Towards the Classification and Regionalisation of the Water-dependent Ecosystems of the Murray-Darling Basin

Contract Number: MD1461

Final Report 29th July 2010

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Scope of Report

This report is for internal MDBA purposes. As such the intended audience of the report is familiar with the various processes and terms used (e.g. Key Environmental Assets etc) and the data analysis behind the identification of KEAs).

Milestone Criteria

The contract between the Murray-Darling Basin Authority (the Authority or MDBA) and Christopher Auricht (Auricht Projects) which commenced in December 2009 requires Mr. Auricht to deliver a number of Milestone outputs.

This report is submitted in fulfilment of Milestone No. 3 – being a final report.

Milestone Deliverables	*Status*
1. Final outputs including delivery of spatial products as described in the project brief.	☑ Completed in June 2010
2. Tax Invoice	☑ Tax Invoice Submitted June 2010
Assessment Criteria	**Status**
1. Receipt of Final Report	
2. Receipt of tax invoice	

Contributors and Acknowledgements

The implementation of the pilot project addressing the development of a 'Classification and Regionalisation of the Water-dependent Ecosystems of the Murray-Darling Basin' reflects inputs from numerous contributors.

The following is a brief listing of those who have been involved in activities related to the project.

Consultant

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New South Wales – Sarah Imgraben and Eren Turak

Victoria – Phil Papas, Janet Holmes and Shanaugh Lyon

South Australia – Ben Fee, Rebecca Turner, Holly Hershman, Glen Scholz and Matt Miles

The time, resources and effort provided by State agencies is very much appreciated and contributed significantly to the success of the project.

Executive Summary

Main Findings

1. Developing a contemporary classification of non-riverine wetlands using jurisdictional wetland datasets can be completed, with some modification of existing data, in Queensland, Victoria and South Australia. (Unfortunately during the period of the project, New South Wales did not have suitable consistent wetland mapping, or resources, to apply attributes for the NSW portion of the Murray Darling Basin, MDB).
2. There is scope for the outcome from this project to support the identification of Key Environmental Assets, KEAs, via two approaches i) under KEA Criteria 2 (i.e. Natural, near natural rare or unique Water Dependent Ecosystem, WDE), by identifying those that contain rare or unique attributes based on their number and type; and, ii) by identifying those that occur within KEA Category 2 i.e. KEA's within largely hydrologically unmodified catchments.
3. The network of KEA identified by the Murray Darling Basin Authority (MDBA) 'capture' a sample of the wetland types across the MDB in the three states assessed (Qld, Vic, SA). In Queensland it is possible to identify the % of each MDB wetland type considered as part of the KEA network, where results range from 12% for wetland type 14 (Arid/ Semi-arid saline lakes) to 100% for wetland type 4b (Coastal/ Sub-Coastal floodplain wet heath swamps). In South Australia KEA's were identified at the aggregated or higher Flood Plain Inundation Response Unit (FIRU)level i.e. not the individual wetland type level. Based on analysis it is clear however, that the full range of aquatic ecosystem types are represented within FIRU's that meet at least one KEA criteria. To this end - of the 112 FIRU's comprising the South Australian Dataset - 9 (or less than 1%) failed to meet any KEA criteria, 22 (or approx 20%) meet 1 KEA criteria, 27 (or 24%) meet 2 KEA criteria, 23 (or 21%) meet 3 KEA criteria, 16 (or 14 %) meet 4 KEA criteria, and 15 (or 13%) meet all 5 KEA criteria. Results for Victoria reveal that the most common wetland types within their KEA network are Palustrine Systems comprised of temperate climate, river water source, seasonal (<= 1 year) water source/frequency, fresh water type, tree dominated vegetation, basin landform, floodplain landscape with overbank hydrological connectivity. Wetland types of this nature account for 71 (or 40 %.) of the 176 records. (Note in the case of Victoria the 176 wetlands represent 82 separate KEA complexes).
4. There is now the capacity to review any proposed network of lacustrine and palustrine KEA's (within in the Queensland, Victoria and South Australian portions of the MDB), and determine whether a representative sample of WDE types have been selected.

Background

Auricht Projects was engaged by the Murray-Darling Basin Authority (MDBA) to contribute to the process of developing a classification and regionalisation for the Murray-Darling Basin (MDB); and, assessing the ability of existing jurisdictional datasets and processes to determine whether the MDBA's current Key Environmental Assets (KEA's) represent the full range of aquatic ecosystem types occurring within the Basin.

Scope of Work

Overall the objectives of the project focused on:

- Assessing the utility of existing jurisdictional datasets to identify aquatic ecosystems (number and type)
- Assessing whether the current KEA network has 'captured' a representative sample of the aquatic ecosystem types within each jurisdiction i.e. requires the ability to identify which types (either at the individual polygon or aggregated/group complex level) have been identified as Key Environmental Assets
- Identifying issues encountered as part of the above process
- Identifying potential next steps

Within the above context, analysis was largely confined to Lacustrine and Palustrine systems i.e. Riverine, Subterranean and Estuarine were considered out-of-scope for analysis. (Note: the above approach does not fully cater for floodplain habitats – though in South Australia they are considered, at least in part, given that the KEA assessment was carried out at the floodplain complex level. In addition, given that South Australia included riverine elements within their dataset these have been included within the analysis carried out for South Australia).

Approach

The method adopted for the project has been both analytical and collaborative, adopting a thematic approach in line with the scope and objectives of the project. A schedule of meetings and working sessions was established with the MDBA early in the project in order to develop a program focussing on:

- Organisation and implementation of a classification and regionalisation workshop
- Identification of jurisdictional contacts
- Development of pilot success criteria
- Data access arrangements to obtain existing classification (aquatic ecosystem type) and extent datasets
- Data collation, harmonisation and validation
- Development of jurisdictional databases
- Data analysis
- Development of standard and value-added outputs
- Synthesis and reporting

Close contact was maintained throughout the process with both jurisdictional contacts and the MDBA project officer Mr. Jeff Richardson. Collectively, this provided a transparent and efficient process in which the consultant worked directly with all stakeholders.

Capacity Indicators

It is important that the current project provides a method to enable stakeholders (i.e. the MDBA and State jurisdictions) to obtain an informed view on the current status of existing data to support a classification and regionalisation for the MDB. The following key capacity indicators (KCI's) were developed to assist in providing clarity around this requirement:

a) The ability of State datasets to identify aquatic ecosystems (number and type)
b) The ability of State datasets to assess whether the KEA network has 'captured' a representative sample of the aquatic ecosystem types within each jurisdiction
c) The ability of State datasets and classifications to support assessment of rare or unique Water Dependent Ecosystems WDE's)

d) The ability of States to apply draft MDBA AE classification attributes to existing wetland layers

Evaluation of Datasets

A large number of datasets containing information on aquatic ecosystems exist for the MDB. Unfortunately however, the overall situation is that many are disparate, fragmented, inconsistent, and, collated and stored according to differing standards. The following simple criteria were established to assess the suitability of datasets for use within the project.

- Extent Coverage - Mapping or inventory operating at least at the State level, though Basin-wide or cross-jurisdictional preferred
- Methodology – Approach described in the scientific literature or in technical reports
- Classification Completeness – Needs to be ecologically meaningful i.e. Aquatic Ecosystem classification incorporates a range of habit types below lacustrine, palustrine, riverine classes (and ideally based on attributes)
- Currency – dataset is considered up-to-date
- Accessible – dataset is available
- Format – dataset is in a GIS ready format
- Scale – dataset is at a suitable scale e.g. 1:250,00 or finer

Application of the above criteria resulted in only a small number of datasets being appropriate for use (or fit-for-purpose) in Queensland, Victoria and South Australia. Importantly none from New South Wales were considered suitable within the resource constraints and time frame for the pilot.

Analysis and Findings

Overall the current project demonstrated that, with the exception of New South Wales, existing State level datasets can be used to identify WDE's including number, extent and type. Based on findings from the pilot it can be demonstrated that existing KEA's also capture the full range of lacustrine and palustrine aquatic systems known to occur within the Queensland, Victorian and South Australian portion of the Basin. Additional analysis for Queensland demonstrates that it is a simple process to identify which assets occur as:

- Category 1: IKEA's (Indicative KEA's);
- Category 2: KEA's within largely hydrologically unmodified catchments; or,
- Category 3: Other KEA's

(Note: it is also possible to undertake the above analysis for South Australia and Victoria, however resources and time constraints prevented this from being undertaken).

Further to the above, findings from the Queensland example highlight the need for some form of spatial aggregation to identify a higher order unit (e.g. complex of wetlands) to constitute the actual KEA. That is, the large number of aquatic habitats that meet KEA criteria in Queensland may create management issues, especially as it relates to intervention activities carried out within an Adaptive Management Framework. To this end, of the 12,693 habitats used in the pilot, a total 3,016 (or approximately 25%) meet KEA criteria within the Queensland portion of the MDB.

By contrast South Australia adopted a spatial aggregation approach to identify a higher level unit - the Flood Plain Response Unit (or FIRU) which includes both the floodplain area and wetlands - on which they based their KEA assessment. In this respect the aggregation of aquatic ecosystem types (including riverine) to the FIRU unit has provided an appropriate scale to manage for ecosystem function outcomes.

In total, 103 FIRU's meet at least one KEA criteria within the South Australian River Murray Floodplain area of the MDB. Results from the South Australian pilot also demonstrate that it is a simple process to identify which wetland types occur within each FIRU (or KEA), and that importantly the full range of lacustrine and palustrine types are represented (i.e. 'captured') as KEA's. (Note: Further work is required to determine the interactions between various aquatic ecosystem types within each FIRU).

Victoria identified KEA's as either a) a single polygon; or, b) a cluster of polygons of various aquatic ecosystem types. Similarly, as a result of work carried out under the project it is also possible to undertake analysis of lacustrine and palustrine types within the Victorian portion of the MDB.

In relation to supporting the MDBA's KEA process, the pilot demonstrated that existing datasets for Queensland, Victoria and South Australia have the potential to support KEA criterion 2, especially as it relates to the identification of rare or unique WDE's based on aquatic ecosystem classification attributes. In addition, the pilot demonstrated that:

- once KEA information (i.e. KEA criteria information for each asset) is entered into a database and subsequently joined with respective spatial layers it is possible to both identify and visualise the actual location of certain types of WDE; and,
- that through simple structured querying processes it is also possible to easily query and visualise information for KEA criteria, condition and ecological value etc within a spatial context.

In this respect, it is clear that the development of a spatial classified aquatic ecosystem layer for the MDB provides a strong foundation or framework from which to support the overall KEA process.

Within this context, tasks completed for Victoria demonstrate that it is possible to retrospectively apply classification attributes to existing spatial layers, and that the resultant database has considerable potential to support numerous processes e.g. querying to identify aquatic ecosystems that meet certain classification criteria. In this respect - though out of scope within the current pilot - it would now also be possible to identify similar lacustrine and palustrine wetlands in all three States (i.e. Queensland, Victoria and South Australia) based on simple query requests to various attributes within the respective databases. This identifies the possibility of adding value to current MDBA processes through merging existing state classification attribute data to create a consistent MDB-wide wetland classification.

Data Issues

Data Management - A number of data management issues were identified through the course of the pilot, though none proved fatal. That is, standard database cleansing and validation routines were adopted which enabled data to be transformed into a format suitable for use in the pilot. Such issues do however identify the need for standard best practise routines to be applied.

Cross-border Comparisons – such comparisons are dependent on the ability to be able to compare 'like' systems in one jurisdiction with the 'same' type of system in another (even if the types are given different names between jurisdictions). The current pilot was undertaken on a State basis, however cross-border lacustrine and palustrine comparisons between jurisdictions would be now possible for Queensland, Victoria and South Australia. The adoption of an attribute based classification (as proposed at the 14th December 2009 Classification and Regionalisation workshop and demonstrated in the current project) is key to supporting this process.

Classification Attribution and the Development of a Seamless WDE Layer for the MDB – Findings from the pilot demonstrate that it is possible to develop a standardised lacustrine and palustrine classification system for the MDB, and where required to retrospectively attribute existing aquatic habitat mapping datasets. The challenge however remains to develop a seamless layer for the MDB that captures all environmental assets (both surface and subsurface), and to apply classification attributes to them. In this respect, some of the recent work of the AETG related to the development of an attribute based Australian National Aquatic Ecosystem Classification scheme is of particular interest – especially as it relates to each major aquatic system type i.e. lacustrine, palustrine, riverine, estuary/marine and subterranean groupings.

Next Steps

Based on the findings of the pilot a number of issues and activities have been identified for future consideration. In brief these include:

- *Classification and extent datasets* – extending the pilot to include NSW. The challenge remains to develop a seamless Basin-wide attribute rich dataset for covering the full range of aquatic systems occurring i.e. lacustrine, palustrine, riverine, subterranean and estuarine. In this regard, the vision is to develop a consistent, comprehensive and efficient Basin-wide environmental asset database as part of an enduring process.
- *Linkage with other projects and processes* – numerous 'linkage' opportunities exist which could add considerable benefits for the MDBA do to increased synergies and efficiencies. For example the current MDBA-CEWH Environmental Asset Database, the National Water Commission '*Groundwater Dependent Ecosystem Atlas*' and '*National Standards on Groundwater Mapping, Definitions and Assessment Projects'* , plus the body of work currently being undertaken by the Aquatic Ecosystem Task Group. Further analysis based on the pilot datasets for Queensland, Victoria and South Australia could also be carried out on the water regime datasets generated as part of the recently completed CSIRO NWC Ecological Outcomes of Flow Regimes project. In addition, linkage to South Australia's recently updated wetland prioritisation dataset may add further value to process (as it relates to the South Australian portion of the MDB).
- *Aggregation and Site Delineation* - The need to address the issue of aggregation and site delineation. Scope exists for a standard approach, and the development of a guideline to ensure consistency between jurisdictions.
- *Aquatic Ecosystem Regionalisation* - Further work on an Aquatic Ecosystem Regionalisation for the MDB. The current work of the AETG based on the broad drivers of climate, hydrology and geomorphology provides a suitable basis to further develop a suitable regionalisation for the basin. In this respect additional resources are required to test the utility of existing fundamental datasets within the Basin.

Collaborative Approach - Continuing to foster a collaborative approach in which the MDBA works in partnership with jurisdictions – to this end the pilot demonstrated the benefits that can be leveraged within this paradigm. In this respect it should be acknowledged that the States contributed significant in-kind resources to the current project thereby ensuring various tasks were completed. The MDB now has a more accurate appreciation of the real issues involved in developing a classification; and, importantly, access to significantly improved spatial datasets – especially as they relate to lacustrine and palustrine for South Australia and Victoria – that are linked to KEA criteria, condition, and values type information.

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1 Introduction

1.1 The Murray-Darling Basin Authority and the National Water Act (2007)

The Murray-Darling Basin Authority (the Authority or MDBA) has been established under the Water Act 2007 (the Act), and under the Act is tasked with the responsibility of developing and implementing the 'Basin Plan'.

According to Section 20 of the Act, the purpose of the Murray-Darling Basin Plan (or the Basin Plan) is to provide for the integrated management of the Basin water resources in a way that promotes the objectives of the Act. In this respect the Basin Plan is intended to be a strategic plan for the integrated and sustainable management of water resources in the Murray-Darling Basin (MDB).

Some of the main functions of the Basin Plan include:

- Setting and enforcing environmentally sustainable limits on the quantities of surface water and groundwater that may be taken from Basin water resources
- Setting Basin-wide environmental objectives, and water quality and salinity objectives
- Developing efficient water trading regimes across the Basin
- Setting requirements that must be met by State water resource plans
- Improving water security for all uses of Basin water resources

The Water Act (s21) requires that the Authority and the Minister, in exercising their powers and performing their functions in relation to the Basin Plan must:

a) *take into account the principles of ecologically sustainable development which includes the principle that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation; and*
b) *act on the basis of best available scientific knowledge and socio-economic analysis.*

1.1.1 Draft Environmental Objectives

The following draft statements frame the contextual setting related to environmental objectives of the Act.

