RURAL FLOODPLAIN MANAGEMENT PLANS

Background Document to the Floodplain Management Plan for the Lower Namoi Valley Floodplain 2020—Appendices

Water Management Act 2000

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Abbreviations

Abbreviation	Description
ABS	Australian Bureau of Statistics
AEP	annual exceedance probability
AHIMS	Aboriginal Heritage Information Management System
ASDST	Aboriginal Sites Decision Support Tool
DEM	digital elevation model
DPI	NSW Department of Primary Industries
FMP	floodplain management plan
FPWEC	First Peoples' Water Engagement Council
GVAP	gross value of agricultural production
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
LiDAR	light detection and ranging
LGA	local government area
ML	megalitres
NSW	New South Wales
OEH	former NSW Office of Environment and Heritage
pers. comm	personal communication
PCT	plant community type
ROC	receiver operator characteristic
SDM	species distribution model
SRTM	Shuttle radar topography mission
TAG	Technical Advisory Group
Upper Namoi Valley FMP 2019	*Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019*
WM Act	*Water Management Act 2000*
WSP	water sharing plan

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

Table A1.1. Approach to rural floodplain management planning 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* (Water Act) • Other statutory boundaries and infrastructure features (for example, water sharing plans, roads, floodplain harvesting registrations of Interest)	Map of floodplain boundary to be designated under the *Water Management Act 2000* (WM Act)
2—identify existing flood works	• Flood work licences • Area of land protected by flood works identified from spatial data such as flood imagery, LiDAR and aerial photography • Local knowledge of licensing staff	• Map of area of land protected by flood works • Number of existing approved flood work licences
3—review existing rural floodplain management arrangements	• First-generation floodplain development guidelines and studies (non-statutory) • Second-generation rural floodplain management plans (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 regimes
5—identify and prioritise floodplain assets	• Identified from peer-reviewed literature, relevant legislation, policies, databases and registers • Various spatial data (for example, PCT mapping) • Optimum watering requirements • Conservation significance of assets determined from Technical Advisory Group (TAG) and Marxan • Cultural assets also identified from Aboriginal Technical Working Group 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, Australian Bureau of Agricultural and Resource Economics, 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 and 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 flood management plans (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 with 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 interagency regional panel 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	• Interagency regional panel provides whole-of-government endorsement of the FMP • Key stakeholders and the community's feedback are 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 Lower Namoi Valley

Floodplain management planning in the Lower Namoi Valley Floodplain, and indeed the whole of New South Wales (NSW), 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 govern water management.

Government planning in the Lower Namoi Floodplain has focused particularly on the area between Narrabri and Burren Junction, where there is intensive irrigation development and a large number of constructed embankments protecting cropped land from small to medium floods. There is less floodplain development downstream of Burren Junction, although there is some embanked farmland along the Namoi River and Pian Creek.

A detailed history of floodplain management in the Lower Namoi Valley Floodplain is outlined below.

The emergent need to manage earthworks on floodplains (1912–80s)

In 1912, the NSW Government began to take on a legal responsibility for water management by enacting the Water Act. The enactment of the Water Act did not initially change floodplain management in the state. In later decades, however, the Water Act would become the principal driver of floodplain management after amendments were made in response to changes in flood patterns caused by flood works.

Burton et al. (1994) describe the changes in agricultural practice in NSW as they relate to floodplain management:

> From the 1960s there developed a major change in agricultural practice, from low intensity to high intensity landuse, on the wide flood plains of the inland river systems of New South Wales. This change was influenced by three major factors: a major program of large dam construction, which led to expectations of an assured water supply; the consequential replacement of low intensity grazing by intensive irrigation; and a change in Government policy, which encouraged private irrigation development. These changes resulted in a proliferation of uncoordinated earthworks in the form of channels and levees over large tracts of natural floodplain.

Stream flows in the Namoi catchment are regulated by Keepit Dam on the Namoi River, Split Rock Dam on the Manilla River and Chaffey Dam on the Peel River. The dams were completed in 1960, 1976 and 1984, respectively. When Keepit Dam was completed in 1960, the regulated water supply allowed for significant irrigation development to support large scale and intensive crop production. Major private irrigation development further intensified in the 1990s.

Burton et al. (1994) then go on to describe how major flood events in the 1970s revealed changes in flood patterns caused by uncoordinated earthworks:

> Major flood events during the 1970s revealed that the spread of uncoordinated earthworks had, in many locations, produced major changes in the traditional patterns of flooding. As a consequence, heavy crop losses occurred within the newly-developed irrigation areas and flood damages were experienced in other areas which had previously been considered to be relatively flood-free. These

> flood events highlighted a need for the rationalisation of existing and possible future irrigation developments and also demonstrated a need to implement flood protection measures. Because flood insurance to cover agricultural losses was not available, various kinds of structural flood protection measures were seen to provide the most appropriate means for the reduction of flood damages.

The *Water Resources Commission Act 1976*

At the time, the revealed changes in flood patterns could not be effectively addressed under existing legislation, as Burton et al. (1994) explain:

> The existing legislation did not permit the effective control and coordination of this type of land development. Part 2 of the existing Water Act provided only for the licensing of works which could affect the distribution of floodwaters flowing in, to or from, or contained in, a river or lake. The legislation did not relate to works on flood-prone land remote from a river or lake.

Burton et al. (1994) describe how a new Act was introduced to allow the government to strategically address flooding problems using levee/floodway schemes published as ‘Guidelines’ (referred to in this project as first-generation rural floodplain development guidelines:

> The enactment of the *Water Resources Commission Act* in 1976 permitted the then Commission to investigate, formulate and implement flood mitigation strategies on a valley-wide basis. Under the provisions of this legislation, the Commission prepared a number of levee/floodway schemes for the worst-affected areas. These schemes, which were judged to provide the most cost-effective flood mitigation measures for private irrigation areas, were funded and implemented by the benefiting landholders.

First-generation rural floodplain development guidelines

The first-generation rural floodplain development guidelines aimed to provide floodways of adequate hydraulic capacity and continuity by restoring as far as practical the natural pattern of flood channels for the effective conveyance of flood flows. Flood protection of developed land was accomplished by the construction of levees bordering the floodways.

The schemes were designed to provide protection against flooding for a range of recurrence intervals, depending upon the nature of the crop and the local topography. The actual degree of protection provided ranged from 1 in 5 years to almost 1 in 100 years (Burton et al. 1994).

Planning principles

The planning of the guidelines was based upon the following principles (Burton et al. 1994):

- the proposed system of floodways should conform as closely as was reasonably possible to the natural drainage pattern;
- the area of flood-protected land should be maximised, provided that no other properties were adversely affected as a result;
- all floodways should be maintained in a clear condition free of obstructions but could, where possible, be sown to grain crops;

- existing levees and banks extending across the direction of flow and causing an undesirable redistribution of floodwaters should be reduced to ground level;
- floodways should discharge as closely as practicable to the location of natural floodways;
- the exit of floodwater from floodways should be at rates and depths similar to those which would be experienced under natural conditions;
- local drainage should be the responsibility of individual landholders.

Four first-generation rural floodplain development guidelines in the Lower Namoi Valley Floodplain were undertaken by the NSW Government and consultants from the late 1970s to the early 1980s:

- *Guidelines for Boolcarrol to Bulyeroi floodplain development* (NSW Water Resources Commission 1980)
- *Guidelines for Gardens to Drildool floodplain development* (NSW Water Resources Commission no date)
- *Guidelines for Merah North to Burren Junction floodplain development* (NSW Water Resources Commission 1978).
- *Restoration of Namoi River Floodplain Waterways: Final Proposal* (1976) NSW Water Resources Commission (superseded)

Issues with the guidelines

As Burton et al. (1994) describe, the schemes were subject to individual scrutiny by the Commission as well as close community consultation with affected landholders. The guidelines were non-statutory and were implemented on a voluntary basis by landholders with individuals meeting the full cost of their flood protection works. For these reasons, there were issues with landholder participation. As Burton et al. (1994) highlight:

> Where Guidelines have been prepared, significant impediments to the implementation of proposed schemes have sometimes occurred because of the desires of individual landholders to pursue different farming practices and their varying perceptions of the need to participate in an integrated flood protection scheme. Under such circumstances, substantial modifications to proposed schemes have been required which have resulted in a lower degree of flood protection for some properties.
>
> Furthermore, land use decisions can be transient and variable from time to time and this can lead to situations where properties whose former owners have opted out of schemes come later to be participants in such schemes. The private land tenure system is considered to confer this right on landowners.

Key changes to the legislative and policy framework (1984–95)

In 1984 two key changes in legislation affecting floodplain management occurred: an amendment to the Water Act to include Part 8 and the introduction of the Flood Prone Land Policy 1984.

Part 8 Flood control works added to the Water Act

The amendment of the Water Act to include Part 8 Flood control works in 1984 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.

Part 8 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 also allowed for the designation of floodplains, which are areas where controlled work approvals must be obtained (Section 166).

The original Lower Namoi Valley Floodplain was designated on 18 September 1984 under the Water Act.

Public roads and railways made exempt (1995)

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.

The Flood Prone Land Policy 1984

The Flood Prone Land Policy 1984 was introduced with the primary objective to:

> … reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land.
>
> The policy promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable.
>
> *Floodplain Development Manual (2005)*

The policy 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 requires:

- a merit approach to be adopted for all development decisions
- 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
- action to minimise the potential for flood losses to be balanced by the application of ecologically sensitive planning and development controls.

Floodplain Development Manual (1986)

In 1986, the *Floodplain Development Manual* was released by the NSW Government to support the Flood Prone Land Policy 1984. It assisted consent authorities to deal with flood liable land.

Second-generation rural floodplain management plans under the Water Act (1999–2009)

The period from 1999 to 2009 was a significant decade for rural floodplain management. Important legislative changes occurred, including:

- amendments to Part 8 of the Water Act to:
    - allow for the preparation of statutory rural floodplain management plans (FMPs) (Section 166A) (referred to in this project as second-generation rural FMPs)
    - include matters for general consideration when assessing flood work approvals (Section 166C)
    - be able to assess flood works outside a designated floodplain
- enactment of the WM Act.

Amendments to Part 8 of the Water Act

Second-generation rural FMPs (Section 166A)

Floodplain management strategies prior to 1999, such as first-generation rural floodplain development guidelines and floodplain management studies, were not statutory. This all changed in 1999 when Part 8 of the Water Act was amended to allow for more strategic coordination of controlled works through the preparation of statutory second-generation rural FMPs.

The amendment outlined 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.

The new strategy was developed in response to strong community support for a change in the then current practice. A key objective was to develop the FMPs 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.

The Natural Heritage Trust, Natural Disaster Management Program and the state-assisted Floodplain Management Program provided funding for a $5 million program to prepare the rural FMPs. Overall, 21 rural second-generation FMPs were developed across NSW, covering 25,470 square kilometres.

In the Lower Namoi Valley Floodplain, one second-generation statutory rural FMP was made under the Water Act, the *Narrabri to Wee Waa Floodplain Management Plan* (September 2005).

Section 166A also required that rural FMPs be developed in accordance with the provisions and policies of the NSW *Floodplain Development Manual* and NSW Flood Prone Land Policy.

The second-generation FMPs typically aimed to cater for flood flows, provide flood mitigation, encourage sustainability and maintain flooding to flood-dependent ecosystems. They were designed to adhere to an overall set of floodplain management principles listed in the FMPs as well as the legal Matters for general consideration (Section 166C).

The floodplain management principles adopted for the *Narrabri to Wee Waa Floodplain Management Plan* by the floodplain management committee are listed in Appendix 3 of this document. These principles are generally consistent across all the second-generation rural FMPs developed.

Second-generation rural FMPs developed under Part 8 superseded any first-generation rural development guidelines made for the same area.

Matters for general consideration (Section 166C)

Section 166C Matters for general consideration was also added as an amendment in 1999. It follows that:

(1) The Ministerial Corporation, in exercising its functions under this Division with respect to approvals, must have regard to the following matters, and any other matters that it considers relevant:

a. the contents of any relevant floodplain management plan or any other relevant Government policy

b. 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

c. the effect or likely effect on water flows in downstream river sections

d. any geographical features, or other matters, or Aboriginal interest that may be affected by a controlled work

e. the effect or likely effect of a controlled work on the passage, flow and distribution of any floodwaters

f. the effect or likely effect of a controlled work on existing dominant flood ways or exits from flood ways, rates of flow, floodwater levels and the duration of inundation

g. the protection of the environment

h. any other matter relating to the desirability or otherwise of a controlled work

(2) The Ministerial Corporation is to ensure that the notice of its determination to grant or refuse an approval, renew or refuse to renew an approval, impose conditions on an approval or vary or revoke the conditions of an approval includes a statement of the reasons for the determination and of the extent to which the Ministerial Corporation took into account the matters set out in subsection (1) in making that determination.

Flood works outside a designated floodplain

The amendments to Part 8 allowed for areas not designated as part of a floodplain to be covered by Part 8. This meant that works in these areas were now required 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 was used when assessing such works.

Floodplain Development Manual (2001–05)

The *Floodplain Development Manual* was updated in 2001 to make it applicable to rural areas as well as to be consistent with a series of improvements to both policy and practice, including emphasising the need:

- to explicitly consider the full range of flood sizes up to and including the probable maximum flood (PMF) when developing a floodplain risk management plan;
- to recognise existing, future and continuing flood risk on a strategic rather than on an ad hoc individual proposal basis;
- for local councils, with support from State Government, to manage local overland flooding in a similar manner to riverine flooding; and
- to promote the preparation and adoption of local flood plans (prepared under the guidance of SES [State Emergency Service]) 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 WM Act

In 2000, the 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 WM Act is the culmination of the NSW water reform process driven by the Council of Australian Governments.

The WM Act contains general water management principles and floodplain management provisions that relate closely to existing provisions under the amended Part 8. Sections 29 and 30 detail the core and additional provisions to be considered when developing floodplain management plans.

Section 5(2) of the water management principles state:

(2) Generally:

a. water sources, floodplains and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded, and

b. habitats, animals and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored, and

c. the water quality of all water sources should be protected and, wherever possible, enhances [sic], and

d. the cumulative impacts of water management licences and approvals and other activities on water sources and their dependent ecosystems should be considered and minimised, and

e. geographical and other features of Aboriginal significance should be protected, and

f. geographical and other features of major cultural, heritage or spiritual significance should be protected, and

g. the social and economic benefits to the community should be maximised, and

h. the principles of adaptive management should be applied, which should be responsive to monitoring and improvements in understanding of ecological water requirements.

Section 5(6) of the water management principles state:

(6) In relation to floodplain management:

a) floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and

b) the impacts of flood works on other water users should be avoided or minimised, and

c) the existing and future risk to human life and property arising from occupation of floodplains must be minimised.

Section 29 core provisions of Division 5 floodplain management state:

The floodplain management provisions of a management plan for a water management area must deal with the following matters:

a) identification of the existing and natural flooding regimes in the area, in terms of the frequency, duration, nature and extent of flooding

b) the identification of the ecological benefits of flooding in the area, with particular regard to wetlands and other floodplain ecosystems and groundwater recharge

c) 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

d) the risk to life and property from the effects of flooding.

Section 30 additional provisions of Division 5 floodplain management state:

The floodplain management provisions of a management plan for a water management area may also deal with the following matters:

a) proposals for the construction of new flood works

b) the modification or removal of existing flood works

c) restoration or rehabilitation of land, water sources or their dependent ecosystems, in particular in relation to the following:

   i. the passage, flow and distribution of floodwater

   ii. existing dominant floodways and exits from floodways

   iii. rates of flow, floodwater levels and duration of inundation

   iv. downstream water flows

   v. natural flood regimes, including spatial and temporal variability

d) the control of activities that may affect or be affected by the frequency, duration, nature or extent of flooding within the water management area

e) the preservation and enhancement of the quality of water in the water sources in the area during and after flooding

f) other measures to give effect to the water management principles and the objects of this Act

g) such other matters as are prescribed by the regulations.

Third-generation rural FMPs under the WM Act (2010–current)

The Healthy Floodplains Project commenced in 2010 to develop third-generation rural FMPs and license floodplain harvesting water extractions (not a focus of this report). The project was awarded $36 million by the Australian Government in June 2012, with additional contributions by the NSW Government.

Third-generation rural FMPs are currently being developed, and the rural floodplain management planning approach is being revised primarily in response to changes to the legislative and policy framework governing water management in NSW. The key change to legislation was the introduction of the WM Act, which has replaced the now repealed Part 8 of the Water Act.

The Lower Namoi Valley FMP consolidates floodplain management measures from existing plans and guidelines and supersedes all existing FMPs in the Lower Namoi Valley Floodplain. Concurrently, the Lower Namoi Valley Floodplain designated under the Water Act has been repealed and a new Lower Namoi Valley Floodplain designated under the WM Act. The designation of the new floodplain is for the purpose of administering flood works and floodplain harvesting activities.

These third-generation rural FMPs are being prepared for floodplains in the north of the Murray–Darling Basin in accordance with the floodplain planning and environmental protection provisions of the WM Act.

In principle, the new third-generation rural FMPs involve only minimal change for landholders wishing to construct or amend flood works; nevertheless, the structure and content of the new FMPs have changed to reflect better available information and the specific requirements of the WM Act.

The new rural FMPs contain maps of clearly delineated management zones and transparent rules and assessment criteria to coordinate flood work development. These features provide greater clarity and consistency for landholders applying to build or amend flood works. Importantly, third-generation rural FMPs cover the extent of major flooding in a valley, filling in any gaps between existing FMPs, which focused on smaller problem areas.

As the new rural FMPs are developed, they supersede any existing first-generation floodplain development guidelines or second-generation rural FMPs in the same area.

These new rural FMPs build on the existing floodplain management legacy. For instance, where appropriate, existing floodplain management planning measures are integrated into the new rural FMPs.

The new rural FMP approach is an important next step in strategically coordinating flood work development and will:

- provide future certainty to landholders about where they can construct flood works
- fast-track the approval process for new flood works
- increase awareness of and minimise adverse risk to life and property from the effects of flooding
- maintain flood connectivity to existing floodplain assets, including ecological and cultural assets
- assist with floodplain management for the whole of rural NSW
- effect the orderly passage of floodwaters through the floodplain
- contribute to the protection of ecological, cultural, heritage and spiritual features that are significant to Aboriginal people and other stakeholders.

The new floodplain management provisions 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.

Appendix 3: Review of existing floodplain management arrangements

A detailed review of the 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)

Existing rural FMPs were statutory documents prepared under Part 8 of the Water Act. Part 8 of the Water Act has since been repealed, and these plans have been transitioned to minister's plans under Schedule 9 of the WM Act.

There is one second-generation rural FMP in the Lower Namoi Valley Floodplain, which covered about 72,000 ha, or 15%, of the floodplain known as the *Narrabri to Wee Waa Floodplain Management Plan*.

Floodplain management principles

FMPs adhered to an overall set of management principles. The floodplain management principles used in the *Narrabri to Wee Waa Floodplain Management Plan* are listed below:

- defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain
- any system of defined 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 flow paths
- 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 landuses
- 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)
- should the community agree there may be scope to depart from the natural/historical drainage pattern, provided it is hydraulically and environmentally feasible.

These principles were adhered to and reflected within the existing FMPs' 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 the existing FMP. Flood study modelling used MIKE 11 (modelling software) and was done using 'pre-development conditions' and 'existing conditions'.

Design flood events

The design floods used in the *Narrabri to Wee Waa Floodplain Management Plan* were the 25-year annual recurrence interval (1971) and the 100-year annual recurrence interval (year not specified).

Types of controlled works considered for approval

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

Exemptions to controlled work approvals

The FMP did not specify certain controlled works that would be exempt from needing an approval.

Advertising requirements

The floodway network was the basis for assessing applications to construct controlled works. Controlled works proposed to be located inside the floodway network are assessed as noncomplying 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 concerning the adopted assessment criteria are also assessed as noncomplying and required advertising.

Assessment process/criteria for assessing flood work applications

Flood control works located within floodways and outside delineated areas are assessed as noncomplying works. Noncomplying 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 noncomplying 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 concerning 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 are summarised in Table A3.1 and outlined in detail in Tables A3.2 to A3.5.

Table A3.1. Summary of assessment criteria in second-generation FMPs

Historical	Socio-economic	Ecological	Flooding
• Old guidelines • Concerns and objections	• Disruption to daily life • Health impact • Cost of the works • Infrastructure damage • Equity	• Wetland connectivity • Floodplain plants and animals • Soil condition and structure • Fish passage • Cultural sites • Groundwater recharge	• Natural flooding characteristics • Hydraulic capacity • Pondage and flow duration • Redistribution • Flow velocities • Works in floodways

Table A3.2. Historical assessment criteria used to assess flood work applications in previous FMPs

Historical assessment criteria	Description
Old guidelines/Complying works (for existing works)	Works that comply with the original guidelines will normally be accepted, unless additional information and/or flood observations illustrate that the works may have a significant adverse impact on flood flows
Community concerns and objections	Any ongoing concerns and objections from neighbouring landholders must be taken into consideration during the assessment process

Table A3.3 Socio-economic assessment criteria used to assess flood work applications in previous FMPs

Socio-economic assessment criteria	Description
Disruption to daily life	Unless previously agreed between all affected landholders, works should not result in significant disruption to the daily life of surrounding landholders (for example, property access)
Health impact	Works should not impose negative health impacts or stress on surrounding landholders
Cost of the works	Are the associated cost and benefits of undertaking the work warranted? In some cases, it may be necessary to undertake a cost/benefit analysis (a preliminary assessment may be adequate) to weigh up the hydraulic and/or environmental benefits of undertaking the work against the required expenditure. This must be determined through consultation with the affected stakeholders and the department.
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 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.

Table A3.4 Ecological assessment criteria used to assess flood work applications in previous FMPs

Ecological assessment criteria	Description
Wetland connectivity	Flood control works should not block or restrict natural flow paths or floodways that feed wetland areas or alter the flooding regime to those areas.
Floodplain plants and animals/flood-dependent ecosystems	Works should not isolate flood-dependent stands of vegetation from flood flow. The potential impact on habitat availability and threatened species may need to be assessed.

Ecological assessment criteria	Description
Soil condition and structure	Works should not impose 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	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 Land 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.

Table A3.5 Flooding behaviour assessment criteria used to assess flood work applications in previous FMPs

Flooding behaviour	Description
Natural flooding characteristics	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	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	Works should not significantly impact pondage duration on the developed floodplain or cause flood peak travel time to unduly accelerate to downstream users
Works in floodways	Generally proposed flood control works will not be approved within the FMP floodway network, with the exception of farm access roads below 30 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	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 following guideline values: increase in peak levels on a neighbour’s boundary to be a maximum of 10% (up to the limit of 10 cm) of the predevelopment levels percentage peak redistribution to be a maximum of 2% of the predevelopment distribution. Each case should be assessed individually against the above guideline values, and a more satisfactory outcome may be achieved by holding discussions with all affected landholders. Applications for works that exceed the above redistribution guidelines will be considered as noncomplying works and must be subject to the Part 8 approval application process. Such works will generally not be approved unless an agreement has been reached between the applicant, the department and downstream landholders and the relevant environmental criteria met.

	Please note that it is at the department's discretion whether to consider or approve any proposed work that results in a peak flood level increase of more than 20 cm or results in a percentage redistribution of more than 5%.
Flow velocities	Flood control works should not significantly increase velocities of flood flow within floodways. Velocities should be of an order that does not significantly increase erosion and siltation under various land uses. As a general rule, velocities should not increase by more than 50% from the predevelopment flow velocities. The maximum permissible velocity for different ground conditions, as a general rule, is: 0.4 m/s for bare soil 0.6 m/s for crop 0.8 m/s for native tussocky grass.

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

Previous non-statutory floodplain development guidelines prepared in the Lower Namoi Valley Floodplain covered approximately 15% of the floodplain. The guidelines were not statutory documents and were developed for issue to landholders. They outlined a system of floodways to remain unobstructed by future development. The guidelines suggested areas that could be protected from flooding by levees, should the landholders desire. Considerable flexibility existed in locating the floodways on individual properties. However, it was generally recommended to not affect inlet and outlet conditions at upstream and downstream property boundaries. The NSW Government could use the information contained in the guidelines to assist with the assessment of flood work development applications.

First-generation rural floodplain development guidelines in the Lower Namoi Valley Floodplain include:

- *Guidelines for Boolcarrol to Bulyeroi floodplain development* (NSW Water Resources Commission, 1980)
- *Guidelines for Gardens to Drildool floodplain development* (NSW Water Resources Commission, no date)
- *Guidelines for Merah North to Burren Junction floodplain development* (NSW Water Resources Commission, 1978)
- [1]*Restoration of Namoi River Floodplain Waterways: Final Proposal (*NSW Water Resources Commission, 1976) (superseded).

See Figure A3.2.

[1] A report recommending strategies to improve this scheme was released in 1984 by the NSW Water Resources Commission titled *Proposed modifications to Narrabri—Wee Waa Floodway Restoration Scheme*. In 2005, this scheme was superseded by the Narrabri to Wee Waa FMP.

