Scoping Study into the Establishment of a Long Term Ecological Monitoring Network in the Murray-Darling Basin

November 2007

Gawne, B. & Price A

MURRAY-DARLING BASIN COMMISSION

The Murray-Darling Freshwater Research Centre

Scoping Study into the Establishment of a Long Term Ecological Monitoring Network in the Murray-Darling Basin
A report prepared for the Murray-Darling Basin Commission by the Murray-Darling Freshwater Research Centre

July 2007
Gawne, B.

For further information contact:
Ben Gawne
Murray-Darling Freshwater Research Centre
PO Box 991
Wodonga, VIC, 3689
Ph (02) 6058 2300
Fax (02) 6059 7531

Cover Photo: Aerial view of a portion of the Macquarrie Marshes. Photo Credit: Ben Gawne.

The Murray-Darling Freshwater Research Centre is a joint venture between the Murray Darling Basin Commission CSIRO Land and Water and La Trobe University, that aims to answer locally relevant research questions to help guide water managers, and ultimately improve the health of our rivers, lakes and wetlands.

Scoping Study into the Establishment of a Long Term Ecological Monitoring Network in the Murray-Darling Basin

A report prepared for the Murray-Darling Basin Commission by
the Murray-Darling Freshwater Research Centre

November 2007

Executive summary

Wetlands dominate the riverine landscape in the Murray-Darling Basin and are internationally recognised as some of our most significant environmental assets. Wetlands play an important role in maintaining the health and integrity of river systems and are crucial in providing ecosystem services. Wetlands provide critical habitats for plants, invertebrates, fish, birds, and mammals, including rare and threatened species and thus, are important in maintaining regional and national biodiversity. Wetlands also perform important ecological functions such as nutrient cycling, production of living plants and animals and decomposition of organic matter. In addition, wetlands have significant cultural and recreational values. In regions with variable climates, such as Murray-Darling Basin, wetlands are also important in flood mitigation and provide drought refuges. Many wetlands in the Murray-Darling Basin are of national and international importance.

The wetland ecosystems of the Murray-Darling Basin are changing rapidly and are subject to a wide range of processes that could significantly alter their character and ability to provide critical ecosystem services. These changes include water resource development, land use changes and the introduction of animals and plants that may directly and through complex interactions affect the character of wetlands and therefore the ecosystem services that they provide.

One of the MDBC objectives is the protection and enhancement of the Basin's shared environmental assets and water resources. If the MDBC is to achieve this objective, sustainable management of wetlands will be an essential component of their management strategy. The MDBC is also responsible for the equitable and efficient management of water resources These responsibility means that MDBC operations will have significant effects on the condition of floodplains and wetlands within the MDB. Sustainable management requires implementation of a monitoring program as the data is necessary to report on the status of environmental assets, determine whether management intervention is required, identify the required management actions, determine whether the intervention has been successful and identify ways in which the intervention could be improved. The development of a monitoring program requires several steps:

System Inventory
Identification and Prioritisation of Assets
System Understanding
Determine Objectives and Targets
Assessment and Monitoring

Currently, wetland monitoring is required at several jurisdictional levels, including federal and state governments, the MDBC and Catchment Management Organisations. However, despite significant investment in monitoring river health, there has been very little investment in the development of wetland monitoring programs. At best, ad-hoc arrangements exist for monitoring wetlands, and in many cases they are ignored because of the lack of suitable monitoring techniques. Thus wetland monitoring is often incomplete and inconsistent at both regional and state levels. This has resulted in a paucity of information regarding wetland condition and an inability to sustainability manage wetlands across much of Australia.

The National Land and Water Resources Audit, National Water Commission, Department if Environment and Water, the NRM Ministerial Council, the Wetlands and Waterbirds Taskforce and all state governments have accepted the need for the development of wetland monitoring programs and the need for a consistent approach. In light of this, the National Land and Water Resources Audit (NLWRA), in conjunction with state agencies undertook the National Wetland Indicators Review which developed a framework for monitoring wetland extent, distribution and condition. The National Wetland Indicators Review undertook an extensive review of the different programs, indicators, and frameworks currently being used to monitor wetlands in Australia and overseas, and held jurisdictional workshops and national workshops to develop and reach national agreement on a set of indicators and guidelines for extent, distribution and condition of lacustrine and palustrine wetlands. This review was used to develop nationally consistent and coherent wetland indicators relating to wetland extent, distribution and

condition, protocols, and methodologies to inform national natural resource management processes at a variety of scales ranging from individual wetland, regional and state-wide scale (e.g. the Australian Wetland Inventory, State of the Environment reporting, Ramsar Convention implementation, and NRM national, state and regional monitoring and evaluation). The report also reviewed government programs to clarify the relationship between the proposed wetland monitoring program and other water initiatives such as the National Water Commission's Framework for the Assessment of River and Wetland Health (FARWH).

It should be noted that the NLWRA framework is an extent and condition assessment and is not appropriate for evaluation of the effectiveness of specific management interventions (intervention assessment). The MDBC will be involved in decisions about the management of flows in the northern MDB and as a consequence should consider the development of an intervention assessment program to compliment any condition assessment undertaken in the northern MDB.

The NLWRA framework has the support of federal, state and regional jurisdictions and the proposed framework has been agreed to by the Wetlands and Waterbirds Taskforce and has been presented to the Aquatic Ecosystems Taskforce for consideration. The proposed indicators are currently being trialled and sampling protocols and methodologies are being developed for a number of indicators.

Given the widespread support for the NLWRA framework, there can be no value in duplicating this framework. Thus, it would appear sensible for the MDBC to support its implementation. The major issue for the MDBC is what role it should play in implementation of the NLWRA and where can the MDBC add value to the data that might be generated in order to further improve its capacity to meet its objectives.

This report provides a summary of the NLWRA framework and of the current approaches being taken to System Inventory, Identification and Prioritisation of Assets, Intervention Monitoring, System Understanding and Condition Assessment. The report outlines the management need in all of these areas and provides the MDBC with options for collaboration with the various institutions involved in implementing the NLWRA framework

In order for the MDBC to maximise the value of wetland monitoring data it will be important that the data is gathered in a consistent manner throughout the MDB and that the data is consistent with other monitoring programs being undertaken by the MDBC. The best way for the MDBC to achieve consistency will be to provide leadership in the development of wetland monitoring programs in the northern MDB.

The report identifies 4 areas in which the MDBC can provide leadership in the development of wetland condition monitoring in the northern MDB.

- Development of conceptual models for Northern Basin wetlands:
- Indicator development and sampling methodologies:
- Determination of the potential for the use of remote sensing in gathering wetland extent, distribution and condition information.
- Development and production of wetland information sheets that will be an invaluable resource for NRM managers at all tiers of government

Given the range of options available to the Commission and the current state of development of the National Program it has not been possible for this report to go into detail about the institutional arrangements that would be appropriate or the quantum of investment required from the MDBC. It is clear that a collaborative approach will yield the best outcome but the level of investment will depend on the options chosen and the level of investment being made in that area by the state and federal governments.

.

Contents

List of Figures

List of Tables

Introduction

Wetlands dominate the riverine landscape in the Murray-Darling Basin and are internationally recognised as some of our most significant environmental assets. In NSW alone wetlands represent 6.5% of the land area with floodplain wetlands covering 4 million hectares or 6% of the land area. In addition there are over 2,000 freshwater lakes covering an area of nearly 300,000 hectares (Kingsford et al., 2004). Wetlands are significant assets, not only because of the land they occupy but also for their productivity and diversity and the role they play in maintaining the health and integrity of river systems and, as a consequence, human communities. They are particularly important in the Murray-Darling Basin due to the dry and variable climate. During wet periods they mitigate flooding and are important breeding and feeding sites for an array of flora and fauna. During dry periods they become refuges for flora and fauna. A number of the Murray-Darling Basin's wetlands are recognised under the Convention on Wetlands of International Importance (Ramsar) i.e. Macquarie Marshes, Gwydir wetlands, Narran Lakes and Currawinya Lakes and 66 wetlands in the northern Murray-Darling Basin are currently recognised as being nationally important in the Directory of Important Wetlands in Australia (DIWA, Environment Australia, 2001). As a consequence there is widespread acceptance of the importance of wetlands as significant environmental assets and providers of important ecosystem services.

One of the MDBC objectives is the protection and enhancement of the Basin's shared environmental assets and water resources. This objective is linked to the idea of sustainable development, which requires that we find the balance between consumptive and environmental water use. The Murray-Darling Basin Ministerial Council has long recognised the importance of wetlands and released its Floodplain Wetland Management Strategy in November 1998 and is putting considerable funding into improving the health of key wetlands (e.g. Narran Lakes, Barmah Forest).

The wetland ecosystems of the Murray-Darling Basin are changing rapidly and are subject to a wide range of processes that could significantly alter their character and ability to provide critical ecosystem services. These changes include water resource development that has led to a reduction in the volume of water flowing through the system and the frequency and duration of flood events (Webb McKeown & Associates, 2007). Both connect wetlands to their river channel and provide the water required to sustain their flora and fauna. There have also been changes to land use and the introduction of animals and plants that may directly and through complex interactions affect the character of wetlands and therefore the ecosystem services that they provide.

