



Environment,
Climate Change
& Water



Floodplain Management Plan

Lachlan River (Gooloogong to Jemalong Gap)

January 2011

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Cover photos (clockwise from main photo):

North Condobolin Road upstream of Jemalong Gap, 26 April 1990 (Steve Hogg, NSW Dept of Water Resources)

Bundaburrah Creek at Back Marsden Road crossing (Paul Bendeich, DECCW)

Railway at Grawlin Plains, 4 August 1990 (Steve Hogg, NSW Dept of Water Resources)

River red gum woodland upstream of Forbes (Paul Bendeich, DECCW)

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Department of Environment, Climate Change and Water NSW

59–61 Goulburn Street, Sydney

PO Box A290, Sydney South, NSW 1232

Phone: 131 555 or (02) 9995 5000 (switchboard)

Fax: (02) 9995 5999

TTY: (02) 9211 4723

Email: info@environment.nsw.gov.au

Web: www.environment.nsw.gov.au

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Abbreviations

ARI	Average recurrence interval
CMA	Catchment Management Authority
DCP	Development Control Plan
DECCW	Department of Environment, Climate Change and Water NSW
EIA	Environmentally important area
EP&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i>
FMP	Floodplain management plan
FMC	Lachlan River Floodplain Management Committee, Gooloogong to Jemalong
FRMS	Floodplain risk management study
FS	Flood study
NOW	NSW Office of Water
PVP	Property Vegetation Plan
WMA	NSW <i>Water Management Act 2000</i>

Glossary

<i>anabranch</i>	a channel of a river or creek that leaves the main channel and re-enters downstream
<i>average recurrence interval</i>	the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event
<i>ecosystem</i>	a biological system involving interaction between living organisms and their immediate physical, chemical and biological environment
<i>effluent stream</i>	a stream that leaves a watercourse and does not return to it
<i>environmentally important area</i>	areas that have important environmental and/or cultural features that rely on inundation by floodwaters to sustain essential ecological processes
<i>flood control works</i>	works such as levees, roads and channels that can affect the distribution of floodwaters on the floodplain; known as 'controlled works' in the <i>NSW Water Act 1912</i>
<i>flood dependent ecosystem</i>	an ecosystem that depends on periodic flooding to support essential ecological processes
<i>floodplain</i>	an area of land which is subject to inundation by floods up to and including the probable maximum flood
<i>floodway network</i>	the area of floodplain required for the unobstructed and orderly passage of a flood of given magnitude
<i>FMP floodplain</i>	designated floodplain under section 166(1) of Part 8 of the <i>NSW Water Act 1912</i>
<i>habitat</i>	the type of environment in which a plant or animal lives, including physical and chemical conditions
<i>hydraulics</i>	the study of water flow in relation to watercourses and the land surface; in particular the assessment of water level and velocity
<i>hydrology</i>	the study of the rainfall and runoff process; in particular, the assessment of peak flows and flow volumes
<i>invertebrates</i>	animals without backbones, including zooplankton, worms, insects, shellfish, crabs, shrimps and snails
<i>probable maximum flood</i>	the largest flood that could conceivably occur at a particular location
<i>riparian</i>	the interface between land and a flowing surface water body, typically characterized by water-dependent vegetation and often subject to flooding; the riparian zone has a significant role in soil conservation, biodiversity and water quality
<i>threatened species</i>	species of plant or animal listed as vulnerable or endangered on the schedules of the <i>NSW Threatened Species Conservation Act 1995</i>
<i>wetland</i>	an area that is wet for a long enough period such that the plants and animals living in it are adapted to, and often dependent on, living in wet conditions for at least part of their life cycle

Preface

The development of irrigation on the Lachlan River floodplain, particularly since completion of the enlargement of Wyangala Dam in 1971, has led to concerns about the impacts of associated works on flood behaviour. Flood control works such as levees, channels, and other embankments, can alter floodwater distribution, increase flood risk to floodplain occupiers and cause environmental problems by isolating flood dependent ecosystems, such as wetlands, from flooding.

The NSW Government's *Flood Prone Land Policy* aims to provide solutions to existing flooding problems and ensure that new development within flood prone areas is compatible with the prevailing flood risk and does not create additional flooding problems in other areas. Under the policy, the rural flood risk within the state for areas west of the Great Dividing Range is managed by the NSW Government. These management provisions are set out in Part 8 of the *Water Act 1912*, under which the Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan (FMP) has been prepared.

The Department of Environment, Climate Change and Water NSW (DECCW) is responsible for preparing rural floodplain management plans that define requirements for managing floodwaters within floodplains. Approval of works and compliance functions under Part 8 of the *Water Act* are the responsibility of the NSW Office of Water (NOW), which has been established as an office within DECCW.

The Lachlan River Gooloogong to Jemalong Gap FMP has been prepared by DECCW for the Water Administration Ministerial Corporation under Part 8 of the *Water Act* and in accordance with processes outlined in the NSW Government's *Floodplain Development Manual* (2005), which supports the *Flood Prone Land Policy*. The FMP was prepared with advice from the Lachlan River Floodplain Management Committee, Gooloogong to Jemalong Gap (the FMC), which comprised representatives from the community, stakeholder groups, and government agencies. Funding for the FMP was provided by the Commonwealth Natural Disaster Mitigation Program, with state financial support.

The FMP replaces the *Guidelines for Floodplain Development Lachlan Valley Gooloogong to Jemalong Gap* prepared in 1979 (the '1979 Guidelines'; Water Resources Commission 1979) which have served as the main reference when assessing earthwork development on the floodplain but are now outdated and required revision to be consistent with present day natural resource management principles and legislative requirements.

Developing the FMP has progressed through three primary stages:

- preparation of a flood study (FS) – completed by Sinclair Knight Merz in 2003, the study defines the nature and extent of flooding and flood-related issues (hydraulic, environmental and cultural) in technical terms
- preparation of a floodplain risk management study (FRMS) – completed by Sinclair Knight Merz in 2010, the study evaluates management options based on a consideration of social, environmental, and economic factors, in order to address existing and future flood risk and flood management issues, and
- preparation of this floodplain management plan – outlines strategies to manage flood risk and flood management issues, and to support the natural functions of the floodplain environment.

The FMP was publicly exhibited from February – March 2007 and submissions received were taken into account in the preparation of the final plan.

The FMP aims to coordinate the existing and future development of flood control works so that flood risk is minimised and the natural functions of the floodplain environment are

sustained. It outlines required actions for areas of potential hydraulic restriction and allows for future floodplain management planning by identifying a floodway network of adequate hydraulic capacity and continuity to effectively convey floodwaters and support the floodplain environment.

The FMP, including the FMP floodway network, forms the basis for determining whether flood control works on the floodplain will be granted approval under Part 8 of the Water Act. It also details the approval process and assessment criteria for proposed and existing works. Implementation of the FMP will provide the community with greater security against flood risk and allow for sustainable management of flood dependent ecosystems.

The FMP floodway network is designed to convey floodwaters to environmentally important areas (EIAs) within the FMP floodplain and downstream floodplains. EIAs are areas that have important environmental and/or cultural features that rely on inundation by floodwaters to sustain essential ecological processes. They include areas of flood dependent vegetation (mainly river red gum and black box woodland), wetlands, and floodplain watercourses. A high proportion of EIAs have been captured within the FMP floodway network thereby assuring their ongoing flood connectivity, including about 1000 ha of flood dependent vegetation not within the 1979 Guidelines' floodway network.

Following floods, the performance of the FMP will be assessed against three key performance indicators:

- Existing and proposed flood control works are constructed, maintained and modified in accordance with the FMP.
- The FMP floodway network allows for the orderly passage of floodwaters during a range of floods.
- The FMP floodway network allows for the delivery of floodwaters to support floodplain ecosystems.

The performance of the FMP floodway network during floods will be assessed using flood monitoring information. This information will be measured against the FMP's objectives and the hydraulic, environmental, economic and social indicators outlined in the FMP.

Dense vegetation cover within the FMP floodway network may increase hydraulic roughness and reduce floodway efficiency. There is a range of options under the *Native Vegetation Act 2003* and other relevant legislation to manage vegetation so that the FMP floodway network is maintained and operates as designed during floods.

It is expected that the FMP will be adopted as a Minister's plan under the *Water Management Act 2000* (WMA) when Part 8 of the Water Act is repealed. The FMP is required to be reviewed at five-yearly intervals in accordance with the WMA.

Triggers for review include significant flood events, changes to land use, impediments to implementation, and changes to factors that influence decisions. Climate change has the potential to result in many direct and indirect changes to floodplains, including their hydrology, as well as the institutional framework in which floodplains are managed. Flooding patterns may alter due to changes in monthly average rainfall, the distribution of rainfall and rainfall intensity. Changes to groundwater and soil moisture could further influence the magnitude and duration of floods. Any direct or indirect impacts of climate change on agriculture will have a strong flow-on effect on floodplain management as many rural floodplain landowners are primary producers. Early adaptive responses will decrease longer-term vulnerability and economic costs. Therefore, any review of the FMP will look at the plan's capacity to adapt to address climate change impact on flood risk, flood dependent ecosystems and rural economies.

1 Introduction

1.1 Vision and objectives

The FMP has been prepared to provide strategic guidance to NSW Government agencies and landholders in the management of floodwaters on the Lachlan River Gooloogong to Jemalong Gap floodplain (FMP floodplain). The overall vision for the FMP is:

to coordinate floodplain development to minimise flood risk to occupiers and users of the floodplain while addressing the environmental, social and economic interests of the Lachlan River Valley.

The floodplain management objectives of the FMP linked to its overall vision are:

- to achieve a coordinated, balanced approach to floodplain management taking into account hydraulic, environmental and economic considerations and legislative requirements
- to ensure the sustainable and equitable use of floodplain resources
- to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible (NSW Flood Prone Land Policy objective)
- to coordinate floodplain development in order to minimise adverse changes to flood flow patterns
- to increase the sustainable social, economic and ecological benefits of using the floodplain
- to improve and maintain the diversity and well being of riverine and floodplain ecosystems that depend on flood inundation, and
- to take into account the cumulative impact on flooding behaviour of individual developments.

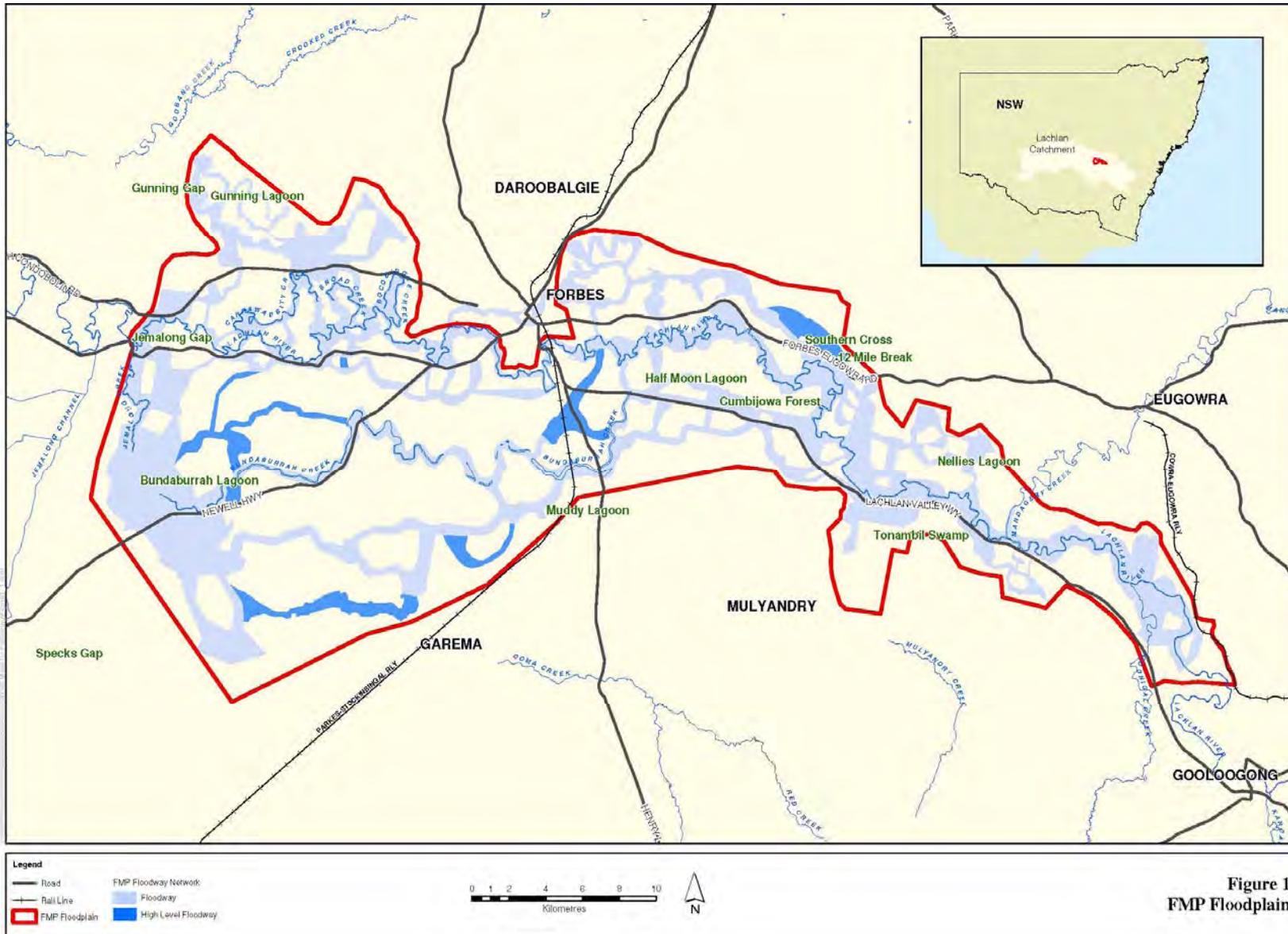
In order to achieve the above objectives the process for developing the FMP included:

- embracing the floodplain management principles adopted by the FMC
- supporting studies to investigate strategic planning measures to restore the natural functions of the floodplain whilst minimising flood risk to private assets and public infrastructure
- facilitating a community consultation process to ensure community ownership, and
- ensuring management options comply with state policies such as the Flood Prone Land Policy and State Rivers and Estuaries Policy, environmental legislation, relevant planning instruments and relevant resource management plans.

