



MURRUMBIDGEE RIVER  
WAGGA WAGGA RIPARIAN  
VEGETATION  
MANAGEMENT PLAN



WMA WATER  
AUGUST 2017



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WAGGA WAGGA RIPARIAN VEGETATION  
MANAGEMENT PLAN

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For

WMA WATER AND WAGGA WAGGA CITY COUNCIL

By

WARATAH ECO WORKS

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# 1 INTRODUCTION

## 1.1 BACKGROUND

This vegetation management plan (VMP) is being prepared as part of the Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan (FRMS&P). The plan is being prepared by WMAwater for Wagga Wagga City Council. In their brief for the plan Wagga Wagga City Council sought specific advice for the management of vegetation on the floodplain. Attention was drawn to the Draft Guideline for the Assessment of Feasibility of Vegetation Management as a Floodplain Risk Management Measure for Existing Urban Areas recently prepared in 2015 by the NSW Office of Environment and Heritage.

The need for advice on vegetation management on the floodplain was highlighted following the preparation of flood modeling for the Wagga Wagga Levee Design (WMAwater 2014). The preparation of the model highlighted the change in vegetation density on the flood plain over time and particularly the increase in vegetation density from 1990 to 2014.

This vegetation management plan sets out:

- the aims of the vegetation management plan (VMP)
- a data review; preliminary hydraulic modeling and field assessment;
- the planning context of the study area;
- the site assessment results;
- the revised hydraulic modeling results;
- the opportunities and constraints around riparian vegetation management for flood mitigation; and
- appropriate vegetation management actions to achieve ecological benefits and contribute to long term flood management.

## 1.2 AIMS OF THE VMP

The aim of the VMP is to:

- Provide specific advice to Wagga Wagga City Council for the management of vegetation on the floodplain.

## 1.3 METHODOLOGY

This VMP has been undertaken as a three stage process.

- Initially the feasibility of vegetation management as a flood risk management (FRM) measure was assessed using preliminary hydraulic modeling to identify what could be achieved in regard to flood levels by a reduction in vegetation and which areas were the most critical for such management.
- In parallel vegetation communities were ground truthed and opportunities and constraints to vegetation management identified in light of State Government legislation and relevant guidelines.



- Areas identified during ground truthing were subject to further modeling to assess the impacts of vegetation management on flood behaviour.

#### 1.4 STUDY AREA

The study area involves the floodplain of the Murrumbidgee River and adjacent areas shown on Figure 1. It is located generally between the Malebo Gap downstream, and the village of Oura upstream. The focus of the VMP has been from Oura to the city of Wagga Wagga.

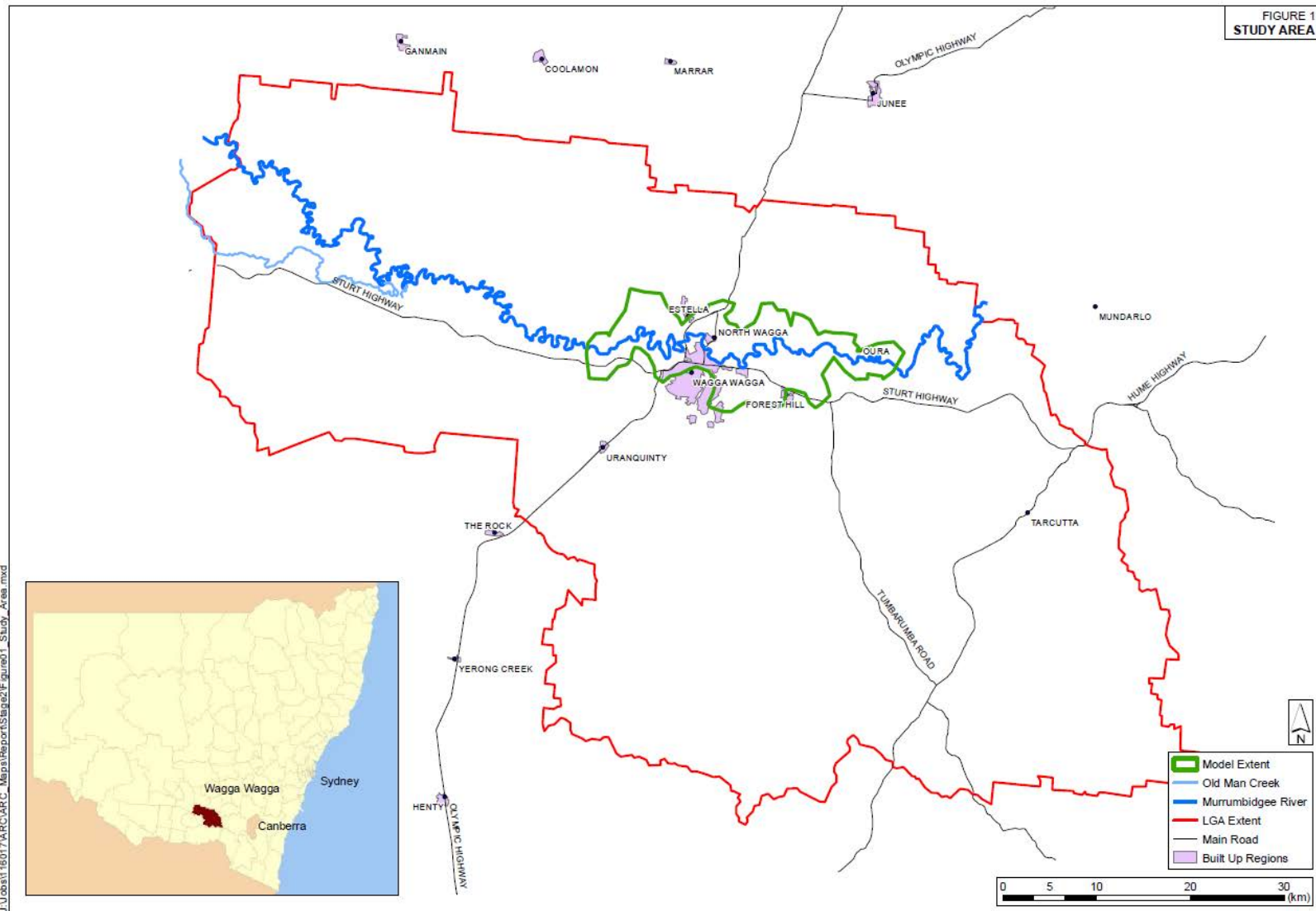


Figure 1 Study Area

## 2 PLANNING CONTEXT

### 2.1 LOCAL STRATEGIC PLANS

#### 2.1.1 RIVERSIDE STRATEGIC MASTER PLAN

The Riverside Strategic Master Plan (WWCC and Land and Property Management Authority 2010) was developed in 2009 after extensive consultation with the community of Wagga Wagga (WWCC undated). The Master Plan was adopted by Wagga Wagga City Council in May 2010 and provides the guiding principles behind the future development of the riverside precincts in the city (WWCC undated). The plan covers an area from Wiradjuri Reserve in the north, through Wilks Park to Thompson Street in the south. It identifies 3 specific precincts:

- Wiradjuri and Wilks (more natural areas);
- Hampden Terraces (the northern gateway);
- The Bend (includes the civic precinct and Wagga Beach).

The natural environment is described along with the soil landscape and biodiversity. The plan details the biodiversity values of the riverine forests found in Wiradjuri and Wilks Parks. The management of natural areas is briefly discussed including Council's approach to not thinning dense regrowth of river red gums. The plan sets out the understanding that widely separated round trunks have a lower impact than dense undergrowth on hydraulic roughness or flood flow friction loss. The plan indicates the author's support a balanced approach of ecological mixed layer plantings in more open areas.

The plan details the key biodiversity values of the riverside precincts including:

- Areas of native grassy woodlands through Wilks Park;
- The area west of Wiradjuri Park should be protected with strategic planning;
- Major revegetation has occurred in Wilks Park;
- West of Wiradjuri Reserve is an area of high biodiversity values due to the presence of mature river red gums and wetland species;
- The presence of threatened bird species in the parks and the endangered population of Squirrel Gliders listed on the NSW Threatened Species Conservation Act.

#### 2.1.2 RIVERINA REGIONAL STRATEGIC WEED MANAGEMENT PLAN 2017 – 2022

The Riverina Regional Strategic Weed Management Plan (the Plan) supports Goal 1 of the NSW Biosecurity Strategy: *"biosecurity is a shared responsibility"*. The plan was prepared by the Riverina Regional Weeds Committee (RWC) on behalf of the Riverina Local Land Services Board, with guidance from the State Weeds Committee and Local Land Services. The Plan focuses on weed risks that affect animal and plant industries, biodiversity, sociocultural factors, and infrastructure and service industries (Riverina Local Land Services 2017).

The Plan aims to achieve goals that focus on shared responsibility for weed management, sustainable landscapes and collaborative leadership and innovation. It sets out the priorities for weed management for the five years ahead and outlines strategies and actions to achieve goals (Riverina Local Land Services 2017). The Plan outlines the tools available under the Biosecurity Act 2015, a key feature of which is that it applies to all land in the region, whether public or private (i.e., it is tenure

neutral) (Riverina Local Land Services 2017). The tools available in the plan support the tenure-neutral approach to managing weed biosecurity risk. The plan also outlines land manager obligations under the General Biosecurity Duty (GBD) in the region, which for weeds is broadly defined as: "...any person dealing with plant matter must take measures to prevent, minimise or eliminate the biosecurity risk (as far as is reasonably practicable)". Regional priority weeds have been identified in the plan with recommended measures to discharge the General Biosecurity Duty.

## 2.2 LOCAL PLANNING INSTRUMENTS

### 2.2.1 THE WAGGA WAGGA LOCAL ENVIRONMENTAL PLAN 2010

The Wagga Wagga Local Environmental Plan 2010 (LEP) is the principal legal document for controlling development and guiding planning decisions made by Council to facilitate new development.

The LEP was published on 16 July 2010 and consists of a written document and comprehensive series of maps illustrating the controls applying to land in Wagga Wagga local government area.

### 2.2.2 WAGGA WAGGA DEVELOPMENT CONTROL PLAN 2010

The development control plan is a non-legal document that supports the local environmental plan with more detailed planning and design guidelines.

For development where Wagga Wagga City Council is the consent authority, the following DCPs apply:

- Controls that apply to all development;
- Heritage Conservation;
- Environmental Hazards & Management;
- Natural Resources and Landscape Management;
- Biodiversity Certification Area;
- Villages;
- Subdivision;
- Rural Development;
- Residential Development;
- Business Development;
- Industrial Development;
- Specific Uses and Developments;
- Bomen Urban Release Area;
- Boorooma Urban Release Area;
- Lloyd Urban Release Area; and
- Gobbagombalin Urban Release Area.

### 2.2.3 WAGGA WAGGA DEVELOPMENT CONTROL PLAN 2005

In accordance with section 1.6 of DCP 2010, the following provisions from the Wagga Wagga Development Control Plan 2005 have been carried over and incorporated by reference into DCP 2010:

- Lake Albert Catchment;
- Mitchell Road;
- South Tatton;
- Bakers Lane;
- Bourkelands;
- Hilltop Estate;
- Boorooma Estate;
- Boorooma Estate Proposed Layout Plan;
- Forest Hill;
- Estella & Chapter 44 - Proposed Zone Layout.

#### 2.2.4 WAGGA WAGGA SPATIAL PLAN 2013-2043

The Wagga Wagga Spatial Plan provides clear strategic indicators for development of Wagga Wagga over the next 30 years and beyond. It is the key strategic document for directing and managing urban growth and change in our city, our villages and our rural areas over the next 30 years.

The Plan documents the pressures for growth and identifies current and future opportunities for sustainable growth across the Local Government Area.

#### 2.2.5 LOCAL ENVIRONMENTAL STUDY

The Local Environmental Study (LES) was undertaken by Wilana Associates on behalf of Wagga Wagga City Council. The LES considered the suitability of residential development and made recommendations for future land use planning to support the preparation of the Wagga Wagga Local Environmental Plan 2010.

### 2.3 STATE GOVERNMENT LEGISLATION

#### 2.3.1 BIODIVERSITY CONSERVATION REFORMS

The NSW Parliament has passed a new legislative package which proposes substantial amendments to how biodiversity is managed and ecologically sustainable development delivered in NSW. While this VMP has been prepared under the current legislation at time of writing the legislative changes are significant and it will be of value to Wagga Wagga City Council to revisit this section of the plan once the new legislation has commenced. The legislative changes include:

- repeal of the Native Vegetation Act 2003, Threatened Species Conservation Act 1995 (Threatened Species Act), Nature Conservation Trust Act 2001 and sections of the National Parks & Wildlife Act 1974;
- introduction of a new Biodiversity Conservation Act 2016 (BC Act) (reflecting the contents of the Biodiversity Conservation Bill 2016 (BC Bill)) to replace the repealed legislation above and introduce a new system for managing biodiversity, land management and ecologically sustainable development; and
- amendment of the Local Land Services Act 2013 (NSW) (LLS Act) through the Local Land Services Amendment Act 2016 (LL Act 2016).

The NSW Government is now developing the supporting regulations and other subordinate instruments for this new legislation. Regulations and instruments were placed on public exhibition until June 2017. The reforms are expected to commence on the 25th August 2017.

### 2.3.2 BIODIVERSITY CONSERVATION ACT 2016

The Biodiversity Conservation Act 2016 includes:

- new provisions for the listing of threatened species;
- a new concept called the Areas of Outstanding Biodiversity Value;
- information about how wildlife management will occur;
- sets in the legislation the existing Saving Our Species program;
- establishes the Biodiversity Conservation Trust, to deliver private land conservation guided by the Biodiversity Conservation Investment Strategy; and
- aims to deliver ecologically sustainable development – through a new offsets scheme and Biodiversity Assessment Method and Biodiversity Certification.

The Biodiversity Regulation under the Biodiversity Conservation Act 2016 will support implementation of the Act with increased detail on various features in the BC Act.

### 2.3.3 LOCAL LAND SERVICES AMENDMENT ACT 2016

The LL Act 2016 will cover all land that is outside the Sydney metropolitan area that has a rural zoning. The Vegetation SEPP will apply to land outside these areas. The NSW Government indicates the reforms will establish a new risk-based framework for clearing native vegetation. Provisions about clearing associated with ongoing agricultural land management will be integrated into the Local Land Services Act 2013 (LLS Act). An approval will be required under the LLS Act for some types of clearing. The new native vegetation regulatory map (NV Map) will identify rural land where native vegetation clearing will be exempt from the new native vegetation clearing framework (Category 1 land) or where landholders will need to comply with the LLS Act (Category 2 land). Broadly, Category 1 land will be land that was cleared as at 1990 or which has been legally cleared since then. Category 2 land is land that has not been cleared or has not been legally cleared since 1990. For Category 2 land, which is regulated, there are three types of authorisation under the Act:

- allowable activities;
- clearing under the Land management Code; and
- clearing approved by the Native Vegetation Panel

Allowable activities are similar to RAMAs or routine agricultural management activities under the current *Native Vegetation Act*, but are more streamlined. These include low impact farming activities, such as clearing for a fence line or a dam. Clearing for allowable activities may be carried out without going through any process or obtaining any approval.

Clearing is allowed under the Land Management Code for a variety of purposes, such as controlling invasive native species or thinning vegetation to expand grazing pastures. In some cases, a set aside area will be required.

A clearing approval may be obtained from the Native Vegetation Panel. The panel will be a new body which will assess applications for clearing by looking at the social, environmental and economic factors.

An application for a clearing approval will be required to go through the Biodiversity Assessment Method process. Clearing already approved under other legislation, for example, a development consent from a local council will not require an additional authorisation under the *Local Land Services Act*.

#### 2.3.3.1 LOCAL LAND SERVICES AMENDMENT REGULATION

The Local Land Services Amendment Regulation provides more detail about processes and aspects of the *Local Land Services Act*. Primarily the new sub-category of Category 2 regulated land. This will be called Category 2 - Sensitive Regulated Land. The draft regulation also sets out more detail about the codes, certificates and set aside areas.

The regulation provides more information about how land which contains non-woody vegetation, such as grasslands, will be classed as either Category 1 or Category 2. The regulation also seeks feedback about how the new framework should apply to travelling stock reserves, for example, should all TSRs be classed as Category 2.

#### 2.3.3.2 LAND MANAGEMENT NATIVE VEGETATION CODE

The Land Management Native Vegetation Code is divided into seven parts, each of which permits different types of impacts on native vegetation as listed below.

- Clearing of listed invasive native species;
- Thinning woody vegetation;
- Clearing of certain vegetation for stock fodder;
- Allowing the continuation of historical practices;
- Managing post-1990 regrowth;
- Transitioning from current property vegetation plans to clearing under the codes;
- Farm plan which also allows Category 2 land to be cleared and re-categorised as Category 1, also in exchange for a set aside.

Under each part of the code, clearing will be permitted either with notification or by certification.

#### 2.3.4 BIOSECURITY ACT 2015

The Biosecurity Act 2015 replaces wholly or in part 14 separate pieces of biosecurity related legislation including the Noxious Weeds Act 1993. The new Act provides NSW with the essential tools and powers to manage animal and plant pests and diseases, weeds and contaminants that threaten the NSW economy, environment and community. The Biosecurity Act:

- embeds the principle that biosecurity is a shared responsibility;
- provides modern, flexible tools and powers that allow effective management of pests and diseases, weeds and contaminants across the landscape regardless of whether it is private or public land;
- minimises delays and defines responsibilities in emergency situations;

- provides for risk-based decision making that enables a flexible approach to responding and managing biosecurity risks, regardless of the type of biosecurity matter; and
- supports a national approach to biosecurity and gives effect to intergovernmental biosecurity agreements.

### 2.3.5 NATIVE VEGETATION ACT 2003 (NV ACT) (TO BE REPEALED)

The NV Act will be replaced by the Local Land Services Amendment Act 2016. The Native Vegetation Act 2003 (the Act) sets out how native vegetation is managed in NSW by preventing broadscale clearing unless it improves or maintains environmental outcomes. Under the Act landholders can:

- clear and manage native vegetation without approval if the clearing is permitted such as clearing for a routine agricultural management activities (RAMAs), activities classified as excluded clearing or carried out on land excluded from the operation of the NV Act
- submit property vegetation plans (PVPs) for approval by their Local Land Services (LLS) that can describe how native vegetation will be managed on the property.

The Act regulates the clearing of native vegetation on all land in NSW except for land listed in Schedule 1 of the Act. Excluded land falls into the following categories:

- national parks and other conservation areas;
- state forests and reserves; and
- urban areas.

Native vegetation is classified as any species of vegetation that existed in NSW before pastoral settlement, including trees, saplings, shrubs, scrub, understory, groundcover or wetland plants.

