



Building a NSW Wetland Inventory

Lachlan River Catchment
wetland mapping methods

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Wetlands of the Lachlan River Catchment

1. Background

The first and most basic data requirement for a wetland inventory is to provide data collected so as to enable the major wetland habitats to be delineated and characterised for at least one point in time. A baseline map of wetland extent and type is considered a key and essential feature of the proposed statewide NSW wetland inventory. This is also the key knowledge gap identified in Office of Environment and Heritage's (OEH) Water and Wetlands Knowledge Audit 2011, *What is the extent and location of wetlands in NSW?*

The NSW OEH Water Wetlands and Coasts Science Branch completed a pilot study trialling methods for wetland mapping and classification in 2015-16. Following this pilot study, additional funding was provided to further develop and improve the mapping and classification datasets for the Lachlan River Catchment.

The purpose of this document is to:

- outline the full mapping method so that it can be extended to new areas or repeated, if necessary, in the future
- report on the results of the field-based accuracy assessment
- provide information to potential end users about the data sources, methods and limitations relevant to version 1.0 of the Lachlan River Catchment wetland map.

2. Objectives

Through extensive collaboration through the governance structure, a mapping and classification framework was established that outlines the purpose, principles, goals and objectives, definitions, activities and KPIs for the technical aspect of the project ([Appendix A](#)). From this, the objectives of the study were to:

- develop and release a wetland map that improves on the accuracy of previously available datasets
- include additional wetland typology (attribute) information into the map, consistent with the Australian National Aquatic Ecosystem (ANAE) typology
- complete a field based accuracy assessment of the wetland map.

3. Study Area

The Lachlan catchment was chosen as the pilot study area based on relevance and availability of datasets. The former Catchment Management Authority (CMA) boundary was adopted, as this aligned with staging of the NSW Vegetation mapping program (Figure 1).

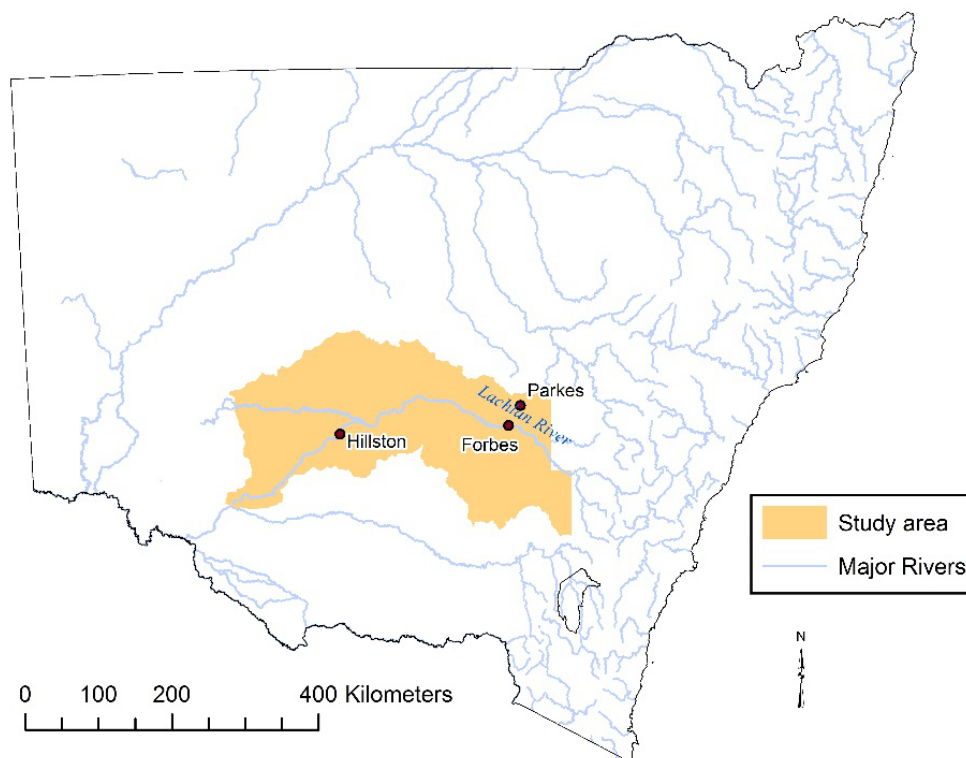


Figure 1 Lachlan River Catchment

3.1 Wetland definitions

For the purposes of a statewide wetland mapping program in New South Wales, this project adopts the definition provided in the NSW Wetland Policy (see box), but with the addition of areas of hydric soils. Hydric soils were included on the recommendation of wetland experts to address difficulties associated with identifying ephemeral types and/or degraded sites that at times may be dry or may not present with characteristic wetland fauna or flora, but nevertheless, would be expected to support wetland biota in wetter phases or if threatening processes were removed. However, very little information or data on hydric soils is available for field assessment or mapping of wetlands in New South Wales. Consequently, this study has not used knowledge of hydric soils to inform mapping of wetland extent or type. This is a limitation of the study and the methods developed to date.

Wetlands are defined as areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving. Examples of wetlands include lakes, lagoon estuaries, rivers, floodplains, swamps, bogs, billabongs, marshes, coral reefs and seagrass beds.

NSW Wetlands policy DECCW 2010

3.2 Typology

3.2.1 Classification versus typology

Classification and typology are sometimes used interchangeably in the published and grey literature for wetlands. For purposes of clarity, we adopt definitions for each that are guided by the Queensland wetland inventory (Brooks *et al.* 2014, Claus *et al.* 2011). Classification includes the full pool of attributes used to characterise wetlands, applied in no particular order. Typology is driven by purpose, and is the hierarchical application of a selected set of attributes to identify wetland types. The ANAE classification framework includes three ‘levels’ of attribute data to be applied at increasingly finer levels of spatial detail (Table 1). If all attributes were included in a typology, this could result in hundreds of classes or ‘wetland types’ (Brooks *et al.* 2014).

