# NSW Long Term Water Plans: Background Information

A description of the development of the 9 LTWPs in NSW

Part A: Introduction

**Department of Planning and Environment**

NSW GOVERNMENT

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# Overview of the background information document

NSW Long Term Water Plans (LTWPs) bring together information from a range of planning material, scientific literature and expert opinion. This varied and complex information has been interpreted and analysed to produce new information products and tools to support development of the plans. The purpose of this background information document is to:

- describe the information sources that informed the development of the LTWPs
- describe how this information was interpreted and analysed
- outline the rationale behind the analyses, methods, assumptions and decisions that have underpinned the LTWPs
- provide a reference for future revision of the LTWPs.

The background information document has been divided into 4 parts for ease of use:

## Part A: Introduction – this document

1. Background to the development of NSW Long Term Water Plans
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# 1. Background to the development of NSW Long Term Water Plans

## 1.1. Context

LTWPs are part of water reform in the Murray–Darling Basin (MDB) (MDBA 2012). The Murray–Darling Basin Plan (the Basin Plan) (Pt 4, Ch. 8) establishes a framework for managing environmental water at the Basin and catchment-scales. The framework is designed to ensure environmental water managers work collaboratively to prioritise water use to meet the long-term needs of native fish, water-dependent native vegetation and waterbirds, and coordinate water use across multiple catchments to achieve Basin-scale outcomes. LTWPs are a key component within this framework.

There are 9 water resource plan areas (WRPAs) in the NSW MDB, and an LTWP has been developed for each one. The purpose of the 9 NSW LTWPs is to describe the flow regimes required to maintain or improve environmental outcomes in each WRPA. They identify:

- priority environmental assets and functions in a WRPA
- ecological objectives and targets for those assets and functions
- environmental water requirements (EWRs) needed to meet those targets and achieve the objectives.

Together with the Basin-wide environmental watering strategy (BWS), LTWPs provide the strategy for the management of water within each of the 9 catchments of the NSW Murray–Darling Basin and describe the environmental outcomes that are expected as a result (MDBA 2014).

LTWPs are required by the Basin Plan to 'have regard to' the BWS and can therefore adopt alternative strategies and approaches where they can be demonstrated to provide improved outcomes. This enables LTWPs to adopt new and emerging information and management strategies, while still linking to the principles that underpin the BWS. The rationales behind instances in which the LTWPs have deviated from information sources, analyses, or approaches described in the BWS are explained in this background information document.

### 1.1.1 Long Term Water Plan alignment with the Basin Plan

Section 8 of the Basin Plan outlines the content (section 8.19) and preparation (section 8.20) requirements of LTWPs. NSW LTWPs have been developed to be consistent with each of the requirements outlined in these sections. Table A.1 presents each of the Basin Plan requirements of LTWPs, along with a brief description of how the requirements have been met.

**Table A.1 Basin Plan requirements of LTWPs, and the relevant sections where the requirement has been met**

| Basin Plan clause | Basin Plan requirements | How the requirements are met | LTWP chapter |
|---|---|---|---|
| **Identification of assets, functions, objectives, targets and environmental watering requirements** | | | |
| 8.19 (1–3) | A long-term watering plan must identify<br>a. priority environmental assets in the water resource plan area<br>b. ecological objectives and ecological targets for those assets<br>c. environmental watering requirements needed to meet those targets in order to achieve those objectives<br>using the method in section 8.49.<br>A long-term watering plan must identify<br>a. priority ecosystem functions in the water resource plan area<br>b. ecological objectives and ecological targets for those functions<br>c. environmental watering requirements needed to meet those targets in order to achieve those objectives<br>using the method in section 8.50.<br>If the Basin-wide environmental watering strategy (BWS) has identified particular assets or functions, and their requirements, a long-term watering plan must be consistent with that part of the BWS. | Priority water-dependent assets are spatially defined | Part A: Chapter 2<br>Part B: Chapter 2, Chapter 3 |
| | | Priority ecosystem functions in the WRPA are described | Part A: Chapter 3.4 |
| | | Ecological objectives and targets are described for the WRPA and for each planning unit (which includes the priority water-dependent assets for the WRPA) | Part A: Chapter 3, Part D: Appendix A |
| | | EWRs needed to meet ecological objectives and targets are described for the WRPA and for each planning unit (which includes the priority water-dependent assets for the WRPA) | Part A: Chapter 4.3<br>Part B: Chapter 2 |
| | | Hydrology is described for priority water-dependent assets that cannot be managed with regulated water delivery | Part B: Chapter 3 |
| **Identification of possible cooperative arrangements** | | | |
| 8.19 (4) | A long-term watering plan must identify possible co-operative arrangements between holders of held environmental water, managers of planned environmental water, and owners or managers of environmental assets for the delivery of environmental water:<br>a. within the water resource plan area<br>b. between that area and upstream and downstream water resource plan areas<br>c. that will ensure that environmental water meets the environmental watering requirements identified above. | Cooperative arrangements are identified in addition to complementary natural resource management and cooperative investment opportunities that will contribute to supporting the LTWP ecological objectives and targets<br>Key partners are identified | Part A: Chapter 7.1 |