### 2.3.6 NATIVE VEGETATION REGULATION 2013 (TO BE REPEALED)

The Native Vegetation Regulation 2013 (the Regulation) commenced on 23 September 2013. It sets out a staged approach to vegetation management in NSW.

Stage 1 – A number of provisions including new or expanded exemptions to clear native vegetation without a property vegetation plan (PVP) take effect from 23 September 2013.

Stage 2 - Self-assessable codes to be made for certain common clearing activities without the need for a PVP will be implemented in 2014.

Stage 3 – Assessment for clearing requiring a PVP will be streamlined and simplified.

### 2.3.7 THREATENED SPECIES CONSERVATION ACT 1995 (TO BE REPEALED)

The *Threatened Species Conservation Act 1995* (TSC Act) provides for the protection of threatened species, populations, endangered ecological communities (EECs) and critical habitats and the identification and assessment of key threatening processes. In relation to development assessment, the provisions of the TSC Act have been integrated into the EP&A Act.

Section 5A of the EP&A Act requires that the assessment of all developments include consideration of whether the proposal is likely to impact on threatened species, populations or ecological communities. It establishes seven factors on which this assessment must be based (the ‘Seven Part Test’). Where a significant impact is considered likely, a Species Impact Statement (SIS) must be prepared.



Should clearing be proposed that would impact on habitat of threatened species or endangered ecological communities listed on the TSC Act assessments of significance would be required.

The impacts of the TSC Act are not applicable to parts of Wagga Wagga due to the Biodiversity Certification Order placed on the City and that part of the study area falls within land that is subject to biodiversity certification (see Figure 2).

### 2.3.8 INFRASTRUCTURE SEPP 2007

State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) aims to facilitate the effective delivery of infrastructure across the State.

Under the Infrastructure SEPP, works defined as flood mitigation works include:

*"work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.*

*Note. Examples of flood mitigation work include levees, barrages, causeways, cuttings, embankments, floodgates and detention basins."*

Clause 50 of the ISEPP outlines that development for the purpose of flood mitigation work may be carried out by, or on behalf of, a public authority without consent on any land.

### 2.3.9 BIODIVERSITY CERTIFICATION

On 24 December 2010, the Minister for Climate Change and the Environment, signed an Order issuing biodiversity certification for the Wagga Wagga Local Environmental Plan. The biodiversity certification remains effective for ten years.

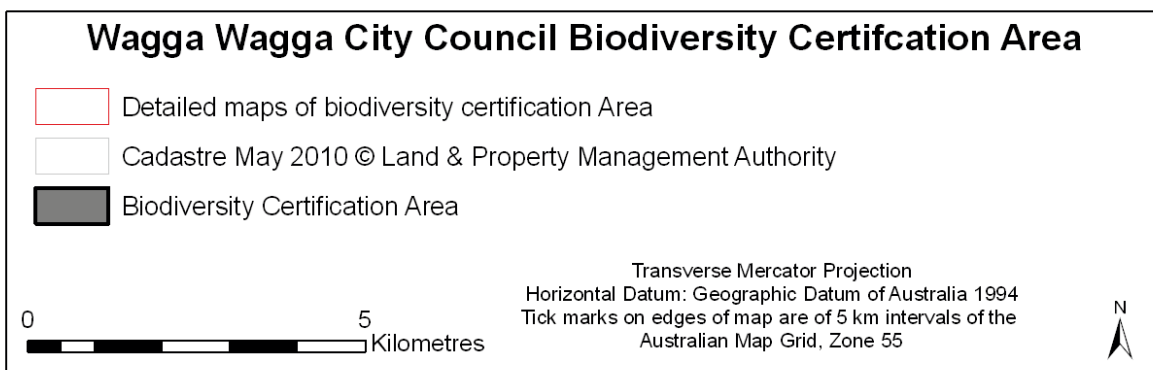
Biodiversity certification essentially suspends the application of Section 5A of the NSW *Environmental Planning and Assessment (EP&A) Act 1979* which deals with the assessment of impacts on threatened species listed on the NSW *Threatened Species Conservation (TSC) Act 1995*.

The area of biodiversity certification (Figure 2) includes all inner urban and Urban Release Areas, including the city centre and its suburban environs, the Lloyd Urban Release Area and the Urban Release Areas of Estella/Boorooma and Bomen to the north of the city centre. The certification covers approximately 10,655 ha of the Wagga Wagga local government area that represents the current and future urban and industrial area around Wagga Wagga city

Biodiversity certification does not apply on land to which the provisions of the Native Vegetation Act apply; in relation to Aboriginal heritage and; where Salinity and other Natural Resource management assessments are required.

### 2.3.10 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The *Protection of the Environment Operations Act, 1997 (POEO Act)* is the primary piece of legislation regulating pollution control and waste disposal in NSW and is administered by the Office of Environment and Heritage (OEH).



**Figure 2 Wagga Wagga City Council Biodiversity Certification Area**

Source: NSW Government Gazette 2010

### 2.3.11 WATER MANAGEMENT ACT 2000

The *Water Management Act 2000 (WM Act)* is administered by the Office of Water, in the Department of Primary Industries (DPI).

The Act outlines that activity approvals must be sought for controlled activities and aquifer interference.

The definition of "controlled activity" means:

*(a) the erection of a building or the carrying out of a work (within the meaning of the Environmental Planning and Assessment Act 1979), or*

*(b) the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or*

*(c) the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or*

*(d) the carrying out of any other activity that affects the quantity or flow of water in a water source.*

However, section 39A in Water Management Regulation 2004 states that;

*(1) Public authorities (other than Landcom) are exempt from section 91E (1) of the Act in relation to all controlled activities that they carry out in, on or under waterfront land.*

As WWCC is a public authority, if they undertake works on their land they are exempt from requiring an activity approval. However the NSW Office of Water can place a stop work order on public authorities should works not be undertaken in accordance with the principles of the Act.

WWCC could also seek a controlled activity exemption for works 40 metres from the river bank from the NSW Office of Water.

### 2.3.12 HERITAGE ACT 1977

The *Heritage Act 1977* provides for the protection of non-Indigenous heritage.

Action is required under this Act in respect of any proposed works where artefacts have been found in the vicinity of the works.

### 2.3.13 NATIONAL PARKS AND WILDLIFE ACT 1974

This Act provides, amongst other things, for the protection of Aboriginal heritage. All Aboriginal objects (termed "relics" prior to amendment of the Act [Amendment Act 2001 No.130]) are protected under Section 90 of the *National Parks and Wildlife Act 1974*. Under Section 90, it is an offence to destroy, deface, damage or desecrate an Aboriginal object or Aboriginal place without the prior issue of a Heritage Impact Permit by the Director-General of the National Parks and Wildlife Service (NPWS). The amended Act requires that reasonable precautions and due diligence must be taken to avoid impacts on Aboriginal objects.

### 2.3.14 FISHERIES MANAGEMENT ACT 1994

The *Fisheries Management (FM) Act 1994* is administered by the Department of Primary Industries (DPI) and covers works that are undertaken within waterways listed as key fish habitat.

The Murrumbidgee River across the study area is identified as key fish habitat.

Under the 'integrated development' provisions of the NSW *Environmental Planning and Assessment Act 1979*, DPI is an 'approval body' for local development that requires one or more of the following permits under the FM Act:

- Section 144 - aquaculture permit , ie cultivating fish or marine vegetation for sale / commercial purposes;
- Section 201 - permit to carry out works of dredging or reclamation, ie any excavation within or filling of water land;
- Section 205 - permit to harm (cut, remove, damage, destroy, shade etc) marine vegetation (mangroves, seagrass and seaweeds);
- Section 219 - permit to obstruct the free passage of fish.

## 2.4 COMMONWEALTH LEGISLATION

### 2.4.1 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) if a significant impact on the environment is a "real or not remote chance or possibility" from a proposed activity, then the proposal has to be referred to the Department of Environment for consideration. Approval from the relevant Federal Minister is also required for any actions that may have a significant impact on matters of National Environmental Significance, except in circumstances which are set out in the EPBC Act. Approval from the Commonwealth is in addition to any approvals under NSW legislation.

## 3 DATA REVIEW

### 3.1 PREVIOUS REPORTS AND MAPPING

Key previous reports considered in the preparation of this VMP include:

- WMAwater (2014) Wagga Wagga Detailed Flood Model Revision Report prepared for Wagga Wagga City Council; and
- NSW Office of Environment and Heritage (OEH) (2015) Draft Guideline for the Assessment of Vegetation Management as a Floodplain Risk Management Measure for Existing Urban Areas.
- Priddy, S. and Mulvaney M. (2005) *The Native Vegetation and Threatened Species of the City of Wagga Wagga*. Department of Environment and Conservation, Queanbeyan NSW.
- Local Land Services (LLS) mapping of existing property vegetation plans (PVPs).

The key findings of these reports are detailed in the following sections.

### 3.2 VEGETATION DENSITY INCREASE IN STUDY AREA

The need for advice on vegetation management on the floodplain was highlighted following the preparation of flood modeling for the Wagga Wagga Levee Design (WMAwater 2014). The preparation of the model highlighted the change in vegetation density on the flood plain over time and particularly the increase in vegetation density from 1990 to 2014.

A detailed literature review (WMAwater 2014) revealed:

- Moderate vegetation density -Pre 1860;
- Decrease in vegetation 1860 –1910 (approx.);
- Low vegetation density 1910 –1990;
- Increase in vegetation density to current state 1990 –2014;
- High vegetation density at time of the 2010 and 2012 floods.

### 3.3 VEGETATION AS A FLOODPLAIN RISK MANAGEMENT MEASURE

Vegetation management is a form of channel improvement that modifies flood behaviour (OEH 2015). Vegetation management aims to:

- improve the hydraulic capacity of watercourses by reducing the hydraulic roughness of a nominated reach.

However the effective works are likely to be located active flow areas which are part of the environmentally sensitive riparian corridor (OEH 2015). The removal of vegetation in the sensitive riparian zone may reduce the extent or length of time an area floods, however it can also impact negatively on erosion and ecological conservation (OEH 2015).

The predicted benefits of vegetation management are subject to flood modeling, where the resulting changes hydraulic roughness with management are assessed. However in stream vegetation can be damaged in flood events and may be swept away altering the predicted hydraulic impacts. The

removal of riparian vegetation can also result in hydrologic impacts due to a decrease in flood attenuation (that is reducing the flood peak).

The cost-effectiveness and practicality of vegetation management as a flood risk management (FRM) measure is also limited by the need for long term management that cannot be funded from legal permissibility and policy context. The NSW Government's vegetation management policy position:

*that by 2015 there to be an increase in extent and improvement in condition of native vegetation ('maintain or improve').* (Natural Resource Commission 2005)

In order to meet this requirement vegetation management for FRM must ensure there is either 'no net loss of', or a demonstrated improvement in the condition of, native vegetation. This may be achieved through the planning, establishment and management of native vegetation offset areas (OEH 2015).

A variety of legislation and guidelines control clearing of vegetation on floodplains and in riparian environments. These are presented in detail in Section 2 Planning Context.

OEH (2015) indicate:

*"It is anticipated that vegetation management would focus on removing problematic exotic species, preserve and reinstate endemic native vegetation and also include measures to control regrowth."*

The cost effectiveness of vegetation management as a FRM measure requires realistic consideration (OEH 2015). The benefits of vegetation management as a FRM measure are difficult to estimate. Vegetation requires appropriate, regular, frequent and long term maintenance that is not funded by the Floodplain Management Program. The policy and legislative setting is prohibitive and the benefits: estimated reduction in flood impacts (principally reduction in flood damages) may come at the expense of ecological values and exacerbate erosion and downstream flood impacts.

### 3.4 EXISTING VEGETATION MAPPING

The Department of Environment and Conservation and Wagga Wagga City Council undertook a project to prepare a model of the native vegetation of the City of Wagga Wagga. Pride and Mulvaney (2005) documented the results of the modeling project.

Floristic sampling undertaken around Wagga Wagga was combined with data sets for the adjoining southern region and for shires north-east of Wagga Wagga (Junee, Cootamundra, Gundagai, Harden and Young). A classification analysis was conducted using the combined datasets. Based on this analysis and additional field traverses, eighteen vegetation communities were identified as occurring in Wagga Wagga.

Five vegetation communities occur within the study area for this project:

- River Red Gum Forest;
- Yellow Box Woodland endangered ecological community (EEC);
- Environmental Plantings;
- Native Derived Grassland; and
- White Box Woodland EEC.

The study area is dominated by River Red Gum Forest with small areas of environmental plantings and native derived grasslands occurring sporadically. A small area of White Box Woodland occurs south of Oura and small patches of Yellow Box Woodland occur downstream of Oura, upstream of Gumly Gumly and downstream of Wagga Wagga City. The distribution of vegetation in the study area is shown in figure 3. (WMAwater TO INSERT)

## 3.5 EXISTING PROTECTED REGROWTH

### 3.5.1 PROTECTED REGROWTH

Protected regrowth is described by NSW OEH (2015a). It is native vegetation that has regrown since 1 January 1990 and has been identified as protected regrowth in a Property Vegetation Plan, an environmental planning instrument, a natural resources management plan or an interim protection order under the Native Vegetation Act. It also includes native vegetation that is regrowth that has been grown or preserved with the assistance of public funds granted for biodiversity conservation purposes.

OEH (2015b) indicates that under the Native Vegetation (NV) Act 2003, all clearing of remnant native vegetation or protected regrowth requires landholders to seek approval to a property vegetation plan (PVP) from their Local Land Service (LLS) unless the clearing is:

- on land that is excluded from operation of the Act
- categorised as excluded clearing, or
- permitted clearing including routine agricultural management activities (RAMAs).

A landholder can submit a PVP to their Local Land Services (LLS) for approval. PVPs describe how native vegetation will be managed on a property.

As an alternative to a PVP, landholders can also obtain a development consent from their LLS to clear native vegetation. Development consent cannot be granted unless the clearing improves or maintains environmental outcomes.

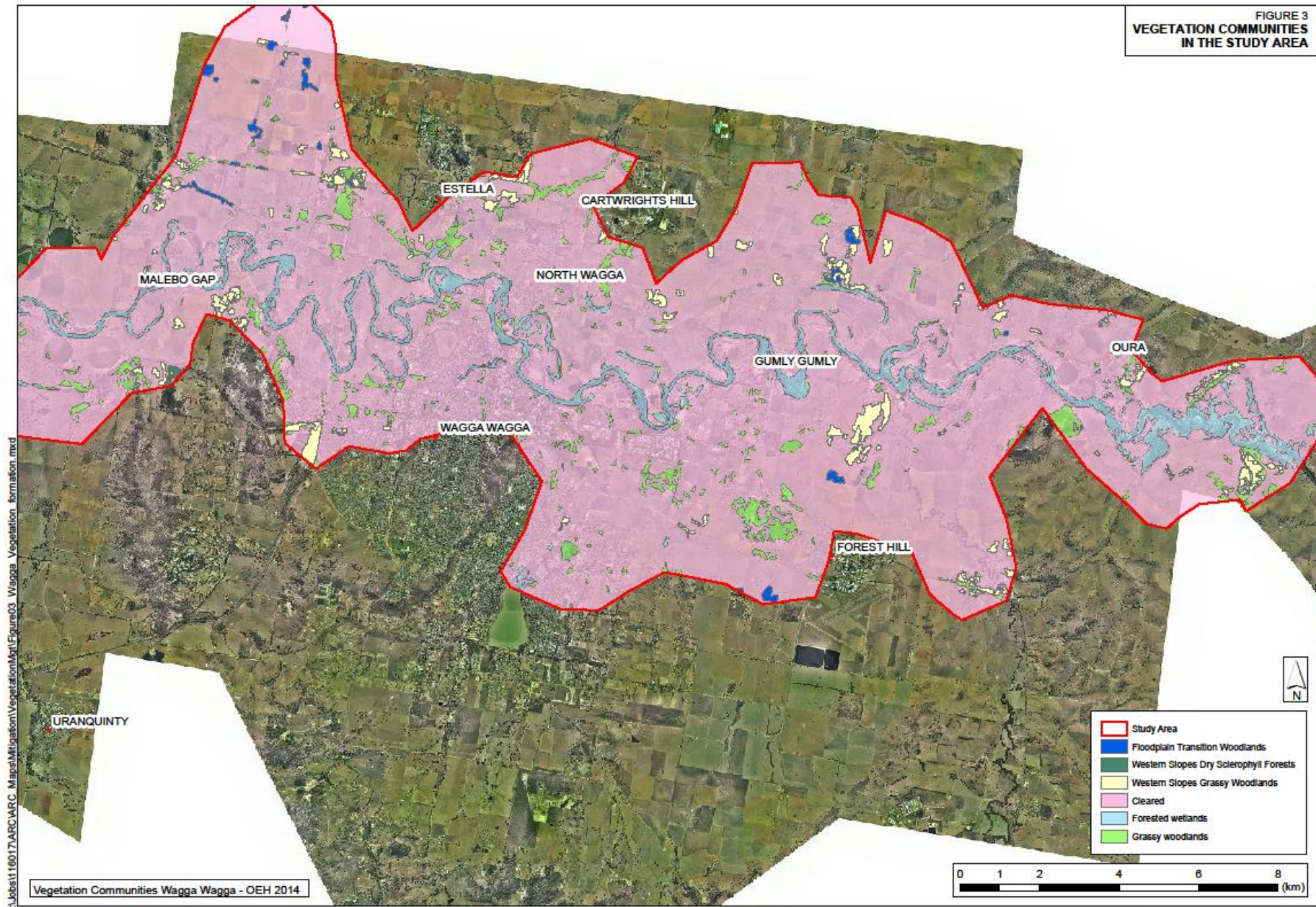


Figure 3 Vegetation Communities in the Study Area





### 3.5.2 PROPERTY VEGETATION PLAN (PVP)

A Property Vegetation Plan (PVP) is described by OEH (2014) as a voluntary, legally binding agreement between a landholder and the Local Land Services (LLS), and may be obtained for a number of reasons, including:

- to obtain clearing approval, and to secure any offsets associated with that clearing;
- to confirm that native vegetation on a property is regrowth, providing a landholder with assurance that they will not need future clearing approval;
- to change the regrowth date of native vegetation to an earlier date, provided that landholders can demonstrate a history of rotational farming practices on the land;
- to confirm whether existing rotational farming, grazing or cultivation practices meet the definitions of these in the Act so that clearing approval will not be required;
- applying for native vegetation incentive funding; and
- to protect native vegetation for future generations.

Areas listed as protected regrowth and registered in a PVP have been mapped in the study area by Riverina Local Land Services (LLS), as shown in Figure 4.

