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Lake Wyangan Floodplain Risk Management Study and Plan

Final Report
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Lake Wyangan
Floodplain Risk Management
Study & Plan
Final Report

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Title :	Lake Wyangan Floodplain Risk Management Study and Plan – Final Report
Author :	Darren Lyons
Synopsis :	This report documents the Lake Wyangan Floodplain Risk Management Study and Plan which investigates and presents a flood risk management strategy for the catchment. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Management Plan, which describes how flood liable lands within Lake Wyangan are to be managed in the future.

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EXECUTIVE SUMMARY

Introduction

The Lake Wyangan Flood Study was completed by BMT WBM in March 2012. The outcome of this study was the production of flood inundation and flood risk mapping for the Lake Wyangan locality, generated from detailed hydrologic and hydraulic modelling of the catchment. The flood study represents the initial stage in the floodplain management process and establishes the basis for the current floodplain risk management study.

The objectives of the Lake Wyangan Floodplain Risk Management Study and Plan (FRMS&P) are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Lake Wyangan locality.

Catchment Description

The study catchment totals an area of around 825km^2 and incorporates the townships of Lake Wyangan and Nericon and numerous agricultural properties. The catchment is a closed system that drains to a number of storages, including Lake Wyangan, Tharbogang Swamp, Nericon Swamp and Campbells Swamp.

Substantial irrigation supply and drainage infrastructure has modified the natural drainage of the catchment. The majority of the catchment naturally drains to Tharbogang Swamp, however under low flow conditions, the Lake View Drain and its associated agricultural drainage divert water from the Tharbogang Swamp catchment into Lake Wyangan.

The catchment has been largely cleared for farming purposes representing 80% of the catchment land use of which around 10% is irrigated agriculture. The other dominant land use is remnant vegetation at around 20% of the catchment. Approximately 5km^2 of the catchment is open water or swamp and around 3km^2 is used for residential and rural residential purposes (both of which constitute <1% of the total catchment area).

Historical Flooding

There is limited documented history of flooding in the catchment given the relatively sparse populations and only minor impacts of recent flood events. The recent March 2012 event provided for widespread flooding across the Murrumbidgee region, including flooding in the Lake Wyangan catchment. Some 133mm of rainfall was recorded in a 24-hour period at Griffith Airport during the event.

The March 1985 event is the largest recorded within the catchment, with a daily rainfall total of 150mm recorded at Griffith Airport. The duration of the event is unknown, given no available continuous rainfall record, but it is likely shorter than 12 hours, representing an event well in excess of

a 1%AEP, when considered in relation to the standard intensity-frequency-duration (IFD) relationships for the study area.

One of the most significant event since lake level records began in 1986 is the March 1989 event. It totalled around 100mm of rainfall at Griffith Airport and caused flooding to farming properties around Lake Wyangan.

Community Consultation

The consultation has aimed to inform the community about the development of the flood study and its likely outcome as a precursor to subsequent floodplain risk management activities. It has provided an opportunity to collect information on their flood experience, in particular historical flood data related to catchment flooding.

A newsletter was released to the community to inform about the project objectives, key study outcomes and invitation for community input. In association with release of the newsletter, Council issued a media release and provided further information to the community in regards to the study through local newspaper, television and radio segments.

Response to the community newsletter was limited, however, a number of interviews were undertaken with local landholders during the course of the study to further discuss local flooding issues and details of the March 2012 event. These locations principally related to the Tharbogang Swamp catchment area, downstream of West Road including the Kubank Estate and the broader Swamp area. The somewhat limited response to the community engagement is perhaps indicative of the relatively few flood problem areas identified for the March 2012 event, and more broadly through both the Flood Study and the Floodplain Risk Management Study.

Flooding Behaviour

The Lake Wyangan Flood Study defined the existing flood behaviour in the Lake Wyangan catchment and established the basis for subsequent floodplain risk management activities. Design flood conditions were established through the development and calibration of appropriate numerical models. The study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions. This study expands the description of flood behaviour within the catchment, particularly in relation to the flood hazard and associated risk. Aspects considered include the size of flood; depth and velocity; flood readiness; rate of rise; duration of flooding; flood warning times; and effective flood access.

Given that the March 2012 flood event occurred after completion of the Flood Study, the adopted design flood conditions were reviewed in relation to the additional flood information resulting from the event. Despite one of the largest rainfall events on record, there was a relatively limited response in Tharbogang Swamp and Lake Wyangan, indicating a potential level of conservatism in the adopted design flood levels. However, for both storages, there is potential for a major event to follow a smaller event or sustained wet period, in which the initial water levels and degree of wetness in the catchment may be higher than typically observed. The potential for these types of conditions warrant some level of conservatism in establishing design flood levels.

The adopted 1% AEP design flood levels of 107.6m AHD for Lake Wyangan and 109.8m AHD for Tharbogang Swamp are therefore considered reasonable. Accordingly, the established design flood

conditions from the Lake Wyangan Flood Study are considered appropriate for adoption and be used as the basis for floodplain risk management in the catchment.

The guidance on flood planning levels within the Griffith Flood Prone Lands Policy is deemed appropriate for application in Lake Wyangan and is summarised below:

Development	Flood Planning Level
Commercial and Industrial	1% AEP flood level with 25% of the floor area at 500mm above the 1% AEP flood level.
Critical Utilities	If necessary to site critical utilities within flood prone land then they must be above the PMF level.
Residential Subdivision	500mm above the 1% AEP flood level
Manufactured Homes	1% AEP flood level.
Garages and Storage Sheds	5% AEP flood level.

A summary of the recommended design flood levels, to be used as the basis for FPLs, for the broader storage areas of Lake Wyangan and Tharbogang Swamp is provided below:

Design Event	Peak Flood Level (m AHD)	
	Lake Wyangan	Tharbogang Swamp
20% AEP	106.5	103.5
10% AEP	106.5	104.2
5% AEP	106.8	105.8
2% AEP	107.2	108.0
1% AEP	107.6	109.8
0.5% AEP	108.1	110.8
PMF (3x1%AEP)	116.1	116.1

Review of Existing Planning Provisions

The local planning instruments which guide development in Lake Wyangan are the Griffith LEP and DCP. The LEP shows areas zoned for future growth. Typically these areas sit outside the main flood extents of the Tharbogang Swamp and Lake Wyangan storages; however, there are local flood flow paths that require consideration in any future development. Appropriate development controls for new development are required with consideration of the flood risk.

Future reviews of the GLEP are being undertaken in accordance with the NSW State Government"s Standard Instrument (Local Environmental Plans) Order 2006, which requires local Council"s to implement a Standard Instrument LEP.

Council has adopted the Griffith Flood Liable Lands Policy (developed as part of the Griffith Floodplain Risk Management Plan). This policy presents a set of flood related assessment criteria to guide the assessment of future development.

The Flood Liable Lands Policy provides an overarching policy for development across the Griffith LGA. No requirements for specific controls additional to the current requirements of the policy have been identified for the Lake Wyangan catchment. Nevertheless, as a matter of course in completion of the Lake Wyangan Floodplain Risk Management Study, the current Policy needs to be updated to incorporate the findings, particularly the establishment of design flood conditions and mapping to be used in land use planning and development control.

It is understood that Council are currently developing a consolidated DCP. It is anticipated this document will coordinate with the structure of the revised Griffith LEP in preparation. The new DCP should contain detailed planning controls that support the LEP update and Land Use Strategy: Beyond 2030 and both must be considered when planning the development of land within Griffith LGA.

Potential Options for Improving Flood Management

The irrigation infrastructure of the Lake View Branch Canal and the Lake View Drain has a significant impact on catchment flood behaviour. The design flood conditions established through the Lake Wyangan Flood Study are based on the existing conditions.

Recommendations PL6 and PL7 of the Griffith Floodplain Risk Management Plan related to the ongoing management of Murrumbidgee Irrigation infrastructure. These overarching recommendations should also incorporate the infrastructure within the Lake Wyangan study area. The following elements are critical in maintaining existing flow distribution in the Lake Wyangan/Tharbogang Swamp catchment and accordingly are recommended to be operated and maintained as such:

- Lake View Branch Canal;
- Lake View Drain; and
- All cross drainage structures (e.g. siphons/pump systems) in the LVBC.

Any future changes to major infrastructure will require an assessment of the potential change in flow distribution between Lake Wyangan and Tharbogang Swamp and any associated impacts.

There is considered little opportunity or indeed requirement for structural options to mitigate existing flooding risks given both the nature of flooding and limited flood risk exposure to existing property. Accordingly, the floodplain risk management plan for the catchment focuses on appropriate planning and development controls to ensure future development does not unduly exacerbate the overall flood risk. However, one location where structural works may be of benefit is the Kubank Road Estate. It is recommended that Council further investigate the potential for the construction of a drainage channel to reduce flood frequency and impacts at this location.

Future development, particularly the proposed future land release areas to the south of Lake Wyangan, will need to take due consideration of the flood conditions established in the current study. The major flood risk emanates from the natural flood flow paths, in particular the key floodway areas identified. Adoption of the updated flood risk mapping incorporated in this study will formalise the baseline conditions for consideration of future development applications.

The key flood planning recommendations from the Griffith FRMS&P are considered to be appropriate for implementation for Lake Wyangan. These include use of the LEP and Flood Liable Lands Policy to guide development, On-site Stormwater Detention to limit increases in site discharge from developments and the Memorandum of Understanding between Council and Murrumbidgee Irrigation.

The recommendations emanating from the Griffith FRMS&P represent overarching flood planning and policy changes applicable across the Griffith LGA. Whilst there are no additional controls or policy modifications specific to Lake Wyangan, the following recommendations for the Lake Wyangan FRMS&P will formalise the flood planning requirements in the Lake Wyangan study area.

- Updated floodplain mapping to be adopted and incorporated in planning documents as appropriate including the LEP, relevant DCP and flood liable lands policy:
    - Flood Planning Area Map – 1% AEP event plus freeboard used as mapping basis.
    - Hydraulic categorisations – definition of floodway, flood storage and flood fringe areas;
    - Hazard and Risk mapping – categorisation of low-high risk for consideration in development applications.
- Update of Section 149 certificates – existing Section 149 certificates for flood prone properties in the study area to be reviewed and updated with current flood study information and data.

Real-time rainfall data recorded at Griffith Airport can be accessed via the BoM website. Whilst rainfall variability across the catchment can be significant, in the absence of other real-time gauges in the catchment, the Griffith station may provide some indication of potential flooding. There is considered to be limited opportunity or indeed requirement for the development of a more formalised flood warning system for the Lake Wyangan catchment.

The Lake Wyangan study area should be incorporated into formal data collection programs to ensure ongoing collection of data and monitoring of flooding conditions in the catchment as they occur. At the minimum, the peak flood water levels in Tharbogang Swamp, North and South Lake Wyangan should be recorded as a matter of course during each flood event, providing future opportunity for review of models, design flood conditions and established flood planning levels.

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods. Community awareness is an on-going process and there is the inherent danger of complacency between events. There are numerous mechanisms to inform the community, with the following recommended to be incorporated in the Lake Wyangan FRMP: updated flood mapping, section 149 certificates and an ongoing flood awareness program.

Floodplain Risk Management Plan

The Lake Wyangan Floodplain Risk Management Plan (FRM Plan) has been developed to direct and co-ordinate the future management of flood prone lands within the Tharbogang Swamp/Lake Wyangan catchment. The FRM Plan sets out a strategy of actions and initiatives that are to be

pursued by agencies and the community in order to adequately address the risks posed by flooding. The actions are as follows:

- Ensure that flooding is duly considered by current planning policy and future reviews;
- Adopt flood risk mapping from the Lake Wyangan Flood Study;
- Maintain existing flow distributions between lakes, governed by the irrigation infrastructure;
- Extend MoU between Council and Murrumbidgee Irrigation to include Lake Wyangan;
- Investigate the Kubank Estate drainage diversion as a measure to reduce flood risk;
- Update the local flood plan to incorporate design flood data from the current study;
- Implement flood data collection program, with flood levels in the lakes as a minimum; and
- Ongoing community awareness to improve flood resilience.

The recommended Plan contains relatively modest financial implications for Council and other responsible authorities. This is largely as a result of no major capital works in terms of flood modification being recommended. The timing of the implementation of recommended measures will depend on overall budgetary commitments of Council and the availability of staff resources. It is envisaged that the Plan would be implemented progressively over a 12-month frame.

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the areas planning strategies. A thorough review every 5 years is warranted to ensure the ongoing relevance of the Plan

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GLOSSARY

annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a flood that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the „100 year ARI flood" or „1 in 100 year flood". The term 100 year ARI flood has been used in this study. See also average recurrence interval (ARI).
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level.
attenuation	Weakening in force or intensity
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe flood size. It is the long-term average number of years between floods of a certain magnitude. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The term 100 year ARI flood has been used in this study. See also annual exceedance probability (AEP).
catchment	The catchment at a particular point is the area of land that drains to that point.
design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100yr ARI or 1% AEP flood).
development	Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.
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).
flood	A relatively high stream flow that 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 behaviour	The pattern / characteristics / nature of a flood.
flood fringe	Land that may be affected by flooding but is not designated as floodway or flood storage.
flood hazard	The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.The degree of flood hazard varies with circumstances across the full range of floods.

flood level	The height of the flood described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (eg the flood level was 7.8 mAHD). Terms also used include flood stage and water level.
flood liable land	see flood prone land
floodplain	Land susceptible to flooding up to the probable maximum flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level.
floodplain risk management study	Studies carried out in accordance with the Floodplain Development Manual (NSW Government, 2005) that assesses options for minimising the danger to life and property during floods. These measures, referred to as „floodplain risk management measures / options", aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a Floodplain Risk Management Plan.
floodplain risk management plan	The outcome of a Floodplain Risk Management Study.
flood planning levels (FPL)	The combination of flood levels and freeboards selected for planning purposes, as determined in Floodplain Risk Management Studies and incorporated in Floodplain Risk Management Plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies..
flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
flood stage	See flood level.
flood storage	Floodplain area that is important for the temporary storage of floodwaters during a flood.
flood study	A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.
floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways 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.
freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determing the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.

high flood hazard	For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	The term given to the study of water flow in rivers, estuaries and coastal systems.
hydrology	The term given to the study of the rainfall-runoff process in catchments.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m AHD	metres Australian Height Datum (AHD).
m/s	metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or „cumecs". A unit of measurement for creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as „overland flows", may or may not re-enter the main channel from which they left; they may be diverted to another water course.
peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
probability	A statistical measure of the likely frequency or occurrence of flooding.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
stage	See flood level.
topography	The shape of the surface features of land
velocity	The term used to describe the speed of floodwaters, usually in m/s.
water level	See flood level.

PART A – FLOODPLAIN RISK MANAGEMENT STUDY

1 INTRODUCTION

The Lake Wyangan Flood Study has been prepared for Griffith City Council (Council) to define the existing flood behaviour in the Lake Wyangan catchment and establish the basis for subsequent floodplain risk management activities.

This project has received technical and financial support from the NSW Government"s Floodplain Management Program.

The Lake Wyangan Flood Study was completed by BMT WBM in March 2012. The outcome of this study was the production of flood inundation and flood risk mapping for the Lake Wyangan locality, generated from detailed hydrologic and hydraulic modelling of the catchment. The flood study represents the initial stage in the floodplain management process and establishes the basis for the current floodplain risk management study.

The objectives of the Lake Wyangan Floodplain Risk Management Study and Plan (FRMS&P) are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Lake Wyangan locality.

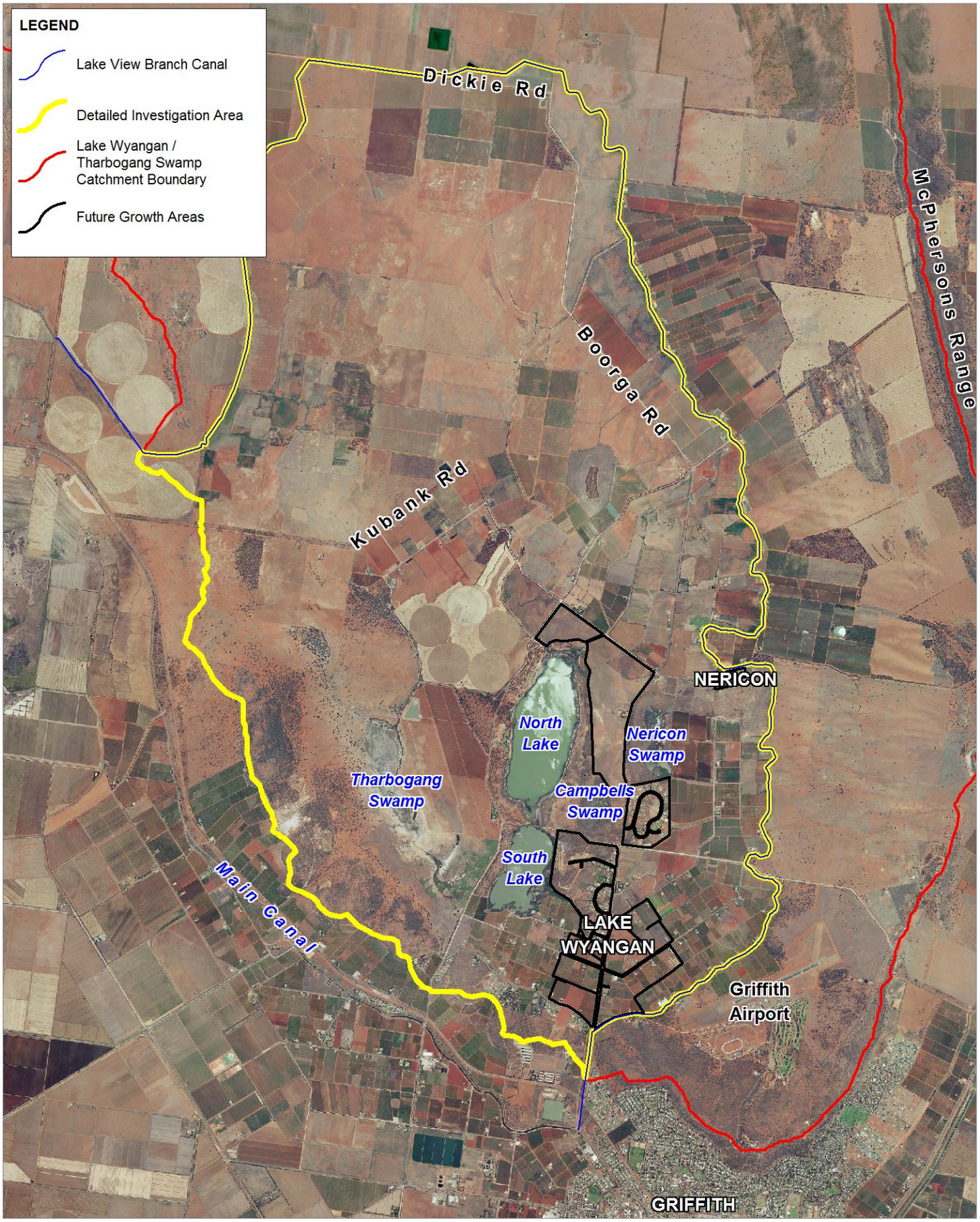
This report documents the Floodplain Risk Management Study and presents a recommended Floodplain Risk Management Plan for Lake Wyangan.

1.1 Study Background

The Lake Wyangan / Tharbogang Swamp catchment is around 825km^2 in size and is a closed system with no natural drainage outlet. The detailed investigation area forms the lower part of the catchment, bounded by the Lake View Branch Canal, and is located a few kilometres to the north of Griffith, as shown in Figure 1-1. Within the detailed investigation area, the future growth areas in Council"s Land Use Strategy – Beyond 2030 (shown in Figure 1-1) are a particular focus.

The north and south lakes of Lake Wyangan are prominent features, being permanent water bodies. There are also a number of ephemeral wetlands, including Tharbogang Swamp, Nericon Swamp and Campbells Swamp. The Lake View Branch Canal supplies irrigation water to the local agriculture and is a major feature of the catchment as it intersects the majority of catchment runoff.

There are two main mechanisms governing flood behaviour in the study area. Flood levels within the storages at the bottom of the catchment are driven by total runoff volumes from the Lake Wyangan / Tharbogang Swamp catchment. Longer duration catchment-wide events will provide the critical conditions for flood levels in Lake Wyangan and the surrounding properties. Local catchment runoff from shorter duration, higher intensity events will provide for the critical conditions on some of the flood flow paths, particularly in the east of the study area.



Title:

Study Locality

Figure: 1-1

Rev: A

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0 1.25 2.5km

Approx. Scale

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Through the undertaking of the flood study it has been found that during flood events the majority of the catchment runoff flows to Tharbogang Swamp rather than Lake Wyangan, as had previously been assumed. Historically there has been little response of Lake Wyangan water levels to rainfall events within the catchment, with only the March 1989 event producing a significant response. The limited response in Lake Wyangan is due to a number of factors:

- It has a relatively small catchment area of around 100km^2, including diverted catchment runoff through the Lake View Drain (Lake Wyangan"s natural catchment is around 75km^2);
- The calibration process found the catchment to indicate a high initial rainfall loss for the events considered. A large amount of rainfall (>60mm) is required before any catchment runoff is generated and a response in the lake can be observed; and
- A proportion of the catchment runoff volume is retained in temporary flood storages in the catchment, rather than further contributing to the flood storage in the lake.

Being a volume-driven closed-catchment system with no natural outlet, flood levels in Lake Wyangan and Tharbogang Swamp are directly related to the catchment runoff volume generated by any given flood event. The high rainfall losses generate relatively small effective rainfall depths and the flood levels are therefore highly sensitive to changes in the adopted initial loss value. The calibration process found an initial loss value of around 60mm to be appropriate for the events considered. However, due to the characteristics of the available design rainfall temporal pattern, this loss value was reduced for design purposes.

Tharbogang Swamp has a much larger catchment area than Lake Wyangan and therefore shows a much greater flood response. Unfortunately there is no history of flood level recording in Tharbogang Swamp to compare to the modelled flood response.

The study also identified a number of local overland flow paths which impact of the planned development areas of Council"s Land Use Strategy: Beyond 2030. It is important that these flow paths are taken into consideration during the stages of development planning.

1.2 The Need for Floodplain Risk Management at Lake Wyangan

As evidenced in the 1985, 1989 and 2012 flood events, there are a number of properties within the Lake Wyangan Township and adjacent to the lakes that are at risk of flooding from both local overland flow paths and elevated lake levels. The wet weather of recent years has also highlighted problems with local drainage capacity.

Within Council"s Land Use Strategy: Beyond 2030 there is planned future development in areas surrounding Lake Wyangan, which includes land release for some 800 residential and rural residential lots over the next 20 years. An understanding of the flood behaviour and associated risks is required to effectively plan and manage this future development.

Floodplain risk management considers the consequences of flooding on the community and aims to develop appropriate floodplain risk management measures to minimise and mitigate the impact of flooding. This incorporates the existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

Accordingly, Council desires to approach local floodplain risk management in a considered and systematic manner. This study comprises the initial stages of that systematic approach, as outlined in the Floodplain Development Manual (NSW Government, 2005). The approach will allow for more informed planning decisions within Lake Wyangan.

1.3 The Floodplain Risk Management Process

The State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the Government's Floodplain Development Manual (2005).

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 risk management responsibilities.

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

Stages of Floodplain Risk Management

	Stage	Description
1	Flood Study	Determines the nature and extent of the flood problem.
2	Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed developments.
3	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of risk management for the floodplain.
4	Implementation of the Floodplain Risk Management Plan	Construction of flood mitigation works to protect existing development. Use of environmental plans to ensure new development is compatible with the flood hazard.

Griffith City Council is responsible for local planning and land management within the Griffith Local Government Area (LGA) including the management of the floodplain of the Lake Wyangan and Tharbogang Swamp catchments.

The first stage of the floodplain risk management process, the Lake Wyangan Flood Study (BMT WBM, 2012) defines the existing flood behaviour and establishes the basis for future floodplain management activities.

The Lake Wyangan Floodplain Risk Management Study and Plan (this document) constitutes the second and third stages of the management process. It has been prepared for Griffith City Council and the Floodplain Management Committee to provide the basis for future management of flood liable land within the catchment.

1.4 About This Report

This report documents the Study's objectives, results and recommendations.

Section 1 introduces the study.

Section 2 provides background information including a catchment description, history of flooding and previous investigations.

Section 3 outlines the community consultation program undertaken.

Section 4 describes the flooding behaviour in the catchment.

Section 5 provides a review of relevant existing planning measures and controls.

Section 6 summarises the assessment of potential floodplain risk management options

Section 7 presents the recommended Floodplain Risk Management Plan.

2 STUDY BACKGROUND

2.1 Catchment Description

The study catchment totals an area of around 825km^2 and incorporates the townships of Lake Wyangan and Nericon and numerous agricultural properties. The catchment is a closed system that drains to a number of storages, including Lake Wyangan, Tharbogang Swamp, Nericon Swamp and Campbells Swamp.

The topography of the catchment is shown in Figure 2-1. The upper catchment, which forms part of the Cocoparra Range, is steep and largely elevated above 200m AHD. The middle section of the catchment is a relatively flat expanse, which is bounded by the southern extension of Tabbita Ridge to the west and by the McPhersons Range to the east. Elevations are typically between 120m AHD to 150m AHD. The study area forms the lower section of the catchment, where elevations are below 120m AHD. The deeper storage areas of Lake Wyangan and Tharbogang Swamp are evident in the topography shown on Figure 2-1.

The natural swamps in the bottom of the catchment include Lake Wyangan, Tharbogang Swamp, Nericon Swamp and Campbells Swamp. South Lake Wyangan was dammed to provide a more permanent water source, whilst North Lake Wyangan was previously mined for Gypsum and subsequently flooded to provide water for irrigation. Typical bed levels of Tharbogang Swamp and South Lake Wyangan are around 103m AHD, with North Lake Wyangan being a little deeper at around 101m AHD. Campbells Swamp and Nericon Swamp are located at higher levels of around 108m AHD and 113m AHD respectively.

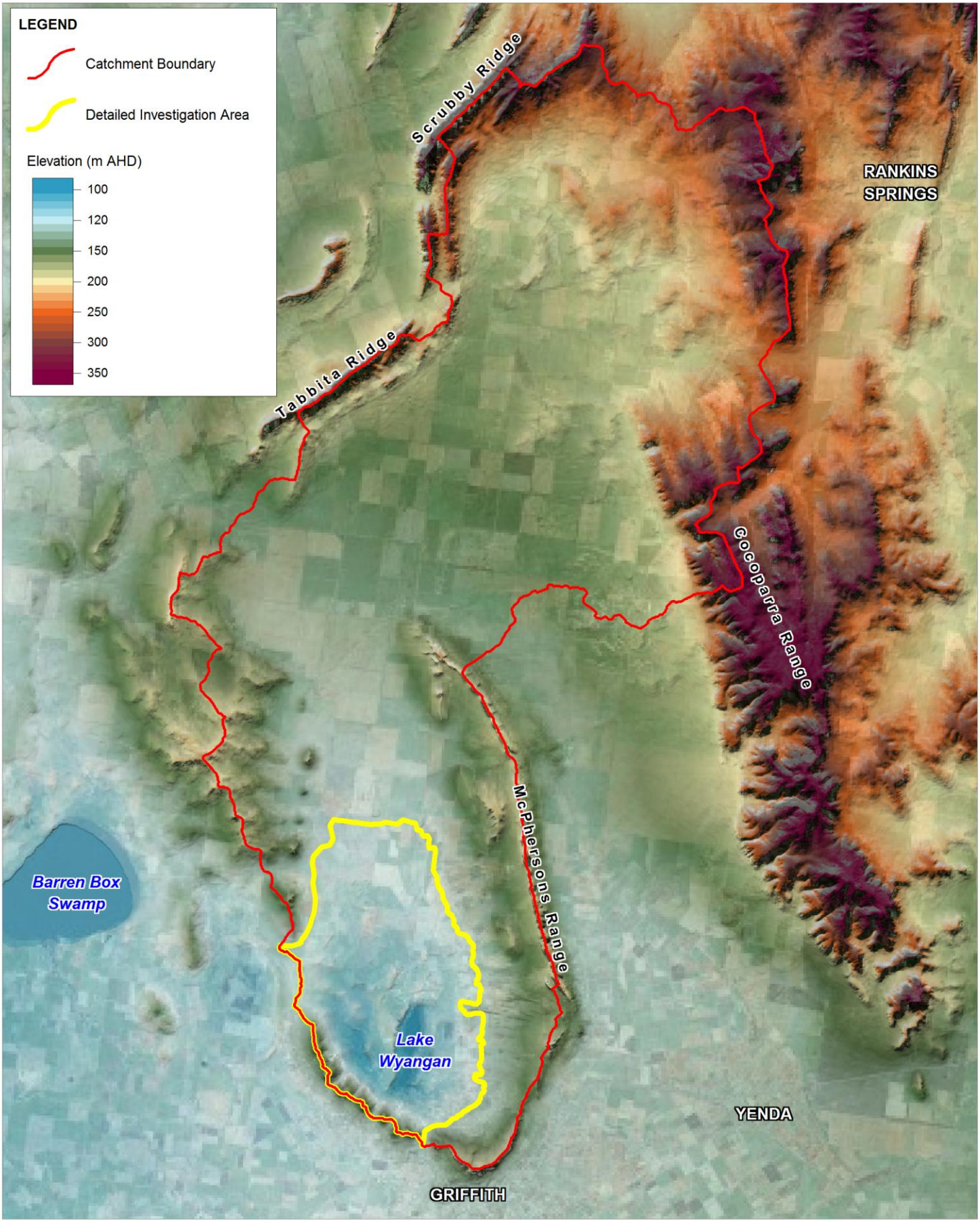
Substantial irrigation supply and drainage infrastructure has modified the natural drainage of the catchment. Historically, the majority of the catchment would have drained to Tharbogang Swamp, whereas now under typical low flow conditions it will drain to Lake Wyangan. In particular, the Lake View Drain and its associated agricultural drainage divert water from the Tharbogang Swamp catchment into Lake Wyangan.