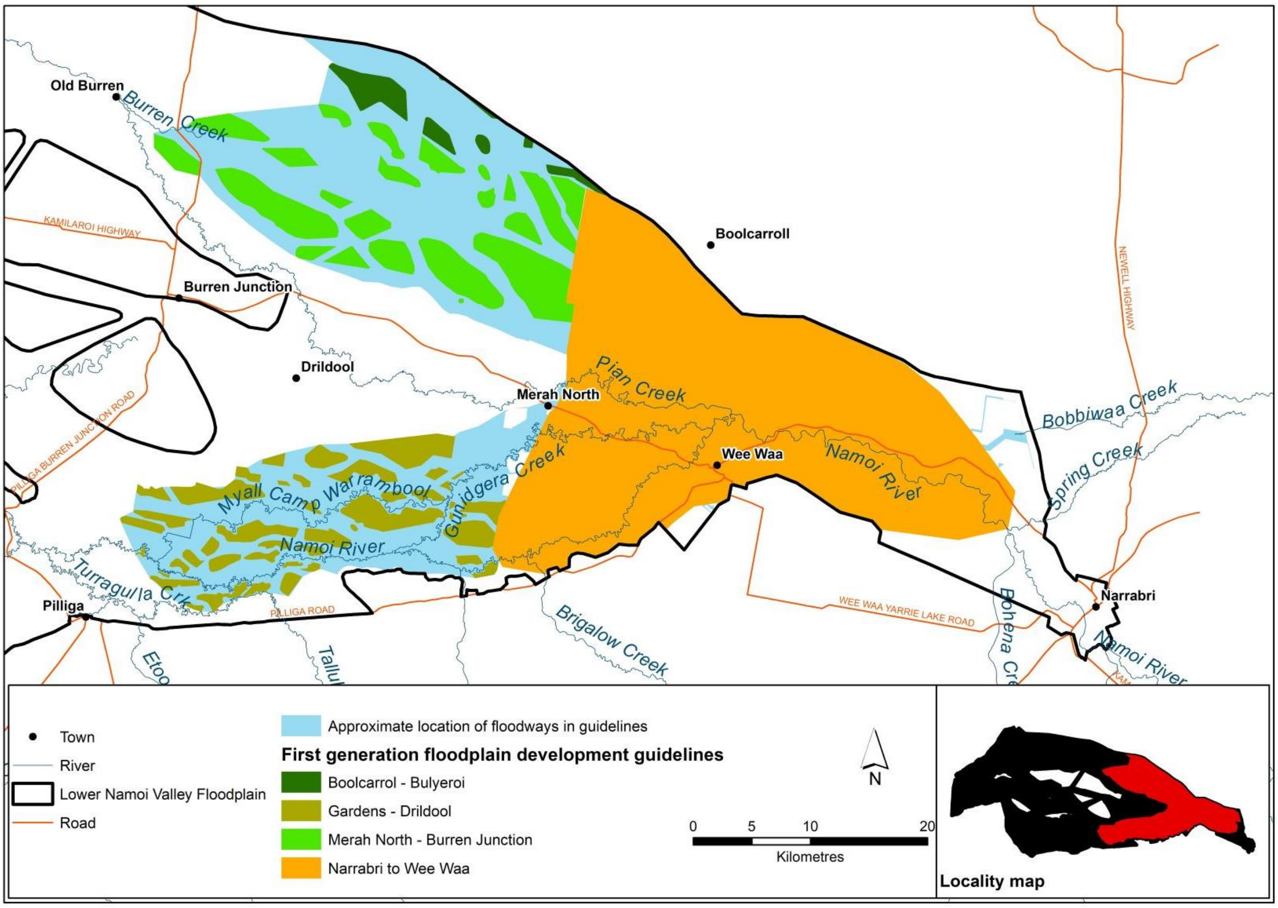


Figure A3.2. Location of first-generation rural floodplain development guidelines

Flood management principles

The planning of the guidelines was based upon the following principles (Burton et al. 1994):

- the proposed system of floodways should conform as closely as was reasonably possible to the natural drainage pattern;
- the area of flood-protected land should be maximised, provided that no other properties were adversely affected as a result;
- all floodways should be maintained in a clear condition free of obstructions but could, where possible, be sown to grain crops;
- existing levees and banks extending across the direction of flow and causing an undesirable redistribution of floodwaters should be reduced to ground level;
- floodways should discharge as closely as practicable to the location of natural floodways;
- the exit of floodwater from floodways should be at rates and depths similar to those which would be experienced under natural conditions;
- local drainage should be the responsibility of individual landholders.

Ecological and cultural heritage considerations

By maintaining the flow paths as naturally as possible, it was generally accepted that flood-dependent ecological and cultural assets were adequately considered. Floodways were arranged to include various swamps and wetlands.

Floodway networks

The guidelines propose a comprehensive scheme for the restoration of floodways to overcome the considerable flood damage experienced in major floods. Inadequate waterway provisions had resulted in a significant redistribution of flood flows and an alteration of traditional flow paths. The guidelines were non-statutory and were implemented on a voluntary basis by landholders with individuals meeting the full cost of their flood protection works.

Hydraulic models

Hydraulic calculations were used to determine if the capacity of the floodways was consistent with flow distribution and of an adequate width to maintain the passage of floodwater through the area.

Design flood events

Design flood events were generally the largest historic flood at the time the guideline was prepared.

Types of works considered for approval

The guidelines were non-statutory and did not restrict the types of flood works that would be considered for approval.

Advertising requirements for applications

The guidelines did not contain advertising requirements.

Assessment process for flood work applications

The guidelines did not contain assessment criteria.

Area not covered by a previous management measure

The area not covered by previous floodplain management measures was approximately 70%, or 406,100 ha, of the new Lower Namoi Valley Floodplain. Most of this area was part of the previously designated Lower Namoi Valley Floodplain 1984. However, about 10%, or 55,000 ha, has been added to the previous Part 8 designated 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 stated that a controlled work is to be assessed as a noncomplying 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 noncomplying.

Appendix 4: Design floods

As outlined in Step 4 of the main background document, two design floods were selected for the Lower Namoi FMP:

- large design flood—January/February 1971, 4% annual exceedance probability (AEP) at the Namoi River at Mollee gauge GS 419039
- small design flood—December 2004, 13% AEP at the Namoi River at Mollee gauge GS 419039.

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

The large design flood was selected:

- to correspond to the existing design flood used in the existing Narrabri to Wee Waa FMP
- 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.

Flood frequency analysis

Selection of appropriate design floods typically involves determining the AEP of historical floods 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 series and seasonal series. For the purpose of this analysis, only annual flood series are used. This is because annual flood series is the most common method of selecting the floods to be analysed. Its values are generally independent, and the series can be easily extracted. An annual flood series consists of the highest instantaneous rate of flow in each year of record.

For the Lower Namoi Valley FMP, the annual flow series was obtained from a number of gauging stations. These stations were chosen based on their location, data period and reliability. The annual flow series for each calendar year was extracted from Hydstra: a hydrologic database administered by the NSW Government. 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, it was assumed that the highest recorded peak was the highest peak for that year.

Table A4.1. Details of selected gauging stations in the Lower Namoi Valley Floodplain

Gauge number	Name	Period of record	Number of years	Per cent of gauged flows
419003	Narrabri Creek at Narrabri	1913–2013	101	67
419039	Namoi River at Mollee	1965–2013	48	60
419021	Namoi River at Bugilbone	1958–2013	55	73

Flood frequency results

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 (IEA, 1987). Here, the Log-Pearson Type III distribution was fitted to the annual datasets for the selected location within the valley.

Because 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* (1987). *Australian Rainfall and Runoff* recommends implementing the expected probability adjustment to remove bias from the estimate. The resulting frequency curves, along with 5% and 95% confidence limits for the five selected locations, are shown in Figure A4.1. Table A4.2 shows the AEPs for various floods at the selected locations within the valley.

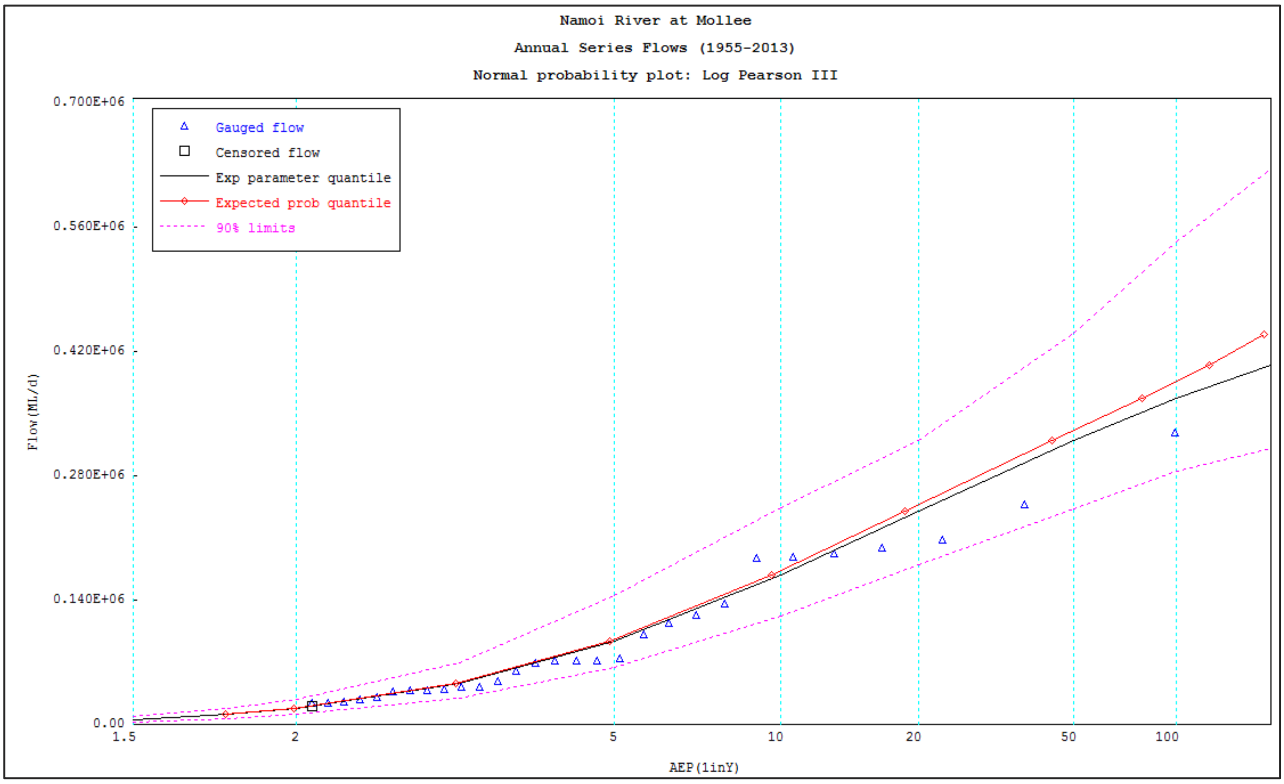


Figure A4.1. Flood frequency curves for the Namoi River at Mollee gauge (GS 419039). Thirty flows below 20,000 ML/day were censored. One per cent AEP equals 380,800 ML/day.

Table A4.2. AEP for historic flood events at selected locations in the Lower Namoi Valley

Location (gauge number)	AEP for 1955 (%)	AEP for 1971 (%)	AEP for 1974 (%)	AEP for 1984 (%)	AEP for 1998 (%)	AEP for 2012 (%)
Narrabri Creek at Narrabri (GS 419003)	0.75	3	6	7	7	14
Namoi River at Mollee (419039)	NA	4	6	6	6	10
Namoi River at Bugilbone (419021)	NA	4	5	6	4	7

Appendix 5: Further detail on two-dimensional hydraulic modelling

MIKE 21 flexible mesh (FM) and MIKE FLOOD FM hydraulic modelling software packages developed by DHI Group were used for the development of the models. Although the Narrabri model was developed in MIKE FLOOD FM, all other models were solely using MIKE 21 FM.

MIKE 21 FM is the finite volume, two-dimensional FM model. The FM is a computational grid that consists of triangular elements that can vary in size to provide greater detail in areas that require it and less detail where it is not required. The user assigns the different mesh resolutions to different parts of the floodplain—that is, finer mesh resolution along the flow paths and floodplain areas where more detail is required, and coarser mesh resolution in the wider floodplain.

MIKE FLOOD FM combines the one-dimensional MIKE 11 model with the two-dimensional MIKE 21 FM model and was used for Narrabri. The reason for using MIKE FLOOD FM was that there was already an existing MIKE 11 model for the town of Narrabri. This was left unchanged for simulating flow through the town but linked to a MIKE 21 FM model downstream of the town to account for overland flow into the wider floodplain.

Extents and layout

Consideration was given to the following elements in constructing the model:

- topographical data coverage and resolution
- location of recorded data (for example, levels/flows for calibration)
- location of controlling features (for example, dams, levees and bridges)
- desired accuracy to meet the study’s objectives
- computational limitations.

The models were constructed to cover most of the floodplain. The floodplain computational grid was too large to be run efficiently in one model. Therefore, the model was split into five reaches, where the flows were passed along each model in series—that is, upstream model outflows were applied as downstream model inflows.

The models were split into the following five sections:

- Narrabri extended from Narrabri to Mollee Weir
- Mollee extended from Mollee Weir to Merah North
- Merah extended from Merah North to Burren Junction
- Burren extended from Burren Junction to Goangra
- Reach 2 extended from Tara to Geera. The major tributary inflows included Pian Creek, the Barwon River and the Namoi River.

Base topography

The ability of the model to provide an accurate representation of the overland flow distribution on the floodplain ultimately depends on the quality of the underlying topographic model. LiDAR coverage of most of the floodplain was captured as part of the Healthy Floodplains Project.

Additional topographic data, such as the 5 m Airborne Digital Sensor (ADS) digital elevation model (DEM) and 30 m shuttle radar topography mission (SRTM) DEM, was used in areas not covered by the LiDAR to extend the models laterally from the river. The ADS DEM is typically less accurate than LiDAR and does not align with the LiDAR along the boundaries. To overcome this issue, the ADS DEM was adjusted using either a constant or, in some cases, a variable factor.

Topographic controls

The Lower Namoi Valley Floodplain is characterised by flat topography with many linear features elevated above the floodplain. These features include road alignments, levee banks and channels associated with irrigation supply, drainage infrastructure and farming practices. The largest of these features present barriers to flood flows and often have associated cross-drainage infrastructure to transfer flows through them. The smaller features act as hydraulic controls, resulting in floodwater ponding behind them before spilling over the crest.

To ensure that the extensive network of topographic features is correctly represented within the model, break lines were created representing elevations along the crests of the embankments from the LiDAR survey. The break lines were imported into the model to ensure that a continuous crest elevation is represented within the model topography. Water levels in the upstream model cells must exceed the crest of the embankment before spilling into the downstream cells. This approach ensures that the influence of the topographic controls across the floodplain is correctly represented.

Hydraulic roughness

The development of the models required the assignment of hydraulic roughness to different areas within the floodplain. These areas were delineated based on the corporate file Landuse V1—May 2011 from the former Office of Environment and Heritage (OEH) geodatabase. The land uses were simplified by grouping them into one of four categories: floodplain, channel, urban and road. The categories were given a roughness (Strickler Coefficient) value, which were assigned within the dfs2 file.

Structures

There are several bridge and culvert crossings over the main channel alignments and tributaries within the model extents. These structures vary in construction type and configuration, with varying degrees of influence on local hydraulic behaviour. Incorporation of these major hydraulic structures in the models provides for simulation of the hydraulic losses associated with these structures and their influence on peak water levels within the study area.

The structures were modelled as per their geometry by using level-width relations within the MIKE 21 FM structures module. The structure geometry was in some cases simplified to effectively implement within the model grid; however, this was unlikely to have any impact on the conveyance through the structure or levels or velocities nearby.

Boundary conditions

In general, discharges are specified at the upstream boundaries, and water level is specified at the downstream boundaries.

Because the models are adjacent to one another, discharge time series results from an upstream model could be used as inflow boundaries to a downstream model. For example, discharge time series results were extracted at the downstream part of the Merah North model and used as inflow boundaries at the same location in the upstream part of the Burren Junction model. To gain accurate discharge results at the downstream extraction location, the models had to be extended farther downstream with a lowered bathymetry and a lower dummy water level boundary at the end. This ensured there was no backwater effect at the extraction location. Taking these results and providing them as an inflow boundary to the adjacent downstream model allowed for consistent flow transfer from the upstream to the downstream models.

For the Mollee Weir to Merah North model, measured discharge data from a gauging station on the Namoi River was used as the upstream model inflow boundary. The downstream boundaries were given as water level or rating curve boundary conditions.

At public exhibition, tributary inflows from creeks flowing out of the Pilliga were raised by an industry stakeholder as a potential issue with the modelling. Initially, these tributary inflows were estimated using the probabilistic rational method outlined in *Australian Rainfall and Runoff* (1987). However, these inflows were subsequently reviewed by comparing the historical timing of flooding coming from Brigalow Creek and the Namoi River. Overall, on average, 67% of the peak Brigalow Creek flow occurred when the Namoi River peaked. Based on this finding, the 1 in 20-year inflows for Pilliga were reduced by 50% when modelling the large design flood, and 100% of the 1 in 20-year inflows for Pilliga were used when modelling the small design flood.

Model validation

The model results were validated over a range of flood magnitudes to demonstrate the suitability of a model for the range of design event magnitudes to be considered. The model results were validated based on the flood events that occurred in 1971, 1984, 1998 and 2004. The 1971 and 2004 flood events formed the large and small design floods, respectively.

Observed and modelled water level hydrographs at selected gauging stations were used for validation. In addition, flood aerial photography and satellite imagery were used for model validation.

Appendix 6: Overview of flood imagery

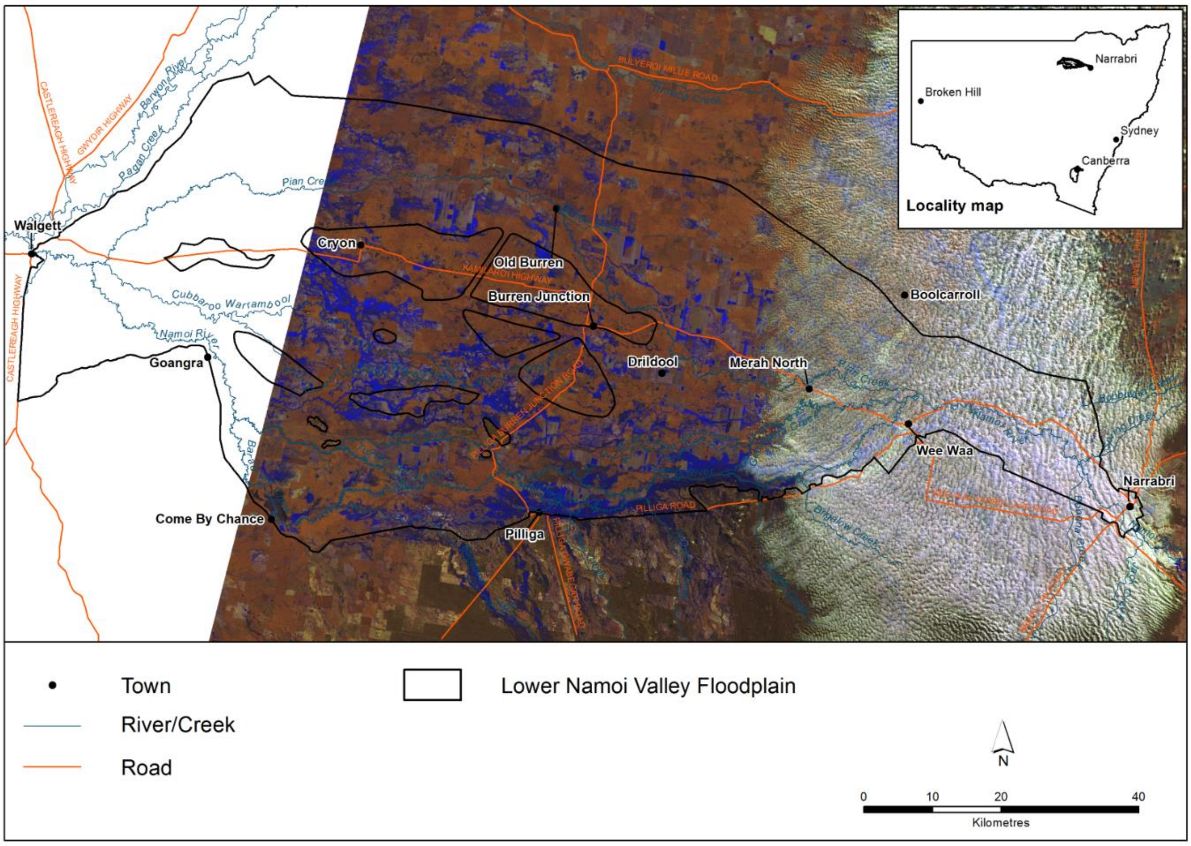


Figure A6.1. Landsat satellite imagery of a flood event captured on 21 July 1998

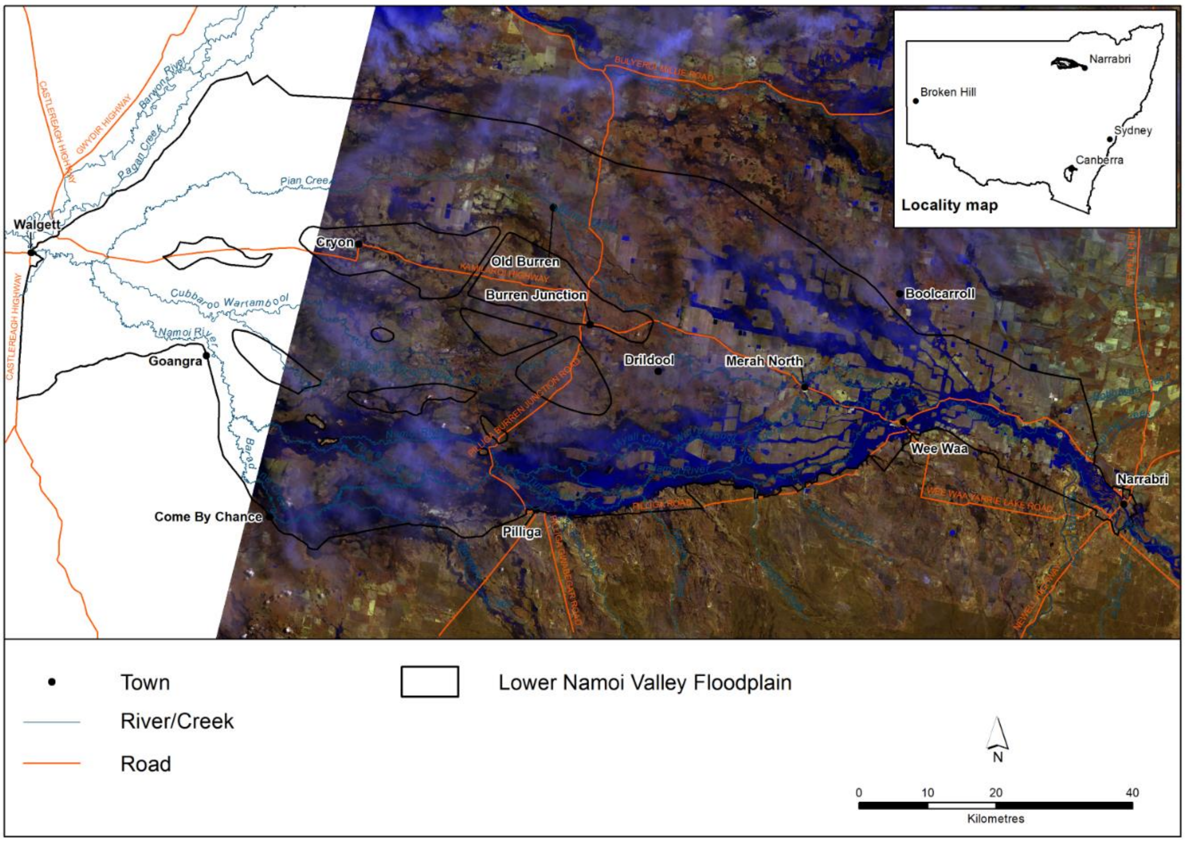


Figure A6.2. Landsat satellite imagery of a flood event captured on 23 November 2000

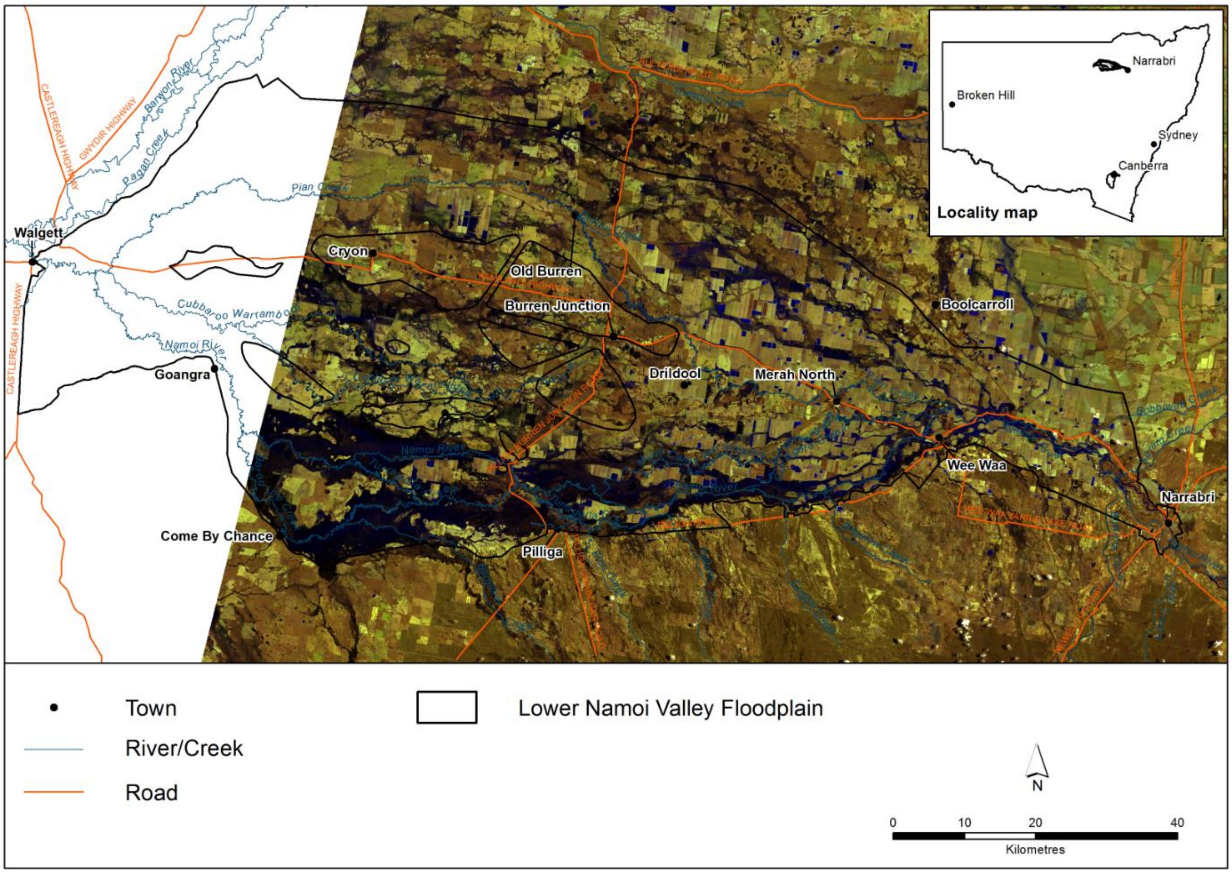


Figure A6.3. Landsat satellite imagery of a flood event captured on 13 December 2010 (east)

