RURAL FLOODPLAIN MANAGEMENT PLANS

Rural floodplain management plans: technical manual for plans developed under the Water Management Act 2000

Version 2.1

June 2020

Published by NSW Department of Planning, Industry and Environment

dpie.nsw.gov.au

Title: Rural floodplain management plans: technical manual for plans developed under the Water Management Act 2000

Subtitle: Version 2.1

First published: June 2018. Revised June 2020.

Department reference number: INT19/115999

More information

www.industry.nsw.gov.au/water

Acknowledgements

Floodplain management plans are being prepared under the NSW Healthy Floodplains Project which is funded by the Australian Government's Sustainable Rural Water Use and Infrastructure Program as part of the implementation of the Murray-Darling Basin Plan in NSW.

Contents

List of Figures

List of Tables

Background

Floodplains are essentially areas of land subject to inundation by flooding. Many of the rural floodplains in the north of the Murray–Darling Basin (MDB) contain western-flowing river systems. Floodwaters from these systems are typically slow-moving and spread over wide, shallow floodplains, remaining on the floodplain for weeks or months. Flooding behaviours are also highly variable. This means that while overbank floods will occur reasonably often, their timing, volume and extent are unpredictable.

Flooding replenishes floodplain ecosystems and agricultural land with water, carbon, sediment and nutrients. The fertile soils and water resources made abundant during floods contribute to floodplains being classed as some of the most productive lands in Australia. For instance, in the MDB, rural floodplains contribute about US$15 billion annually, earning it the name 'Australia's bread basket' (Dahm et al. 2013).

The ecological character of wetlands and many other ecosystems that reside on floodplains is dependent on flooding. Floodwater can trigger native plants to germinate and disperse seeds; provide opportunities for native fish such as silver perch to spawn; and provide waterbird habitat for feeding and breeding. Many nationally and internationally important wetlands residing on floodplains, such as Ramsar wetlands, require flooding for their long-term survival. Flooding is also important for recharging shallow groundwater aquifers.

To Aboriginal people, floodplains are an important source of food, tools and medicinal items, which are plentiful during and following flood events. Often places and objects on the floodplain that contribute to Aboriginal customary law, traditions, history and current practices require flooding, or their value to Aboriginal people is dependent on flooding. Floodplain flora and fauna that depend on flooding also contribute to the social and ceremonial aspects of Aboriginal life as living scarred trees or as totem species.

From the 1960s, there was a proliferation of uncoordinated flood works built to support private irrigation development over large tracts of natural floodplain in inland rural New South Wales (Burton et al. 1994). The works were built after a major program of large dam construction that led to expectations of an assured water supply to support intensive irrigation (Burton et al. 1994). When major flood events occurred in the 1970s, they revealed that these flood works were changing flood behaviour. There were heavy crop losses in newly developed irrigation areas and flood damage in areas that were previously considered to be relatively flood-free (Burton et al. 1994).

In response to the emergent flooding problems, the *Water Resources Commission Act 1976* was introduced to allow the NSW Government to strategically address flooding problems for the first time. This was done using levee/floodway schemes published as non-statutory first-generation guidelines, which were implemented on a voluntary basis by landholders. The schemes were used to guide the location of flood works constructed by landholders for cropland protection while maintaining unimpeded passage for floodwaters.

Changes to legislation during the following few decades further strengthened the NSW Government's involvement in managing the construction of works that can affect flood behaviour. For instance, Part 8 of the *Water Act 1912* (Water Act) was introduced in 1984 to require the licensing of any work that could affect flood-flow distribution and to allow floodplains to be designated.

Part 8 of the WA 1912 was again amended in 1999 to allow for more strategic coordination of controlled works through the preparation of second-generation statutory rural floodplain management plans (FMPs). These FMPs were developed to overcome difficulties with assessing works on an ad-hoc basis.

Part 8 of the WA 1912 was repealed in 2016 and replaced by the relevant provisions of the *Water Management Act 2000* (WM Act). Third-generation WM Act rural FMPs are currently being developed in accordance with the floodplain planning and environmental protection provisions of the WM Act, which relate closely to the now repealed Part 8 of the WA 1912.

Works continue to be built on rural floodplains to enhance the agricultural productivity of land used for grazing, dryland cropping and irrigated cropping. Levees, earthworks, banks and channels are built to protect crops, stock and properties from flooding; to provide on-farm access; and to manage irrigation, stock and domestic water.

In principle, the WM Act rural FMPs will involve only minimal change for landholders wishing to construct or amend flood works. Like the previous generations of plans, the WM Act rural FMPs aim to minimise the impacts of new flood works on flood behaviour. These impacts might include redirecting flow onto adjacent properties; increasing flood levels or velocities; causing crop losses, erosion or scour; or negatively impacting floodplain ecosystems or cultural sites.

Differences between the new and old FMPs are a reflection of better-available information and the specific requirements of the WM Act. The WM Act rural FMPs will contain maps of clearly delineated management zones and transparent rules and assessment criteria to coordinate flood work development. They will also cover the extent of major flooding in a valley, filling in any gaps between existing FMPs, which focused on smaller problem areas.

The WM Act rural FMPs will provide greater clarity and consistency for landholders applying to build or amend flood works. Third-generation WM Act rural FMPs will also:

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

WM Act rural FMPs will supersede existing first-generation guidelines or second-generation rural FMPs. Where appropriate, existing floodplain management planning arrangements will be integrated into the WM Act rural FMPs.

This technical manual seeks to inform local landholders and the wider community on how the new third-generation WM Act rural FMPs are being developed in the MDB, and how the plans will coordinate flood work development. WM Act rural FMPs are currently being prepared for the northern floodplains of the MDB.

Legislative and policy framework

Water management in NSW, including floodplain management, is governed by Commonwealth and state legislation. The WM Act was introduced as the culmination of the national water reform process driven by the Council of Australian Governments (COAG) to sustainably integrate management of all water-based activities (COAG 2004). Third-generation WM Act rural FMPs are currently being developed in accordance with the floodplain planning and environmental protection provisions of the WM Act.

The water management framework provided by the MDB Plan is also being used to coordinate water extraction, environmental water, water quality and the development of flood works on

floodplains. WM Act rural FMPs will be made to be consistent with the relevant parts of the MDB Plan.

Water Management Act 2000

The object of the WM Act is the sustainable and integrated management of the state's water for the benefit of present and future generations.

WM Act rural FMPs will be developed to satisfy the objects and principles of the WM Act. Part 3, Division 5 of the WM Act specifies core provisions that must be dealt with in an FMP for a water management area, as well as additional provisions that may be dealt with. Division 1 of the WM Act outlines general water management principles that water management plans should address, as well as water management principles that relate specifically to floodplain management.

Other legislation and policies

Other legislation and policies relevant to floodplain management that should be considered in preparing WM Act rural FMPs include the following.

Acts

- Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)
- Water Act 2007 (Cwlth)
- Environmental Planning and Assessment Act 1979 (NSW)
- Fisheries Management Act 1994 (NSW)
- National Parks and Wildlife Act 1974 (NSW)
- Biodiversity Conservation Act 2016 (NSW).

Policies and strategies

- Japan–Australia Migratory Bird Agreement (1974); China–Australia Migratory Bird Agreement (1986); and Republic of Korea–Australia Migratory Bird Agreement (2006)
- MDB Plan (2012)
- NSW Biodiversity Strategy (1999)
- NSW Floodplain Harvesting Policy (2013)
- NSW Flood Prone Land Policy (NSW Government 2005)
- NSW State Rivers and Estuaries Policy (1993)
- NSW Strategic Regional Land Use Policy (2012)
- NSW Wetlands Management Policy (1996).

WM Act rural floodplain management planning

The floodplain management planning approach for FMPs developed under the WM Act involves 10 steps (Figure 1).

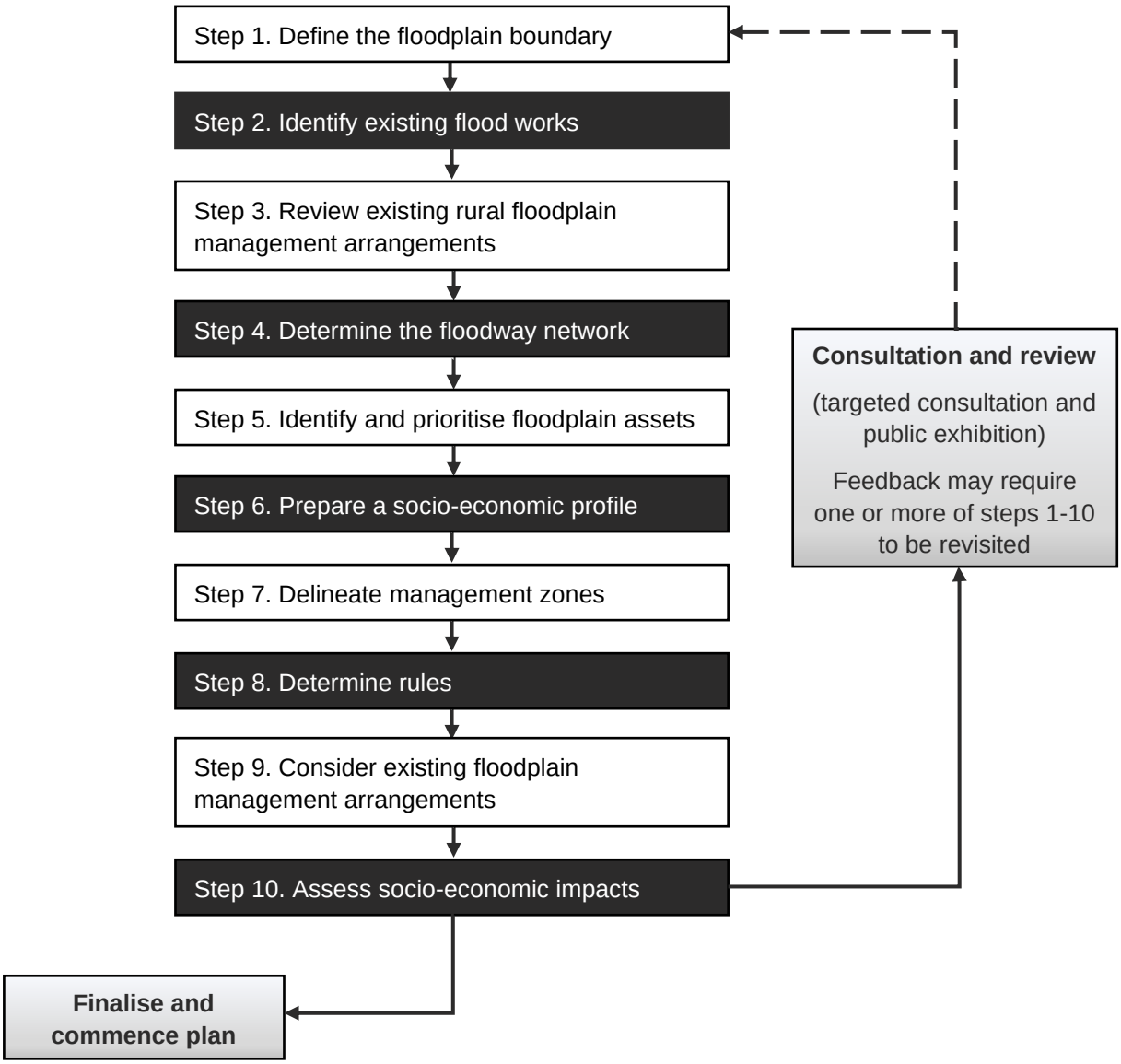

Figure 1. Ten steps used to develop WM Act rural floodplain management plans.

Step 1 is undertaken to define the floodplain boundary pertaining to the WM Act rural FMP.

Steps 2–6 are primarily information-gathering exercises that involve developing a data compendium, identifying and filling data gaps, and documenting key aspects of the floodplain.

Steps 7–9 are decision-making steps that use the information gathered in the previous steps to develop the management zones and rules.

Step 10 ensures consideration of the potential socio-economic impacts from steps 7–9.

Community consultation undertaken during targeted consultation and public exhibition may require earlier steps to be revisited to refine the management zones and rules into a more equitable product. In this way, the process for developing the WM Act rural FMP is iterative.

The 10 steps for developing the management zones and rules in WM Act rural FMPs are described in detail in this document. Appendix 1 contains a flow diagram of the 10 steps, including the input/process and output/outcome related to each step.

Consultation

Engagement and consultation strategies for developing WM Act rural FMPs ensure that all stakeholders and interested parties have an opportunity to examine and comment on the outcomes of the floodplain management assessment and planning.

The NSW Department of Planning, Industry and Environment coordinates the preparation of WMA (Table 1). The department's Environment, Energy and Science Group produces the technical content to support the development of the WM Act rural FMPs (draft boundary, management zones, and the rules and assessment criteria for each management zone).

During the preparation of the technical content, the Environment, Energy and Science Group consults with Technical Advisory Groups (TAGs) and an Aboriginal Technical Working Group (ATWG).

The TAGs provide expert knowledge and technical advice on the WM Act rural FMPs. They are made up of NSW Government agencies and other key agencies involved in water management, including:

- DPI Fisheries
- DPI Agriculture
- Local Land Services
- regional councils
- the Queensland Murray Darling Committee
- the MDB Authority
- the Commonwealth Environmental Water Office.

Consultation with the TAGs aims to collect all available floodplain management planning knowledge in a particular valley, such as historical flood event information as well as data on ecological and cultural assets. The TAGs also help to develop scientifically rigorous methods for the technical assessments undertaken as part of developing the WM Act rural FMPs.

The ATWG is a single consultative group of state and regional cultural heritage experts. It was created to advise on:

- the type, scope and integration of flood-dependent Aboriginal values
- the identification and prioritisation of cultural assets that require protection
- key contacts and knowledge holders in the Aboriginal community to consult with
- cultural knowledge on the history of flooding.

The department's Water group is responsible for the review and formal consultation processes associated with developing the WM Act rural FMPs, and for writing the WM Act rural FMP (the Order or legal Plan).

The development of the WM Act rural FMPs is subject to review at key stages:

- prior to targeted consultation
- prior to public exhibition
- prior to preparation of the FMP for commencement.

Community input into the development of WM Act rural FMPs is sought during two rounds of consultation:

- targeted consultation, which seeks preliminary feedback on the broad concepts
- public exhibition, which involves formal consultation and submission processes, including advertising and exhibition over a minimum of 40 days.

The preparation of WM Act rural FMPs also involves approval processes, including:

- interagency regional panel (IRP) approval
- ministerial approval.

The IRP brings whole-of-government review to the development of WM Act rural FMPs. Its members include DPI (Agriculture and Fisheries interests), the Department of Planning, Industry and Environment (water and environmental interests). Experts from Local Land Services, the Natural Resources Access Regulator and WaterNSW may also attend meetings of the interagency regional panel to provide advice on consultation activities and other matters relevant to their expertise. All submissions received during the public exhibition period are considered by the IRP prior to the preparation of the draft WM Act rural FMP for commencement.

Commencement of the WM Act rural FMPs requires the approval of the Minister for Water with concurrence from the Minister for Environment.

Table 1. Consultation and review strategies during the development of WM Act rural FMPs

Technical development	Review	Consultation	Approvals
WM Act rural FMP: Draft 1			
- Boundary - Management Zones - Rules - Assessment criteria	The NSW Department of Planning, Industry and Environment Whole of government	**Targeted consultation**	Interagency regional panel
WM Act rural FMP: Draft 2			
Updated based on feedback received from targeted consultation	The NSW Department of Planning, Industry and Environment Whole of government	**Public exhibition**	Interagency regional panel Ministerial
WM Act rural FMP: Draft 3			
Updated based on feedback received from public exhibition	The NSW Department of Planning, Industry and Environment Whole of government		Interagency regional panel
WM Act rural FMP: Final			
Completion of the Order (legal Plan) May be updated as a result of the approvals process.			Ministerial

Step 1: Define the floodplain boundary

A floodplain is an area of land that is subject to inundation by floods. Legally, a floodplain is any land declared to be a floodplain by the regulations within the WM Act. Floodplains previously designated by an order in force under section 166(1) of the WA 1912 were automatically considered to be WM Act floodplains when the WM Act provisions came into effect in 2016.

A floodplain is typically defined by investigating the nature and extent of flooding over time (DIPNR 2005). Hydrologic and hydraulic data is often collected and used to determine the nature and extent of flooding for large flood events. This extent is often the hydraulic basis of the floodplain boundary. In some floodplains, topographical information such as slope may be used in the absence of reliable flood extents.