Table 1 Relationship between the preliminary Lachlan wetland typology for the Lachlan River Catchment pilot and the ANAE structure

ANAE structure		Adapted NSW MER typology for Lachlan River Catchment											
Level 1	Regional scale (attributes: hydrology, climate, landform)				Modified Koppen Climatic Divisions								
Level 2	Landscape scale (attributes: water influence, landform, topography, climate)												
Level 3	Class	Surface water			Surface water only								
		Subterranean											
	System	Marine	Estuarine	Lacustrine	Palustrine	Riverine	Floodplain	Fractured	Porous sedimentary rock	Unconsolidated	Cave/Karst	Lacustrine	Palustrine
Habitat	Pool of attributes to determine aquatic habitats (e.g. water type, vegetation, substrate, porosity, water source, water regime)				Water source, Water regime, water type, Vegetation - dominant vegetation structure.								

Note: Adapted from *Assessing the extent and condition of wetlands in NSW*, Monitoring, evaluation and reporting program, Technical report series (NSW MER) (Claus *et al.* 2011).

We investigated the wetland habitat typology proposed by Claus *et al.* (2011) and alignment of classes from this typology with the NSW Vegetation Classification (NSW OEH 2016) and the interim ANAE typology for the Murray Darling Basin (Brooks *et al.* 2014). The NSW MER (Claus *et al.* 2011) wetland habitat typology is consistent with the structure and attributes of the ANAE framework. Therefore, selection and investigation of this typology addresses our broader goal to extend and develop the ANAE classification for NSW wetlands. The NSW Vegetation Classification is the primary ecological classification currently in development in New South Wales to

support biodiversity assessment, planning, and legislation. It is therefore considered essential that a wetland typology be integrated and aligned with the vegetation classification. In addition, the vegetation classification provides an important level of detail for wetland habitat assessment.

3.3 Spatial resolution

The pilot study aimed to develop and test methods for the delineation of wetland boundaries at a scale useful for regional applications. Identification of all wetlands greater than 1 ha in size was targeted, corresponding to an area of about 3 x 3 Landsat pixels (pixel size is 30 metres), for a map product suitable for display at a scale of 1:50 000.

The pilot study also aimed to develop methods for a finer spatial delineation of wetland boundaries and a higher accuracy for discrimination between wetland and non-wetland areas than was provided by the previous NSW statewide wetland map (Kingsford *et al.* 2003). The previous NSW statewide wetland map was produced in 2003 at a scale of 1:250 000 for inland areas and 1:100 000 for coastal areas (Kingsford *et al.* 2003).

Statewide wetland mapping at a regional scale (1:50 000) is considered an achievable goal using the methods undertaken in this pilot study. Such a statewide dataset would support regional, strategic and broad scale assessments and decision making, including provision of a baseline for future statewide monitoring of wetland extent, and a strategic level Ramsar nominations framework.

Users should note that while wetland boundaries are suitable for viewing at 1:50 000, several of the source datasets that provide attribute information to the identified wetland polygons (e.g. soils) are produced at broader or finer scales, and this should be taken into consideration for all applications. Users should refer to the metadata and source data reporting to understand the scale and methods of the original datasets. This document outlines how these datasets have been added to the wetland map.

4. Mapping methods

4.1 Wetland Mapping method - overview

The State Vegetation Type Map: Central West/Lachlan Region (NSW OEH 2016) showing native vegetation for the region, including the plant community type (PCT), provides fine scale mapping of vegetation communities. It does not identify geomorphic features or patterns of inundation over time useful for identifying extent of waterbodies, ephemeral wetland areas, or lacustrine or riverine wetlands. Previous studies in New South Wales have found a time series of Landsat data to be particularly useful for identifying waterbodies and wetted area extent and wetland vegetation in semi-arid New South Wales, although these methods are largely untried for coastal areas.

Our overall approach (Figure 2) was to combine inundation information derived from Landsat imagery, the State Vegetation Type Map and existing waterbody and stream mapping to identify wetland extent and to define wetland boundaries. Attributes were then assigned to each wetland polygon by integrating existing datasets and applying GIS desktop analyses. The resulting version 1.0 (spatial dataset) includes two shapefiles. Wetland polygons are attributed to include:

- wetland ID
- wetland name (for named wetlands)
- wetland system (palustrine, lacustrine, riverine)
- soil type
- geomorphic location
- water regime class
- water type (salinity hazard).

The second dataset is a 'within habitat' spatial layer, which further subdivides wetland polygons according to:

- vegetation structure
- inundation class.

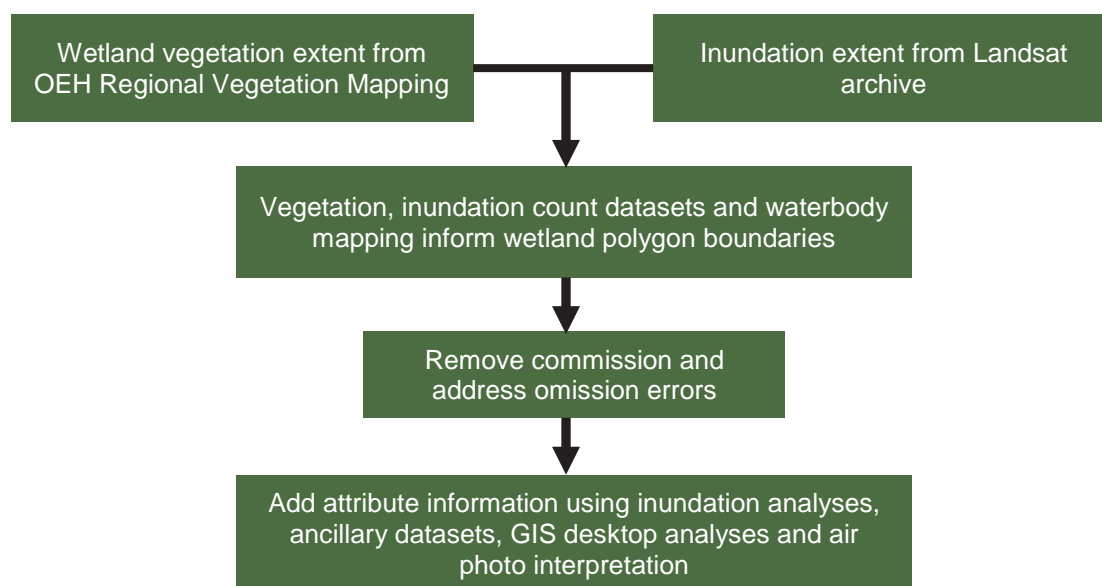


Figure 2 An overview of the process followed to develop the wetland map

4.2 Source datasets for wetland boundaries (polygons)

Seven data sets were collated or developed and then combined to identify wetland boundaries in the Lachlan River Catchment. These datasets are referred to here as:

- 'dd7'
- 'all dates t-10'
- 'all dates t-15' 'best dates' 'vegetation' 'hydro area' (waterbodies)
- 'hydro lines plus stream order' (stream lines and stream order).