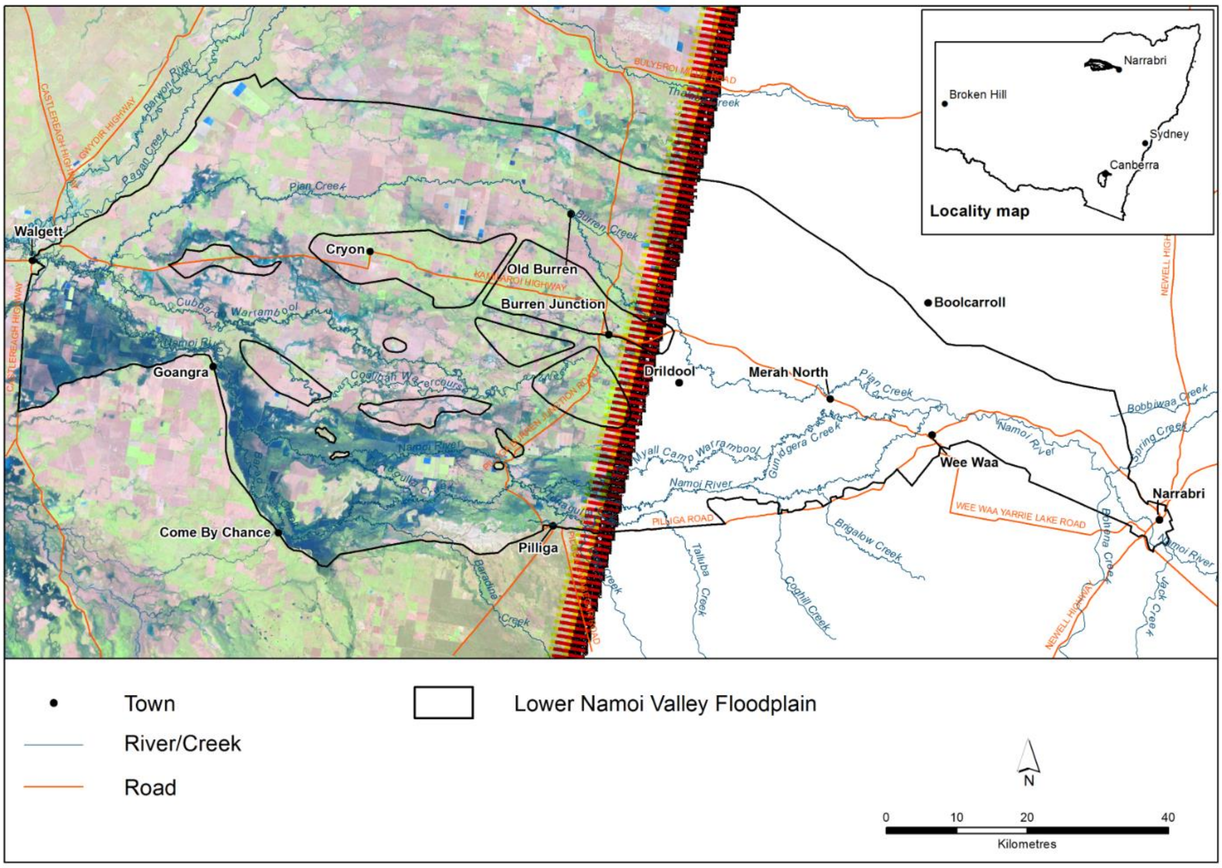


Figure A6.4. Landsat satellite imagery of a flood event captured on 20 December 2010 (west)

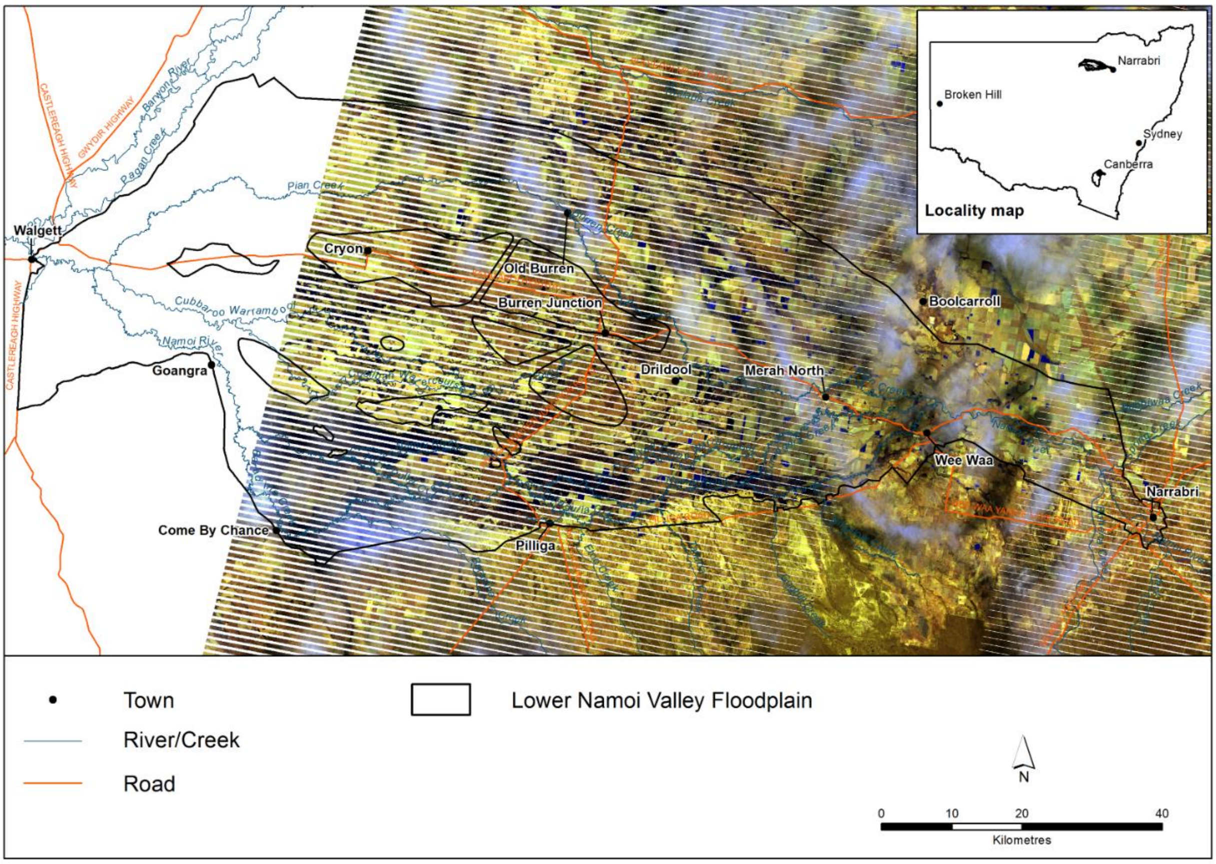


Figure A6.5. Landsat satellite imagery of a flood event captured on December 2010 (east)

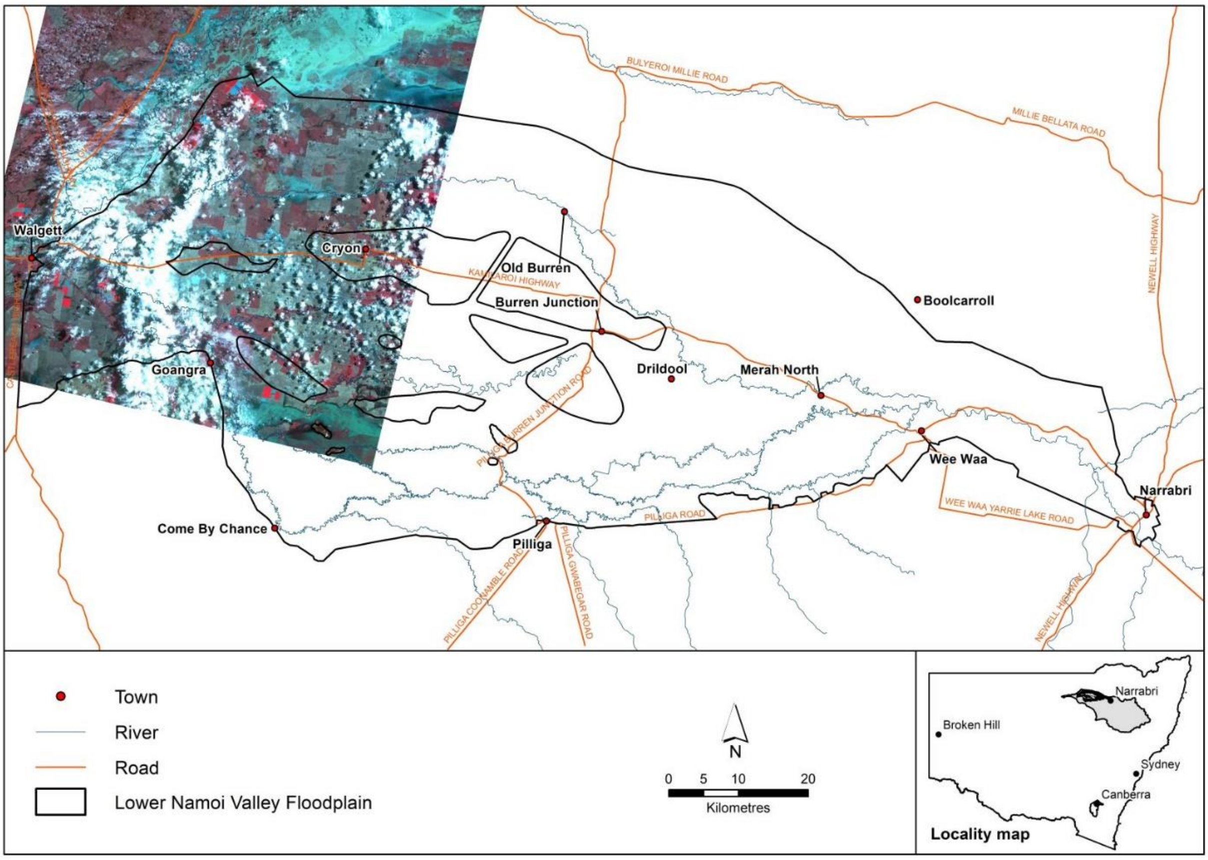


Figure A6.6. Spot 2012 imagery of a flood event around Mungindi and Walgett

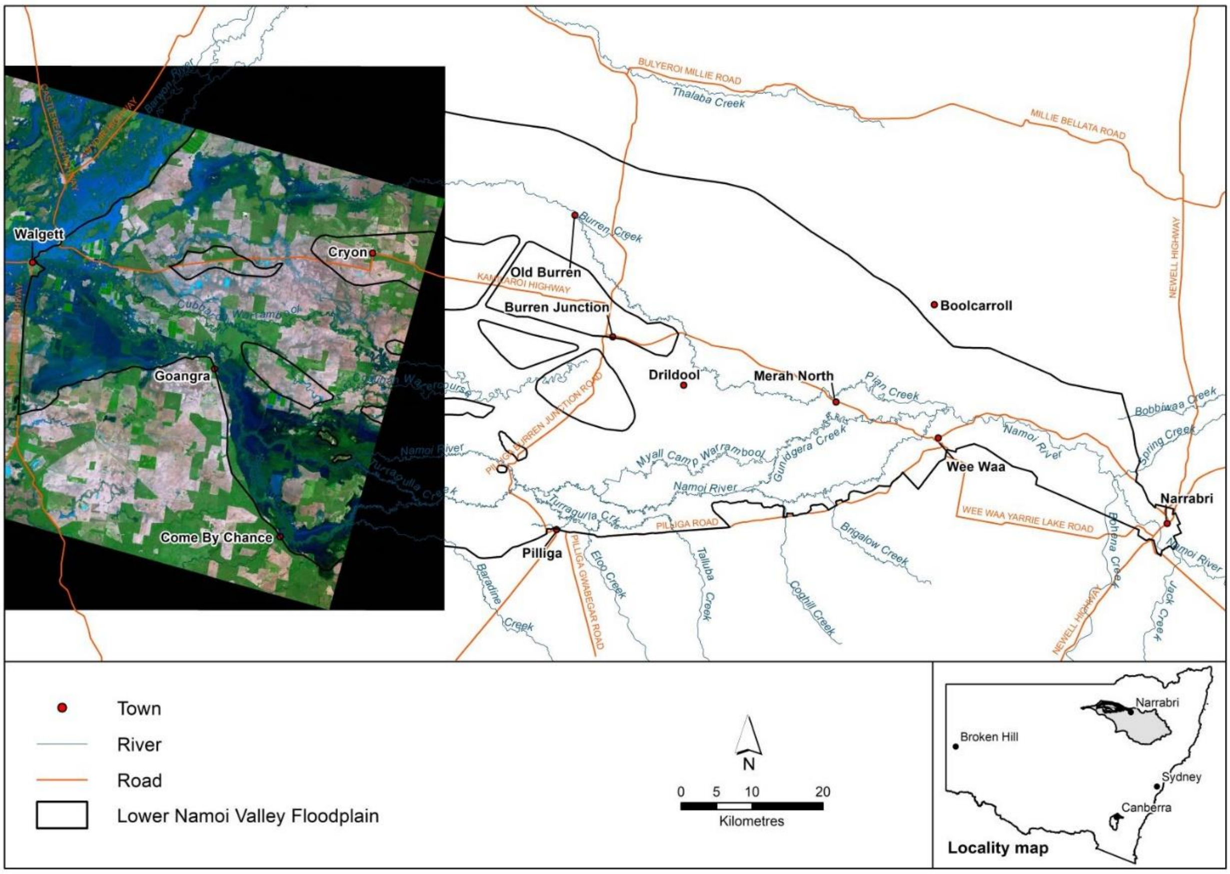


Figure A6.7. Spot 2012 imagery of a flood event around Walgett

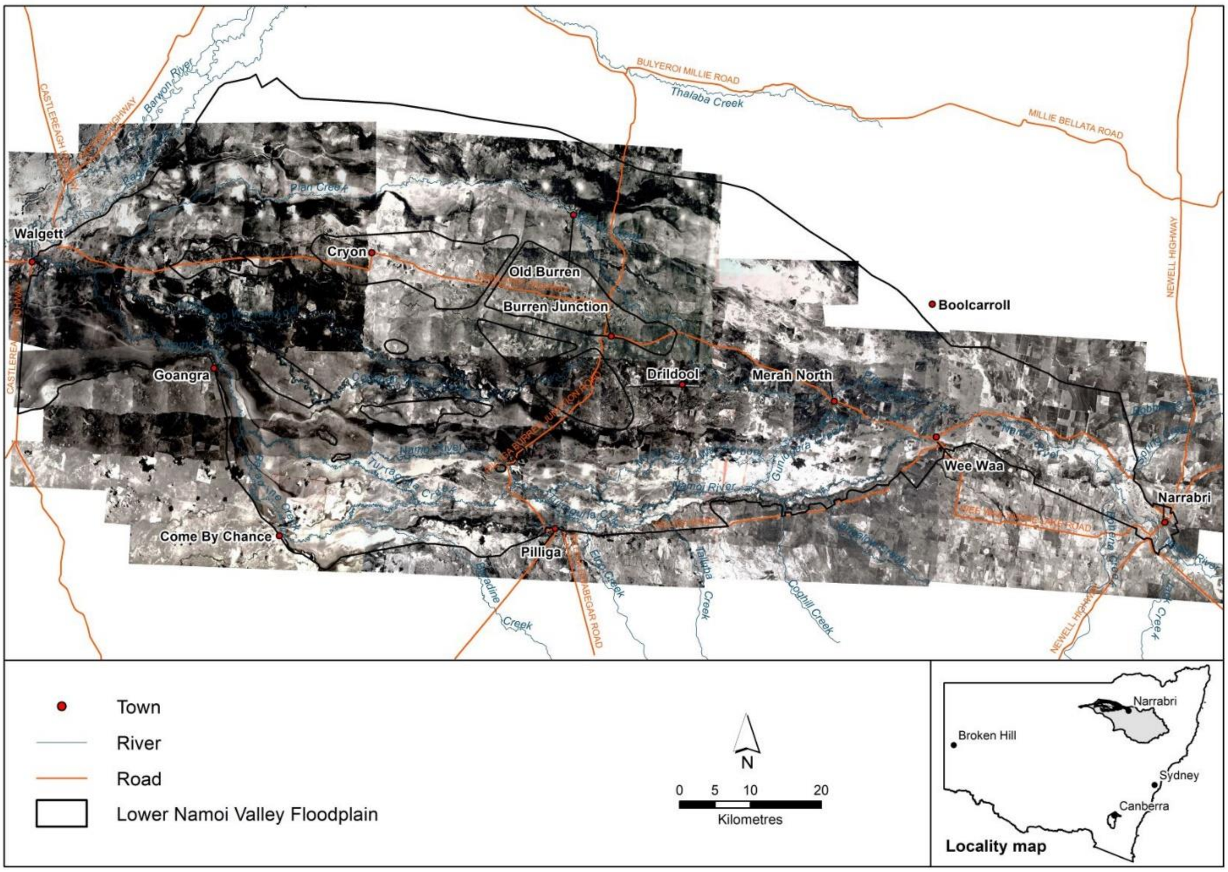


Figure A6.8. Rectified vertical flood photos captured in February 1971

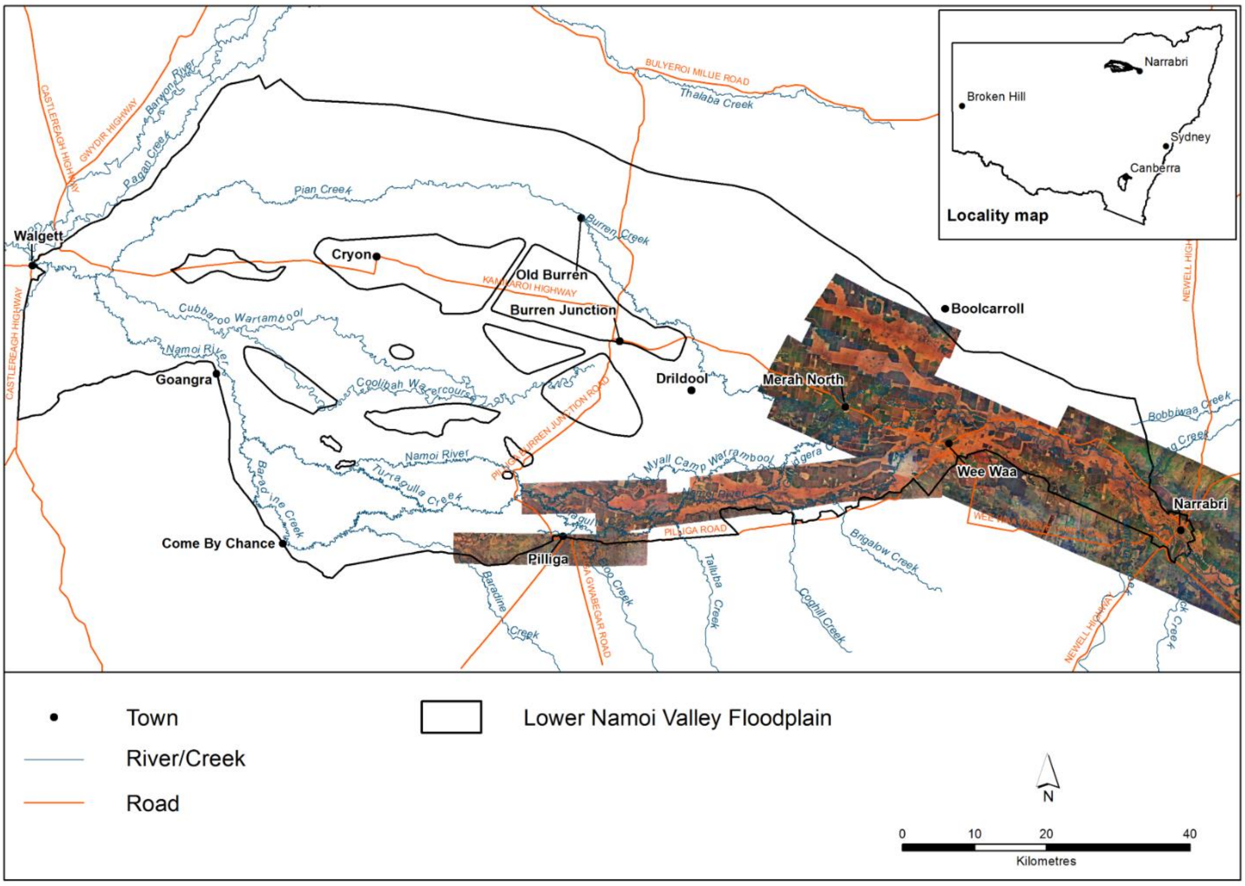


Figure A6.9. Mosaic of aerial photos of a flood event captured on 24 July 1998

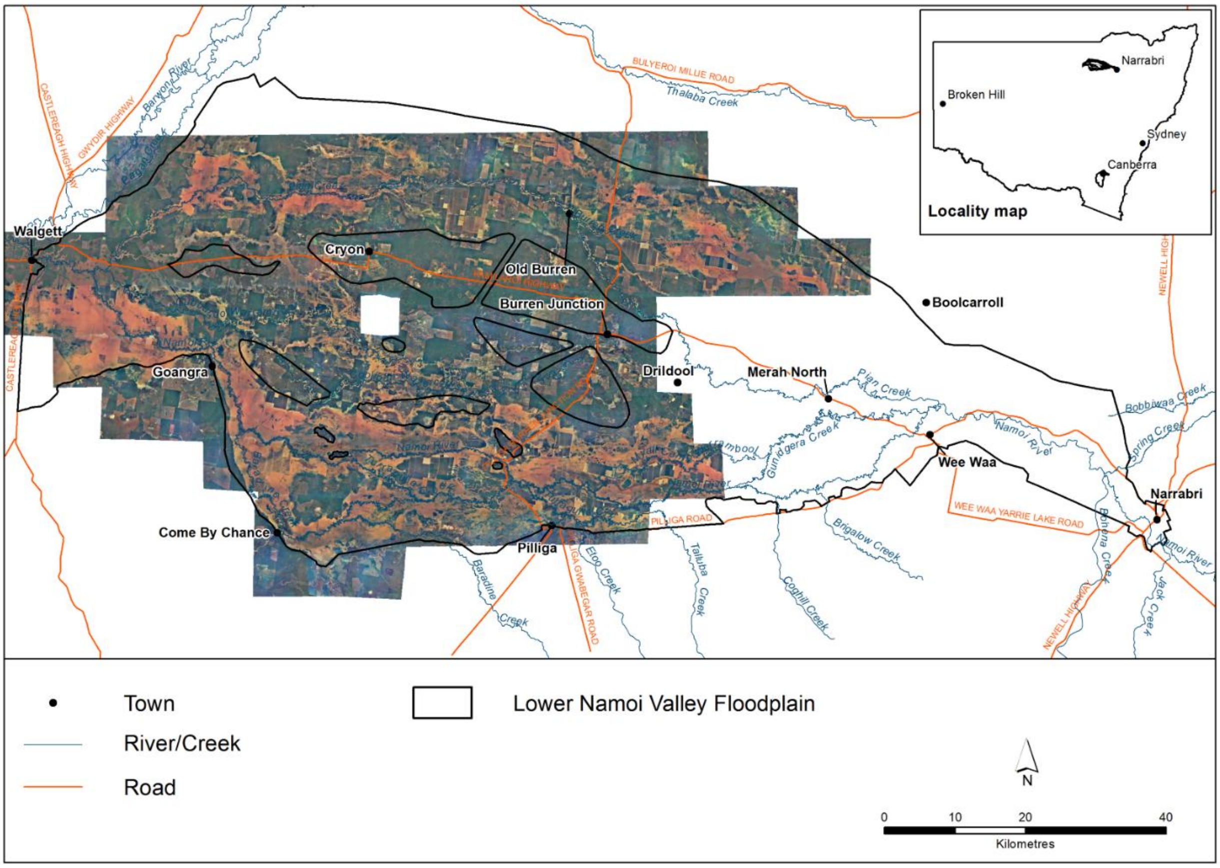


Figure A6.10. Mosaic of aerial photos of a flood event captured on 1 August 1998

Appendix 7: Non-flood-dependent vegetation types

There are 14 non-flood-dependent plant community types (PCTs) identified in the Lower Namoi Valley Floodplain (OEH 2015). See Table A7.1.