Other information often considered for refining the floodplain boundary includes:

- existing WM Act floodplain boundaries
- areas of floodplain harvesting
- water sharing plan boundaries
- cadastral and infrastructure features (such as roads and railways)
- landscape features (such as weirs)
- statutory boundaries (including property, county, parish and local government area boundaries).

Step 2: Identify existing flood works

The core provisions of the WM Act that relate to floodplain management require 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.

Flood works are defined in the WM Act as:

> *a work (such as a barrage, causeway, cutting or embankment):*
>
> - *that is situated:*
>   - *in or in the vicinity of a river, estuary or lake, or*
>   - *within a floodplain, and*
> - *that is of such a size or configuration that, regardless of the purpose for which it is constructed or used, it is likely to have an effect on:*
>   - *the flow of water to or from a river, estuary or lake, or*
>   - *the distribution or flow of floodwater in times of flood*
>
> *and includes all associated pipes, valves, metering equipment and other equipment, but does not include any work declared by the regulations not to be a flood work.*

Step 2 is undertaken to identify information on existing flood works, including mapping the overall footprint of constructed works in the floodplain and quantifying the floodplain area enclosed by flood works. The number of flood work licences in the floodplain is also estimated.

Footprint areas may include:

- below-ground and above-ground supply channels
- infrastructure protection works
- levees
- private access roads
- storages
- stock refuge works
- other earthworks and embankments.

Individual works are not identified in the footprint areas, and linear features such as supply channels are not mapped. Generally, works not visible at a scale of 1:20,000 are not mapped.

Controlled-work approvals granted under the WA 1912 were converted to flood work approvals under the WM Act in 2016.

Various data sources are used to identify existing flood works, including:

- licensed works
- canal watercourse lines and floodwater storages (OEH, Bureau of Meteorology, Australian Hydrological Geospatial Fabric database)
- land-use mapping
- spatial layers from previous floodplain management arrangements
- other topographical data (including LiDAR survey)
- aerial photography, oblique aerial photography and satellite imagery from flooding and dry periods to verify existing flood works.

A thorough review of the developed areas is also conducted by experts from OEH and the Department of Industry.

Developed areas are included in hydraulic modelling and used to assist the delineation of the floodway network (Step 4). They are also considered when delineating the management zones (Step 7).

Step 3: Review existing rural floodplain management arrangements

Step 3 is undertaken to ensure that WM Act rural FMPs adequately consider the existing rural floodplain management arrangements in a floodplain. Existing arrangements are analysed during the development of WM Act rural FMPs to identify:

- floodplain management principles
- ecological considerations
- cultural heritage considerations
- floodway networks and flow paths
- hydraulic models
- design flood events
- assessment criteria for permitting new flood works
- advertising requirements for flood work applications.

In any one floodplain, existing rural floodplain management arrangements may include:

- first-generation rural floodplain development guidelines (non-statutory)

- second-generation rural FMPs prepared under the WA 1912 (transitioned over as Minister's Plans under the WM Act)
- outcomes from flood studies (non-statutory).

Each generation of management measures has evolved in response to changes in community needs; changes to land and water use; an increased awareness of the importance of floodplain ecology; and changes to the legislative and policy framework that governs water management. More detail on the history of rural floodplain management is provided below.

History of rural floodplain management

There is a long history of the NSW Government managing works that can affect flooding in rural areas of the MDB (Figure 2).

In 1912, the NSW Government began to take on legal responsibility for water management by enacting the WA 1912. This did not initially change floodplain management in the state; however, in later decades, amendments to the WA 1912 would make this Act the principal driver of floodplain management in NSW.

From the 1960s, a major change in agricultural practice on rural inland floodplains developed – from low-intensity to high-intensity land use (Burton et al. 1994). This resulted in a proliferation of uncoordinated earthworks, such as channels and levees, built to support private irrigation development over large tracts of natural floodplain (Burton et al. 1994).

Major flood events in the 1970s revealed that the spread of these works had, in many locations, caused major changes to the natural flooding regime. As a result, flood damage, including heavy crop losses, was experienced, demonstrating the need to implement flood protection measures (Burton et al. 1994). It was from this point that the NSW Government took an active role in rural floodplain management, beginning with the development of first-generation rural floodplain development guidelines.

First-generation rural floodplain development guidelines

Floodplain development guidelines were developed by the NSW Government following the enactment of the then *Water Resources Commission Act 1976*. Under the provisions of this legislation, guidelines were prepared for the worst-affected areas to guide the location of flood works constructed by landholders for cropland protection while maintaining unimpeded passage for floodwaters.

The guidelines were non-statutory and implemented on a voluntary basis by landholders. The approach aimed to provide floodways of adequate hydraulic capacity and continuity by restoring or maintaining, as far as practical, the natural pattern of flood channels to effectively convey flood flows.

Flood protection of developed land was accomplished by constructing levees bordering the floodways and was funded and implemented by the benefiting landholders.

These guidelines were used as a reference for coordinating floodplain development and described areas where development was and was not appropriate. In some areas, the guidelines were superseded by rural FMPs, which are statutory.

Second-generation rural FMPs prepared under the Water Act

In 1999, Part 8 of the Water Act was amended to allow for more strategic coordination of controlled works through the preparation of statutory rural FMPs to manage floodwaters. Up until this point, the floodplain development guidelines produced were non-statutory.

Second-generation rural FMPs were developed under the principles of the *NSW Floodplain Development Manual* (DIPNR 2005) and in consultation with a community-based floodplain risk management committee.

Existing FMPs describe environmental assets, identify areas where floodwater passage is impeded, outline the nature and extent of flood works that are permissible on the floodplain, and propose remediation actions to improve flood connectivity.

Outcomes from flood studies (non-statutory)

In some instances, flood studies were undertaken in response to development pressures on rural floodplains. These studies are considered to be non-statutory.

Figure 2. History of legislation and policy affecting floodplain management in rural floodplains

Step 4: Determine the floodway network

Step 4 is undertaken to determine a floodway network with adequate hydraulic capacity and continuity to effectively convey floodwaters. The floodway network is a mapped product made up of:

- a coordinated and integrated network of floodways where a significant discharge of floodwater occurs during floods
- the inundation extents of small and large design floods
- areas that preserve floodplain connectivity
- areas that provide sufficient temporary pondage of floodwater.

The floodway network is the hydraulic basis for determining the management zones and rules. Step 4 involves selecting floods of different magnitudes (design floods) and, where appropriate, constructing hydrologic and hydraulic models to simulate the movement of those floods through the river channels and floodplain.

Modelling data and additional flood data—such as digital elevation models (DEMs), flood aerial photography, satellite imagery, watercourse layers, flood marks and local knowledge – are used to map the floodway network. Where modelling data is not available, the floodway network is mapped using additional flood data only. Any existing floodway network maps are considered.

Maps of the floodway network generally show two hydraulic categories:

- floodways, which are areas where a significant discharge of floodwater occurs
- the inundation extent (determined from hydraulic modelling) or the outer extent of the core floodplain (determined from slope), which includes areas of the floodplain that are important for temporarily storing floodwaters during the passage of a flood.

In some floodplains, floodways may be described as ‘defined’ or ‘ill-defined’. In general, defined floodways are major discharge areas with defined channels or riverbanks, and ill-defined floodways are major discharge areas made up of overland flow paths with no defined channels or riverbanks.

Design floods

Design floods are used to determine the extent of the floodway network and/or for the technical assessment of flood work applications against assessment criteria found in the FMPs.

Modelled design floods are usually based on recorded historical events that are preferably within the living memory of a local community. This approach enables the community to comprehend the magnitude of the flood events being modelled. Where no suitable historical floods are available, a probabilistic design flood is set up using hydrologic models.

Design floods are selected to account for the social, economic, ecological and cultural consequences associated with floods of different severities. A flood frequency analysis is undertaken to help choose the historic design floods by expressing the relative sizes of floods in terms of annual exceedance probability (AEP).

AEP is the probability of an event occurring or being exceeded within a year. It is expressed as a percentage unless events are more frequent than 50% AEP, in which case they are expressed as n exceedances per year (nEY). For example, 2EY is equivalent to a design event with a six-month recurrence interval when there is no seasonality in flood occurrence.

The flood frequency analysis uses available flooding information, which may include records from when the flooding regime was relatively natural, as well as information that encompasses the existing flooding regime. The AEP for all historic events is calculated, and small and large events are selected. The event referred to as the ‘large design flood’ usually has an AEP of

around 5%. It may be larger if a historical flood has a greater recurrence interval and has been previously accepted by the community as a basis for design. This large design flood is used to delineate the limits of the floodway network and the floodway areas. Criteria for selecting a large historic flood include:

- it is the most recent large flood
- it is representative of large floods in the valley
- there is a significant amount of information available for the event
- it has been previously used and widely accepted as the design flood.

The flood event referred to as the 'small design flood' is a smaller-scale event that generally has an AEP of less than 10%. This design flood is used to simulate events that are likely to be more frequent than the large design flood. The small design flood is used to check that critical flow paths to floodplain assets are identified within the floodway network.

For probabilistic simulations, the design flood is calculated using a chosen AEP and is often used in conjunction with a hydrologic model (also known as a rainfall run-off model), which simulates run-off from rainfall on a catchment. Hydrologic models convert a design storm rainfall of a chosen AEP to flow hydrographs using a procedure known as run-off routing. A loss model is used to determine the rainfall excess by subtracting catchment losses, such as soil and surface storage, from the total rainfall. Rainfall excess is then routed through the catchment storage to produce discharge hydrographs at key locations (Mein and Nathan 2010). Similarly, ungauged catchment inflows for historical floods are calculated using a hydrologic model and recorded rainfall. Alternatively, inflows for the probabilistic design flood can be derived for the selected return interval from flood frequency analysis at a gauge.

Modelling of the inundation extent for a 1% AEP flood provides additional hydraulic information. This information is useful for assessing the hydraulic impacts of proposed flood works on floodplain areas that are outside the inundation extent of the design flood. The 1% AEP flood extent is an estimate only, to assist the hydraulic analysis of flood works, and is not normally mapped for rural floodplain planning purposes. This information is retained by the Department of Industry and is made available to landholders where additional supporting information such as hydraulic modelling is required to support applications for flood works.

The gauged historic flood flows and flood flows derived from the hydrological modelling for the small and large design floods are represented by inflow hydrographs, which serve as inputs for the hydraulic models at boundary locations.

Hydraulic models

Computer-based hydraulic models are used to simulate the movement of water for the large and small design floods. The gauged inflows as well as the inflows derived from the hydrological modelling for the small and large design floods are used as inputs for the hydraulic models. The hydraulic models are generally combinations of one-dimensional (1D) river systems, which model channel flow, and two-dimensional (2D) grids, which simulate water flowing over floodplains. Flow within the model domain is described by the shallow water (saint-venant) equations, which consider the conservation of both mass and momentum. The location of flow paths in the models are determined using DEMs, flood aerial photography, satellite imagery, watercourse layers, flood marks and local knowledge.

Hydraulic model outputs used may include:

- discharge, velocity and depth at key locations or across the floodplain
- a depth velocity product map from the large design flood
- inundation extents of the small and large design floods.

These outputs can be used to determine the location and/or appropriate size of each floodway in the floodway network. Alternatively, the model network can be used as the basis for the floodways and then the width of the floodways can be determined using criteria based on additional information such as flood imagery and elevation data.

Floodways have traditionally been viewed as areas of high velocity and depth that convey a significant proportion of floodwaters. Where accurate and high-resolution elevation data is available to build 2D hydraulic models, the models are used to calculate the product of depth and velocity at each model calculation point. The peak depth velocity product values are then mapped for each point. This information can be used to quantitatively identify the size and location of floodways by applying a meaningful threshold to the mapped depth velocity product values (Figure 3). If depth velocity product mapping is not available, thresholds can be set on the modelled discharge or velocity along flow paths.

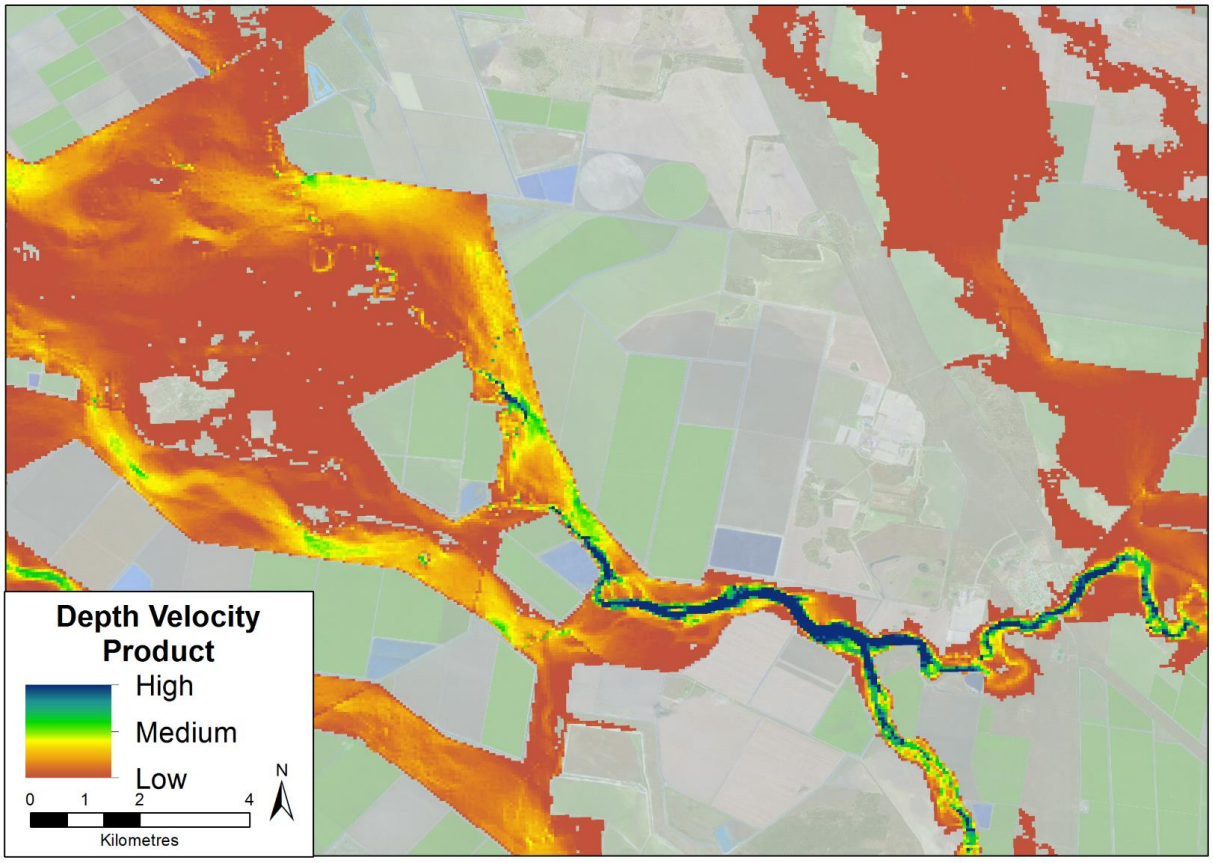

Figure 3. Example of a depth velocity product from a large design flood.

Model calibration

Hydraulic models are calibrated against hydraulic parameters—including water depth or water surface elevation, discharge and velocity—using selected historic flood events that approximate the design flood magnitude and have caused all likely flow paths to be active.

The models are calibrated against a range of data sources, particularly:

- peak flood heights at gauge locations
- available flow distribution calculations for existing floodplain development guidelines
- the peak discharge magnitude and timing at gauge locations
- flood extents from satellite imagery and aerial photography.

A sensitivity analysis is also undertaken on key model parameters, such as surface roughness and inflows, by varying the parameter values and calculating the impact of these changes on the results.

The hydraulic models utilise the best available data, including representation of the developed areas (Step 2). The final choice of appropriate models is governed by the availability of data and the complexity of the floodplain.

Mapping the floodway network

There are no industry-specific procedures for identifying floodways or for defining their extent. However, the advancement of tools used to simulate flooding (such as 2D hydrodynamic models) and improved topographic data (such as LiDAR) allow practitioners to more rigorously interrogate flood characteristics (Thomas and Golaszewski 2012).