As noted above wetlands of the northern MDB can be considered significant environmental assets due to both the critical role they play in supporting biodiversity within the landscape and the range of ecosystem services they provide. As an example of the role of wetlands in supporting biodiversity, wetlands in the northern MDB support 79 species of bird, 60 of whom utilise the wetlands as breeding habitat. Fourteen of these species are international migrants demonstrating that these wetlands have a role in maintaining global biodiversity. There are 241 species of reptile and amphibian recorded within the Darling R. Basin, many of whom rely on wetlands to provide critical habitat (e.g. Turtles and Frogs) or as a source of abundant food. Some of these species can be considered assets in their own right as they have been identified as threatened or endangered. For instance Latham's Snipe is an endangered wader that is protected by the EPBC Act (1999), JAMBA and CAMBA. In these instances, the species may be considered the asset and the wetlands require protection as they provide habitat.

Wetlands also provide critical ecosystem services. In 2005 the Millennium Ecosystem Assessment summarised the ecosystem services provided by healthy ecosystems into 4 categories (Supporting, Provisioning, Regulating & Cultural) that underpin 4 categories of societal benefit (Security, Basic Materials, Health and Social relations). Wetlands are critical landscape components in the provision of Supporting ecosystem services that are required if ecosystems are to provide Provisioning, Regulating or Cultural Services. Supporting ecosystem services include nutrient cycling, primary production and decomposition. Healthy wetlands are hot spots in the landscape for the transformation of nutrients and organic matter. The productivity of wetlands is known to provide a subsidy for less productive areas of

the landscape through the export of material during periods of flooding and through processes such as herbivory and predation of wetland organisms.

The productivity of wetlands underpins Provisioning services such as food (fish, birds, plants) wood and fibre. While direct utilisation of food from wetlands is now uncommon, historically wetlands within the MDB have supported profitable fisheries that have declined due to unsustainable management practices. Lake-bed cropping for food and fibre production is still widespread and these industries rely on the fertility of the soil that was established by the natural wetland processes of flooding, drying, nutrient cycling and decomposition.

Wetlands also undertake a number of regulating functions. Wetlands regulate the quality of water. The cliché of wetlands being the "kidney's" of the river arises due to the deposition of sediment and organic matter in wetlands during periods of high flow. Wetlands also play a critical role in mitigating flood effects. By providing water storage capacity within the landscape, wetlands modify the flood hydrograph, releasing water back into the river channel once flows subside.

Finally, wetlands provide a number of cultural services as inherently beautiful places that provide spiritual, recreational and educational opportunities for communities. The value of wetlands to local communities becomes apparent when these areas are no longer available, for instance because of drought or blue-green algal blooms when property values are seen to decline and tourism industries suffer.

Management need

From the introduction above it is clear that wetlands and some of the organisms that they support are significant environmental assets in river-floodplain ecosystems of the northern MDB whose health is linked to the quality of water resources. As a consequence if the MDBC is to achieve its objective of protecting and enhancing the Basin's shared environmental assets and water resources, sustainable management of wetlands will be an essential component of their management strategy. The need for sustainable management is recognised by the MDBC and the constituent Federal and State Governments, and is reflected in the charter of Catchment Management Organisations (CMOs).

Sustainable management requires implementation of a monitoring program as the data is necessary to report on the status of environmental assets, determine whether management intervention is required, identify the required management actions, determine whether the intervention has been successful and identify ways in which the intervention could be improved. The development of a monitoring program requires several steps;

System Inventory
Identification and Prioritisation of Assets
System Understanding
Determine Objectives and Targets
Assessment and Monitoring

In addition, where management interventions are planned or underway (for example under the Living Murray, and the water sharing / water resource planning processes), intervention monitoring is also required to determine the effect of management actions on wetland ecosystems.

Wetland monitoring is required at several jurisdictional levels, including federal and state governments, the MDBC and CMOs. Some of these requirements are listed below:

- The Federal Government has a requirement for wetland monitoring in order to fulfil its roles in developing appropriate policy and prioritising management activities and to fulfil its national and international reporting requirements including:
    - reporting under the EPBC Act
    - reporting on national NRM targets
    - State of the Environment reports
    - commitments to international treaties such as Ramsar, CAMBA, JAMBA.

- The MDBC requires wetland monitoring if it is to report against its objective of protection and enhancement of environmental assets. This includes reporting on the performance of strategic initiatives such as the Northern Basin Initiative and The Living Murray.
- The NSW and Queensland Governments require wetland monitoring to develop appropriate policy and prioritise management activities and for:
    - State of the Environment reporting
    - Evaluation of the performance of Water Sharing Plans and Water Resource Plans
    - reporting on State NRM targets
- Catchment Management Organisations require wetland monitoring to prioritise regional management activities and to report on catchment NRM targets.

The Federal Government has recognised the need for a national approach to wetland monitoring and has collaborated with the states to develop a consistent approach to wetland monitoring. This commitment has led to the development of national indicators for wetland ecosystem extent, distribution and condition by the National Land and Water Resources Audit.

Report Objective

The NLWRA, NWC, DEW, NRM Ministerial Council, Wetlands, Waterbirds Taskforce and all state governments have accepted the need for the development of wetland monitoring programs and the need for a consistent approach. In light of this, the National Land and Water Resources Audit (NLWRA), in conjunction with state agencies undertook the National Wetland Indicators Review which developed a framework for monitoring wetland extent, distribution and condition. This framework has the support of all the afore-mentioned institutions and, therefore, there can be no value in duplicating this framework. Given the widespread recognition of the need for wetland monitoring and acceptance of the NLWRA framework it would appear sensible for the MDBC to support its implementation. The major issue for the MDBC is what role it should play in implementation of the NLWRA and where can the MDBC add value to the data that might be generated in order to further improve its capacity to meet its objectives.

This report provides a summary of the NLWRA wetland monitoring framework and identifies;

- Issues for the MDBC in the development of its Northern Basin Initiative.
- Roles that the MDBC could fill in implementing the framework and
- Ways in which the data generated could be used to help the MDBC achieve its objectives.

NLWRA Report

The National Wetland Indicators Review is a collaborative project between the National Land & Water Resources Audit (NLWRA), the Department of the Environment and Water Resources (DEW), and the Wetlands & Waterbirds Taskforce (WWTF) and led by the Queensland Department of Natural Resources and Water (NRW). The project aims were to develop nationally consistent and coherent wetland indicators relating to wetland extent, distribution and condition, protocols, and methodologies to inform national natural resource management (NRM) processes at a variety of scales ranging from individual wetland, regional and state-wide scale (e.g. the Australian Wetland Inventory, State of the Environment reporting, Ramsar Convention implementation, and NRM national, state and regional monitoring and evaluation).

The project undertook an extensive review of the different programs, indicators, and frameworks currently being used to monitor wetlands in Australia and overseas, and held jurisdictional workshops and national workshops to develop and reach national agreement on a set of indicators and guidelines for extent, distribution and condition of lacustrine and palustrine wetlands. This review was used to develop a framework for determining the extent, distribution and condition of wetlands throughout Australia (NLWRA, 2007). The report also reviewed government programs to clarify the relationship between the proposed wetland monitoring program and other water initiatives such as the National Water

Commission. The proposed framework has been presented to the Wetlands and Waterbirds Taskforce for consideration, and indicators are currently being trialled.

To avoid duplication, confusion and separation of state/national level reporting and NRM regional reporting, the National Wetland Indicators Framework is proposing to draw upon the National Water Commission's Framework for the Assessment of River and Wetland Health (FARWH) methods for the condition framework. This framework is receiving tacit support from government agencies, and it is intended that this framework will form the basis of national river and wetland health assessments. FARWH is consistent with other frameworks currently in use both nationally and in the states and has been developed to provide methods for comparing and integrating existing river and wetland health outputs to facilitate national reporting from comparable state, territory, and regional NRM assessments e.g. the MDBC's Sustainable Rivers Audit, Victoria's Index of Stream Condition (ISC), Southeast Queensland's EHMP program, and Tasmania's Conservation of Freshwater Values Program. FARWH is based on a hierarchical model of river and wetland function and can be applied to a range of scales, including surface water management areas to deliver a national overview. It is intended that the framework will incorporate a range of river and wetland attributes indicative of key ecological processes that will be aggregated to provide an index. FARWH recommends selecting indicators under six themes:

1. catchment disturbance,
2. physical form,
3. hydrological disturbance,
4. water quality and soils,
5. fringing zone, and
6. aquatic biota,

The selection of specific indicators is left to the discretion of the investigator. A referential approach will be used to assess each indicator and the resulting indices will be aggregated to generate scores that can be reported and compared at the state and/or national level.

The NLWRA framework is consistent with the FARWH in regards to the following principles:

- 'The premise that ecological integrity is a fundamental measure of wetland health, although other components of the environment are just as important, and should be included in an assessment of ecosystem health.
- The use of indicators for measuring key river and wetland ecological processes.
- Selecting indicators under six themes that are the major drivers of ecosystem health.
- The use of a reference based approach to assess each indicator against a pre-existing condition.
- The use of indices that can be aggregated to generate scores which can be reported and compared at the regional, state and/or national level.' (NLWRA, 2007)

Using the FARWH, the National Wetland Indicators Project has provided indicators, protocols and methodologies for undertaking an assessment of wetland condition, extent and distribution, at a range of scales, including at scales appropriate to regional processes and reporting. At a regional scale, CMOs have a requirement for wetland inventory, prioritisation and monitoring programs to evaluate their catchment targets. However, currently they have not been provided with an appropriate framework or the resources required to implement independent, scientifically based ecological wetland mapping, prioritisation and monitoring. The NLWRA framework aims to provide an integrated framework that can be used by federal and state agencies and by CMOs to implement wetland monitoring programs that will suit their individual objectives.