1.2 FMP floodplain overview

1.2.1 General

The FMP floodplain is shown on Figure 1, which also shows the location of the Lachlan Valley. The FMP floodplain includes the Lachlan River floodplain from Gooloogong in the east to Jemalong Gap in the Jemalong–Corridger Range in the west.



The FMP floodplain supports sheep and cattle grazing, dryland farming and irrigated cropping. Wyangala Dam is the main regulatory structure in the Lachlan Valley, supplying water for irrigation, town, stock and domestic use. The dam operates a 'variable space' flood mitigation provision which can be operated for flood mitigation purposes. The dam also provides an environmental water allocation for seasonal watering downstream areas. Carcoar Dam regulates the Belubula River, which joins the Lachlan River just upstream of Gooloogong. This dam has little impact on flooding in the FMP floodplain.

The majority of the FMP floodplain is located in Forbes Shire, except for the area on the northern side of the Lachlan River between Gooloogong and Mandagery Creek, which is in Cabonne Shire.

The FMP floodplain is a designated floodplain under section 166 (1) of Part 8 of the *Water Act 1912*.

1.2.2 Flooding overview

At Gooloogong, the Lachlan River commands a catchment of some 15,900 km². Wyangala Dam regulates flow from approximately half of the upstream catchment; however, the major tributaries, Boorowa and Belubula rivers and Mandagery Creek, join the Lachlan River below Wyangala Dam, with Mandagery Creek joining the Lachlan River downstream of Gooloogong in the FMP floodplain.

While major floods arise from Lachlan River flows, the Belubula River and Mandagery Creek can provide relatively localised high flood levels, however usually without enough flood volume to cause major flooding downstream. The smaller tributaries of Goonigal Creek, Mulyandry Creek and Ooma Creek which join the FMP floodplain from the south are generally not large contributors to major floods.

Within the FMP floodplain area, north of the river, the Southern Cross break feeds Lake Forbes, which passes through the town of Forbes. To the south the major anabranch of Bundaburrah Creek takes high level overflow to Bundaburrah Cowal (also known as Bundaburrah Swamp) before rejoining the Lachlan River at Jemalong Gap. At the lower end of the FMP floodplain, Jemalong Gap provides a greatly reduced waterway area compared to the area downstream of Forbes. A major restriction to flood flows is the Forbes/Stockinbingal Railway which runs in a north–south direction across the FMP floodplain.

In recent years significant floods in the Lachlan River have occurred in 1952, 1974, 1976, 1990 and 1996. The 1952 flood is the highest on record at the Forbes Iron Bridge since measurements at the gauge commenced in 1891.

At Gooloogong the spread of floodwater is generally confined to the river and adjacent river flats; however, below Gooloogong the capacity of the main river channel progressively reduces with the consequence that significant overbank spillage occurs and floodwaters begin to spread over wide areas of the floodplain. Much of this water finds its way into natural depressions and billabongs which interconnect to form active flood runners.

On the northern side of the river the first major breakout downstream of Gooloogong occurs near the Mandagery Creek confluence. Floodwaters escaping the river through the breakout flow into a defined depression known as Nellie's Lagoon. Floodwaters from this lagoon rejoin the river near the important breakout known as the 'Southern Cross'.

The Southern Cross breakout, along with the higher level '12-Mile Break', is located approximately 17 km upstream of Forbes. These breakouts feed a shallow depression

which eventually flows into Lake Forbes within the town itself. All waters from these breakouts eventually pass through Forbes and have a major impact on the flooding of the town. The Lake Forbes floodwaters re-enter the Lachlan River west of the town.

From Forbes to Jemalong Gap, flooding to the north occurs mainly when three local billabongs overflow. These billabongs are associated with Bocobidgle Creek, Broad Creek, and Carrawabbity Creek. Floodwaters overflowing from these billabongs pass north-west in a broad shallow sheet across the North Condobolin Road towards Gunning Gap. In the larger floods floodwaters can pass through Gunning Gap and join the Goobang Creek system.

The flooding pattern on the south side is more complex with major breakouts commencing in the vicinity of Cumbijowa Forest. Floodwaters from the forest pass west via Joss's Lagoon and the Cowra Road, as well as south-west to join Bundaburrah Creek. The major source of the Bundaburrah Creek flow, however, is the Wandary Lane breakout, located about eight kilometres upstream of Forbes. These flows pass into Half Moon Lagoon, across the Cowra Road at Duke's Crossing and into Bundaburrah Creek. The creek finally enters Bundaburrah Cowl before draining through Jemalong Creek into the Lachlan River at Jemalong Gap.

Below Forbes, floodwaters overflow from the river to the south at a number of locations and generally flow parallel to the river before draining to Bundaburrah Cowl.

For more detailed information regarding the flooding characteristics of the FMP floodplain refer to the FS and FRMS reports (Sinclair Knight Merz 2003, 2010).

1.2.3 Environmental overview

Floodplains have a key ecological role in providing organic matter and nutrients that are cycled during floods and support an extensive food base for fish and waterbirds. Within the broader floodplain however, there is a mosaic of environments ranging from terrestrial, that are seldom flooded, to aquatic environments that are permanently wet. In the FMP floodplain, land managed for agricultural production also forms part of this mosaic and clearly, the ecological value of floodplain land will vary according to flooding regime and land-use impacts.

The Lachlan River and its distributaries in the FMP floodplain support a relatively intact corridor of wetlands including floodplain lakes and lagoons, river red gum forest and woodland, and associated lignum shrub lands. Outside the riparian zone, various box forest and woodland communities originally dominated the floodplain. These are now extensively cleared, with little of the indigenous black box, white box, yellow box and grey box types present.

The FMP floodplain is significant culturally due to Aboriginal and European settlement. Aboriginal people traditionally occupied the well-watered parts of the landscape where resources were plentiful. Aboriginal sites of particular relevance to the FMP include scarred and carved trees that are flood dependent (river red gums and black box) and spiritually significant wetlands and water courses. Listed sites of European heritage value have also been considered in the preparation of the FMP.

North of the river major wetlands include Nellie's Lagoon and Lake Forbes. Key wetlands south of the river include Tonambil Swamp, a large depression that is affected by backwater from the Lachlan River and overflow from Mulyandry Creek, Joss's Lagoon, Half Moon Lagoon, Bundaburrah Lagoon, and Bundaburrah Cowl.

The FMP floodplain supports a diversity of fauna species that are affected by flooding patterns. These include some species that depend directly on flooding for maintenance of their life cycles (e.g. waterbirds, invertebrates and native fish) and others that rely on floodplain plants and soils for food and habitat (e.g. honeyeaters).

The ecology of floodplain wetlands and watercourses is dependent on flooding. A key issue for the FMP has been to maintain flood connectivity to these ecosystems and to assess the merits of restoring flood access to ecosystems isolated by flood control works.

Another key issue for the FMP has been to ensure that fish passage is maintained and potentially enhanced along the watercourses such as effluents, anabranches and distributaries, which connect the river to the floodplain. These watercourses are used by those species with a migratory spawning response to floods such as golden perch and silver perch.

For more detailed information on the floodplain environment refer to the FS and the FRMS reports (Sinclair Knight Merz 2003, 2010).

2 Development of the FMP

2.1 Legislative and policy framework

The management of the FMP floodplain must be undertaken within the current legislative and policy framework. A brief summary of the primary pieces of relevant legislation and policy is presented below. Refer to the FRMS (Sinclair Knight Merz 2010) for a detailed overview of the legislation and policy framework for floodplain management.

2.1.1 *Water Act 1912 and Water Management Act 2000*

Development on floodplains in the western rural areas of New South Wales is managed through Part 8 of the *Water Act 1912*. Part 8 was gazetted in 1984 and makes provisions concerning 'controlled works' that affect, or are likely to affect, flooding and/or floodplain functions. Part 8 was amended in 1999 to allow for more strategic control of such works through the preparation of FMPs and a more streamlined and resource efficient approval process. The amended *Water Act* provides for a broader consideration of issues in the approval of existing and proposed controlled works and strengthens NOW's ability to deal with unauthorised works.

DECCW is responsible for preparing rural floodplain management plans under Part 8 of the *Water Act*. Licensing of works and compliance functions under Part 8 are the responsibility of NOW.

The *Water Management Act 2000* (WMA) consolidates most of the Acts previously covering water management in New South Wales and is being phased in gradually as various regulations are developed. It will eventually replace Part 8 of the *Water Act* and is likely to contain floodplain management provisions that relate closely to existing provisions under the amended *Water Act*.

As the regulation of flood control works will ultimately fall under the WMA, it is necessary to consider the objects and principles of that Act in the preparation of plans under Part 8 of the *Water Act 1912*.

Objects of the WMA

The objects of the WMA are to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations and, in particular:

- a) to apply the principles of ecologically sustainable development, and
- b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and
- c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:
 - i) benefits to the environment, and
 - ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and
 - iii) benefits to culture and heritage, and
 - iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water,

-
- d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources,
 - e) to provide for the orderly, efficient and equitable sharing of water from water sources,
 - f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna,
 - g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users,
 - h) to encourage best practice in the management and use of water.

Floodplain management principles of the WMA

In relation to floodplain management, the water management principles of the WMA are as follows:

- 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.
- b) The impacts of flood works on other water users should be avoided or minimised.
- c) The existing and future risk to human life and property arising from occupation of floodplains must be minimised.

The repealed *Rivers and Foreshores Improvement Act 1948*, which allowed for the carrying out of works to remove obstructions and to improve rivers and foreshores, has been replaced by provisions in the WMA for controlled activities. Under the WMA, NOW requires approval for controlled activities which include the removal or deposition of material in the bed of a watercourse or wetland and on adjacent land, and other activities that affect the flow of water in a watercourse. Approval under the WMA would be required where earthworks are proposed in the bed of a watercourse or wetland, or where material is being sourced from a watercourse to construct a flood control work.

Core provisions of the WMA

The WMA specifies core provisions that must be dealt with in a floodplain management plan made for a water management area, and additional provisions that may be dealt with. These provisions have guided the preparation of the FMP. The following section lists these provisions and outlines how they have been addressed in this FMP.

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

A detailed analysis of the flood data spanning numerous historical floods was carried out as part of the FRMS in order to calibrate the computer model and determine the design flood. Satellite imagery of the 1990 flood, which surcharged most of the existing development, provided a good understanding of the natural flood regimes and the extent of flooding.

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

Ecological benefits of flooding on the FMP floodplain are outlined in Sections 6 and 8 of the FMP. Wetlands and other floodplain ecosystems have been specifically considered in the FMP in relation to flood connectivity. Detailed information on the environmental assessment is provided in the FRMS report (Sinclair Knight Merz 2010).

- 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*

Identification of existing flood works was undertaken in detail in the FRMS and the impact of these works on flood behaviour was assessed in relation to flood risk and the flood connectivity of environmentally important areas (EIAs).

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

The FRMS undertook detailed risk analysis under different scenarios to investigate and finally adopt the design flood to be used for the hydraulic design of the FMP floodway network. The FMP is a strategic plan which identifies a network of coordinated floodways that need to be kept open for floods up to and including the design flood, irrespective of whether there are flood protection works or not.

Additional provisions of the WMA

- a) *Proposals for the construction of new flood works*

Section 3 of the FMP outlines the approval and determination process for new flood works. The FMP floodway network (Figure 2, Sheets 1 to 4) will be used as the basis for determining applications for flood works.

- b) *The modification or removal of existing flood works*

This is dealt with in Table 2 in the FMP.

- 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.*

These provisions are reflected in the floodplain management principles (Section 2.3) which formed the basis of decision-making in the preparation of the FMP and the design of the FMP floodway network.

- 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*

The FMP provides guidance on how to control activities associated with flood works (Section 3).

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

Impacts of the FMP on water quality are broadly assessed in Table 4.

- f) *Such other matters as are prescribed by the regulations*

Currently no matters have been prescribed by the regulations.