Additionally, air photo interpretation was used to review the wetland polygons derived from these datasets. commission and omission errors were addressed by manually removing and adding wetland areas. Further detail on each of the datasets and the steps taken to identify wetland boundaries is provided below.

All Landsat images were provided by the OEH Remote Sensing and Analysis team and were accessed on the OEH Imagery and Remote Sensing (IRS) computing facility. The images for the 'all dates t-10', 'all dates t-15', and 'best dates' datasets described below had been processed to standardized surface reflectance data and were corrected to account for topographic and atmospheric variations in reflectance (Flood *et al.* 2013). The images had also been cloud masked using the 'Fmask' technique to record pixels with 'no data' due to the presence of cloud or cloud shadow (Zhu and Woodcock 2012).

4.2.1 Dd7

The dd7 dataset was derived from top of atmosphere (TOA) reflectance data (Danaher 2002). This dataset is a count of wet pixel observations from all available Landsat imagery acquired from 1988 to 2012. Input images had been thresholded to provide inundated/not inundated binary data for each date using the water index developed by Danaher and Collett (2006). The index was originally developed to mask areas of water pixels for statewide vegetation studies. The method is set such that the dataset is sensitive to areas of open water, but is not optimised to identify mixed pixels containing both inundation and vegetation. For this reason, additional inundation datasets were developed and included the 'all dates t-10', 'all dates t-15', and 'best dates' datasets (described below) to assist identification of vegetated wetland areas and inform wetland boundary delineation.

4.2.2 All dates t-10 dataset

The all dates t-10 dataset was generated by applying the water index recently developed by Fisher (2016) to all available images for each Landsat tile. For each Landsat image, the water index was optimised by applying a constant threshold value of -10 to generate layers indicating inundated or not inundated pixels or no data pixels (due to cloud, cloud shadow and other erroneous pixel values). The optimised layers were then combined (stacked on top of one another) to provide the 'all dates t-10' raster dataset that was a count of the total number of inundated observations for each pixel. Known commission errors (false positive inundation counts) included areas with terrain shadow, tall dense forests creating shadows, and building shadow (in urban areas).

4.2.3 All dates t-15 dataset

The all dates t-15 dataset was generated using the same method as for the all dates t-10 dataset, but with a constant threshold value of -15 to separate inundated from non-inundated areas in the water indexed images. This layer was developed to be more 'sensitive' to water under vegetation, and to provide enhanced connectivity information by identifying riverine wetlands (further details are provided below). However, it also contained more commission error than the t-10 dataset.

4.2.4 Best dates dataset

A known issue with application of a water index for time series analyses is that the threshold value required to separate wet areas from dry varies through time, location, and wetter and drier conditions. The reasons for this are not well understood and require further study, but may be related to:

- the relative components of water, vegetation and soil surface covers within a pixel, which are altered under wet and dry conditions
- the presence of cloud within the scene (even if cloud covered pixels and cloud shadow within the scene has been masked)
- other environmental factors
- problems with the radiometric calibration of the Landsat imagery.

This means that on some dates and scenes, a water index based on the chosen threshold value does not perform as well as it does at other locations or at other times. This results in higher amounts of confusion between inundated and dry areas; of most concern is the misclassification of dry areas as inundated. This issue was investigated by generating an additional (third) inundation count dataset that eliminated 'noisy' scenes (scenes that contained higher amounts of cloud and other error). The aim was to produce a dataset from the 'best available' Landsat scenes, with less confusion between inundated and not-inundated areas, particularly for marginal and ephemeral wetland areas with typically fewer inundation observations.

The selection of 'best dates' from the available f-masked Landsat image archive was achieved by creating a set of sample polygons of wetlands (between 500 and 1500 polygons) based on a known wet/flood date for each scene, as well as a small number polygons on non-wetland, and analysing the whole time series of thresholded water index images (wet, dry and no data pixel values provided by our all dates analysis) within these polygon areas. The percentage of inundation and percentage of cloud-free (or unmasked) area in each polygon were recorded for each date. A list of dates where wetland polygons had a high percentage of inundation and low percentage cloud cover was then prepared. This was followed by a second query of the non-wetland polygons to prepare a list of dates which erroneously recorded an unacceptable amount of inundation (usually due to unmasked topographic or cloud shadow) within the identified non-wetland polygons. If any of the dates from the second query coincided with the dates from the first query, they were removed from the candidate best dates list. Dates that were identified in the f-masking process to have a cloud cover of greater than 25% for the whole scene were also removed.

An inundation count was then completed using the binary wet/dry raster layers generated from the all dates analysis above, but including only the image dates ranked highest on the best dates list. In most cases, this best dates list contained between 80 and 120 dates per scene, as opposed to the full archive of 650 to 700 dates. The output was an inundation count dataset calculated from best available dates only ('best dates').

4.2.5 Vegetation

The State Vegetation Type Map: Central West/Lachlan Region Version 1.0 showing native vegetation for the region, including PCT, was provided by the OEH native vegetation mapping team. It was then clipped to the boundary of the Lachlan River Catchment and resampled to 30 metre pixels to align the vegetation data with the Landsat inundation datasets. Pixels were then reclassified from PCTs into three wetland vegetation structural classes and non-wetland:

- non-wetland
- grassland/shrubland wetland
- forest/woodland wetland
- other (may contain wetland areas within the defined and mapped PCT).

Table 2 shows the PCTs we identified as wetlands and reclassified for inclusion with inundation information to determine wetland boundaries.

Table 2 Plant Community Types identified as wetlands or containing some wetlands and reclassified for inclusion with inundation information to determine wetland boundaries.