The following sections review the approaches being taken to System Inventory, Identification and Prioritisation of Assets, Intervention Monitoring, System Understanding and Condition Assessment. In most cases this involves the Federal Government (through NLWRA), NSW and Queensland programs, and in some cases CMOs.

System Inventory

Comprehensive information regarding the distribution, extent and type of wetlands is a fundamental requirement for wetland management, providing a basis for management and planning activities. In addition, wetland mapping provides baseline data for monitoring of changes in wetland distribution and extent, which is required at several jurisdictional levels. Currently at a national level, under the National NRM Monitoring and Evaluation Framework, the extent and distribution of wetlands and the extent and distribution of 'significant wetlands' are the recommended indicators under the indicator heading 'wetland extent and distribution'. These national indicators have been reviewed by the NLWRA project and the outcomes from the NLWRA report are discussed below.

Monitoring of wetland extent and distribution is also required by state jurisdictions. The NSW Natural Resources Commission has set state-wide targets for natural resource management and these are now part of the NSW government's state plan. These targets include a specific priority target that by 2015, the extent of important wetlands is maintained. At a regional level, state-wide targets are required to be incorporated into all NSW Catchment Action Plans. All CMAs within the NSW Northern Murray-Darling Basin have identified the need for mapping and prioritisation of wetlands within their catchments in their Catchment Action Plans and/or investment plans. Whilst there are no state-wide or regional targets that explicitly deal with wetland distribution and extent in Queensland, the first objective under the 'Strategy for the Conservation and Management of Queensland Wetlands', is to 'avoid the loss and degradation of natural wetlands unless overriding public interest can be shown'. Similarly, in both NSW and Queensland, there is no explicit requirement for monitoring of extent or distribution as part of the water sharing plans (NSW) and water resource plans (Queensland). However, the requirement for information regarding wetland extent and distribution is implicit in the river flow objectives that underpin the NSW plans and the ecological outcomes of individual water resource plans. For example, a number of the NSW river flow objectives and ecological outcomes in various water resource plans deal with the protection or maintenance of water levels or inundation patterns in wetland and floodplain ecosystems (Appendix 1).

Whilst all jurisdictions have completed some wetland mapping, coverage is incomplete and methodologies are inconsistent. The status of wetland inventory and mapping across NSW and Queensland summarised below (most information has been taken from the review undertaken as part of the NLWRA project).

Queensland

The Queensland Mapping, Classification and Database Project, which is a component of the Queensland Wetlands Programme, has produced a wetland mapping tool that combines existing mapping layers including topography, vegetation mapping and satellite imagery. Wetlands are classified hierarchically by landscape elements (by drainage division then by basin/catchment) and then by wetland elements (as marine, estuarine, riverine, lacustrine and palustrine with water regime, local hydrology/disturbance and salinity as the modifiers). All Queensland wetlands will be mapped to a 1:100,000 (minimum of 5 ha) scale (mapping is already completed for all Murray-Darling catchments) to provide a base map showing the extent and classification of wetlands in 2001. A method for updating mapping will also be written which will allow for consistent updating in the future and which will provide a tool for monitoring changes in wetland vegetation and wetted area. All data will be entered into The Wetlands Inventory Database, also being developed as part of the Queensland Wetlands Programme.

This method has been widely adopted within Queensland and has been used by the Department of natural Resources and Water for their Environmental Flows Assessment Program (EFAP) and by some regional NRM groups.

New South Wales

Across NSW, inland wetlands that are greater than 1 ha in size have been mapped at 1:250K using satellite imagery and aerial surveys (Kingsford et al., 2003). However, currently there is no mapping of upland wetlands.

Regionally, mapping has been done on a needs basis and is user defined:

- Macquarie Marshes - mapped using landsat MSS and TM data every year since 1979 (1:100000) (DEC).
- Gwydir wetlands - mapped using landsat MSS and TM data since 1987 (1:100000) (DEC).
- Narran Lakes – The Narran lakes have recently been mapped as part of the Narran Ecosystem Project.
- Western CMA: Wetland mapping and prioritisation project nearing completion (undertaken by Peter Bacon, environmental consultant for Woodlots and Wetlands). More detail on prioritisation methods is provided in the following section.
- Namoi CMA: Under the Riverine Ecosystem Program, a wetland inventory and mapping project (including prioritisation of wetlands) is currently being undertaken in the Namoi CMA. This has been developed and is being undertaken by Hale et al. (2006 – from Water's Edge Consulting). Only 10% of wetlands have been surveyed and there are plans to expand on this in the future, using the methods developed by Hale et al. (2006). More detail on prioritisation methods is provided in the following section.
- Central West CMA: The wetland GIS mapping compilation project (being undertaken by WetlandCare Australia) will compile existing data to create a wetland classification GIS data layer (at a scale of 1:250,000) for the Central West Catchment. Wetlands will be classed using the Directory of Important Wetlands classification system. The aims of the project are:
    - To undertake a desktop audit of all wetland mapping projects in the Central West CMA.
    - To map and classify internationally, nationally, and regionally significant wetland areas.
    - To make specific recommendations on matters related to the project.
- Northern Rivers CMA - Mapping of wetlands in the Northern Rivers Catchment has been undertaken by WetlandCare Australia, using a compilation of layers obtained from state and local government and environmental organisations. However, this did not include upland wetlands.

NLWRA approach

The NLWRA framework proposes national indicators for wetland extent and condition and then describes indicators and procedures for undertaking a wetland inventory through mapping and classification of wetlands. Two indicators are recommended:

1. Extent and distribution of wetlands
2. Extent and distribution of significant wetlands

Significant wetlands are considered to be those wetlands that have been identified under the Ramsar, convention are listed in the Directory of Important Wetlands of Australia or, are otherwise identified under other policy or legal instruments (e.g. identified as an ecological asset under an NRM plan). These indicators are aligned to the need for national mapping and inventory, and reporting for both domestic and international reporting.

The proposed indicators require that all wetlands be assigned a wetland type for reporting purposes and to this end, a wetland description tool, to be used for wetland classification was developed. The recommended classification of wetlands is based on the Directory of Important Wetlands (Environment Australia, 2001) and Cowardin et al., (1979) and has been developed to enable the various classification systems used throughout Australia to translate to the DIWA wetland types in order to facilitate national reporting.

Wetlands are initially classified according as either Riverine (wetlands along rivers and streams), Lacustrine (wetlands associated with lakes) and Palustrine (marshes, swamps and bogs). Wetlands are subsequently classified according to their geographic location, climate variables, water sources, dominant vegetation, or other distinguishing characteristics. Classification is undertaken in a hierarchical manner and it has been agreed that at the national level all jurisdictions will follow the 2 large scale classifications specifically the continental and ecosystem classifications. Two finer scale classifications based on

landscape and local characters that include geomorphology/topography, dominant vegetation structure, water regime and water type, will be optional.

In terms of a nationally consistent approach to wetland mapping, the NLWRA project achieved agreement that the Queensland protocol (see above) would be adopted as the standard.

Management need

The state and federal jurisdictions have made considerable progress in undertaking an inventory of wetlands. There are, however, some issues that the MDBC should consider. The first is that the definition of wetlands focuses on those areas in the landscape where water tends to accumulate. This definition excludes shedding floodplains. The Living Murray process has tended to include shedding floodplains in its definition of wetlands and the MDBC may wish to consider whether it wishes to either include floodplains in its definition or consider development of a separate monitoring program for floodplains as they meet all the same criteria as wetlands as far as being environmental assets.

The NLWRA framework includes quantification of wetland extent in its inventory. The report is not clear, however, on how extent will be determined. The MDBC should ensure that the procedure is robust across the entire MDB given the variable nature wetlands across the MDB.