2.1.2 NSW Flood Prone Land Policy

The primary objective of the *NSW Flood Prone Land Policy* (see NSW Government 2005) is to reduce the impacts of flooding on individual owners and occupiers of flood prone land, and to reduce private and public losses caused by flooding. A central tenet of the policy is that land-use proposals for flood prone land be treated within the framework of a strategically generated floodplain risk management plan prepared using a merit approach. The NSW Government's *Floodplain Development Manual* (NSW Government 2005) supports the policy and outlines a merit-based approach to floodplain management.

Forbes Shire Council has revised the floodplain management plan for Forbes township in line with the *NSW Flood Prone Land Policy*. The revised plan is reflected in *Forbes Development Control Plan No. 6: Managing our Flood Risks* (Forbes Shire Council 2002), which sets out controls for specific developments on flood prone land in the Forbes Local Government Area.

2.1.3 Other floodplain management controls

There are several other Acts and policies that are relevant to floodplain management and the approval process for flood control works. The majority of these relate to floodplain environmental matters such as flora and fauna, wetlands, threatened species and fish habitat.

The *Environmental Planning and Assessment Act 1979* (EP&A Act) is of particular importance. In determining applications for flood control works, NOW is required to assess the environmental impact of the works under Part 5 of this Act. Consideration of proposed works under Part 4 of the Act is not required as there is no relevant environmental planning instrument that applies to flood control works in the FMP floodplain. Other relevant legislation includes:

- Native Vegetation Act 2003
- Native Vegetation Conservation Act 1997
- Fisheries Management Act 1994
- Threatened Species Conservation Act 1995
- National Parks and Wildlife Act 1974
- Forestry Act 1916.

In certain circumstances, where a flood control work is likely to impact on a matter of national environmental significance, such as a nationally listed threatened species or a listed migratory species, an approval may also be required under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. These approvals are assessed by the Australian Department of Environment, Water, Heritage and the Arts.

Natural resource management policies that supported decision-making in the FMP included the *State Rivers and Estuaries Policy* (NSW Government 1993), which provides

a framework for the sustainable use, conservation and management of rivers, the *NSW Wetlands Policy* (Department of Environment, Climate Change and Water 2010) and the *State Groundwater Dependent Ecosystems Policy* (Department of Land and Water Conservation 2002).

The draft Floodplain Harvesting Policy, announced by the NSW Government on 3 July 2008, aims to bring floodplain harvesting activities into the statutory framework for water management for the first time. It is proposed that entitlements for floodplain harvesting be established in each valley in New South Wales, that are within existing water sharing plan limits and the Murray–Darling Basin Cap. Eligible works will be assessed to determine whether they can be authorised to take floodplain water. A process will be undertaken to allocate floodplain harvesting licences which would be a share of the total allowable floodplain harvesting volume. Once the policy is finalised (following public consultation), it is intended that the data contained in this FMP, the FRMS and the FS will support the implementation of the policy in the Lachlan Valley.

2.1.4 Relevant management plans

The *NSW State Plan: Investing in a Better Future* (NSW Government 2010) outlines the goals, priorities and targets for the NSW Government to deliver better services and improved outcomes for the communities of New South Wales.

The State Plan priorities for the protection of the natural environment include the provision of better outcomes for native vegetation, biodiversity, land, rivers, and coastal waterways. Paramount to realising such outcomes is the need to meet the NSW Government's statewide targets for natural resource management. The FMP will assist in meeting these targets by improving floodplain biodiversity and increasing the likelihood of water reaching and supporting riverine ecosystems and important wetlands, by removing barriers to natural flooding regimes. The FMP aims to reduce the impacts of flooding on rural communities and supports ecologically sustainable development using practical environmental solutions within a strategic planning framework. The State Plan also identifies a number of current activities that contribute to the improvement of the health of catchments, rivers and wetlands including the implementation of catchment action plans that provide long-term direction for investment in natural resources.

The Lachlan Catchment Management Authority (CMA) worked with local communities to prepare the Lachlan River Catchment Action Plan which was adopted by the NSW Government in January 2007 (Lachlan CMA 2006). The Catchment Action Plan outlines a number of natural resource management targets, several of which are directly relevant to outcomes in the FMP. These include the water target to maintain and improve the health of wetlands, the vegetation target to enhance native riparian vegetation identified as degraded, and the biodiversity target to maintain or enhance habitat features along all streams. The FMP should be viewed as one component of an integrated catchment planning process. Other relevant management plans that are linked to the FMP include:

- Water Sharing Plan for the Regulated River Water Source – Lachlan River 2004, and
- NSW Recovery Plan for Silver Perch 2005.

2.2 Community consultation

Community consultation formed an integral component in the development of the FMP. The FMC was the immediate consultative committee responsible for overseeing the plan's preparation. The FMC comprised representatives from landowners, rural farm groups, Forbes Shire Council and government agencies.

Soon after commencement of the FS, a questionnaire and newsletter were sent out to all rural residents in the FMP floodplain. Some 113 responses to the questionnaire were received. These were analysed and are presented in the FS report (Sinclair Knight Merz 2003).

Two community workshops were held to both inform the participants about the FRMS and seek their input into the issues which they felt were important. Additionally meetings and/or site inspections were held with many key landowners in the valley during the preparation of the FMP.

The FMP was publicly exhibited from 5 February 2007 to 30 March 2007 and four submissions were received. The issues raised in the submissions have been addressed and, where appropriate, the FMP has been amended. All respondents received a reply addressing the issues raised.

2.3 Floodplain management principles

A set of 10 floodplain management principles was adopted by the FMC. These principles were used as a guide for the purpose of making decisions when assessing management strategies and options during the development of the FRMS. The floodplain management principles conform with the general matters for consideration with respect to flood control work approvals set out in section 166C(1) of Part 8 of the *Water Act 1912*.

The principles relating to the hydraulic functions of the floodplain are similar to those used when developing the 1979 Guidelines. The major difference was the addition of environmental principles. This is consistent with the requirement that floodplain management plans made under Part 8 of the Water Act must take into account the protection of the environment.

The FMC adopted the following principles:

1. Defined floodways and exits from floodways should be equitably distributed consistent with natural/historical flowpaths.
2. There may be scope to depart from the natural/historical drainage pattern, provided that the community agrees that the FMP is hydraulically and environmentally feasible and socially and economically acceptable to the community.
3. Defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain.
4. Sufficient flood storage must be retained on the developed floodplain so that the flood wave is not significantly accelerated to downstream areas nor the flood height increased.
5. Velocities and depths of flood flow in defined floodways and exits from defined floodways should not cause significant erosion or increased siltation under various land uses, above what would otherwise be expected in a natural flood event.
6. There should not be any significant detrimental outcomes from the FMP. Any adverse outcomes from existing development in the floodplain should be identified and mitigation measures proposed.
7. There should be no significant detrimental impact from floodplain development on any individual landholder including downstream landholders or community infrastructure or environmental areas due to increases in peak flood levels, peak flows, total volumes and increased drainage times.

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8. Floodplain development should not cause significant redistribution of floodwaters in terms of flow distribution, volumes or flow rates.
 9. The FMP should aim to minimise detrimental impacts from future development and management activities on the floodplain on individual landholders, the environment and society.
 10. Defined floodways should, wherever practicable, allow for the delivery of floodwaters to support floodplain ecosystems.

2.4 Adopted design flood

The overwhelming conclusion from modelling, discussions with landholders and from the floodplain management principles, is that the floodway network should be designed for a medium-sized flood. The FMC agreed that the 15 year average recurrence interval (ARI) flood be adopted as the design flood for the FMP.

3 Plan implementation

The FMP outlines required actions for areas of potential hydraulic restriction and identifies a floodway network to allow for the planning of future flood control works. Implementation of the FMP involves undertaking the actions, approval of works and future property planning. Figure 2 (Sheets 1 to 4) shows the details of the FMP floodway network and Table 2 identifies the required actions for areas with potential hydraulic restrictions.

The FMP must be considered by NOW when reviewing and determining approval applications for flood control works under Part 8 of the *Water Act 1912* or its forthcoming replacement, the WMA.

Landholders affected by the required actions in the FMP (refer to Table 2) who are seeking assistance in developing an implementation program for their property should approach NOW.

3.1 Part 8 approval process for flood control works

3.1.1 General

All activities associated with flood control works are administered by NOW under the relevant sections of Part 8 of the Water Act. Flood control works situated or proposed to be constructed on land within the designated floodplain require an approval under Part 8 of that Act. Applications for new and existing (unauthorised) works within the FMP floodplain will be determined in accordance with the FMP and Part 8 of the Act.

3.1.2 Works that require approval

A work referred to as a flood control work is defined under Part 8 of the Water Act as 'controlled work'. A controlled work requires approval under the Act and is defined in section 165A as:

- a) an earthwork, embankment or levee that is situated, or proposed to be constructed, on land that:
 - i) is, or forms part of, the bank of a river or lake, or
 - ii) is within a floodplain, or
- b) any work that is situated, or proposed to be constructed, on land that:
 - i) is, or forms part of, the bank of a river or lake, or
 - ii) is within a floodplain,and that is declared by order of the Ministerial Corporation published in the Gazette to be a controlled work, or
- c) an earthwork, embankment or levee, wherever situated or proposed to be constructed, that:
 - i) affects or is reasonably likely to affect the flow of water to or from a river or lake, and
 - ii) is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded by water, or
- d) any work, wherever situated or proposed to be constructed, that:

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- i) affects or is reasonably likely to affect the flow of water to or from a river or lake, and
 - ii) is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded by water, and
 - iii) is declared by order of the Ministerial Corporation published in the Gazette to be a controlled work.

3.1.3 Applying for approval

The following is an outline of the steps required by an applicant in applying for approval for a flood control work:

- Step 1* Obtain an application form and discuss your proposal with neighbouring landholders.
- Step 2* Contact a NOW officer to discuss the application and get advice on the information required for the approval process.
- Step 3* Gather supporting information as your application will require you to supply technical information.
- Step 4* Fill in the application form. Complete additional information requirements on the form including the condition of the existing surrounding environment.
- Step 5* Lodge the application with the supporting information and application fee at your local NOW office.

3.1.4 Determination process

All applications under Part 8 of the Water Act, including works considered to be complying with the FMP, must proceed through a set process before NOW determines the application under section 171 of the Act. This process includes (but is not limited to):

Section 166C of the Water Act 1912 – NOW must have regard to the matters for general consideration outlined in section 166C including (but not limited to):

- the contents of any relevant FMP or any other relevant Government policy;
- the need to maintain the natural flood regimes in wetlands and related ecosystems and the preservation of any habitat animals (including fish) or plants that benefit from periodic flooding;
- the effect or likely effect on water flows in downstream river sections;
- any geographical features, or other matters of Aboriginal interest that may be affected by a controlled work;
- the effect or likely effect of a controlled work on the passage, flow and distribution of flood waters;
- the effect or likely effect of a controlled work on existing dominant floodways or exits from floodways, rates of flow, flood water levels and the duration of inundation;
- the protection of the environment; and,
- any other matter relating to the desirability or otherwise of a controlled work.

Part 5 of the *Environmental Planning and Assessment Act 1979* – as there are no relevant environmental planning instruments relating to the FMP all proposals must undergo assessment under Part 5. NOW must take into account the following factors concerning the impact of the flood control works on the environment:

- any environmental impact on a community
- any transformation of a locality
- any environmental impact on the ecosystems of the locality
- any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality
- any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations
- any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)
- any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air
- any long-term effects on the environment
- any degradation of the quality of the environment
- any risk to the safety of the environment
- any reduction in the range of beneficial uses of the environment
- any pollution of the environment
- any environmental problems associated with the disposal of waste
- any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply
- any cumulative environmental effect with other existing or likely future activities.

Floodplain management plan – NOW must consider the FMP and information contained within the FMP including principles, assessment criteria, and any recommendations.

Aboriginal heritage assessment – NOW will liaise with the Culture and Heritage Division of DECCW to assess Aboriginal heritage issues associated with individual applications. Applications will be assessed in accordance with the *National Parks and Wildlife Act 1974*.

Other management plans – NOW must have regard to the contents of any other management plan or policy including those dealing with the delivery of environmental water as specified under section 8 of the WMA.

Additional information – NOW must consider any relevant supporting information that has been provided by the applicant.

3.1.5 Possible determinations

NOW must inform the applicant at the earliest opportunity of the determination of an application for a flood control work. The general terms of approval should be comprehensive enough to cover all of the constraints (terms and conditions) that may be applied to the relevant Part 8 approval. Under the Water Act, there are three possible

determinations: approval of the application, approval of the application subject to conditions, or refusal of the application.

In certain circumstances there may be a right of appeal to the Land and Environment Court in respect of a determination under the Water Act. Before making a determination in respect of an application for flood control works, NOW is required to decide whether the works do or do not comply with the FMP.