Improvements to models and input data have enabled quantitative approaches for delineating floodways to be used, such as depth velocity product thresholds and extents of design floods. Nevertheless, there is no definitive flood modelling procedure that can be applied to automate the process of generating floodway extents, and the methodology should involve iterative assessments (Thomas and Golaszewski 2012).

To develop WM Act rural FMPs, floodway networks are typically delineated from modelled hydraulic parameters where available. Hydraulic model outputs that may be used in floodway network determination include:

- depth velocity product maps for large design floods
- discharge and velocity values along flow paths
- inundation extents for small and large design floods.

These outputs can be used to determine the appropriate size of each floodway and the overall floodway networks (see Table 2 and Figure 4).

Where reliable flood extents can be produced from the large design event, the outer limits are used to determine the extent of the floodway network (Figure 4**Error! Reference source not found.**). In areas where hydraulic data is not sufficient to accurately map the flood extents, the limits to the floodway networks can be determined by using aerial and satellite flood imagery captured for the design events or by using a proxy, such as slope.

Table 2. Summary of criteria used to delineate the hydraulic categories in the floodway network

Hydraulic category	Criteria
Floodways	Areas that have a depth velocity product of a selected threshold (varies for each floodplain) for the large design flood Parts of the small design flood extent that ensure continuity of floodways
Inundation extent	Flood extent up to the large design flood Does not include areas categorised as floodways

Hydraulic modelling outputs may not always account for all of the important floodways. This is often due to the chosen scale for computational points within the model setup. As such, additional data is used to ensure that the floodway networks represent on-ground conditions. This data includes:

- flood aerial photography and satellite imagery
- spatial watercourse layers and topographical mapping
- previous FMPs and development guidelines
- local knowledge obtained from floodplain communities, and floodplain and environmental managers
- derived Landsat flood frequency and extent mapping products (Fisher et al. 2016; Danaher and Collett 2006; Auscover Remote Sensing Data Facility 2016)
- existing flood work development.

The floodway networks are finalised to spatially capture flood behaviour in the floodplain and are used to inform the hydraulic criteria for the management zones.

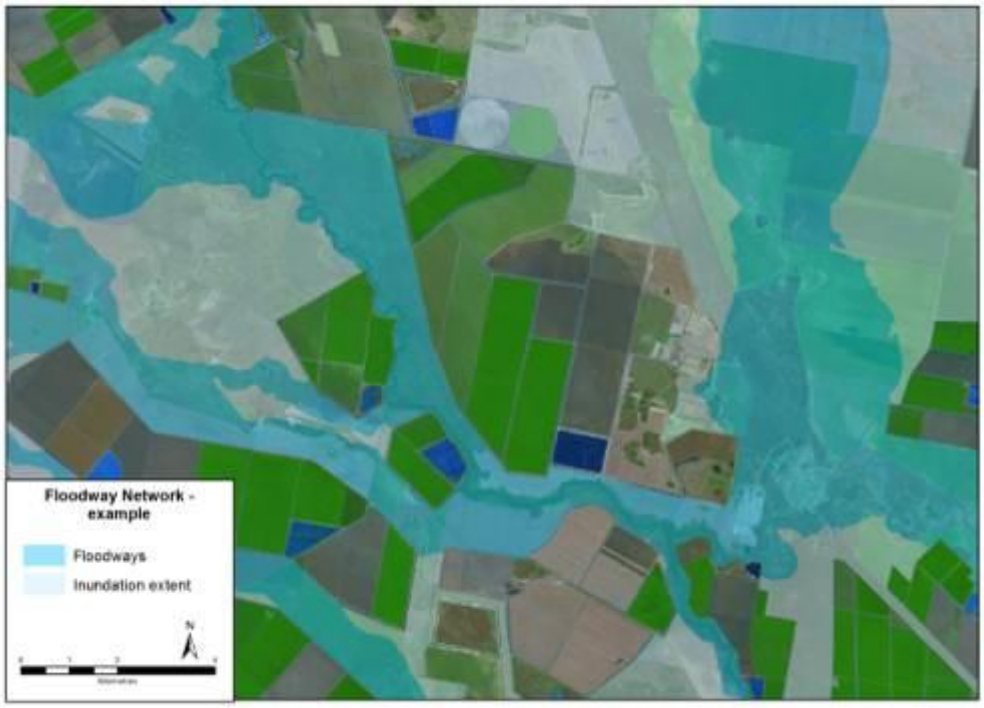

Figure 4. Example of the floodway network

Flooding regimes and the floodway network

The core provisions of the WM Act that relate to floodplain management require the existing and natural flooding regimes in the area to be identified in terms of the frequency, duration, nature and extent of flooding. The mapping of the floodway network integrates information from design flood analysis and hydraulic modelling to address these core provisions in the following ways:

- frequency—a flood frequency analysis is undertaken to select small and large design floods to use when modelling the floodway network. The flood frequency analysis uses flooding information from when the flooding regime was relatively natural, as well as information that encompasses the existing flooding regime
- nature—the hydraulic models that underpin the floodway networks for each floodplain contain information on the nature of flooding, including the size and roughness of floodways and connections between floodways. The models represent rivers, streams, overland flow paths and wetlands to simulate the movement of floodwater through the floodplain
- extent—modelled inundation extents of a small and large design flood are represented in the floodway networks.

Step 5: Identify and prioritise floodplain assets

Floodplain assets are ecological assets, such as semi-permanent wetlands, and cultural assets, such as scarred trees, which are Aboriginal cultural values. Cultural assets also include heritage sites, such as heritage-listed bridges. Floodplain assets can be flood-dependent, such as fish nursery grounds on the floodplain that require inundation to be accessed and utilised by native fish; or flood-impacted, such as Aboriginal burial sites that can be damaged by scour and erosion caused by flooding.

Step 5 identifies and prioritises the many unique and diverse floodplain assets found on the floodplains where FMPs are being prepared. The floodplain assets are then used to inform the design of the management zones and rules in the WM Act rural FMPs.

Floodplain assets identified as a high priority for protection will be considered in the design of the management zones, so that:

- flow paths are kept free from flood works that may prevent water from reaching assets
- the redirection of flow onto assets that are susceptible to damage from erosion is prevented
- the incidence of ground disturbance to assets, where it is caused by the construction or modification of existing flood works, is prevented.

To further minimise adverse impacts associated with flood work development, all floodplain assets, regardless of their level of priority, are considered when determining the rules for the management zones (Step 8). In these ways, the WM Act rural FMPs can protect flood connectivity to assets to help meet the following two objectives:

- to contribute to the protection and improvement of the environmental health of wetlands, other floodplain ecosystems and groundwater recharge
- to contribute to the protection of ecological, cultural, heritage and spiritual features that are significant to Aboriginal people and other stakeholders.

Purpose of identifying floodplain assets

Floodplain assets are defined to reflect the floodplain features that require protection and restoration under the water management principles of the WM Act.

These floodplain features include:

- floodplains and dependent ecosystems, including groundwater and wetlands
- habitats, animals and plants that benefit from water or are potentially affected by managed activities
- geographical and other features of significance to Indigenous people
- geographical and other features of major cultural, heritage or spiritual significance.

The protection of these floodplain features brings social and economic benefits to the community.

Most of the identified floodplain assets are dependent on the many benefits of flooding for their structure, function and long-term survival. Flooding is a vital natural process that replenishes floodplain ecosystems with water, carbon, sediment and nutrients, which drive pulses of ecological productivity. To meet the core provisions of the WM Act, the ecological benefits of flooding are listed in the FMP.

These benefits generally include floodwaters maintaining or improving the structure, condition and diversity of wetland and riverine ecosystems. The specific ecological benefits of flooding may include the:

- contribution to sediment, nutrient and carbon cycling
- promotion of growth and recruitment of vegetation, including flowering, seeding and germination
- provision of breeding habitat for waterbirds, amphibious fauna and fish
- provision of opportunities for floodplain fauna to migrate, reproduce and feed
- recharge of groundwater reserves
- replenishment of drought refuges such as waterholes
- improvement of the resilience of wetland ecosystems.

The cultural benefits of flooding generally include:

- enabling cultural processes that are dependent on flooding, such as:
    - harvesting resources during a flood
    - undertaking cultural activities that can only occur during a flood
    - visitation and access during flooding
- continuing cultural practices by:
    - preserving Aboriginal cultural values
    - maintaining the potential for cultural renewal
    - maintaining a spiritual connection with the floodplain landscape.

WM Act rural FMPs aim to promote the ecological and cultural benefits of flooding. The processes for identifying and prioritising ecological and cultural assets vary and are described in detail below.

Ecological assets

For the purposes of WM Act rural FMPs, ecological assets are wetlands or other floodplain ecosystems (including watercourses) that depend on flooding to maintain their ecological character. Areas where groundwater reserves are recharged by floodwaters are also ecological assets. Ecological assets are spatially explicit (able to be mapped) and are set in the floodplain landscape.

Flood-dependent ecological assets rely on regular flooding, and floodplain connectivity provides opportunities for assets to be watered during flood flows. Ecological assets make up floodplain ecosystems, including habitat for fish, amphibians, reptiles, waterbirds, woodland birds, mammals, and invertebrate and microbial biota. They also provide other valuable ecosystem services such as drought refuge, nutrient cycling, carbon storage and groundwater recharge. As well as maintaining the ecological character of assets, flooding is also important for flushing systems of excess nutrients and sediment, improving water quality, and providing opportunities for flora and fauna to disperse and breed over the floodplain.

Biodiversity features of conservation significance recognised in national, state and local legislation, policies and programs are considered when identifying ecological assets. Such features may include listed species, communities and habitats; wetlands identified by the Ramsar Convention on Wetlands of International Importance; and bilateral migratory bird agreements. Relevant government programs and management plans include the MDB Authority's Key Environmental Assets, the Directory of Important Wetlands in Australia, and environmental watering plans.

Ecological assets are also identified in refereed scientific and government literature, through consultation with environmental specialists, and by conducting spatial analyses of existing environment datasets. Such datasets include inundation gradients, vegetation mapping, soil mapping (including type and infiltration), and flora and fauna occurrence data.

After ecological assets are identified, wetlands and other floodplain ecosystems are categorised into hydro-ecological functional groups according to the flooding requirements of their vegetation communities. The grouping of vegetation communities in this way is possible because the spatial distribution of floodplain vegetation may be driven by the inundation gradients produced by flooding patterns at two timescales: short-term (months), driven by individual flood events; and long-term (decades), driven by historical inundation frequency (Thomas et al. 2010). Information on the flooding requirements of vegetation communities is a key consideration when deciding which areas should become which management zone (see Step 7). In general, the more frequently an asset requires flooding, the more restrictive a management zone it should be covered by.

Prioritisation of ecological assets

Management zones may be adjusted based on the priority of the ecological asset (conservation significance) and its flood dependency. Based on this information, ecological assets may be included in management zones to ensure flood connectivity is maintained and to reduce the potential impact of future flood work development on their ecological character.

The conservation planning decision-support software Marxan was used to assist in determining areas of high conservation significance where floodplain connectivity should be secured (Ball and Possingham 2000; Possingham et al. 2000; Ball et al. 2009). Marxan was used to analyse key ecological surrogates to represent biodiversity patterns and identify floodplain areas that complement each other. This produced an efficient, well-connected system with the aim of ensuring the future persistence of flood-dependent ecological assets. Marxan was used to provide an initial assessment of the priority of ecological assets across the floodplains.

Following the Marxan assessment, management zones were adjusted based on the flood dependency of an ecological asset and expert advice on conservation significance.

Marxan has been used in a wide range of natural resource management applications to address the comprehensiveness, adequacy, representativeness and efficiency (CARE) principles of systematic conservation planning. Marxan's original purpose was to produce cost-effective networks of biodiversity features in a landscape to assist with the design of new reserve systems, such as national parks.

The floodplain landscapes where the FMPs are being developed are highly complex. They also exhibit a high diversity of plants, animals and microscopic organisms that occupy floodplain ecosystems and habitats created and maintained by flooding. This floodplain biodiversity needs to be adequately represented in the prioritisation process. To ensure this, data on several key features of biodiversity (hereafter 'surrogates') is chosen for input into the software.

Typically, surrogates are selected if they:

- can be defined spatially (mapped)
- are areas of conservation significance, which may be identified or protected in state, national or international legislation
- collectively represent biodiversity patterns across the floodplain and therefore represent different degrees of flood dependency.

Surrogates may include mapped information on:

- vegetation communities
- occurrence records for fauna such as waterbirds, freshwater fish, turtles and amphibians, as well as modelled fauna distributions
- habitats of rare and threatened species associated with floodplain environments
- ecosystems requiring special protection or consideration, such as Ramsar wetlands.

In addition to data on surrogates, Marxan requires the following inputs:

- a study area (the floodplain) that is partitioned into planning units
- a constraints layer that represents the relative cost of selecting one planning unit over another
- targets, which are conservation objectives for each surrogate.

Marxan is run with these inputs using a simulated annealing optimisation method (a way of finding an optimal solution to a problem by comparing many possible solutions). This method finds the planning units that best meet the conservation targets for the surrogates at the lowest cost (Ball and Possingham 2000). Typically, the decision-support software is run using 1 million iterations across 100 runs, where each run will produce a set of planning units that will meet the targets and have an associated cost. The outputs include:

- a planning unit portfolio for each run—a map of the planning units that have been included in the solution used to reach the conservation targets in line with the conservation planning principles built into the algorithm
- the minimum set solution (best solution)— the planning unit portfolio that best reaches the conservation targets at the lowest cost (Figure 5)
- the summed solution (map of irreplaceability)—a map showing the number of times each planning unit was selected to be part of a run. This can be used as an indication of the relative conservation significance of each planning unit (Figure 6).

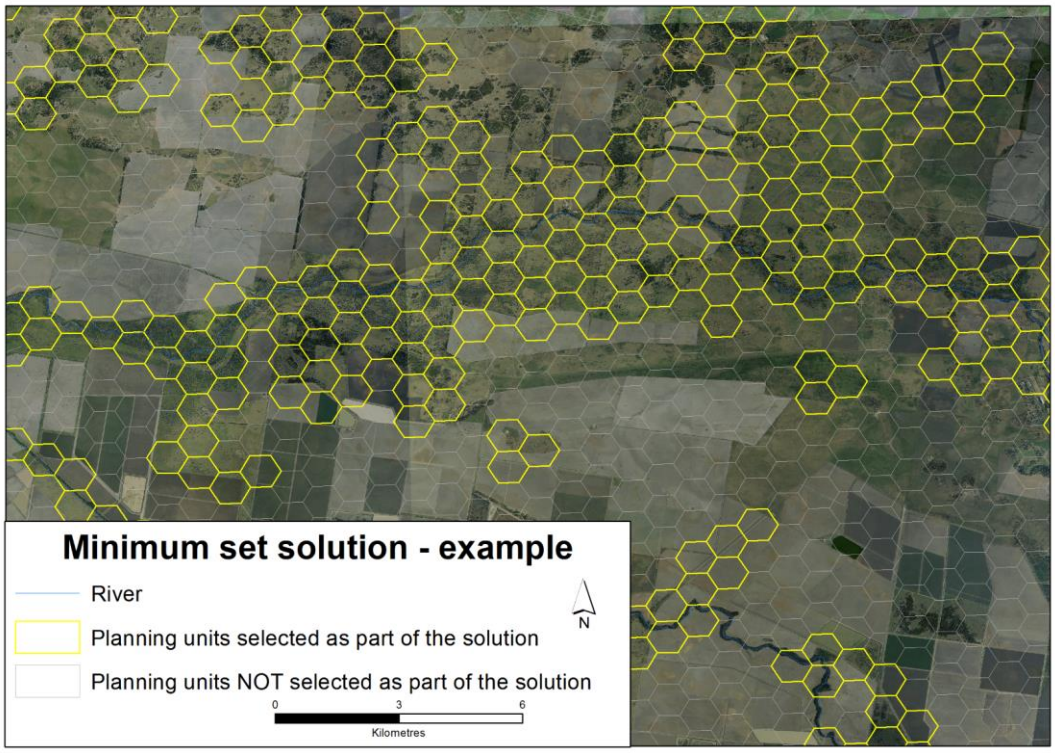

Figure 5. Example of a minimum set solution.

Yellow hexagons are the planning units included within the best solution.