Identification and Prioritisation of Assets

National

Currently, RAMSAR and the Directory of Important Wetlands in Australia (DIWA) are the primary mechanisms for the identification of wetland assets in Australia. Whilst some jurisdictions have developed additional tools for identifying aquatic assets (see below for Queensland and NSW), there is little consistency across jurisdictions and there is no nationally consistent approach to the identification, categorisation and management of aquatic assets. As a consequence, the Federal government is currently developing a national framework for the identification and classification of high conservation value aquatic ecosystems (HCVAE). As a first step, Sinclair Knight Merz recently undertook a review of existing policy, planning and legislative frameworks used to identify, classify and manage HCVAE across Australia. The results from this review are now being used by the Aquatic Ecosystems Taskforce to develop a draft national framework for the identification and classification of HCVAE. Some draft criteria have been developed and these will be trialled in a pilot project to be undertaken in the northern Murray-Darling Basin. These are:

1. International recognition - Any site will meet criterion 1 if it is listed under:
    - Ramsar Convention
    - World Heritage Convention (where aquatic ecosystems attributes are explicit in statement against criteria)
    - East-Asian-Australasian Shorebird Network
2. Representativeness - a site that is assessed as an outstanding representative example of a particular wetland type when compared with similar wetlands at a national scale will meet Criterion 2. A site may be recognized as a representative HCVAE aquatic ecosystem at national scale if it is:
    - of a spatial and temporal scale that illustrates the full characteristics of its class, for example a river intact from headwater to ocean or major convergence, or a wetland that responds periodically to cycles of water availability and is either,
        - in natural or near-natural condition with the processes that sustain it intact or
        - the only remaining example of such a system on a continental scale
3. Diversity - To meet the threshold for national significance, a site must demonstrate diversity in any of the following ways:
    - For diversity of aquatic ecosystem types or classes: incorporate at least 3 or more aquatic ecosystem types or classes that are hydrologically connected and interdependent

- for diversity of communities: include all or most of the communities typical of that ecosystem class
- for species diversity:
    - have a species diversity (specify index) that exceeds the expected diversity or is more than 2 standard deviations from mean or
    - have a high diversity of taxa at higher taxonomic levels (genus, family)

4. Distinctiveness - For HCVAE at national level, the site must meet at least one of the following attributes:
    - The rare and threatened species and communities must meet national thresholds for listing under EPBC, either by their listing under the EPBC Act or by rigorous application of the EPBC guidelines.
    - Rare, unusual and/or threatened aquatic ecosystem classes and geomorphological features will be assessed by expert opinion using available data sets. In future, these attributes will be assessed systematically through a bioregional and classification analysis. Classes and features must be rare on a continental scale.
    - Threatened aquatic ecosystem classes or habitats will be isolated by analysis of key threatening processes with impacts across a national scale, the rate of progress of change and scale of impact, together with an assessment of pre 1790 distribution of these classes or features. Threatened ecosystem classes or habitats must:
        - have been lost to a significant degree nation-wide or
        - be an uncommon type that is specifically under threat, resulting in decline in occurrence or condition, nation-wide
5. Critical Habitat - at national level an HCVAE will be one or more of the following:
    - species or numbers of species, or a location that typically sustains wetland species under conditions of stress, as shown by the large numbers of individuals that are attracted to that site under conditions such as drought or,
    - the location for intensive breeding activity, notably for birds or fish. It may attract species that do not inhabit the area in mature stages but use the area solely for breeding or,
    - a place that is the most utilised by migratory birds at a regional scale, or
    - considered significant for life cycle of some species if it maintains a natural regime of drying and wetting that is critical for the existence of those species and/or communities.
    - supports at least 10% of a dependent species assemblage or community.

A site that meets at least one of these criteria may be considered as a HCVAE. Two supplementary criteria are also included:

6. Evolutionary history - Sites which have met at least one core criterion at national level will meet supplementary criterion 6 if they meet at least one of the following:
    - Habitat for an unusually high diversity of endemic taxa with limited geographical distribution
    - Habitat for a diversity of taxa endemic at higher taxonomic levels (genus or above)
    - Habitat for a group of endemic species suggesting a centre of speciation
    - Habitat for a sequence of related taxa indicative of evolutionary processes
    - Habitat for iconic species recognized as ‘living fossils’, relictual species that appear as key links in evolution
7. Naturalness - All sites that meet any of Criteria 1 – 5 will be assessed and described for degree of naturalness and nature of disturbance using appropriate methodologies.

The supplementary criteria are not sufficient alone to justify recognition as a HCVAE. However, these values will be recorded as additional information for HCVAE sites and may be used for possible prioritisation of sites (which is not included as part of this framework).

Queensland

There are a number of mechanisms for identifying and categorising aquatic assets in Queensland. These include the declaration of fish habitat areas, wetland mapping and categorisation (see section on System Inventory), the identification of of-concern and endangered regional ecosystems and the identification of assets through the AquaBAMM (Aquatic Biodiversity Assessment and Mapping Method) process. The method was developed by the Queensland EPA and Parks and Wildlife service and is based on their Biodiversity Assessment and Mapping Method for terrestrial ecosystems. AquaBAMM is a decision support tool that uses existing data and expert input to assess conservation value in aquatic ecosystems on the basis of 8 criteria (Table 1)

Table 1. AquaBAMM criteria and indicators

Criteria	**Indicators**
1. Naturalness – Aquatic	
	1.1 Exotic flora/fauna
	1.2 Aquatic communities/assemblages
	1.3 Channel features modification
	1.4 Hydrological modification
	1.5 Water quality
2. Naturalness – Catchment	
	2.1 Exotic flora/fauna
	2.2 Riparian disturbance
	2.3. Catchment disturbance
	2.4 Flow modification
3. Diversity and Richness	
	3.1 Species
	3.2 Communities/assemblages
	3.3 Habitat
	3.4 Geomorphology
4. Threatened Species and Ecosystems	
	4.1 Species
	4.2 Communities/assemblages
5. Priority Species and Ecosystems	
	5.1 Species
	5.2 Ecosystems
6. Special Features	
	6.1 Geomorphic features
	6. 2 Ecological processes
	6.3 Habitat
	6.4 Hydrological
7. Connectivity	
	7.1 Significant species or populations
	7.2 Groundwater dependent ecosystems
	7.3 Floodplain and wetland ecosystems
	7.4 Terrestrial ecosystems
	7.5 Estuarine and marine ecosystems
8. Representativeness	(None developed for the Burnett catchment)

Indicators and associated measures have been identified for each criterion (appendix 3). Each criterion is rated as very low, low, medium, high or very high and these are combined to give an overall assessment of conservation value. AquaBAMM has been piloted for riverine wetlands in the Burnett River Catchment with positive results and the method will be further developed for non-riverine wetlands and application in other catchments. AquaBAMM is also being used by the Department of Natural Resources and Water in the identification and selection of flow-dependent ecological assets for the Water Resource Planning Environmental Flows Assessment Program (C. Ellway, pers. comm.).

New South Wales

With the exception of Ramsar and DIWA, there are no agreed principles for identifying, categorising or

prioritising aquatic assets in NSW. As outlined in the previous section, a number of Catchment Management Authorities are undertaking wetland mapping and prioritisation projects, however, methodologies differ among catchments. These projects include:

- Western CMA: Wetland mapping and prioritisation project nearing completion (undertaken by Peter Bacon, environmental consultant for Woodlots and Wetlands), which developed a framework for mapping and prioritising wetlands on private properties. Criteria for wetland assessment includes:
    - Flood frequency
    - Flood duration
    - Wetland area
    - Connectivity
    - Habitat
    - Wildlife abundance
    - Archaeological and natural heritage

  Each category is given a score and threats to the wetland values are then assessed and scored. Potential to successfully address the threats are also addressed. The results are then aggregated to give an overall wetland ranking, which will be used to determine priorities for funding and management activities.
- Namoi CMA: Under the Riverine Ecosystem Program, a wetland inventory and mapping project (including prioritisation of wetlands) is currently being undertaken in the Namoi CMA. This has been developed and is being undertaken by Hale et al. (2006 – from Water's Edge Consulting). This will provide the basis for future investment into activities related to wetlands. Only 10% of wetlands have been surveyed and there are plans to expand on this in the future, using the methods developed by Hale et al. (2006).Wetlands are being prioritised on the basis of:
    - Size
    - Area
    - Landuse
    - Hydrology
    - Geomorphology
    - Vegetation

NLWRA approach

Identification or prioritisation of assets is not dealt with under this framework.

Management need

The Federal and Queensland approaches appear to differ significantly in intent and scale. The Queensland approach provides a mechanism for prioritisation of wetlands which may be used at multiple scales (e.g. prioritisation at local, regional, state or higher scales) and is strongly focussed on individual wetland characteristics. The Federal approach appears to be aimed at identification rather than prioritisation of assets and is more broadly focussed on continental/national significance of particular features of aquatic ecosystems. It does not appear that the Federal approach will be readily applicable at smaller spatial scales (e.g. regional scales). There will need to be reconciliation of the Queensland and Federal approaches to asset identification and prioritisation. Currently the MDBC's support for a pilot evaluation of the federal criteria is consistent with the MDBC's need to have a consistent approach across the entire MDB. Ultimately, the MDBC will need to find a way of either: finding common ground between the Federal and Queensland approaches; integrating the data from the two programs; or support a parallel process.

Intervention Monitoring

In the Northern Murray-Darling Basin, there are two significant monitoring programs, the Environmental Flows Assessment Program (EFAP) and the Integrated Monitoring of Environmental Flows (IMEF)

program, that seek to determine the efficacy of management interventions. These programs are described below.

Queensland

The Queensland EFAP is being undertaken by the Department of Natural Resources and Water to assess the ecological performance of each water resource plan in meeting its stated ecological outcomes (see Table 3 for examples of ecological outcomes that relate to wetlands). This program includes ecological monitoring and assessment. Part of this assessment will include research and monitoring to determine '1) the hydraulic habitat requirements of selected ecological assets (representative of ecological outcomes); 2) if current flow management strategies and environmental flow rules are providing these critical water requirements; and 3) the risks faced by selected ecological assets and evaluate if ecological outcomes are likely to be met under current flow management strategies'. The process for assessing the water resource plans is shown below (Figure 1).