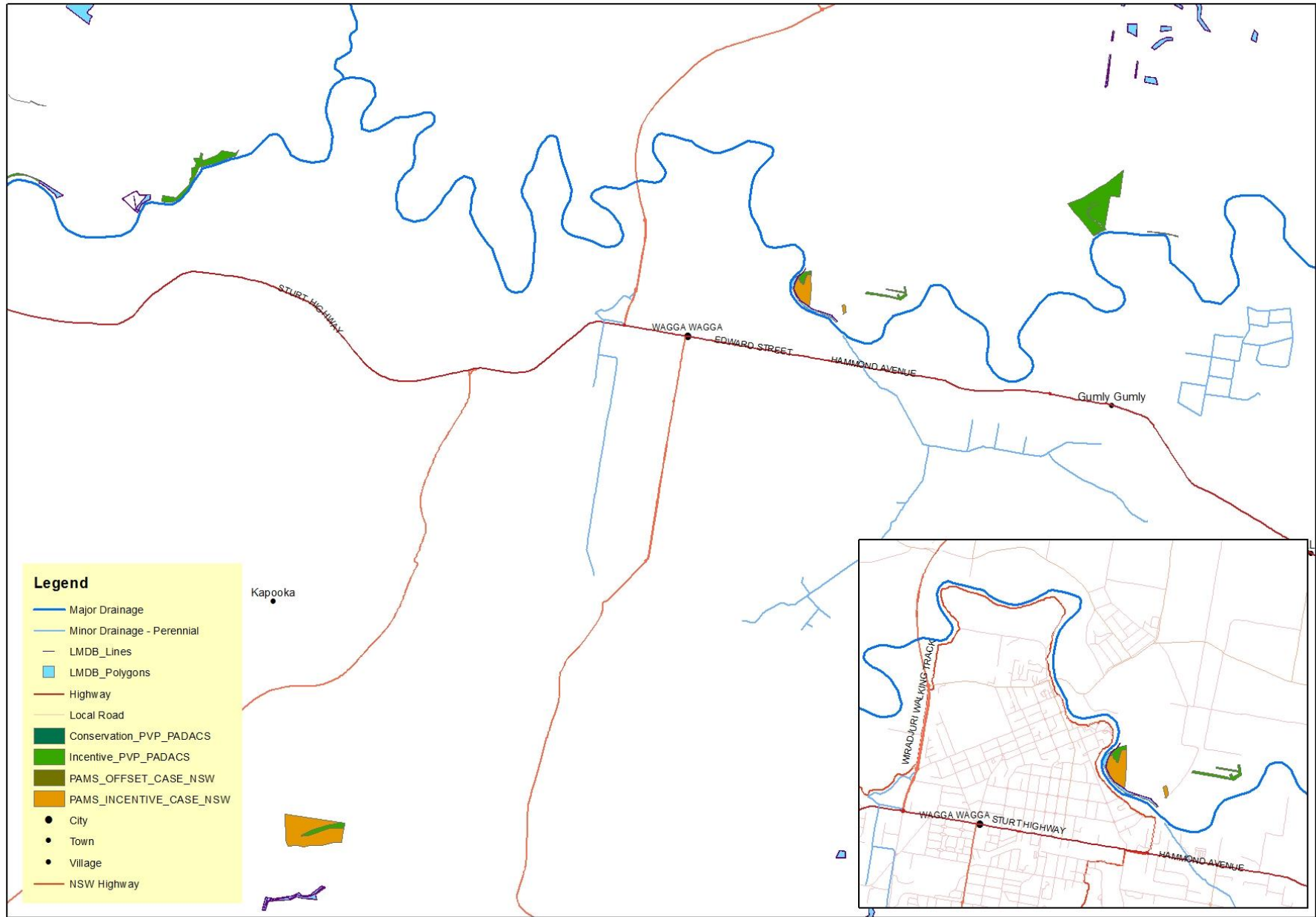


Figure 4 Areas of protected regrowth in the study area (source Riverina LLS)

Four PVP's containing protected regrowth vegetation have been identified in the study area:

- PVP 4841 Pregar Island revegetation and regeneration;
- PVP 7270 Pregar Island Willow Removal;
- PVP unknown corner of Hale and Hinkler North Wagga Wagga revegetation;
- PVP 5846 Oura Road, Eunanoreenya revegetation (to be undertaken).

### 3.5.3 ROUTINE AGRICULTURAL MANAGEMENT ACTIVITIES

Clearing of protected regrowth can only be undertaken under the NV Act 2003 as routine agricultural management activities (RAMAS).

Under the NV Act 2003, routine agricultural management activities (RAMAS) include the following activity on land carried out by or on behalf of the landholder:

*Section 11, 1 (i) any activity reasonably considered necessary to remove or reduce an imminent risk of serious personal injury or damage to property.*

Protected riparian land is land within 20 metres of the bed or bank of a prescribed stream. The use of RAMAs on protected riparian land is limited to the activities listed in Table 1.

Table 1 : RAMAs available on areas identified as protected riparian land

Clearing type	Maximum clearing distance permitted
Maintenance of safety clearances around electricity transmission lines	15 metres (where clearing is carried out by an employee of or contractor to a local government or electricity supply authority)
Fencing (other than boundary fence) to improve management of the protected riparian land	6 metres total width of clearing, and only for fencing that is reasonably required to be constructed on protected riparian land
Boundary fence	6 metres on either side
Farm road	metres total width of clearing, and only if the: <ul style="list-style-type: none"> <li>• road is reasonably required to access a site within protected riparian land, and</li> <li>• route of the road minimises the clearing required</li> </ul>
Clearing done pursuant to an obligation arising under an eradication order or pest control order under Part 10 of the Local Land Services Act 2013	Minimum extent necessary
The removal of noxious weeds under the Noxious Weeds Act 1993	Minimum extent necessary

Clearing undertaken subject to a Ministerial Order (excluding paddock trees and mulga) under Division 3, Part 6 of the Native Vegetation Regulation 2013	Minimum extent necessary
Clearing for conservation purposes under clause 50 of the Native Vegetation Regulation 2013	Minimum extent necessary
Clearing in accordance with a scientific license under section 132C of the National Parks and Wildlife Act 1974	Minimum extent necessary
Any activity reasonably considered necessary to remove or reduce an imminent risk of serious personal injury or damage to property	Minimum extent necessary

## 4 SITE ASSESSMENT RESULTS

### 4.1 SITE INSPECTION APPROACH

Prior to the site inspection preliminary mapping was prepared to identify areas of interest for site assessment. The mapping contained an aerial photo base, a velocity x depth grid and the vegetation layer (OEH 2011).

The Velocity x Depth grid provided a good indication of how the flow is distributed in a 1%AEP flood event. From this mapping areas of vegetation in areas of high flow were identified along with areas that if subject to vegetation management may benefit properties. A variety of areas were identified for further investigation, these are listed in Appendix A. Two key areas were identified for investigation at Gobbagombalin Bridge and in between the main town and north Wagga levees.

The site inspection involved four team members in two boats undertaking a visual inspection of vegetation along the Murrumbidgee River Channel between Oura in the east and Wagga City just upstream of Wiradjuri Bridge in the west. At key areas the teams traversed the bank areas investigating the density and quality of the native vegetation and confirming the vegetation community.

### 4.2 SITE INSPECTION RESULTS SUMMARY

The site inspection results are presented in Appendix A, the locations of detailed site inspections are shown in figures 1 and 2 in Appendix A.

The site inspection revealed the following key points:

- The vegetation around Oura was consistent with the vegetation mapping and supported River Red Gum *Eucalyptus camaldulensis* open forest with a grazed or mown understory.
- The vegetation densities upstream of Wagga Wagga in areas of high flow are lower than downstream.
- Vegetation in high flow areas upstream of Wagga Wagga is characterised by large mature River Red Gums *Eucalyptus camaldulensis* with a grassed understory.
- Vegetation upstream of Wagga Wagga also included occasional pockets of forest with a variety of age classes which included a lower density of large mature River Red Gums along with patches of regenerating canopy species.
- Occasional patches of Willows *Salix* spp. Occurred between Oura and Gumly.
- Around the confluence with Kyeamba Creek and sporadically in other areas large volumes of snags and debris likely from the 2010 and 2012 flood events are evident.
- The density of willows in the channel increased significantly between Gumly Gumly and Eunony Bridge.
- Around the city of Wagga Wagga and downstream vegetation occurs at higher densities.
- North Wagga Flats south of Hampden Avenue (upstream of Wilks Park) supports Regrowth River Red Gum forest with a variety of age classes. A variety of introduced species occur here including willows, small and large leaf privet *Ligustrum sinense* and *L. lucidum* the occasional Phoenix Palm and Osage Orange with occasional grass and ground cover weeds.

- Wilks Park: the area of high flow supports an open River Red Gum Forest with an open grassy understory. Vegetation closer to the bank is significantly denser with a variety of canopy age classes present in areas of dense regeneration.
- Areas around Wiradjuri Reserve and downstream of Wiradjuri on the high flow path high densities of willows occur on the river banks with a large volume of debris.
- Introduced deciduous canopy trees occur on the river banks around Wiradjuri Reserve
- The island in the River east of Wiradjuri Reserve supports a high density of willows in the canopy.
- The vegetation on the eastern bank at the meander opposite Wiradjuri Reserve supports a high density of introduced canopy species included the Common Fig *Ficus carica*, willows *Salix* spp. and Osage Orange *Maclura pomifera*.
- The vegetation along the bank opposite Marrambidya wetland supports high densities of willows along with other introduced species

### 4.3 VEGETATION COMMUNITIES

The following summaries of vegetation communities in the study area have been developed from Priddy and Mulvaney (2005). Their distribution in the study area is shown in Figure 3.

### 4.4 RIVER RED GUM FOREST

Characteristic Canopy Species	<i>Eucalyptus camaldulensis</i> , ( <i>Eucalyptus melliodora</i> )
Characteristic Understory Species	<i>Pratia concolor</i> , <i>Oxalis perennans</i> , <i>Ranunculus lappaceus</i> and <i>R. undosus</i>
Estimated Pre-1750 extent	20,277 ha
Estimated current extent	6,449 ha (32%)
Reservation Status	VP
TSC Act/EPBC Act	Not recommended for listing – additional information on the community from other parts of NSW is required.
Threats	Weed invasion; changes to river flows; clearing

**VP** = Not or very poorly reserved (<1%) **P** = Poorly reserved (1-5%) **M** = Moderately well conserved (5-10%) **AC** = Adequately conserved (10-25%) **EC** = Exceptionally well conserved (>25%).

The River Red Gum Forest community dominated the study area that was visited during the site assessment. It generally occurred as an open forest with a canopy dominated by River Red Gum *Eucalyptus camaldulensis*. The understory upstream of Gumly Gumly was often subject to grazing or was maintained as mown grassland in reserves. Closer to Wagga City the community often contained patches of willows *Salix spp.* as a small tree layer on the river bank and from the top of bank a dense grassed understory reaching 1 metre was present with a variety of annual and herbaceous weeds. In Wilks Park significant regeneration of River Red Gum is occurring and native plantings have been installed in Wilks Park and at North Wagga Flats. Native plantings in Wilks Park are recognised as protected regrowth along with a number of other areas shown in Figure 4.

#### 4.5 WHITE BOX WOODLAND

Characteristic Canopy Species	<i>Eucalyptus albens</i> , <i>Eucalyptus blakelyi</i> , <i>Eucalyptus melliodora</i>
Characteristic Understory Species	<i>Bothriochloa macra</i> , <i>Austrostipa scabra</i> subsp. <i>falcata</i> , <i>Elymus scaber</i> , <i>Austrodanthonia racemosa</i> , <i>Aristida ramosa</i> , <i>Lomandra filiformis</i> , <i>Austrostipa bigeniculata</i> , <i>Austrodanthonia linkii</i> , <i>Oxalis perennans</i> , <i>Tricoryne elatior</i>
Estimated Pre-1750 extent	68,156 ha
Estimated current extent	1,495 ha (2%)
Reservation Status	VP
TSC Act/EPBC Act	Listed (White Box-Yellow Box-Blakely's Red Gum Woodland on the TSC Act) Endangered Ecological Community
Threats	Further clearing of remnants, including paddock trees; certain grazing regimes.

A small area of White Box Woodland occurs south of Oura. It was not subject to field investigations as this area would not be subject to vegetation management.

This community is included within the definition of White Box-Yellow Box-Blakely's Red Gum Woodland, an Endangered Ecological Community listed on the NSW *Threatened Species Conservation Act 1995*.

#### 4.6 YELLOW BOX WOODLAND

Characteristic Canopy Species	<i>Eucalyptus melliodora</i> , <i>E. blakelyi</i> , <i>E. microcarpa</i>
Characteristic Understory Species	<i>Bothriochloa macra</i> , <i>Austrostipa bigeniculata</i> , <i>Elymus scaber</i> , <i>Convolvulus erubescens</i> , <i>Sida corrugata</i> , <i>Goodenia pinnatifida</i> , <i>Vittadinia cuneata</i> , <i>Austrodanthonia auriculata</i> , <i>Austrodanthonia setacea</i>
Estimated Pre-1750 extent	93,683 ha
Estimated current extent	2,806 ha (3%)
Reservation Status	VP
TSC Act/EPBC Act	Listed (White Box-Yellow Box-Blakely's Red Gum Woodland on the TSC Act) Endangered Ecological Community
Threats	Clearing of small remnants, including paddock trees, for expansion of irrigated cropping areas; weed invasion; excessive grazing of remnants;

Small patches of Yellow Box Woodland occur downstream of Oura, upstream of Gumly Gumly and downstream of Wagga Wagga City. This vegetation community will not be subject to vegetation management for flood mitigation.



This community is included within the definition of White Box-Yellow Box-Blakely's Red Gum Woodland, an Endangered Ecological Community listed on the NSW Threatened Species Conservation Act 1995.

#### 4.7 ENVIRONMENTAL PLANTINGS

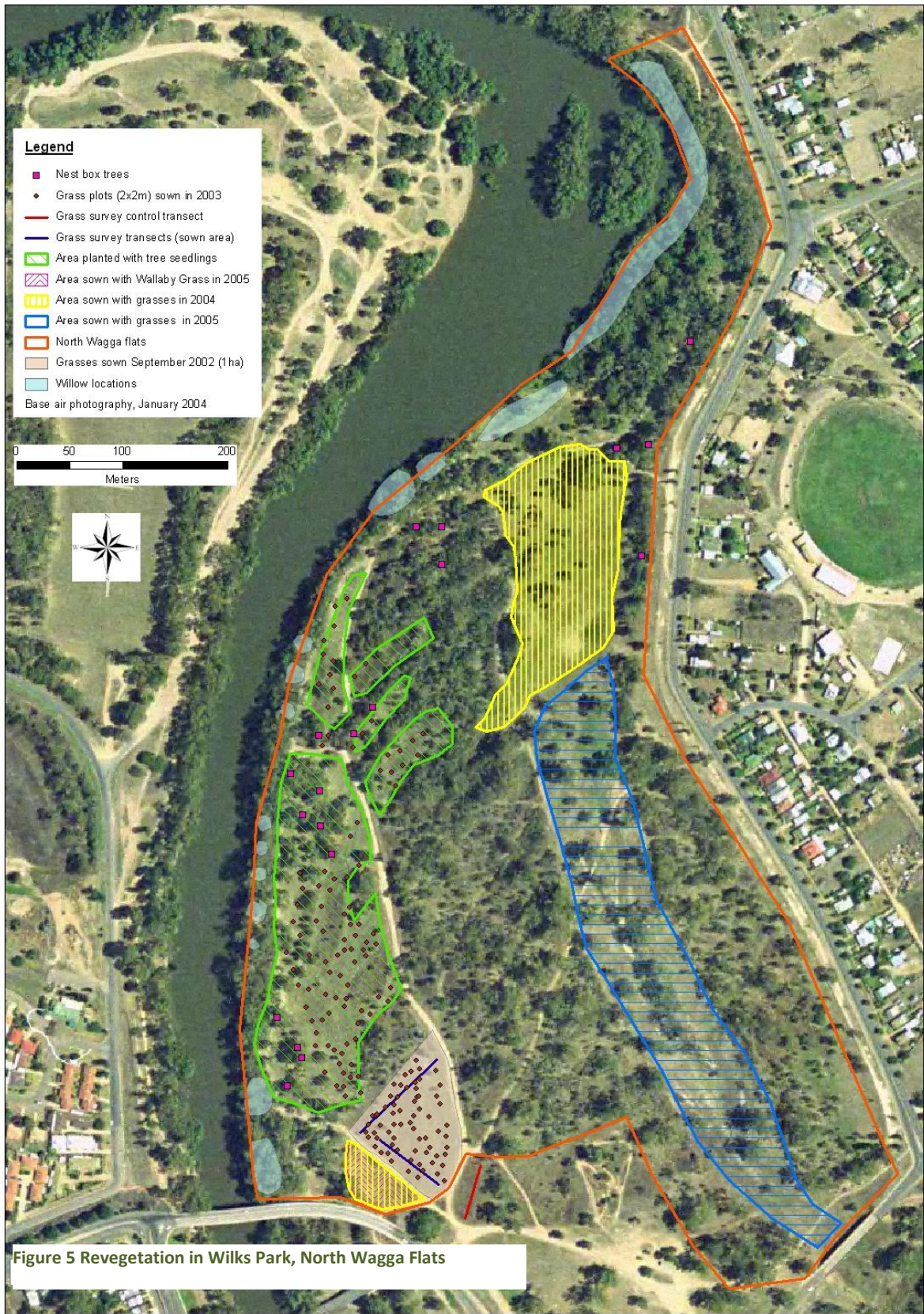
A range of environmental plantings have been undertaken at North Wagga Flats and in Wilks Park. The environmental plantings in Wilks Park include canopy plantings and native grasses. The distribution and extent of plantings is shown in Figure 5.

#### 4.8 NATIVE DERIVED GRASSLAND

Patches of derived native grassland occur north of Wagga Wagga where the train line crosses the Murrumbidgee River, near Eunanoreenya, on the northern bank of the Murrumbidgee opposite the confluence with Kyeamba Creek, on the southern bank of the river east of the Kyeamba Creek confluence and north east of Oura.

Derived native grassland occur where the tree canopy and mid layer has been almost entirely removed but the native ground layer remains largely intact (SEWPAC 2012).

Temperate grasslands are widespread in NSW across the tablelands slopes and plains. They are tussock grasslands characterised by Kangaroo Grass (*Themeda*), wallaby grasses (*Stipa*), and tussock and snowgrasses (*Poa*) (NRAC 2010).



