for individual landholders adversely affected by the works;
- raising all levee and spillways would lower flood levels in overbank areas, but would increase flood levels downstream and increase the likelihood of catastrophic levee/spillway failure in a large flood.

It is therefore not recommended to alter the level of the Oakhampton Spillways, due to the complications that would arise, particularly with regard to redistribution of flood risk.

8.3.2. Maitland Ring Levee

The Maitland Ring Levee protects Central/South Maitland and Horseshoe Bend from the combined flood mechanisms of:

- Hunter River flows along the Oakhampton floodway; and
- flooding of Wallis and Fishery Creeks, which is exacerbated during Hunter River floods by the closure of the Wallis Creek floodgates at the Hunter River confluence.

The Ring Levee is not a single embankment or wall, but rather consists of several components including:

- the railway line floodgates near Maitland railway station;
- formalised levee embankments;
- natural areas of high ground, such as the southern edge of Maitland Park;
- the horse track at Maitland showground; and
- sections of Les Darcy Drive, High Street, and the railway embankment.

An indicative alignment of the levee is shown on Figure 18. The alignment is indicative only, as in the natural ground sections there is no formalised levee easement or other identifying factor distinguishing the alignment. This raises issues for the levee security, as the alignment cannot be identified for development control purposes, and development of private property in these areas could potentially reduce the protection level.

The current general level of protection given by the Ring Levee is the 2% AEP flood (including some freeboard). Parts of the levee alignment, such as the railway gates, are approximately at the 2% AEP level (i.e. no freeboard). The protection level appears to be mainly a result of the level of natural ground sections of the alignment, rather than being based on providing protection to a given design flood standard. It is necessary to consider whether the Ring levee should be raised to increase the protection level, or whether to include freeboard for a nominated protection level. However, the levee cannot be raised without first formalising the levee alignment.

A damages assessment indicated that the benefits of increasing the level of protection from the Ring Levee from the 2% AEP to the 1.4% AEP level (70 year ARI) would be very minor (less than $10,000 change to AAD), as overtopping of the current levee in the 1.4% AEP flood would not cause extensive inundation within the levee, and would not be sufficient to overtop High Street and inundate Horseshoe Bend. Significant benefit would only be obtained by raising the levee to provide 1% AEP, which would reduce AAD by $100,000 to $150,000.

Based on these estimates of changes to AAD, upgrading the ring levee would only produce a benefit/cost ratio greater than 1 if 1% AEP protection could be obtained for less than $2M. This would require raising of the full 3 kilometre length of levee including railway gates by over 1.5 m, which is not estimated to be achievable for that cost.

ACTIONS

An audit of the Ring Levee is recommended to determine its gradient, and to formalise the alignment for the purposes of planning and development control.

Upgrades to the protection level offered by the Ring Levee are not recommended at this time, primarily due to poor cost/benefit metrics, impacts on flood levels outside the levee, and the increased consequences that would result from failure of the higher levee.

8.3.3. Oakhampton Road Control

In the two most recent Hunter River flood events to cause flow down the Oakhampton Floodway, the Oakhampton Road embankment control (located immediately south of the Oakhampton Spillway No. 1) failed and was partially washed out due to overtopping (see Photo 2 and Photo 3).

Photo 2: Failure of Oakhampton Road Control Embankment – March 1977

Photo 3: Failure of Oakhampton Road Control Embankment – June 2007

These failures suggest that the road embankment has not been designed to manage sustained overtopping, even for relatively minor flows across the Oakhampton No.1 Spillway as occurred in 1977 and 2007. OEH indicated that it views the responsibility for the 2007 failure as being due to illegal structures built by Ausgrid and Maitland City Council. According to OEH, Council constructed a pipe under the road at the western floodway edge but did not provide adequate scour protection, and on the eastern side Augrid erected a telegraph pole without scour protection around the base. As part of reconstruction works, the gabion mattress was extended to higher ground on each side of the floodway. However, it is acknowledged that the transition point between the gabion mattress and existing ground may be a scour point in future floods.

If future failures occur each time the road is overtopped (roughly a 10% chance per year), the repetitive costs of replacement for the road, and the intangible economic costs caused by road closure, are likely to exceed the cost of constructing an embankment capable of withstanding overtopping up to a reasonable design standard.

ACTIONS

It is recommended that the embankment design for the Oakhampton Road control be reviewed, and the embankment upgraded if required to withstand overtopping for events up to approximately the 1% AEP design flood.

9. PROPERTY MODIFICATION MEASURES

9.1. Development Control Planning and Flood Planning Levels

DESCRIPTION

The strategic assessment of flood risk can prevent development occurring in areas with a high hazard and/or with the potential to have significant impacts upon flood behaviour in other areas. It can also reduce the potential damage to new developments likely to be affected by flooding to acceptable levels. Development control planning includes both zoning and development controls.

The division of flood prone land into appropriate land use zones can be an effective and long term means of limiting danger to personal safety and flood damage to future developments. Zoning of flood prone land should be based on an objective assessment of land suitability and capability, flood risk, environmental and other factors. In many cases it is possible to develop flood prone lands without resulting in undue risk to life and property.

Development controls for Maitland are stipulated via a number of planning documents including the Local Environmental Plan (LEP 2011), the Maitland City DCP, and various localised Development Control Plans.

DISCUSSION

Development control planning can reduce the effects of flooding on future development by minimising flood damages and managing risk. In some areas where the FPL or other criteria can only be achieved at considerable additional cost, there is community resistance to implementing these measures.

The following issues need to be addressed when considering flood related development control policies.

- Ensure Adequate Access: Development controls should restrict intensified development in areas where adequate evacuation is not available, preferably rising away from the direction of flood inundation. The current DCP contains an objective along these lines.
- Set Back from Waterways: A minimum setback for development from waterways and floodways should be considered. A buffer zone for development from levees and other key elements of the Lower Hunter Valley Flood Mitigation Scheme is also appropriate.
- Fill (or excavation) in the Floodplain: Filling of land for development can result in it no longer being flood liable, however it can also affect flow patterns or even cause flood levels to rise. Filling for building pads in flood-liable areas (in-fill development) should therefore only be permitted if it does not affect local drainage issues or result in significant flood impacts. Due to the immensity of the Hunter River floodplain around Maitland, large amounts of filling could occur without having a significant impact on broad flood levels. Development controls for importation of fill are discussed in detail in Section 9.6 below.

- Building Materials: Some building materials are less susceptible to damage by floodwaters, or are easier to clean after a flood. By using such materials, flood damages can be minimised. Flood proofing guidelines are already contained in Section 5.0 of the DCP.
- Structural Soundness when Inundated: Floodwaters can impact upon the structural soundness of buildings in a number of ways relating to flow velocities, depths and associated debris loads. The DCP requires certification of the soundness of structures for the local hydraulic conditions by a suitably qualified engineer.
- Fencing: Fences, whether solid or open, can impact upon flood behaviour by altering flow paths. This impact will depend upon the type of fence and its location relative to the flow path. At Maitland this is unlikely to be a significant issue for residential areas which are primarily affected by backwater flooding. Fences should not intrude into floodways or overland flow easements.
- Non-Residential and Special Use Properties: The flood related development requirements for all non-residential properties need to be clearly identified, including Special Use (hospitals, transformers and other power infrastructure, schools, halls, SES headquarters, etc.).
- Climate Change: Should be addressed (refer to Section 5.3 for discussion).
- Flood Planning Levels: The FPL is used to define land subject to flood related development controls and is generally adopted as the minimum level to which floor levels in the flood affected areas must be built. The FPL includes a freeboard above the design flood level. It is common practice to set minimum floor levels for residential buildings as this reduces the frequency and extent of flood damages. Freeboards provide reasonable certainty that the reduced level of risk exposure selected (by deciding upon a particular event to provide flood protection for) is actually provided. It is common practice throughout NSW to use a FPL of the 1% AEP event plus a 0.5 m freeboard. Other FPLs greater than the 1% AEP such as the PMF may need to be considered where personal safety is a factor, such as evacuation planning or placement of critical infrastructure.
- Wording on 149 Certificates: This should be reviewed every 2 years to ensure that the wording accurately reflects Council's intentions. The information contained in Section 149(5) certificates should be reviewed for currency, and to determine whether Council can supply additional relevant information.
- Formalise Flood Policy: It is essential that Council develop a clear and unambiguous flood policy which is located in a single document.

ACTIONS

While existing development control policies are reasonably comprehensive, flood-related sections of the Maitland LEP and DCP should be immediately revised to address the following issues:

- Mapping in the LEP should be revised to reflect current flood modelling from the 2010 Flood Study. The current mapping is stated as showing the extent of the Flood Planning Area (land below the 1% AEP + 0.5 m flood level), but the provided maps are actually estimates of the 1% AEP and 1955 flood extents based on outdated information.
- Land inundated in the PMF event should be identified.

- Terminology should be revised to be consistent between the two documents, and with the Floodplain Development Manual to increase clarity of the policies. For example, terms such as Design Floor Level and Flood Planning Level are currently used interchangeably.

Consideration should also be given to revising the following aspects of the policies:

- Council should consider specifying default FPLs for Commercial and Industrial development, with deviations from this default to be allowable on a merits-based approach. Currently the DCP does not specify FPL requirements for some types of development.
- Council should consider restricting certain types of development within the Hunter River PMF extent, such as critical public infrastructure. There are currently no development restrictions for land within the PMF extent that is above the 1% AEP + 0.5 m level.
- Council should consider providing additional information on Section 149(5) certificates such as design flood levels, floor levels, and flood protection levels provided by levees. Under the EPA Act 1979 Section 149(6), Council would not incur liability in respect of this information being provided in good faith.
- A DA is required for filling of flood prone land. Council should consider specifying criteria relating to whether flood modelling is required to support a filling application, as moderate levels of filling can be accommodated in some circumstances without requiring a detailed modelling assessment (see Section 9.6).

9.2. House Raising and Flood Proofing

DESCRIPTION

House raising has been widely used throughout NSW to reduce the risk of inundation above habitable floor levels. However it has limited application as it is not suitable for all building types. It is also more common in areas where the depth of inundation is sufficient that raising the buildings allows creation of an underfloor garage or non-habitable room area.

House raising is suitable for most non-brick single storey buildings on piers and is particularly relevant to those situated in low hazard areas on the floodplain. The benefit of house raising is that it can reduce or eliminate inundation above the floor and consequently reduces the flood damages (see Photo 4 and Photo 5 for examples in the area).

An alternative to house raising for buildings that cannot be raised is flood proofing or sealing of the entry points to the buildings. This measure has the advantage that it is generally less expensive than house raising and causes less social disruption. However this measure is really only suitable for commercial and industrial buildings where there are limited entry points and aesthetic considerations are less of an issue. The relatively high flood depths (over 2 m) for many flood affected residential properties also preclude flood proofing as a viable strategy to prevent internal inundation.

Photo 4: House Raising Example 1 – Lorn

Photo 5: House Raising Example 2 – South Maitland

Based upon our experience we do not consider flood proofing a viable measure for most residential buildings in Maitland. Table 19 summarises advantages and disadvantages of house raising.

Table 19: Advantages and Disadvantages of House Raising

ISSUE	COMMENT
ADVANTAGES:	
Can be cost effective (benefit/cost ratio >1).	Generally the majority of suitable low lying buildings which would provide a B/C ratio of >1 have either already been raised or are not suitable due to construction type or low value of the existing building.
Nil maintenance cost.	May provide additional under floor usage.
Resident can still enjoy benefits of existing life style.	Residents do not have to move but will be inconvenienced during the course of work.
Grants are available.	Each application is assessed on its merits.
DISADVANTAGES:	
The benefit/cost ratio is small unless the building is frequently inundated.	In Maitland and Lorn, the levees prevent frequent inundation up to the 2% AEP, and significant raising (over 1 m) would be required for many properties to prevent inundation in the 1% AEP. These high costs and narrow benefit range result in a low cost-benefit ratio for properties within the levee extents.
Grants only cover the basic costs of raising the structure.	Residents may have to provide their own funds to raise (say) pergolas or garages attached to the house. This can be a significant drawback for many residents.
Many buildings are not suitable.	Detailed inspection may preclude a number of buildings initially considered to be suitable (e.g. stone fireplaces).
Residents are "dislodged" for a period.	The residents may have to move for several weeks.
Aesthetic issues	Where houses must be raised several metres, the aesthetic qualities or heritage value of the property can be affected. This is a particular issue at Central Maitland where there are significant heritage-related constraints.
Low acceptance by residents.	In some locations there is a low acceptance by the residents. Generally where the building is frequently inundated the residents take up the offer. However, where the building is less frequently inundated (possibly never in the owner's lifetime) the residents reject the offer. This is evident in Maitland where instances of house raising are low.

DISCUSSION

Of the 2720 properties for which floor level survey was obtained, just over half (1473) are single storey construction on piers, and roughly half again (719) are below the FPL, making them suitable for house-raising. On average, these properties would need to be raised by 1.88 m, with 85 properties requiring raising of between 3 m and 4 m above existing levels.

The damages assessment indicates that for these 719 properties, total AAD is $1.72M or approximately $2,300 per property an average. The reduction in AAD from raising all of these properties to the 1% AEP +0.5 m level would be $750,000, giving a residual AAD of $970,000, or $1,350 per property on average.

The Nett Present Value of the reduced damages from raising all suitable houses is estimated to be $14.3M using a Discount Factor of 7% over 50 years, or just under $20,000 per house. The benefit/cost ratio is therefore less than 0.3 at a cost of $70,000 to raise each house.

The main reason for the relatively poor benefit/cost ratio is that most of the houses that meet the above criteria are within the Ring Levee, and are therefore protected from significant damage up to the 2% AEP event, yet are affected by significant flood depths in the 1% AEP flood event. The advantages are therefore only achieved for a relatively small range of floods, and in urban areas are outweighed by the disadvantages such as:

- inconvenience of displacement while the works are undertaken;
- risk of damage to the structure during the raising process;
- inconvenience with regards to access, due to the height of floor level above street level; and
- aesthetic/streetscape considerations.

The cost effectiveness of house raising is increased when the existing property is subject to frequent inundation. Due to the Lower Hunter Valley Flood Mitigation Scheme, there are not likely to be many properties that meet these criteria. House raising in Maitland is therefore primarily suitable for flood-affected existing properties in more rural areas, assuming the buildings are of suitable construction. Other areas where house raising may be cost effective may include properties along the Oakhampton Floodway north-east of Long Bridge.

ACTIONS

Residents should be aware that house raising can be a cost effective solution for long term reduction of flood damages at residential properties, although not all types of house construction are amenable to raising. Applications for funding assistance for house-raising must be made on a case-by-case basis.

Due to the relatively long period of time elapsed since the 5% AEP flood level was exceeded at Maitland, uptake of house raising is unlikely to be high. Enthusiasm for house raising may increase in the aftermath of a large flood that widely inundates rural and urban areas (2% AEP or greater).

9.3. Amphibious Housing

DESCRIPTION

Amphibious housing is a relatively new concept which has been recently implemented in various locations in the Netherlands (Photo 6) and the United Kingdom (Photo 7), but not yet in Australia.

Photo 6: Amphibious Housing Concept (left) and Coastal Amphibious Housing in Maasbommel, The Netherlands (right)

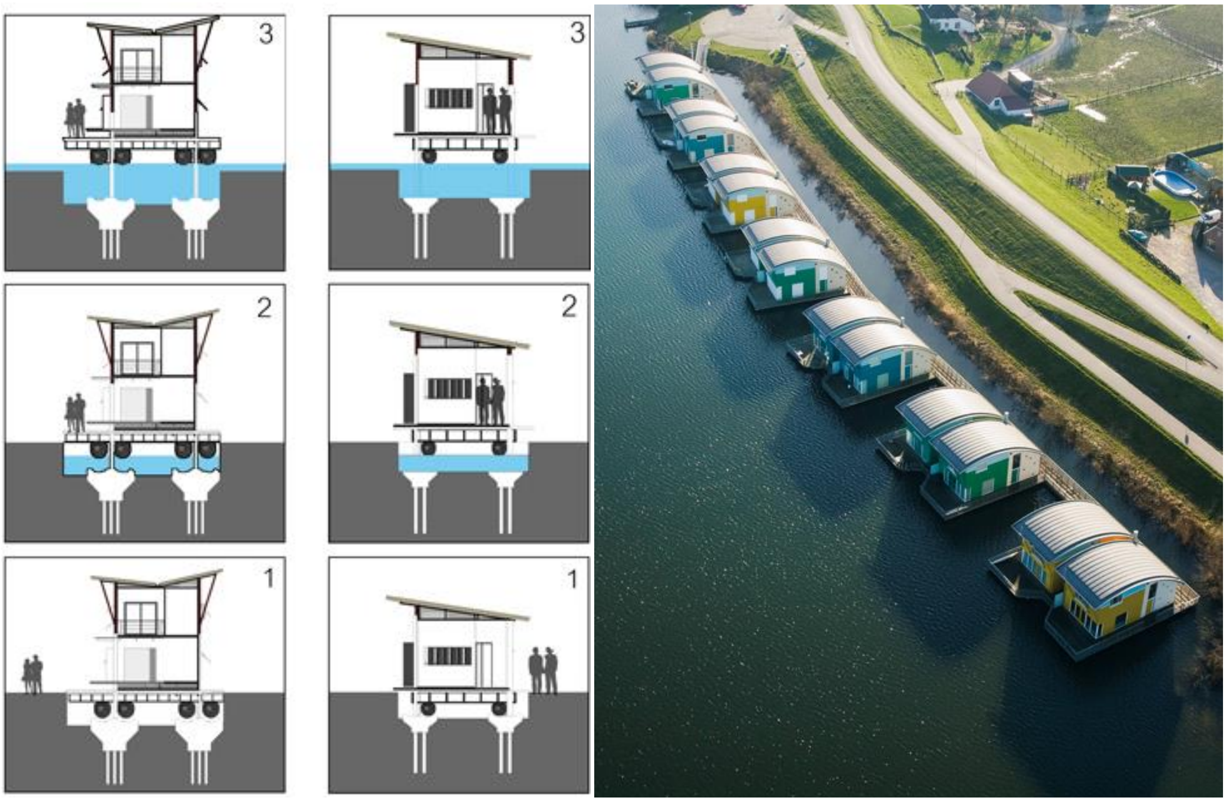
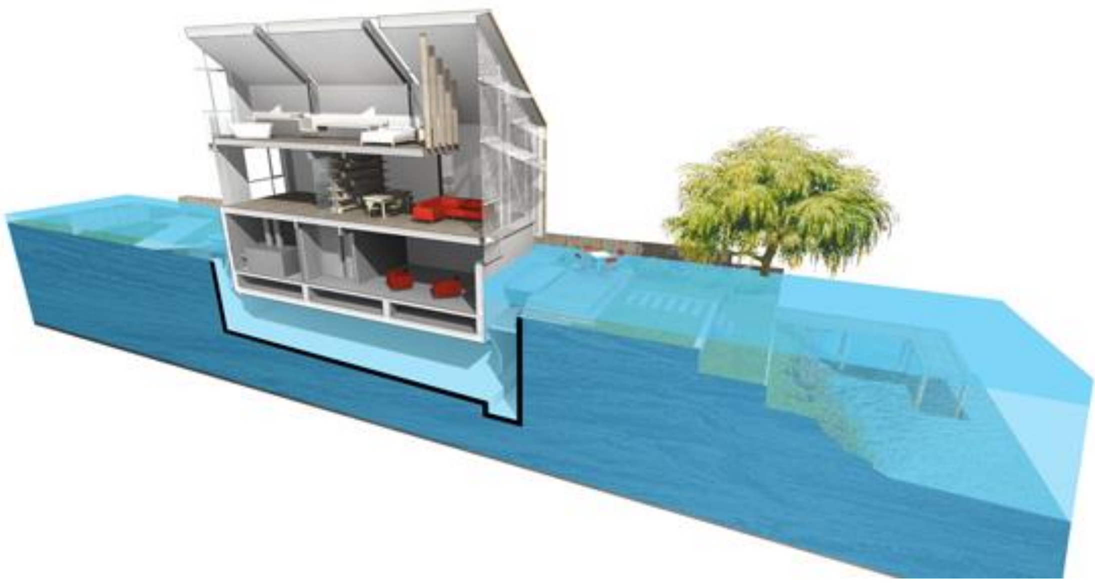


Photo 7: Amphibious Dwelling Approved for Construction – Thames River at Buckhamshire



Under normal conditions, an amphibious house is designed to rest on the ground on fixed foundations, inside a tanked basement. However during a flood situation the entire building is designed to rise up in a dock and float there, remaining buoyed by the flood waters. This is achieved by using a wet dock, comprised of retaining walls and base slab that sits underneath the home. When flooding occurs the dock fills with water and the house rises accordingly. To prevent the house from floating away, permanent vertical posts are arranged close to the sidewalls. These vertical posts can be designed to contain flexible utility/service cables, to prevent damage/disconnection during the flood.

DISCUSSION

If successful, amphibious housing has the advantage of eliminating the aesthetic and access issues of fixed elevated pier construction. Amphibious housing is yet to be widely implemented and tested, and should therefore still be regarded as experimental until the long-term performance of the structures is proven. For these reasons it is unlikely to be widely adopted, however there may be an opportunity for individual developments in flood-liable residential areas of Maitland to test out this approach.

It is therefore considered appropriate for Council to consider specifying amphibious housing as an alternative to fixed elevated pier constructions, provided due diligence is carried out as part of the DA. This would include specifying the design behaviour of the structure for floods up to and including the PMF, and requiring the minimum entry points to the structure to be able to rise above the relevant FPL at a minimum (i.e. above the 1% AEP + 0.5 m level).

ACTIONS

Council should consider including a reference to Amphibious Housing within the DCP, subject to a DA being approved, as a form of housing construction that can be considered for approval in flood-liable areas.

9.4. Rezoning

DESCRIPTION

Zoning of land for uses compatible with the flood risk is generally one of the most effective measures for mitigating flood risk for future development. Rezoning can be more complicated for existing development areas, if it becomes apparent that the land use is not compatible with the level of flood risk. This is particularly complex for residential areas, where compensation for existing property owners must be considered.

DISCUSSION

As part of the LEP 2011 revision, several areas of Maitland were rezoned, and the zoning categories were revised. The 2(b) Flood Liable Residential zone, which previously has prevented construction of new dwellings, was removed. Only two urban residential zoning categories were retained – General Residential (R1) and Large Lot Residential (R5).

Under the revised zoning, most of Central Maitland is now comprised of Mixed-Use (B4), Commercial Core (B3), General Residential (R1) and Public Recreation (RE1) land-use areas (see Figure 4). The zoning facilitates the introduction of new housing stock and increase of population in accordance with the objective of the Central Maitland Structure Plan (Reference 19). Current development controls allow building of new dwellings in the B4 and R1 zones (although single dwellings are not permitted in the B4 zone), provided that habitable floor levels are above the FPL and other structural standards are met.

Land use zoning in Central Maitland is inherently challenging due to several factors including flood risk, heritage, and compatibility of new development with existing. The Mixed-Use B4 zoning presents a reasonable compromise between these constraints and Council's intentions to encourage the development and revitalise the area as expressed in the Central Maitland Structure Plan. This zoning type allows for multiple-dwelling residential development (e.g. townhouses with car parking on the ground floor), residential apartments or mixed-use development such as shop-top housing, which would allow for habitable rooms to be placed above the FPL.

In the areas where existing ground levels are below the 1% AEP level, rezoning of flood liable land for higher density development could encourage people to purchase and demolish existing flood liable property and redevelop the area in accordance with Council's flood related development controls. There is already evidence of the B4 rezoning producing this outcome in Central Maitland.

The two main R1 residential areas are Horseshoe Bend and the area bounded approximately by Ken Tubman Drive, Victoria / Bulwer / Elgin Streets, and Athel Dombrain Drive. The R1 residential zoned area of Horseshoe Bend contains primarily existing housing stock built prior to 1955. Under current floodplain management practices, the flood risk would be incompatible with this area being newly zoned as R1 residential. Since 1955, the objective of development controls at Maitland has been to not allow replacement of housing stock in the high flood hazard areas of Horseshoe Bend and South/Central Maitland. These policies have reduced the urban residential population of these areas and reduced the risk of flood damages in this area, although there have been negative consequences associated with this withdrawal, as identified in Reference 19.

From a floodplain risk management perspective, allowing new residential-only development in high flood hazard areas is generally undesirable, although mixed use and raised higher-density dwellings as encouraged by the B4 zoning are preferable to the existing low-standing housing stock, as long as the structures are designed in accordance with the flood risk. However, rezoning of these localised areas away from R1 (residential only) purposes is unlikely to be practical.

Current community perceptions tend to underestimate the flood risk (see newspaper article in Photo 8, which demonstrates some dubious community understanding of the 1955 flood event), as most current residents of Central Maitland have not experienced inundation of their properties. These perceptions are strengthened by factors such as relatively cheap land values, and widespread appreciation of the risk is unlikely to increase until severe flooding occurs.

These considerations create a conundrum for areas like Horseshoe Bend, where the type of building required to be commensurate with the flood risk may not match the preferences of developers. As highlighted in the article (Photo 8 - below), the difficulties and expense of constructing habitable floor levels above the FPL will discourage new lower-density residential development in areas where the FPL is more than 1.5 m above existing ground levels. Furthermore, there are a number of new release lots suitable for development currently available in flood-free areas of Rutherford, Anambah, East Maitland and Tenambit, and these lots are likely to prove more attractive to developers than sites with existing flood problems. The cost to purchase the existing land, demolish and redevelop can make this measure less financially favourable than alternatives. The increase in new development as a result of the 2011 rezoning (to R1 General Residential) of Horseshoe Bend may therefore be muted.

Photo 8: Maitland Mercury Newspaper Article from 11th January 2013

Hands tied needlessly, says would be developer

HORSESHOE BEND

SAM NORRIS

With families struggling to find homes in Maitland some of the city's prime real estate is being used as horse yards.

Real estate agents have sold and resold vacant central Maitland and Horseshoe Bend lots to hopeful investors since 1955 but many remain bare despite recent zoning changes.

Central Maitland landholder and would-be developer Margaret Ettershank said Maitland City Council had needlessly stalled development because of a "man made flood".

"The 1955 flood was an 'unnatural disaster' with the opening of the flood gates [of the Glenbawn Dam that was under construction] at the wrong time," she said.

"There weren't any issues in 2007 and with all the work they've done since '55 the risk is a lot less."

Ms Ettershank said she was given false hope when her property was rezoned as a result of the Maitland local environment plan 2011 that lifted the old flood constrained zoning from large parts of Horseshoe Bend and her property behind the Mount View playing fields.

Council urban growth manager Ian Shillington said there was no reason properly planned homes couldn't be built.

"There could be any number of market reasons and perceived constraints why those areas haven't gone ahead," he said.

"The previous zone was earmarked flood constrained [and] other areas were probably more desirable for that reason."

Not withstanding development controls that set out minimum floor heights to keep residents dry in a one-in-100 year event – just over 11 metres of water at Belmore Bridge – Mr Shillington said Maitland was now zoned to grow.

"We're trying to stimulate a market that has been dormant for some time," he said.

Council assets manager Chris McGrath said history showed that Maitland must be careful, pointing to the town's biggest flood at 12 metres in January 1820.

"You only have to look at the Queensland planning approach that was relatively blase that led to a massive bill to taxpayers and hikes to insurance premiums," he said.

"There is a tendency of residents to take an out of site out of mind attitude but Maitland council takes a responsible approach and adheres to state guidelines."

Ms Ettershank looked at other options including temporary accommodation on two lots adjoining her home measuring 1600sq m in total.

Even a manufactured home, trucked to site, would need a development application she was told – a stipulation she baulked at.

"I don't want to spend hundreds if not thousands for them to tell me that I can't do it," she said.

The future zoning of high hazard flood liable R1 residential areas in Central Maitland and Horseshoe Bend is likely to come under scrutiny when these areas are next flooded. A flood large enough to overtop the Maitland Ring Levee would be likely to damage a significant proportion of the existing housing stock beyond repair. If this scenario were to occur within the next decade, the community may support widespread rezoning away from residential uses, possibly augmented by other measures such as voluntary purchase.

ACTIONS

The 2011 rezoning of Central Maitland contains widespread use of the B4 zoning and some R1 areas, to facilitate new development in accordance with the Structure Plan. While the zoning of high flood hazard areas as R1 residential-only uses is not optimal, other zonings are impractical given the amount of existing housing stock (mostly pre-1950s) in such areas. It will be important that flood-related development controls still be applied to ensure that new development is appropriately resilient to the flood risk.

9.5. Voluntary Purchase

Parts of Maitland including Central Maitland and Horseshoe Bend are covered by an existing voluntary purchase scheme. Applications must be made on a case-by-case basis. Very few properties have been acquired under the scheme during the period of its implementation. Voluntary purchase of all the residential buildings inundated above floor level in the 1% AEP flood (say $500,000 per building) cannot be economically or socially justified due to the large number of buildings affected. Generally, Government funding is only available for voluntary purchase of buildings that are frequently flooded in a high hazard area.

OEH informed WMAwater that the primary purpose of the scheme was to remove existing structures from the floodways and improve the hydraulic conveyance of the floodways, potentially reducing flood levels for adjacent properties. The reduction in flood damages and risk by removing properties from high hazard areas was seen as a secondary benefit, and other houses in high hazard areas (but not floodways) were not included in the scheme. At the time of writing, OEH is undertaking a review of the scheme to assess the hydraulic benefits of removing the structures, and determine whether it would make a significant difference to flood heights. It is expected that if modelling shows no significant difference in flood heights then the program will be terminated.

Voluntary purchase schemes for areas protected by levees have similar limitations to those relating to rezoning (previous section). Owners of buildings where there is a strong economic justification for voluntary purchase often elect not to sell because:

- If the property is owner-occupied, the relatively low value of the property results in the resident being unable to find equivalent flood-free properties at a comparable price; or
- If the property is leased, the majority of contents damages are borne by the tenant, who may subsequently move. Provided there is no major structural damage, new tenants can be found. The landlord may value the ongoing rental income from the property higher than the amount obtained from a voluntary purchase scheme, particularly if capital values recover in the period between floods.

The above factors are particularly relevant for low-lying areas protected by levees, where inundation does not occur in minor to moderate floods (so the period between inundation events is relatively long), but the damages incurred in major floods are high.

ACTIONS

Council and OEH should review the existing voluntary purchase scheme in light of land rezoning implemented via the 2011 LEP. It may be worthwhile retaining the scheme on a case-by-case basis for highly vulnerable properties (taking into consideration factors such as isolation, hazard and frequency of flooding). However uptake is likely to remain low unless there is a shift in community perception of flood risk.

9.6. Importation of Fill

Filling of flood liable land for development is a method of reducing damages by raising development above a design flood level to prevent inundation. The approach is similar to house-raising, except it has the potential to cause adverse impacts on flood levels in neighbouring properties, as the floodwaters that are displaced by the fill will generally increase inundation depths in the vicinity of the filling. These impacts can be negated if fill is obtained from nearby in the floodplain (i.e. there is no importation of fill from external sources).

On very large floodplains, significant amounts of fill can often be imported without producing notable impacts, although there is a point at which the cumulative filling will produce adverse consequences. Impacts resulting from cumulative fill scenarios can be readily assessed using available hydraulic models, but there are administrative challenges for Councils to keep track of imported fill over time.

There is merit in assessing the sensitivity of Hunter River flood levels in Maitland to filling of flood storage areas. Current Maitland City development controls require a DA to be submitted for any importation of fill, and Council will often require hydraulic modelling of impacts to be undertaken in support of the DA. Assessment of cumulative fill scenarios as part of this study may provide Council with sufficient information to set thresholds for:

- filling that can be undertaken without a DA; and/or
- filling that requires a DA but not a hydraulic modelling assessment.

The following scenarios were initially assessed by hydraulic modelling to provide some context about likely cumulative impacts for different hypothetical scenarios:

A) Complete filling of all flood fringe areas (see Figure F3 for the modelled fill extents and depths);
B) Filling of 10% of flood storage areas, up to a maximum of 10,000 m^3 per individual cadastre lot (see Figure F5 for the modelled fill extents and depths); and
C) Filling of areas zoned R1 general residential to the 1% AEP flood level (see Figure F7 for the modelled fill extents and depths).

In each case, ground levels in the model were adjusted to reflect the fill scenario, and the change in peak flood levels for the 1% AEP flood event was calculated. The impacts for options A, B and C are shown on Figure F4, Figure F6, and Figure F8 respectively.

The modelling indicates that filling of all flood fringe areas would result in significant impacts of approximately 0.06 m across the Bolwarra and Kings Island areas, 0.03 m in Wentworth Swamp and Louth Park, and localised impacts of up to 0.5 m to some properties in Raworth. These relatively large localised impacts are due to the changes in flow distribution from filling some large areas by up to 1.5 m (the threshold for distinguishing flood fringe from flood storage).

Filling of 10% of all flood storage areas would increase 1% AEP flood levels throughout the areas between Wentworth Swamp and Pitnacree by 0.03 m (30 mm). It should be recognised that realisation of this scenario would require importation of over 4,400,000 m^3 of fill, which is likely to exceed the demand or requirements of the relevant landholders. In light of this consideration the impact is considered relatively benign, and the results indicate that considerable filling of flood storage areas can be accommodated without causing significant impacts on peak flood levels.

Modelling of Scenario C, total filling of areas currently zoned R1 residential in Central Maitland (including Horseshoe Bend), results in impacts of less than 0.01 m across the study area. This impact is not considered significant.

These scenarios indicate that it may be appropriate to remove the requirement for hydraulic modelling in support of individual development applications, for example under the following conditions:

- Filling of flood storage areas (up to say 7,000 m^3 per lot) associated with construction of a dwelling in Rural zones, where construction of a new dwelling is otherwise permitted in line with other requirements (such as evacuation) in flood liable areas.
- Filling of flood storage areas (up to say 3,000 m^3 per lot) associated with construction of a mound to provide refuge for stock during floods, or to provide storage for plant/machinery for example.
- Filling of lots to the 1% AEP flood level for the purposes of dwelling construction in lots currently zoned R1 General Residential.

Introduction of such allowances may reduce cost burdens associated with DA submission for filling, and result in improved flood risk management outcomes, due to lower damages to property and loss of stock. If implemented, the cumulative effects of filling must be monitored by Council (i.e. collected in a database), to provide equitable outcomes for all landowners and avoid a “first come, first served” mentality.

Based on the above analysis, Council included proposed revisions to allow limited filling of flood storage areas under certain circumstances in the draft DCP that was publically exhibited in late 2014. Newcastle City Council made a submission identifying that the filling allowed by these provisions was not specifically modelled as part of the initial fill scenarios. WMAwater therefore updated the modelling to include a scenario reflecting the proposed DCP provisions, if they were to be cumulatively implemented for every lot within the LGA. . The impacts from this scenario are presented in Figure F9.

The results indicate that even with full filling up to the maximum DCP eligibility criteria for every lot within the LGA (which is unlikely to occur, and would probably take decades to complete), the impacts are relatively minor, and are largely confined to the storage areas of Wallis and Swamp Creek. Importantly, the changes to flood levels and velocities would not extend beyond the LGA boundaries into neighbouring jurisdictions.

ACTIONS

Council should establish a database of imported fill to floodplain areas. Council should consider revising the DCP to allow moderate importation of fill without requiring hydraulic modelling in support of the DA, under certain circumstances.

10. SUMMARY

10.1. Flood Risk Management Measures

The identified measures were assessed based on impacts on flood levels, reduction in property damage, feasibility, social impacts, environmental impacts, economic impacts and the long term performance given likely impacts of climate change. A score for each of the management options was determined using the criteria matrix described in Table 20 . The outcomes of this assessment are presented in Table 21.

Table 20: Evaluation Criteria for Flood Risk Mitigation Measures

Category	-3	-2	-1	0	1	2	3
Impact on Flood Behaviour	>100mm increase	50 to 100mm increase	<50mm increase	Mixed impact / no change	<50mm decrease	50 to 100mm decrease	>100mm decrease
Number of Properties Benefited	>10 adversely affected	5 to 10 adversely affected	<5 adversely affected	none	<5	5 to 10	>10
Technical Feasibility	n/a	major issues	moderate issues	minor issues	no issues	n/a	n/a
Community Acceptance	majority opposition	moderate opposition	minor opposition	Neutral or mixed	minor support	moderate support	majority support
Economic Merits (Benefit/Cost)	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Financial Feasibility	n/a	very high cost	high cost	medium cost	low cost	very low cost	n/a
Environmental and Ecological Benefits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Impacts on Evacuation	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 Effectiveness	major disbenefit	moderate disbenefit	minor disbenefit	neutral	moderate	good	excellent
Risk to Life	major increase	moderate increase	minor increase	neutral	minor benefit	moderate benefit	major benefit

Table 21: Summary Assessment of Identified Floodplain Management Measures

Measure	Score										
	Impact on Flood Behaviour	Number of Properties Benefited	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental and Ecological Benefits	Impacts on Evacuation	Political/ administrative Issues	Long Term Effectiveness	Risk to Life	TOTAL
FLOOD MODIFICATION MEASURES:												
Sharkies Lane Levee	0	3	0	1	0	0	0	0	0	1	0	**5**
Private Trzecinski Bridge Levee	0	0	1	1	2	2	0	0	0	1	0	**7**
Oakhampton Floodway Levee	-2	3	-1	1	0	0	0	0	0	1	0	**2**
Maitland Ring Levee Upgrade	-1	3	-1	1	0	0	0	0	0	1	0	**3**
Modify Spillway Levels	-3	0	0	-2	2	1	0	1	0	1	1	**1**
Reinforce Oakhampton Road Control	0	2	0	1	1	2	0	1	0	1	1	**9**
PROPERTY MODIFICATION MEASURES:												
House Raising / Flood Proofing / Amphibious Housing	-	3	-1	-1	1	1	0	1	0	1	1	**4**
Voluntary Purchase	-	3	-	-1	-1	-1	0	1	-1	2	1	**3**
Rezoning	-	3	-	-3	0	2	0	2	-1	3	2	**8**
Development Control Planning and Flood Planning Levels	-	3	1	-1	2	2	0	1	0	3	1	**11**
RESPONSE MODIFICATION MEASURES:												
Upgrade evacuation route (existing Long Bridge)*	-	3	0	1	0	-1	0	1	-*	3	1	**8**
Upgrade evacuation route (realigned Long Bridge)*	-	3	-1	1	0	-2	0	3	-*	3	3	**10**
Flood Warning and Evacuation Planning	-	3	1	2	1	2	0	2	0	2	1	**14**
Public Information and Raising Flood Awareness	0	3	n/a	2	1	2	0	1	0	2	1	**12**

* Requires joint initiative by Maitland City Council and Roads and Maritime Services

NOTE: where the impact of a measure is not readily quantifiable, or is highly variable as it depends on case-by-case details, a neutral (-) score is assigned.

10.2. Climate Change

The potential impact of increased design flood levels in the catchment due to climate change is discussed in Section 5.4. Modelling indicates that increases to rainfall intensity would have more impact on Hunter River flood levels than sea level rise. Mapping of hazard and hydraulic categories for the 1% AEP event with various increased rainfall intensity scenarios is shown in Appendix D.

As discussed in Section 5.3, projections of rainfall changes involve far more uncertainty than those for sea level rise, and there is additional uncertainty about whether additional rainfall would result in greater runoff for large catchments like the Hunter River, given the likelihood of generally drier catchment conditions.

The most significant change in flood behaviour for the 1% AEP event with increased runoff is the formation of a flood runner through the Rutherford area near Maitland Airport, flowing through to Wentworth Swamp.

ACTIONS

There is insufficient certainty surrounding rainfall increases from climate change to warrant changes to development control policies in Maitland at this stage. Council should continue to monitor the available literature and reassess Council's LEP and DCP as appropriate.

At a minimum Council should obtain the most current information available from the BOM, CSIRO and OEH every two years, and review development control and land-use zoning in affected areas if required.

11. PUBLIC EXHIBITION OF REPORT

A draft version of this report was placed on public exhibition for a period of 11 weeks from 12th November 2014 until 30th January 2015. Copies of the report were placed in Council offices and libraries, and made available online from Council's website, and announcements were made through local media outlets encouraging feedback about the report.

During the exhibition period, three two-hour public information sessions were held at Maitland Town Hall on 4th December, 2014. The sessions commenced at 11am, 2pm and 6pm. Several written submissions were received by members of the public who attended these sessions.

The exhibition of this FRMS&P report coincided with Council's public exhibition of proposed changes to the Maitland LEP and DCP. The proposed LEP included updated flood mapping based on the outcomes of this study. The proposed DCP included a revised chapter on floodplain management, which was one of the recommended outcomes of this FRMS&P.

The written submissions to the public exhibition process are included in Appendix G. The submissions include comments on both the FRMS&P prepared by WMAwater as well as the proposed LEP and DCP amendments prepared by Maitland City Council.

One major point of contention amongst the community and other stakeholders was the proposed DCP provision to allow new two-storey development to have habitable rooms below the Flood Planning Level under certain circumstances. This provision was strongly opposed by several community members, as well as the SES and the NSW Office of Environment and Heritage. WMAwater also did not agree with this provision, and advised Council that it did not meet the requirements of the NSW Floodplain Development Manual for managing flood risk (in WMAwater's view).

The Floodplain Management Committee discussed this issue, and adopted the following resolution as its formal position:

> *The Committee notes the submissions received by Council on the proposed provision in the MDCP 2011 Floodplain Management that would allow up to 50% habitable floorspace on the ground floor for dwellings located on land below the Flood Planning Level (FPL). Based on the submissions and Council's analysis of the potential planning implications of the proposed provisions, the Committee supports the removal of this provision from the draft DCP to be considered by Council. The Committee supports further amendments being considered for the DCP that provides further design guidance on suitable residential types in Central Maitland that meet the FPL for habitable uses.*

There were no significant revisions or updates to the Floodplain Risk Management Plan arising from the exhibition period and submission process. The most significant revision to the Floodplain Risk Management Study was the inclusion of additional modelling of potential impacts from cumulative filling of flood storage areas, in response to the submission received from Newcastle City Council (see Section 9.6 for details).

12. HUNTER RIVER FLOODPLAIN RISK MANAGEMENT PLAN

12.1. Introduction

The Hunter River Floodplain Risk Management Plan has been prepared in accordance with the NSW Floodplain Development Manual (Reference 1). The Plan:

- *Is based on a comprehensive and detailed evaluation of factors that affect and are affected by the use of flood prone land;*
- *Represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land; and*
- *Provides a long-term path for the future development of the community.*

12.2. Risk Management Measures Considered

A matrix of possible management measures was prepared and evaluated taking into account a range of parameters. This process eliminated a number of flood risk management measures (refer to Section 6.4) including:

- Flood mitigation dams on the basis of high cost, large footprint, and environmental impact;
- Retarding basins and on-site detention on the basis that they are not large enough to influence Hunter River flooding;
- Major channel engineering works and flow path diversions on the basis of high cost, environmental impact, and potential adverse flood impacts downstream;
- Voluntary purchase of all flood liable buildings due to a very poor benefit/cost ratio and lack of community support,
- Flood insurance, which is a means of re-distributing flood damages rather than mitigating them.

Other measures were evaluated in detail from Section 7 to Section 9, and the outcomes are summarised in Table 22 on the following page.

Table 22: Summary of Measures Investigated in Floodplain Risk Management Study

MEASURE	PURPOSE	COMMENT
FLOOD MODIFICATION:		
LEVEES, SPILLWAYS, and EMBANKMENTS (Section 8)	To prevent inundation up to a given design protection level.	A range of options were reviewed. It is recommended to: • Complete an audit of existing levees to determine construction quality and crest levels. • Construct a levee at the Private Trzecinski Bridge to match the Fishery Creek protection level against flooding of the New England Highway; • Upgrade the Oakhampton Road control embankment to reduce likelihood of failure (as occurred in 1977 and 2007).
PROPERTY MODIFICATION:		
HOUSE RAISING (Section 9.2)	Prevent flooding of existing buildings by raising the floor level above the floodwaters.	All flood damages will not be prevented. Only suitable for non-brick buildings on piers. The cost is approximately $60,000 to $80,000 per house, but can vary considerably and is unlikely to be cost effective for many properties in Maitland. Only suitable for a small number of buildings and not attractive to all residents.
FLOOD PROOFING (Section 9.2)	Prevent flooding of existing buildings by sealing all the entry points.	Generally only suitable for brick, slab on ground buildings, that experience relatively shallow inundation. Less viable for residential buildings. Good for protecting the foundations of raised buildings from damage.
AMPHIBIOUS HOUSING (Section 9.3)	Prevent flooding above floor level by allowing building to float, like a pontoon.	Relatively new concept that has been implemented in the Netherlands and United Kingdom. May be suitable for new residential development where fixed raised construction is untenable.
DEVELOPMENT CONTROL PLANNING AND FLOOD PLANNING LEVELS (Section 9.1)	Prevent new development or renovation that is inconsistent with the flood risk of the land.	While existing development control policies are reasonably comprehensive, Council should review and revise the LEP and DCP to improve clarity and address some inconsistencies. FPLs should be reviewed to consider inclusion of extreme events for critical public infrastructure and emergency management. Provision of flood-related information on the Section 149(5) Certificate should be considered.
RESPONSE MODIFICATION:		
FLOOD WARNING AND EVACUATION PLANNING (Section 7.3)	Enable people to prepare and evacuate, to reduce damages to property and injury to persons.	System currently in place but it is based largely on regional catchment data. Given the size of population affected, and the need to evacuate early, opportunities should be explored to use recent modelling methodologies to improve the reliability of flood forecasting. Review of the Local Flood Plan should ensure that all up to date information is incorporated, including recent design flood information, and new residential development in Rutherford.
UPGRADE EVACUATION ROUTES (Section 7.2)	To improve evacuation for floods larger than the 5% AEP	Required to mitigate the increased risk to life resulting from new residential development in Central Maitland and Lorn under the Structure Plan. The most effective route appears to be a modified or re-aligned Long Bridge (Route 1, 2 or 3 – Figure 13).
PUBLIC INFORMATION AND RAISING FLOOD AWARENESS (Section 7.4)	Educate people to prepare themselves and their properties for floods, to minimise flood damages and reduce the risk.	A cheap and effective method of reducing flood damages which requires continued effort. Current educational programs implemented by the CMA and SES are working effectively. Measures have been identified that Council can implement to complement existing programs.

12.3. Floodplain Risk Management Measures in Plan

The recommended measures are as follows (in no particular order within each priority group).

HIGH Priority

1. Review and revise the DCP and LEP to reflect updated design flood modelling, address flood events greater than the 1% AEP event, and improve clarity with consideration of the following issues:
    - Mapping in the LEP should be revised to reflect current flood modelling from the 2010 Flood Study. The current mapping is stated as showing the extent of the Flood Planning Area (land below the 1% AEP + 0.5 m flood level), but the provided maps are actually estimates of the 1% AEP and 1955 flood extents based on outdated information.
    - Land inundated in the PMF event should be identified.
    - Terminology should be revised to be consistent between the two documents, and with the Floodplain Development Manual to increase clarity of the policies. For example, terms such as Design Floor Level and Flood Planning Level are currently used interchangeably.
    - Council should consider specifying default FPLs for Commercial and Industrial development, with deviations from this default to be allowable on a merits-based approach. Currently the DCP does not specify FPL requirements for some types of development.
    - Council should consider restricting certain types of development within the Hunter River PMF extent, such as critical public infrastructure. There are currently no development restrictions for land within the PMF extent that is above the 1% AEP + 0.5 m level.
    - Council should consider providing additional information on Section 149(5) certificates such as design flood levels, floor levels, and flood protection levels provided by levees. Under the EPA Act 1979 Section 149(6), Council would not incur liability in respect of this information being provided in good faith.
    - A DA is required for filling of flood prone land. Council should consider specifying criteria relating to whether flood modelling is required to support a filling application, as moderate levels of filling can be accommodated in some circumstances without requiring a detailed modelling assessment (see Section 9.6). A database should be established to track authorised fill importation.

    - **Cost:** Low
    - **Responsibility:** Maitland City Council and Department of Planning and Environment

2. The Structure Plan reverses previous policies to manage risk to life by reducing population and requires an alternative strategy for management of risk to life, which is best achieved by a higher level evacuation route from Central Maitland. Council to engage with RMS to undertake a detailed feasibility and route selection study for the

construction of a high level evacuation route, providing rising evacuation for Central Maitland and Lorn.

- **Cost:** High
- **Responsibility:** Roads & Maritime Services and Maitland City Council

3. Complete an audit of levees protecting urban areas and major spillways, including geotechnical investigation and survey of crest levels. For planning and development control purposes, formalise the alignment of all levees not currently recognised in the OEH database (such as the Maitland Ring Levee central section). Council to liaise with Public Works and OEH to determine the extent of any previous inspection and maintenance.
    - **Cost:** Low
    - **Responsibility:** Maitland City Council and Office of Environment & Heritage

4. Public Information and Flood Awareness Programs. Council to distribute an SES FloodSafe guide (see Appendix E) to all flood-affected properties, along with local flood risk information for each property (such as floor levels and design flood levels), and information about evacuation routes. Council to erect large road signs on major evacuation routes, indicating the estimated level for selected historical and design flood events.
    - **Cost:** Low
    - **Responsibility:** Hunter Local Land Services, State Emergency Services and Maitland City Council

MEDIUM Priority

1. Undertake a review of the flood warning system for the Hunter River, exploring opportunities for more advanced modelling methodologies, and if necessary update.
    - **Cost:** Low
    - **Responsibility:** Bureau of Meteorology

2. Inform the SES of the outcomes of this Plan and the possible implications for flood evacuation. SES to finalise the update of the Local Flood Plan, and to check that it is consistent with modelling from the 2010 Flood Study (Reference 2).
    - **Cost:** Low
    - **Responsibility:** Maitland City Council and State Emergency Services

3. Undertake a detailed investigation to construct a levee at Fishery Creek in the vicinity of Private Trzecinski Bridge (Figure 15).
    - **Cost:** Low
    - **Responsibility:** Maitland City Council and Roads & Maritime Services

LOW Priority

1. Maintain ongoing community flood awareness program with a focus on evacuation procedures and ensuring personal safety during floods.
   - **Cost:** Low
   - **Responsibility:** Maitland City Council and SES

2. Inform prospective developers of measures such as house raising, flood proofing, voluntary purchase schemes and amphibious housing, and facilitate funding assistance of such measures where appropriate.
   - **Cost:** Low to evaluate. Variable depending on property characteristics
   - **Responsibility:** Maitland City Council, local community, OEH

3. Review and if necessary reinforce Oakhampton Road control embankment to reduce likelihood of failure during overtopping events, as occurred in 1977 and 2007.
   - **Cost:** Moderate
   - **Responsibility:** Maitland City Council, Office of Environment and Heritage and Roads and Maritime Services

13. ACKNOWLEDGEMENTS

This study was carried out by WMAwater (consulting engineers) and funded by Maitland City Council and the NSW Office of Environment and Heritage. The assistance of the following in providing data and guidance is gratefully acknowledged:

- Floodplain Management Committee;
- Maitland City Council;
- Office of Environment and Heritage;
- Maitland and Newcastle SES;
- Hunter-Central River Catchment Management Authority;
- Bureau of Meteorology;
- Roads & Maritime Services; and
- residents of Maitland.

14. REFERENCES

1. NSW Government
   Floodplain Development Manual
   April 2005.

2. WMAwater
   Hunter River (Branxton to Green Rocks) Flood Study
   Maitland City Council, December 2010.

3. Webb Mckeown & Associates
   Hunter River (Oakhampton to Green Rocks) Supplementary Flood Study
   Maitland City Council, 1998.

4. Webb Mckeown & Associates
   Hunter River Floodplain Management Study
   Maitland City Council, 1998.

5. Webb Mckeown & Associates
   City of Maitland – Floodplain Management Plan
   Maitland City Council, 2007.

6. WBM Oceanics
   Singleton Flood Study
   Singleton Shire Council, May 2003.

7. Maitland City Council
   Maitland Local Environment Plan 2011
   http://www.legislation.nsw.gov.au/viewtop/inforce/epi+681+2011+cd+0+N/
   Last Accessed 28 January 2013

8. Maitland City Council
   Hunter River Floodplain Management Development Control Plan No. 29
   August 2000

9. Maitland City Council
   Maitland City Wide Development Control Plan
   December 2011

10. State Emergency Services
    NSW State Flood Plan
    June 2008

11. State Emergency Services
    Maitland City Local Flood Plan
    June 2013

12. Cardno
Long Bridge Maitland – Flood Stability Structural Assessment
March 2009.

13. Public Works Department NSW
Lower Hunter River Floodplain Atlas
Second Edition, November 1983.

14. Sinclair Knight & Partners Pty Ltd
Hunter Valley Floodplain Management Study
March 1981.

15. Public Works Department NSW
Hunter Valley Flood Mitigation – Central Maitland Land Use Study
December1982.

16. Maitland City Council
Central Maitland Development Control Plan No. 8
June 1986.

17. Maitland City Council
Local Environment Plan 1993 (Repealed)
http://www.legislation.nsw.gov.au/viewtop/inforce/epi+465+1993+cd+0+Y/
Accessed 28 January 2013.

18. Maitland City Council
Maitland Urban Settlement Strategy
2000.

19. City Plan Urban Design
Central Maitland Structure Plan
Maitland City Council, November 2009.

20. Hunter-Central Rivers Catchment Management Authority
Hunter-Central Rivers Catchment Action Plan

21. New South Wales Government
Flood Risk Management Guideline – Flood Emergency Response Planning Classification of Communities
October 2007

22. Cessnock City Council
Flooding in June 2007
Hunter Community Recovery Fund, September 2008.

23. Chas Keys
Making Communities Safer in Times of Flood
Floodplain Management Authorities, 2008

24. WMAwater
Review of Branxton Flood Levels
Cessnock City Council, December 2013

25. New South Wales Government
NSW Sea Level Rise Policy Statement
October 2009

26. New South Wales Government
Practical Consideration of Climate Change – Floodplain Risk Management Guideline
New South Wales Government, 2007.

27. New South Wales Government
Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments
October 2009

28. New South Wwales Government
Coastal Protection Amendment Act 2012 No. 71
http://www.legislation.nsw.gov.au/maintop/view/inforce/act+71+2012+cd+0+N
Accessed 28 January 2013.