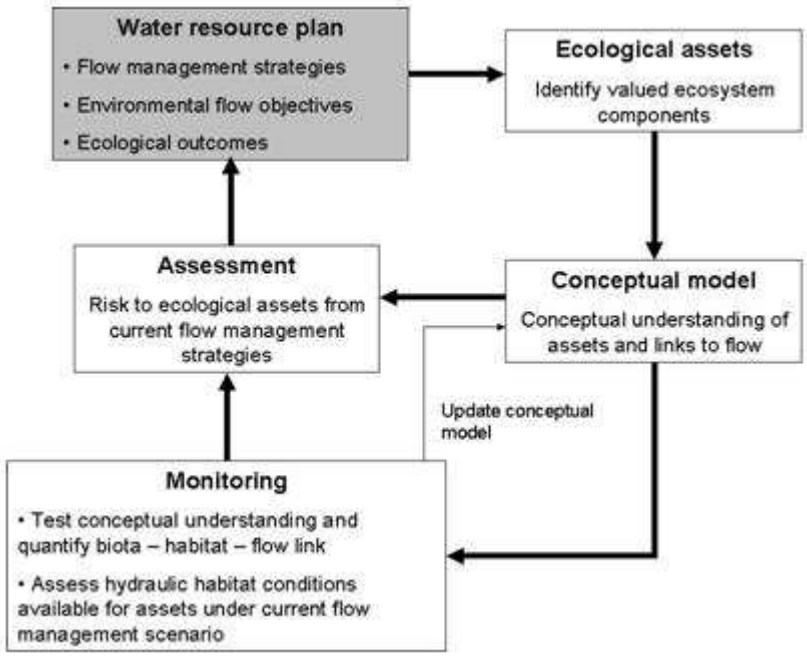

Figure 1. Flow chart showing the assessment and monitoring process for Queensland's water resource plans.

In the Northern Murray-Darling Basin identification and selection of flow-dependent ecological assets has been undertaken for all catchments in the Queensland Murray-Darling Basin. The risk posed to the selected flow-dependent ecological assets under the current water management compared to pre-development using flow statistics from the hydrological IQQM model is currently being assessed. At this early stage, it is unclear whether wetlands have been identified as critical assets and if so, whether these will be the focus of monitoring activities.

New South Wales

The NSW IMEF program is being undertaken to assess the environmental effects of the water-sharing flow rules for all NSW. This program may provide useful insights into the relationship between hydrology and ecosystem responses. The IMEF program is hypothesis-based and is being undertaken for all regulated rivers and the Barwon-Darling. The monitoring program aims to:

- 'measure changes in the hydrology, habitats, animals, plants and ecological processes in the major regulated river systems and the Barwon-Darling, following the application of environmental flow rules;
- test the relationships over time between environmental flow and ecosystem responses; and
- provide scientific information which is needed to review river flow objectives and rules.' (DLWC)

IMEF monitoring is being conducted at a number of riverine and wetland sites across NSW. A total of 46 wetlands, including 22 in the Northern Basin, are being monitored. Wetland-specific hypotheses have been developed and are being tested in floodplains and wetlands. These are:

- That natural wetting of flood plains, temporary steams and billabongs could restore breeding, feeding and growth of plants and animals.
- By wetting low-lying riverine wetlands more frequently, the exchange of plants, animals and food material between these wetlands and the river is also likely to occur more often.

Wetted area, macroinvertebrates, vegetation, birds, fish and frogs are being used as indicators to test these hypotheses.

NLWRA approach

Intervention monitoring is not dealt with under this framework.

Management need

There is a clear need for a consistent approach to intervention assessment in the northern MDB. NSW has taken a hypothesis based approach to intervention assessment with wetland selection secondary to the issue of testing the hypothesis. Queensland has taken an asset based approach but the process is still in early stages. The MDBC will need to determine whether the outcomes from these 2 processes are consistent with their requirements or asset identification process.

The MDBC will also need to develop a consistent approach to the monitoring of wetlands to assess the effectiveness of interventions. The approach taken in TLM has been to develop hypotheses that describe the link between interventions and objectives. Once these hypotheses have been developed, standard protocols need to be developed in order to enable synthesis of information from a variety of similar interventions throughout the area of interest. The NSW IMEF process may provide a basis on which to build.

Ideally it would be desirable if the data gathered during intervention assessment could be integrated with condition assessment in order to reduce costs and provide a better assessment of both the condition of wetlands and the impact of interventions. This has not been a consideration of existing intervention assessment programs in the northern MDB.

Condition Assessment: Introduction

NLWRA approach

The NLWRA report proposes that there should not be a single set of condition indicators mandated for all wetlands, rather, that managers should utilise their system understanding to develop conceptual models of wetlands and utilise these models to select appropriate indicators. A number of conceptual models have been developed for Queensland wetlands under the Queensland Wetlands Programme Wetland Indicators Scoping Study (Conrick 2007) which formed part of the Queensland Wetlands Programme, however work is still required on the development of conceptual models for wetlands that occur within the northern Murray-Darling Basin (M. Ronan, pers. comm.).

Management need

If the implementation of a monitoring program for wetlands in the northern MDB is to be successful it will depend on our system understanding and the conceptual models derived from it. As a consequence it will be important to synthesise the knowledge that has been generated by the jurisdictions and multiple research institutions involved in generating the knowledge. Conceptual models will also need to be

developed for northern Murray-Darling Basin wetlands and it would appear sensible that these be consistent with existing / developing conceptual models.

Our system understanding is developing, but far from adequate if managers are to predict the outcomes of particular policies of interventions or understand the potential trade-offs associated with their decisions. As a consequence managers will need to continue to invest in the generation of new knowledge concerning the function of aquatic ecosystems in the northern basin. It is, however, just as important that the value of all knowledge generated is maximised and available to managers to inform their management.

System Understanding to Underpin Condition Assessment

The body of knowledge that we have about how an ecosystem functions and supports its diverse species and communities through time constitutes our system understanding. This body of knowledge underpins each step in the development of an inventory and subsequent adaptive management. Our understanding of the factors that influence wetland character will underpin our decisions about the identification and classification of wetlands. Our system understanding will also be critical to the development of condition assessments and monitoring programs, the design of interventions and the review of the effectiveness of management strategies.

Our system understanding can be enhanced by research and effective monitoring programs. There are, therefore, a number of institutions undertaking activities that have the capacity to enhance our system understanding. Our knowledge of the Darling River has been comprehensively summarised in "The Darling" (2004) published by the MDBC. While the 'Darling' book represents a significant body of work there are still considerable knowledge gaps that a number of institutions are currently working to fill.

The following is a brief overview of some of the other institutions and the types of research being undertaking in the Northern Murray-Darling Basin. The summary is based on a workshop held by the MDBC in Brisbane in June 2007. The summary is structured around the conceptualisation that components of system understanding relate to one of four essential system components, specifically; habitat, connectivity, metabolic function or biota.

Habitat

Considerable investment has been made in determining the habitat requirements of key groups, including fish, birds and vegetation. Griffith University, University of New England, University of Canberra, Charles Sturt University, Murray-Darling Freshwater Research Centre and the NSW and Queensland Governments have all been involved in projects that have examined the influence of flow and channel morphology in determining the fish community composition and abundance. Among the large projects undertaken have been the CRC for freshwater Ecology Dryland Refugia project, the South Australian and Queensland Government Arid Zone Rivers Project and the University of Canberra Narran Lakes Project. One of the main foci of the research has been improving our understanding of the role of residual pools as refuges for fish. While the knowledge generated has improved our understanding it is also revealed significant variation in the habitat requirements of species such as golden perch between the northern and southern regions of the MDB. This variation will increase the uncertainty associated with applying knowledge generated in the southern MDB to northern systems. One project that may shed some light on the extent of variation is the MDBC funded fish spawning and recruitment project.

The dynamics of bird communities has been championed by Richard Kingsford (now at UNSW) and Mike Maher (NSW DECC). A summary of this work can be found in chapter 10 of 'The Darling'. Their work continues to refine our understanding of the habitat requirements of birds and the factors that influence habitat utilisation.

The University of Canberra, University of New England, Griffith University and the NSW Government have all invested in improving our understanding of the habitat requirements of vegetation. The major

bodies of work include the Narran project and work undertaken by Margaret Brock when she was based at UNE. These projects have shown that, broadly, habitat for many species is determined by flow and grazing regime. However, the detailed habitat requirements of most species remain poorly known.

Connectivity

The Riverine Landscapes Research Laboratory (University of Canberra) has undertaken research on the exchange of organic matter, nutrients and sediment between floodplain, wetland and main channel habitats. This research has revealed the magnitude and potential significance of the exchange of material during floods. It has also been proposed, but to date not examined, that there are significant exchanges of material between wetlands and floodplains and the surrounding landscape. The research is not yet at a point that predictions about the amount of material exchanged or consequences of altering the exchange could be made.

As part of the Dryland Refugia project Griffith University, the University of Canberra and the NSW and Qld Governments have undertaken a limited amount of work on dispersal of fish that has revealed the importance of floodplain connection and river network architecture. This work has also revealed the potential impacts of barriers to fish dispersal, although further work is required to fully understand the impact that changes in fish dispersal have on community character.

Bird movements have been examined by researchers from Charles Sturt University and the University of NSW. This work is trying to determine the cues for movement and the extent and direction of bird dispersal. Once again because this work is in early stages it is difficult to make predictions.