The catchment has been largely cleared for farming purposes (80%, of which around 10% is irrigated agriculture). The other dominant land use is remnant vegetation at around 20%. Approximately 5km^2 of the catchment is open water or swamp and around 3km^2 is used for residential and rural residential purposes (both of which constitute <1% of the total catchment area).

The most significant transport route is Boorga Road, which connects the settlements of Lake Wyangan and Nericon to the City of Griffith.

2.2 History of Flooding

There is little documented history of flooding in the catchment, as it is sparsely populated and has a low annual average rainfall of <400mm. The recent March 2012 event provided for widespread flooding across the Murrumbidgee region, including flooding in the Lake Wyangan catchment.



Title:

Topography of the Lake Wyangan / Tharbogang Swamp Catchment

Figure: 2-1

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Approx. Scale

BMT WBM

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Despite the significance of the March 2012 rainfall event, with some 120mm-150mm recorded in 24 hours, the resulting inundation largely only affected rural farming property and accordingly reports of extensive damage have been limited.

The March 1985 event is the largest recorded within the catchment, with a daily rainfall total of 150mm recorded at Griffith Airport. The duration of the event is unknown, given no available continuous rainfall record, but it is likely shorter than 12 hours, representing an event well in excess of a 1%AEP, when considered in relation to the standard intensity-frequency-duration (IFD) relationships for the study area.

Prior to March 2012, the most significant event since lake level records began in 1986 is the March 1989 event. It totalled around 100mm of rainfall at Griffith Airport and caused flooding to farming properties around Lake Wyangan.

2.3 Previous Investigations

The Lake Wyangan Flood Study (BMT WBM, 2012) was been prepared for Council to define the existing flood behaviour in the Lake Wyangan catchment and establish the basis for subsequent floodplain risk management activities. The primary objective of the Flood Study was to define the flood behaviour within Lake Wyangan through the establishment of appropriate numerical models. The study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

Prior to the catchment flood study, a number of smaller investigations of the flooding characteristics of the study area have been undertaken over the last decade or so. These studies focused on assessing design flood levels in Lake Wyangan and in particular the 1 in 100 year (1% AEP) level. The studies include:

- Pelican Shores Peri-Urban Development – Lake Wyangan Flood Level Assessment (Hughes Trueman, 2000);
- Pelican Shores Peri-Urban Development – Lake Wyangan Flood Level Assessment (Hughes Trueman, 2001);
- Report on Lakes Road Western Annex – Flood Planning Levels (GHD, 2008);
- Lake Wyangan Investigation – Preliminary 100-Year Flood Level (GHD, 2008); and
- Sunset Waters, Boorga Road, Lake Wyangan, Griffith (Hughes Trueman, 2008).

The studies produced a wide range of flood level estimates, largely as a result of the variation in adopted parameters for the hydrological calculations, including uncertainty as to the catchment size.

The Lake Wyangan Flood Study supersedes the previous investigations and provides the detailed assessment of flood behaviour in the catchment as the basis for the current floodplain risk management study.

The Griffith Floodplain Risk Management Study and Plan (Worley Parsons, 2012) focused on the Main Drain „J" catchment incorporating the villages of Yenda, Beelbangera, Bilbul, Yoogali, Hanwood and parts of Griffith. In terms of relevance for Lake Wyangan however, the study provided for review and recommended update of some key flood planning policy including:

- Griffith Local Environmental Plan (GLEP);
- Griffith Flood Prone Lands Policy; and
- Council On-site Stormwater Detention (OSD) Policy.

3 COMMUNITY CONSULTATION

3.1 The Community Consultation Process

The consultation has aimed to inform the community about the development of the Floodplain Risk Management Study and Plan and its likely outcome as a precursor to ongoing floodplain risk management activities. It has provided an opportunity to collect information on their flood experience, in particular historical flood data related to catchment flooding.

The key elements of the consultation process have been as follows:

- Distribution of a questionnaire to landowners and residents within the study area during the Flood Study process;
- Community newsletter and associated media release and information through local newspaper, television and ABC radio;
- Interviews with landholders;
- Consultation with the Floodplain Management Committee meetings; and
- Public exhibition of the draft Flood Study.

These elements are discussed in detail below.

3.2 Community Questionnaire

A questionnaire was distributed to residents within the study area in undertaking the Flood Study (BMT WBM, 2012) to collect information on their previous flood experience and flooding issues. The focus of the questionnaire was historical flooding information that may be useful for correlating with predicted flooding behaviour from the modelling.

Council mailed out the questionnaire to all residents and businesses located within the study area. Council received back 39 responses, of which 18 had comments relating to flooding.

The focus of the questionnaire was to gather relevant flood information from the community, including photographs, observed flood depths and descriptions of flood behaviour within the catchment. Three responses included photographs showing flooding and drainage problems and another provided video footage. The responses also identified an additional location within the study area at which rainfall depths have been recorded since 2007.

3.3 Community Newsletter

A newsletter was released to the community to inform about the project objectives, key study outcomes and invitation for community input. A copy of the newsletter is provided in Appendix B for reference.

In association with release of the newsletter, Council issued a media release and provided further information to the community in regards to the study through local newspaper, television and radio segments.

Through the processes, the community were invited to participate in the study by providing knowledge on previous flooding history and experiences, locations of existing problem areas and potential management options. Photographs and video material of the March 2012 event was also requested to add to existing flood records.

Response to the community newsletter was limited, however, a number of interviews were undertaken with local landholders during the course of the study to further discuss local flooding issues and details of the March 2012 event. These locations principally related to the Tharbogang Swamp catchment area, downstream of West Road including the Kubank Estate and the broader Swamp area. The somewhat limited response to the community engagement is perhaps indicative of the relatively few flood problem areas identified for the March 2012 event, and more broadly through both the Flood Study and the Floodplain Risk Management Study.

3.4 Floodplain Management Committee

The study has been overseen by the Floodplain Management Committee (Committee). The Committee has assisted and advised Council in the development of the Lake Wyangan Floodplain Risk Management Study. Members of the Floodplain Management Committee include representatives from the following:

- Griffith City Council - Councillors;
- Technical staff from Griffith City Council;
- Representatives from the Office of Environment and Heritage;
- Representatives from Murrumbidgee Irrigation (MI); and
- Representatives from the State Emergency Service (SES); and
- Community representatives.

The Committee is responsible for recommending the outcomes of the study for formal consideration by Council.

Throughout the course of the study a number of Floodplain Management Committee meetings were held to present progress of the study enabling discussion and feedback from the committee.

3.5 Public Exhibition

The public exhibition of the Draft Lake Wyangan Floodplain Risk Management Study & Plan provided an opportunity for the community and other stakeholders to provide feedback and comment on the study process and outcomes.

The Draft Report was placed on public exhibition for a period of 4 weeks. One submission was received of which a copy is provided in Appendix C along with the response to the submission.

4 FLOODING BEHAVIOUR

The principal objective of the Lake Wyangan Flood Study (BMT WBM, 2012) was to define the existing flood behaviour in the Lake Wyangan catchment and establish the basis for subsequent floodplain risk management activities. Design flood conditions were established through the development and calibration of appropriate numerical models. The study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions. Specifically, the study incorporated:

- Compilation and review of existing information pertinent to the study and acquisition of additional data including survey as required;
- Undertaking a community consultation and participation program to identify local flooding concerns, collect information on historical flood behaviour and engage the community in the on-going floodplain risk management process;
- Development and calibration of appropriate hydrologic and hydraulic models;
- Determination of design flood conditions for a range of design event including the 20% AEP, 10% AEP, 2% AEP, 1% AEP, 0.5% AEP and extreme flood event;
- Presentation of study methodology, results and findings in a comprehensive report incorporating appropriate flood mapping; and
- Identification of key locations for consideration during the floodplain risk management process.

Subsequent to completion of the Lake Wyangan Flood Study, the catchment experienced a significant rainfall event in March 2012. This event was associated with the broader regional flooding event across parts of south-western NSW. Within the Griffith LGA, significant flooding was experienced in some localities such as Yenda in association with flooding of the Mirrool Creek and Main Drain „J" catchments. Whilst the impacts of flooding within the Lake Wyangan catchment were less severe than other locations, the collection of data from the event provides an opportunity to review the flood behaviour in the catchment, and consider any implications on the establishment of design flood conditions as the basis for the floodplain risk management study.

4.1 Review of the March 2012 Flood

Extensive flooding throughout the broader south-western region of NSW was experienced in March 2012. The distribution of total rainfall for the week ending 4th March 2012 is shown in Figure 4-1 (source: Bureau of Meteorology). The rainfall stations at Griffith Airport and Rankins Springs recorded weekly totals of 215mm and 235mm respectively. The most significant rain day was for the 24hours to 9:00am on the 4th March for which Griffith and Rankins Springs recorded 133mm and 110mm respectively.

A summary of the recorded daily totals for the week ending 4th March 2012 is shown in Table 4-1 for the available rainfall stations within the locality of the Lake Wyangan catchment.

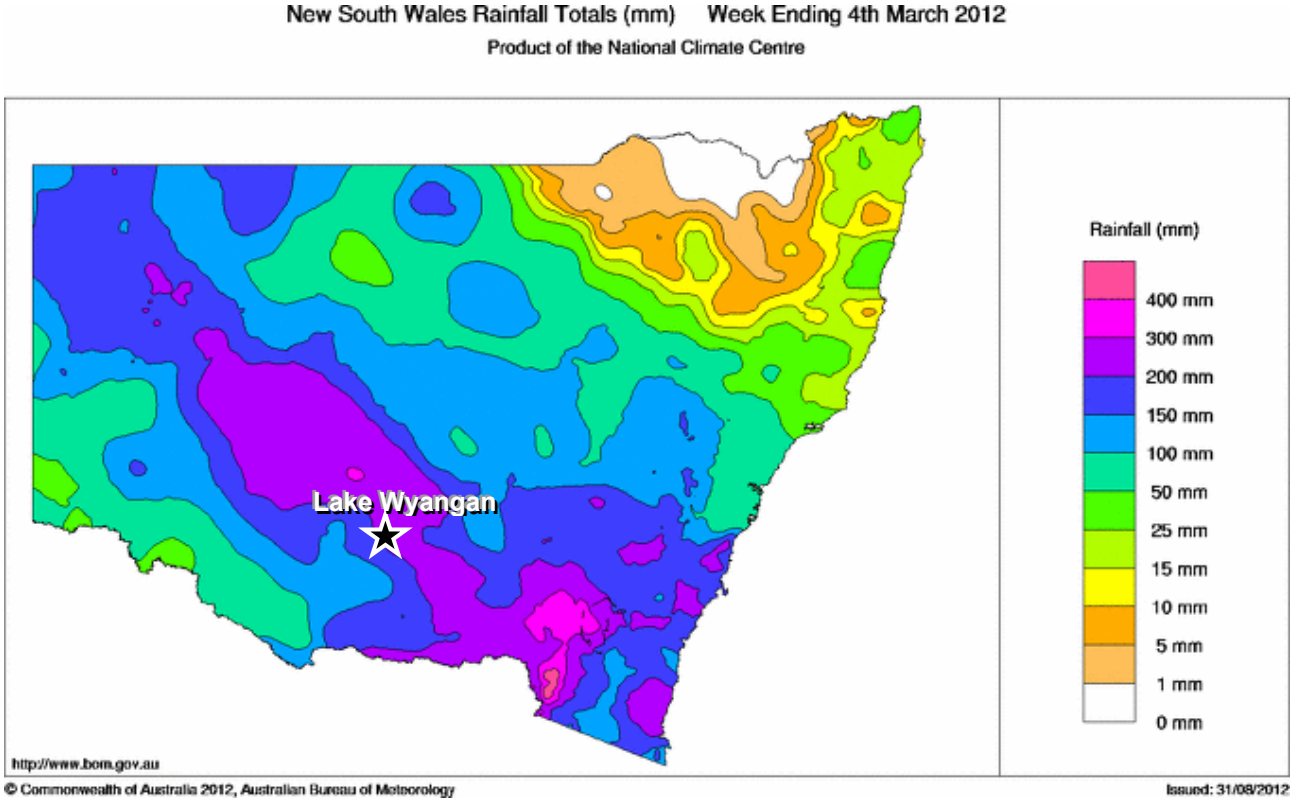


Figure 4-1 NSW Rainfall Distribution Week Ending 4th March 2012

Table 4-1 Recorded Daily Rainfall Totals Week Ending 4th March 2012

Station No.	Name	27th Feb	28th Feb	29th Feb	1st Mar	2nd Mar	3rd Mar	4th Mar
75041	Griffith Airport AWS	0	2.6	30.2	36.8	8.4	13.4	137.2
74118	Whitton (Conapaira St)	22.6	0	30.4	14	8.6	2.8	126.2
74254	Leeton (Fivebough Rd)	6.8	0	27	26	3	0	149.4
75006	Binya Post Office	12	0.8	24	38	7	8	132.2
75025	Goolgowi (Moira St)	0	*	39	31.5	6	29.5	104
75044	Merriwagga (Devon Street)	0.6	4.4	39	0	7.6	*	148.6
75050	Naradhan (Uralba)	1.4	20	74.4	47	12	11.2	99.4
75079	Yenda (Henry Street)	27.6	1.8	24.2	21	16.4	*	149.4
75146	Rankins Springs (Acres)	39	1.6	34	31	8.2	11	110
75166	Darlington Point (St Pauls Close)	30	2.2	48.6	14.6	12.6	4.8	105.6

Note - * indicates no daily reading with combined 2-day rainfall reported on subsequent day

The rainfall totals in Table 4-1 show a general consistency across the region in terms of daily rainfall distribution and the significance of the rainfall for the 4th March with daily totals in excess of 100mm. The rainfall of the 4th March was certainly the condition that resulted in the flooding in the Lake Wyangan catchment. The 50-60mm recorded across the 29th February-1st March would have provided for general wetting up of the catchments prior to the main flood producing rainfall. However, the nature of soils in the catchment is such that infiltration tends to be high with fast recovery from rainfall in terms of soil saturation.

The rainfall hyetograph recorded at Griffith Airport over the week period to the 4th March 2012 is shown in Figure 4-2. The hyetograph shows a period of approximately a day with effectively no rainfall leading up to the main rainfall over the 3rd and 4th of March. Figure 4-3 shows more detailed hyetograph is presented for the main rainfall period providing for some 140mm of rain in approximately 24hours.

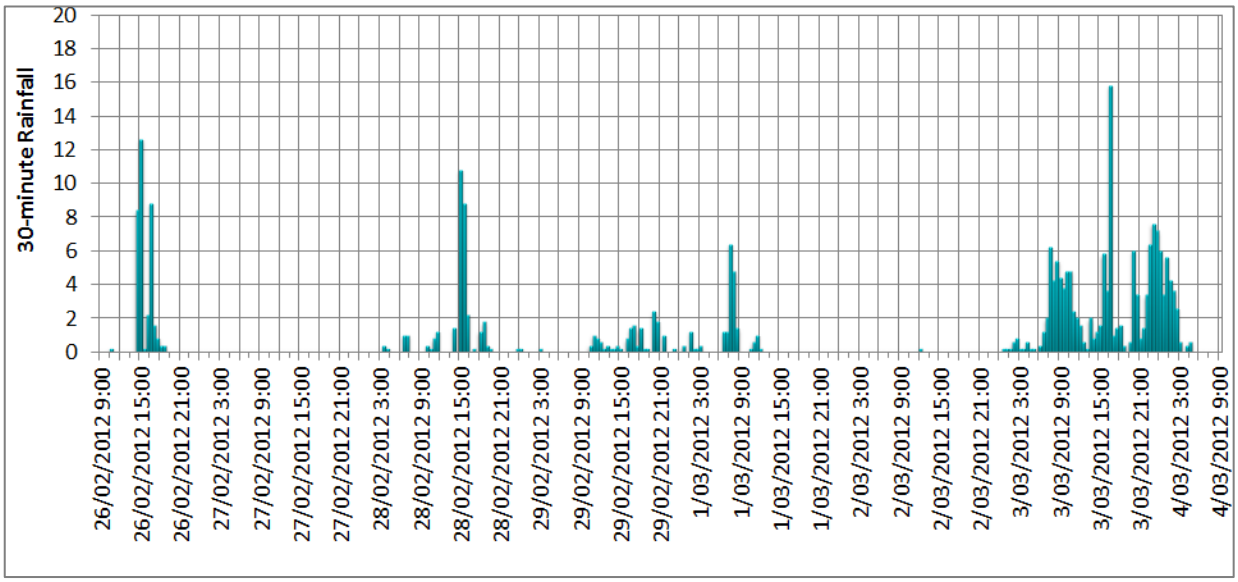


Figure 4-2 Griffith AWS Recorded Rainfall Week Ending 4th March 2012

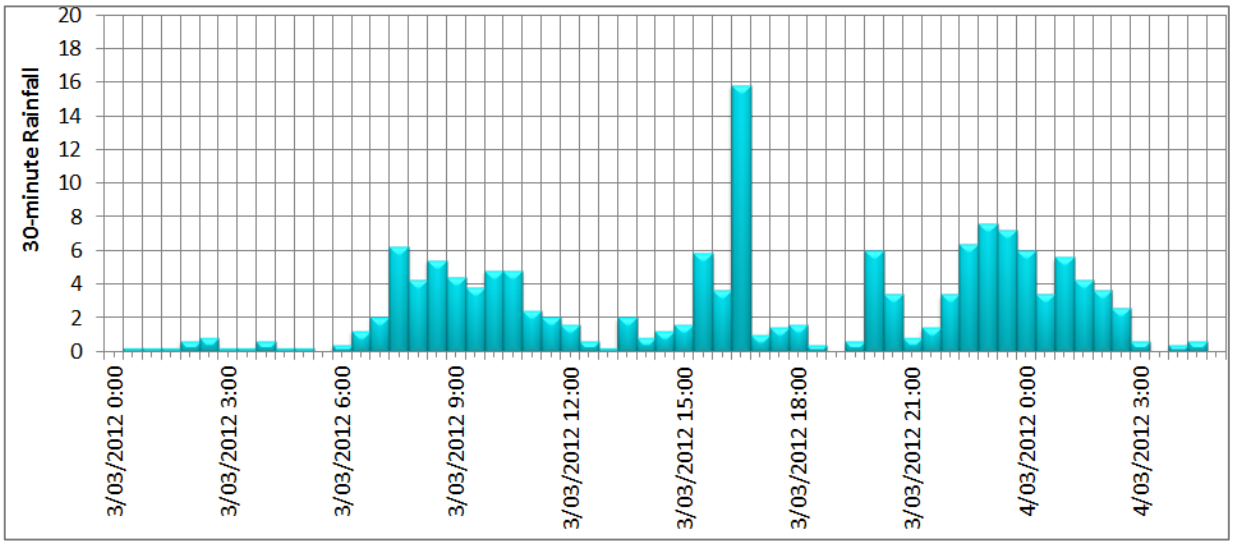
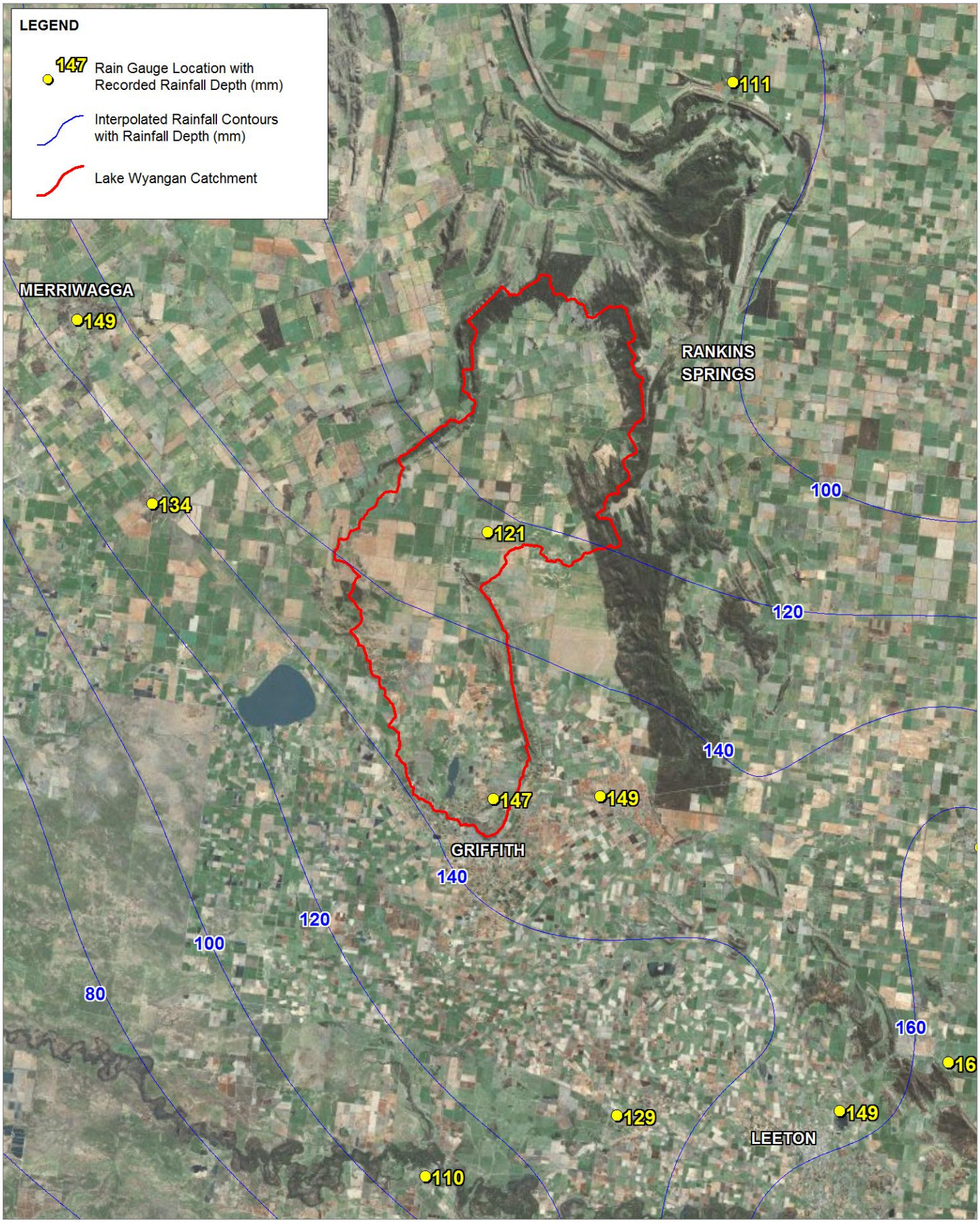


Figure 4-3 Griffith AWS Recorded Rainfall Hyetograph 3rd-4th March 2012

The spatial rainfall distribution for the 2-day recorded totals for the 3rd-4th March is shown in Figure 4-4. Generally it can be seen that a greater rainfall depth was recorded in the southern part of the catchment, however, with totals well in access of 100mm across the entire catchment. Moving from south to north through the catchment the estimated rainfall distribution is largely driven by the recorded totals of 147mm at Griffith in the south, 121mm at Rankins Springs (Acres) in the central catchment and 11mm at Naradhan to the north of the catchment boundary.



Title:

Spatial Variation of Rainfall Depths for the March 2012 Event

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Approx. Scale

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To gain an appreciation of the relative intensity of the March 2012 event, the recorded rainfall depths at Griffith Airport for various storm durations is compared with the design IFD data for Lake Wyangan as shown in Figure 4-5.

The derived depth vs. duration profile for the March 2012 event shows a relatively constant increase in depth with increasing storm duration, also representative of the hyetograph which shows relatively consistent rainfall throughout the event. This gradual accumulation of rainfall over the approximate 24-hour period provides a total rainfall depth of some 143mm, well in excess of the design 1% AEP 24-hour rainfall depth of 117mm. The corresponding recorded rainfall at the Rankins Springs (Acres) gauge of approximately 120mm is also in excess of the design 1% AEP 24-hour rainfall.

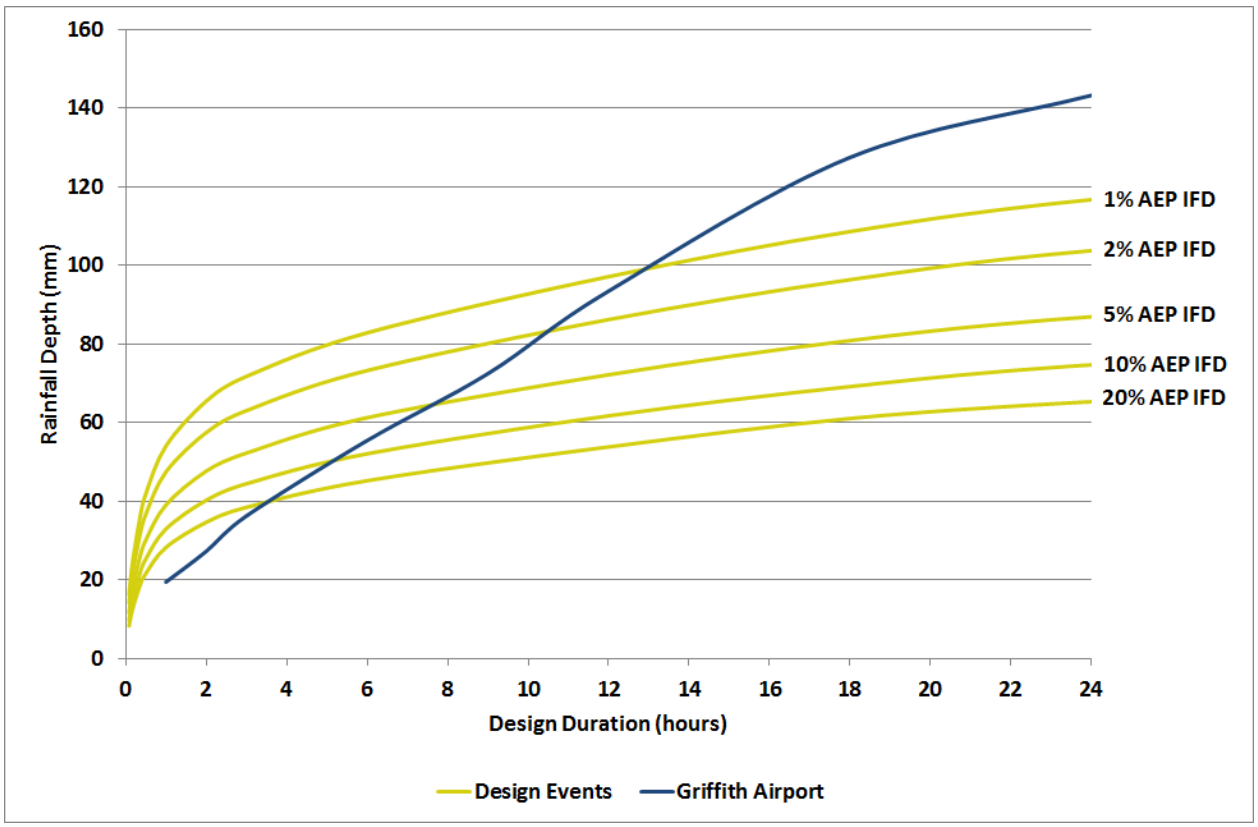
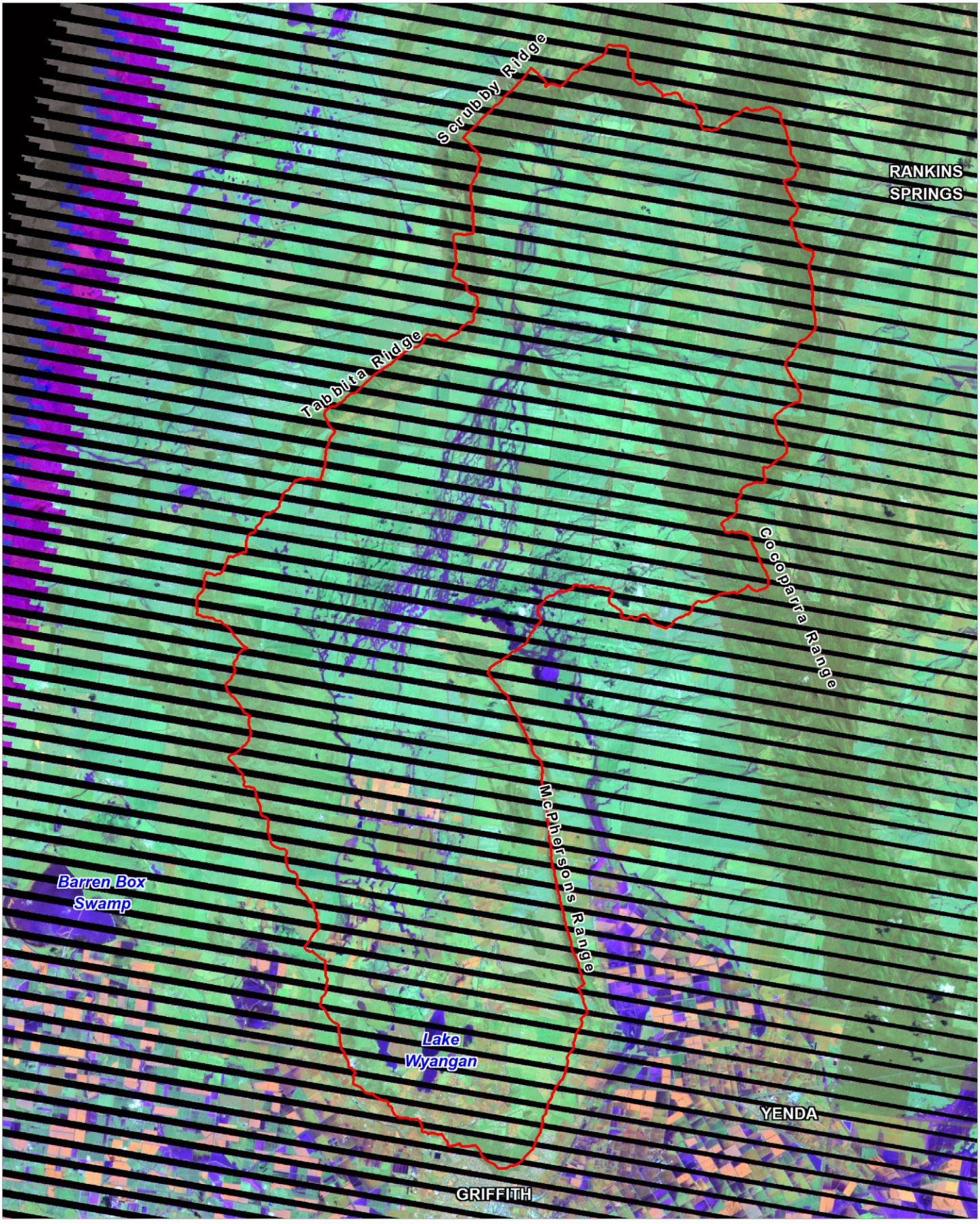


Figure 4-5 Comparison of March 2012 Rainfall with IFD Relationships

The large rainfall received across the entire Lake Wyangan/Tharbogang Swamp catchment provided for the generation of significant runoff. This was captured in a Landsat 7 satellite image on the 4th of March shown in Figure 4-6. The image presented is a false colour composite image using bands 4, 5 and 3 (Near-infrared, Mid-infrared and Red). This combination of bands is useful for identifying water bodies and water content of soils etc. Open water bodies and flood flow paths are clearly defined as blue or black areas.