Plant community type ID	Community name	Wetland vegetation class
36	River red gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Forest/woodland
249	River red gum swampy woodland wetland on cowals (lakes) and associated flood channels in central NSW	Forest/woodland
5	River red gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion	Forest/woodland
7	River red gum – Warrego grass – herbaceous riparian tall open forest wetland mainly in the Riverina Bioregion	Forest/woodland
10	River red gum – black box – woodland wetland of the semi-arid (warm) climatic zone (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Forest/woodland
11	River red gum – Lignum – very tall open forest or woodland wetland on floodplains of semi-arid (warm) climate zone (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Forest/woodland
2	River red gum sedge dominated, very tall, open forest in frequently flooded forest wetland along major rivers and floodplains in south-western NSW	Forest/woodland
9	River red gum – wallaby grass – tall woodland wetland on the outer river red gum zone mainly in the Riverina Bioregion	Forest/woodland
240	River coobah tall shrubland wetland of the floodplains in the Riverina Bioregion and Murray Darling Depression Bioregion.	Forest/woodland
17	Lignum shrubland wetland of the semi-arid (warm) plains (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Grassland/shrubland
24	Canegrass swamp tall grassland wetland of drainage depressions lakes and pans of the inland plains.	Grassland/shrubland

Plant community type ID	Community name	Wetland vegetation class
160	Nitre Goosefoot shrubland wetland on clays of the inland floodplains	May contain areas of wetland
53	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	Grassland/shrubland
182	Cumbungi rushland wetland of shallow semi-permanent water bodies and inland watercourses	Grassland/shrubland
181	Common reed – bushy groundsel – aquatic tall reed land grassland wetland of inland river systems	Grassland/shrubland
12	Shallow marsh wetland of regularly flooded depressions on floodplains mainly in the semi-arid (warm) climatic zone (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Grassland/shrubland
251	Mixed eucalypt woodlands of floodplains in the southern-eastern Cobar Peneplain Bioregion	Forest/woodland
18	Slender glasswort low shrubland in saline wetland depressions in the semi-arid and arid climate zones far western NSW	Grassland/shrubland
13	Black box – Lignum – woodland wetland of the inner floodplains in the semi-arid (warm) climate zone (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Forest/woodland
15	Black box open woodland wetland with chenopod understorey mainly on the outer floodplains in south-western NSW (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Forest/woodland
16	Black box grassy open woodland wetland of rarely flooded depressions in south western NSW (mainly Riverina Bioregion and Murray Darling Depression Bioregion)	Forest/woodland
333	Bottlebrush riparian shrubland wetland of the northern NSW South Western Slopes Bioregion and southern Brigalow Belt South Bioregion	Forest/woodland
85	River oak forest and woodland wetland of the NSW South Western Slopes and South Eastern Highlands Bioregion	Forest/woodland
74	Yellow box – river red gum – tall grassy riverine woodland of NSW South Western Slopes Bioregion and Riverina Bioregion	Forest/woodland
278	Riparian Blakelys red gum – box – shrub – sedge – grass tall open forest of the central NSW South Western Slopes Bioregion	Forest/woodland
242	Rats tail couch sod grassland wetland of inland floodplains	Grassland/shrubland
45	Plains grass grassland on alluvial mainly clay soils in the Riverina Bioregion and NSW South Western Slopes Bioregion.	May contain areas of wetland

4.2.6 Hydro area (waterbodies)

The NSW Hydro Area Dataset¹ is produced by NSW Land and Property Information, and identifies waterbodies across all of New South Wales. The dataset is produced at fine scale and identifies waterbodies using air photo interpretation of water and landform features. Our visual interpretation and understanding of this dataset applied to wetland mapping is that it best identifies open bodies of commonly wet areas. Thickly vegetated wetland areas without distinct geomorphic shapes, such as occurs on floodplain areas, are not identified by this dataset. Furthermore, while some of the identified waterbodies in the far west of the Lachlan catchment support identifiable wetland communities, many other areas mapped as waterbodies appear to be mostly dry and do not support wetland communities. Identified waterbodies were included into the wetland mapping where named, and/or when found that at least some of the area showed an inundation history as recorded in our inundation datasets.

4.2.7 Hydro line (rivers and streams) and Strahler stream order

A dataset named 'Stream Order Strahler' is available internally on the OEH P drive. Very little metadata is available, but it appears this dataset adopts the linework from the NSW Hydro Line Dataset², but with stream order subsequently added to produce the Stream Order Strahler dataset. The method adopted to assign stream order is unclear. A visual analysis of this dataset using high resolution aerial photography, however, indicated it to be the highest quality combined stream line and stream order dataset that was available to us. Thus it was adopted to assist identification of wetlands in this mapping project.

4.3 Identifying wetland boundaries

4.3.1 Stage 1 preliminary wetland boundaries from vegetation mapping and inundation datasets

Each of the all dates, best dates, dd7, and vegetation raster datasets were imported into the Definiens Ecognition software package for analysis and determination of wetland boundaries. Wetland boundaries were identified using feature recognition to identify uniform shapes of inundated pixel observation counts and vegetation.

Step 1

Wetland extent was determined to be the area defined by the criteria:

- all dates water observation count ≥ 14
- dd7 ≥ 3
- best dates ≥ 2
- vegetation = 'shrubland/grassland/sedge/herb wetlands', **or**
- vegetation = 'forest/woodland wetlands'.

¹ This dataset is available on the NSW Spatial Data Catalogue at <https://sdi.nsw.gov.au/nswsdi/catalog/search/resource/details.page?uuid=%7BEC757E51-AE90-4438-9B07-ACA9012386B5%7D>.

² This dataset is available on the NSW Spatial Data Catalogue search page at <https://sdi.nsw.gov.au/catalog/search/> by searching for 'hydroline'.

Step 2

Within the wetland extent defined in Step 1, classes of inundation counts were then identified, with higher class number representing a greater number of inundated pixel observations.