Metabolic function

Metabolic Function is the transformation of organic matter within ecosystems and covers research areas like primary productivity, decomposition and food web studies. Significant work has been undertaken on primary production in northern rivers by researchers from Griffith University (Stuart Bunn) and the University of New Engalnd (Darren Ryder). Far less work has been undertaken in wetlands and floodplain habitats.

The CRC for Freshwater Ecology's Dryland Refugia project undertook food web analysis of a number of systems that suggested that systems were dominated by in-stream algal primary production. This result appeared surprising initially due to the turbid nature of many of the rivers in the region. The NSW Department of Environment and Climate Change are initiating work on food webs within wetlands of the northern Murray-Darling Basin that will complement the work undertaken by the Dryland Refugia project.

Biota

There has been very little research to investigate characteristics of populations such as rates of mortality or recruitment or characteristics of communities such as successional processes or the influence of competition or predation. Projects such as Dryland Refugia have revealed patterns that provide insights into the spread of introduced species such as carp, but these patterns require further investigation.

In addition to the afore-mentioned work, an additional project, 'Establishing benchmarks and trajectories of change in inland wetland ecosystems', being conducted by the Riverine Landscapes Research Laboratory (University of Canberra), is being undertaken in the lower Balonne. This project is using historical records of the condition of riverine ecosystems (e.g. historical rates of sediment accumulation) over the past 200+ years to establish benchmarks of pre-European conditions, to record the natural range in conditions prior to European settlement and to determine the trajectory, timing and rate of recent change for a range of ecologically significant variables. Both the EFAP and the IMEF intervention monitoring programs (see section #) also have the potential to enhance our system understanding in relation to the hydrological requirements of individual species, communities and ecological processes and functions.

Management need

The summary above reveals that knowledge generation is undertaken by a wide range of institutions. This means that there is no strategic oversight of knowledge generation activities in the northern MDB and there is high potential for knowledge fragmentation. As a consequence managers would benefit from the development of an institutional oversight mechanism that would identify potential synergies among research and monitoring programs and also potentially identify knowledge gaps that are common to a number of stakeholders.

Condition Assessment

Monitoring of wetland condition is required at several jurisdictional levels. Currently at a national level, under the National NRM Monitoring and Evaluation Framework, the condition of regionally significant wetlands is a recommended indicator under the Inland Aquatic Ecosystems Integrity Matter for target indicator heading. The agreed measures for this indicator are:

- Colour
- Dissolved oxygen and temperature
- Extent of inundation
- Macroinvertebrate diversity and community composition
- Macroinvertebrate index
- Macroinvertebrate indicator species
- Nutrients (Phosphorus and Nitrogen)
- Transparency
- Vegetation
- Phytoplankton

However, these national indicators and measures have been reviewed by the NLWRA project and the outcomes from this report are discussed below.

Monitoring of wetland condition is also required by state jurisdictions. As previously discussed, state-wide natural resource management targets have been set for NSW and these targets must be incorporated into regional NRM plans. These targets include a specific priority target that 'By 2015 there is an improvement in the condition of important wetlands …'. Whilst there are no state-wide targets that explicitly deal with wetland condition in Queensland, under the Strategy for the Conservation and Management of Queensland Wetlands, the degradation of natural wetlands should be avoided unless overriding public interest can be shown. Regionally, both of the Queensland NRM regional bodies in the Northern Murray-Darling Basin have included wetland targets in their NRM plans. The NRM plan for the Condamine Catchment requires that the condition of 20 regionally significant wetlands be assessed within and held within AUsRivAS band A by 2015. The NRM plan encompassing the remaining catchments in the Queensland Murray-Darling Basin requires that all regionally significant wetlands are maintained by current or better condition by 2035.

The need for monitoring of wetland condition is also implicit in the water sharing plans in NSW and the water resource plans in Queensland. The river flow objectives that underpin the NSW plan's objectives have been developed to produce specific environmental benefits such as healthier wetlands, improved habitat quality and increased variability of habitat for native fish, frogs, waterbirds and other native fauna. Similarly, in Queensland, in water resource plan areas where wetland ecosystems are identified as critical assets, ecological monitoring must be undertaken to evaluate how effectively water management strategies of a water resource plan are in providing the critical flow related conditions required to achieve ecological outcomes.

Every State and Territory in Australia is currently undertaking monitoring of aquatic ecosystems. Much of this work was initiated by the National River Health Program (NRHP) and the development of the AusRivAS models during the 1990s. While the NRHP focussed on rivers, there has not been a complementary development of monitoring in the lacustrine and palustrine wetland arena. At best, ad-hoc arrangements exist for monitoring these wetlands, and in many cases they are ignored because of the lack of suitable monitoring techniques. Thus wetland monitoring is often incomplete and inconsistent at both regional and state levels. The current status of wetland monitoring in each state and territory has been reviewed in the NLWRA Report. Programs that are undertaken in the Northern MDB are summarised below.

National / whole of basin

- National Land and Water Resources Audit
  - Wetlands were assessed nationally as part of the National Land and Water Resources Audit's 2002 Australian Terrestrial Biodiversity Assessment. A rapid assessment criteria was used to rate all nationally important (those listed in the DIWA) and regionally singificant wetlands in relation to current condition and trend. Approximately 4700 regionally important wetlands were identified.Wetland condition was assessed as being
    - degraded (recovery unlikely in medium term);
    - fair (recovery requires significant management intervention);
    - good (recovery would occur in short term with minimum intervention); or
    - near pristine.
  - Wetland trend was rated as:
    - extinction;
    - condition rapidly declining;
    - condition declining;
    - condition static;
    - condition improving; or
    - unknown.
  - Indicators used to assess wetland condition were developed for the National NRM Monitoring and Evaluation Framework and included: water colour; dissolved oxygen and temperature; extent of inundation; macroinvertebrate diversity and community composition; macroinvertebrate index; macroinvertebrate indicator species; nutrients (Phosphorus and Nitrogen); transparency; vegetation ; phytoplankton
- Sustainable Rivers Audit
  - Floodplain theme indicators for lacustrine/palustrine are under development

Queensland

- Water Resource Plans - Environmental Flows Assessment Program (EFAP)
  - Advice on water allocation to wetlands, dependent on stream flows
  - Identification of key ecological assets
  - Confirmation of the hydraulic habitat requirements of selected ecological assets (representative of ecological outcomes);
  - Determine if current flow management strategies and environmental flow rules are providing these critical water requirements
  - Determine the risk of selected ecological assets and evaluate if ecological outcomes are likely to be met under current flow management strategies
  - Uses the critical water requirements of critical assets as indicators of performance
  - In the Northern M-D Basin the identification, selection and prioritisation of flow-dependent ecological assets for all QMDB catchments has been undertaken
- Lower Balonne - Smart Rivers Program: The program aims to sample aspects of the physical (riparian zone), chemical (temperature, DO, EC, pH and turbidity) and biological (aquatic plants, macroinvertebrates and fish) environments twice yearly to allow for the understanding of the condition of rivers and wetlands in the area. A total of 11 wetlands may be monitored depending

on flow and funding. A new project is being developed for the Lower Balonne (to include, Smart Rivers and NRW and potentially NSW State agencies if they agree to come on board). National Water Commission has offered funding of $6 million, to set up a governance framework for flow management in the lower Balonne and for the development and implementation of a monitoring program, if NSW signs off.

- Condamine Catchment – Condition assessments have been undertaken on eight key wetlands and which have been identified as high priority wetlands for management purposes. These wetlands will be monitored (using WetlandCare Australia guidelines) to assess the efficacy of management actions.
- Off-stream storages - hydrology / flow data
- State of the Rivers - data on some wetlands
- Ecological character description for Ramsar sites

New South Wales

- IMEF (Integrated Monitoring of Environmental Flows)
    - Hypothesis based, wetland scale intervention monitoring to test the environmental effects of the flow rules for all regulated rivers and the Barwon-Darling
    - Approximately 12 wetlands assessed each year
    - Indicators for wetland hypotheses are: wetted area, macroinvertebrates, plants, birds, frogs
- Lachlan CMA
    - Monitoring of Great Cumbung Swamp using SRA protocols
- DNR Hydrographic network – this program is mainly riverine, however there are some Ramsar wetland sites included.
    - Salinity and temperature at some sites
    - wetland – height, not flow
- Significant wetlands – inundation extent, back 30 years
    - Macquarie Marshes
    - Gwydir Wetlands
    - Narran Lakes

NLWRA approach

The NLWRA Framework has developed a number of indicators for assessing wetland condition. The development of these indicators has been based on the premise that ecological integrity is the fundamental measure of wetland health. The proposed indicators are based around six themes (Table 2) that represent the major elements of river and wetland condition or health. These themes have been modified slightly from the National Water Commission's FARWH framework (on which the NLWRA condition assessment framework is based), to reflect the different requirements and functioning of wetlands. Proposed measures and methods for each indicator are detailed in the NLWRA Report.