## 4.9 ENDANGERED ECOLOGICAL COMMUNITIES

### 4.9.1 WHITE BOX-YELLOW BOX-BLAKELY'S RED GUM WOODLAND EEC

As indicated above the White Box and Yellow Box Woodland vegetation communities are included within the definition of White Box-Yellow Box-Blakely's Red Gum Woodland, an Endangered Ecological Community listed on the NSW *Threatened Species Conservation Act 1995*.

### 4.10 THREATENED FLORA SPECIES

Populations of two threatened plant species, the Yass Daisy (*Ammobium craspedioides*) and Pine Donkey Orchid (*Diuris tricolor*) are known to occur in Wagga Wagga. The Yass Daisy is at the limit of its distribution within Wagga Wagga and the Pine Donkey Orchid is known from only a single small population in the west of the city. Another six threatened plant species have either been recorded in Wagga Wagga historically or are known from nearby populations. These species may all occur in Wagga Wagga. The threatened plant species and their associated vegetation communities are summarised below in Table 2 from Priday and Mulvaney (2005).

Table 2 Threatened Flora Species

Plant Species	Conservation Status	Associated Vegetation Community
Yass Daisy <i>Ammobium craspedioides</i>	NSW: Vulnerable Commonwealth: Vulnerable	A small population of about 50 plants occurs in White Box – Yellow Box – Blakely's Red Gum woodland within Livingstone Nature Reserve
Pine Donkey Orchid <i>Diuris tricolor</i>	NSW: Vulnerable Commonwealth: Not listed	It is mostly scattered in a broad area to the west of Wagga Wagga between Narranderra and Dubbo, but was recently recorded in White Cypress Pine-Yellow Box-Grey Box Woodland in the western section of Wagga Wagga.
Woolly Ragwort <i>Senecio garlandii</i>	NSW: Vulnerable Commonwealth: Not listed	There is a very large population of many thousands of plants at The Rock Nature Reserve and it may occur in similar habitat in Wagga Wagga, such as rocky outcrops in the southern part of the city.
Small Purple-pea <i>Swainsona recta</i>	NSW: Endangered Commonwealth: Endangered	The plant was last recorded in Wagga Wagga in 1900. Small Purple-pea occurred in the grassy understory of woodlands and open-forests dominated by Blakely's Red Gum ( <i>Eucalyptus blakelyi</i> ), Yellow Box ( <i>E. melliodora</i> ), Candlebark Gum ( <i>E. rubida</i> ) and Long-leaved Box ( <i>E. goniocalyx</i> ).
Small Scurf-pea <i>Cullen parvum</i>	NSW: Endangered Commonwealth: Not listed	The Small Scurf-pea is known in New South Wales from only two herbarium collections; one from Wagga Wagga in

		1884 and the other from Jindera (near Albury) in 1967. A small population was recently found near Jerilderie. Large populations have been recorded in grassy gaps in the red gum woodlands of Barmah State Park, just across the border in Victoria.
Claypan Daisy <i>Brachyschome muelleroides</i>	NSW: Vulnerable Commonwealth: Vulnerable	The Claypan Daisy grows in damp areas on the margins of claypans. It was recorded to the west of Wagga Wagga in 1889 and is also known from the Narranderra, Tocumwal and Walbundrie areas.
Mossgiel Daisy <i>Brachycome papillosa</i>	NSW: Vulnerable Commonwealth: Vulnerable	It occurs in grassland and in woodlands dominated by Grey Box and Cypress Pines ( <i>Callitris</i> spp.). This plant has been recorded at Ganmain and may occur within the western section of Wagga Wagga.
Spider Orchid <i>Caladenia arenaria</i>	NSW: Endangered Commonwealth: Endangered	This spider orchid is currently only known to occur in the Riverina between Urana and Narranderra. It may occur in Wagga Wagga in woodlands on sandy soil, especially those dominated by White Cypress Pine ( <i>Callitris glaucophylla</i> ).
Austral Pillwort <i>Pilularia novaehollandiae</i>	NSW: Endangered Commonwealth: Not listed	This species grows in shallow swamps and waterways, often among grasses and sedges. It is most often recorded in drying mud as this is when it is most conspicuous. Most of the records in the Albury-Urana area were from table drains on the sides of roads.

#### 4.11 THREATENED FAUNA SPECIES

Seventeen threatened fauna species have been recorded from Wagga Wagga, at least ten of which are likely to have resident populations within the Local Government Area (LGA). Another two migratory species are likely to occur sporadically within Wagga Wagga depending on the availability of resources (Priday and Mulvaney 2005). The threatened fauna species and their associated vegetation communities are summarised below in Table 3 from Priday and Mulvaney (2005). The species highlighted in bold have been recorded in the Wagga Wagga LGA.

Table 3 Threatened Fauna Species

Fauna Species	Conservation Status	Associated Vegetation Community
Brolga <i>Grus rubicundis</i>	NSW: Vulnerable Commonwealth: Not listed	<b>Wetlands</b> , dry grassland or ploughed paddocks. The Brolga has been recorded only very rarely in Wagga Wagga in recent times. It is likely that this species now occurs only very sporadically in the City.
<b>Blue-billed Duck</b> <i>Oxyura australis</i>	NSW: Vulnerable Commonwealth: Not listed	Deep water in large permanent <b>wetlands</b> and <b>swamps</b> with dense aquatic vegetation. The Blue-billed Duck is recorded occasionally in Wagga Wagga but is unlikely to occur in any great numbers in most years.
<b>Freckled Duck</b> <i>Stictonetta naevosa</i>	NSW: Vulnerable Commonwealth: Not listed	<b>Permanent freshwater swamps</b> and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. The Freckled Duck is recorded occasionally in Wagga Wagga.
Grey Falcon <i>Falco hypoleucos</i>	NSW: Endangered Commonwealth: Not listed	Shrubland, grassland and wooded watercourses of arid and semi-arid regions, occasionally found in open woodlands near the coast. It may also occur near wetlands where surface water attracts prey. The Grey Falcon is likely to be a rare visitor to Wagga Wagga, most likely in the western parts of the City
Square-tailed Kite <i>Lophoictinia isura</i>	NSW: Vulnerable Commonwealth: Not listed	Found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses. The Square-tailed Kite is rarely recorded in Wagga Wagga. It is most likely to be encountered in the more heavily vegetated south-eastern parts of the City or nearby timbered parts of the major watercourses.
<b>Bush Stone Curlew</b> <i>Burhinus grallarius</i>	NSW: Endangered Commonwealth: Not listed	Inhabits <b>open forests and woodlands with a sparse grassy groundlayer</b> and fallen timber. A pair of Bush Stone-curlews lived for many years on the Lake Albert Golf Course. The female was killed by a golf ball and only the male remains. A few other recent sightings

		have been in the western or south-western sections of Wagga Wagga.
Pink Cockatoo <i>Cacatua leadbeateri</i>	NSW: Vulnerable Commonwealth: Not listed	Inhabits a wide range of treed and treeless inland habitats, always within easy reach of water. There are sporadic records of this species in Wagga Wagga where it is most likely to occur as an occasional visitor.
Superb Parrot <i>Polytelis swainsonii</i>	NSW: Vulnerable Commonwealth: Vulnerable	Inhabit <b>Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest.</b> The Superb Parrot is commonly observed in Wagga Wagga. Most records come from Yellow Box Woodland, Grey Box Woodland, White Box Woodland and River Red Gum Forest, although the species may forage in other vegetation types in the LGA.
Turquoise Parrot <i>Neophema pulchella</i>	NSW: Vulnerable Commonwealth: Not listed	Lives on the edges of <b>eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.</b> There are a small number of records of this species in Wagga Wagga. In recent years it has been most frequently recorded in the southernmost part of the LGA around the Murragludrie area and from the Bush Heritage property south of Tarcutta.
Swift Parrot <i>Lathamus discolor</i>	NSW: Endangered Commonwealth: Endangered	Migrates to the Australian south-east mainland between March and October. On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include <b>winter flowering species</b> such as Swamp Mahogany <i>Eucalyptus robusta</i> , Spotted Gum <i>Corymbia maculata</i> , Red Bloodwood <i>C. gummifera</i> , Mugga Ironbark <i>E. sideroxylon</i> , and White Box <i>E. albens</i> . This species is regularly recorded from Wagga Wagga.
Barking Owl <i>Ninox connivens</i>	NSW: Vulnerable Commonwealth: Not listed	Inhabits <b>woodland and open forest</b> , including fragmented remnants and partly cleared farmland. This species was recently recorded in <b>Livingstone Nature Reserve</b> and is

		known from a number of records around the town of Wagga Wagga. It is possible that the species occurs in River Red Gum Forest and larger remnants of woodland and open forest.
<b>Grey-crowned Babbler</b> <i>Pomatostomus temporalis</i>	NSW: Vulnerable Commonwealth: Not listed	Inhabits open <b>Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands</b> on alluvial plains. Several family groups are known from Wagga Wagga, mostly in the northern and western parts.
<b>Gilbert's Whistler</b> <i>Pachycephalus inornatus</i>	NSW: Vulnerable Commonwealth: Not listed	It is widely recorded in mallee shrublands, but also occurs in <b>box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests</b> , though at this stage it is only known to use this habitat along the Murray, Edwards and Wakool Rivers. This species is known from a small number of records in Pomingalarna Park, west of the town of Wagga Wagga.
<b>Speckled Warbler</b> <i>Chthonicola sagittatus</i>	NSW: Vulnerable Commonwealth: Not listed	The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understory, often on rocky ridges or in gullies. In Wagga Wagga the species appears to be restricted to larger areas of native vegetation in the south-east, such as <b>Livingstone Nature Reserve and areas around Tarcutta</b> .
<b>Brown Treecreeper</b> <i>Climacteris picumnus</i>	NSW: Vulnerable Commonwealth: Not listed	The Brown Treecreeper occurs in most vegetation types including South West Slopes <b>Box Gum Woodland, Alluvial Flats Grassy Woodland, White Box Woodland, South West Slopes Riverine Forest and South West Slopes Foothills Forest</b> .  This species has been recorded throughout Wagga Wagga. It was recorded on several occasions during the field surveys.
Hooded Robin <i>Melanodryas cucullatus</i>	NSW: Vulnerable Commonwealth: Not listed	The Hooded Robin prefers lightly wooded country, usually open eucalypt

		<p>woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.</p> <p>The only recent record of this species in Wagga Wagga is in the <b>Tarcutta Hills</b> area. Given the disappearance of this species across much of the South West Slopes, any occurrences of this species within Wagga Wagga should be considered extremely significant.</p>
<p><b>Black-chinned Honeyeater</b> <i>Melithreptis gularis</i></p>	<p>NSW: Vulnerable Commonwealth: Not listed</p>	<p>This species favour <b>Box-Ironbark woodlands</b> dominated by species such as White Box, Grey Box and Red Ironbark as well as River Red Gum Forest.</p> <p>This species has been recorded at several sites in Wagga Wagga, although it is by no means a common species</p>
<p>Regent Honeyeater <i>Xanthomyza phrygia</i></p>	<p>NSW: Critically Endangered Commonwealth: Critically Endangered</p>	<p>The principal habitat of the Regent Honeyeater is Box-Ironbark woodland and open forest, including wooded farmland and urban areas with mature eucalypts. Other important habitat includes coastal Swamp Mahogany (<i>Eucalyptus robusta</i>) forests and riverine She-oak (<i>Allocasuarina</i>) woodlands. Remnant stands of timber, roadside reserves, travelling stock routes and street trees are also important.</p> <p>The Regent Honeyeater is rarely recorded in Wagga Wagga.</p> <p>The decline of the species has been largely attributed to the steady rate of clearing of suitable foraging and nesting habitat and the degradation of much of the remainder</p>
<p><b>Diamond Firetail</b> <i>Stagonopleura guttata</i></p>	<p>NSW: Vulnerable Commonwealth: Not listed</p>	<p>Found in <b>grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum <i>Eucalyptus pauciflora</i> Woodlands.</b></p> <p>Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities.</p>



		Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland. The Diamond Firetail has been recorded from several sites in Wagga Wagga, particularly in the eastern half of the LGA. This
Painted Honeyeater <i>Grantiella picta</i>	NSW: Vulnerable Commonwealth: Vulnerable	There are no DEC Atlas records for Wagga Wagga LGA, but this species has been recorded in several nearby shires.
Squirrel Glider <i>Petaurus norfolcensis</i>	NSW: Endangered Population Commonwealth: Not listed	The Squirrel Glider has been recorded in <b>River Red Gum Forest</b> along the Murrumbidgee River in Wagga Wagga. It is also known from White Box woodlands close to Wagga and may be widespread across the LGA.
Greater Long-eared Bat <i>Nyctophilus timoriensis</i>	NSW: Vulnerable Commonwealth: Vulnerable  Up until recently the <b>South-eastern Long-eared Bat</b> was considered a subspecies of the Greater Long-eared Bat, <i>Nyctophilus timorensis</i> but recent studies have described the bat as a separate species, <b><i>Nyctophilus corbeni</i></b> (Parnaby 2009).	There are no DEC Atlas records for this species within Wagga Wagga Council. The nearest record is 30km to the south-west of Wagga City along the Olympic Highway.
Yellow-bellied Sheath-tail-bat <i>Saccolaimus flaviventris</i>	NSW: Vulnerable Commonwealth: Not listed	There is a small number of records of this species from Wagga Wagga. However, the species may be more common than these records suggest given that insectivorous bats are generally quite difficult to detect.
Southern Bell Frog <i>Litoria raniformis</i>	NSW: Endangered Commonwealth: Vulnerable	Southern Bell Frogs prefer <b>large permanent ponds with abundant vegetation</b> near the banks. During dry times, the species relies on thick vegetation, rocks, logs and large soil cracks in moist environments. There are recent records of this endangered frog from the vicinity of Wagga Wagga and Ladysmith.
Booroolong Frog <i>Litoria booroolongensis</i>	NSW: Endangered Commonwealth: Endangered	This species occurs on or near <b>pebble banks within stream margins, near slow-flowing connected or isolated</b>

		<p><b>pools.</b> These areas also tend to have some vegetation cover, such as ferns, sedges or grasses.</p> <p>The Booroolong Frog has been recorded recently in the east of Wagga Wagga in Umbango Creek near Humula. It is also known from just outside the east of the city from Carabost and Yaven Yaven creeks.</p>
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## 5 REVISED MODELING RESULTS

### 5.1 VEGETATION ROUGHNESS AND FLOODING

Flood modeling can be used to assess the benefits available with varying degrees of vegetation management. The key parameter used in flood modeling to represent existing and planned vegetation density is hydraulic roughness (Manning's  $n$ ). Manning's roughness coefficient is part of Manning's equation, used to determine channel flow. Manning's roughness coefficient ( $n$  value) is used to represent the resistance to flood flows in channels and floodplains. The  $n$  value or Manning's coefficient, is determined by a number of factors that affect the resistance of channels and floodplains. In areas of dense vegetation on floodplains, the major resistance is caused by trees, vines, and under story vegetation. The  $n$  value for a floodplain of this type can be determined by estimating the vegetation density of the floodplain in addition to other factors.

The modeling undertaken for this VMP looked at the existing estimated  $n$  values for the areas modelled and compared flood levels that could occur if the hydraulic roughness were to be reduced. Selection of the Manning's roughness coefficient can be a subjective process based on engineer experience, calibration and reference to texts such as Chow 1959. Hydraulic roughness can be affected by a number of factors, including flood behaviour, modeling tool, terrain steepness and LiDAR resolution.

The following table describes typical ranges of Manning's  $n$  typically assigned to differing vegetation types and densities.

**Table 4 Description of Manning's Roughness Coefficient.**

Manning's $n$	Description
0.025 - 0.035	Short grass with the water depth >> grass height.
0.035 - 0.045	Short grass with the water depth >> grass height on a slightly irregular earth surface. Trees at 10 metre spacing, area is easy to mow.
0.045 - 0.055	Long grass on an irregular (bumpy) surface with few trees. Irregular ground could make grass cutting difficult. Alternatively, trees at 8 metre spacing on an even, well grassed surface, no shrubs, no low branches.
0.055 - 0.065	Long grass, trees at 6 metre spacing, few shrubs. The vegetation is easy to walk through. Area not mowed, but regular maintenance is required to remove weeds and debris.
0.065 - 0.075	Trees at 5 metre spacing, no low branches, few shrubs, walking may be difficult in some areas.
0.075 - 0.085	Trees at 4 metre spacing, some low branches, few shrubs, few restrictions to walking.

0.085 - 0.095	Trees at 3 metre spacing, weeds and long grasses may exist in some locations. Walking becomes difficult due to fallen branches and woody debris.
0.095 - 0.105	Trees at 2 metre spacing, low branches, regular shrubs, no vines. Canopy cover possibly shades weeds and it is difficult to walk through.
0.115 - 0.125	Trees at 1.5 metre spacing with some low branches, a few shrubs. Slow to walk through.
0.145 - 0.155	Trees and shrubs at 1 metre spacing, some vines, low branches, fallen trees, difficult and slow to walk through. Alternatively, a continuous coverage of woody weeds with sparse leaves and no vines.
0.195 - 0.205	Trees and shrubs at 1 metre spacing, plus thick vine cover at flood level and fallen trees. Very difficult to walk through. Alternatively, a continuous coverage of healthy shrubs and woody weeds from ground level to above flood level.

The modeling undertaken for this project assigned Manning's n values to areas of dense vegetation on the floodplain. The modeling ran various scenarios (Section 5.3) that reduced Manning's n value. Please note that in order to reach the lower Manning's n value substantial clearing of the shrub or understorey layer would be required and canopy trees subject to thinning to reach a 5 metre spacing. In areas such as Wilks Park and Wiradjuri Reserve this would mean significant clearing in areas already subject to revegetation.

It should be noted that while the modeling has assessed reducing hydraulic roughness by clearing vegetation, the purpose of vegetation management is not necessarily to reduce flood levels, but to manage new growth and sapling/weed density so as not to increase flood levels into the future.

## 5.2 REVEGETATION AS AN OPPORTUNITY

The option to utilise revegetation upstream of Wagga Wagga was considered during preparation of this VMP. Suitable areas for revegetation upstream of Wagga Wagga and Oura were investigated and subject to modeling to assess the impact of increasing roughness upstream. The modeling revealed that increasing roughness upstream provided no reductions to flood level around the City and so was not pursued further.

## 5.3 MODELING OF VEGETATION CLEARING

Following field investigations various model runs were undertaken where the roughness of dense vegetation was decreased to simulate vegetation management and or clearing. The results are shown in the Figures 6 to 17 following.