- Class 5 → all dates ≥ 125 inundated pixel observations **or** dd7 ≥ 100 inundated pixel observations
- Class 4 → all dates ≥ 60 inundated pixel observations **or** dd7 ≥ 60 inundated pixel observations
- Class 3 → all dates ≥ 20 inundated pixel observations **or** dd7 ≥ 7 inundated pixel observations
- Class 2 → best dates ≥ 4 inundated observation counts **or** dd7 ≥ 4 inundated pixel observations
- Class 1 → all other pixels within the extent defined by Step 1.

Step 3

This step was used to identify outlying (erroneous) pixels in the classes of water counts, and generated uniform areas and coherent shapes of water count classes. Pixels were considered for reassignment into a water observation count class by evaluating the properties of neighbouring pixels. If greater than two sides of any given pixel corresponded to pixels of a single and different class, that pixel was reassigned to the class of its neighbouring pixels.

Step 4

Segments (objects formed from groupings of pixels) were then defined using the Definiens multispectral segmentation tool based on spatial, spectral (inundation counts) and thematic (vegetation class) information. Segments were nested within the defined wetland extent (derived in Step 1) and vegetation thematic layer.

Step 5

Each segment derived from Step 4 was already associated with a vegetation class. Step 5 classified each segment into a water regime class using the following rules.

Segment is:

- 'Commonly wet' if 40 % or more of sub objects (pixels) were Class 5, **or** if $\geq 15\%$ of pixels were Class 4 **and** $\geq 20\%$ pixels were Class 5
- 'Frequently wet' if $\geq 40\%$ Class 4, **or** if $\geq 30\%$ Class 4 **and** $\geq 20\%$ Class 3
- 'Regularly wet' if $\geq 55\%$ Class 3, **or** if $\geq 35\%$ Class 3 **and** 30-65% Class 2
- 'Occasionally wet' if $\geq 35\%$ Class 2 **and** $\geq 30\%$ Class 1
- 'Rarely wet' if not otherwise allocated to a inundation class using the above criteria.

The output from the feature analysis using Definiens Ecognition was a raster dataset with wetland areas identified and classified into vegetation structural class and water regime class.

Step 6 – Riverine wetlands

To identify preliminary riverine wetland extent, a filter on the all dates t-15 dataset was applied to identify channel areas with base flow. The filter identified pixels with

high inundation counts (in channel) adjacent to pixels with lower inundation counts (bank), and object oriented analysis was applied to identify uniform areas with 'linear' shape. The identified 'channel' area was also expanded to include the adjacent uniform vegetated areas and inundation classed areas (i.e. streamside vegetation) which were identified in Step 5 above. A new raster dataset was produced, with the new riverine class added to the vegetation and inundation classes developed in Step 5. The classes are described in Table 3 (Stage 1 output).

Step 7 – Remove commission error

The raster dataset was imported to ArcGIS, and the 30 metre raster dataset converted to polygons. Commission error (inclusion of wetland areas into our dataset that were not really wetlands) was then addressed and potential cropped wetlands identified by using a set of ancillary datasets:

- slope – calculated from Geoscience Australia's SRTM-derived 1 Second Digital Elevation Model³
- landuse – from OEH NSW landuse mapping 2007⁴.

A set of IF/THEN statements divided the wetland polygons into:

- those that were automatically retained (very flat and no cropping – i.e. higher probability the polygon is a wetland)
- those that could be automatically removed (e.g. areas of high slope)
- those that needed to be checked using air photo interpretation to either retain them, eliminate them, or assess modification status from the wetland map (e.g. areas of intermediate slope categories and wetlands modified due to cropping).

Those that were flagged for checking using high resolution imagery were visually assessed and then manually removed using editing tools in Esri ArcGIS 10.1 where we were confident that they were not wetlands.

4.3.2 Stage 2 finalise wetland boundaries through integration with hydro area and hydro lines stream order dataset

This stage combined the wetland extent datasets from the vegetation mapping, inundation analysis, and preliminary riverine mapping, with the hydro area and Strahler stream order datasets, and merged smaller polygons to form final (larger) wetland polygon boundaries. All analysis was completed using ESRI ArcGIS 10.1.

Step 1

Firstly, the classes developed in Stage 1 were reclassified, with new Stage 2 classes forming broader groups for further analysis.

The classes were reclassified according to the table below. 'Definite wetland' areas were associated with a higher level of confidence, due to the mapped presence of a known wetland PCT, and/or higher inundation counts. Areas of shrubland/grassland/herb plant communities with low inundation counts, nitre-

³ See the Geoscience Australia SRTM-derived 1 Second Digital Elevation Models Version 1.0 at <http://pid.geoscience.gov.au/dataset/72759> for data access and metadata.

⁴ Metadata can be found on the NSW Spatial Data Catalogue at <https://sdi.nsw.gov.au/catalog/main/home.page> by searching for 'Landuse'.

goosefoot/plains grass communities with low inundation counts, and areas of low inundation count and no identified wetland plant communities recorded in the vegetation mapping were tagged as 'floodplain wetland'. An intermediate 'Wetland extension' category was used to consider polygons with mid-range inundation counts that had been mapped as a known wetland PCT for later re-assignment into either 'definite wetland' or 'floodplain'.

Table 3 **Reclassification of Stage 1 classes for analysis in Stage 2**

Stage 1 class output	Stage 2 class for further refinement and analysis
Frequently inundated, no wetland PCT identified	Definite wetland
Commonly inundated, no wetland PCT identified	Definite wetland
Regularly inundated, no wetland PCT identified	Definite wetland
Rarely inundated, no wetland PCT identified	Floodplain wetland
Occasionally inundated, no wetland PCT identified	Floodplain wetland
Occasionally inundated – shrubland/grassland wetland PCT	Wetland Extension
Occasionally inundated – nitre goosefoot or plains grass grassland PCT	Floodplain wetland
Occasionally inundated – wetland forest/woodland PCT	Wetland Extension
Regularly inundated – wetland shrubland/grass/sedge/herb PCT	Definite wetland
Rarely inundated – veg wetland shrubland/grass/sedge /herb PCT	Floodplain wetland
Rarely inundated – wetland woodland/forest PCT	Wetland Extension
Regularly inundated – veg nitre goosefoot or plain grass grassland PCT	Definite wetland
Regularly inundated – wetland forest/woodland PCT	Definite wetland
Frequently inundated – wetland shrubland/grass /sedge/herb PCT	Definite wetland
Frequently inundated – wetland forest/woodland PCT	Definite wetland
Frequently inundated – nitre goosefoot or plains grass grassland PCT	Definite wetland
Commonly inundated – wetland shrubland/grass /sedge/herb PCT	Definite wetland
Commonly inundated – wetland forest/woodland PCT	Definite wetland
Commonly inundated – nitre goosefoot or plains grass grassland PCT	Definite wetland
Riverine	Riverine

Note: Stage 1 and Stage 2 classes were developed as interim classes only, and are not included in the published dataset.

