RURAL FLOODPLAIN MANAGEMENT PLANS

Background document to the Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019—Appendices

Water Management Act 2000

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Contents

Abbreviations

Abbreviation	Description
ABS	Australian Bureau of Statistics
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AEP	annual exceedance probability
AHIMS	Aboriginal Heritage Information Management System
ASDST	Aboriginal sites decision support tool
COAG	Council of Australian Governments
DEM	digital elevation model
DPI	NSW Department of Primary Industries
Upper Namoi Valley FMP	*Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FMP	floodplain management plan
GVAP	gross value of agricultural production
IPW	infrastructure protection work
IRP	Interagency Regional Panel
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
LiDAR	light detection and ranging
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	normalised difference vegetation index
NSW	New South Wales
NSW DPI	NSW Department of Primary Industries
OEH	NSW Office of Environment and Heritage
PCT	plant community type
ROC	Receiver operator characteristic
SDM	species distribution model
SEIFA	Socio-Economic Indexes for Areas
SF	selection frequency
TAG	Technical Advisory Group
TSC Act	*Threatened Species Act 1995*
Water Act	*Water Act 1912*
WM Act	*Water Management Act 2000*
WSP	water sharing plan

Appendix 1: Rural floodplain management planning approach under the *Water Management Act 2000*

Step	Key inputs/processes	Key outputs/outcomes
1: Define the floodplain boundary	• Information on the nature and extent of flooding over time • Floodplains designated under Part 8 of the *Water Act 1912* (the Water Act) • Other statutory boundaries and infrastructure features (e.g. WSPs, roads, floodplain harvesting ROIs)	Map of floodplain boundary to be designated under the WM Act
2: Identify existing flood works	• Flood work licenses • Area of land protected by flood works identified from spatial data such as flood imagery, LiDAR and aerial photography • Local knowledge of licensing officers	• Map of area of land protected by flood works • Number of existing approved flood work licenses
3: Review existing rural floodplain management arrangements	• First-generation floodplain development guidelines and studies (non-statutory) • Second-generation rural FMPs (the Water Act)	Information on and analysis of key aspects of existing rural floodplain management arrangements
4: Determine the floodway network	• Design floods • Flood-frequency analysis • Hydrological/hydraulic model input • Flood imagery • Existing floodway networks (Step 3) • Local knowledge	• Map of floodway network, including floodways, inundation extent and areas outside the floodway network • Better understanding of existing flooding regime
5: Identify and prioritise floodplain assets	• Identified from peer-reviewed literature, relevant legislation, policies, databases and registers • Various spatial data (e.g. PCT mapping) • Optimum watering requirements • Conservation significance of assets determined from TAG and Marxan • Cultural assets also identified from ATWG and community consultation	• Definition and maps of ecological and cultural assets • Grouping of ecological assets based on optimum watering requirements • Understanding of flood-dependency of cultural assets • Map of high-priority floodplain assets
6: Prepare a socio-economic profile	• Secondary data sources (ABS, ABARES, State departments) • Local knowledge	Understanding of the baseline profile of the floodplain, including stakeholder identification

Step	Key inputs/processes	Key outputs/outcomes
7: Delineate management zones	• Hydraulic criteria based on information from Steps 1, 2 & 4 • Criteria to ensure appropriate consistency between current and proposed management options based on information from Step 3 • Ecological and cultural criteria based on information from Step 5 • Analysis to ensure equity based on information from Step 6 • Feedback from consultation	Definition and map of management zones, which will generally result in four zones: • Major flood discharge • Flood storage and secondary flood discharge • Flood fringe and existing development • Special ecological and cultural protection
8: Determine draft rules	• Understanding of management zones • Existing types of flood works • Existing and potential flooding problems • Rules from existing rural FMPs • Feedback from consultation	Rules and assessment criteria covering: • Authorised flood works • Acceptable impacts • Advertising requirements • Existing flood works and structures
9: Consider existing floodplain management arrangements	Information on existing floodplain management arrangements gathered in Step 3 is compared against the draft FMP to determine the extent of change.	Extent of change between existing rural floodplain management arrangements and the proposed FMP is determined
10: Assess socio-economic impacts	• Economic data • Area under irrigated crop • Gross margins • Prices • Hydrology data	Social and economic impacts assessed against the base case
Consultation and review	• Draft FMP reviewed by Working Group and IRP at key stages before targeted consultation, public exhibition and plan commencement • Consultation with key stakeholders at targeted consultation and the wider community during public exhibition	• IRP provide whole-of-government endorsement of the FMP • Key stakeholders and the community's feedback is considered in FMP development • Information on community concerns and issues gathered
Plan finalised and commenced	• Revision of socio-economic assessment and impact mitigation strategies	Final FMP is implemented and plan outcomes are achieved.

Appendix 2: History of floodplain management in the Upper Namoi Valley Floodplain

Floodplain management planning in the Upper Namoi Valley Floodplain has evolved in response to changing community needs; changes to land and water use; an increased awareness of the importance of floodplain ecology; and changes to the legislative and policy framework that governs water management. A detailed history of floodplain management in the Upper Namoi Valley Floodplain is outlined below.

In 1912, the NSW Government began to take on a legal responsibility for water management by enacting the *Water Act 1912* (the Water Act). At this time, the legislation did not relate to works on flood-prone land remote from a river or lake; however, Part 2 of the Water Act did provide for the licensing of works that could affect the distribution of floodwaters flowing in, to or from, or contained in, a river or lake.

The enactment of the Water Act did not initially change floodplain management in the Upper Namoi; however, this act would become the principle driver of floodplain management after amendments were made in subsequent decades in response to the potential for flood works to changes flood patterns resulting in increased flood damage.

Until the 1960s, the Liverpool Plains region was almost entirely under native grasses and was used principally for wool production. During this time, the NSW Government was not actively involved in managing flood-work developments as agriculture was dominated by low-intensity grazing and there was an absence of flood works that would affect flooding in the landscape.

However, since then, the flatter country across the Liverpool Plains region has been progressively developed for large-scale and intensive crop production, particularly under strip cropping techniques (Burton et al 1994). Since the 1990s, major private irrigation development has been introduced to parts of the region, particularly from groundwater resources, major creeks and the waters of Lake Goran (Burton et al 1994).

There is increasing evidence that the progressive land-use changes over the past 50 years have substantially modified the surface and sub-surface hydrology of the region, causing more rapid and more frequent flood runoff and significantly modifying the historic flood-flow patterns across the flatter sections of the region (Burton et al 1994). Flooding problems have been aggravated by the many engineering and agricultural works that have been constructed across the region as land use has been modified (Burton et al 1994).

Roads and railways located to suit the hydrology of the region as it existed 50 years ago now provide major interference to natural flood flows and provide focal points for flood discharge concentration (Burton et al 1994). Minor agricultural works, such as levees, irrigation channels, water storages, farm roads and even fence lines, can produce major diversions or concentrations of shallow flood flows, often unexpectedly and to the substantial disadvantage of adjacent landowners (Burton et al 1994).

In 1984, the Flood Prone Land Policy 1984 was introduced to overcome the potential sterilisation of floodplains resulting from rigorous planning controls introduced in the 1977 Environment and Planning Circular No 15. The policy aims to reduce the impact of flooding and flood liability on individual owners and occupiers of flood-prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible. The policy requires:

- a merit approach to be adopted for all development decisions
- for both mainstream and overland flooding to be addressed using strategically generated floodplain risk management plans
- flood mitigation works and measures to reduce the impact of flooding
- for action to minimise the potential for flood losses to be balanced by the application of ecologically sensitive planning and development controls.

The Water Act was also amended in 1984 to include Part 8. This allowed the ministerial corporation to control all private works on the banks of rivers and lakes and on proclaimed floodplains, which could affect the distribution of floodwaters (referred to as controlled works).

Controlled works included earthworks, embankments and levees, as well as access roads, irrigation channels and dams. This provision in the legislation allowed for the designation of floodplains, which are areas where controlled-work approvals must be obtained.

This provision in the legislation also allowed for the preparation of coordinated floodplain management guidelines for the designated flood-affected areas that identify floodways and the suitable location of levees in consultation with landholders and local government.

The introduction of Part 8 of the Water Act heralded the beginning of the NSW Government's involvement in legally controlling flood-work development and planning to prevent future flood works from causing or exacerbating flooding problems. The existing Upper Namoi Valley Floodplain was designated under the Water Act on 18 October 1984.

In 1986, the *Floodplain Development Manual*, which was developed to support the NSW Government's Flood Prone Land Policy, was published. The manual related to the management of flood-liable land in accordance with section 733 of the *Local Government Act 1993*, which exempted councils from liability. The manual applies to urban and rural floodplains across NSW.

In 1993, the NSW Floodplain (Non-tidal) Management Advisory Committee was established by the NSW Government to address floodplain management issues in the Liverpool Plains. The committee, in its final report dated June 1994, recommended that amendments to the existing Water Act be implemented to resolve floodplain management issues in the Liverpool Plains (Burton et al 1994). In this report, the floodplain management problems of the region were summarised into three categories, including problems arising where:

- individual landowners construct diversion banks or levees around parts of their properties to prevent floodwaters from flowing across them ('diversion problems')
- works constructed for irrigation purposes, such as irrigation supply channels or large offstream storages, cause diversion of floodwater away from their natural course ('irrigation scheme problems')
- floodwaters flow across several adjacent properties in definable flow channels and joint landowner actions is needed to develop appropriate drainage schemes ('joint drainage problems').

In 1995, a general regulation to Part 8 of the Water Act was gazetted that prescribed railways (together with associated bridges and railway works) that are vested in Rail Access Corporation and roads (together with associated bridges and road works) that are vested in a council or in the Roads and Traffic Authority as exempt from needing a controlled-work (flood-work) approval.

In 1999, Part 8 of the Water Act was amended to allow for more strategic coordination of controlled works through the preparation of statutory rural floodplain management plans (s.166a). The amendments made rural floodplain management plans the statutory basis for determining flood-control works in order to overcome difficulties with assessment of works on an ad hoc basis. The amendments also allowed for areas not designated as part of a floodplain to be covered by Part 8.

This meant that works in these areas had to be assessed if they could potentially affect flood flow into and out of a stream and affect flooding. Section 166C of the Water Act provides guidelines for the assessment of such works.

It was also required that rural plans be developed in accordance with the provisions and policies of the *NSW Floodplain Development Manual* and NSW Flood Prone Land Policy. Up until this point, the floodplain development guidelines and floodplain management studies produced were not statutory. The new strategy was developed in response to strong community support for a change in the current practice. A key objective was to develop the floodplain management plans using community-based floodplain management committees.

The process for developing the plans included undertaking:

- flood studies to define the nature and extent of flooding and flood-related issues in technical terms
- floodplain risk management studies to evaluate options in consideration of social, environmental and economic factors to address existing and future flood risk and flood management issues
- rural floodplain management plans to outline strategies to manage flood risk and flood management issues and support the natural functions of the floodplain environment.

To facilitate the revised strategy, a $5 million program was jointly funded by the Natural Heritage Trust and state funding to develop plans in 18 inland rural areas across 30,000 km^2. The amendment was to outline a new process to deliver strategic outcomes to manage flood-control works on inland floodplains where these works did not require council consent under rural zonings. Where rural floodplain management plans and development guidelines exist, rural plans replaced the outdated development guidelines.

The Liverpool Plains Floodplain was designated under the Water Act on 16 December 1994. Additionally, during this decade (1990s), 10 first-generation rural floodplain development guidelines and studies that are non-statutory were undertaken by the NSW Government and consultants:

- Borambil–Gunnadilly Floodplain Management Study (Department of Land and Water Conservation (DLWC) 1995a)
- Coomoo Coomoo and Yarraman Creeks Floodplain Management Study (Department of Water Resources (DWR) 1994)
- Breeza to Ruvigne study area comprised the following flood studies:
  - Battery Hill (Barrett Purcell and Associates 1997)
  - Carroll Group (Barrett Purcell and Associates 1998)
  - Long Point properties (Barrett Purcell and Associates 1995)
  - Top River (Webb 2007)
  - Breeza floodplain flooding review (Hugh Barret and Associates 2001)
- Red Bobs (DLWC 1995b; DLWC 1995c)—both studied the utility of proposed flood works
- Lake Goran hydrological study of the impact of land-use change on water levels (Bewsher Consulting 1995).

In 2000, the *Water Management Act 2000* (WM Act) was enacted to replace the Water Act and a range of other acts dealing with water management to achieve sustainable and integrated management for all water-based activities, including water use, drainage, floodplains and groundwater. The repeal of the Water Act has been an ongoing process. The WM Act is the culmination of the NSW water reform process driven by the Council of Australian Governments (COAG).

The WM Act contains floodplain management provisions that relate closely to existing provisions under the amended Part 8. Section 29 and 30 detail the core and additional provisions to be considered when developing floodplain management plans. The core provisions require the plans to deal with:

- identification of the existing and natural flooding regimes in the area, in terms of the frequency, duration, nature and extent of flooding
- the identification of the ecological benefits of flooding in the area, with particular regard to wetlands and other floodplain ecosystems and groundwater recharge
- the identification of existing flood works in the area and the way they are managed, their benefits in terms of the protection they give to life and property, and their ecological impacts, including cumulative impacts
- the risk to life and property from the effects of flooding.

The general water management principles of the WM Act also require that the cumulative impacts of water management licences and approvals, and other activities on water sources and their dependent ecosystems be considered and minimised.

In 2001**,** the *Floodplain Development Manual* was revised to make it consistent with a series of improvements to both policy and practice, including the need to:

- consider the full range of flood sizes up to and including the probable maximum flood when developing a floodplain risk management plan
- recognise existing, future and continuing flood risk on a strategic rather than ad hoc individual proposal basis
- support local councils to manage local overland flooding in a similar manner to riverine flooding
- promote the preparation and adoption of local flood plans (prepared under the guidance of SES) that address flood readiness, response and recovery.

In 2005, the *Floodplain Development Manual* was again updated and gazetted as the manual relating to the development of flood-liable land for the purposes of section 733 of the *Local Government Act 1993*. The updates reflected the significant change in the roles of state agencies and clarified some planning issues that had led to inconsistent interpretations. The manual supports the NSW Government's Flood Prone Land Policy in providing for managing human occupation and use of the floodplain considering risk management principles.

In the Upper Namoi Valley Floodplain, two additional consultant studies were commissioned and two second-generation statutory rural floodplain management plans were made under the Water Act:

- a review of flooding over the Breeza floodplain (Hugh Barrett and Associates 2001)
- Top River flood study (Breeza to Ruvigne) (Webb 2007)
- Blackville Floodplain Management Plan (adopted June 2003)
- Upper Coxs Creek Floodplain Management Plan (adopted 2005).

In 2010, the Healthy Floodplains Project commenced to reform the management of water on floodplains through the development of floodplain management plans as well as licensing of floodplain harvesting water extractions. In June 2012, Stage 1 of the Healthy Floodplains Project was awarded $36 million by the Commonwealth Government, with additional contributions by the NSW Government. The Floodplain Harvesting Policy 2013 was prepared to guide NSW Government agency staff when implementing the Healthy Floodplains Project.

Part 8 of the Water Act is expected to be repealed and replaced in 2015 by the floodplain management provisions of the WM Act. This transition will allow for the adoption of the *Floodplain Management Plan for the Upper Namoi Valley Floodplain* (Upper Namoi Valley FMP). The new floodplain management provisions will allow for the exemption of a specified range of works vested in government agencies as well as certain privately owned works of a minor nature from approval as flood works.

Outside the Healthy Floodplains Project and before the repeal of Part 8 of the *Water Act 1912*, five additional floodplain management plans were adopted in the Upper Namoi Valley Floodplain:

- Caroona–Breeza Floodplain Management Plan (adopted 2006)
- Carroll–Boggabri Floodplain Management Plan (adopted 2006)
- Upper Yarraman Creek Floodplain Management Plan (adopted 2006)
- Warrah Creek Floodplain Management Plan (adopted 2012)
- Lower Coxs Creek Floodplain Management Plan (adopted 2013).

The Upper Namoi Valley FMP will consolidate floodplain management measures from existing plans and guidelines and supersede all existing floodplain management plans in the Upper Namoi Valley Floodplain. Concurrently, the Upper Namoi Valley Floodplain and Liverpool Plains Floodplain designated under the Water Act will be repealed and a new Upper Namoi Valley Floodplain designated under the WM Act. The designation of the new floodplain will be for the purpose of administering flood works and floodplain harvesting activities.

Appendix 3: Detailed review of existing floodplain management arrangements

Existing floodplain management arrangements in the Upper Namoi Valley Floodplain are a combination of second-generation rural floodplain management plans (FMPs) developed under the *Water Act 1912* (the Water Act) and first-generation rural floodplain development guidelines (guidelines) that are non-statutory. A detailed review of these existing floodplain management arrangements is provided below and includes information on:

- floodplain management principles
- ecological and cultural heritage considerations
- floodway networks
- hydraulic models
- design flood events
- types of controlled works considered for approval
- exemptions to flood work approvals
- advertising requirements
- assessment process/criteria for assessing flood-work applications.

Second-generation rural FMPs (*Water Act 1912*)

Existing rural FMPs were statutory documents prepared under Part 8 of the *Water Act 1912* (the Water Act) by the Office of Environment and Heritage (OEH). Part 8 of the Water Act has since been repealed and these plans have been transitioned over as Minister's Plans under the WM Act. The plans were administered by the NSW Office of Water when assessing flood work development applications. In total, these plans cover 274,160 ha or approximately 47% of the Upper Namoi Valley Floodplain (**Error! Reference source not found.**).

Table A3 1 Area covered by second-generation rural FMPs (the Water Act 1912)

FMP	Area (ha)	Proportion of floodplain (%)
Blackville	21,950	4
Caroona–Breeza	19,980	3
Carroll–Boggabri	76,440	13
Lower Coxs	46,850	8
Upper Coxs	43,460	7
Upper Yarraman	15,870	3
Warrah Creek	49,600	8
Total	274,160	47

Floodplain management principles

Section 166C of Part 8 of the Water Act was added as an amendment in 1999 and this section relates closely to the floodplain management provisions of the WM ACT. Section 166C outlines matters for general consideration. Such matters include:

- the contents of any relevant floodplain management plan or any other relevant government policy
- the need to maintain the natural flood regimes in wetlands and related ecosystems and the preservation of any habitat, animals (including fish) or plants that benefit from periodic flooding
- the effect or likely effect on water flows in downstream river sections
- any geographical features, or other matters, or Aboriginal interest that may be affected by a controlled work
- the effect or likely effect of a controlled work on the passage, flow and distribution of any floodwaters

- the effect or likely effect of a controlled work on existing dominant floodways or exits from floodways, rates of flow, floodwater levels and the duration of inundation
- the protection of the environment
- any other matter relating to the desirability or otherwise of a controlled work.

Part 8 of the Water Act was repealed at the end of 2015.

Many of the existing FMPs also listed an overall set of floodplain management principles that the plans adhered to. These principles included:

- defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain
- any system of define floodways should conform as closely as is reasonable to the natural drainage pattern after taking into account the existing floodplain development
- floodway areas should be equitably allocated (between adjacent landholders) consistently with natural/historical flowpaths
- environmental issues related to the FMP need to be identified and investigated, including developing strategies for flood-dependent ecosystems such as wetlands, riparian vegetation and any other environmentally sensitive areas
- the exit of floodwaters from defined floodways should be at rates and depths similar to those that would have been experienced under natural/historical conditions and should discharge as close as practicable to the location of natural/historical floodways
- sufficient pondage must be retained on the developed floodplain so that the flood peak travel time is not unduly accelerated to downstream users or its height increased
- velocities of flood flow in defined floodways should be minimised and be of an order which would not cause erosion or increased siltation under various land uses
- there should be no detrimental impact from floodplain development on any individual landholder or community infrastructure, including increases in peak flood levels and increased drainage times
- floodplain development should not cause significant redistribution of floodwater
- socio-economic issues relating to floodplain management need to be identified and investigated. This includes considering both tangible damages (can be readily measured in monetary terms) and intangible damages (includes increased levels of emotional stress, physical illness and disruption to daily life).

These principles were adhered to and reflected within the existing FMP's adopted assessment criteria and were applied by licensing staff when considering Part 8 applications under the Water Act.

Ecological and cultural heritage considerations

Areas of ecological and cultural significance were identified and considered when mapping the floodway networks in existing plans.

Floodway networks

The existing plans identified floodway networks, which were the basis for assessing applications to construct controlled works.

Hydraulic models

Hydraulic models were used to develop the floodway networks and flood distributions in existing FMPs. The hydraulic models are outlined in Table A3 2.

Table A3 2 Hydraulic models in existing FMPs (the Water Act)

FMP	Existing model type
Blackville	Rectified MIKE11
Carroll to Boggabri	Rectified MIKE11
Caroona to Breeza	Rectified RMA-2
Lower Coxs Creek	Rectified MIKE11
Upper Coxs Creek	Semi-rectified MIKE11
Upper Yarraman	Semi-rectified RUBICON model
Warrah Creek	Rectified MIKE Flood

Design flood events

The design floods used in second-generation rural FMPs (the Water Act) are outline in Table A3 3.

Table A3 3 Design floods used in the second-generation rural FMPs (the Water Act)

FMP	Design flood
Blackville	1998
Caroona–Breeza	Probabilistic 5
Carroll–Boggabri	1984
Lower Coxs	1971
Upper Coxs	1998
Upper Yarraman	Probabilistic 5
Warrah Creek	1998

Types of controlled works considered for approval

In all the existing FMPs, all controlled/flood works would be considered for approval.

Exemptions to controlled-work approvals

Two of the existing rural FMPs specified certain controlled works that would be exempt from needing an approval. These included infrastructure protection works that meet conditions specified in the Warrah Creek FMP, and below-ground supply channels with existing approval under Part 2 of the WM Act in areas outside the Caroona to Breeza FMP.

Advertising requirements

In existing plans, the floodway networks are generally the basis for assessing applications to construct controlled works. Controlled works proposed to be located inside the floodway network are assessed as non-complying and require advertising. Controlled works proposed to be located outside the floodway network are generally assessed as complying and do not require advertising. Flood-control works outside the floodway network that trigger any issues in regard to the adopted assessment criteria are also assessed as non-complying and required advertising.

Some of the FMPs have additional advertising requirements, which are outlined in Table A3 4.

Table A3 4 Additional advertising requirements

FMP	Advertising requirements
Blackville	There are provisions for levees identified in the FMP and those that are not identified in the FMP to determine if they are 'acceptable or not acceptable'. There are also requirements for the works to comply with the general provisions of the plan.
Caroona–Breeza	N/A
Carroll–Boggabri	Flood work applications need to be advertised if the work: • is an infrastructure protection work (IPW) on a small property (less than 20 ha) and is ≥10% of the total property area • is an IPW on a large property (≥20 ha) and is ≥2 ha or ≥1% of the total property area, whichever is the greater • is less than 100 m from an adjoining property's high-value infrastructure • is greater than 50 cm in height (10% of the structure can exceed this and works are preferentially constructed parallel to flow).
Lower Coxs	N/A
Upper Coxs	All flood works require advertising
Upper Yarraman	Flood work applications need to be advertised if they are inside the riparian zone. If they are outside the riparian zone, the works need to be advertised if: • they are ≥10 cm in height • the area protected is ≥20% of the floodplain extending on their side of Yarraman Creek and if the width of any section taken perpendicular to Yarraman Creek and Kickerbell Creek is ≥100 m • they are IPWs and are ≥25 m perpendicular to Yarraman Creek and are ≥2.5ha.
Warrah Creek	N/A

Assessment process/criteria for assessing flood-work applications

In most second-generation FMPs, flood-control works located within floodways and outside delineated areas are assessed as non-complying works. Non-complying works require a detailed investigation of the hydraulic, environmental, social and economic impacts of the proposal. The cumulative impact of these proposals on flood characteristics is also required to be comprehensively addressed. In many cases, applications for non-complying works will be refused or require the modification or removal of works.

Flood-control works outside the floodway network are assessed as complying if they do not trigger any issues in regard to the adopted assessment criteria. The landholder is required to provide the necessary supporting information to demonstrate the application is a complying work.

The assessment criteria for the two floodplain management plans are summarised in Table A3 5 and outlined in detail in Table A3 6.