29. Westra, S., Varley, I., Jordan, P. W., Hill, P. I., Ladson, A. R.
Recent Developments in Climate Science: Implications for Flood Guidelines
Proc. Joint NSW and Victorian Flood Management Conference, February 2009

30. WMAwater
Kempsey-Frederickton Bypass – Flood Impact Assessment
Kempsey Bypass Alliance, November 2012.

Figures

Appendix A

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

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

floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.

habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

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

mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to Awater level@. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

APPENDIX B: HISTORICAL NEWSPAPER ARCHIVES

APPENDIX C: Historical Flood Photographs

Appendix C

APPENDIX D: Climate Change Scenario Mapping

Appendix D

APPENDIX E: Maitland FloodSafe Guide

Appendix E

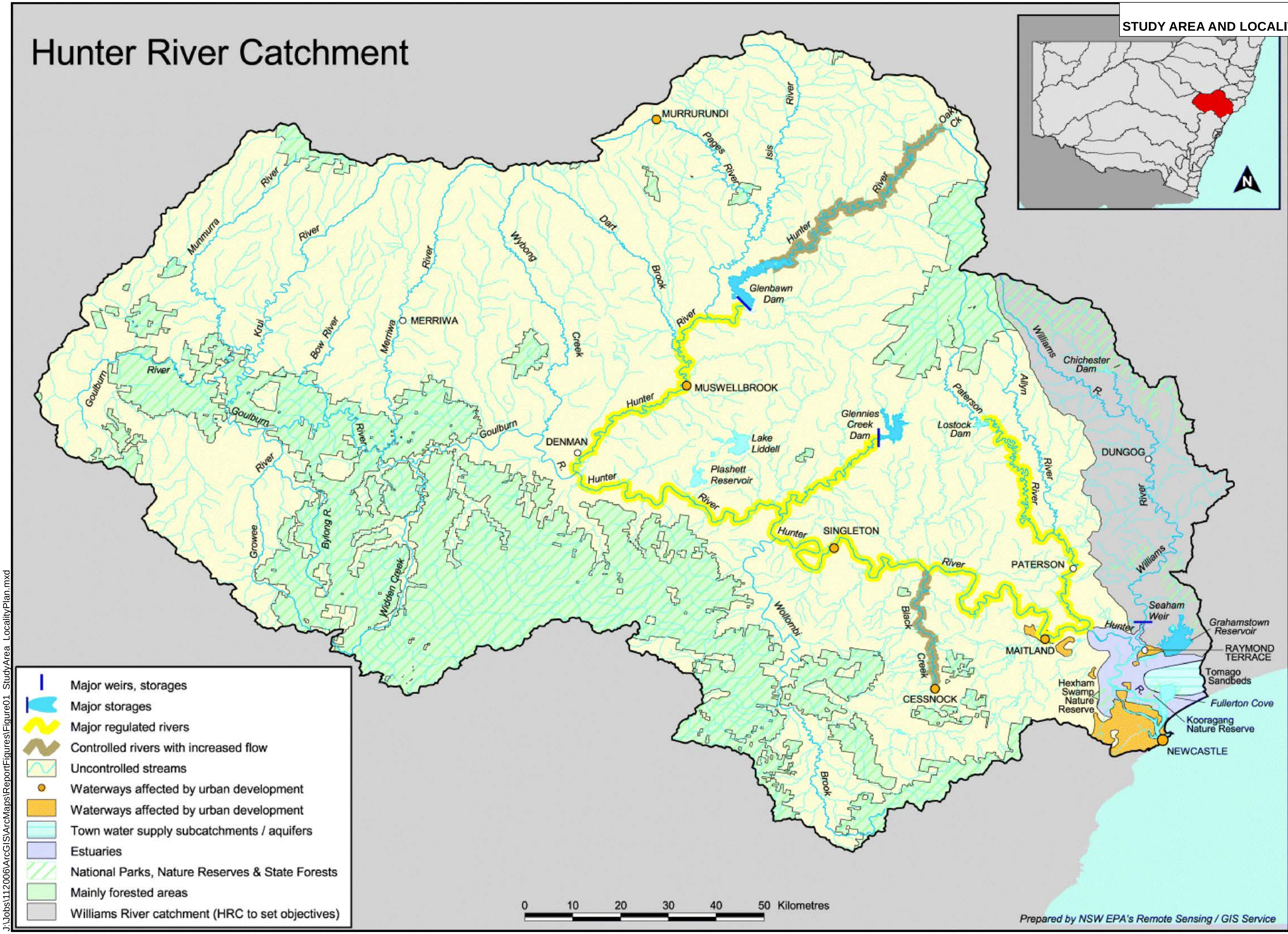
APPENDIX F: Hydraulic Impacts of Mitigation Measures

Appendix F

APPENDIX G: Public Exhibition Submissions

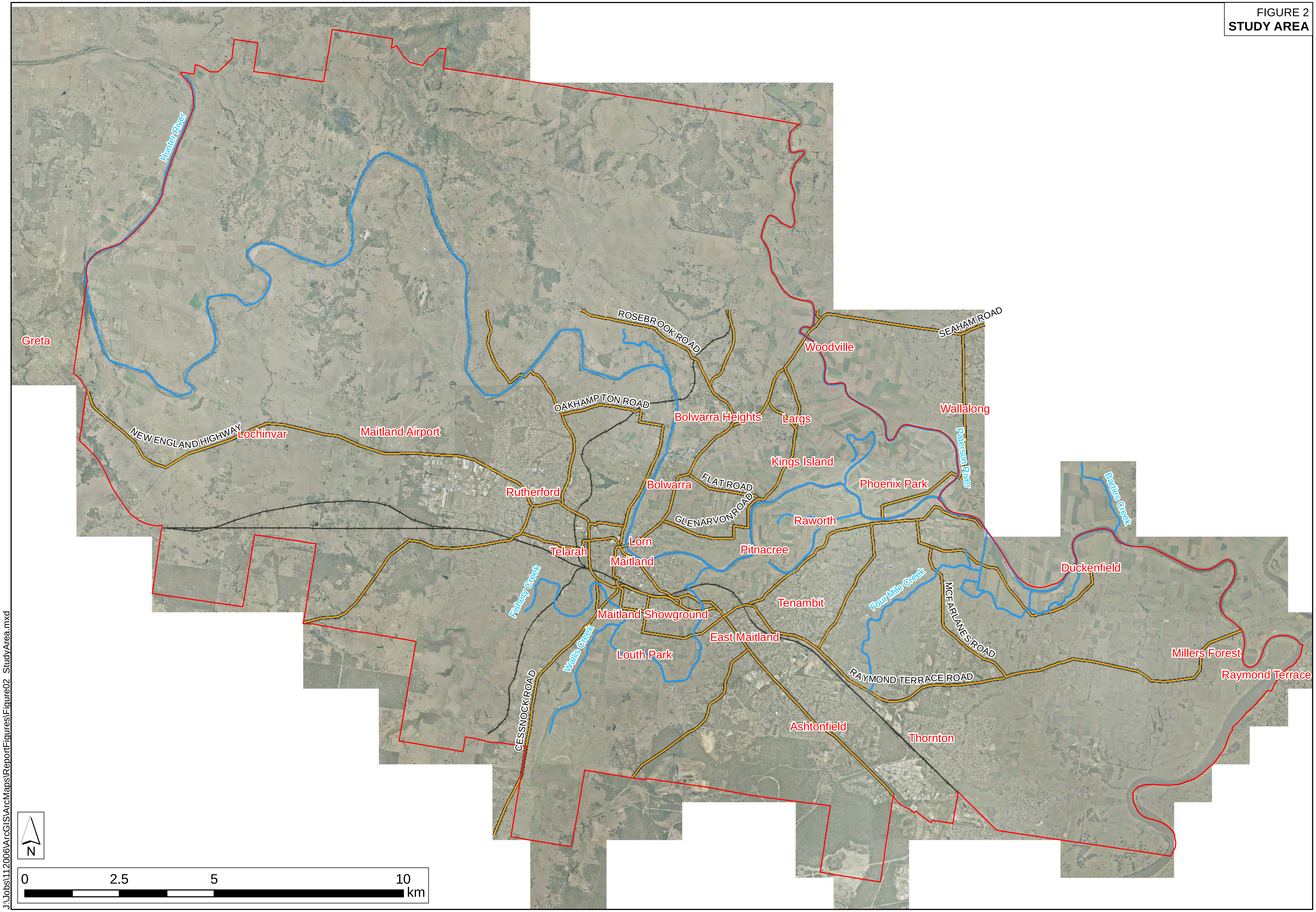
Appendix G

FIGURE 1
STUDY AREA AND LOCALITY PLAN



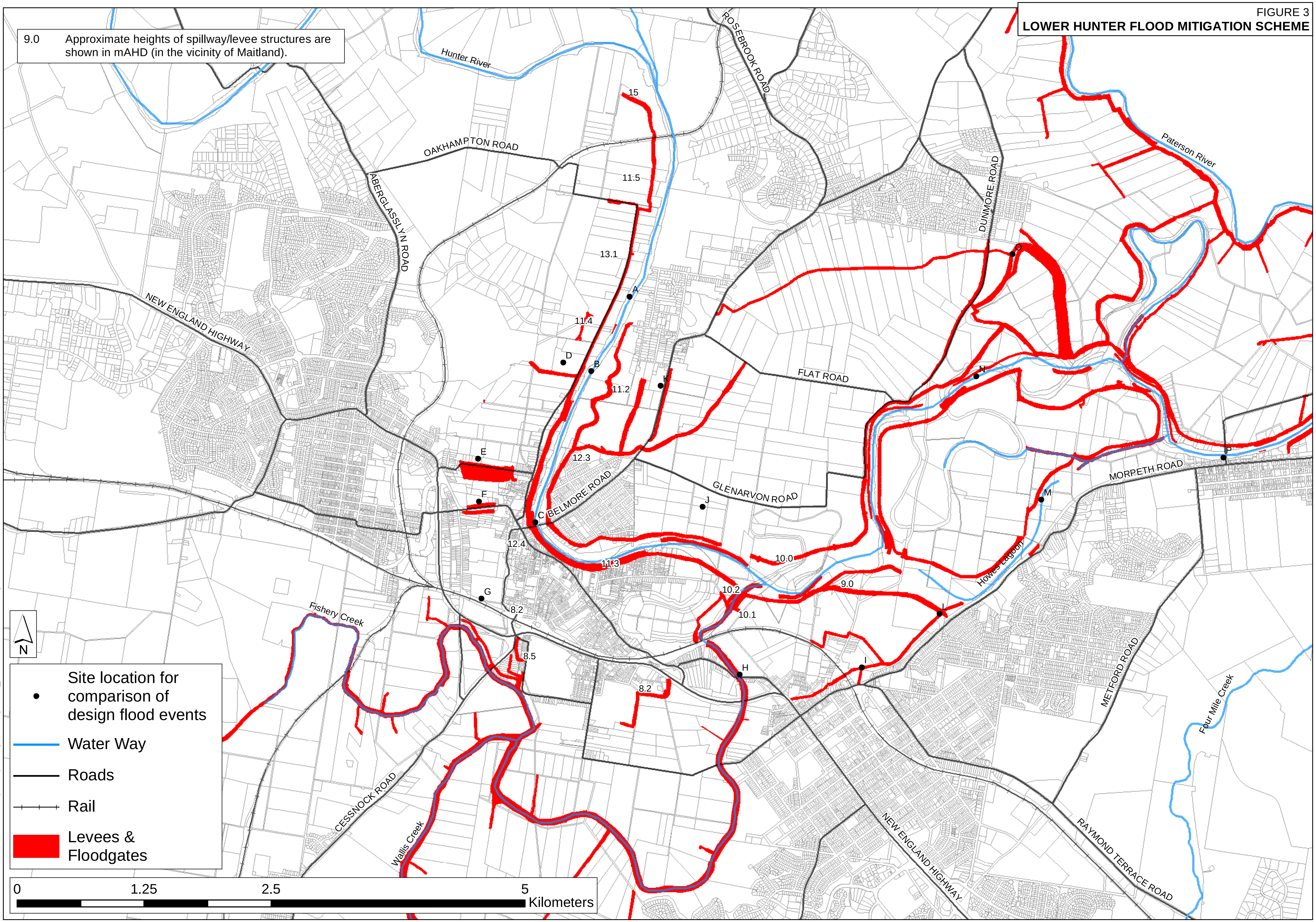
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure01_StudyArea_LocalityPlan.mxd

FIGURE 2
STUDY AREA



J:\Jobs\112006\ArcGIS\ArcMaps\Report\Figures\Figure02_StudyArea.mxd

FIGURE 3
LOWER HUNTER FLOOD MITIGATION SCHEME



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure03_LowerHunterFloodMitigationScheme.mxd

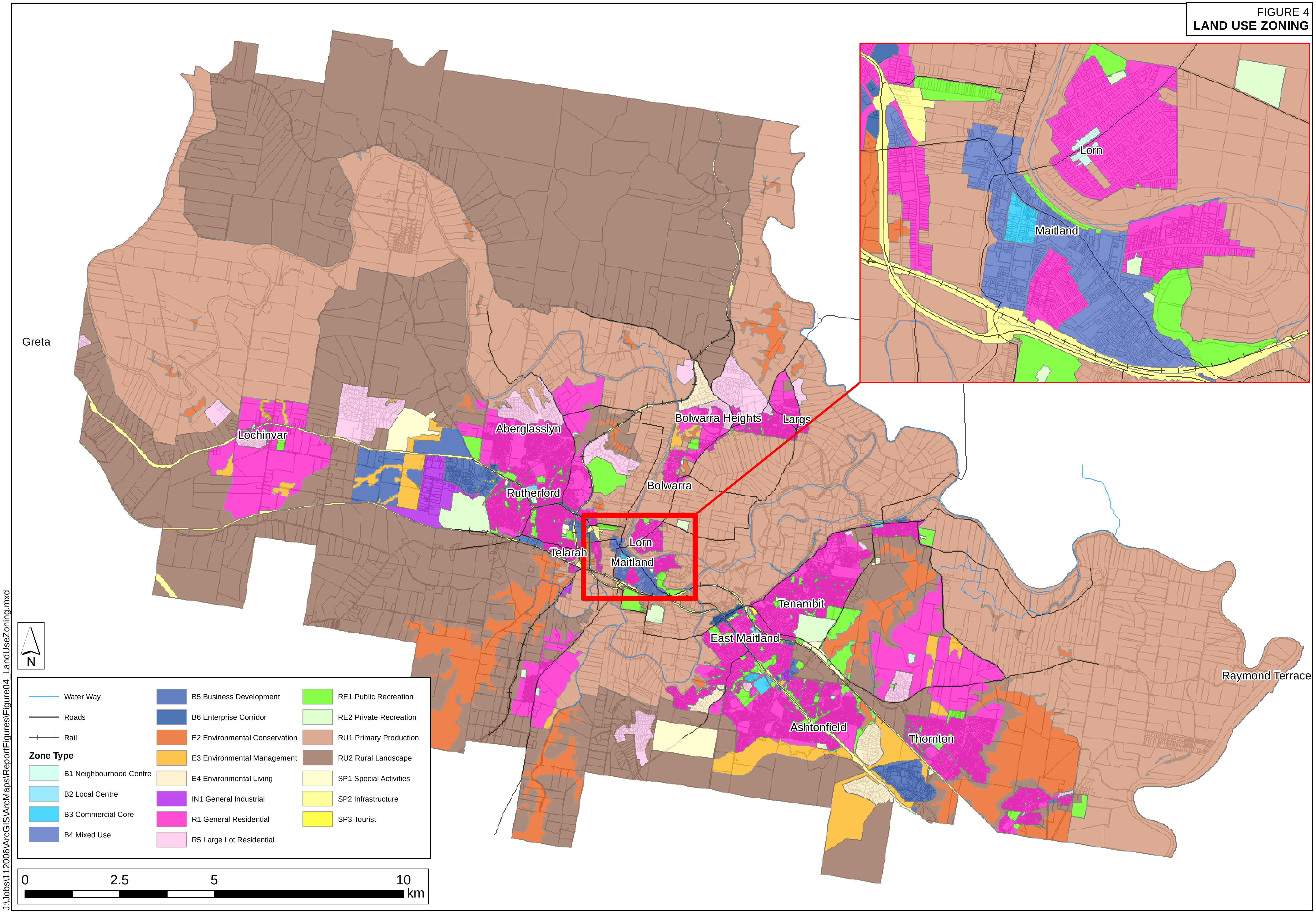
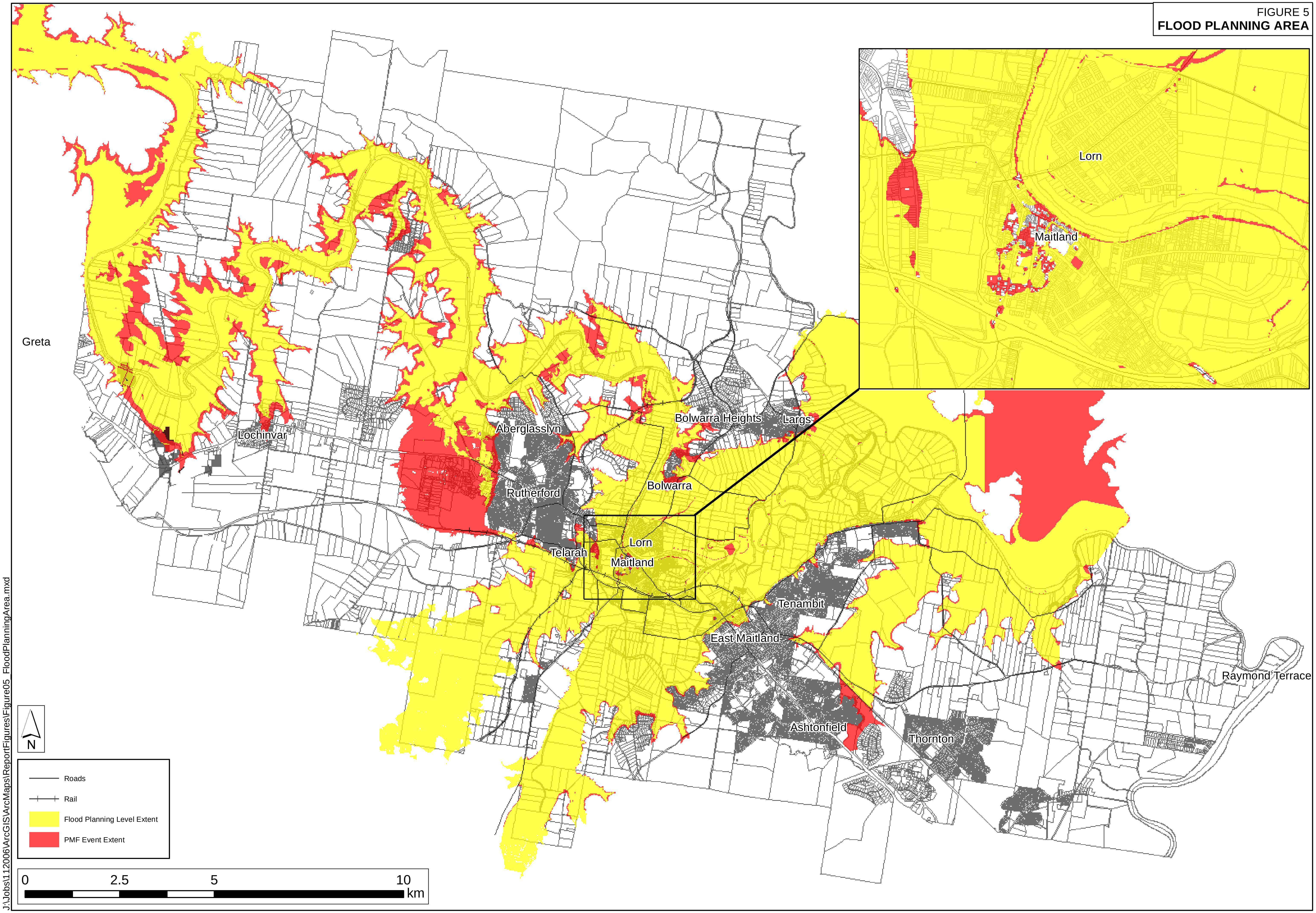


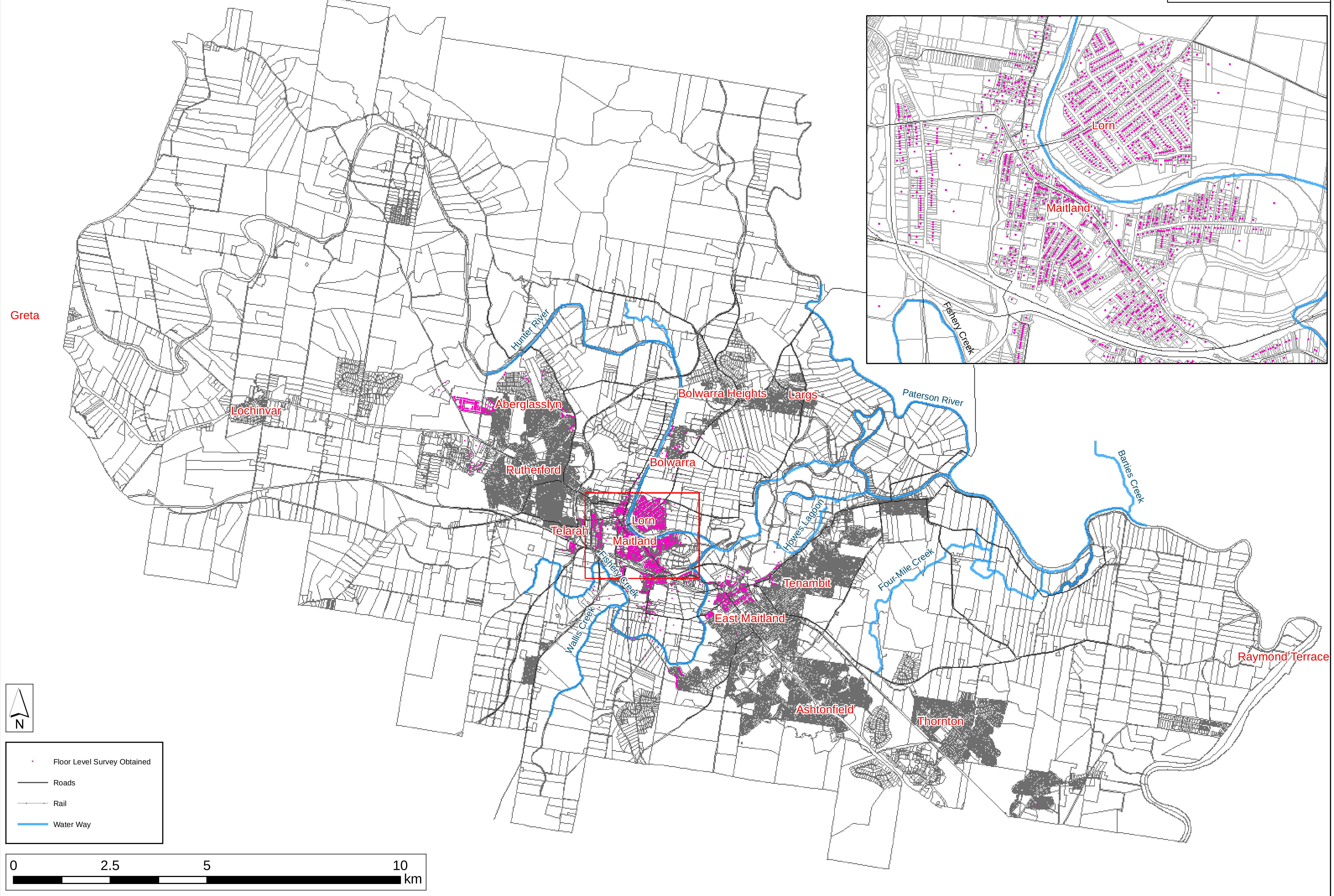
FIGURE 4
LAND USE ZONING
Greta
Lochinvar
Aberglasslyn
Rutherford
Telarah
Lorn
Maitland
Bolwarra
Bolwarra Heights
Largs
Tenambit
East Maitland
Ashtonfield
Thornton
Raymond Terrace
Water Way
Roads
Rail
Zone Type
B1 Neighbourhood Centre
B2 Local Centre
B3 Commercial Core
B4 Mixed Use
B5 Business Development
B6 Enterprise Corridor
E2 Environmental Conservation
E3 Environmental Management
E4 Environmental Living
IN1 General Industrial
R1 General Residential
R5 Large Lot Residential
RE1 Public Recreation
RE2 Private Recreation
RU1 Primary Production
RU2 Rural Landscape
SP1 Special Activities
SP2 Infrastructure
SP3 Tourist
0
2.5
5
10
km
N
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure04_LandUseZoning.mxd

FIGURE 5
FLOOD PLANNING AREA



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure05_FloodPlanningArea.mxd

FIGURE 6
FLOOR LEVEL SURVEY



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure06_FloorLevelSurvey.mxd

FIGURE 7
TRUE HYDRAULIC HAZARD
100Y ARI EVENT

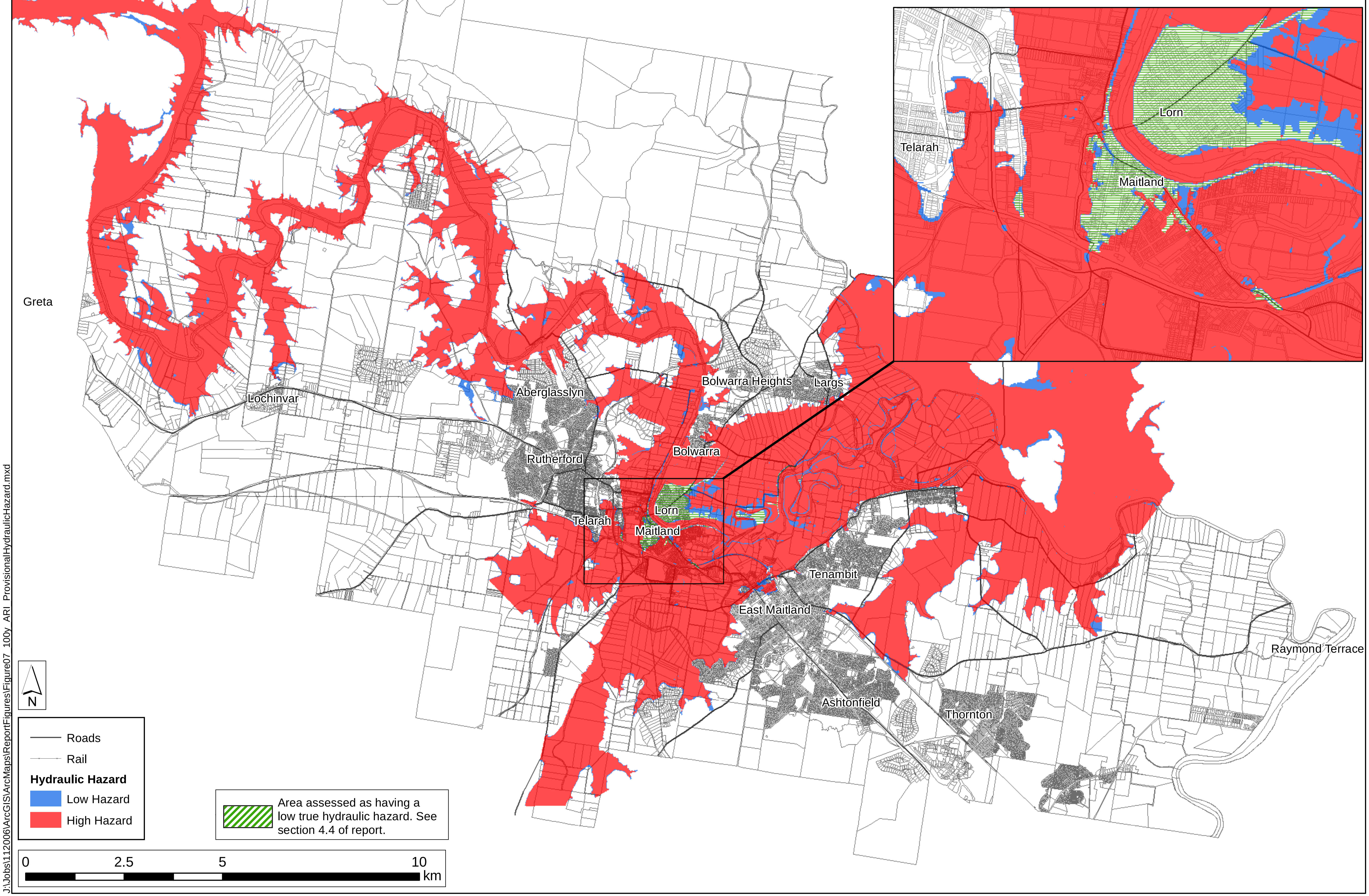
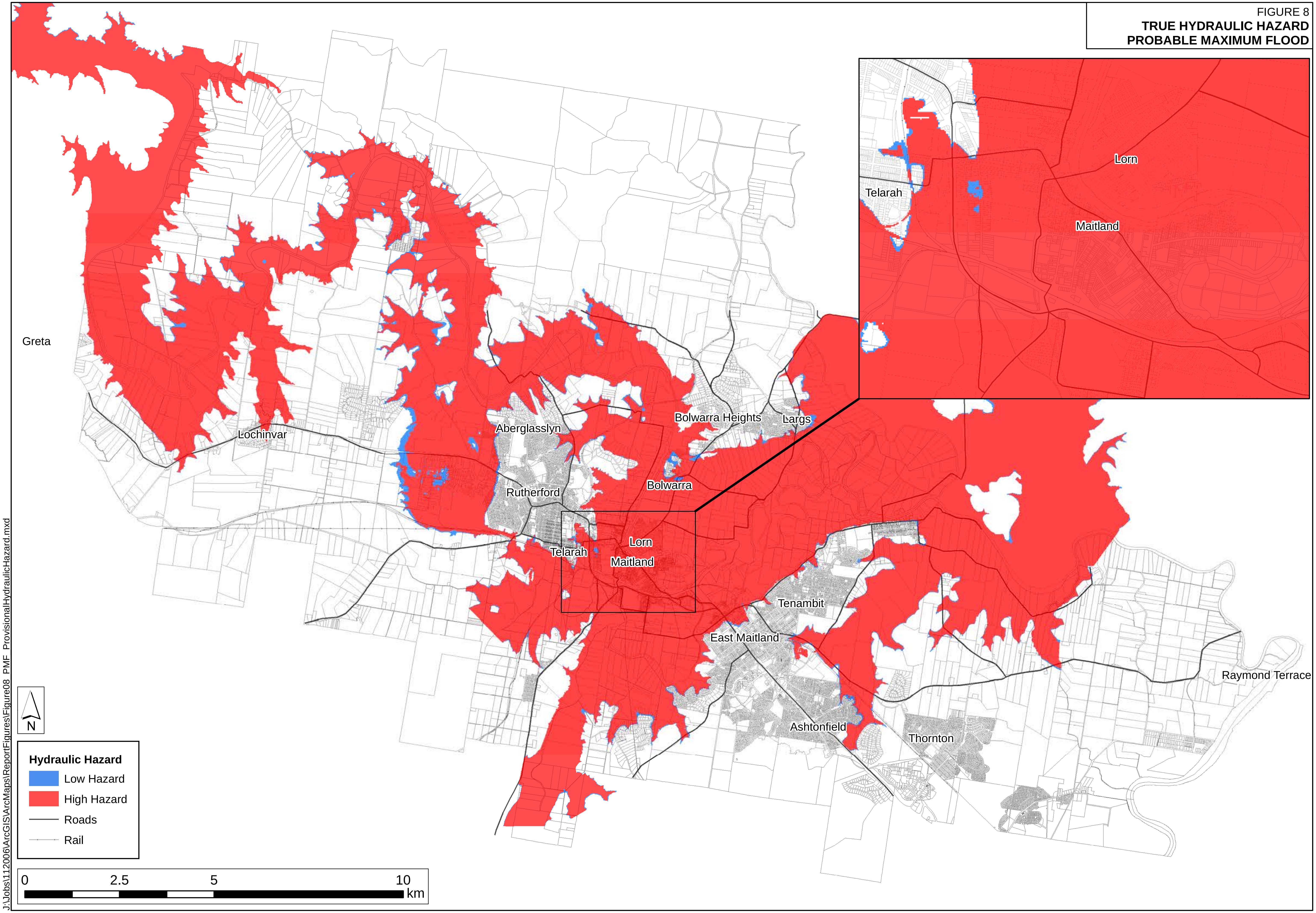
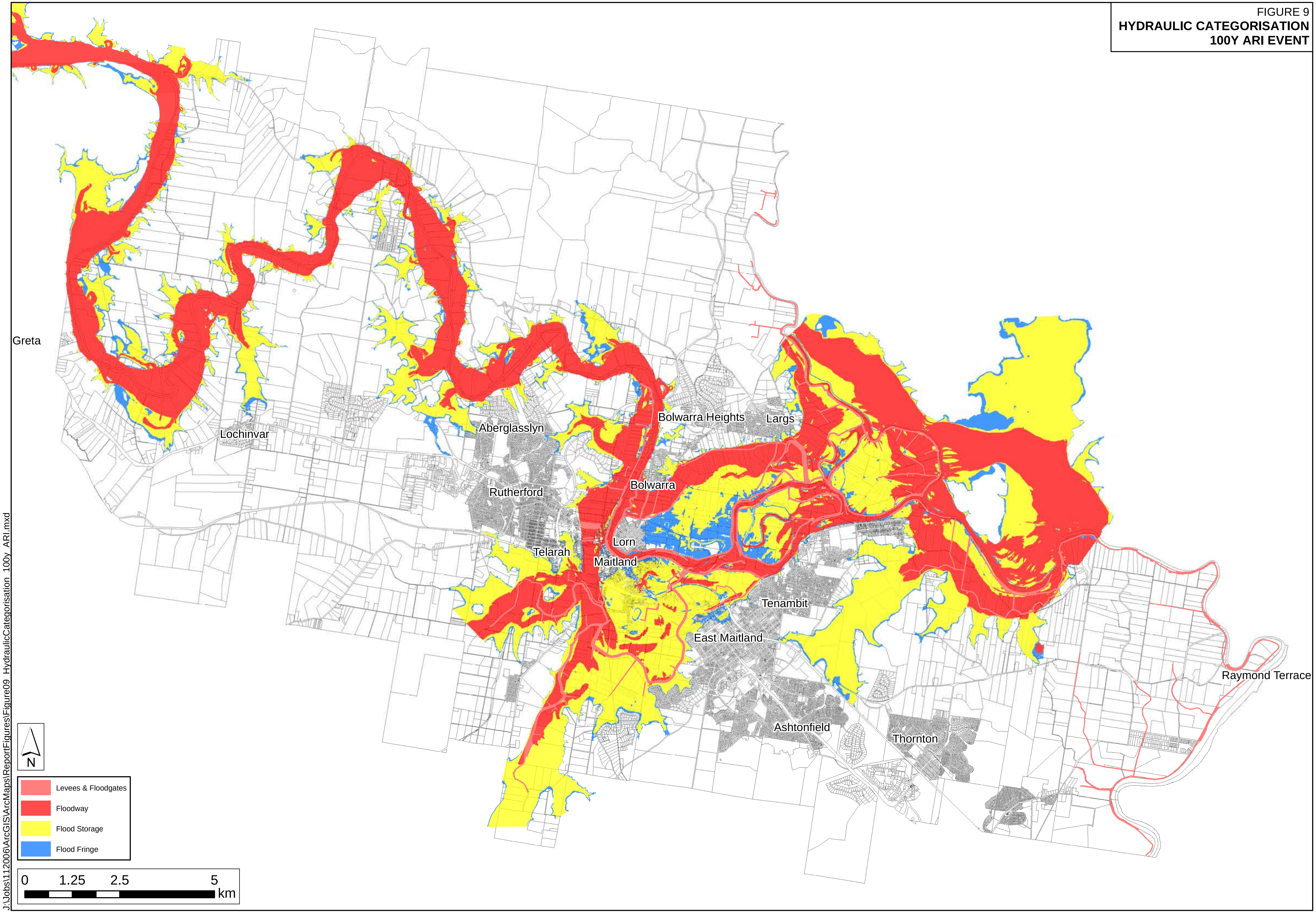


FIGURE 8
TRUE HYDRAULIC HAZARD
PROBABLE MAXIMUM FLOOD



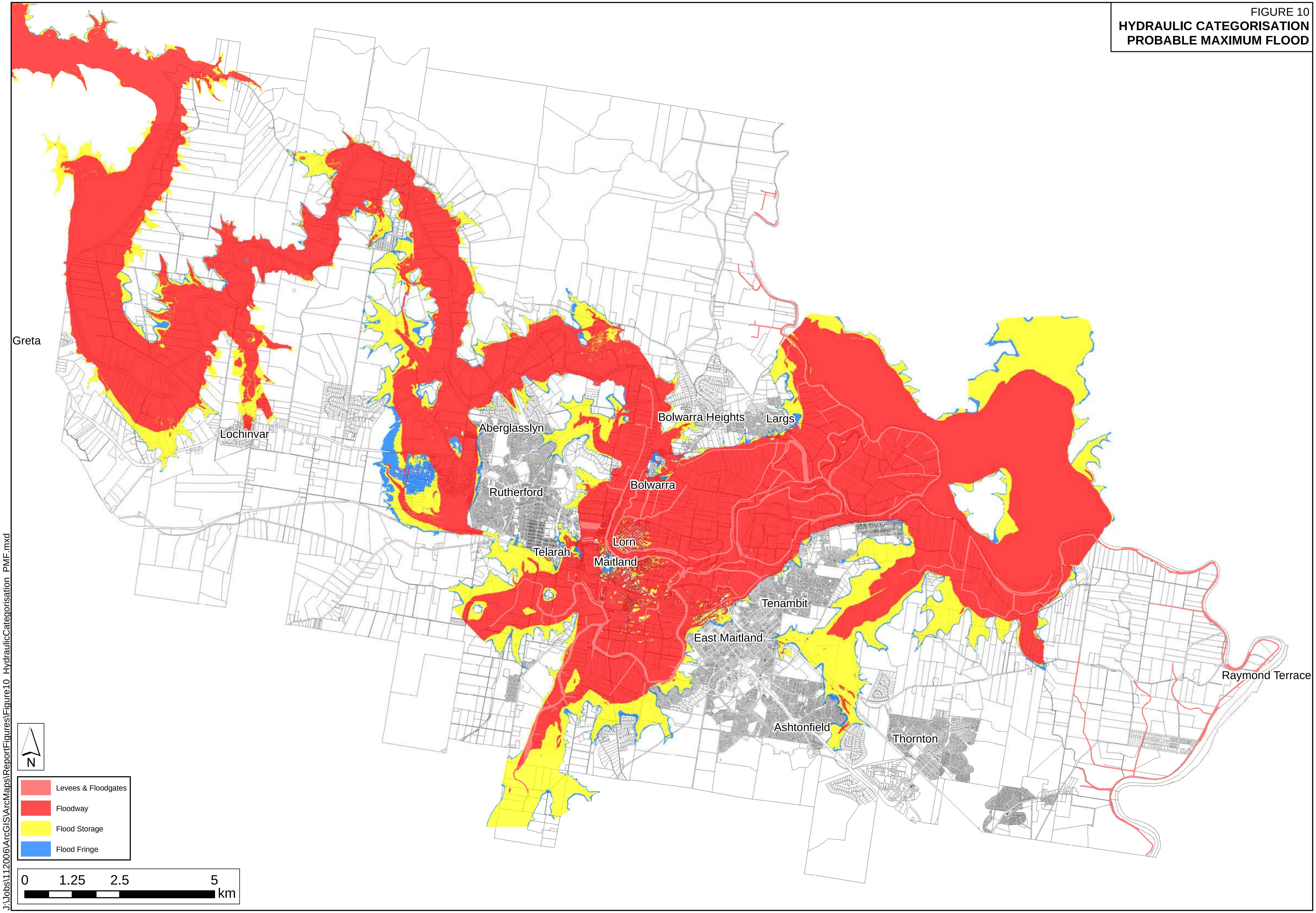
J:\Jobs\112006\ArcGIS\ArcMaps\Report\Figures\Figure08_PMF_ProvisionalHydraulicHazard.mxd

FIGURE 9
HYDRAULIC CATEGORISATION
100Y ARI EVENT



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure09_HydraulicCategorisation_100y_ARI.mxd

FIGURE 10
HYDRAULIC CATEGORISATION
PROBABLE MAXIMUM FLOOD



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure10_HydraulicCategorisation_PMF.mxd

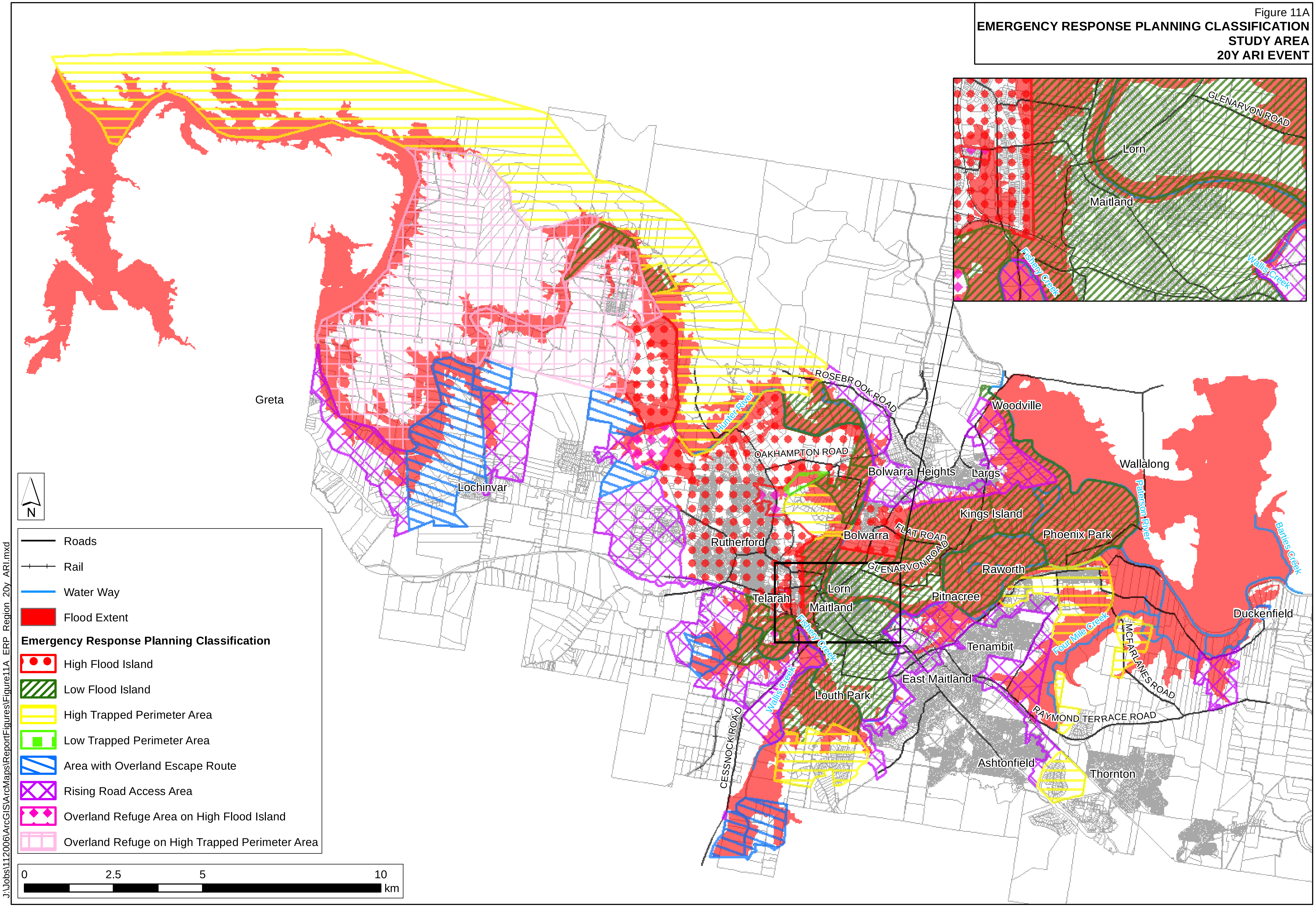


Figure 11A
EMERGENCY RESPONSE PLANNING CLASSIFICATION
STUDY AREA
20Y ARI EVENT
Roads
Rail
Water Way
Flood Extent
Emergency Response Planning Classification
High Flood Island
Low Flood Island
High Trapped Perimeter Area
Low Trapped Perimeter Area
Area with Overland Escape Route
Rising Road Access Area
Overland Refuge Area on High Flood Island
Overland Refuge on High Trapped Perimeter Area
0
2.5
5
10
km
N
Greta
Lochinvar
Rutherford
Telarah
Maitland
Lorn
Bolwarra
Bolwarra Heights
Largs
Woodville
Wallalong
Kings Island
Phoenix Park
Raworth
Pitnacree
Duckenfield
Tenambit
East Maitland
Louth Park
Ashtonfield
Thornton
ROSEBROOK ROAD
OAKHAMPTON ROAD
FLAT ROAD
GLENARVON ROAD
CESSNOCK ROAD
MCFARLANES ROAD
RAYMOND TERRACE ROAD
Hunter River
Paterson River
Barties Creek
Four Mile Creek
Fishery Creek
Wallis Creek
J:\Jobs\112006\ArcGIS\ArcMaps\Report\Figures\Figure11A_ERP_Region_20y_ARI.mxd

Figure 11B
EMERGENCY RESPONSE PLANNING CLASSIFICATION
STUDY AREA
100Y ARI EVENT

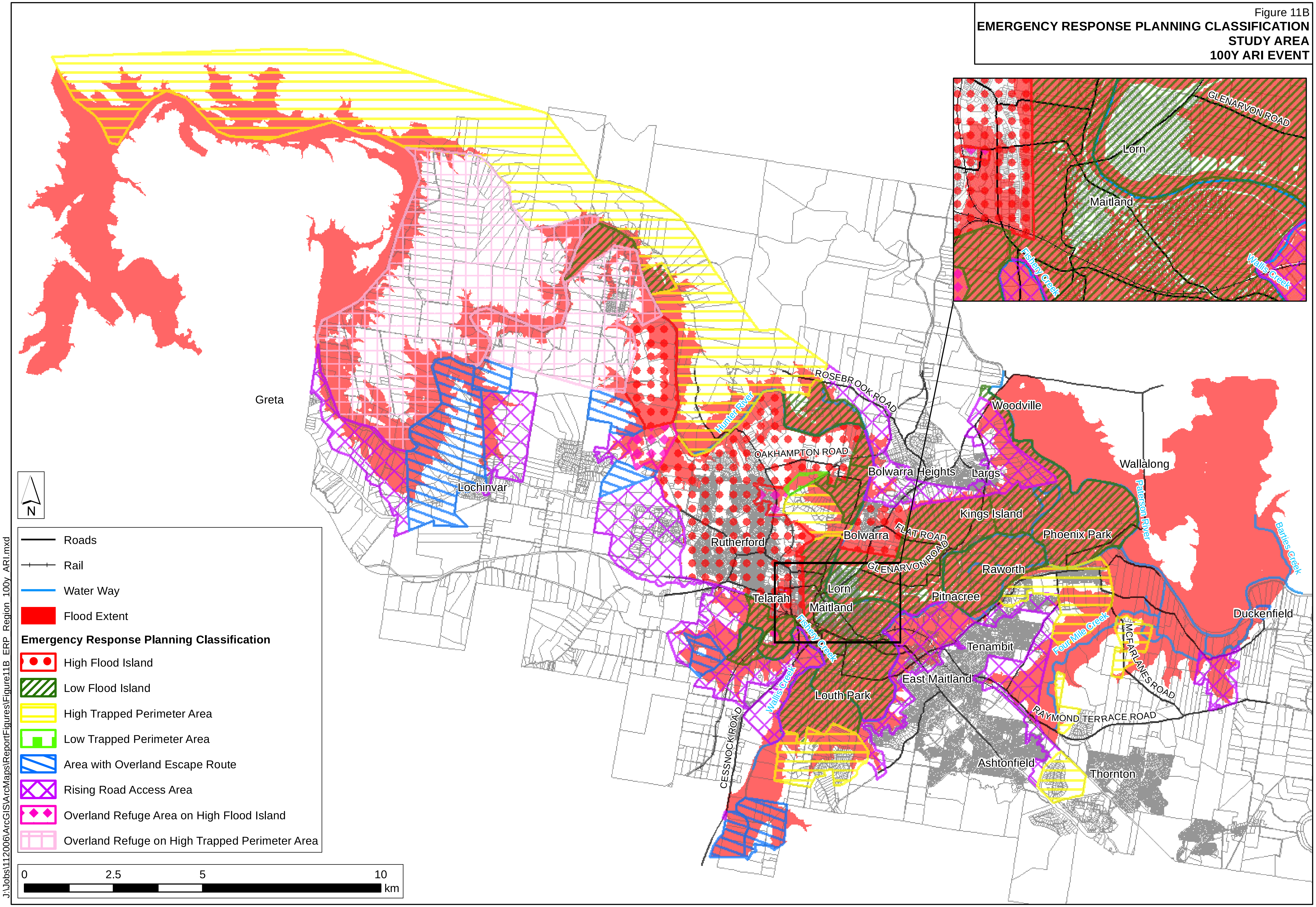
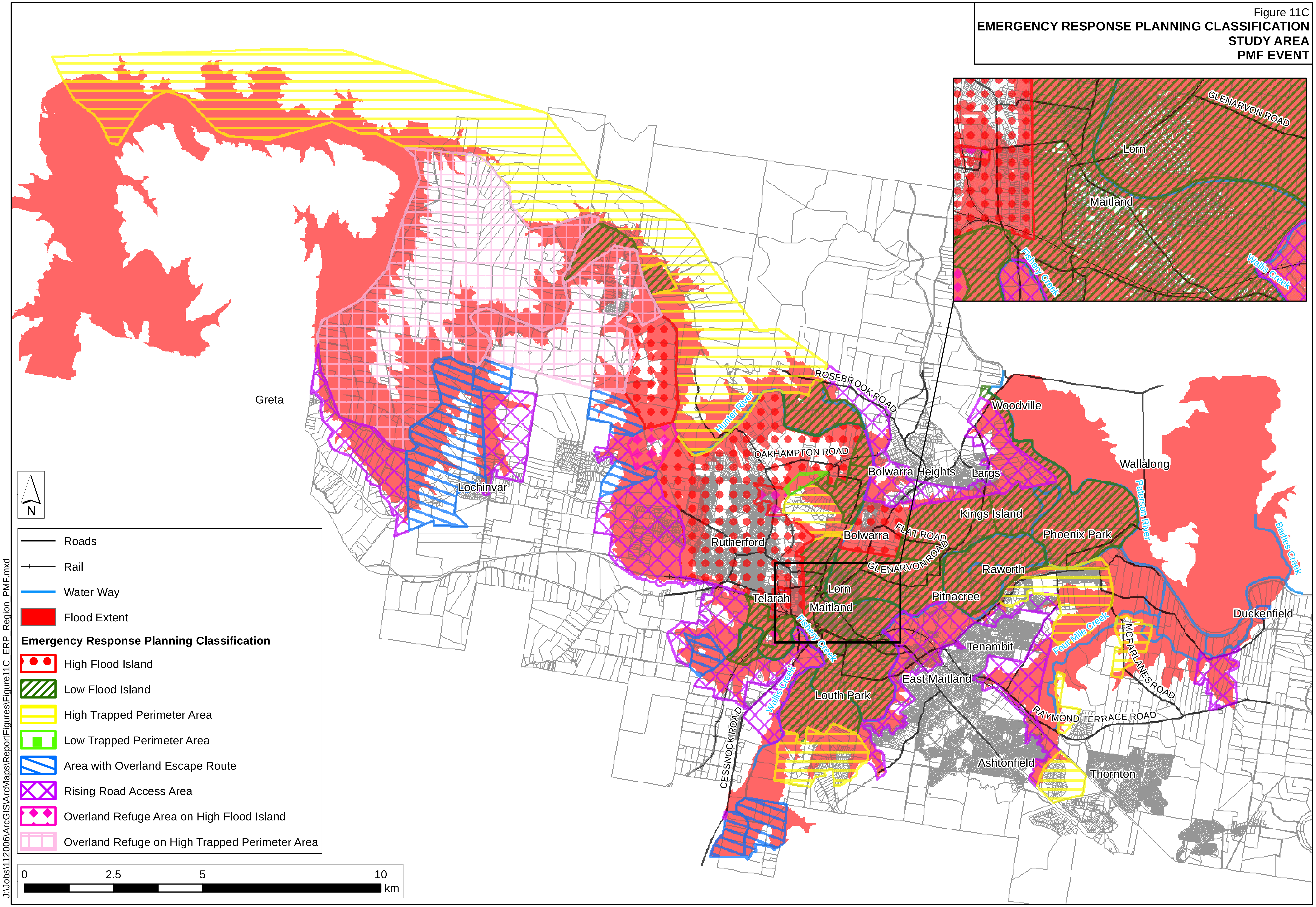


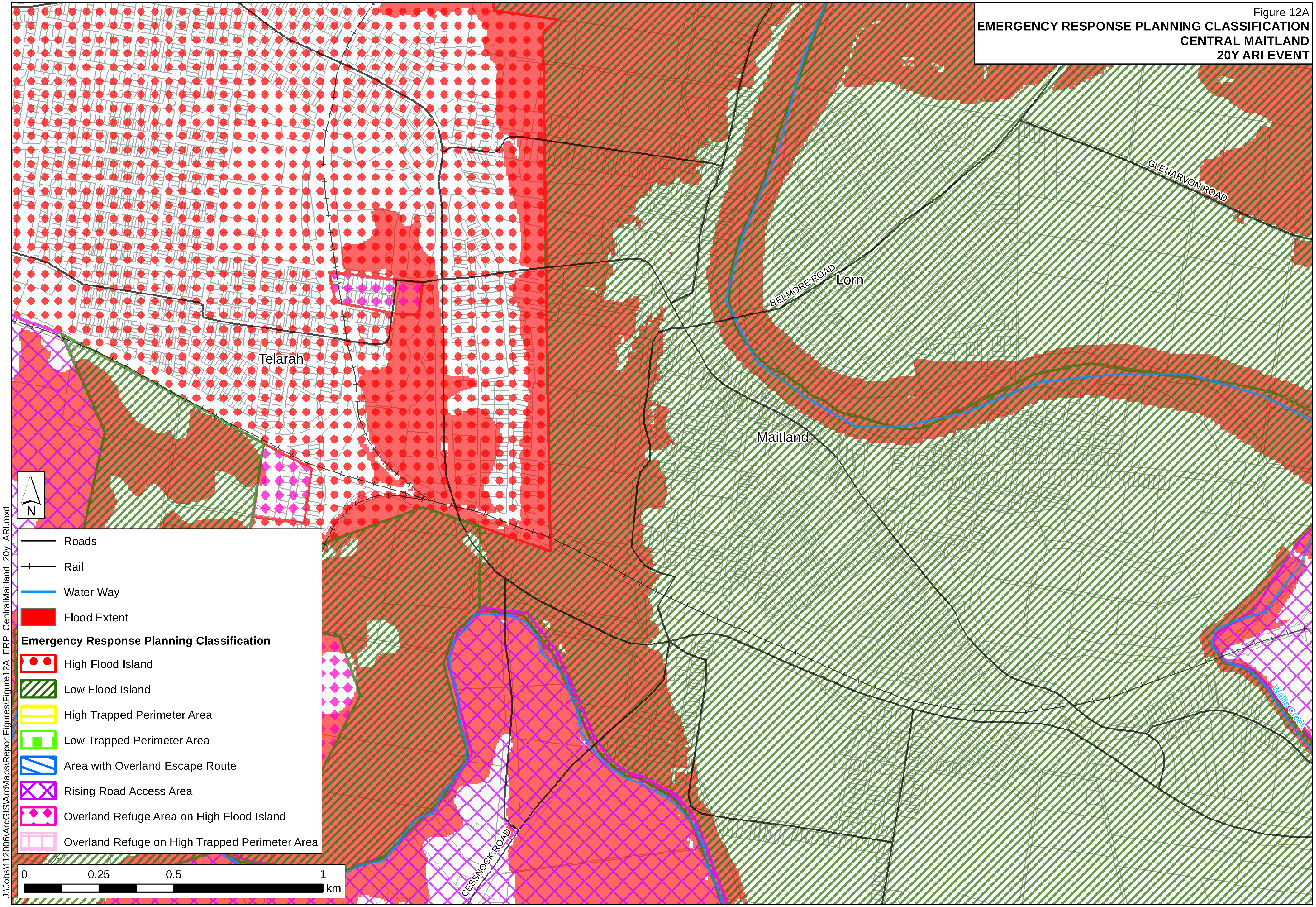
Figure 11C
EMERGENCY RESPONSE PLANNING CLASSIFICATION
STUDY AREA
PMF EVENT



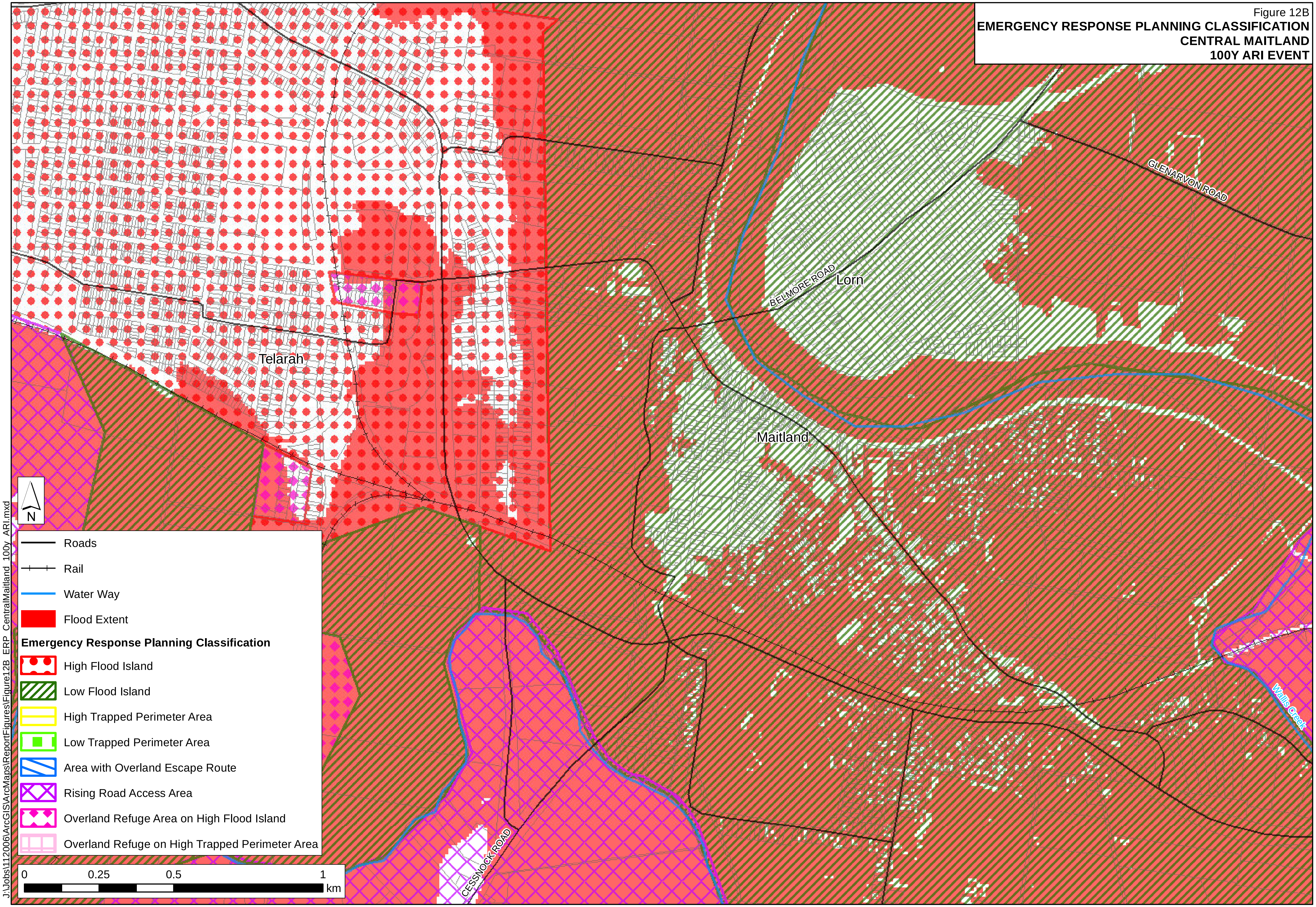
J:\Jobs\112006\ArcGIS\ArcMaps\Report\Figures\Figure11C_ERP_Region_PMF.mxd

Figure 12A

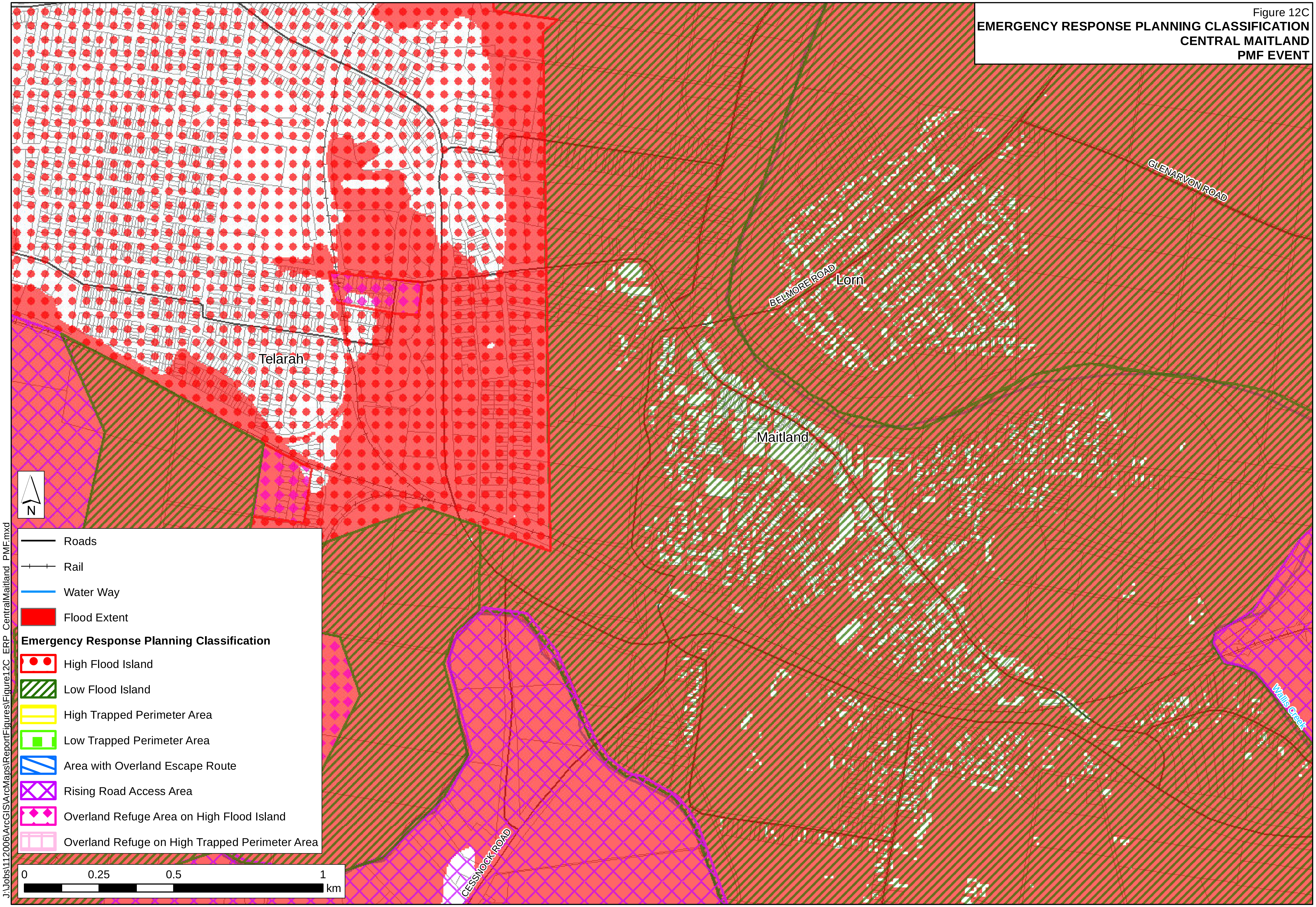
EMERGENCY RESPONSE PLANNING CLASSIFICATION
CENTRAL MAITLAND
20Y ARI EVENT



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure12A_ERP_CentralMaitland_20y_ARI.mxd