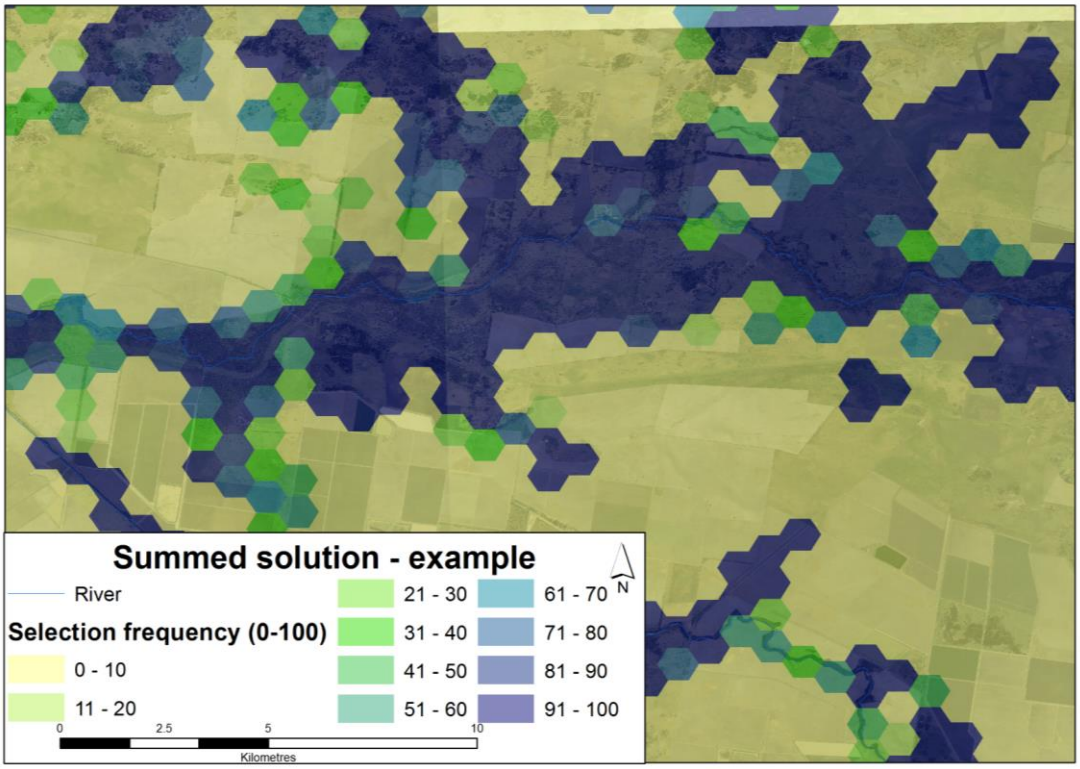

Figure 6. Example of a summed solution generated by 100 runs of Marxan.

The colours show the relative conservation significance of planning units by indicating the number of times a particular planning unit was part of a solution. Areas with a high frequency score (dark blue planning units) are consistently important in the solutions. Areas in yellow have a lower likelihood of being required to meet conservation targets.

The TAG for each floodplain plays an important role in the selection and approval of the proposed method of prioritisation, including the selection of surrogates and the setting of targets for these surrogates.

The steps for prioritising ecological assets using Marxan, including the input into and output from each step, are outlined in Figure 7.

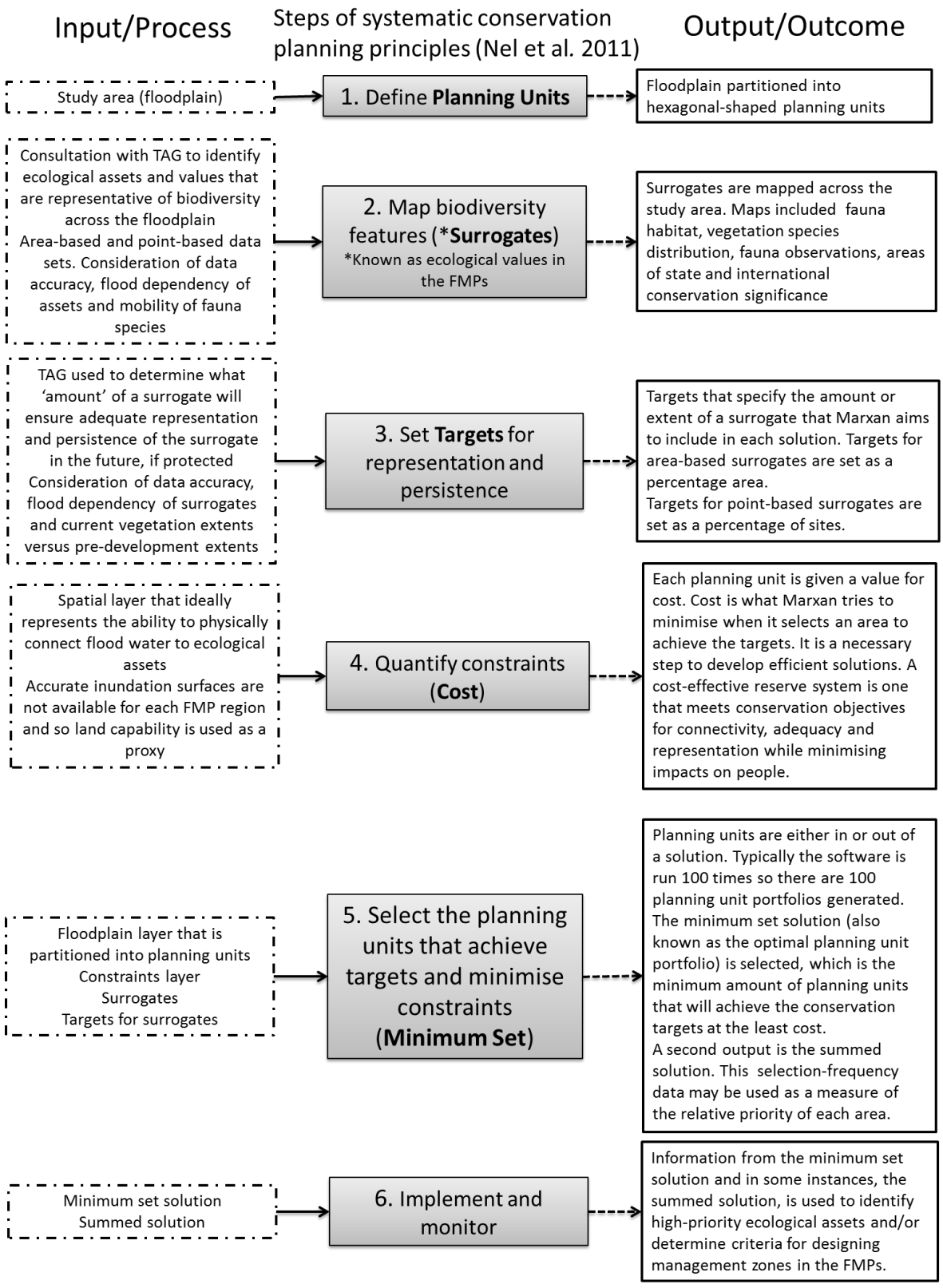

Figure 7. Method used to determine high-priority ecological assets using Marxan decision-support software.

The minimum set solution is the primary Marxan output used to prioritise ecological assets. This is done by relating the selected planning units to natural landscape patterns, which are generally mapped vegetation boundaries. The final product is a map of high-priority ecological assets (Figure 8).

The summed solution may be used as a measure of the relative priority of floodplain areas. It may also be used to justify adjustments to management zones to better protect flood connectivity to ecological assets.

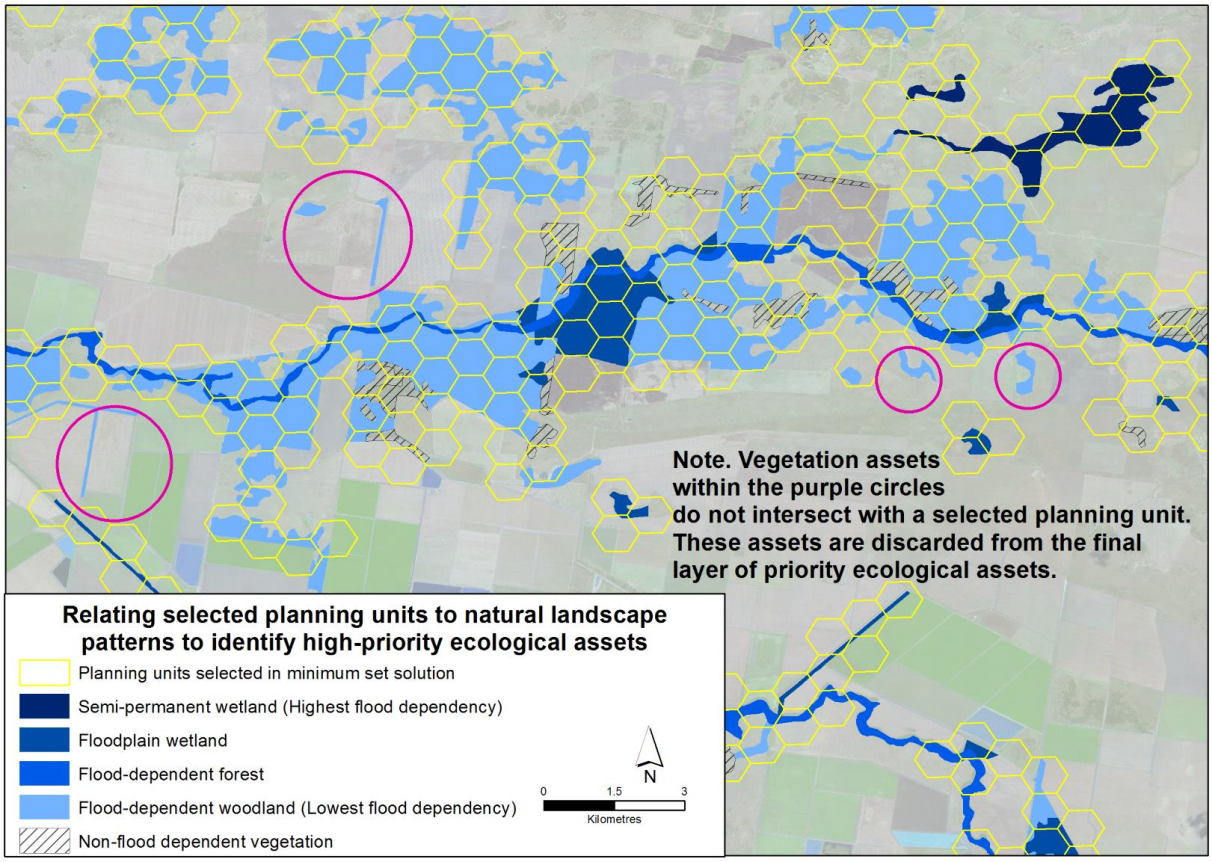

Figure 8. Priority ecological assets are identified by relating planning units selected as part of the minimum set solution to natural landscape patterns.

In this example, non–flood dependent vegetation is shown but is not considered a high-priority asset.

Cultural assets

Cultural assets are objects, places or values that are important for people to maintain their connections, beliefs, customs, behaviours and social interactions. Within the WM Act rural FMPs, two categories are used for cultural assets:

- cultural assets that are dependent on flooding
- cultural assets that are impacted by the effect of flood works on flooding.

Both categories include Aboriginal values and heritage sites.

Aboriginal values

Aboriginal values concern cultural assets that Aboriginal people identify as being important to them. Aboriginal values are intricately connected with the landscape. This connection concerns the physical landscape (land, water, flora and fauna), objects and places that were used by Aboriginal people in the past (archaeological sites), and places that are imbued with significance today and into the future (places with spiritual significance, places of significant events and places connected with memory).

For the purpose of WM Act rural FMPs, Aboriginal values are defined by their relationship to flooding. Flood-dependent Aboriginal values are dependent on flooding for longevity and can include:

- ecological asset(s) that:
  - have been culturally modified, such as scarred trees and tree carvings
  - are recognised for their spiritual or cultural significance
  - are or contain resources that are or were utilised in cultural activities
  - are associated with places that are used for contemporary cultural activities
- places or sites that are or could be used for cultural activities that benefit from flooding, such as fish traps (e.g. stone or stick fish traps).

Flood-impacted Aboriginal values may be adversely impacted by changes in flood-flow distribution caused by flood works and may include those that are vulnerable to erosion by water flow, such as camp sites and burial sites.

Aboriginal community consultation helps identify intangible values that are relevant to the management of the floodplain, such as spiritual places, knowledge, songs, stories or the abundance of flora or fauna used to continue cultural practices.

Flood-dependent and flood-impacted Aboriginal values are identified by:

- reviewing previous studies that investigated cultural values in the floodplain
- consulting with various NSW Government agencies involved with landscape management within the valley (e.g. Local Land Services, National Parks and Wildlife Service, the NSW Department of Planning, Industry and Environment)
- undertaking targeted consultation with members of the Aboriginal community who have knowledge of values connected to the floodplain
- consulting the ATWG, made up of Aboriginal people with a cultural connection to each of the valleys being investigated during the Healthy Floodplains project
- undertaking context-setting using the Aboriginal Sites Decision Support Tool and existing spatial information about the potential distribution of unidentified values (Ridges 2010).

- Aboriginal values are also identified by reviewing the values recorded within the floodplains in the following databases:
  - NSW Aboriginal Heritage Information Management System (AHIMS) (see link at www.environment.nsw.gov.au/licences), which includes:
    - information on Aboriginal objects
    - information about Aboriginal Places
    - archaeological reports
  - MDB Authority Aboriginal Submissions Database
  - NSW State Heritage Inventory (see the Search topic at www.environment.nsw.gov.au/topics/heritage), which includes:
    - Aboriginal Places
    - State Heritage Register
    - Interim Heritage Orders
    - State Agency Heritage Registers
    - heritage items in Local Environmental Plans
  - Australian Heritage Database (see www.environment.gov.au/heritage/publications/australian-heritage-database), which includes places in the:
    - World Heritage List
    - National Heritage List
    - Commonwealth Heritage List

- Register of the National Estate.

Heritage sites

Heritage sites are cultural heritage objects and places listed on Commonwealth, state and local government heritage registers. Some Aboriginal values may also be heritage sites, and heritage sites may be divided into historic heritage sites and Aboriginal heritage sites in WM Act rural FMPs.

Commonwealth, state and local government heritage registers include the:

- Australian Heritage Database
- Historic Heritage Information Management System (HHIMS)
- MDB Authority Aboriginal Submissions Database
- NSW State Heritage Inventory
- NSW AHIMS.

Heritage sites include both Aboriginal and European heritage sites. They are identified by conducting a search of these registers, and then assessed to determine whether they are flood-dependent or flood-impacted. Heritage sites such as bridges, buildings and cemeteries may be sensitive to erosion during flooding.

Hydraulic modelling is used to identify sites potentially at risk from changes in flood behaviour.

Prioritisation of cultural assets

WM Act rural FMPs provide a framework so that cultural assets on the floodplain incur minimal impacts from flood work activities. Cultural assets are protected by not permitting flood works to be developed in areas where flow paths to flood-dependent assets would be obstructed, or where diverted floodwaters would cause significant damage.

The first step for prioritising cultural assets is to determine whether and how cultural assets are affected (dependent or impacted) by floodwater. Non-Aboriginal sites are determined to be flood-dependent or flood-impacted by assessing heritage listing documentation.

To prioritise cultural assets associated with Aboriginal values, the ATWG— made up of Aboriginal people with knowledge of or a connection with the floodplains, or both—is consulted.

Site sensitivity to flood works

The installation or modification of flood works poses a risk to existing unidentified cultural assets that are sensitive to ground disturbance. Examples of Aboriginal cultural assets that would be irreparably damaged by earthworks include Aboriginal camp sites, burial grounds, middens, or scarred trees (in the case of land clearing). Sites that are not flood-dependent but may be potentially impacted by flood work development will be identified in the FMP and the information made available to licensing officers. If a flood work is proposed in the vicinity of such a site, the *National Parks and Wildlife Act 1974* will be triggered and a due diligence assessment will be required to be undertaken to ensure the sites are not impacted by the proposal.

Step 6: Prepare a socio-economic profile

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

Step 6 involves preparing a baseline profile or 'snapshot' of socio-economic factors in the floodplain area.

Developing the profile, or 'snapshot', involves documenting the biophysical, social and economic conditions of the valley. The profile provides a general picture of the catchment in terms of its socio-demographic and economic structures and ensures that the ability of the community to absorb change is appreciated. This information is important to know before options for future water resource management are developed.

The main types of socio-economic information that inform the baseline profile include:

- geographies that are relevant to the socio-economic discussion of water use on the floodplain
- demographic profiles
- employment by industry
- income statistics
- economic wellbeing indicators
- agricultural production statistics.