| Basin Plan clause | Basin Plan requirements | How the requirements are met | LTWP chapter |
|---|---|---|---|
| **Identification of long-term risks** | | | |
| 8.19 (5) | A long-term watering plan must identify<br>a. long-term risks to providing for the environmental watering requirements of priority environmental assets and priority ecosystem functions<br>b. the strategies to manage those risks having regard to the strategies in Chapter 44. | Risks to meeting EWRs of priority environmental assets and functions, as well as risks that affect the capacity to achieve the ecological objectives are discussed. This includes the risks associated with climate change.<br>Potential management strategies for mitigating risks are discussed. | Part A: Chapter 5<br>Part B: Chapter 2, Chapter 3 |
| **Operational constraints** | | | |
| 8.19 (6) | A long-term watering plan must<br>a. identify any operational constraints in relation to environmental watering in the water resource plan area<br>b. include strategies to manage or overcome those constraints. | Constraints to meeting EWRs of priority environmental assets and functions, as well as constraints that affect the capacity to achieve the ecological objectives are discussed<br>Potential management strategies for mitigating constraints are discussed | Part A: Chapter 5<br>Part B: Chapter 2, Chapter 3 |
| **Supporting information** | | | |
| 8.19 (7) | A long-term watering plan must include references to the information that informed its preparation. | Statements are referenced and citations are included throughout the LTWPs | Part A: References<br>Part B: References |
| **Consultation** | | | |
| 8.20 (1) | A Basin State must prepare a long-term watering plan in consultation with<br>a. holders of held environmental water<br>b. managers of planned environmental water<br>c. river operators<br>d. local communities, including bodies established by a Basin State that express community views in relation to environmental watering<br>e. persons materially affected by the management of environmental water | Broad and frequent consultation with key stakeholders was a critical to the development of all LTWPs<br>Groups, agencies and people consulted include (but are not limited to) DPE–Water, EWAGs, NBAN and MLDRIN, WaterNSW, MDBA, CEWO, DPI Fisheries, NPWS, Land Councils, irrigation groups, landholders, catchment water managers, monitoring and evaluation staff, and subject matter experts (including university researchers and environmental consultancies) | Throughout the LTWPs and described in more detail in the LTWP background information document |

### 1.1.2 Building on the Basin-wide environmental watering strategy

The BWS sets out a strategy for bringing about positive environmental change throughout the Murray–Darling Basin. The BWS focuses on 4 important components of the Basin's water-dependent ecosystems. These are:

- river flows and connectivity
- native vegetation
- waterbirds
- native fish.

These 4 theme groups were selected because:

- they are good indicators of the health of a river system and are measurable
- they are important components of healthy functioning water-dependent ecosystems
- they are responsive to environmental flows
- they are highly valued by people
- they have declined appreciably as a result of water resource development
- they require a Basin-wide approach to be managed effectively.

NSW has adopted these ecosystem components as the focus of LTWPs for the same reasons, as well as to ensure alignment with the BWS. The 'Flows and Connectivity' theme in the BWS has been expanded in the LTWPs to 'Ecosystem Functions'. This means that flows and connectivity are treated with other important functions of healthy river systems, such as nutrients and productivity, dispersal opportunities for plants and animals, and the maintenance of suitable habitat. NSW has also considered other water-dependent species in the development of the LTWPs, including frogs and platypus, for example, since biodiversity is a key feature of resilient ecosystems (Oliver et al. 2015).

The LTWPs are plans for whole-of-ecosystem health. While the LTWPs focus on 5 ecosystem components, it is important to note that the benefits of managing water for outcomes in these groups will extend to whole ecosystems (including turtles, bats, macroinvertebrates, etc.).

## 1.2 Information and resources

NSW LTWPs have brought together information from a variety of sources:

- peer reviewed scientific literature – particularly relating to highly technical information
- technical reports
- existing planning material
- spatial data on species distributions
- inundation mapping and hydraulic modelling outputs from a range of government and non-government institutions
- hydrological data from IQQM and Source model outputs as well as observed flow data recorded at gauges
- satellite imagery
- expert advice from natural resource managers, catchment specific Environmental Water Advisory Groups, and community groups

- expert panels comprised of natural resource managers and the scientific community.

Information sources varied for each LTWP area depending on the information available and its relative confidence. In some instances, incomplete information and data collected for other purposes were not suited to the intended analyses in the LTWPs. Therefore, data collected from a variety of primary sources were occasionally used to develop secondary products such as databases and geographic information system (GIS) spatial layers. Where this occurred, explanations are provided in the following chapters and schedules.

Specific data and information sources used are referenced in individual LTWPs, at the end of each chapter of this background information document, and in the catchment specific schedules. Each chapter also acknowledges contributors who were involved in developing the described method or provided information or expert opinion, in addition to the authors.

# 2. Priority environmental assets

## 2.1 Background

As discussed in Chapter 1, Section 8 of the Basin Plan (MDBA 2012) outlines the content and preparation requirements of Long Term Water Plans (LTWPs). Of note with regards to these requirements, Clause 8.19 (1) of the Basin Plan (MDBA 2012) specifies that an LTWP must identify priority environmental assets. This chapter provides a summary of the process to develop water-dependent ecosystem datasets, from which environmental assets are spatially identified. This chapter also identifies the steps taken to identify water-dependent sites of cultural significance to Aboriginal communities.

## 2.2 Development of water-dependent ecosystem datasets

A key step in the identification of environmental assets is to develop water-dependent ecosystem datasets.

The definition of a water-dependent ecosystem, provided in the Commonwealth *Water Act 2007*, has guided DPE–EHG's development of the water-dependent ecosystem datasets:

> **Water-dependent ecosystem** means a surface water ecosystem or a ground water ecosystem, and its natural components and processes, that depends on periodic or sustained inundation, waterlogging or significant inputs of water for its ecological integrity and includes an ecosystem associated with:
>
> a. a wetland; or
> b. a stream and its floodplain; or
> c. a lake or a body of water (whether fresh or saline); or
> d. a salt marsh; or
> e. an estuary; or
> f. a karst system; or
> g. a ground water system;
>
> and a reference to a water-dependent ecosystem includes a reference to the biodiversity of the ecosystem.

With regards to the statement in the Water Act, 'a reference to a water-dependent ecosystem includes a reference to the biodiversity of the ecosystem', for the purposes of the NSW LTWPs, DPE–EHG has interpreted biodiversity to be water-dependent vegetation and fauna. Because it is difficult to map the extent of water-dependent fauna, the statement has been adapted to cover the extent of water-dependent vegetation only. For each WRPA, the water-dependent ecosystem datasets consist of a water-dependent feature dataset and a water-dependent vegetation dataset.

### 2.2.1 Water-dependent features

A spatial layer of surface water-dependent ecosystem features is one that identifies areas that depend on periodic or sustained inundation, waterlogging or significant inputs of water for their ecological integrity. Such features include wetlands, watercourses, floodplains, lakes and other waterbodies, salt marsh, estuaries, karst systems or groundwater systems.