3.1.6 Complying works

Under section 168B(2) of the Water Act, a flood control work is assessed as a complying work if NOW is satisfied that the work complies with the FMP for the area in which the work is situated or proposed to be constructed. For the FMP, complying flood control works are defined as:

- existing (unauthorised) or proposed works located on the limits of the FMP 15 year ARI floodway network that do not exceed the height limitations specified on Figure 2 (Sheets 1 to 4), or
- existing works to be modified in accordance with the required actions in Table 2 of the FMP, or
- existing (unauthorised) or proposed works located outside the limits of the FMP 15 year ARI floodway network and the FMP high level floodways* specified on Figure 2 (Sheets 1 to 4), or
- existing (unauthorised) or proposed works located within the high level floodways specified on Figure 2 (Sheets 1 to 4) which meet the criteria stipulated in Section 7 of the FMP.

* With limited height restrictions for flood control works bordering the FMP 15 year ARI floodway network, floods larger than the 15 year ARI design flood will inundate areas outside of the floodway network. To manage these larger floods, high level floodways within the FMP floodplain have been identified on the basis of the 1990 flood satellite imagery and the 1979 Guidelines.

Development outside of the floodway limits (including the high level floodways) would not in general cause a significant redistribution of design flood flows or a significant increase in flood levels. However, while applications for flood control works in this area will generally be assessed as complying works, the assessment may need to take into account any potential increase in flood hazard or flood damage under flood conditions larger than the design flood. Adverse impacts could result, for example, if extensive works proposed near to the floodway network are substantially higher than the corresponding design level of the floodway network.

Assessment of the flood hazard will be largely qualitative taking into consideration existing works, the extent of proposed works and the potential for localised impacts on neighbouring unprotected properties. Such assessment would not need to go to the details required for works within the floodway unless the impact on overall flood behaviour could be significant and therefore far reaching.

In some cases, a landholder may be required to provide the necessary technical details to demonstrate that the application is a complying work. Where an existing or proposed flood control work is complying, the application for approval will be determined by NOW without the need for advertising to canvass third party objections. Approvals for complying works are likely to be straightforward and expedient, depending on the required assessment of environmental impact.

3.1.7 Non-complying works

Under section 168B(3) of the Water Act, a flood control work is assessed as a non-complying work if NOW is not satisfied that the work complies with the FMP for the area in which the work is situated or proposed to be constructed. For the FMP, non-complying works are defined as:

- existing (unauthorised) or proposed works located within the FMP 15 year ARI floodway network (excluding the high level floodways) as shown on Figure 2 (Sheets 1 to 4), or
- existing (unauthorised) or proposed works located on the limits of the FMP 15 year ARI floodway network that exceed the height limitations specified on Figure 2 (Sheets 1 to 4), or
- existing works that are not modified in accordance with the required actions in Table 2 of the FMP, or
- existing (unauthorised) or proposed works located within the FMP high level floodways specified on Figure 2 (Sheets 1 to 4) which do not meet the criteria stipulated in Section 7 of the FMP.

Non-complying works may be considered for approval after a detailed investigation of hydraulic and environmental impacts. The cumulative impact of proposed works on flooding characteristics needs to be comprehensively addressed. Hydraulic impacts will be assessed against the criteria specified in Section 7. Environmental impacts will be assessed under Part 5 of the EP&A Act and against the criteria specified in Section 7 of the FMP. It is the applicant's responsibility to engage a suitably qualified consultant to undertake the investigation. Where the requested supporting information is not provided, NOW can refuse to deal with the application.

Applications for non-complying works must be advertised and third party objections sought before the application is determined. If an objection is received that cannot be resolved, compulsory mediation will be required. NOW may request additional supporting information from the party who lodged the objection, with failure to do so possibly resulting in the objection being rejected. If NOW grants an approval for an application and an objection has been made, NOW must notify the objector of its determination. The objector may appeal against the determination in the Land and Environment Court.

Any person applying for the approval of works may appeal to the Land and Environment Court against a determination by NOW to refuse to grant the approval or to grant the approval subject to conditions.

3.1.8 Unauthorised works

Unauthorised controlled works include the following:

- works without approval
- works that have been constructed in contravention of an approval
- works that have not been constructed in accordance with approval conditions.

Where unauthorised works are identified, a reasonable time will be allowed for the lodgement of an application under Part 8 of the Water Act. If, after a reasonable time period has elapsed, an application under Part 8 is not lodged for existing unauthorised works, NOW may direct that one or more of the following types of work are carried out by issuing a notice under section 180D of the Act:

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- a) work to remove, modify, repair or restore the controlled work or to render the work ineffectual,
 - b) work to repair any damage caused by the controlled work (including any damage caused to any specified land, river, lake, structure or vegetation, or to the environment),
 - c) work to ensure that any specified land, structure, river, lake or vegetation, or the environment, will not be damaged or adversely affected, or further damaged or further adversely affected, by the controlled work,
 - d) without limiting (a) to (c) above, work to correct or restore any alteration caused by the controlled work to the flow of water into or from, or the quantity of water contained in, any specified river or lake.

In the event of the occupier not complying with the served notice, NOW can carry out the work and recover the costs incurred in doing such work. NOW is not required to give any prior notice of its decision to exercise these powers. The occupier can appeal such action in the Land and Environment Court.

3.1.9 Varying conditions of approved works

If there is a need to vary the conditions of an already approved work, under section 176A of the Water Act, NOW:

- a) must notify the affected person of its intention to vary the conditions,
- b) must give that person a reasonable opportunity to make written submissions to the Ministerial Corporation with respect to the condition concerned, and
- c) must have regard to any submission that is made.

In this regard the holder of the approval would be consulted regarding any variations considered necessary.

3.2 Roads and railways

Roads and railways (and associated bridges, roadworks and railway works) vested in local government or State Government transport agencies, are declared by order as non-controlled works under section 165(2) (a) of the Water Act. However, agencies constructing these works are required to assess their environmental impact under the EP&A Act. In order to ensure coordination of road and rail structures in the FMP, recommended actions for existing and proposed road and railway structures are included in Table 2.

3.3 Flood protection for high-value infrastructure

Landholders can flood protect those parts of their property that contain high-value infrastructure such as houses, workshops, sheds and pumps. Where such works are constructed solely for the direct protection of high-value infrastructure, no Part 8 approval will be required.

However, where such works are integrated into a much larger area of protection incorporating earthworks or levee banks that also protect arable land, then the infrastructure protection may need to be assessed as a Part 8 determination process for flood control works on a property.

3.4 Floodplain harvesting works

Floodwaters play a vital role in replenishing the floodplain and wetland environment and are an important water source for many NSW irrigators.

The NSW Government is developing the Floodplain Harvesting Policy to ensure that floodplain harvesting is appropriately licensed, is sustainable for the long term and to meet requirements under the Murray–Darling Basin Ministerial Council Cap and the National Water Initiative. The National Water Initiative requires New South Wales to establish a framework for managing activities that have the potential to intercept significant volumes of water.

3.5 Block banks

Block banks, which are earthworks situated within waterways, require either of the following types of authorisation, depending on their intended purpose:

- controlled activities approval under the WMA (for vehicle crossings)
- water supply work approval under the WMA (where water supply works are constructed on streams listed in a water sharing plan), or
- licensing under Part 2 of the Water Act (where water supply works are constructed on streams not listed in a water sharing plan).

Authorisation is subject to endorsement by Industry and Investment NSW under the requirements of the *Fisheries Management Act 1994*.

3.6 Potential funding sources for environmental works and public works

There are potential funding sources available for both private and public works as listed in Table 1. The funds are competitive and generally any application has to demonstrate how proposed works are consistent with a plan or policy and produce a natural resource outcome and not just a private benefit.

Table 1 Funding sources

Source	Fund manager	Eligible works
Commonwealth and state assisted Natural Disaster Mitigation Program	State Emergency Management Committee (at state level)	Mainly flood mitigation works (public)
State Assisted Floodplain Management Program	Department of Environment, Climate Change and Water	Local government floodplain management related studies and works (public)
Various incentive funds <ul style="list-style-type: none">• Caring for our Country• Conservation farming incentive funding• Native vegetation incentive program	Lachlan Catchment Management Authority	On-farm works with natural resource management outcomes consistent with targets in the Lachlan Catchment Action Plan

4 FMP floodway network

4.1 Floodway network

The central element of the FMP is the floodway network. The floodway network represents a coordinated and integrated network of flood flow paths of adequate hydraulic capacity and continuity to effectively convey floodwaters and support the floodplain environment. The FMP floodway network is shown on Figure 2 (Sheets 1 to 4). The floodway network provides the basis by which future applications to undertake flood control works are assessed under Part 8 of the Water Act in order to ensure that the primary function of the floodway network (to convey and store floodwaters) is not compromised.

Applications to undertake flood control works located within the identified floodways constituting the FMP floodway network will be assessed as non-complying works and will likely be refused. However, if the applicant can demonstrate that the proposed works will meet the relevant hydraulic and environmental criteria (Sections 7.1 and 7.2 of the FMP) and will meet the requirements of section 166C of the Water Act and Part 5 of the EP&A Act, then the works may be considered for approval.

The FMP floodway network also identifies areas (outside the FMP floodway network) where flood control works will be assessed as complying works and, in general, will be readily approved with appropriate conditions if required (such as limitations on levee heights). All proposals must also undergo assessment under Part 5 of the EP&A Act to take into account any environmental impacts including cumulative impacts with other existing or likely future activities. Section 3 includes further details regarding the approval of flood control works and the administration of the FMP under Part 8 of the Water Act.

Decisions relating to the delineation of the FMP floodway network were largely driven by the floodplain management principles adopted by the FMC as listed in Section 2.3. The hydraulic, environmental, social and economic, and legislative principles are all relevant to the delineation of the floodway network.

In many cases, the respective categories of management principles conflict with each other (e.g. a trade off between hydraulic concerns, environmental concerns and maximising the area that can be protected for agricultural purposes). Decisions have ultimately been made based on a balanced viewpoint taking into account all of the relevant issues under consideration.

The floodway network differs in some areas in comparison to the 1979 Guidelines network. These differences have arisen in response to:

- existing flood control works considerations
- hydraulic considerations, or
- environmental considerations.

4.2 Hydraulic modelling

Implementation of floodplain management measures requires a detailed understanding and knowledge of flooding behaviour within the FMP area. To supplement available information on historical flood events, computer-based hydraulic models can be used to simulate flooding behaviour. Information derived from hydraulic modelling includes flood flow distributions, flood levels, and flood flow velocities within the floodplain.

Hydraulic models are used to design floodway networks and assess the impact on flood behaviour of structural management options and any proposed flood control works.

The Lachlan River floodplain from Gooloogong to Jemalong Gap was hydraulically modelled using the Danish Hydraulic Institute's MIKE 11 model. MIKE 11 is an engineering package specifically designed for unsteady flow computation, particularly in river and floodplain systems. The software program has built in functions for handling hydraulic structures such as culverts and weirs.

Extensive hydraulic modelling was undertaken in the FS to define flood behaviour for historical and existing conditions and to develop a model that could be used for future investigations and assessment of options.

For the FMP the model was run to simulate selected historic flooding conditions to provide estimates of flood levels, flows and velocities for different floodway networks and flood sizes. The results were used to review the performance of the 1979 Guidelines floodway network, assist in determining the design flood and provide estimates of parameters to allow setting of levee crest heights for the adopted design flood. The FRMS report (Sinclair Knight Merz 2010) provides more detailed information regarding this hydraulic modelling of the floodplain.

4.2.1 Design flood

The design flood is the event to be used for the hydraulic design of the FMP floodway network. The selection and adoption of the design flood is aimed at producing an equitable distribution of floodwater across the floodplain that enables floodwater access to flood dependent ecosystems, optimises the use of rural land for agricultural pursuits and gives an acceptable level of flood risk for property and infrastructure.

The process for selecting the design flood for the FMP floodway network involved a review of the performance of the 1979 Guidelines floodway network under different flood magnitudes in relation to hydraulic, environmental and socio-economic considerations. The 1979 Guidelines floodway network was originally designed to convey 1974 flood flows with an average recurrence interval (ARI) of about 50 years and allow landholders to construct flood protection levees along the floodway boundaries. However, more up to date modelling undertaken in the FS showed that the network is unable to cope with this flood magnitude, resulting in a detrimental redistribution of floodwaters and flood levels more than one metre above the original levee height restrictions in the 1979 Guidelines. Consultation with landholders on the FMP floodplain showed that most did not think that it was practical to protect against a 1974 flood magnitude or the slightly smaller 1990 flood. They preferred to see floodwaters spreading out on the floodplain during larger floods, thereby ensuring that flood levels did not rise significantly or cause an adverse redistribution of flood flows.

Based on a consideration of modelling results, landholder consultation and the floodplain management principles (Section 2.3), it was decided that the FMP floodway network should be designed for a medium-sized flood and not a major flood. Further modelling indicated that adopting the 15 year ARI flood would allow landholders to protect against a flood magnitude lying between the 1974 flood and a more frequent event such as the 1996 flood (5–10 year ARI). This would also avoid the relocation of existing floodplain infrastructure bordering the floodway network. Consequently, the design flood adopted for the FMP floodplain was the 15 year ARI flood.

A critical aspect of the FMP is the flow distribution throughout the floodway network. The hydraulic model provides an estimated flow distribution which was used for the

assessment of the hydraulic adequacy of the floodway network. It can also be used for assessing the impacts of proposed floodplain development. Details of the flow distribution derived from the hydraulic model for the adopted 15 year ARI design event are shown in the FRMS report (Sinclair Knight Merz 2010). These design flows were used for the assessment of the hydraulic adequacy of the floodway network.