Table A7.1. Non-flood-dependent PCTs in the Lower Namoi Valley Floodplain

Number	PCT name	PCT number
1	Weeping myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South bioregion	27
2	Brigalow–Belah open forest/woodland on alluvial, often gilgai clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South bioregion	35
3	Mitchell grass grassland—chenopod low open shrubland on floodplains in the semi-arid (hot) and arid zones	43
4	Belah woodland on alluvial plains and low rises in the central NSW wheat belt to Pilliga and Liverpool Plains regions	55
5	Poplar Box–Belah woodland on clay-loam soils on alluvial plains of north-central NSW	56
6	Pilliga Box–White Cypress Pine–Buloke shrubby woodland in the Brigalow Belt South bioregion	88
7	Poplar Box–Yellow Box–Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South bioregion	101
8	Western Rosewood–Wilga–Wild Orange–Belah low woodland of the Brigalow Belt South bioregion and eastern Darling Riverine Plains bioregion	145
9	Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	168
10	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheat belt)	244
11	White Cypress Pine–Narrow-leaved Ironbark–White Bloodwood–red gum shrub grass woodland of the Pilliga–Coonabarabran region, Brigalow Belt South bioregion	396
12	Poplar Box–White Cypress Pine shrub grass tall woodland of the Pilliga–Warialda region, Brigalow Belt South bioregion	397
13	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
14	Buloke–White Cypress Pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, Brigalow Belt South bioregion	411

Appendix 8: Groundwater recharge

The majority of the proposed Lower Namoi Valley Floodplain overlies the Lower Namoi Groundwater Source, extending approximately 100 km downstream from Narrabri to Walgett. The Lower Namoi Groundwater Source (Lower Namoi Alluvium) is an alluvial fan system associated with the Namoi River and its tributaries (Department of Land and Water Conservation, DLWC, 2000).

The majority of extraction from the Lower Namoi Alluvium is occurring between Narrabri and Cryon, where good-quality, high-yielding groundwater occurs (DLWC 1999; Smithson 2009).

Across most of the Lower Namoi Alluvium, two aquifer systems are identified: a shallow and a deep system. These sand and gravel beds are generally separated by a thick sequence of clay. In some areas to the east, there is no discernible difference between the identified aquifer systems, and they act as a single aquifer.

The shallow aquifer occurs to approximately 40 m depth and generally has lower bore yields than the deeper system and is used mostly for stock and domestic purposes.

The deeper system is the most extensive over the area and generally occurs from 40 m to 90 m depth. A third system, the palaeochannel, occurs in the northern part of the water source, generally below 90 m down to approximately 120 m deep (DLWC 2000).

The Lower Namoi Valley Floodplain also overlies the Great Artesian Basin Surat Groundwater Source in the southwest and the Eastern Recharge Groundwater Source in small sections in the east.

Water sharing plans (WSPs) covering these three groundwater sources that have been prepared and adopted in the proposed Lower Namoi Valley Floodplain include the:

- WSP for the Upper and Lower Namoi Groundwater Sources 2019 (472,600 ha, or 83%, of the floodplain)
- WSP for the NSW Great Artesian Basin Groundwater Sources 2008 (1,400 ha, or less than 1%, of the floodplain)
- WSP for the NSW Great Artesian Basin Shallow Groundwater Sources 2011 (96,600 ha, or 17%, of the floodplain).

See Figure A8.1.

Groundwater recharge to the alluvial aquifer system may occur via:

- rainfall infiltration
- leakage from rivers, weir pools and on-farm storages
- infiltration from natural floods as well as irrigation releases
- flow from surrounding aquifers (Barrett 2011; Lamontagne et al. 2011).

A status report is available for the Lower Namoi Groundwater Source: *Groundwater Management Area 001—Groundwater Status Report 2008* (Smithson 2009). Groundwater status reports describe the physical state of the resources for different areas, provide information on groundwater licensing and use, and discuss the response of the groundwater system to variability in groundwater use and rainfall.

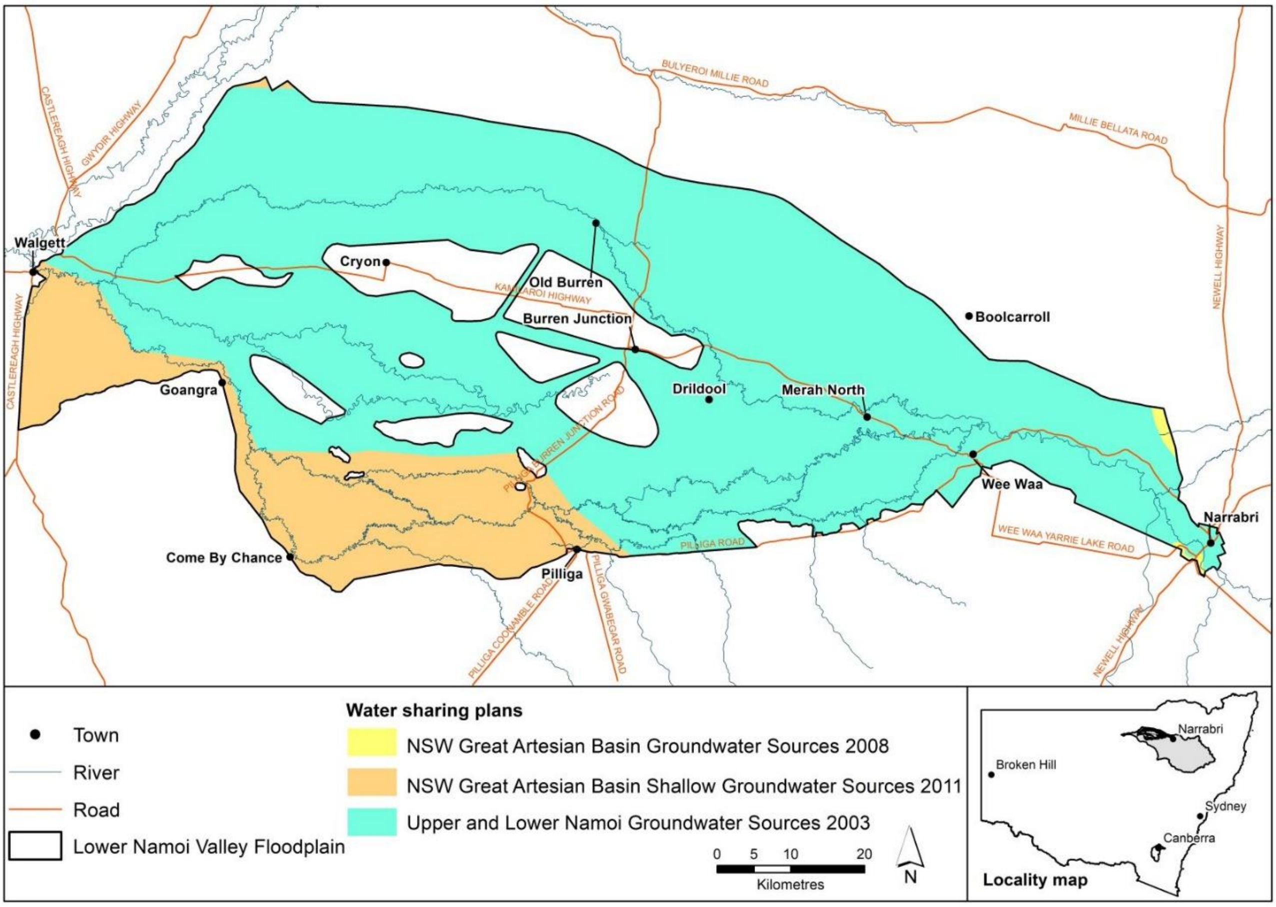


Figure A8.1. WSPs for groundwater sources in the Lower Namoi Valley Floodplain

The status report for the Lower Namoi Groundwater Source does not identify groundwater recharge areas.

The report notes that the WSP allows for an estimated average annual recharge of 86,000 ML per year (Smithson 2009). It also describes groundwater levels:

> Groundwater levels are generally shallower at the eastern, upper end of the catchment. At Narrabri they are around 4–12 m below ground level in the deep and shallow aquifers. Groundwater levels in both aquifers become progressively deeper towards the west and are around 25–34 m below ground level at Cryon.

A groundwater resource map for Narrabri compiled and published in 1988 by the NSW Department of Water Resources—Hydrogeology Unit is available (Hydrogeological series sheet SH 55-12). It includes mapped information on aquifers, groundwater management areas, and groundwater salinity and yield of the surficial aquifer systems.

There is very limited information available on areas of groundwater recharge in the Lower Namoi Valley Floodplain. It is therefore not appropriate to make management decisions for the Lower Namoi FMP 2020 based on areas of groundwater recharge.

If new information on flood-sourced groundwater recharge areas becomes available, the Lower Namoi FMP 2020 may need to be reviewed to ensure that these areas are adequately considered in the design of the management zones and rules.

Appendix 9: 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 predefined 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 the Qmarxan plugin (Apropos Information Systems 2013) executed within Quantum GIS Version 1.8.0 software (QGIS Development Team 2013). The hexagonal shape was selected over other shapes, as it has been shown to produce more efficient and less fragmented planning portfolios (Nhancale and Smith 2011). The 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. This forms the basic Marxan data matrix. Where some areas must be conserved, Marxan can be parameterised to ‘lock in’ (that is, planning units may be forced into the final solution before the algorithm is run). Or, where appropriate, Marxan can be parameterised to exclude them from the final solution (that is, the planning unit may not be considered in the final solution) using status codes. For example, wetlands of national importance in the Upper Namoi Valley FMP 2019, such as Lake Goran, were fixed into the solution (Australian Government—Department of the Environment 2015).

Appendix 10: Marxan prioritisation (targets for ecological surrogates)

Ecological surrogates were identified using environmental data recommended by specialists during 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 and Pressey 2000). Targets were selected for each of the ecological surrogates during a TAG meeting on 27 February 2014 with local experts.

Area-based datasets (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, provided habitat to flood-dependent animals or both.

Target setting for area-based surrogates was initiated at 30% of the predevelopment 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 type—that is, greater than 70% of that vegetation type in the former Border Rivers—Gwydir Catchment Management Authority region had been cleared. The coolibah–black box woodland is also listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (Threatened Species Scientific Committee 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 extents of flood-dependent forest/woodland (wetland) communities were restricted in their distribution to narrow riparian corridors along the Namoi River and Baradine Creek in the Lower 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. 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 on 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 datasets (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. SDMs provide a powerful way of overcoming sparseness of point-based animal 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 animals that are associated with standing water (that is, 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 A10.1).

Table A10.1 Targets for area-based ecological surrogates (animal species distribution models)

Asset types	Description	Total area (ha)	Target (% of sites)	Fixed in solution	Rationale
Frog	Barking marsh frog (*Limnodynastes fletcheri*)	25,8997	10	No	The realised niche is likely to be a subset of the modelled areas.
Frog	Broad-palmed frog (*Litoria latopalmata*)	27,1705	10	No	The realised niche is likely to be a subset of the modelled areas.
Frog	Desert tree frog (*Litoria rubella*)	26,1842	10	No	The realised niche is likely to be a subset of the modelled areas.
Frog	Eastern sign-bearing froglet (*Crinia parinsignifera*)	75,119	10	No	The realised niche is likely to be a subset of the modelled areas.
Turtle	Eastern snake-necked turtle (*Chelodina longicollis*)	232,503	10	No	The realised niche is likely to be a subset of the modelled areas.
Turtle	Macquarie turtle (*Emydura macquarii*)	286,639	10	No	The realised niche is likely to be a subset of the modelled areas.
Turtle	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 calculations were used to assess plot sensitivity (or true positives) against specificity (or false positives) for a range of threshold values. The area under the curve provided 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 A10.2. Environmental variables used to fit SDMs 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 9 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 and Administration 2014

Point-based occurrence data (animals)

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

- 11 species of fish
- 7 species of frogs
- 5 species of amphibious reptiles
- 2 species of mammal[2].

These animal 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 animal observations were sourced from the *NSW Wildlife Atlas* (NSW BioNet www.bionet.nsw.gov.au) and the *Atlas of Living Australia* (www.ala.org.au). The search method was restricted to the Namoi Catchment Management Authority for post-1980 records and

[2] Waterbird observations were excluded from the prioritisation. Due to the birds' 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.

filtered to consider only records that were on the Namoi floodplain. Any data with a spatial accuracy of less than 100 m or an association with a human artefact, such as a farm dam, was removed from the analysis. The watering requirements of all species recorded in the study area were examined (Tables A10.3 to A10.6).

All point-based occurrence surrogates were given 100% targets, as the number of records did not cover a large part of the landscape (Tables A10.3 to A10.6). It was important to include the small number of sites where these wetland indicator species were known to occur.

Table A10.3. Fish targets for point-based ecological surrogates

Fish species	Rationale for selection	Number of records
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 life cycle of the bony herring is mostly within the main channels of generalist 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 and 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 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).	15
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 in-stream habitat, such as rocks, stumps and fallen trees (Humphries et al. 1999; King 2004; Koehn and Harrington 2005; Lintermans 2009). Flows are important factors 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 in-stream 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 in lowland and slope waterways in 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).	8

Fish species	Rationale for selection	Number of records
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). They are wetland opportunists, as they spawn and recruit in floodplain wetlands, as well as in 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 as both wetland and low-flow opportunists, because they tend to spawn and recruit during low flows and use the main channels, floodplain wetlands and secondary channels (Young et al. 2003).	40

Table A10.4. Frog targets for point-based ecological surrogates

Frog species	Rationale for selection	Number of records
Barking marsh 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. It occupies a range of habitats, including flood-dependent river red gum and black box (Wassens 2010). This species is restricted to permanent and semipermanent waters (Anstis 2013).	8
Common eastern froglet *Crinia signifera*	The common eastern froglet occurs in permanent and semipermanent rivers and wetlands. This species is also associated with human-made dams and infrastructure (Wassens 2010). It favours water couch habitat and may prefer to breed in deep and permanent pools (Lintermans and Osborne 2002; OEH 2012).	3
Desert tree frog *Litoria rubella*	The desert tree frog prefers temporary water bodies and relies on spring and summer floods to create suitable breeding habitat (Wassens 2010). Males call from grass tussocks or vegetation near water (Anstis 2013).	9
Eastern sign-bearing froglet *Crinia parinsignifera*	Occurs in rain-fed depressions, semipermanent wetlands, oxbow lagoons, creeks and rivers, and human-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*	The spotted grass frog prefers situations with considerable flooded vegetation, such as tussocks and sedges (Lintermans and 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

Table A10.5. Reptile targets for point-based ecological surrogates

Reptile species	Rationale for selection	Number of records
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 and Hodges 2014).	4

Reptile species	Rationale for selection	Number of records
Eastern snake-necked turtle *Chelodina longicollis*	The eastern snake-necked turtle is found in a range of freshwater aquatic environments, from shallow, ephemeral wetlands to permanent rivers (Kennett et al. 2009). Changes in river flows and in-stream 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 often basks 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 also eats reptiles and small mammals (Ayers et al. 2004; Cogger 2000).	3

Table A10.6. Mammal targets for point-based ecological surrogates

Mammals	Rationale for selection	Number of records
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). They are less common in the rivers and streams of the western slopes of the Great Dividing Range (Grant 1982); however, they are reported to occur in streams flowing through agricultural land in these areas (Lunney et al. 2004). Their dependency on water bodies places them 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 over three kilometres 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 A10.4). These wetlands were identified in local floodplain management plans' records and from previous studies (DNR 2005; Green and Dunkerley 1992).

Table A10.4. Point-based wetlands and their targets, including wetlands identified in existing FMPs

Surrogate	Number	Target (% of sites)
Wetlands and lagoons identified in Caroona–Breeza FMP	2	100
Wetlands and lagoons identified in Narrabri to Wee Waa FMP	21	100
Treloar Springs/Terda Spring	1	100
Emu Hole, Bunda Wallah Waterhole	2	100

Surrogate	Number	Target (% of sites)
Sludge Hole Lagoon/Coolibah Swamp	1	100
Lagoons (Inland Rural Flood Group, OEH)	91	100
Wetlands of the Namoi Valley (Green and Dunkerley 1992)	77	100

Appendix 11: 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 using 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).

NSW land capability classes were used as a surrogate for inundation likelihood to derive the constraint surface for the Namoi Valley plans (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 A11.1 and Figure A11.1).

Table A11.1. 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 of the constraint value to give each planning unit a single value (Figure A11.1).

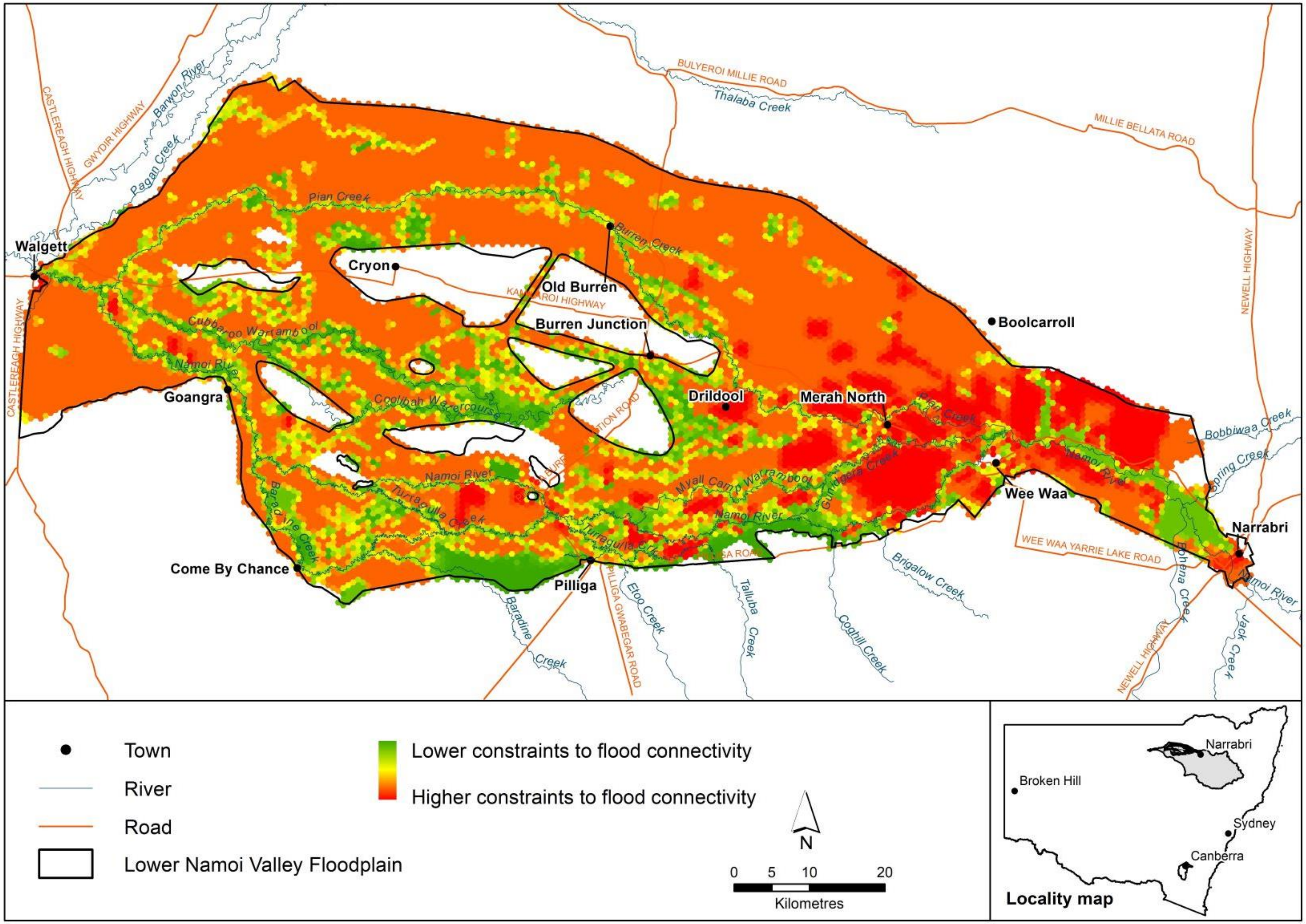


Figure A11.1. Constraint surface for the Lower Namoi Valley Floodplain

Appendix 12: Aboriginal values and water

Cultural flows

Aboriginal people view themselves as an inherent part of the river system. A holistic understanding of how water is connected to the land and rivers and the connection that Indigenous people feel to river systems feeds a strong feeling of responsibility for the health of rivers and floodplains. The Murray Lower Darling Rivers Indigenous Nations and Northern Basin Aboriginal Nations (NBAN) define cultural flows as ‘water entitlements that are legally and beneficially owned by the Indigenous Nations and are of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous Nations. This is our inherent right’. Cultural flows are being integrated into water planning and management.

Work is currently being undertaken by the National Cultural Flows Planning and Research Committee to improve our knowledge of cultural flows, including Indigenous water values and uses, and volumes of water that provide for those values and uses. Cultural flows may improve the health and wellbeing of Aboriginal people and empower Aboriginal communities to care for their country and undertake cultural activities.

This body of work was instigated by NBAN. NBAN is a confederation of 24 member Nations that has advised and advocated on behalf of Ancestral Owners for several years. Its sister organisation, the Murray Lower Darling Rivers Indigenous Nations has produced a document called the *Echuca Declaration,* which is where the adoption of the term ‘cultural flows’ comes from. Both organisations ratified the meaning in 2011, providing the aforementioned consistent definition right across the whole Murray–Darling Basin.

The Lower Namoi Valley FMP 2020 does not address cultural water. However, cultural water will likely be a component of the WSPs being prepared by the department.

Aboriginal Water Initiative

The First Peoples’ Water Engagement Council (FPWEC) was established to provide advice to the former National Water Commission on national Indigenous water issues. The May 2012 advice set the overarching policy framework, including that:

- there must be an Aboriginal water allocation in all water plans
- Aboriginal people are engaged in decision-making, planning and management
- Aboriginal access to water for cultural and economic purposes is mandatory.

The FPWEC also sought to establish and implement a national Aboriginal water strategy through the Council of Australian Governments. The FPWEC ended its tenure in 2012, and an Indigenous Water Advisory Council was formed to carry on the initial work of the FPWEC at a national level.

An Aboriginal Water Initiative (AWI) was established in June 2012 to better the involvement and representation of Aboriginal people in water planning and management in NSW. The initiative allowed the department to start monitoring the success of WSPs in meeting their statutory requirements for performance indicators specific to Aboriginal people, including providing water for Native title rights. The AWI ended in 2017, and internal departmental staff have carried on the work of the initiative in NSW.

All cultural values and features identified through the AWI in the making of the Lower Namoi Valley FMP 2020 have been added to the Aboriginal Heritage Information Management System (AHIMS).

The FMP includes provisions that the AHIMS database be consulted as part of the assessment and approval process of all flood work applications.

Appendix 13: 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. The first is landscape visualisation through the provision of visual products (geospatial layers) that fill in data gaps in the AHIMS data. The other is 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 (see further information on the ASDST website (www.environment.nsw.gov.au/research-and-publications/our-science-and-research/our-research/aboriginal-sites-decision-support-tool).

Landscape visualisation tool

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

- the original (precolonisation) 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 (geospatial layers, numerical reports and interpretive documents) that can be used to support regional planning for Aboriginal site heritage. The tool uses 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 Lower Namoi Valley FMP 2020, the ASDST was used as a context-setting tool to inform where there may be areas of potential flood-dependent sites, and where there are 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 cultural values.

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
- avoid and minimise the impacts of flood works on other water users
- minimise the existing and future flood risk to human life and property arising from occupation on floodplains.

The Lower Namoi Valley FMP 2020 contains management zones and rules that provide an equitable and consistent approach to controlling development on the floodplain. The management zones and rules are 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 has informed the development of management zones and rules for the floodplain (steps 7, 8 and 9 outlined in Appendix 1). Information from this profile is also drawn upon in the socio-economic impact analysis (step 10, see Appendix 1) that identifies and considers the potential socio-economic impacts associated with the implementation of the FMP. The socio-economic impact analysis has been undertaken in coordination with the development of management zones and rules for the Lower Namoi Valley Floodplain.

Study area geography

There are several geographies that are relevant to the socio-economic discussion of water management within the Lower Namoi Valley Floodplain. These geographies are described in detail below.

The Lower Namoi Floodplain Economy

The Lower Namoi Floodplain Economy (Figure A14.1) area includes the Lower Namoi Rural and Urban Floodplains as well as the adjacent areas that engage with the economy of the region. This area extends from Narrabri in the east across to Walgett. Most goods and services consumed in the Lower Namoi Floodplain Economy area are sourced from the regional centre of Narrabri, or the small townships in this area.