Of the above list of water-dependent features, several were not represented within the study:

- estuarine features that do not occur within the NSW portion of the MDB
- groundwater and karst systems, as this study focused on surface water-dependent features. However, groundwater-dependent vegetation communities were considered in the water-dependent vegetation ecosystem dataset.

The water-dependent features datasets were developed using a combination of existing hydrological and land-use datasets to provide the broadest extent of water-dependent ecosystem features within a catchment (Appendix 2.1). The following datasets have been interrogated for relevant water-dependent ecosystem features:

- NSW Hydro Area Dataset
- NSW Landuse dataset
- NSW Directory of Important Wetlands
- Ramsar listed wetlands
- Australian National Aquatic Ecosystem wetlands
- DPE–Water River Styles® stream network.

The NSW Landuse dataset was interrogated and only records that contained keywords relating to water-dependent ecosystems were included. The keywords applied were:

> wetland; swamp; billabong; oxbow; waterhole; riverine; creek; stream; watercourse; lagoon; floodplain; marsh; riparian; cowal; lake; flood; river.

The inclusion of features from the NSW Landuse dataset allows for areas of the landscape with land uses such as 'agricultural – floodplain grazing' to be identified. Many such areas are not recognised with other wetland layers. They are however floodplain ecosystems, which depend on periodic inundation.

Finally, overlapping water-dependent features were merged to form a continuous boundary with the largest combined extent of the input datasets. Each individual polygon is retained and in some areas, there may be 4 or 5 polygons overlapping. This is beneficial as it assists in the naming of water-dependent features and retention of attribute data.

### 2.2.2 Water-dependent vegetation

A spatial layer was created of vegetation communities that depend on periodic or sustained inundation, waterlogging or significant inputs of water for their ecological integrity. This dataset was generated using a wide range of vegetation spatial data. It is recognised that the following limitations are applicable to vegetation datasets:

- each vegetation dataset is only accurate at a distinct point in time and accuracy is likely to decrease as the dataset age increases
- in some locations, more than one vegetation dataset may occur whilst in other locations vegetation mapping is at a spatial resolution too coarse to be useful in this study
- similar vegetation communities can exhibit different water requirements spatially across the MDB.

To generate accurate datasets, the above limitations have been addressed by undertaking quality assurance checks on input datasets, ensuring that high quality and/or more recent datasets supersede older and/or poorer quality datasets.

Vegetation datasets were obtained from DPE–EHG's Biodiversity, Conservation and Science Directorate (BCS), Vegetation Information System and other regionally-based data repositories (Appendix 2.2).

Each vegetation dataset recorded within a catchment was clipped to each WRPA. Each vegetation feature attribute table was analysed for the presence of keywords. Only records that contained keywords relating to flood-dependent vegetation communities were included. Due to variations in vegetation community structure across NSW, a consistent list of keywords was not applied across the state. Keywords were selected by WRPA, based on guidance provided by DPE–EHG BCS, to ensure only flood-dependent vegetation communities relevant to the WRPA were selected.

Keywords were selected based on DPE–EHG's definition of flood-dependent plant communities. To be classified as flood-dependent, a vegetation community must satisfy one or more of the following:

- requires inundation for regeneration
- grows best after inundation has receded
- grows exclusively along watercourses or swamp edges
- needs flows to maintain water levels high/constant (aquatic/semi-aquatic species)
- is found almost solely in damp, moist or wet soil areas, or in gilgais on the plains that get periodically inundated
- relies on flood events for the creation of suitable landscapes for the vegetation community to exist.

Vegetation communities were assigned a hydro-ecological functional group classification based on their level of flood-dependence and their community structures. The 5 categories are non-woody wetland, flood-dependent shrubland, flood-dependent woodland, flood-dependent forest, and floodplain. Each functional group classification has also been assigned an average recurrence interval for flood frequency required to maintain the ecological characteristics of the vegetation community.

### 2.2.3 Water-dependent fauna datasets

In addition to the identification of the extent of water-dependent ecosystems in each catchment, a water-dependent fauna dataset was developed that identified and categorised water-dependent fauna within the MDB. The dataset was in a point spatial format, with a point representing the presence of one or more of a particular species on a unique day. Fish records were not included for the threatened fish species Murray cod and golden perch as they are represented using outputs from a statistical presence model (MaxEnt), discussed further in this chapter. Site records were included in this process to capture all other common species.

Fauna datasets were obtained from a range of sources and as new sources of data are identified these were added to the water-dependent fauna dataset. The following datasets have been incorporated into the water-dependent fauna dataset:

- DPE–EHG BioNet records for NSW (complete list)
- Annual Waterbird Survey of Eastern Australia and other aerial waterbird survey records (sourced from the University of NSW, e.g. Kingsford et al. 2020)
- DPE–EHG BCS fauna records such as waterbirds, wetland fish, frog and turtle records
- DPE–Water fauna data collected as part of the High Ecological Value Aquatic Ecosystem (HEVAE) project
- Commonwealth Environmental Water Office Long Term Intervention Monitoring 2014–15 records.

Only records dated from 1 January 1977 onwards were included in the dataset, in order to reflect more recent wildlife observations. All exotic water-dependent fauna were removed from the dataset (Appendix 2.3).

A list of native fauna species that occur within the MDB was generated using species identified in the above datasets, then each species was assessed as either 'water-dependent' or 'not water-dependent' based on the following criteria.

A species is considered to be 'water-dependent' if it:

- accomplishes all or part of its lifecycle in, or on, water
- shows close or specific dependency on aquatic habitats, and/or
- requires flooding in strictly terrestrial habitats for active life.

A subset of species that conformed to one or more of these criteria was compiled and became the water-dependent species list used in subsequent analyses.

#### Article I. Weighting of fauna records

This study involves identifying water-dependent ecosystems that meet a range of criteria, 2 of these involving the analysis of threatened water-dependent and water-dependent fauna records (Criteria 4 and 5 of the Basin Plan Schedule 8 (MDBA 2012)). However, due to the large numbers and spatial extent of species (fauna) data across each catchment, filtering was applied to the fauna data to enable the outputs to focus on water-dependent ecosystems that provide habitat to species that are most reliant on those habitats. A weighting approach was adopted, which is broadly based on the weighting system applied by DPE–Water when developing the HEVAE framework (Healey et al. 2015).