Table A3 5 Summary of assessment criteria in second-generation floodplain management plans (the Water Act)

Historical	Socio-economic	Ecological	Flooding
Old guidelines	Disruption to daily life	Wetland connectivity	Natural flooding characteristics
Concerns and objections	Health impact	Floodplain flora and fauna	Hydraulic capacity
Time/flood experience (complying works)	Cost of the works	Soil condition and structure	Pondage and flow duration
	Infrastructure damage	Fish passage	Redistribution/flood-flow effects/hydraulic criteria
	Equity	Cultural sites	Flow velocities
	Land use and restrictions	Groundwater recharge	Works in floodways
	Maintenance costs	Riverine environment	

Table A3 6 Assessment criteria used to assess flood work applications in previous floodplain management plans

Assessment criteria	Description	Blackville	Caroona-Breeza	Carroll-Boggabri	Lower Coxs	Upper Coxs	Upper Yarraman	Warrah Creek
HISTORICAL								
Old guidelines/complying flood work (for existing flood work)	Flood works that comply with the existing guidelines (that is, this FMP) will normally be accepted, unless additional information and/or flood observations illustrate that the flood work may have a significant adverse impact on flood flows.	☒	☑	☑	☑	☑	☑	☒
Concerns and objections	Any ongoing concerns and/or objections from neighbouring landholders must be taken into consideration during the assessment process.	☒	☑	☑	☒	☑	☑	☒
Time/flood experience (complying flood work)	For unapproved flood works that have been constructed for a long period of time and have had no reports of unacceptable afflux and/or redistribution during flood events.	☒	☒	☒	☒	☑	☒	☒
SOCIO-ECONOMIC								
Disruption to daily life	Unless previously agreed between all affected landholders, flood works should not result in significant disruption to the daily life of surrounding land holders (for example property access).	☒	☑	☑	☑	☑	☑	☑
Health impact	Works should not impose negative health impacts or stress on surrounding landholders.	☒	☑	☑	☒	☑	☑	☒
Cost of the flood work	Are the associated cost and benefits of undertaking the flood works warranted? In some cases, it may be necessary to undertake a cost/benefit analysis (a preliminary assessment may be adequate) in order to weigh up the hydraulic and/or environmental benefits of undertaking the flood works against the required expenditure. This must be determined through consultation with the affected stakeholders and DNR.	☒	☑	☑	☒	☑	☑	☒
Maintenance costs	Landholder agreements such as those that currently exist for the maintenance of flood works on Pump Station and Big Jacks creeks should considered in other locations where channel stabilisation works would benefit more than one landholder.	☒	☒	☒	☒	☒	☒	☑
Infrastructure damage	Works should not pose any detrimental impact on community infrastructure, including increases in peak flood levels and drainage times.	☒	☑	☑	☑	☑	☑	☑
Equity	Previous agreements between landholders regarding floodways should hold when a new landholder buys in. That is, the onus is on the new landholders (the 'buyer beware' principle). This is a legal issue and not one that the FMP attempts to cover. However, it is strongly suggested that written proof regarding these agreements be kept in case a legal issue arises.	☒	☑	☑	☑	☑	☑	☑
ECOLOGICAL								
Wetland connectivity	Flood works should not block or restrict natural flowpaths or floodways that feed wetland areas nor alter the flooding regime to those areas.	☒	☑	☒	☒	☑	☒	☒
Floodplain flora and fauna/flood-dependent ecosystems	Flood works should not isolate flood-dependent stands of vegetation from flood flow. The potential impact on habitat availability and threatened species	☒	☑	☑	☑	☑	☑	☑

Assessment criteria	Description	Blackville	Caroona-Breeza	Carroll-Boggabri	Lower Coxs	Upper Coxs	Upper Yarraman	Warrah Creek
	may need to be assessed.							
Soil condition and structure	Flood works should not impost negative impacts on soil structure or condition. For example, works should not increase the potential for scour or erosion and should not block flow to significant areas of floodplain soils.	☒	☑	☑	☑	☑	☑	☑
Fish passage	Flood works should not significantly block or restrict the free passage and migration of fish within the floodplain environment.	☒	☑	☑	☑	☑	☑	☑
Cultural sites	Unless an agreement has been reached with the National Parks and Wildlife Service and the local Aboriginal Lands Council, works should not destroy or damage any Aboriginal site or relic and should not block or restrict the delivery of flood flows to sacred and carved trees that rely on flooding regimes	☒	☑	☑	☑	☑	☑	☑
Groundwater recharge	Works should not block or restrict flood flow to identified groundwater recharge areas.	☒	☑	☑	☑	☑	☑	☒
Riverine environment	Flood works should not result in any excavation or removal of material from within, or within 40 m of the top of, the high creek bank and must be consistent with the Rivers and Foreshore Impact Act and must be consistent with the Native Vegetation Conservation Act. Flood works should not occur within 20 m from top of the creek bank. To be read in conjunction with other criteria and special consideration to be given to breakouts in the immediate vicinity.	☒	☒	☒	☒	☑	☒	☒
FLOODING								
Natural flooding characteristics	Flood works should not result in a significant departure from the natural flooding or drainage pattern of the floodplain (after taking into account the existing floodplain development).	☒	☑	☑	☒	☑	☑	☒
Hydraulic capacity	Flood works should not reduce the hydraulic capacity and continuity of floodway areas (should enable the orderly passage of floodwaters through the floodplain).	☒	☑	☑	☒	☑	☑	☑
Pondage and flow duration	Flood works should not significantly impact on pondage duration on the developed floodplain or cause flood peak travel time to unduly accelerate to downstream users.	☒	☑	☑	☒	☑	☑	☑
Pondage and flow duration	Drainage duration to be within 12 hours of natural/existing drainage time.	N/A	12	24	N/A	N/A	N/A	N/A
Flood Works in floodways	Generally proposed flood works will not be approved within the FMP floodway network, with the exception of farm access roads below 15 cm above ground level and supply channels at or below ground level (assuming that such works do not result in significant redistribution or trigger other assessment criteria).	☒	☑	☒	☒	☒	☒	☒
Redistribution/flood-flow effects/hydraulic criteria	Acceptable increases in flood heights and percentage redistribution of peak flood discharges, as a result of structural works on the floodplain, should be assessed against the conditions given for complying flood works. Applications that do not meet the requirements will be considered as non-complying works and must be subject to the more detailed Part 8 approval	☒	☑	☑	☑	☑	☑	☑[A]

Assessment criteria	Description	Blackville	Caroona-Breeza	Carroll-Boggabri	Lower Coxs	Upper Coxs	Upper Yarraman	Warrah Creek
	process.							
Redistribution/flood-flow effects/hydraulic criteria	Redistribution—flood height (advertising/lower limit)	N/A	10 cm	10 cm	10 cm	10 cm	N/A	N/A
Redistribution/flood-flow effects/hydraulic criteria	Redistribution—flood height (not acceptable/upper limit)	N/A	30 cm	N/A	20 cm	20 cm	10 cm[B]	10 cm
Redistribution/flood-flow effects/hydraulic criteria	Redistribution—% of peak flood discharges (cumulative)	N/A	2%	10%	5%	5%	N/A	N/A
Redistribution/flood-flow effects/hydraulic criteria	Redistribution—% of peak flood discharges (local)	N/A	100 m[C]	5%	2–2.5%	2–2.5%	5%	N/A
Flow velocities	Flood works should not significantly increase velocities of flood flow in areas flooded by the design flood. Velocities should be of an order that does not significantly increase erosion and siltation under various land uses.	☒	☑	☑	☑	☑	☑	☑
Flow velocities	Maximum percentage increase		50%	50%	50%	50%	20%	N/A
Flow velocities	Maximum permissible flow velocities	☒	☑	☑	☑	☑	☑	☑

[A] Drains and private roads/access tracks had specific criteria

[B] Unacceptable impact is any increase on flood level near high-value infrastructure

[C] Onto a neighbour's property

First-generation: rural floodplain development guidelines and floodplain management studies (non-statutory)

Non-statutory floodplain management studies prepared in the Upper Namoi Valley Floodplain include:

- Boggabri to Narrabri flood study
- Borambil–Gunnadilly Floodplain Management Study (DLWC 1995a)
- Coomoo Coomoo and Yarraman Creeks Floodplain Management Study (DWR 1994)
- Breeza to Gunnedah flood study
- Breeza to Ruvigne study area comprised the following flood studies:
    - Battery Hill (Barrett Purcell and Associates 1997)
    - Carroll Group (Barrett Purcell and Associates 1998)
    - Long Point properties (Barrett Purcell and Associates 1995)
    - Top River (Webb 2007)
    - Breeza floodplain flooding review (Hugh Barret and Associates 2001)
- Red Bobs (DLWC 1995b; DLWC 1995c)—both studied the utility of proposed flood works
- Lake Goran hydrological study of the impact of land-use change on water levels (Bewsher Consulting 1995).

Area not covered by an existing management measure

The area not covered by existing management measures is approximately 53% or 314,450 ha of the Upper Namoi Valley Floodplain. Most of this area was part of the previous designated Namoi floodplain. However, about 6% of the floodplain, or 35,000 ha, has been added to the Part 8 floodplain.

Flood work applications for areas not covered by an existing management measure that were part of the designated floodplain would have been assessed under Part 8 of the Water Act. Section 168B 3b of the Water Act states that a controlled work is to be assessed as a non-complying controlled work if the controlled work is situated or proposed to be constructed in an area that is not the subject of a floodplain management plan.

Areas not designated as part of the floodplain were also covered by Part 8. Amendments to Part 8 of the Water Act were introduced in 1999 to allow works in these areas to be assessed if the work could potentially affect flood flow into and out of a stream and affect flooding. Section 166C of the Water Act provides guidelines for the assessment of such works. In areas outside a designated floodplain, all flood work applications would have been considered for approval and there were no exemptions. They also would have been assessed as non-complying.

Appendix 4: Design floods

Step 4 outlines the selected design floods for the Draft Upper Namoi Valley FMP.

Table A4 1shows the large and small design floods for each of the 11 sub-areas across the floodplain, including the gauge at which the AEP of the flood is determined.

Table A4 1: Annual exceedance probability (AEP) for selected large and small design flood events at 11 sub-areas selected across the Upper Namoi Valley FMP.

Sub-area	Gauge	Large design flood	Large design flood	Small design flood	Small design flood
		Year	AEP (%)	Year	AEP (%)
Blackville	Mooki at Caroona	1998	5	Probabilistic 20	20
Boggabri to Narrabri	Namoi River at Boggabri	1984	5	Probabilistic 20	20
Borambil to Gunnadilly	Quirindi	1984	2	Probabilistic 20	20
Breeza to Ruvigne	Mooki River at Breeza, Namoi River at Boggabri	1984	5/5	Probabilistic 20	20
Carroll to Boggabri	Namoi River at Boggabri	1984	5	Probabilistic 20	20
Caroona to Breeza	Mooki River at Breeza	Probabilistic 5	5	Probabilistic 20	20
Goran Lake	Mooki River at Caroona, Coxs Creek at Tambar Springs	1998	5/6	Probabilistic 20	20
Lower Coxs Creek	Coxs Creeks at Boggabri	1971	4	Probabilistic 20	20
Upper Coxs Creek	Coxs Creek at Tambar Springs	1998	6	Probabilistic 20	20
Upper Yarraman	Mooki at Caroona	Probabilistic 5	5	Probabilistic 20	20
Warrah Creek	Mooki at Caroona	1998	5	1992	20

The small design floods were selected to ensure that critical flow paths to floodplain assets are considered during the technical assessment of a flood work applications.

The large design floods were selected:

- to correspond to an existing design flood used in existing FMPs and floodplain management study areas where possible
- to be one of the most recent large floods and therefore likely to be in the collective memory of floodplain users
- to be representative of large floods in the valley
- where there was a significant amount of information available for the event
- to approximate a 5% AEP flood event, which is a similar magnitude to the design floods used historically.

Large and small design floods were selected for each sub-area. The proposed large design flood was the same as the current design flood for five of the 11 sub-areas and differed for two of the sub-areas. Floodplain management study areas did not have a current design flood in place so for these four sub-areas new proposed large design floods were introduced. Further detail is provided below for the justification for the selection of design floods in each of the 11 sub-areas.

Table A4 2: Comparison of proposed and current large design floods

No.	FMP	Sub-area	Design flood year	Design flood year
			Proposed	Current
1	Y	Blackville	1998	1998
2	N	Boggabri to Narrabri	1984	N/A
3	N	Borambil to Gunnadilly	1984	N/A
4	N	Breeza to Ruvigne	1984	N/A
5	Y	Carroll to Boggabri	1984	1984
6	Y	Caroona to Breeza	Probabilistic 5	Probabilistic 5
7	N	Goran Lake	1998	N/A
8	Y	Lower Coxs Creek	1971	1971
9	Y	Upper Coxs Creek	1998	1998
10	Y	Upper Yarraman	Probabilistic 5	Probabilistic 20
11	Y	Warrah Creek	1998	1992

Of the seven sub-areas covered by a second-generation FMP, five have the same design floods as what is already in place (Table A4 2). For the Upper Yarraman Creek and Warrah Creek FMP sub-areas, different large design floods were selected compared to the floods used in the existing FMPs. In the Upper Yarraman, probabilistic flows were relied on rather than historical flood events. In the Warrah Creek FMP sub-area, the existing design flood for the second-generation FMP covering the Warrah Creek sub-area is relatively small (20% AEP). It was therefore proposed to use the 1998 flood, which is a larger flood, with some additional criteria for minimum conveyance in order to match the requirement of using a 5% AEP flood. The 1998 flood was recommended because it is used in many other sub-areas, including the adjacent Blackville catchment.

In the Boggabri to Narrabri sub-area, the 1998 flood would have been too large so the 1984 was selected.

In the Borambil to Gunnadilly sub-area, analysis of rain gauges within the Quirindi Creek catchment shows that the 1998 flood, which was the preferred design flood, was not significant. The 1984 flood, while having a much lower AEP at Quirindi, is comparatively higher in the Mooki at Breeza and further west in Coxs Creek. This suggests that the rainfall gradient may be from east to west in the 1984 flood and that the flow in Quirindi Creek further west of Quirindi town may have a higher AEP.

In the Breeza to Ruvigne sub-area, the 1998 flood would also have been too large. The 1984 flood, which has a 6% AEP at Breeza and a 5% AEP at Boggabri, was selected instead. Flows may be modified so that flows at Breeza match flows from the downstream end of Caroona to Breeza. In the Goran Lake sub-area, the 1998 flood was selected as the large design flood to match those of the adjacent catchments.

Two small design floods that approximate a 20% AEP flood event were selected across the floodplain. A probabilistic flood of 20% AEP was selected for all of the sub-areas except for the Warrah Creek sub-area, where the 1992 small design flood was selected. The 1992 flood is a 20% AEP flood at the Mooki River at Caroona gauge and was selected because it was the design flood for the second-generation FMP covering the Warrah Creek sub-area.

The 1992 flood was selected as the small design flood for the Warrah Creek sub-area because it is the current design flood and because it approximates a 20% AEP flood, which is the requirement for the small design flood.

Although not a design flood per se, the 1% AEP flood was also selected to provide additional hydraulic information. This additional information will be used to assess the hydraulic impacts of proposed flood works located in floodplain areas outside the inundation extent of the large design flood. The 1% AEP flood extent is an estimate only, to assist the hydraulic analysis of flood works, and was not mapped for rural floodplain planning purposes or used to design the floodway network. This information is retained by the department and made available to landholders where additional supporting information such as hydraulic modelling is required to support applications for flood works.

Flood-frequency analysis

Selection of appropriate design floods typically involves determining a flood's AEP using flood-frequency analysis. Flood-frequency analysis studies are used to determine the relationship between peak flood discharge at a location of interest and the likelihood that a flood event of that size or greater will occur.

The technique involves using observed peak flow (or flood volume) data to calculate statistical information such as mean values, standard deviations, skewness, and recurrence intervals. This statistical data is then used to fit the flood data to a statistical distribution and is then presented in the form of graphs and tables. These graphs and tables can indicate the likelihood of flood flows as a function of recurrence, interval or exceedance probability. Flood-frequency distributions can take on many forms according to the equations used to carry out the statistical analysis.

The data used for flood-frequency analyses can include annual flood series, partial flood series, monthly and seasonal series. For the purpose of this analysis, only annual flood series are used. This is because annual flood series are the most common method of selecting the floods to be analysed, their values are generally independent and the series can be easily extracted (IEAust 1997). An annual flood series comprises the highest instantaneous rate of flow in each year of record.

For the Upper Namoi Valley, the annual flow series was obtained from four gauging stations. These stations were chosen based on their location, data period and reliability (Table A4 3).

The annual flow series for each calendar year was extracted from Hydstra, a hydrologic database administered by the department (Hydstra 2012). Gaps within the annual series were filled by first checking the daily flow record of a nearby gauge for a major flow event over the gap period. If no flow event occurred, we assumed that the highest recorded peak was the highest peak for that year.

Table A4 3: Details of selected gauging stations in the Upper Namoi Valley.

Station No	Gauge	Period of record	Number of years	Percent of gauged flows
419001	Namoi River at Gunnedah	1891–2013	122	40
419012	Namoi River at Boggabri	1911–2013	102	48
419027	Mooki River at Breeza	1957–2013	58	80
419033	Coxs Creek at Tambar Springs	1966–2013	48	50

Several flood-frequency distribution types were tested against the data and it was found that the Log-Pearson Type III was the most suitable. This is the most commonly used distribution in Australia (IEAust 1997). Here the Log-Pearson Type 111 distribution was fitted to the annual data sets for the five selected locations within the valley. Since values at the lower end of the observed range of flood peaks (below 30 m^3/s) can distort the fitted probability distribution and affect the estimates of large floods, these values were deleted from the Coxs Creek at Tambar Annual Flood Series.

Since the recorded flood peaks are only a small sample of peaks actually occurring over a longer period, an expected probability adjustment was made using the procedure set out in Australian Rainfall and Runoff (ARR) (Pilgrim 1987). ARR (1998) recommends implementing the expected probability adjustment to remove bias from the estimate. The results of the flood-frequency analysis are shown in Table A4 4.

Table A4 4: Annual exceedance probability (AEP) for historic flood events at selected locations in the Upper Namoi Valley

Location (Gauging station number)	AEP for 1955	AEP for 1971	AEP for 1984	AEP for 1998	AEP for 2000	AEP for 2012
Namoi River at Gunnedah (419001)	<1	5	6	5	4	18
Namoi River at Boggabri (419012)	2	3	5	6	6	15
Mooki River at Breeza (419027)	-	6	16	3	4	33
Coxs Creek at Tambar Springs (419033)	-	33	7	5	6	33

Over the years, a number of flood-frequency analysis studies have been undertaken for the Liverpool Plains. Some of these have been undertaken for the same locations but at different times for different projects. A flood-frequency analysis study was undertaken as part of this step and the dataset was compared to datasets from the following reports to select appropriate design floods:

- Inland Rural Flood Unit Internal flood-frequency analysis (2003–11)
- DIPNR (2003) Lower Coxs Creek Flood Study. NSW Department of Infrastructure, Planning and Natural Resources, Tamworth 2003
- Trueman, H. (2005) Final Warrah Creek Flood Study Revision 5.0.
- SMEC Australian Pty Ltd (2003) Carroll to Boggabri flood study and compendium data. Report for DLWC.
- DIPNR (2003) Blackville Floodplain Management Plan. Prepared by Perrens Consultants Pty Ltd and Gunnedah Management Consultants for DIPNR, Barwon Regional Office, Tamworth NSW.

In some instances, the datasets report different AEPs for the same flood event. This is because there are a number of variables that need to be accounted for, including:

- availability of data (period of record)
- type of data used (mean versus maximum daily data, the rating curve used)
- frequency distribution applied
- parameters of the distribution and software used to determine those parameters.

These variables can account for the differences found between different AEPs estimated by different analyses undertaken for the same location, while variability in rainfall across different catchments accounts for the differences found in estimated AEP at different locations.

The following additional reports were examined as part of this study and were used to assist in the description of the flood events:

- DNR (2006c) Upper Yarraman Creek Floodplain Management Plan August 2006.
- DNR (2005a) Caroona–Breeza Floodplain Management Plan August 2005.
- DNR (2005d) Upper Coxs Creek Floodplain Management Plan November 2005.
- DLWC (1995a) Borambil to Gunnadilly Floodplain Management Study. DLWC, Parramatta NSW.
- DWR (1994) Coomoo Coomoo and Yarraman Creeks Floodplain Management Study. DWR River Management Branch, Parramatta NSW.
- Bewsher Consulting (1995) Hydrological Study of Lake Goran*.* DWR and Bewsher Consulting Pty Ltd—Consulting Engineers, Epping NSW.

Appendix 5: Overview of flood imagery

The following is an overview of the flood imagery that was primarily used when delineating the management zones in the proposed Upper Namoi Valley Floodplain:

- Landsat satellite imagery captured in:
  - 1998 on 21 July (**Error! Reference source not found.**)
  - 2000 on 23 November (Figure A5 2)
  - 2010 on 6 December and 13 December (Figure A5 3)
- rectified vertical flood photographs captured on:
  - 31 January 1984 for a 70 km run and a 50 km run east of Gunnedah (Figure A5 4)
  - February 1971 for a run approximately 20 km upstream of Narrabri (Figure A5 5).
  - 24 July 1998 along the Namoi River from the junction of the Mooki River until Narrabri (Figure A5 6).