The image has captured the “front” of the flood flow paths emanating from the upper catchment area. The majority of the flow can be seen to be passing the northern end of the Macphersons Range, moving south towards Tharbogang Swamp. The flows contributed by the southern catchment area can be seen moving along a well-defined flow path towards Tharbogang Swamp.



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Landsat 7 Image - 4th March 2012

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Two of the key outcomes of the Lake Wyangan Flood Study were the confirmation of the total catchment area of Lake Wyangan/Tharbogang Swamp and the confirmation the majority of the area actually drains to Tharbogang Swamp as opposed to Lake Wyangan. The flow path distribution captured in the satellite image provides further confirmation of these catchment characteristics.

The major storages of Lake Wyangan and Tharbogang Swamp are visible in the image. The extent of Tharbogang Swamp at such an early point in the event is notable. However, given the long travel times for overland flows from the upper catchment, the image captured is well before the main flow contributions. Availability of other aerial imagery however captures the extent of Tharbogang Swamp after the event. Figure 4-7 shows the extent of water in Tharbogang Swamp in January 2011, representative of a more typical condition in Tharbogang Swamp, and the extent on 21st March 2012 some two weeks after the flood event. It is understood that the peak water level in Tharbogang Swamp was slightly higher than shown in the aerial image with information from landholders.

23rd January 2011 **21st March 2012** (images Google Earth)

Figure 4-7 Extent of Tharbogang Swamp Pre- and Post- March 2012 Event

The bed of Tharbogang Swamp is typically at around 103.2m AHD. The peak flood level following the March 2012 event is estimated to be approximately 106m AHD. Unfortunately there are not any other recorded historical flood levels in Tharbogang Swamp to provide for a relative comparison. However, the recorded rainfall is known to have been one of the highest daily rainfall totals on record.

Rainfall has been recorded at the Rankins Springs gauge since 1887. Prior to March 2012, the highest daily rainfall total recorded was 94mm (recorded 3rd December 1980, 11th January 1910). The

highest 2-day total recorded was some 126mm (11th January 1910). Accordingly, over some 130years of records the March 2012 rainfall represents the highest recorded rainfall.

The Griffith CSIRO and Griffith Airport rainfall gauges provide a continuous record of daily rainfall from 1914 onwards. The highest daily rainfall total recorded in this period for Griffith was the 150mm recorded on the 20th March 1985. This event was documented in the Lake Wyangan Flood Study and was used for model validation. The intense storm was a localised event centred on Griffith with no corresponding rainfall recorded at the Rankins Springs rainfall gauges. The second highest daily rainfall total recorded was 95mm (recorded for 1st January 1984 and 4th March 1959). Prior to the March 2012 event, the January 1984 and March 1959 events also represent the highest 2-day rainfall totals recorded at Griffith, being 108mm and 113mm respectively.

As discussed in the Lake Wyangan Flood Study, the Tharbogang Swamp catchment is some seven times larger than the catchment of Lake Wyangan. Accordingly, the somewhat smaller catchment area provides for significantly less flood response in Lake Wyangan. The peak flood level for the March 2012 event is approximately 106.5m AHD for Lake Wyangan. This represents only a moderate increase in Lake levels above normal operation conditions.

Considering the rainfall records from Griffith and Rankins Springs, the recorded March 2012 event represents one of most significant rainfall events for broad scale flooding across the whole catchment. Despite the significance of the rainfall event, the inundation patterns observed from March 2012 provided for relatively limited impact on property in the broader catchment. The most significant impacts were limited to inundation of rural holdings, particularly those located along the main identified flow paths in the catchment.

4.2 Design Flood Conditions

The Lake Wyangan Flood Study (BMT WBM, 2012) defined the design flood conditions for a range of design event magnitudes, utilising detailed models of the catchment. With both Tharbogang Swamp and Lake Wyangan being a terminal lake system, and accordingly volume driven in terms of peak flood level condition, the flood conditions are very sensitive to effective runoff.

In assessing historical events, the model calibration process found high rainfall losses to be appropriate for the events considered. The high rainfall losses generate relatively small effective rainfall depths and accordingly lower volume contributions to the lower storages. Again for the March 2012 event, the response in both Lake Wyangan and Tharbogang Swamp was relatively minor considering the significance of the rainfall. This again demonstrated the potential for high rainfall losses in the system.

There are a number of potential losses in the Tharbogang Swamp/Lake Wyangan catchments that influence the effective runoff generated during rainfall events including:

- Initial losses to storage and infiltration -somewhat dependent on the antecedent conditions within the catchment;
- Continuing losses mostly attributed to ongoing infiltration throughout the event, these losses can be high considering the long travel times for flows from the upper catchment ; and

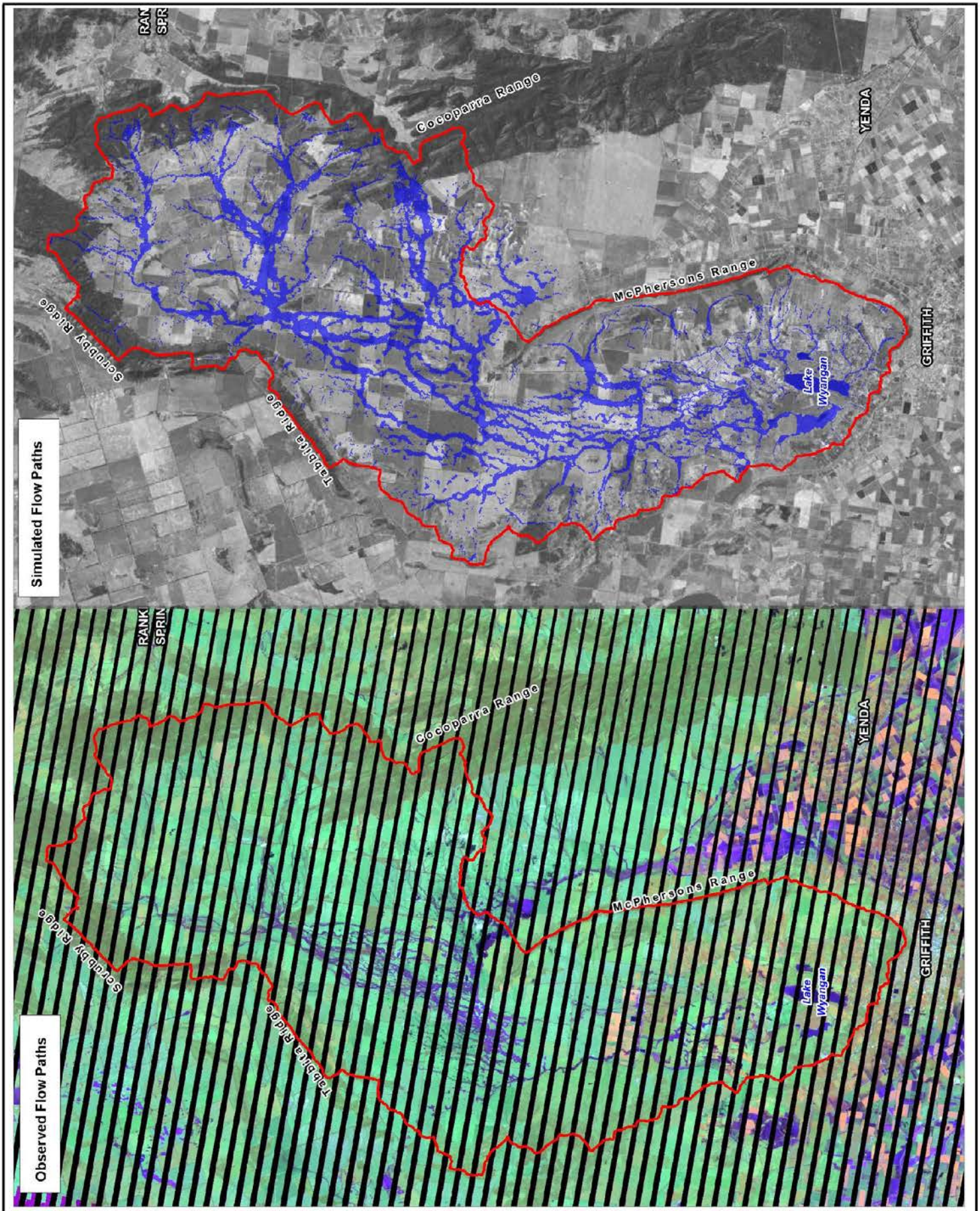
- System storage – the relatively flat nature of the topography and extensive agriculture in the catchment provides for significant storage of floodwater in local depressions and behind embankment features.

The sensitivity of design flood conditions in Tharbogang Swamp/Lake Wyangan to effective runoff was noted in the Flood Study. Table 4-2 shows the modelled peak flood levels within the main storages of the study catchment, for a range of initial loss conditions with the adopted design conditions highlighted in bold text. The results show that the flood levels in both Lake Wyangan and Tharbogang Swamp are highly sensitive to the adopted initial loss conditions. This is due to the large proportion of rainfall volume that is lost and results in a relatively small effective rainfall. The range of modelled flood levels for Tharbogang Swamp is much greater than that of Lake Wyangan. This is due to Tharbogang Swamp having a much larger catchment area than Lake Wyangan, being around seven times the size.

Table 4-2 Summary of Design Flood Levels

	Design Event	Peak Flood Level (m AHD)		
		North Lake	South Lake	Tharbogang Swamp
15mm IL	20% AEP	**106.5**	**106.0**	106.6
	10% AEP	**106.5**	**106.5**	108.1
	5% AEP	**106.8**	**106.8**	109.6
	2% AEP	**107.2**	**107.2**	110.7
	1% AEP	**107.6**	**107.6**	111.6
	0.5% AEP	**108.1**	**108.1**	112.2
35mm IL	20% AEP	106.4	105.9	**103.5**
	10% AEP	106.5	105.9	**104.2**
	5% AEP	106.5	106.0	**105.8**
	2% AEP	106.5	106.5	**108.0**
	1% AEP	106.9	106.9	**109.8**
	0.5% AEP	107.2	107.2	**110.8**
60mm IL	20% AEP	106.3	105.9	103.4
	10% AEP	106.3	105.9	103.4
	5% AEP	106.3	105.9	103.5
	2% AEP	106.5	106.0	104.6
	1% AEP	106.5	106.2	106.6
	0.5% AEP	106.6	106.6	108.5

The design flood levels are highly sensitive to rainfall losses with the typically high losses having been associated with historical events, including March 2012. For the adopted design conditions, more conservative (lower loss) conditions are adopted with the consideration of potentially wetter antecedent conditions, and variation in temporal pattern of rainfall which can influence the effective rainfall.



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Comparison of Observed and Simulated Flow Paths

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4.2.1 Comparison of March 2012 Event to Design Conditions

The principal events generating significant runoff in the Tharbogang Swamp catchment that were used for model calibration in the Lake Wyangan Flood Study were the March 1989 and December 2007 events. The calibration process found that rainfall losses of 60mm initial loss and 4mm/hr continuing loss were appropriate for simulating the observed peak flood level condition.

The developed model was used to simulate the March 2012 event. The initial loss/continuing loss required in the model to match the observed peak flood level condition in Tharbogang Swamp and Lake Wyangan were found to be 70mm initial loss and 6mm/hr continuing loss. Given the rainfall experienced in the March 2012, these losses equate to overall catchment effective rainfall of only some 8-9mm. It is likely that there are significant transmission losses in runoff being conveyed from the upper catchment through to Tharbogang Swamp.

Simulation of the March 2012 event with a 60mm initial loss and 4mm/hr continuing loss provided for a peak Tharbogang Swamp flood level of approximately 110.5m AHD (compared to 106.0m observed) and peak Lake Wyangan flood level of 108m AHD (compared to 106.8m AHD). This again highlights the sensitivity of the system to effective rainfall.

Each of the calibration events, including March 2012, therefore required significant rainfall losses in order to match observed peak flood level conditions in the lower storages. As noted, being a volume driven system the peak flood levels in Tharbogang Swamp and Lake Wyangan are very sensitive to effective rainfall across the catchment.

Lower rainfall losses than those determined from the historical event calibration were adopted for design event conditions in the Flood Study on the basis of:

- limitations of design temporal patterns, and the influence of high initial loss rates in reducing the effective rainfall from the main design burst,
- the 35mm initial loss and 4mm/hr continuing loss represent the upper limits of the recommended loss parameters in AR&R for the NSW zones; and
- potential for wetter antecedent conditions than experienced in recorded historical events.

Given the limitations of the initial continuing loss method, consideration has been given to alternative hydrological methods. The Rainfall Curve Number Method (developed by the former US Soil Conservation Service) is an alternative method for estimating the relationship between infiltration and runoff for given rainfall conditions. The method utilises an empirical function to derive rainfall excess dependent on a runoff curve number for characteristic land cover descriptions and a hydrologic soil group.

In calibrating the March 2012 event using this method, a curve number of 45 was found to best represent peak design flood levels in Tharbogang Swamp and a curve number of 50 for Lake Wyangan. Runoff curve numbers vary from 30 to 100; lower numbers indicate low runoff potential while larger numbers are for increasing runoff potential. The lower the curve number, the more permeable the soil is. The relatively low curve numbers are consistent with the higher initial and continuing losses required for the event. A slightly higher curve number for Lake Wyangan is

considered appropriate given there is some proportion of urbanised catchment and less agricultural lands.

Applying the method with adopted curve numbers to design events provides a comparison to the adopted design flood level conditions summarised in Table 4-2. Given the potential for wetter antecedent conditions and accordingly lower infiltration potential, slightly higher curve numbers of 45 and 50 have been adopted for Tharbogang Swamp and Lake Wyangan catchments respectively.

Table 4-3 summarises the simulated peak 1% AEP flood levels in Lake Wyangan and Tharbogang Swamp for a range of design storm durations. Being a volume driven system as discussed, the longer duration events typically provide for higher runoff volumes, albeit with reduced peak flows in comparison to the shorter durations.

Table 4-3 Peak Flood Levels Using Curve Number Method

Design Event	Peak Flood Level (m AHD)	
	Lake Wyangan	Tharbogang Swamp
1% AEP 18-hour	106.5	105.6
1% AEP 24-hour	106.6	106.4
1% AEP 48-hour	107.0	107.7
1% AEP 72-hour	107.2	109.4

As shown in Table 4-3, the 72-hour duration event provides for peak flood levels of the order of 107.2m AHD for Lake Wyangan and 109.4m AHD for Tharbogang Swamp. These levels compare reasonably well to the adopted 1% AEP design flood levels summarised in Table 4-2.

In all simulations the starting water level conditions in both Lake Wyangan and Tharbogang Swamp are relatively low. For Lake Wyangan, the typical operating level of 106.2m AHD has been adopted. For both storages, there is potential for the initial condition at the onset of a major flood event to be higher. Whilst Lake Wyangan water levels is typically driven by the seasonal irrigation practices, and it is not uncommon for water levels in the system to be higher than 106.2m AHD. For Tharbogang Swamp, the storage has been considered dry at the start of the event. For both storages, there is potential for a major event to follow a smaller event or sustained wet period in which the initial water levels may be higher than typically observed. The potential for these types of conditions warrant some level conservatism in establishing design flood levels.

The adopted 1% AEP design flood levels of 107.6m AHD for Lake Wyangan and 109.8m AHD for Tharbogang Swamp are therefore considered reasonable. Accordingly, the established design flood conditions from the Lake Wyangan Flood Study are considered appropriate for adoption and be used as the basis for floodplain risk management in the catchment.

4.3 Flood Risk Mapping

4.3.1 Hydraulic Categories

Criteria set out in the Floodplain Development Manual (NSW Government, 2005) allow for the floodplain to be compartmentalised into different flood hydraulic categories, generally comprising:

- Floodway;
- Flood Storage; and
- Flood Fringe.

In simplified terms the Manual guides that:

- **Floodways** are 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 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. 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.
- **Flood Fringe** areas are the remaining area of flood prone land after floodway and flood storage areas have been defined.

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual are essentially qualitative in nature, given that flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding.

In accordance with the Floodplain Development Manual, Floodways are areas and flowpaths that convey the majority of flood flows. In simple terms, flood flow at any location can be approximated by the product of velocity and depth (v*d). Using the results of the computer modelling, a v*d threshold was able to be determined wherein approximately 80% of total floodplain flows were contained. For the 1% AEP catchment flood conditions, this threshold was approximately v*d=0.1.

Flood Fringes are non-floodway areas that, if filled, would not have a significant impact on flood levels, velocities and flowpaths. Computer model simulations were again carried out to iteratively assess the differentiation between Flood Storages and Flood Fringes. Based on these modelling results, it was established that for flash flood environments, Flood Fringes are areas where flood depths are less than 0.5m for a 1% AEP event. The resulting definition of flood hydraulic categories is defined in Table 4-4.

Table 4-4 Hydraulic categories

Floodway	Velocity * Depth > 0.1	Areas and flow paths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Velocity * Depth < 0.1 and Depth > 0.5 metres	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Velocity * Depth < 0.1 and Depth < 0.5 metres	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

The hydraulic categories (Floodways, Flood Storages and Flood Fringes) across the Lake Wyangan study area are shown in Figure 4-9.

The general principle is to keep floodways free for flood flow and, in this regard, development is not encouraged. The 1% AEP floodway is reasonably well defined through the existing major flow paths in the lower catchment. The main flood route through to Tharbogang Swamp runs through the rural properties downstream of Dickie Road and the LVBC. This floodway then runs through the Kubank Road estate before discharging into Tharbogang Swamp.

Other identified floodways areas are in the Nericon locality discharging into Lake Wyangan (North Lake), a smaller floodway discharging directly to Nericon Swamp from the east, and a network of floodway in the southern part of the study area discharging to Lake Wyangan (South Lake). All of these floodway areas emanate from the catchment area east of the LVBC.

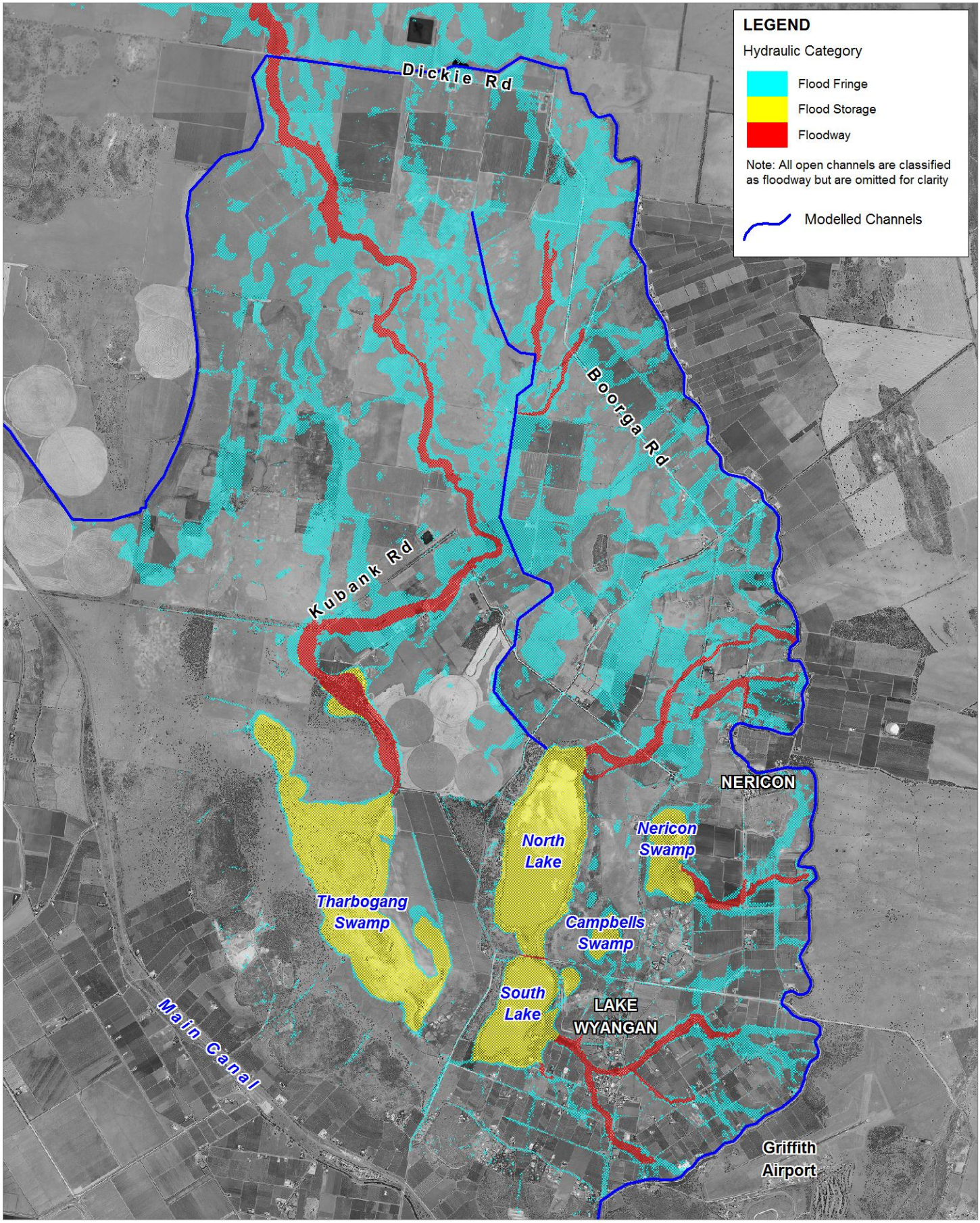
4.3.2 Flood Hazard

Hazard categorisation is carried out to establish how hazardous (i.e. dangerous) various parts of the floodplain are. Primarily the hazard is a function of the depth and velocity of floodwater, however, the hazard categorisation considers a wider range of flood risks, particularly those relating to personal safety and evacuation. These hazard factors are derived from both hydraulic risk factors (such as depths and velocities) and human / behavioural issues (such as flood readiness). These considerations are summarised below in the context of the Lake Wyangan flood environment.

Size of Flood

The size of flood will have an obvious and significant influence on the degree of flood risk. Relatively frequent or minor floods would typically be associated with a low flood hazard, whilst the major or rare flood events are likely to provide for high hazard flood conditions.

Whilst many of the identified overland flow paths may become active in relatively frequent flood events (e.g. up to 10% AEP event), the depth of flooding and peak velocities are such that only low to medium hazard conditions are anticipated. The 1% AEP flood presents substantially greater risk and is the event magnitude primarily used for development planning.



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Hydraulic Categories Defined at the 1% AEP Event

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Depth and Velocity

Depth and velocity hazards have been identified according to the provisional hydraulic hazard categories provided in the Floodplain Development Manual. This has been further sub-categorised to show the predominant „type" of hydraulic hazard (i.e. high velocity, depth, or combination) as shown in Figure 4-10 below.

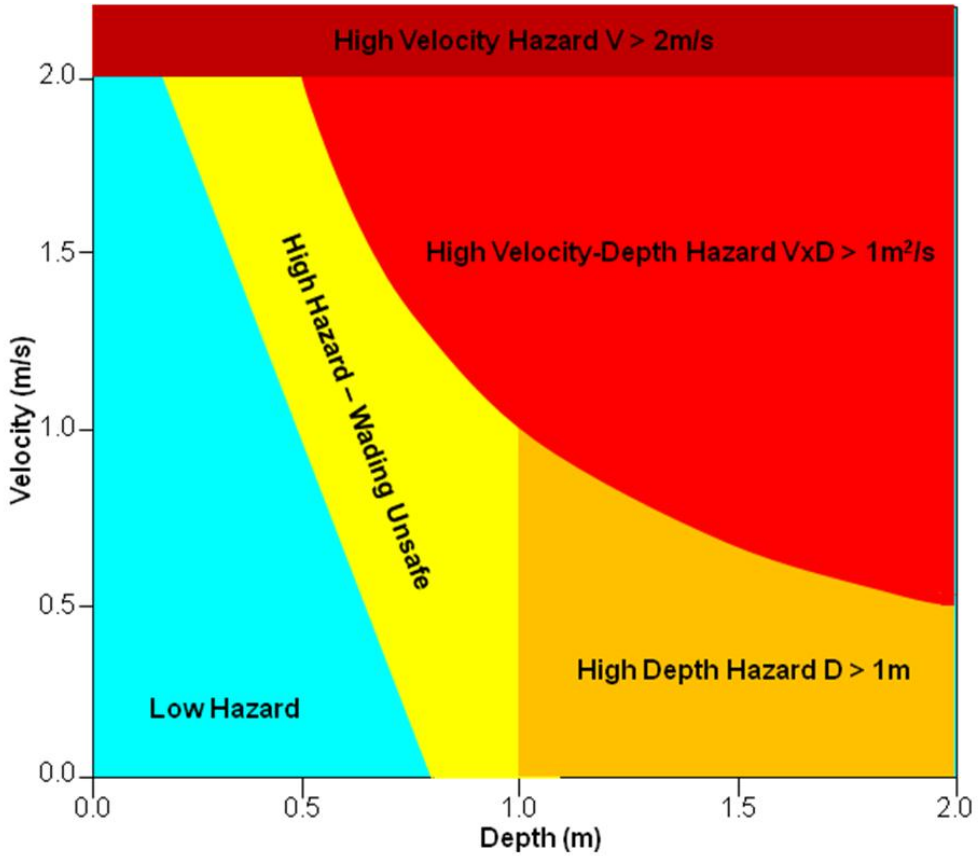


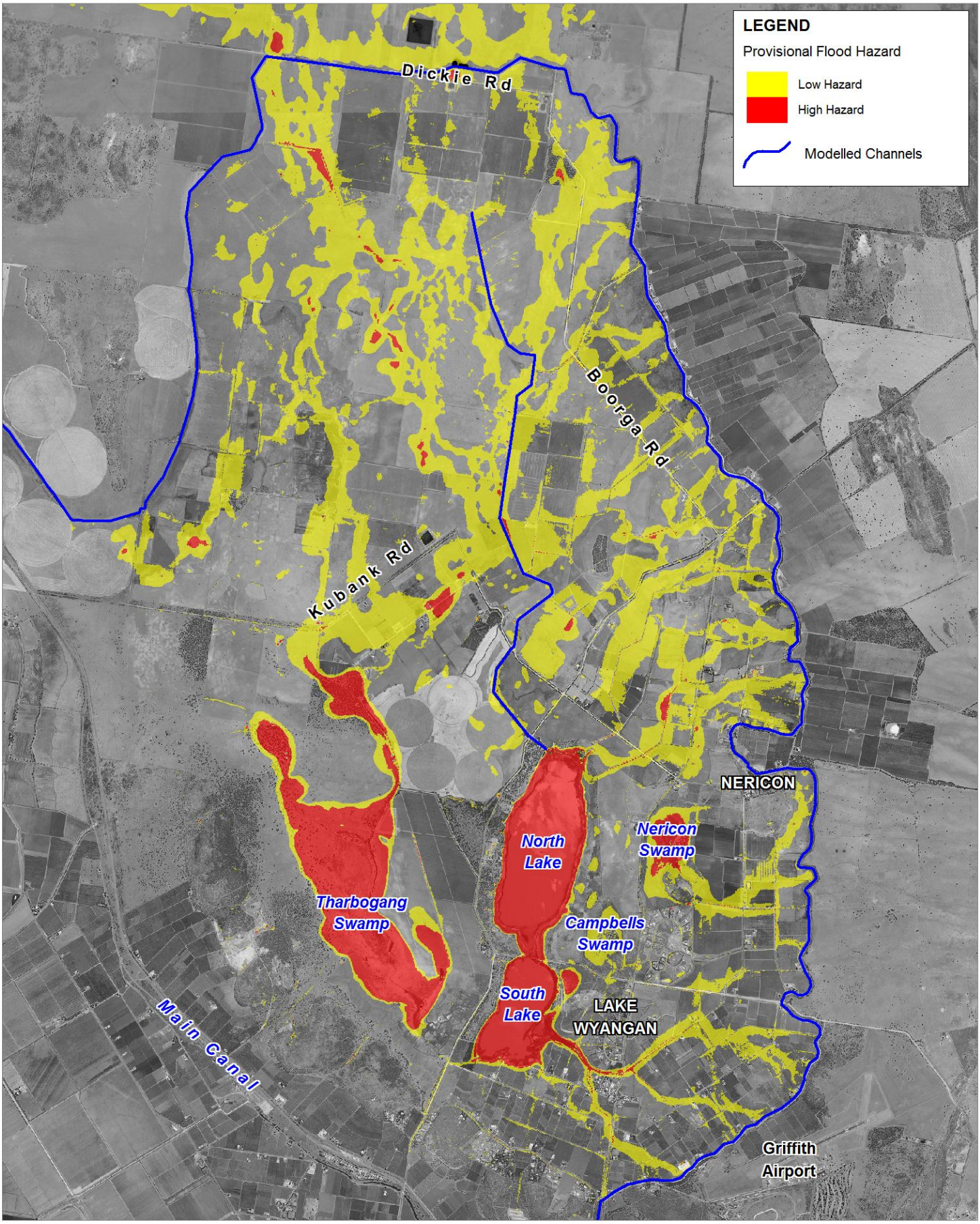
Figure 4-10 Hydraulic Hazard as a function of depth and velocity

The hydraulic hazard defined as a function of the velocity-depth product is shown in Figure 4-11 for the 1% AEP flood magnitude. Outside of the main swamp storage areas, which are high hazard in relation to the storage depths, the remainder of the floodplain is typically classified low hazard. This is reflective of the general flow conditions which are typically relatively low flow depth and low to moderate flow velocity.