The modeling only applies a roughness reduction in areas of dense vegetation. The reduction in roughness is shown as a reduction of 0.01, 0.02 and 0.03 for:

- Option A considers vegetation management in the area upstream of Gobbagombalin Bridge;

- Option B considers clearing in the Area between Wagga and North Wagga;
- Option A and B combines clearing or vegetation management in both areas.

### 5.3.1 ROUGHNESS

Vegetation management would aim to reduce roughness levels from 0.1 (see plate 1 following) down to 0.07 (see plate 2 following).



Plate 1 Vegetation with a roughness of 0.1



Plate 2 Vegetation with roughness of 0.07

Reducing roughness by 0.01 would require thinning of some canopy vegetation to achieve a 3 metre separation along with some reduction in understorey and weed control.

Reducing roughness by 0.02 would require increased canopy thinning, under pruning of low branches and a significant reduction in shrub or understorey vegetation particularly in Wiradjuri Reserve, revegetated areas of Wilks Park and in Marrambidya Wetland.

Reducing vegetation by 0.03 would require significant canopy thinning across most areas to achieve the 5 metre canopy tree separation, under pruning of low branches and removal of most shrubs across all areas supporting dense vegetation.

### 5.3.2 RESULTS IN THE 1% AEP EVENT

Figure 6 shows the extent of flood mitigation that would be achieved in a 1% AEP event with a roughness reduction of 0.01 in the area covered by the red polygon. A reduction in flooding by 0.02 to 0.05 metres (or between 2 and 5 centimetres) would be experienced in North Wagga and across the area shaded in pale green. This would require a significant reduction in understorey and canopy thinning across the area of high biodiversity west of Wiradjuri Reserve and in Marrambidya Wetland. Understorey would also be removed or significantly reduced on the northern bank of the Murrumbidgee River in an area identified as supporting introduced vegetation.

Figures 7 and 8 show the increased reduction in flood levels and the increased extent of flood reduction in a 1 in 100 year flood event across areas south of the Olympic Highway with a continued decrease in vegetation density.

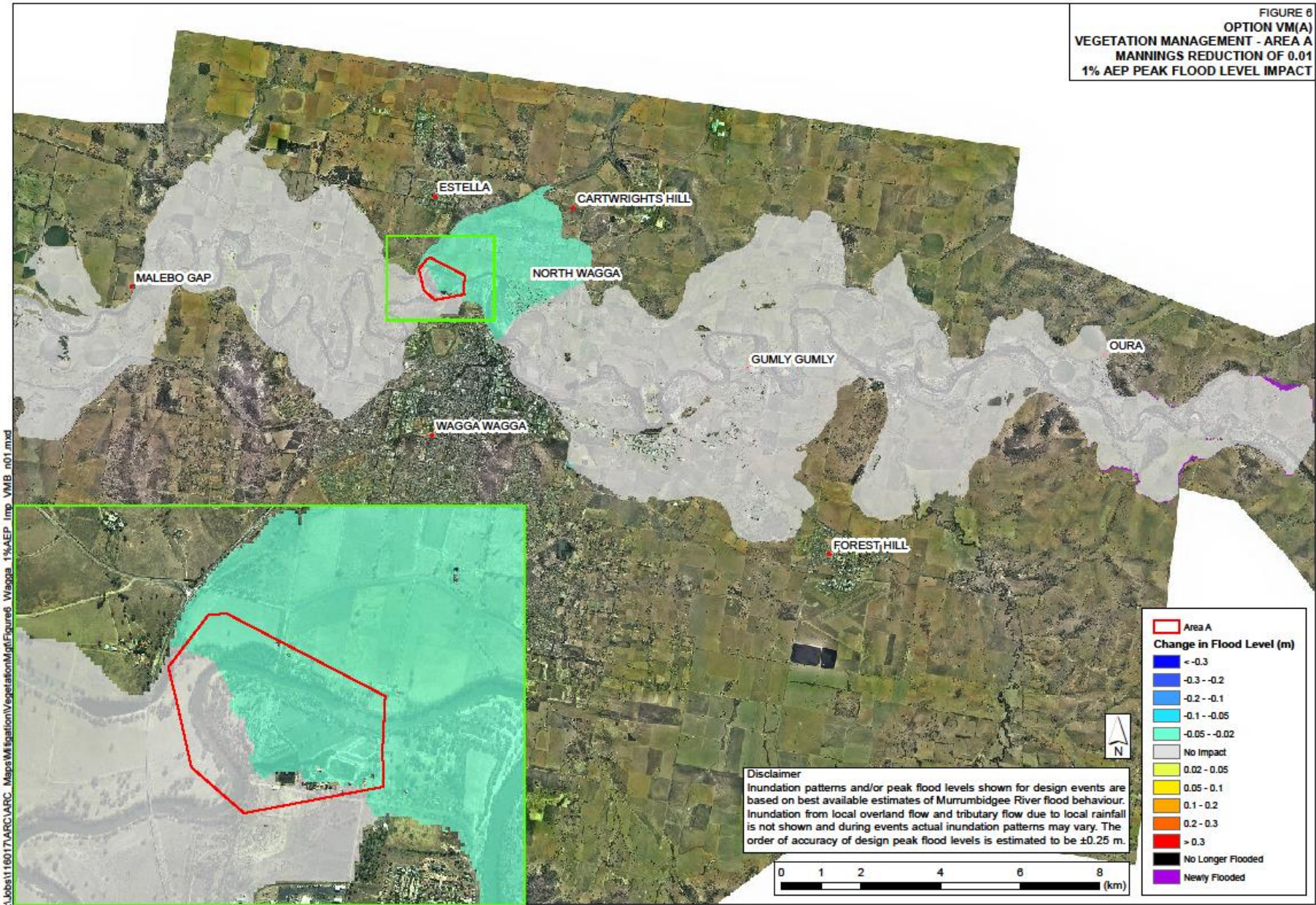


Figure 6

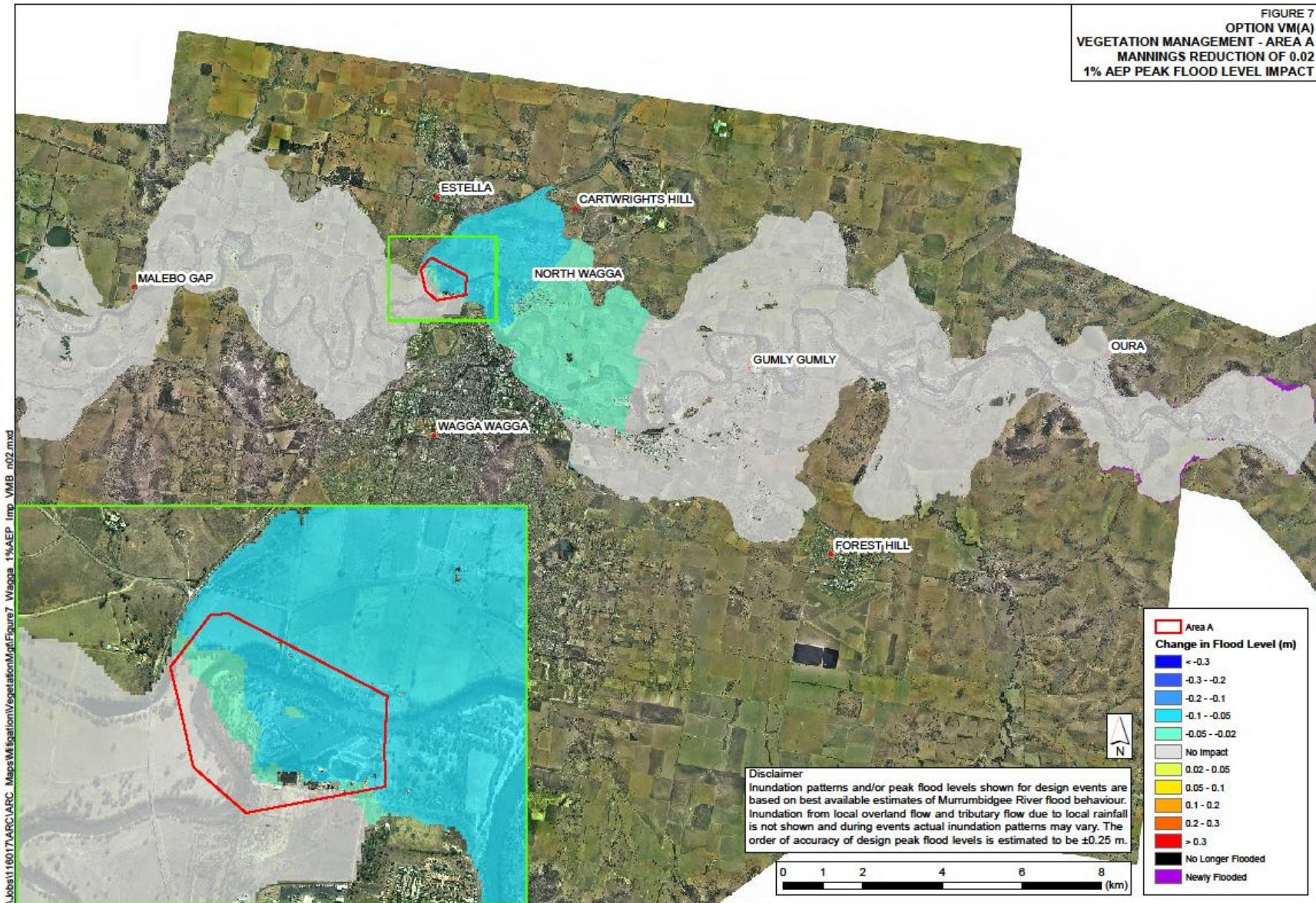


Figure 7



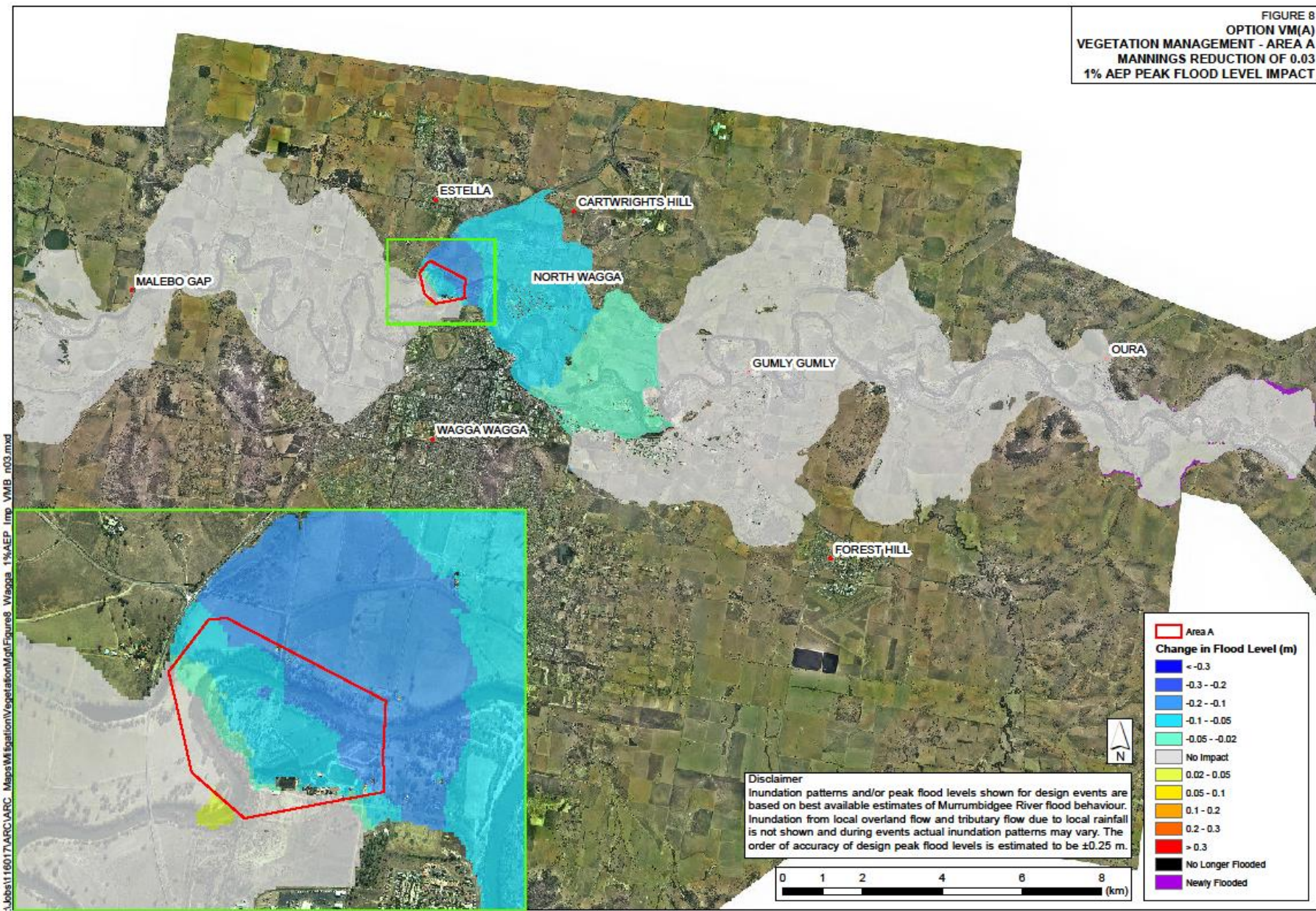


Figure 8

Option B considers clearing in the area between Wagga and North Wagga, this would include reducing overall vegetation density in Wiradjuri Reserve and throughout Wilks Park. Figure 9 shows a reduction in roughness of 0.01, while figures 10 and 11 show an increasing reduction in roughness of 0.02 and 0.03 with a corresponding reduction in vegetation.

Figure 9 indicates that with a reduction in roughness of 0.01 a reduction in flooding of between 0.02 and 0.05 metres (2 to 5 centimetres) would be experienced across parts of North Wagga and south through parts of Wilks Park and rural lands towards the railway line.

Figure 10 shows part of those same areas would experience a reduction in flooding of between 0.05 and 0.1 of a metre in flooding, while a greater area would experience a smaller reduction in flooding of between 0.02 and 0.05 metres (2 to 5 centimetres).

Figure 11 reveals a larger area including additional areas in North Wagga would experience a reduction in flooding of between 0.05 and 0.1 of a metre, (5 to 10 centimetres) while a slightly larger area would experience a smaller reduction in flooding of between 0.02 and 0.05 metres (2 to 5 centimetres).