The reasoning behind a weighting score was that a water-dependent ecosystem had greater likelihood of being identified when it supported certain water-dependent species as listed below:

- the water-dependent ecosystem supports water-dependent species that are highly water-dependent and thus rely heavily on that particular water-dependent ecosystem (Table A.2)
- the water-dependent ecosystem supports water-dependent sessile species (Table A.3)
- the water-dependent ecosystem supports water-dependent species listed as threatened under state or Commonwealth legislation (Table A.4).

Each fauna species was allocated a score for each of the 3 weightings: water-dependence (Table A.2), mobility (Table A.3) and conservation status (Table A.4). The 3 weighting scores were then multiplied together to calculate an overall species weighting.

For example, a species that is highly water-dependent (weighting = 3), highly mobile at the catchment scale (weighting = 1) and non-threatened (weighting = 1), such as the Pacific black duck (*Anas superciliosa*), has an overall species weighting of 3. A highly water-dependent (weighting = 3), moderately mobile at the reach scale (weighting = 2) and vulnerable listed (weighting = 2) species such as the Murray cod (*Maccullochella peelii*) has an overall species weighting of 12.

**Table A.2 Weightings applied to fauna records based on water-dependence**

| Species' water-dependence characteristics | Weighting score |
|---|---|
| Not water-dependent | 0 |
| Dependent on a water-dependent ecosystem | 1 |
| Requires access to a temporary waterbody, or temporary access to a permanent waterbody | 2 |
| Requires access to a permanent waterbody | 3 |

**Table A.3 Weightings applied to fauna records based on mobility**

| Species' mobility characteristics | Weighting score |
|---|---|
| Catchment scale | 1 |
| Reach/regional scale | 2 |
| Waterbody/site scale | 3 |

**Table A.4 Weightings applied to fauna records based on conservation status**

| Species' conservation status | Weighting score |
|---|---|
| Not threatened | 1 |
| Vulnerable | 2 |
| Endangered | 3 |
| Critically endangered | 5 |

### 2.2.4 Native fish MaxEnt datasets

DPI Fisheries has undertaken statistical modelling to generate spatial datasets of the predicted extent for a range of threatened fish species, including Murray cod (*Maccullochella peelii*) and golden perch (*Macquaria ambigua*), across the NSW portion of the MDB. The statistical modelling consisted of generalised additive modelling analysis,

to model relationships between the fish assemblage metrics/indicators/index and environmental and River Style® attributes of stream segments.

Modelling of the current geographic distribution of each listed threatened freshwater fish species or population was done using MaxEnt 3.3.3 (a widely used species distribution modelling program that utilises presence records to generate probabilities of occurrence based on a suite of environmental variables quantified across the area of interest) with greater than 33% probability of occurrence used to predict presence of threatened species for the Fish Community Status project (DPI 2015).

### 2.2.5 Water-dependent AHIMS sites of Aboriginal cultural significance

A dataset of water-dependent Aboriginal Heritage Information Management System (AHIMS) sites of Aboriginal cultural significance was developed, for utilisation in the identification of environment assets (Criterion 3 – vital habitat) and as a basis for consultation with key Aboriginal groups. These sites were developed in close collaboration with DPE–Water's Aboriginal Water Initiative (AWI) and Heritage NSW.

The following datasets were used to identify water-dependent sites of cultural significance:

- DPE–EHG's AHIMS
- NSW LTWP water-dependent ecosystem features dataset
- NSW LTWP water-dependent vegetation dataset
- NSW Government's Healthy Floodplains project Zone A (and Zone D if present)
- NSW Government's Healthy Floodplains cultural heritage sites.

The process for identifying water-dependent AHIMS sites of Aboriginal cultural significance was as follows:

1. Select AHIMS sites (point records), with a 50 m search buffer, that intersect any of the following water-dependent feature datasets:
    - fall within the boundary of a feature contained in the NSW LTWP water-dependent ecosystem features dataset
    - fall within the boundary of a feature contained in the NSW LTWP water-dependent vegetation dataset
    - fall within the boundary of any identified Healthy Floodplains cultural heritage sites
    - fall within the boundary of a Healthy Floodplains project Zone A or D.
2. Filter all AHIMS sites using targeted keywords:
    - Select AHIMS sites that have the following 'features' attributes: Aboriginal ceremony and dreaming, Aboriginal resource gathering, earth mound, fish trap, habitation structure, hearth, shell, modified tree, water hole.
    - Select AHIMS sites with the following keywords in the site name: fish, pond, creek, river, lagoon, spring, bridge, waterhole.
3. Combine AHIMS sites from steps 1 and 2 and remove duplicate AHIMS sites.
4. Undertake a review of potential water-dependant sites of Aboriginal cultural significance in conjunction with DPE–Water's AWI and Heritage NSW.
5. Use the selected sites as the basis for consultation with relevant Aboriginal groups (such as Land Councils, Murray Lower Darling Rivers Indigenous Nations (MLDRIN) and Northern Basin Aboriginal Nations (NBAN)).

## 2.3 Criteria for identifying environmental assets

To meet the requirements of the Basin Plan (MDBA 2012), each LTWP includes a stocktake of water-dependent environmental assets across the WRPA using GIS. Schedule 8 of the Basin Plan (MDBA 2012) provides guidance on what constitutes an environmental asset, and we have interpreted this guidance to form a spatial method that identifies water-dependent environmental assets. There are 5 criteria listed within the Basin Plan (MDBA 2012), which are listed below.

This section outlines the method to generate mapped extents for each criterion.