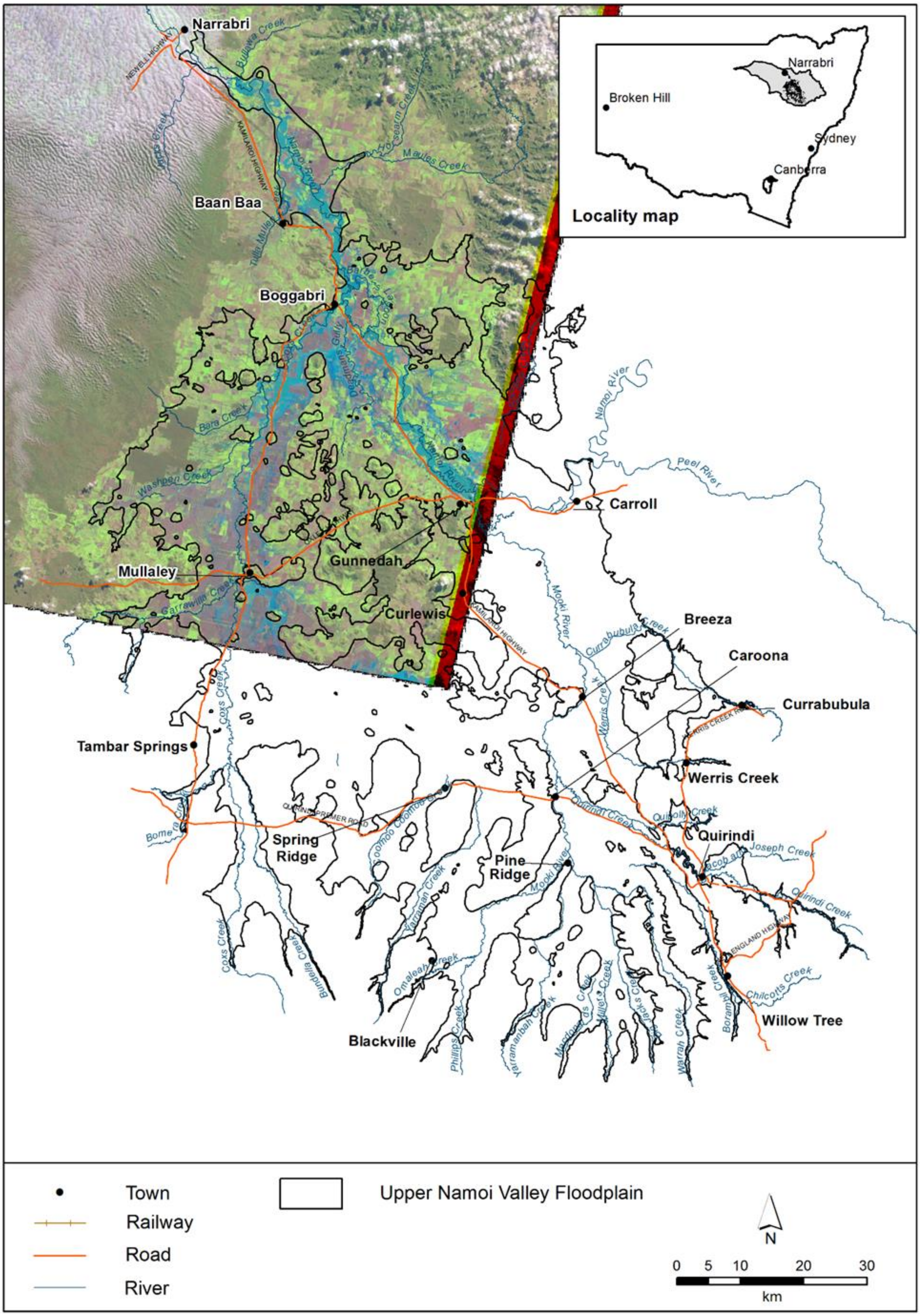

Figure A5 1 Landsat 5 image flood event captured on 21 July 1998

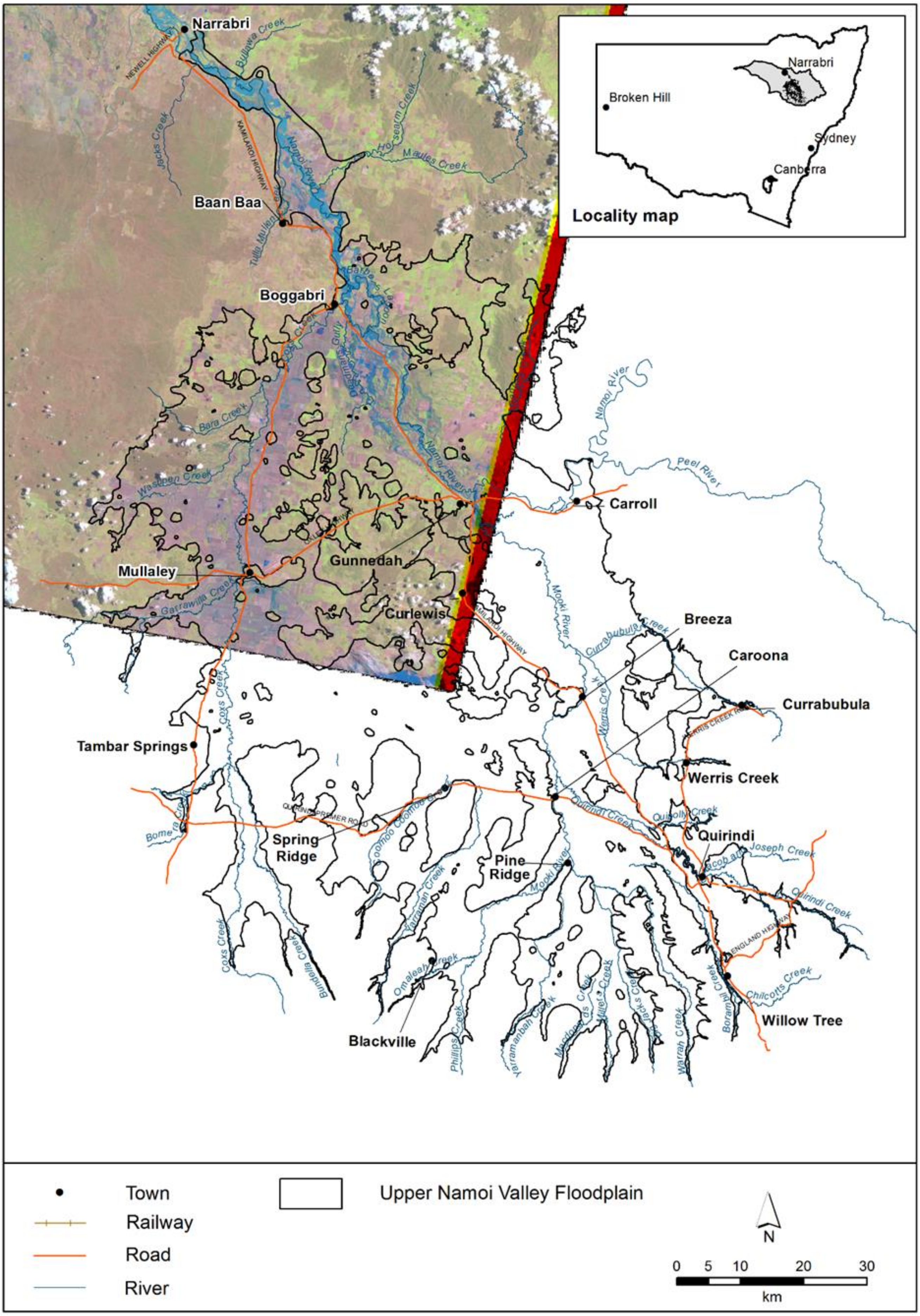

Figure A5 2 Landsat 7 image of a flood event captured on 23 November 2000

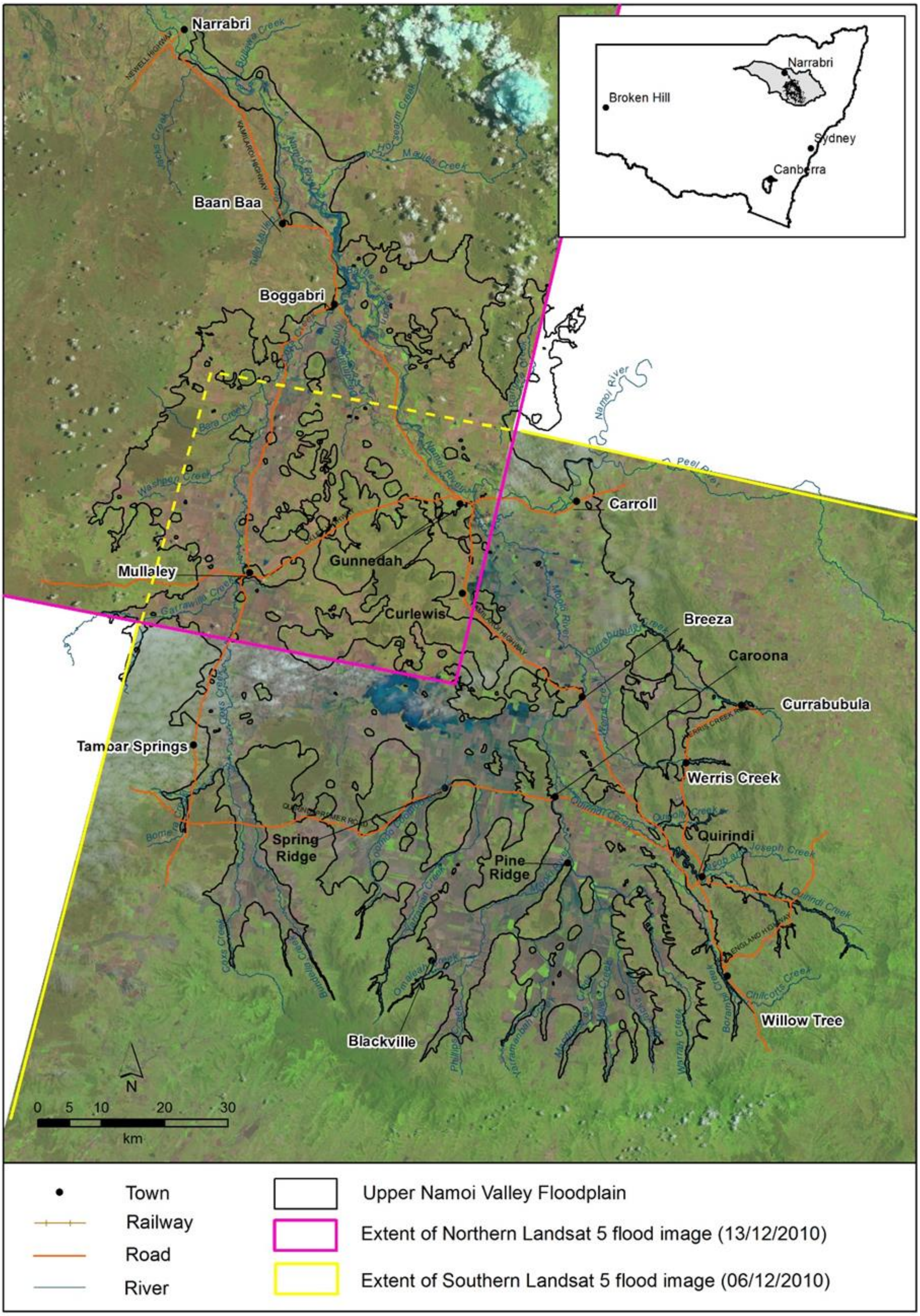

Figure A5 3 Landsat 5 images of flood events in the Upper Namoi Valley FMP on 6 December (southern image) and 13 December 2010 (northern image)

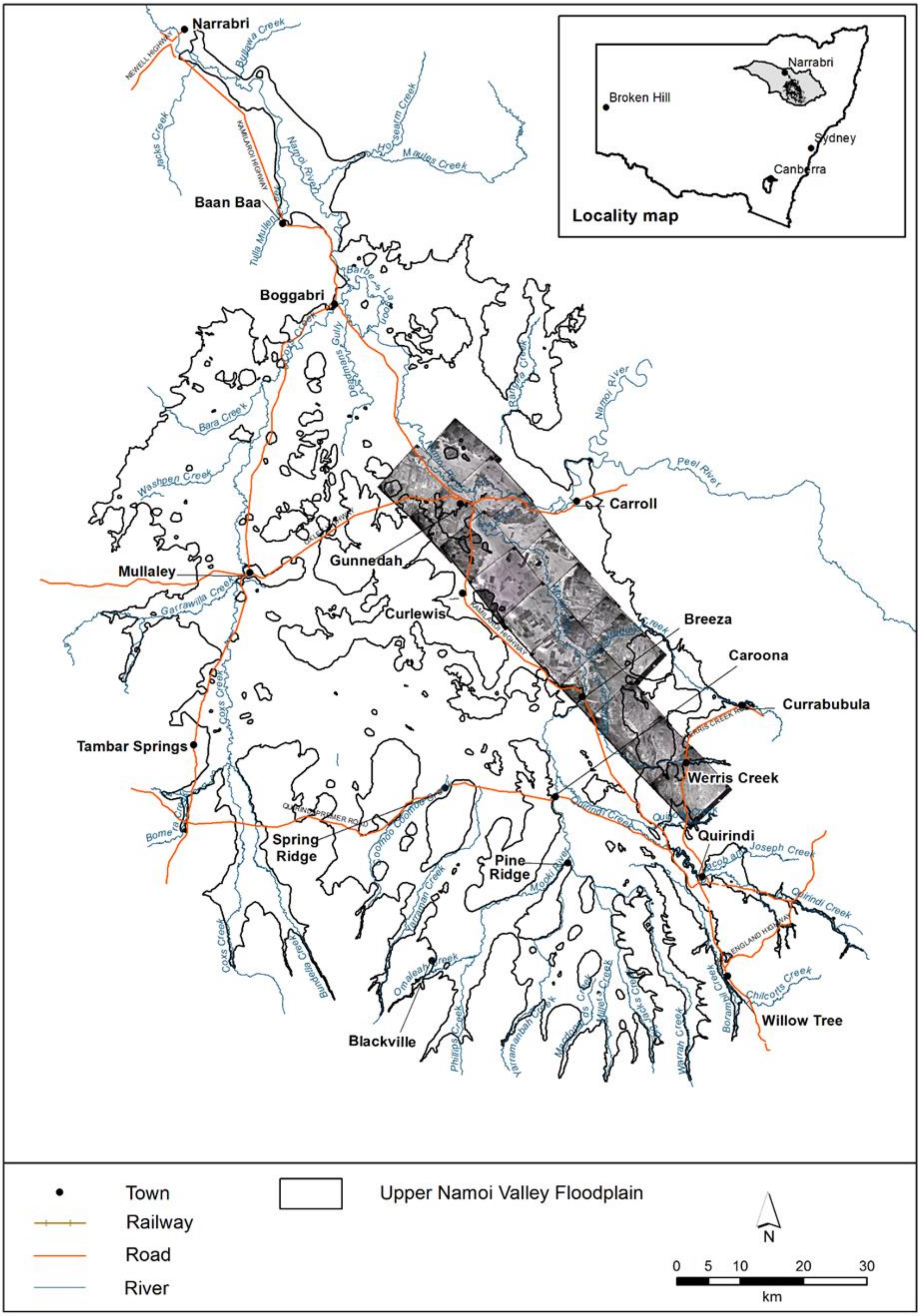

Figure A5 4 Rectified vertical flood photos captured on 31 January 1984 for a 70 km run and a 50 km run east of Gunnedah

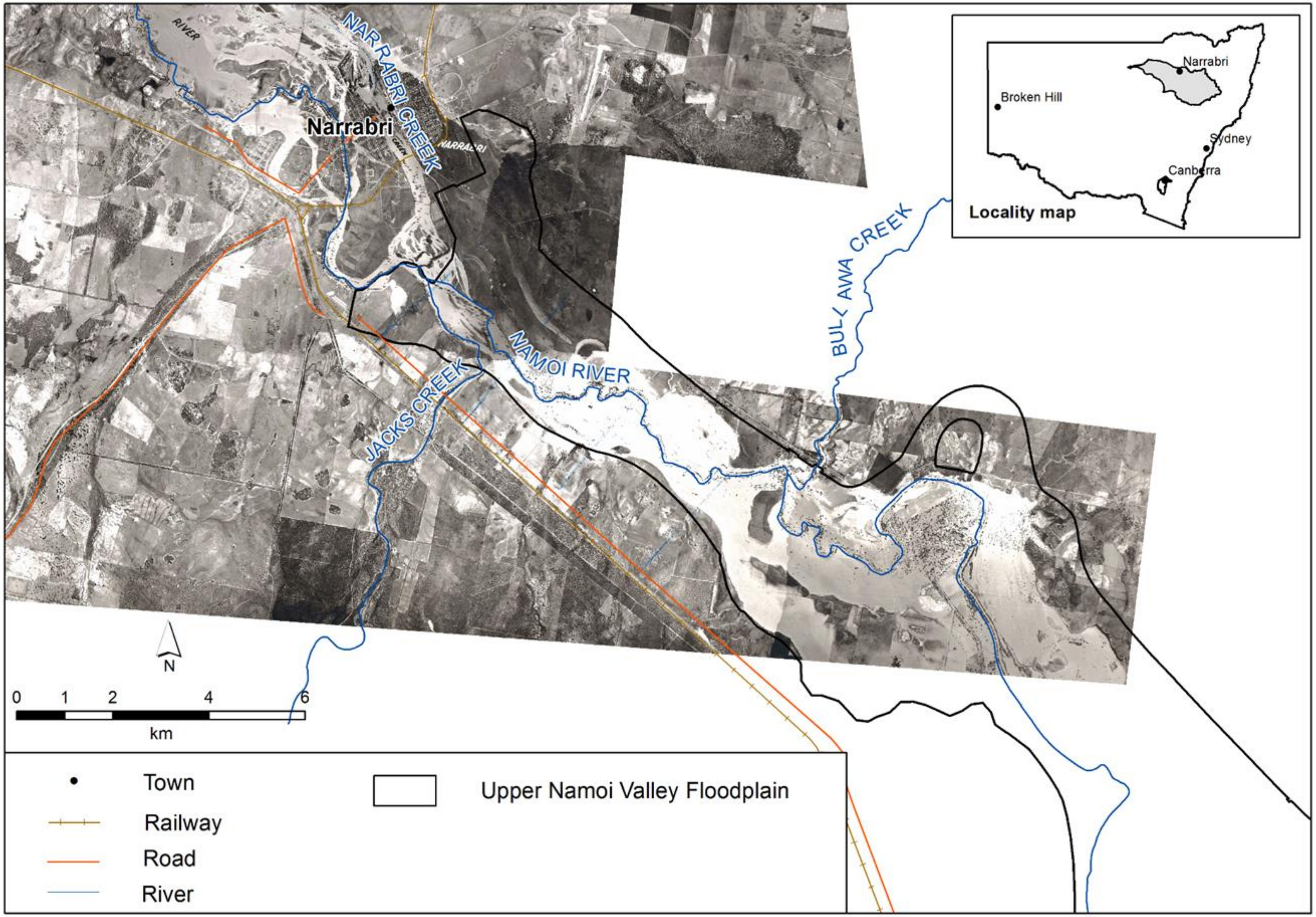

Figure A5 5 Vertical imagery of a flood event captured in February 1971 (Catd No. 46/548)

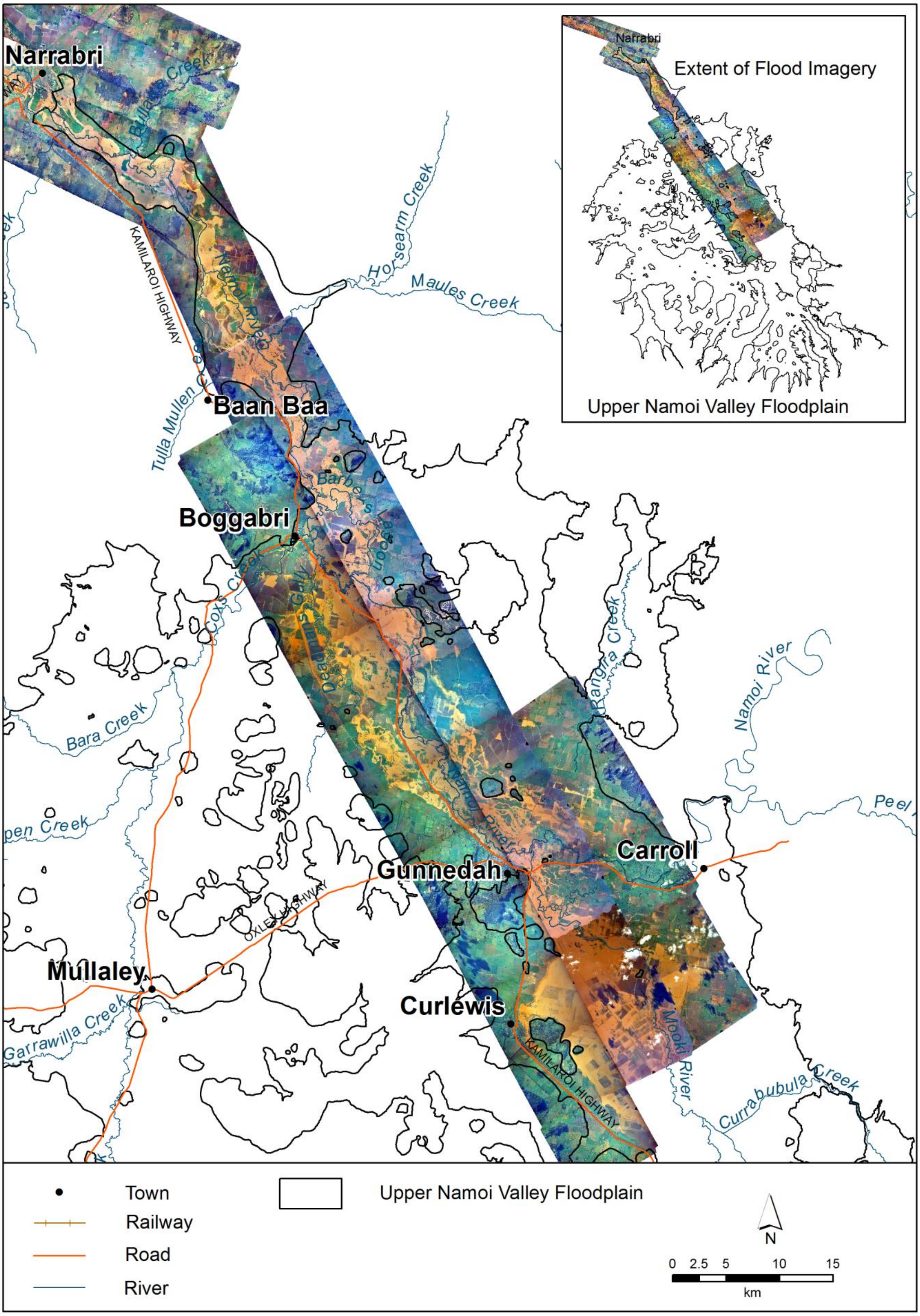

Figure A5 6 Vertical imagery of a flood event captured on 24 July 1998 along the Namoi River from the junction of the Mooki River to Narrabri

Appendix 6: Non-flood-dependent vegetation types

There are 50 non-flood-dependent plant community types (PCTs) identified in the Upper Namoi Valley Floodplain (OEH 2015) (Table A6 1).

Table A6 1: Non-flood-dependent plant community types (PCTs) in the Upper Namoi Valley Floodplain

No.	PCT name	PCT No.
1	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	55
2	Belah, wilga, +/-[1] white box dry viney scrub woodland in the NSW Brigalow Belt South Bioregion	378
3	Black cypress pine, narrow-leaved Ironbark, red gum, +/-[1] white bloodwood shrubby open forest on hills of the southern Pilliga, Coonabarabran and Garawilla regions, Brigalow Belt South Bioregion	417
4	Blakely's red gum, yellow box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	599
5	Blakely's red gum, yellow box grassy woodland of the New England Tablelands Bioregion	510
6	Blue-leaved ironbark, black cypress pine shrubby sandstone open forest in the southern Brigalow Belt South Bioregion (including Goonoo)	467
7	Broombush, wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	141
8	Buloke, white cypress pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, Brigalow Belt South Bioregion	411
9	Derived copperburr shrubland of the NSW northern inland alluvial floodplains	165
10	Dirty Gum, buloke, white cypress pine, ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	148
11	Fuzzy box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregions	202
12	Grey box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion	516
13	Liverpool Plains grassland mainly on basaltic black earth soils, Brigalow Belt South Bioregion	102
14	Mock olive, tumbledown red gum, red ash, wilga siliceous rocky hill low woodland/shrubland in the Gunnedah–Tambar Springs region, Brigalow Belt South Bioregion	439
15	Mock olive, wilga, peach bush, carissa semi-evergreen vine thicket (dry rainforest) mainly on basalt soils in the Brigalow Belt South Bioregion	147
16	Narrow-leaved ironbark, black cypress, pine, stringybark, +/-[1] grey gum, +/-[1] narrow-leaved wattle shrubby open forest on sandstone hills in the southern Brigalow Belt South Bioregion and Sydney Basin Bioregion	479
17	Narrow-leaved ironbark, black cypress pine, white box shrubby woodland in sedimentary hills of the Gunnedah region, Brigalow Belt South Bioregion	459
18	Narrow-leaved ironbark, white cypress pine, buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	398

No.	PCT name	PCT No.
19	Narrow-leaved ironbark, white cypress pine, +/-[1] buloke tall open forest or woodland of the Warialda to Yetman region, Brigalow Belt South Bioregion	373
20	Ooline closed forest (dry rainforest) on sandstone and conglomerate rises and hills in the Brigalow Belt South Bioregion	113
21	Pilliga box, white cypress pine, buloke shrubby woodland in the Brigalow Belt South Bioregion	88
22	Poplar box, white cypress pine shrub grass tall woodland of the Pilliga–Warialda region, Brigalow Belt South Bioregion	397
23	Poplar box, yellow box, western grey box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion	101
24	Rough-barked apple, box - Sticky Daisy Bush - cough bush grass-shrub hillslope open forest in the BBS Bioregion	381
25	Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion	281
26	Rough-barked Apple - Red Stringybark - Black Cypress Pine - red gum sand valley woodland of the Garawilla region, Brigalow Belt South Bioregion	455
27	Rough-barked Apple - White Cypress Pine - Blakely's Red Gum riparian open forest/woodland of the Nandewar Bioregion and New England Tableland Bioregion	544
28	Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region	401
29	Silver-leaved Ironbark - White Cypress Pine shrubby open forest of Brigalow Belt South Bioregion and Nandewar Bioregion	594
30	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	444
31	Silvertop Stringybark - Yellow Box - Apple Box - Rough-barked Apple shrub grass open forest mainly on southern slopes of the Liverpool Range, Brigalow Belt South Bioregion	492
32	Slender Saltbush - samphire - copperburr low open shrubland wetland on irregularly inundated floodplains mainly in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	211
33	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	27
34	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	81
35	White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	405
36	White Bloodwood - Red Ironbark - Black Cypress Pine woodland on sandstone hills in the Garawilla - Liverpool Plains region, Brigalow Belt South Bioregion	457
37	White Box - cypress pine - Silver-leaved Ironbark shrub grass open forest/woodland of the northern Brigalow Belt South Bioregion and Nandewar Bioregion	597

No.	PCT name	PCT No.
38	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	589
39	White Box - White Cypress Pine shrub grass hills woodland in the Brigalow Belt South Bioregion and Nandewar Bioregion	435
40	White Box - White Cypress Pine shrubby hills open forest mainly in the Nandewar Bioregion	588
41	White Box grass shrub hill woodland on clay to loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion	434
42	White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, BBS Bioregion	433
43	White Box shrubby woodland of the western Liverpool Range, Warrumbungle Range and south-west Pilliga forests, Brigalow Belt South Bioregion	393
44	White Cypress Pine - Narrow-leaved Ironbark - White Bloodwood - red gum shrub grass woodland of the Pilliga - Coonabarabran region, Brigalow Belt South Bioregion	396
45	White Cypress Pine - red gum grass-shrub woodland on sandstone hills of the Caroona region, Liverpool Plains, Brigalow Belt South Bioregion	463
46	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion	418
47	Wild Quince – Mock Olive – Rusty Fig – lamboto – Sweet Pittosporum dry rainforest of rocky and scree areas of the Nandewar Bioregion and New England Tableland Bioregion	547
48	Yarran shrubland of the NSW central to northern slopes and plains	77
49	Yellow Box - White Cypress Pine alluvial terrace flats grassy woodland in the Pilliga forests and surrounds, Brigalow Belt South Bioregion	421
50	Yellow Box grassy woodland on lower hillslopes and valley flats in the southern NSW Brigalow Belt South Bioregion.	437

[1]+/- means ‘with or without’.

Appendix 7: Groundwater recharge

Water sharing plans (WSP) for groundwater sources that have been prepared and adopted in the proposed Upper Namoi Valley Floodplain include (Figure A7 1):

- WSP for the Upper and Lower Namoi Groundwater Sources 2003 (342,700 ha or 58% of the floodplain)
- WSP for the NSW Great Artesian Basin Groundwater Sources 2008 (1,500 ha or less than 1% of the floodplain)
- WSP for the NSW Murray–Darling Basin Porous Rock Groundwater Sources 2011 (226,300ha or 38% of the floodplain)
- WSP for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources 2011 (12,700 ha or 2% of the floodplain)
- WSP for the Namoi Unregulated and Alluvial Water Sources 2012 (5,500 ha or 1% of the floodplain)

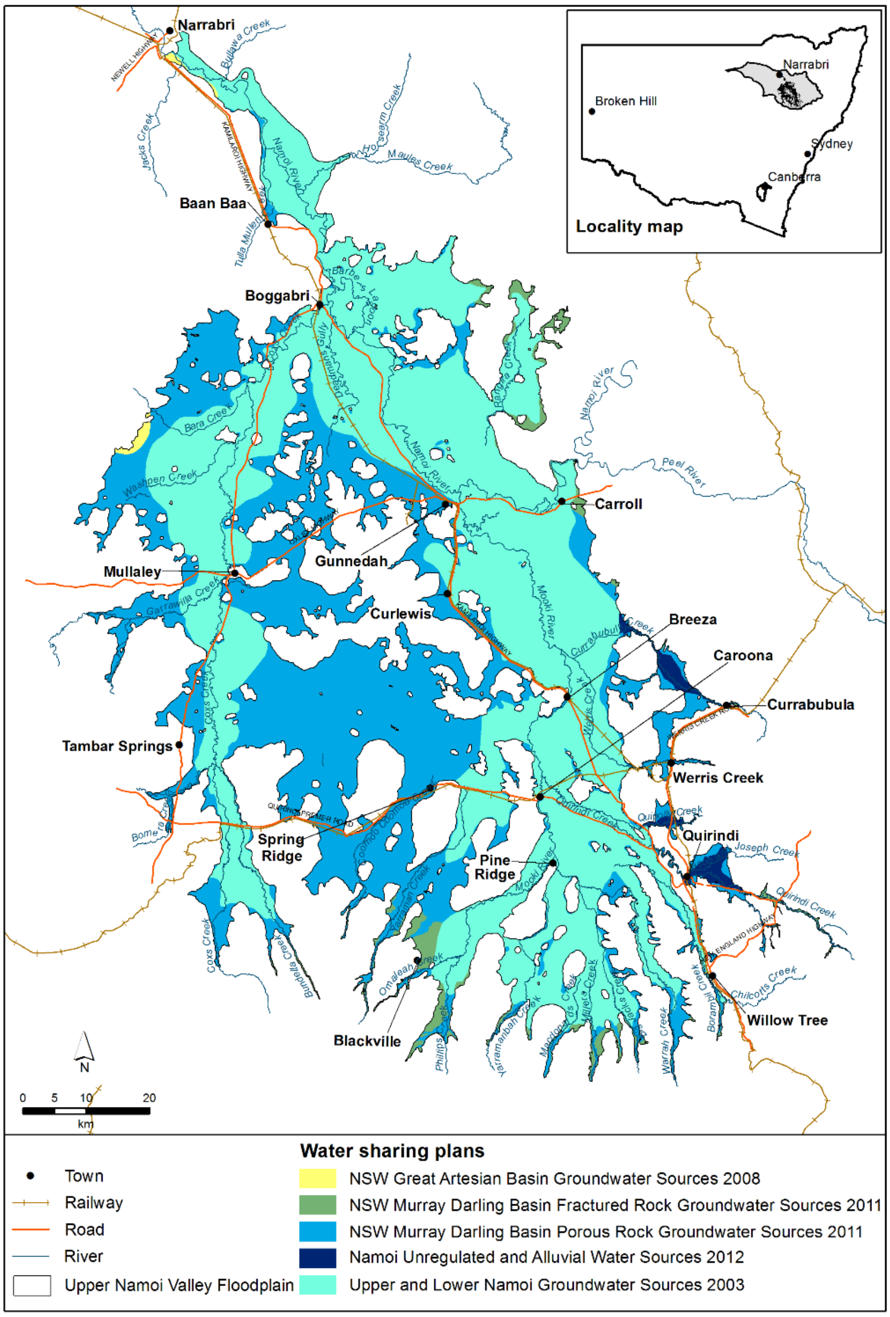

Figure A7 1 Water sharing plans for groundwater sources in the Upper Namoi Valley Floodplain

A status report is available for the Upper Namoi Groundwater Source and information from this report is summarised below.