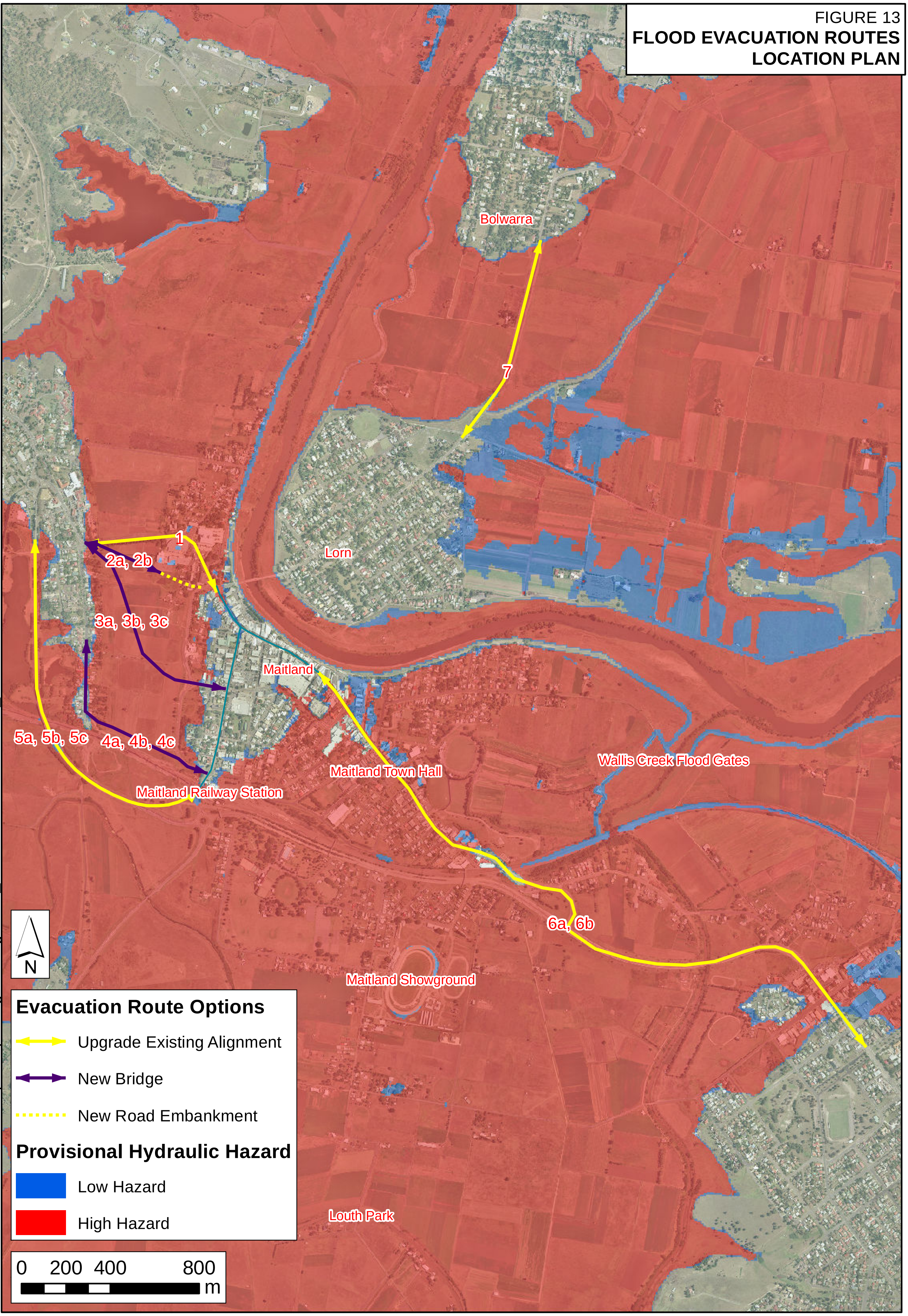


J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure12B_ERP_CentralMaitland_100y_ARI.mxd



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure12C_ERP_CentralMaitland_PMF.mxd

FIGURE 13
FLOOD EVACUATION ROUTES LOCATION PLAN



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure13_FloodEvacuationRoutes_Edited.mxd

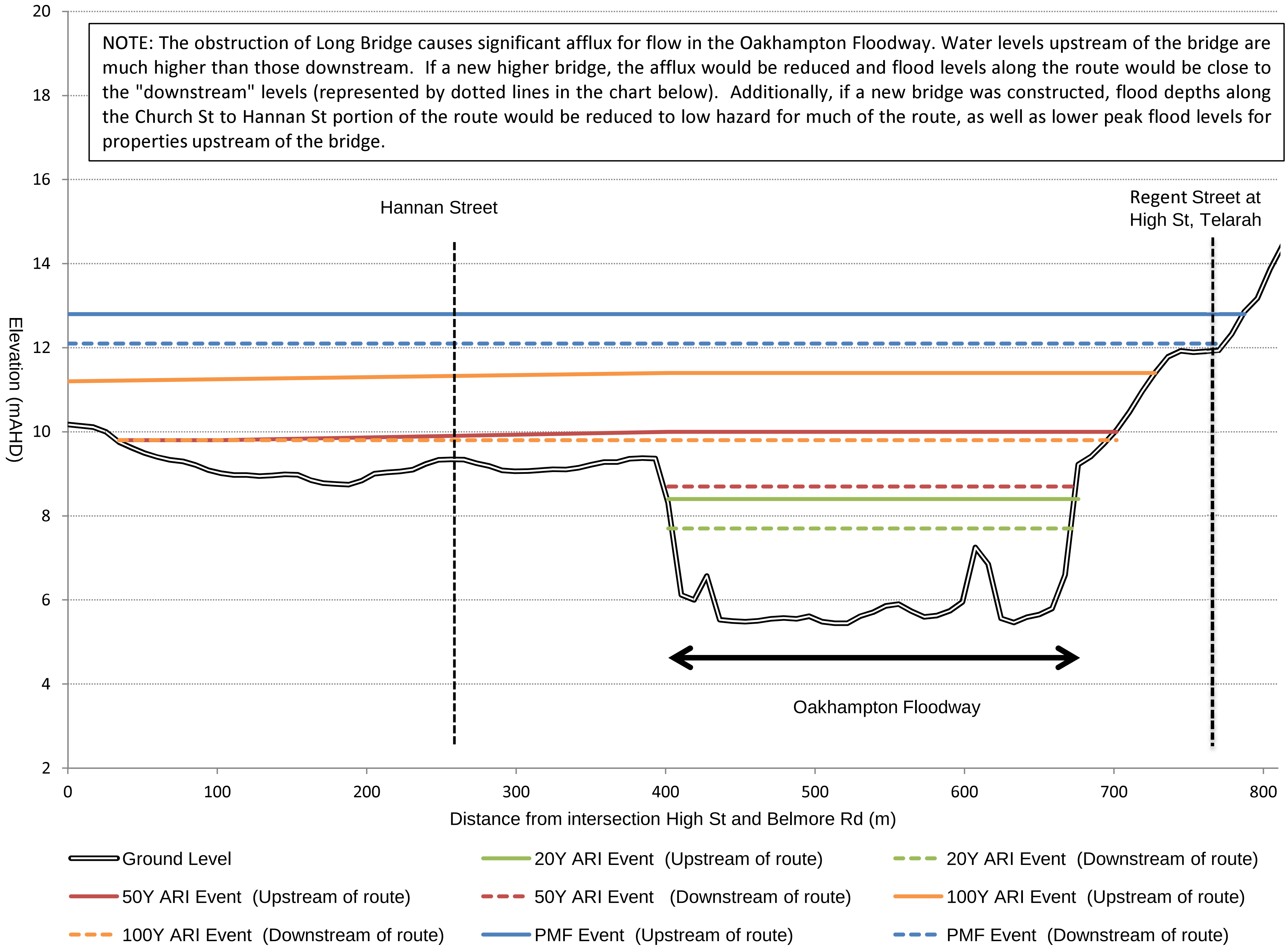


FIGURE 14A
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES
ROUTE OPTION 1

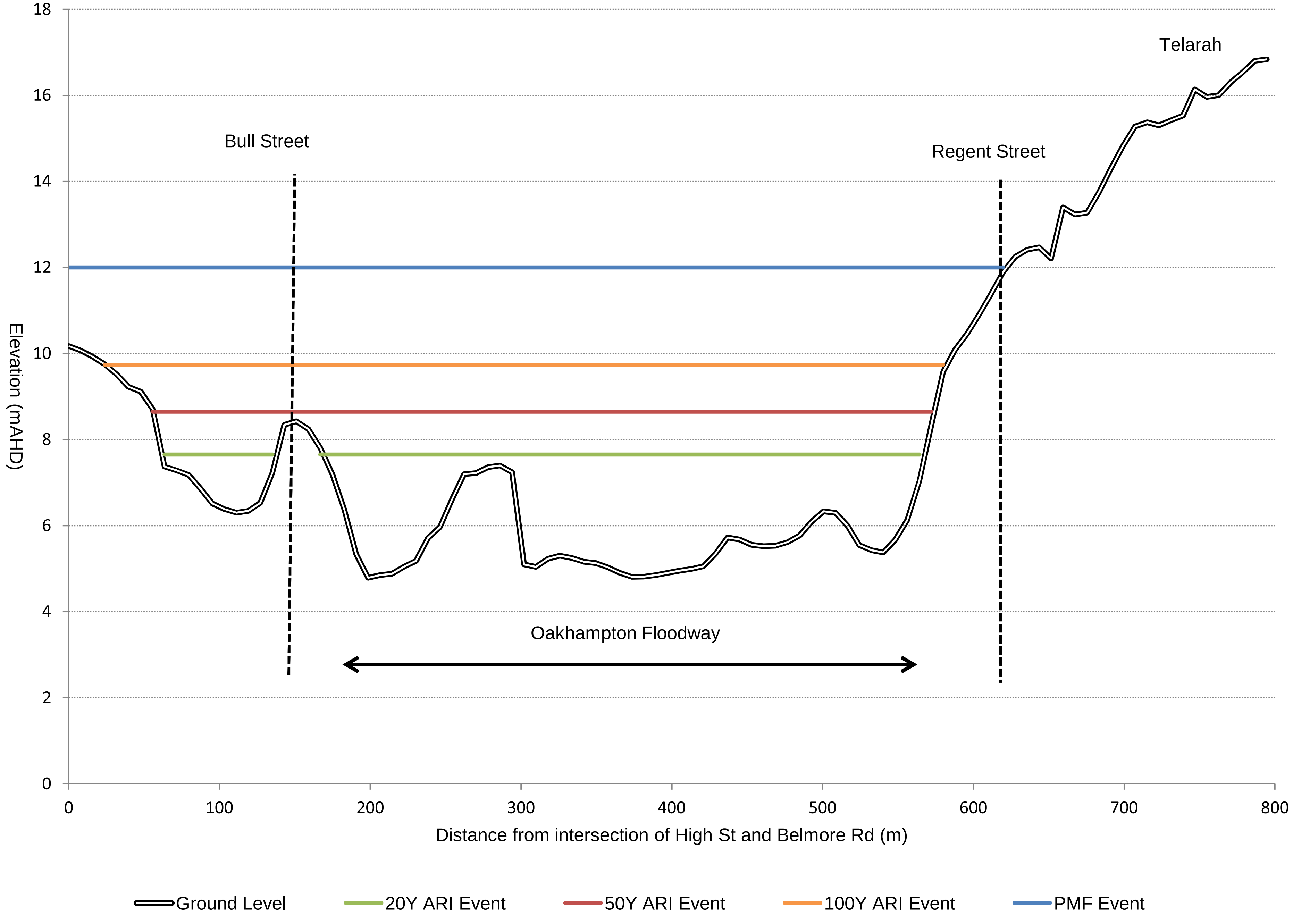


FIGURE 14B
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES
ROUTE OPTION 2

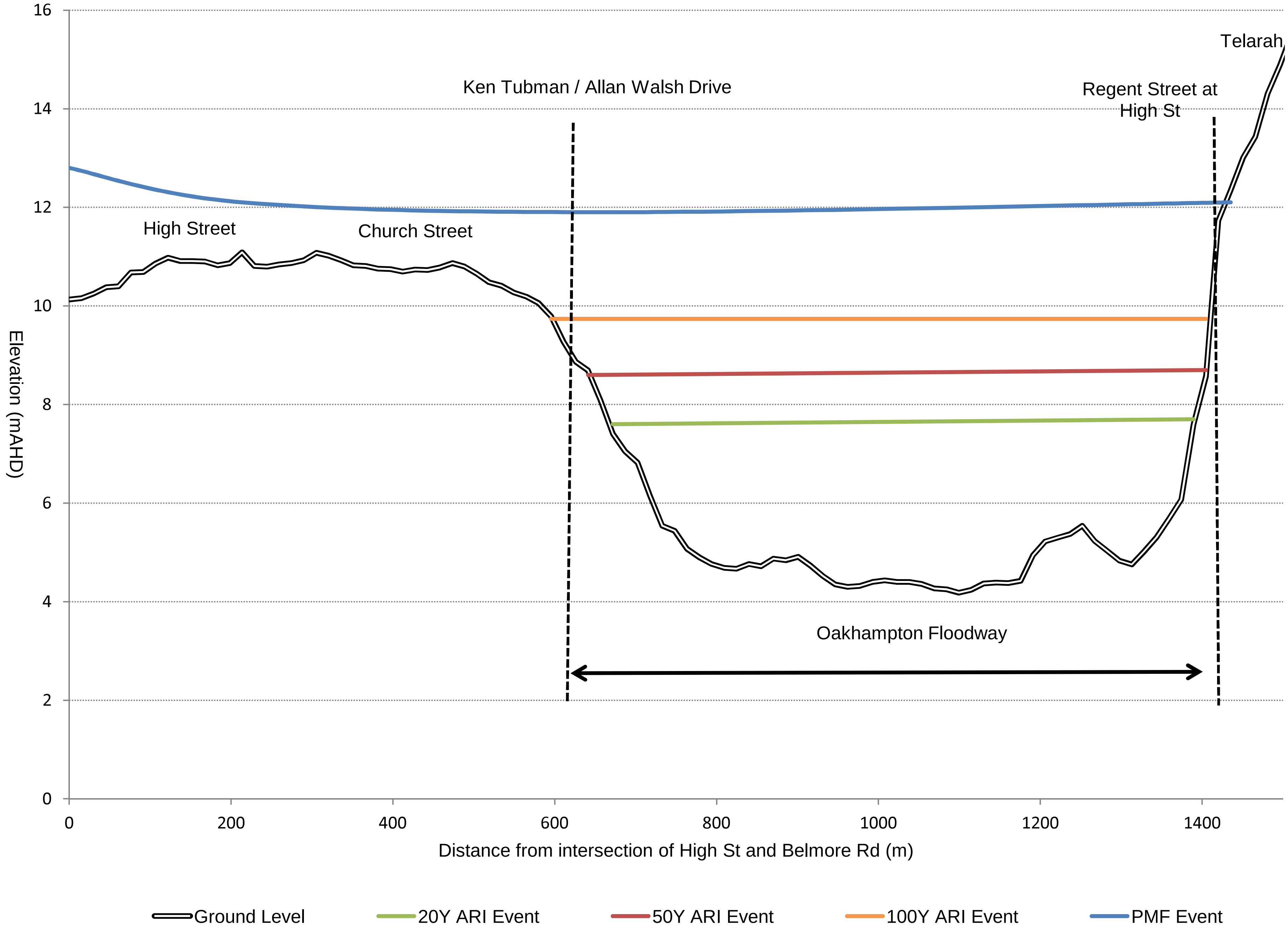


FIGURE 14C
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES ROUTE OPTION 3

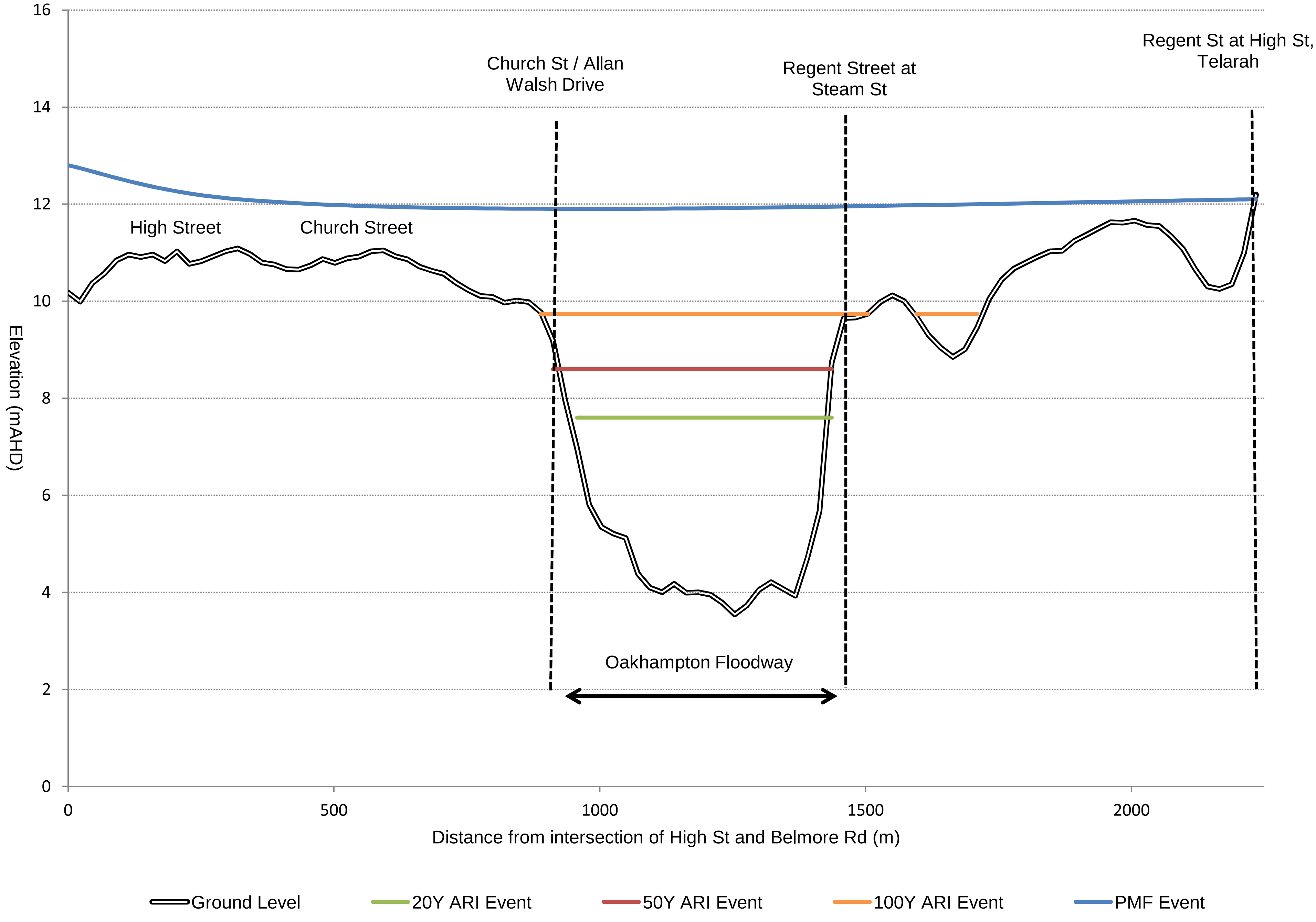


FIGURE 14D
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES
ROUTE OPTION 4

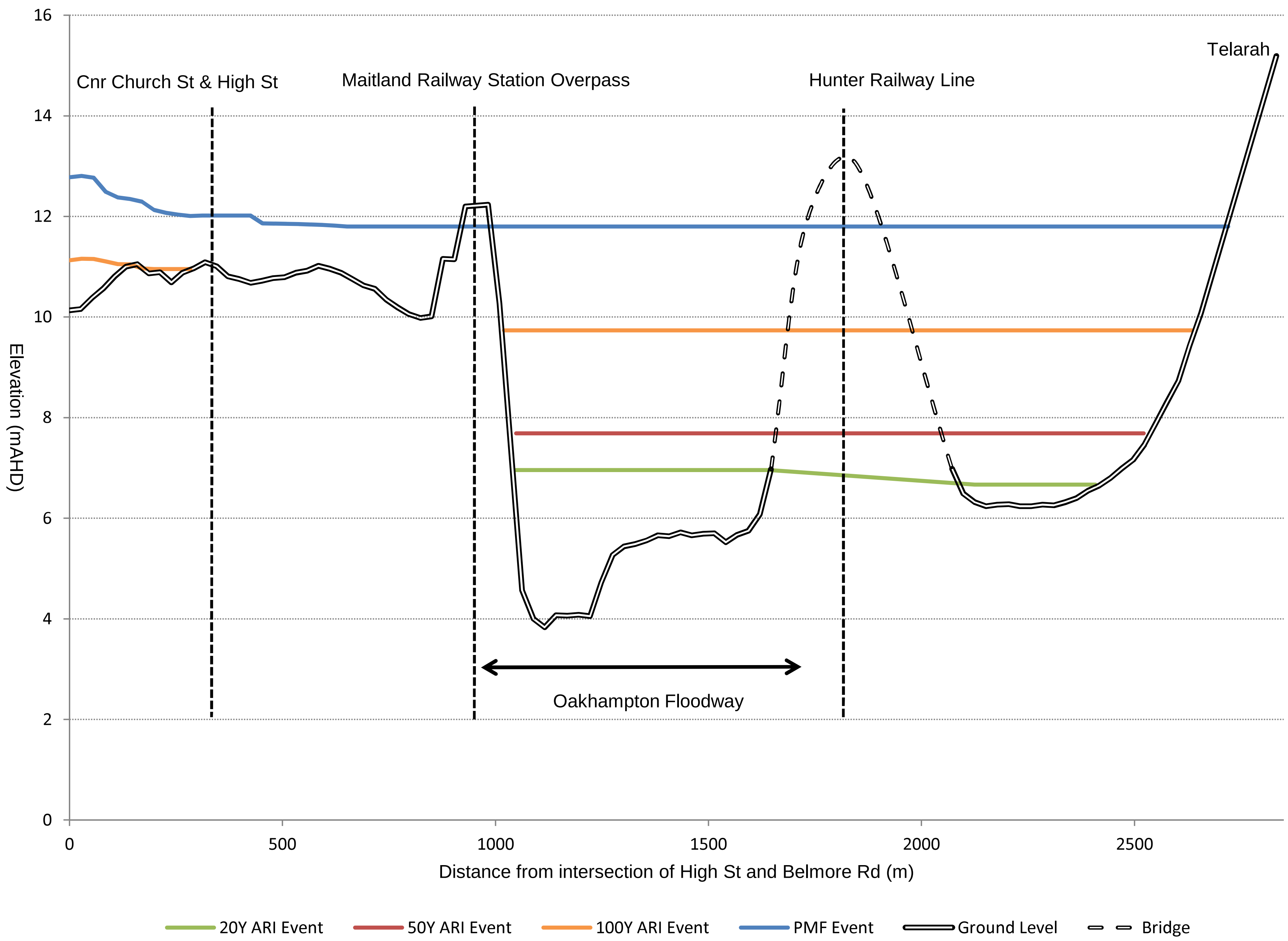


FIGURE 14E
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES
ROUTE OPTION 5

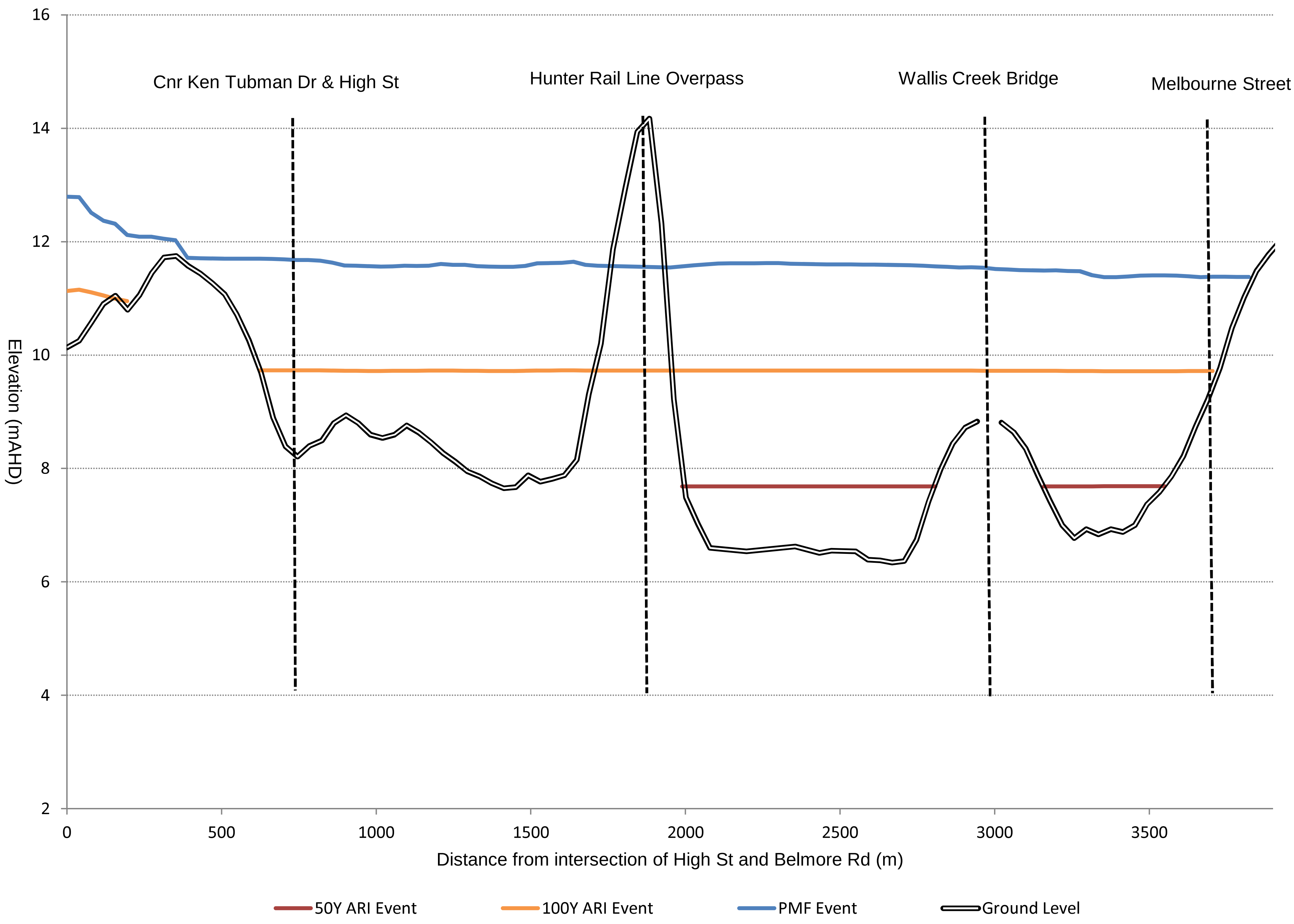


FIGURE 14F
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES
ROUTE OPTION 6

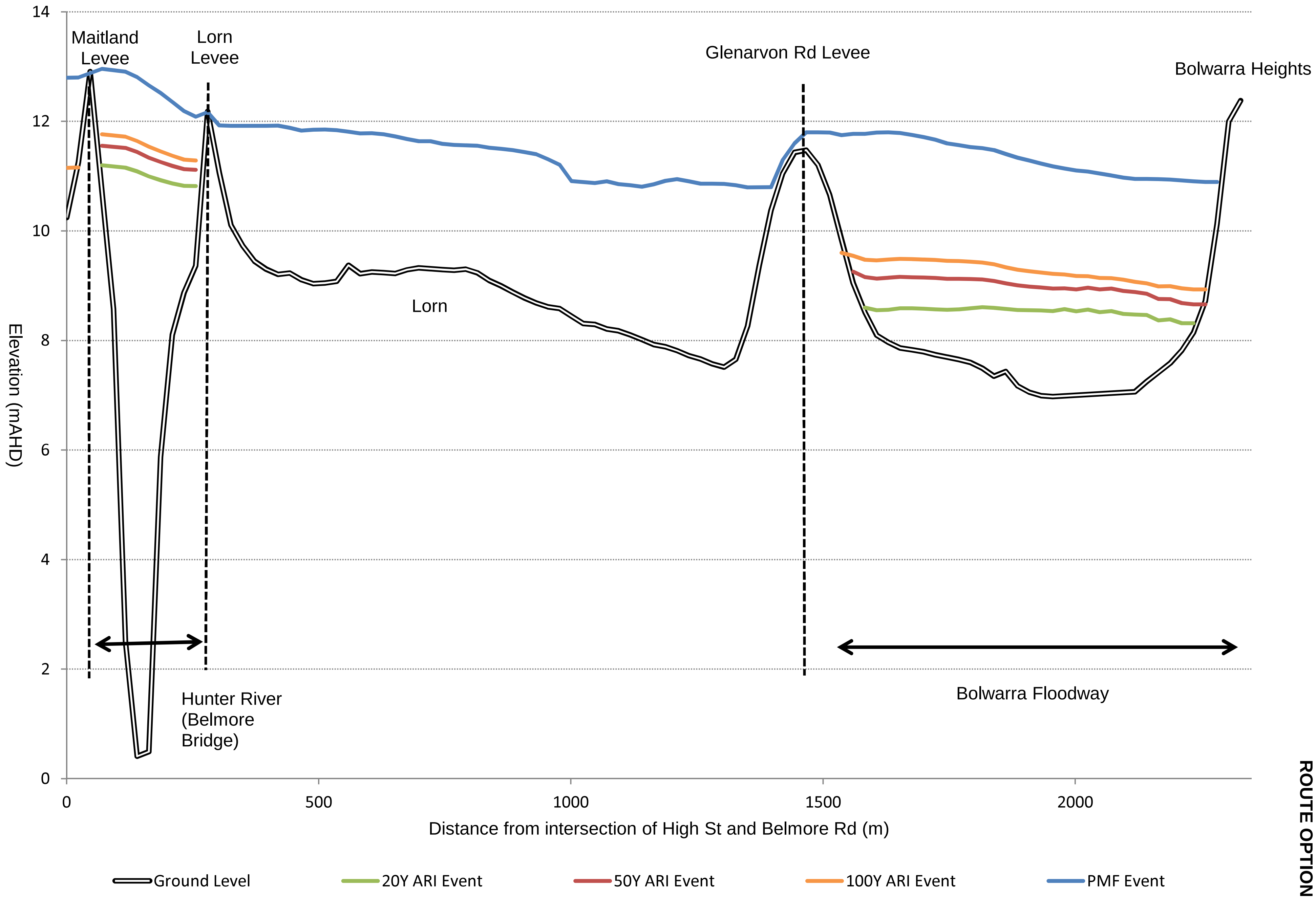


FIGURE 14G
DESIGN FLOOD LEVELS AND EVACUATION ROUTE PROFILES
ROUTE OPTION 7

Figure 15

PRIVATE TRZECINSKI BRIDGE MEMORIAL LEVEE LOCATION PLAN

J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure15_PrivateTrzecinskiBridgeMemorialLevee.mxd

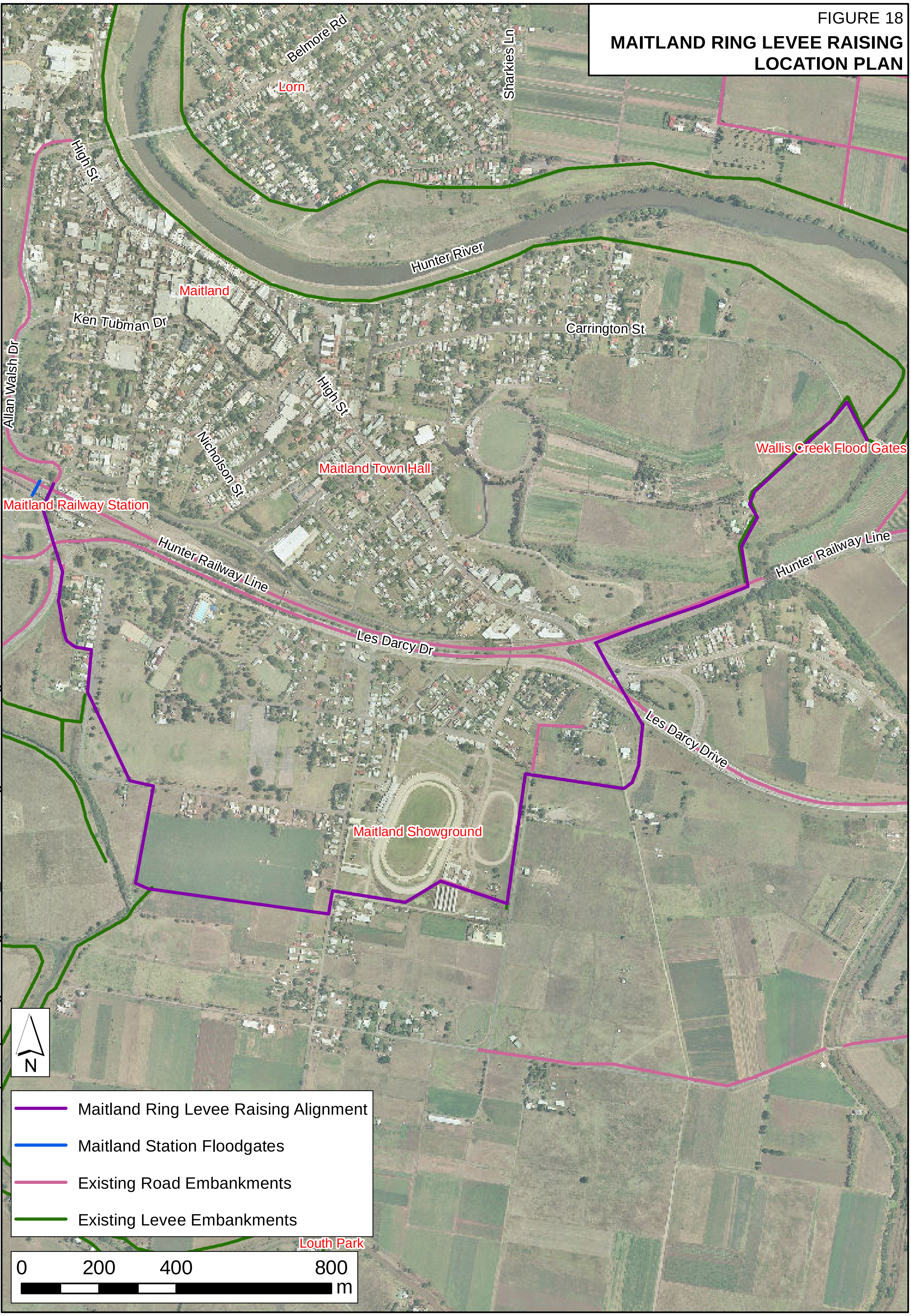
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure16_Oakhampton Spillway Raising.mxd

FIGURE 17

SHARKIES LANE LEVEE LOCATION PLAN

J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure17_SharkiesLaneLevee.mxd

FIGURE 18
MAITLAND RING LEVEE RAISING LOCATION PLAN



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure18_MaitlandRingLeveeRaising.mxd

FIGURE 19

OAKHAMPTON FLOODWAY LEVEE LOCATION PLAN

J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\Figure19_OakhamptonFloodwayLevee.mxd

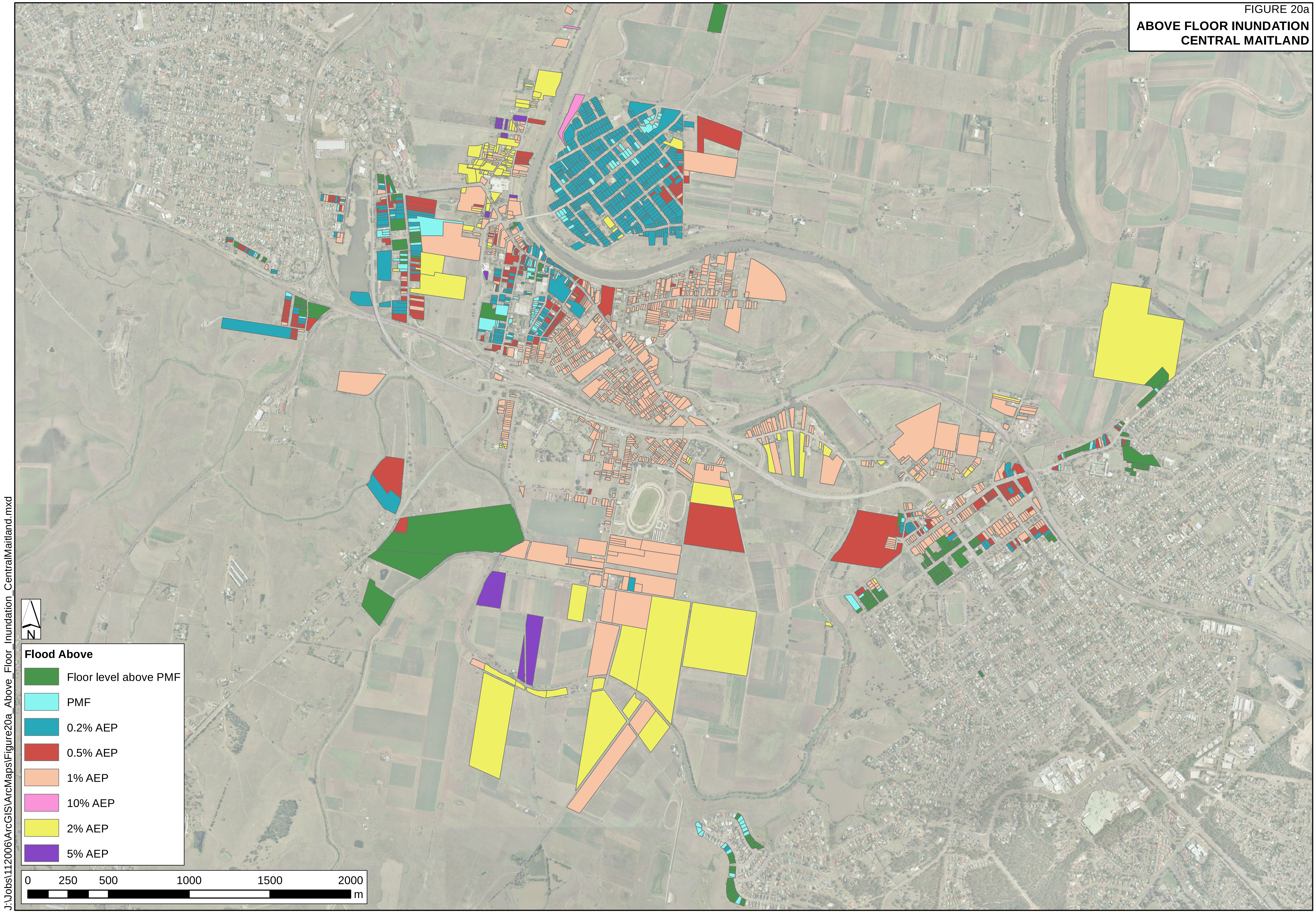
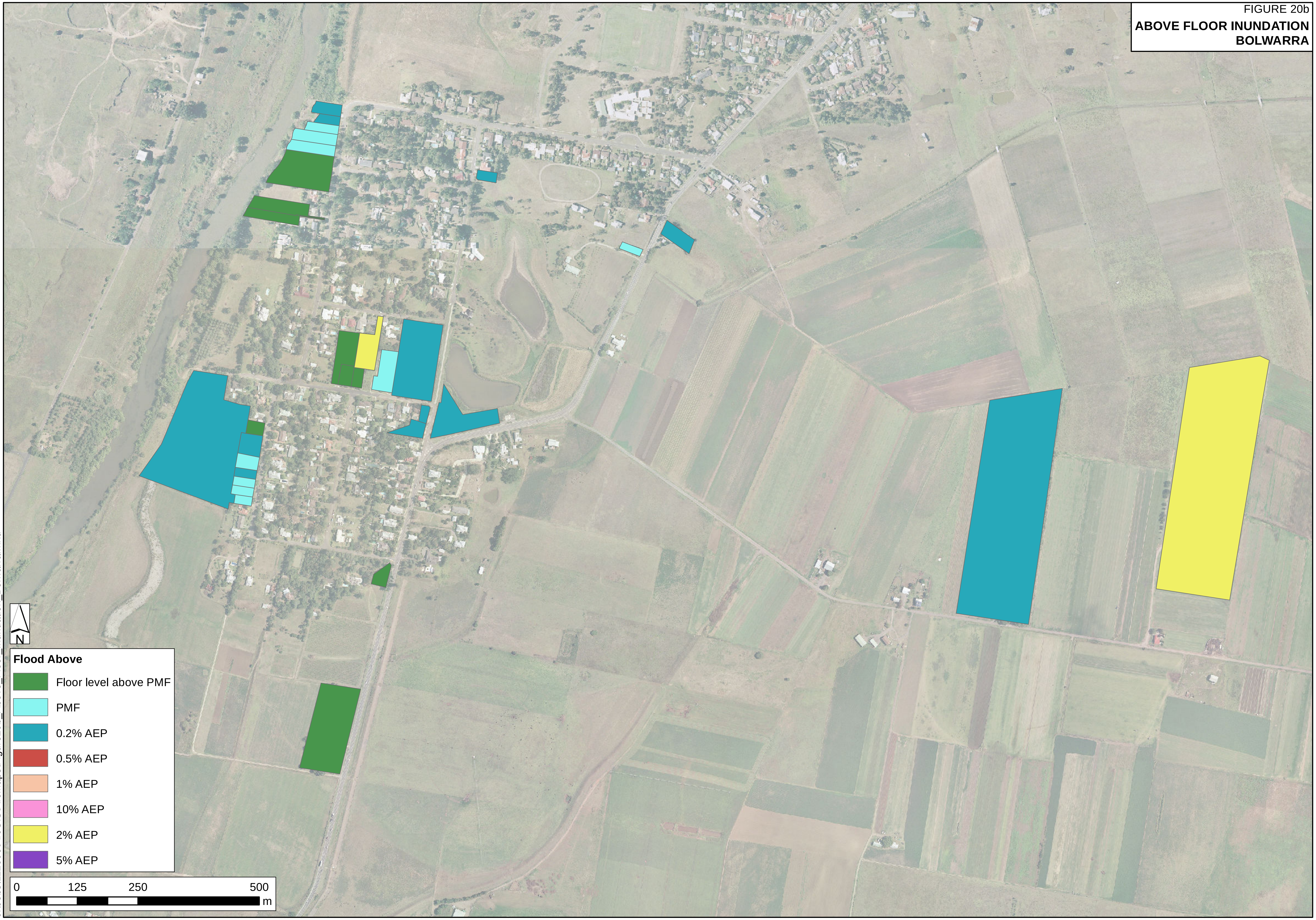


FIGURE 20a
ABOVE FLOOR INUNDATION
CENTRAL MAITLAND
Flood Above
Floor level above PMF
PMF
0.2% AEP
0.5% AEP
1% AEP
10% AEP
2% AEP
5% AEP
N
0
250
500
1000
1500
2000
m
J:\Jobs\112006\ArcGIS\ArcMaps\Figure20a_Above_Floor_Inundation_CentralMaitland.mxd

FIGURE 20b

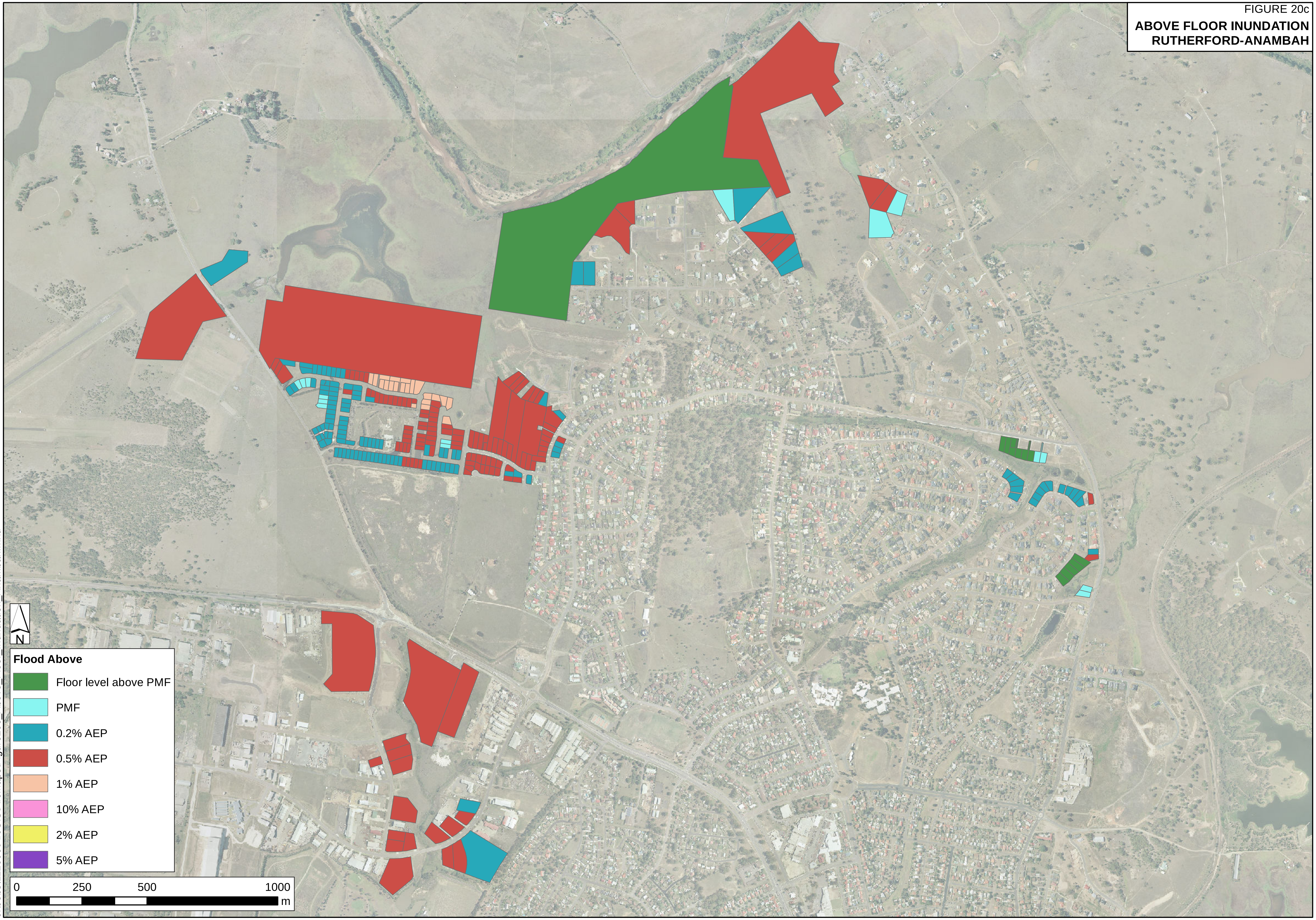
ABOVE FLOOR INUNDATION BOLWARRA



J:\Jobs\112006\ArcGIS\ArcMaps\Figure20b_Above_Floor_Inundation_Bolwarra.mxd

FIGURE 20c

ABOVE FLOOR INUNDATION RUTHERFORD-ANAMBAH



J:\Jobs\112006\ArcGIS\ArcMaps\Figure20c_Above_Floor_Inundation_Anambah.mxd

HUNTER RIVER DISTRICT.

CALAMITOUS FLOOD.

PART OF MAITLAND SUBMERGED.

(From the Empire's Correspondent.)

It is my melancholy duty to record the occurrence of one of the greatest floods that have happened within the memory of the oldest resident in this district. All admit that the river has risen higher than the flood in 1840, and it is maintained by some that it almost approximates to that of 1832.

On Monday last the weather was very fine and hopes were entertained that the long continued rains had at length abated ; the river also had fallen to its customary level. Tuesday morning was also fair, but cloudy till the afternoon when rain began again to fall, at first in light showers but afterwards in torrents. The wind also rose, and during the whole night the wind and rain were terrific, with occasional vivid flashes of lightning, but no thunder. With all the rain, however, no one seemed to anticipate any great rise in the river.

At a very late hour on Tuesday evening the rise in the river was scarcely perceptible ; but on Wednesday morning it began to rise with almost unexampled rapidity. By midday it was almost bank high ; and fears of a flood then began to be entertained for the first time. During the afternoon, and up to about 10 o'clock at night, it continued steadily to rise at the rate of about one foot per hour, until in Maitland it broke completely over the High-street, at the Queen's Arms Inn, almost opposite Mr Levien's stores, and a little below the Rose Inn. Before this, however, it had burst over the Horse Shoe Bend, covering a large portion of it with water to a great depth, and coming close up to the back of the *Mercury* office.

Early on Thursday morning it was reported that it had broke over Hall's Creek dam, and shortly after it came rushing like a torrent under the Long Bridge, filling up the whole of the low land until it stood nearly seven feet high. During the whole of Thursday the water continued flowing over the High-street, at the place where it first broke through, and also higher up the town, until it filled up completely the whole of the Race-course and adjacent land, presenting on all sides as far as the eye could reach a sea of water. On crossing the river to the Bolwarra Estate nothing can be seen for many miles but immense sheet of water ; and, viewing the scene from the Morpeth-road, a little below East Maitland, the Paterson and the Hunter appear to be one immense river without a single spot of land in sight.

Early on Wednesday evening the police began exerting themselves in anticipation of a flood by warning the people on the low lands to remove from their houses. About ten o'clock at night boats were in requisition for the removal of the inhabitants from their houses on the Horse Shoe Bend ; and the lower wards of the hospital and a portion of Turner's mill were thrown open for the accommodation of the houseless. Few of the inhabitants were in bed during the whole night, and the firing of guns from the other side of the river was heard repeatedly, announcing the distress and danger of the settlers. Early on Thursday morning, Sergeant Kerrigan, with a picked crew, consisting of John Bathgate, James Russell, George KennIwell, Thomas Ogle, and another, started for Bolwarra, and during the day rescued a great many individuals from the most imminent danger. A man and a woman were found on a table, and everything deluged with water. In another house fifteen individuals were found who had collected there from houses which were flooded in lower localities. At Bolwarra House nearly one hundred individuals had

were flooded in lower localities. At Bolwarra House nearly one hundred individuals had

sought and obtained shelter. Wherever the boat sallies, cradles, and all kinds of household furniture, with stacks of hay, poultry, &c., were seen floating about ; and there is not a doubt but thousands of individuals are reduced to abject poverty. I have to mention one fatal accident which has already reached us here. A young man named Franklin, a carpenter, with two others was busily engaged on Thursday forenoon with a boat rescuing the people on the Horse Shoe Bend and about 11 o'clock they pulled down the river to the willow tree behind the store of Mr. A. Dickson, when the boat swamped. The other two men sprung up into the tree, but Franklin was carried down the river and seen no more. The police at East Maitland made great exertions to save the settlers, and I am told rescued about one hundred individuals. At Morpeth the river rose over the Queen's Wharf fully more than seven feet ; and almost the whole of the goods in the stores of the two Steam Navigation Companies have been lost or destroyed, notwithstanding all the efforts of the managers to save them. Mr. Hough, I am told, has sustained a loss of nearly £2000 by the flooding of his store at Morpeth. I have also been informed that Bishop's bridge, on the Wolombi, has been carried away, and that the mail on Wednesday went no further than Black Creek, the bridge there having been washed away. The destruction of property of all kinds has been enormous, and there is not now the slightest hope of a wheat crop for the ensuing year. All that has been sown has been destroyed. Trade is at a complete standstill and many of the stores are shut up.

Maitland, June 19, 1857.

HUNTER RIVER DISTRICT.

STATISTICS OF THE LATE FLOOD.

(From the Empire's Correspondent.)

Maitland June 26, 1857.

The flood having now considerably abated, an opportunity has been afforded for collecting, to a considerable extent, accurate statistics of the damage actually done, and of partially estimating its probable effects on the crops of the ensuing year

In preparing such statistics I think the proper method is if possible, to ascertain the whole loss, and not merely to obtain the amount of losses sustained by those who might or will apply for assistance from the public subscription now being raised. By the latter method a very meagre account indeed will be given, whereas by the former the public will be made aware of the great loss which the colony has sustained by this almost unprecedented deluge.

In the present report I am only able to give the statistics of the three boroughs of West Maitland, East Maitland, and Morpeth ; but these, so far as they at present go, may, I believe, be relied on as authentic. I have made it my duty to become personally conversant with the facts stated, and can thus vouch for their accuracy The other districts overtaken by this calamity I shall report on as speedily as possible.

In West Maitland the total number of houses within the borough is 873, and of these 183 have been partially submerged by the recent flood, and their inhabitants forced to leave their dwellings. These are spread over the town as follows. Smith's cottages, two houses ; Mr. Russell's High-street, one ; Stapleton's place, two ; Chester's lane, five ; adjoining Long Bridge, five ; back of Hospital, three ; near Fishery Creek-bridge, two ; in the back of the town from Nicholson's slaughter-house to Mr. S. Clift's on Wallis's Creek, thirty seven ; John-street (entirely submerged), eleven ; Durham-street, two ; Victoria-street, one ; Devonshire-street and places adjacent, twenty-four ; near Polka-castle, three ; Rose-street, nine ; High-street, adjoining the Queen's Arms Inn, Rose Inn, &c., nineteen ; Abbott-street, nine ; from the blacksmith's shop foot of High-street to Victoria Bridge, five ; Horseshoe Bend, forty-two. Total as above 183.

And as near as can be ascertained the number of the population thus left houseless amounted to 930 persons.

It is to be remembered that this does not include any of those houses, where the water merely flooded the back yards or gardens, or even those houses that were totally surrounded by water ; but such only as were really either more or less flooded, and where it would have been dangerous for the inhabitants to remain a single hour longer. The number of houses thus threatened by the flood, from which in many instances the furniture was removed, or in which the furniture was packed up ready for removal, cannot be reckoned less than one hundred more.

At the lowest calculation, then, about twelve hundred individuals were, during the flood, indebted to their more fortunate neighbours for shelter and accommodation ; and it is certainly a matter of the highest thankfulness that so large a number of the population of a comparatively small town were furnished with assistance by their neighbours, and so very few were under the necessity of availing themselves of the shelter of the hospital or the bowling saloon.

Fortunately, the river, after reaching its highest flood, began to recede at a very rapid rate, and at the time I now write (Friday morning) a large number of the houseless have returned to their abodes. Still, although the period between the rise and fall of the flood has barely exceeded a week, a large amount of injury has been sustained by the removal of the furniture the flooding of the furniture where it could not be removed, the permanent injury done to the

the flooding of the furniture where it could not be removed, the permanent injury done to the houses, and the non-employment of the inhabitants in their usual vocations. It would be almost impossible to state the loss sustained, and perhaps each individual reading these remarks can to a certain extent, approximate to the total loss by imagining himself placed in similar circumstances and then calculating what would be his own loss.

But, besides the losses thus enumerated, great damage has been done in West Maitland to the gardens, fencing, and other improvements and comforts which the inhabitants had made and gathered around them. Small vineyards, orange groves, fruit trees, and vegetable gardens have been to a large extent destroyed, and there is not the slightest doubt that West Maitland will not, during the next season, present such a smiling and comfortable appearance as it was wont to exhibit The damage done to the crops, lucerne paddocks, &c., I reserve for the report of the floods in the country districts.

PART I.

The earliest great floods in the Hunter of which we have received any authentic accounts seem to have been those which occurred between the years 1818 and 1820, the highest being that of 1820, a short account of which is given in the *Maitland Mercury* of 3rd September, 1857, from which I extract the following description, said to have been given by an eye-witness :—"A large portion of the present site of East Maitland, then a bush, as well as the country around, was flooded. A small rise at the back of Ogg's was dry, and a small piece of the present Melbourne-street, near the Hunter River Hotel, was also just dry; but, with these exceptions, all the lower parts occupied by the present town were flooded."

"In West Maitland the only houses then existing were a hut nearly opposite the present site of the Waterloo Hotel;" another hut, "nearly on the site of Messrs Dickson & Co.'s present stores, and a hut built in the rear of the present Angel Inn. The flood was up to the wall plates of the first hut, touching the shingles; up to the window-sill of the second, and was in the third; but the top of Bourke land, and the high ground extending back from the river near the Fitz Roy Hotel towards St. Mary's Church, were dry," although Mr. Eckford (the gentleman from whom the information is derived) does not speak positively as to how broad or long the dry land was.

The next highest flood after this was that of 1832, which Mr. Eckford thinks attained a height of within 8 feet of that of 1820.

The article then goes on to say, "that if, as we believe, the present flood (*i.e.*, the great flood of August, 1857) was, at West Maitland, 29 feet above high water mark, the June flood (of 1857) was over 26 feet, the 1840 flood was about 26 feet, the flood of 1832 was 29 feet, that of 1826 was less than 29 feet, and the flood of 1820 was 37 feet." The respective heights of the above-named floods may be thus recapitulated, viz.:—

At Maitland—

* 1857—Flood of August	....	29 ft.	above	high water.
" Do. of July	26 ft. 8 in. to	27 ft.	"	"
" Do. of June	....	26	"	"
1840—Do.	....	26	"	"
1832—Do.	......about	29	"	"
1826—Do.	..less than	29	"	"
1820—Do.	.....nearly	37	"	"

At Morpeth—

1857—Flood of June.....................	10 ft.	above	high water.
" Do. of August..................	14·9	"	"
1840—Do....................................	8 ft.	"	"
1832—Do....................................	Not given.		

Proceeding with the extract, we find is stated, "Every old resident we have conversed with is quite positive that more water came down in each of the 1857 floods than during any former flood within their remembrance; and they account for the lesser height of the river by the great extent of land now cleared as compared with the then densely wooded country, and by the river also being now more clear of obstructions in the way of snags, &c." This explanation of the probable cause of the river not attaining the same height now as formerly is perfectly reasonable, and may, no doubt, be received as correct. When the river now overflows its banks, it has an open valley to spread over; formerly, the dense growth of trees and underwood, bound together and intertwined in an almost impenetrable mass by the vines, offered a barrier to the waters on either side; so that the discharging section of the river being strictly confined to the channel proper, the waters were pent up until they attained such a height as was sufficient to restore the equilibrium. And in point of fact, supposing the river to attain a height of 8 feet at Maitland above the flood of 1857, as the flood of 1820 is said to have done, and assuming that it rose to 5 feet above that of 1857 at Morpeth, which would be a fair allowance, taking into account the extent of the level country, I find that, with the increased area, hydraulic

country, I find that, with the increased area, hydraulic
mean depth, and slope of surface thus allowed, the natural channel would be almost sufficient to carry off all the waters of a flood like that of 1857, as fast as they came down to Maitland. The calculations give four-fifths; the remaining one fifth would probably have drained back into the swamps of Bolwarra and Dagworth, as at present.

There is, of course, some difficulty, in the absence of actual measurements, carefully recorded, in determining the precise heights of former floods; but Mr. Eckford's reminiscences of the flood of 1820 may probably be relied upon; and, as referring to the highest known flood since the settlement of the colony, are very important—because, if it can be shown, as has been asserted, that in the flood of 1857 more water came down in a given time when the flood was at its height than was the case in 1820, we have the experience of forty-seven years instead of ten to guide us in our computations. It is a consideration of very considerable importance in dealing with a subject of this kind, or when designing works on large rivers, to know what height has the highest known flood attained to—a question which we very often find it difficult to get satisfactorily answered.

We are in possession of very full information as to the height, duration, rate of rise and of fall of the more recent floods of 1857, 1861, 1864, and 1867; the last of which is generally admitted to have been amongst the highest since that of 1820. And it will be important, when we come to consider what would be the effect if the river were again rigidly confined within its banks by partial embankments, or by "levées," as they are technically termed, to have these accurate measurements as to floods which there is good reason to believe have been the severest that have occurred within the last half-century.

Reverting to the accounts of floods as published in the *Maitland Mercury* and other local papers, we find that the years 1856 and 1857 were unusually wet, and that in the month of June in the latter year the Hunter River district was visited by the heaviest flood which had been seen since 1832. The rain commenced to fall heavily on Tuesday afternoon, June 17th, and continued falling during Wednesday. The water rose with unusual rapidity at West Maitland, "commencing at 1 or 2 feet above high water mark, at 5 o'clock on Wednesday morning, the 18th June,—it reached 26 feet before 5 o'clock on Thursday morning, that is in little more than twenty-four hours." The current is described "as vastly more rapid and more sustained than in any previous flood, bringing down a considerable quantity of large timber, much exceeding the ordinary amount of flood timber."

After receding a few inches at West Maitland on Thursday and on Friday in the forenoon, it commenced to rise again on Friday afternoon, continuing until past midnight, when it attained to one inch higher than on Thursday.