Draft Overarching Basin Environmental Objectives:

> *Provide for the integrated management of basin water resources in a way that promotes the objectives of the Water Act 2007 through; giving effect to international agreements; protecting and restoring ecological values and ecosystem services; improving water security; and in doing so, optimising economic, social and environmental outcomes.*

Draft Environmental Objectives:

> *Protect key environmental assets (KEA's) and ecosystems of the Basin and conserve biodiversity, by:*
>
> - *Maintaining and improving ecosystem functions and services*
> - *Improving their ecological resilience to threats and risks in a changing environment*
> - *Setting enforceable limits on the quantities of surface water and groundwater that provide for an environmentally sustainable level of take*
> - *Setting environmental watering requirements through a whole of Basin water resource plan*

Draft Environmental Outcomes:

Improved management of environmental water

Water dependent ecosystems are more resilient to climate change and variability (e.g. drought)

Water taken from the Basin does not compromise key environmental assets, ecosystem functions and environmental outcomes or the productive base of the water resource

1.2 Identification of Key Environmental Assets

Box 1 below provides contextual information from the Act relevant to the identification of Key Environmental Assets.

Box 1 - Definitions

Section 4 of the Water Act 2007 defines Environmental Assets to include:

- Water-dependent ecosystems
- Ecosystem services
- Sites with ecological significance

In this respect it defines a 'Water-dependent ecosystem' as a surface water ecosystem or a ground water ecosystem, and its natural components and processes that depends on periodic or sustained inundation, waterlogging or significant inputs of water for its ecological integrity and includes an ecosystem associated with:

- A wetland
- A stream and its floodplain
- A lake or a body of water (whether fresh or saline)
- A salt marsh
- An estuary
- A karst system
- A ground water system

The Act goes on the mention that a reference to a water-dependent ecosystem includes a reference to the biodiversity of the ecosystem

The process proposed by the MDBA for the identification of Key Environmental Assets (KEA's) comprises two main steps. The first involves the development of an inventory of environmental assets within the Basin, and the second, the development and application of criteria which when applied to the inventory of assets will determine which are considered key for the purpose of the Basin Plan. To this end three categories of KEA are envisaged, viz:

- Category 1: Indicative Key Environmental Assets (IKEA's) for which water modelling to inform the determination of environmental water requirements has been completed;
- Category 2: KEA's being those that occur in largely hydrological unmodified catchments (note this doesn't necessarily mean that an individual KEA within this group is in pristine condition); and,
- Category 3: KEA's being those that meet KEA criteria but our outside of the Category 1 IKEA and Category 2 largely hydrologically unmodified catchment KEA groups.

Within the above context, some assets e.g. Internationally listed sites such as Ramsar, are easily identified from existing data sources, however given that the objective is to protect and restore the ecological values of the MDB, international sites etc are only a part of the overall picture. That is, there is a need to define,

delineate and classify ecosystems generally across the Basin, and to undertake some form of structured analysis to ensure that all aquatic ecosystem types are represented within the KEA process. Additional information on the KEA criteria and process is presented in Attachment 1.

1.3 Statement of Need

Given the draft environmental objectives and outcomes above, it follows that any approach to the determination of key environmental assets and functions within the Murray-Darling Basin must therefore:

- Provide for the integrated management of the Basin water resources in a way that promotes the objectives of the Act (S 3)
- Protect and restore key environmental assets and ecosystems of the Basin and conserve biodiversity (S 28 (1), (d) and (e))

In this regard KEA's are those water dependent ecosystems (WDE's)[1] that fulfil one or a number of criteria – refer Attachment 1. Of particular interest to the current project is *Criterion 2*: *The water-dependent ecosystem is natural or near-natural, rare of unique*. This criterion is designed to capture those WDE's that are rare or unique, thereby providing a mechanism to identify the diversity of ecosystems in the Basin as a component of biodiversity under the Act. For example, the only instance of the particular WDE in the Basin e.g. the Coorong Estuary. Collectively, this speaks of the need for an ecologically based robust classification and regionalisation (and their underlying datasets) that can be applied seamlessly throughout the MDB to support the process of determining environmental assets. Application of such a classification and regionalisation scheme will enable both a) the identification of configurations of complementary areas; and, b) comparative assessments between areas. Such areas may be at different scales – for example, they may be at the broader ecosystem level that provides or supports certain ecosystem services (or, functions), or, at a more localised 'site-scale'. It is against this background that the current project was commissioned i.e. to support the process of developing a Classification and Regionalisation of Water-dependent ecosystems of the Murray-Darling Basin, and to identify issues when dealing with existing classification systems and datasets.

Box 2 – Classification Requirements

The ability to be able to compare different water-dependent ecosystems and apply the KEA assessment criteria in a consistent manner identifies the need for a classification that is:

- Applicable at multiple scales (spatial and temporal)
- Utilises and integrates existing datasets – builds on existing work
- Integrates between different aquatic habitats
- Is transparent, comprehensive and inclusive
- Is practical and easy to use and can be applied with different levels of data i.e. workable in both data rich and data poor areas
- Is both scientifically rigorous and ecologically meaningful

Note: KEA *Criteria 5: The water-dependent ecosystem supports or is capable of supporting significant biodiversity* may also be inferred from conceptual modelling based on the classification.

[1] Within this context a water dependent ecosystem refers to a surface or groundwater ecosystem (and its natural components and processes) that depends on periodic or sustained inundation, water logging or significant inputs of water for its ecological integrity.

1.4 Project Objectives and Scope

To assist in the process of developing a classification and regionalisation of the water-dependent ecosystems of the Murray-Darling Basin, the MDBA have engaged Auricht Projects to work jointly with the MDBA and jurisdictions to implement a pilot wetland classification project.

Specifically the consultant is required to:

- Engage with relevant data holders to ensure that their data is available for the pilot process
- Run a workshop to be attended by representatives of each of the Basin States to inform participants of the proposed process and get agreement on the approach
- Run analyses as identified from the workshop
- Report on the outputs including delivery of spatial products as described in the project brief

Based on the overall objectives therefore focus on:

1. Assessing the utility of existing jurisdictional datasets to identify aquatic ecosystems (number and type)
2. Assessing whether the KEA network has 'captured' a representative sample of the habitat types within each jurisdiction. i.e. requires the ability to identify which habitats (either at the individual habitat or aggregated/group complex level) have been identified as Key Environmental Assets
3. Identifying issues encountered as part of the above process
4. Identifying potential next steps

1.5 Project Approach and Methodology

The method adopted for the project has been both analytical and collaborative, adopting a thematic approach in line with the scope and objectives of the project. A schedule of meetings and working sessions was established with the MDBA early in the project in order to develop a program focussing on:

- Organisation and implementation of a workshop
- Identification of jurisdictional contacts
- Development of some form of pilot success criteria
- Data access arrangements to obtain existing classification datasets
- Data collation, harmonisation and validation
- Development of jurisdictional databases
- Data analysis
- Development of standard and value-added outputs
- Synthesis and reporting

Close contact was maintained throughout the process with both jurisdictional contacts and the MDBA project officer Mr. Jeff Richardson. Collectively, this provided a transparent and efficient process in which the consultant worked directly with all stakeholders. In this respect it should be noted however that several data and administration issues were encountered during the collation, harmonisation and validation phase of the project resulting in significant delays and additional (time and processing) resources being expended to complete the project.

To assist in expediting data management processes and to provide a central communication point of information for the project a 'Share-point' web site was established – refer http://www.auricht.com/mdba/index.html user = mdba pass = mdba_10

1.6 Capacity Indicators

It is important that the current project provides a method to enable stakeholders (i.e. the MDBA and State jurisdictions) to obtain an informed view on the current status of existing data in support of a classification and regionalisation for the MDB. The following key capacity indicators (KCI's) have been developed to assist in providing clarity around this requirement:

a) The ability of State datasets to identify aquatic ecosystems (number and type)
b) The ability of State datasets to assess whether the KEA network has 'captured' a representative sample of the habitat types within each jurisdiction
c) The ability of State datasets and classifications to support assessment of rare or unique WDE's
d) The ability of States to apply draft MDBA AE classification attributes to existing wetland layers

2 Status of Datasets and Classification in support of Key Environmental Asset Identification for the MDB

2.1 General

The lack of knowledge on the nature, condition, extent and distribution of aquatic ecosystems throughout Australia has been recognised for some time. In most situations aquatic ecosystem datasets are disparate, fragmented, inconsistent, and collated and stored according to differing standards. In this respect the MDB is no different, and as a result a seamless basin wide coverage based on a standardised (and ecologically meaningful) wetland classification framework does not exist. This in turn creates difficulties when making comparisons, either within or between jurisdictions, and presents substantial challenges for management policy development and implementation.

Box 3 - Classification Dataset Requirements

In order for datasets to be fit for purpose for the identification of KEA's they need to fulfil the following criteria:

- Extent Coverage - Mapping or inventory operating at least at the State level, though Basin-wide or cross-jurisdictional preferred
- Methodology – Approach described in the scientific literature or in technical reports
- Classification Completeness – Needs to be ecologically meaningful i.e. Aquatic Ecosystem classification incorporates a range of habit types below lacustrine, palustrine, riverine classes (and ideally based on attributes)
- Currency – dataset is considered up-to-date
- Accessible – dataset is available
- Format – dataset is in a GIS ready format
- Scale – dataset is at a suitable scale e.g. 1:250,00 or finer

2.2 Potential Aquatic Ecosystem related Datasets

Based on recent inventories, reviews, data trawls and metadata catalogues[2] and the outcomes of the MDBA classification December 2009 workshop, it is clear that a large pool of aquatic ecosystem spatial datasets is available for the MDB. Notwithstanding, the utility and fitness for purpose of these datasets to provide a consistent ecologically meaningful wetland classification dataset for the MDB is very limited, thereby presenting a major challenge to the MDBA. The following provides an overview of selected datasets, along with comments relative to the criteria provided in Box 3 above.

2.2.1 National Level Databases

The Australian Wetlands Database provides online access to information on Australia's Ramsar Wetlands and sites listed within DIWA including criteria for selection and wetland classification classes. Refer: http://www.environment.gov.au/water/topics/wetlands/database/index.html

Comment – Database is available in a GIS ready format and is generally of suitable scale. It is however limited in coverage - both in terms of delineating wetland extent, and capturing all wetlands in an area. It should be noted however that the selection of DIWA and Ramsar sites is not based on a systematic overview of the total aquatic ecosystems or habitats within a region. As a result there are some major constraints when using the dataset to guide the identification of KEA's within the MDB. DIWA and Ramsar databases do however provide a valuable source of contextual information. See for example DIWA and Ramsar information on the Riverland Wetland Complex http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=SA048 and http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=29

2.2.2 MDB Level Datasets

A number of ecological datasets exist for the MDB – see for example, CSIRO's metadata catalogue of ecological related datasets for the MDB as part of the Ecological Outcomes of Flow Regimes project recently completed for the National Water Commission (NWC). Refer Attachment 2 and http://www.csiro.au/resources/Ecological-Outcomes-of-Flow-Regimes-Report.html, and the MDBA's GIS Metadata Catalogue of Environmental Datasets. Refer http://mdba.gov.au/services/spatial_data and http://asdd.ga.gov.au/asdd/tech/zap/advanced.zap?tterm1=the&ffield1=any&syntax=html&number=221&target=mdbc-1&spatialcase=

Of the existing MDB datasets the *Wetlands of the Murray Darling Basin - Series 2 (1993)* is the most relevant dataset. (Note: this dataset is often referred to as the 'Kingsford' layer).

Comment – Dataset is accessible, in a GIS ready format, and at an appropriate scale. It is however restricted in its ability to differentiate between wetland types due to its limited classification element i.e. it is not ecologically meaningful at the scale required for identifying the range of KEA's within the MDB. The actual purpose was to map the maximum extent of the MDB wetlands within a ten year period (1983-1993) based on the presence of water, and to classify these as floodplain wetlands, freshwater lakes, saline lakes or reservoirs. The dataset does however have

[2] See for example the work of Auricht and Watkins in 2008 who conducted a national data trawl of wetland datasets plus http://lwa.gov.au/products/pn22036 and http://lwa.gov.au/products/pn21590

considerable contextual value in that it provides complete Basin-wide extent coverage information based on a standardised methodology.

2.2.3 State Level Datasets

A range of datasets exist at jurisdictional level, however only Queensland and Victoria have a seamless State-level comprehensive coverage of the MDB. In this respect the Queensland data (based on the QLD Wetlands Program) is the most comprehensive in terms of classification detail and derived information products, where-as the Victorian data (based on the 1994 wetland dataset) has good extent data but a relatively limited classification system – it does however have water source, depth, duration and dominant vegetation attributes and therefore has potential to support a more detailed attribute classification. South Australia has excellent wetland spatial and classification data available for the River Murray Floodplain area of the MDB. Outside of this area a Statewide spatial dataset exists in which the entire South Australian portion of the MDB is mapped at approximately 1:50,000. At this stage however, the non-1956 floodplain and non Eastern Mount Lofty Ranges have not been inventoried and validated.. New South Wales has a number of fragmented wetland datasets (often at Catchment Management Authority level), however the only State-wide coverage is the 'Kingsford' layer, which as mentioned above only employs a higher-level classification.

It should be noted that New South Wales, and South Australia are currently working on the development of updated seamless State-wide coverages based on improved classification standards, while Victoria is working on a new classification system based on their existing Statewide coverage. Unfortunately, based on existing resource availability, it is unlikely that these will be available in the immediate to mid-term timeframe for some jurisdictions.

3 Jurisdictional Workshop

A jurisdictional workshop was held in Canberra on 14th December 2009 involving representation from Queensland, New South Wales, Victoria, South Australia, the MDBA and DEWHA.

The aim of the workshop was to:

- Develop and agree on a Basin-wide water dependent ecosystem (WDE) classification
- Clarify the status of existing jurisdictional datasets and the ability to cross-walk State classifications into the MDB classification.

Outcomes from the workshop were reported in a Milestone (project progress report) to the MDBA. The following provides a summary.

3.1 Attributes for an MDB Water Dependent Ecosystem Classification

Overall there was consensus in adopting the Tier 3 AETG[3] national aquatic

[3] The Aquatic Ecosystems Task Group (AETG) is a multi-jurisdictional body established by the Natural Resource Management Ministerial Council (NRMMC) to:

- Provide a nationally coordinated approach to policy development for relevant cross-jurisdictional issues within the aquatic ecosystems context
- Develop a national policy framework for the identification, classification and management of high conservation value aquatic ecosystems (HCVAE's)

ecosystem classification categories i.e. Lacustrine, Palustrine, Riverine, Estuarine, Marine, and Subterranean, which sit above existing habitat mapping activities. Given the current status of the AETG development of the 'Australian National Aquatic Ecosystem' (ANAE) classification (i.e. work on subterranean is somewhat less advanced than other classes) it was decided to concentrate on the inland aquatic group (i.e. lacustrine, palustrine and riverine) in the first instance.