The Upper Namoi Groundwater Source is split into 12 zones and includes all water contained in the unconsolidated alluvial sediment aquifers associated with the Namoi River and its tributaries. The alluvial aquifer system is formed by the unconsolidated sediments associated with the Namoi River, Mooki River and Coxs Creek and the alluvium area covers approximately 300,000 ha (Barrett 2011). The alluvial sediments are generally defined by two layers: the shallower Narrabri formation (up to 30-40 m) and the more productive deeper Gunnedah formation (generally 40-100 m but up to 170 m at it deepest) (Barrett 2011). These formations consist mainly of sand, gravel and clay and their thickness is largely controlled by the bedrock topography (Barrett 2011).

Groundwater recharge to the alluvial aquifer system can occur via (CSIRO 2007; Barrett 2011; Lamontagne et al. 2011):

- rainfall infiltration
- leakage from rivers, weir pools and on-farm storages
- infiltration from natural floods as well as irrigation releases
- flow from surrounding aquifers, such as leakage between the upper Narrabri formation and the lower Gunnedah formation.

The groundwater recharge mechanisms in other Groundwater Source areas are likely to be similar to the Upper Namoi Groundwater Source where the floodplain overlies ‘alluvials’ (Cate Barrett pers. comm.).

Aquifers in the Upper Namoi are high-yielding and provide good-quality groundwater across wide areas of the alluvial plain (Barrett 2011). The Gunnedah formation is the most productive aquifer and main palaeochannel which is generally limited to the central portions of the valley and in most cases does not follow the present drainage lines (Barrett 2011). The coarse sediment that makes up the palaeochannels allows for high groundwater extraction rates (Barrett 2011).

Major areas of groundwater connection are at the top of the valley along the Peel River and between Gunnedah and Boggabri (Badenhop et al. 2012). Much of the valley is considered to be in transition or disconnected due to the large stresses and long-term decline occurring (Badenhop et al. 2012). Downstream of the confluence of Coxs Creek and the Namoi River, there are few areas of connection (Badenhop et al. 2012).

In places, the basement rocks form narrow valleys which restrict groundwater movement through the alluvial aquifers (Barrett 2011). The main constrictions occur at Gin’s Leap north of Boggabri, in Cox’s Creek at Mullaley and at Mooki River at Breeza (Brownbill unpublished).

There are approximately 1100 production bores across the Upper Namoi water sources. Monitoring of these bores has shown that usage across the Upper Namoi Alluvium has generally been well below the estimated average annual recharge (Barrett 2011). Groundwater use is concentrated near Curlewis on the Breeza Plain and on Coxs Creek (Badenhop et al. 2012).

Recharge to the aquifer system drives saline outbreak in the floodplain, and the Liverpool Plains catchment is a National Dryland Salinity Program focus catchment. The Pine Ridge and Lake Goran catchments are of particular focus due to poor surface drainage, and their groundwater outlets are laterally and vertically constricted by bedrock highs, which lead to groundwater discharge and evaporative concentration of salt in the lower reaches (Dawes et al. 2000).

Appendix 8: Marxan prioritisation (planning units)

The Upper and Lower Namoi floodplains are considered as one contiguous floodplain and planning units were defined across this area. Planning units are area-based polygons of a pre-defined shape and size that might be included in (or excluded from) the final Marxan solution. These units form the basis of the Marxan analysis.

To create the planning units, the Namoi floodplain was divided into 50 ha hexagonal planning units (n = 24, 712) using Qmarxan plugin (Apropos Information Systems Inc. 2013) executed within Quantum GIS Version 1.8.0 software (QGIS Development Team 2013). The hexagonal shape was selected over other shapes as they have been shown to produce more efficient and less-fragmented planning portfolios (Nhancale & Smith 2011). Their consistent size helps to reduce area-related bias (Loos 2011). The amount of each biodiversity feature in each planning unit was calculated using the Qmarxan plugin in Quantum GIS (QGIS Development Team 2013). The extent of all biodiversity features within each planning unit is assessed to determine the relative importance of individual planning units and this forms the basic Marxan data matrix. Where some areas must be conserved, Marxan can be parameterised to ‘lock in’ (i.e. planning units may be forced into the final solution before the algorithm is run) or where appropriate, exclude them from the final solution (i.e. the planning unit may not be considered in the final solution), using status codes. For example, wetlands of national importance, such as Lake Goran (NSW005; Australian Government - Department of the Environment 2015), were fixed into the solution.

Appendix 9: Marxan prioritisation (targets for ecological surrogates)

Ecological surrogates were identified using environmental data recommended by specialists during Technical Advisory Group (TAG) workshops. This data was either area-based or point-based. Targets are conservation objectives that specify the amount of an ecological surrogate that would be needed to be conserved to ensure the persistence of that ecological surrogate (Margules & Pressey 2000). Targets were selected for each of the ecological surrogates during a TAG meeting on 27 February 2014 with local experts.

Area-based data sets (mapped vegetation)

Area-based data for vegetation was the primary ecological surrogate for the Marxan prioritisation. Mapped vegetation was chosen if it was dependent on flooding and/or provided habitat to flood-dependent fauna.

Target setting for area-based surrogates was initiated at 30% of the pre-development area, below which there is a steep drop-off in biodiversity (Ausseil et al. 2011). The 30% habitat area has also been recommended by the World Conservation Union (IUCN 2003). To determine the percentage area of vegetation surrogates remaining in the Namoi floodplain, a pre-1750 vegetation reconstruction map (Eco Logical Australia 2013) was compared to the current spatial extent of mapped vegetation surrogates.

Both coolibah and coolibah–black box flood-dependent woodland surrogates were considered to be an over-cleared BioMetric vegetation vegetation type i.e. had > 70% of that vegetation type in the former Border Rivers–Gwydir Catchment Management Authority (CMA) region had been cleared. The coolabah–black box woodland is also listed as an endangered ecological community under the *Biodiversity Conservation Act 2016* and the EPBC Act (TSSC 2011). Therefore, the targets were set at 100% of the remaining vegetation for the coolibah and coolibah–black box flood-dependent woodland surrogates.

The spatial extent of flood-dependent forest/woodland (wetland) communities were restricted to narrow riparian corridors surrounded by agricultural land in the Upper Namoi Valley Floodplain. Maintenance of these vegetation communities was considered essential as they provide native corridors that improve connectivity.

All of the remaining flood-dependent vegetation was considered by local experts from the TAG to be of conservation significance, and targets were set at 100% for all vegetation surrogates in the Marxan analysis.

Marxan can be parameterised to fix or exclude planning units into the final solution through the use of status codes. As part of the target setting, the TAG made recommendations as to whether a vegetation surrogate should be fixed into the solution. All flood-dependent vegetation except for flood-dependent woodland was fixed into the solution.

Area-based data sets (species distribution models)

Species distribution models (SDMs) can make inferences of the likelihood of finding a species in areas where reliable observations do not occur (Hernandez et al. 2006). Correlative SDMs use associations between environmental variables and known species occurrence records to identify environmental conditions within which populations can be maintained. Species distribution models provide a powerful way of overcoming sparseness of point-based fauna distribution data by relating them to geographic or environmental predictors (Elith and Leathwick 2009). The spatial distribution of environments that are suitable for the species can then be estimated across a study region (Pearson 2007). The rationale for this approach is that environmental conditions at occurrence locations can reasonably explain species' physiology and probability of existence (Franklin 2013). SDMs have been used in other systematic conservation planning studies in riverine ecosystems using Marxan (Esselman and Allan 2011; Linke et al. 2012; Hermoso et al. 2013).

Eight flood-dependent fauna that are associated with standing water (i.e. wetland habitats) for all or part of their life cycle were selected as surrogates to build SDMs (Jansen and Healey 2003; Wassens 2010). In this study, SDMs (Maxent v. 3.3.3k, (Philips et al 2010)) relate records from the NSW Wildlife Atlas to a suite of environmental variables at selected locations over the Upper and Lower Namoi Valley Floodplains (Table A9 1).

Table A9 1: Targets for area-based ecological surrogates (fauna species distribution models)

Asset types	Description	Total area (ha)	Target (% of sites)	Fixed in solution	Rationale
Frogs	Barking marsh frog (*Limnodynastes fletcheri*)	25,8997	10	No	The realised niche is likely to be a subset of the modelled areas.
Frogs	Broad-palmed frog (*Litoria latopalmata*)	27,1705	10	No	The realised niche is likely to be a subset of the modelled areas.
Frogs	Desert tree frog (*Litoria rubella*)	26,1842	10	No	The realised niche is likely to be a subset of the modelled areas.
Frogs	Eastern sign-bearing froglet (*Crinia parinsignifera*)	75,119	10	No	The realised niche is likely to be a subset of the modelled areas.
Turtles	Eastern snake-necked turtle (*Chelodina longicollis*)	232,503	10	No	The realised niche is likely to be a subset of the modelled areas.
Turtles	Macquarie turtle (*Emydura macquarii*)	286,639	10	No	The realised niche is likely to be a subset of the modelled areas.
Turtles	Broad-shelled turtle (*Chelodina (Macrochelodina) expansa*)	179,339	10	No	The realised niche is likely to be a subset of the modelled areas.
Snake	Red-bellied black snake (*Pseudechis porphyriacus*)	73,827	10	No	The realised niche is likely to be a subset of the modelled areas.

SDMs may overestimate the likelihood of a species occurring. Although it can be difficult to evaluate overestimation in SDMs that use presence data only, the SDMs were evaluated using receiver operator characteristic (ROC) calculations (Hernandez et al. 2006). ROC was used to assess plot sensitivity (or true positives) against specificity (or false positives) for a range of threshold values, with the area under the curve providing a measure of the ability of the model to discriminate between presences and absences (Wen et al. 2015). The ROC values ranged from 0.88 to 0.96, which is considered to be an acceptable range for conservation planning (Pearce and Ferrier 2000). Nevertheless, the models were weighted lower (a 10% of sites target) than other mapped surrogates in the Marxan analysis to acknowledge that the actual distribution of species may be a subset of the modelled distribution.

Table A9 2: Environmental variables used to fit SDM over the Upper and Lower Namoi Valley Floodplains

Type	Resolution	Description
Climate[1]	1 km	Annual mean temperature
Climate[1]	1 km	Mean diurnal range (mean of monthly temperature or maximum temperature to minimum temperature)
Climate[1]	1 km	Temperature isothermality
Climate[1]	1 km	Temperature seasonality (standard deviation multiplied by 100)
Climate[1]	1 km	Mean temperature of wettest quarter
Climate[1]	1 km	Mean temperature of driest quarter
Climate[1]	1 km	Precipitation of driest month
Climate[1]	1 km	Precipitation of seasonality (coefficient of variation)
Climate[1]	1 km	Precipitation of wettest quarter
Climate[1]	1 km	Precipitation of warmest quarter
Climate[1]	1 km	Precipitation of coldest quarter
Topography[2]	250 m	Altitude
Topography[2]	250 m	Built from nine second DEM derived streams database (Geoscience Australia 2011)
Topography[2]	250 m	Amount of upstream area (in number of cells) draining into each cell calculated from the 90 m SRTM elevation data
Vegetation[3]	250 m	Annual mean Normalised Difference Vegetation Index (NDVI) calculated from the monthly Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI (2000–12)
Vegetation[3]	250 m	Annual maximum NDVI calculated from the monthly MODIS NDVI (2000–12)
Vegetation[3]	250 m	Standard deviation of annual mean NDVI
Vegetation[3]	250 m	Annual mean of the standard deviation of monthly NDVI (January 2000–December 2012)

[1] Bioclim (Busby 1991)

[2] Geoscience Australia 2011 and OEH 2013

[3] NASA & Administration 2014

Point-based occurrence data (fauna)

Ecological surrogates derived from point-based data for fauna included:

- 11 species of fish
- seven species of frogs
- five species of amphibious reptiles
- two species of mammal[1].

These fauna species and assemblages were selected because they have a high dependence on floodwater. A score for presence or absence for the species was assigned to all planning units. If the point record was within a planning unit, the species was considered present. Point-based records of fauna observations were sourced from the Atlas of NSW Wildlife (BioNet www.bionet.nsw.gov.au) and the Atlas of Living Australia (www.ala.org.au). The search method was restricted to the Namoi CMA for post-1980 records and filtered to only consider records that were on the Namoi floodplain. Any data with a spatial accuracy of less than 100 metres or an association with a human artefact, such as a farm dam, was removed from the analysis. Fish records were acquired from the NSW Freshwater Fish Research Database (accessed in 2014) which collates data from sites sampled by the NSW Department of Primary Industry—Fisheries over the last 20 years (NSW DPI 2013).

The watering requirements of all species recorded in the study area was examined (Table A9 3).

All point-based occurrence surrogates were given 100% targets (Table A9 3) as the number of records did not cover a large part of the landscape. It was decided that it was important to include the small number of sites where these wetland indicator species where known to occur.

Table A9 3: Targets for point-based ecological surrogates

Fauna	Rationale for selection	No. of records
Fish		
Australian smelt *Retropinna semoni*	Occurs in lowland and slope waterways of the Namoi Valley (DPI 2006). Barriers to fish passage, in the form of weirs, may be fragmenting populations (Lintermans 2009).	19
Bony herring *Nematalosa erebi*	Associated with lowland and mid-slope rivers in the Namoi Valley (DPI 2006; DPI 2012). The lifecycle of the bony herring is mostly within the main channels generalist of aquatic ecosystems. But it will also use anabranches, billabongs and floodplain wetlands during its life-cycle (Young et al. 2003).	41
Darling River hardyhead *Craterocephalus amniculus*	Known to occur in the Namoi Valley, found in slow-flowing, clear, shallow waters or in aquatic vegetation along the edge of these waters or on the edges of faster-flowing habitats (Lintermans 2009).	1
Freshwater (eel-tailed) catfish *Tandanus tandanus*	The freshwater catfish is recorded in the Namoi Valley, where small populations occur upstream of Wee Waa (DPI 2012; DPI 2014). This species is associated with lowland lakes and slow-flowing rivers (DPI 2006; Lintermans 2009). Cold-water pollution below dams, barriers to movement, changes to natural flow regimes including loss of habitat due to alterations to flow patterns and flooding regimes have contributed to the decline of this species (DPI 2014; Lintermans 2009). The Murray–Darling Basin population of eel-tailed catfish is listed as an endangered population in NSW (DPI 2015).	15

[1] Waterbird observations were excluded from the prioritisation. Due to their high mobility, some observations are likely transitions between areas of core habitat. Colonial waterbird breeding habitat, both mapped and modelled, was used instead of point data to include this important wetland group.

Fauna	Rationale for selection	No. of records
Golden perch *Macquaria ambigua*	Historical records indicate that this species was once found in the Lower Namoi Valley. This species is associated with lowland slow-moving waters (DPI 2012), where it spawns. Large numbers of juveniles then live in nurseries on an inundated floodplain and shallow lake habitats before migrating long distances upstream (Gehrke and Harris 2004; Lintermans 2009). River regulation, including barriers to migration and recolonisation, have disrupted migrations and breeding behaviour as this species requires flow pulses or floods for spawning (Humphries et al 1999; Lintermans 2009).	30
Murray cod *Maccullochella peelii*	Historical records indicate that the Murray cod used to be common in the Lower Namoi Valley (DPI 2012). This species is restricted to riverine habitats and is associated with complex instream habitat such as rocks, stumps and fallen trees (Humphries et al 1999; King 2004; Koehn and Harrington 2005; Lintermans 2009). Flows are an important factor in larval survivorship and subsequent recruitment of Murray cod (Cheshire and Ye 2008). Adverse alterations in aquatic habitat have contributed to the decline of available habitat (Kalatzis and Baker 2010).	27
Murray–Darling rainbow fish *Melanotaenia fluviatilis*	Recorded in the Namoi Valley. This species prefers aquatic habitat associated with instream vegetation in slow moving waters of rivers, billabongs and swamps (DPI 2012; Lintermans 2009). The Murray–Darling rainbow fish spawns and recruits during low flow periods but it is known to use floodplain habitats (Young et al. 2003).	24
Silver perch *Bidyanus bidyanus*	The silver perch was commonly found lowland and slope waterways the Namoi catchment (DPI 2006; DPI 2012). It prefers fast-flowing, open waters, especially where there are rapids and runs. This species relies on flow pulses or floods for spawning (Humphries et al. 1999). Modification of natural river flows through the construction of barriers has led to reduced opportunities for dispersal, spawning and migration. This species has experienced local decline (DPI 2005; DPI 2014) and is listed as a vulnerable species in NSW (DPI 2017).	8
Spangled perch *Leiopotherapon unicolor*	Historical records indicate the species' presence in the Lower Namoi Valley (DPI 2012). The spangled perch is found in rivers, wetlands and intermittent streams (Lintermans 2009). Flood events maximise recruitment, and reduced flood frequency and access to floodplains disadvantages it (Lintermans 2009).	36
Un-specked hardyhead *Craterocephalus stercusmuscarum fulvus*	Found around the margins of large, slow-flowing, lowland rivers and in lakes, backwaters and billabongs. This species is associated with shallow vegetated areas with sandy or muddy substrate (Lintermans 2009). Wetland opportunists as they spawn and recruit in floodplain wetlands, as well as lakes, anabranches and billabongs, during in-channel flows (Young et al. 2003).	14
Unidentified carp gudgeon *Hypseleotris* species	This species group is associated with slow-flowing or still waters, normally associated with macrophyte beds or other aquatic vegetation (Lintermans 2009). This group is regarded both as wetland and low-flow opportunists, since they tend to spawn and recruit during low flows and utilise the main channels, floodplain wetlands and secondary channels (Young et al. 2003).	40
Frogs		
Fletcher's frog *Limnodynastes fletcheri*	Has a strong preference for areas with emergent vegetation, such as spike rush and cumbungi, particularly after flooding (Croft 2012; Healey et al. 1997; Wassens 2010).	7
Broad-palmed frog *Litoria latopalmata*	The broad-palmed frog is commonly found in the middle and upper reaches of the Namoi River and associated tributaries. The broad-palmed frog occupies a range of habitats, including flood-dependent river red gum and black box (Wassens 2010). This species is restricted to areas of permanent and semi-permanent waters (Anstis 2013).	8
Common eastern froglet *Crinia signifera*	The common eastern froglet occurs in permanent and semi-permanent rivers and wetlands. This species is also associated with man-made dams and infrastructure (Wassens 2010). It favours water couch habitat and may prefer to breed in deep and permanent pools (Lintermans & Osborne 2002; OEH 2012).	3
Desert tree frog *Litoria rubella*	The desert tree frog prefers temporary water bodies and is reliant on spring and summer floods to create suitable breeding habitat (Wassens 2010). Males call from grass tussocks or vegetation near water (Anstis 2013).	9

Fauna	Rationale for selection	No. of records
Eastern sign-bearing froglet *Crinia parinsignifera*	Occurs in rain-fed depressions, semi-permanent wetlands, oxbow lagoons, creeks and rivers and man-made dams and infrastructure (Wassens 2010).	2
Salmon-striped frog *Limnodynastes salmini*	The salmon-striped frog is associated with flooded grasses and dams. The tadpoles prefer warmer, shallow water with vegetation cover (Anstis 2013).	7
Spotted grass frog *Limnodynastes tasmaniensis*	Prefers situations where there is considerable flooded vegetation such as tussocks and sedges (Lintermans & Osborne 2002). This species will colonise any temporary or permanent pond or grassland soak (Anstis 2013). During drought periods, adults congregate around permanent water (Wassens 2010).	10
Reptiles		
Broad-shelled turtle *Chelodina Macrochelodina expansa*	The broad-shelled turtle is recorded in the Namoi Valley, where it prefers lacustrine habitats and slow-flowing water bodies. This species is frequently found in permanent lakes and billabongs connected to main river channels (Bower & Hodges 2014).	4
Eastern snake-necked turtle *Chelodina longicollis*	The eastern snake-necked turtle is found in range of freshwater aquatic environments, from shallow, ephemeral wetlands to permanent rivers (Kennett et al. 2009). Changes in river flows and instream habitat modification associated with human-induced disturbance may threaten populations of this species (Kennett et al. 2009).	7
Eastern water skink *Eulamprus quoyii*	Usually found in the riparian zones of slow-flowing creeks and estuaries. The eastern water skink is often seen basking besides small creeks, larger stream and rivers, but is not restricted to areas near freshwater (Cogger 2000).	2
Murray turtle *Emydura macquarii*	Occurs primarily in rivers and water bodies associated with rivers such as backwaters, oxbows, anabranches and deep, permanent waterholes on floodplains (Chessman 1988).	3
Red-bellied black snake *Pseudechis porphyriacus*	Associated with streams, swamps and lagoons. The red-bellied black snake mostly feeds on frogs, but reptiles and small mammals are also eaten (Ayers et al. 2004; Cogger 2000).	3
Mammals		
Platypus *Ornithorhynchus anatinus*	Adapted to feed exclusively in an aquatic environment. The diet of platypus consists of aquatic insects and crustaceans in riverine environments (Faragher et al. 1979; Grant 1982). It is less common in the rivers and streams of the western slopes of the Great Dividing Range (Grant 1982), but it is reported to occur in streams flowing through agricultural land in these areas (Lunney et al. 2004). Its dependency on water bodies places it at risk of sudden declines due to anthropogenic habitat modification of stream, lake and wetland systems (Kolomyjec et al. 2013).	3
Water rat *Hydromys chrysogaster*	Inhabits streams, rivers and wetlands throughout the Murray–Darling Basin (Scott and Grant 1997) .This species may be found in permanent, swampy or lacustrine habitats associated with major drainages (Dickman 2004). Water rats can occur in high numbers by permanent wetlands and prefer slower moving waters and dense vegetation cover (CSIRO 2004; Scott and Grant 1997). The water rat is often associated with irrigation infrastructure and may be a vagrant at ephemeral waters, travelling more than 3 km overland to exploit new resources (Dickman 2004; Scott and Grant 1997).	2

Point-based occurrence data (wetlands)

Point-based wetland locations were also considered in the Marxan analysis (Table A9 4). These wetlands were identified in local floodplain management plans' records and from previous studies (DNR 2006a, Green & Dunkerley 1992).

Table A9 4: Point-based wetlands and their targets, including wetlands identified in existing FMPs.

Surrogate	Number	Target (% of sites)
Wetlands and lagoons identified in FMPs		
Caroona–Breeza	2	100
Springs, swamps and waterholes		
Treloar Springs/Terda Springs	1	100
Emu Hole, Bunda Wallah Waterhole	2	100
Wetlands and lagoons		
Lagoons (Inland Rural Flood Group, OEH)	24	100
Wetlands of the Namoi Valley (Green and Dunkerley 1992)	48	100

Appendix 10: Marxan prioritisation (constraint surface)

Marxan addresses the minimum-set problem, which is to meet a set of targets at the lowest cost. It minimises an objective function via a process of simulated annealing to select important parts of the landscape from a larger pool of potential areas (or planning units) taking into account planning-unit costs and the locations of the conservation features for protection (Ball et al. 2009). Efficiency is a core objective of Marxan. The use of a constraint surface in ecological prioritisation, therefore, allows Marxan to create efficient planning solutions. A cost-efficient network of priority areas is also one that is comprehensive, representative and adequate for the least possible cost and is more likely to be defensible in light of competing interests (Wilson et al. 2009).

New South Wales land capability classes were used as a surrogate for inundation likelihood to derive the constraint surface for the Namoi Valley plan (Emery 1986). The eight-class classification is based on an assessment of the biophysical characteristics of the land and the extent to which these will limit a particular type of land use and the technology available for land management (Emery 1986).

Low constraint classes were most likely to be associated with high inundation frequency, the central constraint class was more likely to fall in moderate inundation likelihood and the high constraint class was associated with a low likelihood of inundation. A spatially explicit inundation frequency index derived from satellite imagery was not available for the Namoi floodplain. Eight land capability constraint classes were associated with inundation likelihood and given low to high constraint values for use in Marxan (Table A10 1,Figure A10 1).

Table A10 1: NSW land capability class and their constraint weightings

NSW Land Capability Class	Land Capability codes	Constraint value in Marxan
Nature reserve	N.R	0.45
State forest	S.F	0.45
Other—land best protected by green timber, cliffs, lakes or swamps and other lands unsuitable for agricultural and pastoral production	7, 8	0.50
Land suitable for grazing but no cultivation	6	0.65
Land suitable for grazing with occasional cultivation	4, 5	0.75
Land suitable for regular cultivation	1, 2, 3	0.85
Flood irrigation	FI	1
Urban area	U	1

The constraint surface represented the ability to physically connect water to floodplain assets and was used to constrain the selection of planning units in the Marxan solution. The land capability constraint values were fitted to the planning unit layer to create the constraint surface. This was done by generating an area-weighted mean (AWM) of the constraint value to give each planning unit a single value (Figure A10 1).