By daybreak on Saturday it had again fallen from 1 to 2 inches; by Sunday morning it had fallen 2 or 3 feet; from which time it continued steadily falling till, on Monday evening, the waters had receded about 8 feet

It may be as well to recapitulate here the substance of the information as above given in connection with the rise and fall of the flood of June, 1857,† at West Maitland:—

On Wednesday, 17th June, at 5 a.m., flood level above h.w., 2'.‡
On Thursday, 18th June, at 5 a.m., level above h.w., 26'.
Friday, 19th June, say 25'.
Do., midnight, say 26' 1".
Saturday, 5 a.m., 25' 10".
Do., 6 p.m., say 25'.
Sunday, 6 a.m., 23' to 24'.
Monday, 22nd, evening, 18'.5

Sunday, 6 a.m., 23' to 24'.
Monday, 22nd, evening, 18'.§

The Hunter, the Paterson, and the Williams were all in flood about the same time, and the water attained its greatest height at Morpeth, namely, about 10 feet above high water mark, before 8 o'clock on Thursday afternoon. The crest of the flood wave would thus seem to have taken from twelve to fifteen hours to travel from Maitland to Morpeth, being at the rate of about one and a quarter mile per hour.

At Morpeth, the water rose rapidly till 6 p.m. on Wednesday, 17th June. From 6 p.m. to 10 p.m. it rose 6 inches. From 10 p.m. to 4·30 a.m. on Thursday it rose 3 feet. From 4·30 a.m. to 6 a.m. it rose 8 inches, and continued rising throughout the day. At 8 p.m. commenced to recede, at 10 p.m. had lowered 2 inches; on Friday, at 10 a.m. had fallen 9 inches, at 3 p.m., 11 or 12 inches.

It was noticed that the more rapid rise took place between 2 a.m. and 4 a.m. on Thursday, which was about the time, or shortly after, that the water had attained the greatest elevation at Maitland.

This rapid rise, must, I think, be solely attributable to the flood water; the backing up of the tide could have had very little (if any) influence on it, as the tides were at this time at the neaps, and it would have been low water at Morpeth about 2 a.m., and high water about 8 a.m.

By Monday afternoon the waters had receded at Morpeth to within about 2 feet of high water mark, spring tides.

It may be noted then that on—

Wednesday the 17th, the river was rising rapidly at Morpeth till 6 p.m.
6 p.m. to 10 p.m., it had risen 6 inches.
From 10 p.m. to
Thursday ... 4 a.m., 3 feet. 4 a.m. to 6 a.m., 8 inches; at 8 p.m., was 10 feet above high water; commencing to recede.
10 p.m., had fallen 2 inches.
Friday ..... 10 a.m., 9' 3" above high water.
" 3 p.m., 9' 1" above high water.
Monday, 22nd 2' above high water.

Raymond Terrace was flooded, and the water rose to the floor of Mr. Portus' mill.

At Singleton, on Wednesday the 17th, it was raining heavily; on Thursday, the weather is reported as being fine, but the river was rising rapidly—on Thursday evening it had risen very high. Detailed measurements of the height of the flood at Singleton and the other towns on the Upper Hunter are not given.

On Thursday, the Wollombi brook was running fearfully high.

The foregoing dates and heights would afford the means of calculating approximately the amount of the water brought by the river down to West Maitland, as well as the amount discharged past Morpeth, the difference between the former and the latter being the quantity spilled over the banks between these places, and which went to inundate the adjoining low-lying lands; but I

went to inundate the adjoining low-lying lands; but I
have not made these calculations, it being unnecessary to do so, as the subsequent flood of August, 1857, and the last flood of June, 1867, were higher, and we have more detailed information as regards their levels, velocity, and the quantity of water discharged.

At the time of which I am writing, but few attempts had been made to protect the town of Maitland from the effects of floods, and what had been done seems to have had but little effect, so that when the waters rose to about 20 feet, they commenced flowing in many places over the banks; and as the ground generally falls as it recedes from the river, the flood soon commenced to inundate the swamps and low ground at the back. The Horse-shoe Bend, it is said, was the first point submerged; next, the river overflowed the bank at High-street nearly opposite the Queen's Arms; and as it continued to rise, it found other outlets into the low land about the Racecourse, and up the valley of Wallis' Creek.

By this flood a considerable part of West Maitland was laid under water, and nearly one half of the houses were more or less submerged, some having the water up to the eaves. The dam at Hall's Creek burst, allowing a large body of water to flow up that creek and flood the back land. By the waters flowing up Wallis' Creek "the whole of the flat lands on Louth Park, Dagworth, Hungerford Swamps, and for miles further up, were submerged; and so rapid was the inundation, that a great many persons were surrounded by water and cut off from all hope of escape."

At Bolwarra immense loss was sustained. The rapid inundation completely covered hundreds of acres, and while some families who were on the alert escaped, others were surrounded by the flood before they could do so, and were lost.

At East Maitland the damage done was comparatively slight; but from East Maitland to Morpeth the road is said to have been bordered on the left by an almost unbroken sheet of water, while at Morpeth the damage done was said to have amounted to £15,000.

Such is a short account of the first, or June flood of the year 1857, taken from the files of the *Maitland Mercury*, in which paper nearly every fact of interest or importance connected with the floods of the Hunter seems to have been carefully collected, and clearly and ably set forth.

The first rapid rise in the Hunter, was clearly due to the flooding of the Wollombi and its other lower tributaries; for we find it bank high at West Maitland on Thursday morning, at which time it had only commenced rising rapidly at Singleton; but the second rise at Maitland at midnight on Friday was probably due to the arrival of the crest of the flood wave which had culminated at Singleton on Thursday evening, and which had thus travelled down the river at the rate of about 1½ mile per hour.

The next flood in the Hunter was that of July, 1857.*

It commenced raining on Sunday evening the 26th, continued raining all that night, the following day, and all Tuesday, and in the early part of Tuesday night came down in furious driving showers.

At 8 a.m. on Tuesday, the 28th, the river stood at about 1 foot above high water mark†—

By noon it had risen to 3 feet.
5 p.m., 10 feet, being at the rate of 17 inches per hour.
‡9 p.m., from 17 to 18 feet, or 22 inches per hour.
11 p.m., to 19 feet, rising at the rate of 6 inches per hour.§
Wednesday, July 29th, at 4 a.m. had risen to 23 feet.
7 a.m., 24 feet 6 inches.
Noon, 26 feet.
Thursday, July 30th, still rising.

Friday, July 31st, height 26 feet 8½ inches to 27 feet, at which level the water continued from 9 a.m. to 12 o'clock. By 2 p.m. on Friday, the water had fallen ¼ of

* The correct heights, as given by subsequent measurements, are—

	ft.	in.
At Bolwarra	32	8
At the Bridge	30	0
At High-street	27	2
Mean height, say	29	10

† Full Moon, 6th June, 5·37 a.m.
‡ Moon, last quarter, 15th June, 7·34 morning.
§ New Moon, 22nd, 8·6 morning.

o'clock. By 2 p.m. on Friday, the water had fallen ½ of an inch, by 5 p.m. 2 inches, by 9 a.m. on Saturday, 3 inches. During Saturday night the waters continued falling fast. From Sunday to Monday morning, the fall was inconsiderable, and at noon of the latter day the river was almost at a standstill, there being scarcely any current.

It was remarked that while this flood was at its highest, the rate of current was about 5 miles per hour at Maitland, which is a close approximation to the calculated velocity as given by Dubuat's and the other formulæ.

At Morpeth, at 12 30 on Wednesday, the 29th July, the river stood about 6 feet 6 inches above high water. On Wednesday evening it had risen to 8 feet above high water. On Thursday evening it attained its highest level, namely, 10 feet 7 inches above high water. For a short time, about two o'clock on Tuesday, the current at Morpeth was running (if anything) up stream, caused by the flood in the Paterson; but about 4 p.m. the greater body of water rushing down the Hunter bore the smaller stream before it, and re-established the downward current.

It will be observed here that this flood attained its greatest height at Morpeth earlier than it did at West Maitland. This is, I think, to be attributed to the backing up of the Hunter by the Paterson in the early part of the flood.

In this, as in the former flood, I am unable to observe that the tides had any influence on the rise of the water or the time of the greatest height of the flood at Morpeth, as it would have been low water of neap tides about 11 30 p.m., on Thursday (about the time that it is said the flood attained its greatest height), so that the flood was falling while the tide was rising.

I have been careful to see if there be any connection between the state of the tides and of the flood at Morpeth, but without being able to discover the slightest.

At Singleton, on Tuesday, the river commenced rising; on Wednesday it continued to do so with great rapidity; on Thursday, the 30th, at 8 a m., it was at its highest, being 4 feet above last flood, and 5 feet below that of 1832. At 8 p.m. of the same day the river had fallen 4 feet, or at the rate of 4 inches per hour.

The crest of the flood-wave leaving Singleton at 8 a.m. on Thursday, arrived at Maitland on Friday between 9 a m. and 12 am., showing its rate of descent to be nearly 2 miles per hour.

On the occasion of this flood, the waters broke at West Maitland over all the points of overflow of the former flood, inundating the back country to a greater extent than had then occurred, the back water having reached to within 1 foot of the height of the river; and it is surmised that if the river had continued at its full height for another day, the backwater would have risen to fully its level.

On Wednesday morning the water had commenced to pour across High-street at various points, and continued running in a strong stream for two days, till, as we have seen, the back water on Friday evening rose within a foot of the level of the river, which at that time had receded 2 or 3 inches. We thus gain some idea of the enormous capacity of the flooded back country as a compensating reservoir to the river.

In this flood the waters fell faster than they did in the June flood—the river continued falling at the rate of about 1½ foot per day; on Wednesday having fallen to 16 feet, on Friday, August 7th, to 19 feet, from the highest point attained, being then about 8 feet above high water mark. The back water was then fast receding, being rapidly drained off by Wallis' Creek.

We now come to the August floods of the same year (1857), the highest by which the country had been visited since 1820, and which caused such wide-spread desolation over the Lower Hunter.

The rain commenced falling on Wednesday evening,

The rain commenced falling on Wednesday evening, the 19th August, on a country thoroughly saturated by the two preceding floods, which had filled every waterhole and swamp, and spread over every plain. Thus, all the natural reservoirs being already filled to overflowing, it is not to be wondered at, when the unusually heavy rainfall is considered, that this flood should have come down with unprecedented rapidity, and have attained to the extraordinary height it did. The flood diagram attached to this report shows that the total quantity of water which passed down the river, from the commencement to the termination of the flood, amounted to over 80,000 millions of cubic feet, a quantity which would account for nearly 5 inches of rainfall over the entire valley of the Hunter. The total rainfall for the months August and September was 6 1 inches.

It commenced raining, as I have said, on Wednesday evening, and continued throughout Thursday and Thursday night, raining heavily, and blowing a gale of wind from the south-east; but it was not till about sundown of the latter day that the river commenced to rise in West Maitland, and a gentle current was perceptible.

On Friday, the 21st, at daylight, the river was seen to be rising, but was not yet very high. At 7·30 a more rapid rise took place, the water being then 11 feet above high water.

Continuing to rise rapidly, it had reached, by 11 a.m., 19 feet above high water; by 12 30 it had risen to 22 feet; and by 2 30 p.m , it was about 25 feet. So rapid a rate of rise had never before been observed at Maitland.

Early on Friday, the 21st, the river had commenced flowing through Hall's Creek, on to the low lands on the south and west of the town, which were already partly submerged by the heavy rain. At about 5 p.m. on Friday the water was running in a strong stream across High-street, opposite the Queen's Arms Hotel, the water being then 26 feet above high water mark; but the current in the river at this time was not so rapid as it had been during the June flood. By 7 p m. the water was pouring into High-street, near the Wesleyan Chapel; by 8 p.m., still raining, though not so frequently, the water had nearly crossed the road; at 10 p.m., it had risen to the level of the July flood, namely, about 27 feet above high water, and was still rising. On Saturday morning, at 9 o'clock, it had reached to 1 foot above the level of the July flood, or 28 feet above high water, with a very rapid current in the river. A pause then occurred, and no perceptible rise took place for several hours, till about 5 p.m. on Saturday it commenced rising very slowly, and continued rising until Sunday evening about sundown, when it attained its greatest height, namely, 29 feet above high water. Shortly after, or about 7 p m. on Sunday, a slight decrease was perceptible; and by midnight it was obvious that the overflow had diminished. On Monday morning it had fallen 4 inches, and continued to fall steadily during that day and the next; and by Wednesday, the 2nd September, it had fallen 19½ feet from its highest point.

In this, as in the former floods, it was observed that, with a rise of about 20 feet, the water commenced to overflow at one or two points at the Horse-shoe Bend; at 24 or 25 feet, it commenced to overflow at High-street—first below the Rose Inn, then near Bussell's; at 26 to 27 feet, it commenced to overflow the dams or levées at the Falls, and the line of the bank along the Free Church-

* New Moon, 21 July, 4 27 a.m.
† Maitland Mercury, 30 July, 1857.
‡ Broke over the low land at Horse-shoe Bend.
§ Moon, first quarter, 29 July.
|| New Moon, 20 August, 2·20 p.m.

feet, it commenced to overflow the dams or levées at the Falls, and the line of the bank along the Free Church-street, and at the foot of Hunter-street.

The points within the town of West Maitland where the overflow from the river was heaviest (sufficiently strong to sweep away houses) was at the Falls, at Bussell's, at the Rose Inn, and at Wallis' Creek, where the current of the backwater overflowed and swept in a strong stream towards East Maitland.

About one quarter of the town remained above water, namely, from a little above the Buck's Head Inn on the one side to the Northumberland Hotel on the other, and from the high bank of the river to the flat on which St. Mary's Church and Mr. Baldwin's house stands. A few other patches were also dry. But the remainder of the town was under water to a greater or less depth.

The information thus collected of the August flood may be condensed as follows :—

Wednesday evening (August 19th)—commenced raining.
Thursday, at sundown (August 20th*) no signs of rise.
,, gentle current perceptible in river.
Friday, daylight—river rising.
,, 7·30 a.m.—height, 11 feet; rising rapidly.
,, 11 a.m.— ,, 19 feet, or at a rate of rise of 2 feet 3 inches per hour.
,, 12·30—height, 22 feet; rate, 18 inches per hour.
,, 2 30 p m.—25 feet; rate, 18 inches per hour.
,, 5 p.m.— 26 ,, ,, 5 inches per hour.
,, 6 p m.—26 feet 3 inches.
,, 7 p.m.—26 ,, 9 inches.
,, 10 p.m —27 feet.
Saturday, 9 a.m.—28 feet.
,, forenoon, water stationary.
,, 5 p.m.—recommenced rising.
Sunday, at sundown, reached 29 feet.

The points where the water broke over the banks of the river, as well as the portion of West Maitland inundated by this and the other floods, as far they can be ascertained from the accounts given in the *Mercury* newspaper, will be shown on the accompanying plan of the town.

At Morpeth, between 6·30 a.m. on Friday, and 3 p.m. of the same day, the river rose 6 feet, being then about 7 feet 5 inches above high water, and rising at the rate of about 8 inches per hour; the current was not very strong, in consequence, as was supposed, of the waters of the Paterson as well as of the Williams being both level with those of the Hunter. About 9 p.m. on Friday the river had risen to 10 feet 7 inches (the level of the last flood); it continued to rise rapidly during the night, and by Saturday morning the whole country on the opposite side to Morpeth was like one inland sea.

The Paterson had come down bank high on Friday morning before the Hunter, and broke over Phœnix Park and Dunmore.

On Sunday at 11 p.m. the river was at its height, being 3 feet 8 inches above the last flood, and 14 feet 9 inches above high water.

At twelve o'clock on Sunday night it commenced to fall slightly—by 8 a.m. on Monday it had gone down 2½ inches, by noon only 3½ inches.

The flood, as we have seen, attained its greatest height at West Maitland at sundown on Sunday, and at Morpeth reached its greatest elevation at 11 p.m.—showing that the crest of the flood wave took 6 or 7 hours to travel from the former to the latter.

It was new moon on Thursday, August 20th, at 2h. 29m. 49s. a m, so that it would have been high water at Newcastle about 8·45 a.m., and at Morpeth about 3 hours later, that is, about 11·45 a.m.; and on examining the state of the tides and of the river on the following day (on Monday at noon), when the water was still 13 feet 11½ inches above its ordinary high water level, I am unable to perceive that there was any alteration of level which could indicate that the flood was at

level, I am unable to perceive that there was any alteration of level which could indicate that the flood was at
all affected by the tides; and we also find that lower down the river, at Raymond Terrace, Hexham, and almost as far as Newcastle even, the tidal action seems to be neutralised by that of the flood.

Recapitulation of rise and fall at Morpeth :—

Friday, Aug. 21—From 6·30 a.m. to 3 p.m. river rose 6 feet = 7′ 5″ above high water.
Rate, 8 inches per hour. 9 p.m., 10′ 7″ above h. w.
Saturday...... Rising slowly.
Sunday ......11 p.m., 14′ 9″ above high water. 12 o'clock, commenced falling slightly
Monday ......8 a m. 14′ 6½″ Noon, 14′ 5½″.

At Raymond Terrace this flood rose with unusual rapidity, and attained a height of about 5 feet above that of the last flood, or 7·82 feet above high water.

Tracing this flood downwards from the head waters of the Hunter, we find that at Musclebrook the water reached its greatest height on Friday night at 10 o'clock. At Singleton, Thursday, August 20th, there was no appearance of rise in the river. On Friday, August 21, the river had risen during the night with unprecedented rapidity, about 3 feet per hour. On Saturday it was still rising rapidly, the water breaking over the banks above the town. On Sunday morning, at four o'clock, it attained its greatest height (46 feet above summer level), and commenced to fall. On Monday, at noon, the river was falling.

It would thus seem that the crest of the flood or wave was, at

Musclebrook—on Friday, at 10 a.m.

At Singleton (about 85 miles)—on Sunday, at 4 a m, having come down at the rate of about 2 miles per hour; the fall being say 3·8 feet per mile.

At West Maitland (49 miles)—on Sunday, at 5 p m., about 3·8 miles per hour; fall being at the rate of 2 088 feet per mile.

Morpeth (17 miles)—on Sunday, at 11 p m., 2·8 miles per hour; fall, at rate of, say 1 foot per mile.

Such are the salient features of the great flood of August, 1857, which I have dwelt on at some length, as it and the flood of 1867 form the ground on which I base my calculations as to the quantity of water to be dealt with in any scheme which may be proposed for abating the injuries done by these floods.

By these floods it was estimated that 35,000 acres of land were inundated, four hundred families reduced to destitution, and injury to the amount of £150,000 inflicted on the district, from loss of crops and stock and damage of various kinds.† These lastnamed injuries and losses were not caused, however, by the floods alone, for it is pretty generally admitted that during wet seasons, even when there has been no flood of importance, that the rain falling on the surface, added to the drainage from the adjoining ridges, is sufficient to lay under water a considerable extent of the richest and best land in the neighbourhood of the Maitlands; the land in the immediate neighbourhood of the river having been raised by the alluvial deposits of ages to a higher level than that of the back lands, a feature of all large rivers, it follows that the drainage into the river from the back lands is rarely perfect in its natural or unimproved state.

From 1857, to February, 1861, there were occasional freshes in the Hunter, but nothing of sufficient importance to warrant further notice; but on the latter date the Hunter was visited by another high fresh.

On Wednesday‡ and Thursday, the 6th and 7th of February, it came on to rain very heavily, and early on Friday night, February the 8th, the river commenced to rise; on Saturday morning, the 9th, at 6 o'clock, it had

* New moon, 2·30 a.m., 20th.
† See debate, Legislative Assembly.
‡ Moon in last quarter, 2nd Feb., 6 4 p.m.

risen 8 feet above ordinary high-water mark; by 6 p.m. it had risen to 12 feet. At 6 a.m. on Sunday morning* it had risen to 15 feet, with a very rapid current, and by 2 p.m. on Sunday it attained its greatest height, being then about 16 feet above high water. The water commenced to recede about 4 p.m. and by Sunday it had gone down about 4 inches.

At 6 a.m. on Monday the water had receded 3 feet, or to 13 feet above high water, and on Monday evening it had gone down to 11 feet above high water.

Little or no damage was done to the town by this flood, but a considerable extent of the low-lying land back from the river was inundated by the water, which for some two or three days continued flowing up Wallis' Creek.

We thus observe that a flood 16 feet in height, while it does no injury to the town, is capable of doing considerable damage to the crops on the low lands, in consequence of the absence of any proper system of drainage.

Early in the following month of March, there was another fresh in the Hunter, which rose to 15 feet 6 inches above high water. Commencing to rise on Friday at sundown, it attained its greatest height on Sunday the 3rd, about mid-day,† and commenced falling slowly about an hour or two after; it had gone down 6 inches by sundown, and 2 feet 6 inches by Monday morning. But a second rise took place during the day, and by sundown the river again stood at its highest point—15 feet 6 inches.

This second rise was attributed to the arrival of the flood wave of the Goulburn River—the largest tributary of the Upper Hunter.

The effects of this flood were similar to the last. The town sustained no damage, but the flat country towards the head of Wallis' Creek was again laid under water.

About the latter end of April—barely two months after the last described fresh—the Hunter was visited by another flood.

There had been a good deal of rain for the preceding ten or twelve days; but on Saturday and Sunday, the 27th and 28th April,‡ it came down with great violence, still further flooding the low lands about West Maitland and Hexham, from which the water left by the flood of March had not drained off.

On Sunday evening, the 28th, the river showed symptoms of a rise. After midnight it commenced rising rapidly; and by 8 o'clock on Monday morning the 29th, it had risen from 13 to 14 feet above high water. By noon on Monday the river had risen to 16 feet, and at about 8 p.m. it had risen to 19 feet, when it became stationary. It then commenced falling slowly, and by 7 a.m. on Tuesday, the 30th, it had gone down nearly 2 feet. But about 9 a.m. it commenced to rise, and at 2 p.m. had again risen to 19 feet, and continued rising slowly, with a rapid current carrying down much heavy timber, till about 3 a.m. on Wednesday, when it attained its greatest height, of 21 feet above high water. At this level the water remained stationary all day, and until about 7·30 p.m. (16½ hours), at which time it re-commenced falling, and at 8·15 p.m. had gone down 1 inch.

On Wednesday night it fell 1 foot. By noon on Thursday it had fallen 2 feet; by sundown, 3 feet; and by daylight on Friday morning, nearly 6 feet; at 1 p.m., 7 feet; at sundown, 8 feet. The river being then confined within its proper banks, no further record of the rate of fall seems to have been kept.

It was observed of this flood, that, although on all former occasions a rise of 21 feet would have seriously flooded the flat lands in and near the town on the right bank of the river; on this occasion, in consequence of the dams which had been thrown across the creeks leading into the back lands, comparatively little injury was caused by the river water, except by that which flowed up Wallis'

the river water, except by that which flowed up Wallis'
Creek, and thence out over the low lands at its head.

On the left bank of the river it was different, the low lands about Bolwarra being all overflowed.

We thus find that, at this time, a rise of 21 feet in the river, although still inundating all the low-lying lands, had ceased to cause any injury to the town, in consequence of the measures which had been taken by the inhabitants to embank it out.

Some notice was taken of the time which the flood waters took in travelling from Singleton to West Maitland, on this occasion, and it was estimated that the rate of speed was from three to five miles per hour.

The first rise during this flood at Singleton stopped at 10 feet on Monday morning; but as the first rise at West Maitland culminated at 8 a.m. at 19 feet, it must have been caused mainly by the waters of the Black Creek, Anvil Creek, and other creeks joining the Hunter below Singleton.

The second rise at Singleton commenced on Monday afternoon, and continued until Tuesday morning, the 30th. At 8 a.m., it was eighteen feet above the usual height, and by 1 p.m. on the same day attained its greatest height.

The second rise at Singleton is attributed to the arrival of the flood waters of the Goulburn, which, passing on, also caused the second rise at West Maitland. The second rise, as we have seen, commenced at Singleton at about 5 o'clock on Monday afternoon, and at Maitland at about 8 a.m on Tuesday, or about 15 hours later, and attained its greatest height at Singleton at 1 p.m. on Tuesday and at West Maitland about 3 a.m. on Wednesday—about fourteen hours later; which, the distance being, as I have said, about 49 miles, gives a velocity of about three and a half miles per hour.

It will be observed that, in this flood, as well as in each of those of 1857, there was a second rise in the river after it had attained its first elevation and had commenced falling, and during this last-described flood, it reached a greater height by 2 feet during the second rise than it did during the first.

The next flood that occurred during 1861 was that of July.

It commenced raining over the valley of the Hunter on Tuesday, July 23rd,§ and continued almost without intermission for the remainder of the week.

The immediate consequences of the local rain was, the accumulation of sheets of water in all the hollows about the town, but the river itself did not shew any symptoms of a rise till Wednesday night.

At 7 a.m. on Thursday, it had attained a height of 7 or 8 feet above its ordinary high water level; at about 3 p.m. it had risen to 10 or 11 feet, and early on Thursday night it had risen to 14 feet above high water. During the night it continued to rise rapidly—3 to 6 inches per hour, and at 10 a.m. on Friday it attained a height of 22 feet.

Continuing to rise slowly, at midnight on Friday it commenced flowing over the river bank at High-street, near Messrs. Hall and Co.'s stores; and by 5 a.m. on Saturday it had reached to 24 feet above high water, and continuing to rise more slowly, it reached its maximum at about 3 p.m. on Saturday, when it stood at 25 feet 4 inches above high water mark, being nearly at the same level as the June flood of 1857.

Shortly after 3 o'clock on Saturday it commenced to fall slowly at first, but then more rapidly. At 3 a.m. on Sunday it had receded 1 foot 4 inches; at 9 a.m. on Sunday it had fallen 2 feet 4 inches from its highest. At 5 o'clock on Monday afternoon it had gone down 8 feet, being then about 17 feet above high water; and by Wednesday, August 6th, it had receded to within 4 or 5 feet of its ordinary level.

An unusual feature in this flood was the height attained by the river at so early a stage of the rain; and that, when it commenced falling, it went down almost as rapidly as it rose.

that, when it commenced falling, it went down almost as rapidly as it rose.

Heights at West Maitland.

1861—July 24—Wednesday, river stood at h.w.
,, 25—Thursday, 7 a.m., say at 7′ 6″
,, 25— ,, 3 p.m., ,, 10′ 6″
,, 25— ,, 10 p.m., ,, 14′ 0″
,, 26—Friday, 10 a.m., ,, 22′ 0″
,, 26— ,, midnight, ,, 23′ 0″
(Over bank at High-street.)
,, 27—Saturday, 5 a.m., ,, 24′ 0″
,, 27— ,, 3 p.m., ,, 25′ 4″
,, 28—Sunday, 3 a.m., ,, 24′ 0″
,, 28— ,, 9 a.m., ,, 23′ 0″
,, 29—Monday, 5 p.m., ,, 17′ 0″
Aug. 7—Wednesday, 4 to 5 feet above h.w.

Heights at Singleton.

July 25—Thursday, 4 a.m., river commenced to rise.
25— ,, Evening, had risen 12 feet; rising at the rate of 1 foot per hour.
26—Friday, 9 a.m., 18′ 0″
26— ,, noon, 22′ 0″
27—Saturday, 3 a.m., 26′ 0″
27— ,, 10 a.m., 24′ 0″
28—Sunday, 9.30 a.m., 14′ 0″
29—Monday, 7 p.m., 4′ 0″

Musclebrook.

July 26—Friday, forenoon, river at its greatest height.
26— ,, noon, had commenced falling.
27—Saturday, 10 a.m., fallen 12 feet.

Morpeth.

July 26—Friday morning, river over Queen's Wharf.
27—Saturday, midnight, 9′ 0″ above h.w.
28—Sunday, subsiding rapidly.
29—Monday, noon, 2 feet above ordinary h.w. springs.

This flood, which rose with unusual rapidity, subsided almost as quickly. This perhaps is in some measure attributable to the rain having ceased to fall heavily after Saturday morning, as well as to the circumstance of the Paterson and Williams being but slightly flooded, thus allowing the waters of the Hunter to drain off more rapidly than they would have done had they been pent up by the back water of those rivers, as occurred in some of the former floods.

The rapid subsidence of the water prevented much injury being done to the crops; "even the young wheat was in many cases saved." This fact should be borne in mind when we are considering the question of drainage.

* New Moon, 10th, 9 0 a.m.
† Moon in last quarter, 4th, at 5·20 a.m.
‡ Full Moon, 26th, 5·26 a.m.
§ Full Moon, 22nd, 8·10 a.m.
‖ Full Moon at 8·10 a.m., 22nd.
¶ New Moon, 6th, 10·46 p.m.

The waters of the Hunter had not returned to their ordinary level after the flood of July, when they again commenced to rise. On Tuesday morning, August 6th,* it commenced raining slightly, gradually increasing to a steady continuous rain on Tuesday night, Wednesday, and Wednesday night, and the following day and night.

West Maitland.

August 7—Wednesday, noon, the river commenced rising slowly, being then 4′ or 5′ above its ordinary level.
,, 7— ,, at sundown, it had risen to 5′ 6″
,, 8—Thursday, morning, within 3′ or 4′ of the level of last flood, and rising 5″ or 6″ per hour.
,, 8— ,, 1 p.m., flowing over High-street
,, 8— ,, at nightfall, rising very slowly—almost imperceptibly.
,, 8— ,, at nightfall, rising very slowly—almost imperceptibly.
,, 8— ,, midnight, 25′ 6″ above ordinary level.
,, 9—Friday, 6 a.m., commenced to fall at rate of ½″ per hour.
,, 9— ,, 8 p.m., the water stood at 25′ 2″
,, 10—Saturday, morning, about 25′
,, 11—Sunday, River falling steadily and uniformly.
,, 12—Monday, evening, about 13 feet above h.w.

Singleton

August 7—Wednesday, 5·43 p.m., river had risen 3 feet
,, 8—Thursday, 9 16 a.m., rising 1′ per hour, was then 20′ above ordinary level
,, 8— ,, 11·38 a.m., 21′.
,, 8— ,, 5·52 p.m., rising 5″ per hour.
,, 9—Friday, 10 14 a.m., 24′ 9″.
,, 9— ,, 4·55 p.m., commenced falling, having reached 25′ above ordinary level.
,, 9— ,, 5·47 p.m., 24′ 8″.

Musclebrook.

August 7—Wednesday, 5 41 p.m., river risen 3′ or 4′.
,, 8—Thursday, 5 52 p.m., at standstill.
,, 9—Friday, 10·14 a.m., falling.

Morpeth

August 9—Friday, 2 a.m., river had risen to 11′ 2″ above h.w., and then commenced falling.
,, 9—Friday, sundown, 10′ 10″ above h.w.

Raymond Terrace

August 9—Friday, 2 a.m., river attained its greatest height being 3 feet below flood of August, 1857—5′ 7″ above h.w.

By this as by the preceding floods, the whole of the low land on both banks of the river were laid under water. Louth Park and Dagworth are described as seas, and Phœnix Park, Bolwarra, and Dunmore as being one sheet of water. Considerable damage was done to the standing crops; and the town also suffered somewhat, the water rising to the eaves of many of the houses in John-street.

A considerable amount of damage was also caused by this flood to the residents of the Paterson and Williams, on both of which the alluvial flats were flooded.

The rains on this occasion seem to have been principally confined to the coast line, and not to have extended very far or very heavily inland; hence probably the reason why we find the flood culminating at Maitland before it reached its highest at Singleton.

On this, as on the occasions of former floods, the state of the tides, whether at flood or ebb, springs or neaps, seems not to have had any influence on the height, duration, or rate of rise or fall of the flood-wave at Maitland or Morpeth. In fact, when it is remembered that at Newcastle, during heavy floods, the range of tide is only altered about 1 foot, it is difficult to imagine that it can have any influence on the height of the water at Maitland; and although there is a sensible increase in the velocity with which the flood waters rush out through the narrows at the entrance to Newcastle at the latter part of the ebb, the tide is not found to affect very sensibly the level of the water as far up as Hexham and Raymond Terrace; between which places and the outfall at Newcastle there are capacious areas for the water to expand over afforded by the river itself, the low-lying land upon its margin, and the wide estuary of Fullerton Cove, all of which act as compensating or regulating reservoirs, and are capable of receiving many hours' discharge of the river without sensibly affecting its level.

It will be observed as an unusual thing, in this flood, that the highest rise at West Maitland, Morpeth, and Raymond Terrace was almost coincident—the times being at Maitland, midnight, on Thursday, August 8th; at Morpeth, 2 a.m., on Friday; and, at Raymond Terrace, Morpeth, 2 a.m., on Friday; and, at Raymond Terrace, the same as at Morpeth.

Such was the last flood of the year 1861; and from that till the year 1864, the district seems to have remained undisturbed by flood alarms.

In the early part of the year 1864, the cycle of wet seasons again came round, and the week previously having been showery, on Wednesday, February 10th,‡ a close, steady rain commenced to fall, which soon made itself felt in the river. Towards the close of that day the water had risen about 1 foot, and continued rising at the rate of 1 foot per hour during the night.

By 9 a.m. on Thursday, the river had risen 17 feet above its ordinary level, with a rapid current, bearing on the surface large quantities of heavy timber. The rise continued during Thursday at the rate of about 6 inches per hour, causing successive overflows of the lower portions of the banks, and at Wallis' Creek. By Thursday evening it had broken over the bank at High-street. This overflow relieved the river and checked its rapid rise, but nevertheless the water continued steadily, though now slowly, to rise during Thursday night and Friday, and by Friday evening it had attained a height of 28 feet above its ordinary level, being then about 1 foot below the flood of August, 1857, still rising, but very slowly, and running rapidly.

It was remarkable that some houses and some parts of the town which escaped in the great flood of 1857 were flooded on this occasion (though, as has been stated, the general level was 1 foot lower in this than in the former), and others which on both occasions suffered, were invaded at different periods, as regards the times at which the waters broke over the banks at High-street and at the Falls.

The water still continuing slowly to rise, by sundown on Saturday, the 13th February, the greatest height, namely 28 feet 4 inches, was attained, or 8 inches below the height of the flood of August, 1857.

On Saturday night the river commenced to fall, and continued falling through Sunday; and Sunday night the river again returned within its banks, and by 8 o'clock on Monday morning it had fallen fully 10 feet from the highest level. The fall continued to Wednesday, the 17th, when the water had receded 18 feet.

Although considerable injury was done in the town by the water flowing over the river bank, and the low-lying lands in the vicinity of the river were submerged to nearly the same extent as during the great flood of 1857 (indeed, in some places of the Horse-shoe Bend it was said to have attained a greater height) looking across over Phœnix Park from Morpeth, it is asserted that the water was seen, in an unbroken sheet, extending for four or five miles; yet the much dreaded back water in rear and to the south of West Maitland did not rise to within some 4 feet of the level of that flood, in consequence of the empty state of the lagoons and swamps previous to the occurrence of this latter flood.

The following will show approximately the time at which the flood attained the maximum height at the undermentioned places:—

West Maitland.

February 10th.—Wednesday afternoon. River commenced to rise, being then 1 foot above high water mark.

11th.—Thursday morning. River 17 feet above high water; evening, breaking over High-street, 22 feet above high water.

12th.—Friday evening. 27 feet above high water.

13th.—Saturday morning. 27 feet 6 inches above high water.

Do., about sundown. 28 feet 4 inches above high water.

Do., at night. Commenced falling gradually.

14th.—Sunday night. Continued falling—the river being within its banks.

15th.—Monday, 8 a.m., it had fallen 10 feet, or 18 feet 4 inches from high water mark.

17th.—Wednesday, the river had fallen 17 feet, being about 11 feet 4 inches above the ordinary height.

Singleton.

10th.—Wednesday, 5·15 p.m. River rising 1 foot per hour.

11th.—Thursday, between 6 a.m. and 2·15 p.m. River, which had risen at the rate of 2 feet per hour, had attained a height of 25 feet, and continued rising at the rate of about 1 foot per hour. 6·15 p.m., river rising at rate of 6 inches per hour.

12th.—Friday, 7·45 a.m. River within 2 feet of flood of August, 1857, or 44 feet above ordinary level.

3·15 p.m. Risen 6 inches since morning, or within 18 inches of August flood, 1857—44 feet 6 inches.

6·47 p.m. River just commencing to fall, being within 16 inches of last-named flood, or 44 feet 8 inches above ordinary level.

15th.—Monday evening. River had fallen 35 feet.

---

* New Moon, 6th, 10·58 p.m.

† This gave 3·4 miles per hour as the rate of speed of the flood when between Musclebrook and Singleton.

‡ New Moon, 6th February.

Musclebrook.

12th.—Friday, 3 a.m. River commenced to fall, being then 1 foot above level of flood of 1857.

Had commenced to fall at *Singleton*, as before stated, at 6·47 p.m.

Morpeth.

13th.—Saturday, 12 p.m. River commenced to fall, having attained to within 2 feet of the height of the flood of August 1857, or 12 feet above ordinary high water, and 8 feet above the Steam Company's Wharf.

16th.—Tuesday. River had fallen 8 feet.

17th.—Wednesday. Fallen 11 feet, and continued falling steadily.

In the following month there was another flood in the Hunter. The river commenced rising on Tuesday, the 23rd March,* and by Friday, the 26th, had risen to about 21 feet above its ordinary level.

On Wednesday, March the 30th, the river, which had receded to about 5 feet above its ordinary level, again commenced to rise, and by 7 p.m. on Thursday, 31st March, had risen 20 feet.

Another flood commenced in June of this year.

The rain commenced to fall on Thursday night, June 2nd,† and early on Friday morning, the 3rd, the river was found to have risen 6 feet above its ordinary level, and continued through the day rising at the rate of about 1 foot per hour; and on Friday evening it had reached to 20 feet above its ordinary level. Continuing slowly to rise, by 2 a.m. on Saturday it commenced flowing over the banks, and by noon it had reached its greatest height, and then stood at from 23 to 24 feet above high water mark; and the backwater continuing above high water mark; and the backwater continuing to rise, by Sunday evening it had spread over every acre of cultivation between Maitland and the range of hills to the southward. "From the Morpeth Road, on Saturday, an extensive view of the flooded land was obtained, the expanse of water gradually increasing as one approached Morpeth, whence for miles nothing but water and partly submerged houses could be seen."

On this occasion, both the Williams and Paterson were likewise in flood, and the latter overflowed its banks at various points, submerging all the low lands.

At Morpeth, on Saturday at noon, the water had risen to within 14 inches of the February flood, or (say) 11 feet above high water.

One of the peculiarities of this inundation was, the great length of time the water remained at its greatest height at West Maitland, namely,—from noon on Saturday, till near Monday morning, at which latter time it had fallen but 2 feet, and was then subsiding very slowly.

At Singleton the flood culminated at 9 p.m. on Saturday, when the river stood at 28 feet above its ordinary level.

The flood having reached its greatest height at West Maitland, 9 hours before it attained its full height at Singleton, shews that the rise at the former place was mainly due to the local rainfall, and the flooding of the Wollombi, and the creeks entering the river between those two places.

It was observed on the occasion of this flood, that the Paterson rose with a rapidity never known before. The river, which on Thursday evening was at its usual level, had risen about 17 feet on Friday morning, and continuing to rise during that day with fearful rapidity, by midnight it had attained its greatest height, and then stood at 40 feet above its usual level, or within 3 feet of the great flood of August, 1857. About two hours afterwards it commenced to recede, and at daylight on Saturday had gone down about 2 feet, and by the evening about 6 feet.

The flood in the Williams, on this occasion, rose to within 3 feet of the height of that of August, 1857.

On the following week to that referred to in the foregoing account, and before the river had had time to go down to its ordinary level, the district was visited by another flood, of even greater severity than the last.

At dawn on Saturday, June 11th, the river, which had subsided to within about 9 feet of its ordinary level, was observed to be again rising (having risen 2 feet during the night); it was then at 11 feet above its ordinary level. It continued to rise rapidly during Saturday. From 6 p.m. on Saturday, to 10 a.m. on Sunday, the river rose 3 feet 10 inches at the Wallis' Creek embankment; and from that time to 8 a.m. on Monday, June 13th, the river had risen 1 foot 10 inches—a mean average rate of 1 inch per hour. At 10 a.m. the river was 23 feet 6 inches above high water mark. At 4 p.m. it had risen to 24 feet 3½ inches, or at the rate of about 1½ inch per hour. At 9.30 p.m. it had risen to 24 feet 9 inches, or about 1 inch per hour. At 6·45 a.m. on Tuesday it had risen 7 inches more, or (say) to 25 feet 4 inches; from this time till about 9·30 the river remained stationary, but it then commenced to rise again, at the rate of about ½ inch per hour until 6 p.m., after which it continued to rise more slowly till at 6.30 a.m. on Wednesday the 15th, when the river stood at 26 feet above high water.

Continuing still to rise very slowly, at a little before midnight on Wednesday the water was about 26 feet 2 inches above its ordinary level, being then about 2 feet 2 inches below the flood of 1864 (February), and about 2 feet 10 inches below the August flood of 1857. Shortly after midnight the waters commenced to recede.

At Singleton, the river rose slowly till about Sunday evening, when it commenced to rise more rapidly; and at about 9 a.m. on Monday, was rising at the rate of 1 foot per hour, being then about 34 feet above the usual level. At 1 p.m. it had risen to 36 feet, having been

foot per hour, being then about 34 feet above the usual level. At 1 p.m. it had risen to 36 feet, having been rising at the rate of 13 inches per hour. At 4 p.m. it was at 37 feet above the level, rising 4 inches per hour. At 7.3 p.m. it was 38 feet.

On Tuesday evening at 8 p.m. the river commenced falling, having reached to within 2 feet 8 inches of the February flood, or 41 feet 10 inches above ordinary level.

On Wednesday at 11 a.m., it had fallen about 3 feet.

At Muscle brook it had commenced falling on Tuesday morning; at Singleton, on Tuesday evening; at West Maitland, Tuesday midnight.

During this flood, two houses at the Bend in High-street, which had been partially undermined by former floods, were swept away, the inmates of one just escaping, but those of the other house (Mr. Fairfield and his family) were swept away with their house into the swollen river. His wife and another woman were drowned; he himself, with two of the children, were rescued from the wreck, after the house had grounded among some trees.

Scarcely had the flood of June subsided, when, about the middle of the following month, another flood swept over the district.

On Friday, 15th July, the river again began to rise, and continued rising slowly through Saturday 16th; and about midnight on Sunday the flood attained its greatest height at West Maitland, being then about 25 feet above high water mark. For about two hours it remained at that level, and then commenced slowly to recede.

Again, in the following month occurred another flood, though not so severe a one as the last.

On Tuesday morning, August 9th, the river began to rise at the rate of about 11 inches per hour. By Wednesday morning, the 10th, it had risen to 19 feet, and by Thursday evening reached to 24 feet above ordinary high water mark, and continuing to rise slowly till Friday evening at 8 o'clock, when it reached to within a few inches of the height of the last flood, or about 24 feet 9 inches above high water.

At Singleton, at 11·45 a.m. the river had risen to 36 feet above its ordinary level, and shortly afterwards commenced falling.

It was my intention to have given a brief summary of all the important floods which have occurred in the Hunter River since the year 1857, at which time public attention began to be drawn to the subject, but I find that my space will not permit me to do so; and as the year 1865 and the following year were comparatively dry—no serious flood occurring until the last year of 1867—I shall pass them over, and come to the last flood of June of that year, which, for height, duration, and amount of injury inflicted, has only been equalled by the great flood of August, 1857. And it is a curious coincidence, that the decennial periods of 1857 and 1867 should be marked by floods of unusual severity, number, and magnitude.

On Monday evening, June 17th, it commenced raining slightly, and continued falling with increased force throughout Tuesday, Wednesday, and Thursday. During Thursday night and Friday morning the rain fell in torrents, accompanied by a heavy south-easterly gale.

Up to Wednesday evening there was little apparent change in the river at Maitland, but on Thursday morning it was found to have risen 9 feet, and at 4 p.m. on the same day had reached to 18 feet above tide level, and at the same hour on Friday afternoon the river had attained a height of 27 feet above its ordinary high water level; it was then rising at the rate of about 3 inches per hour, and continued to do so till about 7 a.m. on Sunday, when it reached its greatest height, being then generally about 4 inches above the great flood of August, 1857, or say generally 30 feet above ordinary high water; in some places it was considerably more, in others less.

It then, after remaining stationary for some time, commenced falling slowly. By 11 a.m. the water had fallen ½ inch; at 1 p.m. it had fallen 1½ inch; at 8 p.m. 4 inches menced falling slowly. By 11 a.m. the water had fallen ¾ inch; at 1 p.m. it had fallen 1½ inch; at 8 p.m. 4 inches and by 8 a.m. on Monday had fallen about 10 inches.

All this time the river continued steadily pouring over the levées which had been erected at various points to keep it out, deluging the town, and steadily adding to the great backwater which covered the country to the south, on both sides of Wallis' Creek.

Many causes, such as the great height it attained, the rapidity of its rise, the peculiar inclemency of the weather, and the prevalence of sickness amongst many of the poorer inhabitants of the town and surrounding district, combined to render the effects of this flood peculiarly disastrous. It was likewise marked by an unusual amount of injury done to the banks of the river, the caving or slips from the Falls downwards, being frequent.

* Full Moon, 23rd.
† New Moon, 4th.
‡ Moon, 3rd quarter, 19th.
§ Moon, first quarter, 11th.

At Singleton, at 10 a.m. on Thursday, June 20th, the river had risen 12 feet; at noon, 13 feet 6 inches; at 3 p.m., 14 feet 9 inches; at 6 p.m., 15 feet. At 8 a.m on Friday, 30 feet; at 12 20 p.m, 37 feet above the ordinary level; at 5 p.m., the river still rising 9 inches per hour; 9 p.m., rising slowly. On Saturday, at 7 a.m., rising four inches within the hour, being then above the level of the flood of 1857. About noon on Saturday it must have attained its maximum, when the water stood at 1 inch above the last-named flood.

At Dunmore, on the Paterson, this flood was stated to have risen to a height of 15 inches above the flood of August, 1857; and at Raymond Terrace, to 8 inches above the same flood.

When the river breaks over its banks, it leaves the heaviest particles of the drift mud and debris on the immediate banks; and it is only the lighter matter which passes on into the swamps and flat lands in the rear. Thus the river banks are always receiving addition to their height in a more rapid ratio than the back lands. Whence it is that large rivers in a flat country are generally bordered by extensive tracts of swampy land, more or less under water after each flood. In such cases, the mere banking out of the river is not sufficient; it becomes necessary to have recourse to some system of artificial drainage to facilitate the discharge of the water, whether received from the river or from the smaller creeks. And if a judicious system of local drainage be undertaken, I can imagine that, so far from the inundations caused by overflows of the river being injurious, they would, on the contrary, be in the highest degree beneficial. By the flood deposits those rich alluvial soils have been in the first instance formed, and it is by this same process only that their richness can be maintained. The banks of the Nile, without their annual inundation, would soon be reduced to a desert; and the height of the river in times of flood has for ages been the measure of the favourableness or otherwise of the season, of plenty or scarcity to the people.

In many parts of England the most careful arrangements are made to admit the mud-charged water of the floods to the low lands, where it is allowed to stand until it has deposited the alluvial matter held in suspension and is then permitted to drain off. There is no reason why the same thing should not be done on the rich alluvial lands of the Hunter; it is the only means by which their extraordinary fertility can be preserved, and, if judiciously carried out, the whole of the advantages of this natural process of "top-dressing" may be secured without very much injury to the growing crops.

On the flood plan of the Hunter, which accompanies this Report, I have sketched out generally the system of

this Report, I have sketched out generally the system of
drainage I would recommend. It is only a sketch, and does not profess to lay down the exact direction, number or capacity of the subordinate drains, as I am not in possession of sufficiently detailed information as to the levels of the various parts of the country to enable me to do so.*

The urgent necessity for some such system of drainage will become obvious on examining the flood plan made immediately after the flood of 1857, by Mr. Adams, who reported the feasibility of preventing a recurrence of the inundations, by excavating a canal which should divert the course of the Hunter through the Bolwarra Estate, and discharge the water again into the river at Largs. I do not question that such a canal might in a slight degree relieve the upper parts of the river, but the extent of relief it would afford is, as I shall endeavour to shew when I come to that part of the subject, much over-estimated.

[Parts II. and III. will appear in Saturday's issue]

* The necessity for some such system of local drainage is indicated by the following remarks in the *Maitland Mercury* of the 19th October, 1858:—"It has now, we imagine, been proved beyond the shadow of a doubt that nearly all the low lands in the Hunter River district are flooded, more or less, after rainy weather, and that a few days' rain only, has the effect of turning many localities, containing some thousands of acres of crop, into large inland seas, and this irrespective of any addition which may be received from the rivers in times of high flood. It is, therefore, highly necessary, if the district is to be an agricultural one, and its rich soil is to be tilled by the industrious settler, that some scheme of drainage should be devised."

FLOOD IN THE HUNTER.

We have again the misfortune to have to report the occurrence of a flood in the Hunter River. At the time of our writing (eleven on Monday morning) the town of West Maitland has escaped, except a very small portion. But the flood waters are spreading over a wide extent of cultivated land on the banks of Wallis' Creek and its tributaries, not only destroying the young crops sown and growing since the great flood of February-March—but rendering it almost hopeless that the land will be again dry enough to plough and re-sow before the winter season is over.

As we mentioned in a previous *Mercury*, the continued dry westerly winds which lasted for a week or two, and these being followed by a remarkably genial pleasant after-summer of two or three days, aroused the general fear that another heavy rain-storm was about to visit us as a consequence. The rain did come, at the close of the week ending May 29, and gave us a slight fresh in the Hunter, rising to eleven feet at the Belmore Bridge on Sunday, May 30, and to slighter figures elsewhere; but happily the rain did not continue long enough to do any mischief.

The rain, however, again set in a day or two afterwards, at first only with a very slight mizzle or Scotch mist, making the roads and pathways very dirty, but not causing a flow of water. The weather, however, was exceedingly warm for the season, and all old residents feared what might follow so unseasonable a warmth. Early on last Saturday morning in especial the warmth of fires in rooms was almost disagreeable.

The present rain-storm then set in. About daybreak on Saturday a gentle steady rain was falling, and it continued to fall all day, until ten o'clock on Saturday evening. Occasionally a gusty shower would come along of heavier power, but generally the rain came down steadily, but with scarcely any cessation. Before night it was plain that a high fresh would undoubtedly occur in the Hunter. The rain lessened very much after ten on Saturday evening, in Maitland, and though occasional showers fell during Sunday, it was not until after sundown that any heavy rain occurred. Then, before six o'clock on Sunday evening, a pouring shower set in, with a good deal of wind, and fell very heavily for above an hour, and for nearly three hours afterwards it rained pretty heavily. The wind had now changed to the west, some stars shone out, and no rain whatever we believe has fallen since ten on Sunday evening. The wind was easterly during the rain storm, sometimes a little to the north, and sometimes a little to the south, of east.

As everybody but the members of the Improvement Committee of the West Maitland Borough Council anticipated flood danger by noon on Saturday, from the known fact that the continual rain then falling found nearly all the creeks in the Hunter district already in slight fresh, and the lagoons well filled, from the rains of the previous week—we waited on Mr. Morgan, the obliging West Maitland telegraph master, after the dinner hour, and asked the favour of his obtaining public weather telegrams, and also of his arranging for their continuance through Sunday. We may mention that some years since we applied to the Government to authorise this plan being followed, whenever there was even a probability of a high fresh, and perhaps of a flood, occurring, so as to give timely information to the numerous farmers round Maitland within flood reach, and also to the numerous inhabitants of West Maitland who are in the same predicament,—and that the Government, after enquiry into the facts of previous floods, granted the request—at the same time Government, after enquiry into the facts of previous floods, granted the request—at the same time throwing on us (the *Mercury* office) the responsibility of never applying to the telegraph master for such public weather telegrams unless there was reasonable probability of public danger. By public telegrams are meant telegrams not paid for, and which, in these weather cases, are obtained not only at the cost of the Government, sometimes to the interruption of private telegrams (which are paid for)—but always to the personal trouble and inconvenience of the various telegraph masters—most of all to the West Maitland Telegraph Master. In this respect the public of the Hunter district are under great obligations to the Government and to the telegraph masters. And Mr. Morgan, in particular, has been specially obliging—the extent of the weather inforformation thus acquired, hours, often many hours, before the swollen waters could possibly reach Maitland by the river—by Mr. Morgan, and made public at his office door, and by us at the *Mercury* office door, must have saved the people of the district, who chose to be on the alert in time, large sums of money, and large quantities of produce.

The Improvement Committee of the West Maitland Borough Council have not been sufficiently on the alert on the present occasion—and by neglecting to close with a few sand bags, on Saturday afternoon, the Odd-street drain tunnel into the river, they had to do it on Sunday morning with many sand bags, and so imperfectly, that a good deal of water has drained up through, has spread over the lower land, and if the river keeps high much longer, some of the houses will be flooded.

The river at West Maitland began to rise slowly on Saturday afternoon. But Wallis' Creek rose on this occasion in advance of the river. On Saturday, at sundown, the creek water was running with a good current into the river. And as a consequence, when the river water a few hours afterwards commenced to force its way up the creek, a piling up of the waters must have occurred, and by midnight of Saturday we are informed the creek was overflowing near the railway line, and the overflow water was crossing Steam-street, West Maitland.

The river at West Maitland rose very rapidly during Saturday night, and by eight o'clock on Sunday morning it stood at the mark 24 feet at Belmore Bridge—that is, 21 feet above high water mark, the Belmore Bridge marks commencing at the dead low-water mark. By the bye—a little paint, to restore the figures to fair view, is wanted. The many floods have nearly obliterated them. During Sunday a slow steady rise went on; by noon the height was 25 feet, by eight in the evening it was 26 feet good. During Sunday night a further rise occurred, however, from the heavy rains of Sunday evening, and by eight on Monday morning the height was 28 feet 6 inches. A slow gradual rise was then going on, but only a few inches more were reached.

Recently, since the great flood of February-March, the Improvement Committee of the West Maitland Borough Council had very wisely set themselves to inspecting and strengthening all the town embankments, wherever needed, and the present rise found the town very well prepared to meet it. But heavy continuous rains test new earthwork severely, and on Sunday and yesterday it was found necessary to keep a constant watch on the embankments, and to keep strengthening and raising them at some points. This was done, and with the exception already pointed out in Odd-street, and an invasion on the western side in John-street from the Steam-street overflow water, the town was kept dry. It may be worthy of notice that the present flood, of 26 feet above high water, would have (without embankments) been running across High-street at several points on to the low grounds at the south part of the town, and would have flooded the greater part of the Horse Shoe Bend—where about a thousand of the West Maitlanders live.

At seven last evening the report from the Belmore

At seven last evening the report from the Belmore bridge was—river at a standstill for several hours past. The height reached was something over 29 feet. Elsewhere in the town, river observers thought a slight fall was perceptible before sundown. At a late hour we heard that though at Eelah, say eight miles up the river, the river was at a standstill all the afternoon; yet at Oswald, some miles higher, it was still rising at twelve o'clock. The latest news from Singleton, in the afternoon, was—river slowly falling, now 31 feet. If therefore the cloudy appearance of last evening passes off without more rain, we shall expect to see a welcome fall of a couple of feet on Tuesday morning in the river height.

Last evening our reporter started on foot to attend a meeting at East Maitland, the temporary bridge over Wallis' Creek being dangerous for horses after sundown. But in the interval between his two visits, the piling-up process, where the conflicting waters met—of the river going up the creek channel, and the creek waters coming down it (which we have elsewhere mentioned) had produced the same effect that it did in one of the floods some years ago, when also the creek rose before the river did. A part of the raised water started for East Maitland. And it had reached it before last evening, for then it was not possible to get on foot much past the Black Horse Inn, the road being covered with a stream of water rushing across it. And even on the western side of the Victoria Bridge, the overflow water had travelled westerly nearly as far as Mr. Weller's. The effect of the water on the temporary bridge over Wallis' Creek has already been described. Last evening the Mayor of West Maitland (Mr. W. H. Smith) sent a telegram to the Minister for Works, representing this difficulty, and asking that the new bridge might be opened for traffic. A reply had not been received when we went to press, but we have no doubt that, under the circumstances, the required permission will be granted, to be used to-day if necessary. The public will understand that the contractor could not give permission to use the bridge till his work had been passed by the proper authorities.

Our reporter has visited as much of the neighbouring land as could be managed yesterday, and his description follows. While at foot we publish all the Weather Telegrams so obligingly obtained for the public by Mr. Morgan's efforts.

HUNTER FLOODS.

(To the Editor of the Maitland Mercury.)

SIR,—I am again about to trouble you with further observations about the floods, and for the purpose this time to bring more directly under the eyes of the people of Maitland the great increase ringbarking has caused upon the inflow of water into the river, and consequently that it takes less rainfall now to bring the river up than it did before such took place. As an illustration of how this comes to be so I have but to say gullies and watercourses I knew dry 30 years ago, and always so except during a rainfall, and then requiring twenty-four hours of heavy rain to fill them up, are now constantly full of water, and the moment or nearly so rain now falls they are influenced by it and begin to carry their tribute to the river. This, bear in mind, does not apply to a few detached gullies, but to the whole of the tributaries of the Hunter, be they large or small—for ringbarking has become universal—increasing the water they carry to the river at least by 50 per cent. to what it must have been when all was in a state of nature. This being so, it must be apparent to all the river is more liable to flood than ever, and if in this visitation just now passed through the downpour had been general over the watershed of the Hunter, where would Maitland have been?

It is curious to note how confined comparatively to a narrow band this heavy rainfall was. I myself at the time of the rain, the cause of the flood, was in Dungog weatherbound. The heavy rain did not much extend above there; in fact, the Upper Williams was not flooded. All the water that put the river in flood at Dungog came from a tributary called the Myall Creek, that junctions in the town Nor were the heads of the Allyn or Paterson Rivers affected by it, or any of the heads of the water courses tributary to the Hunter till you pass Murrurundi. The rain storm seems to have taken a course over Singleton, thence to Merriwa and Cassilis, altogether missing the Wollombi on its way. Therefore it becomes self-evident how very small a part of the watershed of the Hunter brought this flood, and how much grearer it would have been if the whole watershed had suffered.

There is another effect ring-barking is having on the country besides increasing the water. It is practically altering the features of the country by large landslips, specially where it is hilly or mountainous and the rock not far from the surface, say 5 or 6 feet or even more. The decay of the roots of the trees killed by the ringbarking, which held or bound the soil together, cause it to slide into the gullies and changing the appearance of the hills; also, I believe, sending much

into the gullies and changing the appearance of the hills; also, I believe, sending much

sand and drift into the river, the deposit of which has been so noticeable in this flood wherever the water has been.

In conclusion, I would allude to a circumstance which may have escaped the notice of many, and that is—if the Hunter is the first to come down in flood it takes up possession of its bed, backing up the Paterson and Williams, and runs off quickly. Such I believe to have been the case in the recent flood, for if the Williams and Paterson waters had reached the Hunter River bed first they would have blocked it up and backed its waters. Now, I know from observation in this case it was the Hunter that backed up the Paterson. I passed through the Paterson township on Saturday, the 9th of March, and in Tocal Avenue the river was without current: a piece of paper would not move, showing the Hunter was backing it up; the Paterson River then being some 20 feet or more above its ordinary level. This should show to all how small is the fall of these streams within tidal influence, and their incapacity, no matter how dealt with, to carry off such deluges of water as the recent one.—I remain, etc.,

H. O'S. WHITE.

13th April, 1893.

THE MAITLAND FLOODS.

(*To the Editor of the Maitland Mercury.*)

SIR,—I am again about to trespass on your kindness, and ask you to publish further remarks of mine about the fl[illegible]s of Maitland. In my letter publ[illegible]ed by you on the 21st instant, I but gave a brief account of such river rises as had occurred in the earlier days prior to 1857, and the belief of my late father that such were unpreventable; but still he had ideas that alleviation could be given, though still the waters would come, but not with the destroying effect just experienced.