Accordingly (based on recent work by all four State jurisdictions as part of the AETG / High Conservation Value Aquatic Ecosystem, HCVAE. process) there was general consensus that it would possible to contribute towards the development of a consistent classification for Lacustrine/Palustrine and Riverine that is based on a set of standard attributes. In this respect the following attributes were proposed:

Lacustrine / Palustrine

- Climate Zone (Köppen classification) and possibly NSW Alpine classes.
- Water Source (Primary - river, local, groundwater) (Link to NWC)
- Water Type (Fresh, Saline)
- Water Regime (Frequency - Permanent, Seasonal, Ephemeral) and (Duration - Permanent, <= 1 year, > 1 year)
- Soil / Substrate (Rock, sand, mineral, organic)
- Vegetation (Tree, Shrub, Grass/herb/sedge, Submerged)
- Landform (Basin, Flat)
- Landscape context (Floodplain, non-floodplain)
- Hydro-connectivity (Terminal Branch, Through-flow, Over-bank)
- Biodiversity Data (Discussions following the workshop indicate that this should not be considered a classification attribute *per se* but rather be addressed within the KEA process using existing contextual data sources. In many cases reliable data is not available to populate this attribute consistently).

Riverine

- Climate (Köppen classification) and/or some other relevant classification
- Water Type (Saline, Fresh) and Turbidity, Water Chemistry
- Water Regime (Perennial, Ephemeral)
- Landscape Setting (Functional Process Zones and Valley Process Zones FPZ and VPZ's? upland/mid-slope/lowland ?)
- Riparian Vegetation (NVIS and other jurisdictional sources)
- Geology
- Connectivity to groundwater / floodplain

It was considered that the above form a useful starting point from which to look at potential cross-walks with existing State based systems, though it was acknowledged that the availability of attributed datasets (especially for rivers and in the case of New South Wales Lacustrine and Palustrine as well) may pose a major constraint.

3.2 Regionalisation

Regionalisations are a widely recognised and applied geospatial unit for conservation planning that are formulated to represent patterns of environmental and ecological variables known to influence the distribution of biodiversity and features at broad scales. In Australia bioregions have been developed at a continental scale for terrestrial ecosystems (Interim Biogeographic Regions of Australia – IBRA, Tackway and Cresswell, 1995 refer http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html), and marine ecosystems (Interim Marine and Coastal Regionalisation of Australia – IMCRA, which has since been upgraded to the

Integrated Marine and Coastal Regionalisation of Australia refer http://www.environment.gov.au/coasts/mbp/imcra/index.html), however no freshwater ecosystem bioregionalisation or aquatic eco-regionalisation has been developed that has been endorsed for use by jurisdictions. Giving consideration to current timelines for the pilot project and the enormity of the task of developing (and testing the utility and application) of an aquatic ecosystem regionalisation for the MDB it is considered that this task should be postponed until issues surrounding the development and application of an aquatic ecosystem classification are established. It was however identified that such a regionalisation - at the broad level - would logically involve climate, hydrology and geomorphology / physiography (land form) elements as the major drivers of ecological processes. In this respect it should be noted that seamless Australia wide datasets for all three elements currently exist and so the process of developing a form of regionalisation for the MDB has potential merit and is worthy of further consideration.

3.3 Way Forward

The workshop agreed that there was value in:

- Obtaining existing State level wetland datasets – and where appropriate enhancing these through the application of attributes to support the identification of the range of wetlands within each jurisdiction.
- Further exploring the issue of developing a MDB-wide classification for wetlands and riverine categories based on the attributes identified above.

Box 4 – Attributes to Determine Typology

The approach to identifying different aquatic habitats is based on their physical characteristics (attributes) rather than their detailed biodiversity assemblages etc. In this sense, it is the culling and/or combining of various attributes, and 'attribute decision rules' that are key to the process of differentiating different types of habitat. Both Queensland and South Australia have attribute datasets available for the MDB, while Victoria can potentially apply them. Unfortunately New South Wales does not currently have suitable wetland mapping or resources to apply attributes for the NSW portion of the MDB.

4 Analysis and Issues

4.1 Selected Data and Information Sources

Based on a collaborative approach (involving jurisdictions and the MDBA), it was decided to confine the scope of the current pilot to lacustrine and palustrine systems i.e. not include riverine due to the lack of suitable consistent data.

Giving consideration to the criteria presented in Box 3 the following datasets were identified for use within the project:

- Queensland: State-wide Aquatic Ecosystem Assessment (ACA) for riverine (catchments) and non-riverine (wetlands) based on the QLD AquaBAMM methodology and the QLD Wetland Mapping Program dataset. Refer: http://www.epa.qld.gov.au/wetlandinfo/site/SupportTools/AssessmentMethods/AquaBAMM.html Note: two versions of the QLD Wetland Mapping Dataset are available. E.g. Version 1.3 (based on2001 imagery), and Version 2.0 released in 2009 (based on 2005 imagery). Version 2.0 has detailed wetland classification to habitat level based on the QLD wetland mapping typology refer -

http://www.epa.qld.gov.au/wetlandinfo/site/WetlandDefinitionstart/WetlandDefinitions/Typologyintro/Typology.html, however the public domain release of Ver 1.3 only had classification according to major wetland system e.g. Lacustrine, Palustrine, Estuarine, Marine, Riverine (which may include fringing riverine vegetation) and non waterbody/wetlands etc. Both the Ver 1.3 and 2.0 datasets contain a rich level of attribution e.g. hydrologocial and salinity modifiers, water regime, remnant veg cover etc.

Metadata for:

- the QLD Wetland Mapping dataset is at http://atlas.information.qld.gov.au/atlas/WetlandMaps/metadata/QLD_WETLAND_MAP_SYSTEM.xml
- QLD Wetland Springs is at http://atlas.information.qld.gov.au/atlas/WetlandMaps/metadata/QLD_WETLAND_MAP_SPRINGS.xml and
- QLD Wetland Streams Mapping is at http://atlas.information.qld.gov.au/atlas/WetlandMaps/metadata/QLD_WETLAND_MAP_STREAMS.xml

- New South Wales: no appropriate aquatic ecosystem classification data layer available. As such, NSW has been excluded from the pilot.
- Victoria: State-wide 1994 wetland layer. Refer http://metadata.nre.vic.gov.au/metadata/anzlic_report.cfm?dataset_name=WETLAND_1994). Only has classification information at the higher 'system' type level – though it has some good attribute information e.g. water source, depth and dominant vegetation. Victoria agreed to enhance this dataset by applying additional attribute information e.g. climate etc to a subset of MDB aquatic ecosystems which meet KEA criteria . The resultant dataset would then support the identification of specific aquatic ecosystem types below the system level. Similarly through the use of attribute filtering or structured query procedures it will be possible to identify types meeting certain criteria. Victoria also has a river reach dataset – though this was not included within the scope of the current project.
- South Australia: River Murray 2008 Wetland Mapping (based on DIWA classification), updated in 2009 to incorporate the recently developed South Australia Aquatic Ecosystem (SAAE) Classification. South Australia also has a Flood Plain Inundation Response Unit (FIRU's) dataset which is a higher level spatial unit above the wetland mapping layer that illustrates the extent of floodplain wetting at various volumes. South Australia also has a river reach dataset. Other data of interest is the updated wetland prioritisation dataset containing information on condition and value at the individual wetland habitat level. Note: identification of KEA's for the River Murray region of the MDB occurs at the FIRU scale.

Additional material for all jurisdictions includes the KEA assessment database i.e. MDBA criteria and environmental values.

4.2 Application and Utility of Existing Datasets

One of the central aims of the current project was to identify the range of issues encountered when applying jurisdictional classifications and datasets in the support of a standardised water dependent ecosystem classification for the MDB.

The following presents a brief outline of issues identified for testing at State level, along with summary data processing work-flows and analysis of jurisdictional wetland datasets. A review of issues encountered is also provided for each jurisdiction.

4.3 Queensland Work-Flow and Analysis

As indicated above, Queensland is well positioned with wetland mapping data at both the system and habitat level. Following a review of existing QLD data available to the project it was decided to test the utility of this data to identify a) the number and types of wetlands, b) how these are represented as KEA's within the MDB e.g. how many occur as Category 1 - IKEA, Category 2 (i.e. occurring in largely hydrologically unmodified catchments), or Category 3 KEA types.

Aim – To identify (number and type) of aquatic ecosystems within the QLD portion of the Murray-Darling Basin and to assess which have been identified as Key Environmental Assets.

Data sources – The following datasets are available:

- Wetland mapping from the Queensland wetland mapping dataset ver 1.3 (Based on 2001 Landsat Imagery)
- Wetland mapping from the Queensland wetland mapping dataset ver 2.0 (Based on 2005 Landsat Imagery)
- The QLD MDB ACA riverine and non-riverine datasets. KEA's have been identified for Riverine (based on sub-catchments) and non-riverine based on the application of the QLD AquaBAMM Aquatic Conservation Assessment (ACA) methodology. In the case of the non-riverine assessment KEA identification it is understood that the lineage for the wetland polygons can be traced back to the wetland mapping Ver 1.3 dataset however, some changes were been made, and as a result there is not always a 1:1 match between the ACA non-riverine dataset and the Ver 1.3 wetland mapping dataset. It is understood that some of the changes included removal of artificial and highly modified habitats etc. Figure 1 below illustrates some of the differences between the version 2.0 and 1.3 datasets. In this case the outline blue polygon on the left is from the ver 1.3 which contains two ver 2.0 wetland types.

Figure 1: Version 1.3 mapping dataset on the left which contains two ver 2.0 habitat types.

Other datasets of relevance include the MDBA's Category 1: IKEA and Category B (Largely hydrologically unmodified catchment) areas.

Scope – Given that the riverine KEA's have only been identified at the sub-catchment scale (based on reaches) and don't include a riverine habitat typology the overall QLD analysis was confined to the non-riverine (i.e. wetland) dataset.

Processing Work-flow – As mentioned above, the ACA KEA data non-riverine layer (based on the Ver 1.3 wetland mapping) does not have wetland habitat typology integrated into the dataset. As such, it was not possible to do a simple structured query language (SQL) query on the database to select KEA's that meet MDBA criteria and analysis these by wetland habitat type. Given that the Version 2.0 wetland mapping dataset does have wetland habitat typology included, a theme-on-

theme (spatial relationship) routine was carried out to integrate the version 2.0 wetland typology into the Ver 1.3 and ACA KEA datasets. This was achieved by adding a new attribute field 'Hab_Type' to both the ver 1.3 wetland mapping and ACA KEA datasets and populating it based on the results of the spatial relationship routine. It was then possible to carry out an analysis to identify the type of wetlands within the Ver 1.3 and ACA non-riverine datasets.

KEA wetlands were subsequently identified based on a simple SQL query to select any wetlands within the ACA dataset that meet one of the MDBA criteria 2-5. Note: criteria 1 international recognition for QLD is to be achieved via other data sources e.g. Ramsar etc. The actual expression for the above query is "MDBA_cr2" = 'y' OR "MDBA_cr3" = 'y' OR "MDBA_cr4" = 'y' OR "MDBA_cr5" = 'y'.

Analysis - The results of the above analysis are presented in Table1 below. In summary a total of 14,308 wetland polygons from the QLD wetland mapping version 1.3 dataset are located within the MDB, of which a number are actually unclassified and some contain more than one ver 2.0 wetland type. Based on the results of the spatial relationship mentioned above - and analysis of the ACA KEA dataset for wetlands that meet at least one of the MDBA criteria - it can be seen that a total of 10,810 wetland records occur within the MDB of which 3013 (or 28%) meet at least one of the MDBA criteria. (Note the figure of 10,810 exclude riverine and unknown habitats). Of the KEA wetland records that meet MDBA criteria, 46 or 2% are located within the MDBA's IKEA category, 931 or 31% occur within the KEA Category 2 (largely hydrologically unmodified catchment) group, and 2,039 or 68% occur only as Category 3 KEA assets. Based on Table 1 it is also evident that of the nineteen wetland habitat types (excluding riverine and unclassified types) that occur within the QLD portion of the MDB all are represented as a KEA's - either as a Category 1, 2 or 3 KEA assets. As such, it can be concluded that the full range of wetland types are represented. An indication on the actual percentage of each wetland type represented as a KEA is also presented. In this respect Arid / Semi-arid Saline Lakes (12%), Arid / Semi-arid non-floodplain lignum swamps (15%), Arid / Semi-arid non-floodplain grass, sedge, herb swamps (22%), Arid / Semi-arid fresh non-floodplain lakes (16%), and Arid / semi-arid fresh non-floodplain lakes – claypans (24%) are all below 25 % represented (based on the total number that occur). This may be an issue requiring further consideration by the MDBA and demonstrates that standard conservation planning methods as they relate to levels of protection (i.e. percent represented) can be applied. Refer Box 5. Note: Riverine 0.2% is not considered relevant as these sites will largely be picked up within the riverine dataset.

Data Issues – The main issue encountered with the Queensland datasets related to the lack of uniformity in wetland Id's between the Version 1.3 and 2.0 datasets, and the ACA dataset – even though in some cases the geometry between the datasets remained the same. This created a minor delay when joining various datasets based on unique wetland Id. These limitations were however overcome following discussion with technical staff in Queensland to provide clarity around the use of the wetland polygon Id attribute.

Other issues include the number of wetland polygons classified as unknown, though these are not considered to pose any real issue for the MDBA in using existing Queensland datasets. For example, of the 15,928 version 2.0 polygons within the QLD portion of the MDB, a total of 1,750 (approx 11 per cent) are unclassified. Interestingly, of these a subset of 1,150 (or approx 7 per cent) are less than 5 hectares. It is possible that the presence of these polygons may in part be attributed to noise in the process of integrating satellite derived information into the mapping process.

Box 5 – CAR Principles

The method developed for the identification of KEA's gives consideration to the CAR principles as used by the National Reserve System (NRS).

In this respect the NRS is underpinned by a scientific framework to ensure that Australia progressively extends protection to examples of all our ecosystems.

The scientific framework has a clear objective – to develop a 'comprehensive, adequate and representative' system of protected areas – commonly referred to as the 'CAR' reserve system.

Specifically CAR means:

- Comprehensive: the inclusion in the National Reserve System of examples of regional-scale ecosystems in each bioregion
- Adequate: the inclusion of sufficient levels of each ecosystem within the protected area network to provide ecological viability and to maintain the integrity of populations, species and communities
- Representative: the inclusion of areas at a finer scale, to encompass the variability of habitat within ecosystems

The goal of a CAR system of reserves for Australia was endorsed by all Australian governments as signatories to the National Strategy for Conservation of Australia's Biological Diversity (1996), and the National Forest Policy statement (1992)..

Other issues – the high number of wetland polygons that actually fulfil one of more KEA criteria (i.e. 3,013 out of the 10,810 classified polygons) identifies the need for some form of aggregation and higher spatial management unit when considering KEA's. (Note: in this respect South Australia chose their higher level FIRU unit for the identification of KEA's i.e. they realised the individual polygon layer didn't take into consideration connectivity of lower level aquatic ecosystems with other wetlands, floodplains or habitats etc).

Value-added products – As part of the current project it has been possible to create a single spatial layer combining both wetland type and KEA attribute information for Queensland. Additional tasks carried out on the Queensland dataset included analysis of the MDBA's draft spatial layers for Indicative Key Environmental Assets (IKEA;s) and Category 2 areas (i.e. largely hydrologically unmodified catchments) to determine what wetland types they include - based on the QLD wetland mapping series version 2.0 dataset. The results of this work revealed that six wetland types (excluding flood plains) are represented in IKEAs', and fifteen types within Category 2 (largely hydrologically unmodified catchments). Copies of the actual analysis spreadsheets and GIS data layers are available from the share-point web site.

Gaps - Further work is required in Queensland to complete datasets for riverine and subterranean attributes thereby completing the coverage of all aquatic systems within the QLD portion of the MDB.