4.2.2 Floods larger than the design flood

Within the FMP floodplain levee heights will be restricted to modelled 15 year ARI flood levels. As a result, larger floods (such as a 1974 magnitude flood) will overtop the levee system and sufficient storage will be provided for attenuation. It is expected that an overtopping flood would cause localised damage to some levees but generally floodwaters will tend to follow natural flow paths.

A number of high level floodways have been identified from 1990 flood satellite imagery and analysis of the 1979 Guidelines floodway network. It is expected that these floodways will not operate in a 15 year ARI flood; however, it is preferable that they are not restricted by development in the future. Accordingly, the identified high level floodways are included within the FMP floodway network.

The combination of levee height restrictions and high level floodways will mitigate the potential risk of larger floods on the FMP floodplain by allowing for a relatively natural flow distribution during these floods.

4.3 Floodway assessment considerations

Analysis of the floodway network involved identifying potential hydraulic and environmental areas of concern then assessing these in terms of whether their impact on flooding was acceptable. If not, modifications were recommended to make them acceptable. The following summarises this process.

4.3.1 Hydraulic

The assessment of hydraulic issues associated with the review of the floodway network and flood control works involved the following tasks:

- consideration of the adopted floodplain management principles (refer to Section 2.3)
- the hydraulic adequacy and impacts of the floodway in varying flood events, but most notably the adopted flow conditions for the design event
- the use of the hydraulic model to assist in quantifying the hydraulic impacts of different options/scenarios and existing flood control works. The application of the model was focused on those flood control works which:
 - are wholly or partly intruding into the floodway system
 - were raised by landholders at the community workshops or through returned questionnaires as being of concern.

In general, works complying with the 1979 Guidelines and any additional approval conditions were accepted, as the 1979 Guidelines floodway alignment was not significantly modified

- on-site discussions and inspections with landholders regarding their views on the floodway network and flood control works issues.

4.3.2 Environmental

Floodplain management plans must take into account principles relating to the protection of the environment. In particular, they must contain strategies to manage flood control works so that the natural functions of the floodplain environment are supported.

The review of the floodway network included an assessment of issues associated with the present status of flood access to flood dependent ecosystems. The environmental assessment was undertaken taking into account the environmental principles given in Section 2.3. The 1979 Guidelines and associated floodway network were prepared with less emphasis given to environmental considerations.

An important consideration has been to include environmentally important areas (EIAs), including vegetation, wetlands and watercourses that depend on flooding, within the floodway network where practicable. Where such ecosystems were located outside the 1979 Guidelines floodway network and not affected by existing works, the floodway was adjusted to include them. This has meant that in some areas the floodways are wider than would otherwise be required based on hydraulic assessment.

Where EIAs were affected by existing works, a set of assessment criteria developed in consultation with the FMC was applied. The criteria were developed to identify those ecosystems possessing moderate or higher environmental value which were to be considered for reconnection to the flooding regime.

4.3.3 Social and economic considerations

Social and economic considerations were an ever present factor when assessing the hydraulic and environmental related floodway issues. The impact of decisions on farm operations in relation to the layout and extent of the floodway network was discussed at length with landholders during the various community consultation activities, notably the three rounds of community workshops and at numerous on-site meetings with individual landholders.

The decision to adopt the 15 year ARI event was in large part based on avoiding significant adverse social and economic impacts associated with the adoption of a larger design flood. These impacts potentially include the construction of larger and more expensive levees and the modification of existing infrastructure to accommodate a broader floodway network. It was also consistent with the level of protection against flooding widely sought by rural landholders. It is generally seen to represent an appropriate balance between achieving an acceptable flood risk and not unnecessarily tying up an excessively large floodway area for hydraulic reasons associated with rare floods.

Field assessments, where possible, were carried out in the company of landholders to ensure that social and economic considerations were adequately understood and taken into account in assessing hydraulic options and options to reconnect EIAs affected by existing works.

4.3.4 Flooding in Forbes township

Forbes township has experienced large flood events that have isolated the town and inundated floodplains. The flood event of 1952 is the largest flood on record in Forbes and in recent times, flooding occurred in 1974, 1976, 1990, 1996 and 1998. Forbes Shire Council adopted 'Forbes Development Control Plan (DCP) No. 6 (Managing our Flood Risks)' in 2002 to control development within the 'Forbes Township Floodplain' and the 'Rural Flood Precinct'. The DCP aims (among other matters) to minimise the potential

impact of flooding, increase public awareness of flooding, reduce the risk to life, provide detailed building controls for development in the floodplain and provide a risk-based approach to development. The 'Adopted Flood Level', which is defined in the DCP, is the flood level for the 1952 flood in Forbes (a flood event with an ARI of 100 to 200 years) under current land-use and topography conditions. This flood level is used as the basis for a range of planning controls specified in the DCP including minimum habitable floor levels in residential areas which are set at the Adopted Flood Level plus 0.5 m freeboard.

The design flood adopted in the FMP is significantly smaller than the design flood adopted in Forbes DCP No. 6. Rural levees are mainly constructed to protect cropland and other agricultural pursuits and levee heights along the FMP floodway network are restricted up to the flood level resulting from the adopted 15 year ARI event. High level floodways are included in the FMP so that flood events larger than the design event can be passed with minimum obstruction. In the event of floods larger than the design event, the rural levees will be overtopped and the natural flood pattern restored. As a result, the FMP will have negligible impact on flooding in the township of Forbes.

4.4 Floodway vegetation management

Dense vegetation cover within the FMP floodway network may increase hydraulic roughness and reduce efficiency. In some areas of the FMP floodway network, increases in vegetation density could have the effect of blockages and cause redistribution of flood flows or increases in flood levels.

There is a range of measures available under current legislation that may allow thinning of vegetation in the FMP floodway network.

4.4.1 Native Vegetation Act 2003

Measures available under the *Native Vegetation Act 2003* that may be suitable for managing vegetation in the FMP floodway network include clearing of regrowth and Property Vegetation Plans (PVPs). Landholders proposing to thin vegetation in floodways are advised to contact the Lachlan CMA in the first instance.

Regrowth

Regrowth, which is permitted to be cleared, includes vegetation that has regrown since 1990 on previously cleared land. It does not include protected regrowth (including vegetation within 20 m of the bank of a watercourse) or vegetation that has regrown after clearing caused by a natural event such as fire or flood. Landholders unsure about the status of regrowth on their properties should seek advice from the Lachlan CMA.

Continuing Use PVPs

Continuing Use PVPs provide long-term certainty for ongoing farming practices. They cover a number of provisions for managing native vegetation including identification of regrowth (as above), the continuation of existing agricultural practices and, in exceptional circumstances, changing the regrowth date. PVPs that change the regrowth date allow landholders to alter the starting date for regrowth for the continuation of existing cultivation, grazing or rotational farming practices. Landholders proposing to prepare Continuing Use PVPs should seek advice from the Lachlan CMA.

Invasive Native Scrub PVPs

Invasive Native Scrub PVPs may be appropriate for the clearing of native vegetation in floodways in cases where listed species, including black box and river red gum, have

regenerated densely following natural or artificial disturbance, and the regeneration results in a change of structure and/or composition of the vegetation community. Invasive Native Scrub PVPs have thinning rules that are suitable for clearing to improve hydraulic efficiency.

Thinning PVPs

Thinning PVPs allow the removal of individual trees and shrubs to predetermined benchmarks for particular vegetation types. Thinning benchmarks for floodplain vegetation types specify a higher density than is allowable under Invasive Native Scrub PVPs. Consequently, Thinning PVPs may be too restrictive to improve hydraulic efficiency.

4.4.2 Native Vegetation Conservation Act 1997

Certain provisions of the *Native Vegetation Conservation Act 1997* that regulate the removal of exotic vegetation and dead timber on State Protected Land, including land within 20 m of the bed or bank of a prescribed stream, remain in effect. Applications for the removal of such vegetation may require approval from DECCW. Clearing dead trees and exotic trees will not require approval if the clearing is carried out in accordance with the *Guideline for the Clearing of Exotic Trees and Dead Native Trees on State Protected Land* (NSW Government 2006).

4.4.3 Removal of vegetation on waterfront land

The removal of vegetation on 'waterfront land' is a controlled activity under the WMA. Waterfront land includes the bed of any watercourse and land within 40 m of its high bank and the bed of any wetland and land within 40 m of its shore. Under the Act, controlled activities require approval from NOW; however, the Water Management Regulation 2004 exempts activities that comprise nothing more than the removal of vegetation, provided they are lawful under other legislation. Notwithstanding this, landholders may still seek approval for the removal of vegetation as a controlled activity under the WMA and if approval is granted, the clearing would be exempt from the requirements of the *Native Vegetation Act 2003*. This ensures that only one approval is required for clearing native vegetation on waterfront land. Clearing approved under the WMA would also be exempt from the requirements of the *Native Vegetation Conservation Act 1997*, if applicable (Section 4.4.2).

4.4.4 Recommended floodway vegetation management approach

From the range of available vegetation management measures, two options, regrowth clearing and Invasive Native Scrub PVPs, are considered to be the most appropriate for thinning in floodways to improve hydraulic efficiency. Regrowth (as defined under the *Native Vegetation Act*) can be cleared without a permit using the full range of clearing methods but cannot be cleared within 20 m of the bank of a watercourse. Invasive Native Scrub PVPs allow clearing to densities that are suitable for floodway maintenance and can be used throughout the FMP floodway network (including in riparian areas).

Vegetation thinning is most critical in narrow sections of the FMP floodway network where increased densities can lead to the redistribution of flood flows and increased flood levels. Community awareness of the need to manage vegetation in critical sections of the FMP floodway network is important; particularly as properties change ownership and land-use changes occur over time. Suitable maintenance measures need to be adopted to limit the density of vegetation cover to appropriate benchmarks. The hydraulic design of the FMP floodway network, including design flood levels, is based on adopting the vegetation cover

for the 1996 historical flood event. Property owners are encouraged to seek advice from the Lachlan CMA as to the most suitable land-use management options within floodways. The Lachlan CMA will assist in promoting community awareness of vegetation maintenance needs in critical sections of the FMP floodway network through its role in providing community education and training in vegetation management.

The clearing of invasive native scrub in floodways may lead to improved biodiversity due to reduced competition or increased opportunity for structural and floristic diversity. In such cases, funding through the Lachlan Catchment Action Plan may be available to support the cost of activities associated with the management of the vegetation (such as fencing and controlled grazing) but is not available for the cost of clearing.

5 Potential hydraulic restrictions – required actions

In order to finalise the FMP floodway network, identified areas with potential hydraulic restrictions were investigated. These areas included existing flood control works that were identified from aerial photography, satellite imagery, information from landholders and site inspections as possibly resulting in flooding problems. Satellite imagery captured in February 2000 towards the end of the cropping season was used to determine potential irrigation areas (with actively growing vegetation) within the 1979 Guidelines floodway network. These areas were further investigated to determine the presence of irrigation infrastructure that could potentially obstruct flood flows.

The required actions for potential hydraulic restrictions are given in Table 2 and the locations of the potential hydraulic restrictions identified are shown on Figure 2 (Sheets 1 to 4). In order to minimise social and economic impacts, approved flood control works consistent with the 1979 Guidelines were generally condoned.

It is important to remember that all proposed and existing flood control works within the FMP floodplain require approval under Part 8 of the Water Act. Where no approval exists, NOW may take the relevant action(s) under the Act.

With regard to the issues outlined in Table 2, please note the following:

- Specific structural modifications to existing flood control works will be administered under the relevant sections of Part 8.
- Minor modifications to existing approved flood control works will be administered through modifying the Part 8 approval conditions under section 176A of the Water Act.
- With regard to unauthorised flood control works, directions for remedial work(s) may be used as a means of encouraging landholders to bring the subject work(s) within the Water Act by lodging an application for approval that is complying with the FMP (refer to Section 3.1.6). It is envisaged that the approval process for complying works will be more expedient including development consent from the local council (where applicable).

Refer to Section 3 for further details regarding approval of flood control works and administration of the FMP under Part 8 of the Water Act.