He always upheld that a great mistake was made in closing the old mouth of Wallis's Creek at the back of the Garrick's Head, and erecting flood gates where the new channel starts running, as it does at right angles, into the river. The old mouth in time of flood was the safety valve of West Maitland, the waters flowing up it relieving the river—thus doing away with the necessity of embankments—filling in the low lands of Louth Park, and coming into the back of the town dead water, doing no harm but the inconvenience they caused, and the trouble of clearing the mud it left behind. Of course, at such times the farmers lost their crops, but only their crops, not that which grew them. On how many farms of Bolwarra would the land have been enriched, not impoverished, had the embankments not existed? And the townspeople have to thank the closing of the old mouth for the great expenditure of money to save High-street opposite the Queen's Arms—the closing of the creek causing a sharp turn in the current of the water, hence the erosion and strain on that particular part.

There are many who think the river could be relieved by a cutting from Bolwarra House to the Paterson. This is a mistake. Such a cutting would bring destruction to the alluvial lands of the Paterson, literally swamp and destroy them, thereby injuring Maitland. Let any one give himself the trouble to estimate the capacity of a canal to contain and turn the waters at such a time from the town and if possible to construct such a one, what the effect would be upon the place the waters were directed to. The Paterson has

waters were directed to. The Paterson has
enough to do with its own waters without being troubled with those of the Hunter.

The proper and only way of relieving the river is from the side by way of Wallis' Creek and Howe's Lagoon. I would strongly advise people to give up embanking higher than the natural banks of the river, for to do otherwise will but destroy your main support—your agricultural lands, devastating and impoverishing them, and some day bring on a worse catastrophe than the one just passed through, for you must have seen from the papers that a large part of the Hunter watershed was hardly touched by the rainfall; therefore, 5 or 6 feet more ought have been added to the height of this flood, which would have been certain destruction to much of the town.

In writing of Wallis' Creek I did not mention the change the river has made in its course, and the partial filling up of the old channel. This filling in is caused, I believe, by the large land slips—close at hand—in the Horse Shoe Bend, the debris of which the river through making a fresh outlet has deposited there by its side wash, and I should not be surprised if, when another high flood comes, it will be removed, thus giving the river two channels. One thing is certain, no time should be lost in protecting the banks of the new course, otherwise much valuable land will go into the river. Nothing but another high fresh will prove how High-street will be effected by the change in the river. I fear the water will still make that way when very high.

In conclusion I would mention that before closing the mouth of Wallis's Creek no alteration took place in the course of the river and its banks remained intact. At the bottom of Hunter-street, where the river now runs, was a large dry gravel bed nearly a hundred yards across in its widest part and the river then ran close into the high bank opposite Mrs. McDougall's house and was but some 60 yards wide, this general beach extended all round the point of the Bend. I furthermore would say all hydraulic engineers of celebrity deprecate the interference with the celebrity deprecate the interference with the course of such rivers as the Hunter.—Yours etc.,

H. O'S. WHITE.

West Maitland, 30th March, 1893.

(To the Editor of the Maitland Mercury.)

SIR,—It is not my intention to enter into a controversy with your Goulburn River correspondent as to whether protection is or is not losing its hold in this electorate. The general election will doubtless place that question beyond speculation. In the meantime, it will be remembered that at the last occasion on which the voice of the electors was heard, the two freetrade candidates figured conspicuously at the bottom of the poll,—one of them being compelled to contribute £40 to the Consolidated Revenue. When your correspondent first referred to the Premier's visit to this town he made certain statements which were utterly opposed to facts. These I promptly contradicted. And now, in his reply, which appears in your issue of Saturday last, he coolly informs us that when he sent his report he had not heard of any demonstration to the Premier. In addition to this, he aggravates his previous offence by making a number of other representations, which are just about as reliable as those which, according to his own admission, were written in ignorance of the facts. It is most pitiable to observe the manner in which he squirms under the lash, and attempts to wriggle out of an unenviable position by insulting and ridiculing the Aldermen and others who waited on the Premier. These gentlemen are regarded by your correspondent as mere nonentities. Of course it was to be regretted that the "men of note" referred to were not present to do honour to Sir George Dibbs. No doubt when Sir Henry Parkes pays his promised visit to Muswellbrook he will be more fortunate, as he will be welcomed by at least one man of note, in the person of your Goulburn River correspondent.

YOUR MUSWELLBROOK
CORRESPONDENT.

March 29th, 1893.

ORIGINAL CORRESPONDENCE.

FLOODS IN THE HUNTER.

(*To the Editor of the Maitland Mercury.*)

SIR,—At such a time of disaster and desolation as this flood brings to Maitland, I trust it may not be considered unseemly for me (though an unknown individual to the public) to write on this fearful calamity, and give to the inhabitants of the district the knowledge I possess, gathered from the experience of my late father, George Boyle White, the first (or nearly so) Government surveyor of the Hunter. He it was who first laid out East Maitland as a town, and subdivided the land where the town of West Maitland now stands into farms for agricultural purposes—what nature intended it for, not the use it has since been put to.

My father's knowledge of Maitland dates back to the year 1826, and at which time in this same month of March came a similar visitation to the one just passed, and I fancy slightly higher than it has been. At that time no buildings existed in West Maitland, other than the huts of cedar getters. All was in a primitive state with cedar brush and swamp; no obstruction was there to the spread of the waters. And they then covered the land on which the town stands, with one small exception, and that is a small piece of ground where the Bank of Australasia and Mr. Isaac Gorrick's buildings now stand, and that was awash with the flood; and one vast sheet of water extended from Campbell's Hill to the surrounding high lands, reaching to within 66 feet of the old East Maitland lockup.

From that time up to the year 1832 the river was quiet, no rise of consequence taking place, but then again it came up into flood, and although not so high as that of 1826 did more damage. Lots of land had been cleared, and coming at harvest time it destroyed the crops, the heads of the wheat at Singleton, nearly five feet high being only visible above the water and men trying to gather them in baskets.

After this a period of eight years passed without a flood when again the river woke up, and in January 1840 rose 40 feet at Singleton, again submerging Maitland but much lower than the previous floods spoken of. From that time to the year 1857 (with which many now living are conversant) no fresh occurred; in fact, for a period of three years the river ceased to run at Singleton, and for miles its bed was dry, with here and there a water hole. This great drought took place in '47, '48, '49.

This spell without floods made people think they were a thing of the past. The clearing of the land and opening of the country, they argued, had done away with them, and though repeatedly told by my father that they and their belongings world

away with them, and though repeatedly told by my father that they and their belongings world
some day be carried to the ocean, they laughed at him. When 1857 came they changed their note and saw their error.

Since then fruitless attempts have been made to save the town from inundation to the detriment of the surrounding lands, hundreds of acres have been destroyed and will continue to be so, if these futile efforts are continued.

My late father always maintained no engineering could save West Maitland from these visitations because of the want of fall, the south east gales that always accompany these heavy rains sweeping as they do over the wide Pacific Ocean into the river mouth raise the sea to such a height that the river cannot flow, rendering Maitland nothing but a basin which fills in while the gale and rain last. No remedy is there for this but breaking the rim of the basin and that is the ocean. How is it to be done? If such is the case, which my late father always affirmed was so, straightening the river and cutting canals is but money thrown away. Trusting you will see proper to publish this.—I remain, etc.

H. O. S. WHITE.

17th March, 1893.

PREVENTION OF FLOODS IN THE HUNTER.

(To the Editor of the Maitland Mercury.)

SIR,—It is a problem that the most eminent engineers have so far failed to solve—how floods and their consequent ill effects on the Hunter valley can be prevented. It would, therefore, be highly presumptuous in an outsider to propose or even suggest any scheme for that purpose. But to give your readers an opportunity for discussion on the most important subject that could occupy their thoughts at the present time, I would crave space to advance a few ideas with the object of having the matter thoroughly ventilated. Without having any pretence to scientific attainment, but having 30 years' knowledge of the Hunter valley, of the floods during that time, of the means adopted to prevent their destructive effects, of the failure of these means so far, of the loss, destruction and expense that such failure has entailed, I claim to have some knowledge, and therefore make no apology for what I advance. In looking back 30 years I remember the agitation, the public meetings, the oratory, the deputations, and the surveyors' reports, etc., that floods could and would be prevented. We had reports on the subject from such eminent engineers as Mr. Moriarty, Mr. W. Clark, Mr. Gordon, Mr. Darley, and others. With what results? The result is that to-day we are in the same position that we were when the first report on the subject was submitted 25 years ago; and that after the expenditure of £100,000 on dams, embankments, and cuttings, the destruction caused by the late floods has been greater than any of its predecessors. And why has the destruction been greater? It will be said by some that the rainfall was greater in a given time. Admitted that in the valleys of the Upper Hunter and Goulburn it was greater. Yet in the Paterson and Williams it has been much greater in the past, so that it is not altogether owing to the great rainfall, but to the means adopted by the committees along the Hunter valley above and

mittees along the Hunter valley above and

around Maitland that the late destruction is due. Any person during the last few years visiting Maitland, or reading the reports of the several committees entrusted with the erection of embankments, &c., would certainly at once conclude that inside the embankments of West and East Maitland, Oakhampton, and Bolwarra were contained the whole wealth, population, enterprise, and prosperity of the Hunter Valley. Though recognising the right of every man to use every means to protect his own person and property, still morality and religion teach that the means used should not be injurious to our neighbour. I trust that the lesson taught by the late flood (that embankments or any local efforts to deal with the flood waters are useless) will stir up the authorities to prevent the useless expenditure of public monys or the carrying out of any work that will be beneficial to the few at the expense of the many, and that a comprehensive scheme of cuttings, such as recommended by Mr. Gordon, will be adopted. That such a scheme is practicable the late flood has proved, and many people think that if the money expended in making embankments had been expended on cuttings, to-day there would be a nearly straight waterway from Bolwarra to Hexham. That the flow of water has indicated the course of the proposed cutting any person visiting the several districts can see. And standing on the hill at Bolwarra House the whole scheme as proposed can be seen at a glance. By a cutting near Bolwarra House in a line with the river above that place, Maitland would be entirely cut off from the river course, and therefore all expenditure on protective embankments would be unnecessary, and as the course of the river would be reduced from 45 to 16 miles the water under ordinary circumstances would be at Hexham, which has now only reached Morpeth. That the Bolwarra cutting is practicable and could be carried out at much less expense than estimated is apparent from the fact that the surface only requires to be moved, a passage made, and the river itself would do the rest. From Berry Park across to Duckholes the flood indicates the course the river would take slightly helped by the

the river would take slightly helped by the removal of a few obstructions, and during the late flood actually ran to a depth of 3 feet over an officially alleged ridge of 44 feet above the level of the river. On visiting the locality I find the flood actually flowed in a straight line from below Morpeth crossing above Duckenfield to the river at Hexham. If these cuttings were made I contend that the possibility of a flood with a rainfall of 5 or even 10 inches would be reduced to a minimum, and the destructive effects of even 20 inches rainfall would be greatly lessene d In conclusion I would urge all interested to fully consider the best course to adopt, not only to protect West Maitland, but to protect the farming industry of the whole district, which is of far more importance to the colony, and also to protect the taxpayer who in the past has been forced to contribute to an utterly useless expenditure.—Yours, etc.,

ONWARD.

Hinton, March 30th, 1893.

ORIGINAL CORRESPONDENCE.

FLOOD PREVENTION ON THE HUNTER.

(To the Editor of the Maitland Mercury.)

SIR,—Your correspondent "Onward" gives some figures in reference to a cutting which he proposes, which, if correct, mean much more than he seems to draw from them. Roughly speaking "Onward" asserts that a straight channel could be made for the Hunter from Bolwarra to Hexham, which would be only about one-third as long as the present river channel. Now, if this be true it means that the fall per mile in the new channel would be three times as great as in the old one, and the water would move through at least twice as fast. That is, the increased fall would enable the new channel to discharge twice the quantity of water in a given time that could be discharged by the old one. As the new channel would only be about one-third as long as the old one from that course with only the same fall, it would discharge three times as much water in a given time. From these two courses the discharge would be in any given time about five times as great as through the old channel. But there is yet another advantage, and that is straightness, which greatly facilitates the discharge of water. One other point that must not be lost sight of is that within a measurable time the Lower Hunter, from its great natural advantages in the form of inexhaustible supplies of coal close to the sea, rich agricultural lands, and plenty of fresh water, must become the manufacturing centre of Australia. Then the interests involved will be so great that an artificial channel for the river must be maintained at any cost. In such case it will be much cheaper to maintain 16 miles of river banks rather than 45 miles, and whatever is spent in the meantime on the old channel is money thrown away. To sum up, if your correspondent is correct as to distances and the practicability of making the channel he suggests, then, after such a channel were made, it would require a rainfall about five times as great as that we have just experienced to make a flood equal to that of March, 1893. This must be self-evident, as the new channel would in any given time discharge at least five times as much water as the old one does, and the height of the flood depends altogether on the time required to discharge the rainfall. I have not been at the trouble of making exact calculations of the rate of discharge of such a channel as that suggested by your correspondent, but the figures given are within

respondent, but the figures given are within
the mark, and are capable of being tested with the same exact mathematical certainty with which we can test the proposition that two and two make four.—I am, etc.,

W. E. ABBOTT.

Wingen, April 3rd, 1893.

THE RECENT FLOOD.

(To the Editor of the Maitland Mercury.)

SIR,—I enclose the recorded rainfall here during the last flood of the Hunter:—

March	8th....................	135	points
"	9th....................	216	"
"	10th..................	77	"
	Total	4.28	inches.

There was no flood here either in the Page River or the Kingdom Ponds Creek, only a strong fresh, and as the record was taken only about 14 miles from the top of the Liverpool Range, the rainfall must have been much lighter higher up on the mountains. Had the rainfall from Muswellbrook downwards extended to the summit of the Dividing Range, at least, twice the quantity of water would have been sent down on Maitland.—I am, &c.,

W. E. ABBOTT.

Wingen, March 26, 1893.

"Was Rome founded by Romeo?" inquired a pupil of the teacher. "No, my son," replied the wise man; "it was Juliet who was found dead by Romeo."

HUNTER RIVER FLOOD PREVENTION.

(FROM OUR CORRESPONDENT.)

EAST MAITLAND, Friday.

A mass meeting of residents of Newcastle and the Hunter River districts was held this afternoon on the Bank-street Reserve, East Maitland, for the purpose of dealing with the question of flood mitigation in the Hunter River Valley. Mr. G. T. Chambers (Mayor of East Maitland) occupied the chair, and among those present were the Right Rev. Dr. Stanton (Bishop of Newcastle), Canon Tyrell (East Maitland), Canon Goddard (Morpeth), Hon. J. N. Brunker (Colonial Secretary), Messrs. J. Gillies, H. H. Brown, T. Dick, R. A. Price, A. Edden, J. S. Law, D. Watkins, J. L. Fegan, W. H. Wilks, Ms.L.A., H. Crothers (Mayor of West Maitland), W. B. Sharp (Mayor of Newcastle), C. T. Wakely (Mayor of Morpeth), Dr. Meredith (Mayor of Raymond Terrace), A. Pryor (Mayor of Greta), Aldermen Taylor, Ross, Ribee, F. A. S. Bowden, Young, Quinton, Wilkinson, Dr. R. G. Alcorn, Lipscomb (East Maitland), Aldermen Bourke, Ewing, Foster, Waller, Petherbridge, Dr. S. Alcorn, Cunningham, and Watson (Morpeth), Aldermen White, Porteus, and Heydon, J. D. Prentice, John Pearse, T. H. Pearse, R. Scobie, John Lee, John Eales, E. Capper, and a large number of influential and representative residents.

The chairman read apologies from Bishop Murray, the Hon. Alexander Brown, and Mr. S. Clift.

The CHAIRMAN said it afforded him much pleasure to see such a large gathering, as it showed that the people were really alive to their position, and wished to be united on the question at issue. Sketching the history of the Hunter River Valley, he showed how, in the earlier periods of its history, the various channels had been formed. What was now the Hunter River Valley had originally been an estuary of the sea, but the banks, islands, and channels had through the course of years been gradually formed, and to-day they found the river inclined to change its course as frequently as in the past. He remembered the time when the Hunter was navigable for small vessels to a point beyond the Belmore Bridge, but owing to the presence of sandbanks and obstruction caused by the demolition of the banks during floods this had become impossible. The immense tracts of country cleared and ringbarked in past years has destroyed the power of absorption, and three times the amount of water would have been necessary to make the Hunter rise to the level it did at present. A fall say of three inches over the watershed of the Hunter in years gone by would not do any more damage than a fall of one inch to-day. He would not, however, detain them longer, but would call upon Mr. Sharp to move the first resolution, namely,—"That this meeting requests the Government to carry out a scheme for the mitigation of the floods in the Hunter River district."

Mr. SHARP said he was gratified to see the representative nature of the gathering, and considered the chances of securing their object were greater than ever they had been before. In the past there had been some little feud existing between the towns of Newcastle and Maitland, but this he hoped would be a thing of the past. The time had come for united action, and he hoped that they would never again witness the scenes of desolation such as were occasioned by the floods of recent years.

In seconding the resolution, Mr. H. CROTHERS,

the floods of recent years.

In seconding the resolution, Mr. H. CROTHERS, Mayor of Maitland, said it was the simple duty of every resident of the district to work for the adoption of some scheme. The resolution did not bind them to anything except unanimity of purpose. He did not want a scheme to benefit West Maitland at the expense of any other district.

Mr. R. A. PRICE, M.L.A., supported the resolution in a speech. He said the people were in some measure to blame for the present state of affairs. A flood occurred, and when in distress they commenced an agitation, but in 24 hours they forgot all about it, and so the matter went on for years. The time had come for something more definite. They must work unitedly and persistently to secure their purpose. The area of the Hunter district affected by flood was something like 12,000 square miles. The evidence taken in 1820 showed that it was quite possible to have a flood eclipsing any previously experienced. They should take into consideration the experience of great American authorities and the work done on their rivers. What, he asked, had they done in the past except memorialise the reigning Ministry? It was a reflection on the Government that no definite steps had been taken to prevent disaster, and he hoped the time would soon come when a comprehensive scheme would be adopted, one which would deal with the whole question from Singleton to Newcastle. It was a question of national importance, and should be treated as such.

Mr. J. L. FEGAN, M.L.A., said he was there to show that he sympathised with the movement. He did not consider his electorate would lose anything by the expense entailed by such scheme. There was a great deal of poverty in his electorate, but he considered it would be his duty to assist in preventing a recurrence of floods in this district, where, owing to them, poverty was equally existing. They must put aside all localism, and work for one common purpose.

Mr. WILKS, M.L.A., briefly supported the resolution. As one who had spent years of his boyhood in the district he could quite understand the necessity for prompt action, and promised to support the matter when it came before the House. He, however, was not an engineer, and considered they should leave the engineering to the Government experts, who would advise them.

Mr. W. S. LAW, M.L.A., said some 200,000 people come within the area affected by the proposed schemes expected to be drained thereby. If the Colonial Secretary brought forward a scheme, and was backed up by local members, he was sure success would attend their efforts.

Mr. A. EDDEN, M.L.A., said he came there because he knew the object was good, and his previous experience of Maitland enabled him to see that the desired work was necessary, and he would support the scheme.

Mr. WATKIN, M.L.A., said he did not propose to show them how to do the work. Want of unity seemed to have been the reason of their failure. The money now spent at Shea's Creek would be more properly employed in preventing a recurrence of floods in the Hunter.

The resolution was then put to the meeting and carried unanimously.

The second resolution, which was entrusted to Mr. R. Scobie, was as follows:—"That any scheme of flood mitigation must include a canal or cutting on the southern side of Duckenfield from below Raymond Terrace." Mr. Scobie said he favoured the scheme because it was the most practicable and the least costly. A great many schemes had been propounded, but this was, in his opinion, the best. They had a scheme here schemes had been propounded, but this was, in his opinion, the best. They had a scheme here which would cost under £100,000, and they should endeavour to have it adopted.

Mr. JOHN LEE, in seconding the motion, said one pleasant feature had come under his notice. Messrs. John Eales had promised to give the necessary land without compensation. It was a splendid example. The meeting encouraged him, and made him feel hopeful. Amateur engineers would propound their scheme and make trouble. The want of unanimity in the past had been their weakness, but this meeting gave him courage, and enabled him to look forward with hopefulness. If they went as a body considering each other and helping each other success would attend their efforts. The unemployed now in the district would enable the Government to carry on the work, and find employment for those who really wanted help. The Government should start the work before the winter commenced.

Mr. H. H. BROWN, in supporting the resolution, said it was no use talking of the past. What they wanted to know was how to avoid floods. His own electorate had suffered, and he was there that day to show his sympathy with the movement. Any scheme of flood prevention must be a national one; the losses of the individual were in effect the losses of the State. He would do all in his power to bring the matter to a satisfactory issue.

Dr. Meredith proposed the following amendment,—"That in the opinion of this meeting the Government be urged to prepare a scheme to carry out the objects of the first resolution." The amendment was seconded by Mr. Kearney.

Mr. GILLIES regretted that he was called on to support an amendment. As member for West Maitland he felt it his duty to assist the movement for the good of all. It would not be right to adopt any scheme, but to go to the Government and ask them to adopt some method which would deal with the whole question from Singleton to Newcastle. He was not satisfied with the reports of the engineers up to date, nor did he think they should be considered as conclusive. He would not have spoken that day but for a question asked in the House some nights ago. It had been said that the people of the Maitland district had contributed £8000 towards the cost of building embankments. That statement was wrong. He asked them to vote for Dr. Meredith's amendment, as it was the wisest course. If the resolution was carried, the people living down the river could not support the scheme, and consequently they would fail by reason of their antagonism. They must be united if they would succeed.

The Chairman then put the resolution, which was carried, the Chairman ruling the amendment out of order.

Dr. MEREDITH moved the third resolution. The speeches made there to-day showed clearly that those who had spoken would not give their consent to any scheme which did not protect the residents of the Lower Hunter. The resolution was as follows:—"That this meeting disapproves of any cuttings or canals being made about Raymond Terrace and Maitland until such time as the works at the lower end of the river are completed."

The resolution was briefly seconded by Mr. William Lane, and carried.

It was resolved that a deputation should place the resolutions before the Government, and that a league be formed.

On the motion of the Hon. J. N. Brunker a vote of thhnks to the chairman terminated the meeting.

A COLOSSAL SCHEME.

PREVENTION OF FLOODS AT WEST MAITLAND.

A RESERVOIR 35 SQUARE MILES IN EXTENT.

ESTIMATED COST, £550,000.

DIVERGENT ENGINEERING VIEWS.

The disastrous floods which have periodically devasted West Maitland through the gathering waters on the enormous watershed of the Hunter River have on several occasions directed attention to the necessity for something being done to prevent a repetition of the loss of life and property. In response to the energetic appeals of Mr. Gillies, the representative of the West Maitland electorate, the Minister for Works, Mr. J. H. Young, empowered Mr. Price, Assistant-engineer of Public Works, to make a careful inspection of the locality, and report as to what measures he considered should be adopted to mitigate or, if possible, prevent a repetition of floods in the future.

As the result of a careful consideration of the matter, Mr. Price is convinced "that no system of channels could save West Maitland when such extraordinary rainfalls occur." Hence he is satisfied that "any scheme for straightening and deepening the lower river must start from the ocean." He considers the works now in progress at Newcastle will be beneficial in securing an improved flood discharge for Hexham, Raymond Terrace, and the Lower Williams; but they will have no effect at Morpeth, except during small floods.

To prevent a flood rising higher than 8ft. at Raymond Terrace would necessitate the cutting of a huge canal 300ft. wide, 12 miles long, seven miles of it 43ft. deep, and five miles 20ft. deep. This would involve an expenditure of over £1,000,000, and even then it would only reduce the level of the 1893 flood by 7ft. Naturally enough, Mr Price rejected such a proposal as Utopian. Such a large sum of money spent in building training walls on the lower river would have a better effect and improve navigation; whereas the suggested canal would ruin it, unless carefully maintained and regulated.

Failing to find any solution of the difficulty by attempting to reduce the flood levels by cuttings on the lower river, Mr. Price turned his attention to the upper river and its tributaries, in the hope of getting a suitable site to build a reservoir large enough to regulate a whole flood or half a one, as suggested by Mr. Gordon. He discovered a favourable site at Woodlands, on the Hunter, about 10 miles below the Goulburn Junction. After thoroughly examining the upper tributaries of the Hunter River, Mr. Price formed the opinion that it would be more economical and effective to "create one great lake by constructing a high masonry dam at Woodlands, below Denman, than to form a great number of smaller reservoirs on the tributaries." Borings showed that the foundation would be on hard blue shale, with certainly two coal seams.

The colossal nature of the undertaking may be judged by the fact that to raise the water level at Woodlands by means of the proposed dam to a height of 130ft. above summer level would, writes Mr. Price, "submerge over 33 square miles of plain, and would back up the Hunter and Goulburn rivers for ten and eight miles respectively above the junction near Denman." This, unfortunately, would flood the township of Denman, "which would have to be removed to higher ground," observes Mr. Price. This would, however, be an advantage, as the township is now completely submerged during high floods, which sweep houses away and cause loss of life. The maximum capacity of the proposed dam is estimated at 40,000,000,000 cubic feet, and the greatest depth of this immense body, covering 35 square miles, would be 130ft.

As Mr. Price remarks: "It is hard to realise such an immense body of water as 40,000,000,000 cubic feet. No artificial reservoir in the world at all approaches it." In a word, the proposed reservoir would be 23½ times larger than the Prospect Reservoir, which supplies Sydney with water. Mr. Price set down the estimated cost of the work at £550,000, and points out that as the whole country will benefit by the protection afforded to the railways a large proportion of the cost of the work should be undertaken by the country at large.

THE CHIEF ENGINEER'S COMMENTS.

taken by the country at large.

THE CHIEF ENGINEER'S COMMENTS.

Commenting upon the report the Engineer-in-Chief of Public Works, Mr. C. W. Darley, writes:—"There is no doubt that the height of flood waters in the lower river can be reduced, and, to a considerable extent regulated, by impounding water in the upper part of the valley," but he utters a warning note when he says:—"Great care must be exercised in releasing impounded water . . . for if the flood water be kept up to a level exceeding a banker for a considerable time, it may do much more injury to property than by letting a big wave pass quickly down the valley."

A difference of opinion exists between Mr. Darley and his assistant as to the probable cost of building the dam. On this point Mr. Darley says:—"Mr. Price, I think, has taken too sanguine a view as to the probable cost of the dam. The prices are cut altogether too fine, and I doubt if any competent contractor will be ready to tender at the figures quoted. I am of the opinion that the very lowest cost at which this undertaking could be completed would be £900,000."

One of the most serious comments of the Engineer-in-Chief is embodied in the following remark:—"I have also some doubts as to whether such a great dam could be safely built on a shale and coal bed formation."

Both officers, however, agree on one point, namely, that it would be injudicious to expend large sums of money in making flood cuttings in the lower river to reduce the flood height at certain places. "This," observes Mr. Darley, "might be beneficial to certain places, but would mean destruction to other places lower down."

FLOOD PREVENTION IN THE HUNTER RIVER.

RECOMMENDATIONS BY MR. C. NAPIER BELL.

TO COST OVER A MILLION.

RESERVOIR SCHEMES CONDEMNED.

A DRAINAGE BOARD PROPOSED.

The report by Mr. C. Napier Bell, M. Inst. C.E., upon flood prevention in the Hunter River, was presented to Parliament last night. It is a long document, and refers in detail to the various schemes by other engineers and departmental officers having the same object in view. In 1897 the late Mr. Price, C.E., having carefully inspected the whole district of the Hunter and its tributaries, found a site nine miles below Denman, which he considered suitable for a dam for an impounding reservoir. In fact, with a dam 130ft. high it would hold the unheard-of quantity of forty thousand million cubic feet of water. Such a quantity would very probably be more than any one flood from the Goulburn and Hunter Rivers, below the junction of which the dam is situated, and Mr. Price emphatically recommended the adoption of this system of mitigating the Hunter floods, and added his conviction that no other method would be successful. Mr. Napier Bell, however, agrees with Mr. C. W. Darley, Engineer-in-Chief, that it would be difficult, if not impossible, to handle this vast body of impounded water. He points out also that the Newcastle harbour might be affected. Any tampering with the river would certainly result in affecting the depth of water on Newcastle bar, which is maintained at its present depth by the existing flow of the river, flood waters, and tides together; and if any considerable quantity of flood water were taken out of the river, whether by relief channels or impounding reservoirs, some injurious effect would most likely be felt on the bar. In fact, the bar as it is may be too narrow or too shallow for the tidal basin inside. On certain occasions, it is pointed out, the proposed reservoir would not have served its purpose, neither would it on the more frequent occasions when two floods follow each other at short intervals. In any case, seeing how uncertain is the arrival of floods, how uncertain what rainfall will produce one, how careful the man must be who handles such a vast body of water, and how entirely new and experimental is such a method of regulating floods, Mr. Bell thinks it would be more prudent to let some other country try the experiment first, and see how it works. Coming to his own proposals to mitigate the floods in the Lower Hunter, Mr. Bell says that, although the floods may be lowered between Maitland and Morpeth, he does not think that they can be lowered between Morpeth and Hexham by any works within a reasonable cost. By spreading over the land the floods are now as low as they can be; but if they are prevented by levees or embankments from so spreading their height will not be lowered. Uniform gradients from Newcastle to Morpeth may be given to the bottom by dredging, and the narrow parts may be enlarged to give a uniform sectional waterway; but still the river channel will not hold a big flood within its natural banks; so that if the water is to be kept off the land the flood must be shut in between embankments, and will be as high as ever. It is pointed out that nothing now can make the banks, and the town of West Maitland, reasonably safe unless a straighter course is made for the river as far as Morpeth. Mr. Bell shows his reasons for believing that if the river were so straightened the height of the floods would not be raised at Morpeth, or anywhere else down the river. The fact is, the report states, that such a flood as that of 1893 cannot be controlled; and if Maitland can be secured against it, it must be left to burst the banks and go all over the country, for if the diversion is cut it will not rise so high over the Bolwarra and Pitnacree districts as it did then. The diversion from Maitland to Morpeth would only benefit the Maitland, Bolwarra, and Pitnacree districts, and the question remained as to what should be done for the country between Morpeth and Hexham. Finally, Mr. Bell states that the safest way to attain the object sought of preventing floods from inundating the land without producing violent and

ham. Finally, Mr. Bell states that the safest way
to attain the object sought of preventing floods from

inundating the land without producing violent and unlooked-for changes, would be to gradually carry on the work of embanking and dredging together. First, beginning at the lower end to raise the banks, say 5ft. high, between Hexham and Morpeth, and to dredge and enlarge the channel so as to keep down the extra height of floods as much as possible; then, in succeeding years, to raise the banks a few feet more, dredging and enlarging the channel at the same time. In the end, the banks being raised as high as experience showed they required to be, and the river dredged and enlarged to correspond, there would be a fair chance of permanency in the work, the floods would be very little higher than they are now, and the land entirely protected from all but unusually high floods, which would breach the banks, and then they must be made up again. Great floods occur only at long intervals, and in every country where land is protected in this way they never pretend to expect complete immunity from accidents by unusually high floods. Commencing from below and working up, the results would be useful from the commencement; and as the lower river, from Hexham downward, is not in such urgent need of protection from floods as the Maitland district, the people should be content during the time necessary for the completion of the work. The work contemplated is to improve and embank the river from Hexham upward to Morpeth, it being assumed that the river, as it is below Hexham, will carry off the flood water, without much change of height, to Newcastle and the sea. Taking the different views of the case into consideration Mr. Bell's advice would be to straighten the river between West Maitland and Morpeth, cut through the two sharp bends above the Williams, remove the obstructions at Green Rocks, and make a cut 500ft. wide through the shoals of the North Channel. This would greatly relieve the floods, and might be all that is required for many years to come. There are many places in want of good drainage, which, in some cases, is prevented by not having authority to drain through other people's land. This could be put right if there was a drainage board, or board of river conservators, under the authority of which all requirements, such as drainage, the position of embankments, the protection of the banks with stone, the checking of encroachments of the river, regulations of the planting of willows along the banks, prohibition of throwing trees into the river, and generally, all matters connected with the river and the district would be controlled. To straighten the river between Maitland and Morpeth, and enlarge the river-bed up to Belmore Bridge, would, Mr. Bell estimates, cost about £200,000, which is a very large sum, but it would relieve Maitland and the Bolwarra districts of all anxiety from floods. Besides this, he recommends that two bends above the Williams be cut through, the obstructions at Green Rocks removed, and a deep cut be made through the shoals of the north channel. These would cost £253,065. The total estimate for improving and embanking the whole river is £1,076,600, which is about £130,000 more than he estimates Mr. Price's proposed dam would cost, and it is a much safer and more trustworthy way of alleviating the floods of the Hunter.

COUNTRY NEWS.

HUNTER RIVER FLOOD MITIGATION.

WEST MAITLAND, Friday.

A conference of local governing bodies was held yesterday to revive the question of flood mitigation. The conference deemed the time opportune for a scheme of flood mitigation, and that ways and means should be considered.

A deputation from the West Maitland Council waited on Mr. C. W. Tye (Under-Secretary for Public Works), and asked for assistance to replace the embankment at Wallis Creek, which collapsed in a recent flood. Mr. Tye said he would consider the request.

The embankment protects the lower end of Maitland and South Maitland. When it gave way a temporary sand bag and timber structure was placed in position.

Residents of East Maitland waited on Mr. Tye, asking that assistance should be granted to build up the bank at East Maitland to check the overflow of the flood waters. Mr. Tye promised that the district engineer would prepare a report.

HUNTER RIVER FLOOD

MAITLAND'S ESCAPE

From a maximum height in the flood on Friday at midday, of 31½ feet, the river at Maitland had fallen on Sunday evening to 16 feet, the low rate of falling being due to the water being held back by the Paterson being in flood, and also to the great rainfall in the upper reaches of many of the little tributaries of the Upper Hunter and Goulburn rivers. The great bulk of the water has moved away from the flooded farms, but they will be useless for farming purposes for some weeks.

It was fortunate for Maitland that the big embankment at the foot of the Horseshoe Bend, erected to divert the stream direct into Gillies' Cutting, did not collapse, like the embankment erected at the other end of the old river bed near the railway, as there would then have been a strong stream operating against the High-street embankment, and menacing the town.

The flood water was clear of the tram line in Newcastle-street, East Maitland on Friday evening, and the through service between East and West Maitland was resumed on Saturday morning, the line not having been seriously interfered with by the flow of flood water over the road.

1000 HOMELESS

Flood Devastation Continues

WEST MAITLAND ISOLATED

Hunter River Nearly 1893 Record Level

SYDNEY, Thursday.

News of the devastation by the flood waters is gradually trickling through. It is estimated that at least 1000 persons are homeless in the Hunter River district. Besides the Maitland Town Hall, the Catholic Hall, St. Mary's and the public schools were thrown open as shelters. Many persons who were compelled to leave their homes, escaped with only what they stood up in.

The river is now 36 feet 6 inches above normal low water mark, and was still rising this morning. Water is rushing through the shops in the business centre of West Maitland and then down High Street. It is three feet deep in front of the post office and all services are disorganised. Throughout the district rations are being served to those in distress.

Rescue parties worked heroically throughout the night in an endeavour to keep the flood waters from finding their way through the protecting embankments at Oakhampton, only half a mile away from Maitland. This morning West Maitland was isolated by rail and road. The river was only six inches below the record height of the 1893 flood. At one house Constable Cromelin had to break a window on the top floor with an axe in order to rescue a man, his wife and a sick baby, who were trapped in a bedroom. The water was up to the ceiling on the lower floor. Seven swagmen were rescued from the roof of one old hut, after spending the night there. An old couple refused to leave their home, couple refused to leave their home, notwithstanding the entreaties of their son, and eventually a constable was obliged to carry them through the water which was waist high.

RAILWAY LINES FLOODED

Road communication north of Newcastle is still completely disorganised and the Railway Department holds no hope of restoring the services to-day. At West Maitland the water is level with the platform, blocking both the main northern and North Coast lines. At Tarro the line is under water and traffic between Newcastle and Maitland has been suspended since last night. The North Coast and Kempsey mail trains, which left Sydney on Tuesday night, are still marooned at Coopernook and Taree on account of washaways.

Further torrential falls in the district surrounding the Manning, Hastings and Macleay Rivers were reported at the weather bureau this morning. In the lower regions of the Hunter Valley the position is slightly improved, but there have been further heavy falls in the Upper Hunter, where the position is considered serious.

POSITION IMPROVED

The acting State Meteorologist, in a statement this morning, stated: "From information we have received we judge that the situation in the Hunter Valley generally was improved, although it would take some time for the flood waters to come down. Heavy showers are likely throughout the district today, but a recurrence of the tremendous falls of last night and yesterday are not likely." He predicted that by tonight the position generally would be very much better.

The Railway Department advised today that the following trains have been discontinued until further notice: 4.4 p.m., Moree; 5.45 Kempsey, 8.30 South Grafton and beyond, 9.5 Glen Innes

Grafton and beyond, 9.5 Glen Innes mail. All train arrangements for to-day and to-morrow are undecided, pending the receipt of further news.

The department further advises that there will be an intermediate service for stations north of Singleton on the main line and also north of Kempsey on the North Coast line.

LUCERNE CROPS DESTROYED

Further details of the floods in the Hunter district show that thousands of acres of land are submerged and lucerne crops of great value have been destroyed. George Bridland, a well known farmer, narrowly escaped drowning after his sulky capsized near West Maitland. He was rescued by a flood boat.

During the voyage of the steamer Elveric from Kembla to Newcastle a seaman was swept overboard by the heavy seas and drowned. The man was not missed until the vessel reached Sydney early this morning.

TRAIN FOR WALLANGARRA

Some of the marooned passengers on the Kempsey mail are sleeping in the train. The North West, Glen Innes, Tamworth, North Coast and Kempsey mail trains did not run to Sydney to-day. No trains have left Sydney for north of West Maitland since Tuesday, but a train is being despatched at 3.30 p.m. for Wallangarra via the western line. It is not expected that it will reach Wallangarra until 6.37 to-morrow night, connecting with the Queensland train. The Glen Innes and North West mail trains and the two Brisbane expresses which left north yesterday detoured via the western line.

GRADUALLY RECEDING

The acting weather man (Mr. Camm) said to-night that the floods in the Hunter Valley were gradually receding. There were indications that during the next 24 hours further heavy rain may next 24 hours further heavy rain may be expected about the Eastings and Macleay rivers, and parts of the Manning. Generally speaking, however, the weather was gradually improving. His information was that the rain had practically ceased at the head waters of all these rivers..

FIGHT AGAINST WATER

The water has risen to a depth of three feet in the town of Hexham, and families have removed to safety. A desperate fight is being carried on against the water at Lornd, a residential area of Maitland, where the houses are now lower than the river level. All shop proprietors and employees are assisting gangs to strengthen the river bank.

GAS MAINS BROKEN

Further serious flooding occurred when Hall's Creek overflowed this afternoon and spread over a large area of land. In some parts, gas mains have been broken and electricity supplies interrupted.

A dredge fouled a cable under the Manning River at Taree this afternoon and telephonic communication with the whole North Coast from Taree was severed. It will be some days before the telephone service can be restored.

The Railway Department is unable to state when the North Coast services will be restored. Two trains will leave Sydney to-morrow for Wallangarra via Mudgee.

MANY WASHAWAYS

Many railway washaways have been reported and at some parts the water is many feet deep over the lines. Hundreds of men toiled throughout the night repairing some of the most serious breaks.

The river at Singleton has risen to 43 feet 6 inches. At West Mait-

The river at Singleton has risen to 43 feet 6 inches. At West Maitland, the latest report indicates that the position is becoming worse. The river is at the 37ft. 6in. level and the Weather Bureau states that this breaks all records since 1920.

Many residents were washed out at Oakhampton to-day, where the river banks gave way and flooded property to a depth of several feet.

ISOLATED

Two men named Trainer and Richardson were caught in the current of the Wollamba River near Taree, and the boat capsized. Trainer is in the middle of the flood standing on a small piece of high ground, while Richardson is isolated in a tree top in the centre of the swift current. The police are attempting to rescue them.

At Taree, the flood is the second highest in the district's history and it will take the farmers years to recover their losses. Practically all winter fodder has been destroyed.

Morning Bulletin (Rockhampton, Qld. : 1878 - 1954), Monday 20 June 1949, page 1, 4

WORST FLOODS IN N.S.W. HISTORY

EVACUATION OF FOUR TOWNS; SIX DEAD; VAST DAMAGE

SYDNEY, June 19.—In the worst flood in the history of New South Wales, four Hunter River towns — Singleton, Warkworth, Oakhampton and portion of Maitland—were evacuated, six people were drowned, and enormous damage resulted.

The flood is beginning to recede and as the waters fall, extensive damage to homes, farms and crops, is being revealed.

R.A.A.F. planes have been ordered to fly 2000 army blankets to flood areas. Police cars have left Sydney with more blankets.

In the Wyong and Tuggerah areas, south of Newcastle, families are clinging precariously to the tops of houses awaiting rescue by police and volunteers manning emergency craft.

Flood deaths are: George Pye, 25, of Windsor; Esme Gordon, 16, swept away at Coolongolook, near Forster; George Gardiner, 25 and Basil Clifton, 18, drowned at Maison Dieu, near Singleton; Robert Arthur, 21, of Croydon, and Samuel Stace, 70, Woolongong.

CYCLONIC DOWNPOUR

Up to 10 o'clock this morning 14 in. of rain have been recorded in the Gosford district.

After days of cyclonic downpour, the Hunter River burst its banks today and flood waters poured into towns.

Dozens of people are marooned on roofs near Wyong waiting for police rescue boats.

At Singleton, the river rose 42 ft. Police ordered townspeople to evacuate their homes at 7 a.m. Residential areas are flooded and refugees have been

at 7 a.m. Residential areas are flooded and refugees have been

sent to the court house and Town Hall.

Mothers and their babies were evacuated in rowing boats from the Fairholme Maternity Hospital.

AT MAITLAND

The evacuation of more than 500 flood refugees from the Maitland Town Hall began today. At mid-day yesterday the water was 3 ft deep and lapping the top step. Later, it rose through the Town Clerk's office floor and at 5.30 the water was 3 in. deep.

The city is now isloated to normal traffic. Water is 2 ft. deep over the low bridge at North Maitland and the southern approach from Newcastle was been impassable since Saturday night.

An official count at mid-day is that 1600 homes are under water or uninhabitable. Most of Maitland's 20,000 people are now in the higher section between the police station and the post office.

Attempts are now being made to take the evacuees by truck to Largs and Lochinvar. Big army-type trucks are able

Big army-type trucks are able to cross the long bridge.

All halls and hotels are full and private homes are taking in people.

This morning sandbags in the streets gave way and water poured into the Horseshoe Bend section of the city, where about 1000 people had their homes.

"When Horseshoe Bend goes, everything goes," said an old Maitland resident. "1893 was the only flood that reached the bend."

Army ducks, one from the Northern Rivers, and one from the First Tracked Amphibious vehicle squadron, RAASC, have rescued more than 2000 people since the floods began and are one of the reasons there have been no drownings to date.

Captain E. L. Stocks, commander of one of the ducks, said people had refused to be taken off in many parts of the town.

POLICE POLICY

The army and police have adopted the policy of letting people stay behind unless they are in immediate danger.

One of those who said she would stay, was an old woman who shouted: "The 1893 flood was right up to my verandah. This is nothing." The water was about 30 in. from her top veranda of the two-storey house.

Boat crews are still taking people from isolated houses.

Maitland is without gas. The bunkers were swamped today. Electricity, which comes from Newcastle by high-tension line, is still functioning.

Police and council men say they do not think the water can go much higher.

"But we have been thinking that since yesterday," said one. "This flood is pretty big."

The lower South Coast road to Woolongong will be closed for two or three days. On

to Woolongong will be closed for two or three days. On

some parts of the road, boulders weighing up to 30 tons have crashed down from the cliff-tops, while in other parts the bitumen surface has cracked and in some instances portions of it have been washed into the sea.

PENSIONER DROWNED

Samuel Stace, 70, a pensioner, was found drowned in a small creek on the outskirts of Woolongong early this morning. He lived alone in a shack, which was reached by a bridge over the creek.

It is thought he was returning last night after spending

(Continued on Page Four)

WORST FLOODS IN N.S.W. HISTORY

(Continued from Page One)

the day in Wollongong and, in the darkness, did not notice that the bridge was covered by several feet of water as the result of the heavy rain. His body was found caught by tree branches a few yards down from the bridge.

Although flood waters of the Capertee River are gradually receding, parts of the remote shale oil centre of Glen Davis are still under water and the town is isolated. Most of the residents of the "bag town" section were evacuated to-day.

Serious damage has been caused to the National Oil Pty Ltd works by the flood, but the extent cannot yet be assessed. Two huge petrol storage tanks were extensively damaged.

Stranded by line washaways since Friday night, several hundred passengers aboard two divisions of the Brisbane mail, at Taree, have been suffering severe hardship. For two days they have had no changes of clothing in the very wet, cold and dirty conditions.

BITTER COMPLAINTS

Passengers complained bitterly yesterday that the railway refreshment rooms had made no effort to meet the extra demand. The trains which left Brisbane on Friday, at 11 a.m. and 11.45 a.m., were stopped at Taree 12 hours later.

Passengers were told by railway officials that the line was under water in several places between Taree and Maitland. Porters at the Taree station told them that it might be days before they can get through.

A party of 14 of the passengers left Taree by truck for Sydney yesterday afternoon. They completed the 235-mile

Sydney yesterday afternoon. They completed the 235-mile journey in 12 hours, after battling at times through 4 ft of water.

Two of the party, Mrs F. O'Brien and her 18-year-old daughter, said yesterday that the party had decided to hire the truck, a large transport, because conditions on the train were too severe.

"No consideration was shown to passengers at Taree," said Mrs O'Brien. "We were told that the truck trip would be hazardous and that we might not get through. We all dedecided that we would much rather take the risk than stay on the train."

Mrs O'Brien added that the first meal made available at the refreshment rooms was breakfast at 7 a.m., eight hours after the train arrived. The rooms were then shut from 8 a.m. until 1.30 p.m. The charge for the truck trip was £2/10/- each. A woman with three young children had to stay on the train because she could not afford the truck fare.

Miss O'Brien said that the truck had passed long lines of stranded traffic. In places there were 50 to 60 vehicles in the one line halted by water to 4 ft deep. The driver of the truck left the main road several times to avoid particularly bad sections.

They by-passed Maitland because they were told they could not possibly get through.

Miss O'Brien added that she thought her party was the first to get through from north of Wyong.

"I am feeling very sorry for the mothers on the stranded train," she said. "They must be having a terrible time."

BLANKETS DISTRIBUTED

BLANKETS DISTRIBUTED

The Minister for Social Services (Mr F. J. Finnan) said tonight that 2200 army blankets from Greta military camp were distributed today to flood evacuees in the Maitland area.

He said that RAAF Dakotas were standing by at Richmond and Schofield aerodromes ready to carry supplies to any of the distressed areas.

Mr Finnan said that as the number of evacuated homes had increased from 500 to 2000, food shortages at Maitland were likely. The RAAF planes might be needed to drop food supplies because Maitland was isolated. Fodder for marooned stock might also have to be dropped to prevent further stock losses.

"There are at least 1000 evacuees housed in 12 public halls in Maitland," said Mr Finnan. "The rising waters are now entering these halls. Welfare officers are working night and day and have completed arrangements for these people to move into Greta camp. The first batch of them is expected to arrive here tonight. Welfare officers have obtained food supplies from the railway. The food position tonight at Maitland is still very serious. Water is lapping the funnels of the engines in the Maitland railway yard."

The flood situation at Windsor tonight, Mr Finnan said, was also serious. Residents expected a further rise of 15 ft in the river.

NIGHT OF HORROR

Refugees from Pitt Town Bottom, about five miles from Windsor, today told of a night of horror when the Hawkesbury River swept into their homes early this morning. About 13 people were rescued from their flooded homes in that area today. Three young babies were among the evacuees.

babies were among the evacuees.

Mrs D. Douglas, mother of two of the babies, said she would never go back to the house.

"I will never forget last night," she said.

Another refugee, 80-year-old Mrs George Jenkins, could not talk of her experience.

She said: "I cannot speak of it. I am going away from here."

Everybody had been evacuated from Pitt Town Bottom this afternoon. The flood is nearly 40 ft above normal at Windsor and is still rising.

The latest reports from the Hunter River flood centres suggest that the next 10 hours will be critical between Hexham (about 12 miles from Newcastle) and Singleton. Incoming tides will bank up the flood waters between Hexham and Maitland which tonight was isolated to normal means of traffic.

FARMERS, HIT BY FLOOD, CHANGE JOBS

From Our Staff Correspondent

MAITLAND, Sunday.—Their flood losses had forced many farmers in the Maitland district to take jobs as roadworkers, Mr. T. G. Elkin, a stock and station agent of Raymond Terrace, said to-day.

Mr. Elkin, who is 79, said the flood was the worst in his memory—"much worse than the 1893 flood.

"Milk production will be cut in the district for at least four months," he said. "I've never seen such devastation of farms."

He estimated the damage to farms in the Maitland district at more than £200,000.

Police and other officials estimate the damage in the town and countryside at £350,000.

The morale of Maitland people, many of them badly short of money, has been shaken by this second flood in 12 months.

They fear another flood will occur within another year, and say they would not be able to carry on.

But only a few want to leave Maitland.

Most who have suffered have gone back to their homes, and are patching them as best they can.

Some will not be able to return to their houses for weeks; and others cannot return, because their houses have been wrecked by the water and wind.

The Social Welfare Department has accommodated and fed more than 500 people, some almost penniless, in public halls.

TOUR BY ASSESSORS

In addition to the work done by the Social Welfare Department, assessors appointed by the Maitland Flood Relief Committee are now touring areas and estimating damage to properties.

touring areas and estimating damage to properties.

Money from "The Sydney Morning Herald" Flood Relief Fund will help these people repair their homes and carry on.

I accompanied Mr. R. Porter, an assessor for the South Mait-

I accompanied Mr. R. Porter, an assessor for the South Mait-land area, when he inspected some homes yesterday.

The first home visited was that of Mr. Raymond Gray, 42, of Walker Street. The house has been so badly smashed by floodwater and wind it will have to be demolished.

"I've been terribly worried," Mr. Gray said. "I can't go back to my home and I've got no more money to build elsewhere.

"I was flooded out last year and it cost me all my savings."

"LOT OF CRYING"

Mr. Porter next called on Mrs. M. Gillan, a neighbour of Mr. Gray's.

A wall of her home has been knocked out. The house is a shambles beyond repair.

Mrs. Gillan, who has six children, said: "I've done a lot of crying. This is a terrible blow.

"My husband is a railway worker. He will have to do his best to put the house together somehow, as we have nowhere else to live.

"I stored our clothes in the loft, but the water reached there and they are ruined.

"We were flooded out last year, too, and lost our furniture then. We got our furniture out this time."

Mr. Porter assessed 700 of the 1,500 claims in the June flood last year. He expects he will finish his present job in a month.

Maitland authorities say the State and Federal Governments should straighten the Hunter River's present channel from Oakhampton to Morpeth, clear silt from the river bed, and build dams on the upper reaches.

HUNTER RIVER A MENACE AGAIN

Maitland Facing New Flood Crisis

SYDNEY, June 19.—Police issued a warning to Maitland residents at 9 p.m. to-night that a critical position would be reached in Maitland between 9 p.m. and midnight.

The Hunter level at Maitland dropped 8 feet to-day, but reports from centres upstream were that the river was rising rapidly. The first volume of this inrush is expected to reach Maitland before midnight.

Men taking bread to flood-bound families at Miller's Forest and Nelson's Plains to-day narrowly escaped being swept away when their launch sank after being holed by a fence post in six feet of water. The men were rescued by a farmer who was travelling downstream in a boat.

It is believed that the plight of some of the families in the area is serious.

12 Aerodromes Closed.

About 50 yards of roadway between Mossvale and Nowra was covered by a landslide from the Barrenbarry Mountain late this evening.

Some roads in the Windsor district were still covered with as much as five feet of water.

The N.R.M.A. said main roads were quickly becoming trafficable again in most areas.

Part of the Maitland-Newcastle line to-day was still under water, but train services were back to normal, a Railways Department spokesman said to-day.

Twelve aerodromes in the country were closed, but only a few air services weer interrupted.

Farmer Drowned.

A dairy farmer, Claude Cooge (37), was drowned to-day in swirling floodwaters at Wybong Creek, Muswellbrook. Police said he was trying to take cans of cream across the creek when his cart overturned. His body has not yet been found.

Sydney's Deluge.

Total rainfall in the Sydney metropolitan area in the month of June to date has been 2100 points. The weather broke to-day, and only 14 points fell. No rain has fallen for about eight hours.

Coal Delivery Retarded.

Coal supplies to Sydney and interstate ports may be seriously reduced unless the flood recedes in the east Greta area, where the coal line has been undermined and is under water.

Only about 12,000 of the normal daily output of 25,000 tons from the Cessnock-Kurri mines may be brought over the alternative line—J. & A. Brown Company's private line—because empty trains must be taken back to the mines this way.

Coal is being stored in hoppers and dumped "at grass" about the pitheads to keep the mines working, but in a few days all storage space will be taken up and further production will be impossible.

space will be taken up and further production will be impossible.

Gale Damage.

A gale which struck Macksville this morning, blew down several farm sheds and outbuildings, uprooted trees, damaged roofs, and flattened the thick walls of a building under construction in Macksville's business centre.

An electric power line broke north of Nambucca Heads, leaving the whole district without power and lights until 1 p.m.

The Pacific Highway is impassable about six miles south of Macksville.

Flood Control Is Lagging In Hunter Valley

The century-old struggle against floods in the Hunter River Valley is at last making some headway. The stages of public protests and Government promises have been passed, and the stage of action reached.

Unfortunately the responsible State departments, pleading a shortage of loan funds, have kept action in low gear. But the position, nevertheless, is that 268,000 people of the valley are at least four years ahead of the people of the Macleay, and still further ahead of the people of the Lachlan, in their campaign.

THE Hunter Valley has experienced seven major floods (37 feet or higher) since white settlement began. These came in 1820, 1893, 1913, 1930, 1949, 1950 and 1951.

Since 1892, no fewer than 27 floods have exceeded the critical height of 23 feet.

Departmental officers, Royal Commissions, and consulting engineers issued reports on the Hunter River's flood problems in 1868, 1870, 1877, 1890, 1894, 1897, 1899, 1901, 1903, and 1913.

But these reports made little impression on the State Government.

Then, in 1948, came the Huddleston Report issued by the Hunter River Flood Mitigation Committee.

The committee, headed by Mr. G. Huddleston, a brilliant engineer from the Water Conservation and Irrigation Commission, recommended a 20-year programme which would cost about £8,500,000.

The N.S.W. Government accepted most of the committee's recommendations because it considered the Hunter Valley worthy of big expenditure.

The valley is a "tongue" of lowland penetrating some 160 lowland penetrating some 160 miles north-west from the coast into the rugged eastern highlands. Its 6,400 square-mile basin, the most extensive on the N.S.W. coast, is drained by the Hunter-Goulburn river system.

Dairy farming is the main activity on the fertile river flats. Sheep farming predominates on the undulating lands beyond the flats.

Valley's Riches

But the valley also contains Australia's most important coal deposits, the huge steel plants of Newcastle and many other secondary industries.

This combination of both primary and secondary industries makes the valley an exceptionally valuable economic unit. Such a unit, the Government has finally decided, is well worth protecting from the worst injuries of flood waters.

Government departments responsible for the river-control work took the Huddleston Report as their pattern. It recommended:

- **Forestry:** Planting of protective forests in the highlands at the heads of the catchment area.
- **Soil Conservation:** Development of woodlots by landholders; regeneration of dense pastures; gully stabilisation; silt weirs and dams; mechanical soil conservation measures.
- **Flood Control Reservoirs:** Construction of three reservoirs, Flood Control Reservoirs: Construction of three reservoirs, to hold about 160,000 acre-feet in all; relocation and enlargement of two proposed irrigation reservoirs to provide an additional 313,000 acre-feet for flood control.
- **River Improvement:** Clearing of growth and snags; survey and plan for bank stabilisation, particularly in the mid-river section; two minor cuttings at McRae's Hollow and Narrowgut; survey and plan for realignment of levee banks; diversion at the junction of the Hunter and William Rivers; dredging of the lower river and reclamation of adjacent lands.

Government departments have been active in forestry, but the results of this work will not be seen for many years. The Forestry Commission is at present studying the slopes of the Mount Royal Ranges to determine whether or not 30,000 acres should be reserved.

Simple, But Vital

Soil conservation measures are basically as simple as they are important. The farmer who ploughs straight up and down the side of a hill forms natural drains which help rainwater carry away his fields. But the farmer who follows the hill's natural contours with his plough helps his fields retain the rainwater.

fields retain the rainwater.

The Soil Conservation Service employs 100 persons, including 20 skilled soil conservationists, in the Hunter Valley. This team, which operates from Scone, Denman, Singleton, Muswellbrook, Murrurundi, and Merriwa, is equipped with 28 earth-moving units worth £170,000, and 25 motor vehicles.

The service has carried out 13 major and 100 minor demonstrations to help landholders start conservation work on their own properties, and 63 landholders have so far hired the service's plant to carry out erosion control works, at a cost of about £6,000.

The service has already treated mechanically, or introduced conservation farming practices, on 139 properties covering a total area of 262,000 acres.

The dam-building programme suggested in the Huddleston Report is still on the drawing board and the tempo of preliminary work has slowed considerably.

The Department of Conservation plans eight dams for the Hunter Valley; but construction has started on only one—Glenbawn, near Scone.

Glenbawn, which has been under construction for nearly six years, will be the first large, rolled earth-fill dam completed in Australia. It will hold 183,000 acre-feet of water for irrigation and will have a reserve of 113,000 acre-feet for flood reduction.

By April 30 last, the Department of Conservation had spent £2,541,997 on the dam. Work is still proceeding on foundation stripping, a diversion channel, and some preliminary construction for the main wall. But man-

By A STAFF CORRESPONDENT

power has been cut from 580 to 340, although labour is readily available locally.

State Parliament approved a second dam in March, 1950, which will be used mainly for flood reduction. This dam, to be built at Warkworth, on Wollombi Brook, will hold 400,000 acre-feet, 70,000 acre-feet of which will be used for irrigation.

Wollombi Brook, a tributary entering the Hunter River above Singleton, is responsible for most of the Lower Hunter's flood troubles.

Total flow at Maitland during

troubles.

Total flow at Maitland during the 1949 flood was estimated at 718,000 acre-feet. The Wollombi contributed 425,000 acre-feet, or 59.19 per cent. of this total run-off.

Warkworth Dam would obviously reduce this unwelcome contribution. But a spokesman for the Department of Conservation said this week: "The outlook for funds has pushed the construction of this dam further into the future."

Financial difficulties have also pushed six other dams—Fal Brook, Glendon Brook, Rouchel Brook, Foybrook, Kerrabee, and Brushy—well out of sight.

River improvement, the last of the Huddleston Committee's recommendations, has lagged badly since 1948. The Minister for Public Works, Mr. J. B. Renshaw, is responsible for this work on the Lower Hunter.

"Work is nearing completion on about a quarter of a mile of bank protection at McRae's Hollow, where a cut has been put through to strengthen the course of the river," said Mr. Renshaw this week. "A departmental engineer is at present investigating the possibilities of another cut-off at Narrowgut, near Morpeth."

Merely Tidying

This statement might seem to imply that the Department of Public Works made the cut-off at McRae's Hollow. But, in point of fact, the river itself did this when, in the 1949 and 1950 floods, it straightened its own course. Mr. Renshaw's workmen are merely tidying up and reinforcing nature's handiwork.

The Narrowgut cut-off now being investigated by a departmental engineer was investigated and recommended by the Huddleston Committee four years ago. Perhaps, in time, nature will do that job, too.

"Erosion on the right bank of the Hunter River at Belmore Bridge and damage to the existing protection downstream have been surveyed, and proposed works are being designed," said Mr. Renshaw.

This erosion is conspicuous because it seems likely, unless checked, to undermine Maitland's main bridge. There are many other instances of unchecked but less conspicuous erosion along the banks of the Hunter.