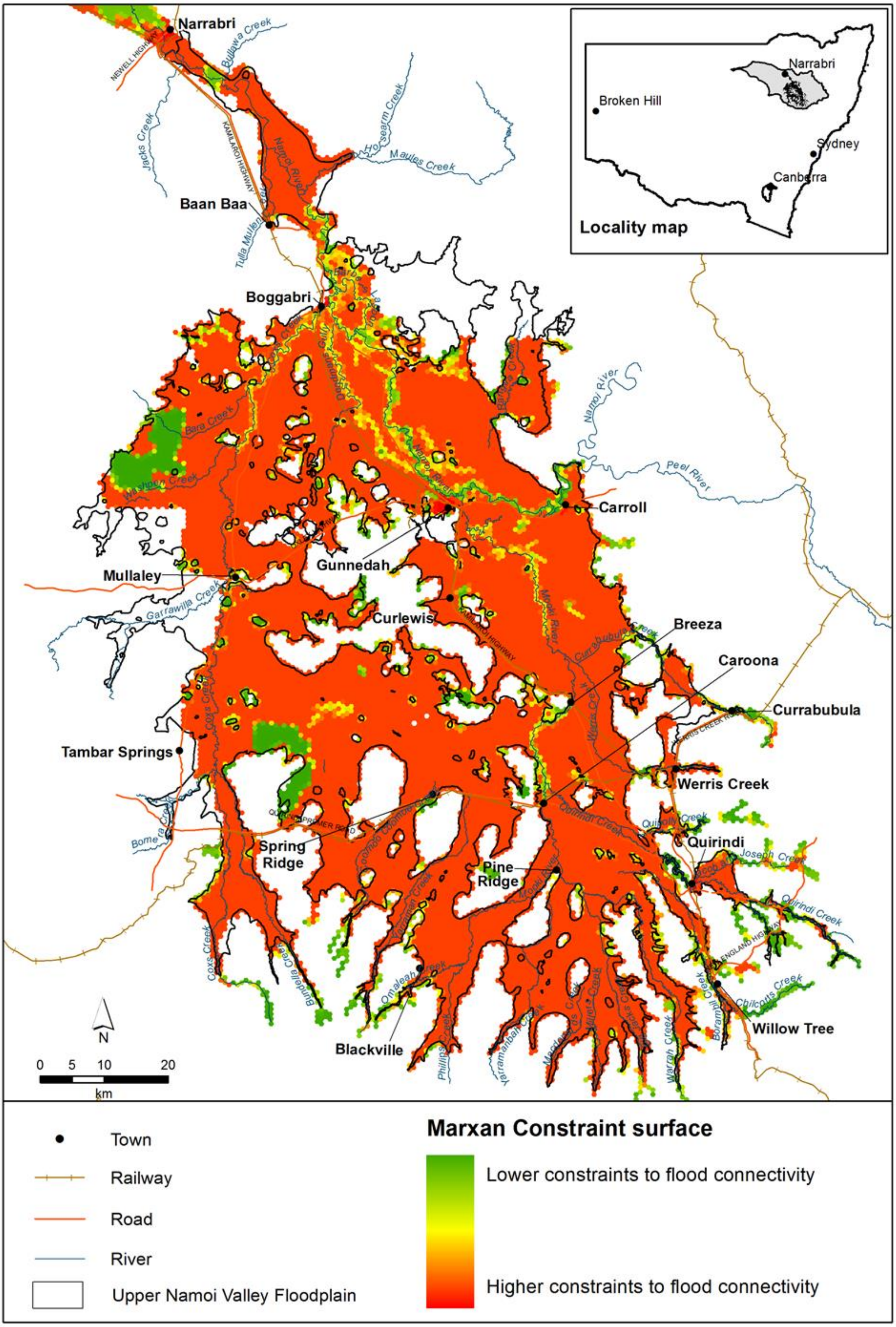

Figure A10 1: Constraint surface for the Upper Namoi Valley Floodplain

Appendix 11: Aboriginal Sites Decision Support Tool

The Aboriginal sites decision support tool (ASDST) was developed to meet a critical need in regional planning: whole-of-landscape data describing Aboriginal site issues. There are two key components of the ASDST: landscape visualisation through the provision of visual products (GIS layers) that fill in data gaps in the Aboriginal Heritage Information Management System (AHIMS) data; and analysis, by generating information products designed to meet the need of incorporating Aboriginal site heritage information into regional, park, land and natural resource management planning.

The tool is based on and a leader in international best practice in archaeological site predictive modelling and has been successfully applied as part of a variety of projects across NSW (further information is on the ASDST website—www.environment.nsw.gov.au/licences/AboriginalSitesDecisionSupportTool.htm).

Landscape visualisation tool

A suite of statewide products (GIS layers) of the ASDST has been developed to support regional-scale context setting and strategic planning. These layers provide users with landscape context about:

- the original (pre-colonisation) potential distribution of AHIMS features
- the current potential distribution of AHIMS features
- the accumulated impact on AHIMS features across the landscape
- the reliability and validation priority of the ASDST products
- a classification of the landscape into areas with similar AHIMS feature profiles.

Analytical tool

The analytical component of the ASDST generates information products (GIS layers, numerical reports and interpretive documents) that can be used to support regional planning for Aboriginal site heritage. The tool utilises modelled information about:

- accumulated impacts
- gap analysis
- representativeness.

In turn, this information can be used to report on issues, including:

- degree of loss of different AHIMS features in the landscape
- assessment priority and developing survey strategies
- conservation priority.

For the Upper Namoi Valley FMP, the ASDST was used as a context-setting tool to inform where there may be areas of potential flood-dependent sites and where there were significant knowledge gaps arising from gaps in the systematic survey for flood-dependent Aboriginal sites. The ASDST data products were used to inform the identification of priority conservation areas for Aboriginal values.

Appendix 12: Upper Namoi Valley FMP Management Zones map series

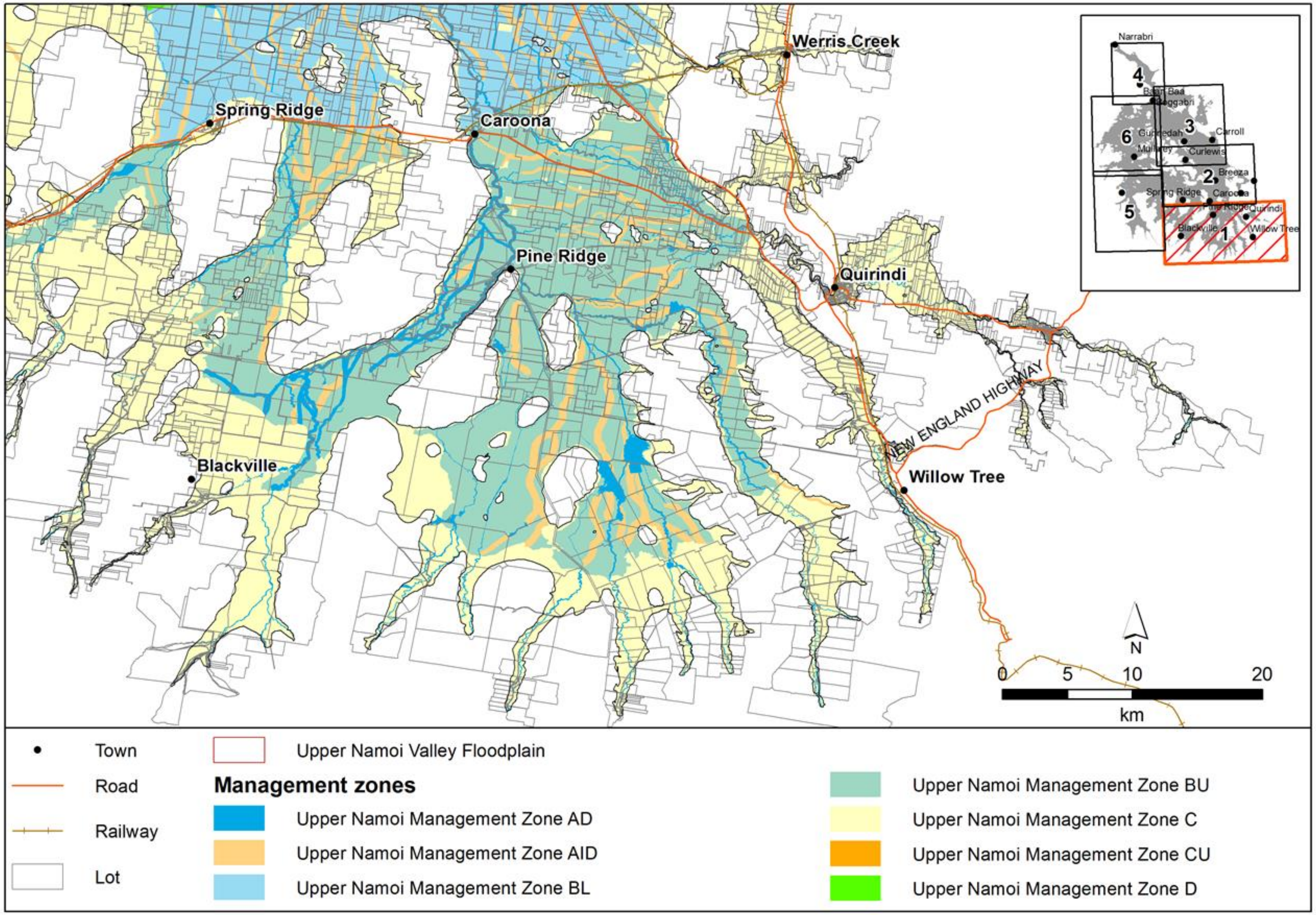

Figure A12 1: Management zones in the Upper Namoi Valley FMP—map one of six

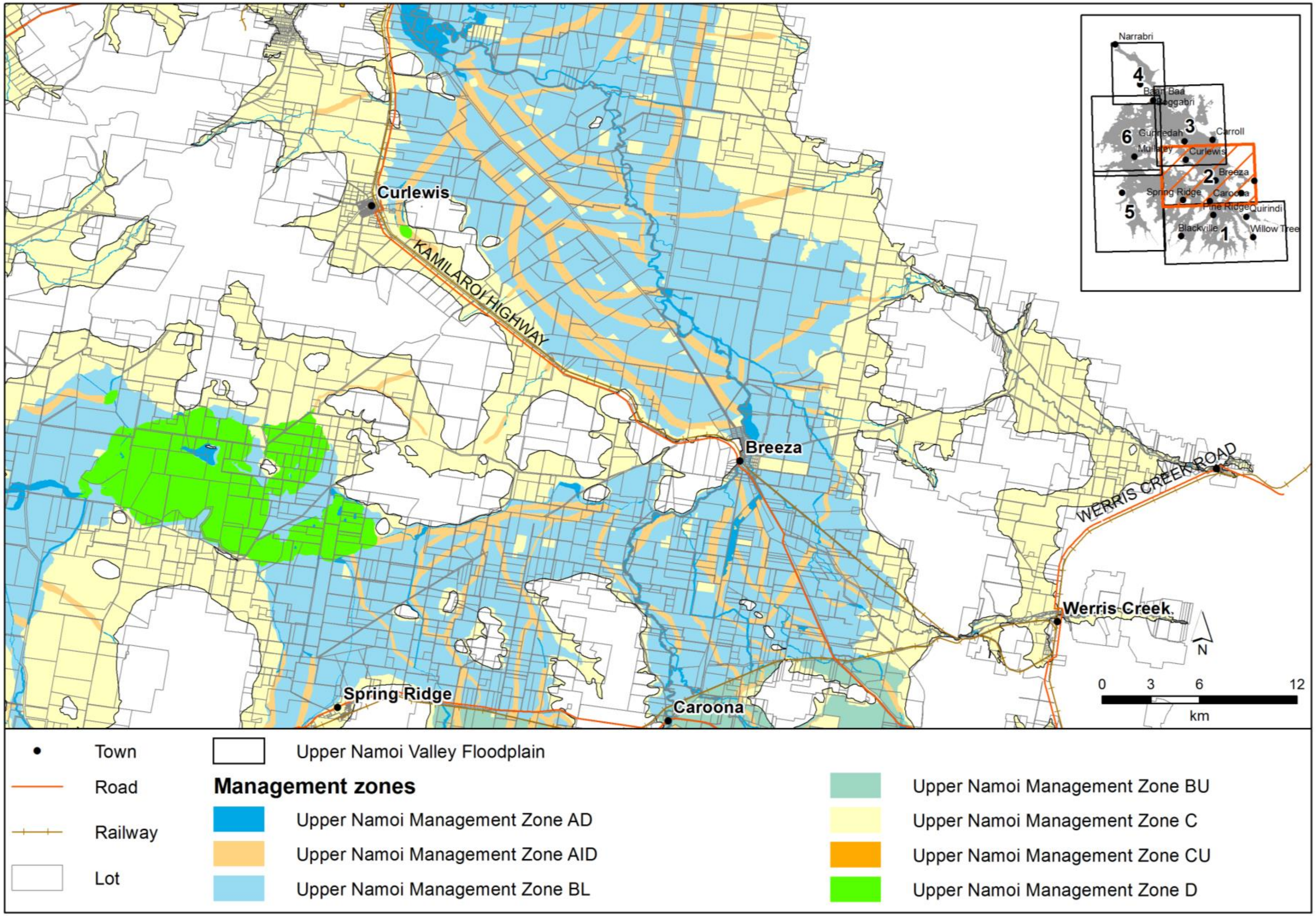

Figure A12 2: Management zones in the Upper Namoi Valley FMP—map two of six

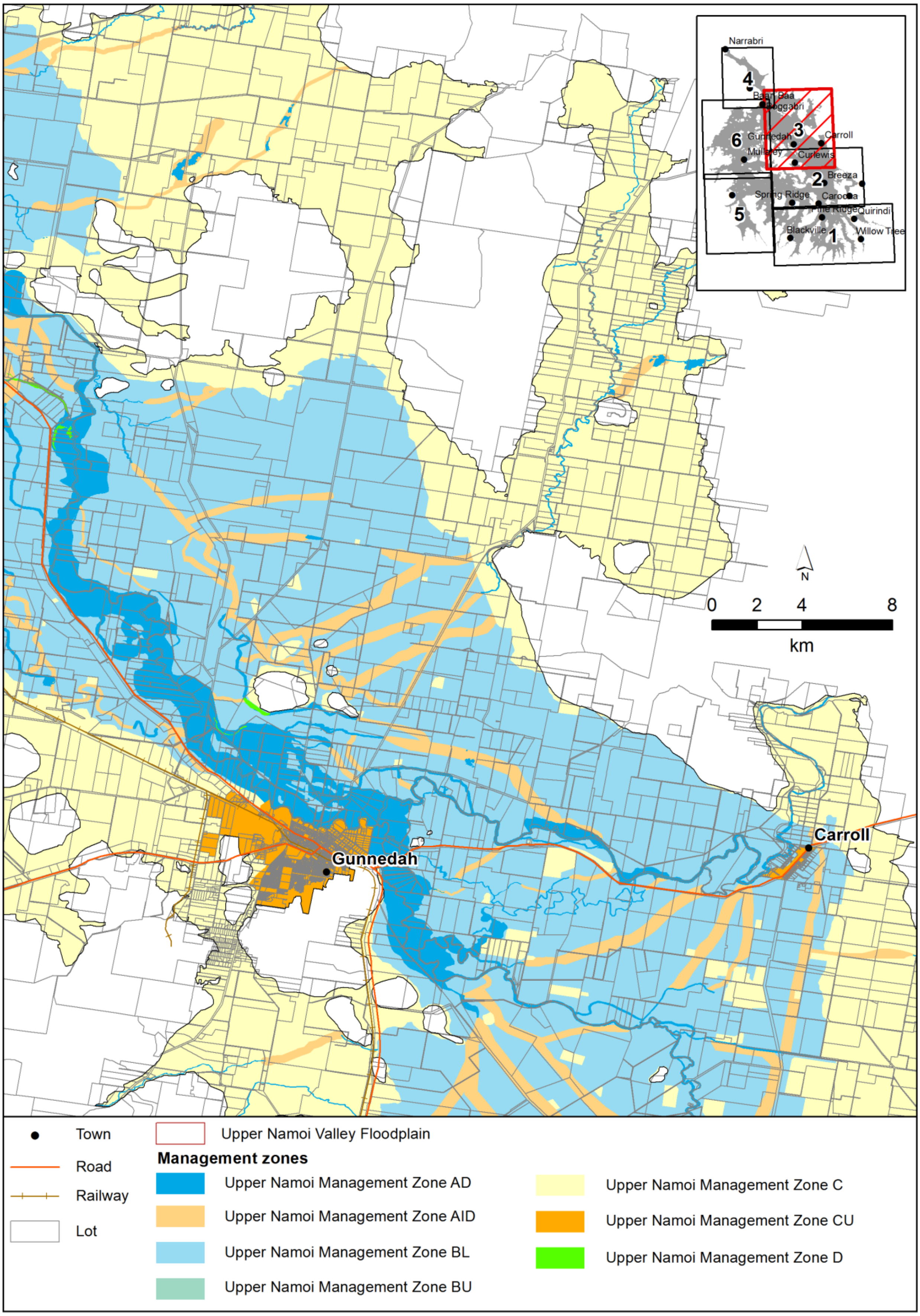

Figure A12 3: Management zones in the Upper Namoi Valley FMP—map three of six

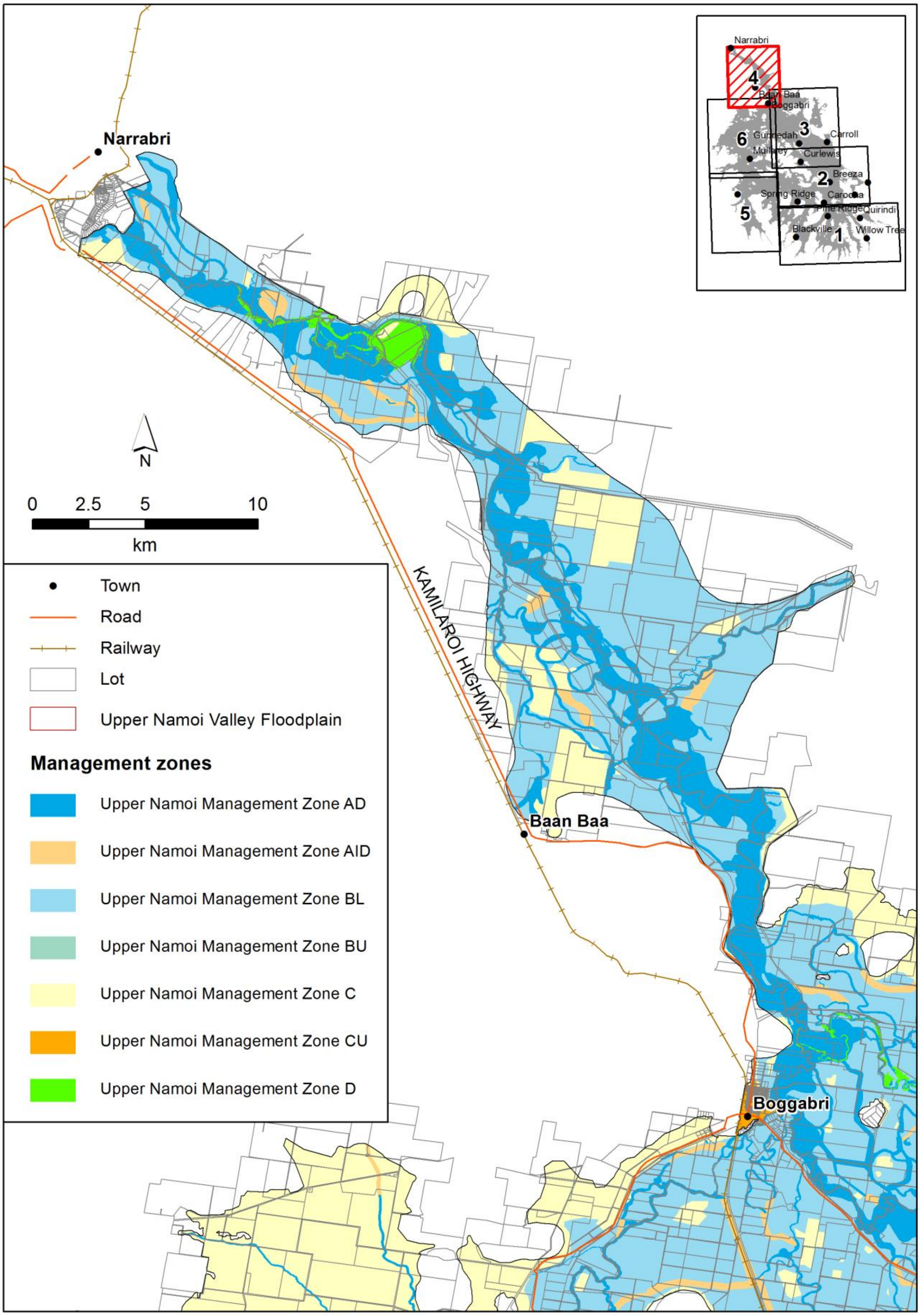

Figure A12 4: Management zones in the Upper Namoi Valley FMP—map four of six

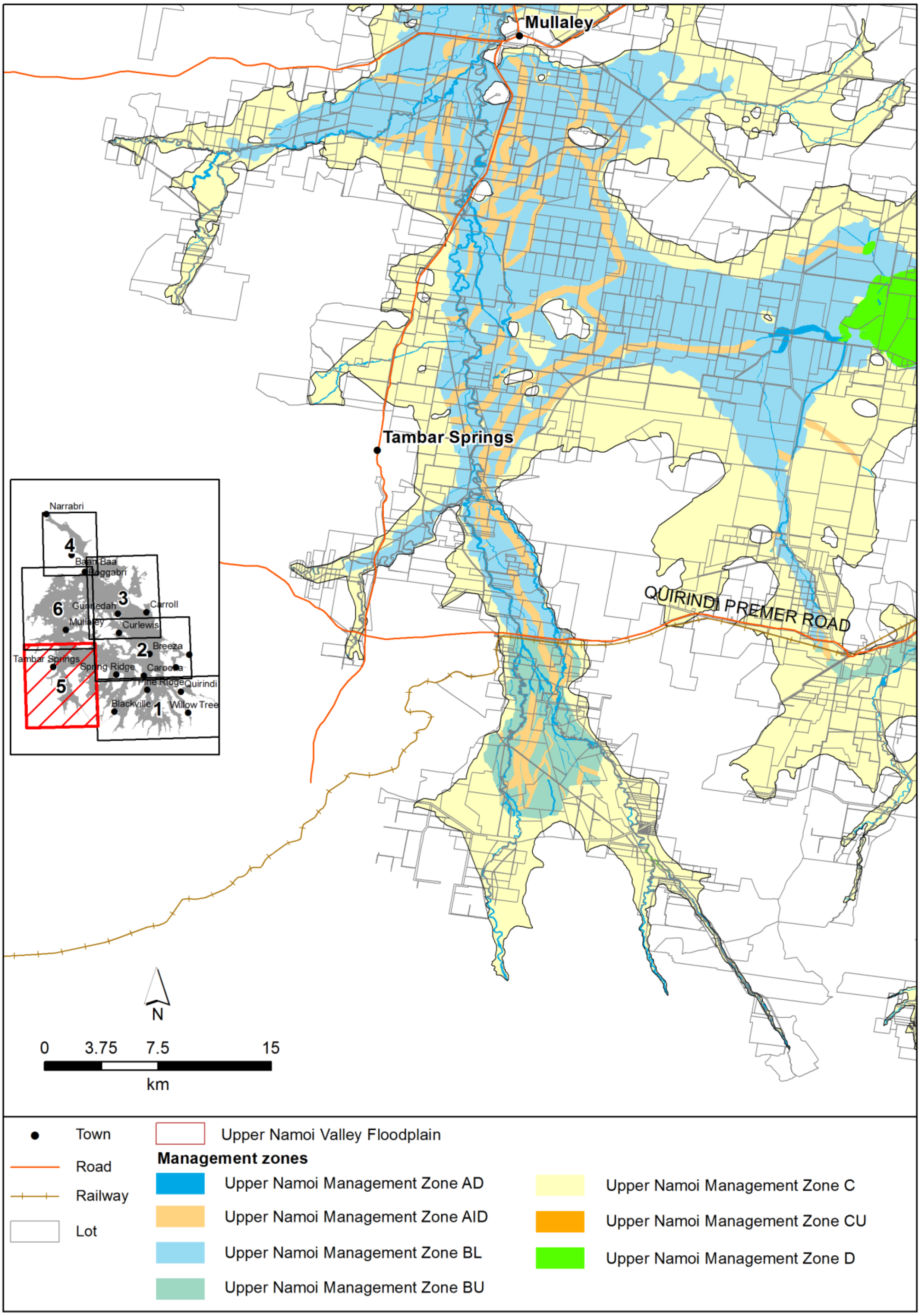

Figure A12 5 Management zones in the Upper Namoi Valley FMP—map five of six

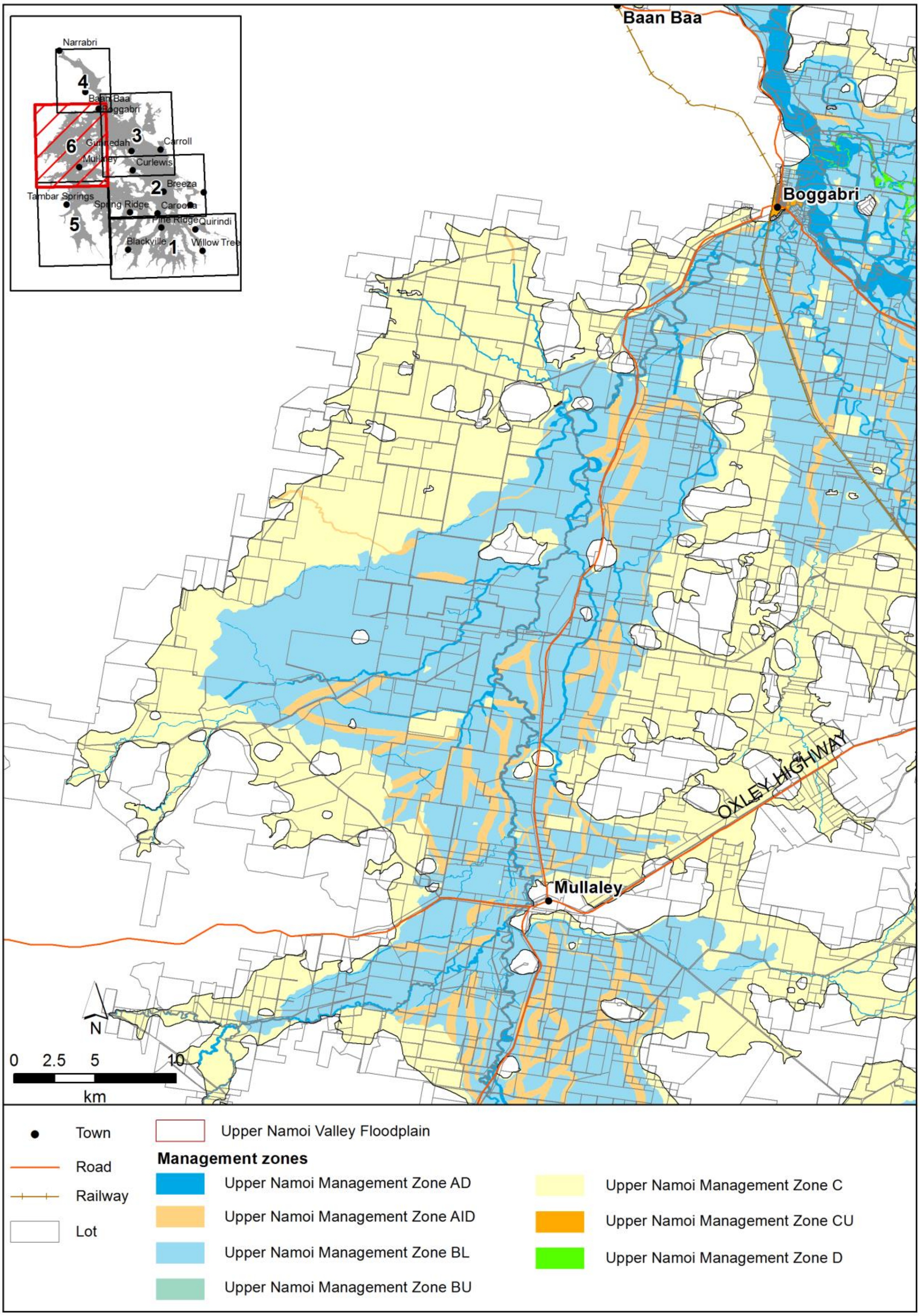

Figure A12 6: Management zones in the Upper Namoi Valley FMP—map six of six

Appendix 13: Description of Management Zone D Assets

Barbers Lagoon

Barbers Lagoon is a well-defined anabranch of the Namoi River which leaves the river approximately six kilometres south east of Boggabri and re-joins it approximately two kilometres north of Boggabri. The lagoon and adjacent floodplain support River Red Gum riparian tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion: PCT 78 and black tea-tree, river oak, wilga riparian low forest/shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion: PCT 112 (OEH 2015) which has remained intact, except for the last two or three kilometres of the lagoon where extensive clearing has taken place and grassland dominates.