There are some high hazard areas however, and these are typically located on the main overland flow paths. These areas generally correspond to the identified floodways shown in Figure 4-9. For events in excess in the 1% AEP event, greater flows will be conveyed in these floodway areas providing for higher hydraulic hazard conditions as result of the higher depth and flow velocities.

Flood Readiness

The term „flood readiness" encompasses a broad range of factors, including familiarity with flooding in the catchment, awareness of evacuation procedures and preparation for a flood (e.g. development of flood plans). Flood readiness can refer to individuals, organisations, communities and businesses.



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Hydraulic Hazard: 1% AEP Event

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Recent rainfall events such as 4th March 2012 and 8th November generating overland flooding have heightened the awareness of the community to flooding within the catchment. However, floods of significantly greater magnitude will occur such that the implications of an event of these magnitudes need to be appreciated by the community.

The majority of existing property more severely impacted by flooding is rural holdings/active farms. Typically the existing farming landholders have a strong understanding and appreciation of inundation and flow patterns on their lot and indeed many are longer term occupiers of the land who have first-hand experience of previous flooding conditions.

Rate of Rise

The rate of rise of floodwaters is typically a function of the catchments topographical characteristics such as size, shape and slope, and also influences such as soil types and land use. Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A high rate of rise adds an additional hazard by reducing the amount of time available to prepare and implement appropriate flood response.

The majority of the study area would typically have a relatively slow rate of rise given the extensive catchment area extending to the north from Rankins Springs. Travel times through the catchment may be of the order of days. In the southern part of the catchment however, the local catchments are somewhat smaller, and with some steeper upper reaches coming off the Macpherson Range. Flood response can be relatively fast. This would have been evidenced in the March 1985 catchment event where a localised storm event provided for some 150mm of rainfall to be recorded at Griffith Airport. Figure 4-12 shows a photograph of the flood condition for this event at the Boorga Rd/Smeeth Rd intersection with high depth and velocity flow areas. With intense rainfall conditions, this type of flow condition may occur within a matter of hours.

Figure 4-12 Flooding at the Boorga Road – Smeeth Road Intersection (March 1985)

Duration of Flooding

The greater the duration of flood inundation the greater the potential impacts on damages and disruption to the community. The duration of flooding is largely related to the size and duration of the rainfall event over the catchment. For areas draining to Tharbogang Swamp, the large size of the contributing catchment area may provide for flow over a number of days as the flood is conveyed through the catchment. For the local catchments draining to Lake Wyangan, the duration of flooding would be expected to be significantly less, perhaps a matter of hours dependent on the rainfall conditions. For areas fringing the main swamp storage areas, i.e. Tharbogang Swamp, Lake Wyangan, Campbells Swamp and Nericon Swamp, the duration of flooding may be measured in the order of weeks. These durations will be driven by the overall flood volumes/storage levels in the system and the relative drawdown over time dependent on evapotranspiration and infiltration to deeper groundwater.

Flood Warning Times

The amount of warning available for an approaching flood can have a significant impact on the risk. Less warning time clearly represents a greater risk to the community as there is less opportunity to respond appropriately and implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

To assess flood warning opportunity for Lake Wyangan, consideration has been given to the levels of warning times as defined in Table 4-5.

Table 4-5 Flood warning time categories

no effective warning	<1 hr	No time for pro-active and systematic organisation of flood mitigation, evacuation, emergency response etc. Individuals would be self-directed in regards to emergency response.
minimal warning	1-6 hrs	Limited assistance and direction likely from emergency services. Measures requiring minimal time for implementation may be appropriate for flood management.
moderate warning	6-12 hrs	Potential assistance and direction from emergency services, depending on time of day. Measures requiring moderate time, or less, for implementation may be appropriate for flood management.
good warning	12+ hrs	Significant assistance and direction from emergency services may be available, including assistance with evacuation. Most measures requiring some form of on-demand implementation would be appropriate for flood management.

Again considering typical flood response, the expected peak flood conditions in the Tharbogang Swamp catchment area may be experienced some 12-124 hours after the onset of flood producing

rainfall. It should be noted however, that for major flood events (e.g. 1% AEP event) inundation to the lowest-lying areas of the floodplain may happen sooner. Given that most of the property affected in the Tharbogang Swamp drainage area is rural/agricultural holdings, there is therefore at least some available warning time which may enable appropriate action to limit damage to farming operations.

For the local southern catchments draining to Lake Wyangan, some flood events may provide for only minimal warning time. The affected areas around Nericon and Lake Wyangan include some residential area, therefore the limited flood warning time may provide for limited external assistance at the onset of flooding. This is a key consideration for future development in the catchment, such that development is undertaken with due consideration of the flood risk and appropriate development controls are in place to ensure that the overall flood risk is not increased through inappropriate development.

Effective Flood Access

Access and evacuation difficulties arise from:

- high depths and velocities of floodwaters over access routes;
- difficulties associated with wading (uneven ground, obstruction such as fences);
- the distance higher, flood free ground;
- the number of people and capacity of evacuation routes;
- the inability to communicate with evacuation and emergency services;
- the availability of suitable equipment (e.g. heavy vehicles); and
- a low level of community awareness of evacuation procedures or requirements.

The major difficulty in the Lake Wyangan catchment for flood access will arise from many local unsealed roads being impassable due to wet conditions.

4.3.3 Adopted Final Hazard Categories

Flood risk, or hazard, is a measure of the overall potential adverse impact of flooding that considers threat to life, danger and difficulty in evacuating people and possessions, and the potential for damage, social disruption and loss of production. The degree of flood risk varies across a catchment. The following categorisation has been adopted in the study consistent with the existing Griffith Flood Liable Lands Policy to identify relative risk within the catchment and to guide planning controls appropriate for the different flood risk categories:

- Low Hazard Flood Fringe;
- Low Hazard Flood Storage;
- Low Hazard Floodway;
- High Hazard Flood Fringe;

- High Hazard Flood Storage;
- High Hazard Floodway.

The final hazard category mapping is shown in Figure 4-13 based on the considerations detailed in 4.3.1 and 4.3.2.

4.4 Flood Planning Levels and Flood Planning Area

The flood planning levels are the flood levels selected for planning purposes, and will directly determine the area of land that should be subject to flood-related building and development controls. Within the Griffith LGA, the Residential Flood Planning Level has been adopted as the 1% AEP (100-year ARI) flood event plus an allowable freeboard of 500 mm.

The Residential Flood Planning Level has been adopted in accordance with the guidelines outlined in the Floodplain Development Manual. A review of various factors that affect the appropriate freeboard, such as risk to life, flood behaviour, social, economic and environment issues established that there is no obvious reason at Griffith to adopt a freeboard above the standard 500 mm.

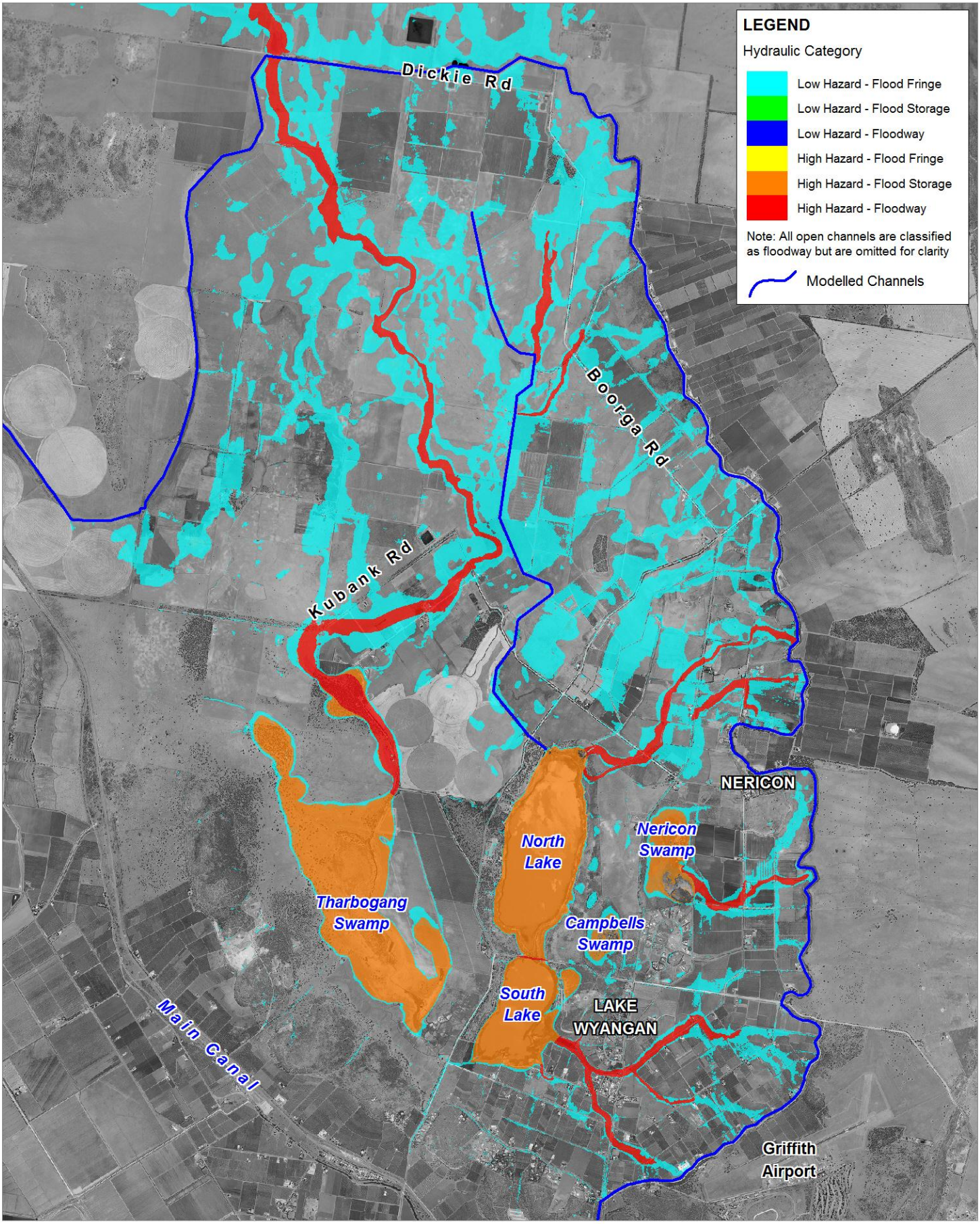
The hazard posed by flooding to residents, as documented elsewhere in this report, has also been considered. Particular attention was given to hydraulic and hazard categorisation. Significantly, the hazard throughout most of the floodplain (excluding the Lake storages) during the 1% AEP event is predominantly low (*refer to Section 4.3.3*). This suggests that hazard associated with flooding is not significant enough to warrant any increase in the standard freeboard. In addition, 500 mm represents the freeboard currently used adopted by Council for residential development in flood prone land.

The 1% AEP (100-year ARI) flood level (plus freeboard) has been retained as the principal floor level control for residential land uses in the Lake Wyangan study area. This is an important component of the proposed planning controls. The decision was based on a consideration of:

- the unacceptable increase in flood risks and damages, should a lower level be adopted;
- an unacceptable impost on future development, if a higher level was adopted;
- inconsistencies with recent development approvals if a level different from the 1% AEP flood was adopted; and
- recognition that the community views the residential floor level control as the principal component of the Council floodplain controls, and that changes to this control should not be made unless very strong arguments exist.

The Griffith Flood Prone Lands Policy identifies a graded set of Flood Planning Levels applicable to different land use as summarised below:

Commercial & Industrial = 1% AEP (100-year ARI) flood level with 25% of the floor area to be 500 mm above the 1% AEP flood level. Council will give consideration to a lower floor level (*absolute minimum 5% AEP (1:20-yearARI) flood level)* only in circumstances to achieve mobility access standards and compatibility with existing street frontages.



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Final Hazard Categories

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Critical Utilities = If at all avoidable, critical utilities should be constructed outside of flood prone land. Where construction of critical facilities within flood prone land is unavoidable, they shall be flood free during the PMF event.

Residential Subdivision = 1% AEP (100-year ARI) + 500 mm freeboard

Manufactured Homes = 1% AEP (100-year ARI) flood level

Garages and Storage sheds = 5% AEP (20-year ARI) flood level

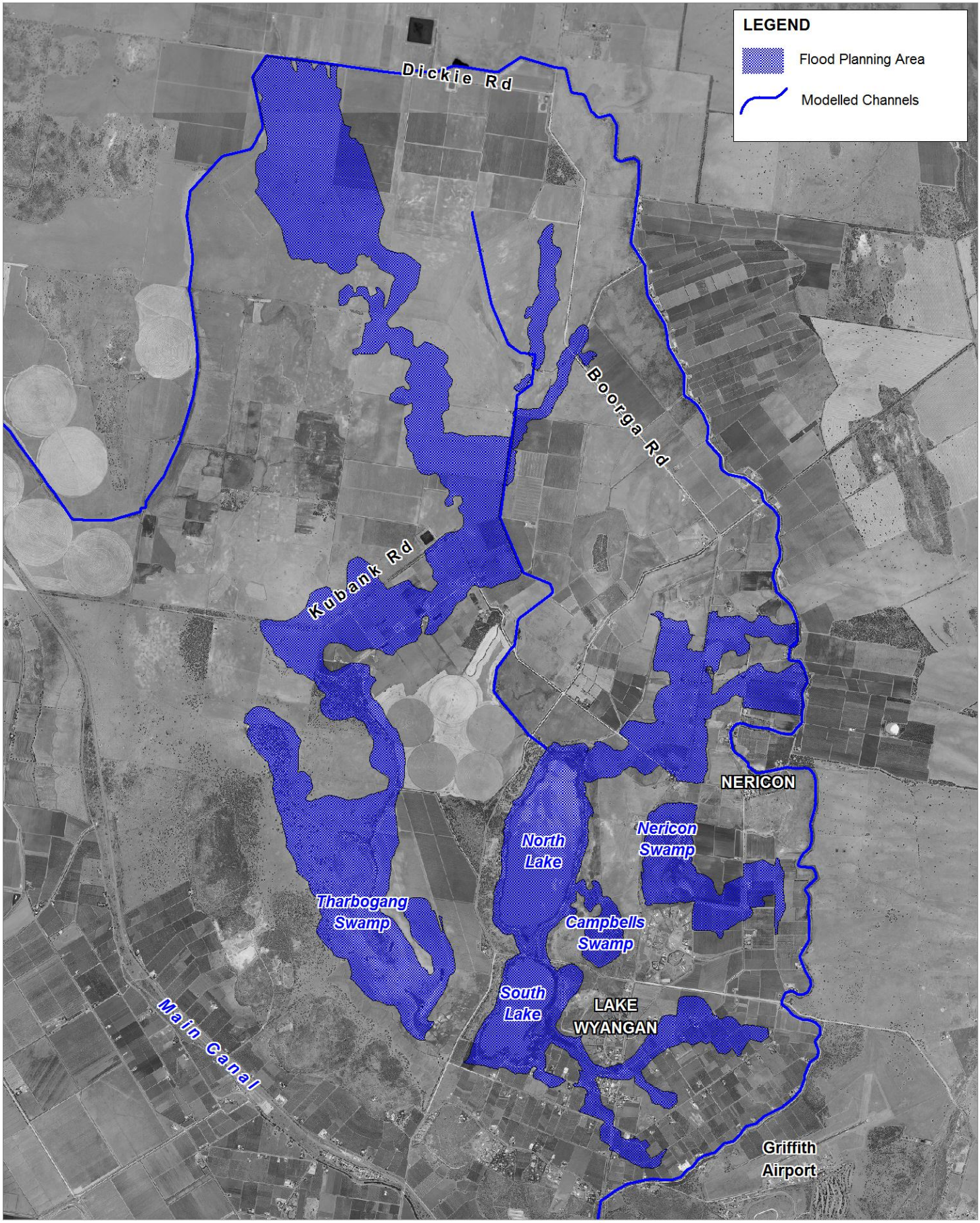
These LGA wide planning levels as espoused in the current policy are considered appropriate for Lake Wyangan study area. In completion of the Floodplain Risk Management Study and Plan for Lake Wyangan, the Council is able to supply the flood planning levels for properties located within the study area.

A summary of the recommended design flood levels, to be used as the basis for FPLs, for the broader storage areas of Lake Wyangan and Tharbogang Swamp is provided in Table 4-2.

Table 4-6 Recommended Design Flood Levels

Design Event	Peak Flood Level (m AHD)	
	Lake Wyangan	Tharbogang Swamp
20% AEP	106.5	103.5
10% AEP	106.5	104.2
5% AEP	106.8	105.8
2% AEP	107.2	108.0
1% AEP	107.6	109.8
0.5% AEP	108.1	110.8
PMF (3x1%AEP)	116.1	116.1

The Flood Planning Level is used to define the Flood Planning Area (FPA), being the area of land that should be subject to flood-related building and development controls. The adopted FPA for the Lake Wyangan study area is shown in Figure 4-14. The FPA is based on the 1% AEP flood level plus 0.5m.



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Flood Planning Area

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5 REVIEW OF EXISTING PLANNING PROVISIONS

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of the Lake Wyangan catchment (as well as across the wider LGA).

A review of existing planning controls has been undertaken with the objective to:

- review the existing planning and development controls framework relevant to the formulation of planning instruments and the assessment of development applications in the Lake Wyangan floodplain, and
- make specific planning recommendations in regards to flood risk management, including an outline of suggested planning controls.

5.1 Local Environmental Plan

A Local Environmental Plan (LEP) is prepared in accordance with Part 3 Division 4 of the EP&A Act 1979 and operates as a local planning instrument that establishes the framework for the planning and control of land uses. The LEP defines zones, permissible land uses within those zones, and specific development standards and special considerations with regard to the use or development of land.

The Griffith Local Environmental Plan 2002 (GLEP 2002) came into effect on 29 November 2002. . Future reviews of the GLEP are being undertaken in accordance with the NSW State Government"s Standard Instrument (Local Environmental Plans) Order 2006, which requires local Council"s to implement a Standard Instrument LEP. The State Government has created the Standard Instrument LEP to assist in streamlining the NSW Planning system.

Clause 26 of the Griffith Local Environmental Plan 2002 relates to development on flood liable land. The LEP provisions incorporate general considerations in regard to development of flood liable land. These provisions require the approval process to consider the impact of proposed development on local flood behaviour, the impact of flooding on the development and the requirements of adopted Floodplain Management Plans that are applicable. Specifically Clause 26 states:

(1) Objectives:

a) To minimise potential flood damage by ensuring that only appropriate development occurs on flood liable land; and

b) To minimise the effects of flooding on the community.

(2) For the purposes of this clause, flood liable land is:

a) land likely to be inundated in a 1 in 100 year flood, as identified on mapping held in the office of the Council, or

b) land likely to be inundated in a 1 in 100 year flood because of topography or proximity to a watercourse or irrigation supply or drainage channel.

(3) Consent must not be granted to development of any flood liable land unless the consent authority has considered:

a) a survey identifying the level of the land relative to the 1 in 100 year flood level, and

b) the likelihood of loss of life or property from flooding, and

c) the likelihood of increased demand for flood mitigation measures and emergency services, and

d) any impediments to the operation of floodway systems in times of flood, and

e) the effect of proposed development on adjoining land in times of flood, and

f) limits on the intensity of development of urban flood liable land, and

g) the provision of services and facilities appropriate to the flood liability of the land, and

h) the effect of the proposed development on the watertable of that land or of land in its immediate vicinity.

The 1% AEP flood envelope is typically used for flood planning purposes as stated in the existing LEP conditions. The Floodplain Development Manual requires consideration of flood risk up to and including the PMF, and indeed the definition of flood liable land on the Manual includes all land up to and including the PMF. It is understood that Council is currently reviewing the LEP in line with the new standard instrument and will include the most recent flood related clause agreed to by the NSW Office of Environment and Heritage (OEH) and Department of Planning.

5.1.1 Land Use

The GLEP 2002 identifies a number of broad land use zones including Rural, Residential, Business, Industrial, Special Uses, Recreation, Environment Protection and National Parks/Nature Reserves. There is no specific zoning category related to flooding.

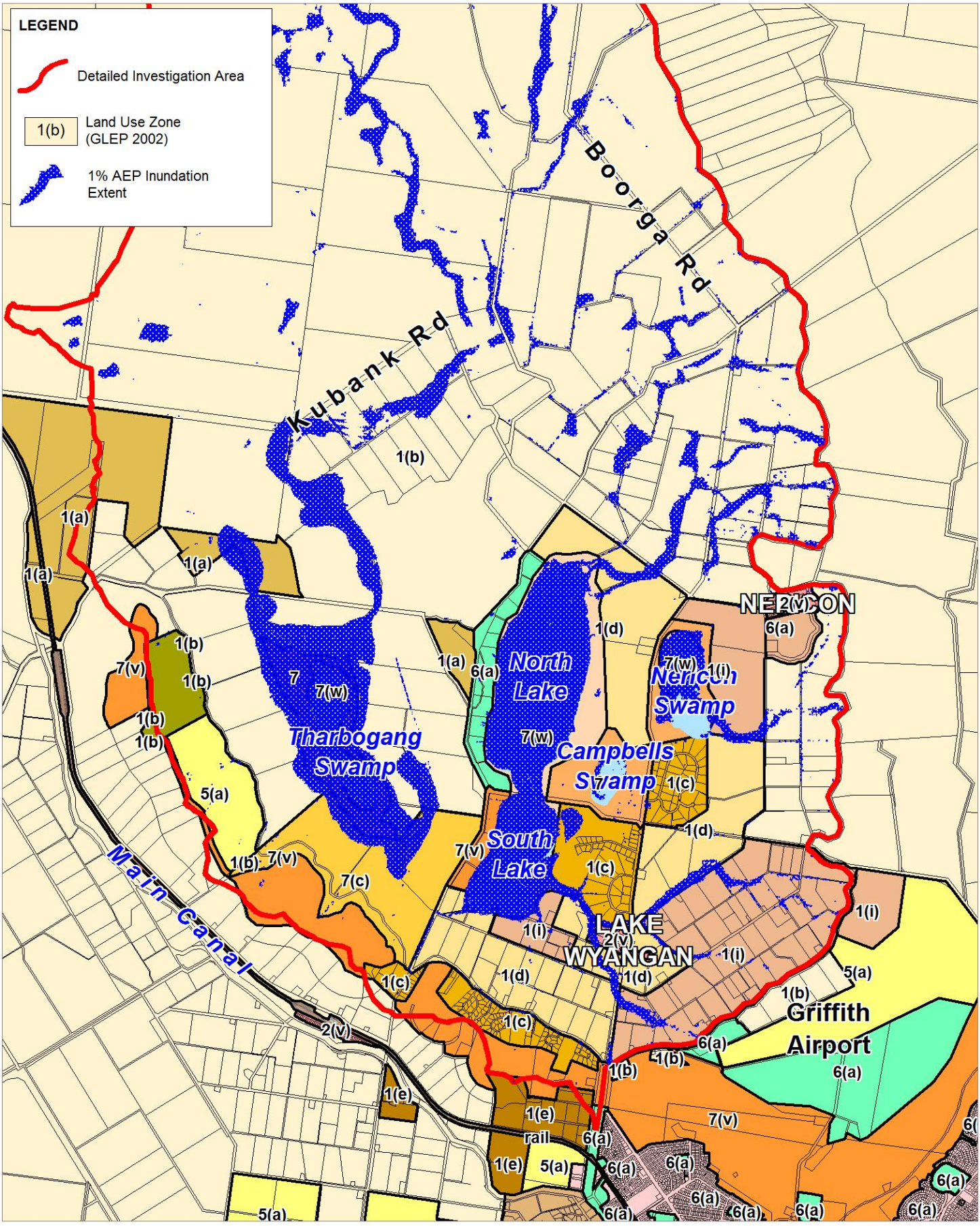
The new LEP template introduces a new suite of pre-defined land use zoning categories, aimed at providing consistency from one LGA to the next. Council will be required to assign land use zonings to all areas within the LGA, including existing and future development areas, based on stated objectives for each zoning and provisions made for each zoning.

The existing land use zonings in the Lake Wyangan Floodplain Risk Management Study area is shown in Figure 5-1. The 1% AEP flood inundation extent is shown as an overlay on Figure 5-1. There are a number different existing zone areas which

Zone 1a – Rural - largely provides for existing agricultural land to be maintained.

Zone 1b – Rural Agricultural Protection – the objective of the zone is to preserve areas of higher agricultural quality.

Zone 1c – Rural Residential – provides for large lot rural residential subdivision.



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Land Use Zoning

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Zone 1d – General Expansion –provides for potential further expansion of residential area (possibly higher density).

Zone 1i – Investigation –land identified as needed for a long-term future designated land use.

Existing development is generally consistent with the land use zonings. Current rural land use zonings within Lake Wyangan would limit the amount of future new development within the flood planning area. There is however planned development within the general expansion areas and investigation zones. Typically these areas sit outside the main flood extents of the Tharbogang Swamp and Lake Wyangan storages; however, there are local flood flow paths that require consideration in any future development. Appropriate development controls for new development are required with consideration of the flood risk.

5.2 Development Control Plans

A Development Control Plan (DCP) is established under the provisions of Part 3 Division 6 of the EP&A Act 1979. A DCP provides more detailed provisions with respect to development in particular areas, and is to be considered by Council in determining development applications.

It is understood that Council are currently developing a consolidated DCP. It is anticipated this document will coordinate with the structure of the revised Griffith LEP in preparation. The new DCP should contain detailed planning controls that support the LEP update and Land Use Strategy: Beyond 2030 and both must be considered when planning the development of land within Griffith LGA.

The purpose of a DCP from a floodplain risk management perspective is to provide a practical application of Council"s Flood Policy and is to be taken into consideration by Griffith City Council when exercising its environmental assessment and planning functions in relation to new development within the Griffith LGA.

The DCP should address the directions in flood risk management that are embodied in the NSW Government"s *Flood Prone Land Policy* and which are emphasised in the 2005 edition of the government"s *Floodplain Development Manual*.

Council has adopted the Griffith Flood Liable Lands Policy (developed as part of the Griffith Floodplain Risk Management Plan, Worley Parsons 2012). This policy presents a set of flood related assessment criteria to guide the assessment of future development.