The socio-economic profiles are used to design management zones and rules with an equitable and consistent approach to coordinating development on the floodplain. The profile is also used to ensure the WM Act rural FMPs minimise the impact that flood work development may have on neighbouring properties, which will in turn help minimise the risk to life and property from the effects of flooding.

Information from this assessment will be used in a socio-economic impact analysis to identify and take into account potential socio-economic impacts associated with implementing the WM Act rural FMPs. The socio-economic impact analysis is undertaken in coordination with the development of management zones and rules for a valley (Step 10). The socio-economic profile analysis also informs steps 7, 8 and 9.

Step 7: Delineate management zones

The WM Act rural FMPs will contain management zones to coordinate the development of flood works on the floodplains to protect the passage of floodwaters. A management zone is an area in the floodplain that has specific rules and assessment criteria to define the type and nature of flood works that can be licensed in that area. The rules for each management zone are determined in Step 8.

In accordance with the floodplain planning provisions and environmental protection provisions of the WM Act, management zones are developed to deal explicitly with proposals for the construction of new flood works and the amendment of existing flood works. The objective across each of the floodplains is to prevent future flood works and amendments to existing flood works from causing or exacerbating flooding problems, and to maintain connectivity to floodplain assets.

Types of management zone

In Step 7, management zones are delineated by grouping together common requirements for managing flood works on a rural floodplain. Step 7 generally results in five different management zones, including the:

- major flood discharge zone (which may be split into defined and ill-defined zones if these floodways were identified in Step 4)
- flood storage and secondary flood discharge zone
- flood fringe and existing developed areas zone

- urban areas managed by local council zone
- special ecological and cultural protection zone.

A general description of these five management zones is provided below.

Major flood discharge zone

This zone typically:

- includes floodways that convey significant floodwater discharge during the small and large design floods
- is important for conveying floodwater to floodplain assets during large and small flood events, including environmental flow releases and along natural flood flow corridors
- would be adversely impacted by uncoordinated flood work development in terms of flood behaviour
- ensures a reduction in the risk to life and property by limiting flood work developments to prevent flood flow redistribution as well as increased flood velocities and flood levels
- ensures there is continuity of flow and flow paths and assists in maintaining the overall flow distribution on the floodplain.

Depending on the topography and flood behaviour in the floodplain, this zone may be split into ill-defined and defined floodways (see Step 4 for more detail).

Flood storage and secondary flood discharge zone

This zone typically:

- includes areas of the floodplain that are important for temporarily storing floodwaters during the passage of a flood
- has an outer boundary defined by the inundation extent of the large design flood and/or available elevation data
- is important for conveying floodwater to floodplain assets during larger flood events
- is important in managing the cumulative and local impact of works on flood behaviour.

Flood fringe and existing developed areas zone

This zone typically:

- includes areas outside the inundation extent of the large design flood and existing developed areas
- contains flood-fringe areas where flood work development is unlikely to have a significant effect on flood behaviour.

Urban areas managed by local council

This zone includes urban areas where flood risk is managed by local councils through flood risk management plans and studies developed in accordance with the *Floodplain Development Manual* (NSW Government 2005).

Special ecological and cultural protection zone

This zone typically includes areas with special ecological and/or cultural value that have a very high degree of floodwater dependency.

Criteria to delineate management zones

The nature and location of the management zones are determined using hydraulic, ecological and cultural criteria, as well as criteria to ensure the new plans reflect current floodplain management arrangements (**Error! Reference source not found.**).

Table 3. General description of criteria used to delineate management zones

Criteria	General description of criteria used to delineate management zones
Hydraulic criteria	• Establishment of preliminary management zones based on **hydraulic criteria** • Criteria to be based on flood behaviour and results from modelling
Ecological criteria	• Adjustment of management zones based on **ecological criteria** to maintain flood connectivity to flood-dependent ecological assets • Criteria will determine the appropriate zone for ecological assets and methods for adjusting management zones accordingly • Establishment of special ecological and cultural protection zone for special ecological assets with very high flood dependency
Cultural criteria	• Adjustment of management zones based on **cultural criteria** to maintain flood connectivity to flood-dependent cultural assets • Criteria will determine the appropriate zone for the cultural assets and methods for adjusting management zones accordingly • Establishment of special ecological and cultural protection zone for special cultural assets with very high flood dependency
Criteria to better reflect current floodplain management arrangements	• Adjustment of management zones after **consideration of current floodplain management arrangements** • Where required, criteria will be proposed to better reflect current floodplain management arrangements

The criteria used to develop management zones consider the impact of existing and future development on flooding in rivers and floodplains; the flood risk to life and property; the flood connectivity of floodplain assets; and the social and economic impacts of restricting flood work development.

As required by the WM Act, this approach aims to strike an optimal balance between hydraulic, ecological, cultural, social and economic considerations. The zones and rules are designed to address local impacts as well as cumulative impacts. Furthermore, the number and type of zones is the minimum required to meet the management objectives.

Hydraulic criteria

Preliminary management zones are established based on hydraulic criteria, which are developed from information on flood behaviour contained in the floodway networks.

Typically, the three hydraulic categories in the floodway network and the area outside of the floodway network identified during Step 4 are the basis for four different management zones, so that the (9 and Figure 10):

- ‘floodways’ are the hydraulic basis for the major flood discharge zone (referred to as MZ A)
- ‘inundation extent’ is the hydraulic basis for the flood storage and secondary flood discharge zone (referred to as MZ B)
- ‘flood fringe’ (i.e. areas outside the floodway network) is the hydraulic basis for the flood fringe zone (referred to as MZ C).

Typically, the urban areas managed by local council zone (referred to as MZ CU) and the special ecological and cultural protection zone (referred to as MZ D) do not have a hydraulic basis.

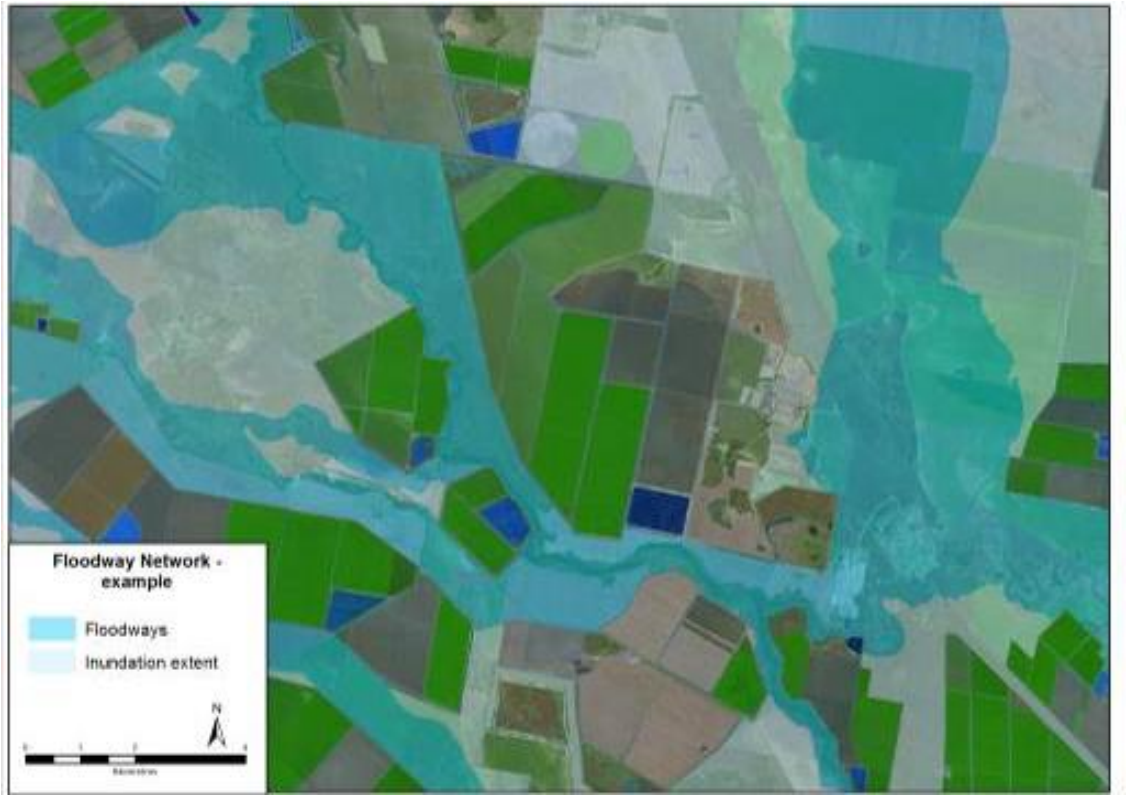

Figure 9. Example of a floodway network

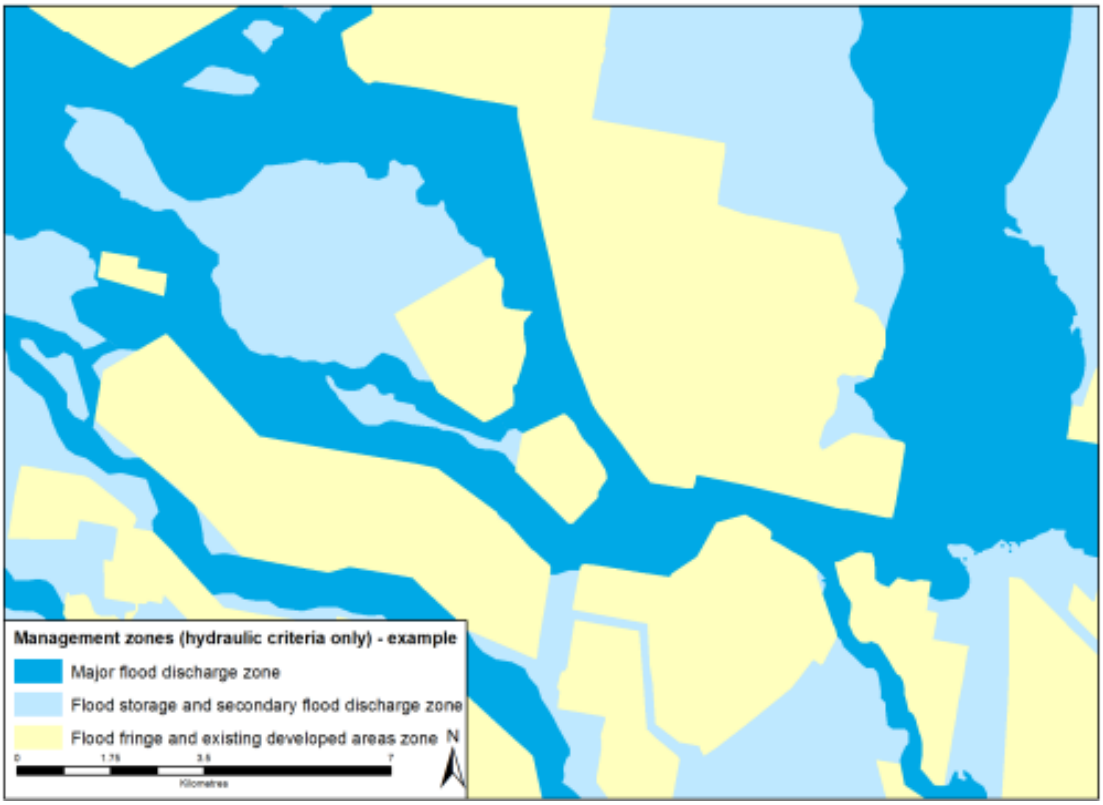

Figure 10. Example of how a floodway network is translated into management zones based on hydraulic criteria alone.

The hydraulic criteria for management zones based on flood behaviour spatially captured in the floodway network are presented in Table 4.

Table 4. Hydraulic criteria based on flood behaviour

Management zone	Hydraulic description	Typical hydraulic criteria

Major flood discharge zone	• Areas represented by a significant discharge of floodwaters during small and large design floods
	• Uncontrolled flood work development can have a high impact on flood behaviour
		• This zone includes:
		  ○ areas that exceed the appropriate hydraulic threshold in a large design flood
		  ○ parts of the small design flood extent that ensure continuity of the floodways

Flood storage and secondary flood discharge zone	• Inundation extent of the small and large design floods • Uncontrolled flood work development has a moderate impact on flood behaviour; however, cumulative impacts can be significant	• This zone includes areas flooded by the large design flood events that are not classified as being in the high-impact management zone • Floodwater passage is dominated by major temporary floodwater pondage areas • Some active flow paths are present
Flood fringe and existing developed areas zone	Areas outside the floodway network • Uncontrolled flood work development has a low impact on flood behaviour; however, cumulative impacts can be significant	• This zone includes areas of the floodplain that lie outside the extent of the large design flood

Ecological criteria

The WM Act rural FMPs aim to ensure that flood connectivity to wetlands, watercourses, floodplain ecosystems and areas of groundwater recharge is maintained or improved through the coordination of new flood work developments or modifications of existing flood works.

There are a wide range of aquatic habitats of ecological importance in floodplains, including oxbow lagoons, wetlands and many endangered ecological communities as well as species protected under state legislation (see Step 5 for more information). Floodplain water flows are crucial to maintain the structure, function and long-term survival of these flood-dependent communities. The distribution of vegetation across a floodplain may reflect the water regime (Casanova and Brock 2000). The timescales of flooding and the spatial extent of wet/dry ecotone may influence the types of plants that can germinate, grow and reproduce (Brock and Casanova 1997; Capon and Brock 2006).

Ecological criteria for management zones are determined to minimise the likelihood that new flood work development might change the passage of floodwater in a way that is harmful to an asset. For instance, negative impacts may occur when floodwaters are blocked or diverted from reaching assets that are dependent on flooding.

The general approach for ecological criteria is to:

1. Categorise high-priority assets[1] into hydro-ecological functional groups (also called asset sub-types) according to the watering requirements of the dominant or canopy species in a vegetation community (Figure 11)

[1] High-priority assets were identified using Marxan in Step 5.

2. group high-priority assets into common management zones where the assets have similar requirements for flood flows (based on asset sub-types). For instance, assets that thrive in frequently flooded conditions, such as semi-permanent wetland, will be recommended to be mapped as MZ A (Figure 12)
3. compare the high-priority asset sub-types to management zones based on hydraulic criteria (Figure 13)
4. determine if there is hydraulic justification to amend management zones (Figure 14), that is:
    a. is flooded by the small design flood
    b. can be connected to a flow path identified in flood imagery
    c. can be connected to a flow path or channel identified in DEM or LiDAR
    d. is immediately adjacent to the recommended management zone
5. make amendments to management zones (Figure 15).

If the management zones cannot be amended, then there are opportunities to develop rules that aim to protect flood connectivity to the asset (Step 8).

Ecological criteria differ slightly between floodplains; however, usually a combination of vegetation mapping, key fish passage, hydraulic data and floodplain topography is used to determine the detail of the criteria.

Special ecological protection zone

Typically, the ecological criteria have allowances for mapping an asset as MZ D where the asset is a location or feature with:

- a high degree of floodwater dependency, and
- a high degree of habitat complexity, and
- a history of supporting a diversity or abundance of waterbird, native fish or frog populations, or
- the functional capacity to act as an aquatic drought refuge, or
- recognition in or protection by a local, state or commonwealth environmental policy.

Other ecological criteria

In some floodplains, consideration may be given to widening MZ A along tracts of floodplain land identified as important for conveying significant floodwater discharge during smaller flood events (less than 10% AEP flood). Such areas are considered highly important for connecting flood-dependent communities to floodwater.

Where applicable, these areas are consistent with the efforts of OEH to implement environmental watering plans and consider ecological assets and values identified by the state. For instance, in the Gwydir floodplain, ecological water flow corridors were identified to protect the passage of floodwater actively managed by licensed environmental water deliveries. It is important to note that the majority of all flood events likely to flow through ecological water flow corridors will be derived from natural and regulated river flows.

In other floodplains, tracts of floodplain land within low-lying areas bordering a watercourse that contain important flood-dependent vegetation may be mapped as MZ A. Background documents published for each WM Act rural FMP will specify the ecological criteria adopted in detail.

Please note that the WM Act rural FMPs do not control flow volumes or timing, but coordinate the development of flood works to protect the passage of water.