Table 2 Required actions for areas with potential hydraulic restrictions

Ref no.	Figure 2 Sheet	Property /Site	Description	Actions	Action by whom	Priority ¹
1	1	'North Gobothery'	Landowner has applied to NOW to extend previously approved low level protection. This proposed extension is not supported by the adopted floodway alignment.	Landowner to provide supporting information on hydraulic and environmental grounds for proposed extensions to approved low level protection.	Landowner	Medium
2	1	'River-sleigh'	Area identified from satellite imagery is close to the river but does not contain irrigation infrastructure following closer review. It consists of existing mature river red gums and other vegetation. It is used for grazing and has no levees or other impeding structures. Further review of the satellite image shows that the area does not appear as bright red as other irrigated areas. The area may also have seemed irrigated due to vegetation growth after a small flood that had occurred a few months earlier.	No action required.	NA	NA
3	1	'Riverview'	Area identified from satellite imagery as being possible irrigation contains native vegetation and no infrastructure following closer review. Area to the south-west of this site has bank protection in accordance with the option detailed in the 1979 Guidelines. The 1979 Guidelines required that the banks be 'low level'. Works are approved with low level condition and floodway width of 65 m.	No action required.	NA	NA
4	1	'Walla Wallah'	High level floodway based on 1990 flood satellite image. The 1979 Guidelines identified a potential floodway in this area 'subject to agreement with landowners'.	Monitor flood flows in this area and review the adequacy of the floodway as required.	NOW / landowner	Ongoing
5	1	'New Park'	a) Area close to the road identified from satellite imagery is native vegetation following closer review. There is no irrigation infrastructure blocking the floodway. b) Landowners believe that flooding has become much worse in their area than previously. The replacement of the causeway at Parsons Creek with a culvert (4 m wide and 3.5 m high) and raising of the road have resulted in a bottleneck forcing more floodwaters to remain on the south side of the Lachlan Valley Way. continued...	No action required. Hydraulic modelling shows that additional waterway area is desirable, either as a culvert or causeway to the east of the existing culvert. An additional waterway area of 42 m ² under the existing vertical alignment of the road is desirable to handle the design flow.	NA Forbes Shire Council	NA Medium

Ref no.	Figure 2 Sheet	Property /Site	Description	Actions	Action by whom	Priority ¹
5 cont.	1	'New Park' continued	c) The Lachlan Valley Way is frequently crossed by channel siphons supplying water to the south of the road at both Ref. Nos. 5 and 8. These siphons are quite narrow, less than 50 m, which is much less than the design width of the floodway of about 200–300 m.	Monitor area during future floods.	NOW	Ongoing
6	1	'Robeen'	Area identified from satellite imagery has no irrigation infrastructure present following closer review.	No action required.	NA	NA
7	1	'Pine Park'	Area identified from satellite imagery has no irrigation infrastructure adjacent to the creek following closer review.	No action required.	NA	NA
8	1	'Parkside'	a) Area close to the road identified from satellite imagery is native vegetation following closer review. There is no irrigation infrastructure blocking the floodway. b) Landowners believe that flooding has become much worse in their area than previously. The replacement of the causeway at Parsons Creek with a culvert (4 m wide and 3.5 m high) and raising of the road have resulted in a bottleneck forcing more floodwaters to remain on the south side of the Lachlan Valley Way. c) The Lachlan Valley Way is frequently crossed by channel siphons supplying water to the south of the road at both Ref. Nos. 5 and 8. These siphons are quite narrow, less than 50 m, which is much less than the design width of the floodway of about 200–300 m.	No action required. Hydraulic modelling shows that additional waterway area is desirable, either as a culvert or causeway to the east of the existing culvert. An additional waterway area of 42 m ² under the existing vertical alignment of the road is desirable to handle the design flow. Monitor area during future floods.	NA Forbes Shire Council NOW	NA Medium Ongoing
9	1	'Timaroo'	Area identified from satellite imagery includes irrigated crops but is not protected with levees following closer review. Some of the vegetation shown on the satellite image is in the 'seepage' area and is not irrigated.	No action required.	NA	NA
10	1	'Kaloola'	Area along the creek line identified from satellite imagery is likely to be native vegetation and not irrigation.	Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so, whether they would be overtopped in a design flood.	NOW	Medium
11	1	'Wallamarra'	Area identified from satellite imagery has no irrigation infrastructure present following closer review.	No action required.	NA	NA

Ref no.	Figure 2 Sheet	Property /Site	Description	Actions	Action by whom	Priority ¹
12	1	'Pine Park'	Area with banks identified from satellite imagery was the subject of a Land Board Hearing involving a previous owner. Adjacent landowners interviewed said that floodwaters could not escape to the north and instead would flow west and flood their land. Review of the area indicates that some of the required remedial works have been carried out on the property, but banks remain which may hinder the free passage of floods, up to and including the design flood, to the north.	Remaining banks subject to the decision of the Land Board to be modified in consultation with NOW and in accordance with agreed outcomes.	Landowner	High
13	1	'Kara Kara'	Area identified from satellite imagery has no irrigation infrastructure present following closer review.	No action required.	NA	NA
14	2	Newell Highway	The Newell Highway, south of Forbes, crosses a number of floodways including Bundaburrah Creek and Ooma Creek. The highway is generally at about natural ground level and so does not cause a restriction to floodwaters. However, in a number of locations the road is elevated for approaches to bridges and crossing depressions. Detailed topographic plans were not available but it is likely that at these locations the road forms a minor restriction, particularly for minor floods.	RTA to assess flood impacts of any likely maintenance or upgrading of the Newell Highway in consultation with NOW. Any proposed upgrade should meet FMP adopted assessment criteria.	RTA	Ongoing
15	1	'Lachlan Park'	Area identified from satellite imagery has some irrigation structures and banks which may be hindering flow.	Carry out an inspection of the property and assess whether there are any banks that may block floodwaters. Monitor area during future floods.	NOW NOW / Landowner	High Ongoing
16	1	'Salisbury'	Owner's orchard was severely flooded in 1990. He believes that there are major problems with flood flow distribution in his area. His orchard is consistent with the 1979 Guidelines and is not blocking the floodway. Vegetation shown close to the road is the native vegetation along the road easement.	Monitor area during future floods.	NOW / Landowner	Ongoing
17	1	'Lachlan Park'	Area identified from satellite imagery has some irrigation structures and banks which may be hindering flow.	Carry out an inspection of the property and assess whether there are any banks that may block floodwaters. Monitor area during future floods.	NOW NOW / Landowner	High Ongoing

Ref no.	Figure 2 Sheet	Property /Site	Description	Actions	Action by whom	Priority ¹
18	3	Parkes-Stockinbingal Railway	The railway line through Forbes crosses Bundaburrah Creek at this location. The owner of the adjacent property says that the viaduct across the floodplain is not long enough and in a major flood, there is about 0.5 m afflux between the upstream and downstream sides. However, it is unlikely that State Rail would be willing to upgrade the viaduct. The benefit of the restriction is that floodwaters are held on the upstream side of the viaduct and therefore reduce flooding downstream.	State Rail to consult with DECCW on: <ul style="list-style-type: none"> any plans to upgrade the viaduct any proposed upgrade should meet FMP adopted assessment criteria. 	State Rail	Ongoing
19	3	'Werai'	Area identified from satellite imagery is irrigated and there are a number of works on the property.	Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so, whether they would be overtopped in a design flood.	NOW	Medium
20	3	'Champsaur'	A preliminary inspection of the property from the road indicates that there may be some restrictions due to supply channels and banks. Important breakout from the left bank of the Lachlan and a feeder floodway to Bundaburrah Creek.	Carry out an inspection of the property and assess whether there are any banks and if so, whether they would be overtopped in a design flood.	NOW	High
21	3	'Allandale'	Area identified from satellite imagery is irrigated and there are a number of works on the property.	Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so, whether they would be overtopped in a design flood.	NOW	Medium
22	3	'Sandhills'	<p>Very important breakout to the north which comes back into Forbes through the golf course and Lake Forbes. Any change to ground levels or road level in this area has major implications on flow distribution in the Lachlan River, the Southern Cross floodway, the 12 Mile Break and the flow to Bundaburrah Creek.</p> <p>There are very complex issues relating to levees in the Southern Cross area and flow distribution.</p> <p>Detailed hydraulic modelling was undertaken for Southern Cross breakout and 12 Mile Break. Modelling results indicated the following:</p> <ul style="list-style-type: none"> Southern Cross breakout flows first when a flood occurs but the 12 Mile Break carries more water in the larger event. Importance of both Southern Cross breakout and the 12 Mile Break are more pronounced for flood events larger than the design flood. <p>continued...</p>	<p>Maintain high level floodway for the 12 Mile Break.</p> <p>Monitor area during future floods.</p>	<p>Landowners / Forbes Shire Council NOW</p> <p>Landowners / Forbes Shire Council NOW</p>	<p>Ongoing</p> <p>Ongoing</p>

Ref no.	Figure 2 Sheet	Property /Site	Description	Actions	Action by whom	Priority ¹
22 cont.	3	'Sandhills' continued	<ul style="list-style-type: none"> Construction of any new banks and/or raising of existing banks (including Eugowra Road) in the vicinity of Southern Cross breakout and the 12 Mile Break would change flow distribution between Lachlan River and Bundaburrah Creek. Existing unauthorised works on the floodplain on the north and southern banks of the Lachlan River downstream of Southern Cross breakout between 'Ulmarra' and 'Sandhills' would have no significant impact on the regional flood flow distribution for the design flood. The works would however, have localised impacts for the design flood. 			
23	3	'Yamma'	Area identified from satellite imagery as irrigated cropping is native vegetation and the floodway is not obstructed by works following closer review. Existing banks on the property are constructed on the alignment of the 1979 Guidelines floodway network.	No action required.	NA	NA
24	3	'Riverie'	Area identified from satellite imagery requires property inspection to confirm any blockage of floodway.	Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so, whether they would be overtopped in the design flood.	NOW	High
25	3	'Waugan Park'	Area identified from satellite imagery requires property inspection to confirm any blockage of floodway.	Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so, whether they would be overtopped in the design flood.	NOW	High
26	3	'Vychan'	Area identified from satellite imagery requires property inspection to confirm any blockage of floodway.	Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so, whether they would be overtopped in the design flood.	NOW	High

Key:

High priority – These measures are considered very important in relation to the performance of the FMP floodway network and should as a consequence be implemented in the shorter term.

Medium priority – These measures are desirable for hydraulic and/or environmental reasons.

Ongoing – These issues may require further investigation or have not been fully resolved and therefore may need further investigation.

6 Environmental assessment

6.1 Assessment approach

Flood control works undertaken in the past have in some instances resulted in the exclusion or restriction of floodwater access to flood dependent ecosystem areas. Other sites, although retaining floodwater access to date, have been located outside the 1979 Guidelines floodway network and as such could be isolated by flood control works in the future.

The environmental assessment approach taken in preparing the FMP focused on those parts of the floodplain of higher environmental value that support a high proportion of the ecological functions that occur during floods. These areas were identified as environmentally important areas (EIAs) and are defined as areas that have important environmental and/or cultural features that rely on inundation by floodwaters to sustain essential ecological processes. They include areas of flood dependent vegetation, wetlands and floodplain watercourses.

EIAs were initially identified from a desktop analysis of available mapping and then analysed using hydraulic information and flood photography to determine those that were connected to the flooding regime and those that were isolated by existing works. The floodway layer from the 1979 Guidelines was overlain on the environmental mapping to indicate EIAs that could potentially be isolated by future development. Ground truthing of EIAs isolated or potentially isolated from flooding was then undertaken to determine the environmental value of the EIAs identified and to check their flood connectivity. A total of 16 sites were inspected. The locations of these sites are shown on Figure 2 (Sheets 1 to 4).

EIAs located outside the 1979 Guidelines floodway network and found not to be affected by flood control works were included in the FMP floodway network to maintain ongoing flood connectivity.

Environmental criteria, developed in consultation with the FMC, were applied to determine the environmental value of EIAs affected by works. This was done to ensure that management actions in the FMP to reconnect EIAs to flooding were warranted (based on ecological factors) and targeted those works affecting ecosystems of moderate or higher environmental value. The criteria assigned an environmental value score to the EIAs based on size, ecological condition, habitat value, uniqueness, cultural significance, rehabilitation potential, vegetation connectivity and special features.

EIAs with moderate or higher environmental value were further assessed based on social and economic considerations associated with restoring flood access. Consultation with landholders during the assessment process included discussions on the practicality of reconnecting EIAs to the flood regime. Further information on the environmental assessments for the 16 sites inspected is provided in the FRMS report (Sinclair Knight Merz 2010).

EIAs located within the 1979 Guidelines floodway network and known not to be affected by flood control works were not subject to detailed assessment. All of these sites have been retained within the FMP floodway network, thereby reasonably assuring that future floodwater access to these ecosystems is maintained.

6.2 Adopted outcomes

Adopted outcomes from the assessment of the 16 potential EIAs identified outside the 1979 Guidelines floodway network were influenced by the presence of existing works. The assessment resulted in the following outcomes:

- EIAs affected by works (10 sites) – The adopted outcome was to maintain flood connectivity by including them in the FMP floodway network. Refer to Figure 3 (Sheets 1 to 2).
- EIAs affected by works (five sites) – Four sites were assessed as having low environmental value and no action was taken to modify these works. One EIA was assessed as having moderate environmental value but restoration of flooding was not considered to be a practical option due to economic and social considerations.

Another potential EIA was found on inspection to be irrigated cropland. This site was not assessed as an EIA and no action was taken to modify associated works.

Table 3 below specifies the observed ecosystem types and the outcomes determined for the EIAs assessed. The locations of the EIAs are shown on Figure 2 (Sheets 1 to 4).