Step 2

This step refined and adjusted the Stage 2 riverine class using the Strahler Stream Order dataset and air photo interpretation. All wetland polygons that intersected with a stream order of three or greater in the hydro line–stream order dataset were

selected. If these polygons were not already assigned to the 'riverine' Stage 2 class, they were added to the 'riverine' class and air photo interpretation (API) was undertaken to confirm classification as riverine. If not confirmed as riverine, reclassification of Stage 2 class was updated to either definite wetland (no channel) or error. Polygons identified as error were deleted, and then the area of the remaining polygons was calculated for use in subsequent steps.

Step 3

This step integrated data from the Hydro Area Dataset. The output from the previous step (Step 2) was spatially intersected with the Hydro Area Dataset and then:

- if a polygon in the combined dataset was labelled 'channel', 'creek', 'gully' or 'river' after the intersection, the Stage 2 class was updated to 'riverine'.
- if a polygon in the combined dataset was labelled 'basin', 'bore', 'cowal', 'dam', 'hole(s)', 'lagoon', 'lake', 'pond', 'swamp', 'tank(s)', 'water', 'waterhole' or 'well' **and**
 - Stage 2 class (initial) is definite wetland or review wetland extension, then **stage 2 class** (revised) is definite wetland
 - Stage 2 class (initial) is review or blank, then Stage 2 class (revised) = review
 - Stage 2 class (initial) is riverine, then Stage 2 class (revised) is riverine
- polygons in the combined dataset with '**HydroName**' or '**HydroNameT**' but no label were manually assigned to Stage 2 class definite wetland or floodplain wetland
- remaining un-named polygons derived from the Hydro Area Dataset were deleted.

Step 4

A review of the draft dataset identified several areas of wetlands that had not already been identified from the vegetation mapping, inundation, or Hydro Area Dataset (i.e. omission error). These areas were manually added using a 'best available' air photo layer provided by Land and Property Information NSW, and a statewide SPOT mosaic captured in 2011, which corresponded to a wetter period in the Lachlan River Catchment at the end of the Millennium Drought. These were added to the dataset resulting from Step 3 and classed as 'definite wetland'.

In addition, expert review identified commission error resulting from error that appeared as banding in the Landsat inundation data in the mid catchment around Lake Cowal. This error was manually removed, again by using the 'best available' air photo layer provided by Land and Property Information NSW, and a statewide SPOT mosaic captured in 2011, to guide air photo interpretation and delineation of wetland boundaries.

Step 5

To finalise the polygon boundaries, all remaining 'wetland extension' polygons were merged into the largest adjacent 'definite wetland' or 'floodplain wetland' polygon, and all non-riverine polygons less than 0.8 hectares were merged into the adjacent largest polygon or deleted if isolated. All polygons were then given a unique wetland ID number ('WI_ID').

4.4 Add typology and additional attribute information to wetland polygons

The final stage of map development was to add wetland type and additional attribute information from existing, ancillary datasets to produce a wetland map dataset consistent with the ANAE framework for wetland classification.

4.4.1 Climatic division

Broad climate and landform divisions were attributed to wetland polygons using the modified Köppen climate division of Claus *et al.* (2011) (see also Peel *et al.* 2007). A spatial dataset was derived using the 1 second SRTM digital elevation model⁵ intersected with a spatial dataset for Köppen climate regions⁶. The standard climate divisions are based on long-term rainfall, temperature and humidity observations, which were modified for New South Wales to further include landform through consideration of elevation. Within the study area, this equated to the temperate climate division divided into separate upland (>700 metres) and inland (<700 metres). Each wetland polygon was subsequently attributed as either: temperate upland, temperate inland or semi-arid.

4.4.2 Wetland Name

Steps 3 to 5 above (section 4.3.2) adopted the boundaries of named waterbodies in the Hydro Area Dataset, and hydro area names were also adopted directly into the Lachlan River Catchment wetland map. Names are consistent with the topographic database maintained by NSW government. See section 4.2.6 for a description of the Hydro Area Dataset.

4.4.3 Soils

Soil type was attributed to wetland polygons using soil orders from the Australian Soil Classification (ASC) (Isbell 1998).

There are 14 soil orders described for Australia. The orders are mapped for New South Wales at 1:100,000 or 1:250,000 scale with 100 or 250 metre accuracy (dependent on accuracy of the source data). Anthroposols (human-made) and hydrosols (prolonged seasonal saturation) are not present in the mapping for the study area.

Each wetland polygon was attributed with data from the soil type dataset, using zonal statistics to assign majority area soil type to the wetland polygon.

4.4.4 Geomorphic position

Geomorphic position was attributed to wetland polygons using the Slope Relief Classification of Gallant and Austin (2012; 30 metre resolution) to determine landform pattern (Speight 2009). Landform pattern describes the geomorphic character of an

⁵ Provided by Geoscience Australia on the Digital Elevation Data webpage at <http://www.ga.gov.au/scientific-topics/national-location-information/digital-elevation-data>.

⁶ Available from Australian Government Bureau of Meteorology Climate classification maps at http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp?maptype=kpn#maps.

area within a landscape, roughly 600m², primarily considering relief (difference in elevation) and modal slope (most common slope class) parameters.

Each wetland polygon was attributed with geomorphic position using zonal statistics to assign majority area geomorphic position to the wetland polygon.