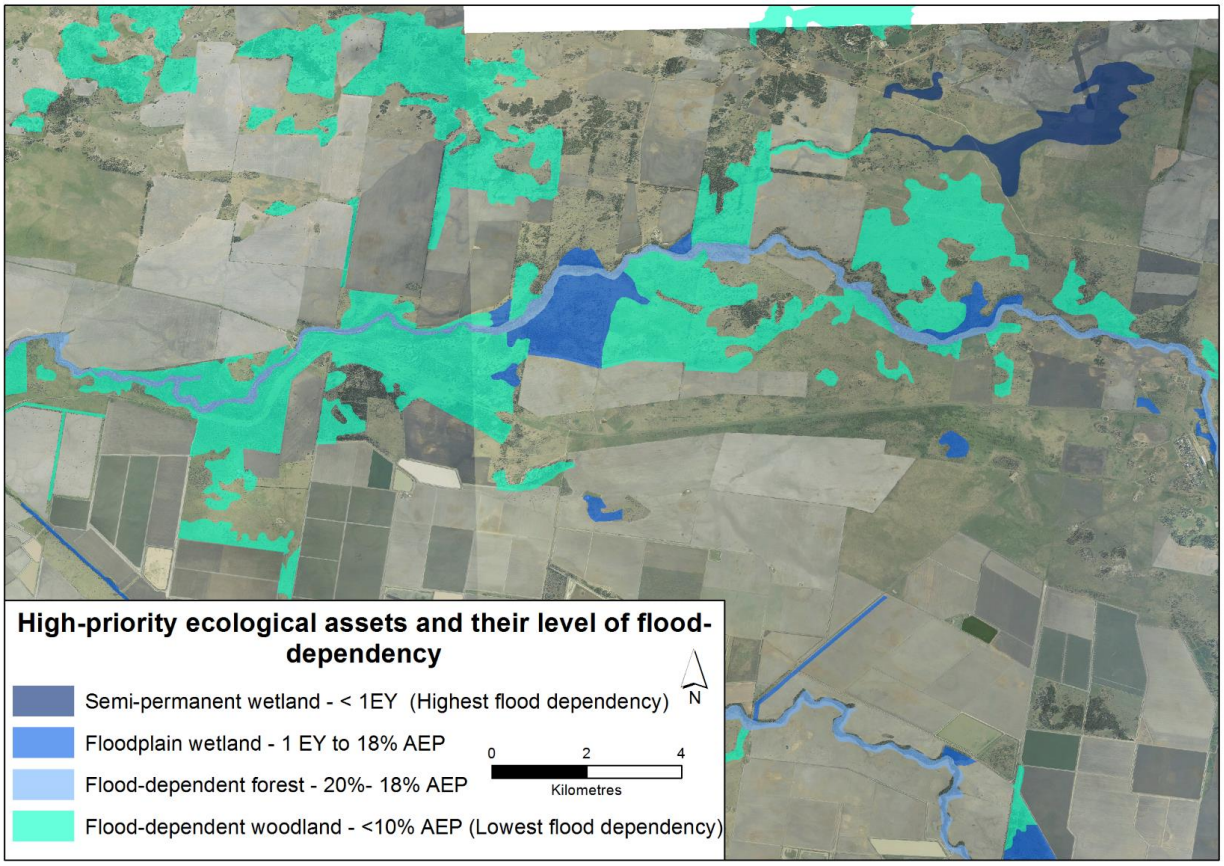

Figure 11. High-priority flood-dependent vegetation categorised according to flood dependency

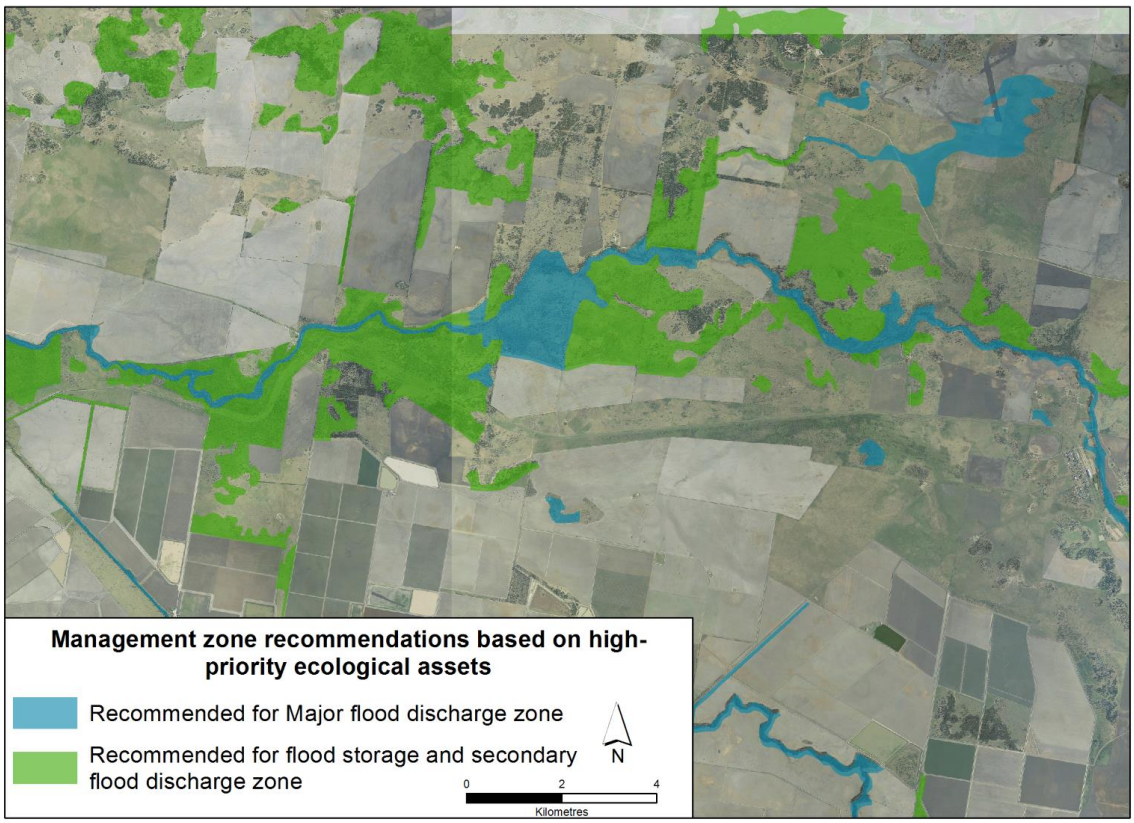

Figure 12. Management zone recommendations based on flood dependency of ecological assets

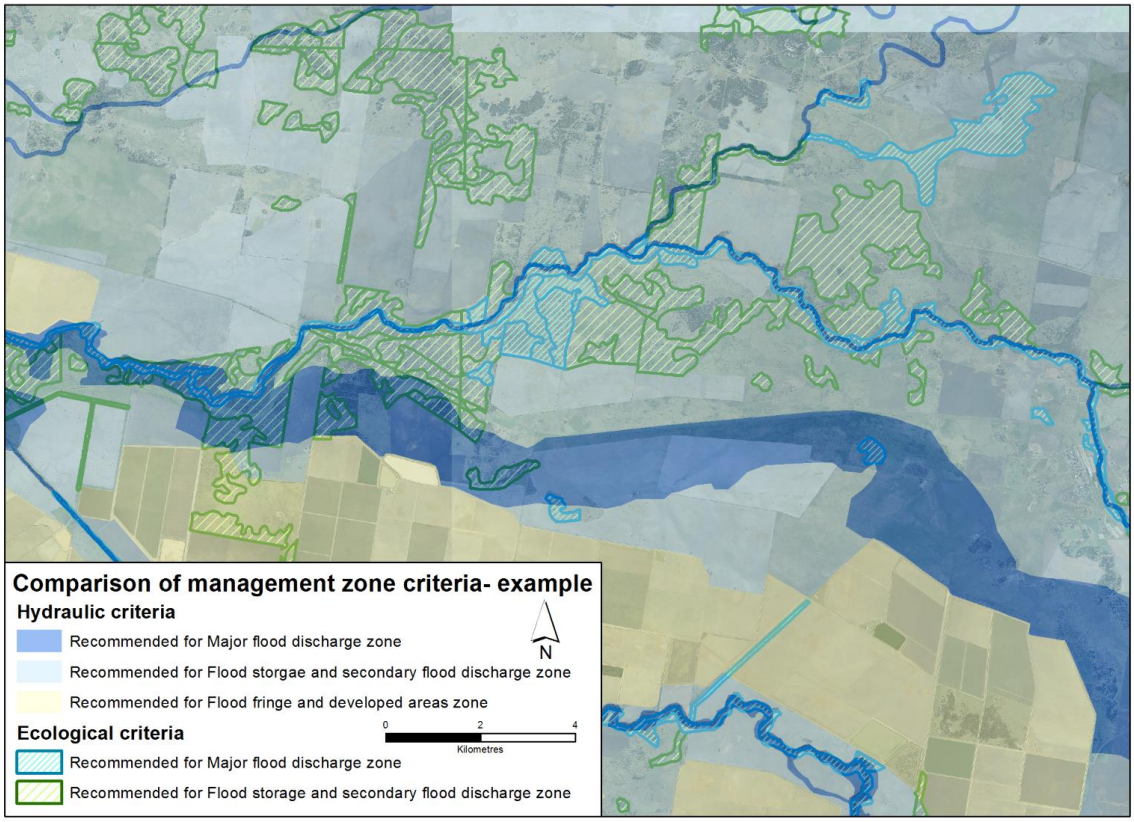

Figure 13. Management zone recommendations based on hydraulic versus ecological criteria

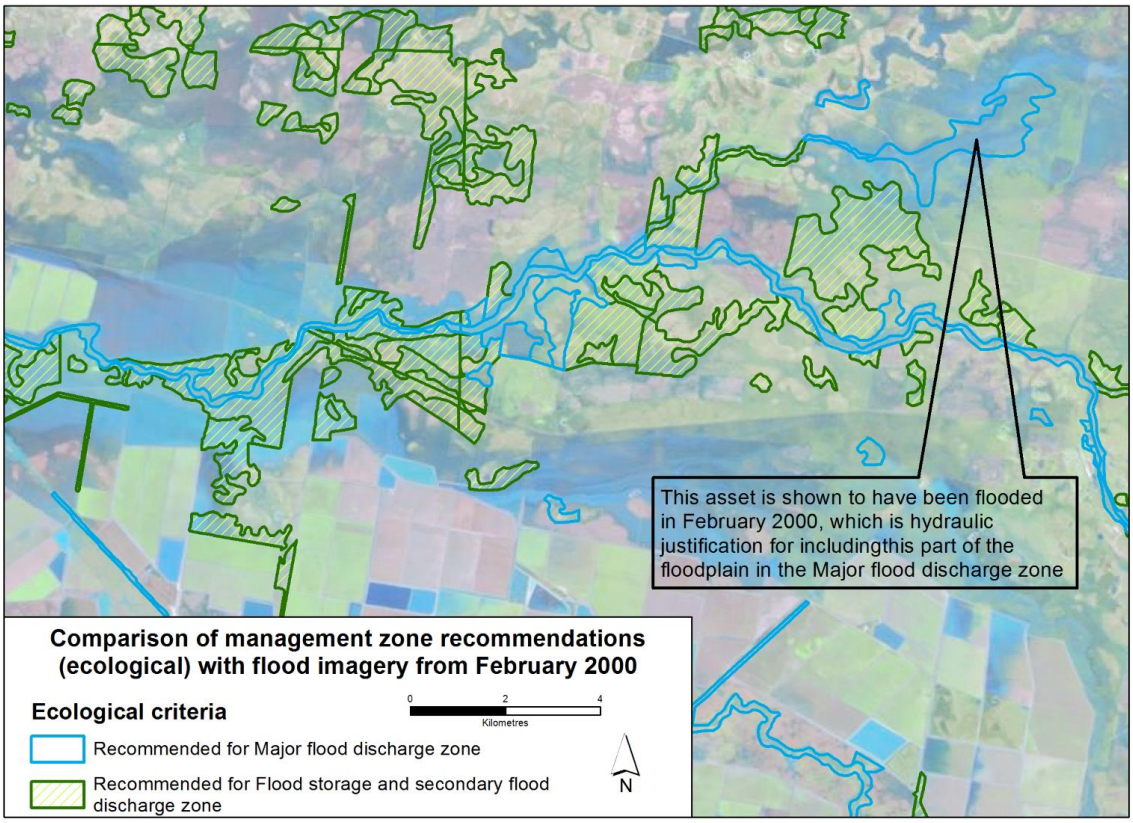

Figure 14. Identifying hydraulic justification for modifying zones based on ecological criteria

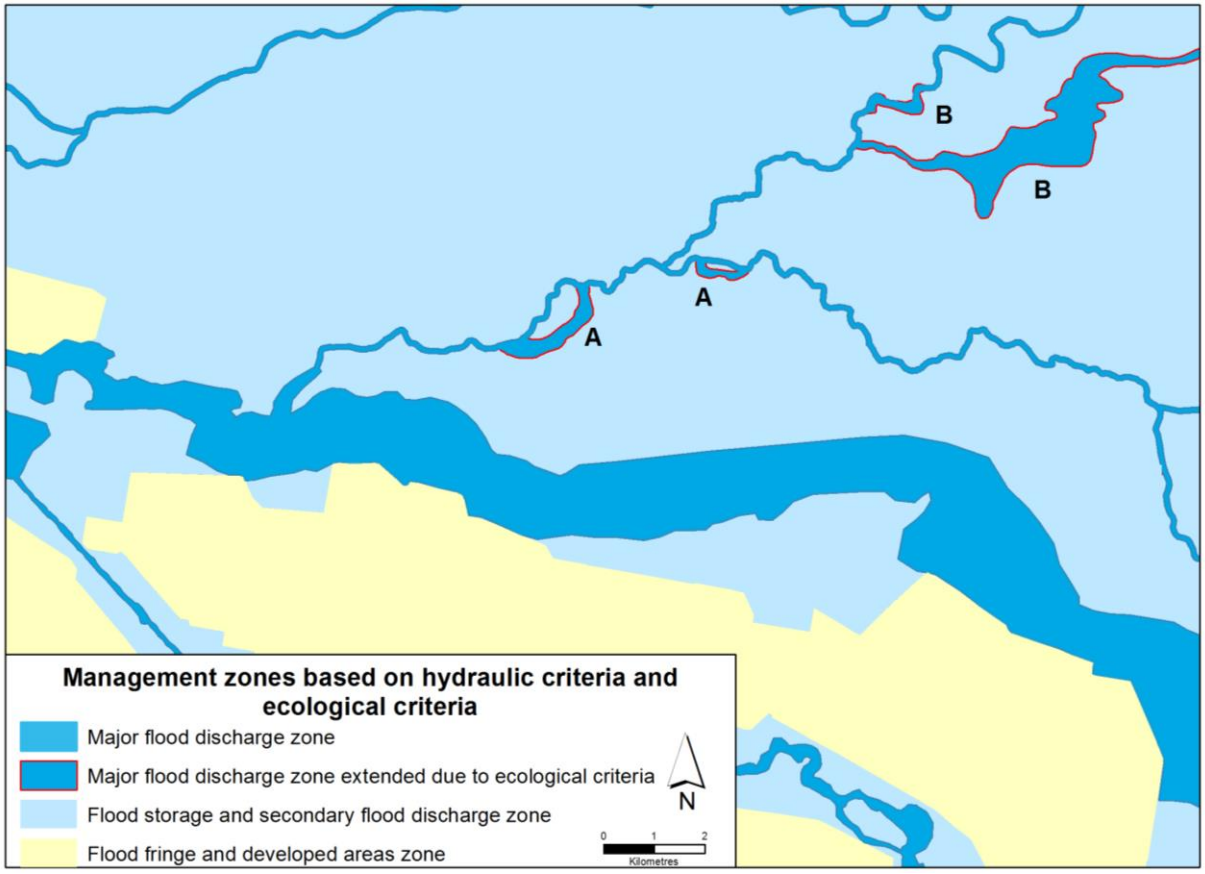

Figure 15. Amendments to management zones based on ecological criteria

'A' was delineated to better connect floodplain wetland and flood-dependent forest to flooding. Channels were identified by flood imagery and LiDAR. 'B' shows the major flood discharge zone extended to include the extent of the semi-permanent wetland.

Cultural criteria

Cultural criteria are developed to ensure that flood-dependent Aboriginal heritage sites and values are not impacted by flood behaviour changes caused by flood work development. Historic heritage sites that are not flood-dependent are not included as part of the cultural criteria for delineating management zones.