The proposed indicators under these themes are a mixture of biotic and abiotic elements and were selected to represent those components that are the most important and responsive parts of the ecosystem. The NLWRA framework does attempt to prescribe indicators for wetland monitoring but suggests that there needs to be an understanding of the individual wetland in terms of its physical, biological and chemical processes, and that indicators should be selected to reflect the changes that may occur to a wetland under different impacts. The NLWRA framework recommends that the selection of indicators be ecologically-based, using conceptual models that identify key wetland ecological and physical drivers and pressures. The Queensland Wetlands Programme Wetland Indicators Scoping Study (Conrick 2007) has developed conceptual models for some Queensland wetland types and these will form the basis for developing conceptual models for major wetland types across Australia.

Indicators will be used to compare wetland condition against a pre-existing or nominated reference condition. The specific reference condition used may vary among indicators and may include pre-European or least-impact land use, modelled natural flows, ecological character descriptions from

Ramsar, or reference year. Specific measures have also been developed for most of the proposed indicators (Appendix 2).

Table 2. NLWRA proposed themes and indictors for the assessment of wetland condition.

Theme	Proposed Indicator
Catchment disturbance	Disturbance in the catchment
Physical form and process	Area of wetland - change in wetland area Wetland topography - change through erosion, excavation, banks and levees, deposition or rehabilitation Soil disturbance - change through physical disturbance, compaction or cultivation
Hydrological disturbance	Physical modification to hydrology in-flow, drainage and extraction (catchment and wetland scale) Changes to water regime timing, frequency, duration, extent and depth, and variability including groundwater contribution
Water and Soil Quality	Turbidity regime Salinity regime Change in pH Soil properties - change in salinity and acidity
Fringing Zone	Change in fringing zone - as measured by change in vegetation condition and extent
Biota	Change in wetland vegetation Change in invertebrate diversity and community composition Change in wetland-dependent vertebrates (fish, frogs, reptiles, birds, mammals) - presence, breeding and abundance Change in introduced species- presence and abundance Change in algae - as a measure of primary productivity rather than water quality

Management need

There are six fundamental issues that the MDBC will need to consider when evaluating the NLWRA framework and its relevance to developing a monitoring program for the northern MDB. The first is that the framework has evolved from a wetlands perspective through initiatives such as Ramsar. As a consequence it tends to treat wetlands as the standard reporting unit. This will not always be appropriate to the MDBC objectives that will need to;

- integrate wetland condition into a broader assessment of environmental condition
- integrate the monitoring program into the broader NRM landscape.

Secondly, the program is established to assess wetland "integrity". "Integrity is maintained when a wetland is able to maintain key ecological and physical processes, ecosystem services, and communities of organisms (NLWRA 2007). While this appears reasonable it is not clear at what point a system loses integrity, that is, how much change is acceptable. Given that no wetland within the MDB is unmodified, it could be argued that no wetland currently has integrity which raises the question of when we would have achieved the objective. If the answer to that is when it is similar to the pre-1750 condition, then this is not a particularly useful benchmark. The MDBC should be cautious in this area. The monitoring program may be appropriate, but the objective would seem poorly suited for the MDBC's purposes. There are similar issues with the use of the term 'health', that will also need to be addressed at some stage.

The program states in a number of sections that managers should select indicators. This is a relatively simplistic view of what they are proposing and inappropriate nomenclature in some instances. There are two imbedded issues. The first is that if wetlands are being managed because they support populations of species regarded as assets (e.g. endangered species, long lived trees), then the monitoring program should not try and identify indicators of these things, but assess them directly. Secondly, it is clear that the framework that they have proposed aligns with the framework we identify above of a system being composed of habitat, connectivity, metabolic function and biota. Each of these face threats that, in some instances, we are aware of. The NLWRA framework uses our system understanding to assess a number of habitat variables directly (e.g. Physical Form), a number of connectivity issues (e.g. catchment disturbance) indirectly and some threats directly (e.g. hydrological alteration). The MDBC may wish to consider a more direct evaluation of the condition of identified assets and threats rather than persisting with the 'indicators' paradigm.

Regardless of the design or the monitoring program, it will be important that a reference condition be developed against which any monitoring data can be evaluated. This is not a trivial task given the widespread chronic degradation of our wetland ecosystems. It would appear sensible that a coordinated effort be made to develop reference condition for wetlands in the northern MDB that all jurisdictions could utilise.

The NLWRA program advocates the aggregation of scores from the themes and "indicators". The aggregation of scores is problematic and can undermine the intent of the program. The MDBC has invested considerable effort through the SRA to develop ways of integrating data to provide an assessment. The MDBC would be in a strong position to offer leadership in this area as a monitoring program is developed in the northern MDB.

In an ideal world the condition assessment would meet a variety of objectives, including;

MDBC objectives
Federal Government objectives
State Government objectives
Catchment Management Objectives and
NGO Objectives e.g. cotton industry, conservation groups

While this may be possible there may also need to be compromises with some parameters being monitored for one purpose that may not be relevant to other objectives. The extent to which any one program can meet all potential objectives will need to be determined, but can not be evaluated until conceptual models have been developed and our system understanding has been interrogated to develop a monitoring design.

Comments on Individual Themes

1. Catchment Disturbance. This theme will quantify catchment changes that are likely to affect inputs to the wetland, such as clearing, agricultural development etc. The protocols for this are yet to be finalised and the jurisdictions need to reach agreement. As the protocols need development there may be opportunities for involvement of the MDBC in this process. The value to the MDBC of involvement in this development process might be the ability to harmonise the data requirements with other broad scale condition assessments that the MDBC is either currently involved in, or may wish to develop in the future.
2. Physical Form. This theme will quantify the area, topography and extent of soil disturbance. The protocols for describing topography are yet to be finalised. Given the investments made by the MDBC in acquiring LIDAR data and developing the Murray Wetlands Database, the Commission may wish to become involved in this process to ensure that the value of existing investments and experience is maximised.
3. Hydrological Disturbance. The challenge associated with this theme is developing appropriate indices given the extremely variable flow regimes of Australian Rivers. The Hydrological Disturbance data is of relevance to a large number of programs such as the water sharing plans and the NWI. As the MDBC has hydrological expertise they may be able to play a role in the

development of the Hydrological indicators that would help ensure that the data gathered is useful to a broad range of programs across jurisdictions.

4. Water and Soil Quality. The Sustainable Rivers Audit has decided that gathering water quality data to undertake condition assessment does not provide a good return on investment. This issue is to be resolved by the NLWRA project. The MDBC does maintain a water quality monitoring program and engagement of the 2 MDBC programs in the development of this theme would be valuable. It is interesting to note that the objective of the framework is wetland integrity that includes ecosystem processes and services and yet none of these are being assessed directly. It would be possible for some direct assessment of ecosystem services such as water purification to be undertaken as part of this theme.
5. Fringing Zone. This theme examines the zone immediately outside the vegetation that relies on inundation. The development of a northern MDB wetland monitoring program will need to ensure that the data gathered by this component is compatible with other programs undertaken by the MDBC and is consistent with the broader condition assessments undertaken by the Commission.
6. Biota. This theme will assess wetland vegetation, invertebrates, wetland dependent vertebrates, introduced species and algae. As noted above, these are all treated as indicators when some may actually be considered assets and others threats. An additional concern is that the benchmark of the framework is wetland integrity that is supposed to relate to ecological processes and yet only one process, algal productivity, is assessed, and then only indirectly. Process measures should be considered as they are essential to understanding ecosystems and complex systems due to the strong relationship between ecosystem structure and function. This has been acknowledged by AEON who are monitoring primary production and nitrogen cycling should be considered.
   The list of biota to be monitored is specified in the agreement but arises from the development of wetland conceptual models. The MDBC may also wish to ensure coordination among its programs to ensure that data gathered under a wetland monitoring program could be integrated with assessments of other system components.

Implementation

Following the production of the NLWRA Report, the wetland Matters for Target, Indicator Headings and recommended indicators have been discussed and agreed upon by the Wetlands and Waterbirds taskforce, have been presented to the Aquatic Ecosystems Task Group for approval and a work plan has been developed to further progress the development and implementation of the recommended indicators.

Should the MDBC decide to invest in wetland monitoring in the Northern Basin, there are two main options that could be considered:

2. *Collaboration with the Federal and State jurisdictions in implementing the NLWRA framework.*

MDBC collaboration with other jurisdictions in the implementation of the NLWRA framework could occur via the provision of additional resources to aid in the development and implementation of this program, or via MDBC's direct involvement in one of four key areas:

- Development of conceptual models for Northern Basin wetlands: Whilst ome conceptual models have been developed under the Queensland Wetlands Programme, work is still required on the development of conceptual models for wetlands that occur within the northern Murray-Darling Basin.
- Indicator development and sampling methodologies: Although recommended indicators have been agreed upon, indicator methods and protocols have not yet been developed for a number of indicators. These include catchment disturbance, hydrological disturbance, physical forms and processes, fringing zone vegetation and biota.
- Determination of the potential for the use of remote sensing in gathering wetland extent, distribution and condition information.

- Development and production of wetland information sheets: It is envisaged that information sheets will be produced for all individual wetlands/wetland complexes. The MDBC could play an important role in the development of information sheets for Northern Basin wetlands.

3. Development of an independent wetland monitoring program

The MDBC may decide that the approach taken by the NLWRA framework will not meet their objectives for wetland monitoring in the Northern Basin (for example, if intervention monitoring, rather than ongoing condition assessment, is seen as a high priority). In this case, MDBC may wish to develop a separate monitoring program, based on their identified needs and objectives, that could run in parallel with the NLWRA framework monitoring.