Investigation of draining Louth Park, Maitland, by a proposed channel through Howe's Lagoon.

Park, Maitland, by a proposed channel through Howe's Lagoon, was proceeding, said Mr. Renshaw.

The South Maitland Flood Mitigation Committee, an organisation of South Maitland resi-

THIS is the last of three articles surveying the problem of river flood control in New South Wales.

The first article, which appeared on July 15, dealt with the Lachlan River; the second, published yesterday, drew attention to the delay in taking action to tame the fierce-flooding Macleay River.

● To-day's article reviews the work in hand, and projected, to lessen flood damage in the rich Hunter River Valley.

dents, first advanced this scheme to reduce floods in their district. The Federal Department of National Development, the Joint Coal Board, and the Department of Railways have all investigated and approved the scheme . . . But no one has done anything about it.

"By intense dredging activities, the department has now removed the heavy flood-siltation in Newcastle Harbour," said Mr. Renshaw, **"and all channels have been restored to their pre-flood depths, and are now being widened and still further deepened."**

Dredging Delay

But the department has not yet dredged the river bed. One of the most startling features of recent floods has been the fact that a given amount of rainfall now causes more severe flooding **than it did in the past.**

The 1930 flood, with an intensity 25 per cent. lower than the 1913 **flood** and 40 per cent. lower than some earlier floods, was higher at West Maitland than any previous flood had been. Heavy siltation in the river bed explains this.

"If silt is allowed to keep piling up in the river, what's the good of our drainage system?" asked the secretary of the Upper Hunter Rural Co-operative Society, Mr. Cyril Adam.

Members of Mr. Adam's

Society, Mr. Cyril Adam.

Members of Mr. Adam's society control 100 miles of drains along the Hunter River flats.

"Our drains help disperse flood waters quickly," said Mr. Adam. "But every year the river bed is silting higher and aggravating the dispersion problem. Silt is even blocking the outlet of many of our drains. In a few years, we'll be able to walk across the Hunter River at Raymond Terrace.

"For years we've been striving to get some form of centralised authority on the Hunter. Now we have the Hunter Valley Conservation Trust. Let's hope the trust is allowed to do something."

This 19-month-old trust consists of a chairman, eight local representatives, and five technical representatives from Government departments.

Funds Not Spent

The trust is an advisory—not a constructing—authority. But it has power to clear land liable to bad erosion; to limit stock carried on any lands; and to levy a conservation rate on landholders within the trust area. Last year, the trust collected £20,000, none of which has yet been spent.

The Government, however, has approved the introduction of an amendment to the Hunter Valley Conservation Trust Act which will authorise the trust to spend money on river bank improvement, flood mitigation measures, afforestation, and soil conservation.

An annual income of £20,000 would not go far, of course, on these projects. But many people in the Hunter Valley regard the trust as a potential organisation which **could** do much for their valley.

Although much can be done to protect the Hunter River Valley from floods, very little has actually been done yet.

If the Hunter (or the Macleay, or the Lachlan) rose in high flood this month, Maitland (or Kempsey, or Forbes) would suffer just as badly as, if not worse than, before.

Singleton Argus (NSW : 1880 - 1954) , Friday 15 August 1952, page 5

Record Flood In Hunter Occurred 132 Yrs. Ago

RIVER CHANNEL CHANGES RESPONSIBLE FOR MORE FREQUENT INUNDATIONS IN PAST

Earliest flood in the Hunter about which there is any definite information occurred in 1818, two years before the district was discovered.

It left behind it obvious traces of its severity such as trees which had lodged in the branches of others a long way from the ground.

Before that, however, the erratic behaviour of the Hunter was well known to the blacks, who handed down authentic stories of bygone floods from generation to generation.

But what was the biggest flood ever known in the Hunter Valley ?

There are plenty of aged people in Singleton who claim that the deluge of March 1893, in which month 1314 points of rain fell, caused the greatest inundation ever. But that is because they were not alive when a worse one occurred in 1820, 73 years earlier.

From a study of Singleton's history it would appear that there was a long standing controversy over the date of the flood of floods.

Eighty years ago, a Royal Commission on Floods, which sat in the local Court House, was told by Mr. John Eckford, of Maitland, that the river rose seven feet higher than that of 1826, its nearest rival.

He selected three spots, each a considerable distance apart which the water had reached and the Commission ordered an expert to take measurements. The levels agreed so the argument was settled for all time.

ROSE 63 FEET

In his evidence Mr. Wyndham, of Dalwood, said that the 1820 flood reached 63 feet above summer level.

Nevertheless the 1826 flood must have been a corker, for Rev. Alfred Glennie to tell the Commission that, in his opinion, the river rose higher than the one six years

opinion, the river rose higher than the one six years earlier.

That floods were more frequent in the early days is easily proved. In the 17 years between 1857 and 1874, for instance, the Hunter "played up" five times—in 1857, 1861, 1867, 1870 and 1874.

The earlier frequencies are understood to have been based upon the fact that the river channel differed vastly from what it is today and that the water had not the same means of escape to the sea as it has at present.

DOUBLES ITS WIDTH

This belief was supported by evidence given by Mr. Alex Munro at the Commission, who knew the Hunter since 1830. He said the river channel at Singleton had greatly increased in size in the vicinity of the town.

A local chemist, Mr. W. C. [illegible]esley, at one time member for the district, said during his 28 years' residence in the town the Hunter had doubled its width.

The 1857 flood was claimed by Mr. John Brown to be greater than that of 1826, but no other witness agreed with him.

In July, 1861, the Hunter rose after a tremendous fall of rain, flooded the lower Hunter, but did not overflow its banks at Singleton.

Hunter, but did not overflow its banks at Singleton.

A month later the old river was in flood again. The water did not rise as high as its predecessor, but Maitland was flooded again. At Glennie's Creek the rise was reported to be much higher than in 1857, which seems extraordinary.

WASHED OUT OF OFFICE

About this time (1861) the ford at the foot of George Street was impassable for two months, and hundreds of teams conveying foodstuffs to the north were held up. From the outcry arose a demand for a bridge, and about [illegible] years later the Dunolly Bridge was built.

In 1867 telegraph lines across the river were snapped by flood debris and the telegraphist washed out of his office. The Wesleyan Church and schoolroom at Wollombi disappeared in the water, followed by a store and contents at Broke.

The inundation of March, 1870, came quietly and unexpectedly because there had been comparatively little rain, but it did a lot of damage and seven people were drowned at Denman.

At Muswellbrook a prisoner in the local lock-up kicked up a fuss because the water was up to his shoulders.

HOLIDAY VISITATION

The flood of 1874 arrived, of all days, on Anniversary Day. Three local residents, who struck the current at the corner of George and Macquarie streets while rowing a boat, had a frightening experience when the craft was dashed against a railing which tore out its bottom.

The same day a large flood boat, returning from rescue work at Dunolly received a tremendous bump near the Fitzroy Hotel and sank with seven occupants. Luckily none was drowned. The bump occurred when the boat struck the top of a street government post which tore a large hole in it.

After 1874 a number of important floods occurred in the Hunter until the Singleton people know as the worst they have seen came along in 1893. There were some drowning cases along in 1893. There were some drowning cases and a house and furniture owned by a railway employee sailed down the stream.

ALWAYS CATCHES IT

Maitland people recall the terrible damage the 1893 flood did to the town. Every street was feet deep in water and at the station the tops of railway carriages were covered. Even the floors of some balconies were flooded.

Twenty years later in 1913 the next big outbreak occurred and left the usual trail of desolation in its wake.

A milder one was recorded in June of 1930, when 12 inches of rain fell.

And then, of course, there was its successor when, on the morning of June 18, 1949 the Hunter decided that Singleton streets were due for a wash; but it was gone within a comparatively few hours only to provide Maitland with another catastrophe.

For the cause that lacks assistance,
'Gainst the wrongs that need resistance,
For the future in the distance,
And the good that we can do.

The Canberra Times

THURSDAY, MARCH 17, 1955

FACING THE FLOOD PROBLEMS

OUT OF THE bitter experience of flood disasters, Maitland has come to the conclusion that a major removal from Hunter River flats susceptible to flooding has to be undertaken. The cost of removal of the main business centre has been stated by the Mayor of Maitland at £15,000,000. This includes compensation for the cost of removal, but it is probable that this estimate includes costs that should not properly be charged against public funds. The essential point is that Maitland has decided to discontinue to disregard the lessons of repeated flood disasters, namely that a portion of the city has been built on alluvial flats that should never have been used for any purpose except farming. It has required courage for the Mayor and Council to declare that the oldest township on the Hunter should be moved, in view of the long history of a centre which was flourishing when Newcastle was unknown, but if the cost of past floods could be estimated, and the probable costs of future disasters could be known, the estimates for the building of new Maitland would probably be fully justified.

Having embarked on a correct decision, it is now essential that the consequential steps should be brought into balance. The scheme will deserve careful consideration by all Governments to determine what portion of the costs should be borne by Maitland itself, and what should be underwritten by the nation. In this examination, it is important to realise that there is no single remedy for flood disasters. Removal of built up areas from flood danger zones is an act of prudence, but it could be described in some cases as a correction for foolhardiness. On the other hand, it may save townspeople from disaster but leave others without protection. Avoidance of flood risk does not fulfil the requirements of flood mitigation. Much of the flood risks in Australia are due to the removal of natural cover which would reduce run-off from heavy rains. Artificial means have to be used to restore the balance of nature, and this calls for dams across the head waters of streams to hold back the crest of flood waters, so that extremes in flow may be averted in rainy seasons and reserves of water may be available in dry periods. The answer to the Maitland problem must thus be sought in attacking the flood risks of the Hunter valley as a whole. Therefore a reasonable balance has to be struck between preventing people exposing themselves in chronic flood areas, and in mitigating extremes of nature which produce floods in any case. Maitland seems likely to provide a starting point for attacking the flood problem in all danger areas, but care has to be taken to ensure that the programme to be adopted is the complete, not a partial, answer.

FLOOD PREVENTION IN THE HUNTER RIVER.

REPORT BY C. NAPIER BELL, M. INST., C.E.

To the Honorable the Minister for Public Works,—

Sir,—Acting under your instructions, I arrived at Sydney on the night of 21st March, and at once proceeded to read and make notes from the great mass of documents which, during the last thirty years, had been collected and stored at the Public Works Office, as well as to inspect the plans and sections made from the late Mr. Moriarty's time till quite recently by different engineers who had reported on this subject.

After an interruption for Easter holidays, on the 12th April I went to Newcastle, and, in a steam-launch, went up the Hunter as far as Pitnacree; also up the Williams and Paterson, and spent many days driving and walking all over the flooded districts, such as Miller's Forest, Phœnix Park, Largs, Dunmore, Morpeth, Wallis and Fishery Creeks, Bolwarra, and Oakhampton.

I then, according to your instructions, took such evidence on the subject of floods as people were willing to come and give me, which evidence, collected all over the district as far up as Muswellbrook, I have attached hereto.

On the 6th May I went to Muswellbrook, and drove all over the Upper Hunter district as far up as Page's Creek; also up the Goulburn as far as the bridge; to Denman and to the site of the proposed dam for an impounding reservoir; to the mouths of all the large creeks or tributaries; then to Singleton and all over that district; and, on the 17th May, back to East Maitland, where I stayed to make plans and calculations, and write this report.

Although all particulars respecting the Hunter and its floods, and the conditions which give rise to the flooding of the lower districts, have been repeatedly set forth in much detail in many previous reports since 1869, I think that, to make my report better understood, it will be necessary to repeat some of what has been said so often, if only to avoid the necessity of referring back to previous originals.

The first very complete report on the floods of the Hunter was made by the late Mr. Moriarty, Engineer-in-Chief for Harbours and Rivers, in 1869, who, in making minute calculations of flood discharge, and the distribution of flood-waters over different parts of the flooded districts, has left to subsequent investigators almost the only data that there is on the subject, and everyone after him has taken his observations and calculations as the basis on which they deal with the question.

Mr. Moriarty, after indicating what might be done to mitigate the disastrous effects of these floods, was possibly deterred by the magnitude of the phenomena he had before him, and only recommended some slight palliative measures, which he thought might relieve the West Mait'and and Bolwarra districts. At the same time he expressed a warning of the danger that would be incurred if West Maitland erected high embankments round

a warning of the danger that would be incurred if West Maitland erected high embankments round
the town; if it were attempted to block the flood overflow at Cummins; if the great backwater of Wallis and Fishery Creeks were shut in by flood-gates; or if people were allowed to embank the lands of Bolwarra.

In 1870, the Government appointed a Royal Commission to investigate the subject of the Hunter River floods, which they did in a very exhaustive manner, and collected a great quantity of evidence from residents and others who knew all about the floods; but the result of their investigations was that the Royal Commission was unable to recommend anything to be done, evidently under the impression that as much harm as good might arise from undertaking any work to mitigate the floods. The Commission reiterated the warnings of Mr. Moriarty not to close the flood overflow at Graham's (or Cummins), not to raise the embankments round West Maitland, not to shut the floods out of Wallis and Fishery Creek valleys, and not to embank the Bolwarra lands.

In 1890, Mr. Gordon made a very complete report, accompanied by a large number of plans, sections, diagrams, and calculations. He remarked that it was impracticable, or even preposterous, to attempt to "take off the top of the flood" by diversions to Port Stephens or Lake Macquarie, or from Wallis Creek to Hexham; and I quite agree with him that it is so.

Mr. Gordon made two recommendations: One was the construction of about six impounding reservoirs on six of the upper tributaries and larger creeks, by which a great flood should be he'd back until the flood water from the lower river should have passed by, when the water held up in the six reservoirs was to be let go; the effect being that only about half a flood was to come down at a time. This project was to be accompanied by some comparatively slight works in strengthening the most crooked parts of the river between Maitland and Morpeth, and some small amount of dredging below Morpeth. Mr. Gordon favours this project on account of less cost, quicker construction, less interference with rights of property, and more certainty of effecting the desired object of keeping down the height of high floods.

He discussed the project of widening and deepening the whole of the river from Hexham to Morpeth, but dismisses it for his less costly project of diverting and shortening the river, by his diversion called No. III, from Eales' Flat to near Hexham.

Mr. Gordon's second recommendation, therefore, is to make a diversion of the river between the Horse-shoe Bend at West Maitland and Morpeth, called No. II, to widen and deepen the river from Morpeth to Eales' Flat, to cut a diversion from Eales' Flat to near Hexham, called by him No. III, of a dimension to carry 108,000 cubic feet a second, leaving 53,000 cubic feet a second to flow in the present main river round by Raymond Terrace, and finally to deepen and widen the main river from above Hexham, where his diversion No. III comes out, to Ash Island; the stuff excavated, both in diversions and main river, to form embankments on each side to keep floods within them.

He estimates the total cost of making the six reservoirs, with the reduced amount of dredging, protective works, etc., at £714,565, and the cost of making diversions II and III, with the necessary dredging, at £664,500.

Mr. C. W. Darley, Engineer-in-Chief for Public dredging, at £664,500.

Mr. C. W. Darley, Engineer-in-Chief for Public Works, objects to Mr. Gordon's project for six reservoirs as being much under-estimated; and thinks that under the conditions which frequently obtain during floods, such as floods coming in pairs, or occasionally several floods following each other, that it is doubtful whether the floods in the Upper Hunter could be retained in the proposed reservoirs before another flood came on top of them; and that if the water in the reservoirs was let out after a flood the effect would be that the river would be kept in half flood, or bank full, for double the length of time which it naturally is now; and that this state of things would be more injurious to farmers than a big flood coming and going in its own time.

Mr. Darley objects to Mr. Gordon's project of diverting and dredging as greatly underestimated, and as injuriously interfering with the navigation of the river, and the water rights at Raymond Terrace and settlers along the banks; he thinks that the river would silt up from Eales' Flat to Raymond Terrace; and from Raymond Terrace to Hexham the navigation would be seriously impeded, if not assisted by expensive training walls.

Mr. H. D. Walsh, District Engineer, Harbours and Rivers, Newcastle, in 1894 proposed making a diversion, called the Bolwarra flood channel, along the foot of the hills on the Bolwarra side from Hayes' Lagoon to Largs, to come into use when the river rose to the 20-foot level at Belmore Bridge; to discharge 20,000 cubic feet a second; to enlarge the river where this diversion entered it at Narrowgut Reach to Morpeth, at an estimated cost of £118,000; to make an overflow channel from above Pitnacree Bridge into Howe's Lagoon, and from there into the main river at estimated cost of £11,200; to make an overflow channel from Duckenfield to Greenaway's Creek, estimated to cost £50,000; and to remove some of the rock at Green Rocks at a cost of £6000.

In 1897 the late Mr. Price, C.E., having carefully inspected the whole district of the Hunter and its tributaries, found a site 9 miles below Denman which he considered suitable for a dam for an impounding reservoir, which would hold so great a quantity of water that Mr. Gordon's six reservoirs would all be contained in the one, and a great deal more—in fact, with a dam 130 feet high it would hold the unheard-of quantity of forty thousand million cubic feet of water. Such a quantity would very probably be more than any one flood from the Goulburn and Hunter Rivers, below the junction of which the dam is situated, and Mr. Price emphatically recommended the adoption of this system of mitigating the Hunter floods, and added his conviction that no other method would be successful.

Mr. C. W. Darley, in his report on Mr. Price's project, repeats the objections he urged to Mr. Gordon's similar project, and states his opinion that, beside the injury of keeping the river in half flood for double the natural time, it would be difficult, if not impossible, to handle this vast body of impounded water so as to give the relief sought and not to do harm; and he calls attention to the danger to all people in the valley below, of having this body of water stored above them. Mr. Price also referred to the possibility of utilising the water in his dam for irrigation; but Mr. Darley shows that, under the circumstances, this would be impracticable, as it would not be possible to make

shows that, under the circumstances, this would be impracticable, as it would not be possible to make the impounded water serve two purposes diametrically opposite to each other.

The above reports, with a great mass of evidence, and no end of plans, sections, cross-sections, &c., are the data which I find at hand—in fact, nothing could be more complete than the information of this kind collected during the last thirty years. The only thing left in doubt is the quantity of water discharged in high floods, which it is almost impossible to measure correctly, unless one took measurements of current velocity during a flood at the cross-section of the river under trial; and this has never been done.

The watershed of the Hunter, with its tributaries, contains 9,127 square miles, of which the Williams and Paterson have 857 square miles, leaving 8270 square miles as the watershed of the Hunter proper. This may be divided into the Lower Hunter, between Maitland and the sea, 1095 square miles; the Central, between Maitland and the junction of the two main rivers, the Hunter and Goulburn, 1944 square miles; and the Upper District, from the junction to top of watershed, 5230 square miles.

The Williams and Paterson tributaries, at the lower part of the river, have each a tidal part of about 20 miles up from their mouths, beyond which they enter the hills and reach the top of their watershed in a distance of about 50 miles. The Hunter, Paterson, and Williams all head up in the same range of mountains, which are from 2000 to 4000 feet high.

The Hunter is tidal to West Maitland, a distance by the river of 44 miles from the sea at Newcastle. From Maitland to the junction of the Goulburn the bed of the river rises at the rate of a little over 2 feet per mile, and in this stretch it receives four large tributaries which bring down heavy floods. From the junction of the Goulburn, both rivers rise more rapidly to the top of their watershed in the Liverpool Ranges, about 4000 feet high.

The Hunter Valley, from the sea to very near the top of its watershed, is the finest and most fertile valley I have seen, and I do not think there is any like it in these colonies. Flats of the richest alluvial soil, from half a mile to four miles wide, form its meadow lands, and higher terraces of alluvial soil in many places make the total valley from 5 to 12 miles wide.

The upper valley—that is, from Maitland upward—has its meadow lands heavily flooded in high floods; but as the people do not generally live on the flooded land, the farmers and graziers do not object to the floods, which, they say, greatly enrich and refresh the soil. Singleton and Denman stand on the flooded ground, and in consequence suffer damage when high floods occur.

At Maitland the valley becomes more flat, and spreads out in great alluvial plains, through the upper part of which, from Maitland to Morpeth, the river winds and turns in a most unusually crooked course; so that, although the straight distance is 3¼ miles, the distance by the river is 14¼ miles. But lately, the effect of closing the great backwater of Wallis Creek, and embanking the Lorn and Bolwarra land, the floods have become more violent at this part, and have broken through three of the bends and reduced the length of the river between Maitland and Morpeth from 14¼ to 8¾ miles.

From Morpeth to Newcastle the river continually increases in width and depth, probably under the action of the tides; and although it has great increases in width and depth, probably under the action of the tides; and although it has great turns and loops, it is nothing like so crooked as above Morpeth. At 28 miles from Newcastle the Paterson joins the Hunter, and at Raymond Terrace, 19 miles from Newcastle, the Williams comes in. Both of these tributaries flow in winding courses through rich alluvial flats, also heavily flooded by the obstruction which the Hunter offers to the discharge of their own waters.

Although the tide reaches to Maitland, where it has now a range about 18 inches, but formerly about 3 feet, the bed of the Hunter has a gradual slope from Maitland to Ash Island, the depth increasing from 3 feet to about 20 feet below water. The surface of the land also slopes, though irregularly, from about 28 feet above low-water at Maitland, to about 6 feet above low-water at Ash Island, which is close to Newcastle. In most places the banks of the river are from 4 to 6 feet higher than the land further back from the river.

Just below West Maitland, two creeks called Wallis and Fishery Creeks enter the river, which, coming from the south-west, flow for nearly 10 miles through wide flat valleys of rich alluvial soil, which valleys, before flood-gates shut them in, were filled at every flood by backwater from the Hunter; and, as these valleys are very low, a flood in the Hunter used to store in them an enormous body of water.

Three miles above Maitland, there is a low place in the right bank through which the floods used to overflow to the extent, according to Mr. Moriarty, of about 20,000 cubic feet a second, and pouring through what appears like an old channel of the river, discharged into the valley of Wallis Creek; so that in a flood, Maitland became an island with the flood in front and behind it. Maitland is situated on the naturally raised bank between the river and this overflow, and the highest known *flood, that of 1820, nearly topped the highest part* of this position.

The alluvial plains of the Lower Hunter, which are subject to be flooded, are estimated at from 35,000 to 40,000 acres; but so fertile is the land that each acre of them is worth at least ten acres of possibly any other land in the country, with the exception of similar land on the Northern rivers. The selling price of this land varies from £60 to £20 an acre.

Floods in the Hunter are so extremely irregular that farmers cannot make any provision against them. A high flood may occur twice or even six times in a year, or there may be many years without any high flood. Floods in winter do not cause so much loss of crops, but those of summer frequently kill or greatly damage them. The flood of 1857 is said to have caused damage to the amount of £150,000, and that of 1893 very much more.

The town of West Maitland is partly inundated by all high floods; in that of 1893, parts of the town were under water from 3 to 12 feet deep, damaging goods and furniture very seriously. The entire width of the valley between Maitland and Morpeth, about 2 miles from hills to hills, was flooded in 1893 to various depths from 3 to 15 feet deep, and numerous dwellings built on the highest spots were surrounded by water, some up to the eaves of the roof.

As the land is chiefly devoted to the cultivation to lucerne, with patches of maize, sorghum, potatoes, &c., few cattle are pastured on the fields; but every farm keeps cows and horses, which, if the flood comes gradually, may be driven away to the low hills which bound each side of the valley;

flood comes gradually, may be driven away to the low hills which bound each side of the valley;
but a sudden flood like 1893, rising to its height in the night, was the cause of a great number of cattle and horses, besides pigs and fowls, being drowned.

It is to be observed that the people are to blame for much of the damage and inconvenience they suffer, for whereas in Queensland houses are built with the floors raised from 6 to 9 feet above the ground, here the people build with floors flat on the ground. In West Maitland, in situations liable to be deeply flooded, numbers of houses are seen with the floors lower than the street, and it would seem as if no efforts are made to try and remedy the inconveniences of their position. I was told of houses washed away near Raymond Terrace, but rebuilt just as before, with the floors flat on the ground.

I have said above that the inclination of the bed of the Hunter from Singleton to Maitland is about 2 feet a mile; but after passing West Maitland it curves about in such an extraordinary manner that its fall is not quite half a foot per mile as far as Morpeth; whereas, if it had a straight course, its fall would still be 2 feet a mile. The consequence of this is that as soon as a high flood reaches Maitland it overflows and covers the whole valley. The crooked river channel then becomes inoperative; so that when most wanted there is no channel between Maitland and Morpeth, and the river takes charge of the valley two miles wide. The flow in the channel under these conditions being nearly stopped, it is extensively silted up; and although to some extent this silting is cleared away by smaller freshes which do not overflow, yet the channel in the crooked parts is far shallower and narrower than in other parts where the flow of the flood is not checked.

The whole of these plains have been formed by deposits from the river, the soil being a sandy loam, with beds of sand through it. Every flood lays down on the land a new deposit of silt or sand; but it is noticed that the flooded area between Maitland and Morpeth (including the valleys of Wallis and Fishery Creeks) are being silted or warped with great rapidity. Thus I am told of places which were lagoons or swamps thirty years ago and are now cultivated; in other places fences are silted up to their tops; and I was shown a house near Pitnacree which, some years ago, was built with its floor 3 feet 6 inches above ground, but is now level with the surface.

This rapid silting of the country between Maitland and Morpeth is due to the crooked course of the river channel causing the floods to overflow more frequently, and it receives the first tribute of silt before those parts lower down. All this valuable warping, which is making higher and better land, will be entirely stopped by the embankments which the people have put up to keep out the floods.

It is generally believed that the fertility of this land depends on the periodical top-dressing of silt which floods lay down, and instances are given where land has been enclosed by embankments for many years that its fertility is seriously impaired. If this is true, then those lands from which floods are excluded will in time have to resort to manure, which would be a heavy tax, possibly amounting to more than the former loss and damage by floods.

This, however, is a question which the farmers seem to have made up their minds about; for, since

This, however, is a question which the farmers seem to have made up their minds about; for, since the reports of Mr. Moriarty and the Royal Commission, all of whom deprecated the embanking of the flooded land, the whole of the left bank has been embanked from Bolwarra House to Largs; also the great flood overflow at Cummins' has been closed by a stop-bank, the right bank has been embanked from Oakhampton to Maitland, the town is surrounded by banks, and the great back-water of Wallis Creek is closed by flood-gates; the right bank is further embanked from the flood-gates to Pitnacree, and a great part of the Phœnix Park is enclosed.

The Bolwarra and town embankments are made up to 1893 flood level, so is the top bank at Cummins'; but the top of the Wallis Creek flood-gates is 7 feet below 1893 flood level. Thus everything that Mr. Moriarty and the Royal Commissioners warned them not to do has been done. But the Commissioners warned them that if they did these things the banks would break under some great flood, and no one could tell what would happen. Strange to say the great flood did come in 1893; all the banks gave way, and nothing particular happened in Maitland with the exception of much goods and furniture spoiled.

The late Mr. Price shows that in the great flood of 1893 the rainfall in the twenty-four hours over the Lower Hunter district was 13 inches, on the central area 9 inches, and on the upper district 4 inches. From evidence given me I believe the rainfall in the upper district was greater than 4 inches; for at Denman it was 5·1 on the 9th March and 2·1 on the 10th; and at Muswellbrook they say it was 9 inches, but possibly this may be for the two days 9th and 10th March, and in any case a rainfall in twenty-four hours should not be taken as the measure for a great downpour lasting perhaps three days, and resulting in a high flood.

Mr. Moriarty, from very uncertain data, reckons that the flood of 1857 was caused by a rainfall of 5 inches over the entire centre and upper districts. But the 1893 flood was about 6 feet higher than that of 1857.

All previous reports notice the extreme irregularity of the Hunter floods. A diagram by Mr. Gordon,, shows that from 1856, while there is one interval of ten years without any flood, there were six floods in 1870 in three months, and it is also noticed that floods frequently come in pairs separated by one or two weeks. In the last twenty-five years there have been eight high floods, which, at Singleton, ranged in height above summer level from 38 to 47 feet.

According to Mr. Moriarty, the distance by way of the river from Singleton to Maitland is 49 miles, and the 1857 flood took twelve hours to travel that distance, while it took six hours to travel from Maitland to Morpeth, about 17 miles, by way of the river; but from Muswellbrook to Singleton, which is a shorter distance than from Singleton to Maitland, it took forty hours. These times are for the crest of the flood, and do not indicate so much the speed at which the flood travels as the time the flood takes to fill all the wide spaces that are inundated; so that there must be a great deal to fill from Muswellbrook to Singleton; less to fill from Singleton to Maitland; and more to fill from Maitland to Morpeth; and the flood can only attain its crest height when these places are filled.

The maximum quantity of water carried by a high flood I find to be most difficult to arrive at, as there are no observations at the particular places

high flood I find to be most difficult to arrive at, as there are no observations at the particular places where the whole of the flood passed. Thus, Mr. Moriarty gives the discharge of 1857 flood at Singleton as 131,416 cubic feet a second. That was the quantity flowing in the channel of the river, but he omitted to estimate the great body of water which was flowing 2 miles wide over the fields south of the town.

Then Mr. Moriarty has given the discharge of the river channel at Oakhampton at 132,283 cubic feet a second, but omits to estimate what flowed through the overflow at Cummins and over the banks between Oakhampton and the section he took. But if he had taken his section above the overflow at Cummins (or Graham's), where the whole river has to pass, he might have found the quantity to be about 154,000 cubic feet a second; although this is uncertain, because one can only assume the gradient of the flood surface at this place.

It is well known that the Williams and Paterson generally receive the first of the rains, and, bringing down their floods, fill up the lower river before the Hunter comes down with its flood. Usually the floods from these lower tributaries have had time to subside considerably before the main flood arrives; at other times the two floods meet before the Paterson and Williams have had time to subside; and all these circumstances make the floods extremely irregular in height and duration.

It is also noticed that usually the Hunter flood comes down in a double wave, the first being caused by the large tributary creeks between Denman and Maitland, shortly after followed by the main flood out of the Hunter and Goulburn.

This feature is indicated, but not very clearly shown, in the 1893 flood, which at Singleton attained its maximum height on Thursday, at midnight, and soon afterwards commenced to fall very slowly; on Friday it was falling rapidly, and on Saturday the flood had gone down. At Maitland, on Wednesday, at midnight, the flood had risen 30 feet, and continued slowly rising till Thursday night; it then rose more smartly, and at 4 p.m. on Friday attained its top height of 37 feet.

This does not show, as people assume, that the Cockfighter and other tributaries below the junction of the Hunter and Goulburn are capable of raising the flood at Maitland to nearly the height that the combined flood of the Hunter and Goulburn does; because the flood from the Hunter and Goulburn, long before attaining its top height at Singleton, has already helped to fill the river-bed all the way to Maitland; and if the Hunter and Goulburn had been kept back by a dam, the flood from the tributaries below it would have been insignificant.

Observations of this kind are not accurate, and may be misleading. The only way to get accurate knowledge of the floods in their courses is to have stations every 4 or 5 miles along the river, accurately levelled from one datum, and when flood occurs to take gauge readings of the rise of the water at the same time at every station; but this is not likely to be done, as it would require a number of persons kept on the look-out, for no one can tell how long.

Mr. Moriarty remarks about this first wave, that it rises with great rapidity, but rarely attains a dangerous height, and soon commences to subside; but before it has had time to get away through the crooked channel between Maitland and Morpeth

it is overtaken by the second wave, and the flood then attains its greatest height; and a section herewith, taken right across the valley from Morpeth tramline to the hill at Largs, shows the condition of things in 1857 and 1893 floods.

There have been numerous projects advocated for reducing the height of floods in the Lower Hunter, all taking the form of relief or overflow channels. One proposes to cut an overflow channel to Macquarie Lake; another to cut a relief channel from Wallis Creek to Hexham; another to cut a relief channel from Raymond Terrace to Port Stephens. These projects are utterly impracticable, and need not further be considered.

Then we have Mr. Gordon's project to cut a relief channel from Eales' Flat to the river above Hexham to carry a part of the flood, leaving the remainder to flow round by the main river by way of Raymond Terrace; and finally we have Mr. Price's project of a great impounding reservoir below Denman.

If floods carried nothing but clear water any of these schemes might work well; but it must not be forgotten that vast quantities of silt and sand are also carried, and any diminution of the body of water is at once attended with the process of silting-up. For this reason, if there is to be any shortening or diversion of the river, it should be the whole river or not at all.

Every one must have observed that if part of the water is taken away from a river, the channel at once silts up to correspond with the lessened quantity of water, so that floods will not be lowered in this way.

On this subject a highly scientific and experienced engineer, Mr. J. G. Morrison, in a lecture delivered at Shanghai in 1888, remarks:—"When the Chinese have been troubled with floods in their rivers, they have always been too ready to cut extra channels to carry off the surplus waters. This is, as a rule, the exact opposite of what should be done. The extra channel lowers the velocity, the river deposits more silt, the bed rises, and the level of floods becomes worse than ever."

Also, Mr. Gustav Deyer, speaking of the work of the Mississippi Flood Commissioners, remarks:— "Outlets in any form, whether waste weirs, reservoirs, or waterways connecting directly with the sea, all come under the same head, and require the same treatment; each part of the volume of which the main channel is temporarily relieved will require a proportionate expenditure for construction and maintenance, and the object in view will fail of accomplishment. The Mississippi Commission has accordingly striven to raise the levees and dredge the channels, and concentrating the scour by groins, so as to get uniform velocity."

The prosperity of the whole district depends on the harbour at Newcastle, and any tampering with the river will certainly result in affecting the depth of water on Newcastle bar, which is maintained at its present depth by the existing flow of the river, flood waters, and tides together; and if any considerable quantity of flood-water were taken out of the river, whether by relief channels or impounding reservoirs, some injurious effect would most likely be felt on the bar. In fact, the bar as it is may be too narrow or too shallow for the tidal basin inside, as is seen in Mr. Moriarty's tide diagram, which shows that high-water spring tide is 1 foot 6 inches lower at Hexham than it is at sea, indicating that the flood-tide of high-water springs is throttled either at the bar or among the shallows of Bullock

the flood-tide of high-water springs is throttled either at the bar or among the shallows of Bullock
Island.

The entrance at Newcastle is constantly threatened by the encroachment of the sand-spit on the north beach, which has increased greatly during the last thirty years, and the Harbour-master tells me that in the absence of floods the bar slowly silts up, but every 20-feet fresh clears it out again (meaning 20 feet of flood on Maitland gauge). If that is true, then a great flood with a velocity of 8 knots over the bar might clear away the accumulations of years both on and round about the bar.

It may be useful for future reference to note here that the tide at Newcastle seems to have had very little effect on the 1893 flood; thus, at low-water, when there should for that day have been 1 foot on the tide-guage, it showed 6 feet; and at high-water, when it should have stood at 6 feet, it showed 6 feet 8 inches. Also, the velocity of ebb-tide over the bar is about 6 feet a second, while that of the 1893 flood was about 13 feet a second.

Before I can discuss any proposals of my own for mitigating the floods, I must state my objections to the previous proposals of Mr. Gordon and Mr. Price.

Mr. Gordon proposes to cut a straight diversion of the river, called by him Diversion No. II., from the Horse-shoe Bend, near Maitland, through Howe's Lagoon to the bend at Morpeth, the diversion to carry the whole flood, which he takes to be 140,000 cubic feet a second. In the making of this diversion he adopts it only on condition that the whole of the river below Morpeth be so improved that it can take away the extra quantity of water which the Diversion No. II. will bring to Morpeth over and above what comes to Morpeth now; or, as he says, to enable the lower river to take away the flood which at present is retarded at Maitland.

From this it follows that the river channel is to be enlarged from Morpeth to Eales' Flat. At Eales' Flat, in order to keep down the height of floods, and save the expense of enlarging the river channel between Eales' Flat and Raymond Terrace down to Hexham, he proposes to cut Diversion No. III., which, leaving the river at Eales' Flat, shall cut through the rock ridge, then through Miller's Forest, and out again into the river near Greenaway's Creek, 3 miles above Hexham.

At Eales' Flat he has increased his quantity of flood by 21,000 cubic feet a second, which he takes as the flood discharge of the Paterson, his total being 161,000 cubic feet a second. Of this Mr. Gordon proposes to pass 108,000 cubic feet through Diversion No. III., leaving 53,000 cubic feet to flow through the main river round by Raymond Terrace to Hexham.

At Greenaway's Creek, which is the outlet of No. III., he adds 22,000 cubic feet for the flood of the Williams, making a total of 183,000 cubic feet, to carry which he proposes to enlarge the river channel from Greenaway's Creek to Ash Island, where the river splits into two channels, which he infers, I presume, will carry the quantity without much alteration of height over its present flood rise, and so on to Newcastle and the sea.

In the above scheme I quite agree as to the advantages of Diversion No. II.; but I do not admit that, as a consequence, it is necessary to enlarge the river below Morpeth, or, in fact, to do anything at all to the lower river in consequence of making Diversion No. II. The reasons for this will be stated further on.

Respecting Diversion No. III., I said above that I do not believe any diversion will be successful

Respecting Diversion No. III., I said above that I do not believe any diversion will be successful unless the whole river is turned into it, and, consequently, that it would be a useless expense to turn a part only through the diversion. It cannot be said of this diversion, as of many other short cuts in rivers, that the river in time would take charge, and pass entirely through, because it cannot do so on account of the rock cutting at the ridge mentioned above. But if the main river had 108,000 cubic feet taken away from it, and was left with only 53,000 cubic feet, no one can doubt that it would rapidly silt up to fit its diminished requirements. It would become half as deep and much narrower than it is now. I do not think any one can predict exactly what would happen in this case, because so much depends on the nature of the sediment that would be lodged with floods. With the shingle and heavy sands of New Zealand rivers, I should say that in such a case the main river would finally close up altogether, considerably raising the height of floods, and flowing with increased depth and velocity through the diversion. However, I can only say with confidence that the main river would silt up considerably, and block the navigation between Hexham and Eales' Flat.

Again, as long as the main river below Eales' Flat kept its present depth and width, the making of Diversion No. III. would, of course, lower the height of floods at Eales' Flat and Raymond Terrace; but when the main river had silted up to fit its new conditions, the floods would be as high as ever.

The proposal which Mr. Gordon favours as a more certain and quicker-executed remedy for the floods is to build on the upper parts of the Hunter and Goulburn, and on four of its large tributary creeks, six impounding reservoirs capable of holding back half a great flood. No one knows what these six reservoirs would cost, because the sites for them are not yet known. Mr. C. W. Darley, in his report on Mr. Gordon's scheme, thinks they would cost much more than Mr. Gordon estimated. Without knowing where these reservoirs would be placed, I can only infer that if they were placed high up in the steep and rocky parts of the rivers they are to dam, they would hold too little water to be of any use; and if they were placed in the lower parts, they would inundate and render useless just as much land between them as Mr. Price's great dam below Denman would do, and all of these creeks have beautiful fertile valleys in their lower parts. Although the danger to people in the main valley would be less than with Mr. Price's dam, the difficulty of handling and letting out the stored-up water so as to produce the desired effect would probably be even greater than in one big dam.

Works of this kind cannot be looked on as permanent, because the holding capacity is diminished by every flood, or small fresh, which lodges gravel, sand, and silt in the reservoir; and the smaller the reservoir, the shorter is its life from this cause. Take, for instance, the following example:—In 1874, the Selwyn (New Zealand) County Council erected a concrete dam across the Kowai River, with the object of raising the water sufficiently to flow through a tunnel to irrigate the higher plains. The dam was about 22 feet high above the bed of the river, and dammed the river back in a lake about a mile long. In 1883 I had to report on the

the river, and dammed the river back in a lake about a mile long. In 1883 I had to report on the
tunnel, the invert of which was being cut up, and to my astonishment I found the lake filled up with shingle and sand level with the top of the wall; just a pot-hole was with difficulty kept open to supply the tunnel, and the scouring sluice was buried in sand and would not work.

Of course in a case of this sort the silt and sand in the river below the dam would be greatly diminished, and might even relieve much of the necessary dredging at Newcastle; but the evil would only be evaded, not cured, for when the dams had silted up the position would be as bad as ever. In many reservoirs tanks are provided to catch the detritus before it enters the main reservoirs, which have to be cleared out from time to time; but one can hardly imagine the labour it would take to clear out the stuff brought down these great creeks in a flood. It is also to the point to observe that usually reservoirs are very large, and are supplied by small streams, but here the reverse of this would obtain, and the effect might be that, although ordinary reservoirs may last 100 years without having their holding capacity impaired by silting up, reservoirs of this character might not last twenty years.

In order to form an opinion of the late Mr. Price's proposal to mitigate the heights of floods by means of a flood storage reservoir, I went to see the site of the dam he proposed to build, which is about 9 miles below Denman and 6½ miles below the junctions of the two main rivers, Hunter and Goulburn. I also examined the valleys of each river for some distance above Denman.

The area of land that would be inundated when the dam was full would be according to the size of the flood that was retained. That of 1893 might require the dam to be of the full height of 130 feet as proposed, when the land submerged would be about 23,000 acres, the 1857 flood proportionately less.

The whole of this land is of excellent quality, quite as fertile as that of Pitnacree or Bolwarra. It produces lucerne, maize, wheat, sorghum, clover, potatoes, pumpkins, fruit, and in good seasons abundant pasture. I got much evidence as to the supposed effect of flooding this land when the sluices of the proposed dam should be closed. Between the time of closing the sluices and getting the water off the land again we may assume that the land would be under water for a fortnight; but on occasions when floods come in pairs, as they often do, the land might be submerged for nearly a month.

All the evidence given me was to the effect that the pastures would be ruined by such a submersion, and that cultivation would be abandoned. Witnesses represented that after holding up a flood the deposition of silt would be enormous, and that all finer grasses would be killed; that it would take six to eight months before the coarse grasses would spring up through the deposits, and during that time the pastures would be useless.

One can only make a guess at the quantity of silt that a great flood would lay down over the land; but if the muddy and sandy water of a flood contained one-fiftieth of its bulk of silt, which is less than quarter of an inch of sediment deposited from a pail of water 12 inches deep, then the deposit of a flood might be about 9 inches deep over the whole surface, which would mean that where the water stood 1 foot deep there would be a deposit of ¼ inch, and where it stood 100 feet deep the deposit would be 2 feet deep. It was also represented that

¼ inch, and where it stood 100 feet deep the deposit would be 2 feet deep. It was also represented that a flood brings down incredible quantities of drift timber, which, when the dam was emptied, would pile up great masses at the dam, and there be buried in the deposits of mud and sand.

This beautiful valley is at present held by great proprietors, and there is little cultivation; but if it were held in small holdings it would be all cultivated, and would be most productive.

My witnesses showed that the large proprietors could not dispense with that part of their holdings which lies in the flats of the valley and would be submerged, for if their cattle were put off the flats by the flooding and subsequent want of grass, their hill pastures would be overcrowded, because, as they say, their hill pastures produce no fat beasts; in fact, they were unanimous in the opinion that landowners would not part with their flats unless their whole properties were taken also. I got a list of six proprietors holding 82,200 acres, of which 19,100 acres were in the river flats, and would be submerged.

Witnesses valued the flats at £10 per acre, and were of opinion that, subject to being submerged from time to time, the land might let at from 1s 6d to 2s 6d per acre yearly rent, the rent value at present being 5s to 6s per acre, but they thought that no one could rent the land unless they had the adjacent hills to drive their stock to when the dam was filled.

It was also represented to me that the village of Denman, 250 people, with churches, schoolhouse, post office, hotels, shops, and dwelling-houses, must be shifted on to the hills, and all existing roads and bridges would be rendered useless where they pass through the proposed submerged land.

Many witnesses expressed great fear of living below such a dam, and the Mayor said that the people of Singleton would be in great dread of such a body of water being held up above the town, and would unanimously oppose the construction of the dam.

I cannot help agreeing with what the Mayor of Singleton and other witnesses expressed, that it would be unreasonable to injure 23,000 acres of the finest land in the colony in order to afford a partial relief from flooding to the lands of the Lower Hunter, and that the dam at Denman would be a standing menace to everyone living in the Hunter Valley below it.

One cannot deny that there is some risk of a dam of this magnitude giving way, however carefully built; and it is well-known that several great dams, both of earth and of masonry, have burst with disastrous consequences; and whatever justification there may be for erecting a great dam across some rocky river gorge, to place one across a fertile populated valley and impound up such a vast body of water would involve a responsibility which I do not think any Government would care to incur.

At the site of the dam there is a steep rocky hill on the right bank, at the foot of which is the river flowing in a flat meadow 600 feet wide, the river itself being about 200 feet wide. From the meadow the site on the left bank is located on a low ridge rising in terraces to a hill 30 chains from the river. The dam would stand on the back of this ridge, with ground 40 feet lower, 500 feet off, on the lower side; thus the site is excellent on the right bank, but by no means the best on the left.

The borings show sandstone, shale, and coal on the right, and yellow shale, gravel, to blue shale on the

right, and yellow shale, gravel, to blue shale on the
left. To get in the foundations across the river and its 600 feet of flats, the excavation would have to be about 60 feet deep to reach the blue shale; in such a trench, liable to be flooded at any time by the river, there is always the possibility of getting bad work just where the best is required for safety. The low ground below the ridge on the left side, mentioned above, is a bad feature, only to be remedied by sinking the foundations much deeper, depending on the dip of the beds of shale.

One should not omit to consider the enormous mass of sand and mud which would be brought into this reservoir, not only by big floods, but by every freshet, and what could not be washed out through the sluices must remain there. In a very few years I imagine the bed of the reservoir would be silted up to the level of the sluices, and after that the silting would go on year by year, diminishing the capacity of the reservoir, unless it could be washed out through the sluices; and it seems to me that only a small part of the deposits could be got rid of in that way.

I do not know how a flood stopped back in this reservoir would be disposed of. No one can tell what rainfall is going to cause a flood. I heard of a case where four inches of rain in twenty-four hours did not raise the Goulburn nor Hunter more than a few feet, because the rain was preceded by nine months of drought; yet the 1893 flood, the greatest ever experienced, according to Mr. Price, was caused by four inches, the country being previously well soaked. But between such extremes there are many means, among which it would take a wise man to know which should be stopped back and which allowed to go down the river.

Then it is known that floods frequently come in pairs. If the first to arrive is held back, it would have to be let out very quickly so as not to have the second on top of it. If it were held up too long the second flood would find the reservoir with the first flood still in it, and when the second had passed over the dam, the reservoir would have to be emptied, which would prolong the flooded condition of the river to an injurious length of time, seeing that while the river was thus kept bank high, all adjacent lands would be water-logged for want of drainage outlet.

A case occurred in 1870 when six floods followed each other between 5th March and 25th May. If each of these had been held up in the dam and let out again, the lower river would have run bank high for nearly three months, and all the lands would have been water-logged for that time.

But the first reached its height at Singleton from the 11th to the 12th and the second between the 18th and 19th, so that there was no time between these to let the first flood out of the dam before the second was on top of it. On the 16th, the first flood had gone down greatly, and it is not unlikely that, seeing the weather cleared up, the keeper of the dam would have opened the sluices; but immediately he did so, the second flood was coming, and he would have to shut the sluices forthwith, for if he did not he would blend the two floods into one. In like manner, between the fourth and fifth floods of this series, there was hardly time to empty the dam of the fourth before the fifth was at hand, and the fourth was the highest of them all.

the fifth was at hand, and the fourth was the highest of them all.

Now, under these circumstances, this reservoir would not have served its purpose; neither would it on the more frequent occasions, when two floods follow each other at short intervals. In any case, seeing how uncertain is the arrival of floods, how uncertain what rainfall will produce one, how careful the man must be who handles such a vast body of water, and how entirely new and experimental is such a method of regulating floods, I think it would be more prudent to let some other country try the experiment first, and see how it works. One knows that this method of restraining great floods has been proposed in France and other countries, but I notice that they have never carried it out.

Mr. Walsh proposes to cut a channel at Duckenfield, through the ridge there, with the object of lowering the height of floods by this overflow.

The bottom of this channel is to be sloped from high-water mark at Duckenfield to high-water mark at Greenaway's Creek, where it joins the river again.

The effect of this would be, that the depth of water in the cutting at the entrance would be the height of flood above high-water mark. In 1893 the flood was 20 feet above high-water mark at Duckenfield, and 13 feet above high-water mark at Greenaway's Creek. The slope of surface of water in the cut would, therefore, be 1 in 3500.

As Mr. Walsh says that the discharging area would be 4800 square feet, the quantity this channel could discharge would be 30,000 cubic feet a second at the top of 1893 flood. The effect of withdrawing 30,000 cubic feet from the main river, calculated at the cross-section at Green Rocks just below, would be to lower its height about 1 foot 4 inches. But as the water in the main river was lowered, that in the overflow channel would be lowered also, and the discharge would be less than 30,000 cubic feet a second; therefore, the effective lowering of height would be less than 1 foot 4 inches, and it would not be worth while to spend £49,400 for such a trifling reduction in the height of floods.

The 1857 flood would be scarcely affected in height by this overflow channel, because it would flow through it only 12 feet deep, and discharge about 14,000 cubic feet a second.

I have no plans of Mr. Walsh's proposed flood overflow channel at Holwarra, by which to calculate what his proposal to take off 20,000 cubic feet a second from the top of a flood would lower its height.

Mr. Walsh says that when the river should rise to 33 feet on Belmore gauge, this proposed channel would be discharging 20,000 cubic feet a second.

The 1857 flood rose to 29 feet on the gauge; therefore the cutting would not draw anything like 20,000 cubic feet from that flood; but the 1870 flood rose to 34 feet, and it would therefore take more. In any case, judging from the above calculations of the effect at Duckenfield, the effective lowering of flood height would not be much—certainly not worth the estimated cost of £118,000—and it would be much more useful to remove the great obstruction to the flow of a high flood, which Mr. Walsh mentions as existing at Green Rocks.

I come now to my own proposals to mitigate the floods in the Lower Hunter; and I must first say that, although the floods may be lowered between Maitland and Morpeth, I do not think that they can be lowered between Morpeth and Hinton by

Maitland and Morpeth, I do not think that they can be lowered between Morpeth and Hexham by any works within a reasonable cost. By spreading over the land, the floods are now as low as they can be; but if they are prevented by levees or embankments from so spreading, their height will not be lowered. The section herewith shows that uniform gradients from Newcastle to Morpeth may be given to the bottom by dredging, and the narrow parts may be enlarged to give a uniform sectional waterway; but still the river channel will not hold a big flood within its natural banks; so that if the water is to be kept off the land, the flood must be shut in between embankments, and will be as high as ever.

I will therefore first consider the case between Maitland and Morpeth.

On the section herewith I show a diversion from Pitnacree to Morpeth, shortening the river from its former length of 14¼ miles, or its present length of 8¾, to 3½ miles; and I must observe that it is not now advisable to keep to Mr. Gordon's Diversion No. II., because the river is greatly altered since his report.

Mr. Moriarty, Mr. Gordon, and Mr. Price asserted that this should on no account be done unless the whole of the river to Hexham was previously improved, so as to take away the extra water that the cutting would bring down, and so raise the flood level at Morpeth and the lower river.

I wish to show that the diversion from Maitland to Morpeth may be cut, and that it will have no injurious effect on the river at Morpeth, nor anywhere down the river; and as it appears to me to be urgently necessary, for the safety of Maitland and adjacent land, that this diversion should be cut, but it is not urgently necessary to improve the river all the way to Hexham, I must try and make it clear on this point; because unless people are convinced that no injurious effects will follow the cutting of the diversion, it will never be done.

Mr. Moriarty has gauged the discharge of the river channel at various cross sections from Maitland to Morpeth, and has taken the fall by which the discharge at each section is calculated as the difference of height divided by the length measured round about the windings of the river, which method, as he shows, reduces the flood gradient from 1 in 3246 at Maitland to 1 in 9359 at and below Pitnacree, and from this he deduces the quantity received at Morpeth, while the flood was at its height at Maitland, as 37,730 cubic feet a second.

I cannot believe this statement, for as long as the flood is contained within the banks of the river Mr. Moriarty's calculations are correct; but as soon as the flood overflows the banks, the calculations cease to be true, and by the time the flood has filled the whole width of the valley, 2 miles wide, and to an average depth of 6¼ feet in 18[illegible], and 10¼ feet in 1893, the river channel has ceased to flow.

This shows that instead of Morpeth receiving, as Mr. Moriarty and Mr. Gordon call it, a "retarded flood," and therefore being protected from the great body of the flood which is raging at Maitland, it really receives the great body of the flood, just as much as Maitland is doing.

The fallacy of reckoning the discharge and deducing consequences from the flow of the crooked river channel may be seen by examining the facts of the case. The river, in a length of 14¼ miles, turns and twists in every direction, some of the reaches being across, and some against, the general turns and twists in every direction, [illegible] reaches being across, and some against, the general slope towards Morpeth. As soon as the flood, rising above the banks, begins to flow over the land down the general slope towards Morpeth, those reaches

of the river which lie against this slope have the surface level of the water highest at their lower level end of the reach, and lowest at their higher end; then the water in this reach not only ceases to flow, but flows the wrong way and spills over the banks. This phenomenon was confirmed by the evidence of a settler, who observed in the 1893 flood that the reach of the river between 8¼ and 9 miles above Pitnacree Bridge was flowing the wrong way—that is, from the bridge towards the 8¼ mile point, where there was a great overflow.

Those reaches, on the contrary, which lie in the same direction as the general slope, partake of the general velocity of the wide inundation, flowing over the land, which is swifter than the current in the river channel before it overflowed, as may be proved by calculating the velocity in the channel with its slope of 1 in 9,300, and that of the overflow over the land with its slope of 1 in 2,100.

This shows that the crooked channel from Maitland to Morpeth is not the vehicle of a high flood, and therefore calculations of the flood discharge made from the sections of the river channel are wrong. On the contrary, the entire width of the valley with its slope of 1 in 2,100 is then the waterway of the flood; and if, as Mr. Moriarty says, the discharge of the 1857 flood at Belmore Bridge was 132,000 cubic feet a second, then it seems to me that the flood stream everywhere between Maitland and Morpeth was discharging the same quantity.

The quantity of 37,700 cubic feet a second, which Mr. Moriarty asserts was all that flowed past Morpeth, while 132,000 cubic feet were flowing at Oakhampton, is quite out of the question. I have had a section taken right across the valley, from the high land at the Morpeth tram to the high land at Largs, and on it is drawn the level of the floods of 1893 and 1857. This shows a body of water 8,900 feet wide, with average depth for 1893 of 10½ feet, and for 1857 of 6¼ feet; the gradient of the surface in the latter was 1 in 1,600, the area of the waterway was 55,000 square feet, the calculated velocity is 5¼ feet a second. But, as this gives a quantity out of all reason, we must assume that there were obstructions, and that the velocity was less. If we take it at 2½ feet a second, this gives more than the 132,000 said to have been flowing at Maitland; and, as this section is only 50 chains from Morpeth, we cannot avoid the conviction that at the same moment this quantity was also passing Morpeth.

Mr. Moriarty calculated that if a straight channel were made from Maitland to Morpeth, the floods would be lowered at the former and raised at the latter place, because, as he asserts, the flood is delayed in coming down the crooked channel. He does not seem to have taken the water flowing all over the land as part of the flood to be reckoned with; but it is quite evident that in 1857 flood, four times as much water flowed over the valley as was possible to flow in the river channel, and in the 1893 flood seven times as much. As I understand the phenomenon, about the same quantity of water must flow past each place; from which I infer that if the excessively winding channel of the river were straightened, the flood would rise no higher at Morpeth than it does at present.

The Royal Commissioners evidently saw that straightening the river from Maitland to Morpeth would not have the effect of raising the flood at Morpeth, and that it would lower the flood height at Maitland. But it is not easy to follow their reasoning on what they call the local effect to be produced by the disgorging of the water at the outlet—that is, at the great bend at Morpeth. They return to Mr. Moriarty's views about the carrying capacity of the river channel at Morpeth, which, as they assert, is only capable of carrying 40,000 cubic feet. From this they draw the conclusion that the straightened channel must not be made capable of carrying within its banks more than 40,000 cubic feet, because if the capacity were made to carry, say, 60,000 cubic feet, while the channel at Morpeth can only carry 40,000, "20,000 cubic feet would be suddenly shot over the banks at the bend at Morpeth, producing, probably, the most disastrous results." This leads one to suppose they thought that the water would issue from the straight cut like a cataract. But nothing like that could occur; because, the flood coming down the cut, and the flood getting away below its mouth, would swell and rise equally together. This anticipation of theirs seems the more unintelligible, seeing that they acknowledge that at the top of the flood, the whole river is at its equilibrium of flow, or "in train," as it is called; so that as much as is brought down by the cut, precisely the same quantity would be flowing away in every part of the river. In this condition it is no longer a question of what quantity the channel at Morpeth is capable of carrying, for the whole country below Morpeth is overflowed—the river is "in train," and all that comes from one part is flowing away at the other.

I have said already that the height of the floods cannot be part is flowing away at the other.

I have said already that the height of the floods cannot be lowered in the river below Morpeth, but that is no reason why it should not be lowered where it is urgently necessary—that is, between Maitland and Morpeth. There the people, in a sort of heedless self-defence, have embanked the town and the land, and have shut the floods out of Wallis Creek., and as the case now stands, either the banks must break at every flood, or the river must be straightened to save them.

If the people below Morpeth should take a notion to embank their lands also, then the height of floods will rise, and either dredging improvements will have to be undertaken to keep it down, or the consequences must be put up with, until, in the course of years, the increased velocity of the confined floods will gradually scour out the channel to suit itself. In a great flood the quantity of water to be confined is so great that of course the banks will burst right and left, which infers that the embanking below Morpeth must be carried out very gradually, and the river improved at the same time, or else it must be left as it is.

I can understand a flood being delayed in time, but I do not agree that in a case like this it can be delayed in quantity; and as the settlers of Morpeth are greatly afraid that if improvements are made in the present winding channel it will "bring the flood down upon them," I will try by a simple example to explain that no change in the usual flood-level can take place.

The straight distance from Maitland to Morpeth is 3½ miles, and by the winding of the river 14½ miles, and the fall being the same for both, the crooked river has a far flatter gradient than a straight cut would have. The river winds about in a flat valley, 2 miles wide, which slopes at about the same rate of fall as the straight cut would have.

Now, take a tin trough, 3½ feet long, 6 inches wide, with sides 6 inches high; set it under the tap of a tank with a fall of ½ an inch, turn on the water at the rate of 1 cubic foot of water a second, and in about one second the trough will be discharging 1 cubic foot a second at its lower end, and will no overflow.

Take another similar trough 14½ feet long, but bent into twists and kinks, so that its two ends are 3½ feet apart; lay it on a flat table, 3½ feet long by 2 feet wide, scribe on the table the outline of the trough, and cut it out; then sink the trough in this groove so that its top sides are flush with the table. Then set the table with a fall of ½ an inch under the tap of the tank at its top end, and turn on the water at the rate of 1 cubic foot a second. The water will flow slowly round the bends and kinks, and, being thus delayed, will soon overflow its sides and inundate the flat table; but, the table being much steeper gradient than the trough, the water will rush down the slope, falling into the trough wherever it crosses its path; and the result will be that in about seven seconds the water will have reached the lower end, with 3½ cubic feet of water in the trough, and 3½ cubic feet overflowed on the table; and the water will continue to flow from the lower end at the rate of 1 cubic foot a second, just the same as the straight one is doing. This shows that the flood is delayed in time but not in quantity.

There is only one way by which the flow at the lower end can be made less than 1 cubic foot a second, which is by shutting off the tap before the water has reached the lower end.

The above is just like the case which occurs at Morpeth in a high flood; and the only way by which the flow at Morpeth can be less than it is at Maitland is that during the time the maximum flood is taking to pass from Maitland to Morpeth the supply at Maitland should suddenly fail. But if this is true at this place it is true everywhere down the river to the sea, provided that during the time the height of the flood is travelling to the sea the full supply is kept up at Maitland.

According to Mr. Moriarty, the 1857 flood kept at its maximum height at Singleton for seventeen hours, at Maitland for twenty-seven hours, and at Morpeth for twenty-four hours; so that if the flood-level had kept up at Singleton for any length of time, the flood at Morpeth would have risen no higher.