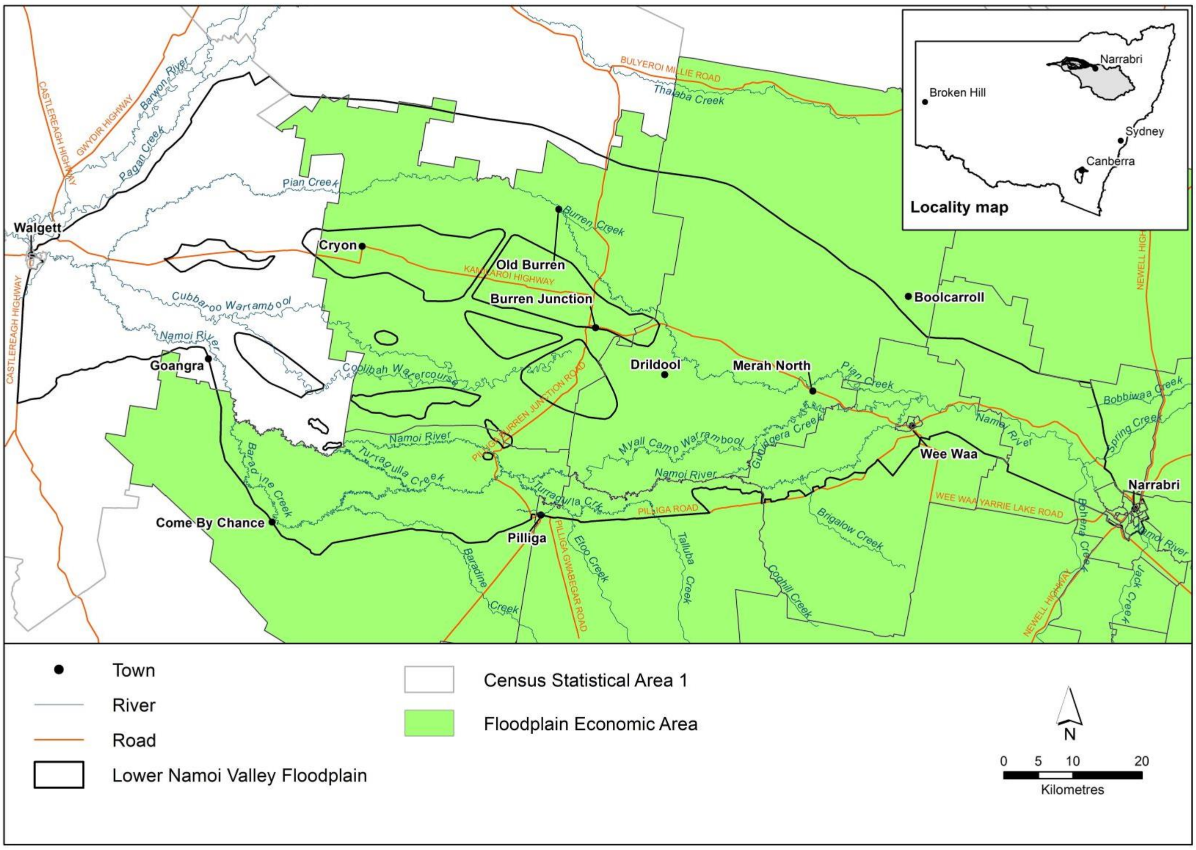


Figure A14.1 Lower Namoi Valley Floodplain and the Floodplain Economy area (Source: Based on ABS data, ABS 2011b)

The Lower Namoi Rural Floodplain

The Lower Namoi Rural Floodplain (Figure A14.2) is the rural area that follows the Namoi River from near the town of Narrabri across to Walgett. This area is the Lower Namoi Rural Floodplain and will be directly impacted by the Lower Namoi Valley FMP 2020. 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.

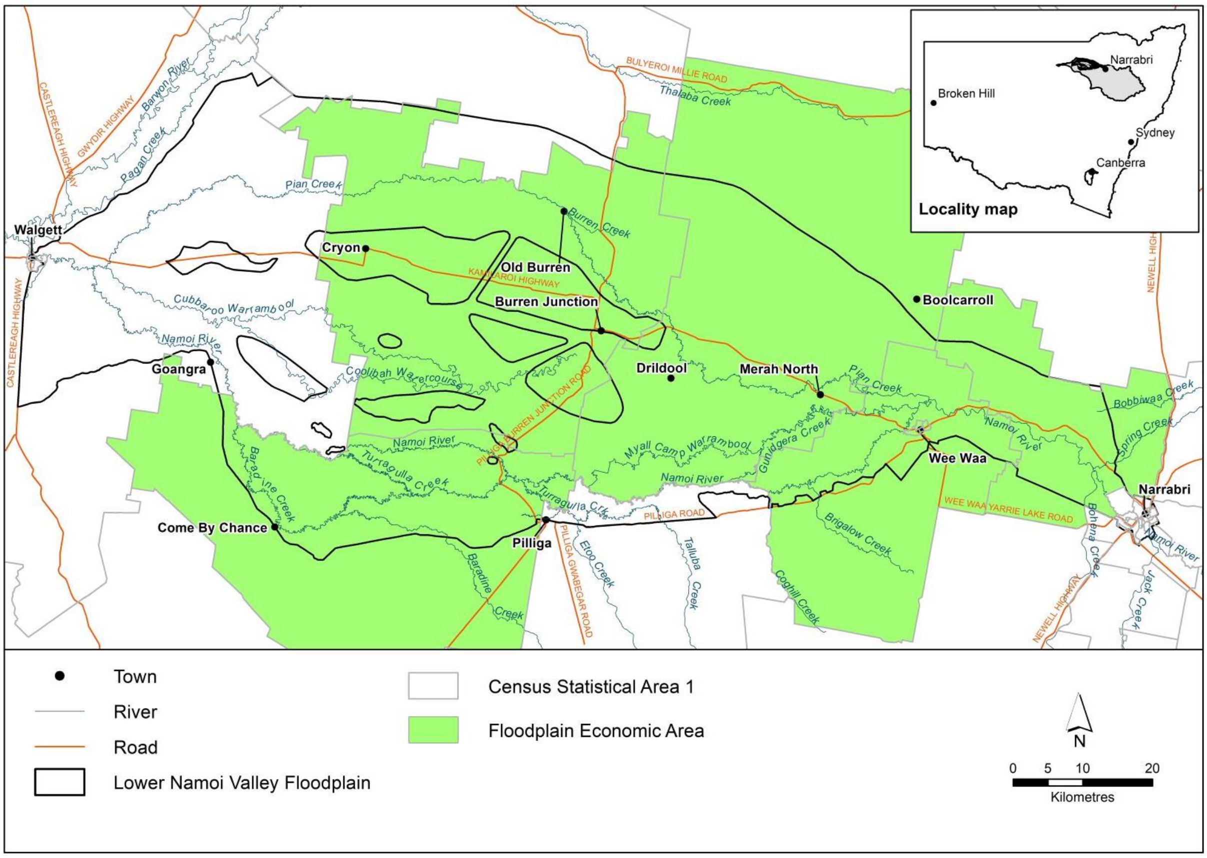


Figure A14.2 Lower Namoi Valley Floodplain and the Rural Floodplain area (Source: Based on ABS data, ABS 2011b)

The Lower Namoi Urban Floodplain

The regional centre of Narrabri and the township of Wee Waa constitute the third area, the Lower Namoi Urban Floodplain. While this area is situated on or adjacent to the floodplain and is affected by floodwater, floodwater management is provided for under the *Local Government Act 1993*. The communities that live in these towns are reliant upon the surrounding rural floodplain areas both as a source of employment and as a consumer of services.

Data sources

Data for the Lower Namoi Valley Floodplain Economy, the Lower Namoi Rural Floodplain and the Lower 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[3]. The boundaries closely align with the boundary of the Lower Namoi Valley Floodplain Economy area and those of the Rural and Urban Floodplain areas. The SA1 areas referenced to calculate values for the Lower Namoi Rural Floodplain are presented in Figure A14.2. Regional population trends for the Narrabri and the Walgett local government areas (LGAs) have been drawn from the ABS Regional Population Growth 2013 data (ABS 2016). These population trends are presented in Figure A14.4.

[3] Statistical Areas Level 1 (SA1s) have been designed as the smallest unit for the release of ABS Census data. SA1s generally have a population of 200 to 800 people, and an average population of about 400 people. They are built from whole mesh blocks, and there are approximately 55,000 SA1s covering the whole of Australia (ABS 2014).

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 (IRSAD) scores are mapped and presented in Figure A14.4.

Agricultural production 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 three regions that partially cover the Lower Namoi Valley Floodplain agricultural region: Narrabri, Narrabri Region and Walgett–Lightning Ridge regions. SA2 areas represent a community that interacts socially and economically[4]. The SA2 areas used to describe the agriculture of the Lower Namoi Valley FMP 2020 area are presented in Figure A14.3.

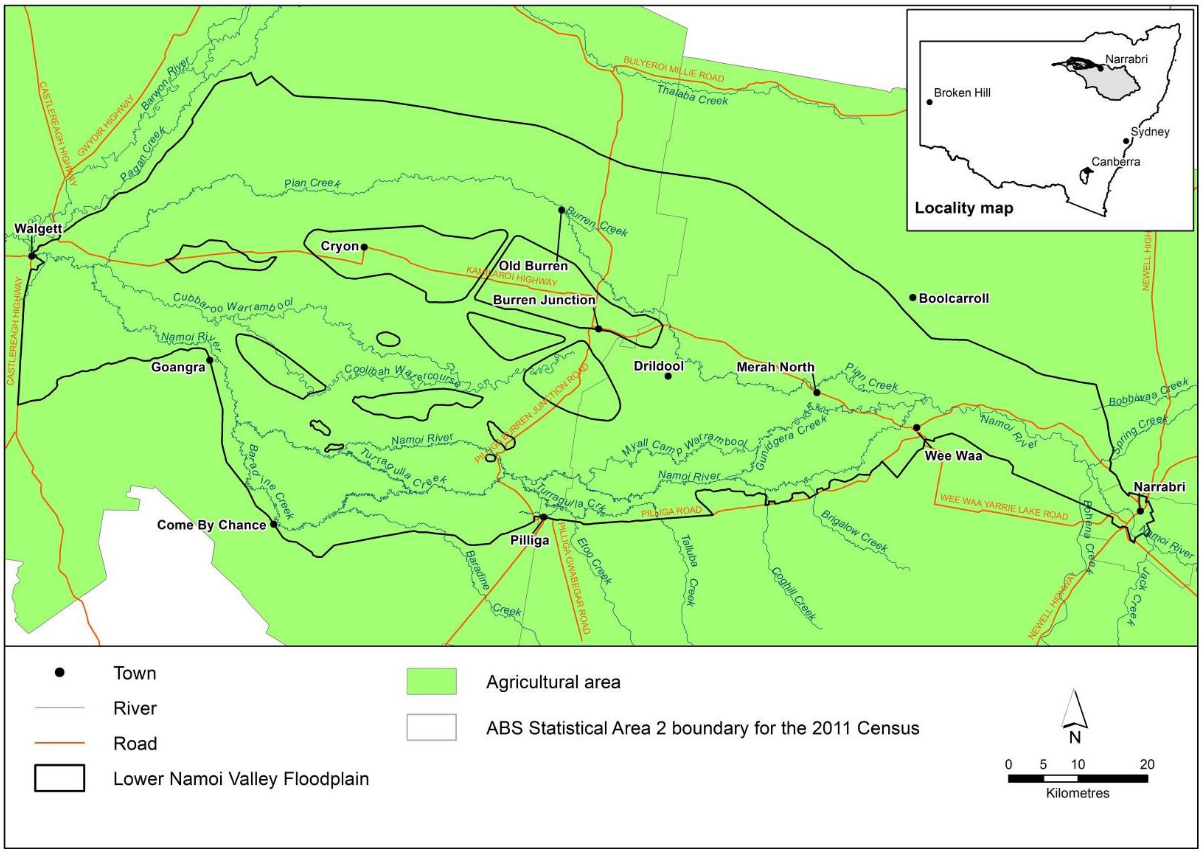


Figure A14.3 Lower and Upper Namoi Valley Floodplains and the Namoi agricultural region (Source: Based on ABS data, ABS 2011b)

Demographic profiles

Regional populations have stabilised over recent years with the estimated population for the Narrabri LGA recovering slightly. Regional population trends since 2004 for the Narrabri and Walgett LGAs are presented in Figure A14.4.

[4] Statistical Areas Level 2 (SA2s) are a general-purpose medium-sized area built from whole SA1s. Their aim is to represent a community that interacts together socially and economically. SA2s generally have a population range of 3,000 to 25,000 people, and have an average population of about 10,000 people. There are 2,196 SA2s covering the whole of Australia (ABS 2014).

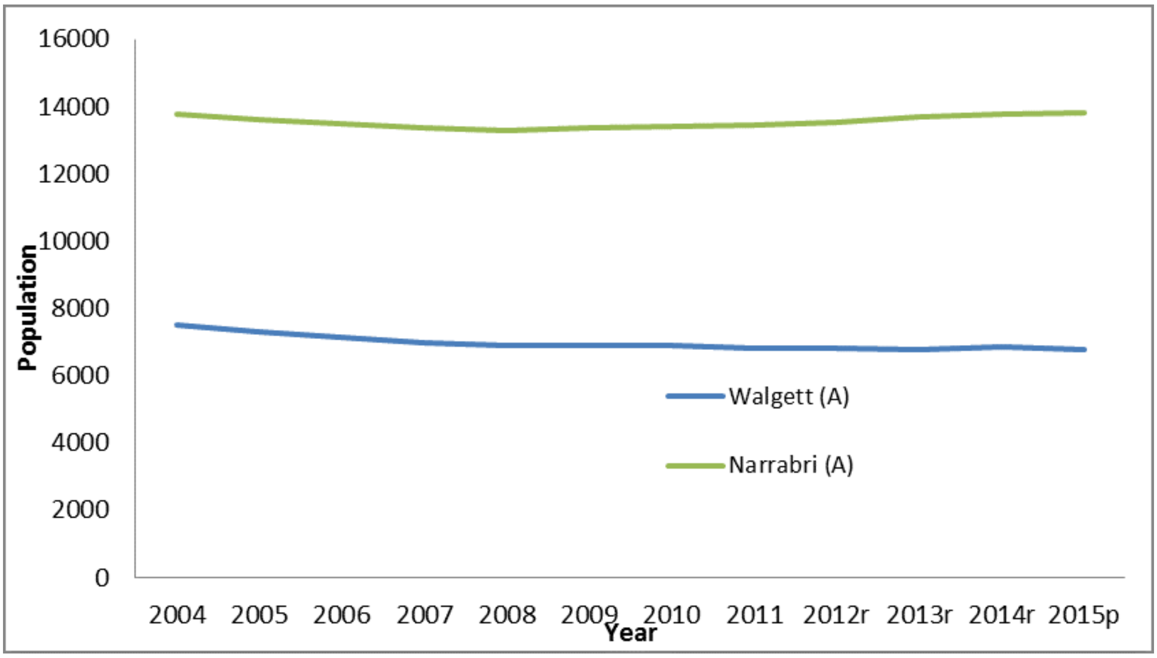


Figure A14.4 Regional population trend by LGA 2004–14 (Source: Based on ABS data, ABS 2016)

Lower Namoi Floodplain Economy

The population of the Lower Namoi Floodplain Economy area (Figure A14.1) is estimated to be 9,270 people, of whom 72% live in towns. The major towns of this area are Narrabri and Wee Waa. The total of the overall Lower Namoi Floodplain Economy population does not equal the total of the Lower Namoi Rural and Lower Namoi Urban Floodplain populations, as the boundary of the Lower Namoi Floodplain Economy area includes areas in addition to the Rural and Urban Floodplain areas (see Figure A14.1 and Figure A14.2).

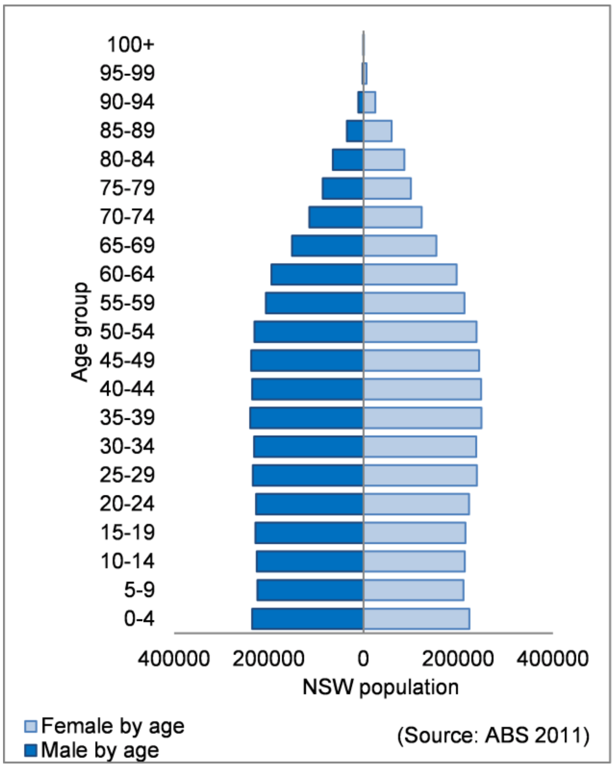
The Indigenous community makes up 12.5% of the Lower Namoi Floodplain Economy population, which is substantially higher than the NSW state proportion of 2.5%.

There is almost the same number of males and females living in the Lower Namoi Floodplain Economy area; the sex ratio (the number of males per 100 females) is 101.1.

The dependency ratio of the Lower Namoi Floodplain Economy, a measure of the number of the population that is not of working age per 100 persons of working age (aged 15–64) is 62. 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 15–39 age groups, compared with the under-15 and over-40 age groups and compared with NSW. This under-representation is demonstrated to a greater extent in the Rural Floodplain.

The age by sex distribution of NSW and the age by sex distribution of the Lower Namoi Floodplain Economy is presented in Figure A14.5.



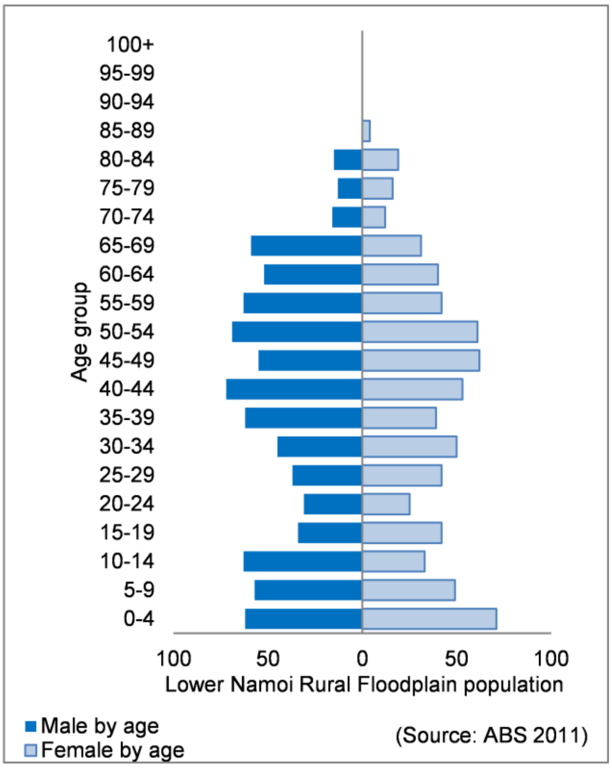


Figure A14.5 NSW (left) and Lower Namoi Rural Floodplain (right) population by age group and sex

The Lower Namoi Rural Floodplain

The estimated population of the Lower Namoi Rural Floodplain is 1,500 people, calculated on the area of 759,157 ha. The population density of the Rural Floodplain is estimated to be 20 people per square kilometre.

The Indigenous proportion of this community is 14.0%, which is almost six times that of the NSW community at 2.5%. There are more males than females in this population, with the sex ratio of 116.5 considerably higher than the NSW state sex ratio of 97.2. The dependency ratio of the Lower Namoi Rural Floodplain is 53. However, as discussed regarding the dependency ratio calculated for the Lower 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 15–39 age groups (see Figure A14.5). 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 Lower Namoi Rural Floodplain is also presented in Figure A14.5.

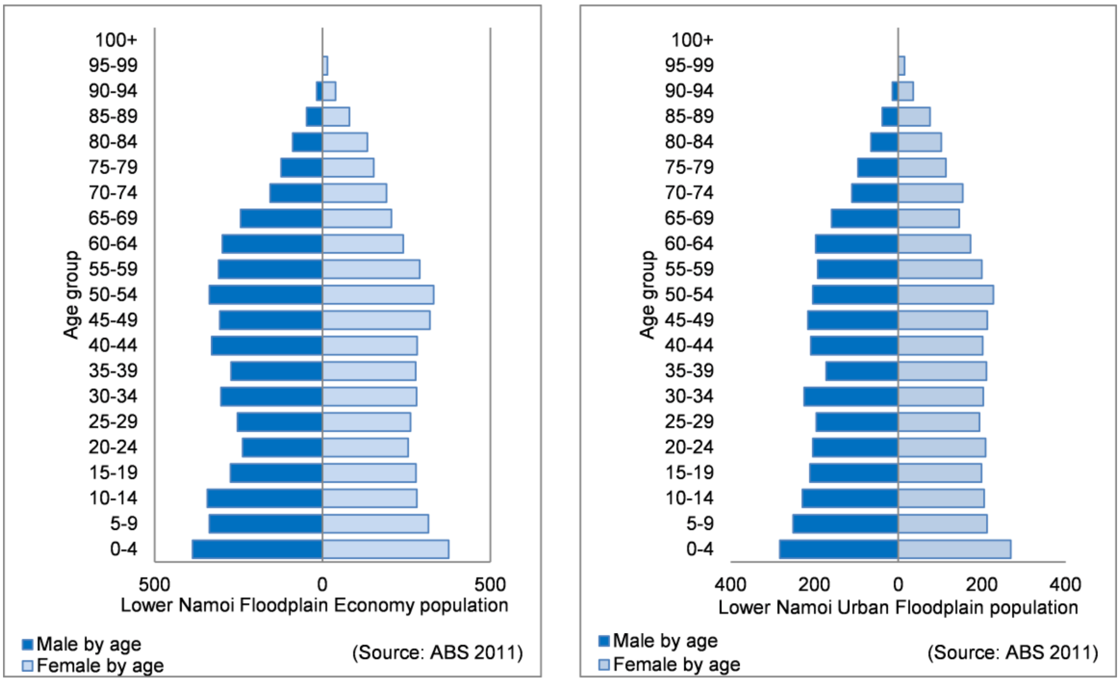


Figure A14.6 Lower Namoi Floodplain Economy (left) and Lower Namoi Urban Floodplain (right) population by age group and sex 2011

The Lower Namoi Urban Floodplain

The Lower Namoi Urban Floodplain has a population of 6,633 people across 28,100 ha. The population density of the Rural Floodplain is estimated to be 220 people per hectare.

The Indigenous community constitutes 14.3% of the community, which is similar to the Rural Floodplain proportion of 14.0% but much larger than the NSW proportion of 2.5%.

The sex ratio of the Lower Namoi Urban Floodplain is 97.4, which is lower than the Rural Floodplain and similar to the NSW state sex ratio.

The dependency ratio is 63, higher than the adjacent Rural Floodplain community dependency ratio of 53 and higher than the NSW state dependency ratio of 51.

The age by sex distribution of the Lower Namoi Urban Floodplain is presented in Figure A14.6. It is interesting to note that the urban community does not reflect the same degree of under-representation in the 15–39 age groups as observed in the rural community.

Household income

Lower Namoi Floodplain Economy

The weekly household income in the Lower Namoi Floodplain Economy closely correlates with that of the Lower Namoi Urban Floodplain, with 72% of the population living in the townships. The proportion of low-income households in the Lower Namoi Floodplain Economy, at 31%, is greater than the NSW state proportion of 23%. The medium-income proportion of 59% in the Lower Namoi Floodplain Economy is marginally greater than the NSW proportion of 56%. Consequently, the high-income household proportion of 10% is lower than the NSW state proportion of 22%.

The weekly household income proportions for NSW and for the Lower Namoi Floodplain Economy, Rural Floodplain and Urban Floodplain, are presented in Figure A14.7.

The Lower Namoi Rural Floodplain

The Lower Namoi Rural Floodplain households in 2011 are slightly less prosperous compared with their NSW state counterparts, with fewer households in the high-income category. The number of households with weekly incomes of more than $2,500 is 15%, compared with 22% for NSW. The rural floodplain proportion of households in the medium-income range ($600 to $2,499 per week) at 59% is above the NSW state proportion of 56%. The low-income proportion of 24% is similar to the state proportion of 23%.

The Lower Namoi Urban Floodplain

The Lower Namoi Urban Floodplain community has a higher proportion of low-income (33%) and slightly higher proportion of medium-income (58%) households than the NSW state, and consequently a lower proportion (9%) of high-income households.