### 2.3.1 Basin Plan requirements

The method of identifying environmental assets is set out in Section 8.49 of the Basin Plan (MDBA 2012). There are 3 key steps involved, which are detailed below (1a–c):

**8.49 Method for identifying environmental assets and their environmental watering requirements**

(1) An environmental asset that requires environmental watering, and its environmental watering requirements, must be identified having regard to the information on the environmental assets and ecosystem functions database, using the following method:

(a) identify any environmental asset that meets one or more of the assessment indicators for any of the 5 criteria specified in the table in Schedule 8; and

(b) identify the environmental assets that can be actively managed with water (priority environmental assets); and

(c) for priority environmental assets, identify ecological objectives that are consistent with the criteria used to identify those assets; and

(d) identify ecological targets to achieve those objectives; and

(e) in accordance with section 8.51 determine the environmental watering requirements needed to meet the targets in order to achieve the objectives.

(2) This method may be applied in a flexible manner, having regard to the particular circumstances.

Step 1 consists of a whole-of-catchment assessment of environmental assets without regard to water delivery constraints. Following the identification of environmental assets within each WRPA, each identified asset is assessed for its ability to be actively managed with water. Assets that are assessed as being capable of being actively managed with water are referred to in the Basin Plan (MDBA 2012) as priority environmental assets (Step 2). Ecological objectives are derived for priority environmental assets, for the criteria that each asset satisfies (Step 3).

Schedule 8 of the Basin Plan (MDBA 2012) provides a list of the criteria used to identify an environmental asset. There are 5 criteria:

- **Criterion 1**: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements.

- **Criterion 2**: The water-dependent ecosystem is natural or near-natural, rare or unique.
- **Criterion 3**: The water-dependent ecosystem provides vital habitat.
- **Criterion 4**: Water-dependent ecosystems that support Commonwealth, state or territory listed threatened species or communities.
- **Criterion 5**: The water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity.

Note that each criterion refers directly to the assessment of water-dependent ecosystems. The method for determining whether a water-dependent ecosystem meets each criterion is detailed below.

## Article II. Criterion 1 – International agreements

### *Article III. Requirements and interpretation*

Criterion 1: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements.

Water-dependent ecosystem features were selected using the following guidance, set out in Schedule 8 of the Basin Plan (MDBA 2012):

*A water-dependent ecosystem is an environmental asset that requires environmental watering:*

*a. if it is a declared Ramsar wetland; or*

*b. with environmental watering, is capable of supporting a species listed in or under the JAMBA (J), CAMBA (C), ROKAMBA (K), or the Bonn Convention.*

DPE–EHG's interpretation of this criterion is as follows. For Part (a), all Ramsar sites within NSW are considered to be environmental assets. For Part (b), an environmental asset is a water-dependent ecosystem feature that supports a listed species, which in theory could be any water-dependent ecosystem in a catchment. However, this criterion has been constrained to only include water-dependent ecosystems where a listed species has been recorded within 1,000 m of the feature, to account for localised species movement patterns whilst still recognising that water-dependent ecosystem features selected are likely to have been utilised by the internationally listed species.

A review of listed species was undertaken, including reviewing the June 2015 amendment to the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. This resulted in the removal of the white bellied sea eagle (*Haliaeetus leucogaster*) from the listed species. In addition, several species were removed from DPE–EHG's analysis:

- Rainbow bee eater (*Merops ornatus*): This species is not considered to be highly water-dependent. Its affinity for nesting in river banks and frequency of observation, results in the identification of watercourses that are unlikely to support other highly water-dependent listed species.
- White-tailed tropicbird (*Phaethon lepturus lepturus*): This species ranges widely over oceans surrounding coastal breeding locations. Any records within the Basin are considered to be vagrants.
- White-throated needletail (*Hirundpaus caudacutus*): This is a widely dispersed and highly aerial species often found over inland plains and in a wide variety of locations not only associated with water-dependent features.

- Fork-tailed swift (*Apus pacificus*): This is a widely dispersed and highly aerial species often found over inland plains and in a wide variety of locations not only associated with water-dependent features.

In addition, known waterbird breeding sites in each WRPA are considered to be capable of supporting listed species and are included within this criterion.

*Article IV. Datasets and geospatial analysis method*

The following datasets were applied to identify Criterion 1 sites:

- WRPA specific water-dependent ecosystem features dataset
- WRPA specific water-dependent vegetation dataset
- water-dependent fauna dataset (for selected listings with an international status of J, C, K or BC), clipped to WRPA, with the above mentioned species removed
- DPE–EHG's known waterbird breeding sites dataset
- Australian Ramsar Wetlands dataset, clipped to WRPA.

For part (a), extract Ramsar polygon boundaries within the WRPA and attribute with a criterion number of 1a.

For part (b), undertake a spatial location search between internationally listed fauna records and water-dependent ecosystem features with a search radius of 1,000 m. Select all known waterbird breeding sites in the WRPA. Attribute selected records with a criterion number of 1b.

## Article V. Criterion 2 – Natural or near-natural, rare or unique

*Article VI. Requirements and interpretation*

Criterion 2: The water-dependent ecosystem is natural or near-natural, rare or unique.

Water-dependent ecosystem features were selected using the following guidance, set out in Schedule 8 of the Basin Plan (MDBA 2012):

*A water-dependent ecosystem is an environmental asset that requires environmental watering if it:*

a. *represents a natural or near-natural example of a particular type of water-dependent ecosystem as evidenced by a relative lack of post-1788 human induced hydrologic disturbance or adverse impacts on ecological character; or*
b. *represents the only example of a particular type of water-dependent ecosystem in the Murray–Darling Basin; or*
c. *represents a rare example of a particular type of water-dependent ecosystem in the Murray–Darling Basin.*

DPE–EHG's interpretation of this criterion is as follows. For part (a), there is a series of 3 filters involved in identifying natural or near-natural sections of watercourse in a catchment:

**Filter 1:**

Sections of watercourse downstream of reservoirs or significant instream dams are no longer considered to have a natural or near-natural hydrological regime until they confluence with an identical or higher order watercourse with a natural or near-natural hydrological regime. What constitutes a significant instream dam is subjective but has been taken to be an impoundment that would significantly impact on 80$^{th}$ percentile low river flows within the watercourse. An MDBA spatial layer of weirs (MDBA 2013) was reviewed against aerial imagery to identify significant instream dams.