Table 1: Analysis of QLD wetland types and MDBA KEA Criteria

Code	Typology	Total number of each wetland type Ver 1.3	Total # wetlands that meet a criteria	Category 1 IKEA	Category 2 Largely unmodified Catchments	Category 3 Other KEA's	Total KEA % Re-presented	Total # non-KEA i.e. don't meet criteria	Total non-KEA %
6	Coastal/ Sub-coastal floodplain lakes	87	29	4	0	25	33%	58	67%
9	Coastal/ Sub-coastal non-floodplain soil lakes	16	6	0	0	6	38%	10	63%
10	Arid/ Semi-arid saline swamps	13	4	0	4	0	31%	9	69%
14	Arid/ Semi-arid saline lakes	33	4	0	2	2	12%	29	88%
15	Arid/ Semi-arid fresh floodplain lakes	28	10	0	8	2	36%	18	64%
40	Artificial/ highly modified wetlands (dams, ring tanks, irrigation channels, drains, canals)	4113	505	12	31	462	12%	3608	88%
11a	Arid/ Semi-arid floodplain tree swamps	211	54	0	45	9	26%	157	74%
11b	Arid/ Semi-arid floodplain lignum swamps	132	48	0	41	7	36%	84	64%
11c	Arid/ Semi-arid floodplain grass, sedge, herb swamps	44	28	1	13	14	64%	16	36%
12a	Arid/ Semi-arid non-floodplain tree swamps	130	53	0	4	49	41%	77	59%
12b	Arid/ Semi-arid non-floodplain lignum swamps	374	55	0	21	34	15%	319	85%
12c	Arid/ Semi-arid non-floodplain grass, sedge, herb swamps	931	202	0	102	100	22%	729	78%
16a	Arid/ Semi-arid fresh non-floodplain lakes	148	24	0	23	1	16%	124	84%
16b	Arid/ Semi-arid fresh non-floodplain lakes - claypans	2611	627	0	619	8	24%	1984	76%
2a	Coastal/ Sub-Coastal non-floodplain tree swamps (Melaleuca and Eucalypt)	53	14	0	4	10	26%	39	74%
2c	Coastal/ Sub-coastal non-floodplain grass, sedge and herb swamps	1	1	0	0	1	100%	0	0%
4a	Coastal/ Sub-coastal floodplain tree swamps (Melaleuca and Eucalypt)	877	526	22	11	493	60%	351	40%
4b	Coastal/ Sub-Coastal floodplain wet heath swamps	5	5	0	0	5	100%	0	0%
4c	Coastal/ Sub-coastal floodplain grass, sedge and herb swamps	1003	818	7	0	811	82%	185	18%
	Total	**10810**	**3013**	**46**	**928**	**2039**			

4.4 South Australian Work-Flow and Analysis

Aim – To assess the utility of existing datasets to identify aquatic ecosystems (number and type) within the South Australia portion of the Murray-Darling Basin, and to assess which have been identified as Key Environmental Assets.

Data sources – The following datasets are available for South Australia:

- 2008 Wetland mapping for the River Murray Floodplain classified according to DIWA (Shapefile)
- 2009 wetland mapping for the River Murray Floodplain classified according to both the recently developed South Australian Aquatic Ecosystem (SAAE) classification and DIWA (Shapefile). Note: This dataset was updated as part of the current project with actual attribute information incorporated into the dataset.
- Floodplain Inundation Response Units – FIRU's (KEA Management Asset Unit level) Shapefile
- KEA MDBA criteria and Environmental Values Assessment (Excel Spreadsheet)

Other datasets of relevance include the MDBA's Category 1 IKEA and Category 2 (Largely hydrologically unmodified catchment) areas. (Note: Wetland mapping and drainage lines across the state are also available, along with reach type and wetland classification in the Eastern Mount Lofty Ranges EMLR – as part of the EMLR Water Allocation Plan. It is understood that the Coorong and Lower Lakes has also been mapped with improvements currently being made to apply the South Australian Aquatic Ecosystem, SAAE, Classification to the dataset).

Scope – The spatial extent of the above datasets is confined to the 1956 flood level which in effect includes all wetlands within the River Murray portion of the MDB from the Lower Lakes to the Victorian/New South Wales border. It doesn't however include KEA's identified outside this area such as those on the Eastern Mount Lofty Ranges.

The 2009 wetland mapping doesn't have the SAAE classification applied to the Lower Lakes, though this is currently being addressed under a separate process. For the purposes of the current project, analysis was completed on the 2009 SAAE wetland mapping dataset and the 2009 KEA units (which as mentioned above are based on the FIRU units).

Processing Work-flow – Involved initial data quality routines to check integrity of the underlying data sources including field type, range checks and missing data etc. Observations of the 2009 wetland polygon dataset revealed that the SAAE attribute information was stored as descriptive text rather than as a 'code' which would create processing inefficiencies. As a result, a database routine was run to recode these to conform to standards developed as part of the 'River Murray Wetland Classification Project (DEH)'. Refer Table 2 for a list of types and codes. In addition, a new code 'Unk' was added for records where no classification information was available i.e. it hadn't been classified (i.e. un-assigned or unknown) at this stage.

Error checks were also run on the FIRU layer. This layer was found to contain 113 records of which one was identified as 'unknown'. Further observation of this record reveals that it was in fact a multi-part polygon comprising 48 separate parts – mostly comprising old dairy flats in the lower portion of the river, or small unclassified areas. Refer Figure 2. A data processing routine was subsequently run to explode the unknown FIRU into separate polygons, with an additional routine used to assign Id's for these new records. As a result the final FIRU dataset contained 160 records of which 48 are unknown. Additional fields were then added to the FIRU spatial layer for:

- Specific type and area for each habitat known to occur within the area of interest
- Total Area (Hectares and Sq Km)
- Combined SAAE types

Table 2 SAAE Wetland Types within the River Murray

CODE	TYPE	Count
ER	Ephemeral Reach	150
FP	Floodplain	2
PLTB	Permanent Lake - Terminal Branch	73
PLTF	Permanent Lake - Throughflow	79
PR	Permanent Reach	128
PSTB	Permanent Swamp - Terminal Branch	63
PSTF	Permanent Swamp - Throughflow	63
SSW	Saline Swamp	39
SR	Seasonal Reach	8
TWOB	Temporary Wetland - Overbank Flow	345
TWTB	Temporary Wetland - Terminal Branch	200
TWTF	Temporary Wetland - Throughflow	238
	Total Count	1,388

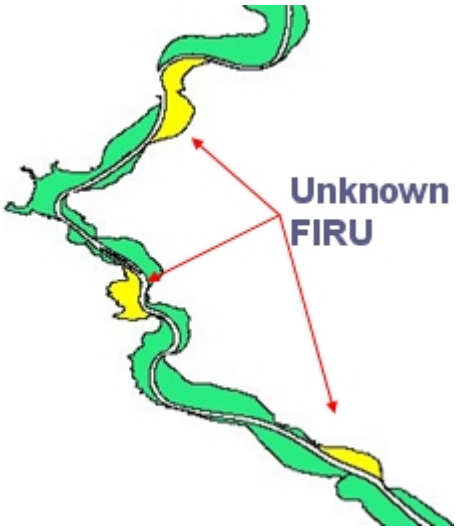

Figure 2: Unknown 'multi-part' FIRU record

Two theme-on-theme spatial relationship routines were then completed to identify which SAAE wetland habitats (number, total area and type) occur within each FIRU unit. The first assigned counts and area for each SAAE type within each FIRU unit, while the second populated the combined SAAE type field. Cross-checking between the outputs of the two routines provided an added level of quality assurance.

Additional routines were also carried out to join the KEA spreadsheet to the spatial new FIRU layer. This process was reasonably straight forward however, some correction was required do to spelling mis-matches between the two data sources.

Integration of the KEA spreadsheet has the added value in that it contains information on the number and type of KEA criteria meet, justification and environmental values.

Note: the original wetland polygon dataset did not contain SAAE attribute information. Following discussion with jurisdictional staff this data was added as part of an updated wetland layer which now contains complete information on SAAE habitat type, climate, landscape setting, landform, substrate, hydrology, water source, salinity, inflow and persistence attributes.

Analysis – The resultant database was then analysed to determine whether all SAAE wetlands types were included within South Australia's KEA dataset. Observation of Tables 2 and 3 reveals that all wetland types occurring within the South Australian portion of the River Murray are indeed represented as KEA's, and that many of the KEA FIRU assets contain a large mix of wetland types. For example, the Katarapko Floodplain complex contains 144 separate wetlands comprising nine different wetland types, while the Riverland Ramsar FIRU contains 98 wetland features comprising all twelve wetland types.

Of the FIRU assets identified within the River Murray area only nine i.e. Cowirra Landing, Maidment Lagoon, McBean Pound Complex, Paschkes Flat, Pellaring Flat, Reedy Island Flat, Teal Flat, Tobalong, and opp. Murbko Flat (u/s end) do not meet any KEA criteria. (This represents less than 1% of the 112 FIRU's included in the analysis). Further, a total of 22 FIRU's or approx 20% meet 1 KEA criteria, 27 or 24% meet 2 KEA criteria, 23 or 21% meet 3 KEA criteria, 16 or 14 % meet 4 KEA criteria, and 15 or 13% meet all 5 KEA criteria.

Issues – As a result of routine checks on the original 2009 wetland polygon dataset a number of minor issues were identified. For example, 893 of the 2,963 wetland polygons were below 1 hectare, of which 433 did not have a typology applied to them. These issues were subsequently addressed in collaboration with jurisdictional staff resulting in a number of small un-assigned wetland areas (Slither type polygons) being eliminated and the overall dataset updated – including the incorporation of SAAE classification attributes. As such, the final dataset now contains a total of 1,611 polygons of which 1,388 occur within FIRU's. Importantly none are un-assigned.

Though the above issues caused some delays in the work plan, overall both the FIRU and wetland polygon layer are now considered rigorous. As such, it can be concluded that the South Australian River Murray datasets now provide an excellent basis for supporting spatial KEA type analysis and the development of a wetland classification system for the MDB. Further, given the relative consistency between South Australia, Queensland and Victorian attributes it is possible through standard database routines to undertake various comparative analyses involving all three datasets. It should be noted however that this process was not carried out as it was identified as being out of scope for the current pilot.

Gaps - Further work is required in South Australia to complete SAAE habitat datasets for the Lower Lakes and Eastern Mount Lofty areas thereby providing a full coverage for the South Australian portion of the MDB. It is understood that South Australia is working to address these issues and for the River Murray region is also currently working on an integrated database which incorporates the wetland mapping (including updated condition, values and prioritisation information), river reaches and FIRU's into the one corporate database with standard naming and coding conventions applied.

Table 3: Analysis of South Australian Wetland Types and MDBA KEA Criteria

ASSET_NAME (FIRU)	No of KEA Criteria	HECTARES	WDE Poly Count	SAAE_TYPES	DIWA_TYPES
Ajax Achilles	4	104.785	3	PLTF, TWTB, TWOB	B9, B10
Banrock Ramsar Complex (inc Wigley Reach)	5	1251.343	35	TWOB, TWTF, PSTF, PR, ER, TWTB	B12, B10, B1, B4, B9
Big Bend	1	242.929	4	PSTB, TWOB, PLTF	B9, B4
Big and Little Toolunka	5	811.801	22	ER, TWTF, TWTB, TWOB, PLTF, PLTB, PR, SSw, PSTF	B10, B12, B1, B9, B2
Boggy Flat	3	31.706	5	ER, PR, TWTB, PLTF, PLTB	B10, B9
Bow Hill	1	127.849	4	PLTF, TWTB, PLTB	B9
Brenda Park / Morphetts Flat Complex	4	802.3	19	PSTB, PLTF, TWTF, TWTB, PR, ER	B6, B2, B10, B1, B9
Cadell Complex	3	272.737	7	ER, TWTB, TWTF, SSw	B12, B10
Caurnamont	2	234.291	2	TWOB, PLTB	B9, B12
Clarks Sandbar	2	347.751	1	SSw	B10
Complex opposite Yarra Glen	2	153.123	5	TWTF, TWOB	B12, B10
Coolcha Lagoon	2	209.154	2	PLTB, PLTF	B9
Cowirra Landing	0	480.818	4	PLTB, TWOB, TWTF, TWTB	B10, B9
Craignook	3	277.079	7	TWTB, TWTF, TWOB, PLTB, PLTF	B10, B12, B9
Devlins Pound	2	114.405	4	TWTF, TWOB, PSTB	B9, B12
Devon Downs Complex	4	1086.649	17	PR, TWOB, PLTB, PLTF, ER, PSTF, TWTB	B9, B12, B1, B4, B11, B5
Disher Creek	3	2123.182	8	SSw, TWOB, TWTB, PR, TWTF,	B12, B1, B10, B4
Donald Flat	1	371.963	6	ER, TWOB, TWTF, TWTB, PLTF	B10, B6, B4, B9
Forster Lagoon	2	214.743	2	PLTB, PR	B9, B1
Glen Devlin Complex	3	311.669	9	TWTF, TWOB, TWTB	B10, B4, B12
Glen Lee	1	113.788	3	ER, TWTB, TWOB	B12, B10
Greenways Landing	1	45.443	2	TWTB, PLTB	B12, B9
Gurra Floodplain	5	3315.078	42	TWOB, TWTB, PSTB, PLTB, TWTF, ER, PR, PLTF, SSw	B12, B10, B2, B9, B6, B8, B5, B1
Hart Lagoon	4	275.544	2	PLTB, TWTB	B6, B10
Hogwash Bend Complex	3	204.158	8	TWOB, TWTB, ER, TWTF	B10, B6, B12
Holder Bend/Ross/Jaeschke	1	421.157	6	TWTF, PLTF, TWOB, TWTB	B10, B12, B5, B6
Irwin Flat	3	201.994	15	TWTF, TWTB, PLTF, TWOB, PSTB	B12, B10, B9
Island Reach	1	260.874	10	TWTB, TWOB, TWTF	B10, B11, B4, B12
Katarapko Floodplain	5	8839.807	144	ER, TWTB, TWOB, TWTF, PSTB, SR, PR, PSTF, PLTB, SSw, PLTF,	B10, B12, B1, B2, B9, B7, C6, B4, B6, Unk

ASSET_NAME (FIRU)	No of KEA Criteria	HECTARES	WDE Poly Count	SAAE_TYPES	DIWA_TYPES
Kingston Common	1	150.45	4	TWOB, PSTF	B9, B4
Kroehns Landing	2	192.777	5	PLTF, TWOB, PR, PLTB	B10, B5, B1
Lake Carlet	5	547.075	8	PLTF, PLTB, TWOB, PSTF	B9, B10, B5
Lara Inlet	2	24.61	2	TWTB, ER	
Loch Luna and Wachtels Lagoon	5	6446.492	25	ER, PR, SSw, PSTB, TWTB, PSTF, SR, TWOB, PLTF, TWTF, PLTB,	B9, B5, B1, C7, B10, B12, B4
Loveday Swamps and Mussel Lagoons	3	1509.369	18	ER, TWOB, PSTB, PLTB, TWTB, PSTF, TWTF, SSw, PR	B6, B1, B10, B9, B2, B12
Loxton Floodplain	2	69.651	3	TWTB, TWTF, TWOB	B12
Lyrup Causeway	3	325.262	17	TWTB, TWTF, TWOB, PLTB, PSTF, PSTB	B4, B12, B9, Unk
Lyrup East	1	265.389	15	TWOB, TWTF, TWTB, SSw, PSTB, PLTF	B9, B10, B12
Maidment Lagoon	0	154.824	6	TWOB, PLTB, PLTF, TWTB	B5, B9, B12
Maize Island Complex	2	376.269	9	TWTF, TWTB, TWOB, ER	B2, B10, B9
Mannum Swamps	3	301.348	2	PLTB, PLTF	B9
Markaranka Complex	4	564.804	11	TWTF, TWOB, ER, TWTB	B9, B12, B10, B6
Marks Landing	1	393.593	3	PLTF, PR	B9, B1
Martins Bend	3	200.634	7	PSTB, TWTB, PLTF, SSw, TWOB, TWTF	B12, B9
Mason Rock	2	504.838	1	PSTF	B9
McBean Pound Complex	0	115.652	4	ER, PSTF, PLTB	B9
Mobilong Swamp incl. Rocky Gully	5	514.596	6	TWTF, TWTB, PR, SSw	Unk, B10, C1, C7, B3
Molo Flat (Taylors Flat) (including imm u/s of Mo*	2	632.847	5	TWTF, TWTB, ER	B6, B10
Moorundie Complex	4	1588.613	20	TWTF, PLTB, PLTF, TWOB, FP, PR, TWTB, PSTF, ER	B1, B12, B5, B9, B2, B10, B4, B6
Morgan East & Morgan CP	4	526.634	23	TWTF, PR, PLTF, TWOB, TWTB, ER	B10, B9
Murbko Flat Complex	3	573.428	10	PSTF, TWTF, PR, TWOB, PLTF, TWTB	B12, B9, B4, B10
Murbko South Complex	2	265.642	11	PLTB, TWTF, PR, TWOB, TWTB	B1, B5
Murbpook Lagoon	3	280.197	5	PSTF, PLTB, TWTF	B9, B10, B6
Murrundi	3	1861.808	4	PSTF, TWOB, TWTB	B9
Mypolonga/Toora Levee/Jury Swamp	4	930.545	7	PSTF, TWOB, PSTB	B9, B10, B12
Neeta Flat Depressions	3	656.954	7	TWOB, ER, TWTB	B10, B2, B4, B12
Nelwart / Bookmark	1	731.951	8	PLTB, TWOB, TWTF, SR, PSTB	B2, B9, B5
Nigra/Schillers	5	565.032	14	TWTF, PR, TWOB, PLTF, PSTB, TWTB, ER	B6, B10, B2, B1, B12, B9
Nikalapko Complex	2	637.518	8	TWTB, TWTF, TWOB	B10, B4, B12, B6