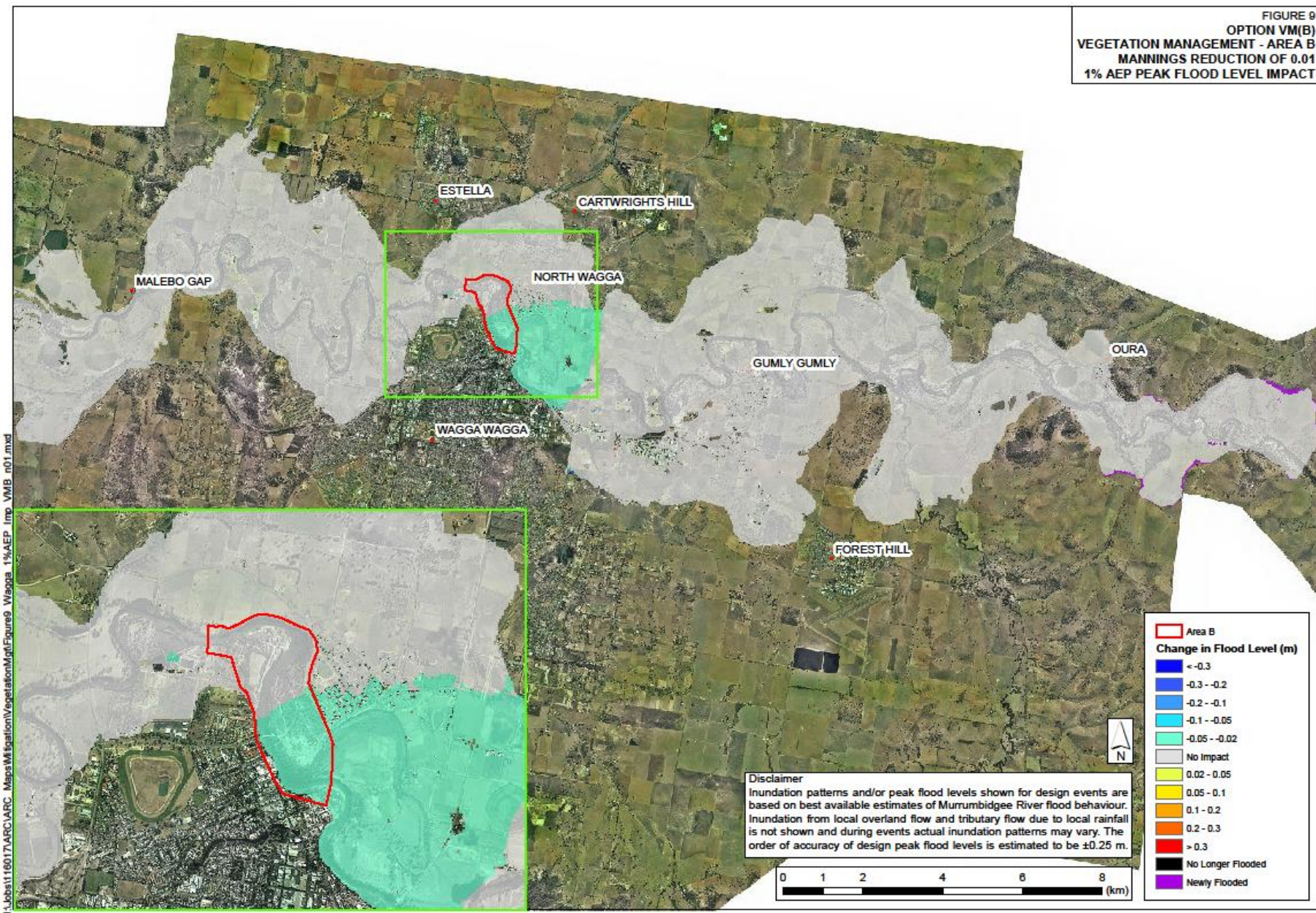


Figure 9

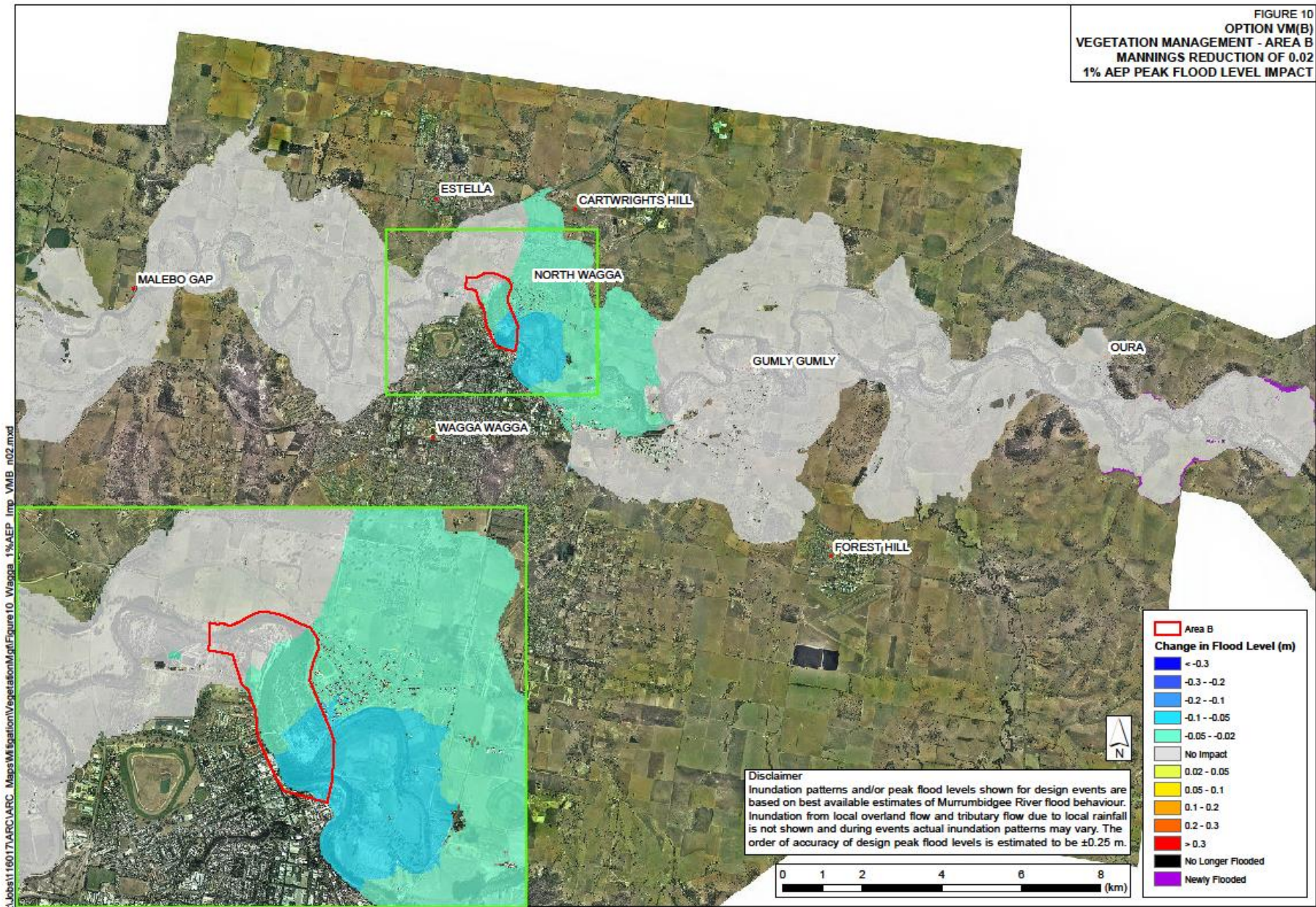


Figure 10

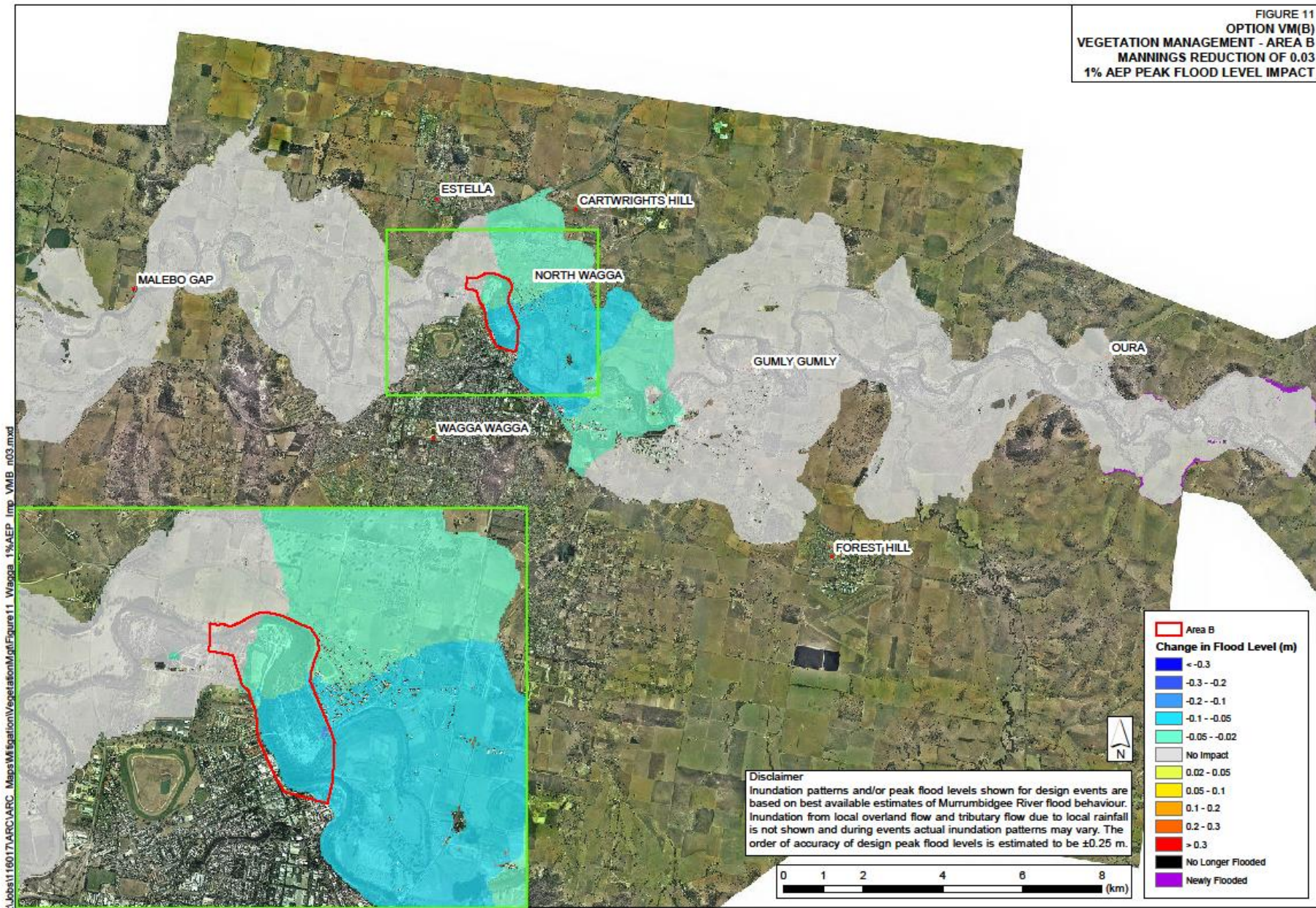


Figure 11



Option A and B combines clearing or vegetation management in both areas. Vegetation management would be undertaken in the area of high biodiversity west of Wiradjuri Reserve and in Marrambidya Wetland and including understorey on the northern bank of the Murrumbidgee in an area identified as supporting introduced vegetation. Vegetation management would also be undertaken in Wiradjuri Reserve and throughout Wilks Park. The areas that would be subject to vegetation management are again shown in the red polygons.

Figure 12 indicates that reducing roughness by 0.01 across both areas would result in reduced flooding in part of North Wagga and south across part of Wilks Park and North Wagga Flats by 0.05 to 0.1 of a metre (5 to 10 centimetres).

Figure 13 indicates that with a further reduction of 0.02 in roughness the extent of flooding would be reduced by 0.05 to 0.1 of a metre (5 to 10 centimetres) across greater areas. Figure 14 shows the greatest reduction in flood reduction across the largest extent, revealing a reduction in flooding by 0.1 to 0.2 metres (10 to 20 centimetres) across an area extending from the Olympic Highway near Estella in the north south across North Wagga to the railway line in the south.

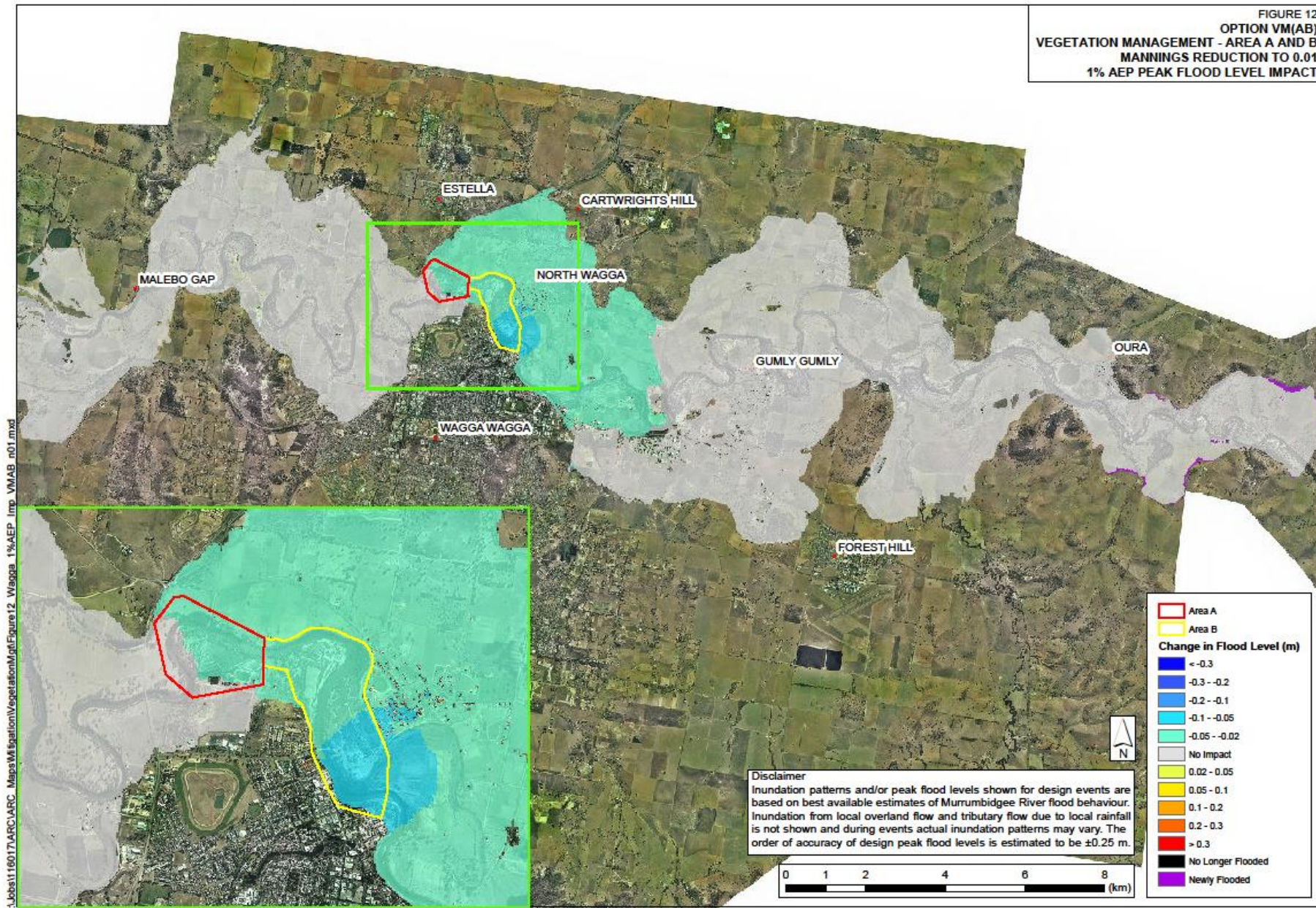


Figure 12



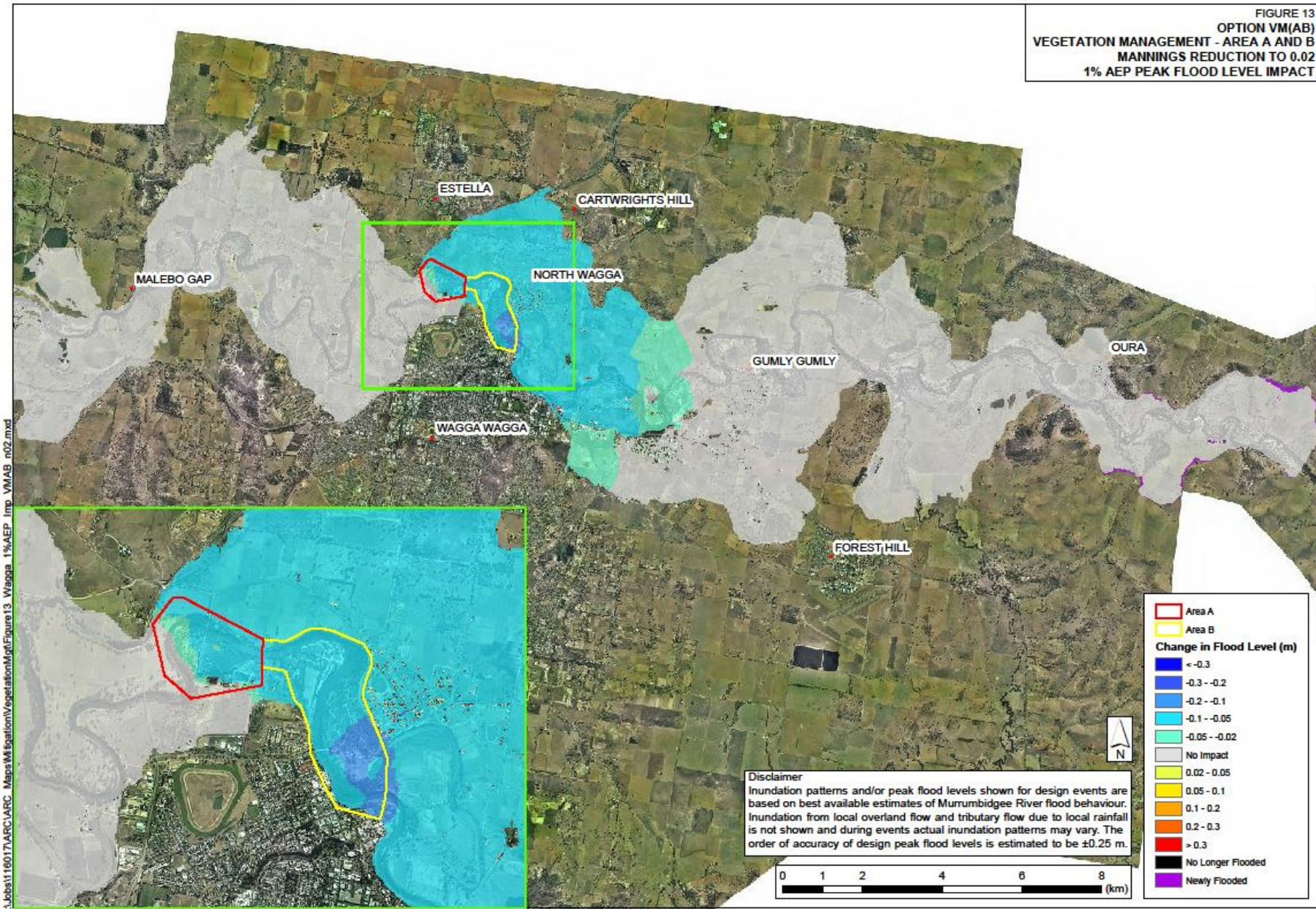


Figure 13

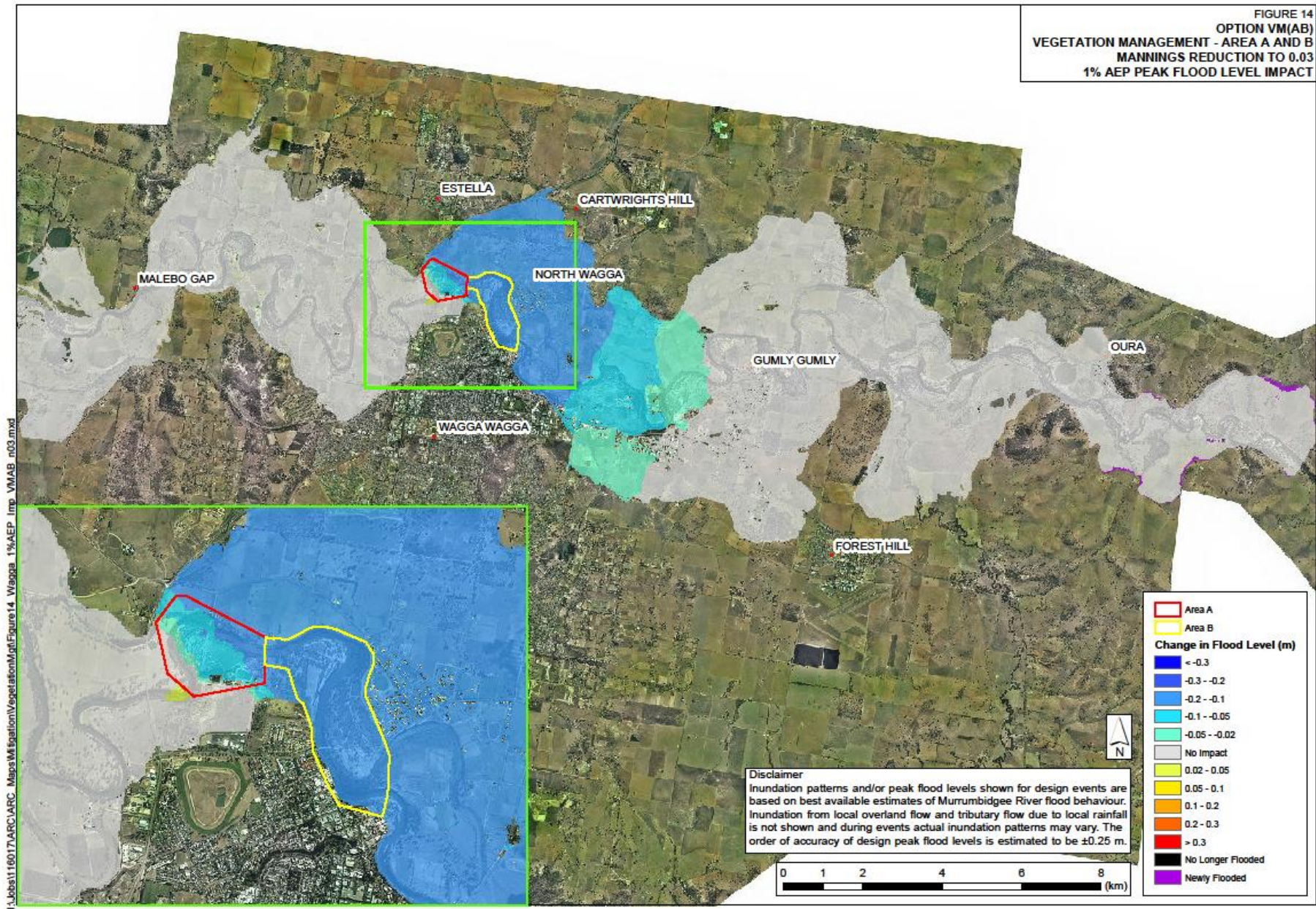


Figure 14



### 5.3.3 RESULTS IN THE 5% AEP EVENT

In a 1 in 20 year event the results were expected to reveal a greater reduction in flood levels and extent with vegetation management or clearing. However overall this was not the case and the results were consistent with the minor flood reductions observed in a 1 in 100 year event. Modeling considers the combined option A and B scenarios described in Section 5.3. The reduction in roughness is shown as a reduction of 0.01, 0.02 and 0.03 for:

- Option A and B which combines clearing or vegetation management in both areas.