But according to the same authority the top of the flood took six hours to reach Morpeth from Maitland, so that by the time it reached Morpeth, and for twenty-one hours afterwards, the full supply was kept up at Maitland; therefore the crooked channel of the river did not keep back any of the flood, and the fears of settlers down the river that works to straighten the channel will be injurious to them are groundless, for they have experienced the full maximum flood already, and they can get no less from a crooked instead of a straight channel.

Another proof of this is given by calculation of the flood discharge at the section above Cummins' Dam, which gives for the 1893 flood about 250,000 cubic feet, while at Eales' Flat, making a deduction for the flow of the Paterson, the quantity is about 246,000 cubic feet a second. Both these sections contain the whole flow of the river; but the calculations must be taken as only approximate, as the gradient of the flood is uncertain at both sections.

As I do not wish this subject of "retarded floods" to be misunderstood, I will explain that under suitable conditions a flood may be retarded both in time and quantity, and in large rivers it usually is so.

Thus the 1857 flood took twelve hours to come from Singleton to Maitland, and Mr. Moriarty says that its maximum discharge was maintained at Singleton for seventeen hours; therefore the quantity discharging at Singleton was not abated at Maitland. But suppose the river were so long that the top of the flood took three days to come down, then the quantity that passed Maitland in a given time would have been less than at Singleton (assuming that no additional water came into the river between the two places), because the supply at Singleton, lasting only seventeen hours at its maximum, was abated before the flood, taking three days to reach Maitland; and the longer the river is the more will a great flood in its upper part be abated in its lower.

We may also try to show how the case of the 1893 flood is reduced in quantity by time. Mr. Price says in his report that 4 inches of rain fell in the Upper Hunter district, producing 48,680 millions of cubic feet, or at the rate of 562,511 cubic feet a second; and that the central district, with 9 inches of rain, produced 36,130 millions of cubic feet, or at the rate of 418,176 cubic feet a second, and suppose that the rain after the twenty-four hours fall above stated cleared off.

Mr. Price thinks that about 70 per cent. of the rainfall may have reached the rivers, the remainder following afterwards by draining through the rocks and soil. Then 70 per cent. of 562,511 cubic feet is 393,750 cubic feet a second, and to find approximately the rate at which this passed Maitland, we must assume the time it took to travel that distance. Say the rain took one day to fall, one day to reach the mouth of the Hunter and Goulburn, one day to reach Singleton, and half a day to reach Maitland—that is, the rain of one day must be distributed over 3½ days, which reduces the 393,750 cubic feet to 112,530 cubic feet a second.

Then the central district yielded 70 per cent. of 418,176 cubic feet, equal to 292 723 cubic feet a second, and say it took one day to fall, one day to reach Singleton, and half a day to reach Maitland, or two and a half days, which reduces the 292,723 cubic feet to 117,090 cubic feet a second. But as they came down together, by reason of the obstruction to the flow of the first flood waters between Maitland and Morpeth, as described by Mr. Moriarty (see page 27 of his Report), they passed Maitland at the rate of 229,620 cubic feet a second.

This is merely a guess at the actual facts; but it is singular that the above quantity of 230,000 cubic feet a second is not far off the quantity ascertained by calculation as passing the section above Cummins' Dam at the height of the 1893 flood.

In case it is thought that I have gone into this subject of "retarded floods" at a tedious length, I must remark that Mr. Moriarty (page 31), Mr. Gordon (page 6), and Mr. Price (page 2), all agree in asserting that no straightening of the river between Maitland and Morpeth can be done without raising the flood to a disastrous height at Morpeth, unless the river is improved at a great cost all the way down to Hexham; whereas I have shown quite clearly that straightening the river would have no effect on the height of the flood at Morpeth.

I attach hereto a plan, showing the embankments that have been raised on both banks of the river. These banks have been raised without regard to the effect that they may have on the height of floods, and, as a fact, they have caused the floods to rise higher than they did before; also the great reservoir, or back-water, of Wallis Creek, is now closed by gates to all but very high floods, and the flood overflow at Cummins' is closed by a a stop bank. All these banks are now up to the level of the 1893 flood, but the top of Wallis Creek floodgates is 7 feet below that level.

There can be no question now of undoing this work, and the thing to be done is to make the banks reasonably safe—especially the banks round the town of West Maitland should have particular care; but the banks are not such as the town should have for its own safety. All the land on which the banks stand should be public property. The banks should have a core of clay sunk down into the original ground; they should be at least 15 feet wide on top, and it would be safer if they were made a public roadway, so that their condition could always be seen. At present they are of various widths, from 6 to 9 feet, and, as they are fenced off where they pass through private property, they cannot be properly inspected. In places there are fences on top of them, with post-holes sunk deep along the top; in other places they are tramped down 2 or 3 feet low, where cattle pass over. Along the Oakhampton Road the banks are too light, and very unsafe. I think the road itself should be raised to serve as the bank.

The banks on the Bolwarra side are not made with the hope of keeping out very high floods, and, although they are up to 1893 flood level, they may be breached whenever they are topped by the rising water; and the same is the case with the West Maitland banks.

Nothing now can make these banks, and the town of West Maitland, reasonably safe unless a straighter course is made for the river as far as Morpeth. I have shown my reasons for believing that if the river were so straightened the height of floods would not be raised at Morpeth, or anywhere else down the river.

The embanking of Maitland and the Bolwarra lands having raised the height and increased the rush of floods over the land, has caused three of the loop-like bends of the river to break through, and before long two more will break through, and then the river will have a much shorter course to Morpeth.

Still this is not the best course, and would not be so effective as a straighter and shorter one; besides, the river at present flows on high ground. But if it were diverted through Howe's Lagoon it would be on ground over 10 feet lower, and it is always best to have the river on the lowest ground. The proposed diversion is shown on plan herewith; but when it comes to be undertaken it should be decided which course should be taken of two lines shown on plan, the lower of which would save the bridge at Pitnacree, but the upper would require a new bridge. Borings should be put down so as to get the required depth of cutting clear of the rock, which will be found some depth down, near Howe's Lagoon.

For this diversion I have taken the flood as discharging 150,000 cubic feet a second, which is about the quantity of the 1857 flood. The diversion being 400 feet wide at the bottom, and the flood 37 feet deep in it, with an inclination of 1 in 3,300, the effect would be that the flood would be lowered over 7 feet at Belmore Bridge below what it was in 1857, 5 feet opposite Horse-shoe Bend, 3 feet at Pitnacree Bridge, and remain the same height at Morpeth as it was in 1857.

The 1893 flood, discharging 260,000 cubic feet a second, would not fit this channel unless the banks were raised very high, so as to confine it within them; in which case such a flood as that of 1893 would be the same height as it was at Belmore Bridge, about 4 feet higher than it was at Pitnacree, and the same height as it was at Morpeth, always supposing nothing is done to the river below Morpeth; but the whole flood would be contained between the banks raised at each side from the excavations. Seeing that the channel will not reduce the height of the 1893 flood, I must explain that on the occasion of the flood in 1893 the stop bank at Cummins' carried away, letting a prodigious quantity of water flow down on the south side of Maitland; also, the Bolwarra and town banks burst, letting the water spread all over the country.

If none of these banks had given away, the height of the flood would have been over 6 feet higher than it was at Belmore Bridge, remaining as it was at Morpeth. The same may be said of the 1857 flood, which, if it came now, when all these banks are up and Wallis Creek closed, would rise many feet higher than it did when it flowed all over the country in 1857.

This diversion, therefore, will considerably lower a flood like that of 1857 in the neighbourhood of Maitland and Pitnacree, and contain it all between its banks. If the banks are raised to a considerable height it will also contain the 1893 flood; but it will not lower it at Belmore Bridge under what its level was on that occasion. It will raise its level at Pitnacree above what it was, and leave it as it was at Morpeth.

If, however, when this diversion is made, a flood like that of 1893 should occur, and the banks all burst, as they did then, the height of the flood would be some feet lower than it was in 1893.

The new channel could not be cut without making high and very wide banks on each side out of the excavations, and filling up all low places within reach of the dredge pumps.

This would confine a flood like that of 1857, except that the old river channel should be left open, so that it may silt up more quickly. Of course, the flood would get in by that opening and flood the old channel within a few feet as high as it did in 1857; but in a flood like that of 1893 the old channel would be flooded even higher than it was in 1893, supposing the banks did not break above the opening; and, in fact, if it is proposed to keep such a flood as that of 1893 within the banks, then all the banks now existing round about the windings of the old channel must be raised considerably in height.

The fact is, that such a flood as that of 1893 cannot be controlled; and if Maitland can be secured against it, it must be left to burst the banks and go all over the country, for if the diversion is cut it will not rise so high over the Bolwarra and Pitnacree districts as it did then.

If such a diversion as that mentioned above were made, one must expect to incur considerable expense in keeping the river in its new channel, for in the soft, silty soil it would immediately commence to deviate, and if left alone would in time develop as many twists and turns as it has now. This tendency must be stopped, as soon as the current begins to eat into either bank, by protecting with stone, of which there is abundance close at hand.

The diversion from Maitland to Morpeth will only benefit the Maitland, Bolwarra, and Pitnacree districts, and the question remains as to what should be done for the country between Morpeth and Hexham.

I have stated above the objections I find to Mr. Gordon's proposal to divert part of the river from Eales' Flat, through Miller's Forest, to Hexham; and I think there are equally strong objections against diverting the whole river through that part, such as the opposition of settlers and landowners in the Miller's Forest, the ruining of the navigable channel of the main river between Eales' Flat and Hexham, which, diverting the whole river through Miller's Forest, would cause it to silt up.

This would certainly give rise to claims for damage by the people of Raymond Terrace and holders of property along the river, who would be deprived of those advantages of navigation which they enjoy at present. As long as any contemplated works are kept to the existing river channel, whoever undertakes them will be within their rights: but whenever one leaves the main river, then one becomes liable for all the unforseen consequences, whatever they may be.

To divert the whole river through Miller's Forest is an immense work. To carry a flood of 175,000 cubic feet a second,

To divert the whole river through Miller's Forest is an immense work. To carry a flood of 175,000 cubic feet a second,
the cutting would require to be 500 feet wide at the bottom and 37 feet deep; the flood retained by the side banks would be 35 feet deep in the cutting. This would cost about £400,000, and make many years to finish. The outlay would be of no benefit until its completion, and, after completion, repairs and maintenance to keep the river from attacking its soft banks would require continual expenditure.

Rather than incur the great cost, as well as all the risks and liabilities of making such a diversion, I would prefer to keep to the main river, even if to deepen and widen it so as to reduce the flood level should cost more money than the diversion mentioned above. In other countries, in similar circumstances, the practice is to embank the flooded land, and improve the river by dredging. Glasgow used to be inundated in its lower parts by floods in the Clyde, but they have deepened and widened the river, and are no more troubled with floods; and, after careful consideration, I can see nothing better to be done in this case.

I think that the first step to take in order to improve the flood-carrying capacity of the river should be to straighten the two sharp bends, as shown on plan herewith, and next to enlarge and deepen the waterway at Green Rocks. At this place Mr. Walsh, C.E., of the Harbours and Rivers Department, observes that in the 1893 flood there was a fall in the surface of the water of 2 feet in about a mile, and the current was running at the speed of 11 miles an hour, or 16 feet a second. This plainly indicates a great obstruction, which should be removed, even if nothing else were to be done to the river. But the cause of this obstruction must be verified, for I observe that on the right bank embankments have been built close to the river; and as there is high ground opposite on the left bank, the flood is here gorged to a very narrow passage, which may be the cause of the extraordinary obstruction observed by Mr. Walsh during the 1893 flood. If this is found to be the cause, then these embankments must be removed; and they should not be erected at this place nearer the river than a quarter of a mile.

It, however, the serious obstruction observed at this place is caused by the rocks of Green Rocks, then the first thing to be done to assist in lowering the height of floods is to remove this bar of rocks to an ample width and depth, but chiefly depth, as shallow width is of no use.

Mr. Walsh in his report advocated enlarging the waterway, by cutting back the rock at low-water level; but, considering how very small is the effect of any enlargement which has only a shallow depth, I would recommend that the enlargement be cut down to the depth of the deepest part of the river at this place. There is no difficulty in doing this by rock-drills worked on a punt, the rock blasted by dynamite to be raised by dredging. In the Brisbane River a great reef of rocks was deepened to 26 feet in this way in a very short time.

I show on a section of the whole river herewith, and on the cross sections pertaining to it, how the channel might be enlarged and dredged to a uniform width and gradient which would contain within the embankment such a flood as that of 1857. This shows no reduction whatever in the height of such a flood, owing to the fact mentioned before, that the flood, when spread all over the land, is as low as it possibly can be.

It shows, however, that the flood-level can be kept down to the same height as is attained by Mr. Gordon's plan of diverting part of the river through Miller's Forest, which is seen by inspecting the figures indicating flood-heights on his section and on the one herewith.

This work, shown on the section and cross-sections, looks very well on paper, but the following considerations cannot be overlooked.

There are so many uncertainties attending the dredging of a river that no one can tell exactly what the result would be. Thus, if the channel were dredged and enlarged to accommodate a big flood it would be far too large for a small one, and the many small ones that intervene between each big one would silt up the enlarged channel to such an extent that when a big flood occurred it would fail to scour out all that had been deposited in the interval. This is what occurs in ill-designed sewers, and causes so much trouble. Of course, if the river channel could be dug out to such a shape that small floods would be accommodated equally with great ones, the channel would keep clear of deposit; but in an ordinary river this is impossible.

In enlarging a river artificially, in places where the river is curved, the now enlarged section will not suit the requirements of the current which, in such places, requires extra depth and not extra width; consequently, if extra width is given it will be silted up. At present the river is of unequal width, and where it is wide it is shallow, and where narrow, deep. An artificial channel of uniform width and depth can only keep so provided the channel is straight. If it is curved the river will soon make the curved places deep and narrow; and, as the river is not only frequently curved, but curved in reverse directions, it is obvious that if it is given a uniform width and depth it will not keep so for long. Any improvements, therefore, in the river channel are almost unmanageable unless the river is trained within stone training walls.

In the Mississippi, it is remarked that only such dredging as is done in the natural axis of the current is permanent, and if

In the Mississippi, it is remarked that only such dredging as is done in the natural axis of the current is permanent, and if this is not studied for every bend and reach the dredging will silt up again. In undertaking such work in this river, it would have to be carried out with much experienced observation, so as to choose the best position and direction in which to deepen or widen, because in a river without training walls, dredging, heedlessly done, will certainly be work thrown away. I have seen much money thrown away by not observing such indispensable precautions in dredging a river.

As is done in other countries, the land might be embanked and the river left alone. But in this case it is evident that at present the height of floods is as low as it can be, because they spread all over the land, and if the water is to be shut in between embankments the height of floods must be greater than it is now. From trials which I made on sections of the river as it now exists, with assumed flood gradients, the 1857 flood, for instance, would be raised 9 or 10 feet higher if shut in between embankments 400 feet away from the river bank at each side, and the 1893 flood far higher than it attained in 1893.

Such a raising of the flood height would affect the height of floods all up the river possible as far as Maitland. From this it would appear that embankments, without widening and deepening the river, would rid the lands of inundation, but would raise the flood level to a dangerous height, if it could be contained within the banks.

Nevertheless, there is no doubt that embanking the river, however low the embankments might be, would promote scour. By so much of the water not being allowed to spread over the land the height of floods would be raised. This would increase the velocity, which would increase the scour and so deepen the channel.

From the above considerations, I think the safest way to attain the object sought, of preventing floods from inundating the land without producing violent and unlooked-for changes, would be to gradually carry on the work of embanking and dredging together. First, beginning at the lower end to raise the banks, say 5ft. high, between Hexham and Morpeth, and to dredge and enlarge the channel so as to keep down the extra height of floods as much as possible; then, in succeeding years, to raise the banks a few feet more, dredging and enlarging the channel at the same time. In the end, the banks being raised as high as experience shows they require to be, and the river dredged and enlarged to correspond, there would be a fair chance of permanency in the work, the floods would be very little higher than they are now, and the land entirely protected from all but unusually high floods, which would breach the banks, and then they must be made up again. Great floods occur only at long intervals, and in every country where land is protected in this way they never pretend to expect complete immunity by accidents by unusually high floods.

Fortunately for this part of the Lower Hunter there is high ground all along the river at moderate distances from it, on both sides; so that there is no necessity for people to live within the limits of the flooded land, and those who cannot afford to live on the rising ground should leave the district for the sake of their own safety.

It would take many years to finish the work of gradually rising banks and dredging the river, the time depending on the number of dredges employed; but commencing from below and working up, the results would be useful from the commencement; and as the lower river, from Hexham downward, is not in such urgent need of protection from floods as the Maitland district, the people should be content during the time necessary for the completion of the work. Some countries have taken centuries to carry out works of this kind, and in the Mississippi they have been working at the levees and dredging the river for the last sixty years.

The Williams and Paterson have flats which it is equally important to protect from floods, and the work of making banks is required here also. But there is no necessity to dredge any part of the Williams, and at only two or three shoal places is it required on the Paterson. The banks for these two rivers could, therefore, be made from ditches in the usual way.

It is important that the embankments made from the dredgings be set back from the river banks as far as possible, so as to give the floods more room, and prevent the embankments being undermined by changes in the river. There is no waste of land by doing this, as the land outside is even better pasture than the land enclosed.

The modern high-power suction dredges can do this work, and only such should be used; two dredges, each capable of discharging 1,500 tons an hour, and depositing at a distance of 1,000 feet, and eighteen feet above water level, should be employed. In America, suction dredges are used to make levees, and they are said to do the work at a cost of 3d per cubic yard.

The stuff dredged to improve the river channel must be placed on either side to form embankments, and in most places this material would be greatly in excess of what is required to form the embankments; consequently, the dredgings would form great mounds on either side of the river. The width of these mounds, depending on the amount of dredging at any particular place, might be over 300 feet; but as the material would most likely be a muddy sand, the mounds themselves would be good

place, might be over 300 feet; but as the material would most likely be a muddy sand, the mounds themselves would be good land, growing abundant grass; and even where the dredgings were pure sand, there would be no difficulty for the dredge to pump over the mounds a thick covering of silt and earth, procured from the adjoining banks of the river. Such mounds should be immediately sown with grass, to protect the slopes from waves from high winds when the river was in flood.

I cannot tell whether the land occupied by the dredgings to form these banks would have to be purchased. One would naturally infer that landowners would not charge for the land, which would not be lost to them; and they would have the further benefit, that all low, swampy places within range of the pumps could be filled up with the dredgings, and made high and dry.

The work contemplated above is to improve and embank the river from Hexham upward to Morpeth, it being assumed that the river, as it is below Hexham, will carry off the flood water, without much change of height, to Newcastle and the sea.

But if the longitudinal section of the river herewith is examined, it is seen that the existing river channel from Morpeth to Hexham has a good depth, and somewhat uniform inclination, till it reaches Hexham. At this place the river separates into the north and south channels, which, after a course of some miles, unite again in the harbour of Newcastle.

Immediately below the point of separation, the north channel becomes very shallow, and encumbered with sand-banks; but when they meet again there is a depth of over 36 feet below low-water.

This is probably the place where the tide is throttled, as mentioned above, and if a wide cut were dredged through the shallow part of the north channel, the tide would flow more freely up the river as far as Morpeth. The result of this would be increase of scour in the whole river, resulting in giving a more uniform depth and increased get-away for floods.

It would cost much money to dredge through these shoals a cut, say, 500 feet wide to a depth of 20 feet at low water; but such a cut, if properly located to fit the curves of the river, would be permanent, and would greatly benefit the river above it, both as regards tidal flow and flood discharge. I believe that the final result would be that the south channel would silt up, the dredged cut through the shoals of the north channel would correspondingly enlarge and deepen, and after a few years the whole river would flow through the north channel with a permanent depth of over 20 feet where now the greatest depth is 8 or 9 feet.

There is no possible advantage in having two channels, the north and south, to let either the floods out or the tide in, as one channel with ample depth is far more effective than two shallow ones, for both these purposes.

The above projects to deepen and embank the river between Morpeth and Hexham would cost large sums of money, and many years of time. It is very improbable that owners of land along the river could bear any but a small part of the cost, and consequently, unless there was a very urgent need of the improvements which the work contemplates, it is not likely to be done.

It does not seem to me that, between Morpeth and Hexham, there is any urgent need to improve matters as they now are; and if settlers and owners protest that there is, it is not unlikely that their views on the subject would be modified, if they were asked to contribute towards the cost of remedying the present state of things. No one can deny that they suffer heavy losses and damages when great floods occur, but between times they reap very profitable crops, and the floods are acknowledged to leave behind them some benefits in the way of renewed fertility of the land.

Taking these different views of the case into consideration, my advice would be to straighten the river between West Maitland and Morpeth, cut through the two sharp bends above the Williams, remove the obstructions at Green Rocks, and make a cut 500 feet wide through the shoals of the North Channel. This would greatly relieve the floods, and might be all that is required for many years to come.

Since 1869, when Mr. Moriarty wrote about the want of a system of proper drainage for the cultivated land, this has been much improved. Still there are many places in want of good drainage, which, in some cases, is prevented by not having authority to drain through other peoples land. This could be put right if there was a Drainage Board, or Board of River Conservators, under the authority of which all requirements, such as drainage, the positions of embankments, the protection of the banks with stone, the checking of encroachments of the river, regulations of the planting of willows along the banks, prohibition of throwing trees into the river, and generally, all matters connected with the river and the district would be controlled.

At present they are lining the left bank of the river with stone below Maitland to prevent the bank wearing away; but the bank is wearing away, because the river is now so shut in with embankments; and if the enlarging of the river-bed, shown on my cross-sections, should be carried out, all this stone would have to be removed.

A Board of River Conservators would see that no work was done on the river or its banks unless in accordance with a well-considered plan.

done on the river or its banks unless in accordance with a well-considered plan.

The estimates given below show the immense total of 59,000,000 of cubic yards to be dredged to make the river capable of carrying a high flood within embankments; the flood quantities being 150,000 cubic feet a second above the Paterson, 171,000 cubic feet above the Williams, and 193,000 cubic feet below the Williams. The estimate is divided into—1st, from Maitland to the mouth of the Paterson; 2nd, from the Paterson to the Williams, including two cuttings to straighten bends; 3rd from the Williams to Ash Island; and 4th, making a cut 500 feet wide through the shallows of the North Channel, which I believe would have a most beneficial result in lowering the floods of the river, as well as enabling the increased flow of the tides to keep the whole river channel in a better condition than it is now. This cut, also, by doing away with the throttling of the tides, which I assume to be caused by this shoal, would have a beneficial effect on the bar at Newcastle.

To straighten the river between Maitland and Morpeth, and enlarge the river bed up to Belmore Bridge, would, by this estimate, cost about £200,000, which is a very large sum, but it would relieve Maitland and the Bolwarra districts of all anxiety from floods.

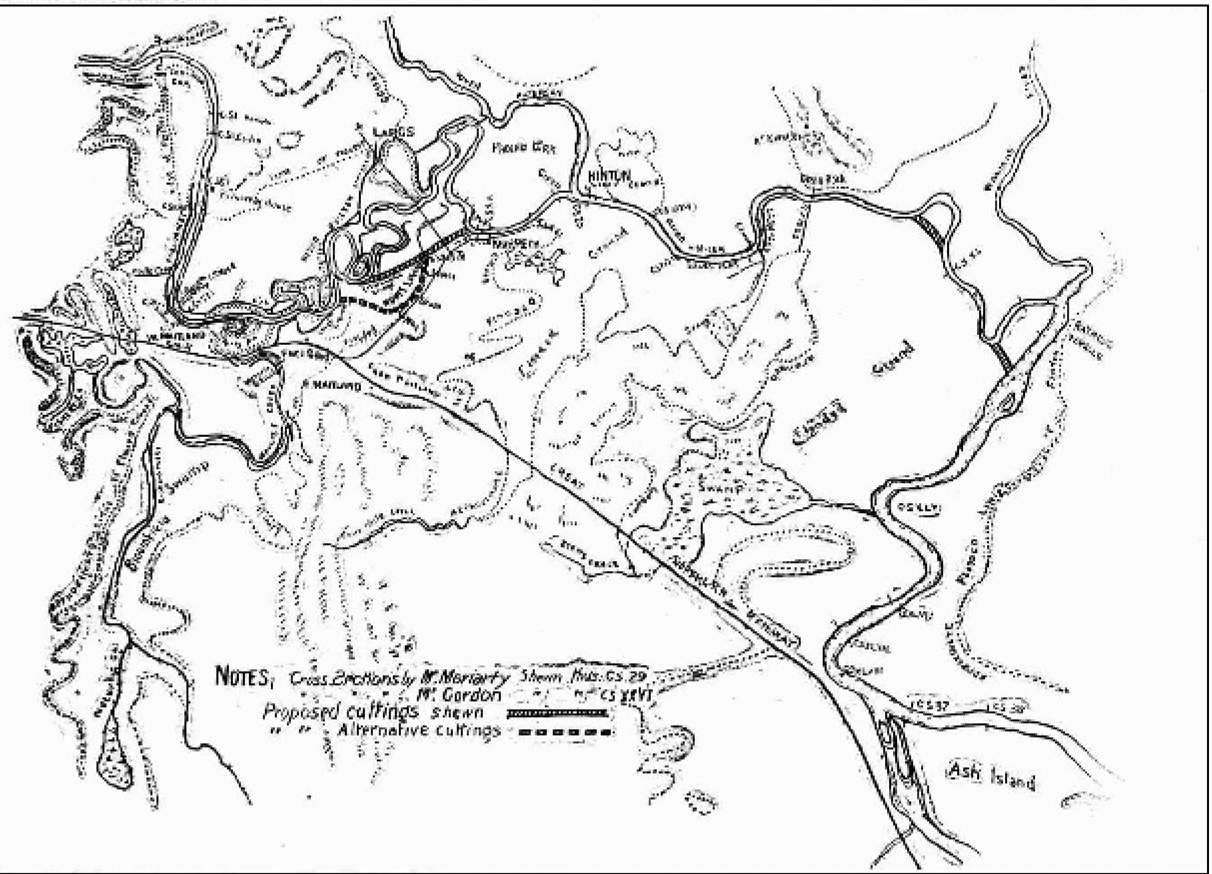
Besides this, I recommend that two bends above the Williams be cut through, the obstructions at Green Rocks removed, and a deep cut be made through the shoals of the North Channel. These would cost £253,065.

The total estimate for improving and embanking the whole river is £1,076,600, which is about £130,000 more than I estimate that Mr. Price's proposed dam would cost, and it is a much safer and more trustworthy way of alleviating the floods of the Hunter.

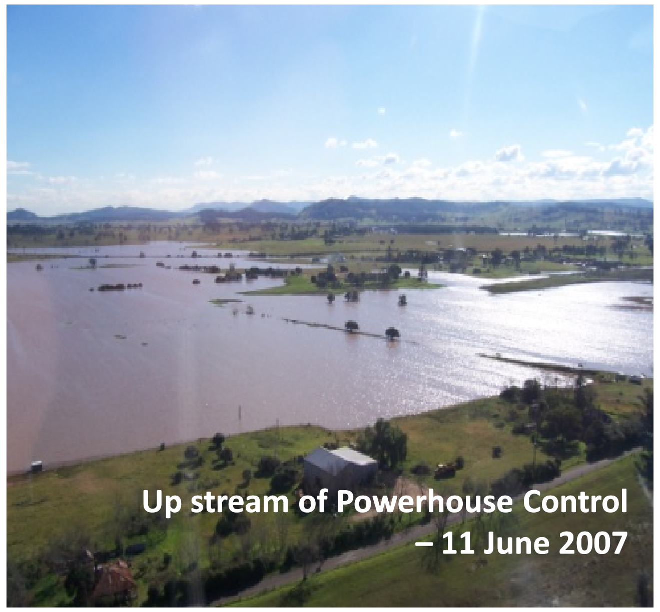
I have the honour to be, Sir, your obedient servant,

C. NAPIER BELL,
M. Inst. C.E.

East Maitland, 20th June, 1899.



The above map shows Mr. Bell's proposed means of mitigating floods. They include embankments on each side of the river from Hexham up to Bolwarra House, a system of regular and unceasing dredging, to keep the channel clear, and diversion of the course of the river at four places. Two cuts at the lower part of the channel will carry floodwater into the main river below Raymond Terrace. Between Maitland and Morpeth alternative cuts are proposed. One will take the current direct through a short neck of land and under Pitnacree Bridge; and, utilising the river channel for a short distance, will continue in an almost straight line to Morpeth. The alternative cut would avoid Pitnacree Bridge altogether and utilise Howe's Lagoon.



Up stream of Powerhouse Control – 11 June 2007

Oakhampton Railway and No 1 Spillway – 11 June 2007

Oakhampton Road Control – 11 June 2007

Powerhouse Control – 11 June 2007

Mt Pleasant Street Control – 11 June 2007

New England Highway - 11 June 2007

View to Fishery Creek – 11 June 2007

East Maitland – 11 June 2007

Melbourne Street, East Maitland – 11 June 2007

Down stream of East Maitland Railway Line – 11 June 2007

No Overtopping of the Bolwarra Spillway – 10 June 2007

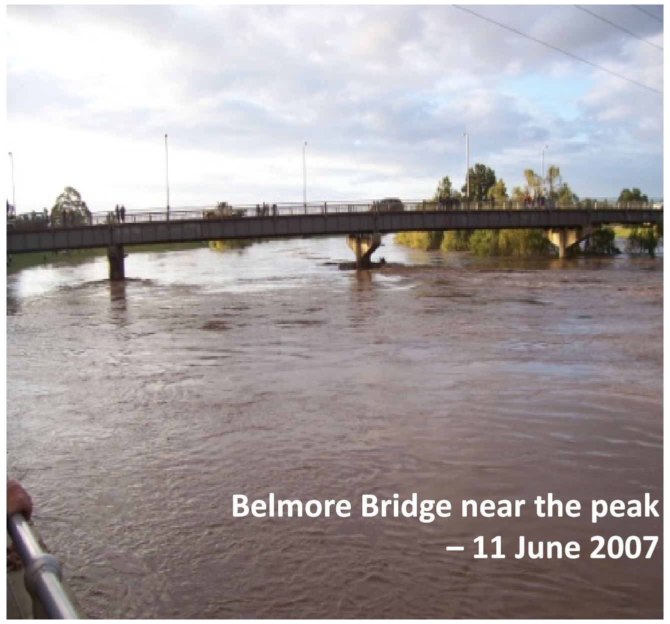
Overtopping of the Oakhampton Spillway No.1 – 10 June 2007

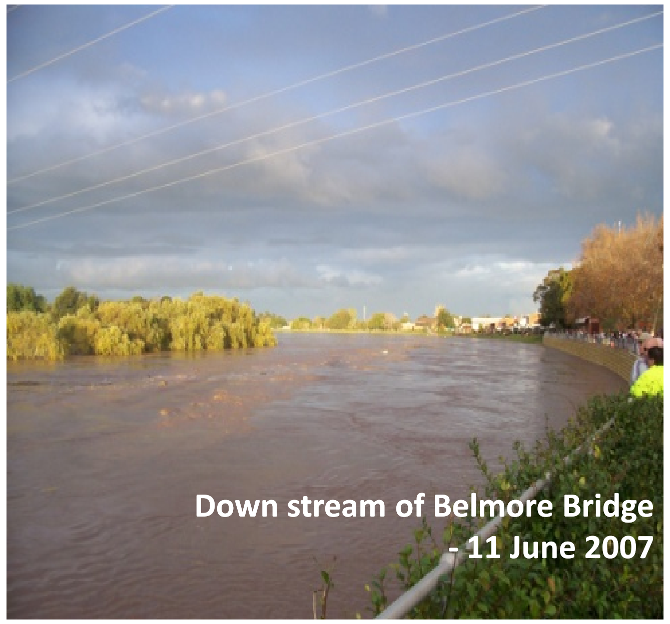

Oakhampton Road Failure – 13 June 2007


Erosion down stream of Belmore Bridge – 11 June 2007


Long Bridge – 11 June 2007


Long Bridge – 11 June 2007


Belmore Bridge near the peak – 11 June 2007


Down stream of Belmore Bridge – 11 June 2007


View to East Maitland – 11 June 2007


Wallis Creek – 11 June 2007


Maitland Railway Station – 11 June 2007


New England Highway – 11 June 2007


Mt Pleasant Street Control – 11 June 2007

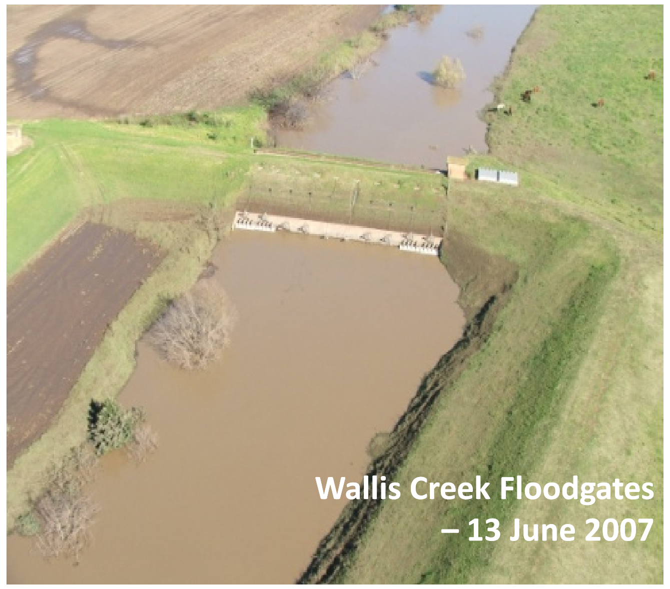

Powerhouse Control – 11 June 2007

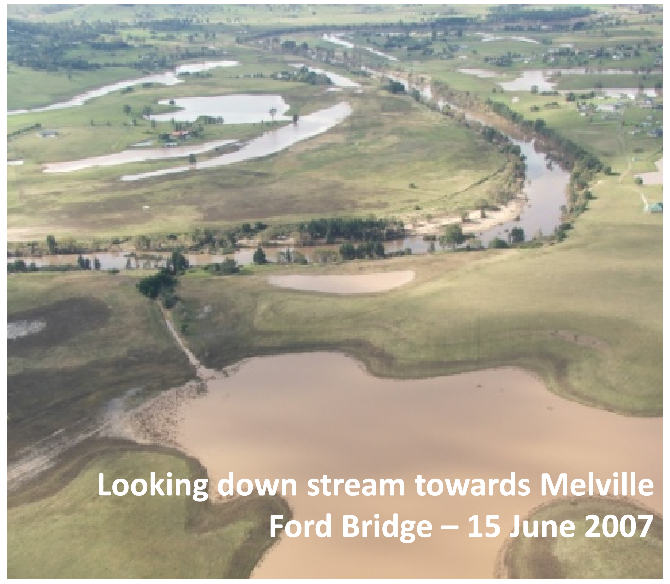
JUNE 2007 FLOOD PHOTOGRAPHS
SET C


Hunter River at Melville Ford Bridge – 13 June 2007


Oakhampton Road – 13 June 2007


Maitland Railway Station – 13 June 2007

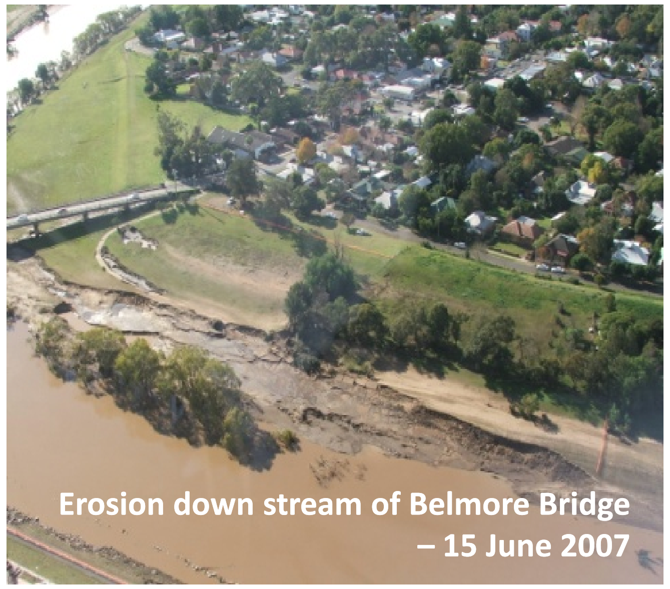

Wallis Creek Floodgates – 13 June 2007


Looking down stream towards Melville Ford Bridge – 15 June 2007


Oakhampton Floodway – 15 June 2007


Oakhampton Floodway – 15 June 2007


Long Bridge – 15 June 2007


Erosion down stream of Belmore Bridge – 15 June 2007


Hunter River & Oakhampton Floodway in background – 15 June 2007


Oakhampton Floodway – 15 June 2007


Wallis Creek Floodgates – 15 June 2007

Hunter River at Luskintyre Bridge
– 13 June 2007

Branxton
– 13 June 2007

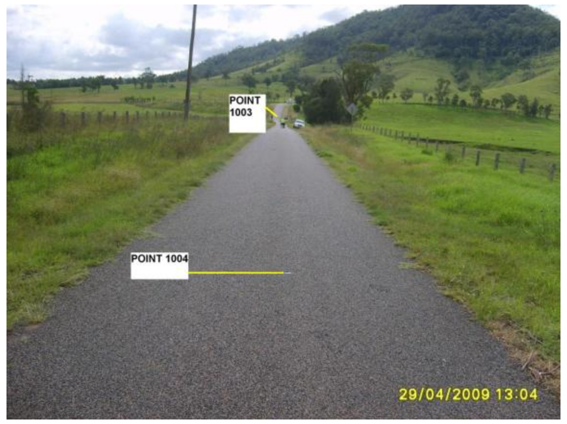
Singleton
– 12 June 2007

1.90 Hillsborough Rd

1.90 Hillsborough Rd 2

26 Daniel Av

29 Blue Gum Dr Aberglasslyn



66 Hillsborough Rd, White spray painted dot location of peak flood level

66 Hillsborough Rd

96 Melville Ford Rd, Peak flood level located at 'notch' half way between gate and post


236 Melville Ford Rd, Black texta mark on shed door location of peak level, roughly peaked midnight 10.11-06-07

122 Stanhope Rd

674 Stanhope Rd

255 Pywells Rd

723 Anambah Rd

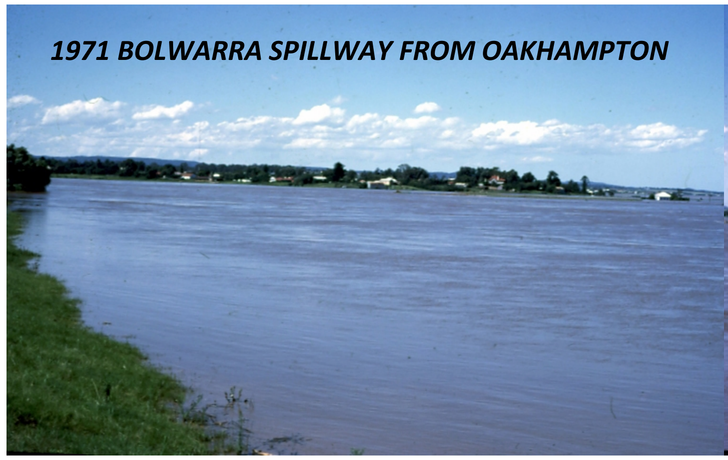
993 Luskintyre Rd, 'teepee' shaped stakes location of peak flood level

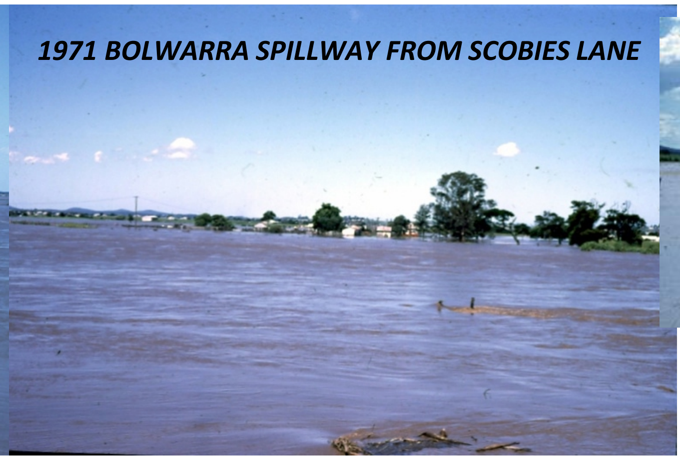
Elderslie Bridge

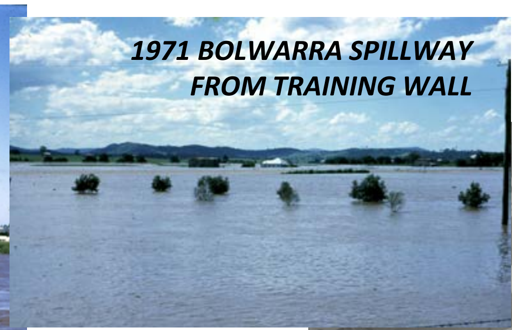
Intersection Maitvale Luskintyre

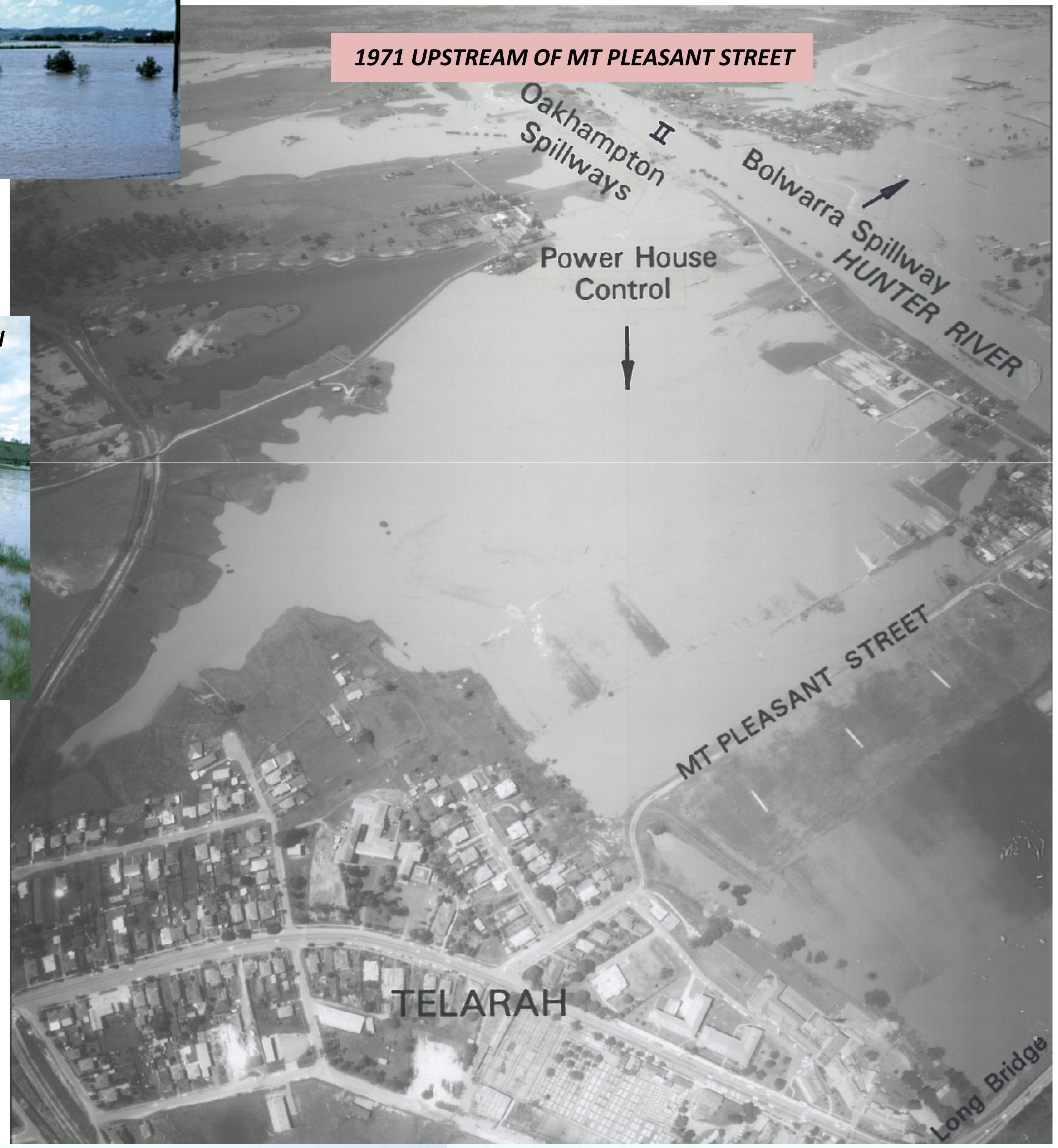
St Joseph Lochinvar

AERIAL PHOTOGRAPHS
JAN/FEB 1971 & MARCH 1977 FLOODS


1971 BOLWARRA SPILLWAY FROM OAKHAMPTON

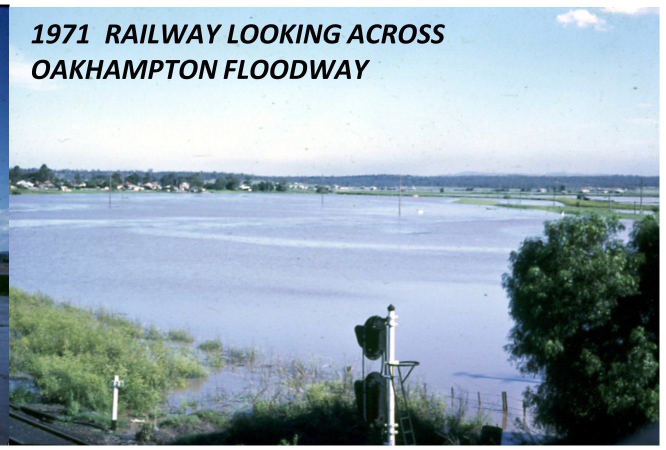

1971 BOLWARRA SPILLWAY FROM SCOBIES LANE


1971 BOLWARRA SPILLWAY FROM TRAINING WALL

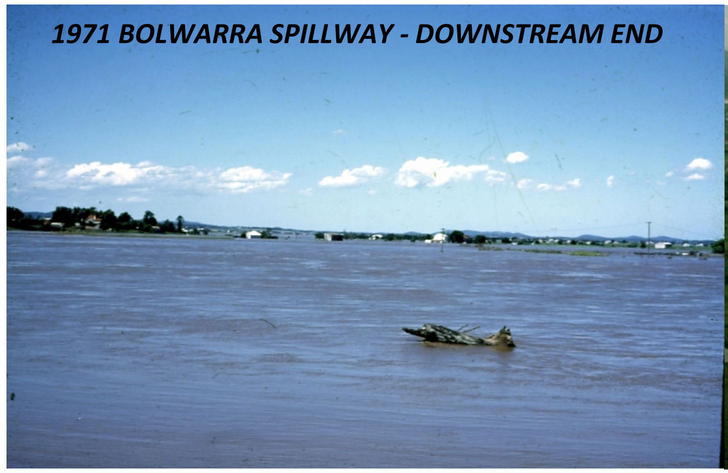


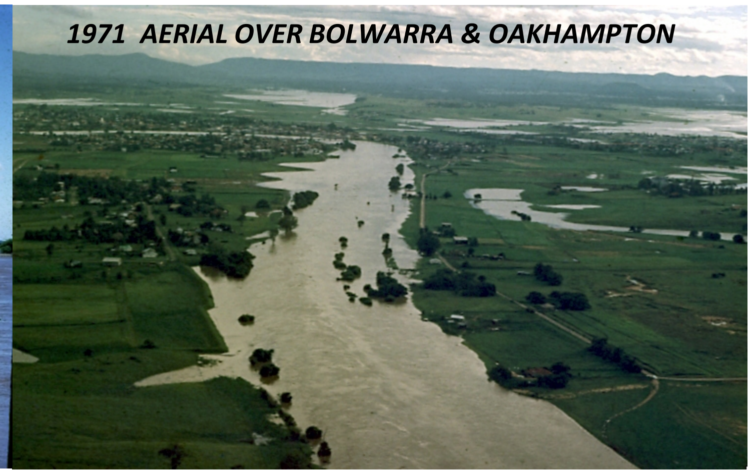
1971 UPSTREAM OF MT PLEASANT STREET


1971 POWERHOUSE CONTROL OVERTOPPING

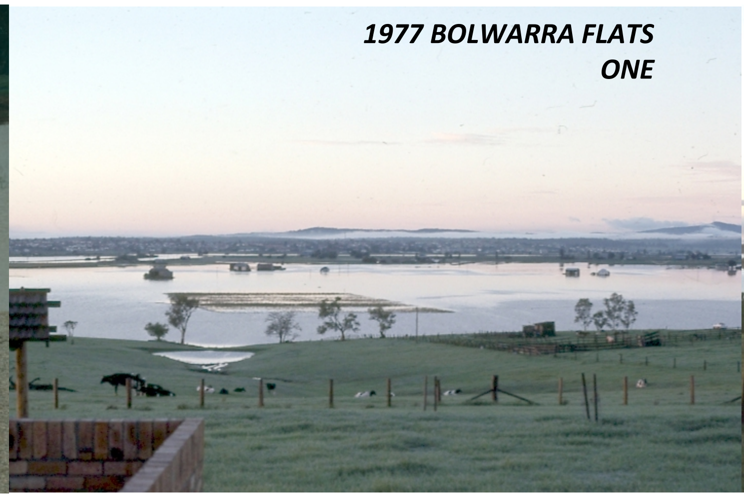

1971 RAILWAY LOOKING ACROSS OAKHAMPTON FLOODWAY


1971 OAKHAMPTON SPILLWAY NO. 1


1971 BOLWARRA SPILLWAY - DOWNSTREAM END


1971 AERIAL OVER BOLWARRA & OAKHAMPTON

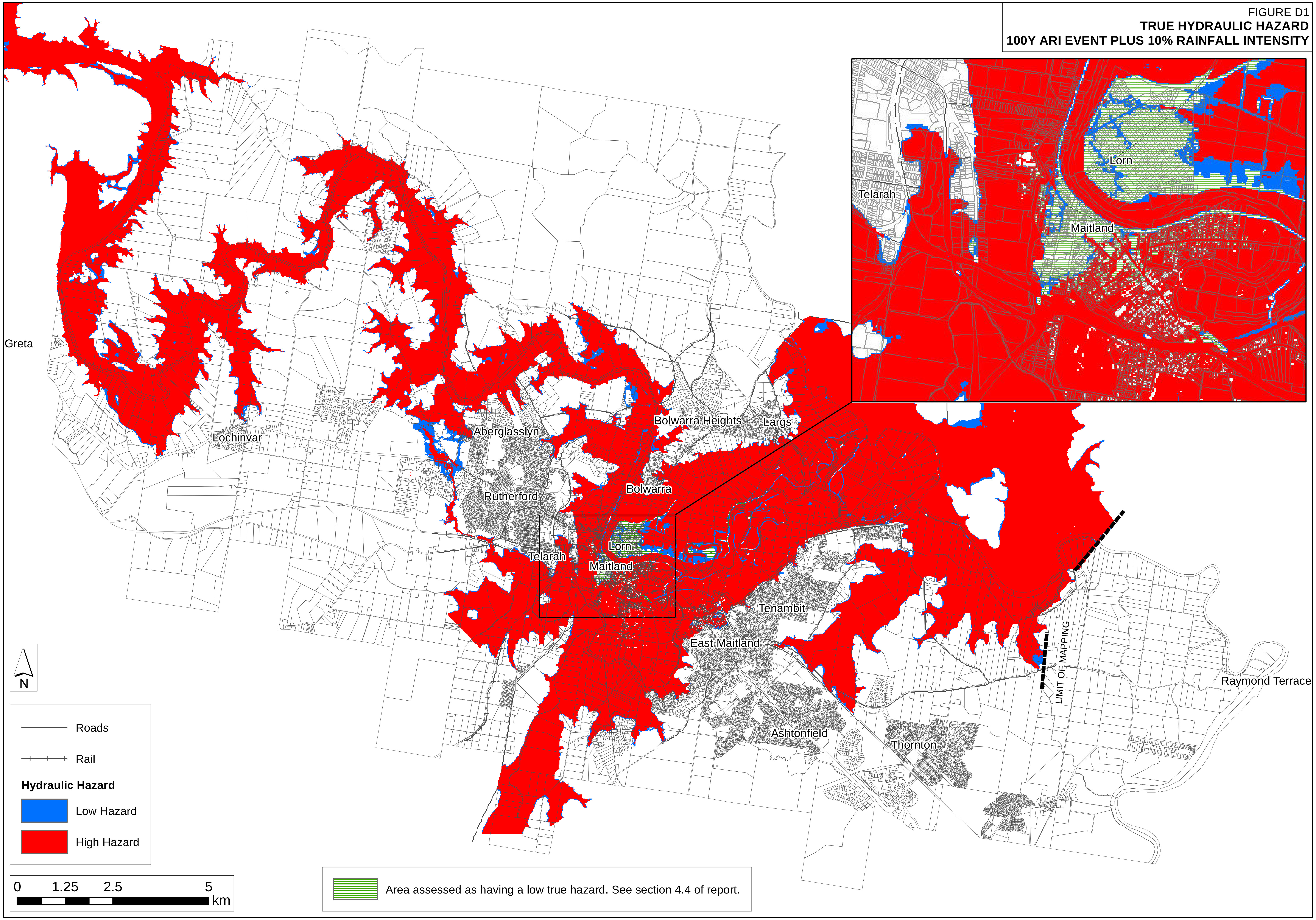

OAKHAMPTON ROAD 1977 FLOOD


1977 BOLWARRA FLATS ONE


1977 BOLWARRA FLATS TWO

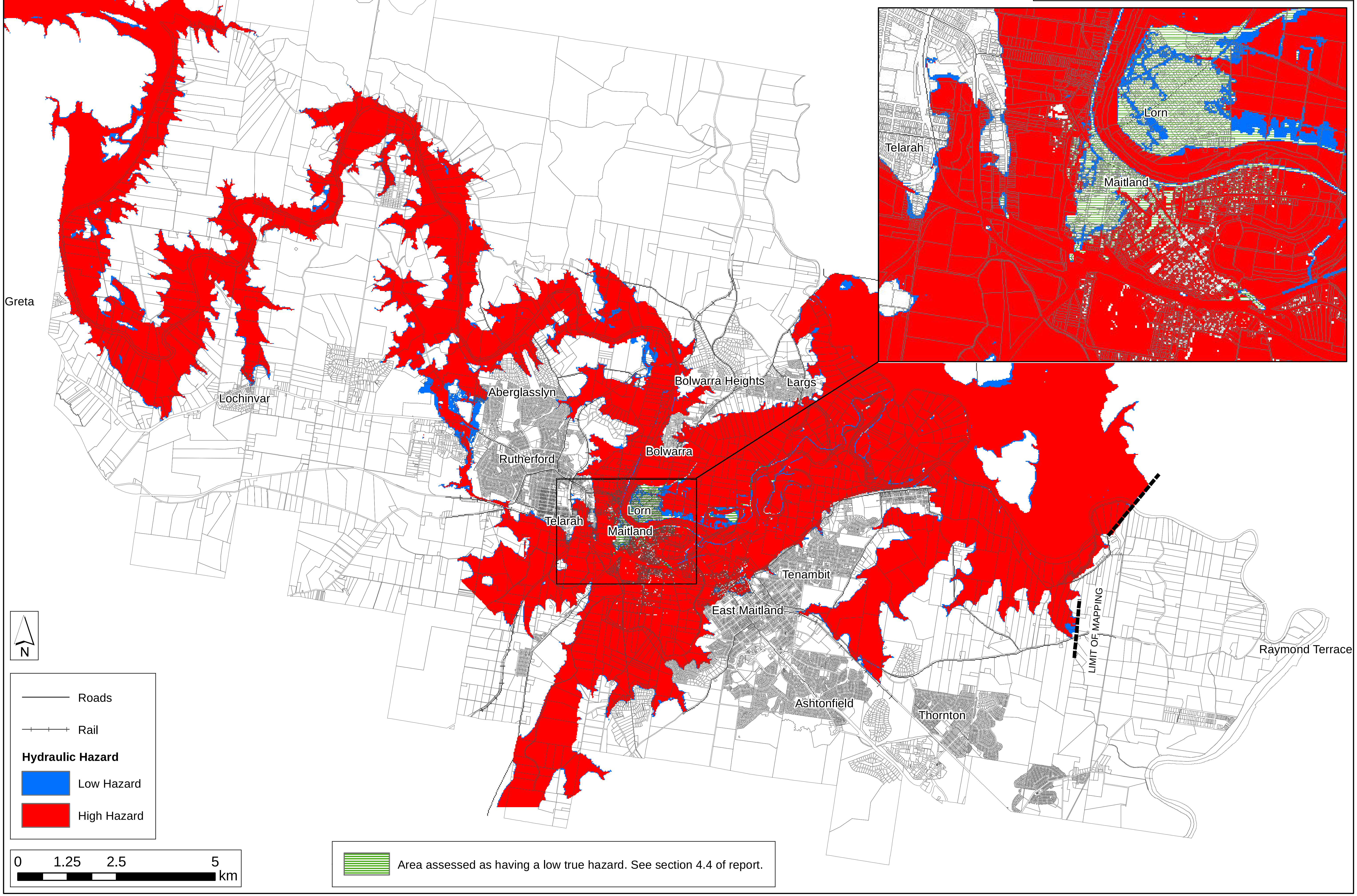

1977 BOLWARRA FLATS THREE

FIGURE D1
TRUE HYDRAULIC HAZARD
100Y ARI EVENT PLUS 10% RAINFALL INTENSITY



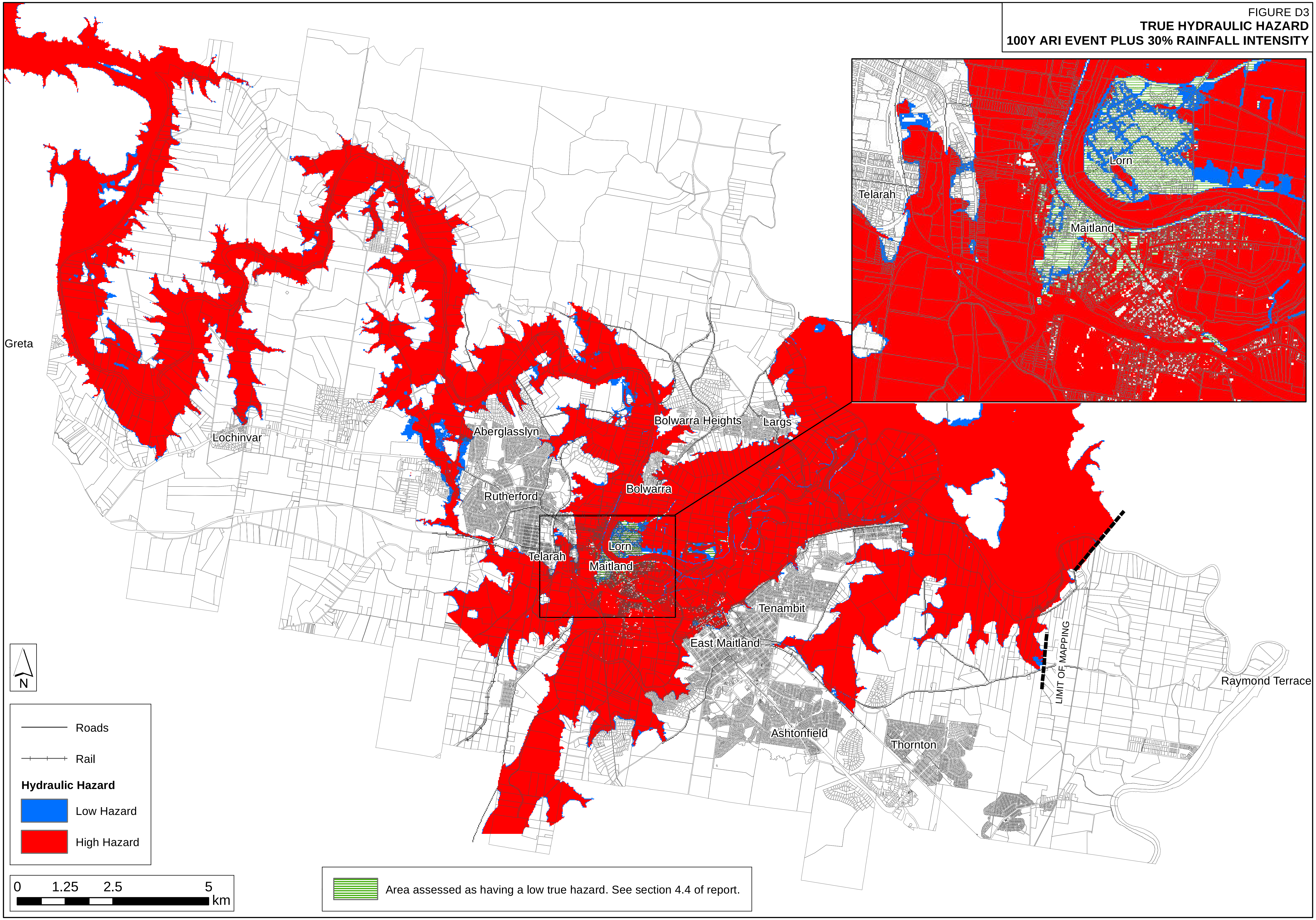
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureD1_Hazard_100y_ARI_plus10pc.mxd