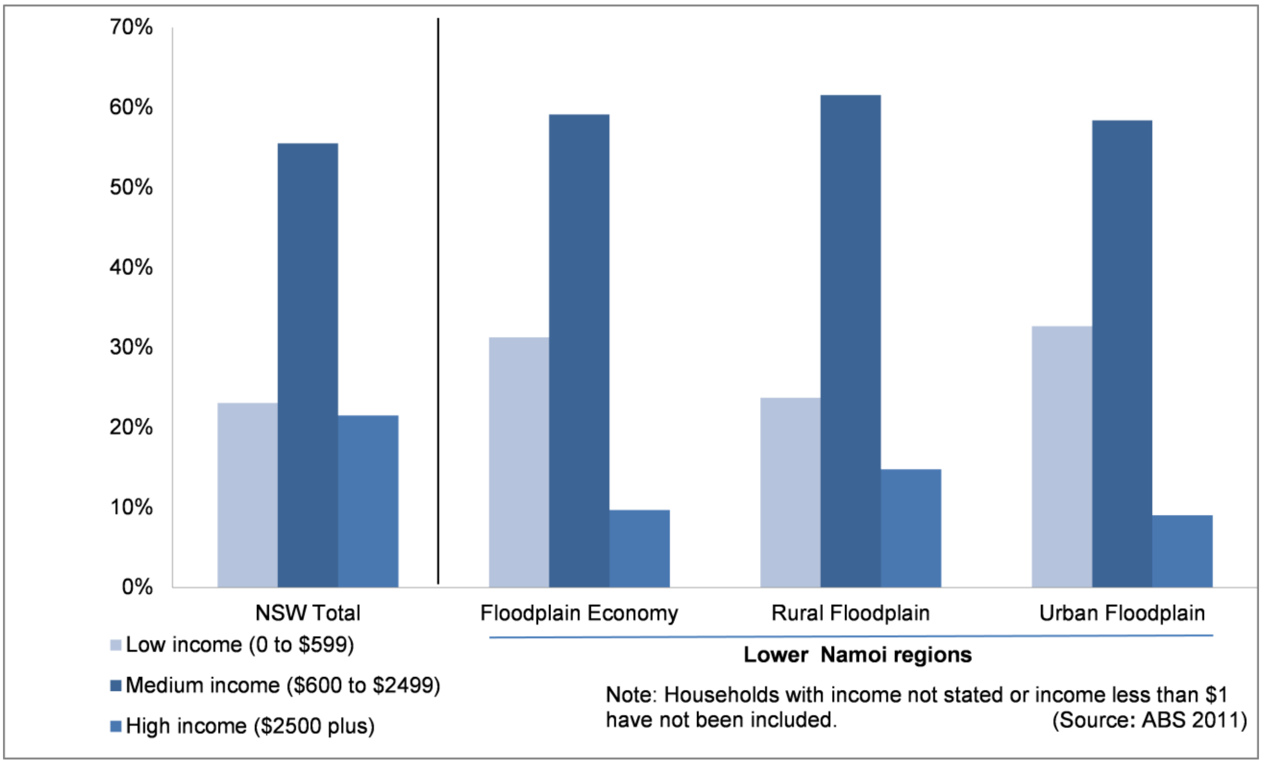
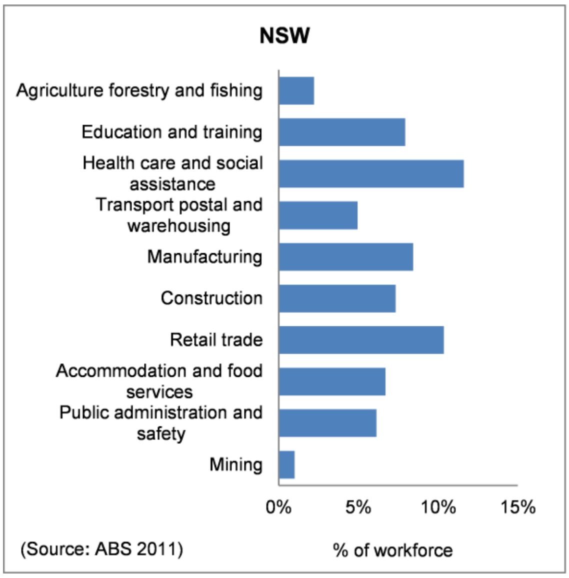


Figure A14.7 Distribution of households in low-, medium- and high-income categories (%)

Employment

Lower Namoi Floodplain Economy

The labour force of the Lower Namoi Floodplain Economy is 4,100 people. The number of people 15 years and above is 7,230. 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 57.1% and is slightly lower than the NSW participation rate of 56.2%. Employment in the Lower Namoi Floodplain Economy is predominantly within the agricultural, forestry and fishing sector, with 25% of employment (1,038 people). In contrast, the NSW state agriculture sector engages 2% of the workforce. There is a relatively even distribution of the remaining 75% of employment among the remaining sectors. The next most significant employment sectors are retail trade and healthcare with 9% of employment. Employment by sector in the Lower Namoi Floodplain Economy and for NSW are presented in Figure A14.8.



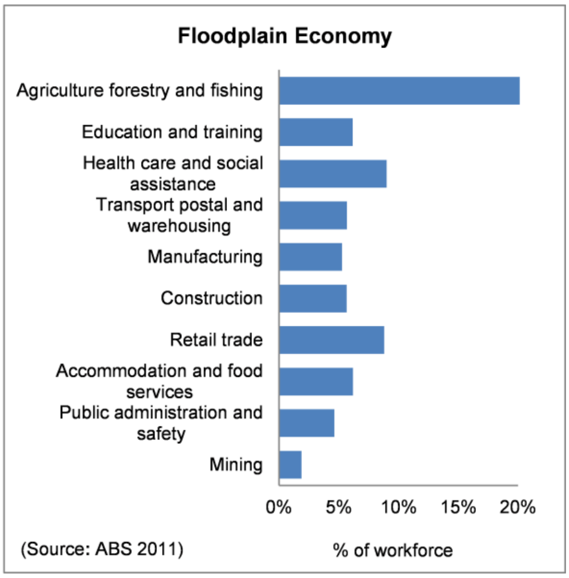


Figure A14.8 NSW employment by industry sector 2011 (left) and Lower Namoi Floodplain Economy employment by industry sector 2011 (right)

The Lower Namoi Rural Floodplain

The labour force of the Rural Floodplain is 810 people. The population 15 years and above is 1,160 people. The labour force participation rate is 69.7%, markedly higher than the NSW participation rate of 56.2%.

Employment in the Lower Namoi Rural Floodplain is dominated by the agriculture, forestry and fishing sector, with 64% of the workforce (516 people) working in the agricultural industry. This is in sharp contrast to the NSW state agriculture sector, which engages only 2% of the workforce (Figure A14.8). The next most significant employment sector of the Lower Namoi Rural Floodplain is healthcare, comprising 5% of the workforce. Employment by sector in the Rural Floodplain is presented in Figure A14.9.

The Lower Namoi Urban Floodplain

The labour force of the Urban Floodplain is 2,810 people. The population 15 years and above is 5,180 people. The labour force participation rate is 54.1%, lower than both the participation rate in the Rural Floodplain and the NSW average.

In contrast with the surrounding rural community, employment in the Lower Namoi Urban Floodplain is reasonably evenly distributed across sectors. A significant proportion of the workforce is employed in the service sector. Retail trade, healthcare and social assistance are the most significant employers, with 11% of the workforce each. This is the same proportion of workers as in the agricultural sector. Employment by sector in the Urban Floodplain is presented in Figure A14.9.

Estimated employment of the Lower Namoi Valley FMP 2020 area

Given the location of the townships, it is likely that at least half of the 1,000 Lower Namoi Urban Floodplain residents employed in the agriculture 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 Lower Namoi Valley FMP 2020 is around 650 people, counting the 510 agriculture workers from the Rural Floodplain and half of the 300 agriculture workers from the Urban Floodplain.

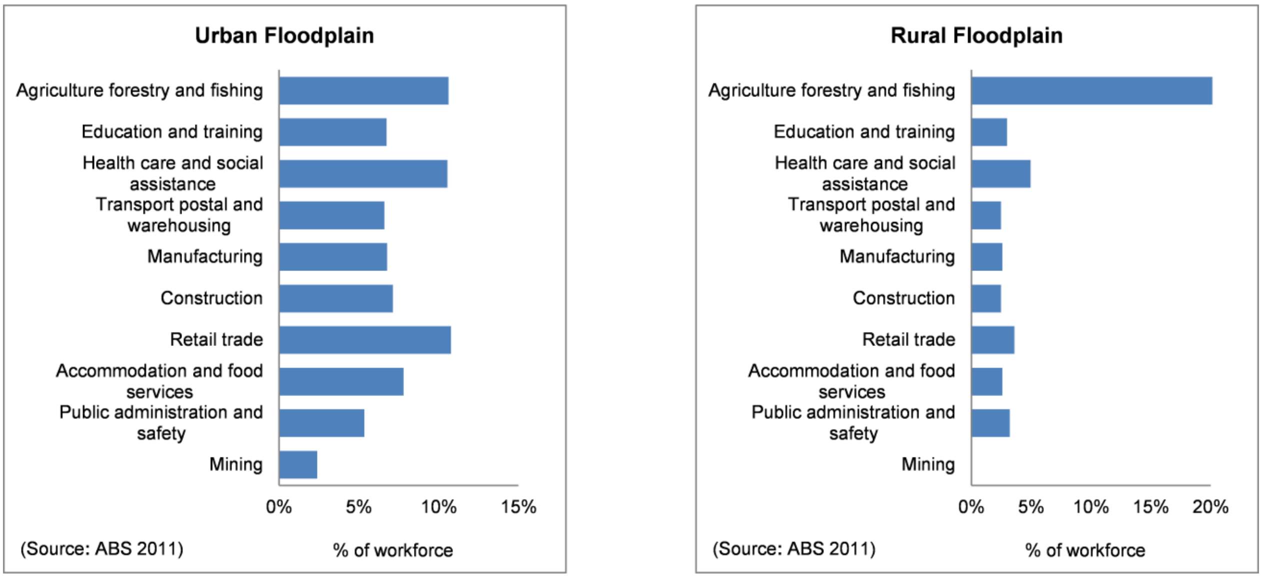


Figure A14.9. Lower Namoi Urban Floodplain (left) and Lower Namoi Rural Floodplain (right) employment by industry sector 2011

Economic wellbeing indicators

Socio-Economic Indexes for Areas 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 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 key regions are:

- LGAs of Narrabri, Narrabri Region and Walgett, which are in the fourth and first decile of NSW, reasonably to most disadvantaged
- The lowest SA1 area score is 685 (decile 1 in the state), which is the SA1 of Walgett.
- The highest scoring area has a score of 1,092 (decile 9 in the state), which is the town of Narrabri (ABS 2011c).

The range and distribution of the IRSAD scores for the floodplain area are presented in Figure A14.10. 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.

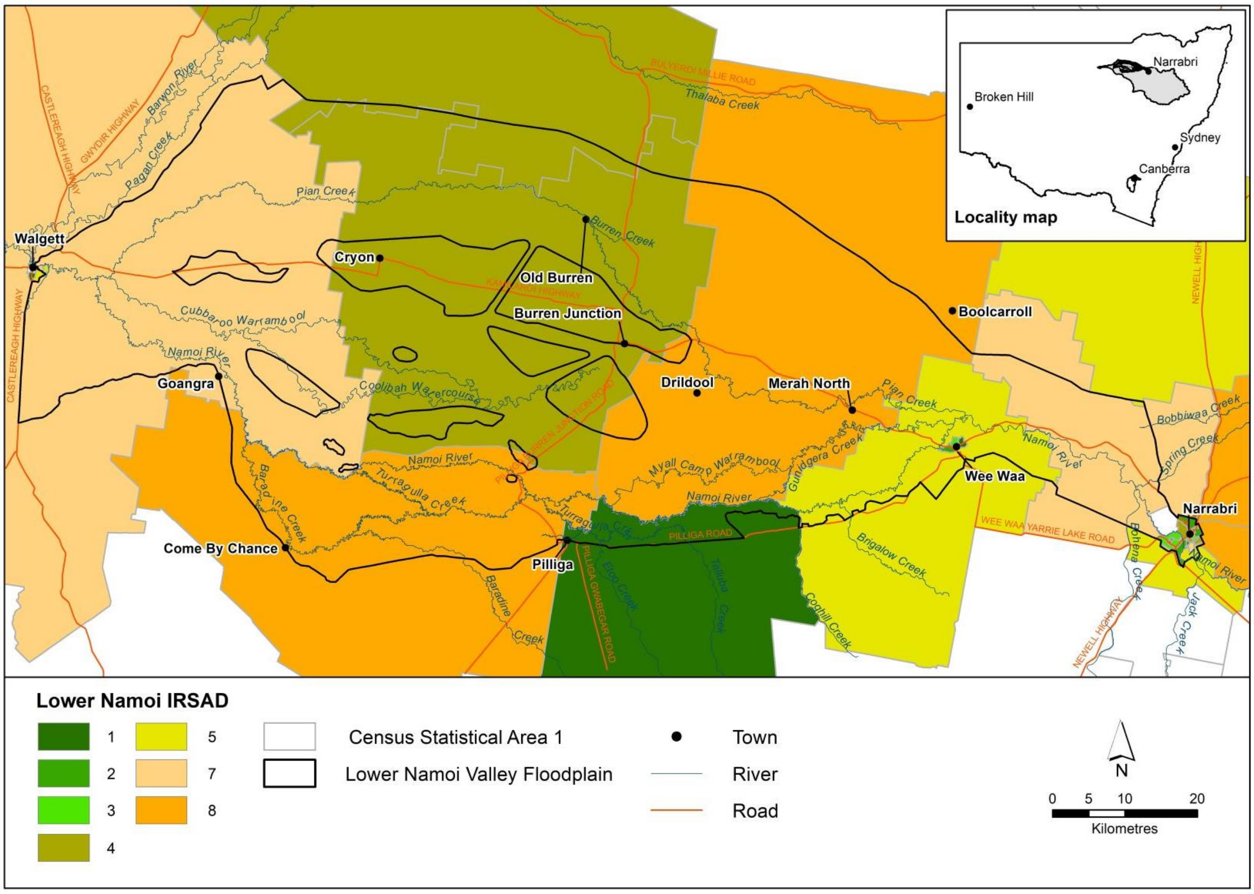


Figure A14.10. Index of Relative Socio-economic Advantage and Disadvantage (IRSAD), state decile (Source: Based on ABS data, ABS 2011c)

Agricultural production

Lower Namoi Floodplain Economy

The economy of the Lower Namoi Valley FMP 2020 area is interwoven with the economy of the adjacent communities, 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 Lower Namoi Floodplain Economy (Figure A14.1).

Agricultural production is the significant production activity of the region's economy. Agricultural production is predominantly cropping, which is dominated by cotton and, to a lesser extent, wheat. Irrigation on the Lower Namoi 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 Narrabri, Narrabri Region and Walgett–Lightning Ridge regions that cover the majority of the Lower Namoi Valley FMP 2020 and the Lower Namoi Floodplain Economy area (ABS 2011a). The combined area of these three regions is different to the FMP area, with the boundaries of the FMP area within the boundaries of these combined regions (Figure A14.3).

Lower Namoi Valley FMP 2020 area: Agricultural production

In the agricultural region in which the Lower Namoi Valley FMP 2020 area is located, broadacre cropping and livestock production are the predominant agricultural products. The value and area of holding these products in the Lower Namoi Valley FMP 2020 area 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 Lower Namoi Valley FMP 2020 area are Narrabri 19%, Narrabri Region 17% and Walgett–Lightning Ridge 13%
- for each region, the value and area of agricultural production of individual crops and products within the Lower Namoi Valley FMP 2020 area as a percentage of total production within these regions is proportionate to the estimated proportion of land area of the region within the Lower Namoi Valley FMP 2020 area
- the estimates for the Lower Namoi Valley FMP 2020 area equal the sum of the proportion of the estimates for the Narrabri, Narrabri Region and Walgett–Lighting Ridge regions.

As agricultural production is not evenly distributed across the area of these regions, the values derived and presented here provide estimates only of the value of production and the area of holding in the FMP area. Horticulture and pig, goat 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 Lower Namoi Valley FMP 2020 area, using a farm holding area of 445,483 ha, is estimated to be $116.1 million, or 1% of the total NSW GVAP. Broadacre cropping constitutes 89% of the GVAP ($103.8 million) of the FMP area production, using 189,930 ha, or 30% of the area. The highest-value-producing individual broadacre crops are cotton, yielding $50 million, or 3%, and wheat, yielding $39 million, or 17%, of the total Lower Namoi Valley Floodplain GVAP. Livestock and livestock products yield $12 million, accounting for 10% of the GVAP while using 66% of the area. Data for GVAP and area of holding is presented in Table A14.1 and Table A14.2.

Lower Namoi Valley FMP 2020 area: Irrigated agricultural production

The ABS Agricultural Census 2011 identifies the area watered and the quantity of water used by irrigated agricultural production for the Narrabri, Narrabri Region and Walgett–Lightning Ridge regions in 2010–11 (ABS 2011a).

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

- 19% of the irrigated agriculture in the Narrabri, 17% of the Narrabri Region and 13% of Walgett–Lightning Ridge were included in the Lower 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 9,692 ha of irrigated land in the Lower Namoi Valley Floodplain. This area of irrigated land constitutes approximately 2% of the area of the FMP farm holding area.

It is estimated that 50,200 ML of water was extracted for agricultural irrigation across the Narrabri, Narrabri Region and Walgett–Lightning Ridge regions in 2010–11. The majority of the irrigation water used in 2010–11 was applied to cotton (47,700 ML, 95%). Irrigation for cotton used an estimated 8,900 ha, or 92% of the estimated Lower Namoi Floodplain irrigated area.

Data for irrigation activity is presented in Table A14.3 and Table A14.4.

Table A14.1. Overview of gross value of agricultural production 2011 by region and NSW total (Source: Based on ABS Agricultural Census 2011 data)

Agricultural commodities produced	Narrabri ($M)	Narrabri Region ($M)	Walgett–Lightning Ridge ($M)	Estimated total Lower Namoi Floodplain ($M)	NSW total ($M)
Cereal crops—cereals for grain—wheat for grain	3.50	71.80	191.60	38.59	2,511.40
Cereal crops—cereals for grain—excluding wheat	1.10	10.10	24.30	5.19	997.50
Legumes for grain	0.80	14.80	39.50	7.97	237.40
Oilseeds	0.30	2.60	4.00	1.04	438.10
Hay—pasture and cereal and other crops cut for hay	0.20	1.60	1.90	0.57	283.60
Other crops—cotton	4.50	206.00	102.80	50.29	1,125.70
Other crops—excluding cotton	0	0.40	0.30	0.11	96.50
Total value of broadacre crops	10.40	307.30	364.40	103.77	5,690.20
Fruit	0	3.90	0	0	1,708.10
Nurseries, cut flowers and cultivated turf	0	0	0	0	311.60
Total horticulture	**0**	**3.90**	**0**	**0**	**2,019.70**
Whole milk	0	0	0	0	504.70
Slaughtered and other disposals—cattle and calves	2.80	15.40	22.40	6.19	1,616.10
Wool	0.10	3.40	20.90	3.39	852.70
Slaughtered and other disposals—sheep and lambs	0.10	2.30	13.60	2.23	609.80
Slaughtered and other disposals—pigs	0	3.10	0	0.54	166.20
Slaughtered and other disposals—goats	0	0	0.10	0.01	6.00
Eggs produced for human consumption	0	0	0	0	193.80
Slaughtered and other disposals—poultry	0	0	0	0	686.00
Total livestock and livestock products	**3.00**	**24.40**	**57.00**	**12.35**	**4,635.40**
Agriculture—total value ($M)	**13.40**	**334.70**	**421.40**	**116.12**	**11,714.00**

Note. The ABS Agricultural Census 2011 identifies the area watered and the quantity of water used by irrigated agricultural production for the Narrabri, Narrabri Region and Walgett–Lightning Ridge regions in 2010–11 (ABS 2011a). 19% of the irrigated agriculture in the Narrabri, 17% of the Narrabri Region and 13% of Walgett–Lightning Ridge were included in the Lower Namoi Valley Floodplain.

Table A14.2. Overview of land (ha) mainly used for agricultural production 2011 (Source: Based on ABS Agricultural Census 2011 data)

Agricultural commodities produced (ha)	Narrabri	Narrabri Region	Walgett–Lightning Ridge	Estimated Lower Namoi Floodplain	NSW
Cereal crops—wheat for grain (ha)	5,652	100,287	354,100	75,897	3,814,726
Cereal crops—other than wheat for grain (ha)	1,337	19,154	64,472	13,996	1,637,949
Non-cereal crops—cotton (ha)	838	60,857	31,569	13,728	329,665
Non cereal crops—other than cotton (ha)	1,890	56,650	133,505	31,072	1,262,087
Land mainly used for agriculture—crops (ha)	13,369	278,193	637,406	150,207	9,209,190
Orchard fruit and nut trees (ha)	1	389	0	0	47,483
Grapevines for wine production (ha)	0	14	0	0	42,246
Nurseries, cut flowers and cultivated turf (ha)	0	0	0	0	4,529
Hay and silage—hay (ha)	271	2,625	4,620	1,203	312,513
Pasture seed production—clean pasture seed produced (ha)	0	9	0	1	18,280
Land mainly used for agriculture—total grazing (ha)	32,538	247,007	1,475,390	295,250	46,419,229
Land mainly used for agriculture—other agricultural purposes (ha)	20	98	53	26	29,377
Land mainly used for agriculture—forestry plantation (ha)	0	279	0	-	112,489
Total area of holding (ha)	**48,936**	**569,460**	**2,160,269**	**445,483**	**58,326,346**

Note. The ABS Agricultural Census 2011 identifies the area watered and the quantity of water used by irrigated agricultural production for the Narrabri, Narrabri Region and Walgett–Lightning Ridge regions in 2010–11 (ABS 2011a). 19% of the irrigated agriculture in the Narrabri, 17% of the Narrabri Region and 13% of Walgett–Lightning Ridge were included in the Lower Namoi Valley Floodplain.

Table A14.3. Area (ha) of irrigated agricultural production 2011 (Source: Based on ABS Agricultural Census 2011 data)

Area watered	Narrabri	Narrabri Region	Walgett-Lightning Ridge	Estimated Lower Namoi Floodplain	NSW
Cereal crops—for grain or seed (for example, wheat/oats/maize) (ha)	519.8	973.2	1158.5	414.81	5,377,721.20
Other crops—broadacre other (for example, canola/field beans/lupins/sunflowers/poppies) (ha)	23.3	452.5	519.9	148.94	1,261,888.30
Other crops—cotton (ha)	746.9	37,235.7	19,051	8,948.61	329,664.70
Cereal crops—cut for hay (including wheat/oats, forage, sorghum) (ha)	0.3	53.5	0	9.15	104,018.90
Fruit or nut trees/plantation or berry fruits (excluding grapes) (ha)	0	406.4	0	69.09	49,842.40
Grapevines (ha)	0	13.5	0.5	2.36	44,154.60
Nurseries, cut flowers and cultivated turf (ha)	0	0	0	0	4,528.70
Pasture—cut for hay (ha)	0	49.2	0	8.36	165,216.60
Pasture—for grazing (ha)	79.2	427.8	26.1	91.17	46,419,229.50
Pasture—for seed (ha)	0	0	0	0	18,280.40

Area watered	Narrabri	Narrabri Region	Walgett-Lightning Ridge	Estimated Lower Namoi Floodplain	NSW
Total area watered and used—area watered (ha)	**1,404.4**	**39,877.7**	**21,310.2**	**9,692.49**	**674,064.20**

Note. The ABS Agricultural Census 2011 identifies the area watered and the quantity of water used by irrigated agricultural production for the Narrabri, Narrabri Region and Walgett–Lightning Ridge regions in 2010–11 (ABS 2011a). 19% of the irrigated agriculture in the Narrabri, 17% of the Narrabri Region and 13% of Walgett–Lightning Ridge were included in the Lower Namoi Valley Floodplain.

Table A14.4. Overview of irrigated agricultural production 2011 (ML) (Source: based on ABS Agricultural Census 2011 data)

Water for agricultural production	Narrabri (ML)	Narrabri Region (ML)	Walgett-Lightning Ridge (ML)	Estimated Lower Namoi Floodplain (ML)	NSW (ML)
Cereal crops—cut for hay (including wheat/oats/forage sorghum) (ML)	0.6	76.3	0	13.09	13,989.40
Cereal crops—for grain or seed (for example, wheat/oats/maize) (ML)	788.7	1658	3,987.3	950.06	203,840.60
Other crops—broadacre other (ML)	93.3	970.8	5,593.6	909.93	809,078.30
Other crops—cotton—volume applied (ML)	2,856.2	195,363.3	106,919.8	47,654.01	1,073,849.00
Fruit or nut trees/plantation or berry fruits (excluding grapes) (ML)	0	2,612.9	0	444.19	94,237.10
Grapevines (ML)	0	8.1	1.3	1.55	106,593.60
Nurseries, cut flowers and cultivated turf (ML)	0	0	0	0	17,596.40
Pasture—cut for hay (ML)	0	54.2	0	9.21	78,405.70
Pasture—for grazing (ML)	100.6	511.5	41.7	111.49	232,628.50
Pasture—for seed (ML)	0	0	0	0	6,281.30
Total area watered and used (ML)	**3,851**	**201,779.5**	**116,651.8**	**50,198.94**	**2,745,896.30**

Note. The ABS Agricultural Census 2011 identifies the area watered and the quantity of water used by irrigated agricultural production for the Narrabri, Narrabri Region and Walgett–Lightning Ridge regions in 2010–11 (ABS 2011a). 19% of the irrigated agriculture in the Narrabri, 17% of the Narrabri Region and 13% of Walgett–Lightning Ridge were included in the Lower Namoi Valley Floodplain.