Barbers Lagoon begins to flow when the Namoi River is roughly three-quarters bank-full. This corresponds to a discharge of about 11,400 ML/d in the Namoi River (3.2 m on the Gunnedah gauge—White and Keenan 1987). The lagoon also receives runoff from Bollol and Driggle Draggle Creeks. Bed level varies along the channel and after about three months of dry weather the lagoon dries to a series of waterholes, which may be replenished by runoff from the creeks. The lagoon will dry completely after about 18 months of dry weather (Keenan, pers. comm.)

Numerous shallow channels and depressions are associated with the lagoon, most being inundated when Barbers Lagoon reaches bank-full and above (Green and Dunkerley 1992). The lagoon has been studied under the Integrated Monitoring of Environmental Flows program (IMEF) and retains water for long periods fringed by warrego summer grass (*Paspalidium jubiflorum*) and water couch (*Paspalum distichum*), which are found on the water’s edge. The lagoon also has inflow tributaries so may receive runoff water from local rainfall as well as from Namoi River flows. At the downstream end, adjacent to a road reserve, are the deepest pools in the lagoon (Barma Water Resources et al. 2012). Aquatic macrophytes have not been recorded in the deeper water areas (W Mawhinney (NOW), 2011, pers.comm.).

Barbers Lagoon provides the functional capacity to act as an aquatic drought refuge and has a history of supporting a diversity/abundance of bird and fish populations (Thoms et al. 1999). The lagoon may support a variety of waterbird species when conditions are favourable, including Australian pelican (*Pelecanus conspicillatus*), white-faced heron (*Egretta novaehollandiae*) and the yellow-billed spoonbill (*Platalea flavipes*) (OEH 2017).

Native fish species recorded in Barbers Lagoon include spangled perch (*Leiopotherapon unicolor*) and bony herring (*Nematalosa erebi*) (NSW Department of Primary Industries 2013).

Broadwater Lagoon

Broadwater Lagoon is a large shallow ‘u’-shaped lagoon located on the northern side of the Namoi River with shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains: PCT 53 surrounded by river red gum riparian tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion: PCT 78 (OEH 2015, Green and Dunkerley 1992).

The lagoon provides the functional capacity to act as an aquatic drought refuge for a range of aquatic biota, including the eastern snake-necked turtle (*Chelodina longicollis*), and it may support a diversity or abundance of frog species, including the barking marsh frog (*Limnodynastes fletcheri*), broad-palmed frog (*Litoria latopalmata*) and the Peron’s tree frog (*Litoria peronii*) (OEH 2017). The lagoon supports a diversity of waterbird species when conditions are favourable. A total of 21 waterbird species have been recorded at Broadwater Lagoon, including the Latham’s snipe (*Gallinago hardwickii*), which is listed under the Japan-Australia Migratory Bird Agreement (JAMBA) and the Korea-Australia Migratory Bird Agreement (ROKAMBA), and the grey teal (*Anas gracilis*), pacific black duck (*Anas superciliosa*), Australasian darter (*Anhinga novaehollandiae*), eastern great egret (*Ardea modesta*), white-necked heron (*Ardea pacifica*), hardhead (*Aythya australis*), Australian wood duck (*Chenonetta jubata*), black swan (*Cygnus atratus*), plumed whistling-duck (*Dendrocygna eytoni*), white-faced heron (*Egretta novaehollandiae*), Eurasian coot (*Fulica atra*), dusky moorhen (*Gallinula tenebrosa*), black-winged stilt (*Himantopus himantopus*), pink-eared duck (*Malacorhynchus membranaceus*), little pied cormorant (*Microcarbo melanoleucos*), nankeen night heron

(*Nycticorax caledonicus*), glossy ibis (*Plegadis falcinellus*), hoary-headed grebe (*Poliocephalus poliocephalus*), Australasian grebe (*Tachybaptus novaehollandiae*) and the straw-necked ibis (*Threskiornis spinicollis*) (OEH 2017).

Bundella Lagoon

Bundella Lagoon is an open-water lagoon along Bundella Creek, fringed with flood-dependent vegetation (OEH 2015), including river oak, rough-barked apple, red gum, box riparian tall woodland (wetland) of the Brigalow Belt South and Nandewar Bioregions (PCT 84). The Bundella Lagoon provides the functional capacity to act as an aquatic drought refuge.

Curlewis Swamp

Curlewis Swamp is located in a large, flat, open depression confined between footslopes of Long Mountain and Mill Ridge (OEH 2012). It is a relatively undisturbed large wetland dominated by *Juncus* spp. and *Eleocharis* spp. (Green and Dunkerley 1992) and nardoo (*Marsilea drummondii*) (Namoi CMA 2008). The swamp is also made up of the following vegetation (OEH 2015):

- shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains, PCT: 53
- water couch marsh grassland wetland of frequently flooded inland watercourses, PCT: 204.

The swamp is fringed by river red gum (river red gum riparian tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion; PCT 78 (OEH 2015; Namoi CMA 2008).

Curlewis Swamp is filled only by local runoff. North of the swamp is a broad overflow area where water spills out of the swamp and flows through the Curlewis Town Common. Here the vegetation is dominated by sparse river red gum, lignum and grasses (Green and Dunkerley 1992). The swamp is subject to inundation both from downslope inflows and from floods extending upslope from the Liverpool Plains. The swamp is subject to flooding from Watermark Gully and minor streams draining Long Mountain. This area may also be occasionally backfilled by extensive flooding of the Mooki River (OEH 2012).

Goran Swamp

Goran Swamp is an inland floodplain lake (Kingsford et al. 2004) approximately two kilometres north-west of Lake Goran, surrounded by cropping land.

Gulligal Lagoon

Gulligal Lagoon is a large open-water lagoon fringed with river red gum riparian tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion: PCT 78 (OEH 2015).

The large wetlands contain virtually permanent water and have not completely dried for at least 17 years (Keenan, pers. comm.). The lagoon is four kilometres long and is narrow and deep with river red gum on the banks but no other fringing aquatic species. The southern bank is Crown Reserve (Travelling Stock Reserve), while the northern bank is freehold, and both sides appear to be subject to grazing pressure.

Gulligal Lagoon would probably act as a drought refuge for wildlife when other lagoons in the area were drying. When visited in January 1991, a flock of maned ducks were the only species using the lagoon as other shallower wetlands along the river were inundated at this time (Green and Dunkerley 1992). European carp and some other small fish (possibly mosquito fish) were observed in the water. The lagoon is used for public recreation—duck shooting, yabbying and canoeing—and provides water for irrigation and domestic pumping (Keenan, pers. comm.).

The lagoon provides important habitat for native fish species, including olive perchlet (*Ambassis agassizii*). It acts as a drought refuge in the mid-Namoi region and was restocked with breeding pairs of purple spotted gudgeon in late 2009 as part of the Namoi Demonstration Reach–Namoi Aquatic Habitat Initiative project and the Wetlands on Farms program (DPI 2009; Department of the Environment 2015). Gulligal Lagoon has a history of supporting a diversity/abundance of bird and fish populations (Thoms et al. 1999), including six species of native fish: spangled perch (*Leiopotherapon unicolor*), un-specked hardyhead (*Craterocephalus stercusmuscarum fulvus*), Australian smelt (*Retropinna semoni*), Murray–Darling rainbowfish (*Melanotaenia fluviatilis*), bony herring (*Nematalosa erebi*) and carp gudgeon (*Hypseleotris* spp.) (NSW Department of Primary Industries 2013).

The lagoon is inundated during medium-sized floods and begins to fill at a discharge of approximately 38,200 ML/d (6.8 m on Gunnedah gauge). Water begins to spill out over the road at approximately 230,300 ML/d (8.5m) (Keenan, pers. comm.). The lagoon is connected to the Namoi River and fills as a result of flooding, with Collygra Creek and Deadmans Gully as important contributors. The lagoon has been known to fill when the Namoi River at Gunnedah is at five metres, a height at which most of the river does not break its banks (Barma Water Resources et al. 2012).

Gunnible Lagoon

Gunnible Lagoon is an open-water lagoon supporting shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains: PCT 53 (OEH 2015). The lagoon is bordered by cultivated fields and has limited fringing vegetation.

The lagoon has the functional capacity to act as an aquatic drought refuge and has a history of supporting a diversity/abundance of bird and fish populations (Thoms et al. 1999). When visited it was being used by large numbers of waterbirds, which were feeding in the shallow water around the margins of the lagoon. Species present included black swans (*Cygnus atratus*), straw-necked ibis (*Threskiornis spinicollis* (200+)), Australasian grebes (*Tachybaptus novaehollandiae*), cormorants, spoonbills and large numbers of ducks (Green and Dunkerley 1992).

Lake Goran

Lake Goran is the largest natural wetland in the Namoi Valley and is a nationally significant wetland listed on the Australian Wetlands Database (Australian Government—Department of Environment 2015). The ephemeral nature of Lake Goran suggests that the wetland would be highly productive when filled after a dry period, providing a good supply of food for wetland biota, including waterbirds. The islands in the lake provide safe areas for nesting and roosting. Observations of waterbirds at Lake Goran suggest that the lake may be of similar character and importance for waterbirds as other large ephemeral basins such as Narran Lake and those associated with the Darling River. When very full, the lake may overflow eastwards into the Mooki River via Native Dog Gully; however, this happens only after a sequence of very wet years and is a rare event having occurred only three times this century (Green and Dunkerley 1992). Lake Goran is the terminus of a large internal drainage basin with a catchment of over 170,000 ha. When full, it has a surface area of over 5000 ha. The Lake Goran catchment does not regularly contribute any inflow to the Namoi River (CSIRO 2007) and only during large floods does the lake or catchment overflow into the Mooki River and the Namoi River flows (NOW 2013). It is recognised as an important habitat for waterbirds, particularly migratory birds protected under international migratory bird agreements (NOW 2013). A total of 51 waterbird species have been recorded, including 11 species listed under the Japan-Australia and China-Australia Migratory Bird Agreements (North West Local Land Service 2016). It is an important link in the wetlands of eastern Australia and provides refuge for migratory waterbirds that travel vast distances from the northern hemisphere. The lake provides habitat for freckled ducks, which are a specialist filter feeder and are listed as vulnerable in NSW under the Biodiversity Conservation Act 2016 (North West Local Land Service 2016). Lake Goran can act as a drought refuge when wetlands further inland are dry.

Lake Goran supports a range of different wetland plant species, including curly pondweed (*Potamogeton crispus*) and curled dock (*Rumex crispus*) (Namoi CMA 2008).

Landry Lagoon

Landry Lagoon is a long, narrow lagoon of about 20 ha with a dense fringe of river red gum (*Eucalyptus camaldulensis*) (Green and Dunkerley 1992). It receives local drainage from the east via Rangina Creek but may also receive water from the Namoi River (one kilometre away) during a flood. A discharge of approximately 76,000 ML/d (7.60 m on the Gunnedah gauge) in the Namoi River is required before water will enter the lagoon from the river (White and Keenan 1987).

Landry Lagoon provides the functional capacity to act as an aquatic drought refuge and may support waterbird species when conditions are favourable, including grey teal (*Anas gracilis*) and the Australasian darter (*Anhinga novaehollandiae*) (OEH 2017). Landry Lagoon has a history of supporting native fish species, including spangled perch (*Leiopotherapon unicolor*), golden perch (*Macquaria ambigua*), bony herring (*Nematalosa erebi*), Murray–Darling rainbowfish (*Melanotaenia fluviatilis*) and carp gudgeon (*Hypseleotris* spp.) (NSW Department of Primary Industries 2013).

Nicholsons Lagoon

Nicholsons Lagoon is a small ephemeral waterbody that becomes inundated during major flooding events (DNR 2006a). Nicholsons Lagoon is likely to provide the functional capacity to act as an aquatic drought refuge, providing habitat for a range of aquatic biota in times of drought. Mapped vegetation includes wetlands and marshes, Darling Riverine Plains, Brigalow Belt South and Nandewar: RVC 70 (Eco Logical Australia 2013).

Unnamed lagoon near Tarriaro

The unnamed lagoon near Tarriaro is an open-water lagoon with shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains: PCT 53 (OEH 2015) fringed with River Red Gum riparian tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion: PCT 78 adjacent to the Namoi River. The lagoon provides the functional capacity to act as an aquatic drought refuge and may support a diversity or abundance of waterbird and frog species. A total of eight species of frog have been recorded in the unnamed lagoon near Tarriaro, including the eastern sign-bearing froglet (*Crinia parinsignifera*), long-thumbed frog (*Limnodynastes fletcheri*), spotted grass frog (*Limnodynastes tasmaniensis*), green tree frog (*Litoria caerulea*), broad-palmed frog (*Litoria latopalmata*), peron’s tree frog (*Litoria peronii*), desert tree frog (*Litoria rubella*) and the ornate burrowing frog (*Platyplectrum ornatum*) (OEH 2017).

Appendix 14: Socio-economic profile

The water management principles of the WM Act require that planning on floodplains considers the socio-economic impacts of flood work management strategies to maximise the social and economic benefits to the community; to avoid and minimise the impacts of flood works on other water users; and to minimise the existing and future flood risk to human life and property arising from occupation on floodplains.

The Upper Namoi Valley FMP will contain management zones and rules that provide an equitable and consistent approach to controlling development on the floodplain. The management zones and rules will be designed to minimise the impact that flood work development may have on neighbouring properties, which will help to minimise the risk to life and property from the effects of flooding.

A socio-economic profile of the floodplain area is required so that the social and economic impact of development controls in the floodplain and flood risk to life and property from the effects of flooding can be effectively considered. In addition, it is important that before options about future water resource management can be developed, the floodplain area is understood and the ability of the community to absorb change is appreciated.

The focus of the profile of socio-economic factors is to assemble existing key socio-economic data, which will provide a general picture of the catchment in terms of its socio-demographic and economic structures. Developing the profile, or ‘snapshot’, involves documenting the biophysical, social and economic conditions of the valley to help understand the floodplain. The main types of socio-economic information that inform the baseline profile include:

- geographies that are relevant to the socio-economic discussion of the floodplain
- demographic profiles
- household income statistics
- employment statistics
- economic wellbeing indicators
- agricultural production statistics.

Information from this profile will inform the development of management zones and rules for the floodplain (steps 7 and 8). Information from this profile will also be drawn upon in the socio-economic impact analysis (Step 10) that identifies and considers the potential socio-economic impacts associated with the implementation of the FMP. The socio-economic impact analysis will be undertaken in coordination with the development of management zones and rules for the Upper Namoi Valley Floodplain.

Study area geography

Three geographies that are relevant to the socio-economic discussion of water management within the Upper Namoi Valley Floodplain were examined. These geographies are described in detail below.

Upper Namoi floodplain Economy

The Upper Namoi Floodplain Economy (Figure A13 1) area includes the Upper Namoi Rural and Urban Floodplains as well as the adjacent areas in the Gwydir and Castlereagh catchments that engage with the economy of the region. This area (1,565,100 ha) extends from the Liverpool Range in the south east to Narrabri in the north west. Most goods and services consumed in the Upper Namoi Floodplain Economy area are sourced from the regional centres of Gunnedah, Narrabri, Quirindi and the small townships in this area.

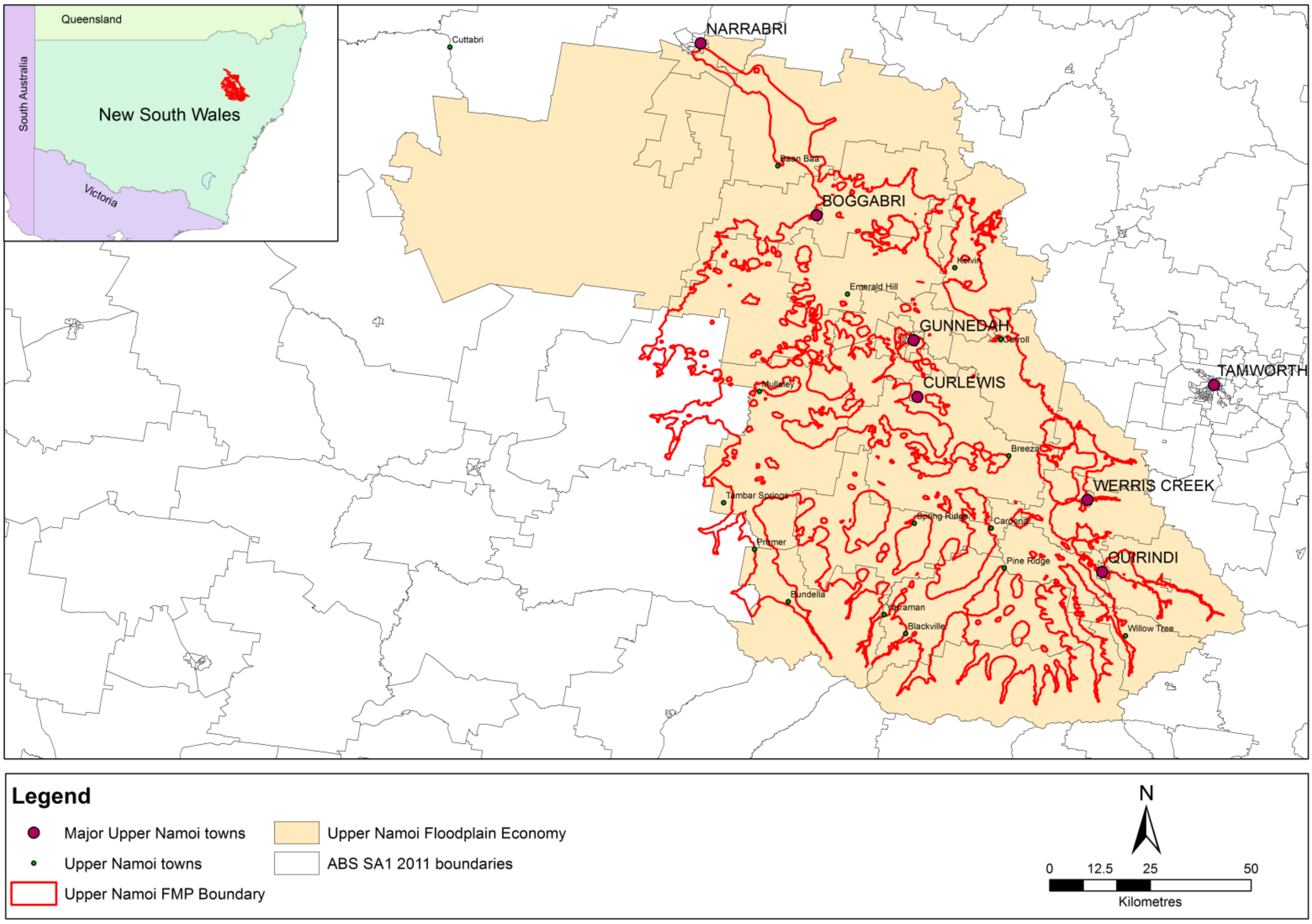

Figure A13 1: Upper Namoi Valley Floodplain and the Upper Namoi Floodplain Economy area (data source: ABS 2011b)

Upper Namoi Rural Floodplain

The Upper Namoi Rural Floodplain (Figure A13 1) is the rural area downstream of the Liverpool Range to the Namoi River at Narrabri. The Upper Namoi Valley Floodplain narrows from Boggabri to Narrabri following the Namoi River. This area of 702,500 ha is the Upper Namoi Rural Floodplain and will be directly impacted by the Upper Namoi Valley FMP. The community residents who live and work in this area are predominantly agriculture-based, but the community does include people who live in small rural towns. There are limited community services and infrastructure in this area; most of the required farm inputs and human services are provided from the local towns and the three regional centres.

Upper Namoi Urban Floodplain

The regional centre of Gunnedah, part of the Narrabri and Quirindi regional centres and the townships of Boggabri, Carroll, Curlewis, Caroona and Werris Creek constitute the third area, the Upper Namoi Urban Floodplain (Figure A13 2). While this area is situated on or adjacent to the floodplain and is affected by flood water, flood water management is provided under the *Local Government Act 1993*. The communities that live in these towns are reliant upon the surrounding rural floodplain areas (e.g. as a source of employment).

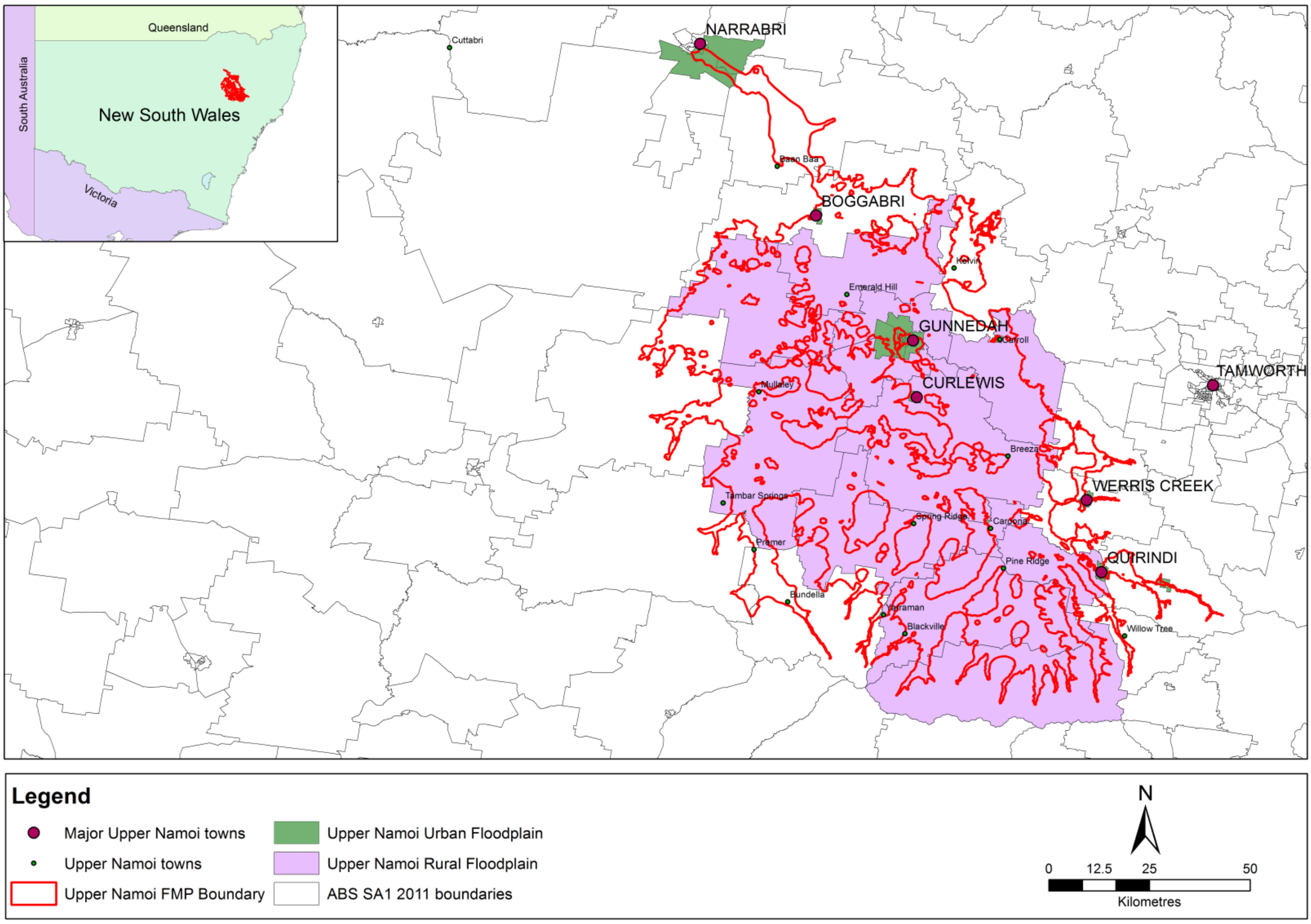

Figure A13 2: Upper Namoi Valley Floodplain and the Upper Namoi Rural Floodplain area (data source: ABS 2011b)

Data sources

Regional population trends for the Narrabri, Gunnedah and Liverpool Plains Local Government Areas have been drawn from the ABS Regional Population Growth 2013 data (ABS 2013). These population trends are presented in Figure A13 4.