Table 3 Potential EIAs assessed

EIA no.	Observed ecosystem	FMP outcome
1	River red gum woodland	Floodway inclusion
2	River red gum woodland	Floodway inclusion
3	River red gum woodland	Floodway inclusion
4	Shallow cropped depression	No action
5	River red gum woodland	Floodway inclusion
6	Shallow cropped depression	No action
7	River red gum woodland	Floodway inclusion
8	Flood runners with scattered yellow box & river red gum	Floodway inclusion
9	River red gum depression	Floodway inclusion
10	Shallow cropped wetland	Floodway inclusion
11	Cropped wetland	No action
12	Cropped depression	No action
13	River red gum woodland / open wetland	Floodway inclusion
14	River red gum woodland	Floodway inclusion
15	Irrigated crop layout	No action
16	Shallow cropped depression / farm dams	No action

The ecosystems assessed are not the complete set of EIAs in the FMP floodplain. The majority of EIAs were included within the 1979 Guidelines floodway network and are connected to flooding. These EIAs are incorporated into the FMP floodway network, thus reasonably assuring their ongoing flood connectivity. Figure 3 (Sheets 1 to 2) shows wetland vegetation mapping, prepared by the NSW Department of Water Resources in 1989, relative to the FMP floodway network, and provides an indication of the extent of EIAs in the FMP floodplain.

7 Criteria for assessing works

7.1 Criteria for high level floodways

The following criteria will apply to the existing (unauthorised) or proposed works located within the high level floodways:

- The works do not cause an increase of greater than 100 mm in flood levels for floods larger than the 15 year ARI design flood.
- The works do not cause any significant redistribution of peak flood flows for floods larger than the 15 year ARI design flood (i.e. more than a 5% redistribution of flow).
- The works do not cause any significant increase in floodway velocities. Velocities should be of an order that is below the threshold of erosion for the potential land usage.
- The works do not block, impede or divert the flooding regimes in flood dependent ecosystems within the FMP high level floodway network.

To assist in such assessment in the high level floodways the modelled flood parameters for the 1974 historical flood are presented in the FRMS report (Sinclair Knight Merz 2010). This flood has an estimated ARI of about 50 years. The environmental impacts of the works applications will need to be assessed under Part 5 of the EP&A Act.

Existing (unauthorised) or proposed works within the high level floodways that do not meet the above criteria will be assessed as non-complying works and will need to be modified to meet the criteria.

7.2 Criteria for non-complying works (15 year ARI design flood)

Landholders applying for approval of non-complying works will need to engage a suitably qualified consultant to investigate the hydraulic and environmental impact of the works. Applications will be assessed against the matters raised in section 166C of the Water Act (see Section 3.1.4) and the following hydraulic and environmental criteria:

- The works do not cause any increase in the **15 year ARI design flood levels** (as shown on Figure 2 Sheets 1 to 4).
- The works do not cause any significant redistribution of peak flood flows for 15 year ARI (i.e. more than a 5% redistribution of the **15 year ARI design peak floodway flows** (refer to FRMS)).
- The works do not cause any significant increase in floodway velocities under **15 year ARI design peak floodway flow** (refer to FRMS) conditions. Velocities should be of an order that is below the threshold of erosion for the potential land usage.
- The works do not block, impede or divert the flooding regimes in flood dependent ecosystems within the FMP 15 year ARI floodway network.

In addition, the environmental impacts of works will be assessed against Part 5 of the EP&A Act (refer Section 3.1.4).

8 Environmental impacts of the FMP

8.1 Overview

Implementing the FMP will have a positive impact on the floodplain environment by ensuring the long-term maintenance of flood connectivity between the Lachlan River, watercourses and EIAs on the FMP floodplain.

The FMP will ensure flood flow access to the floodplain area within the FMP floodway network, including an area of about 1000 ha of EIAs previously excluded from the 1979 Guidelines floodway network. The FMP floodway network has been sized to convey a flood with an ARI of 15 years in the FMP floodplain. As well, in line with principles adopted by the committee, it has been designed to conform as closely as reasonably possible to the natural drainage pattern and to allow for the delivery of floodwaters to support floodplain ecosystems. Because of these design criteria, the FMP floodway network includes a high proportion of existing floodplain ecosystems. Future flood connectivity to these ecosystems is reasonably assured since approval for future works within the FMP floodway network will be unlikely and would only be granted following a detailed assessment of impact including the requirements of the EP&A Act.

Although the FMP will allow for potential development outside the floodway network subject to environmental clearances, advice from some graziers in the FMP floodplain indicates that widespread construction of levees is not a likely proposition under current farming practice. As a result, while future development may cause some reduction in flood connectivity outside the FMP floodway network and reduce the ecological benefits of flooding in this area, the impact is not expected to be significant based on current projections.

The impacts of the FMP have been assessed by considering the impacts on the individual components of the floodplain environment. These impacts are summarised in Table 4 below.

Table 4 Summary of environmental impacts

Factor	Impact
Soils	<ul style="list-style-type: none"> Flood connectivity will benefit soil condition and structure within the FMP floodway network and undeveloped areas of the floodplain. Floods will provide sediment, soil moisture recharge and nutrient release in these areas.
EIAs (wetlands & watercourses)	<ul style="list-style-type: none"> All EIAs with existing connection to the flooding regime are contained within the FMP floodway network. Since new works in the floodway network will require a detailed assessment of impact (including impacts on wetlands) long-term maintenance of flood flow connectivity to these wetlands is ensured. Existing works affecting five EIAs assessed (about 320 ha) will be retained without modification. These areas have been highly modified for agriculture. Four of the sites (about 100 ha) were assessed as having low environmental value. The 200 ha cleared section of Bundaburrah Swamp assessed had a moderate environmental value but was considered to have low practicality for modifying the associated levee banks due to major economic impacts. Overall impact of retaining existing works at these EIAs is not significant.
Floodplain vegetation continued...	<ul style="list-style-type: none"> Existing flood dependent vegetation, consisting mainly of river red gum and black box, is contained within the FMP floodway network with the exception of a small number of individual trees (refer to Figure 3 Sheets 1 to 2). This vegetation includes an additional 1000 ha of EIAs previously outside the 1979 Guidelines floodway network. This will maintain flood connectivity and vegetation health since approval for future works within the FMP floodway network will be unlikely and would only be granted following a detailed assessment of impact.

Factor	Impact
Floodplain vegetation continued	<ul style="list-style-type: none"> Continued disconnection of the five EIAs affected by existing works will have a negligible impact on native vegetation as the areas are, with the exception of a small number of trees, currently cleared. Four threatened plant species associated with floodplain environments are known or predicted to occur in the FMP floodplain. These include Wakool speargrass (<i>Austrostipa wakoolica</i>), winged peppergrass (<i>Lepidium monoplocoides</i>), austral pillwort (<i>Pilularia novaehollandiae</i>) and spikerush (<i>Eleocharis obicis</i>). These species would be expected to benefit from the FMP because it will allow ongoing flood connectivity and help to maintain or restore the condition of EIAs that may support them.
Fauna	<ul style="list-style-type: none"> Proposed floodplain management measures will benefit terrestrial fauna species relying directly on flooding (e.g. waterbirds) and those utilising floodplain habitats, by enhancing or maintaining flood connectivity to floodplain ecosystems. Up to 34 threatened fauna species may potentially occur in the FMP floodplain based on known habitat preferences. Of these, four species (magpie goose, freckled duck, Australasian bittern and brolga) have a direct dependence on flooding to maintain their life cycles. Implementation of the proposed floodplain management measures will maintain flood flow access to habitat in EIAs currently connected to the flooding regime.
Aquatic fauna	<ul style="list-style-type: none"> The FMP floodway network will be integral in ensuring ongoing flood connectivity between the river, floodplain watercourses and wetlands. This connectivity is vital in maintaining the habitat value of the FMP floodplain as a food source for aquatic invertebrates and fish and as a breeding ground for migratory fish, including golden perch and silver perch, the latter being a threatened species. This is expected to benefit the aquatic ecological community of the lowland Lachlan River catchment (listed as an endangered ecological community) including Murray cod, a nationally listed threatened species recorded on the FMP floodplain, and other listed threatened species which potentially inhabit the FMP floodplain.
Water quality	<ul style="list-style-type: none"> Risk of surplus nutrient and pesticide transport through inundation of cropped areas or through excessive scour or erosion will be restricted as the FMP floodway network has been designed to limit flood velocities and to minimise the flood risk to complying agricultural development. Proposed measures to maintain flood flow access to existing wetlands connected to the flooding will allow for a continuation or improvement of flood dilution and flushing of any salt that may accumulate in wetlands and floodplain watercourses. There may be some risk of salt accretion in the 320 ha of EIAs that remain blocked from flood flows, however each of these sites receives local runoff that would tend to offset this impact by providing periodic flushing flows.
Groundwater	<ul style="list-style-type: none"> Major recharge of the upper aquifer (the Cowra Formation) occurs when larger floods (as in 1990) inundate the floodplain. Although detailed information on groundwater accession behaviour on the floodplain is not available, recharge is known to occur through ephemeral flood runners, particularly those containing sandy/alluvial layers. All existing floodplain watercourses are included in the FMP floodway network, thus allowing for ongoing groundwater recharge during floods. Recharge from the upper aquifer to the deeper aquifer (the Lachlan Formation) occurs through pressure-driven leakage and is a long-term process.
Aboriginal heritage continued...	<ul style="list-style-type: none"> Information on the location of recorded Aboriginal sites in the FMP floodplain has been obtained from the Aboriginal Heritage Information Management System. Aboriginal sites of greatest relevance to the FMP are likely to include scarred river red gum or black box trees, wetlands and watercourses of spiritual importance (flood dependent) and burial sites (subject to flood erosion). Recorded sites that are flood dependent are largely contained within EIAs that lie within the FMP floodway network and ongoing flood access to these sites is reasonably assured. Four recorded scarred trees lie outside the FMP floodway network in relatively clear areas that did not receive general flooding in the 1990 flood. A further eight scarred trees outside the FMP floodway network are located in areas of grey box and yellow box woodland that is not flood dependent.

Factor	Impact
Aboriginal heritage continued	<ul style="list-style-type: none"> Other Aboriginal sites (not recorded) that are flood dependent are expected to be largely contained within EIAs. The FMP floodway network includes all EIAs with existing connectivity to the flooding regime and a high proportion of all EIAs on the floodplain (as indicated on Figure 3 Sheets 1 to 2). Ongoing flood access to unrecorded Aboriginal sites that are flood dependent is therefore reasonably assured. Flood damage to on-ground Aboriginal sites (such as burial sites) may occur naturally, however the FMP floodway network has been designed to minimise flood velocities and accordingly, would be expected to reduce the risk of erosion damage to these sites during floods.
European heritage	<ul style="list-style-type: none"> One historical site, a lone grave on 'Wongajong', has been listed on the Register of the National Estate. The grave is located on higher ground above the northern bank of Bundaburrah Creek and is not likely to be flooded.

8.2 Catchment impacts

The Belubula River and two smaller tributaries, Kangaroooby Creek and Pipeclay Creek, join the Lachlan floodplain directly upstream of Gooloogong. There are a number of floodplain wetlands in this area, notably Goodwin's Swamp which is associated with Pipe Clay Creek. The FMP floodway network will maintain corridors throughout the floodplain for the free passage of floods and is not likely to adversely affect the hydrology of the tributaries or floodplain wetlands upstream.

Downstream of Jemalong Gap, the floodplain broadens and includes significant natural resources. This area, which contains numerous wetlands (including Lake Cowal) and supports a high diversity of waterbirds and native fish when flooded, is included in the Jemalong Gap to Condobolin Floodplain Management Plan that is currently in preparation. Principles guiding decision-making in that FMP are consistent with those in the FMP and consequently measures in both FMPs are expected to provide compatible outcomes.

The FMP floodway network is based on the natural drainage pattern and the exit of floodwaters from the floodway network is expected to be at rates and depths similar to those that would have been experienced under natural/historical conditions. The FMP floodway network will preserve flood flow paths and allow for future delivery of the flood regime to downstream ecosystems.

9 Monitoring and review

9.1 Performance indicators

The performance of the FMP will be assessed against three sets of performance indicators:

- Existing and proposed flood control works are constructed, maintained and modified in accordance with the FMP.
- The FMP floodway network allows for the orderly passage of floodwaters during a range of floods.
- The FMP floodway network allows for the delivery of floodwaters to support floodplain ecosystems.

The process of approval of flood control works will provide a measure of works that abide by the FMP and works that are not approved will need to be removed. An audit of works should be carried out after the majority of approvals are completed.

The performance of the FMP floodway network during floods would be assessed from information gathered during flood monitoring activities. This information should be measured against the objectives of the FMP. In particular the following should be considered with comparison made to historical flood events:

Hydraulic:

- improved passage of flood waters through the FMP floodplain, and
- structures performing to the agreed hydraulic criteria.

Environmental:

- improved fish passage
- improved habitat for plants and animals that utilise floodplains, and
- increased flood connectivity to wetlands.

Economic:

- lesser flood damage.

Social:

- improved access during floods, and
- clarity for the community in actions carried out during a flood.

In order to assess the performance of the FMP against these indicators, a monitoring program is proposed as outlined below.

9.2 Flood monitoring

Monitoring of hydraulic flood behaviour would identify any problem areas and whether any modifications or upgrades are required. Depending on the size of the flood, monitoring would range from simple observation to measuring of flows and levels followed by additional hydraulic analyses.