ASSET_NAME (FIRU)	No of KEA Criteria	HECTARES	WDE Poly Count	SAAE_TYPES	DIWA_TYPES
North Caurnamont	1	193.654	6	PLTF, TWOB, TWTB, PLTB	B10, B9, B12, B5
North Purnong	2	163.187	2	PLTF, PLTB	B9
North West Bend	3	633.601	7	TWTF, TWOB, PSTF	B9, B12, B8, B10
Overland Corner	4	475.08	14	TWOB, PR, TWTF, ER, TWTB	B10, B4, B12
Paisley Creek/Edsons Flat	3	237.138	6	TWTB, PLTF, PLTB, PSTF	B9, B10
Parcoola West	2	256.411	4	TWTF, TWOB, TWTB	B12, B10
Paringa Paddock	4	806.33	16	PSTB, TWTF, PLTB, TWOB, PR, PSTF	B10, B9, B4
Paschkes Flat	0	162.935	2	TWTB	B10
Pellaring Flat	0	323.507	5	PLTB, PSTF, TWOB	B9, B10
Penns Inlet	1	35.549	2	PSTF, PSTB	B9
Pike-Mundic	5	6438.007	109	TWOB, TWTB, PLTF, TWTF, PSTB, ER, PR, PSTF, PLTB	B10, B12, B9, B1, B4, B2, Unk, B8, B5
Pompoota/Paiwalla/Sunnyside	4	461.617	6	PSTB, PSTF, PLTB	Unk, B9
Punyelroo	2	354.497	4	TWOB, PSTB, PLTB	B9, B4
Pyap Complex	4	1904.485	24	TWTB, PLTF, TWTF, TWOB, PR, ER	B2, B9, B10, B12, B8, B1
Qualco Swamp	1	204.609	2	TWOB, TWTB	B10
Ramco Lagoon	5	182.877	3	SSw, PR	B1, B6
Reedy Creek Mannum	5	611.091	17	TWOB, TWTF, TWTB, PSTF, PLTF	B10, B12, Unk, B3, B9
Reedy Island Flat	0	121.856	2	PSTF, TWTB	B9
Reid Flat	1	210.159	2	TWTF, TWTB	B4
Rilli Lagoons	4	272.979	10	TWOB, TWTF, TWTB	B10, B12
Riverglades	4	78.008	2	PSTF	B9
Riverland Ramsar	5	29851.428	298	ER, PSTB, PR, TWOB, TWTF, TWTB, PSTF, PLTB, SR, SSw, PLTF, FP,	B10, B2, B9, B1, B12, B4, B5, B8, Unk, B6
Roonka/Arlunga	1	485.148	13	TWTB, TWOB, PSTB, PSTF, ER, PLTF, PR	B10, B12, B9, B1
Saltbush Flat	1	253.39	4	TWTB, PLTF, PR, PLTB	B10, B9, B1
Sinclair Flat	2	142.068	7	PSTF, TWTF, PLTF, PLTB	B9
Smiths Swamp	1	29.009	7	TWOB, PLTB, PSTB	B9
Spectacle Lakes / Beldora Complex	5	1881.688	40	TWTF, TWOB, TWTB, ER, PR, PSTF, PLTB	B12, B10, B2, B6, B9
Swan Reach Complex	5	615.26	15	TWOB, PLTB, PLTF, PR, TWTB	B5, B9, B10, B4, B12, B1
Swan Reach Ferry	2	316.658	2	PLTF, TWTB	B9, B12
Swanport Wetland	3	113.587	1	PSTF	B9
Tailem Bend	3	198.276	1	PLTB	B9

ASSET_NAME (FIRU)	No of KEA Criteria	HECTARES	WDE Poly Count	SAAE_TYPES	DIWA_TYPES
Taworri Complex	2	163.988	8	TWOB, TWTB, PLTF, PLTB	B12, B9, Unk, B10
Teal Flat	0	203.253	3	PLTB, TWOB	B9
Thiele Flat	2	126.351	3	ER, SSw	B8
Tobalong	0	577.971	3	PSTF, PLTB, TWOB	C2, B10, B9
Ukee Boat Club	2	254.498	1	PSTF	B9
Walker Flat Complex	2	334.962	4	PSTB, ER, PLTB, PSTF	B5, B9
Wall Levee/Wood Lane	3	340.971	2	TWOB, PSTB	B9, B10
Wall Swamp	2	37.971	1	PLTF	B9
Wellington Complex	4	496.669	2	TWTB, PLTF	B10, B9, Unk
Wellington Spit	3	215.534	0		B13, B9, B10
Weston Flat Lagoon	1	182.407	2	TWTF	B10
Wigley Flat (Akuna)	3	136.745	4	TWTF, TWTB	B4, B10
Wongulla Lagoon/Marne Mouth	5	363.592	5	TWTF, TWOB, PLTF	B5, B12, B4
Yarra Complex	3	814.914	15	TWTF, TWOB, TWTB, PLTB, ER	B10, B12, B9
Yatco Lagoon	4	1081.822	11	PLTF, PR, ER, TWTF, TWTB, TWOB	B12, B5, B2, B10
Younghusband Complex	1	132.399	12	PSTF, PLTF, TWTB, TWTF, PLTB, TWOB	B12, B8, B9, B4
Younghusband West	2	252.219	6	TWTB, TWOB, TWTF, PLTF	Unk, B9, B10
opp. Hogwash Bend	1	168.601	2	TWTF	
opp. Murbko Flat (d/s end)	1	25.278	0	None	
opp. Murbko Flat (u/s end)	0	11.587	0	None	
opp. Swan Reach Complex	2	39.988	1	TWOB	B2
opp. Ukee	2	61.253	4	TWTB, SSw	
Total			**1,388**		

4.5 Victorian Work-Flow and Analysis

Aim – to identify the range of issues encountered when applying classification attributes to the Victorian 1994 wetland layer.

Data sources – The following datasets are available:

- State-wide 1994 Wetland mapping Ver 2.0 (Shapefile)
- DIWA KEA dataset (Shapefile) KEA MDBA criteria and Environmental Values Assessment (Word Document
- KEA MDBA criteria and Environmental Values Assessment (Word Document)
- Wetland typology attribution for KEA wetland assets (Access database)

Other datasets of relevance include the MDBA's Category 1 IKEA and Category 2 (Largely hydrologically unmodified catchment) areas.

Scope – As mentioned previously Victorian only have higher level type classification information available. A review of metadata reveals this is based on coarse hydrological and vegetation attributes for the following categories – Deep marsh, Shallow marsh, Meadow, Open water, Permanent Saline and Semi Saline. The dataset does however have useful attribute information e.g. water source, depth and dominant vegetation etc. For the purposes of the pilot project the extent of the datasets for Victoria is confined to those records that have been identified as KEA's within the Victorian portion of the MDB. Within the above context, tasks carried out for Victoria were confined to identifying the issues encountered when applying classification attributes and linking KEA contextual information i.e. aquatic ecosystem types (based on various attribute combinations) were not defined, nor analysis for representativeness carried out.

Processing Work-flow – several preliminary data quality routines were completed to check the integrity of the underlying data sources including field type, range checks, duplicates spatial records, missing data and the existence of unique Id's between spatial and contextual datasets etc. Cross-checks between the various contextual (Word document and Access Database) and spatial datasets identified a number of issues requiring attention to ensure datasets were both rigorous and suitable for processing. Collectively, this resulted in a number of data cleansing steps which in effect culminated in a form of 'standard' being enforced.

As a result, the work-flow completed involved:

- Data access
- Data collation, harmonisation and validation
- Data linkage between spatial and contextual layers

Attribute Application – the process of applying attributes to the KEA spatial data involved categorising each of the 176 records (that comprise 82 separate KEA complexes) according to the following:

- System Type – Lacustrine (58), Riverine (2), or Palustrine (116)
- Climate – Semi-arid (75), or Temperate (101)
- Water Source – Groundwater (50), Local (35), or River (91)
- Water Regime Frequency – Ephemeral (16), Permanent (1), or Seasonal (159)
- Water Regime Permanency - <= 1 Year (173), > 1 Year (2), or Permanent (1)
- Water Type – Fresh (120) or Saline (56)
- Soil Substrate – Unknown (Resources not available to populate records for this attribute)

- Dominant Vegetation – Grass/herb/sedge (33), Shrub (2), Tree (83), or None (58). Note: additional information for other vegetation is also included within the dataset.
- Landform – Basin (176) or Flat (0)
- Landscape Context – Floodplain (117), or Non-Floodplain (59)
- Hydrological Connectivity – Over-bank (84), Terminal Branch (59), or Through-flow (33)
- Additional notes – supplementary information was included for wetlands that receive water from more than one source and where water regime permanency differs for certain elements of the wetland complex

Additional documentation outlining the methods employed when applying the above attributes is given as Attachment 3.

Analysis – Due to resource constraints, no major analysis of the dataset was planned, however based on the information presented above it is clear that a suitable database capable of supporting analysis now exists. As such, Victoria is currently well placed to support the process of identifying specific wetland types based on standard database queries. For example, it is possible find all records matching the following criteria – Palustrine, Semi-arid, River source, Ephemeral wetlands. Running this query returns 8 records based on the following SQL expression "Type" = 'Palustrine' and "Climate_zone" = 'Semi-arid' and " Water_source " = 'River' and "Water_regime" = 'Ephemeral'.

The most common wetland type within the Victorian KEA network are Palustrine Systems comprised of temperate climate, river water source, seasonal water source,<= 1 year water regime frequency, fresh water type, tree dominated vegetation, basin landform, floodplain landscape with overbank hydrological connectivity. Wetland habitats of this nature account for 71 of the 176 records or 40 %. (Note: the 176 habitats represent 82 separate KEA complexes).

The SQL query for the above is "Climate_zone '= 'Temperate inland' and "Water_source" = 'River' and "Water_regime_frequency"= 'Seasonal' and "Water_regime_permanency" = '<= 1 year' and "Water_type" = 'Fresh' and "Vegetation_main" = 'Tree' and "Landform = 'Basin' and "Landform_context" = 'Floodplain' and "Hydro_connectivity" = 'Over-bank'

Issues – As indicated above a number of issues were encountered, such as mis-matches, and duplicates etc. In the main these are considered normal issues encountered when dealing with databases – especially those which occur (or are developed) in the absence of pre-defined standards for naming conventions, and work-flow procedures. An example of mis-matches in naming convention is a KEA record named as 'Muckatah Depression 26 wetlands (Heron & Joyce)' in one database and just 'Muckatah Depression' in another. Such inconsistencies can readily be addressed by the development and adoption of simple Quality Assurance and Quality Control procedures including the use of compliance statements etc. Interestingly the issues identified above are common within the generic NRM community and are the reason why the National Land & Water Resources Audit and ANZLIC – the Spatial Information Council jointly funded the development of the NRM Information Management Toolkit. Refer Box 6.

Box 6 – Best Practice in Data and Database Management

A range of generic best practice material is commonly available – see for example the NLWRA / ANZLIC National Resources Information Management Toolkit designed to increase management of data and information capacity. Refer: http://www.nlwra.gov.au/national-land-and-water-resources-audit/natural-resources-information-management-toolkit

The components of the Toolkit of most relevance to CEWH in the development of the EAD include Module 1 - Information Management, Module 2 – Data Management Principles, Module 4 – Spatial Data Priorities, Standards and Compliance, and Module 6 – Project Management and Justification. In to the above, ANZLIC - the Spatial Information Council has also developed a suite of inter-related policies and guidelines designed to assist organisations in spatial data management. For example:

- *Guidelines for Custodianship*
- *Policy Statement on Spatial Data Management*
- *Metadata Protocol and Standard Metadata Profile*
- *Guiding Principles for Spatial Data Access and Pricing Policy*
- *Privacy Guidelines for Spatial Data*
- *Access to Sensitive Spatial Data*

Refer: http://www.anzlic.org.au/policies.html

Other issues of note highlighted in the above findings include the need to re-think the proposed water source categories to cater for those systems that receive significant water from more than one source e.g. local and groundwater, which has important implications for management. In this respect, these findings have already been incorporated into the latest release of the attribute based draft Australian National Aquatic Ecosystem Classification currently being developed by the AETG.

Gaps - Further work is required in Victoria to complete attribution of those lacustrine and palustrine systems not included within the pilot dataset and to also address the issue of riverine and subterranean systems. To this end a State-wide river reach dataset exists to which classification attributes could readily be applied.

5 Summary of Findings

5.1 Synthesis

The following presents a brief synthesis of the pilot relative to the objectives and key capacity indicators (KCI's) identified in Sections 1.4 and 1.6. Within this context the KCI element may be seen as type of proxy outcome statement.

Objectives 1– Assessing the utility of existing datasets to identify aquatic ecosystems (number and type); and, 2) to assess whether the KEA network has 'captured' a representative sample of the habitat types within each jurisdiction.

Key Capacity Indicator a) The ability of State datasets to identify aquatic ecosystems (number and type)

Comment – Involved accessing, collating and harmonising State datasets for subsequent analysis. Overall, it can be seen that existing datasets can be used to

identify WDE's including number, extent and type. Based on findings from the pilot (at least for Queensland and South Australia) it can be demonstrated that existing KEA's also capture the full range of lacustrine and palustrine aquatic systems for the MDB areas within these jurisdictions.

KCI b) The ability of State datasets to identify which have been identified as KEA's, and whether the existing KEA network captures all types

Comment – Overall the current pilot demonstrated that, with the exception of New South Wales, existing State level datasets can be used to identify WDE's including number, extent and type. Based on findings from the pilot it can be demonstrated that existing KEA's also capture the full range of lacustrine and palustrine aquatic systems known to occur within the Queensland, Victorian and South Australian portion of the Basin. Additional analysis for Queensland demonstrates that it is a simple process to identify which assets occur as:

- Category 1: IKEA's (Indicative KEA's);
- Category 2: KEA's within largely hydrologically unmodified catchments; or,
- Category 3: Other KEA's

(Note: it is also possible to undertake the above analysis for South Australia and Victoria, however resources and time constraints prevented this from being undertaken).