Appendix 15: The Lower Namoi Valley Management Zones

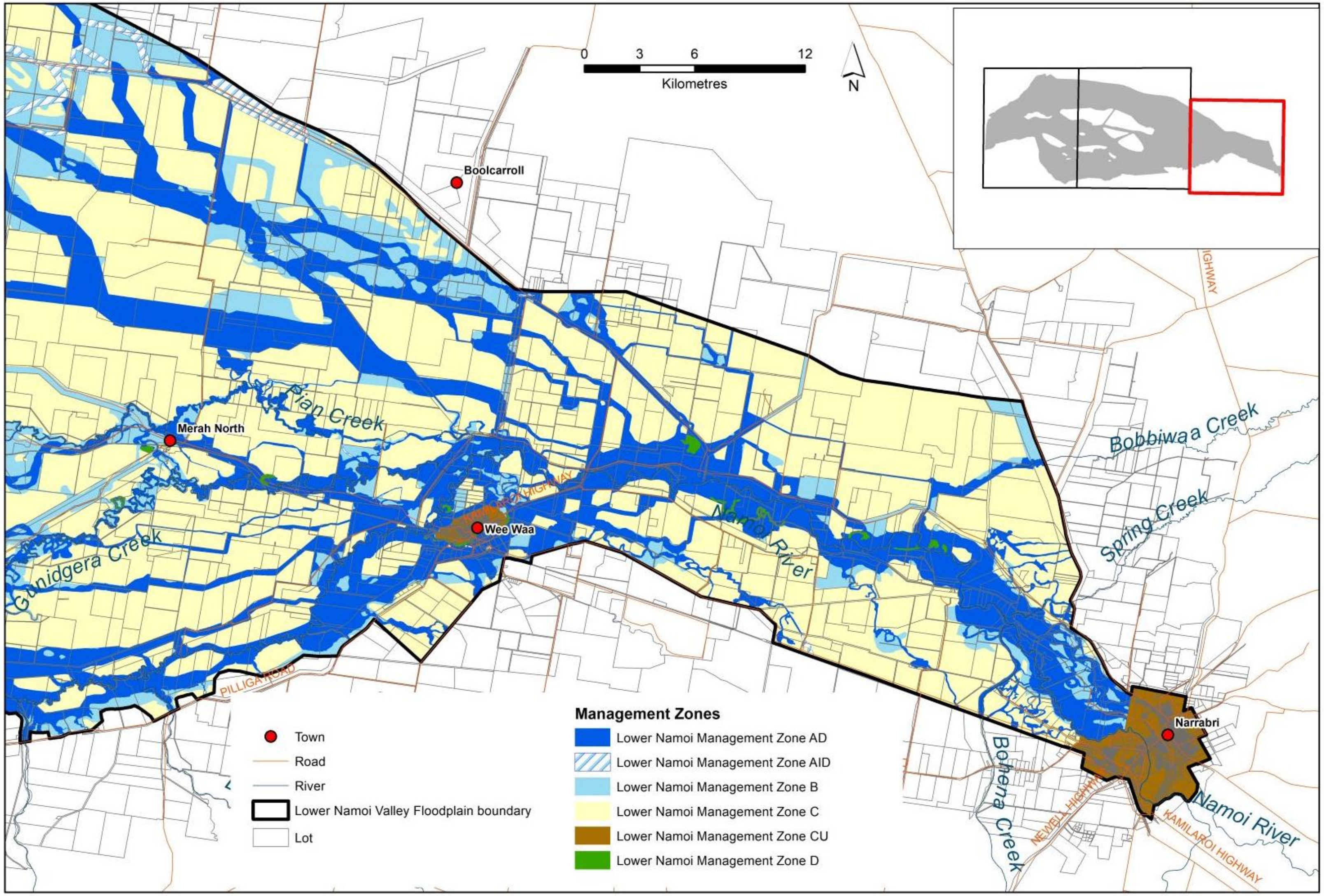


Figure A15.1. Management zones in the Lower Namoi Valley Floodplain—section one of three

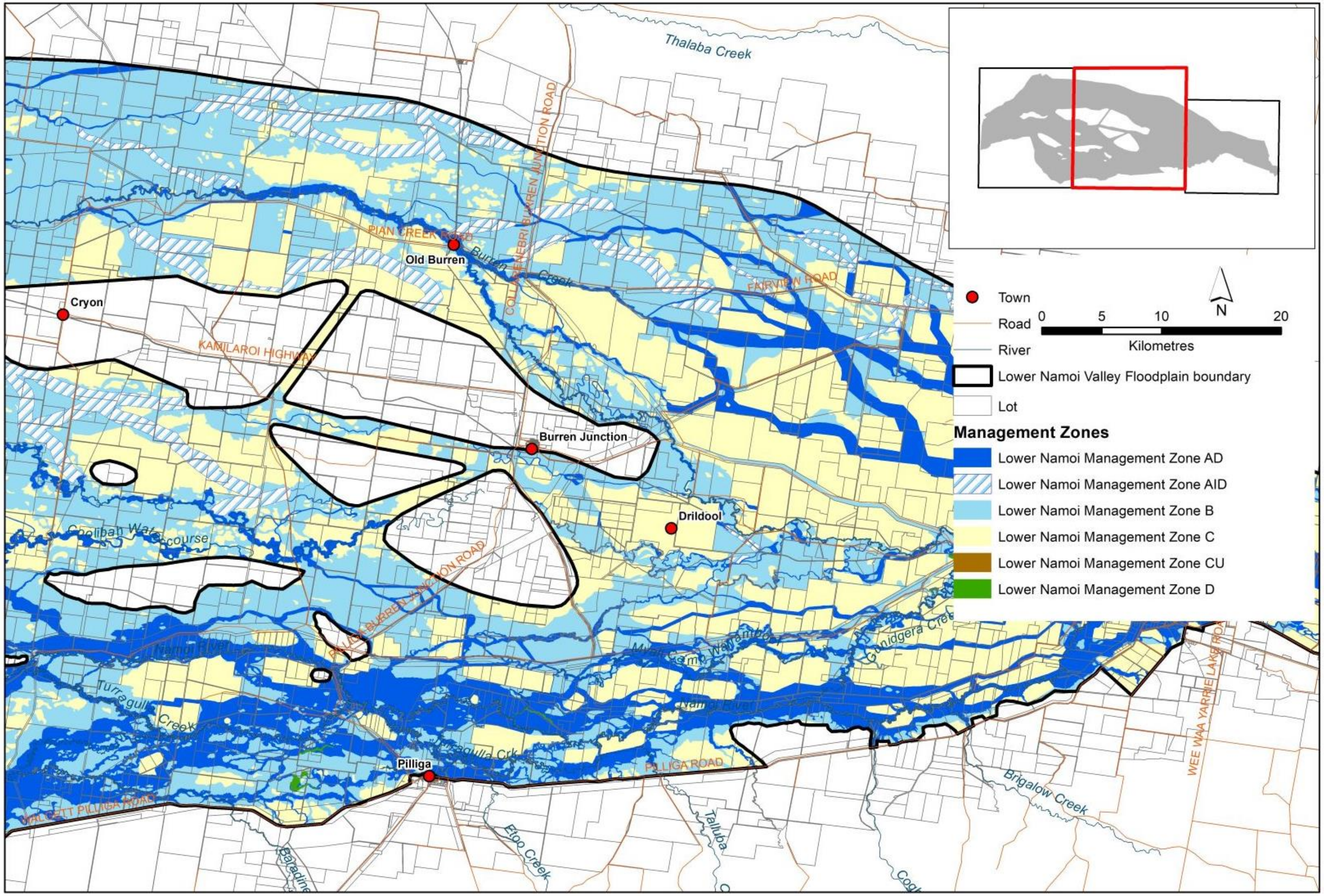


Figure A15.2. Management zones in the Lower Namoi Valley Floodplain—section two of three

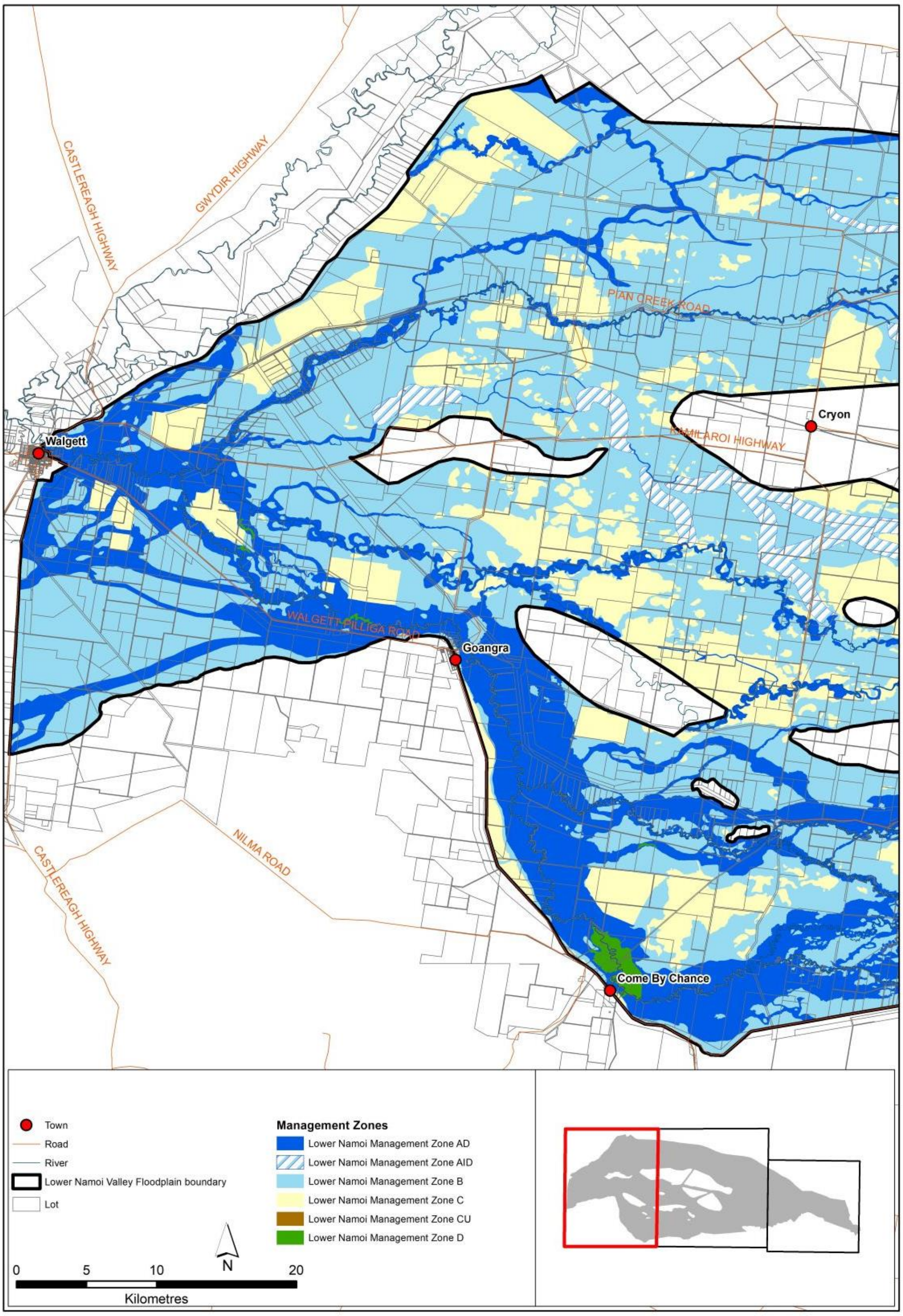


Figure A15.3. Management zones in the Lower Namoi Valley Floodplain—section three of three

Appendix 16: Description of Management Zone D areas of ecological and/or cultural significance

Eighteen floodplain areas were recommended to become management zone D. All 18 areas have high ecological value, and a description of the ecological significance of each Management Zone D area is provided in Table A16.1. The Aboriginal cultural significance of the areas, where relevant, is not listed here in order to protect cultural sensitivities.

Table A16.1. List of floodplain assets classified as Management Zone D

No.	Area	Size (ha)	Ecological significance	Flood works present/altered hydrologically	Easting	Northing
1	Baraneal Lagoons	40	Functional capacity to act as an aquatic drought refuge	No	627211	6666285
2	Bungle Gully	824	Waterbird breeding habitat. Functional capacity to act as an aquatic drought refuge	Yes	643074	6641616
3	Camp Pool	15	Functional capacity to act as an aquatic drought refuge	No	673314	6643107
4	Coolibah Swamp	105	Waterbird feeding habitat. Functional capacity to act as an aquatic drought refuge	No	672068	6640423
5	Eulah Lagoon	16	Waterbird feeding habitat. Functional capacity to act as an aquatic drought refuge.	No	644956	6649990
6	Gurleigh Lagoon (Sheep Station Creek)	85	Functional capacity to act as an aquatic drought refuge	Yes	748044	6653964
7	Krui Swamp	17	Waterbird habitat. Functional capacity to act as an aquatic drought refuge	No	719772	6658376
8	Locharba Lagoons	25	Functional capacity to act as an aquatic drought refuge	No	756906	6652326
9	Unnamed Lagoon A	11	Functional capacity to act as an aquatic drought refuge	Yes	733945	6654867
10	Unnamed Lagoon B	27	Functional capacity to act as an aquatic drought refuge	Yes	620561	6672770
11	Unnamed Lagoon C	14	Waterbird habitat. Functional capacity to act as an aquatic drought refuge	No	620333	6671352
12	Unnamed Lagoon D	13	Functional capacity to act as an aquatic drought refuge	Yes	755511	6652178
13	Warrian Lagoon	31	Functional capacity to act as an aquatic drought refuge	No	689295	6645942
14	Wee Waa Lagoon	55	Waterbird and native freshwater fish habitat. Freshwater mollusc habitat. Functional capacity to act as an aquatic drought refuge	No	735239	6653442
15	Weeta Waa Lagoon	25	Waterbird feeding and breeding habitat. Freshwater mollusc habitat. Functional capacity to act as an aquatic drought refuge	Yes	718371	6655643

No.	Area	Size (ha)	Ecological significance	Flood works present/altered hydrologically	Easting	Northing
16	Wirebrush Lagoon	53	Waterbird feeding and breeding habitat. High structural diversity of vegetation. Functional capacity to act as an aquatic drought refuge	No	745471	6658088
17	Woodlands Billabong	20	Waterbird feeding and breeding habitat. Functional capacity to act as an aquatic drought refuge	Yes	725302	6656767
18	Yarral Lagoon	21	Functional capacity to act as an aquatic drought refuge	Yes	753301	6653117

Note: Coordinates were calculated using Geocentric Datum of Australia 1994, Map Grid of Australia 55.

Baraneal Lagoons

Lagoons located on the northern side of the Namoi River downstream of Goangra providing the functional capacity to act as an aquatic drought refuge. Mapped flood-dependent PCTs (OEH 2015) include coolibah–river cooba–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39).

Bungle Gully

The lower section of Baradine Creek is dominated by river coobah swamp wetland on the floodplains of the Darling Riverine Plains bioregion and Brigalow Belt South bioregion (PCT 241) and coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39). The main feature of the creek is Bungle Gully, which was constructed in the early 1900s and ponds water for a considerable distance upstream. The dam stores water for stock and domestic use and for wildlife. The dam is surrounded by coolibah with river coobah and lignum, which becomes inundated during floods.

Landholders recollect that these lignum areas have supported waterbird rookeries in the past (B. Buchanan, pers. comm.) (Ibis, *Threskiornis* spp., spoonbills, *Platalea* spp. etc.) but no records were ever kept of these events. Historical waterbird observations for Bungle Gully indicate large numbers (less than 1,000) of Australian white ibis (*Threskiornis moluccus*) and straw-necked Ibis (*Threskiornis spinicollis*) at Bungle Gully (OEH 2016 NSW BioNet—default sighting data) and presence of Australian wood duck (*Chenonetta jubata)* and Australian pelican (*Pelecanus conspicillatus)* (Aerial Waterbird Survey of Eastern Australia data).

It is likely that when inundated, these surrounding areas are still being used as rookery areas by waterbirds. The dam was inspected at the dam wall on Bungle Gully in November 2015. Areas of dense river coobah—lignum were observed surrounding the dam, and the landowner confirmed that the vegetation was used by waterbirds as breeding habitat but that it also provided shelter for large numbers of feral pigs (B. Buchanan, pers. comm.).

The dam was also inspected in April 1991 (Green and Dunkerley 1992) and a thick fringe of cumbungi was growing around the margins along with some *Eleocharis* spp. (heavily grazed). Small numbers of birds were seen on the dam, including white-faced herons (*Ardea novaehollandiae),* little black cormorants (*Phalacrocorax sulcirostris*), a little pied cormorant (*Phalacrocorax melanoleucos),* a flock of black ducks (*Anas superciliosa*) and an egret (*Ardea* spp). Black swans (*Cygnus atratus*) are also known to use the dam, and European carp and golden perch inhabit the water (J. Hodgson, pers. comm.).

It is likely that the dam is a valuable drought refuge as it is the only extensive permanent water in the Lower Namoi Valley Floodplain.

Figure A16.1. Bungle Gully dam (J Taylor, OEH 2015).

Camp Pool

Camp Pool is a long, narrow lagoon providing the functional capacity to act as an aquatic drought refuge surrounded by coolibah and located on a small anabranch of Turragulla Creek. Mapped flood-dependent PCTs (OEH 2015) include lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South bioregion and Darling Riverine Plains bioregion (PCT 247), river coobah swamp wetland on the floodplains of the Darling Riverine Plains bioregion and Brigalow Belt South bioregion (PCT 241), coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) and coolibah open woodland wetland with chenopod/grassy ground cover on grey and brown clay floodplains (PCT 40).

Coolibah Swamp

Coolibah Swamp is a shallow depression on Keepit Creek approximately 10 km west of Pilliga with coolibah and lignum vegetation (Green and Dunkerley 1992). Mapped flood-dependent PCTs (OEH 2015) include coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) and water couch marsh grassland wetland of frequently flooded inland watercourses (PCT 204).

Eulah Lagoon

Eulah Lagoon on the property of Garthowen is a long, narrow lagoon on Ulah Creek, with coolibah, river cooba and lignum vegetation along its banks. It was full when visited in April 1991 (Green and Dunkerley 1992) and is probably a relatively permanent source of water. It becomes inundated at similar levels to Turragulla Creek (that is, during low floods). Other than cattle, which were grazing around the margins, a white-faced heron (*Ardea novaehollandiae*) and European carp were the only wildlife observed. Eulah Lagoon is located on a floodway between the Namoi River and Baradine Creek. Upstream of the lagoon, a very dense stand of coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) occurs and marks the flow of water from the Namoi River to the lagoon. Water flowing out of Eulah Lagoon spreads out over a wide area, flowing through a web of shallow channels through more woodland of coolibah, river cooba and lignum towards Baradine Creek.

Gurleigh Lagoon and Sheep Station Creek

Gurleigh Lagoon and Sheep Station Creek form a short anabranch of the Namoi River. The lagoon is connected to the creek, and both are deep narrow channels dominated by river red gum and river oaks. Sheep Station Creek has been dammed at either end since 1972 to retain water for stock and irrigation of grain, oilseed and cotton, and is partly backed by a levee (Green and Dunkerley 1992). Standing dead trees occur within the channel. Freshes from the river supply part of the creek while minor floods will fill the whole creek and lagoon. The creek begins to flow at about 23,600 ML/d in the Namoi River (4.88 m at the Mollee gauge) (White and Keenan 1987). Barma Water Resources et al. 2012 identifies it as a flood-dependent ecological asset in the Namoi river red gum corridor, Mollee Weir to Gunidgera Weir. The lagoon and creek are fringed with flood-dependent PCTs (OEH 2015), including river red gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains bioregion (PCT 36), coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) and shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53).

Krui Swamp

Shallow swamp providing waterbird habitat (Broome et al. 1978), surrounded by coolibah woodland adjacent to Kamilaroi Highway and Pian Creek. The main source of water is local drainage, filling after intense rain (Barma Water Resources et al. 2012). The swamp provides good habitat for a variety of waterbird species including waterbirds observed by Broome et al. 1978, including sharp-tailed sandpipers (*Calidris acuminata),* black swans (*Cygnus atratus*), Eurasian coots (*Fulica atra),* grebes, pelicans (*Pelecanus conspicillatus*), pink-eared ducks (*Malacorhynchus membranaceus*) and Australasian shovelers (*Anas rhynchotis*).

Locharba Lagoons

The Locharba Lagoons comprise two lagoons (shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains, PCT 53) located south of the Kamilaroi Highway on the northern side of the Namoi River. They are fringed with river red gum riparian tall woodland/open forest wetland in the Nandewar bioregion and Brigalow Belt South bioregion (PCT 78). The mapped flood-dependent PCTs (OEH 2015) include coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39).

Reedy Lagoon

Reedy Lagoon is a narrow lagoon with a fringe of river red gums along the channel and several shallow depressions nearby (mostly cultivated). The mapped flood-dependent PCTs (OEH 2015) include shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53) and coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39). Identified in Barma Water Resources et al. 2012 as a flood-dependent ecological asset within the Namoi river red gum corridor (Mollee Weir to Gunidgera Weir).

Unnamed Lagoon A

A U-shaped lagoon just north of Wee Waa on the southern side of the Namoi River provides the functional capacity to act as an aquatic drought refuge fringed with river red gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains bioregion (PCT 36) and coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39). One of a few small U-shaped lagoons within the riverine zone offering the only natural wetland habitat in this section of the Lower Namoi River (Green and Dunkerley 1992).

Unnamed Lagoon B

A large linear lagoon providing the functional capacity to act as an aquatic drought refuge adjacent to Dead Bullock Warrambool. The lagoon is fringed with flood-dependent PCTs (OEH 2015) including coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) on its northern side and black box woodland wetland on NSW central and northern floodplains, including the Darling Riverine Plains bioregion and Brigalow Belt South bioregion (PCT 37) on its southern bank.

Unnamed Lagoon C

A medium-sized broad lagoon on the northern side of the Namoi River providing the functional capacity to act as an aquatic drought refuge. The lagoon provides habitat for a variety of waterbird species, including Australasian darter (*Anhinga melanogaster*), Australasian grebe (*Tachybaptus novaehollandiae*), Australian pelican (*Pelecanus conspicillatus*), Australian white ibis (*Threskiornis aethiopica*), Australian wood duck (*Chenonetta jubata*), eastern great egret (*Ardea alba*), Eurasian coot (*Fulica atra*), glossy ibis (*Plegadis falcinellus*), great cormorant (*Phalacrocorax carbo*), grey teal (*Anas gracilis*), hoary-headed grebe (*Poliocephalus poliocephalus)*, little black cormorant (*Phalacrocorax sulcirostris*), little egret (*Egretta garzetta)*, Pacific black duck (*Anas superciliosa*), royal spoonbill (*Platalea regia*), silver gull (*Larus novaehollandiae*), straw-necked Ibis (*Threskiornis spinicollis*), white-faced heron (*Egretta novaehollandiae)*, white-necked heron (*Ardea pacifica)* and yellow-billed spoonbill (*Platalea flavipes)* (*Atlas of Australian Birds* data). The lagoon is fringed on its southern side with flood-dependent lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South bioregion and Darling Riverine Plains bioregion (PCT 247).

Unnamed Lagoon D

A narrow lagoon on the southern side of the Namoi River providing the functional capacity to act as an aquatic drought refuge. Mapped flood-dependent PCTs (OEH 2015) include areas of shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53). The lagoon is fringed with coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) and river red gum riparian tall woodland and open forest wetland in the Nandewar bioregion and Brigalow Belt South bioregion (PCT 78).

Warrian Lagoon

A long, narrow lagoon between the Namoi River and Duncans Warrambool providing the functional capacity to act as an aquatic drought refuge. The lagoon is fringed with flood-dependent PCTs (OEH 2015) including shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53) and lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South bioregion and Darling Riverine Plains bioregion (PCT 247).

Wee Waa Lagoon

A long, narrow lagoon providing the functional capacity to act as an aquatic drought refuge located on the southeastern side of Wee Waa. It is subject to flooding from the Namoi system, as well as from local flows from the Pilliga Scrub area. The Wee Waa levee abuts the lagoon (Barma Water Resources et al. 2012). There are a number of large snags in the lagoon that provide fish habitat. The lagoon is a major asset for the Wee Waa community, a bird hotspot attracting a range of terrestrial and waterbirds. The lagoon corridor is a wildlife corridor that links back to the main river channel (Narrabri Shire Council 2011). Waterbird species observed at Wee Waa Lagoon include cormorants (*Phalacrocorax*spp.) and darters (*Anhinga melanogaster*) (Narrabri Shire Council 2015). The lagoon provides habitat for freshwater molluscs. Records of aquatic snails sourced from the Australian Museum (30 July 2014) indicate historical presence of river snails (*Notopala sublineata*) and pouch snails (*Glyptophysa gibbosa*) in the lagoon (Gould 1846). The river snail is listed as an endangered species in NSW in Schedule 4 of the *Fisheries Management Act 1994* and International Union for Conservation of Nature (Ponder 1996). The lagoon is fringed with flood-dependent PCTs (OEH 2015), including shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53) and coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39). The lagoon was identified in Barma Water Resources et al. 2012 as a flood-dependent ecological asset within the Namoi river red gum corridor (Mollee Weir to Gunidgera Weir).

Figure A16.2. Wee Waa Lagoon (S Hunter, OEH, November 2015)

Weeta Waa Lagoon

Weeta Waa Lagoon is actually a large meander of Gunidgera Creek that has been cut off from the rest of the creek by dams at either end. A channel has been constructed allowing the creek to bypass the lagoon (Green and Dunkerley 1992). The water stored is used for the irrigation of cotton and grains as well as stock and domestic supply. The dominant vegetation is cumbungi with some *Juncus* spp. and *Cyperus* spp. (G. Napier, pers. comm.). The banks are vegetated by coolibah, river cooba and lignum. Numerous dead trees occur in the water. Waterbird species observed include musk duck (*Biziura lobate*), maned duck (*Chenonetta jubata*), black duck (*Anas superciliosa*) and pelicans (*Pelecanus conspicillatus*), with both maned duck and black duck breeding. Freshwater mussels also occur in the lagoon (Broome et al. 1978). Mapped flood-dependent PCTs (OEH 2015) include coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39). The lagoon is noted in Barma Water Resources et al. 2012 as a flood-dependent ecological asset (Namoi Billabongs, Gunidgera Weir to Weeta Weir).