Figure 15 shows the extent of flood mitigation that would be achieved in a 1 in 20 year flood event with a roughness reduction of 0.01. Flood level changes range from no impact on flooding up to 0.01 (1 centimetre) in the north eastern area covered by the red polygon. A reduction in flooding by 0.02 to 0.05 metres (or between 2 and 5 centimetres) would be experienced in North Wagga and across the area shaded in pale green and between 5 and 10 centimetres in the area shaded pale blue. This would require a significant reduction in understorey and canopy thinning across the area of high biodiversity west of Wiradjuri Reserve and in Marrambidya Wetland. Understorey would also be removed or significantly reduced on the northern bank of the Murrumbidgee River in an area identified as supporting introduced vegetation.

Figure 17 indicates minor further reductions in flooding ranging from no change to 0.02 to 0.05 metres (or between 2 and 5 centimetres) in the area covered by the red polygon, to between 2 and 10 centimetres in North Wagga.

Figure 18 shows the greatest reduction in flood levels, this would require canopy thinning to 5 metres between canopy trees, canopy under pruning and shrub removal across the areas of vegetation including revegetation areas in Wilks Park, across Wiradjuri Reserve and in Marrambidya Wetland. The change in flood levels in the option A area (red polygon) range from no change to between 0.1m (10 centimetres) and 0.2m (20 centimetres). In area B (North Wagga) the flood level reductions range from between 0.1m (10 centimetres) and 0.2m (20 centimetres), with a small area in central North Wagga achieving a reduction of greater than 0.3m (30 centimetres).

Note however that the purpose of vegetation management is not to provide wide-scale flood level reductions, but to manage new growth and weed and sapling densities so as not to increase flood levels into the future.

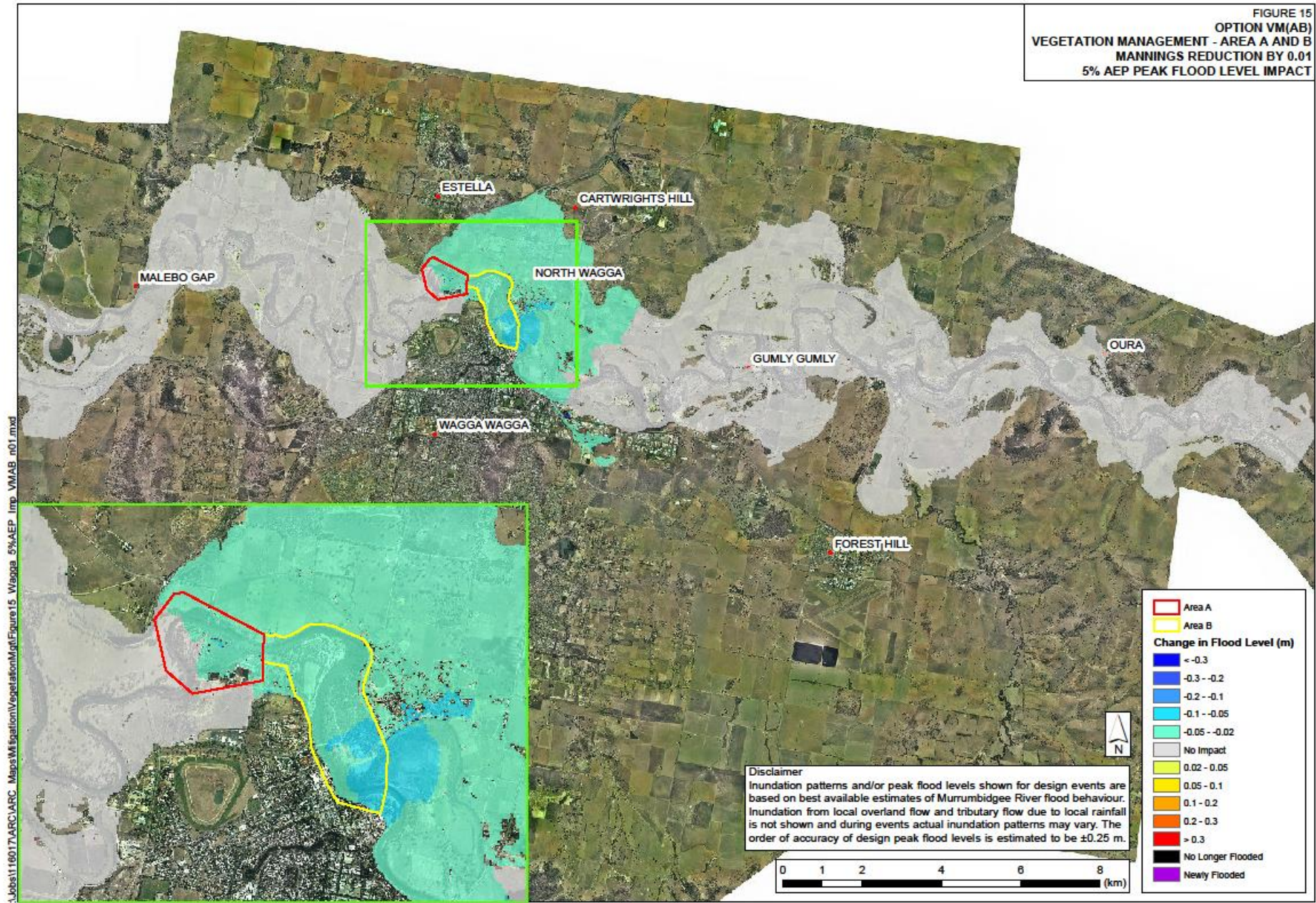


Figure 15

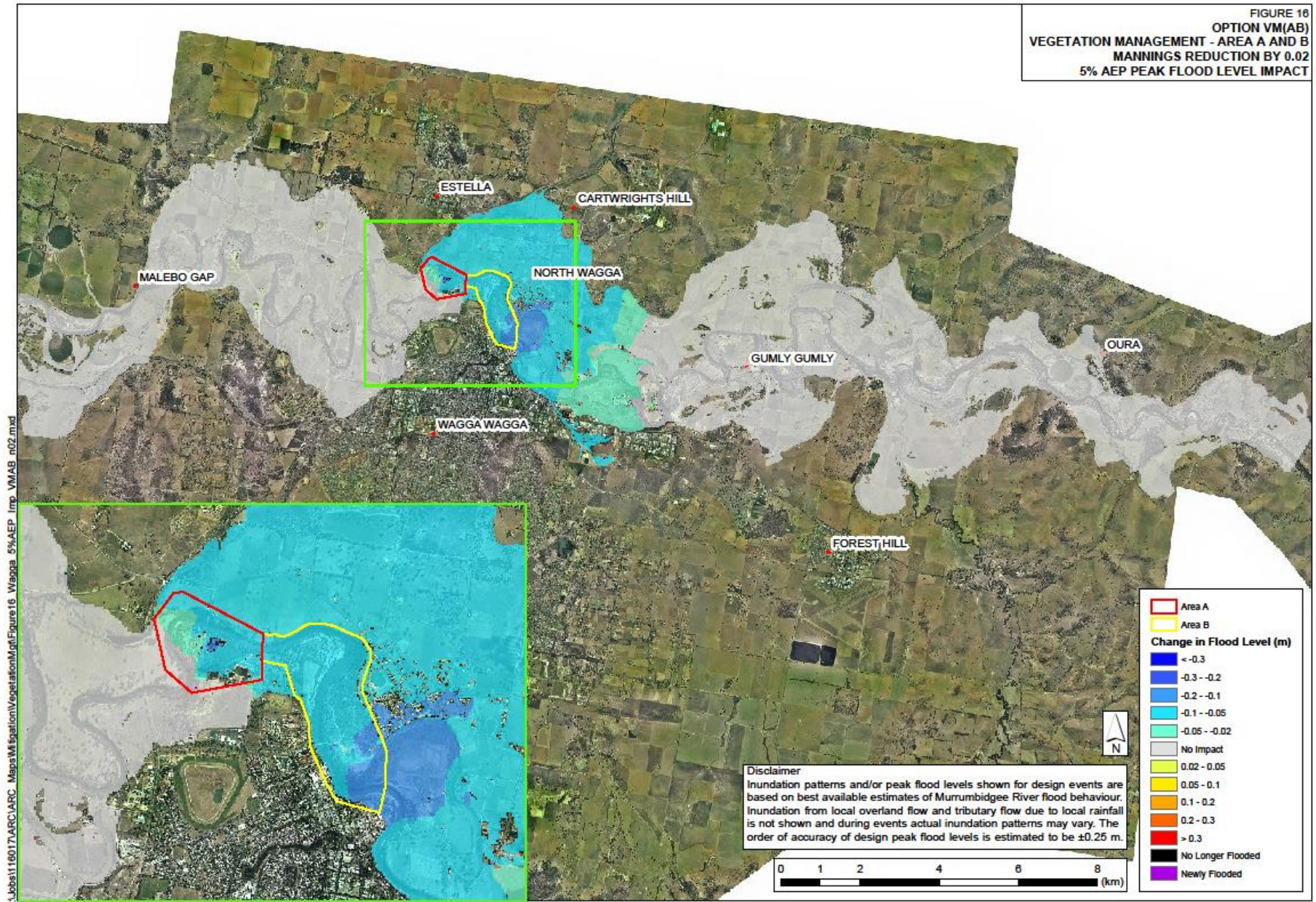


Figure 16

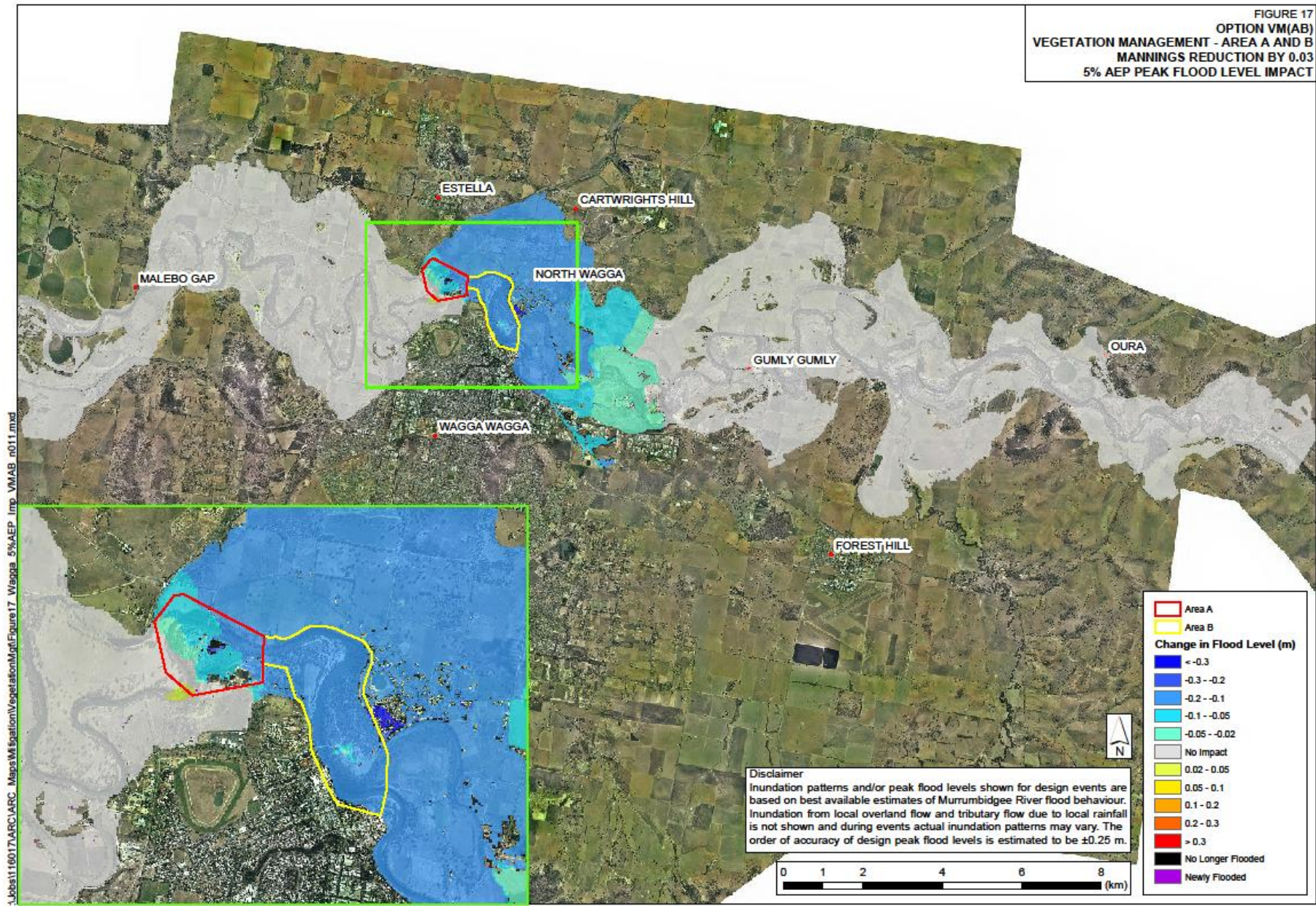


Figure 17





## 6 VEGETATION MANAGEMENT

### 6.1 SUMMARY

- The reductions in peak flood levels achieved in flooding across the areas of option A and Option B were less than expected.
- Modeling indicates modest benefits ranging from no change to a reduction in flooding of between 0.05m (5 centimetres) to 0.2m (20 centimetres) would be achieved in a 1% AEP event with significant vegetation clearing required to achieve the maximum benefits.
- Modeling for the 5% AEP event was also expected to deliver greater reductions in flood levels, however benefits again were modest with reductions in flooding ranging from no change to between 0.1m (10 centimetres) to 0.2m (20 centimetres) across the option A and B areas with a small area of central North Wagga achieving a reduction of 0.3m (30 centimetres).
- The modeling results and flood level reductions are consistent with minor reductions up stream of Wagga in cleared lands in east Wagga.
- The ecological cost of the modest flood level benefits would be significant with canopy thinning, under pruning and understorey removal of native vegetation where it occurs across the option areas.
- Significant clearing of vegetation would be required in high ecological value vegetation located in revegetated areas in Wilks Reserve, Wiradjuri Reserve and Marrambidya Wetland.
- Vegetation management would also be required on private lands where dense vegetation occurred.
- A reduction in hydraulic roughness can be achieved through management of riparian vegetation including the treatment of key weed species, however this will not reduce the roughness level to the required 0.07 to realise even the modest flood level reductions revealed by the modeling.

### 6.2 OPPORTUNITIES

Vegetation management including the removal of understorey vegetation and thinning of canopy trees across a relatively wide area of the environmentally significant lands around Wagga Wagga including Wilks Park, Wiradjuri Reserve and Marrambidya Wetland would lead to modest decreases in flooding from 0.05 of a metre to a maximum of 0.2 of a metre with the reduction of roughness to 0.07 across the areas of option A and option B in a 1% AEP flood event. These modest gains are less than expected. Significant gains in the reduction of flooding across the modelled area would require broadscale clearing across environmentally sensitive lands and this is not recommended from an ecological perspective.

In a 1 in 20 year flood event significant vegetation management would be required to achieve modest gains ranging from no change to flood levels through 0.1m (10 centimetres) and 0.2m (20 centimetres) with a small area in central North Wagga achieving a flood level reduction of 0.3m (30 centimetres).

Within the areas identified as option A and option B there are pockets of willows that occur on the river bank and result in a locally high roughness level of between 0.1 and 0.12. The removal of dense pockets of willows throughout the study area would contribute to ecological values but is unlikely to make a significant contribution to the reduction of flooding across the study area.

The river red gum forests along the Murrumbidgee around the city of Wagga Wagga provide habitat for a variety of threatened species, and the treatment of willows and other introduced plant species will contribute to habitat values for a variety of threatened species. In many areas where mature river red gums occur with a mown or grazed understorey there is little if any canopy recruitment. The identification of pockets within mature riparian vegetation areas for the exclusion of mowing and treatment of weeds to allow for canopy recruitment would be of significant long term ecological value.

### 6.3 CONSTRAINTS

A new suite of legislation has been passed by the NSW parliament and is expected to commence on the 24<sup>TH</sup> of August 2017 with a full set of supporting regulations. The implementation of the new Biodiversity reforms remains uncertain. This Vegetation Management plan has been prepared in accordance with the current legislation including:

- The Native Vegetation Act 2003;
- The Threatened Species Conservation Act 1995;
- National Parks & Wildlife Act 1974;
- Local Land Services Act 2013.

This legislation will be replaced by the:

- Biodiversity Conservation Act 2016; and
- Amendment of the Local Land Services Act 2013 through the Local Land Services Amendment Act 2016.

The legislative component of this VMP will need to be reconsidered once the new legislation has commenced and the instruments are better understood. In the interim any consideration of implementation of this VMP should be undertaken in partnership with the Riverina Local Land Services.

Currently a variety of threatened species are known or likely to occur in the Wagga Wagga LGA including the study area (see tables 2 and 3). Canopy thinning and removal or significant modification of the understorey in the River Red Gum forests that occur in the study area would impact on habitat values for a variety of threatened fauna species (see table 3) which include species listed on the commonwealth EPBC Act (which remains current). Careful consideration of the legislation will be required prior to planning for any vegetation management in the study area.