Further to the above, findings from the Queensland example highlight the need for some form of spatial aggregation to identify a higher order unit (e.g. complex of wetlands) to constitute the actual KEA. That is, the large number of aquatic habitats that meet KEA criteria in Queensland may create management issues, especially as it relates to intervention activities carried out within an Adaptive Management Framework. To this end, of the 12,693 habitats used in the pilot, a total 3,016 (or approximately 25%) meet KEA criteria within the Queensland portion of the MDB.

By contrast South Australia adopted a spatial aggregation approach to identify a higher level unit - the Flood Plain Response Unit (or FIRU) which includes both the floodplain area and wetlands - on which they based their KEA assessment. In this respect the aggregation of aquatic ecosystem types (including riverine) to the FIRU unit has provided an appropriate scale to manage for ecosystem function outcomes. In total, 103 FIRU's meet at least one KEA criteria within the South Australian River Murray Floodplain area of the MDB. Results from the South Australian pilot also demonstrate that it is a simple process to identify which wetland types occur within each FIRU (or KEA), and that importantly the full range of lacustrine and palustrine types are represented (i.e. 'captured') as KEA's. (Note: Further work is required to determine the interactions between various aquatic ecosystem types within each FIRU).

Victoria identified KEA's as either a) a single polygon; or, b) a cluster of polygons of various aquatic ecosystem types. Similarly, as a result of work carried out under the project it is also possible to undertake analysis of lacustrine and palustrine types within the Victorian portion of the MDB.

KCI c) The ability of State datasets and classifications to support assessment of rare or unique WDE's

Comment – The current pilot demonstrated that existing datasets for Queensland, Victoria and South Australia have the potential to support KEA criterion 2, especially as it relates to the identification of rare or unique WDE's based on aquatic ecosystem classification attributes. In addition, the pilot demonstrated that:

- once KEA information (i.e. KEA criteria information for each asset) is entered into a database and subsequently joined with respective spatial layers it is

possible to both identify and visualise the actual location of certain types of WDE; and,

- that through simple structured querying processes it is also possible to easily query and visualise information for KEA criteria, condition and ecological value etc within a spatial context.

In this respect, it is clear that the development of a spatial classified aquatic ecosystem layer for the MDB provides a strong foundation or framework from which to support the overall KEA process.

Within this context, tasks completed for Victoria demonstrate that it is possible to retrospectively apply classification attributes to existing spatial layers, and that the resultant database has considerable potential to support numerous processes e.g. querying to identify aquatic ecosystems that meet certain classification criteria. In this respect - though out of scope within the current pilot - it would now also be possible to identify similar lacustrine and palustrine wetlands in all three States (i.e. Queensland, Victoria and South Australia) based on simple query requests to various attributes within the respective databases. This identifies the possibility of adding value to current MDBA processes through merging existing state classification attribute data to create a consistent MDB-wide wetland classification.

KCI d) The ability of States to apply classification attributes to existing wetland layers

Results from Victoria demonstrate that it is possible to retrospectively apply classification attributes to existing spatial layers, and that the resultant database has considerable potential to support numerous processes e.g. querying to identify habitats that meet certain classification criteria. In this respect - though out of scope within the current pilot - it would now also be possible to identify similar lacustrine and palustrine wetlands in all three States (i.e. Queensland, Victoria and South Australia) based on simple query requests (to various attributes) within the respective databases. This identifies the possibility of adding value to current MDBA processes.

5.2 Issues

Objective 3 - Identify issues encountered as part of the above process

Data Management - A number of data management issues were identified through the course of the pilot, though none proved fatal. That is, standard database cleansing and validation routines were adopted which enabled data to be transformed into a format suitable for use in the pilot. Such issues do however identify the need for standard best practise routines to be applied.

Cross-border Comparisons – such comparisons are dependent on the ability to be able to compare 'like' systems in one jurisdiction with the 'same' type of system in another (even if the types are given different names in different jurisdictions). The current pilot was undertaken on a State basis, however as mentioned above, cross-border lacustrine and palustrine comparisons between jurisdictions would be now possible for Queensland, Victoria and South Australia. The adoption of an attribute based classification (as proposed at the 14th December 2009 Classification and Regionalisation workshop and demonstrated in the current project) is key to supporting this process.

Classification Attribution and the Development of a Seamless WDE Layer for the MDB – Findings from the pilot demonstrate that it is possible to develop a standardised lacustrine and palustrine classification system for the MDB, and where required to retrospectively attribute existing aquatic habitat mapping datasets. The challenge remains however to develop a seamless layer for the MDB that captures all environmental assets (both surface and subsurface), and to apply classification

attributes to them. In this respect, some of the recent work of the AETG related to the development of an attribute based Australian National Aquatic Ecosystem Classification scheme is of particular interest – especially as it relates to each major aquatic system type i.e. lacustrine, palustrine, riverine, estuary/marine and subterranean groupings.

Table 4 below presents a subjective summary of the current status of State databases and processes to support various headline type elements involved in developing a classification framework in support to the KEA process for the MDB. Note: in this respect the framework involves extent and boundary, typology and attribute, conceptual model, values and condition elements. Information to populate the table is drawn from the current project, plus other sources including the author's current knowledge of datasets and processes at jurisdictional level.

Table 4: Ability of datasets / processes to support the MDB Environmental Asset Database

Jurisdiction	Asset Extent Boundary	Typology or Attributes	Conceptual Models	Values	Condition
Queensland					
Lacustrine and Palustrine	✓✓✓✓	✓✓✓✓	✓✓✓✓	✓✓✓*	?
Riverine	✓✓	?	✓✓?	✓✓*	✓✓*
Subterranean	✓?	?	?	?	?
NSW					
Lacustrine and Palustrine	✓	✓✓*	✓✓*	✓✓*	?
Riverine	✓✓	✓✓	✓✓*?	✓✓*	✓✓*
Subterranean	✓?	?	?	?	?
Victoria					
Lacustrine and Palustrine	✓✓	✓✓	✓	✓✓*	✓✓✓✓
Riverine	✓✓✓	✓✓*	?	✓✓*	✓✓✓✓
Subterranean	✓?	?	?	?	?
South Australia					
Lacustrine and Palustrine	✓✓✓✓	✓✓✓✓	✓✓✓	✓✓✓	✓✓✓
Riverine	✓✓✓	✓✓✓	✓✓✓?	✓✓*	✓✓*
Subterranean	✓?	?	?	?	?

Key:

✓ Only limited value to inform the process – generally limited by coverage and richness, with identifiable gaps and limitations

✓✓ Moderate to good value to inform the process – limited by coverage, attribute richness, or not integrated within existing mapping datasets

✓✓✓ Good to excellent value to inform the process – some minor gaps or limitations

✓✓✓✓ Excellent value – no perceived gaps or limitations

* Contained in studies and reports i.e. not necessarily integrated within a database

? Unknown status

Based on the above it can be seen that in relation to habitat extent and typology/attribute elements for lacustrine and palustrine systems, both Queensland and South Australia are well positioned, while Victoria is reasonably well positioned. New South Wales however, is limited in that it does not have a suitable seamless dataset for which attributes have been applied. It does however have a new attribute typology classification system, which when coupled with the Kingsford wetland layers offers potential to develop a suitable baseline pool of habitats.

Though riverine systems were excluded from the scope of the current project the above table indicates that suitable datasets on extent are believed to exist in all jurisdictions. Notwithstanding, they are all believed to be somewhat limited in terms of typology and classification attributes.

Similarly, subterranean systems were also excluded from the current scope of the project. The above table indicates that in all jurisdictions little information appears to be available. This situation may be addressed however via the upcoming NWC Groundwater-dependent Atlas (GDE) project. (For additional information refer Section 5.3 next steps).

5.3 Next Steps

Objective 4 – Identify potential next steps

Further work on classification and extent datasets

The current work was limited in resources (time and budget) and as a result it did not attempt to undertake cross-jurisdictional type comparisons, nor focus on improving existing mapping. One of the biggest limitations highlighted in the current pilot however relates to the lack of suitable data for New South Wales. Given the favourable results of the pilot carried out to populate classification attributes in Victoria, and the fact that the Statewide Kingsford layer exists for New South Wales, consideration should be given to assessing the resources required to populate classification attributes for NSW based on the Kingsford mapping. In many cases attributes for climate and water regime etc can be obtained from existing datasets e.g. Köppen for Climate, and the recent work of CSIRO in relation to Ecological Outcomes of Flow Regimes for Water Regime. It should also be noted that in affect the CSRIO dataset also provides information on extent. Refer http://www.csiro.au/resources/Ecological-Outcomes-of-Flow-Regimes-Report.html

Further work to extend the pilot to rivers and groundwater systems (based on classification attributes), and to provide complete lacustrine / palustrine attribution for additional areas in South Australia and Victoria portions of the MDB should also be considered. Collectively, this would contribute significantly to a seamless dataset for the MDB covering all water dependent ecosystems. In this respect, it should be noted that the draft riverine and lacustrine / palustrine attributes identified at the MDBA December 2009 classification and regionalisation workshop provided a significant contribution to two recent AETG national workshops (held in April 2010) to identify riverine and subterranean attributes for use within the national ANAE classification scheme.

Note: the issue of viewing floodplains as a separate entity within the classification scheme also requires attention. It is possible that this issue could be addressed as part of the development of aggregation guidelines for the identification and delineation of higher level assets above the habitat scale.

Within the context of the overall classification and extent dataset issue, the vision should be to develop a consistent, comprehensive and efficient Basin-wide environmental asset database as part of an enduring process.

Potential Linkage Projects and Processes

Linkage of the South Australian data to the recently completed wetland prioritisation dataset (containing information on condition and value at the wetland habitat level) may add additional value for the South Australian portion of the MDB. Other areas of interest include linkage of the pilot findings (and spatial layers) into the Environmental Asset Database currently being developed jointly for the MDB by the MDBA and Commonwealth Environmental Water holder (CEWH). Once integrated this has the ability to inform CEWH in determining priorities and location for their environmental water allocations. Similarly linkage with the NWC GDE Atlas and Groundwater Classification projects may be of interest to the MDBA. Refer – Atlas of Groundwater-dependent Ecosystems http://www.nwc.gov.au/www/html/1054-atlas-of-groundwater-dependent-ecosystems-.asp?intSiteID=1 and National Standards on Groundwater Mapping, Definitions and Assessment http://www.nwc.gov.au/www/html/628--national-standards-on-groundwater-mapping-definitions-and-assessment.asp?intSiteID=1

Likewise, close linkage with the AETG is also recommended – especially as it relates to the issues of classification, regionalisations and guidelines for aggregation and asset (or site) delineation aspects.

Further analysis based of the pilot datasets for Queensland, Victoria and South Australia could also be carried out on the water regime datasets generated as part of the recently completed CSIRO NWC Ecological Outcomes of Flow Regimes project.

Need to address the issue of Aggregation and Asset Delineation

The results of the pilot also highlight the urgent need to address the issue of aggregation and the identification of assets above the individual habitat mapping scale. Such a requirement is consistent with the MDBA needs in regard to a) the identification of configurations of complementary areas; and, b) comparative assessments between areas, noting that such areas may be at different scales – for example, they may be at the broader ecosystem level that provides or supports certain ecosystem services (or, functions), or, at a more localised 'site-scale'. In this respect it can be mentioned that there is considerable jurisdictional support for a standardised consistent approach to the identification and delineation of higher level assets, and scope for a joint Guideline. (Note: Similar issues have been encountered by jurisdictions involved in AETG trials to test the draft national HCVAE framework – Refer http://www.environment.gov.au/water/publications/environmental/ecosystems/hcvae.html)

Aquatic Ecosystem Regionalisation

The potential for additional work on a broad aquatic ecosystem regionalisation for the MDB is also worthy of further consideration. In this context, close cooperation with activities under the AETG in relation to the development of the national attribute ANAE aquatic ecosystem classification is recommended. The proposed ANAE classification scheme incorporates a broad aquatic eco-regionalisation above the habitat level.

Collaborative Approach

Finally, the goodwill and commitment demonstrated by jurisdictions in the current pilot demonstrates that it is possible (and highly productive) to work in a collaborative paradigm (at both the policy and technical level) involving State level jurisdictions and the MDBA. Considerable resources were leveraged by Queensland, South Australia and Victoria in particular to solve data issues and upgrade datasets to enable

satisfactory completion of the pilot. Similarly, all four basin States contributed to the classification and regionalisation workshop, and the assessment of existing data sources. In this sense, the current pilot also demonstrated the benefit of using a suitably experienced consultant to act as a catalyst and conduit to build a knowledgebase, and facilitate the flow of data and information between the stakeholders. As such, it can be concluded that both the MDBA and jurisdictions have benefited from being involved in the current pilot i.e. outputs and outcomes weren't only in one direction.

Attachment 1: MDBA KEA Criteria

The following section provides further detail on the achievement indicators and reasoning for each of the five criteria for determining key environmental assets.

Criterion 1: The water-dependent ecosystem is formally recognised in, and/or is capable of supporting species listed in, international agreements.

Achievement Indicators: the water-dependent ecosystems must be:

- listed under the Ramsar Convention; and/or include at least one species listed in at least one of the following international agreements:
    - JAMBA
    - CAMBA or
    - ROKAMBA.

Justification: The Act requires that the Basin Plan be developed so as to give effect to relevant international agreements. This includes, but is not limited to, the Ramsar Convention, JAMBA, CAMBA, ROKAMBA, the Bonn Convention and the Biodiversity Convention.

The Bonn Convention covers all migratory species e.g. blue whales. Acting on legal advice, it was determined that the species which are water dependant and relevant to the Murray-Darling Basin under the Bonn Convention are covered by the JAMBA/CAMBA/ROKAMBA agreements. Therefore when an asset fulfils criterion 1 by supporting JAMBA/CAMBA/ROKAMBA species, commitments under the Bonn Convention are also being fulfilled.

The Biodiversity Convention is another international agreement relevant to the Basin Plan. Acting on legal advice, it was determined that by assessing assets using the five criterion, which have regard to Annex 1 of the Biodiversity Convention, the Authority would be fulfilling Australian commitments under this agreement.

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

Achievement Indicators: The water-dependent ecosystems must:

- represent a natural or near-natural example of a particular type, as evidenced by a relative lack of human-induced hydrological disturbance and/or adverse impacts on ecological character; or
- represent the only example of a particular type in the Basin; or
- represent rare or unique examples of a particular type in the Basin.

Justification: This criterion provides the mechanism to identify water-dependent ecosystems that have to date been maintained in good condition. These natural or near-natural water-dependent ecosystems play a critical role in long-term biodiversity conservation, which is a component of the relevant obligations under the Biodiversity Convention. This criterion also captures those water-dependent ecosystems that are unique or the only remaining example in the Basin (for example the Coorong estuary), which provides a mechanism to identify the diversity of ecosystems in the Basin which is a component of biodiversity under the Act.

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

Achievement Indicators: The water-dependent ecosystems must provide habitat vital for the survival of a water-dependent species, population or ecological community (the environmental asset may include breeding, nursery and feeding sites, movement and migration pathways, and refuges). In particular, the water-dependent ecosystem must:

- provide refuge for native water dependant biota during dry spells and drought; or
- provide pathways for the dispersal and migration of native water-dependant biota; or
- provide important feeding, breeding and nursery sites for native water-dependant biota; or are essential for maintaining (and preventing declines of) native water-dependant biota.

Justification: Vital habitat supports important lifecycle stages and drought refuges for water dependant species which ultimately supports biodiversity by supporting breeding and resilience. This criterion identifies vital habitat which is a core component of the obligation to conserve biodiversity under the Biodiversity Convention.