Data for the Upper Namoi Floodplain Economy, the Upper Namoi Rural Floodplain and the Upper Namoi Urban Floodplain is drawn from the ABS Census of Population and Housing 2011 SA1 level data (ABS 2011b). This includes data on population, including Indigenous community, sex and age ratios; household weekly incomes; and employment, labour participation rates and employment by industry sector. The SA1 areas are the smallest unit for release of census data. The boundaries closely align with the boundary of the Upper Namoi Floodplain Economy area and of the Rural and Urban Floodplain areas. The SA1 areas referenced to calculate values for the Upper Namoi Rural Floodplain are presented in Figure A13 2

Information on the relative socio-economic advantage and disadvantage for the SA1 areas of the floodplain area is drawn from the ABS Census of Population and Housing 2011 Socio-economic Indexes for Areas (ABS 2011c). The Index of Relative Socio-economic Advantage and Disadvantage scores are mapped and presented in Figure A13 10.

Agricultural production derived from the floodplain is a significant component of the floodplain economy. The ABS Agricultural Census 2011 (ABS 2011a) provides comprehensive data on both dry land and irrigated agricultural production at the SA2 level for six regions that partially cover the Upper Namoi floodplain agricultural region: Gunnedah, Gunnedah Region, Narrabri, Narrabri Region, Quirindi and Coonabarabran regions. SA2 areas represent a community that interacts socially and economically. The SA2 areas used to describe the agriculture of the Upper Namoi Valley FMP area are presented in Figure A13 3.

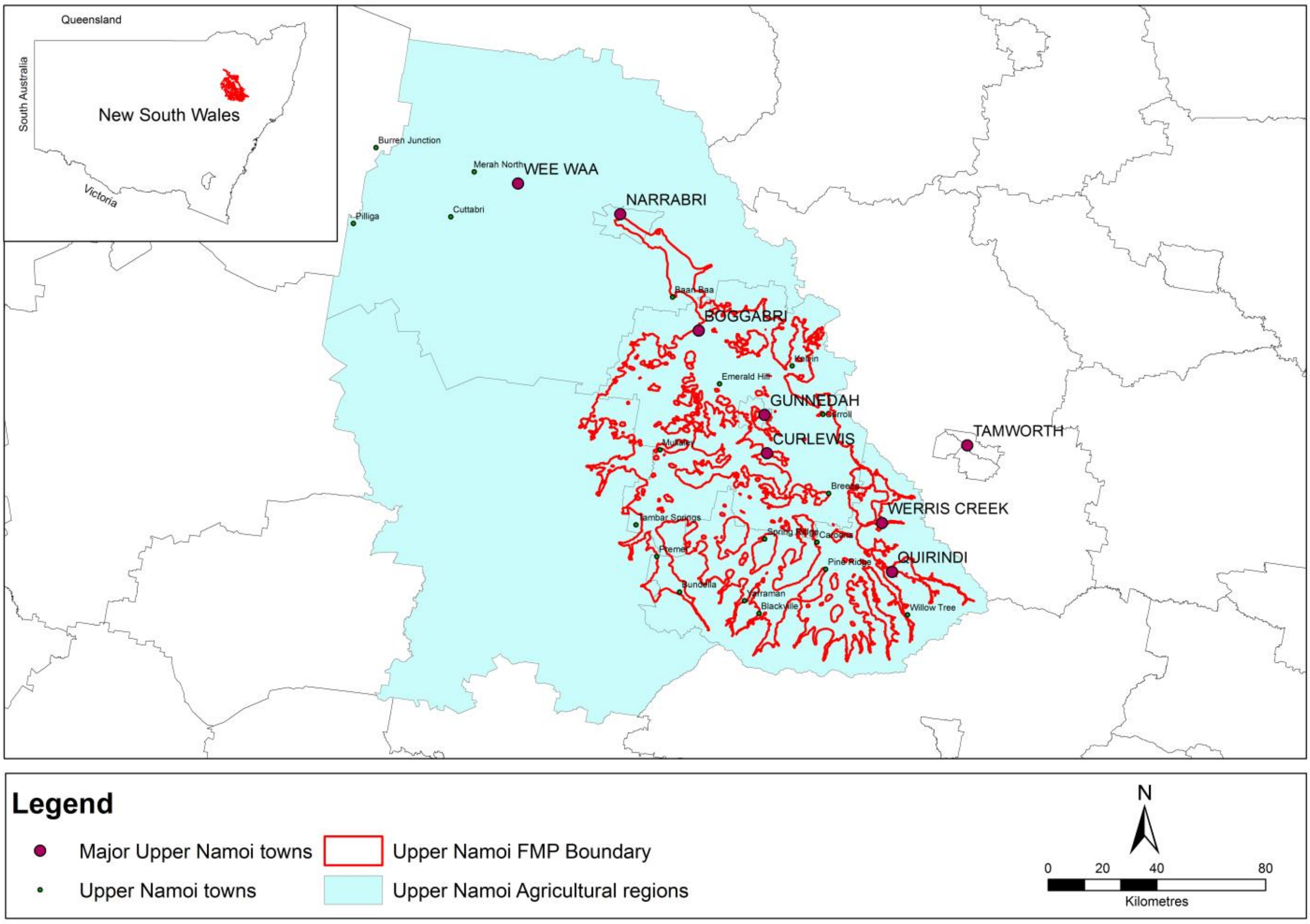

Figure A13 3: Upper Namoi Valley Floodplain and the Upper Namoi Agricultural region (data source: ABS 2011b)

Demographic profiles

Regional populations have stabilised over recent years, with the estimated population for the Gunnedah and Narrabri Local Government Areas recovering slightly. Regional population trends since 2004 for the Narrabri, Gunnedah and Liverpool Plains Local Government Areas are presented in Figure A13 4.

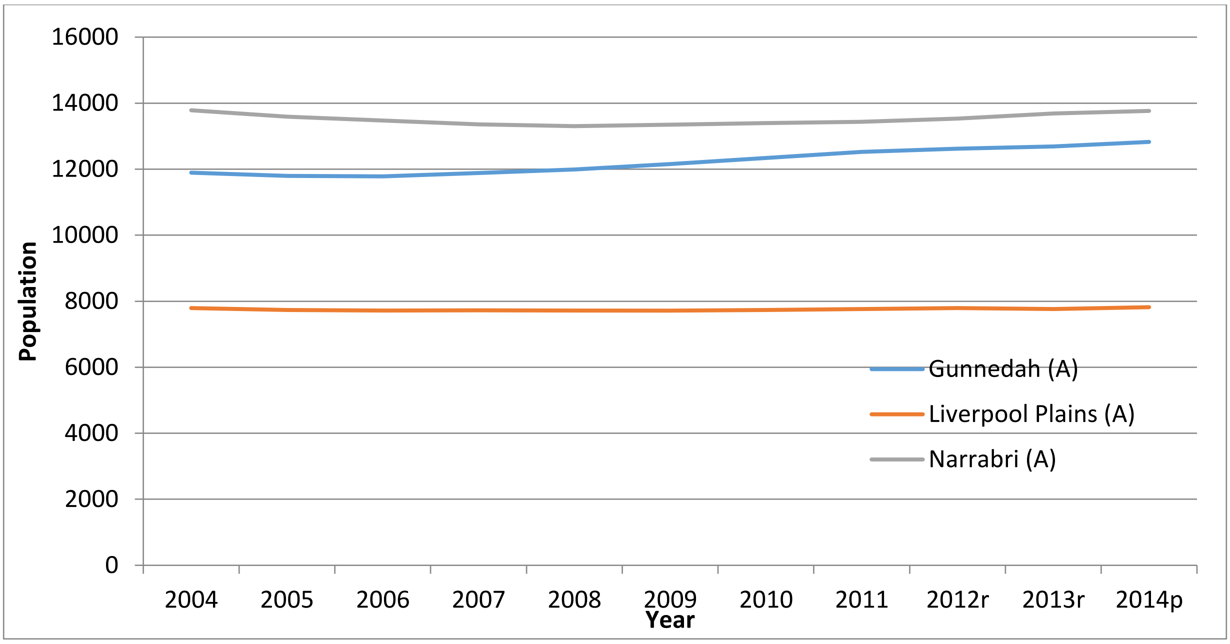

Figure A13 4: Regional population by Local Government Area 2004–14 (data source: ABS 2016)

Upper Namoi Floodplain Economy

The population of the Upper Namoi Floodplain Economy area is estimated to be 23,630 people, of whom 71% live in towns. The major towns of this area are: Gunnedah, Narrabri and Quirindi. The total of the overall Upper Namoi Floodplain Economy population does not equal the total of the Upper Namoi Rural and Upper Namoi Urban Floodplain populations as the boundary of the Upper Namoi Floodplain Economy area includes areas in addition to the rural and urban floodplain areas.

The Indigenous community makes up 10.2% of the Upper Namoi Floodplain Economy population, which is substantially higher than the NSW state proportion of 2.5%.

There is almost the same number of males and females living in the Upper Namoi Floodplain Economy area; the sex ratio (the number of males per 100 females) is 101.2.

The dependency ratio of the Upper Namoi Floodplain Economy, a measure of the number of the population that is not of working age per 100 people of working age (aged 15–64), is 64. This dependency ratio should be read with the understanding that there are a considerable number of farmers over the age of 64 years working in the agricultural sector.

The age by sex distribution of this community reveals an under-representation in the 20–49 age groups, as compared to the under-20 and over-49 age groups and as compared to NSW. This under-representation is demonstrated to a greater extent in the rural floodplain.

The age by sex distribution of NSW is presented in Figure A13 5.The age by sex distribution of the Upper Namoi Floodplain Economy is presented in Figure A13 6.

The Upper Namoi Rural Floodplain

The estimated population of the Upper Namoi Rural Floodplain is 3,630 people, calculated on the area of 7,025 square kilometres. The population density of the rural floodplain is estimated to be 33 people per 100 square kilometres.

The Indigenous proportion of this community is 4.3%, which is almost twice that of the NSW community at 2.5%. There are more males than females in this population, with the sex ratio of 112.3 considerably higher than the NSW state sex ratio of 97.2. The dependency ratio of the Upper Namoi Rural Floodplain is 53. However, as discussed regarding the dependency ratio calculated for the Upper Namoi Floodplain Economy, a considerable number of farmers over the age of 64 years are working in the agricultural sector.

The population pyramid (age by sex) indicates a lower than expected proportion of the population in the 20–49 age groups (Figure A13 5). This is likely to be related to the inaccessibility of secondary and tertiary education opportunities, and associated employment, in this area. The age by sex distribution of the Upper Namoi Rural Floodplain is presented in **Error! Reference source not found.**.

The Upper Namoi Urban Floodplain

The Upper Namoi Urban Floodplain population of 16,670 people includes the urban centres of Gunnedah (with a population of 8,750), part of Narrabri (1,950) and Quirindi (2,580) (ABS 2011b).

The Indigenous community constitutes 12.7% of the community, which is substantially above the rural floodplain proportion of 4.3% and the NSW state proportion of 2.5%. The sex ratio of the Upper Namoi Urban Floodplains is 97.2, which is lower than the rural floodplain and the same as the NSW state sex ratio. The dependency ratio is 69, higher than the adjacent rural floodplain community dependency ratio of 53 and higher than the NSW state dependency ratio of 52. The age by sex distribution of the Upper Namoi Urban Floodplain is presented in Figure A13 6. It is interesting to note that the urban community does not reflect the same degree of under-representation in the 20–49 age groups as observed in the rural community.

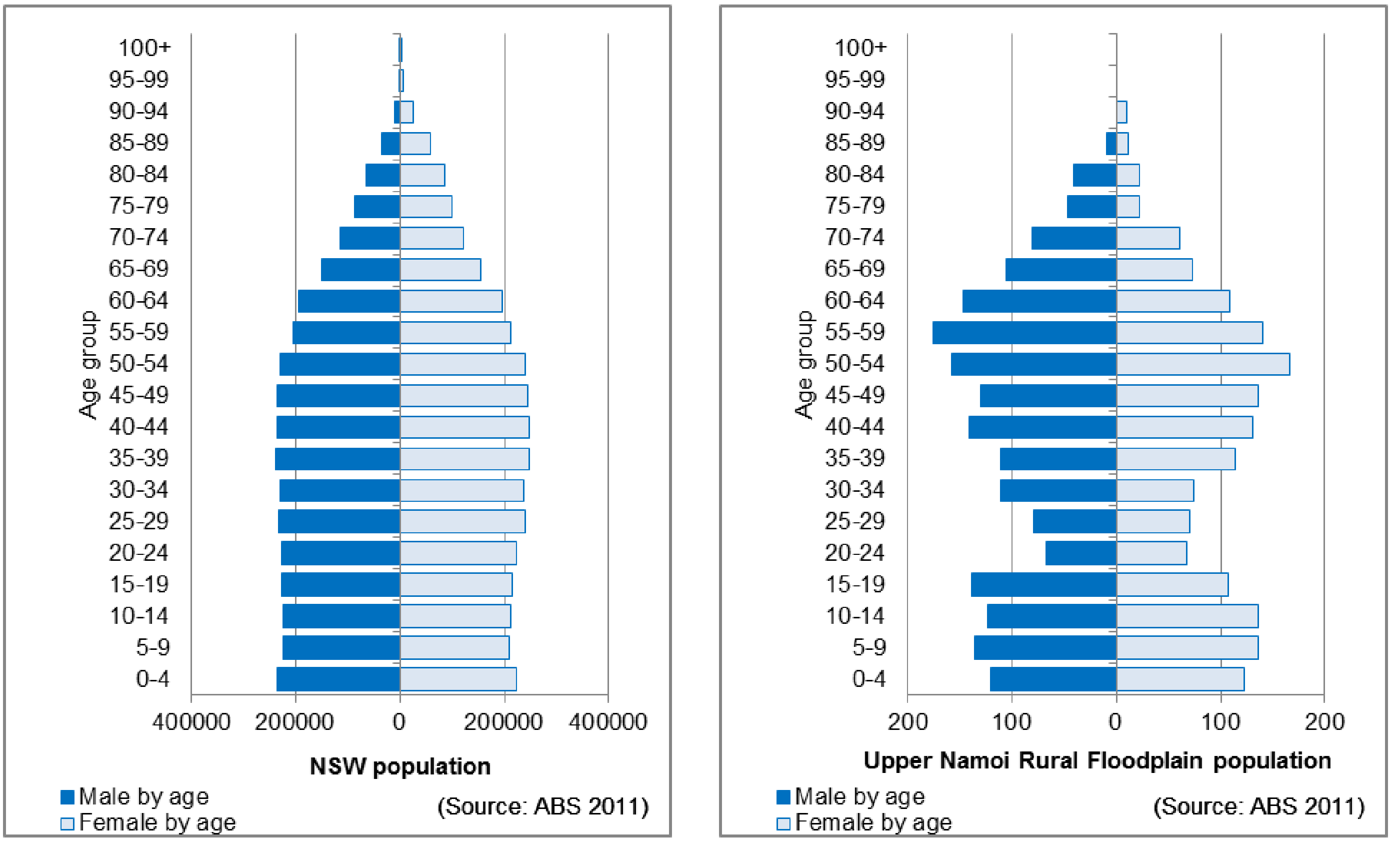

Figure A13 5: NSW population by age group and sex 2011 (left) and Upper Namoi Rural Floodplain population by age group and sex 2011 (right)

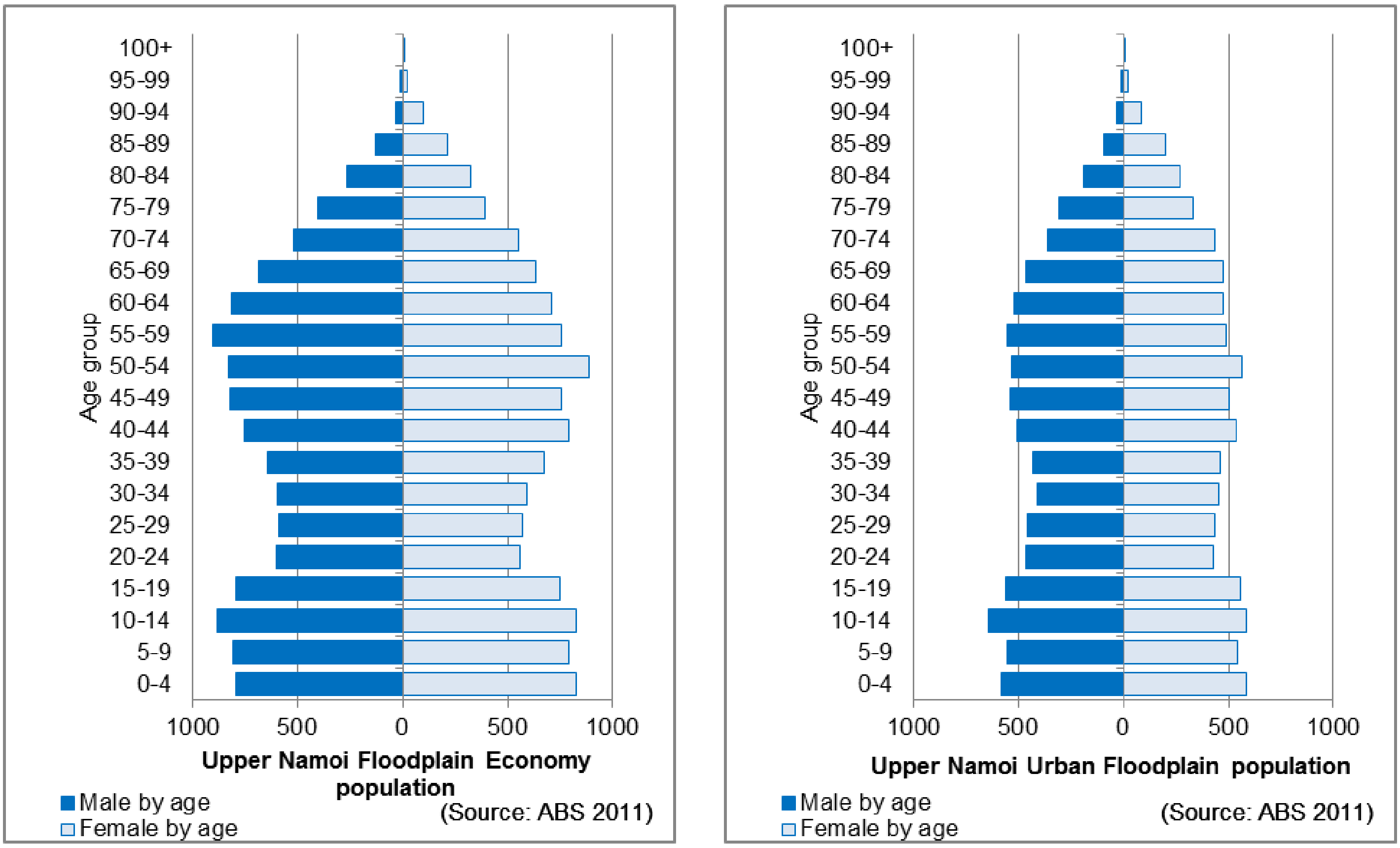

Figure A13 6: Upper Namoi Floodplain Economy population by age group and sex 2011 (left) and Upper Namoi Urban Floodplain population by age group and sex 2011 (right)

Household income

Upper Namoi Floodplain Economy

The weekly household income in the Upper Namoi Floodplain Economy closely correlates with that of the Upper Namoi Urban Floodplain, with 71% of the population living in the townships. The proportion of low-income households in the Upper Namoi Floodplain Economy, at 32%, is greater than the NSW state proportion of 23%. The medium-income proportion of 57% in the Upper Namoi Floodplain Economy is marginally greater than the NSW state proportion of 56%. Consequently, the high-income household proportion of 11% is lower than the NSW state proportion of 21%.

The weekly household income proportions for NSW, and for the Upper Namoi Floodplain Economy, Rural Floodplain and Urban Floodplain, are presented in Figure A13 7.

The Upper Namoi Rural Floodplain

The Upper Namoi Rural Floodplain households in 2011 are slightly less prosperous compared to their NSW state counterparts, with more households in the low-income category. The number of households with weekly incomes of $599 or below is 25%, which is just above the NSW state proportion of 23%. The rural floodplain proportion of households in the medium-income range ($600 to $2,499 per week) is 59%, just above the NSW state proportion of 56%. The high-income proportion of 16% is below the state proportion of 22%.

The Upper Namoi Urban Floodplain

The Upper Namoi Urban Floodplain community has a higher proportion of low-income (34%), the same proportion of medium-income (56%) and consequently a lower proportion (10%) of high-income households as the NSW state.

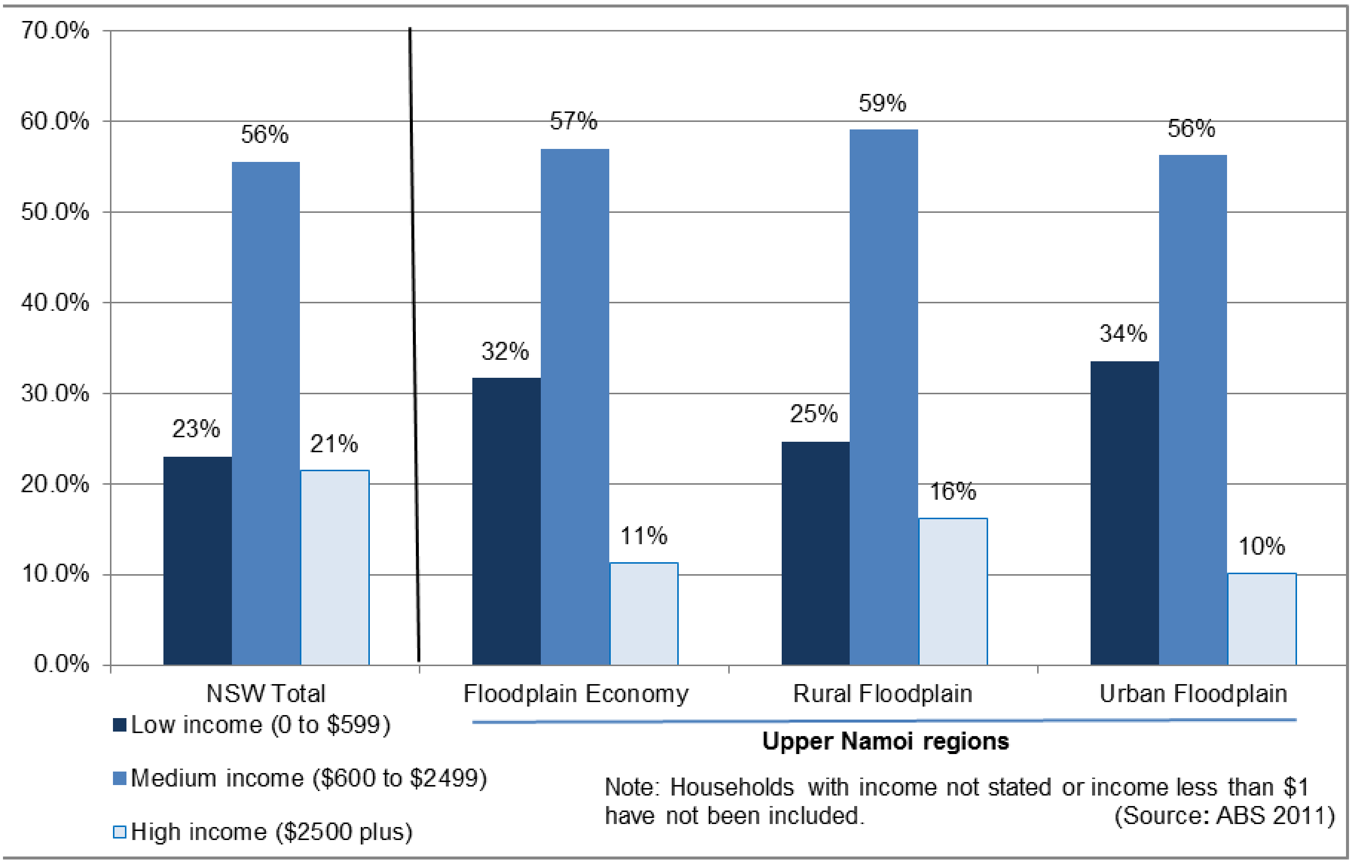

Figure A13 7: Distribution of households in low, medium and high-income categories (per cent)

Employment

Upper Namoi Floodplain Economy

The labour force of the Upper Namoi Floodplain Economy is 10,230 people. The number of people aged 15 years and above is 18,690. The labour force participation rate, which is the number of people in the labour force as a percentage of people aged 15 years and over, is 54.7% and is slightly lower than the NSW state participation rate of 56.2%.

Employment in the Upper Namoi Floodplain Economy is predominantly within the agriculture, forestry and fishing sector, with 19% of employment (1,980 people, with this number including a large agricultural area not on the rural floodplain). In contrast, the NSW state agricultural sector engages 2% of the workforce. There is a relatively even distribution of the remaining 81% of employment among the remaining sectors. The next most significant employment sectors are retail trade and healthcare and social assistance, each with 9% of employment. Employment by sector for the top 10 sectors in the Upper Namoi Floodplain Economy and for NSW are shown in Figure A13 8.

The Upper Namoi Rural Floodplain

The labour force of the Rural Floodplain is 1,910 people. The population aged 15 years and above is 2,860. The labour force participation rate is 66.7%, markedly higher than the NSW participation rate of 56.2%.