### 6.4 VEGETATION MANAGEMENT ACTIVITIES

A variety of actions would be required to contribute to lower roughness levels along the riparian corridor in the study area. These actions would need to be combined with significant clearing to reach the lower roughness levels used in the modeling. However, the actions summarised below will contribute to the maintenance of riparian vegetation to ensure that significant increases in roughness do not occur over time. Selected options should be considered in more detail and prioritised if selected as viable options.

#### 6.4.1 TARGETED WILLOW TREATMENT

The density of willows in the riparian zone were observed to increase significantly between Gumly Gumly and Eunony Bridge. Downstream of Eunony Bridge dense pockets of willows occur sporadically on the river bank.

Successful and coordinated willow treatment has been achieved in the Upper Murrumbidgee Catchment through the development and implementation of the Upper Murrumbidgee Willow Management Strategy (Upper Murrumbidgee Catchment Coordinating Committee 2010). This strategy involved identifying aims and objectives, stakeholder engagement, willow mapping, identification of suitable treatment methods for willows and catchment-wide recommendations and priorities. In addition to these features a willow control strategy for the study area would also include identified sources of funding. In addition, the production of tender documentation for engaging contractors to undertake willow control works and maintenance would also be required.

#### 6.4.2 TREATMENT OF WEEDS IN RIPARIAN AREAS

An increase in introduced species was observed in the understorey of River Red Gum Forest around the city of Wagga Wagga, particularly on the North Wagga flats area and in pockets along the channel around the city.

A coordinated approach to the management of weeds in areas where grazing and mowing are excluded is required. Priority areas include North Wagga Flats, Wilks Park, Wiradjuri Reserve and the islands and vegetation on the meander opposite Marrambidya Wetland (site 26). Key weed species observed included Phoenix palms *Phoenix Canariensis*, Common Fig *Ficus carica*, Osage Orange *Maclura pomifera* and a variety of annual and herbaceous weeds. Left unchecked increasing weed densities in these areas will lead to increased roughness levels. Key features of control efforts should include the recognition of the need for primary (initial) weed control works and secondary (follow up) works that should continue for the long term. Weed control efforts should also take into account the strategies and actions detailed in the Riverina Regional Strategic Weed Management Plan 2017 – 2022.

#### 6.4.3 REDUCTION IN DEBRIS

A key feature observed in some areas along the riparian zone including at the confluence of Kyeamba Creek with the Murrumbidgee River was the presence of high densities of timber debris associated with the 2010 and 2012 flood events. The presence of debris on the river bank and snags and debris within the channel contribute significantly to habitat values for a variety of native fauna species. Careful consideration would be required to identify areas where debris could be reduced while having the least impact on habitat values.

#### 6.4.4 REDUCTION IN SHRUB AND CANOPY REGENERATION LAYER DENSITY

In order to reduce the roughness level in areas close to Wagga Wagga city a reduction in the density of the shrub layer would be required. In some areas this consists primarily of introduced species, including site 26 and various pockets of willows along the river bank. In other areas including Wilks Park higher densities of regenerating canopy species occur as saplings and small trees. The selective thinning of these areas of regenerating canopy would reduce roughness levels. However significant native canopy thinning, under pruning and the removal of the majority of the shrub layer would be required across native vegetation in the study area to reduce roughness levels to Manning's n value 0.07 to achieve the modest gains in flood level reduction revealed by the modeling. Clearing would be required of native vegetation in the Riverine Forest in Wiradjuri and Wilks Park and in the mature River Red Gum Forest of Marrambidya Wetland. This clearing would have potentially significant impacts on the habitat of a variety of threatened fauna species, including threatened bird species and the endangered population of Squirrel Gliders. The impacts on these species would need to be

assessed in detail, however the clearing of native vegetation in these areas is not recommended from an ecological perspective.

## 6.5 WHERE TO FROM HERE?

A number of key actions are required to progress toward implementation of this vegetation management plan, these are summarised below.

- Consult with the Riverina Local Land Services regarding the new legislative setting for the vegetation management plan.
- Undertake weed density mapping along the riparian zone upstream of Wagga to Gumly Gumly and in the riparian zone, across the option A and B areas subject to modeling.
- Prepare a willow control strategy for the study area. Include as a priority task identification of the locations of pockets of Willows in the riparian zone particularly between Gumly Gumly and Eunony Bridge and secondly downstream of Eunony Bridge.
- Consider how weed control in priority areas including North Wagga Flats, Wilks Park, Wiradjuri Reserve and the islands and vegetation on the meander opposite Marrambidya Wetland can be implemented as part of the Riverina Regional Strategic Weed Management Plan 2017 – 2022.
- Identify land tenure along the riparian zone in the study area and consult with the Riverina Local Land Services and landholders to identify areas where debris could be reduced to reasonable levels to maintain ecological values and decrease channel roughness.

## 7 REFERENCES

Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) (2012) *Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-Eastern Australia: A guide to the identification, assessment and management of a nationally threatened ecological community* Environment Protection and Biodiversity Conservation Act 1999 <https://www.environment.gov.au/system/files/resources/e6041636-388e-40cc-9bd4-8c8b2dbe6419/files/grey-box-booklet.pdf>

Natural Resource Commission (NRC) (2005) Recommendations: Statewide Standard and Targets, Natural Resources Commission, Sydney [NaturalresourcemanagementinNSW](#) [NaturalresourcemanagementinNSW](#)

Natural Resources Advisory Council (NRAC) (2010) *Understanding Our Native Grasslands agricultural, environmental and indigenous values and management for the future* <http://www.landcareonline.com.au/wp-content/uploads/2011/03/Understanding-Our-Native-Grasslands.pdf>

NSW Government Gazette Number 137 Friday 17 December 2010 (2010) *Threatened Species Conservation Act 1995 Order Conferring biodiversity certification on the Wagga Wagga Local Environmental Plan 2010* page 6262 [http://www.nsw.gov.au/sites/default/files/Government\\_Gazette\\_24\\_December.pdf](http://www.nsw.gov.au/sites/default/files/Government_Gazette_24_December.pdf)

Office of Environment and Heritage (OEH) (2011) Vegetation of Central Southern NSW /Vegetation\_CentralSouthernNSW\_ADS40\_E\_3884.zip

Office of Environment and Heritage (OEH) (2014) Property Vegetation Plans (PVPs) <http://www.environment.nsw.gov.au/vegetation/pvp.htm> accessed 09/05/2016

Office of Environment and Heritage (OEH) (2015) *DRAFT Guideline for the Assessment of Feasibility of Vegetation Management as a Floodplain Risk Management Measure for Existing Urban Areas*

Office of Environment and Heritage (OEH) (2015a) *Clearing requiring a property vegetation plan or consent* webpage <http://www.environment.nsw.gov.au/vegetation/approval.htm> accessed 09/05/2016

Office of Environment and Heritage (OEH) (2015b) *Clearing requiring a property vegetation plan or consent* <http://www.environment.nsw.gov.au/vegetation/approval.htm> accessed 10/05/2016

Parnaby, H (2009). A taxonomic review of Australian greater long-eared bats previously known as *Nyctophilus timoriensis* (Chiroptera: Vespertilionidae) and some associated taxa. *Australian Zoologist*. 35:39-81.

Friday, S. and Mulvaney M. (2005) *The Native Vegetation and Threatened Species of the City of Wagga Wagga*. Department of Environment and Conservation, Queanbeyan NSW.

Riverina Local Land Services in partnership with the Riverina Regional Weed Committee (2003) Riverina Regional Strategic Weed Management Plan 2017 - 2022 SUMMARY Riverina Local Land

Services [http://www.lockhart.nsw.gov.au/f.ashx/News/02Summary-Draft-Riverina-Strategic-Weed-Mgt-Plan\\_for-print\\_8-2-17-with-cover-\(1\).pdf](http://www.lockhart.nsw.gov.au/f.ashx/News/02Summary-Draft-Riverina-Strategic-Weed-Mgt-Plan_for-print_8-2-17-with-cover-(1).pdf)

Upper Murrumbidgee Catchment Coordinating Committee (2010) *Willow management A Strategy for the Upper Murrumbidgee Catchment* prepared in partnership with the Australian Government and ACT Government.

Wagga Wagga City Council and Land and Property Management Authority (2010) Riverside Wagga Wagga Strategic Masterplan  
[https://issuu.com/riversidewaggawagga/docs/final\\_draft\\_masterplan\\_01-04?e=0/12237200](https://issuu.com/riversidewaggawagga/docs/final_draft_masterplan_01-04?e=0/12237200)

WMAwater (2014) Wagga Wagga Detailed Flood Model Revision Report prepared for Wagga Wagga City Council

APPENDICES

## APPENDIX A SITE ASSESSMENT AREAS

1. Gobbagombalin Bridge North of the River either side of the bridge
2. North West of Marrambidya Wetland – dense vegetated meander flow path on western edge of wetland
3. North east edge of Wiradjuri Reserve
4. North Wagga Flats (Eastern edge of Wilks Park)
5. South West of North Wagga Flats south of Hampden Avenue/ Hampden Bridge
6. Pregar Island Channel in the vicinity of North Wagga Flats (NW of the Island near Island Lane.
7. (For interest only) Meander east of the Waterworks, east of Whittle St Bridge (not immediately upstream of bridge)
8. Gumly Gumly – around the meander at the Economy Quarry and the area between the River and the Economy Bridge Road
9. Oura – west of Oura, southern side of River from meander near circular plowing (north side of river) through Shanty Reserve and west toward Riverside Reserve.




APPENDIX B SITE ASSESSMENT RESULTS SUMMARY


## Appendix B Site Assessment Results Summary

Site No.	Location	Assessment	Photos
1.	Oura	River Red Gum Open Forest with grazed understorey Roughness: .06	
2.	Oura Beach	River Red Gum Open Forest with grass understorey Roughness: .06	

# Appendix B Site Assessment Results Summary

<p>3.</p>	<p>Oura</p>	<p>Occasional willows on bank Roughness (willows on bank): 0.1</p>	
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# Appendix B Site Assessment Results Summary

<p>4.</p>	<p>River Road (Alfred Town)</p>	<p>Regrowth River Red Gum Open Forest with regenerating canopy higher vegetation density Roughness 0.07</p>	
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# Appendix B Site Assessment Results Summary

<p>5.</p>	<p>Kyeamba Creek</p>	<p>River Red Gum Open Forest with occasional dense patches of regenerating canopy and debris on bank Roughness 0.08</p>		
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## Appendix B Site Assessment Results Summary

6.	Mill St Meander (upstream of Gumly Gumly)	Occasional willows on bank Roughness (willows on bank): 0.1		
7.	Gumly Gumly Anabranch	River Red Gum Open Forest		

## Appendix B Site Assessment Results Summary


8.	Gumly Gumly Anabranch	Increasing density of willows Roughness (willows on bank): 0.1		
9.	Gumly Gumly East	River Red Gum Open Forest grassed understorey Roughness 0.06		

## Appendix B Site Assessment Results Summary



10.	Gumly Gumly west	Narrow band of River Red Gum Open Forest fringing river banks Roughness 0.07		
11.	Gumly Gumly Kilpatrick Avenue meander	Patches of willows in narrow band of native riparian vegetation Roughness 0.08 with willows 0.1		





## Appendix B Site Assessment Results Summary

12.	Scotts Lake	Narrow band of riparian vegetation Roughness 0.07		
13.	Eunony Bridge	Narrow band of riparian vegetation Occasional stands of willows Roughness 0.09 to 0.1		



## Appendix B Site Assessment Results Summary

14.	900 metres downstream of Eunony Bridge eastern shore	River Red Open Forest with grazed grass understorey Roughness 0.06		
15	Quarry River bank	Narrow band of native riparian vegetation with dense pockets of willows on the river bank. Landward the understorey is open with a Narrow band of River Red gums with mown/ grazed understorey Roughness 0.08 to 0.1 (willows)		

## Appendix B Site Assessment Results Summary

16.	Abbey Lake	Narrow band of native riparian vegetation with pockets of willow Roughness 0.09 to 0.1 (willows)		
17.	East Wagga	Narrow band of vegetation with construction works landward of river Roughness 0.1		



## Appendix B Site Assessment Results Summary

18.	Levee Park east of Reddoch Dr	Open River Red Gum Forest understorey primarily grass with some regenerating native shrubs Roughness 0.09	
19.	East bank opposite Cross St	Narrow band of native riparian vegetation sporadic occurrence of dense pockets of willows on the river bank Roughness 0.09 to 0.1 (willows)	

## Appendix B Site Assessment Results Summary

20.	Opposite Wagga Beach	<p>Narrow band of native riparian vegetation sporadic occurrence of dense pockets of willows on the river bank</p> <p>Roughness 0.09 to 0.1 (willows)</p>		
21.	North Wagga Flats	<p>River Red Gum Forest with emergent native understorey increased presence of weeds in the understorey including willows, small and large leaf privet Phoenix Palms and Osage Orange with occasional grass and ground cover weeds.</p> <p>Some revegetation has occurred in the northern part of the flats closer to Hampden Avenue.</p> <p>Roughness 0.1</p>		



## Appendix B Site Assessment Results Summary

22.	Wilks Park Riverside	This areas supports a mix of large mature River Red Gums with pockets of dense regenerating canopy species. Roughness 0.1		
23.	Wilks Park flow path	The area occupied by the high flow path on the eastern side of Wilks Park supports an open forest of River Red Gums with an open grassed understorey. Roughness 0.08		

Appendix B Site Assessment Results Summary



<p>24.</p>	<p>Islands in main channel at Wiradjuri Reserve</p>	<p>These islands support some native canopy species and a dense understorey of willows Roughness 0.12</p>		
<p>25.</p>	<p>Wiradjuri Reserve</p>	<p>At the riverbank the reserve supports an open forest with some regenerating canopy species. Roughness 0.09</p>		

## Appendix B Site Assessment Results Summary

26.	Area on eastern bank opposite Marrambidya wetland	This area supports a high density of introduce canopy species included the Common Fig <i>Ficus carica</i> , willows <i>Salix</i> spp. and Osage Orange <i>Maclura pomifera</i> . Roughness 0.1	
27.	Marrambidya wetland	The riparian area supports an open forest with pockets of willows on the river bank and some introduced canopy species. Roughness 0.1	



## Appendix B Site Assessment Results Summary

28.	Western bank opposite Marrambidya wetland	Narrow band of native riparian vegetation. Dense pockets of willows are present. Roughness 0.09 to 0.1 (willows)		
29.	Western bank opposite Marrambidya wetland	Narrow band of native riparian vegetation. Dense pockets of willows are present. Roughness 0.08 to 0.1 (willows)		

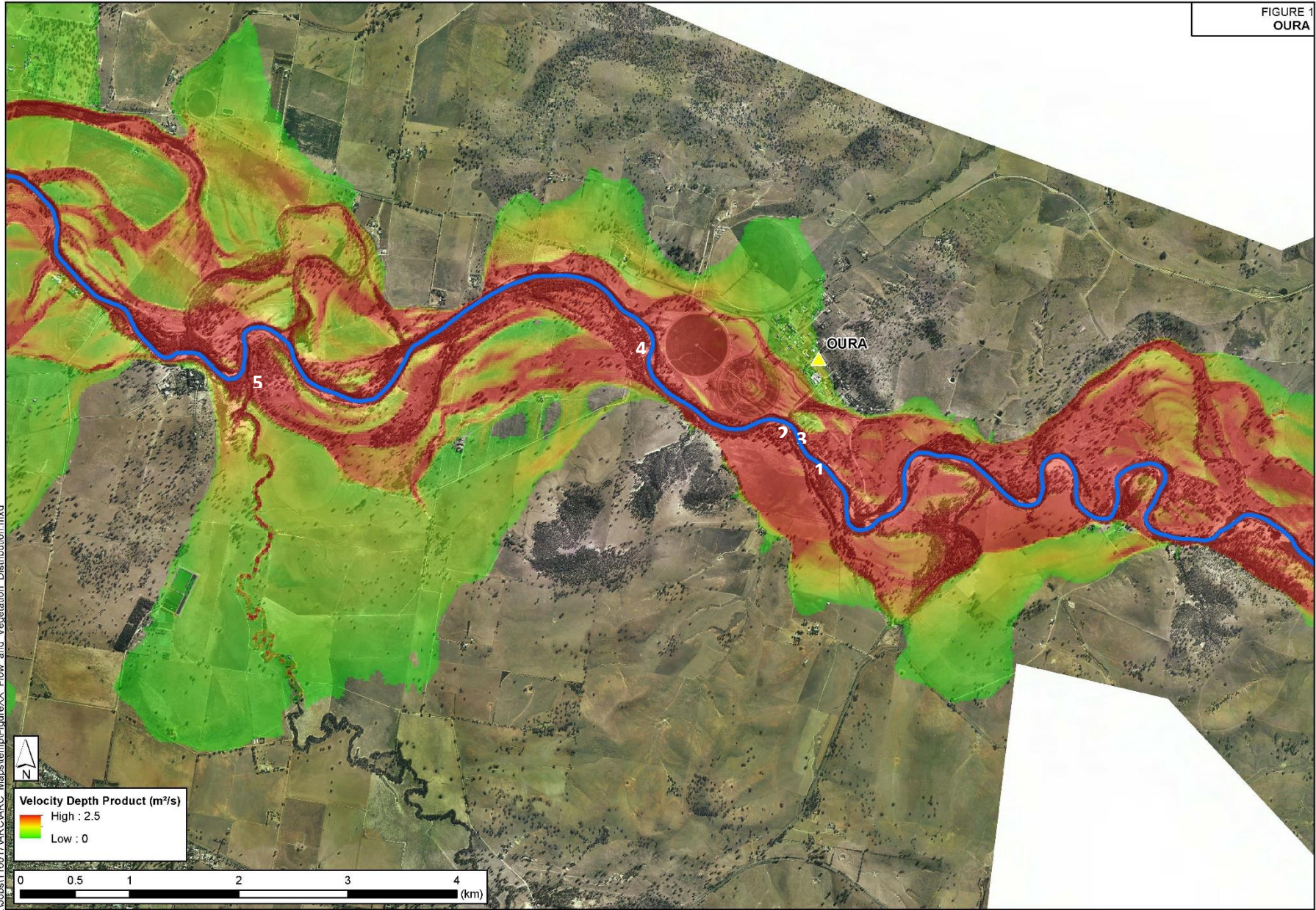
# Appendix B Site Assessment Results Summary

<p>30.</p>	<p>Marrambidya wetland (south)</p>	<p>Regenerating River Red Gum Forest open tall grassy understorey with various pasture weeds. Roughness 0.09</p>		
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# Appendix B Site Assessment Results Summary



FIGURE 1  
OURA



Murrumbi

# Appendix B Site Assessment Results Summary