A list of potential hydraulic restrictions to be monitored is included in Appendix A. For the larger floods, nearing the design flood levels, monitoring should be undertaken in more detail. In particular, as the hydraulic modelling has a significant degree of reliance upon flow estimates, especially peak flows, it will be important to collect data to verify these estimates. An effective monitoring program will require input from DECCW, Forbes Shire Council and landholders. The following is recommended:

- DECCW should undertake aerial photography, collection of satellite imagery, survey, stream gaugings and flow measurements, and
- where safe to do so, Forbes Shire Council and landholders should observe the performance of their part of the floodway network, including marking high flood levels, estimating flow velocities and taking photographs.

Following floods, landholders should estimate flood damage, including crop and fencing losses and damage to private roads. Council should provide an estimate of flood damage to public roads and infrastructure.

Refer to Appendix A for detailed advisory notes on flood monitoring.

9.3 Environmental monitoring

Environmental monitoring during and after floods will determine whether the FMP floodway network is adequately providing flood flow connectivity to EIAs and help to assess the ecological impacts of local flooding. Environmental data would mainly consist of observations with supporting photography wherever possible. The scale of flooding would influence the extent of data collected. For example, in a flood of 1990 proportions, observations of wetland inundation, waterbirds and fish would be extensive in comparison to a relatively small flood.

DECCW should collate environmental data from Forbes Shire Council, landholders and other agencies. Council and landholders could observe, for their areas of the floodplain:

- performance of environmental works modifications during floods
- wetland inundation
- waterbirds and fish presence, and
- regeneration of floodplain vegetation.

Appendix A includes detailed advisory notes on environmental monitoring and sites where the performance of environmental modifications should be monitored during floods.

9.4 Plan review

Floodplain management plans adopted as Minister's plans under the WMA are required to be reviewed at five yearly intervals to determine whether their provisions adequately implement the water management principles of the Act.

If new flood data comes to light following a major flood, the FMP may need to be reviewed and updated earlier than after the statutory five-years. Triggers for review can also include changes to land use, impediments to implementation, and changes to factors that influence decisions. Climate change has the potential to result in direct and indirect changes to floodplains including their hydrology and the institutional framework in which they are managed. Flooding patterns may alter due to changes in monthly average rainfall, the distribution of rainfall and rainfall intensity. Changes to groundwater and soil moisture levels could influence the magnitude and duration of floods.

10 References

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Department of Land and Water Conservation (2002) *State Groundwater Dependent Ecosystems Policy*, NSW Department of Land and Water Conservation, Sydney.

Forbes Shire Council (2002) *Development Control Plan No. 6: Managing our Flood Risks*, Forbes Shire Council, Forbes.

Lachlan Catchment Management Authority (2006) *Lachlan Catchment Action Plan 2006–2016*, Lachlan Catchment Management Authority, Forbes.

NSW Government (1993) *State Rivers and Estuaries Policy*, NSW Government.

NSW Government (2005) *Floodplain Development Manual: the management of flood liable land*, Department of Infrastructure, Planning and Natural Resources, Sydney. This document incorporates the *NSW Flood Prone Land Policy*.

NSW Government (2006) *Guideline for the Clearing of Exotic Trees and Dead Native Trees on State Protected Land*, NSW Government.

NSW Government (2010) *NSW State Plan: Investing in a better future*, NSW Government.

NSW Murray Wetlands Working Group (2002) *Wetlands Watch: A Field Guide for Monitoring Wetlands in the Southern Section of the Murray–Darling Basin*, NSW Murray Wetlands Working Group, Albury.

Sinclair Knight Merz (2003) *Lachlan River Floodplain Management Study (Gooloogong to Jemalong Gap), Data Collection and Flood Study, Phase A Final Report*, report to the NSW Department of Land and Water Conservation, Newcastle.

Sinclair Knight Merz (2010) *Lachlan River Floodplain Risk Management Study (Gooloogong to Jemalong Gap)*.

Water Resources Commission (1979) *Guidelines for Floodplain Development Lachlan Valley Gooloogong to Jemalong Gap*, NSW Water Resources Commission, Sydney.

Appendix A – Monitoring activities

Potential hydraulic restrictions to monitor

Reference	Where to monitor	What to monitor
Figure 2 Sheet 1 – Ref. No. 4	'Walla Wallah'	Monitor area during future floods and review the adequacy of the floodway as required – refer to Table 2 for details.
Figure 2 Sheet 1 – Ref. Nos. 5, 8	Lachlan Valley Way	Monitor area during future floods – refer to Table 2 for details.
Figure 2 Sheet 1 – Ref. Nos. 15, 17	'Lachlan Park'	Monitor area during future floods – refer to Table 2 for details.
Figure 2 Sheet 1 – Ref. No. 16	'Salisbury'	Monitor area during future floods – refer to Table 2 for details.
Figure 2 Sheet 3 – Ref. No. 22	Southern Cross Breakout	Monitor area during future floods – refer to Table 2 for details.

Flood monitoring guidelines for landholders

The following advisory notes specify monitoring activities that should be undertaken by landholders, Forbes Shire Council and DECCW. The collected monitoring data will assist the FMP review process at the required five yearly intervals and after major flooding events. Where necessary, modifications to the FMP can be recommended based on the findings of the review process.

(a) *Hydrologic and hydraulic data*

Flood event characteristics

- Note rainfall depths from private rain gauges throughout the storm event in order to obtain total depth and temporal pattern.
- Note the start and finish times of flooding, as well as when the flood peak arrived.
- Note the duration of the flood peak (how long the peak lasted prior to receding).
- Compare the flooding with other flood events experienced.

Data near stream-flow gauging stations

- Note peak water levels from staff gauges (an average of a number of readings should be taken).
- Take photographs illustrating flood extent and flow pattern.

Floodplain data

- Where possible peg flood peaks across the floodplain (e.g. flood marks or debris on strainer posts, trees, farm sheds or dwellings).
- Note the extent and width of the flooding.

-
- Estimate surface flow velocities (usually expressed in metres per second) and where possible note flow pattern. Velocities can be estimated by timing the movement of floating debris over an approximated length of travel.
 - Where possible measure flood water slope by pegging water levels over a length of one kilometre.
 - Note any obstructions to the passage of flood flow (e.g. roads, levees, banks), and where possible obtain estimated difference in water levels upstream and downstream of the obstruction.
 - Take photographs illustrating flow paths, flooded areas and dry areas, and flow near obstructions.

Note: Select floodplain monitoring sites that are near hydraulic controls such as roads, levees, major overbank flow breakouts, and at defined floodways.

Data along roads and at causeways or floodways

- Where flooded – estimate flow velocities and flow width over the road, as well as the difference in water levels upstream and downstream of the road.
- Where dry – estimate the height out of water.

(b) Flood damage

After a flood event, information is normally sought to assist in determining the nature and cause of any flood damage. Notes and sketches provided by landholders can aid this process.

Farm loss incurred

- Note the location of any damage and estimate the loss of crops and fencing.

Road damage

- Note the location and extent of pavement damage and silt over roads.
- Where possible estimate the length of road cuts.

Erosion and siltation

- Symptoms of stream bed lowering include vertical headcuts in the stream bed, extensive bank erosion on both sides of the stream, headcuts in tributary streams and gullies, exposed gravel or rock beds, exposed pipe capping on bridge piers, and undermining of causeways.
- Causes of stream bank erosion include flood flows and abrupt changes in channel alignment, gullying where overland flow enters streams, bed lowering, and obstructions to stream flow such as weirs or low level crossings.
- Causes of floodplain erosion include unsustainable land-use practices (e.g. clearing), overflows from perched streams, or flow concentration due to floodplain development.
- Causes of floodplain siltation include hill-slope erosion or reduced capacity of the main channel (bridge crossings, excessive vegetation or regrowth, influx of sediment), which result in in-stream sediment being deposited onto the floodplain.

(c) Environmental data

Wetland data

- Note and photograph any changes to the flooding and drying patterns of the wetland.
- Note how long the wetland holds water after a flood event.
- Measure and note how deep the water is in the wetland at different times.
- Note and photograph the condition and variety of wetland plant species over time.

Floodplain vegetation (black box, river red gum, lignum) data

- Note and photograph the extent of floodplain vegetation regeneration over time.
- Note and photograph the extent of flood inundation in the vicinity of floodplain vegetation.

Waterbird and fish observations

- At key sites, such as wetlands, note the abundance and diversity of waterbird species. The easiest method is to group the waterbirds into ducks, grebes, cormorants, etc. and count by 10s, 50s or 100s.
- At key sites, such as wetlands and waterways, note the abundance and diversity of fish species. Dip-netting is the simplest way to monitor small fish in wetlands.

For more information on monitoring wetlands, waterbirds and fish refer to the NSW Murray Wetlands Working Group (2002) document titled *Wetlands Watch: A Field Guide for Monitoring Wetlands in the Southern Section of the Murray–Darling Basin*.

(d) Aerial and ground photography

Photographs (to be taken between identifiable points on a map)

- areas flooded and areas not flooded
- areas of active flow and backwater
- the main flow paths
- known earthworks such as levees, banks, channels
- known problem areas
- roads and railways
- environmental information, as outlined in (c) above
- time and date each photograph was taken.

Monitoring questionnaire

The questionnaire opposite could be filled out by landholders as a means of recording and collating information regarding the characteristics of a flood event, as well as flood damage. Use extra pages if required.

LANDHOLDER MONITORING QUESTIONNAIRE

Hydrologic and hydraulic data

Rainfall depths & duration (private rain gauges).....millimetres at 9:00am each day

Inundation limits – sketch on a map areas inundated, flow paths & areas of backwater

Duration of inundation.....hours / days

Depth of inundation.....metres at location.....

Flow velocity estimates.....metres per second at location

Flood marks – provide location and description, mark levels upstream and downstream of structures (channels, roads, culverts etc)

Identify any flow obstructions – banks, channels, roads, etc.

Compare with previous floods – larger/smaller, etc.

Flood Damage

Crop loss – Yes/No – If yes, describe location & extent

Fence loss – Yes/No – If yes, describe location & extent

Road damage – Yes/No – If yes, describe type, location & extent

Erosion – Yes/No – If yes, describe type, location & extent

Siltation – Yes/No – If yes, describe location & extent

Environmental Data

Duration of flooding in wetland.....days

Depth of flooding in wetland.....metres at location.....

Note numbers and types of waterbirds if present

Note presence of native fish in floodwaters

Note extent of regeneration of floodplain vegetation (following floods)

Forbes Shire Council monitoring activities

These activities are similar to those listed above for landholders but they relate to council works. In particular the performance of road structures should be carefully assessed as well as the impact of all floodplain development on Forbes town. With regard to the road structures, those that are of significance should be monitored over the duration of the flood. Less crucial structures could be observed at peak levels and at overtopping levels for causeways.

Road structures

- Note the head difference across the structure at peak and critical levels.
- Note the depth of flow over causeways.
- Estimate the flow velocity through or across the structure.
- Note whether the structure is affected by debris.
- Note the time when flow commences and finishes.
- Photograph the structure in flood.

Following floods, Council should assess flood damage to roads and infrastructure:

- Note the location and extent of pavement damage and silt over roads.
- Estimate the length of road cuts where possible.
- Note damage to other infrastructure such as culverts or bridges.

DECCW monitoring activities

DECCW's role in monitoring includes the following activities:

Flood photography

- Undertake and obtain on-ground photography of the flood event.
- If necessary, undertake oblique aerial photography of the flood event.
- If necessary, organise vertical aerial photography of the flood event.
- Obtain available satellite imagery of the FMP floodplain under flood.

Survey data

- Collate existing survey data undertaken or organised by DECCW, landholders, or local councils.
- If necessary, obtain additional survey data, particularly in the vicinity of new flood control works (storages, levees, channels, etc.) and structures (bridges, culverts, weirs).

Consultation activities

- Undertake consultation activities with stakeholder groups (landholders, government agencies, local councils, and other interest groups) to source their opinion on the flood event and the performance efficiency of the FMP floodway network.
- Undertake field investigations after flood events to view identified problem areas.

Flow data

- Obtain flood heights and discharge records from gauging stations within the vicinity of the FMP floodplain.
- If necessary, obtain rainfall data from the Bureau of Meteorology and NOW records.

Environmental data

Fish and aquatic invertebrates

- Obtain information regarding fish abundance and diversity within the vicinity of the FMP floodplain. This data can be sourced from Industry and Investment NSW (Fisheries) who undertake sampling on a regular basis.
- Obtain information regarding the abundance and diversity of macroinvertebrates within the vicinity of the FMP floodplain. This data can be sourced from the existing program titled AusRivAS (Australian River Assessment System), which generates health assessments for river sites based on the presence of macroinvertebrates.

Vegetation

- Based on flood photography and field investigations, assess changes in floodplain vegetation following flood events.

Additional data

- Approach government agencies in order to source any relevant environmental data gathered by them in response to a flood event. This may include data in relation to fish, water quality, floodplain vegetation, waterbird observations and wetlands.

Appendix B – FMP Floodway network maps

Figure 2 (Sheets 1 to 4): Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan – floodway network

Figure 3 (Sheets 1 to 2): FMP floodway network and mapped wetland vegetation