FIGURE D2
TRUE HYDRAULIC HAZARD
100Y ARI EVENT PLUS 20% RAINFALL INTENSITY



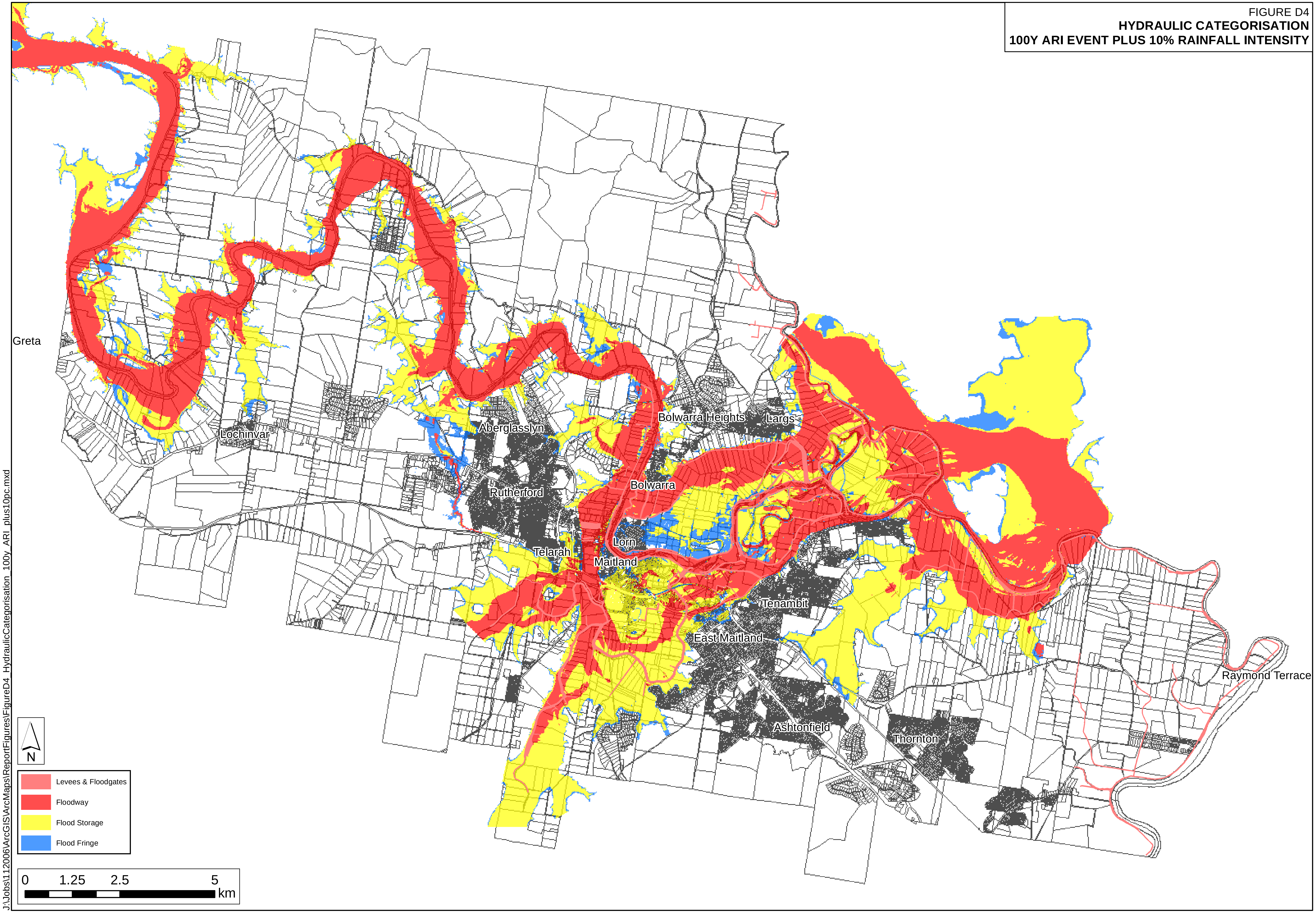
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureD2_Hazard_100y_ARI_plus20pc.mxd

FIGURE D3
TRUE HYDRAULIC HAZARD
100Y ARI EVENT PLUS 30% RAINFALL INTENSITY



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureD3_Hazard_100y_ARI_plus30pc.mxd

FIGURE D4
HYDRAULIC CATEGORISATION
100Y ARI EVENT PLUS 10% RAINFALL INTENSITY

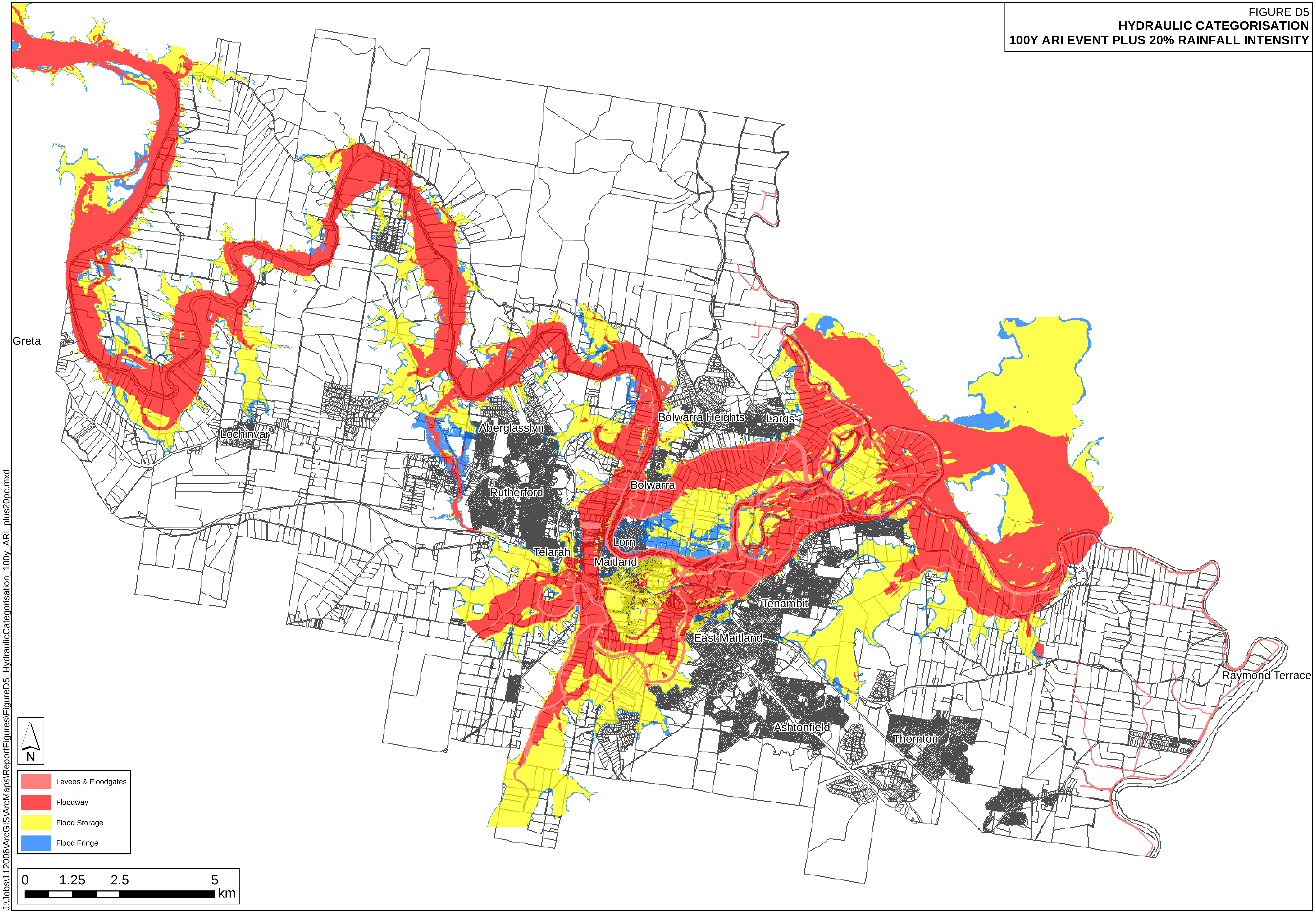


J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureD4_HydraulicCategorisation_100y_ARI_plus10pc.mxd

FIGURE D5

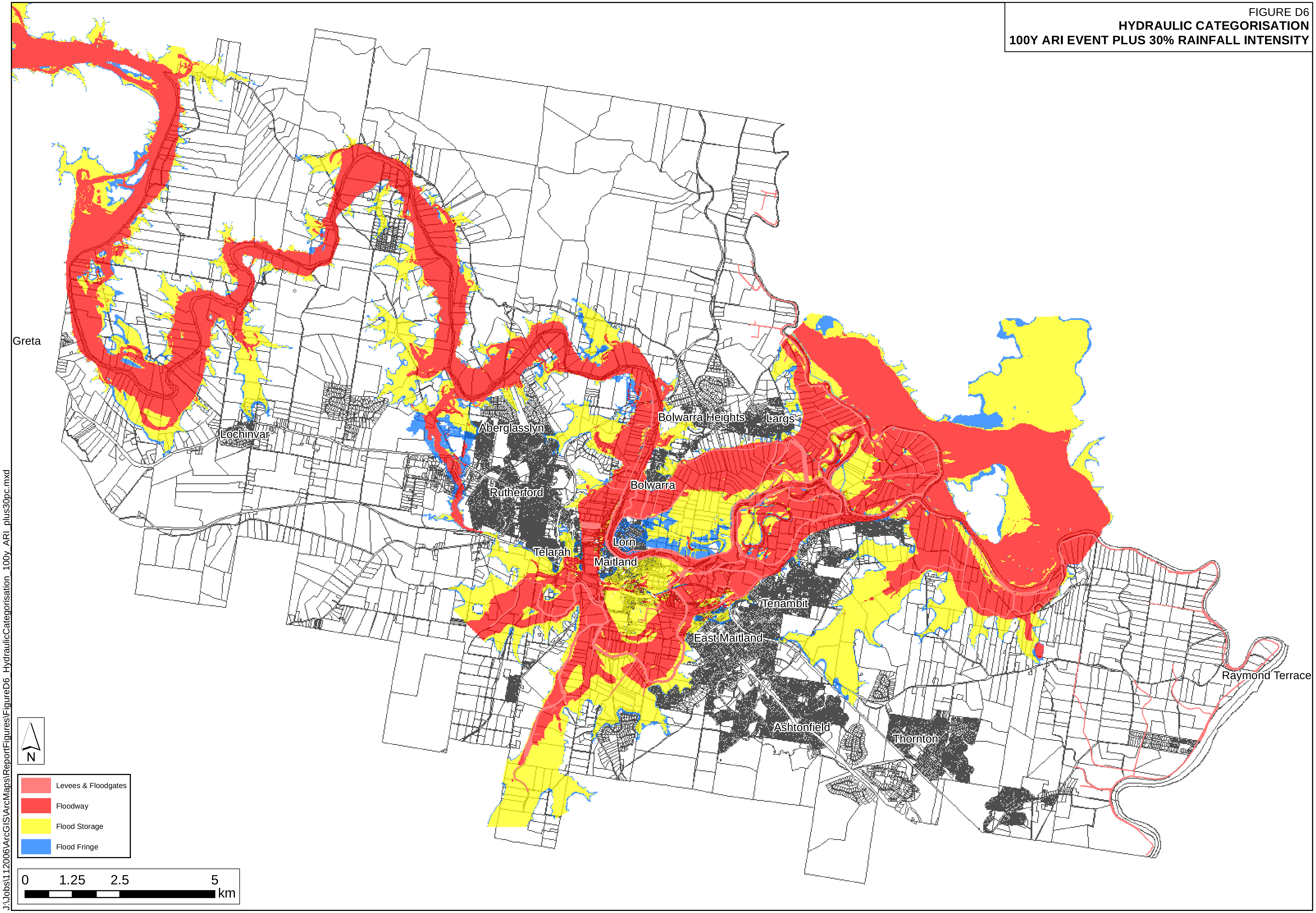
HYDRAULIC CATEGORISATION

100Y ARI EVENT PLUS 20% RAINFALL INTENSITY

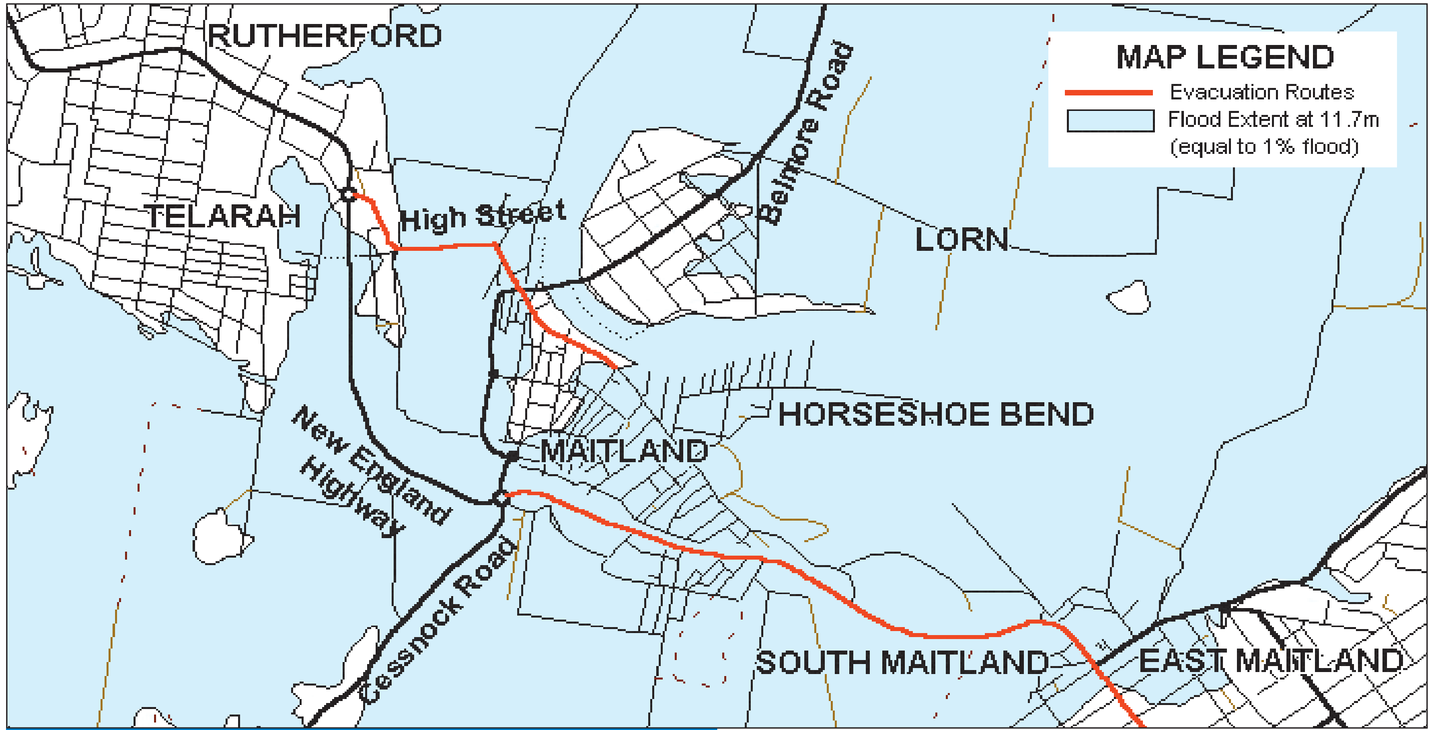


J:\Jobs\112006\ArcGIS\ArcMaps\Report\Figures\FigureD5_HydraulicCategorisation_100y_ARI_plus20pc.mxd

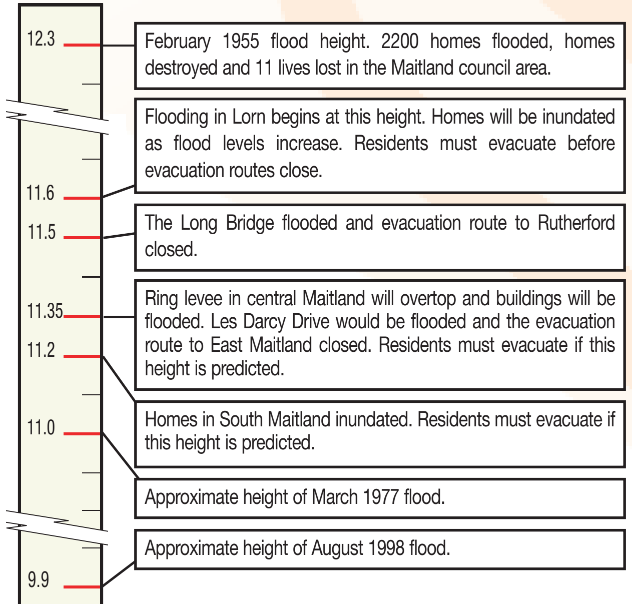
FIGURE D6
HYDRAULIC CATEGORISATION
100Y ARI EVENT PLUS 30% RAINFALL INTENSITY



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureD6_HydraulicCategorisation_100y_ARI_plus30pc.mxd



Flood extent in a 1% flood and evacuation routes



NOTE: Gauge diagram is not to scale

Key heights (in metres) at the Belmore Bridge gauge and their consequences.

Prepare yourself

Some basic measures you can take right now include keeping a list of emergency numbers near the telephone and assembling an emergency kit.

Your emergency kit should contain at all times:

- A portable radio with spare batteries
- A torch with spare batteries
- A first aid kit
- Rubber gloves
- Candles and waterproof matches
- Copies of important papers including emergency contact numbers
- A copy of your emergency plan
- A waterproof bag for valuables

When flooding is likely, place in your emergency kit:

- A good supply of required medications
- Any special requirements for babies and the disabled, infirm or elderly
- Strong shoes
- Fresh food and drinks

How the SES can help you

The State Emergency Service is responsible for dealing with floods in NSW. This includes planning for floods and educating people about how to protect themselves and their property.

During floods, the SES is responsible for flood information, safety advice, evacuation, rescue and providing essentials to people cut off by flood waters.

FOR EMERGENCY HELP IN FLOODS AND STORMS CALL THE SES ON

132 500

Maitland City SES	02 4932 7444
SES website	www.ses.nsw.gov.au
Maitland City Council (business hours)	02 4934 9700
Bureau of Meteorology website	www.bom.gov.au

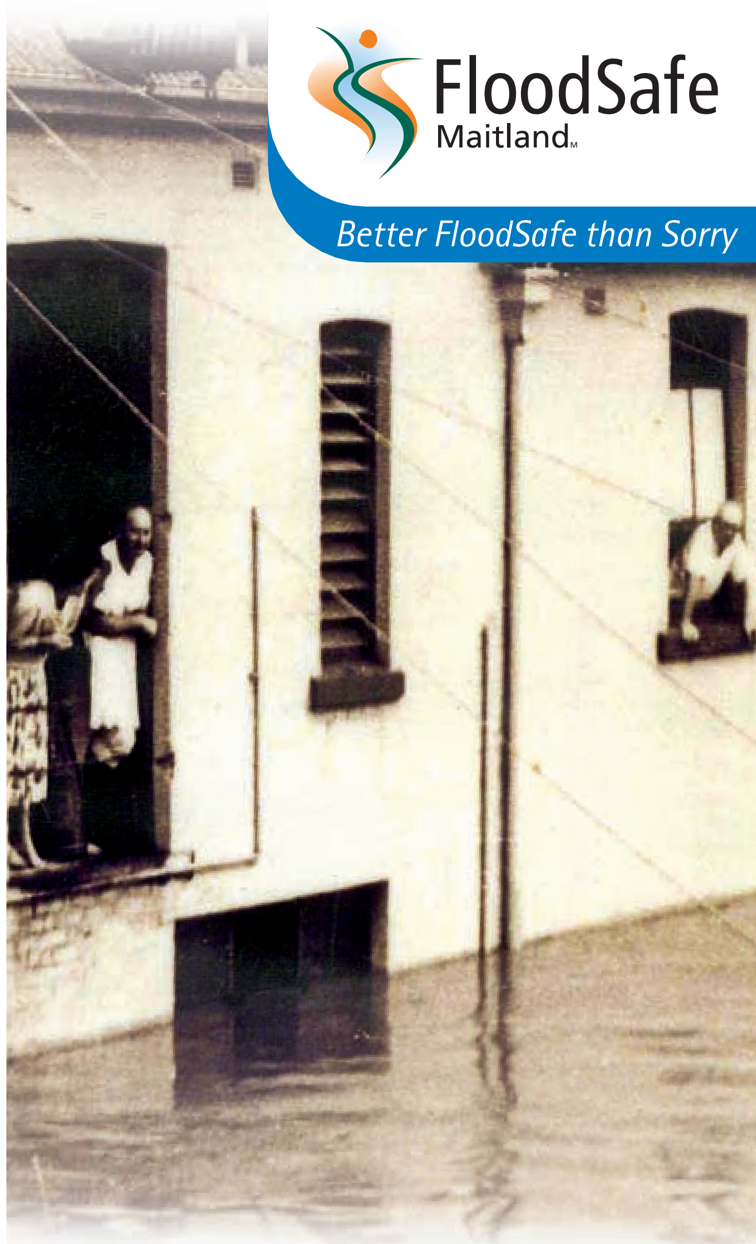
MAITLAND CITY COUNCIL

DoCS

SES STATE EMERGENCY SERVICE

FloodSafe Maitland

Better FloodSafe than Sorry



Protecting yourself from a flood

Victoria St. Maitland in the 1955 flood

SES STATE EMERGENCY SERVICE

FloodSafe for Residences in Central Maitland – Lorn – Horseshoe Bend - South Maitland

Are you at risk from floods?

More than 200 floods have been recorded on the Hunter River since European settlement. Thirteen have peaked at levels above the major flood level of 10.7 metres at the Belmore Bridge gauge. The most severe flood in Maitland was in 1955 when 11 people lost their lives, 2200 homes were flooded (of which some were destroyed) and serious damage was done to infrastructure. In today's terms, the total damage bill for the Hunter Valley from the 1955 flood would be over $2 billion. Few large floods have occurred since, but severe floods, some larger than that of 1955, can and will occur.

Extensive flood mitigation measures including levees, spillways and control banks have been established in Maitland. These measures give protection from smaller floods but cannot protect homes from severe flooding. Outside the levee system numerous roads will be closed by flood water and low-lying land will be flooded.

When a height of approximately 11.2 metres is predicted at the Belmore Bridge gauge, some homes in South Maitland outside the levee system will be flooded and residents will need to evacuate.

The Maitland ring levee is designed to be overtopped when the river reaches a height of approximately 11.35 metres at the Belmore Bridge gauge. When this gauge height is predicted, all residents inside the levee must evacuate. Once the water flows over the ring levee, Central Maitland, Horseshoe Bend and the remainder of South Maitland will be inundated with deep, fast-flowing water.

When a peak height of approximately 11.6 metres or higher is reached, water will begin to flow into the back of Lorn and properties behind the levee will begin to be inundated. Residents should evacuate when this height is predicted.

Maitland in the 1955 flood

Photo courtesy Hunter Catchment Management Trust

Flooding may last for several days. Remaining in your home in a serious flood can be dangerous. Even if you are not actually inundated, your home may become a refuge for vermin, snakes and spiders. There may be no water, sewerage, power, telephone or other services for several days. You may be unable to call for help. Because evacuation routes close early in severe floods, you will need to leave well before water reaches your property. It is dangerous to evacuate too late in a flood as roads may be covered by deep, fast flowing water.

Stay informed

Maitland City Council has information on how flooding may affect your property.

The Maitland City SES Unit can give you information on what you can do to reduce the effects of flooding on your family and your property.

A copy of the Maitland City Local Flood Plan is available at Maitland City Council libraries.

How you will be advised of a coming flood

Flood information including generalised flood forecasts, road closures and advice on evacuations and property protection will be broadcast over local radio stations 2HD AM 1143, KOFM 102.9, 2NUR FM 103.7, NEW-FM 105.3, NX FM 106.9, ABC FM 106.1, ABC AM 1233, Rhema FM 99.7.

When flooding is likely

- Stack your possessions on benches and tables, electrical goods on top
- Secure objects that are likely to float and cause damage
- Relocate waste containers, chemicals and poisons well above floor level
- Locate important papers, valuables and mementoes and put them in your emergency kit
- Move livestock, including horses, to high ground

During a flood

- Avoid driving or walking through flood water - it may be deeper and faster flowing than you realise
- Keep listening to a local radio station for further information and advice
- Keep in contact with your neighbours
- Be prepared to evacuate if advised

Maitland in the 1955 flood – flood debris

Photo courtesy Hunter Catchment Management Trust

If you need to evacuate

- Take your emergency kit with you
- Turn off the electricity, gas and water as you leave
- You will be told which evacuation centre to go to
- Don't leave your pets behind – they may die. Put them on leads or in approved pet containers. Dogs should be muzzled.

When you evacuate

You will need to leave well before roads to high ground are closed by flood water.
The last evacuation route to Rutherford is via High St. and the Long Bridge. The last route to East Maitland is via Les Darcy Dr.
Proceed to the evacuation centre you are asked to go to. Help will be available at the evacuation centre which will be established by the Department of Community Services (DoCS). This centre will also be staffed by representatives from community agencies such as the Red Cross, Salvation Army, Adracare, St Vincent de Paul and Anglicare. Information on the location of the evacuation centre will be provided at the time of the flood. Help available from the evacuation centre includes:

- Temporary accommodation
- Financial assistance
- Personal support
- Refreshments and meals
- Clothing and personal needs
- Contacting family and friends

Recovering from a severe flood

A local recovery centre will be established by DoCS. This centre will be staffed by representatives from a range of government departments and community agencies to help you return to normal living. At the centre you will be able to get advice on everything from insurance to counselling.
In the event of a flood, information will also be available from the DoCS State Disaster Recovery Centre on 1800 018 444.

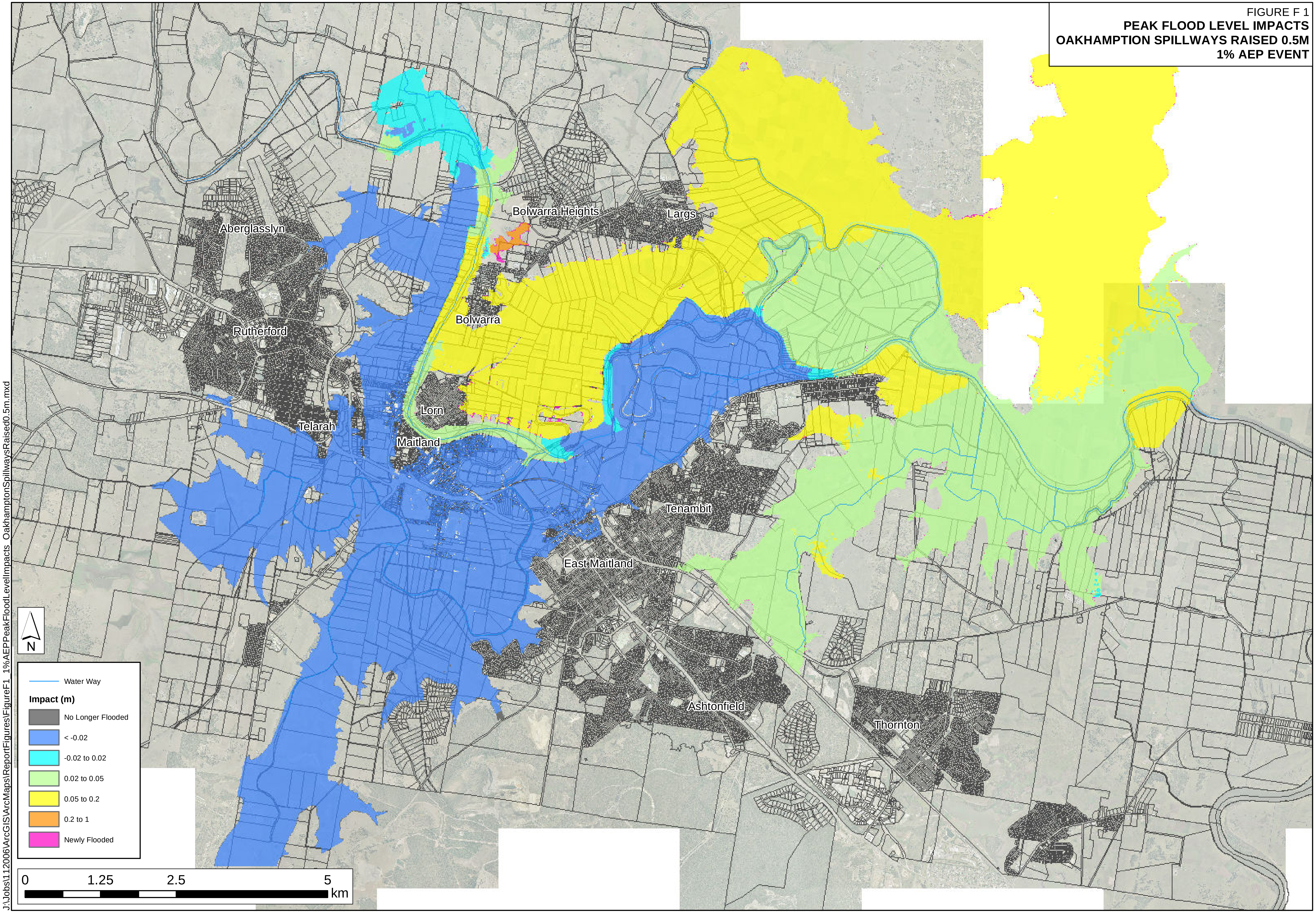
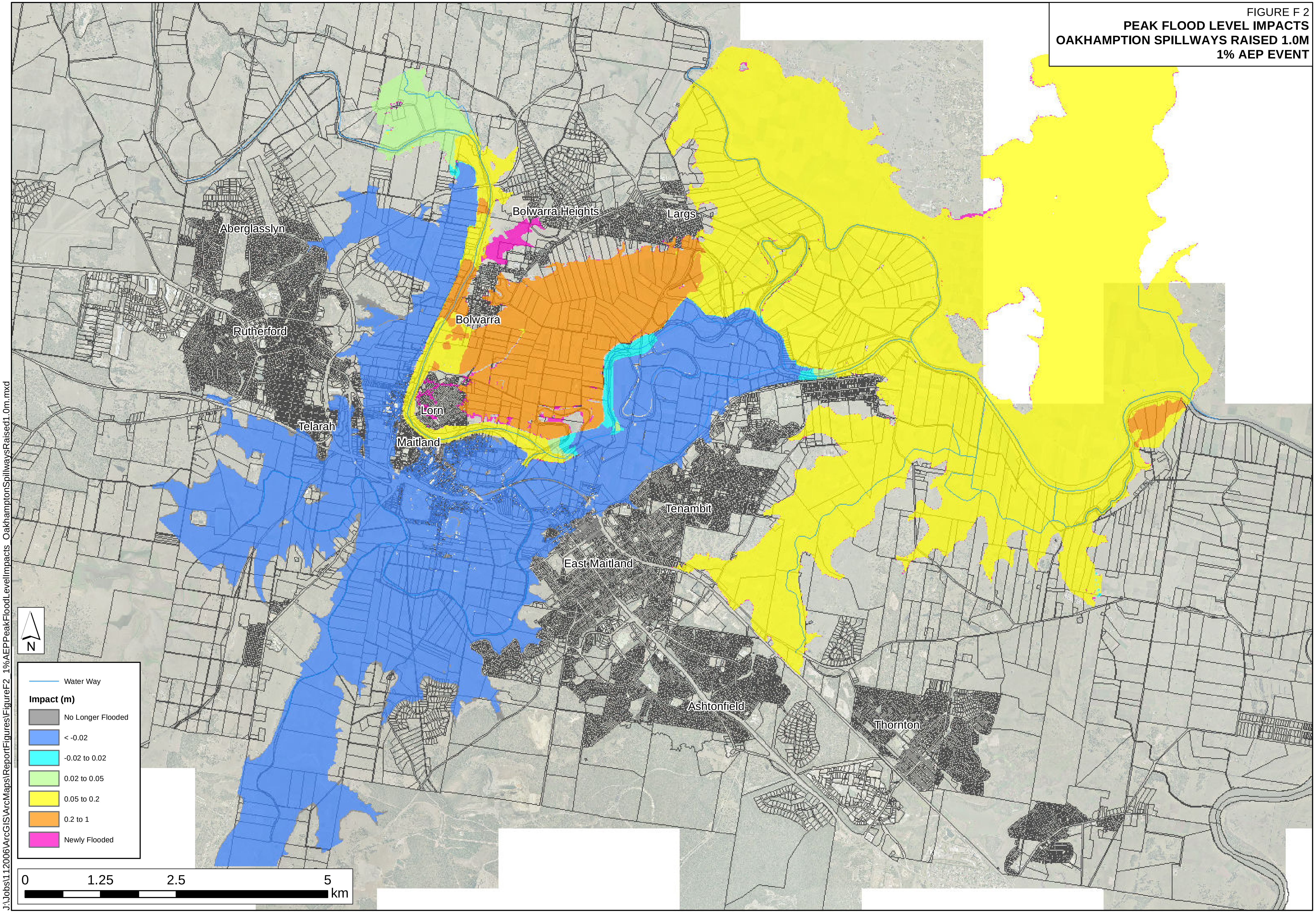


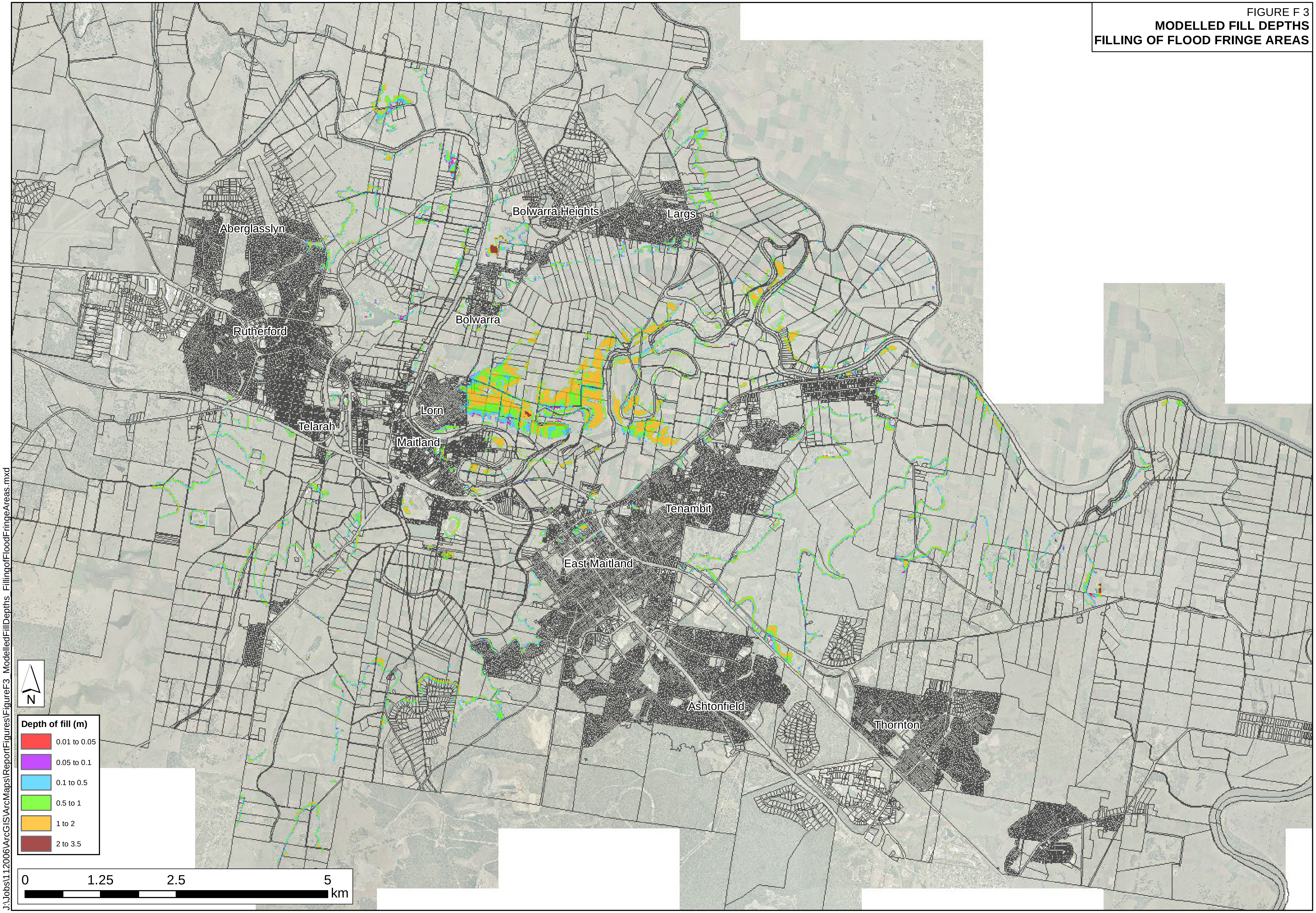
FIGURE F 1
PEAK FLOOD LEVEL IMPACTS
OAKHAMPTION SPILLWAYS RAISED 0.5M
1% AEP EVENT
Bolwarra Heights
Largs
Aberglasslyn
Rutherford
Bolwarra
Lorn
Telarah
Maitland
Tenambit
East Maitland
Ashtonfield
Thornton
N
Water Way
Impact (m)
No Longer Flooded
< -0.02
-0.02 to 0.02
0.02 to 0.05
0.05 to 0.2
0.2 to 1
Newly Flooded
0
1.25
2.5
5
km
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF1_1%AEPPeakFloodLevelImpacts_OakhamptonSpillwaysRaised0.5m.mxd

FIGURE F 2
PEAK FLOOD LEVEL IMPACTS
OAKHAMPTION SPILLWAYS RAISED 1.0M
1% AEP EVENT



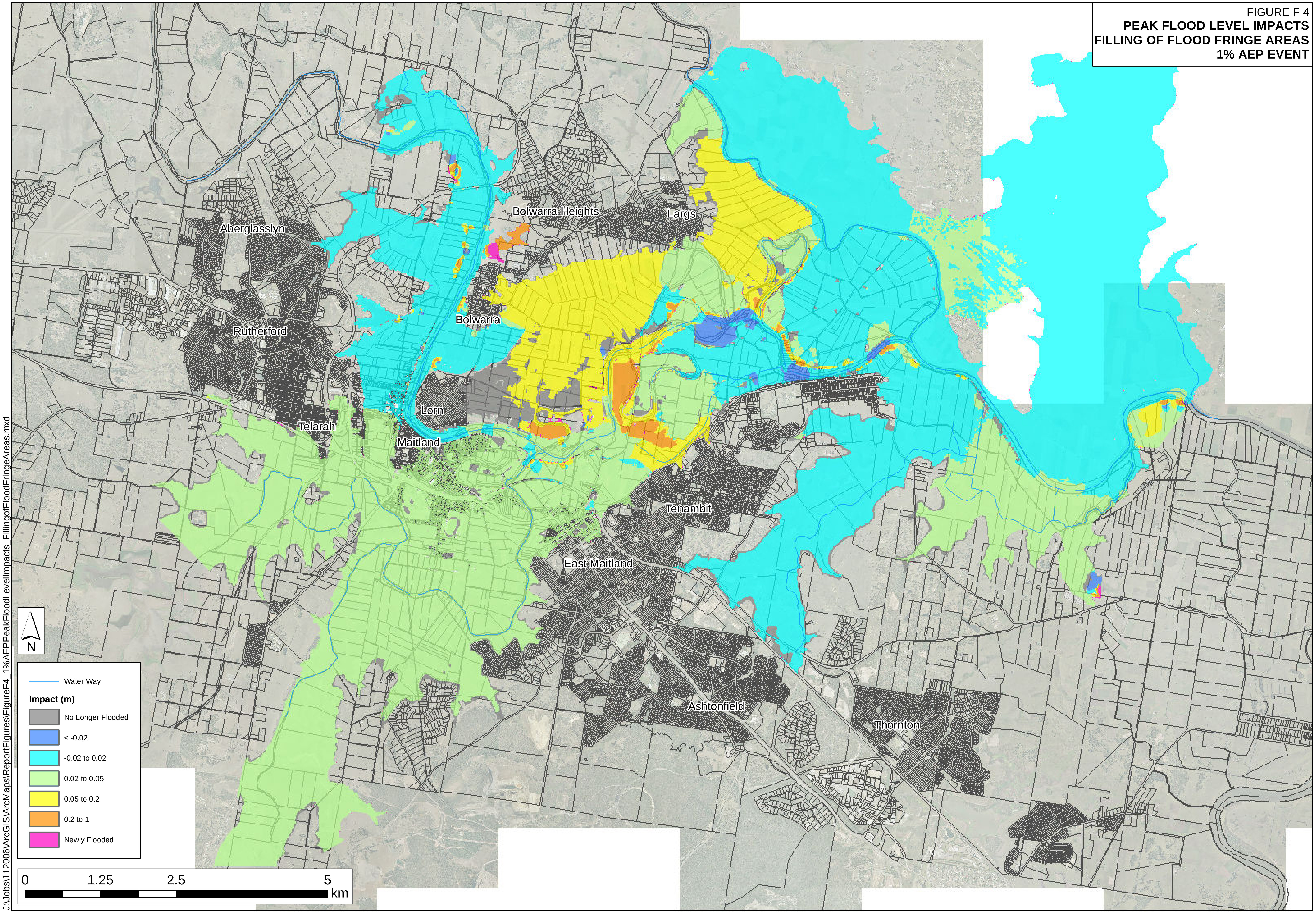
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF2_1%AEPPeakFloodLevelImpacts_OakhamptonSpillwaysRaised1.0m.mxd

FIGURE F 3
MODELLED FILL DEPTHS
FILLING OF FLOOD FRINGE AREAS



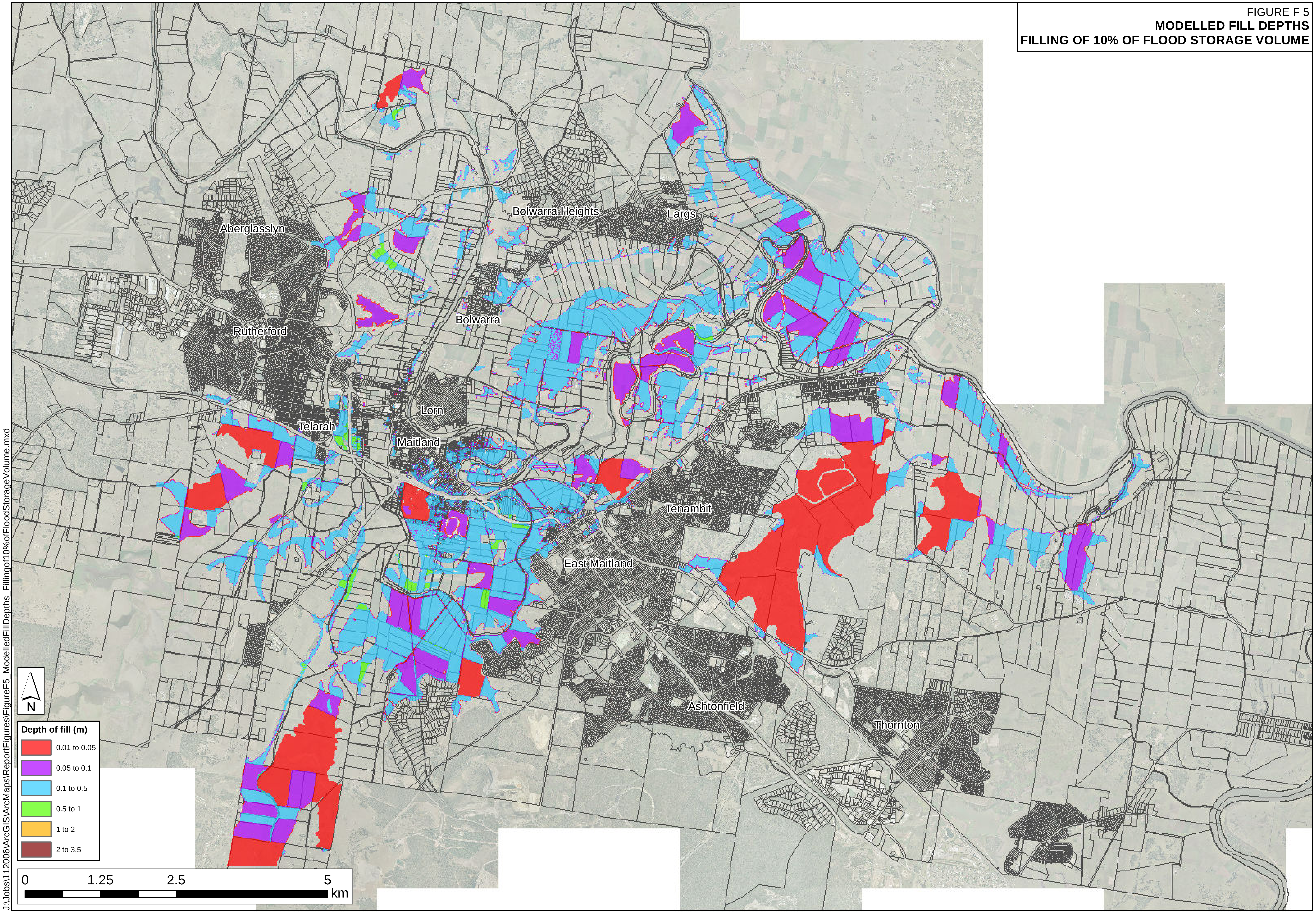
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF3_ModelledFillDepths_FillingofFloodFringeAreas.mxd

FIGURE F 4
PEAK FLOOD LEVEL IMPACTS
FILLING OF FLOOD FRINGE AREAS
1% AEP EVENT



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF4_1%AEPPeakFloodLevelImpacts_FillingofFloodFringeAreas.mxd

FIGURE F 5
MODELLED FILL DEPTHS
FILLING OF 10% OF FLOOD STORAGE VOLUME



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF5_ModelledFillDepths_Fillingof10%ofFloodStorageVolume.mxd

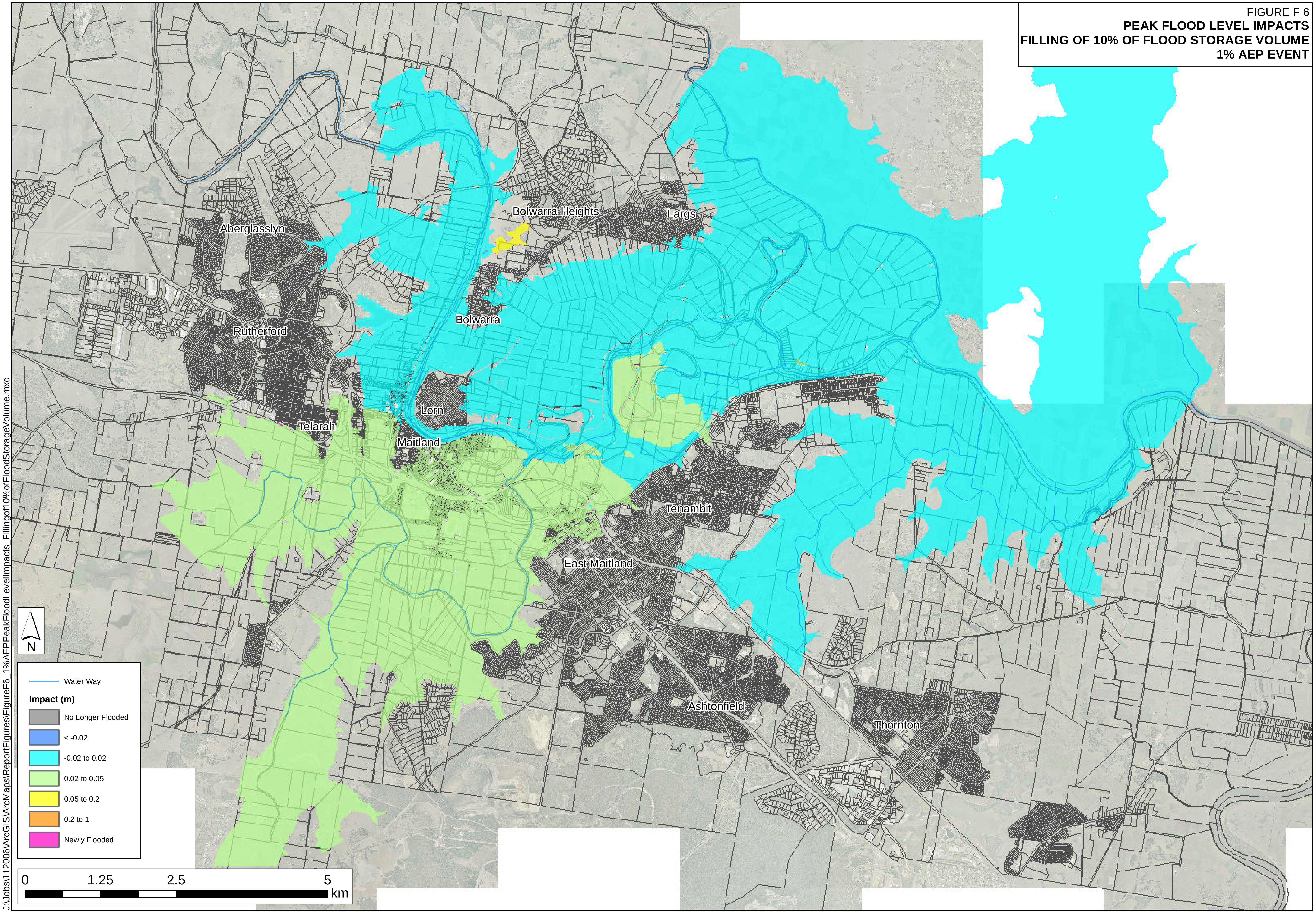


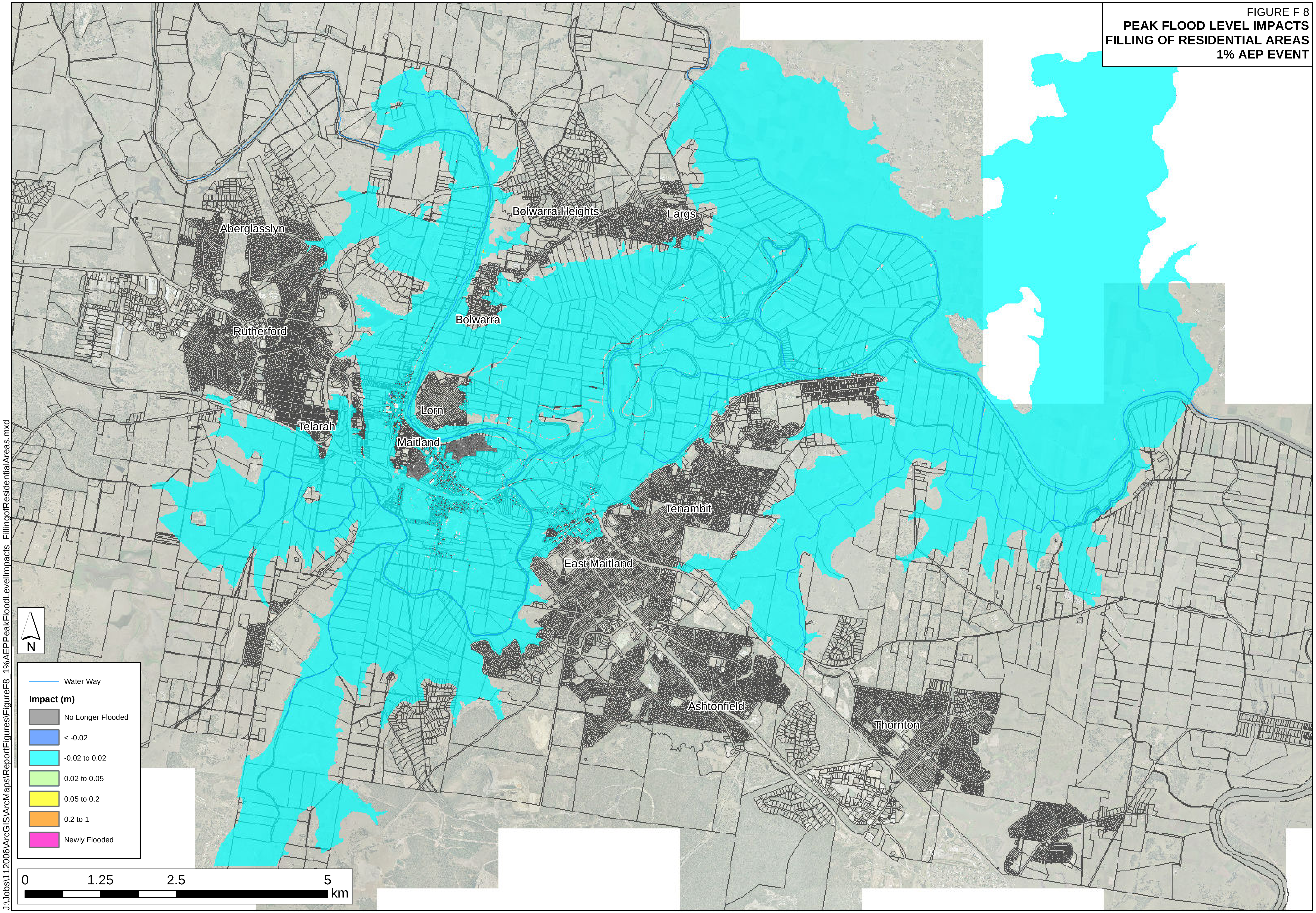
FIGURE F 6
PEAK FLOOD LEVEL IMPACTS
FILLING OF 10% OF FLOOD STORAGE VOLUME
1% AEP EVENT

J:\Jobs\112006\ArcGIS\ArcMaps\Report Figures\FigureF6_1%AEPPeakFloodLevelImpacts_Fillingof10%ofFloodStorageVolume.mxd

FIGURE F 7
MODELLED FILL DEPTHS
FILLING OF RESIDENTIAL AREAS

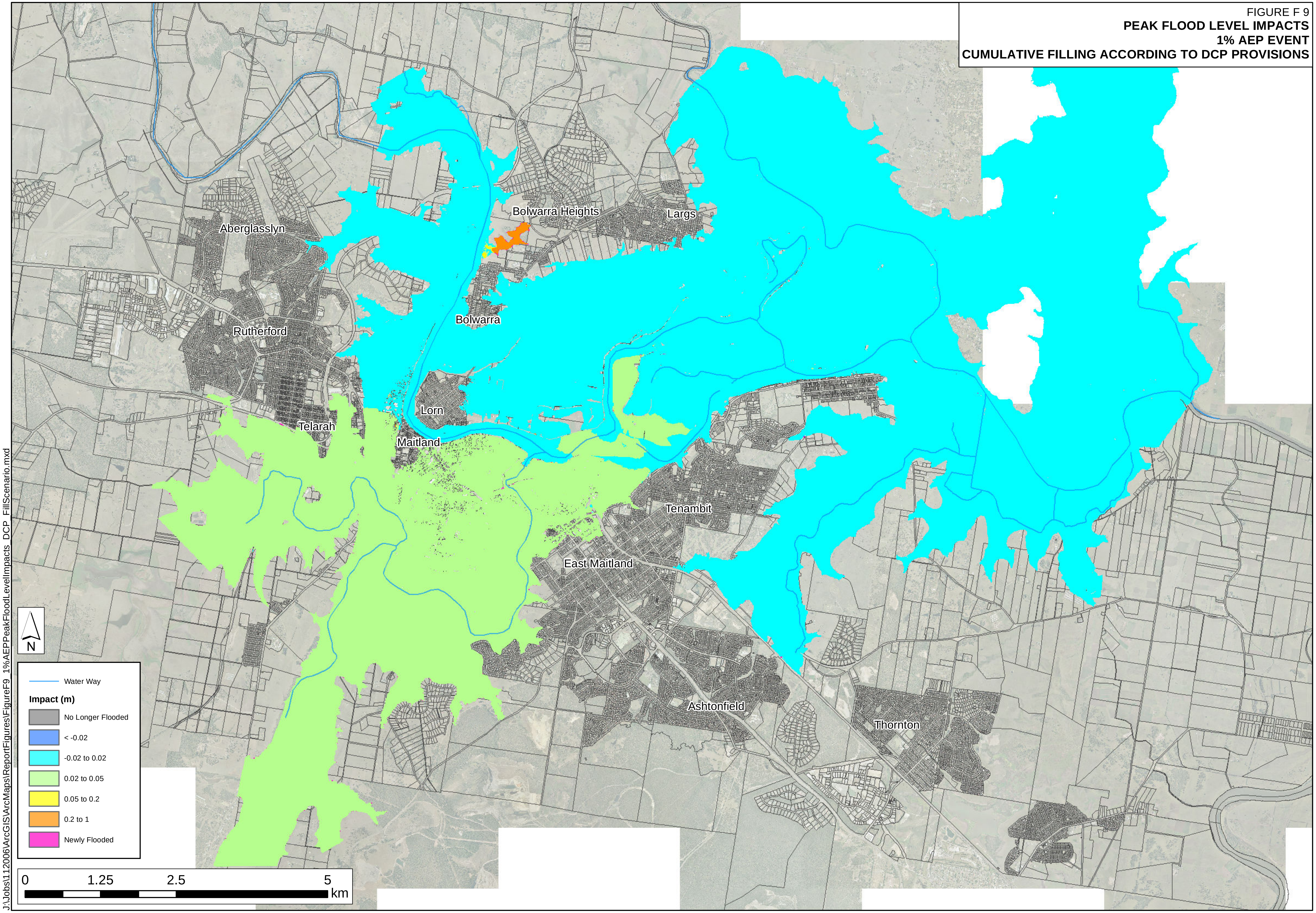
J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF7_ModelledFillDepths_FillingofResidentialAreas.mxd

FIGURE F 8
PEAK FLOOD LEVEL IMPACTS
FILLING OF RESIDENTIAL AREAS
1% AEP EVENT



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF8_1%AEPPeakFloodLevelImpacts_FillingofResidentialAreas.mxd

FIGURE F 9
PEAK FLOOD LEVEL IMPACTS
1% AEP EVENT
CUMULATIVE FILLING ACCORDING TO DCP PROVISIONS



J:\Jobs\112006\ArcGIS\ArcMaps\ReportFigures\FigureF9_1%AEPPeakFloodLevelImpacts_DCP_FillScenario.mxd