Cultural criteria are based on the flood dependency of Aboriginal values and heritage sites determined in Step 5. Cultural criteria are finalised in discussion with TAG members and local Aboriginal heritage experts.

Typically, cultural criteria considers including the following in MZ A:

1. Aboriginal values (excluding scarred or carved trees) that are highly flood-dependent if they:
   - are listed on the NSW AHIMS, or
   - were identified during direct community consultation with the local Aboriginal community
2. scarred/carved tree locations where the trees are:
   - living flood-dependent vegetation that generally requires flooding at least every five years to maintain their ecological character and cultural value
   - in close proximity to MZ A.
3. heritage sites that are flood-dependent and listed as cultural heritage objects or places on Commonwealth, state and local government heritage registers.

As is the case for ecological criteria, cultural criteria must also demonstrate that there is hydraulic justification to amend a zone. Generally, there is considered to be hydraulic justification in instances where the asset:

- is flooded by the small design flood
- can be connected to a flow path identified in flood imagery
- can be connected to a flow path or channel identified in DEM or LiDAR
- is immediately adjacent to the recommended management zone.

If the management zones cannot be amended, then there are opportunities for developing rules that aim to protect flood connectivity to the asset (Step 8).

To ensure management zone refinements represent on-ground conditions, the cultural criteria are validated in the field against expert recommendations and to account for data accuracy and confidence.

Special cultural protection zone

Typically, the cultural criteria have allowances for mapping an asset as MZ D where the asset is a location or landscape feature with a high degree of:

- floodwater dependency, such as swamps, marshes, lagoons, billabongs, rocky bars or warrumbools that are strongly dependent on the passage of floodwater
- cultural significance to the Aboriginal community – including spiritual, archaeological or resource use-values – and the asset is listed on a heritage register or is a place that is recognised for its cultural significance by several senior knowledge holders in the Aboriginal community.

Non–flood dependent cultural assets

Cultural assets that are vulnerable to (i) the effect of erosion associated with the redistribution of flood flow or (ii) the direct impacts of the installation of new flood works or the modification of current works are not dealt with in the design of the management zones. Where identified, these cultural assets will be an additional consideration for licensing staff when assessing flood work applications.

Criteria to better reflect current floodplain management arrangements

Across the floodplains, there is good general acceptance of current floodplain management arrangements. Criteria are developed to ensure the WM Act rural FMPs reflect current floodplain management arrangements wherever appropriate.

The legacy of floodplain management varies for each floodplain and these criteria will as well. Nevertheless, it would be expected that these criteria will generally ensure that:

- floodways are congruent with bordering floodways in different FMPs
- consistency of management zones with historically mapped floodways
- areas of the floodplain enclosed by approved flood works are mapped as MZ C if they are not overtopped during large floods (i.e. not works with limited-height conditions).

Urban areas in the floodplain

These criteria also consider urban areas where flood risk is managed by local councils through flood risk management plans and studies developed in accordance with the *Floodplain Development Manual* (NSW Government 2005), and also includes areas protected by flood mitigation works, such as town levees. These areas are mapped as MZ C–Urban (MZ CU).

In MZ CU, flood works undertaken by councils and private landholders are generally exempt from approval under the WM Act. In accordance with state-wide exemptions, flood works in MZ

CU that would require a flood approval under the WM Act include those on private landholdings where the landholding is greater than 0.2 hectares, unless that flood work is a:

- ring embankment that protects infrastructure and encloses an area less than 2 hectares or less than 10% of the land area, whichever is lesser, or
- earthwork (e.g. farm track, check bank) and less than 15 centimetres above (but not below) ground level.

Summary of management zone criteria

Table 5 provides a general overview of the types of criteria likely to be applied to the various management zones.

Table 5. Summary of criteria that is typically used to delineate management zones

Management Zone	Hydraulic criteria	Ecological criteria	Cultural criteria	Current floodplain management arrangements criteria
MZ A	Areas that meet the threshold for the mapped depth velocity product and/or floodways identified from imagery and elevation data. Parts of a small design flood extent that ensures continuity of the floodways.	High-priority assets that have a high flood dependency, such as water courses and semi-permanent wetland.	Places identified as high value by the community that are dependent on flooding. Flood-dependent assets, such as scarred trees that are in close proximity to floodways	Floodways are made congruent with floodways in bordering FMPs. Consistency of management zones with historically mapped floodways.
MZ B	Areas flooded by small and large design flood events that are not classified as the major flood discharge zone.	Assets that have a moderate flood dependency, such as flood-dependent woodland.	Assets that have a moderate flood-dependency.	Consistency of management zones with historically mapped floodways.
MZ C	Areas of the floodplain that were not flooded by a large design flood event.	The basis of MZ C is generally not ecological. Non flood-dependent vegetation is likely to occur.	The basis of MZ C is generally not cultural. Cultural assets that are impacted by flooding are likely to occur.	areas of the floodplain enclosed by approved flood works are mapped as MZ C if they are not overtopped during large floods (i.e. not works with limited height conditions).

Management Zone	Hydraulic criteria	Ecological criteria	Cultural criteria	Current floodplain management arrangements criteria
MZ CU	The basis of MZ CU is not hydraulic.	The basis of MZ CU is not ecological. If any assets fall within MZ CU, ecological asset mapping will be provided to the relevant local government authority for consideration in land-use planning and assessment of development applications.	The basis of MZ CU is not cultural. If any assets fall within MZ CU, the relevant local government authority will be notified and provided with relevant contact details.	Urban areas where flood risk is managed by local councils through flood risk management plans and studies developed in accordance with the *Floodplain Development Manual* (NSW Government 2005) and also includes areas protected by flood mitigation works, such as town levees
MZ D	There are no specific hydraulic criteria; however, due to the high dependence of assets on flooding, this area would be frequently flooded	MZ D includes assets that are a location of landscape feature, such as a swamp, marsh, lagoon, anabranch or billabong with a high degree of floodwater dependency, and: • a high degree of habitat complexity • a history of supporting a diversity or abundance or waterbird, native fish or frog populations • the functional capacity to act as an aquatic drought refuge • recognition in, or protected by a local, state or Commonwealth environmental policy.	MZ D includes areas of the floodplain that are a location or landscape feature that has a high degree of: • floodwater dependency such as swamps, marshes, lagoons, billabongs, rocky bars or warrumbools that are strongly dependent on the passage of floodwater • cultural significance to the Aboriginal community including spiritual, archaeological or resource use-values and are listing on a heritage register or are a place that is recognised for its cultural significance by several senior knowledge holders in the Aboriginal community.	MZ D will be reviewed for consistency with existing plans. However, these criteria are not the basis for MZ D.

Step 8: Determine draft rules

The management zones and rules together provide the legal framework to determine flood work applications. Step 8 is undertaken to develop specific rules to define the type and nature of future flood works that can be constructed in each management zone.

The rules vary between management zones to reflect differences in flooding behaviour and the floodplain environment. Step 8 is also undertaken to develop rules to license, or modify existing licences for, eligible existing flood works management zones that restrict the types of flood works authorised to be considered for approval.

The rules can be split into five general types, including those that:

- specify the physical nature of authorised flood works
- are advertising requirements
- are assessment criteria to determine the acceptable impacts of flood works
- relate to existing flood structures and works in MZ A and MZ D
- maintain flood flow corridors through ill-defined floodways.

The rules are developed by weighing up the socio-economic impacts of development controls against the potential for different types of flood works to impact on flooding behaviour.

Potential socio-economic impacts associated with management zones and rules will be mitigated by:

- defining flood works that can be applied for in each zone with respect to the social and economic impacts of development controls
- refining rules to coordinate the development of any new flood works
- ensuring the proposed rules are reasonably consistent with existing floodplain management arrangements.

The rules proposed for each FMP should be considered in conjunction with the state-wide exemptions as set out in the Water Management (General) Regulation 2018 (see ‘Exemptions to flood work approvals’ below for further information).

The WM Act rural FMPs will be supported by assessment guidelines to assist licensing officers assessing flood work applications against the rules.

Authorised flood works

Authorised flood works are works for which an application for an approval will be accepted. Applications for authorised flood works will still need to go through the assessment process to receive an approval. Applications for non-authorised flood works will not be approved.

Generally, in MZ B and MZ C/CU, all flood works will be authorised (note that although authorised flood works are eligible to undergo the assessment process, they do not automatically receive an approval and the proposal will be rejected if assessment criteria are not met) (Table 6). In MZ A and MZ D, which are areas of major discharge and/or significance, only minor works will typically be authorised (Table 7). This distinction between the zones reflects the relative risk of flood works impacting on flood behaviour.

Authorised works are determined by considering the optimal balance between hydraulic, ecological, cultural and socio-economic considerations on the floodplain. They are selected to be sympathetic to landholder needs, and decisions are checked against:

- works likely to be approved under existing floodplain management planning arrangements
- targeted consultation with the community and interagency officers.

The rules in the new FMPs will specify the physical nature of authorised flood works in MZ A and MZ D. These rules will ensure that works likely to be approved are fit for purpose. The rules also ensure that landholders can, within reason, build flood works typically used to protect life and property. The rules will be easy to interpret and apply without a detailed technical assessment.

Table 6. Nine types of flood works typically considered in the WM Act rural FMPs

Flood work type	Purpose
Private access road	To ensure landholders have basic provisions to access property
Supply channel (can be above or below ground)	To ensure landholders can access water rights from water sources
Aboriginal value enhancement works*	To provide a positive outcome for an Aboriginal cultural value that is listed in a local, state or Commonwealth heritage register.
Ecological enhancement works*	To provide a positive outcome for an ecological asset that is mapped, recognised in or protected by an FMP, or local, state or Commonwealth environmental plans, policy or legislation.
Heritage site enhancement works*	To provide a positive outcome for an heritage site that is listed in a local, state or Commonwealth heritage register.
Infrastructure protection works	To minimise the risk to life and property from flooding
Stock refuge	To account for animal welfare and to minimise a landholder's potential to lose stock to floodwaters
Other flood protection works (≤40 cm)	Generally, to protect crops and land against inundation from smaller floods
Other flood protection works (>40 cm)	Generally, to protect crops and land from inundation by larger floods

*A new type of flood work defined as part of this planning process.

Table 7. Authorised flood works typically defined for management zones

Management Zone	Authorised flood work
Management Zone A	• Aboriginal value enhancement works • Access roads • Ecological enhancement works • Heritage site enhancement works • Infrastructure protection works • Stock refuges • Supply channels
Management Zones B, C and CU	All types of flood works are authorised
Management Zone D	• Aboriginal cultural value enhancement works • Ecological enhancement works • Heritage site enhancement works

*Note that the WM Act rural FMP for the Gwydir Valley floodplain authorises works in Management Zone D that vary from the list in this table. This is because rules in Management Zone D in the Gwydir Valley floodplain were based on rules in a second-generation FMP. Other valleys where Management Zone D covers a large area, such as the

Macquarie Valley, may also include authorised works of similar types to those listed in Management Zone A. Refer to specific WM Act rural FMPs for more detail.

For MZ A, works will be able to be applied for where their purpose is critical in reducing the potential negative socio-economic impacts of flooding. Depending on the local issues in the floodplain, such works may be limited to those that have minimal impacts on hydraulic, ecological, cultural and socio-economic factors. Examples of the types of flood works that are likely to be authorised in the major flood discharge zone are outlined in Table 7.

The rules in the FMPs provide more detailed specifications for the construction and nature of authorised flood works. Table 8 provides examples of such management rule requirements.

Table 8. Management rule requirements that can apply to different types of flood works in the WM Act rural FMPs

Work application	Management rule requirements
Access road	• specified height limits • causeway requirement; the number of causeways and spacing distances may be stipulated • borrow pit specifications, including depth and location
Infrastructure protection work	• maximum size of work permitted may be based on property size • construction of a flood work must not block a floodway
Supply channel	• specified height limits • structures may be required in the proposed flood work to permit passage of floodwater (e.g. siphon) • spoil removal requirement; rule may stipulate how spoil should be managed after a flood work has been constructed
Stock refuge	• maximum size of work permitted may be based on property size • construction of a flood work must not block a floodway

Advertising requirements

In the WM Act rural FMPs, proposed management rules may have advertising requirements. These requirements will depend on the management zone that a proposed flood work is located in, as well as the nature and construction of the work; that is, whether the proposed works could cause or exacerbate flooding problems. Local landholders have the opportunity to comment on flood work applications that could adversely impact flood behaviour. Landholders applying to construct flood works of a more minor nature will not be required to advertise their proposed works.

If a flood work application is required to be advertised, the application will be open to third-party objections. Third-party objections will be required to be considered by licensing officers when determining approvals. Advertising of applications will therefore be:

- constructive for third parties who need the opportunity to comment on flood works that may potentially impact a feature of the floodplain that is important to them
- potentially time-consuming and costly for applicants who receive objections to their applications and have to participate in mediations that may result in the work not being approved or changes being made to the work originally proposed.

Assessment criteria

These rules will follow a merit-based approach to assessing the potential impact of the specific flood work on flooding behaviour. Rules relating to the acceptable impacts of flood works will be designed to consider the potential for a flood work to have:

- ecological and cultural impacts
- social (drainage) impacts
- local hydraulic impacts
- cumulative hydraulic impacts.

The potential impacts to be assessed when determining a flood work approval will depend on the type of flood work applied for and the management zone the flood work is located in.

Each WM Act rural FMP will consider flood behaviour, ecological, cultural and socio-economic factors when developing these types of rules. Consideration will also be given to existing FMPs and guidelines for identifying existing assessment criteria and their applicability to the WM Act rural FMP. Existing assessment criteria will be incorporated into the rural FMPs where possible.

The main factors considered when developing assessment criteria relating to the acceptable impacts of flood works are outlined in Table 9.

Table 9. Factors considered when developing assessment criteria

Flood behaviour	Ecological and cultural	Socio-economic
• Passage, flow and distribution of floodwaters • Existing dominant floodways and exits from floodways • Rate of flow, floodwater levels and duration of inundation • Upstream and downstream water flows and levels • Spatial and temporal variability of flooding • Cumulative and local impacts of floodplain development on flood behaviour	• Floodplain assets, such as wetlands and flood-dependent sites identified as important • Risk to flood connectivity of floodplain assets posed by existing and future development • Risk to fish passage and the habitat for breeding and feeding	• Economic dependence of the local community on floodplain development • Risk to life and property from the effects of flooding

Existing flood works and structures

Rules to either license eligible existing flood structures or to modify the licences of eligible existing flood works are required in zones that restrict the types of authorised flood works (typically MZ A or MZ D). Such rules are required because there may be existing flood works or structures in these management zones that do not meet the specifications to be an authorised work and:

- were unlicensed flood structures that now require a licence under the WM Act
- were licensed flood works under the Water Act but the owner wishes to apply to modify the work.

The rules will reference the types of existing works that are eligible for application in MZ A or MZ D. These eligible works are likely to be the same for both management zones.

These rules will also allow existing licensed flood works to be modified if they exceed the thresholds in the rules for future flood works, as long as the proposed modification will reduce the impact of the works on the flow patterns.

Flood flow corridors

In floodplains where ill-defined floodways are identified, rules will typically be made to maintain flood flow corridors through ill-defined floodways. Ill-defined floodways are generally areas of a floodplain where a significant discharge of floodwater occurs during floods, with relatively high flood flow velocities and depth, but without defined channels or banks.

Flood flow corridors are generally given a minimum width and requirements to:

- ensure links to any flood flow corridors or floodways on adjacent properties
- assess works applied for within the corridors against the rules of MZ A
- assess works applied for outside the corridors against the rules of MZ B.

The background documents for individual floodplains will detail the specific rules.

Exemptions to flood work approvals

An approval is required to construct or use a flood work under section 91D(1) of the WM Act. However, flood works that satisfy the exemption criteria outlined in the Water Management (General) Regulation 2018 do not require an approval. State-wide exemptions are for works or types of works which are considered low risk or are necessary for public safety, or which are more appropriately overseen by another government body such as a local council.

For further information on state-wide exemptions, refer to the Water Management (General) Regulation 2018.

Step 9: Consider existing floodplain management arrangements

Consideration of existing floodplain management arrangements will be integrated throughout the planning process. Step 9 reports on how these arrangements are considered, including the occurrence of change between existing rural floodplain management arrangements and the WM Act rural FMP.

This step aims to ensure that there is adequate consistency between existing and proposed floodplain management planning measures. FMPs that are within the floodplain boundaries, as defined in Step 1, will be reviewed with respect to their development guidelines and flood studies.