**Filter 2:**

For watercourses identified as natural or near-natural, these watercourses were filtered using River Styles® recovery potential. Naturalness of a watercourse is based on the mapped recovery potential outcomes of river reaches that are closest to unimpaired or easily recoverable to natural conditions (Healey et al. 2015). Conservation recovery potential of a watercourse is indicative of stable geomorphic conditions when generally no recovery is occurring or required (Cook and Schneider 2006). Therefore, watercourses with a River Styles® geomorphic recovery potential of 'rapid recovery' or 'conservation' were considered to be the most appropriate filter for natural or near-natural sections of watercourse.

**Filter 3:**

Watercourses identified from Steps 1 and 2 were then passed through a final hydrological stress filter. Hydrological stress is the ratio of water extraction compared to a flow index, this being low river flow (Healey et al. 2015). Watercourses with a low hydrological stress were selected as the final natural or near-natural watercourses.

In addition, water-dependent ecosystems contained within the NPWS estate boundaries were included within this criterion. National parks are largely unmodified natural systems and may contain areas of significant value to water-dependent fauna (Kennard 2010) and are recognised for both their recovery potential and high level of conservation status.

For parts (b) and (c), these criteria consider the 'uniqueness' and 'rarity' of a water-dependent ecosystem at the Basin scale. Expert opinion and local knowledge are very important in identifying significant Basin water-dependent ecosystems within each WRPA. With regards to water-dependent vegetation ecosystems, endangered ecological communities (EECs) within a catchment should all be reviewed for Basin significance. Critically endangered ecological communities (CEECs) should always be included.

A review of heritage datasets (Register of the National Estate, National Heritage List) is recommended for any inclusion of listed water-dependent ecosystems. Any found (such as the Macquarie Marshes) should be included under Criteria 2b or 2c.

*Article VII. Datasets and geospatial analysis method*

The following datasets were applied to identify Criterion 2 sites:

- WRPA specific water-dependent ecosystems features dataset
- WRPA specific water-dependent vegetation dataset
- DPE–Water's River Styles® stream network, containing watercourses in the WRPA with a natural or near-natural hydrological regime
- NPWS estate within the WRPA
- DPE–EHG's EEC dataset, which includes CEEC
- Heritage NSW datasets.

For part (a), identify River Styles® stream network watercourses with a natural or near-natural hydrological regime then select features from the River Styles® stream network (recovery potential = 'Rapid Recovery' OR 'Conservation') and (hydrological stress = 'Good'). Buffer selected watercourses by 30 m to create streamlines, to replicate the HEVAE method. Select water-dependent vegetation within 400 m of these watercourses. Merge the buffer watercourses and selected water-dependent

vegetation datasets. Select water-dependent ecosystems within the NPWS estate and attribute all features with a criterion number of 2a.

For parts (b) and (c), attribute CEEC polygons within the catchment with a criterion number of 2b or 2c depending on rarity. Other water-dependent ecosystems to be included following expert advice and review of heritage listings.

## Article VIII. Criterion 3 – Vital habitat

### *Article IX. Requirements and interpretation*

Criterion 3: The water-dependent ecosystem provides vital habitat.

Water-dependent ecosystem features were selected using the following guidance, set out in Schedule 8 of the Basin Plan (MDBA 2012):

*A water-dependent ecosystem is an environmental asset that requires environmental watering if it:*

a. *provides vital habitat, including:*
    i. *a refugium for native water-dependent biota during dry spells and drought; or*
    ii. *pathways for the dispersal, migration and movements of native water-dependent biota; or*
    iii. *important feeding, breeding and nursery sites for native water-dependent biota; or*
b. *is essential for maintaining, and preventing declines of, native water-dependent biota.*

DPE–EHG's interpretation of this criterion is as follows.

For part (ai), a refugium is a water-dependent ecosystem where water will persist during dry spells and drought. It is also a water-dependent feature where its nomenclature suggests that water persists in that feature. It is also a water-dependent feature in close proximity to recorded Aboriginal campsites or fishing areas. This is based on the assumption that First Nations people were more likely to establish camps in the vicinity of 'permanent' water sources.

For part (aii), a pathway is a water-dependent ecosystem that provides barrier free opportunities for movement, including river reaches, wetlands and water-dependent areas of vegetation. All watercourses contained within the River Styles® dataset were considered to form pathways within a WRPA for the dispersal of water-dependent biota. In addition, water-dependent ecosystems that fall within Zones A and D as prescribed by the NSW Government's Healthy Floodplains project are areas that are key for floodplain connectivity.

For part (aiii), iconic native water-dependent fauna species based on their cultural, recreational and social values have been selected for each WRPA. This selection process was undertaken in conjunction with DPE–Water's AWI, regionally-based DPE–EHG staff and during environmental watering workshops held for each WRPA.

Important feeding, breeding and nursery sites for native water-dependent fauna also meet this criterion if, should they be removed or isolated, this would impact on the 4 highly recognisable native water-dependent species or known waterbird breeding sites.

### *Article X. Datasets and geospatial analysis method*

The following datasets were applied to identify Criterion 3 sites:

- WRPA specific water-dependent ecosystems features dataset
- WRPA specific water-dependent vegetation dataset

- Joint Remote Sensing Research Program Water Count and Prevalence – Landsat, JRSRP algorithm NSW coverage
- DPE–EHG water-dependent cultural heritage sites
- DPE–Water's River Styles® stream network containing watercourses in the WRPA
- NSW Government's Healthy Floodplains project Zone A (and Zone D if available)
- WRPA specific water-dependent fauna dataset, species list limited to iconic species
- DPI Fisheries GetisOrd dataset of fish biodiversity
- DPE–EHG's known waterbird breeding sites dataset
- NPWS estate within the WRPA.

For part (ai), using the Water Count and Prevalence dataset, reclassify to separate high bands (strong affinity to water) from the remaining bands. Convert the reclassified raster to polygons and calculate area of each separate polygon. In addition, undertake a search of water-dependent features for keywords associated with long-term water features ('billabong', 'lagoon' and 'waterhole'). If sites of water-dependent cultural significance have been identified, select water-dependent ecosystem features that fall within the boundary of that cultural site, and attribute with a criterion number of 3ai.