4.4.5 Water source

A set of decision rules and a national dataset of high-probability groundwater dependent ecosystems was used to attribute all wetland polygons with one or more potential water sources. First, all wetland polygons were attributed a default water source of rainfall-associated localised runoff. Groundwater was attributed as a water source if the wetland polygon intersected high probability of groundwater interaction polygons from the 'Reliant on Surface Expression of Groundwater' or 'Reliant on Subsurface Expression of Groundwater' spatial layers from the National Atlas of Groundwater Dependant Ecosystems (Sinclair Knight Merz 2012). The subsurface expression data has recently been revised (Kuginis *et al.* 2016) using new input data and a revised method. River-fed wetlands were considered to be those with a channel connection. Polygons were identified and attributed with river-fed water source if the wetland polygon intersected the 'hydroLine' spatial layer, where stream order was ≥ 3 . This was further modified to manage river-fed if the polygon also intersected the Lachlan River floodplain, floodway or environmental flow management plan areas relating to the Murray-Darling Basin and Lachlan water sharing plans (MDBA 2012, NSW OEH 2012, 2016).

4.4.6 Landuse

The landuse dataset was sourced from the OEH P drive (internal), and is the version 1 dataset (Landuse V1). This is the statewide version mapped between 2003 and 2007. Metadata can be found on the NSW Spatial Data Catalogue⁷. Each wetland polygon was attributed with data from the landuse dataset, using zonal statistics to assign majority area landuse to the wetland polygon.

4.4.7 Water regime class

A final inundation dataset was derived from the 'all dates t-10' dataset, which represented the percentage of inundated observations of the cloud free observations:

$$\left[\frac{\text{Number of inundated counts for pixel}}{\text{Number of cloud-free observations for pixel}} \right] * 100$$

The inundation dataset for the whole study area was then classified into five ordinal classes, according to percentage ranges:

- 1–5% → '1 rarely inundated'
- 5–25% → '2 occasionally inundated'
- 25–50% → '3 regularly inundated'
- 50–75% → '4 frequently inundated'
- 75–100% → '5 commonly inundated'

The wetland extent polygons were overlaid in ArcGIS 10.1 with the inundation classes, and the percentage area of inundation class of the original wetland polygon

⁷ See <https://sdi.nsw.gov.au/catalog/main/home.page> and search for 'Landuse'.

was calculated. A series of IF statements were then used to determine the inundation class to assign to the original wetland polygon:

- If the percent area of '5 commonly inundated' was $\geq 25\%$, then inundation class was assigned as '5 commonly inundated'.
- If the percent area was $< 25\%$, the accumulated (summed) percent of '5 commonly inundated' and '4 frequently inundated' were considered, and if the summed area was $\geq 25\%$, then the inundation class was assigned as '4 frequently inundated'.

The process was repeated to cumulatively and sequentially assign an inundation class to wetland polygons.

All remaining unassigned wetland polygons that did intersect the inundation but did not meet the accumulated 25% threshold were assigned to the '1 rarely inundated' class.

The result of this analysis is recorded as the 'SW_regime' in the published dataset.

In addition, because the inundation technique underestimates inundation counts in densely vegetated wetland areas, an 'adjusted' inundation class was also generated as follows:

- If the wetland polygon had groundwater or a stream connection identified as a water source **and** the surface water regime was unassigned or '1 rarely inundated', then the adjusted surface water regime was recorded as '2 occasionally inundated'.
- If the wetland polygon had a managed stream connection **and** the surface water regime was unassigned or '1 rarely inundated' or '2 occasionally inundated', the adjusted surface water regime was recorded as '3 regularly inundated'.

Finally, the dataset was intersected with the state-wide NSW Woody Vegetation Extent and FPC [Foliage Projective Cover] 2011 dataset⁸. Polygons that intersected with very low standard deviation FPC, and which had been changed from '1 rarely inundated' to '2 occasionally inundated' in the steps above were corrected back to '1 rarely inundated'. The assumption made here was that wetlands that remained dry despite having a stream connection would have a low standard deviation in foliage projective cover through time.

The final result of this analysis is recorded as the 'DW_regime' in the published v1.0 dataset.

4.4.8 Wetland system

Riverine wetlands had previously been identified using the methods described above (see section 4.3). This step identified palustrine and lacustrine wetland system polygons from those not already identified as riverine. The lacustrine class was derived from the dd7 dataset described above, as this dataset was optimised to identify areas of open water, but is not as sensitive to water beneath vegetation. Using the dd7 dataset, groups (neighbouring pixels) with inundation counts of 25 or greater and a combined area of 89 or more pixels (ie approx. 8 hectares and larger) were identified, and classed as 'preliminary lacustrine'. This dataset was intersected

⁸ Available from the OEH Data Portal at <http://data.environment.nsw.gov.au/dataset/nsw-woody-vegetation-extent-fpc-20119bb42>.

with our wetland polygons. If the preliminary lacustrine area covered 50% or more of the wetland polygon, the wetland polygon was recorded as 'lacustrine' in the published v1.0 dataset.

4.4.9 Water type and salinity hazard

Water type refers to water quality parameters, principally pH and salinity (AETG 2012). Comprehensive data to attribute water type to individual wetland polygons across the study area does not exist, and is noted as a limitation in previous wetland typology applications in New South Wales as well as Victoria and Queensland (QEPA 2005, Brooks *et al.* 2014, DEPI 2014). Assuming water quality plays a large role in determining habitat tolerances and suitability for plant species, we inferred pH and salinity from the NSW Vegetation Information System (VIS) and PCTs (NSW OEH 2014), finding no persistently acidic or saline assemblages and therefore all wetlands are assigned as freshwater in the v1.0 dataset.

In addition, a salinity hazard raster dataset was produced for the Lachlan River Catchment by applying the methods developed by Moore *et al.* (2017), Cowood (2016), Muller *et al.* (2015), and Wooldridge *et al.* (2015). This dataset was developed using understanding of land use (ABARES 2011), soil mapping (Isbell 1998) and previous assessments in the study area (Ahern *et al.* 1998, Naylor *et al.* 1998, NLWRA 2001). Wetland polygons were then each assigned a salinity hazard value representing the majority area value of the salinity hazard raster dataset.