The general objectives of the policy are:

1) to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property;

2) to reduce private & public losses resulting from floods, utilizing ecologically positive methods wherever possible;

3) to alert the community to the hazard and extent of land affected by potential floods;

4) to inform the community of Council"s policy in relation to the use and development of land affected by potential floods;

5) to deal equitably and consistently with all matters requiring Council"s approval on land affected by potential floods, in accordance with the principles contained in the *Floodplain Development Manual* issued by the NSW Government;

6) to increase public awareness of the potential for flooding across the range of flood events up to the probable maximum flood level; and

7) to ensure that planning and development of essential services and land use generally makes appropriate provision for flood related risk.

The Flood Liable Lands Policy provides an overarching policy for development across the Griffith LGA. No requirements for specific controls additional to the current requirements of the policy have been identified for the Lake Wyangan catchment. Nevertheless, as a matter of course in completion of the Lake Wyangan Floodplain Risk Management Study, the current Policy needs to be updated to incorporate the findings, particularly the establishment of design flood conditions and mapping to be used in land use planning and development control as discussed in 4.4.

Specifically, the following sections of the existing Policy require amendment to acknowledge the Lake Wyangan Floodplain Risk Management Study and Plan upon adoption:

- Section 4.4.3 – Existing Provisional Hydraulic and Hazard Category Mapping : final hydraulic and hazard category mapping has been prepared as per Section 4 of the current study ; and
- Section 5 - Flood Planning Level : flood panning levels and the corresponding flood planning area has been prepared as per Section 4 of the current study.

Other LGA wide clauses in the Policy, including relevant planning controls, are appropriate for the Lake Wyangan study area. As these existing controls have been written into the Policy with an LGA wide basis, no further amendments would be required for application to the Lake Wyangan study area.

5.3 Future Catchment Development

Griffith"s first comprehensive spatial planning strategy, GS 2030, was drafted and adopted by Council during 2000. The GS 2030 provided a 30-year vision on the future land use in the Griffith LGA. A number of future development areas were identified in Lake Wyangan within GS 2030. These areas broadly represented the *1d* general expansion zones and *1i* investigation zones within GLEP (2002).

The draft Griffith Land Use Strategy - Beyond 2030 (Griffith City Council, 2012) presents an updated land use strategy utilising additional information compiled since GS 2030, including the completion of a number of flood studies within the Griffith LGA.

The Land Use Strategy includes a series of mapping identifying the future land use vision across the Griffith LGA. This mapping has been consolidated in Figure 5-2 for the Lake Wyangan study area. The future land use for the majority of the study area remains unchanged, largely consisting of:

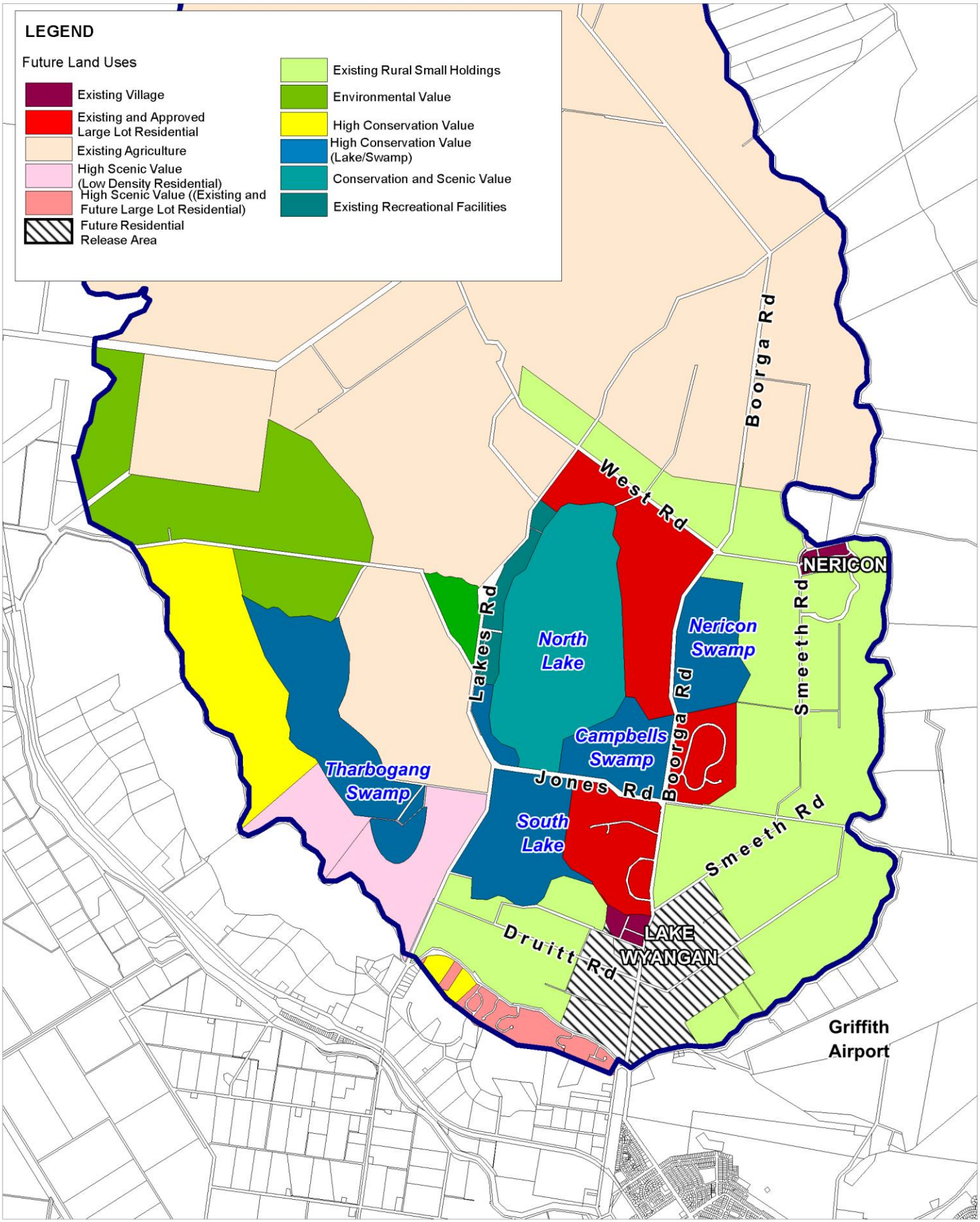
- Existing agriculture;

- Existing rural small holdings; and
- Environmental and conservation surrounding the Lake Wyangan and Tharbogang Swamp water bodies.

Future catchment development includes:

- Development on existing approvals - e.g. Sunset Waters, Pelican Shores estates, Council subdivision and Catanzariti located on the eastern foreshore areas of Lake Wyangan North and South Lakes; and
- Future Land Release – identified area to the south of the existing Lake Wyangan Village (refer to Figure 5-2).

The future land releases provide for urban expansion into the Lake Wyangan locality. One of the major constraints to future development will be the consideration of flood risks. This is discussed further in Section 0.



Title:

Growth Strategy - Future Land Uses

Figure: 5-2

Rev: A

N

0 1 2km

Approx. Scale

BMT WBM

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6 POTENTIAL OPTIONS FOR IMPROVING FLOOD MANAGEMENT

Given the nature of flooding within the Lake Wyangan/Tharbogang Swamp catchment, current flood risk exposure is somewhat limited relative to other catchments within the Griffith LGA. The general flooding condition is typically characterised by relatively shallow depth of flow, with some more significant flow path areas that have been categorised as key floodways (refer Figure 4-9). The extent of affected existing residential property, particularly within the floodway areas, is limited given that much of the existing land use is rural small horticultural holdings. Layout of existing farm properties also typically consider natural flow paths driven by the local topography.

There is considered little opportunity or indeed requirement for structural options to mitigate existing flooding risks given both the nature of flooding and limited flood risk exposure to existing property. Accordingly, the floodplain risk management plan for the catchment focuses on appropriate planning and development controls to ensure future development does not unduly exacerbate the overall flood risk.

There are a number of sensitive areas/issues within the catchment which require more detailed consideration in terms of ongoing floodplain risk management. Further discussion on these areas is provided in the following sections.

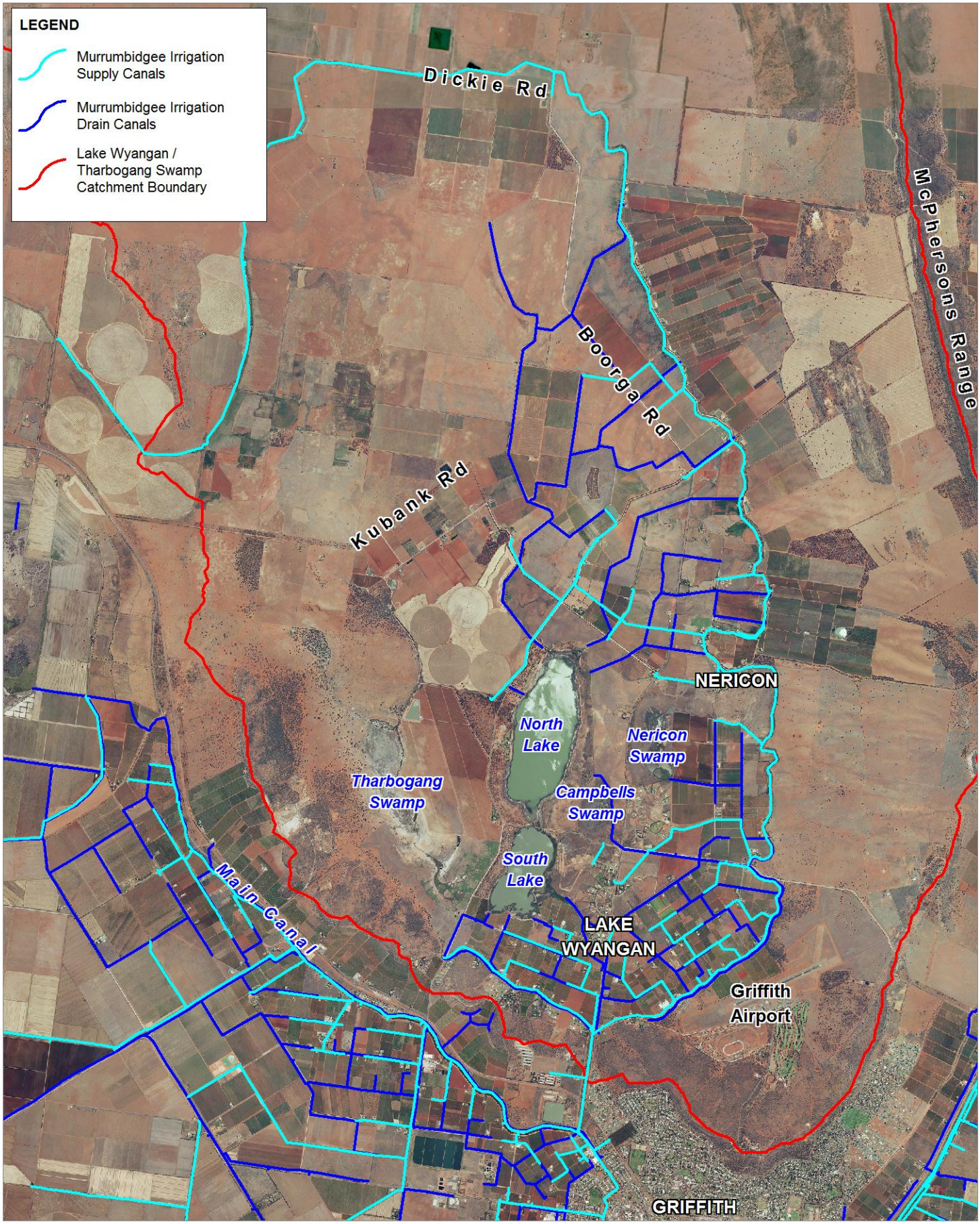
6.1 Murrumbidgee Irrigation Infrastructure

The overall flood inundation patterns within the catchment are principally driven by the underlying topography. However, there are a number of key infrastructures that provide for some level of control on regional flood behaviour. The most significant of these are the major Murrumbidgee Irrigation works, principally the Lake View Branch Canal (LVBC) and Lake View Drain (LVD). The alignment of the LVBC and LVD in relation to the natural overland flow paths is shown in Figure 6-1.

The LVBC is typically elevated above the natural ground surface level providing a barrier to overland flows generated upstream. Cross drainage is provided through siphon type structures along the length of the Canal providing for conveyance of floodwater. Siphon locations are nominally located at existing flow paths providing for appropriate drainage of the upstream catchment areas.

Given the Lake View Branch Canal does act as a barrier to upstream flow, some attenuation of flood flows is expected as flood waters build behind the embankment, with drainage limited by the performance of the siphon structures. Additionally, in the event of overtopping of the LVBC, some floodwater is potentially conveyed within the drain through to the Warburn outlet. Accordingly, the LVBC in its current state may provide for some small level of flood reduction to downstream areas as a result of the diversion and attenuation of flood discharges.

Future changes to the LVBC through potential upgrades/modifications are unlikely to result in significant diversion or redistribution of floodwater considering local topography. There may be some minor change in the flow rates and timing as a result of changes to the existing siphon performance and overtopping of the embankment. It is anticipated that the potential changes to existing flooding regimes would not have a significant impact on the broader catchment flood behaviour. Nevertheless, as a matter of course, the assessment of major work on the existing LVBC will need to incorporate appropriate assessments of the potential flood impact.



Title:

Murrumbidgee Irrigation Supply and Drain Canal Infrastructure

Figure: 6-1

Rev: A

N

0 1.25 2.5km

Approx. Scale

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Perhaps the more critical infrastructure in terms of potential changes to the existing flood behaviour in the catchment is the LVD. The LVD provides irrigation drainage for agriculture located to the north and north-east of Lake Wyangan. The Drain discharges to the north-west corner of the North Lake. The Drain cuts through the ridge that separates the natural catchments of Lake Wyangan and Tharbogang Swamp and as such provides for potential cross-catchment flow transfers.

The top of bank of the LVD typically sits above natural surface and thereby represents an obstruction to overland flow. In relatively simple terms, this provides for any overland flows generated to the east of the LVD alignment to be directed towards Lake Wyangan North Lake, with the overland flows generated to the west of the LVD alignment directed towards Tharbogang Swamp. The design flood level conditions established in the Flood Study are therefore based on this flow distribution.

The existing LVD is somewhat limited in capacity with its existing cross sectional area– it is largely an agricultural drain rather than a major flood channel. Accordingly the LVD only provides for moderate drainage flows to Lake Wyangan.

Whilst the LVD remains in its existing state, acting as a barrier to flow exchange between the Tharbogang Swamp and Lake Wyangan catchments, the existing flow distribution on which the current design flood levels are based will be maintained. Future changes to the LVD as result of upgrade or modifications works that potentially change the flow distribution would require further consideration of the impact on design flood conditions, particularly any substantial increase in flows to Lake Wyangan. The existing flood models developed for the catchment can be used to assess the impact of any future development on flow distribution and resulting peak flood conditions.

Recommendation PL6 and PL7 of the Griffith Floodplain Risk Management Plan (Worley Parsons, 2012) related to the ongoing management of Murrumbidgee Irrigation infrastructure, specifically stating:

- PL6 - The Memorandum of Understanding (MoU), which has been developed to define Council"s and Murrumbidgee Irrigation"s responsibilities in regard to ownership, maintenance and upgrade of drainage channels be adopted by both organisations.
- PL7 - Subsequent to PL6, Council and MI should modify their drainage schedules to adhere to the MoU.

These overarching recommendations should also incorporate the infrastructure within the Lake Wyangan study area. The following elements are critical in maintaining existing flow distribution in the Lake Wyangan/Tharbogang Swamp catchment and accordingly are recommended to be operated and maintained as such:

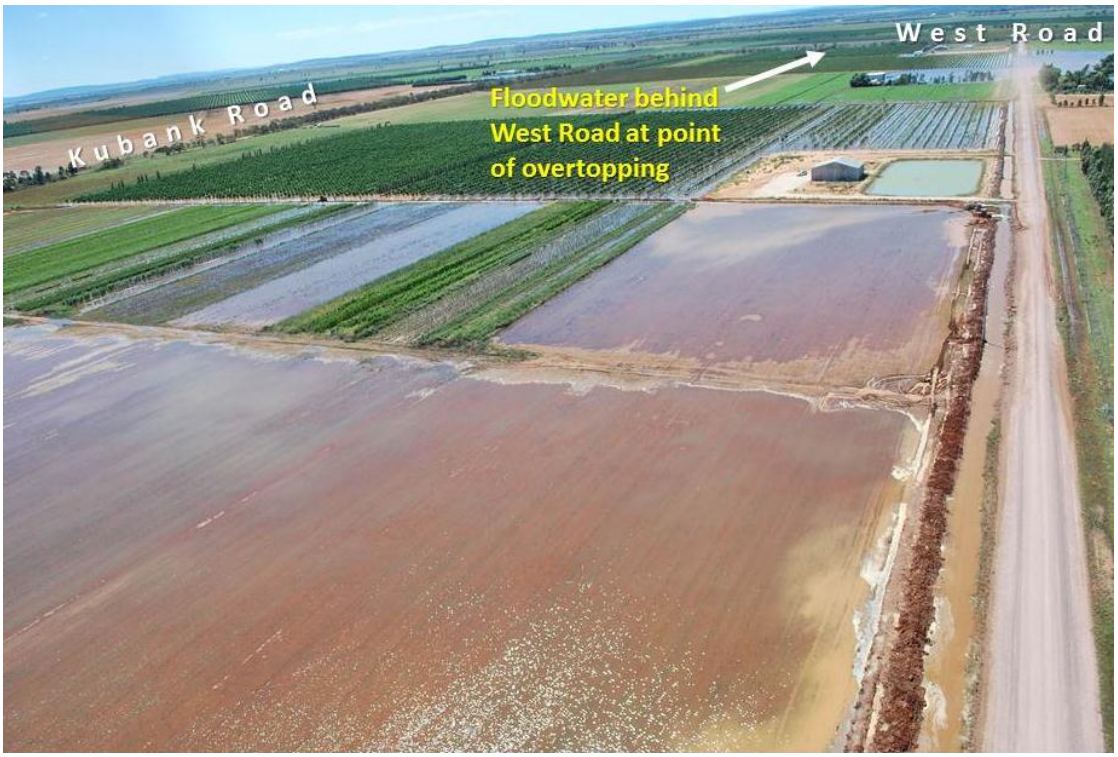
- Lake View Branch Canal;
- Lake View Drain; and
- All cross drainage structures (e.g. siphons/pump systems) in the LVBC.

Any future changes to major infrastructure will require an assessment of the potential change in flow distribution between Lake Wyangan and Tharbogang Swamp and any associated impacts.

6.2 Kubank Road Estate

The Kubank Road Estate contains a number of existing rural small holdings located on the main flowpath into Tharbogang Swamp. A number of recent events including the March 2012 flood event resulted in significant inundation in this locality. The existing topography is such that the majority of flood flows are conveyed through the existing properties resulting in significant inundation to the farms.

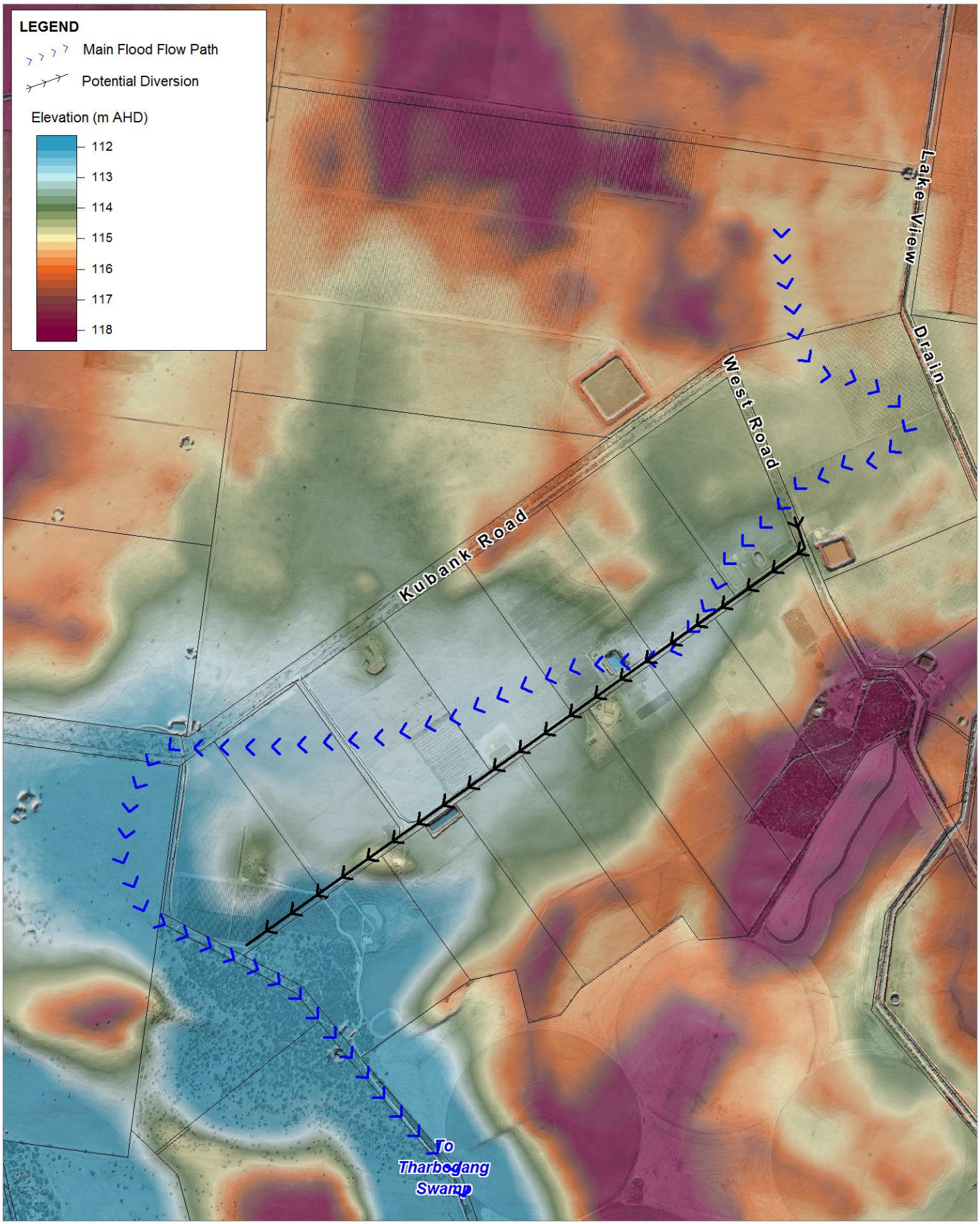
Flows enter the estate through overtopping of West Road at its low point some 500m south of Kubank Road. From the point of overtopping, floodwater tends to generally spread across the downstream properties, providing for widespread inundation. The photograph shown as Figure 6-2 is from the March 2012 event showing inundation of the Kubank Road estate farms. Indicated on the photograph is the floodwater from the main catchment flowpath, pooling behind West Road near the point of overtopping, a condition of which has been simulated in design flood modelling. The local topography is shown in Figure 6-3 clearly showing the main flow path alignment through the existing properties.



Photograph courtesy of V.Mancini

Figure 6-2 March 2012 Inundation at Kubank Road property

From discussion with local landholders, similar flooding was experienced in December 2007. This flooding reported in the Lake Wyangan Flood Study with the December 2007 event utilised for model validation. Some 75mm of rainfall fell in a period of 4-hours on 21st December 2007 contributing to the generation of significant runoff and the resulting inundation at Kubank Road. Based on the design IFD rainfall estimates, both December 2007 and March 2012 were significant rainfall events, with estimated return periods in excess of 50-years and 100-years respectively.



Title:

Local Topography - Kubank Road

Figure: 6-3

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N

0 375 750m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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The nature of the soils in the catchment and the long flow path distance from the upper catchment to Tharbogang Swamp are such that there are significant infiltration losses even during major rainfall events. Accordingly, it is estimated that of the order of 60-70mm of rainfall is required to generate significant runoff in the catchment. This magnitude rainfall was experienced in December 2007 and March 2012.

There is perhaps little opportunity to change the natural flooding regimes through the Kubank Estate which is located on the main flow path alignment of the Tharbogang Swamp catchment. Some on-farm works to locally control the inundation on-site may be possible depending on the volume and flow rates of floodwater spilling across West Road. However, in major events, as experienced in March 2012, it is unlikely that on-farm management of floodwater will be possible given the magnitude of the flood volumes passing through the site.

Figure 6-4 shows the simulated flow hydrograph for the March 2012 event flowing across West Road into the Kubank Estate. There are three key characteristics of the hydrograph which demonstrate the scale of the flooding issue:

- Peak flow in excess of 10m^3/s – to contain a peak flow of such magnitude would require a significant channel;
- The flow volume (represented by the area under the curve) is in excess of 1.2million cubic metres; and
- The duration of flow – flow through the site would typically extend for days as flows progress from the upper catchments through to Tharbogang Swamp.

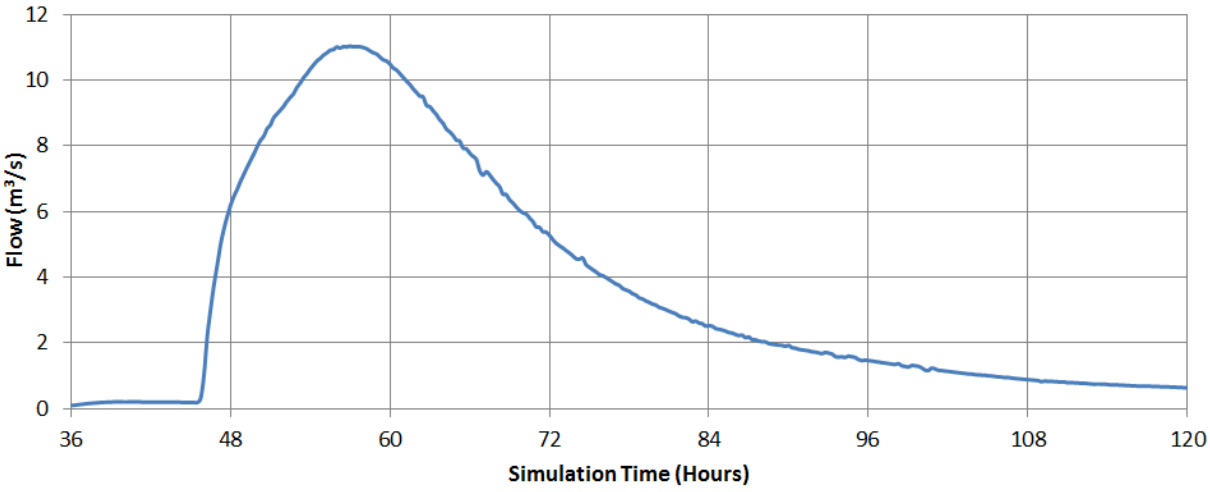


Figure 6-4 Simulated Flow Hydrograph through Kubank Estate – March 2102 Event

The March 2012 event was a very significant rainfall event, and it would appear to be difficult to completely manage flows of this magnitude. Nevertheless, the impact of lesser flood events may be able to be reduced and perhaps frequency of inundation to the estate.

Given the magnitude of the flood volumes, it is not considered feasible to provide temporary flood detention upstream that would sufficiently attenuate the peak flow conditions. Also given that all of the upstream lands are private holdings, there would seem little opportunity for upstream detention.

There is some opportunity for flow diversions through construction of a drainage channel aligned along the roadway as shown in Figure 6-3. The example alignment shown is from the low point in West Road (the point of spilling into the Estate), along the existing road alignment and returning discharge downstream of the estate to the existing flow alignment into Tharbogang Swamp.

The topography along alignment shows some undulation, however, it is anticipated a suitable channel gradient could be obtained (natural grade approx. 1 in 2000). A channel formation consisting of a trapezoidal channel with 5m base width, 1 m depth and grade of 1 in 2000 may be expected to have a capacity of the order of 4 to 5m^3/s.

There are a number of potential constraints however which would need to be considered in further detail, e.g. shallow grades, available land, maintaining existing property access, impacts on neighbouring property etc. It is recommended that Council undertake a further detailed investigation of the feasibility of a diversion channel for the Kubank Estate.