Wirebrush Lagoon

Wirebrush Lagoon is a broad shallow depression that is roughly circular. Its associated flood-dependent vegetation covers an area of approximately 50 ha. The lagoon is semipermanent and Broome et al. (1978) considered the lagoon to possess exceptional habitat value due to its high structural diversity of vegetation and the exclusion of stock from most of the surrounding woodland. The lagoon receives water from the Namoi River during high surplus flows via the Myall Vale channel, a shallow watercourse wooded with coolibah (Green and Dunkerley 1992). This channel begins to flow at a discharge of about 20,000 ML/d (5.3 m on Glencoe gauge). The lagoon will dry after about eight months of dry weather (Keenan, pers. comm.). Wirebrush Lagoon is surrounded by woodland comprising coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) and shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53) with occasional river red gum. At the northern end of the lagoon, there is an area of dense lignum swamp. The shallow nature of the lagoon provides feeding grounds for a variety of waterbird species. Observed in January 1991 were black swans (*Cygnus atratus),* pied stilts (*Himantopus himantopus),* masked lapwings (*Vanellus miles)*, grey teal (*Anas gracilis*) and spoonbills (*Platalea* spp.) (Green and Dunkerley 1992). Other waterbird species recorded at the site by Broome et al. 1978 include large numbers of pink-eared duck (*Malacorhynchus membranaceus*), Australasian shoveler (*Anas rhynchotis*), darters (*Anhinga melanogaster)*, cormorants (*Phalacrocorax* spp.), pelicans (*Pelecanus conspicillatus*), Eurasian coots (*Fulica atra)*, grebes and Latham's snipe (*Gallinago hardwickii)*. The lagoon is mostly used for feeding, but black duck (*Anas superciliosa*) and grey teal (*Anas gracilis*) have been recorded breeding (Broome et al. 1978). The lagoon has a history of supporting a diversity or abundance of bird and fish populations or habitat complexity (Thoms et al. 1999) and was identified in Barma Water Resources et al. 2012 as a flood-dependent ecological asset within the Namoi river red gum corridor (Mollee Weir to Gunidgera Weir).

Figure A16.3. Wirebrush Lagoon (S Hunter, OEH, November 2015)

Woodlands Billabong

Woodlands Billabong is part of a U-shaped lagoon that has been cut in half by the construction of a leveed irrigation channel through the middle (Green and Dunkerley 1992). Surplus flows are pumped into the storage from Gunidgera Creek and floodwaters may also flow over the levee and into the storage. The fringes of the storage and an island in the middle are vegetated by mature river red gums with dense stands of saplings growing around the immediate edge and along the levee (Green and Dunkerley 1992). Broome et al. (1978) recorded large numbers of black duck (*Anas superciliosa*) and grey teal (*Anas gracilis*) breeding here while musk duck (*Biziura lobata*) and maned duck (*Chenonetta jubata*) were also present. Mapped flood-dependent PCTs (OEH 2015) fringing the lagoon include water couch marsh grassland wetland of frequently flooded inland watercourses (PCT 204) and coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39). The billabong was identified by Barma Water Resources et al. (2012) as a flood-dependent ecological asset and one of only several U-shaped lagoons within the riverine zone offering the only natural wetland habitat in the Gunidgera Weir to Weeta Weir section of the Namoi River.

Yarral Lagoon

Yarral Lagoon is a U-shaped lagoon on the northern side of the Namoi River. It is fringed with river red gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains bioregion (PCT 36), coolibah–river coobah–lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains bioregion (PCT 39) and shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53).

Appendix 17: Peak discharge calculation locations

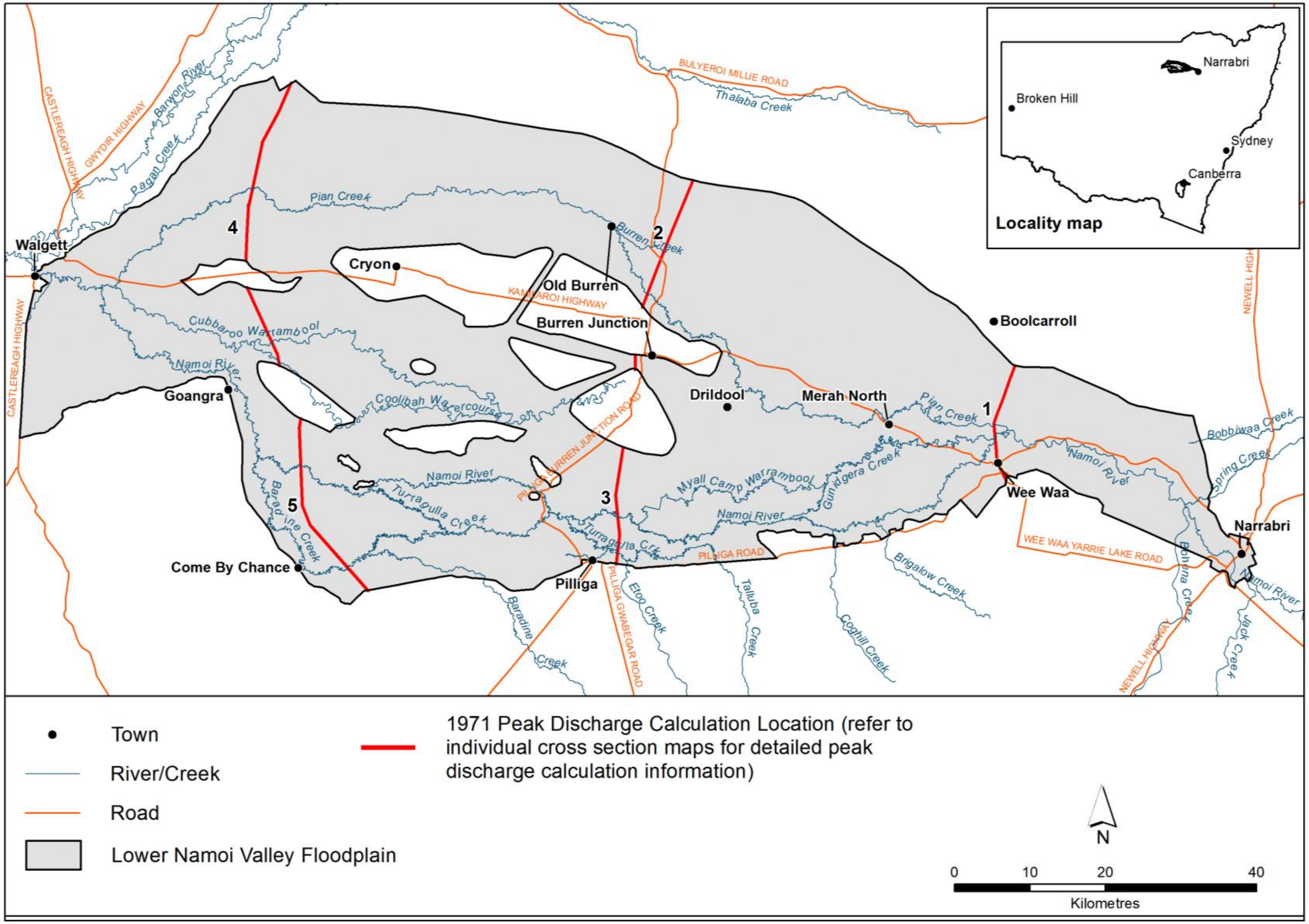


Figure A17.1. Peak discharge calculation locations in 1971 (refer to individual maps for detailed peak discharge calculation information)

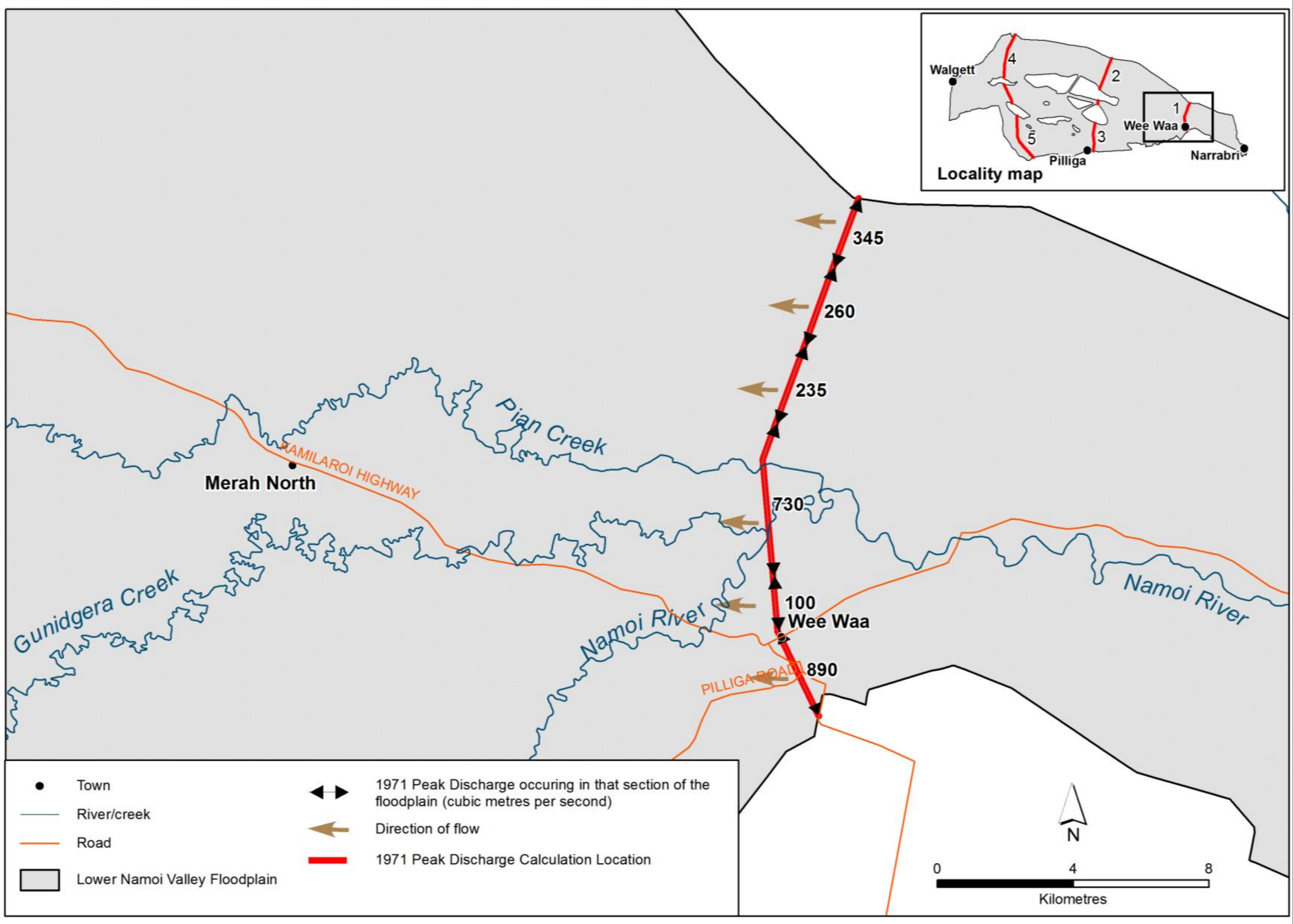


Figure A17.2. Peak discharge calculation location near Wee Waa in 1971 (Section 1)

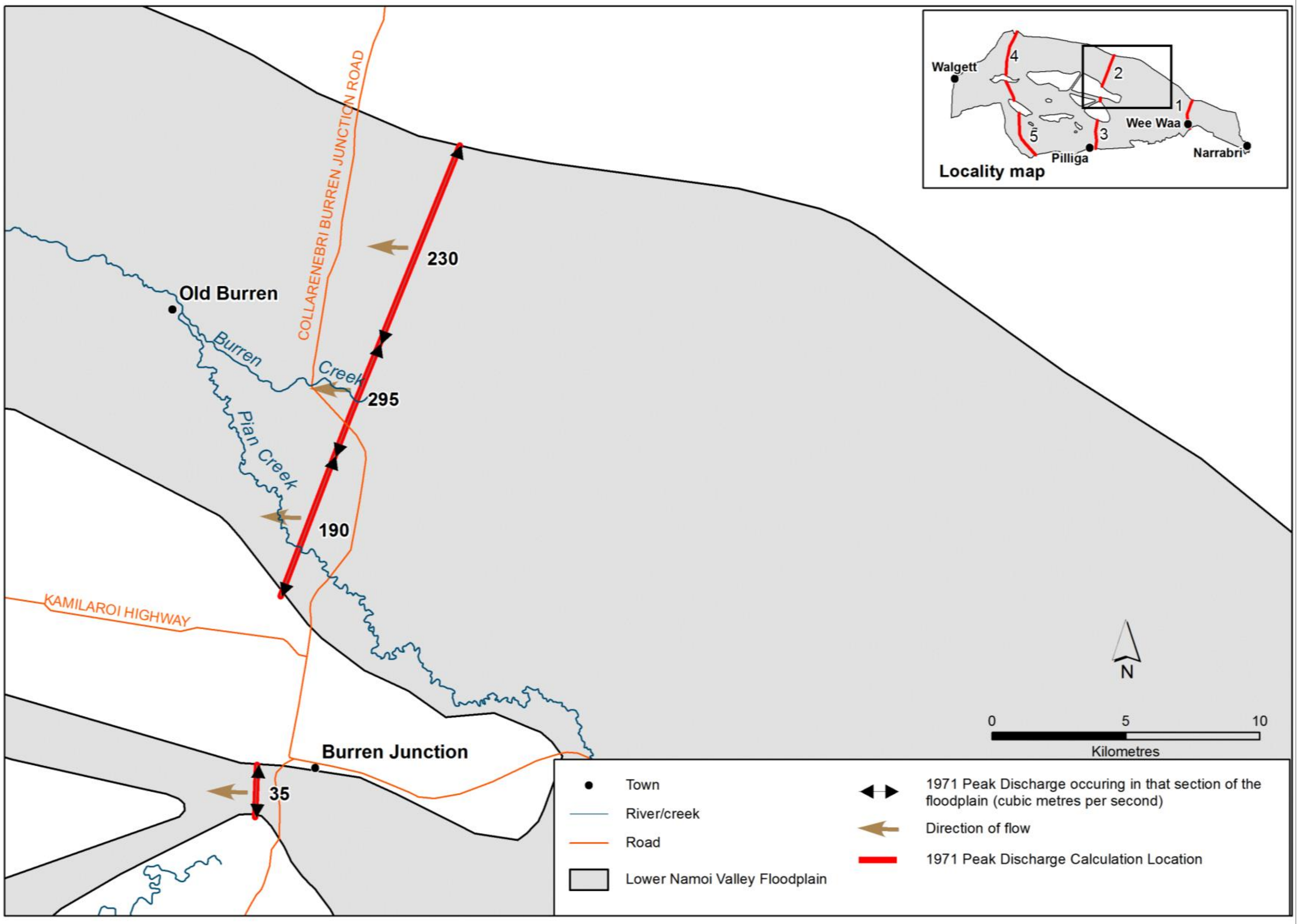


Figure A17.3. Peak discharge calculation locations near Burren Junction in 1971 (Section 2)

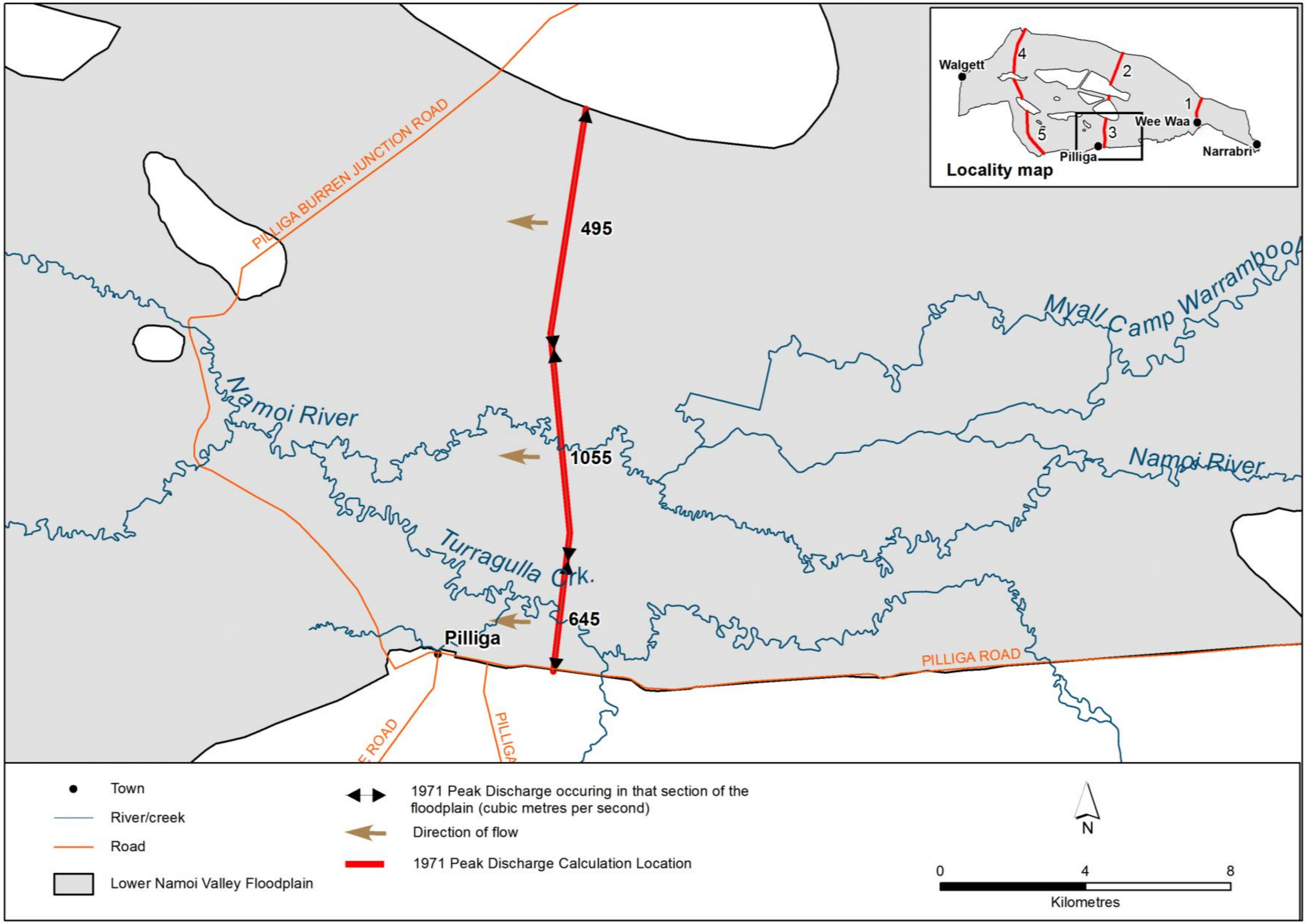


Figure A17.4. Peak discharge calculation location near Pilliga in 1971 (Section 3)

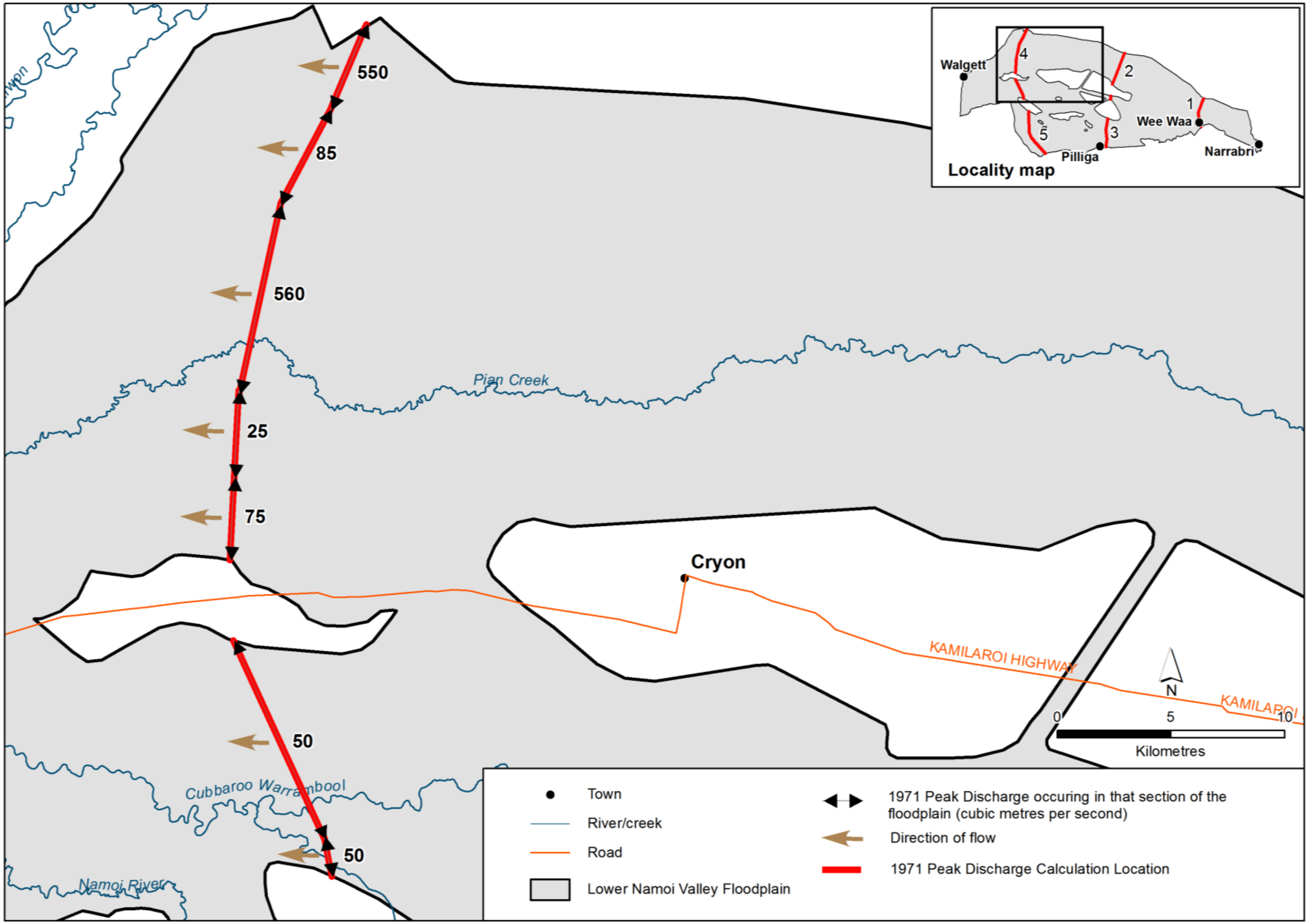


Figure A17.5. Peak discharge calculation location near Cryon in 1971 (Section 4)

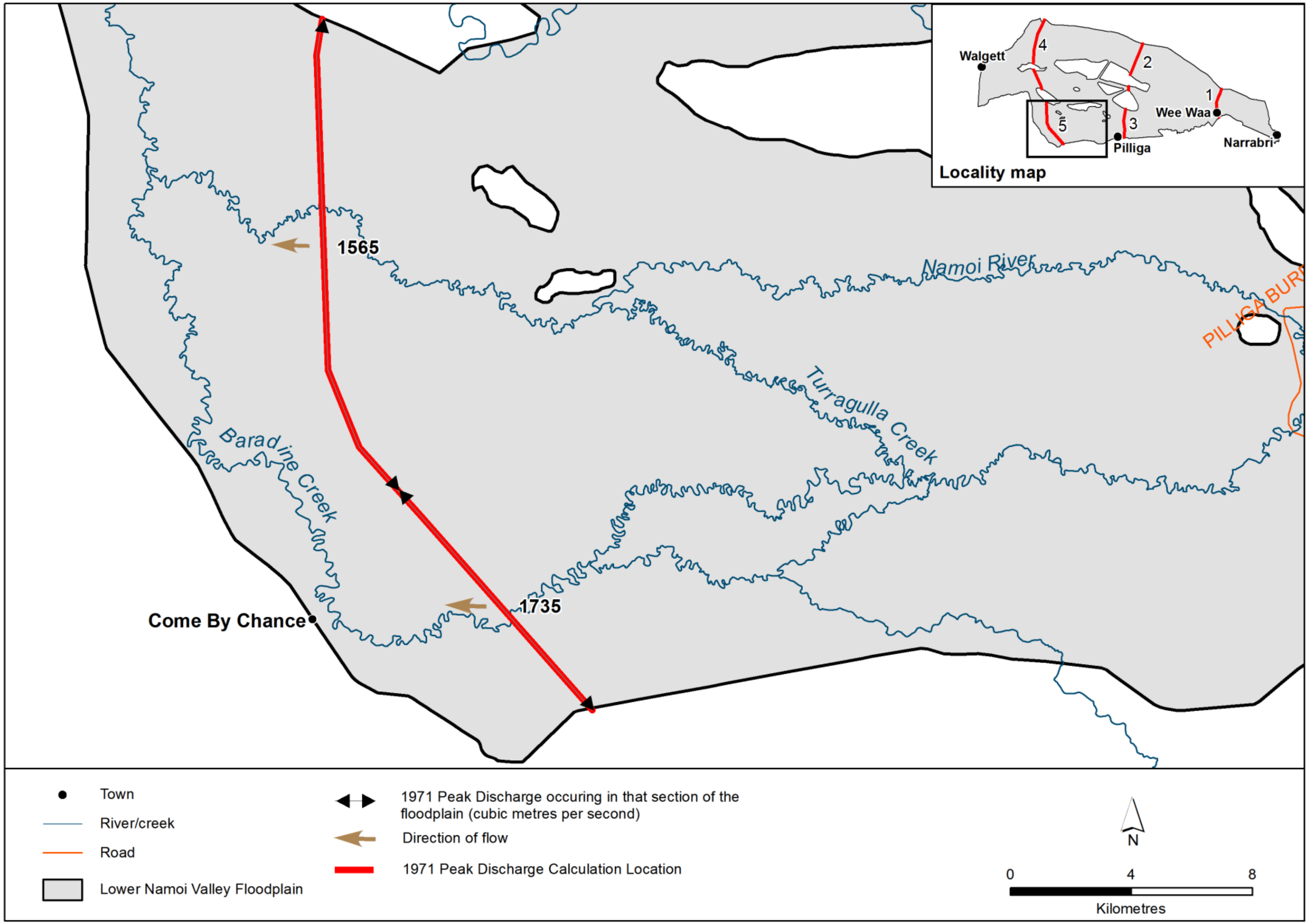


Figure A17.6. Peak discharge calculation locations near Come by Chance in 1971 (Section 5)

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