The application of this criterion is not limited to life history stages of threatened species. This criterion acknowledges the ephemeral nature (both spatially and temporally) of the biodiversity of the Basin and aims to ensure areas important for the long-term retention of biodiversity (such as drought refuges and source populations) are retained.

Criterion 4: The water-dependent ecosystem supports Commonwealth, State or Territory listed threatened species and/or ecological communities.

Achievement Indicator: Must include water-dependent ecosystems that:

- are listed as threatened under relevant Commonwealth, State or Territory legislation or relevant processes; or
- support one or more threatened native water-dependant species listed under relevant Commonwealth, State or Territory legislation listed as a threatened ecological community under relevant Commonwealth, State or Territory legislation

Justification: This criterion identifies the ecosystems that support species and ecological communities listed under relevant Commonwealth, State or Territory legislation. It is the core component of the relevant obligation under the Ramsar Convention and the Biodiversity Convention.

Criterion 5: The water-dependent ecosystem supports or is capable of supporting significant biodiversity.

Achievement Indicators: The water-dependent ecosystem must meet at least one of the following:

- support significant numbers of individuals of native water-dependant species; or
- support significant levels of native biodiversity, at the genus and family taxonomic level, as well as that of communities.

Justification: This criterion is seen to fulfil the remaining component of the relevant obligations under the Biodiversity Convention. It provides for the identification of assets supporting large numbers of species or subspecies which provide a source for recolonisation elsewhere following disturbance, as well as those assets displaying high levels of taxonomic diversity. Inclusion of such sites is important in providing for the long-term viability of the Basin's biodiversity.

Attachment 2: MDB Ecological Metadata Catalogue

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
1	Aerial photographs, Australia												●	national and state mapping authorities, commercial suppliers
2	Aerial waterbird counts, Macquarie Marshes, NSW					●								DECC NSW
3	Aerial waterbird counts, Narran Lakes, NSW					●								DECC NSW
4	Ambient Water Quality Monitoring Macroinvertebrates, SA	●		●										EPA SA
5	Macrobenthos, Coorong and Murray Mouth		●	●							●			Flinders University
6	Ruppia tuberosa cover and density, Coorong						●				●			University of Adelaide
7	Ruppia tuberosa propagule abundance, Coorong						●				●			University of Adelaide
8	Waterbirds, Coorong					●					●			University of Adelaide
9	AUSRIVAS biological assessment of river health in SA			●										EPA SA
10	AUSRIVAS National River Health Database	●		●										DEWHA (and eWater CRC?)
11	AUSRIVAS/SRA invertebrates, Canberra water supply			●										ACTEW Corporation Ltd or eWater CRC
12	AUSRIVAS/SRA invertebrates, NSW			●										eWater CRC
13	AUSRIVAS/SRA invertebrates, Qld			●										eWater CRC
14	AUSRIVAS/SRA invertebrates, SA			●										eWater CRC
15	AUSRIVAS/SRA invertebrates, Victoria			●										eWater CRC
16	Australasian Bittern and Australian Painted Snipe data					●								Birds Australia
17	Australian Bird and Bat Banding Scheme					●								DEWHA
18	Australian Rivers and Catchment Condition Database Streamlines									●		●	●	DEWHA
19	AWRC Major River Basins of Victoria (BASIN100/BASIN100)												●	DPI Vic
20	BA0. Historical Atlas '1770'-1976					●								Birds Australia
21	BA1. (First) Field Atlas 1977-1981					●								Birds Australia
22	BA2. Second and Continuing Field Atlas 1998-present					●								Birds Australia
23	BA3. Victorian Waterbird Dataset 1988-1992					●								Birds Australia
24	BA4. Murray-Darling Basin Waterbird Dataset 1993-1997					●								Birds Australia
25	Benchmarking Rivers Survey, NSW									●				Macquarie University

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
26	Biological Monitoring Program indices based on macroinvertebrate collections, Victoria			●										EPA Vic
27	Biological Survey of South Australia			●	●	●	●	●						DEH SA
28	Birds and Fish project for Gwydir and Lowbidgee				●	●								DECC NSW
29	Booligal CNW breeding					●								DWE NSW
30	Broken River [Creek?] microinvertebrates		●											MDFRC
31	*Callistemon wimmerensis* monitoring, Wimmera, Victoria							●						Wimmera CMA
32	Channel breakdown and floodplain wetland morphodynamics in the Macquarie Marshes									●				Macquarie University
33	Channel metrics, Victoria									●				Melbourne University
34	Chowilla [fish and] macrophytes project						●							SARDI
35	Chowilla environmental watering vegetation monitoring						●	●						SARDI
36	Chowilla fish ecology project				●									SARDI
37	Chowilla vegetation condition monitoring						●	●						SARDI
38	Chowilla-Loveday Murray SA floodplain waterbirds					●								SA government
39	Commercial fisheries catch and effort data, SA				●						●			SARDI
40	Condamine-Balonne Aquatic ecology assessment project 2001	●	●	●	●		●		●					DNRW Qld
41	Coorong fish movement and recruitment				●						●			SARDI
42	Coorong fish surveys				●						●			SARDI
43	Coorong flow related fish and fisheries ecology				●						●			SARDI
45	Dryland Refugia project, Warrego and Border Rivers, Qld, 2003	●	●	●	●				●	●				Data jointly owned by many former CRCFE partners including NRW
46	Cross-section surveys, Victoria									●				DSE Vic
47	Cross-section vegetation surveys, Wimmera, Victoria						●	●						Wimmera CMA
48	Cross-sections and bathymetry data for River Murray floodplain channels and wetlands									●				MDBC
49	DECC hydrodynamic modelling											●		DECC NSW
50	DECC trophic project								●					DECC NSW

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
52	Duck hunter bag sizes, NSW					●								CSIRO
53	Eastern Australia Waterbird Survey					●								DECC NSW
54	Eastern Australian Aerial Survey (EAAS) Transect Bands					●								UNSW
55	Effects of water management on fish spawning and recruitment at Barmah-Millewa Forest				●									DPI Vic
56	e-NRIMS	●		●	●	●	●	●				●		DWLBC SA
57	Estimated Mean Annual Rainfall (RAIN_ANN/), Victoria											●		DSE Vic
58	Estimated Mean Monthly Rainfall (RAIN_{month}/), Victoria											●		DSE Vic
59	Estimated Pre-1750 Major Vegetation Groups, Australia						●	●						DEWHA
60	Eucalyptus largiflorens flowering data							●						
61	Fire History Records of Fires on Public Land. (One layer per Year) (FIRE100_{YEAR}/), Victoria								●					DSE Vic
62	Fish capture data, Victoria				●									DPI Vic
63	Fish habitat assessment of River Murray main channel, SA				●									SARDI
64	Fish in the Macquarie Marshes, Gwydir and Lowbidgee				●									DECC NSW
65	Fish records, Australian National Fish Collection				●									CSIRO Marine & Atmospheric Research
66	Fish recruitment on floodplains, Ovens River				●									DPI Vic
67	Fish release data, Victoria				●									DPI Vic
68	Fish sampling, Canberra water supply				●									ACTEW Corporation Ltd
69	Fish survey data, recent, Wimmera basin, Victoria				●									Wimmera CMA
70	Fisheries, Victoria				●									DSE Vic
71	Flood database, Victoria									●		●		DSE Vic
72	Floodways, Victoria									●		●		DSE Vic
73	Flora 100 (FLORA100/FLORA100), Victoria							●						DSE Vic
74	Flora and Fauna Survey Site Areas (SSITES_POL/SITE_POL), Victoria				●	●		●					●	DSE Vic
75	Flora and Fauna Survey Site Points (SSITES_PT/SITE_PT), Victoria				●	●		●					●	DSE Vic

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
76	Freshwater Fish Database, Victoria				●									DSE Vic
77	Freshwater fish ecological data, SA				●									SARDI
78	Channel form type and condition, Wimmera, Victoria									●				Wimmera CMA
79	Channel form cross-section surveys, Wimmera, Victoria									●				Wimmera CMA
80	Geomorphology dataset (possible), SA									●				
81	Geomorphology survey, Canberra water supply									●				ACTEW Corporation Ltd
82	Goulburn Broken CMA datasets	●		●	●	●								GBCMA
83	Goulburn-Murray phytoplankton		●											GMW
84	Goulburn-Murray water quality	●												GMW
85	Grazing and seedbanks							●	●					DECC NSW
86	Gulpa Island River Red Gum forest experiment							●						CSU
87	Historical sequences of river planform maps and air photos									●			●	
88	Historical fish survey and stocking data, Wimmera, Victoria				●									Wimmera CMA
89	IMEF algae data	●	●									●		DWE NSW
90	IMEF biofilms and carbon data	●	●						●			●		DWE NSW
91	IMEF carbon cycling and nutrients data	●							●			●		DWE NSW + ? Uni
92	IMEF fish data	●			●							●		DWE NSW and DPI NSW
93	IMEF macroinvertebrate data	●		●								●		DWE NSW
94	IMEF riparian, floodplain and aquatic vegetation data	●					●	●				●		DWE NSW
95	IMEF salinity data	●										●		DWE NSW
96	IMEF waterbird data	●				●						●		DWE NSW
97	Impacts of in-channel and floodplain structures on floodplain wetlands, Macquarie Marshes	●		●	●	●	●			●				DWE NSW
98	Index of Stream Condition, Victoria											●	●	DSE Vic
99	Inland fisheries database, SA				●									SARDI
100	Insect records, Australian National Insect Collection			●										DEWHA

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
101	ISC - Physical Form, Victoria									●				DSE Vic
102	Lachlan and Murrumbidgee Rivers waterbirds					●								CSIRO
103	Lachlan River waterbird breeding					●								DWE NSW
104	Lachlan River waterbirds					●								DWE NSW
105	Landsat data												●	ACRES, http://www.ga.gov.au/acres/prod_ser/ and resellers; see also under Access constraints.
106	Larval fish ecology in the Lower River Murray, SA				●									SARDI
107	LiDAR data									●			●	
108	Linear Hydrological Features (HYDRO500/HYDRO500), Victoria											●	●	DSE Vic
109	Lock 1 wetlands drawdown vegetation monitoring, SA						●	●						SARDI
110	Long Term Freshwater monitoring program				●									DPIF Qld
112	Lower Lakes Living Murray vegetation condition monitoring, SA						●	●						SARDI
113	Macroinvertebrate data, floodplain wetlands, SA			●										LaTrobe University?
114	Macroinvertebrate monitoring program			●										MDBC
115	Macroinvertebrates downstream of large dams			●										
116	Macroinvertebrates, SA			●										AWQC
117	Macroinvertebrates, Victoria			●										EPA Vic
118	Macroinvertebrates, water quality, SA	●		●										EPA SA
119	Macroinvertebrates, Wimmera, Victoria			●										Wimmera CMA
120	Mallee CMA datasets	●		●	●	●								
121	Mannum Swamps baseline vegetation survey						●	●						SARDI
122	Markaranka Baseline vegetation survey						●	●						SARDI
123	MDB SedNet model output									●				MDBC
124	MDBC Water Quality Monitoring Program	●			●									MDBC

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
125	Microinvertebrate emergence from wetlands		●											MDFRC
126	Mitchell - State of River Survey									●				DSE Vic
127	Monash Uni drought impact datasets				●									Monash University
128	Monitoring points from Water Resources Data Warehouse, Victoria												●	DSE Vic
129	Moonie River Waterholes	●			●					●		●		DNRW Qld, eWater CRC
130	Moonie Waterhole Refugia project				●					●				Data jointly owned by DNRW and eWater CRC and University of Adelaide
131	Morphological features (MORPH25/MORPH25), Victoria									●				DSE Vic
132	Murray Darling micro-fauna	●	●											University of Adelaide
133	Murray Fishway Project				●				●					SARDI, DSE ARI, NSW DPI Fisheries and MDBC
134	Murrumbidgee Highlands Wetlands data	●				●	●	●						NSW Gov (DECC or DWE)
135	Murrumbidgee River biofilms		●											UNE
136	Murrumbidgee River benthic and water column productivity	●							●					UNE
137	Murrumbidgee wetlands resource book											●		Difficult to tell who owns the IP. The wetland resource book was funded by LWA but largely drew on data from Paul Fraziers work for DLWC. Not sure if DECC or DWE would be the custodian of the original data
138	National database of colonial waterbird breeding records					●								UNSW
139	National SedNet model output									●				NLWRA
140	Native Fish Monitoring, SA				●									SARDI
141	North Central CMA datasets	●		●	●	●								
142	North East CMA datasets	●		●	●	●								
143	NSW Bird Atlas					●								Birds Australia NSW
144	NSW Wildlife Atlas				●	●								DECC NSW

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
145	Optimising environmental watering protocols to maximise benefits for native fish				●									DPI Vic
146	Penfolds lagoon basline vegetation survey, SA						●	●						SARDI
147	Periphyton sampling, Canberra water supply		●											ACTEW Corporation Ltd
148	Periphyton, SA		●											AWQC
149	Phragmites australis mapping						●							Wimmera CMA
150	Phytoplankton, SA		●											AWQC
151	Present Major Vegetation Groups, Australia						●	●						DEWHA
152	Reference Channel database, NSW									●				Macquarie University
153	Regional Groundwater Flow Systems (GFS250/gfs250), Victoria											●		DSE Vic
154	Release locations of inland fish stocking program (INLAND_FISH_POINT/), Victoria				●								●	DPI Vic
155	Response of floodplain vegetation to inundation							●						DECC NSW
156	River Murray floodplain flora survey, SA						●	●						DEH SA
157	River Murray floodplain floristic vegetation, SA						●	●						DEH SA
158	River Murray floodplain tree health, SA							●						DEH SA
159	River Murray floodplain vertebrate fauna survey, SA					●								DEH SA
160	River Murray hydrology data, SA	●										●		DWLBC SA
161	River Murray Wetlands Baseline Survey, SA	●		●	●	●	●	●						MDBNRMB SA
162	River Murray Wetlands vegetation baseline survey 2005, SA						●	●						SARDI
163	River Murray Wetlands vegetation baseline survey 2007, SA						●	●						SARDI
164	River Murray Wetlands vegetation baseline survey 2006, SA						●	●						SARDI
165	River Murray Wetlands fish baseline survey, SA				●									SARDI
166	River Reach relational database											●		Murrumbidgee CMA and Murrumbidgee Irrigation (part of Riverreach project)
167	River red gum canopy condition monitoring							●						Wimmera CMA
168	River Red Gum, Black Box and River Cooba crown condition and							●						MDBNRMB SA

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
	crown density on the Chowilla Floodplain													
169	SA Nature Maps				●	●		●						DEH SA
170	Saline pool response, Wimmera Victoria	●												Wimmera CMA
171	Spot counts of waterbirds, Coorong and Lower Lakes, SA					●					●			MDBNRMB SA, DEH SA
172	Spot monitoring of phytoplankton, zooplankton, inverts, fish, Coorong, SA		●	●	●						●			University of Adelaide
173	Spot monitoring of plants, invertebrates, fish, Coorong, SA			●	●			●			●			University of Adelaide
174	SRA fish sampling, MDB				●									MDBC
175	SRA fish sampling, SA				●									SARDI, DWLBC
176	SRA hydrology program											●		MDBC
177	SRA macroinvertebrate sampling			●										MDBC
178	SRA trials of Physical Form theme									●				MDBC, States
179	State of the Rivers survey - geomorphology, Qld									●				DNRW Qld
182	Statewide Plantation mapping (PLANT100/PLANT100), Victoria							●	●					DSE Vic
183	Streamflow and temperature, Canberra water supply	●										●		ACTEW Corporation Ltd
184	Structural woody habitat surveys, Wimmera Victoria							●						Wimmera CMA
185	Substrate, Wimmera, Victoria									●				Wimmera CMA
186	Synthesis of McKosker's Namoi-Lower Gwydir waterbird counts					●								DECC NSW
187	Testing the flood pulse concept for temperate Australian rivers - assessing fish production. Ovens River				●									DPI Vic
188	Testing the low flow recruitment hypothesis. Broken River [Creek?]				●									DPI Vic
189	Topographic maps												●	national and state mapping authorities
190	VEFMAP - Channel dynamics									●				Victorian government
191	VEFMAP - Channel features survey									●				Victorian government
192	VEFMAP - Fish abundance and composition survey				●									Victorian government
193	VEFMAP - Habitat field survey (Post-event)									●		●		Victorian government