References

Appendix 1 - NSW River Flow Objectives and Water Sharing Plan objectives / Water Resource Plan ecological outcomes that relate to wetlands

NSW River Flow Objectives

1. Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flow
2. Protect natural low flows
3. Protect or restore a proportion of moderate flows, "freshes" and high flows
4. Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems
5. Mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways
6. Maintain or mimic natural flow variability in all rivers
7. Maintain rates of rise and fall of river heights within natural bounds
8. Maintain groundwaters within natural levels, and variability, critical to surface flows or ecosystems
9. Minimise the impact of in-stream structures
10. Minimise downstream water quality impacts of storage releases
11. Ensure river flow management provides for contingencies
12. Maintain or rehabilitate estuarine processes and habitats

Table 3. Water Sharing Plan Objectives and Water Resource Plan Ecological Outcomes that relate to wetland ecosystems.

Objective	Water Sharing/Resource Plan
Implement the relevant river flow objectives to protect, maintain the environmental values of the water source	Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek, Gwydir; Rocky Creek, Cobbadah, Upper Horton and Lower Horton; Tenterfield Creek
Protect, preserve, maintain or enhance the important river flow dependent environmental features and Aboriginal, cultural and heritage values of these water sources	Upper and Lower Namoi
Protect natural water levels in pools, creeks, rivers and wetlands during periods of no flow	Castlereagh River above Binnaway Water Source
Protect aquatic ecosystems	Castlereagh River above Binnaway Water Source
Maintain or enhance the ecological functions and values of riverine environments	Macquarie and Cudgegong
To achieve ecological outcomes consistent with maintaining a healthy riverine environment, floodplains and wetlands	Border Rivers; Moonie; Warrego, Paroo, Bulloo and Nebine; and Condamine-Balonne
Maintain natural riverine habitats that sustain native plants and animals	Border Rivers; Moonie; Warrego, Paroo, Bulloo and Nebine; and Condamine-Balonne
Maintain the natural abundance and species richness of native plants and animals associated with habitats within watercourses, riparian zones, floodplains and wetlands	Border Rivers; Moonie; Warrego, Paroo, Bulloo and Nebine; and Condamine-Balonne
Improve wetland inundation to provide for ecological processes	Border Rivers
Maintain the condition and diversity of native vegetation on the floodplains and related streams	Condamine-Balonne

Maintain the diversity and abundance of native animals within the floodplains and related streams	Condamine-Balonne
Maintain the success of bird-breeding in the Narran lakes and the national parks of the Culgoa floodplain	Condamine-Balonne
Maintain the success of bird-breeding in the Currawinya Lakes systems, the Paroo overflow lakes, the Bulloo Lakes and other significant wetland systems in the Paroo and Bulloo basins	Warrego, Paroo, Bulloo and Nebine
Maintain the unique genetic diversity of aquatic plants and animals within the Paroo and Bulloo basins	Warrego, Paroo, Bulloo and Nebine
Maintain the near pristine condition of riverine habitats and associated native plants and animals within the Paroo and Bulloo basins	Warrego, Paroo, Bulloo and Nebine
Maintain water quality at levels acceptable for water use and to support natural ecological processes	Border Rivers; Moonie; Warrego, Paroo, Bulloo and Nebine; and Condamine-Balonne
Maintain beneficial flooding in the plan area	Warrego, Paroo, Bulloo and Nebine

Appendix 2 - Proposed NLWRA indicators, measures and methods for determining wetland condition

Indicator	Measure	Methods
EXTENT AND DISTRIBUTION		
Extent and distribution of wetlands		EPA (2005). Qld Mapping and Classification Methodology.
Extent and distribution of significant wetlands (Ramsar, DIWA, other policy or legal instruments)		EPA (2005). Qld Mapping and Classification Methodology.
CONDITION		
Catchment Disturbance incorporates the effects of land use, change in vegetation cover and infrastructure (e.g. roads, rail-lines, water regulation, drainage changes) on the likely run-off of water, sediments, nutrients and other contaminants to wetlands. The index should incorporate the effects of large-scale non-point source impacts.		
Disturbance in catchment	Land use Infrastructure Land cover change	Methods and recommended datasets from: •NLWRA (2002) Australian Catchment, River and Estuary Assessment 2002 Vol 1. NLWRA, Canberra. pp 69-77 •WRON (2006) Australian Water Resources 2005. Discovery phase. Appendix D: River health. NWC, Canberra. pp 35-41 Datasets include topographic maps, Land use of Australia, version 2 (NLWRA), Catchment scale land use for Australia, Wild Rivers, and the National land use mapping project.

Indicator	Measure	Methods
Physical Form And Processes uses measures of local topography, physical structure and connectedness (dam, weirs, levee banks, groundwater abstraction) to assess the state of local habitat and its likely ability to support aquatic life. This theme concentrates on the immediate surrounds of the wetland and inside the individual wetland.		
Area of wetland	Percentage reduction in wetland area	DSE (2007) Index of Wetland Condition. Methods Manual (draft).
	Loss in area of original wetland	Clarkson et al. 2004. Handbook for monitoring wetland condition (NZ wetlands)
Wetland topography	Percentage of wetland where activities (excavation and landforming) have resulted in a change in bathymetry	DSE (2007) Index of Wetland Condition. Methods Manual (draft). •'tick and flick' in the field •Bathymetric survey (e.g. Robertson & Massenbauer 2005) •LIDAR (Also refer to current indicator: Extent of inundation)
	Degree of sedimentation/erosion	Clarkson et al. 2004. Handbook for monitoring wetland condition (NZ wetlands)
	Percentage change in bathymetry	No methods sourced - ? Robertson & Massenbauer 2005
Soil disturbance	Percentage and severity of wetland soil disturbance e.g. pugging, driving of vehicles in wetlands, carp mumbling, human trampling	DSE (2007) Index of Wetland Condition. Methods Manual (draft).
	Substrate disturbance – observation of disturbance (none to recently occurred)	Fennessy et al. (2004) Review of rapid methods for assessing wetland condition. EPA/620/R-04/009. USEPA.

Indicator	Measure	Methods
Hydrological Disturbance Both surface water and groundwater regimes are important to aquatic ecosystem function. This theme relies heavily on the premise by Boulton and Brock (1999) that the primary components of the water regime are 'timing, frequency, duration, extent and depth, and variability' and that they are all scale-dependant and are spatially and temporally related to each other		
(Local) Physical modifications to hydrology inflow, drainage and extraction	Severity of activities that change the water regime	DSE (2007) Index of Wetland Condition. Methods Manual (draft).
	Impact of man-made structures	Clarkson et al. 2004. Handbook for monitoring wetland condition (NZ wetlands)
Changes to water regime	REQUIRES MORE DEVELOPMENT AND EXPERT ADVICE	
Water And Soil Quality Water and soils quality considers the effects on biota of changes in water and soil quality characteristics		
Turbidity (light climate) regime	REQUIRES MORE DEVELOPMENT AND EXPERT ADVICE Use trials to collect diurnal data	
Salinity regime		
Change in pH		
Soil properties – change in salinity, acidity		

Indicator	Measure	Methods
Fringing Zone represents structural and condition features of the zone surrounding a wetland.		
Change in fringing zone (measured by change in vegetation condition)	•presence of an intact fringing zone •percentage of the fringing zone that is intact •percentage of natural and exotic vegetation	Spencer et al. (1998) Rapid appraisal wetland condition index. •Continuity of fringing vegetation – estimated by eye for each of the main vegetation layers (incl trees, rushes/sedges, grasses) •Width of fringing vegetation strip – visual estimates at the four major compass points of a wetland DSE (2007) Index of Wetland Condition. Methods
		Manual (draft) •% of wetland perimeter with a buffer •Average buffer width Golus et al. (2006) Wetland Assessment Technique •Width of fringing vegetation Davis et al. (2006) Wetlands bioassessment •Percentage of undisturbed vegetation remaining within (100 m) of edge of wetland (Davis et al.)

Indicator	Measure	Methods
Biota represents the response of biota to changes in the environment. It may be based on sampling of biota sensitive and/or responsive to human disturbance across various scales		
Change in wetland vegetation	REQUIRES MORE DEVELOPMENT AND EXPERT ADVICE – •Develop AusRivAS-style methods •Investigate Vegetation Matter for Target: http://www.nrm.gov.au/monitoring/indicators/vegetation-condition/index.html •Investigate Index of Wetland Condition methods (DSE 2007), Floodplain and Wetland Methods (MDBC 2005)	
Change in invertebrate diversity and community composition	REQUIRES MORE DEVELOPMENT AND EXPERT ADVICE – • Develop AusRivAS-style methods	
Change in wetland-dependent vertebrates (fish, frogs, reptiles, birds, mammals) presence, breeding and abundance	Investigate current methods e.g.: •Fish: SRA, EHMP •Frogs: MDBC (frog calls) •Reptiles: no methods sourced •Birds: MDBC, Kingsford (in prep), •Mammals: no methods sourced	
Change in introduced species (weeds and ferals) presence and abundance	There are several methods for introduced species presence and abundance listed in Appendix 8. Recommend investigation and trials to determine most suitable	
Change in algae (as a measure of primary productivity	REQUIRES MORE DEVELOPMENT AND EXPERT ADVICE	