For part (aii), buffer the River Styles® dataset by 30 m and attribute with a criterion number of 3aii. Select areas of water-dependent vegetation and water-dependent features that fall within Healthy Floodplains project Zone A (and Zone D if available).

For part (aiii) extract iconic species records relevant to the WRPA from the water-dependent fauna dataset. Undertake a kernel density analysis on these records, using a search distance of 5,000 m to identify species occurrence hotspots. Digitise hotspots based on kernel density outputs and clip water-dependent ecosystem datasets to these zones. Take special note of hotspots on same watercourse, where there may be longitudinal linkages between the 2 observation areas. Attribute with a criterion number of 3aiii.

For part (b), select water-dependent ecosystem features within the NPWS estate and attribute with a criterion number of 3b.

## Article XI. Criterion 4 – Listed threatened species

### *Article XII. Requirements and interpretation*

Criterion 4: Water-dependent ecosystems that support Commonwealth, state or territory listed threatened species or communities.

Water-dependent ecosystem features were selected using the following guidance, set out in Schedule 8 of the Basin Plan (MDBA 2012):

*A water-dependent ecosystem is an environmental asset that requires environmental watering if it:*

*a. supports a listed threatened ecological community or listed threatened species; or*

*b. supports water-dependent ecosystems treated as threatened or endangered (however described) under State or Territory law; or*

*c. supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.*

DPE–EHG's interpretation of this criterion is as follows.

For part (a), areas of the landscape utilised by threatened species should be highlighted and water-dependent ecosystems within these areas identified. The significance of

these assets is such that if they were to be removed or isolated, these actions would impact on any of the threatened species known to occur in a catchment. Linkages between areas of significance are considered. Species records are unweighted during this analysis. A key limitation of this dataset (applicable to both points (a) and (c)) is that the use of point records only allows for the identification of areas where monitoring has been undertaken; however, predictive modelling is not available for all species and lacks the spatial accuracy necessary for this analysis. This limitation is partially addressed through the identification of linkages between high value areas by undertaking and analysing kernel density analysis of records.

For part (b), with regards to water-dependent vegetation ecosystems, water-dependent EECs and CEECs within a catchment should all be selected for inclusion. Where the EEC covers a significant portion of a catchment and risks diluting the significance of this criterion, its inclusion should be reviewed for Basin significance. CEECs should always be included.

For part (c), areas of the landscape utilised by water-dependent threatened species should be highlighted and water-dependent ecosystems within these areas identified. The significance of these assets is such that if they were to be removed or isolated, these actions would impact on any of the threatened species known to occur in a catchment. Linkages between areas of significance should be considered. Species records are weighted in accordance with Tables A.2, A.3 and A.4 above.

#### *Article XIII. Datasets and geospatial analysis method*

The following datasets were applied to identify Criterion 4 sites:

- WRPA specific water-dependent ecosystems features dataset
- WRPA specific water-dependent vegetation features dataset
- water-dependent fauna dataset (for selected listings with state or Commonwealth threatened or endangered (however described)), clipped to the WRPA
- all fauna dataset (for selected listings with state or Commonwealth threatened or endangered (however described)), clipped to the WRPA
- DPE–EHG's EEC dataset, which includes CEECs.

For part (a), extract all threatened records from the catchment fauna dataset. Undertake a kernel density analysis on these records (unweighted), using search distances of 5,000 m and 10,000 m to identify species occurrence hotspots at 2 different scales. Digitise hotspots based on kernel density outputs, taking into account linkages across the landscape between hotspot locations (if applicable). Clip water-dependent ecosystems to these zones and attribute with a criterion number of 4a.

For part (b), attribute EEC and CEEC polygons within the catchment with a criterion number of 4b.

For part (c), extract all threatened records from the water-dependent fauna dataset. Undertake a kernel density analysis on these records (weighted), using search distances of 5,000 m and 10,000 m to identify species occurrence hotspots at 2 different scales. Digitise hotspots based on kernel density outputs, taking into account linkages across the landscape between hotspot areas (if applicable). Clip water-dependent ecosystems to these zones and attribute with a criterion number of 4c.

### Article XIV. Criterion 5 – Biodiversity

#### *Article XV. Requirements and interpretation*

Criterion 5: Water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity.

Water-dependent ecosystem features were selected using the following guidance, set out in Schedule 8 of the Basin Plan (MDBA 2012):

*A water-dependent ecosystem is an environmental asset that requires environmental watering if it supports, or with environmental watering is capable of supporting, significant biological diversity. This includes a water-dependent ecosystem that:*

*a. supports, or with environmental watering is capable of supporting, significant numbers of individuals of native water-dependent species; or*

*b. supports, or with environmental watering is capable of supporting, significant levels of native biodiversity at the genus or family taxonomic level, or at the ecological community level.*

DPE–EHG's interpretation of this criterion is as follows.

For part (a), areas of the landscape utilised by water-dependent species includes known locations of recruitment and biodiversity. Waterbird breeding rookeries therefore meet this criterion. In addition, a fish biodiversity layer provided by DPI Fisheries ranks fish monitoring locations by observed species richness and occurrence. Sites with a GetisOrd ranking of 1.96 or higher are in the top 5% of sites in the state and are considered to be examples of significant fish biodiversity (pers. comm DPI Fisheries).

For part (b), areas within the catchment that support high levels of biodiversity should be highlighted and water-dependent ecosystems within these areas identified. For the purposes of this study DPE–EHG has limited biodiversity to water-dependent fauna. Linkages between areas of significance should be considered. Species records are weighted to influence the distribution of sites towards those that support more highly water-dependent and listed species. A key limitation of this dataset is that the use of point records only allows for the identification of areas where monitoring has been undertaken; however, predictive modelling is not available for all species and lacks the spatial accuracy necessary for this analysis. This limitation is partially addressed through the identification of linkages between high value areas.