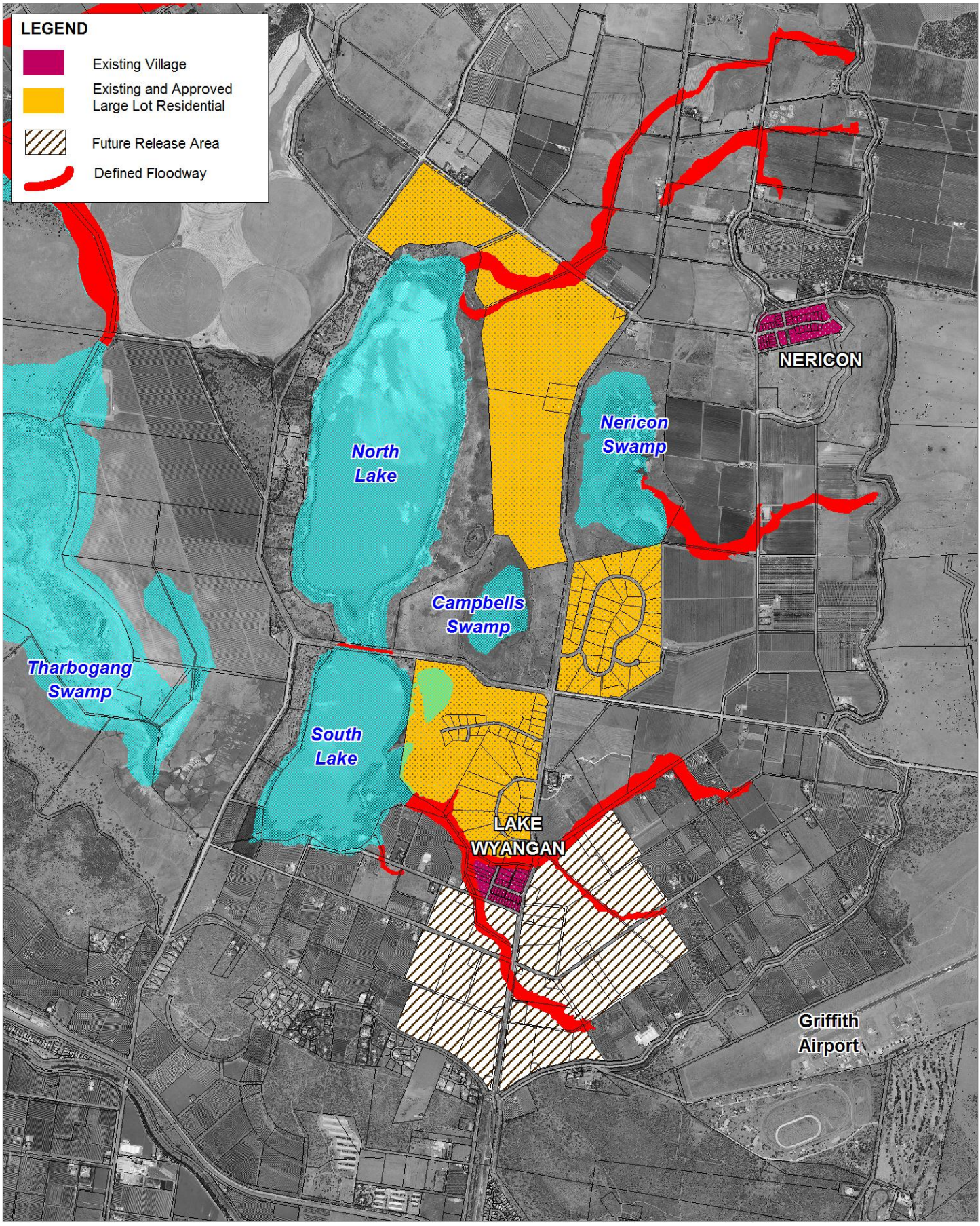
6.3 Future Development Areas

There are a number of future development areas in the Lake Wyangan catchment as incorporated in the Griffith Growth Strategy discussed in Section 5.3. These development areas are shown in Figure 6-5 with respect to the identified floodways.

The future development areas broadly sit outside the main flooding extents of the main storages within the Lake Wyangan catchment. This is also the case for the established communities of Lake Wyangan and Nericon. There had been some variation in estimated design flood level conditions through various investigations in association with the development proposals for some of the approved developments (e.g. Sunset Waters, Pelican Shores). However, the established flood levels from the Lake Wyangan Flood Study (BMT WBM, 2012) do not compromise the existing approvals, with the flood levels used as the basis for the development approvals being somewhat higher.

Future development, particularly the proposed future land release areas to the south of Lake Wyangan, will need to take due consideration of the flood conditions established in the current study. The major flood risk emanates from the natural flood flow paths, in particular the key floodway areas identified. The flooding areas in this part of the catchment are reasonably well defined such that future development layouts can readily accommodate the natural flooding regimes. The extent of flooding is somewhat limited, such that significant development potential can be realised within the nominal development boundaries without unduly exacerbating flood risk in the catchment. Some general flood planning principles for the future development should incorporate:

- Development excluded from floodway area;
- Sufficient provision for conveyance of floodwater up to and including the extreme flood event;
- Minimum floor levels based on the established 1% AEP flood level plus 0.5m freeboard (typical for residential development); and



Title:

Future Development Areas and Floodways

Figure: 6-4

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Approx. Scale

BMT WBM

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- Implementation of development controls in relation to intensifying development including implementation of appropriate OSD Policy to manage potential increase in run-off.

These types of development controls are indicative of existing Council policy. No special conditions are considered to be required specific to the Lake Wyangan study area. Accordingly, Council‟s overarching development policies would be expected to provide for the appropriate planning and control mechanisms to adequately consider the local flooding conditions in assessment of future development applications.

Adoption of the updated flood risk mapping incorporated in this study will formalise the baseline conditions for consideration of future development applications. This mapping includes the:

- Design peak flood level, depth and velocity distributions as established in the Flood Study;
- Hydraulic category, hazard and flood risk mapping established in the current study; and
- Flood Planning area established in the current study.

6.4 Other Floodplain Risk Management Planning Options

Floodplain Risk Management planning within the Griffith LGA has progressed in recent years with the completion of a number studies. One of the most significant of these is the Griffith Floodplain Risk Management Study and Plan (Worley Parsons. 2012) which largely focused on the Main Drain J catchment area. Within this study however, a number of the flood planning recommendations encompassed broader policy development appropriate for the Griffith LGA in general.

Following the adoption of the Griffith FRMS&P in 2012, the adopted Plan provides for progressive implementation of measures with a nominal timeframe of 12 months for the majority of flood planning measures. Indeed the Griffith Growth Strategy notes that Council is committed to ensure all of the recommendations from the study are implemented. Following the extensive flooding in March 2012, particularly within the Main Drain „J‟ study area incorporating major villages such as Yenda and Yoogali, Council are embarking on a review of the Griffith FRMS&P. It is envisaged this review will further consider the flooding mechanisms within this catchment and assess further options for flood mitigation. At this stage however, the broader planning recommendations within the Griffith FRMS&P are expected to continue to be appropriate for ongoing implementation.

The key flood planning recommendations from the Griffith FRMS&P considered to be appropriate for implementation for Lake Wyangan are summarised below.

- Local Environment Plan (LEP) clauses - Griffith City Council is currently in the process of updating their LEP according to the standard template developed by the NSW Dept. of Planning (DoP). The review of flood related clauses of the LEP identified a number of additional items to include in the document. These included the most recent flood related clause agreed to by the NSW Office of Environment and Heritage (OEH) and DoP.
- Flood Liable Lands Policy - A Flood Liable Lands Policy was prepared as part of the Griffith FRMS&P. This document provides flood related controls for development within the Griffith LGA. Prior to development of this Policy, Council has not had an overarching Flood Policy or

Development Control Plan (DCP) specific to Floodplain Risk Management. The Policy is intended to be used as an interim set of guidelines for all flood prone land within the Griffith LGA until incorporated into a comprehensive DCP. The Policy has since been adopted by Council and has been utilised in the current study. Updates to the Policy are recommended acknowledging the completion of the Lake Wyangan Floodplain Risk Management Study and Plan and corresponding flood planning level details and mapping.

- Council On-site Stormwater Detention (OSD) Policy – A previous Council prepared OSD Policy was reviewed as part of the Griffith Floodplain Risk Management Study and updated where required. The Policy has been adopted by Council. This Policy is appropriate for new development within the Lake Wyangan catchment. In particular the Policy should apply to the planned urban release areas. There are a number of identified floodways through some of the proposed future development area, such that application of the OSD Policy will provide for appropriate controls to limit any increase in site discharge and exacerbation of existing flood risk to downstream areas.

- Memorandum of Understanding (MOU) between Council and Murrumbidgee Irrigation - a draft MOU was developed which outlined protocols to guide Council & MI"s management of the drainage channels. Whilst the assessment focused specifically on infrastructure within the Main Drain „J" catchment, underlying principles should be extended to Lake Wyangan infrastructure. A review of existing infrastructure within Lake Wyangan will be required to identify responsibilities for management. The Lake View Branch Canal, Lake View Drain and cross drainage (siphons and pump systems) through the LVBC have been identified as critical infrastructure to ensure the current flow distribution within the catchment is maintained.

The above recommendations emanating from the Griffith FRMS&P represent overarching flood planning and policy changes applicable across the Griffith LGA. Whilst there are no additional controls or policy modifications specific to Lake Wyangan, the following recommendations for the Lake Wyangan FRMS&P will formalise the flood planning requirements in the Lake Wyangan study area.

- Updated floodplain mapping to be adopted and incorporated in planning documents as appropriate including the LEP, relevant DCP and flood liable lands policy:
    - Flood Planning Area Map – 1% AEP event plus freeboard used as mapping basis.
    - Hydraulic categorisations – definition of floodway, flood storage and flood fringe areas;
    - Hazard and Risk mapping – categorisation of low-high risk for consideration in development applications.
- Update of Section 149 certificates – existing Section 149 certificates for flood prone properties in the study area to be reviewed and updated with current flood study information and data.

6.5 Flood Warning and Emergency Response

The Bureau of Meteorology (BoM) prepares and disseminates flood forecasts and warnings and information to the public in close cooperation with state, territory and local government agencies and other stakeholders. Users of flood warning services include emergency management agencies and members of the public, particularly those in flood-prone areas. More detailed local interpretation of BoM flood warning products and information is provided directly to the public by flood response agencies. BoM warning products include early alerts to the possibility of flooding through a flood watch product, with site-specific forecasts of river height and the expected impact in terms of minor, moderate or major flooding in specific river basins.

Where dedicated flood forecasting systems have not been installed, more generalised products are issued on a regional basis. There is no active gauge network for flood warning within the Lake Wyangan catchment. Accordingly any available warning for the Lake Wyangan catchment would be based on generalised warnings in advance of predicted rainfall.

Real-time rainfall data recorded at Griffith Airport can be accessed via the BoM website. Whilst rainfall variability across the catchment can be significant, in the absence of other real-time gauges in the catchment, the Griffith station may provide some indication of potential flooding.

There is considered to be limited opportunity or indeed requirement for the development of a more formalised flood warning system for the Lake Wyangan catchment.

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, Council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan.

As discussed in the study, the relative flood risk exposure to existing property is somewhat limited given the nature of flooding in the catchment and the extent of development. However, as a matter of course, in consultation with the SES the Local Flood Plan should be updated as appropriate with updated flooding information. In particular this may include:

- Acknowledgment of the floodway locations and identification of properties potentially impacted; and
- Locations flood inundation on roads/access that may result in road closures or limit opportunity for flood access.

As noted in both the Flood Study and Floodplain Risk Management Study, there is somewhat limited data on historical flooding within the Lake Wyangan and Tharbogang Swamp catchments. Much of the historical flood information has come from anecdotal reports of flooding from a limited number of landholders. The recent March 2012 event provided an opportunity to collect valuable flood data, however, given the scale of flooding elsewhere in the region, the Lake Wyangan study area was not formally targeted for data collection.

The Lake Wyangan study area should be incorporated into formal data collection programs to ensure ongoing collection of data and monitoring of flooding conditions in the catchment as they occur. At the minimum, the peak flood water levels in Tharbogang Swamp, North and South Lake Wyangan should

be recorded as a matter of course during each flood event. Whilst the North and South Lakes have gauges, often during flood events readings are not taken due to lack of access. Peak flood levels can be pegged and surveyed and later tied into gauge records as appropriate. Similarly for Tharbogang Swamp, in the absence of gauges, peak flood levels at a minimum should be pegged and surveyed to establish and maintain an ongoing peak flood water level record. These records at a minimum will provide future opportunity for review of models, design flood conditions and established flood planning levels.

6.6 Community Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

The basic objectives of the community awareness program are to:

- Make people aware they are living / working in a flood zone
- Receiving, understanding and reacting to flood warnings
- Appropriate actions - e.g. avoid flooded road crossings.

Community awareness is an on-going process and there is the inherent danger of complacency between events. There are numerous mechanisms to inform the community, with the following recommended to be incorporated in the Lake Wyangan FRMP.

- Updated flood mapping - Consolidation of the recent flood risk mapping and, flood data prepared during the floodplain management study into Council"s computer based GIS system. This will provide Council with valuable flood information that can be easily retrieved, and which will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis. Consideration may be given to public access to some flood information/mapping provided through Council"s website.
- Section 149 / Flood certificates - Consideration could also be given to providing information on the flood risk and the flood levels that apply to a particular property on a special flood certificate. These certificates could be appended to the Section 149(5) certificates; provided whenever flood information is requested for a property; or provided on a regular basis to all residents in the study area.
- An ongoing flood awareness program may be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for the Griffith LGA). The aim of this program would be to:
    - Increase community awareness of flood risk;
    - Increase community understanding of what to do before / during / after floods; and
    - Increase awareness of SES role and other agencies.

PART B – FLOODPLAIN RISK MANAGEMENT PLAN

7 DRAFT LAKE WYANGAN FLOODPLAIN RISK MANAGEMENT PLAN

7.1 Introduction

The draft Lake Wyangan Floodplain Risk Management Plan (FRM Plan) has been developed to direct and co-ordinate the future management of flood prone lands within the Tharbogang Swamp/Lake Wyangan catchment. The FRM Plan sets out a strategy of actions and initiatives that are to be pursued by agencies and the community in order to adequately address the risks posed by flooding. Development of the FRM Plan has been guided by the NSW Government"s Floodplain Development Manual (2005).

The FRM Plan covers the Lake Wyangan and Tharbogang Swamp catchments within the Griffith LGA. The detailed study area is limited to the areas downstream of the Lake View Branch Canal. Emphasis is placed on the flood prone parts around Lake Wyangan identified for future development.

The outcomes of the Study provide the basis for this FRM Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

7.2 Recommended Measures

Given the nature of flooding within the Lake Wyangan/Tharbogang Swamp catchment, current flood risk exposure is somewhat limited relative to other catchments within the Griffith LGA. There is considered little opportunity or indeed requirement for structural options to mitigate existing flooding risks given both the nature of flooding and limited flood risk exposure to existing property. Accordingly, the floodplain risk management plan for the catchment focuses on appropriate planning and development controls to ensure future development does not unduly exacerbate the overall flood risk.

Future growth in residential property within the catchment is expected in line with proposed development in the Land Use Strategy: Beyond 2030 and through existing approved large lot development.

7.2.1 Policy

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of the Lake Wyangan catchment (as well as across the wider LGA). Many of the current applicable policy is in a state of review. The following provides a summary of the key documentation that will be applied for future flood planning in Lake Wyangan.

- Griffith Local Environmental Plan (GLEP) - Future reviews of the GLEP are expected to be undertaken in accordance with the NSW State Government"s Standard Instrument (Local Environmental Plans) Order 2006, which requires local Council"s to implement a Standard Instrument LEP. The State Government has created the Standard Instrument LEP to assist in streamlining the NSW Planning system. The review and update is expected to consider the flood

related clause recommendations in the Griffith FRMS&P. It is recommended the GLEP update incorporate the appropriate flood planning layers as adopted in the Lake Wyangan FRMS&P.

- Griffith Flood Liable Lands Policy (CS-CP-403) - A Flood Liable Lands Policy was prepared as part of the Griffith FRMS&P. This document provides flood related controls for development within the Griffith LGA. Prior to development of this Policy, Council has not had an overarching Flood Policy or Development Control Plan (DCP) specific to Floodplain Risk Management. The Policy is intended to be used as an interim set of guidelines for all flood prone land within the Griffith LGA until incorporated into a comprehensive DCP. Specifically, the following sections of the existing Policy require amendment to acknowledge the Lake Wyangan Floodplain Risk Management Study and Plan upon adoption:
    - Section 4.4.3 - Existing Provisional Hydraulic and Hazard Category Mapping : final hydraulic and hazard category mapping has been prepared as per Section 4 of the current study ; and
    - Section 5 - Flood Planning Level : flood panning levels and the corresponding flood planning area has been prepared as per Section 4 of the current study.
- Consolidated Development Control Plan (DCP) – It is understood that Council are currently developing a consolidated DCP. It is anticipated this document will coordinate with the structure of the revised Griffith LEP in preparation. The new DCP should contain detailed planning controls that support the LEP update and 2030 Growth Strategy and both must be considered when planning the development of land within Griffith LGA. The DCP should address the directions in flood risk management that are embodied in the NSW Government"s Flood Prone Land Policy and which are emphasised in the 2005 edition of the government"s Floodplain Development Manual. No requirements for specific controls within the Lake Wyangan catchment have been identified over and above the LGA wide requirements.
- Council On-site Stormwater Detention (OSD) Policy – A previous Council prepared OSD Policy was reviewed as part of the Griffith Floodplain Risk Management Study and updated where required. Elements of the OSD policy are expected to be incorporated in to the DCP or cross referenced accordingly. This Policy is appropriate for new development within the Lake Wyangan catchment. In particular the Policy should apply to the approved residential subdivisions and the proposed urban release areas in the Land Use Strategy: Beyond 2030.

7.2.2 Adopt Flood Risk Mapping

A key output of the Floodplain Risk Management Study is the updated flood risk mapping to be used as the basis for flood risk related development control. It is recommended the mapping be adopted by Council with the recent flood risk mapping and flood level data prepared during the floodplain management study consolidated into Council"s computer based GIS system. Specific recommendations include:

- Updated floodplain mapping to be adopted and incorporated in planning documents as appropriate including the LEP, relevant DCP and flood liable lands policy:
    - Flood Planning Area Map – 1% AEP event plus freeboard used as mapping basis.
    - Hydraulic categorisations – definition of floodway, flood storage and flood fringe areas;

- Hazard and Risk mapping – categorisation of low-high risk for consideration in development applications.

- Update of Section 149 certificates – existing Section 149 certificates for flood prone properties in the study area to be reviewed and updated with current flood study information and data.

7.2.3 Maintain Existing Flow Distribution Between Lakes

The Flood Study and Floodplain Risk Management Study confirmed the flow distribution between the Tharbogang Swamp and Lake Wyangan catchments. Key Murrumbidgee Irrigation infrastructure including the Lake View Branch Canal and Lake View Drain has some controlling influence on the existing flow distribution.

The design flood conditions and associated flood planning considerations adopted in the study are on the basis of the existing flow distribution. Accordingly it is recommended that the existing flow distribution be maintained to ensure the ongoing validity of the current design levels and subsequent flood planning decisions.

7.2.4 Extend MoU between Council and Murrumbidgee Irrigation

As an outcome of the Griffith Floodplain Risk Management Study & Plan, a Memorandum of Understanding (MoU) was developed to define Council‟s and Murrumbidgee Irrigation‟s responsibilities in regard to ownership, maintenance and upgrade of drainage channels. The recommendation of the Griffith FRSM&P was for adoption of the MoU by both organisations and update of maintenance schedules to adhere to the MoU.

The MoU was largely established for identified infrastructure within the Griffith/Main Drain „J" catchment. It is recommended the MoU be extended for works within Lake Wyangan also. As per the recommendation in 7.2.3, the ongoing maintenance and operation of the LVBC and LVD are critical to maintain existing flow distributions in addition to local cross drainage systems (siphons and pump systems).

7.2.5 Investigate Kubank Estate Drainage Diversion

It is recommended further investigation is undertaken to assess the feasibility and progress concept design if warranted of a diversion channel/drain to relieve flooding conditions in the Kubank Estate.

7.2.6 Update Local Flood Plan

The Griffith Local Flood Plan (LFP) outlines preparedness and management operations for all flooding events within the Griffith local government area, including Lake Wyangan. The SES follows the LFP, using information from Flood Intelligence (derived via local knowledge, historical record and completed flood studies) and BoM‟s predictions, to respond in actual flood events.

The Local Flood Plan should be updated to provide design flood data for the full range of events considered in the Flood Study and Floodplain Risk Management Study (up to the PMF). The flood mapping of depth and inundation extents established in the current study will also be provided to the SES to enable an update of property for local flood response.

7.2.7 Implement Flood Data Collection Program

A formal flood data collection program is recommended to ensure ongoing collection of data and monitoring of flooding conditions in the catchment as they occur

At the minimum, the peak flood water levels in Tharbogang Swamp, North and South Lake Wyangan should be recorded as a matter of course during each flood event.

7.2.8 Ongoing Community Awareness

Raising and maintaining flood awareness will provide the community with an appreciation of the flood problem and what can be expected during flood events.

An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for Griffith). The aim of this program would be to:

- Increase community awareness of flood risk;
- Increase community understanding of what to do before / during / after floods; and
- Increase awareness of SES role and other agencies.

Further planned strategies to pursue may include media releases, SES community education training, additional brochures targeting sectors of the community, flood risk workshops with landowners, community groups, and businesses.

7.3 Plan Implementation and Review

The recommended Plan contains relatively modest financial implications for Council and other responsible authorities. This is largely as a result of no major capital works in terms of flood modification being recommended.

The timing of the implementation of recommended measures will depend on overall budgetary commitments of Council and the availability of staff resources. It is envisaged that the Plan would be implemented progressively over a 12-month frame.

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the areas planning strategies.

A thorough review every 5 years is warranted to ensure the ongoing relevance of the Plan.

8 REFERENCES

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GHD (2008) *Lake Wyangan Investigation – Preliminary 100-Year Flood Level*

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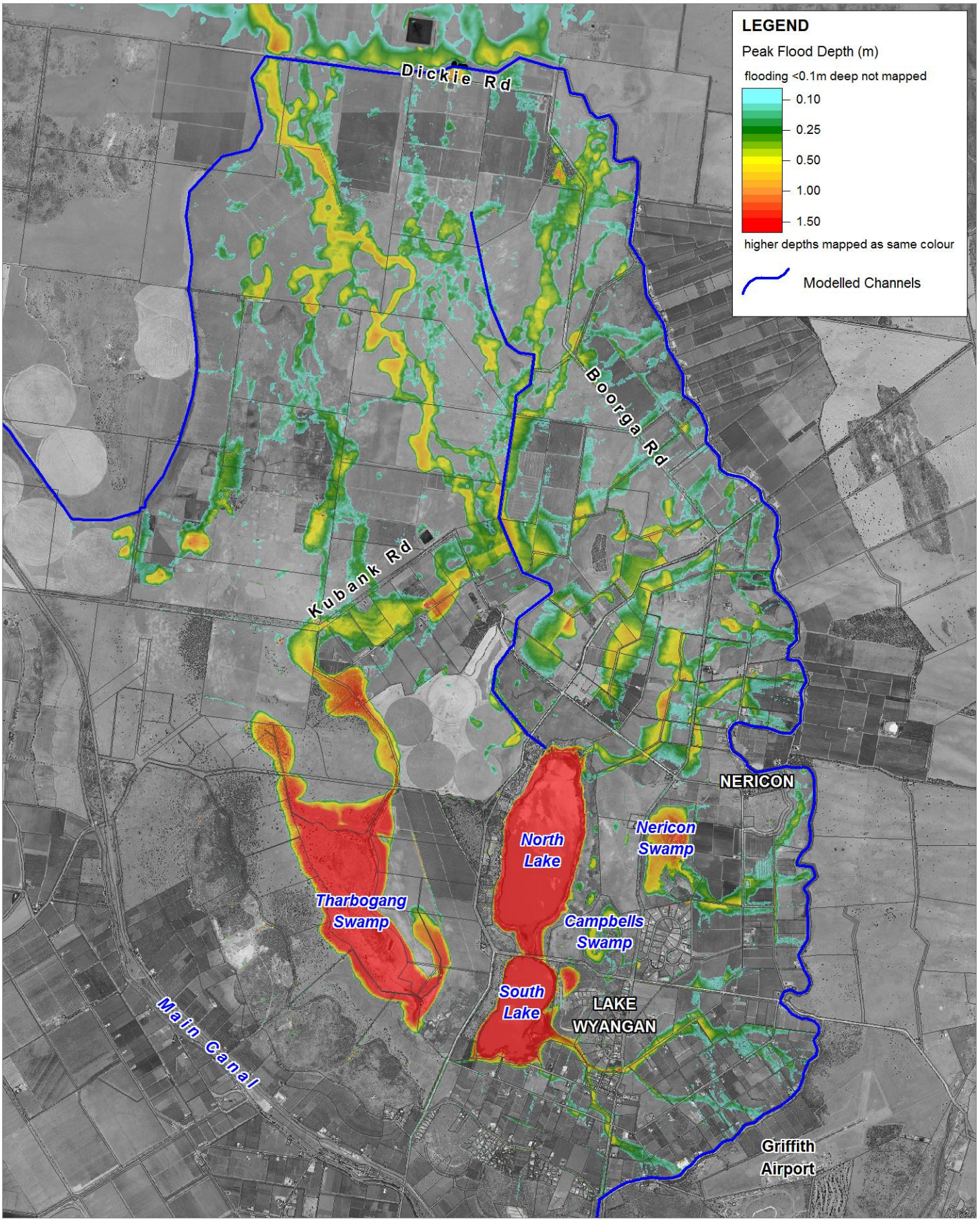
Worley Parsons (2012) *Griffith Floodplain Risk Management Study and Plan*

APPENDIX A: DESIGN FLOOD MAPPING



Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Depths: 1% AEP Event

Figure: **A-1**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

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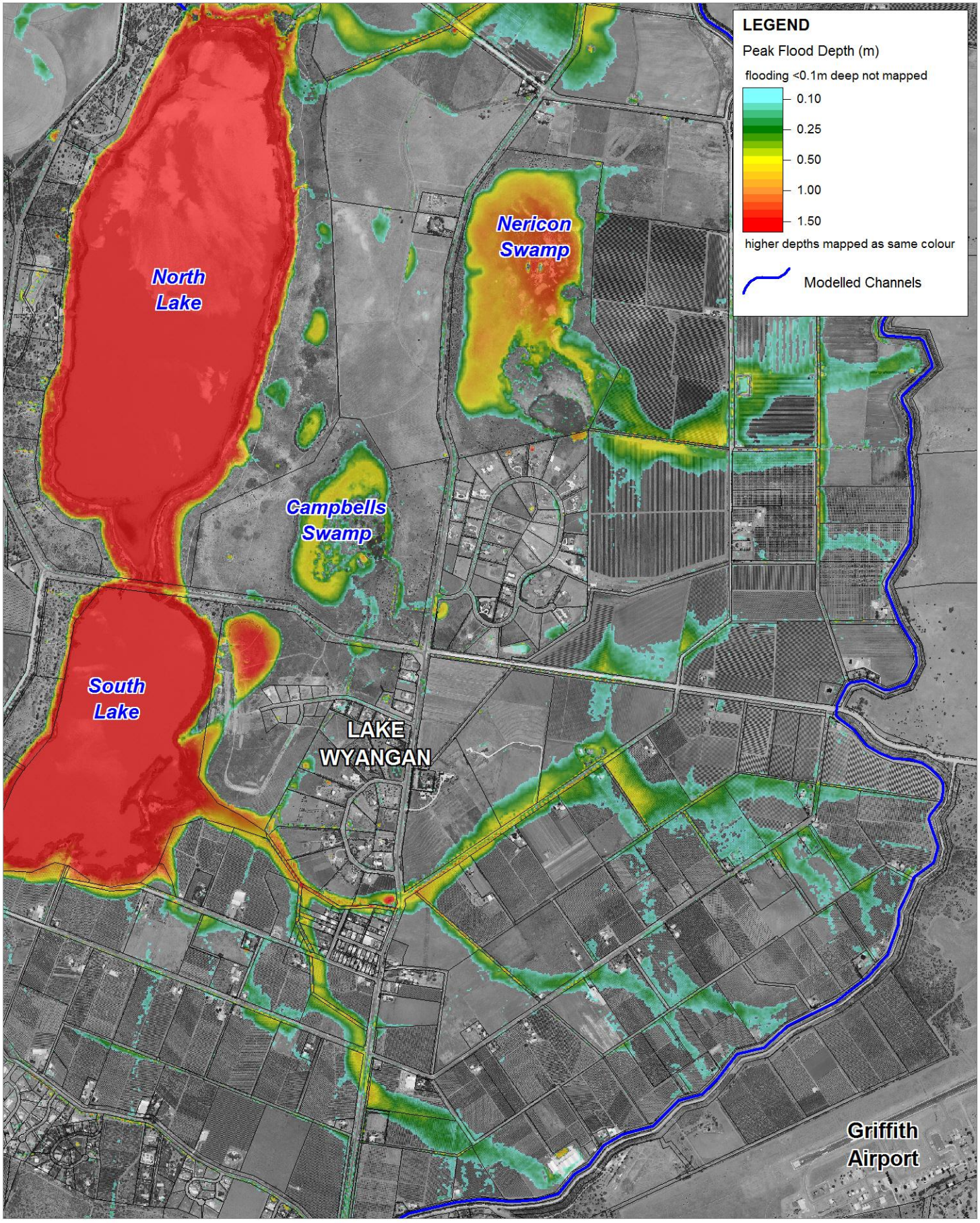

Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Depths: 1% AEP Event

Figure: **A-1(a)**

Rev: **A**

N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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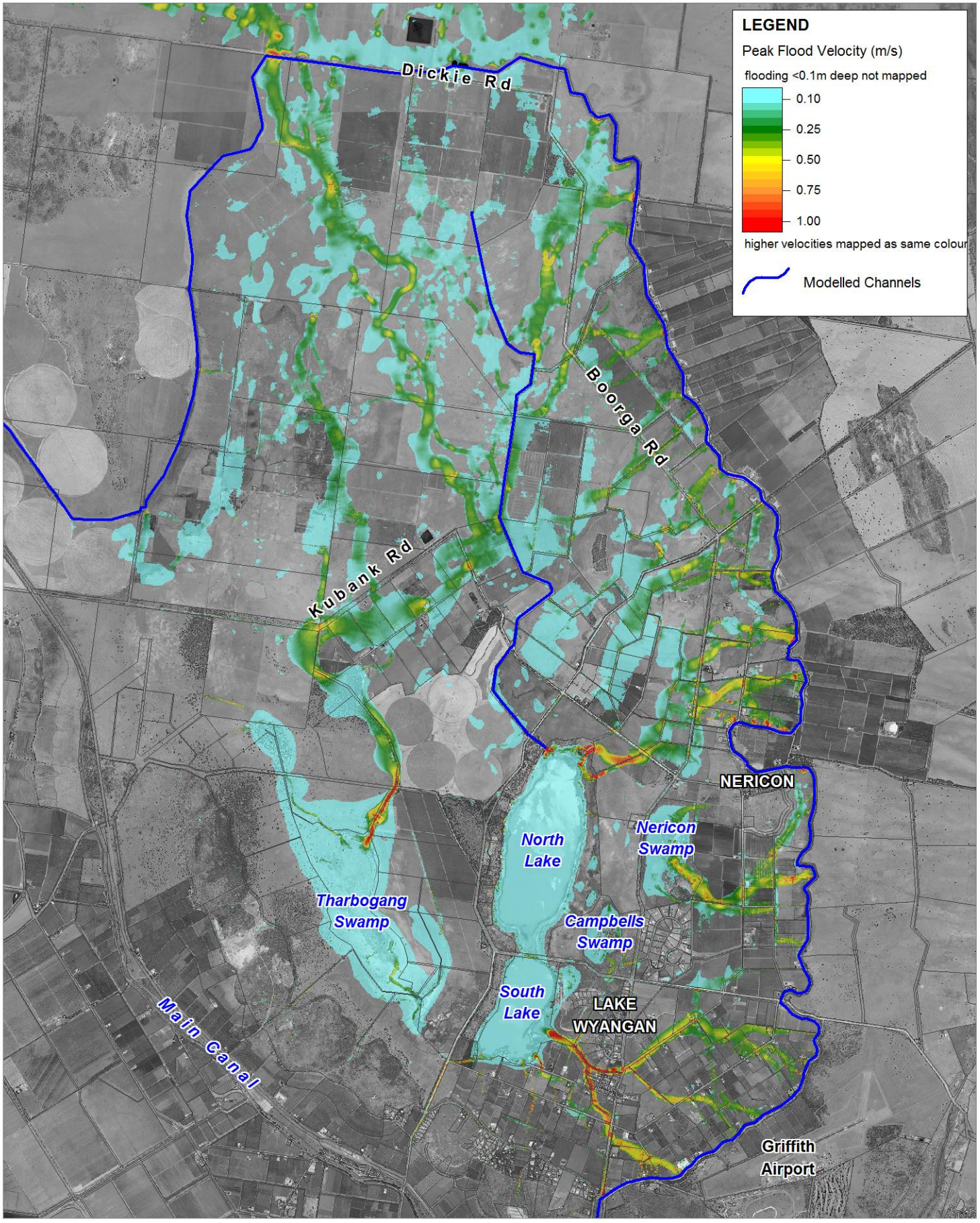

Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Velocities: 1% AEP Event

Figure: **A-2**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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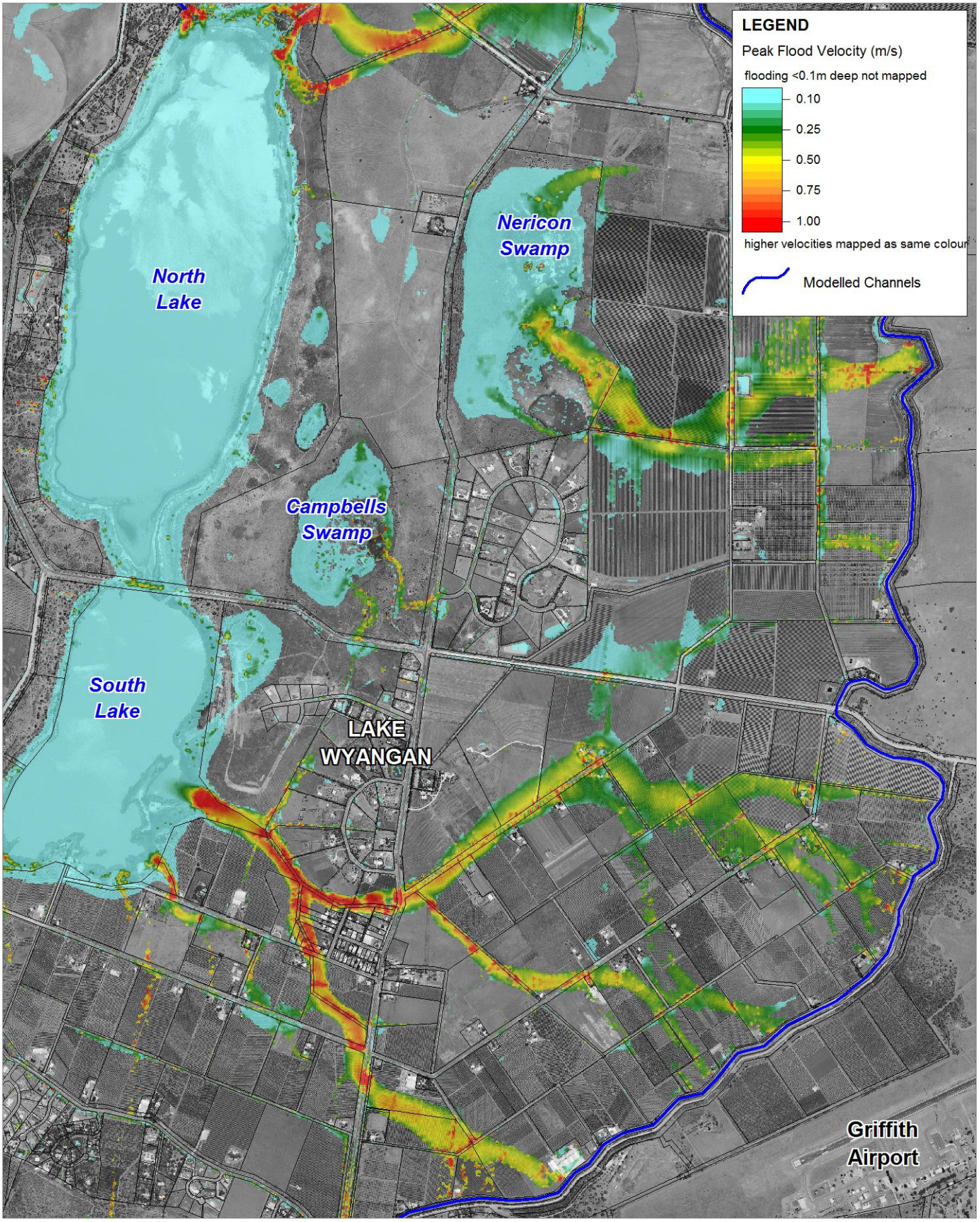

Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Velocities: 1% AEP Event

Figure: **A-2(a)**

Rev: **A**

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BMT WBM
www.bmtwbm.com.au

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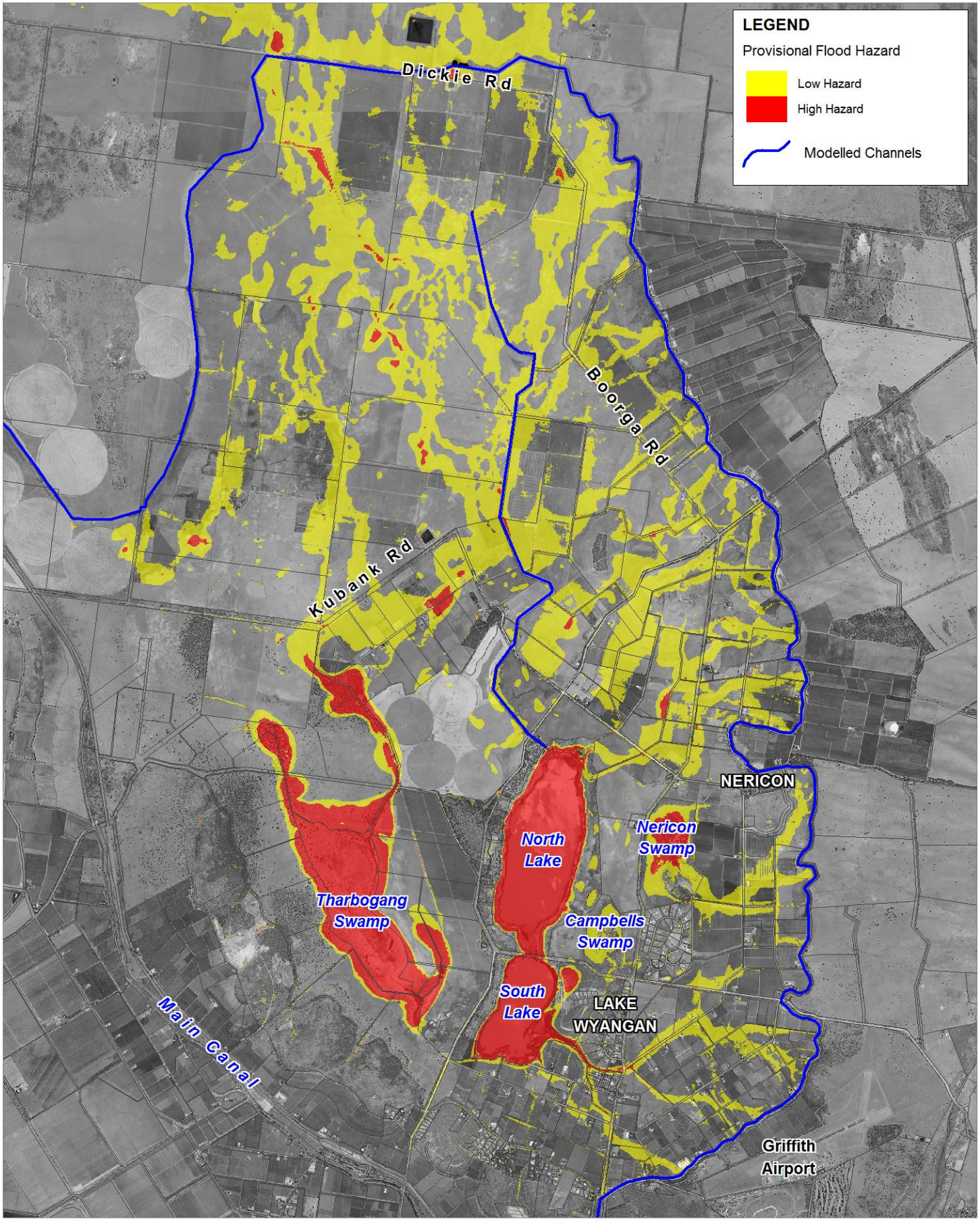

Title:

Lake Wyangan Floodplain Risk Management Study
Provisional Flood Hazard: 1% AEP Event

Figure: **A-3**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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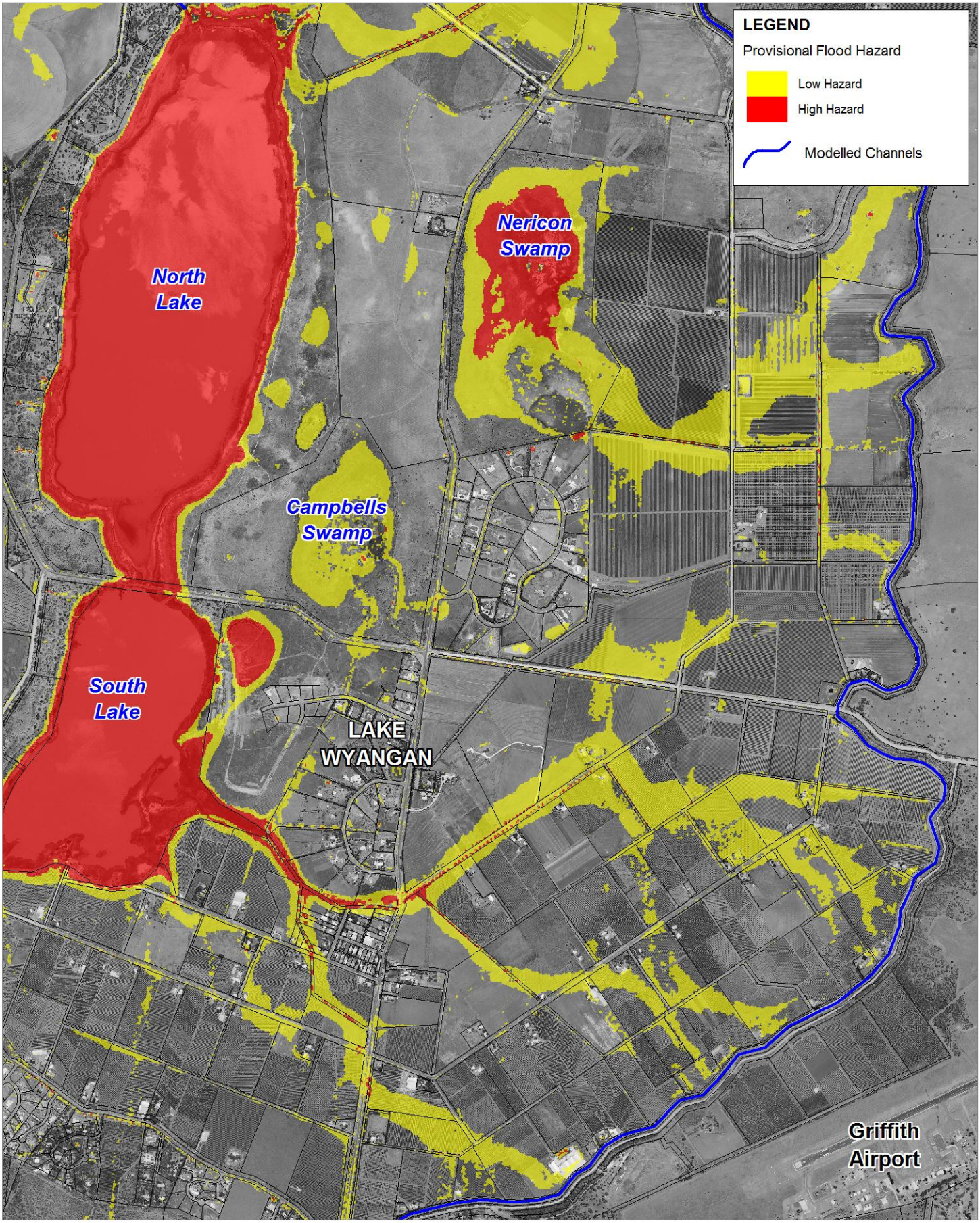

Title:

Hydraulic Hazard: 1% AEP Event

Figure: **A-3(a)**

Rev: **A**

N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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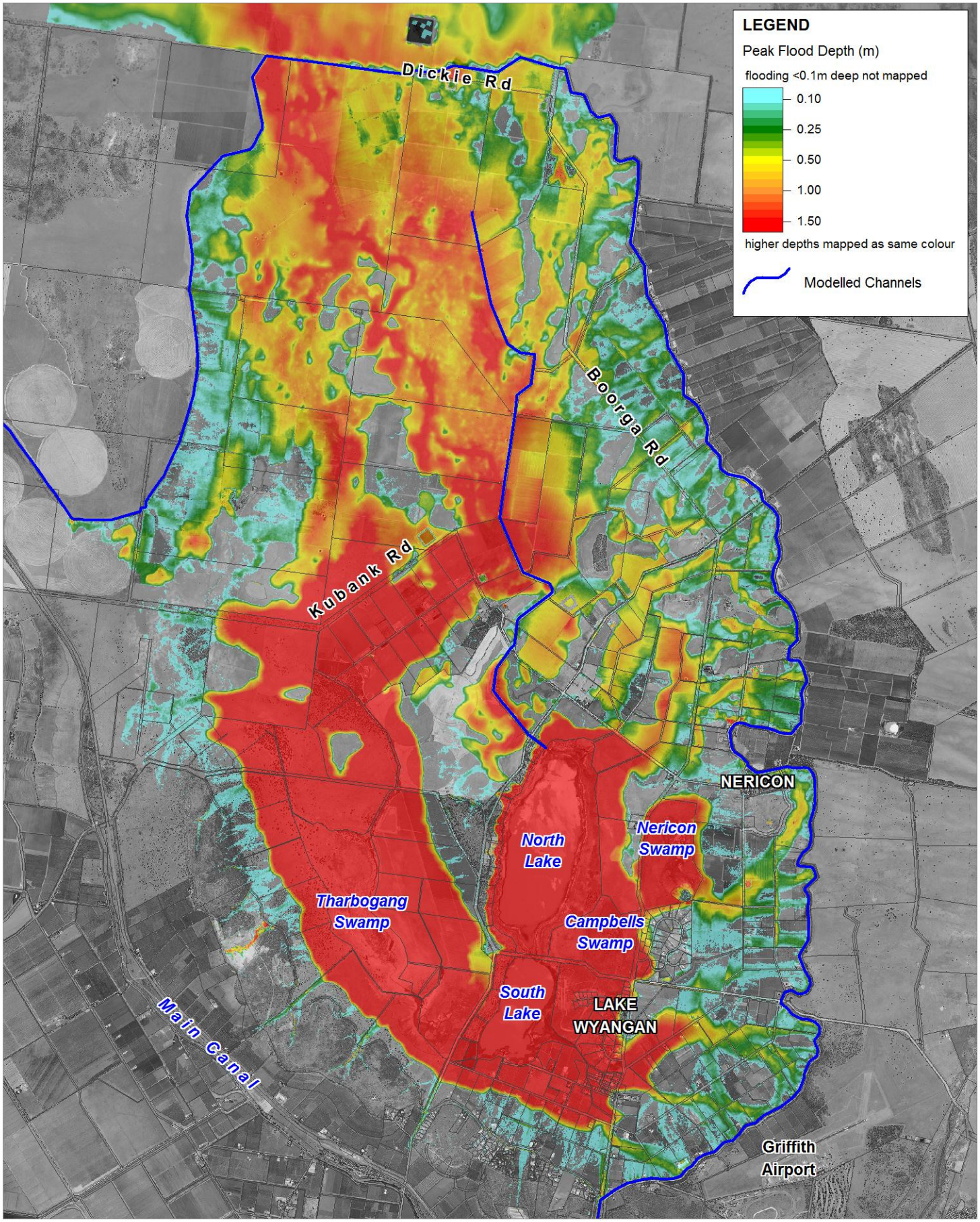

Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Depths: 3x1% AEP (PMF) Event

Figure: **A-4**

Rev: **A**

N

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Approx. Scale

BMT WBM
www.bmtwbm.com.au

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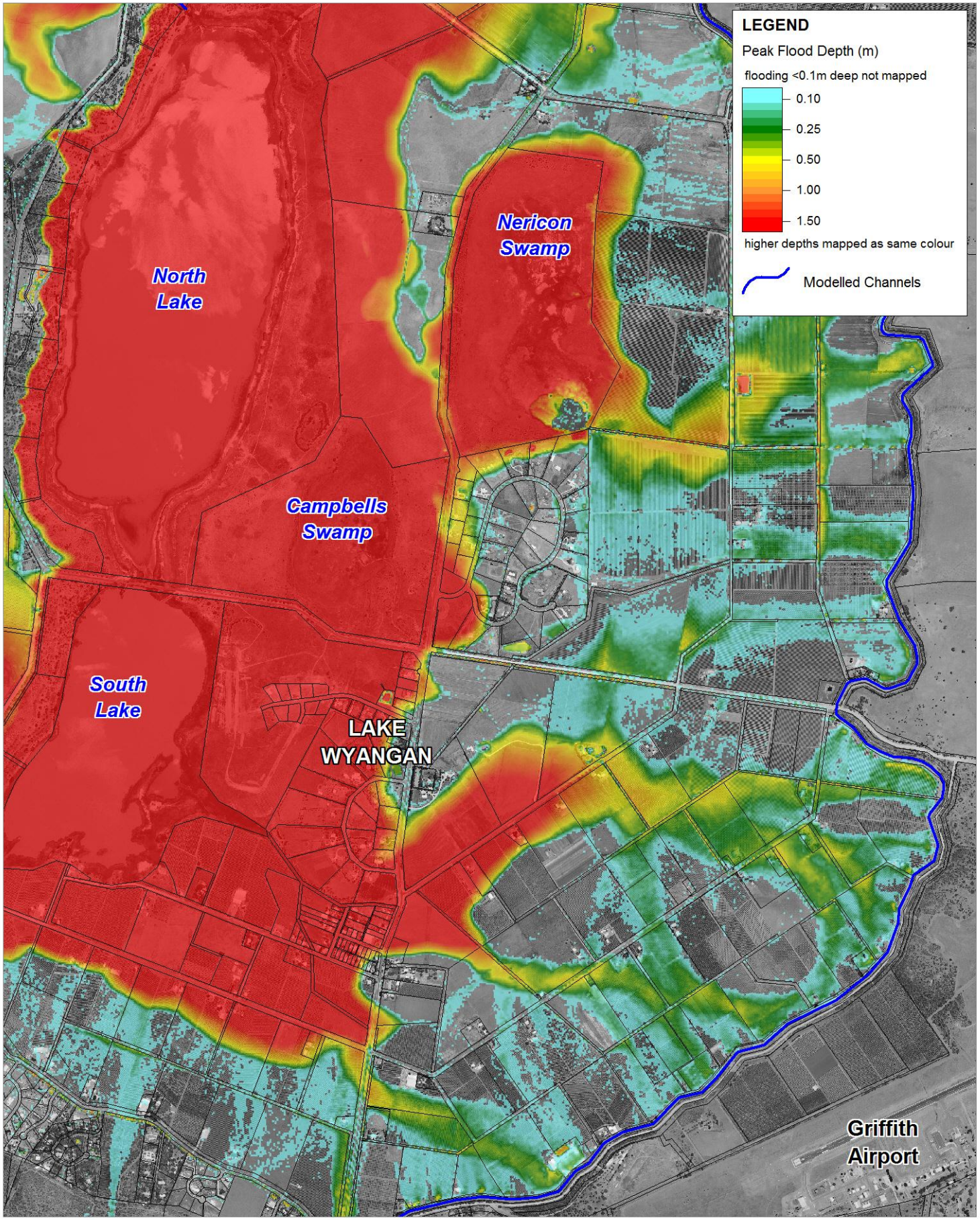


Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Depths: 3x1% AEP (PMF) Event

Figure: **A-4(a)**

Rev: **A**

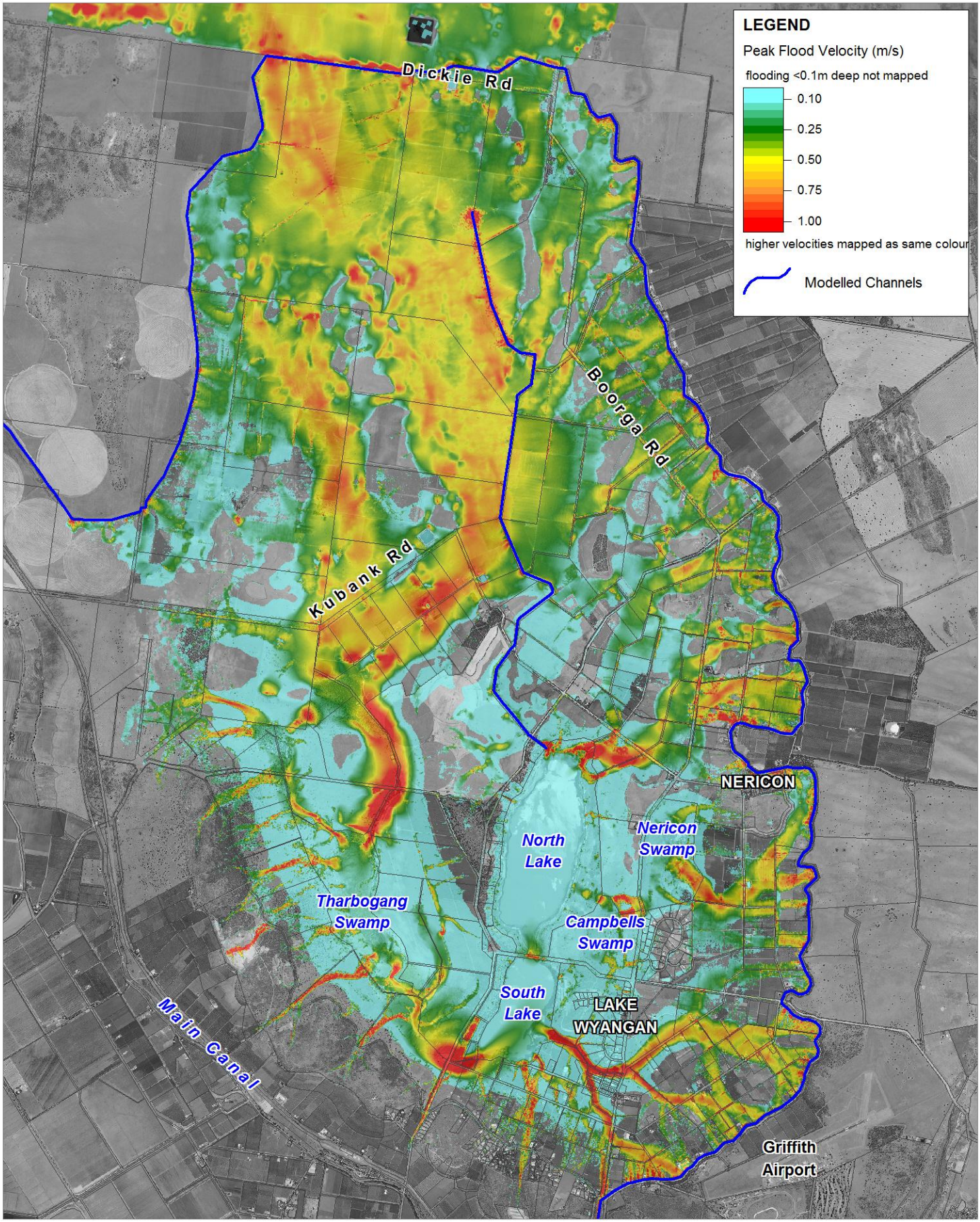
N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N2391_Lake_Wyangan_FRMS\MI\Workspaces\DRG_119_111010_PMF_Depths_a.WOR



Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Velocities: 3x1% AEP (PMF) Event

Figure: **A-5**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

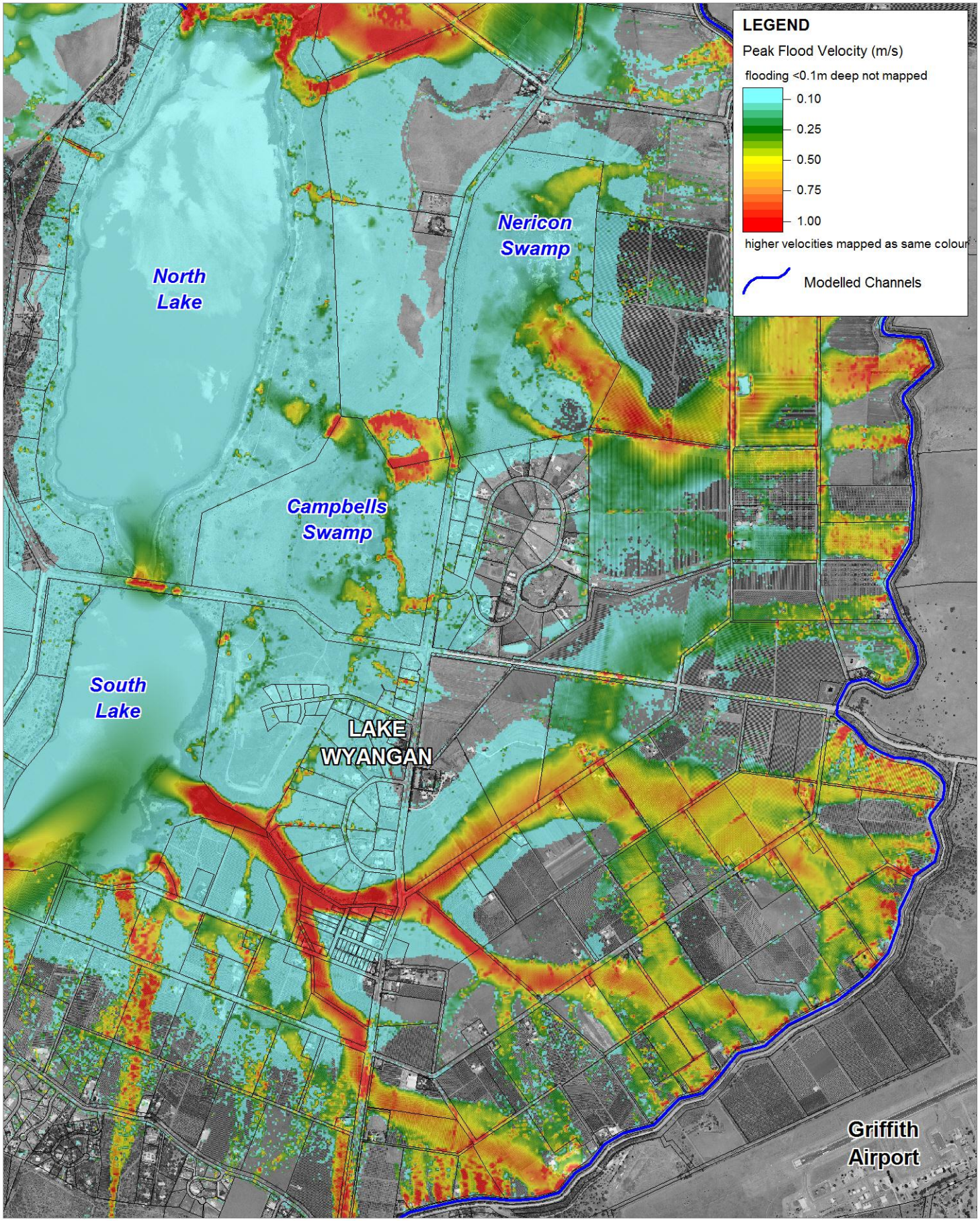
N

0 1.25 2.5km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N2391_Lake_Wyangan_FRMS\MI\Workspaces\DRG_120_111010_PMF_Velocities.WOR