Employment in the Upper Namoi Rural Floodplain is dominated by the agriculture, forestry and fishing sector, with 51% of the workforce (970 people) working in the agricultural industry. This is in sharp contrast to the NSW state agricultural sector, which engages only 2% of the workforce. The next most significant employment sector of the Upper Namoi Rural Floodplain is education and training, constituting 7% of the workforce. Employment by sector for the top 10 sectors in the rural floodplain is presented in Figure A13 9.

The Upper Namoi Urban Floodplain

The labour force of the Urban Floodplain is 6,650 people. The population aged 15 years and above is 13,175. The labour force participation rate is 50.5%, lower than both the participation rate in the rural floodplain and the NSW average.

In contrast with the surrounding rural community, employment in the Upper Namoi Urban Floodplain is reasonably evenly distributed across sectors. A significant proportion of the workforce is employed in the service sectors. The retail trade sector is the most significant employer, with 12% of the workforce, closely followed by healthcare and social assistance (11%), and then by education and training and manufacturing with 8%. Agriculture, forestry and fishing has 6% of the workforce. Employment by sector, for the top 10 sectors in the urban floodplain, is presented in Figure A13 9.

Estimated employment of the Upper Namoi Valley FMP area

Given the location of the townships, it is likely that about half of the 410 Upper Namoi Urban Floodplain residents employed in the agricultural sector work in the adjacent rural floodplain, while the other half would be working in the areas of agriculture outside the floodplain area.

The estimated total employment in the agricultural sector potentially impacted by the Upper Namoi FMP is 1,170 people, counting the 970 agriculture workers from the rural floodplain and half of the 410 agriculture workers from the urban floodplain.

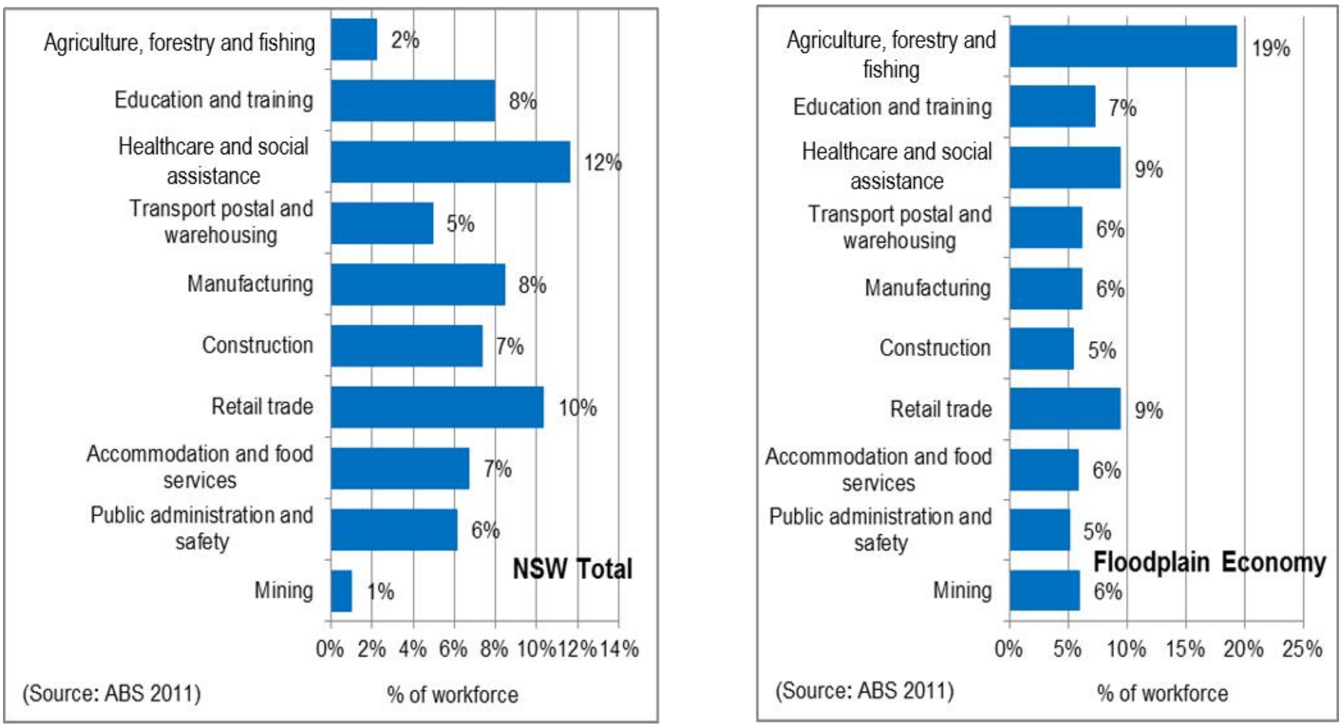

Figure A13 8: NSW employment by industry sector 2011 (left) and Upper Namoi Floodplain Economy industry sector 2011 (right)

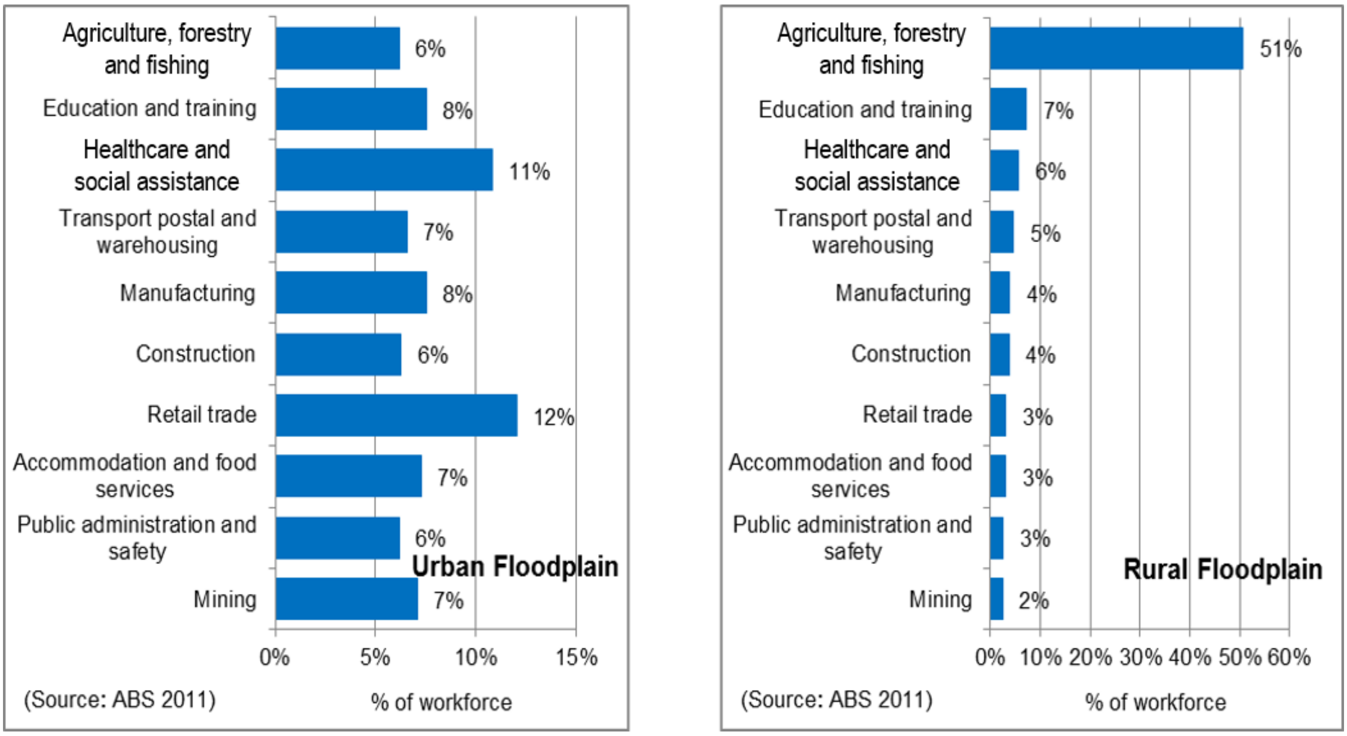

Figure A13 9: Upper Namoi Urban Floodplain employment by industry sector 2011 (left) and Upper Namoi Rural Floodplain employment by industry sector 2011 (right)

Economic wellbeing indicators

Socio-Economic Indexes for Areas (SEIFA) is a product developed by the ABS that ranks areas in Australia according to relative socio-economic advantage and disadvantage (ABS 2011c). The indexes are based on information from the five-yearly census. The index scores are on an arbitrary numerical scale; the scores do not represent some quantity of advantage or disadvantage. As measures of socio-economic level, the indexes are best interpreted as ordinal measures. They can be used to rank (order) areas and are also useful to understand the distribution of socio-economic conditions across different areas.

The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) ranks areas in terms of relative socio-economic advantage and disadvantage. The IRSAD summarises 25 variables that indicate either relative advantage or disadvantage. This index ranks areas on a continuum from most disadvantaged to most advantaged. An area with a high score on this index has a relatively high incidence of advantage and a relatively low incidence of disadvantage.

The IRSAD scores for the whole of the Local Government Areas of Narrabri, Gunnedah and Liverpool Plains are in the fourth, third and second decile of NSW, marginally to reasonably disadvantaged. The lowest SA1 area score is 638 (decile 1 in the state), which is the SA1 of Walhollow near Caroona. The highest-scoring area has a score of 1,072 (decile 8 in the state), which is the rural area north of Mullaley, west of Gunnedah (ABS 2011c). The range and distribution of the IRSAD scores for the floodplain area are presented in Figure A13 10. The dark green areas have a score that is among the lowest 10% of scores for the state, being the relatively more disadvantaged. The red areas are areas of advantage, while the yellow areas are relatively neither advantaged nor disadvantaged. The IRSAD scores for the smaller SA1 areas representing the townships of Gunnedah, Narrabri and Quirindi (Figure A13 10) are shaded green, indicating that they are relatively disadvantaged. The rural floodplain areas are generally shaded yellow to orange (deciles 5 to 8), indicating that they are relatively advantaged.

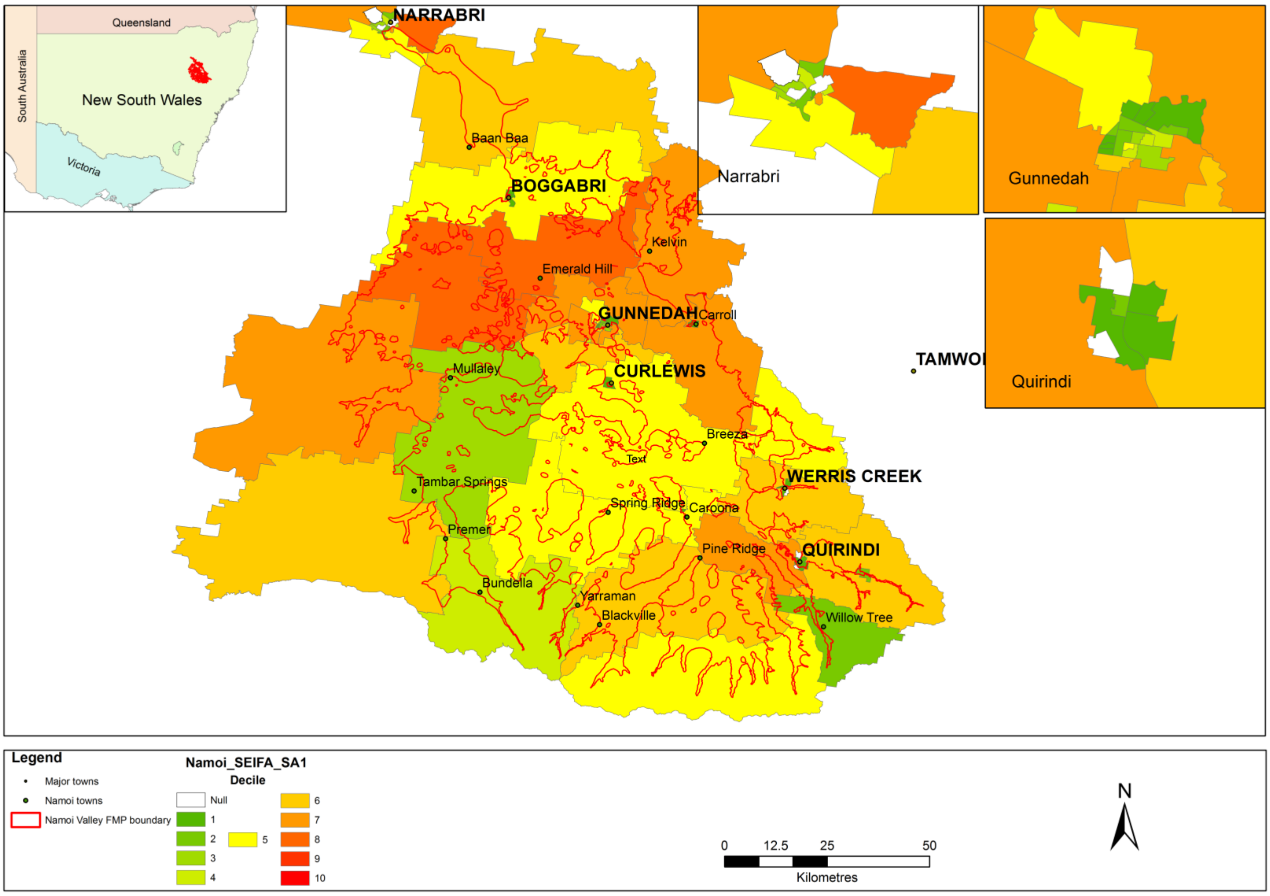

Figure A13 10: Index of Relative Socio-economic Advantage and Disadvantage, state decile

Agricultural production

Upper Namoi Floodplain Economy

The economy of the Upper Namoi Valley Floodplain is interwoven with the economy of the adjacent north-west community, drawing inputs from, passing outputs through and using services from the same business centres as the floodplain. It is appropriate therefore to consider the socio-economic profile of the wider Upper Namoi Valley Floodplain Economy.

Agricultural production is the significant production activity of the region's economy, occupying 93% of the farm holding area in the Upper Namoi Valley Floodplain. Agricultural production is predominantly cropping, which is dominated by cotton and to a lesser extent wheat. Irrigation on the Upper Namoi Valley Floodplain is dominated by irrigated cotton production. The regional economy is structured to process the inputs and outputs of these industries and provide the services they require. The performance of the regional economy responds in large part to the fortunes of the cotton and wheat industries.

The ABS Agricultural Census 2011 provides agricultural production statistics for the Gunnedah, Gunnedah Region, Narrabri, Narrabri Region, Quirindi and Coonabarabran regions that cover the majority of the Upper Namoi Valley Floodplain and the Upper Namoi Floodplain Economy area (ABS 2011a). The combined area of these six regions is distinct from the FMP area, as the combined area includes a substantial area of non-floodplain to the north, south and west of Narrabri, part of the Gwydir River Floodplain.

Upper Namoi Valley Floodplain: Agricultural production

In the agricultural region in which the Upper Namoi Valley Floodplain is located, broadacre cropping and livestock production are the predominant agricultural products. The value and area of holding of these products in the Upper Namoi Valley Floodplain has been estimated based on the following assumptions:

- cotton, wheat and livestock agricultural production and area of holding are evenly distributed throughout the regions
- the estimated areas of each ABS SA2 region within the Upper Namoi Valley FMP area are Gunnedah 61%, Gunnedah Region 62%, part of Narrabri 16%, Narrabri Region 2%, Quirindi 33% and Coonabarabran 3%;
- for each region, the value and area of agricultural production of individual crops and products within the Upper Namoi Valley Floodplain as a percentage of total production within these regions is proportionate to the estimated proportion of land area of the region within the Upper Namoi Valley Floodplain
- the estimates for the Upper Namoi Valley Floodplain are the sum of the proportion of the estimates for the Gunnedah, Gunnedah Region, part of Narrabri, Narrabri Region, Quirindi and Coonabarabran regions.

As agricultural production is not evenly distributed across the area of these regions, the values derived and presented below provide estimates (only) of the value of production and the area of holding in the Upper Namoi Valley Floodplain. Horticultural and pigs, goats and poultry production are not included in the estimated totals because their production is not conventionally undertaken in the floodplain area. The Gross Value of Agricultural Production (GVAP) in 2010–11 in the Upper Namoi Valley Floodplain, using a farm holding area of 659,300 ha, is estimated to be $185 million or 1.6% of total NSW GVAP. Broadacre cropping constitutes 80% of the GVAP ($147.7 million) of the FMP area production, using 189,930 ha or 29% of the area. The highest value-producing individual broadacre crops are cotton, yielding $50 million or 27%, and wheat, yielding $34 million or 18%, of the total Upper Namoi Valley Floodplain GVAP. Livestock and livestock products yield $37 million, accounting for 20% of GVAP while using 71% of the area. Data for GVAP and area of holding is presented in Table A13 1 and

Table A13 2.

Upper Namoi Valley Floodplain: Irrigated agricultural production

The ABS Agricultural Census 2011 identifies the area watered and the quantity of water used by irrigated agricultural production for the Gunnedah, Gunnedah Region, Narrabri, Narrabri Region, Quirindi and Coonabarabran regions in 2010-2011 (ABS 2011a).

The area watered and the quantity of water used by the six regions have been totalled to represent the total irrigated area and quantity of water used in the Upper Namoi Valley Floodplain, based on the assumption that:

- 100% of the irrigated agriculture in the Gunnedah, Gunnedah Region and Quirindi, 16% of Narrabri, 2% of Narrabri Region, and 0% of Coonabarabran region were included in the Upper Namoi Valley Floodplain.
- Horticultural production is not included in the estimated totals because its production is not conventionally undertaken in the floodplain area.

There was a total of 27,200 ha of irrigated land in the Upper Namoi Valley Floodplain in 2010–11. This area of irrigated land constitutes approximately 4% of the area of the FMP farm holding area. It is estimated that 80,500 megalitres of water was extracted for agricultural irrigation across the Gunnedah, Gunnedah Region, part of Narrabri, Narrabri Region and Quirindi regions in 2010-2011. The majority of the irrigation water used in 2010–11 was applied to cotton (58,800 megalitres, 73%), at an estimated average rate of 3.8 megalitres per hectare. Irrigation for cotton used an estimated 15,600 ha or 57% of the estimated Upper Namoi Valley Floodplain irrigated area. Data for irrigation activity is presented in Table A13 3 **Error! Reference source not found.**and Table A13 4**.**

Table A13 1: Gross value of Agricultural production (GVAP) 2011 ($M) (Source: based on ABS Agricultural Census 2011 data)

Gross Value of Agricultural Production ($m)	Gunnedah	Gunnedah Region	Narrabri	Narrabri Region	Quirindi	Coonabarabran	Estimated Upper Namoi Valley Floodplain	New South Wales
Weights	61%	62%	16%	2%	33%	3%		
Broadacre crops								
- Cereal crops—cereals for grain, wheat for grain	2.7	35.2	3.5	71.8	25.4	14.5	34	2,511.4
- Cereal crops—cereals for grain, excluding wheat	0.5	32.8	1.1	10.1	50.5	6.8	37.9	997.5
- Legumes for grain	0.4	8.4	0.8	14.8	2.5	1.3	6.7	237.4
- Oilseeds	0.4	15.0	0.3	2.6	14.4	2.9	14.5	438.1
- Hay—pasture and cereal and other crops cut for hay	0.3	3.8	0.2	1.6	4.2	5.7	4.2	283.6
- Other crops—cotton	2.6	66.0	4.5	206.0	10.6	-	49.9	1,125.7
- Other crops—excluding cotton	-	0.8	-	0.4	0.3	0.5	0.6	96.5
Total broadacre crops	**6.9**	**162.0**	**10.4**	**307.3**	**107.9**	**31.7**	**147.7**	**5,690.2**
Horticulture								
- Fruit	-	0.3	-	3.9	-	0.6	-	1,708.1
- Nurseries and cut flowers and cultivated turf	-	0.1	-	-	-	0.3	-	311.6
Total horticulture	**-**	**0.4**	**-**	**3.9**	**-**	**0.9**	**-**	**2,019.7**
Livestock products								
- Whole milk	-	-	-	-	-	0.8	-	504.7
- Slaughtered and other disposals—cattle and calves	2.4	26.8	2.8	15.4	35.4	41.3	31.8	1,616.1
- Wool	0.1	2.5	0.1	3.4	2.9	12.5	3.0	852.7
- Slaughtered and other disposals—sheep and lambs	0.1	1.8	0.1	2.3	2.8	8.2	2.4	609.8
- Slaughtered and other disposals—pigs	-	2.5	-	3.1	0.1	1.4	-	166.2
- Slaughtered and other disposals—goats	-	0.1	-	-	-	0.2	-	6.0
- Eggs produced for human consumption	-	-	-	-	3.5	0.5	-	193.8
- Slaughtered and other disposals—poultry	-	10.9	-	-	2.4	0.2	-	686.0
Total livestock and livestock products	**2.7**	**44.5**	**3.0**	**24.4**	**47.0**	**57.0**	**37.3**	**4,635.4**
Agriculture—total value ($m)	**9.6**	**206.8**	**13.4**	**334.7**	**155.0**	**97.4**	**185.0**	**11,714.0**

Table A13 2 Land mainly used for agricultural production 2011 (ha)

Agricultural commodities produced (ha)	Gunnedah	Gunnedah Region	Narrabri	Narrabri Region	Quirindi	Coonabarabran	Estimated Upper Namoi Valley Floodplain	New South Wales
Weights	61%	62%	16%	2%	33%	3%		
Broadacre crops								
- Cereal crops—wheat for grain	3,279	50,013	5,652	100,287	31,303	23,801	46,566	3,814,726
- Cereal crops—other than wheat for grain	1,238	49,823	1,337	19,154	53,221	19,820	50,408	1,637,949
- Non-cereal—cotton	1,047	21,412	838	60,857	3,869	-	16,253	329,665
- Non-cereal—other than cotton	1,750	49,330	1,890	56,650	25,719	8,633	41,596	1,262,087
Land mainly used for agriculture—crops	**10,937**	**229,587**	**13,369**	**278,193**	**143,829**	**95,246**	**189,927**	**9,209,190**
Horticulture								
- Orchard fruit and nut trees	2	106	1	389	62	13	-	47,483
- Grapevines for wine production	-	-	-	14	5	32	-	42,246
- Nurseries for cut flowers and cultivated turf	-	1	-	-	-	6	-	4,529
Hay and silage—hay	392	4,580	271	2,625	4,019	8,797	4,778	312,513
Pasture seed production—clean pasture seed produced	-	523	-	9	364	190	451	18,280
Land mainly used for agriculture—total grazing	27,005	270,384	32,538	247,007	309,274	418,618	309,042	46,419,229
Land mainly used for agriculture—other agricultural purposes	1	237	20	98	379	47	279	29,377
Land mainly used for agriculture—forestry plantation	-	92	-	279	224	377	-	112,489
Total area of holding	**38,339**	**526,561**	**48,936**	**569,460**	**476,508**	**574,040**	**659,301**	**58,326,**

Table A13 3 Area of irrigated agriculture production 2011 (ha) (Source: based on ABS Agricultural Census 2011 data)

Area watered	Gunnedah	Gunnedah Region	Narrabri	Narrabri Region	Quirindi	Coonabarabran	Estimated Upper Namoi Valley Floodplain	New South Wales
Weights	100%	100%	16%	2%	100%	0%		
Cereal crops—for grain or seed (e.g. wheat/oats/maize) (ha)	342	3,805	520	973	2,034		6,283	5,377,721
Other crops—broadacre other (e.g. canola/field beans/lupins/sunflowers/poppies) (ha)	-	1,650	23	453	1,249		2,912	1,261,888
Other crops—cotton (ha)	465	13,005	747	37,236	1,281		15,616	329,665
Cereal crops—cut for hay (including wheat/oats/forage/sorghum) (ha)	2	50	0	54	7		60	104,019
Fruit or nut trees/plantation or berry fruits (excluding grapes) (ha)	-	86	-	406	17		N/A	49,842
Grapevines (ha)	**-**	**2**	**-**	**14**	**4**		**N/A**	**44,155**
Nurseries/cut flowers/cultivated turf (ha)	-	1	-	-	-		N/A	4,529
Pasture—cut for hay (ha)	58	418	-	49	417		894	165,217
Pasture—for grazing (ha)	22	748	79	428	247		1,038	46,419,230
Pasture—for seed (ha)	-	108	-	-	260		368	18,280
Total area watered and used—area watered (ha)	**895**	**20,262**	**1,404**	**39,878**	**6,155**		**27,171**	**674,064**

Table A13 4: Irrigated agricultural production 2011 (ML) (Source: based on ABS Agricultural Census 2011 data)

Water for agricultural production	Gunnedah	Gunnedah Region	Narrabri	Narrabri Region	Quirindi	Coonabarabran	Estimated Upper Namoi Valley Floodplain	New South Wales
Weights	100%	100%	16%	2%	100%	0%		
Cereal crops—cut for hay (including wheat/oats/forage/sorghum) (ML)	3	199	1	76	6		209	13,989
Cereal crops—for grain or seed (e.g. wheat/oats/maize) (ML)	183	6,507	789	1,658	3,693		10,541	203,841
Other crops—broadacre other (ML)	-	3,585	93	971	2,139		5,759	809,078
Other crops—cotton, volume applied (ML)	1,922	47,410	2,856	195,363	5,089		58,785	1,073,849
Fruit or nut trees/plantation or berry fruits (excluding grapes) (ML)	-	137	-	2,613	23		N/A	94,237
Grapevines (ML)	-	1	-	8	2		N/A	106,594
Nurseries/cut flowers/cultivated turf (ML)	-	0	-	-	-		N/A	17,596
Pasture—cut for hay (ML)	198	1,458	-	54	1,300		2,956	78,406
Pasture—for grazing (ML)	3	737	101	512	414		1,180	232,629
Pasture—for seed (ML)	-	283	-	-	746		80,460	2,745,896
Total area watered and used (ML)	**2,318**	**61,202**	**3,851**	**201,780**	**15,063**		**80,460**	**2,745,896**

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