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
194	VEFMAP - Habitat field survey (Repeated)									●		●		Victorian government
195	VEFMAP - Habitat field survey in conjuction with 1-dimensional hydraulic modelling									●		●		Victorian government
196	VEFMAP - Larval fish survey				●									Victorian government
197	VEFMAP - Macroinvertebrate survey			●										Victorian government
198	VEFMAP - Management activities				●				●	●			●	Victorian government
199	VEFMAP - River flow											●		Victorian government
200	VEFMAP - River temperature	●												DSE Vic
201	VEFMAP - Vegetation survey						●	●						Victorian government
202	VEFMAP - Water quality	●												DSE Vic
203	VegCon: Mapping Native Vegetation in the Murray Catchment						●	●	●					
204	Vegetation mapping, NSW						●	●						DECC NSW
205	Victorian Wildlife Atlas (VWA)					●		●						DSE Vic
206	Wader Surveys of the Coorong and SE coastal lakes, SA					●					●			AWSG / SA DEH?
207	Salt interception scheme vegetation monitoring, Waikerie, SA						●	●						SARDI
208	Water quality, SA	●												AWQC
209	Water Quality, Victoria	●								●				DSE Vic
210	Water quality, Wimmera, Victoria	●											●	Wimmera CMA
211	Waterbird aerial monitoring, Murray River					●								MDBC/TLM ?
212	Waterbird survey of Barmah-Millewa Wetlands, Murray River (incl. Kiewa Swamp)					●								
213	Waterbird survey of Barren Box Swamp (near Griffith, NSW)					●								
214	Waterbird survey of Booligal Swamp, lower Lachlan River, NSW					●								
215	Waterbird survey of Chowilla Floodplain, Murray River, SA					●								
216	Waterbird survey of Five-Bough Swamp (2 km NE Leeton, NSW)					●								
217	Waterbird survey of Gingham Watercourse Wetlands					●								
218	Waterbird survey of Gwydir Wetlands, lower Gwydir River, NSW					●								

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
219	Waterbird survey of Kerang Wetlands, Loddon River, Vic.					●								
220	Waterbird survey of Kow Swamp, Vic.					●								
221	Waterbird survey of Lake Cowal, NSW					●								
222	Waterbird survey of Lower Bidgee Wetlands, Murrumbidgee River, NSW					●								
223	Waterbird survey of Macquarie Marshes, Macquarie River, NSW					●								
224	Waterbird survey of Menindee Lakes, Darling River, NSW					●								
225	Waterbird survey of Narran Lakes, NSW					●								
226	Waterbird survey of Narrung Narrows, “Prohibited Islands”, River Murray mouth, SA					●					●			
227	Waterbird survey of Paroo Lakes, NSW					●								
228	Waterbird survey of Queensland MDB sites					●								NHT?
229	Waterbird survey of Tuckerbil Swamp, NSW					●								
230	Waterbird survey of Yantabulla Swamp, NSW					●								
231	Waterbird survey, Victoria					●								DSE Vic
232	Waterbird use of 21 ring tanks					●								
233	Wetland Environments and Extent - up to 1994 (WETLAND_1994/WET1994), Victoria												●	DSE Vic
234	Wetland inventories, SA											●		DEH SA
235	Wetlands polygons, SA											●	●	DEH SA
236	Wetting and drying wetland experiments in 16 wetlands, SA					●								
237	Wetting and drying wetland experiments, Lake Merriti, SA					●								
238	Bird food resources, Coorong					●					●			University of Adelaide
239	Narran Science Project	●	●		●	●	●	●	●	●		●		MDBC
240	River water levels and flows, Victoria											●		Victorian government
241	Murray Cod modelling				●									MDBC
242	Downstream mortality of native fish				●									MDBC

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
243	Historical water quality data, Queensland	●												Queensland government
244	Native fish data collection and analysis				●									MDBC
245	Chowilla and Lindsay Wallpolla NDVI imagery							●	●				●	CSIRO
246	Aerial monitoring of waterbird populations of The Living Murray icon sites					●								MDBC
247	Barmah hydrodynamic model											●		CSIRO
248	Carp recruitment success in Barmah-Millewa Forest: a quantitative measure				●									MDBC
249	Monitoring of fish accumulations behind Gulf Creek and Mary Ada regulators				●							●		MDBC
250	Assessing the effectiveness of environmental flows on fish recruitment in Barmah-Millewa Forest				●									MDBC
251	Lower Murray Weir pool manipulation	●		●	●	●	●	●						MDBC
252	Ecological response to environmental flows in Boundary Ck, Mundoo Channel, Tauwitcherie and Goolwa Barrage fishways				●	●	●	●	●					MDBC
253	Improved flow management of Lindsay-Walpolla System			●	●	●	●	●						MDBC
254	Understorey vegetation response to flooding in Barmah-Millewa Forest							●						MDBC
255	Implications of pumping and ponding water on water quality and aquatic biodiversity	●		●	●		●							MDBC
256	Monitoring of resnagging between Lake Hume and Yarrawonga				●					●				MDBC
257	Impacts of drought on distribution of fish communities in Mullaroo Creek-Lindsay River complex				●									MDBC
258	Movement and spawning of freshwater fishes in the Chowilla anabranch system				●									MDBC
259	Effect of weir pool lowering below Lock 1 including the LL [Lower Lakes?], Part 1				●	●	●	●	●					MDBC
260	Effect of weir pool lowering below Lock 1 including the LL [Lower Lakes?], Part 2				●	●	●	●	●					MDBC
261	Ecological outcomes of managed flooding and control structures at Websters Lagoon				●	●	●	●	●					MDBC
262	Environmental watering - 2GL refill of five wetlands below Lock 1				●	●	●	●	●					MDBC

No.	Title	Biogeochemistry	Plankton	Macroinvertebrates	Fish	Birds	Aquatic veg	Riparian & floodplain veg	Ecosystem function	Geomorphology	Estuary	Hydrology	Location	Custodian organisation
263	Wetland disconnection monitoring											●		MDBC
264	Assessment of acid sulphate soils in South Australian wetlands	●												MDBC
265	Monitoring of Lake Albert pumping											●		MDBC
266	Freshwater Fish Research Database, NSW				●									NSW DPI
267	River water levels and flows, NSW											●		NSW government
268	Waterbird outcomes of flow regimes in the Warrego, Paroo and Lower Balonne (Narran)					●								MDBC
269	River salinity levels, NSW	●												NSW government
270	Sea to Hume Program				●						●			MDBC
271	River water quality, Victoria	●												Victorian government
272	Historical flow monitoring data, Queensland											●		Queensland government
273	Mesoscale movement patterns				●									MDBC
274	River Murray Flood Inundation Model (RiM-FIM)											●		CSIRO
275	Murray River Fishway Assessment Program				●									MDBC
276	Chowilla hydrodynamic model											●		SA government
277	Mapping of stand condition for The Living Murray icon sites							●						MDBC
		474	42	16	37	78	76	40	52	20	37	16	41	19	

Source: Overton, I.C., et al eds (2009) 'Ecological Outcomes of Flow Regimes in the Murray-Darling Basin'. Report prepared for the National Water Commission by CSIRO Water for a Healthy Country Flagship. CSIRO, Canberra, http://www.csiro.au/resources/Ecological-Outcomes-of-Flow-Regimes-Report.html

Attachment 3: Victorian Attribute Description

Draft basin plan priority assets classification – Victorian wetlands

Description of wetland attributes

Climate zone

Valid options: Semi-arid, Temperate inland, Temperate upland, Temperate alpine.

Description: The climate attribute describes the Koppen climate class that the wetland falls within.

Data source: Kőppen climate map spatial layer from BOM website.

Method: Using the shapefile of the Kőppen climate zones overlayed with the Wetlands 1994 layer the climate zone could be assigned accurately. Victoria has two Kőppen climate zones: Grassland and Temperate. The climate zones were modified to better reflect the climatic regions of Victoria using the methodology of the from the NSW MER program (reference?). The climate zones in NSW are similar to Victoria so it was deemed suitable to apply the same naming convention. The alterations were to rename grassland to 'semi-arid' and temperate which is split into alpine, upland and inland.

The climatic classes used for Victorian typology are:

1) Semi-arid
2) Temperate
    a) Temperate Inland
    b) Temperate Upland (700 – 1800m)
    c) Temperate Alpine (>1800m)

The majority of sites for fell within the Semi-arid or Temperate inland zone.

Limitations: The Kőppen climate mapping is very broad.

Water source

Valid options: River, Local, Groundwater.

Description: The origin of the primary water source for the wetland system.

Data source: Hydrology layer and wetlands mapping.

Method: River includes wetlands that are filled directly from a river. Local means the wetland is predominantly filled through rainfall in the local area. Groundwater fed wetlands are filled from groundwater that is close to the surface.

Limitations: Many wetlands have multiple water sources and it is difficult to ascertain the relative contribution of these water sources. Irrigation system fed wetlands are difficult to assess.

Water regime

Valid options: Frequency – Permanent, Seasonal, Ephemeral. Duration – Permanent, <=1 year, >1 year.

Description: The frequency of water flowing into the wetland. Permanent means that water is constantly flowing in. Seasonal means water is flowing into the wetland at least, or more than, once a year. Ephemeral means that water flows into the wetland less than once a year.

The duration of the water remaining in the wetland. Permanent means that water remains in the wetland throughout the year. <=1 year means that water remains in the wetland for less than or equal to one year. >1 year means that water remains in the wetland for a period greater than one year but is not permanent.

Data source: Corrick & Norman (1980) wetland classification definition (see table below).

Method: Water regime frequency and duration options were allocated for each of the six Corrick & Norman (1980) wetland classifications based on the period of inundation and depth information from the wetland mapping.

Corrick classification	Period of inundation	Frequency	Duration
Freshwater Meadow (FM)	<4 months/year	Seasonal	<=1 year
Shallow Freshwater Marsh (SFM)	<8 months/year	Seasonal	<=1 year
Deep Freshwater Marsh (DFM)	>8 months/year - permanent	Permanent	<=1 year
Permanent Open Freshwater (POF)	Permanent	Permanent	Permanent (some >1 year)
Semi-Permanent Saline Wetland (SPSW)	<12 months/year	Seasonal	<=1 year
Permanent Saline Wetland (PSW)	Permanent	Permanent	Permanent

Limitations: Many ‘permanent’ wetlands have become dry in the past 5 years so the classification is not accurate during drought conditions. Potential errors with the Wetland 1994 layer.

Water type

Valid options: Fresh, Saline

Description: Salt concentration in the water of the wetland.

Data source: Corrick & Norman (1980) wetland classifications. Wetland 1994 layer.

Method: Assign option from the wetland type (see table above). Two out of the six wetland types are saline, the remaining four are fresh.

Limitations: Potential errors with the wetland mapping.

Soil/substrate

Valid options: Rock, Sand, Mineral, Organic.

Description: This attribute was deemed to difficult to assign and was not completed.

Vegetation

Valid options: Tree, Shrub, Grass/herb/sedge, Submerged.

Description: Presence of water dependent native vegetation at the wetland.

Data source: Corrick & Norman (1980) wetland classification sub-category and Heron & Joyce (2008) for some wetlands.

Also DSE (2004) for Kerang wetlands.

Method: The dominant vegetation type was listed from the information available.

Limitations: Would be good to use aerial photography to confirm the vegetation groupings. Wetland vegetation mapping is not available.

Landform

Valid options: Basin, Flat.

Description: The landform attribute is used to describe the landform of the wetland itself and not the land surrounding it.

Data source: Hydrology 1:100,000 layer. Jones & Miles (2009) used DEM for the S.A. River Murray Wetland Classification Project. DEM information isn't readily available for all the wetlands listed for Victoria

Method: It is expected that all wetlands form basins for the listed sites in Victoria.

Limitations: DEM are not available for all wetlands.

Landscape context

Valid options: Floodplain, Non-floodplain

Description: Landscape context refers to the land surrounding the wetland and can be defined by alluvial plains characterised by frequently active erosion and aggradation by channelled or overbank stream flow (McDonald et al 1998).

The Non-floodplain category refers to systems that may receive some flow from local watershed creeks but are only very rarely or very minimally influenced by true river systems.

Data source: 1 in 100 year flood and Hydrology layers.

Method: Most sites were mapped as floodplain wetlands and were assigned as such if close to a major river system. If a wetland was mapped as a floodplain wetland but had a local water source it was assigned non-floodplain instead.

Limitations: The attribute is very broad but appropriate for a landscape scale classification.

Hydro-connectivity

Valid options: Terminal branch, Through-flow, Over-bank

Description: Hydro-connectivity refers to the hydrological connectedness of wetlands to other aquatic ecosystems.

Data source: Hydrology 1:100,000 layer, topographic mapping

Method: The shape of the hydrology polygon is used to distinguish the hydro-connectivity of wetlands to river systems.

Limitations: The hydrology polygon may not fully represent the hydrology of the wetland, so multiple sources of information need to taken into consideration. It is sometimes difficult to follow the hydrology connections at some wetlands, especially those that are part of an irrigation system (i.e. Torrumbarry Irrigation system).

References:

Corrick, A.H. and Norman, F. I. (1980) Wetlands of Victoria I. Wetlands and waterbirds of the Snowy River and Gippsland Lakes catchment, Proceedings of the Royal Society of Victoria. **91**: 1-15

DSE (2004) Kerang wetlands Ramsar site strategic management plan, Department of Sustainability and Environment, East Melbourne

Heron, S. and Joyce, A. (2008) NRSWS Impact of water availability on significant wetlands. Report prepared for the DSE.

Jones, L. and Miles. M., 2009*, River Murray Wetland Classification Project (DEH)* report to the Riverine Recovery

Project, Department of Water, Land & Biodiversity Conservation.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. 1998, *Australian Soil and Land Survey Field Handbook*, Second Edition, CSIRO Land and Water, Canberra, Australia.

Quick reference table for the attributes

MDBA classification Attributes	Categories	Source of Information
Climate Zone	(Kőppen classification) Modified from NSW MER typology Grassland = semi-arid, Temperate = Temperate inland, Temperate upland, Alpine	Koppen Classification layer from BOM
Water Source	(Primary - river, local, groundwater) (link to NWC)	Hydrology (Hydro 1:100,000) or Heron & Joyce (2008)
Water Regime	(Frequency - Permanent, Seasonal, Ephemeral) and (Duration - Permanent, <= 1 year, > 1 year)	Corrick & Norman (1980)

Water Type	(Fresh, Saline)	Corrick & Norman (1980)
Soil/Substrate	(Rock, sand, mineral, organic)	-
Vegetation	(Tree, Shrub, Grass/herb/sedge, Submerged)	Corrick & Norman (1980), Heron & Joyce (2008)
Landform	(Basin, Flat)	Hydrology (Hydro 1:100,000)
Landscape context	(Floodplain, non-floodplain)	1 in 100 year flood (EXTENT_100Y_ARI)
Hydro-connectivity	(Terminal Branch, Through-flow, Over-bank)	Hydrology (Hydro 1:100,000), Topographic mapping

Note: the data layers Hydrology, 1 in 100 year flood, Wetlands 1994 are available to view on the Biodiversity Interactive Map.

www.dse.vic.gov.au/

Online services>Interactive Maps>Biodiversity Interactive Map