Title:

Lake Wyangan Floodplain Risk Management Study
Peak Flood Velocities: 3x1% AEP (PMF) Event

Figure: **A-5(a)**

Rev: **A**

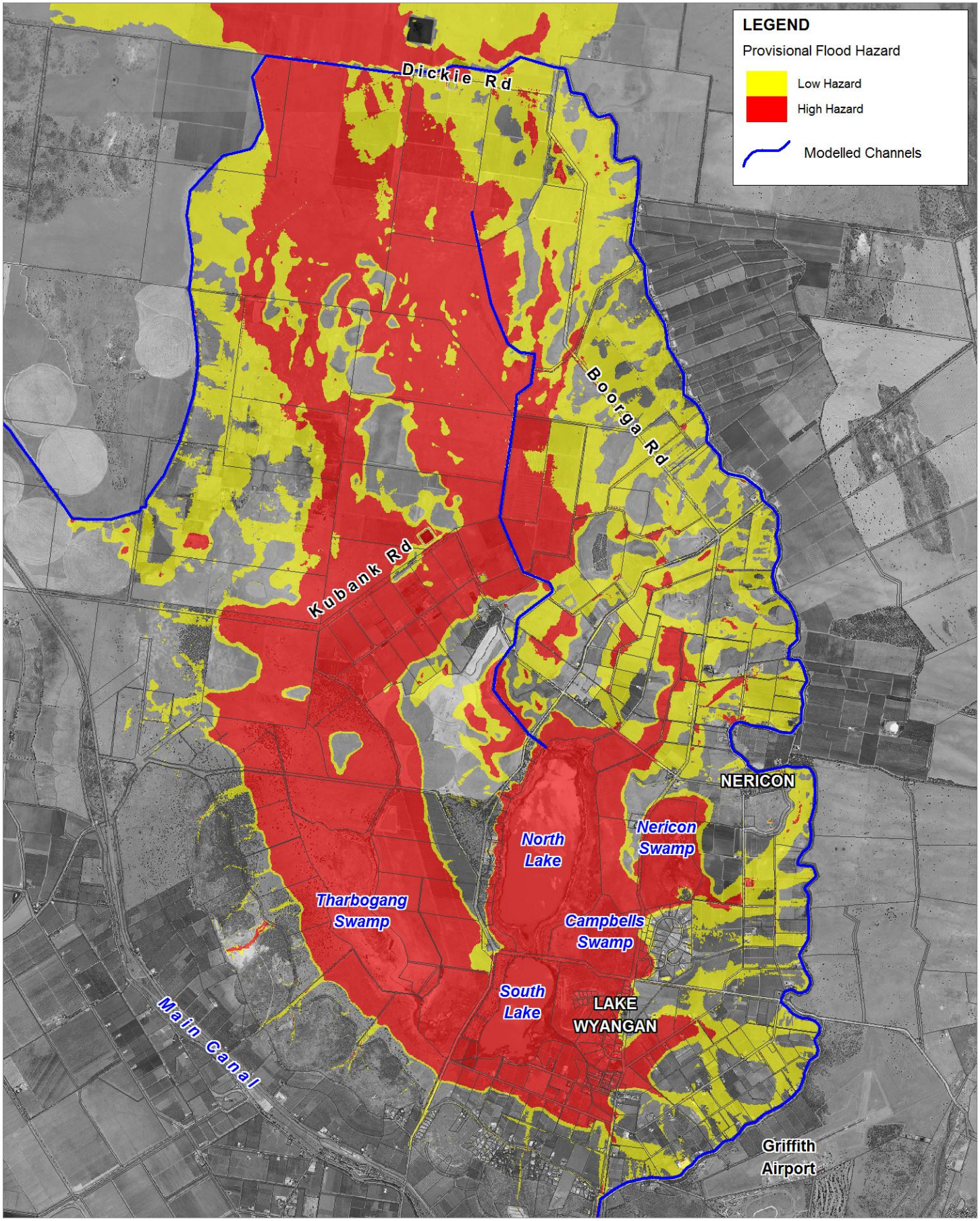
N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N2391_Lake_Wyangan_FRMS\MI\Workspaces\DRG_120_111010_PMF_Velocities_a.WOR



Title:

Lake Wyangan Floodplain Risk Management Study
Provisional Flood Hazard: 3x1% AEP (PMF) Event

Figure: **A-6**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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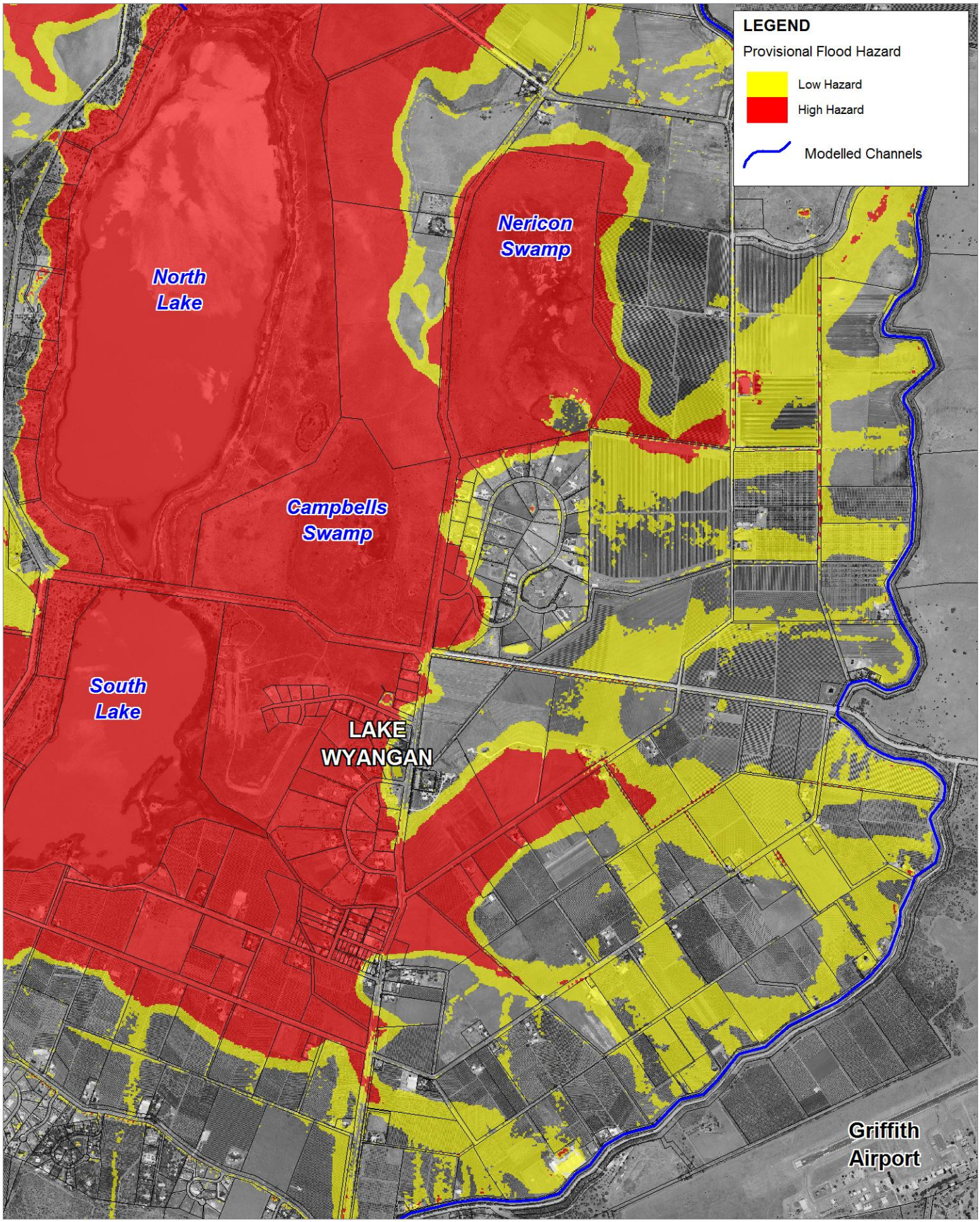

Title:

Lake Wyangan Floodplain Risk Management Study
Provisional Flood Hazard: 3x1% AEP (PMF) Event

Figure: **A-6(a)**

Rev: **A**

N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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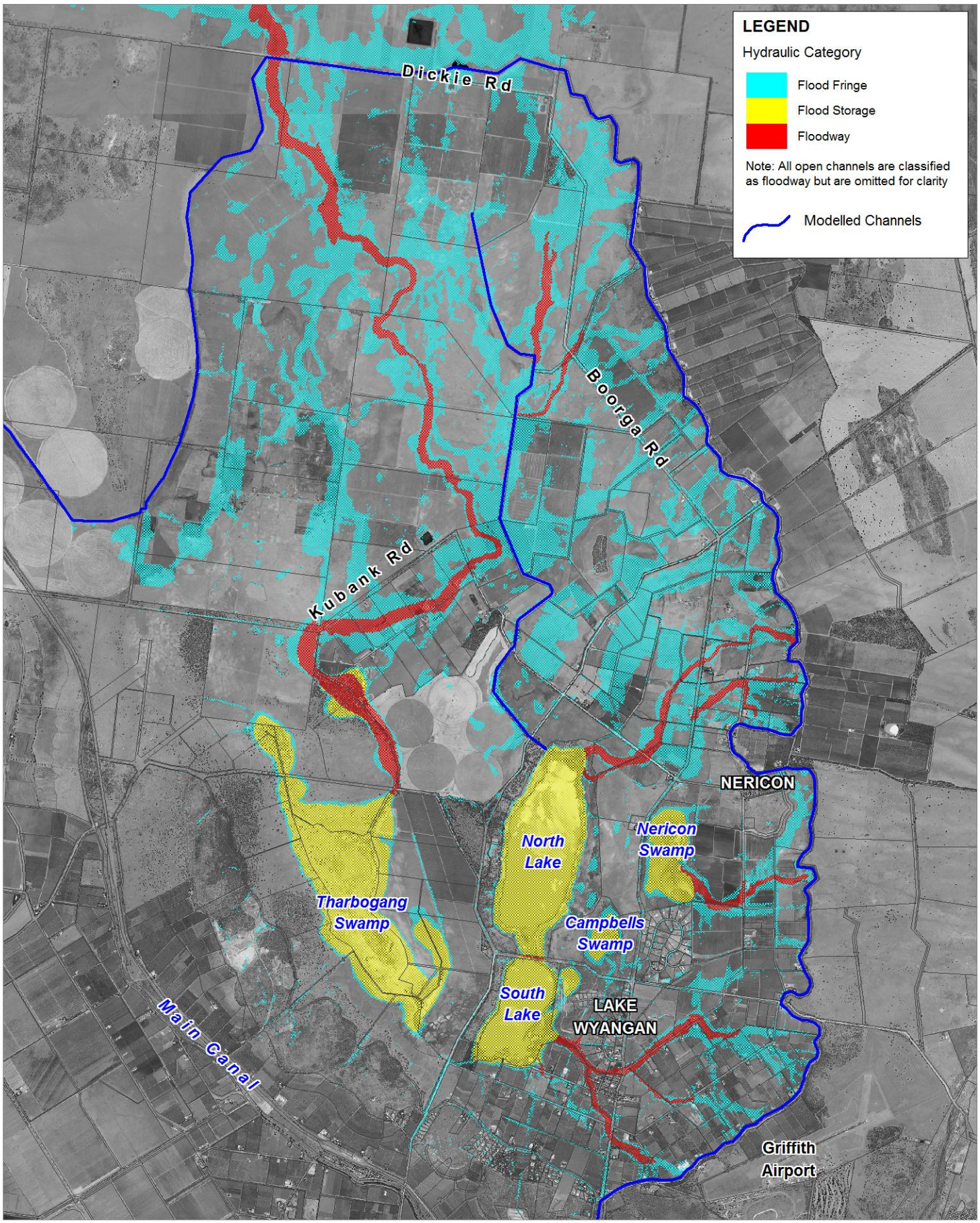


Title:

Hydraulic Categories Defined at the 1% AEP Event

Figure: **A-7**

Rev: **A**

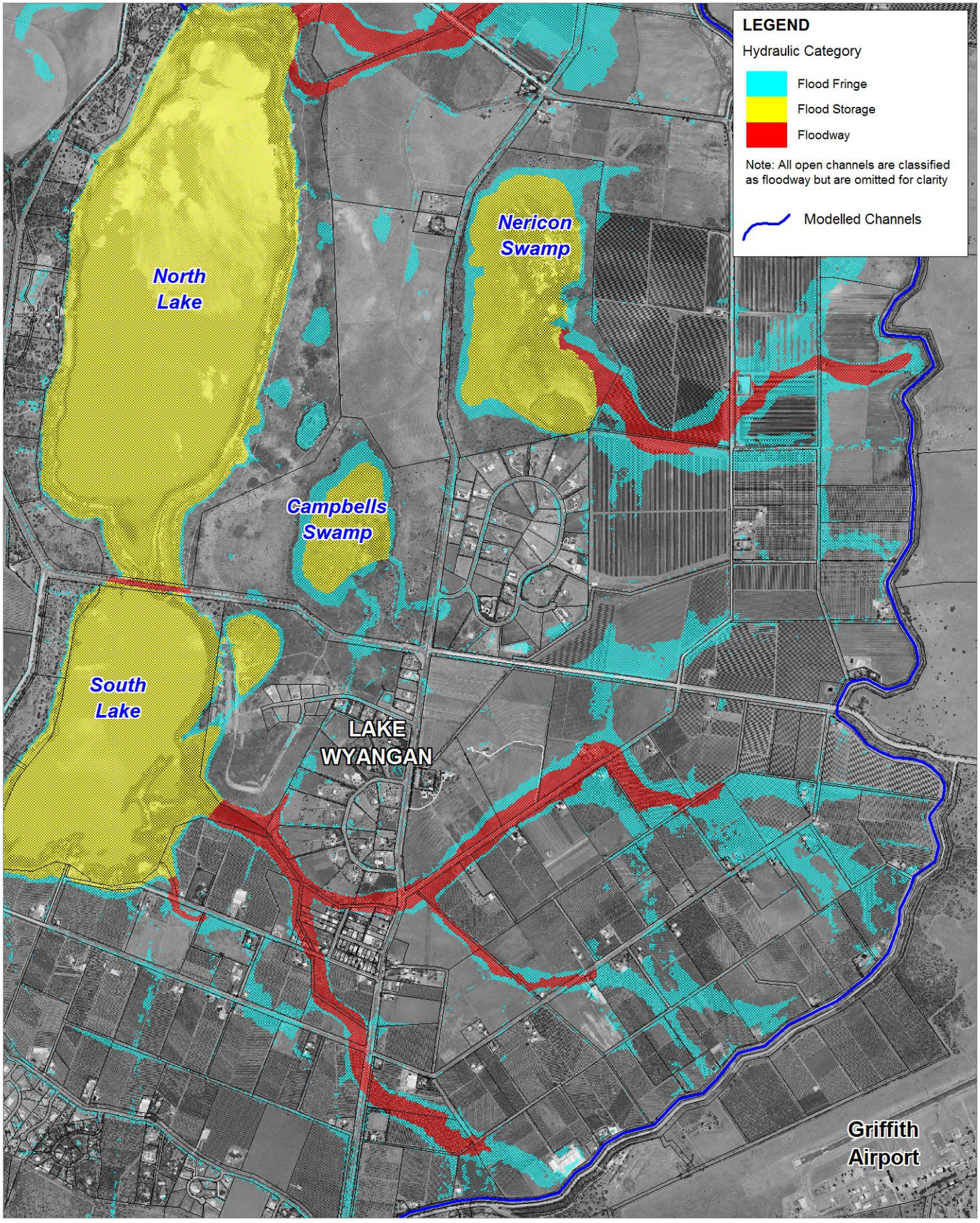
N

0 1.25 2.5km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N2391_Lake_Wyangan_FRMS\MI\Workspaces\DRG_006_130219_1%AEP_Hydcats.WOR



Title:

Hydraulic Categories Defined at the 1% AEP Event

Figure: **A-7(a)**

Rev: **A**

N

0 0.5 1km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N2391_Lake_Wyangan_FRMS\MI\Workspaces\DRG_006_130219_1%AEP_Hydcats_a.WOR

APPENDIX B: COMMUNITY NEWSLETTER

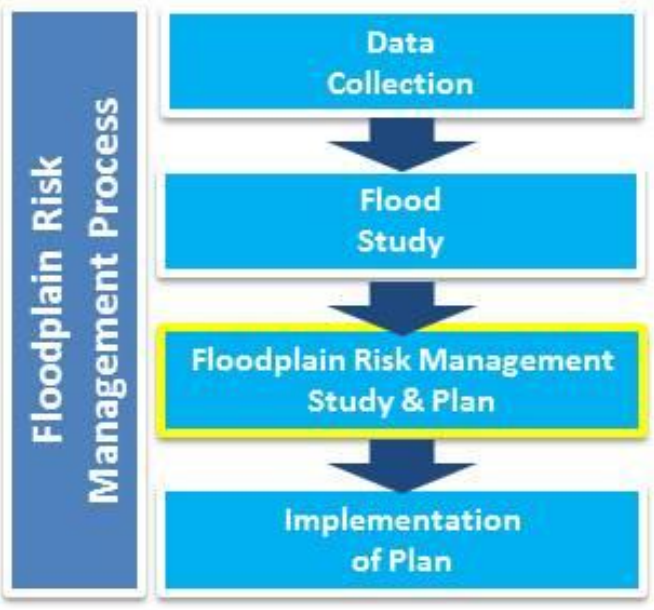
Lake Wyangan Floodplain Risk Management Study

Community Newsletter December 2012

What is the study about?

Griffith City Council is carrying out a flood study to understand and manage flood risks in the Lake Wyangan catchment. This includes the areas draining to Lake Wyangan, Tharbogang Swamp, Campbells Swamp and Nericon Swamp.

The Lake Wyangan Flood Study completed in 2011, investigated in detail the flooding characteristics within the catchment and produced information on flood flows, velocities, levels and extents for a range of flood magnitudes. These design flood conditions will form the basis for assessing various options to reduce the risks and damage caused by flooding within Lake Wyangan and surrounds.



The next stage of the floodplain risk management process, which this study is focused on, is the assessment of a range options to manage these flood risks for existing and future development.

The recent flooding in March 2012 also provides an opportunity to update the flood study and provide a more detailed definition of flood behaviour in the catchment.

Who is responsible?

Griffith City Council will administer the project with input from the Griffith Floodplain Management Committee. The Committee will oversee the study, providing regular input and feedback on key outcomes. The Committee has a broad representation including Councillors, Council Staff, State Govt. representatives, stakeholder groups and community representatives .

BMT WBM, an independent company specialising in flooding and floodplain risk management, will undertake the study.

The NSW Office of Environment and Heritage is providing financial and technical assistance.

Flooding at Boorga/Smeeth Rd March 1985

Griffith city council ...love the lifestyle...

NSW GOVERNMENT Office of Environment & Heritage

BMT WBM

Key Study Outputs

Floodplain Risk Management considers the consequences of flooding on the community and aims to develop appropriate floodplain management measures to minimise and mitigate the impact of flooding. This incorporates the existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

The outcomes of the study provide the basis for the Floodplain Risk Management Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

Information from the study will be used by the State Emergency Service (SES) during flood emergencies and will be used by Council to assist them manage development in flood-affected areas.

Want more information?

For more information about the Lake Wyangan Floodplain Risk Management Study , please contact:

Griffith City Council
Mr Graham Gordon
Phone: 6962 8100
email: Graham.Gordon@griffith.nsw.gov.au

Floodplain Management Committee
Cr Pat Cox
email: gcox@iinet.net.au

Peter Budd
email: architect@budd.net.au

Community input

Community involvement in managing flood risks is essential to improve the decision making process, to identify local concerns and values, and to inform the community about the consequences of flooding and potential management options. There are a number of ways you can be involved in the study:

•Pass on your knowledge and experience about previous flooding history and existing flood problem areas

•Any photographs or video of the recent March 2012 flood (or other events) can be passed on to Council.

•Further information on the study outcomes will be provided at a later stage including public exhibition of the study which will provide further opportunity for feedback from the community.

Tharbogang Swamp March 2012

Lake Wyangan March 1989

Griffith city council ...love the lifestyle...

NSW GOVERNMENT Office of Environment & Heritage

BMT WBM

APPENDIX C: PUBLIC EXHIBITION SUBMISSIONS

A single submission received as attached with corresponding response (note: names removed for privacy).

16 May 2013

[redacted]

General Manager
Griffith City Council
PO Box 485
GRIFFITH NSW 2680

Dear Sir

SUBMISSION REGARDING THE DRAFT LAKE WYANGAN FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

We, the landowners of [redacted] Lake Wyangan [redacted], wish to comment on the Draft Lake Wyangan Floodplain Risk Management Study and Plan. Our property is identified as being flood affected in this Draft Study. After reviewing this document we wish to make comment on the study and seek clarification on the following matters.

Document on exhibition: We downloaded the document from Council's webpage on the first day of the exhibition period, with the document entitled *Final Report R.N2038.001.03 March 2012*, but on 8 May 2013 we downloaded an additional copy from the website titled *Draft Report R.N2391.001.00 March 2013* of which is more up to date and has additional information to the Final Report March 2012. We found this confusing as we had to compare if there were any changes which we may have missed, realising this with only 9 days left of the exhibition period.

Map resolution: The resolution of the PDF flooding maps on exhibition does not provide a great level of clarity to identify the extent of the flooding parameters on each individual property.

Methodology: We found the report to be relatively technical and discussed in depth the research, development and calibration of the model. We note that the document is modelled and calibrated based on three flooding events (1985, 1989 & 2007). The study states that "a reasonable model calibration has been achieved given the available data for the catchment" and that it is mostly based on the data from the March 1989 event. It raises the question of whether this is adequate information to implement development restrictions on properties. It is our understanding that as well as runoff from surrounding properties within the catchment including Scenic Hill, some of the water is from the Griffith Aerodrome. We raise the question of whether stormwater could be more effectively control upstream to prevent disadvantaging development on downstream properties.

Outcomes: We note that the document does not offer much detail on what implications this information will have on the future affected areas of Lake Wyanagn in terms of development, or any mitigation measures proposed. We are of the understanding that mitigation measures are yet to be developed based on the outcomes of this document (implementation of a floodplain risk management plan).

From viewing *Figure A-22 Hydraulic Categories Defined at the 1% AEP Event* in the *Final Report R.N2038.001.03 March 2012* or *Figure 4 - 9 Hydraulic Categories Defined at the 1% AEP Event* in the *Draft Report R.N2391.001.00 March 2013*, it appears that the 'proposed floodway' doesn't greatly affect our property, but is more affected by 'flood fringe'. Flood fringe is described in the study as "*Areas that are low velocity backwaters within the floodplain. Filing of these areas generally has little consequence to overall flood behaviours*". We also note that the depth and velocity of water affecting our property is less than 0.5m in depth and travels at a maximum of

1.0m/s during the 1 in 100 year event. From discussions with Council's Senior Engineering Coordinator, our property is at around 115 m AHD which more than 7m above the design flood level. We have the following questions regarding this study:

- Will the existing Griffith Flood Liable Lands Policy apply to Lake Wyangan once this Policy is adopted? From reading the Griffith Flood Liable Lands Policy, development within the flood fringe areas is more lenient, as opposed to floodway and flood storage. In the future, it is our intention to construct an additional dwelling on the property (replacement dwelling right) as well as a garage and farm sheds. The property has been neglected for many years and we plan to laser level the paddock for farming in the future. What implications will this study have on these activities?
- Will the floodway identified in *Figure 4 - 9 Hydraulic Categories Defined at the 1% AEP Event* be implemented once the study is adopted?

Yours sincerely,

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www.bmtwbm.com.au

Our Ref: DJL: L.N2391.001.docx

31 July 2013

[redacted]

Dear [redacted]

RE: SUBMISSION OF DRAFT LAKE WYANGAN FRMS&P

Thank you for your submission received in regards to the Draft Lake Wyangan Floodplain Risk Management Study and Plan following public exhibition and for your time to attend our subsequent meeting at Griffith City Council on 04th June 2013.

I understand that through our meeting including Council officers, we were able to provide additional information on the project and specifically your property ([redacted]). I trust that the information provided suitably addressed your questions/issues raised.

I am taking this opportunity to provide a formal response to your submission via this letter which provides further response to your queries and also serves as a summary of our previous discussions.

Attached for reference is a copy of the letter received from yourselves. Below are responses to your questions/comments under the same sub-headings.

Document on Exhibition

The document on exhibition is the Draft Lake Wyangan Floodplain Risk Management Study and Plan (ref: R.N2391.001.01). The previous document you refer to is the Lake Wyangan Flood Study (ref: R.N2038.001.03) completed by BMT WBM in March 2012. They are two separate studies, with the Lake Wyangan Flood Study incorporating detailed modelling and analysis to determine the flood characteristics of the catchment including information on flood flows, velocities, levels and extents for a range of flood magnitudes. The Floodplain Risk Management Study focuses more on the management of these flood risks for existing and future development, particularly planning aspects for the catchment. The Floodplain Risk Management Study also took the opportunity to update the flood analysis utilising information from the March 2012 flood event.

Map Resolution

It is acknowledged that mapping in the report at the catchment scale is often difficult to interpret for individual properties. I note that during our meeting at Council offices, we discussed the particular flooding aspects at your property with the aid of higher resolution maps. There was a general agreement that the mapping was representative of the ground conditions at the site. For your information, I have attached a higher resolution map of your property.

Further to the above, whilst it is not possible to provide detailed mapping for all property within the report, some additional mapping has been included in the Final Report that provides further detail in the lower catchment around the Lake Wyangan township. Please note also that the flood mapping layers have been

provided to Council in electronic format (GIS mapping) to enable detailed inspection of flood characteristics at the lot scale.

Methodology

The key flow paths, and in particular floodway areas, are in agreement with the historical flood information collected. The modelling undertaken is considered a sound representation of typical flood conditions and suitable for ongoing flood planning and development control in the study area.

The existing upper catchment of the flow path near your property is largely undeveloped – this principally incorporates the northern slopes of Scenic Hill and the general airport locality. To some degree the runoff from the upper catchment is already controlled by the siphon structures beneath the Lake View Branch Canal. As you rightly suggest, further reduction in peak flows may be achieved through additional flood detention measures in the upper catchment. Such measures have not been incorporated in the current Floodplain Risk Management Plan given:

- The flood risk exposure in the lower catchment area is relatively limited – much of the floodway area aligns with existing roadways and there is only a small amount of existing development affected being largely rural/agricultural land;
- The existing upper catchment is largely natural catchment, with limited development and increase in impervious area from natural condition. The airport development represents only a small percentage of the catchment area; and
- The limited cost-benefit of constructing specific flood management works in this area with land largely within private ownership.

Future development in the catchment however will be subject to specific development controls that provide for management of potential increases in flows through urbanisation.

Outcomes

As stated in the report, given the nature of flooding within the Lake Wyangan/Tharbogang Swamp catchment, current flood risk exposure is somewhat limited relative to other catchments within the Griffith LGA. There is considered little opportunity or indeed requirement for structural options to mitigate existing flooding risks given both the nature of flooding and limited flood risk exposure to existing property. Accordingly, the floodplain risk management plan for the catchment focuses on appropriate planning and development controls to ensure future development does not unduly exacerbate the overall flood risk.

During our meeting at Council, we discussed the specific flood risk at your property and provided further detail of the nature and extent of flooding. Again I have attached more detailed maps for your reference.

The Griffith Flood Prone Land Policy and existing development controls will apply as per the existing policies. However, given the flooding characteristics of your property, there would appear to be few limitations on future development. The majority of the site is either flood free or classified flood fringe at the 1% AEP flood level.

It is also noted that mapping associated with the flood hydraulic categories may be amended in the future, at a local or property scale, subject to appropriate analysis that demonstrates no additional impacts (e.g. if it is to change from floodway to flood storage or fringe). Accordingly future regrading of the site is possible provided it is demonstrated that earthworks on the site do not provide for adverse impacts to neighbouring property.

Once again I would like to thank you for your submission and interest in the study. If you would like further information I would suggest you contact [redacted] at Council in the first instance.

Yours Faithfully
BMT WBM Pty Ltd

[redacted]

Water & Environment Manager - Newcastle

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