### *Article XVI. Datasets and geospatial analysis method*

The following datasets were applied to identify Criterion 5 sites:

- WRPA specific water-dependent ecosystem features dataset
- WRPA specific water-dependent vegetation dataset
- water-dependent fauna dataset, clipped to the WRPA
- DPI Fisheries GetisOrd dataset of fish biodiversity
- DPE–EHG's known waterbird breeding sites dataset.

For part (a), select stream networks identified as containing high value reaches for fish (GetisOrd >1.96). Review potential connectivity between adjacent stream networks and where appropriate select longer lengths of watercourse to connect high value reaches. Select all known waterbird breeding sites in the WRPA. Attribute selected records with a criterion number of 5a.

For part (b), use all records from the water-dependent fauna dataset. Undertake a kernel density analysis on these records (weighted), using search distances of 5,000 m and 10,000 m to identify species occurrence hotspots at 2 different scales. Digitise hotspots based on kernel density outputs, taking into account linkages across the landscape between hotspot areas (if applicable). Clip water-dependent ecosystems to these zones and attribute with a criterion number of 5b.

# Shortened forms

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| AHIMS | Aboriginal Heritage Information Management System |
| AWI | Aboriginal Water Initiative |
| BWS | Basin-wide environmental watering strategy |
| CAMBA | China–Australia Migratory Bird Agreement |
| CEEC | critically endangered ecological community |
| DPE–EHG | NSW Department of Planning and Environment – Environment and Heritage Group |
| DPE–Water | NSW Department of Planning and Environment – Water |
| DPI Fisheries | NSW Department of Primary Industries Fisheries |
| EEC | endangered ecological community |
| EWR | environmental water requirement |
| HEVAE | High Ecological Value Aquatic Ecosystem |
| JAMBA | Japan–Australia Migratory Bird Agreement |
| LTWP | NSW Long Term Water Plan |
| MDB | Murray–Darling Basin |
| MLDRIN | Murray Lower Darling Rivers Indigenous Nations |
| NBAN | Northern Basin Aboriginal Nations |
| NPWS | NSW National Parks and Wildlife Service |
| NSW | New South Wales |
| RoKAMBA | Republic of Korea–Australia Migratory Bird Agreement |
| WRPA | water resource plan area |

# Glossary

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| Basin-wide environmental watering strategy | A strategy that articulates the environmental outcomes that should be possible through water reform. It was developed by the MDBA and underpins the Basin Plan. |
| Cultural water-dependent asset | A place that has social, spiritual and cultural value based on its cultural significance to Aboriginal people. Related to the water resource. |
| Cultural water-dependent value | An object, plant, animal, spiritual connection or use that is dependent on water and has value based on its cultural significance to Aboriginal people. |
| Ecological objective | Objective for the protection and/or restoration of an ecological asset or function. |
| Ecological target | Level of measured performance that must be met to achieve the defined objective. The targets in this LTWP are SMART (Specific/Measurable/Achievable/Realistic/Time-bound). |
| Ecosystem | A biological community of interacting organisms and their physical environment. It includes all the living things in that community, interacting with their non-living environment (weather, earth, sun, soil, climate and atmosphere) and with each other. |
| Ecosystem functions | The processes and interactions occurring within and between ecosystems that sustain plant and animal communities and contribute to the state, integrity and regulation of an ecosystem. |
| Environmental assets | The physical places that make up an ecosystem. |
| Environmental water | Water for the environment. It serves a multitude of benefits not only to the environment, but to communities, industry and society. It includes water directly managed by the NSW and Australian governments (held environmental water) or protected from extraction from waterways (planned environmental water) for meeting the requirements of water-dependent ecosystems. |
| Environmental water requirement | The flow event/s required to support the completion of key known elements of a lifecycle of an organism or group of organisms (taxonomic or spatial), consistent with the objective/target, measured at the most appropriate gauge. EWRs can be met by various flows in a system including natural inflows, held environmental water, planned environmental water, essential supplies, conveyance water and consumptive orders. |
| Estuarine | Relating to a system of deep-water and wetland tidal habitats characterised by fluctuating salinity, where rivers meet the ocean. |
| Groundwater | Water located below the earth's surface in soil pore spaces and in the fractures of rock formations. Groundwater is recharged from, and eventually flows to the surface naturally. |
| Hydro-ecological functional group | A set of species, or collection of organisms, that respond to flow conditions in a similar way. |

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| Long Term Water Plan (NSW) | A requirement of the Basin Plan that gives effect to the Basin-wide environmental watering strategy for each river system and will guide the management of water over the longer term. DPE is responsible for the development of 9 plans for river catchments across NSW, with objectives for 5, 10 and 20-year timeframes. |
| Murray–Darling Basin Plan (Basin Plan) | The Basin Plan as developed by the Murray–Darling Basin Authority under the *Water Act 2007*. |
| Priority ecosystem function | An ecological function defined by the Basin Plan (Schedule 9) that can be affected by held environmental water. |
| Priority environmental asset | A place meeting the criteria set by the Basin Plan (Schedule 8) that is water-dependent and can be affected by held environmental water. |
| Ramsar Convention | An international treaty to maintain the ecological character of key wetlands. |
| Refugium | An area in which a population of plants or animals can survive through a period of decreased water availability. The plural is refugia. |
| Registered cultural asset | A cultural water-dependent asset that is registered in the Aboriginal Heritage Information Management System (AHIMS). |
| Surface water | Water that exists above the ground in rivers, streams, creeks, lakes and reservoirs. Although separate from groundwater, they are interrelated and over extraction of either will impact on the other. |
| Water resource plan areas | Catchment-based divisions of the Murray–Darling Basin defined by a water resource plan. |
| Water resource plans | A policy package prepared by state authorities and accredited by the Australian Government under the Basin Plan. It describes how water will be managed and shared between users in an area to meet Basin Plan outcomes. |
| Water-dependent feature | A spatial layer that identifies areas which depend on periodic or sustained inundation, waterlogging or significant inputs of water for their ecological integrity. Such features include wetlands, watercourses, floodplains, lakes and other waterbodies, salt marsh, estuaries, karst systems or groundwater systems. |
| Water-dependent | An ecosystem or species that depends on periodic or sustained inundation, waterlogging or significant inputs of water for natural functioning and survival. |

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