Table 10 lists examples of previous floodplain management arrangements that are being considered in the development of the WM Act rural FMPs.

The WM Act rural FMPs will supersede existing FMPs. However, the WM Act rural FMPs will be required to consider how flood work development has been managed by these plans to date. The WM Act rural FMPs will endeavour to be consistent with existing floodplain management arrangements.

Table 10. Key aspects of previous floodplain management arrangements considered in the WM Act rural FMPs

Key aspect	FMP management arrangements considered in WM Act rural FMPs
Floodplain management principles	The following FMP principles are considered: • Defined flow paths must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain. • Velocities of flood flows in defined flow paths should be minimised and be of an order that would not cause erosion or increased siltation under different land uses. • There must be due regard for current government policy and legislation. • There should be no adverse impact from floodplain development on any individual landholder or community infrastructure. This includes increases in peak flood levels and increased drainage times. The exit of floodwaters from flow paths should be at rates and depths similar to those that would be experienced under natural or historical conditions and should discharge as closely as possible to the natural or historical location.
Ecological and cultural heritage considerations	• As part of the identification and prioritisation of ecological assets, flood-dependent ecosystem mapping in the FMPs is considered. • Information on Aboriginal and other heritage sites in the FMPs is considered.
Floodway networks/ flow paths	• Floodways identified in floodplain development guidelines are considered in the hydraulic design of the conceptual floodway network. • Floodway networks and flow paths specified in the FMPs are integrated into the FMP floodway network to align them with management zones that restrict flood work development.
Hydraulic models	• Hydraulic models underpinning FMPs are reviewed during FMP modelling studies.
Design flood event	• Design floods in the FMPs are considered for adoption as large design floods in the FMPs subject to analysis of subsequent floods.
Types of works considered for approval	• The types of works considered for approval under current floodplain management arrangements are considered.
Advertising requirements for applications	• Floodplain areas where flood work applications require advertising under adopted FMPs will be considered for inclusion in management zones with rules that require advertising for flood works.
Assessment process/criteria for assessing flood work applications	• Assessment criteria for flood works in the FMPs are considered when proposing management rules for individual valleys, with particular attention to incorporating hydraulic criteria that specify quantifiable limits.

Consideration of existing flood works

Flood works on the floodplain that have been approved and constructed under existing floodplain management planning arrangements are considered in the proposed criteria for

delineating management zones. Wherever possible, areas with existing flood work developments are incorporated into the flood fringe and existing development zone to prevent negative socio-economic impacts associated with flood work development controls.

Step 10: Assess socio-economic impacts

Step 10 is undertaken to determine if the combined impact of the proposed management zones, rules and assessment criteria is equitable, and to give due consideration to the socio-economic impacts of any changes to how flood work development in the floodplain is managed.

The assessment only considers the negative impacts of the proposed FMP and is therefore an impact assessment. Because the benefits of the proposed FMP are not enumerated, it is not a cost–benefit analysis. Each FMP is expected to provide significant benefits that would outweigh the negative impacts. The negative effects of the implementation of the proposed FMP are quantified in dollars (the year is specified in the relevant background document for each WM Act rural FMP).

Identifying socio-economic effects

To understand the effects of changes in water management regimes, it is important to first determine which categories of water work approvals may be affected (both positively and negatively) by the changes in water management. By understanding which categories of water approvals will be affected by the different management options, it will subsequently be possible to identify the negative social, economic, financial and environmental effects on the broader society and the flow-on effects within the region. It is important that both the direct and indirect effects of approvals are identified.

The following value categories are affected by the proposed FMP options: irrigated agriculture, dryland agriculture, grazing, domestic water supply, tourism, other industry, recreation, aesthetic[2], ecological and vicarious[3].

Identifying the socio-economic effects of changes in water management regimes is complex. Some effects, such as employment, may be obvious, while others, such as shifts in the power balance between local groups, may be harder to discover. Obviously, immediate effects will be more visible than delayed social effects, and tangible effects may be more easily identified than intangible ones. In any case, a generic list of questions for consideration is helpful in assisting to identify the socio-economic effects that may arise from the proposed changes in water management regimes. Even if it is proven impossible to determine the strength and timing of an effect, simply being aware of its existence gives an increased sense of control and confidence in the decision process.

Assessing socio-economic effects

The assessment of socio-economic effects will be analysed in two phases: the preliminary assessment (Phase 1) and the detailed assessment (Phase 2). The first phase identifies negative impacts and further defines the characteristics of the proposals. This process helps to determine the level of socio-economic effects. If these effects are significant, then Phase 2 – a more detailed examination of the socio-economic effects – would follow. The detailed assessment will provide a greater level of detail of the significance of those anticipated effects.

During both of these phases, the socio-economic assessment will be comparing and evaluating different proposals raised in the planning process. This information needs to be organised in a way that recognises that the effects will be felt by different groups, at different times and in different forms.

[2] Aesthetic values include the experiential attributes that a river environment provides (e.g. visual amenity).
[3] Vicarious uses of water include values that people derive from the knowledge that something is available for use by themselves or others, either now or in the future (e.g. option, existence, bequest values).

Effects may have several dimensions, such as:

- the extent of the effect (e.g. localised or across region)
- the likelihood of the effect occurring
- the intensity of effect
- the timing and duration of the effect.

In addition, there may be some attributes of the floodplain and the floodplain community (such as the amenity benefits of rule changes) that are affected by particular proposals, but for which it is not possible to determine whether these attributes would be positively or negatively affected. These factors, however, should still be recognised and noted.

One of the important principles is the need to clearly define a base case—a common reference point—with which the reform options can be compared. The impact of a particular proposal is the difference between the socio-economic condition of the region under that proposal and the socio-economic condition of the region under the 'without reform' or base-case scenario.

Each problem or issue that is being analysed will need to:

- clearly state the key assumptions underlying the proposed analysis
- consider the key quality assurance principles in defining the analysis
- identify an appropriate method of analysis, and the tools and techniques to be utilised
- identify appropriate sources of data to collect.

Clearly state key assumptions

All analysis involves assumptions and clearly identifying them is important. Assumptions are the 'state of nature' on which planners and scientists base their analysis. Those who are using the results of the analysis need to understand clearly what this basis is.

Considering key quality assurance principles

In addition to clearly stating key assumptions, it is important to consider the following key quality assurance principles:

- Focus assessment effort on important factors.
- Ensure short-term, long-term and cumulative effects are considered.
- Ensure equity is considered.
- Undertake sensitivity analysis on effects where the risk is significant.
- Refine relative estimates of sensitive socio-economic effects if quantification is difficult.

Identify appropriate methods and techniques

In all cases, the selection of methods to use should conform to five simple rules developed in the Independent Advisory Committee on Socio-economic Analysis Guidelines:

- the methods should produce the information at the appropriate level of precision needed to make informed decisions
- cost and time considerations dictate that the methods employed should be no more complex than is necessary to get the required result
- the methods must be matched to the attributes of the problem being analysed
- the IRP and the stakeholders should be confident about the validity of the method chosen, as trade-offs are to be based on the results of its use

- the objectives of the analysis should be understood and agreed by the IRP and the stakeholders and used as an overarching guide for planning throughout.

Identify appropriate sources of data to collect

The diverse effects of the options are likely to generate a wide range of data requirements. The kinds of data sought will be suggested by the nature of the anticipated consequences identified and the techniques chosen to evaluate them.

The following explains the two phases of the socio-economic assessment.

Phase 1: Preliminary assessment of socio-economic impacts

The preliminary assessment of effects principally involves comparing the relative effects of different proposals; that is, in the initial consideration of the alternative options, it is much more efficient to consider the effects of a proposal relative to another proposal rather than attempting an absolute quantification of the effects of each proposal. By comparing the relative effects of various proposals and the base-case scenario, it is possible to screen the proposals, and to determine which proposals and effects require further consideration.

Simple techniques—such as considering trends, directions of change and basic scoring—and ranking processes can be very useful in identifying the relative merits of the alternative proposals. For each of the proposals, it may also be useful to summarise the characteristics of the effects and present them in a manner that facilitates comparison between proposals.

The preliminary socio-economic assessment will draw from the targeted consultation undertaken in preparing the draft WM Act rural FMPs and contribute to other steps undertaken in developing the plans. This preliminary socio-economic assessment will inform the finalisation of the draft plan, which will then be placed on public exhibition. Feedback from stakeholders will also be invited.

This process will also help to determine the level of socio-economic effects. Where those proposals screened for further consideration are significant, a more detailed examination of social, environmental and/or economic effects should follow. Resource and time considerations require that the detail of the analysis should be only to the level that is essential for effective decision making. The socio-economic impacts are considered in the development of draft management zones, rules and assessment criteria, and in the development of impact management and mitigation strategies where required.

The preliminary socio-economic impact analysis will involve:

- identifying likely sources of economic and social impact
- evaluating issues and options by assessing the social and economic effects of changes on the community
- identifying the potential effects of issues and options on the community
- undertaking a socio-economic impact assessment of proposed management zone scenarios compared with the baseline assessment, which represents the current situation
- determining preferred options based on an understanding of goals and the relative benefits of each option, and their distribution throughout the community. Consideration will also be given to ecological, cultural and hydraulic factors to ensure that a balanced outcome is achieved (see Step 7)
- documenting potential socio-economic impacts and options identified by the targeted community consultation.

Phase 2: Socio-economic impact analysis

Phase 2, which involves detailed analysis, will be undertaken when the Phase 1 analysis indicates that the impact is greater than the threshold (a negative change of greater than 5% is considered a significant level requiring detailed investigation) or there are major concerns raised during the public exhibition.

The stakeholder feedback received during the public exhibition will be used to verify and improve the accuracy of the data used and socio-economic impact predictions, and to provide information so that adjustments and/or modifications can be made if necessary. Potential socio-economic impacts and options identified by the community through public consultation processes will undergo a socio-economic impact analysis.

Other considerations

Existing works

Under the WM Act, flood work approvals replace approvals for controlled works under Part 8 of the Water Act. Other than this change in terminology, the process for applying for a flood work approval is similar to the process for applying for a Part 8 approval.

The WM Act includes transitional provisions to ensure that the actions taken and approvals granted under Part 8 of the Water Act remained valid when the WM Act came into effect in 2016. Controlled-work approvals granted under the Water Act were converted to flood work approvals under the WM Act.

No action on the part of the holder of a controlled-work approval is needed to maintain the validity of their approval.

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

Step	Key inputs/process	Key outputs/outcomes
1—define the floodplain boundary	• Information on the nature and extent of flooding over time • Floodplains designated under Part 8 of the Water Act • Other statutory boundaries and infrastructure features (e.g. water sharing plans, roads and floodplain harvesting register of interest)	Map of floodplain boundary to be designated under the WM Act
2—identify existing flood works	• Flood work licences • Area of land protected by flood works identified from spatial data such as flood imagery, LiDAR and aerial photography • Local knowledge of Department of Industry Water licensing officers	• Map of area of land protected by flood works • Number of existing approved flood work licences
3—review existing rural floodplain management arrangements	• First-generation floodplain development guidelines and studies (non-statutory) • Second-generation rural FMPs (Water Act)	Information on and analysis of key aspects of existing rural floodplain management arrangements
4—determine the floodway network	• Design floods • Flood frequency analysis • Hydrological/hydraulic model input • Flood imagery • Existing floodway networks (Step 3) • Local knowledge	• Map of floodway network, including floodways, inundation extent and areas outside the floodway network • Better understanding of existing flooding regime
5—identify and prioritise floodplain assets	• Identified from peer-reviewed literature, relevant legislation, policies, databases and registers • Various spatial data (e.g. plant community type mapping) • Optimum watering requirements • Conservation significance of assets determined by TAG and Marxan • Cultural assets identified by the ATWG and through community consultation	• Definition and maps of ecological and cultural assets • Grouping of ecological assets based on optimum watering requirements • Understanding of the flood dependency of cultural assets • Map of high-priority floodplain assets
6—prepare a socio-economic profile	• Secondary data sources (including Australian Bureau of Statistics, the Australian Bureau of Agricultural and Resource Economics and Sciences, and NSW Government departments) • Local knowledge	Understanding of the baseline profile of the floodplain, including stakeholder identification

Step	Key inputs/process	Key outputs/outcomes
7—delineate management zones	• Hydraulic criteria based on information from steps 1, 2 and 4 • Criteria to ensure appropriate consistency between current and proposed management options based on information from Step 3 • Ecological and cultural criteria based on information from Step 5 • Analysis to ensure equity based on information from Step 6 • Feedback from consultation	Definition and map of management zones, which will generally result in four zones: • major flood discharge • flood storage and secondary flood discharge • flood fringe and existing development • special ecological and cultural protection
8—determine draft rules	• Understanding of management zones • Existing types of flood works • Existing and potential flooding problems • Rules from existing rural FMPs • Feedback from consultation	Rules and assessment criteria covering: • authorised flood works • acceptable impacts • advertising requirements • existing flood works and structures
9—consider existing floodplain management arrangements	Information on existing floodplain management arrangements gathered in Step 3 is compared against the draft FMP to determine the extent of change	The extent of change between existing rural floodplain management arrangements and the proposed FMP is determined
10—assess socio-economic impacts	• Economic data • Area under irrigated crop • Gross margins • Prices • Hydrology data	Social and economic impacts assessed against the base case
Consultation and review	• Draft FMP is reviewed by the Department of Industry working group and IRP at key stages before targeted consultation, public exhibition and plan commencement • Consultation with key stakeholders during the targeted consultation stage and the wider community during the public exhibition stage	• IRP provides whole-of-government endorsement of the FMP • Feedback from key stakeholders and the community is considered in FMP development • Information on community concerns and issues is gathered
Finalise and commence plan	Revision of socio-economic assessment and impact mitigation strategies	Final FMP is implemented, and plan outcomes are achieved

Appendix 2. Glossary

Aboriginal values are sites, objects, landscapes, resources and beliefs that are important to Aboriginal people as part of their continuing culture.

annual exceedance probability is the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage (%) or as 1 in Y. For example, a flood with an AEP of 5% (or 1 in 20) means there is a 5% (or 1 in 20) chance that a flood of the same size or larger will occur in any one year.

connectivity refers to the unimpeded passage of floodwater through the floodplain. Connectivity is important for instream aquatic processes and biota and the conservation of natural riverine systems.

cultural asset is an object, place or value that is important for people to maintain their connections, beliefs, customs, behaviours and social interaction.

design flood is a flood of known magnitude or annual exceedance probability (AEP), that can be modelled. A design flood is selected to design floodway networks which are used to define management zones for the planning and assessment of the management of flood works on floodplains. The selection is based on an understanding of flood behaviour and associated flood risk. Multiple design floods may be selected to account for the social, economic and ecological consequences associated with floods of different magnitudes.

discharge (or flow) is the rate of flow measured in volume per unit of time (e.g. megalitres per day).

ecological assets are a wetland or other floodplain ecosystem, including watercourses, that depend on flooding to maintain their ecological character. Areas where groundwater reserves are recharged by floodwaters are also considered to be ecological assets. Ecological assets are spatially explicit and are set in the floodplain landscape.

ecological values are surrogates for biodiversity that are used to prioritise the ecological assets. They include fauna and fauna habitat, vegetation communities and areas of conservation significance.

ecosystem is a biological system involving interactions between living organisms and their immediate physical, chemical and biological environment.

fish passage refers to connectivity that facilitates the movement of native fish species between upstream and downstream habitats (longitudinal connectivity) and adjacent riparian and floodplain areas (lateral connectivity). Areas that are important for fish passage include rivers, creeks and flood flow paths.

flood-dependent assets are assets that have been identified in the floodplain management plan as having important ecological or cultural features and which rely on inundation by floodwaters to sustain essential processes.

flooding regime refers to the frequency, duration, nature and extent of flooding.

floodways are areas where a significant discharge of floodwater occurs during small and large design floods.

groundwater recharge areas are areas where water from a flood event leaks through the soil profile into the underlying aquifers.

heritage sites are cultural heritage objects and places listed on Commonwealth, state and local government heritage registers.

infrastructure protection works are flood works that are for the protection of houses, stock yards and other major infrastructure, such as machinery sheds.

management zones are areas in the floodplain that have specific rules to define the purpose, nature and construction of flood works that can occur in those areas.

natural surface level is the average undisturbed surface level in the immediate vicinity.

recharge means the addition of water, usually by infiltration, to an aquifer.