4.4.10 Vegetation structure

Vegetation structure is provided in a separate file. Vegetation polygons are provided as subdivisions of the larger wetland polygons which are assigned a unique wetland ID number (i.e. there is a one to many wetland ID polygon to wetland vegetation polygon relationship). Vegetation structure was assigned to wetland polygons using the State Vegetation Type Map: Central West/Lachlan Region Version 1.0 VIS_ID 4468⁹ showing native vegetation, including PCT. Wetland PCTs (vegetation map units) were identified using Table 2. Identified wetland plant community types in the vegetation map were then allocated a wetland vegetation structural class ('non wetland', 'forest/woodland wetland', 'shrubland wetland' or 'grassland/sedge/herb wetland'). The grassland/sedge/herb (GSH) class was considered to include areas of open water and/or aquatic vegetation in addition to emergent species. This dataset was then intersected with the wetland polygons. Very small polygons (slivers) resulting from the intersection were then removed (merged to the nearest large polygon with the same wetland ID number) using the ArcGIS eliminate tool. Where vegetation was identified as non-native vegetation (open water in the state vegetation type map) and occurred in a lacustrine wetland polygon, the vegetation class was changed to GSH. The wetland vegetation structure classes were also checked against the best available imagery viewed at a scale of 1:50,000, and the vegetation class was updated where inconsistencies were identified.

4.5 Validation and accuracy assessment

The map accuracy was assessed following the methods recommended by Stehman and Czaplewski (1998). Accuracy was assessed for wetland and non-wetland map

⁹ Available on the OEH Data Portal at http://data.environment.nsw.gov.au/dataset/central-west-lachlan-regional-native-vegetation-pct-map-version-1-0-vis_id-4358182f4 (now showing version 1.3).

units, and also for the final wetland vegetation structure classes (wetland forest/woodland, wetland shrubland, wetland GSH, and non-wetland). Users should note that accuracy of additional map attributes, including wetland system, water regime class, landuse, soil type and geomorphic setting, has not been assessed. This was outside the scope of the project.

Field data (rapid vegetation surveys) was collected across the study area and compared with the final map layer. The data was collected over the period April 2016 to February 2017 by OEH staff and Eco Logical Australia from 386 point locations within areas of public land. The sites were selected using a stratified random sampling design applied to wetland/non wetland areas using our draft dataset (Stage 1). Non-wetland areas were clipped to include only the area within 1000 metres of mapped wetland areas.

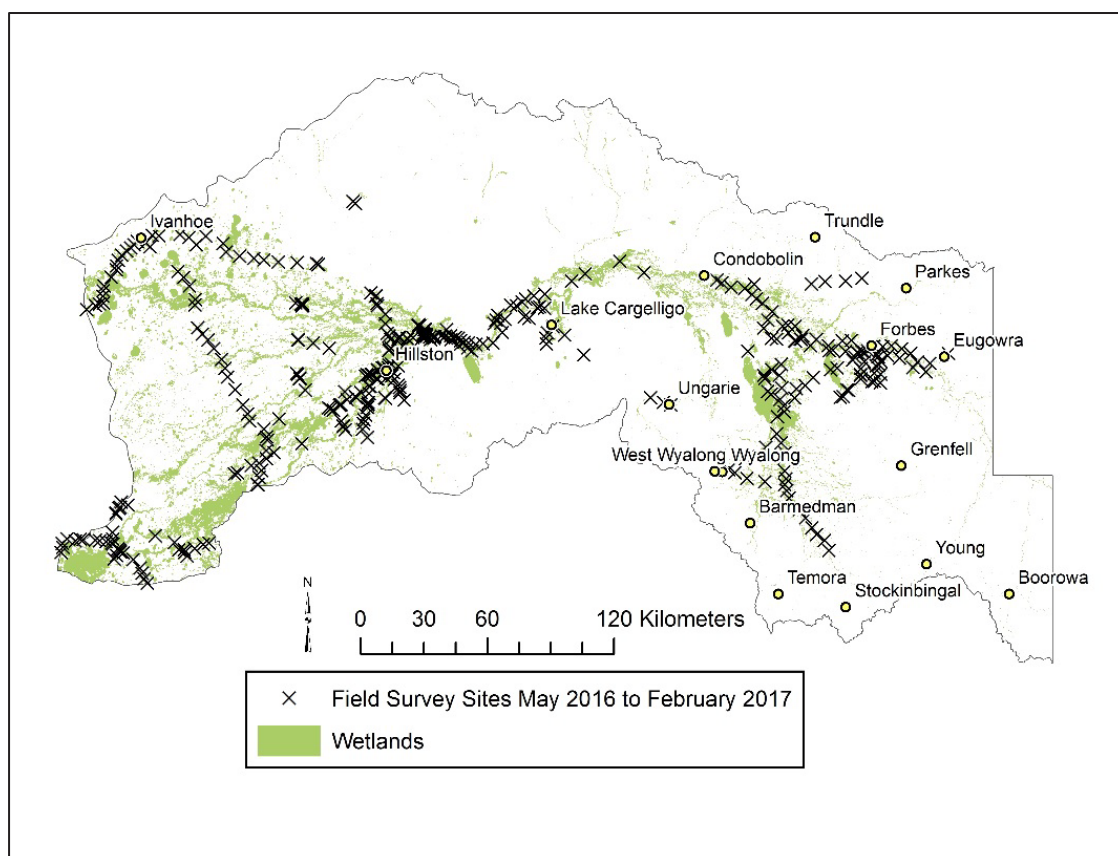


Figure 3 Field survey locations for accuracy assessment of wetland map

Following OEH guidelines for collection of rapid vegetation survey data, the following was recorded at each location:

- dominant three species in the upper, mid, lower stratum
- growth form for each dominant species
- cover (canopy cover) and abundance for each dominant species
- modal height for each stratum
- percentage cover for each stratum (canopy cover).

In addition, we noted any wetland indicator species if they were present but not already included in the identified dominant species.

The rapid vegetation survey data was used to allocate each site to a PCT, using the description and standard classification provided in the NSW OEH VIS Classification

(VIS-C) database. Each site was then allocated to a wetland/non-wetland class and vegetation structural class equivalent to our map units, using the look-up table developed earlier (Table 2).

The overall accuracy (number of observed agreements) was 74.61% (Table 4). However, this does not take into account the pixel size (30 metres) or the positional accuracy of the hand held GPS (around 10 metres). To gain an understanding of the effect of pixel size on overall accuracy, the number of survey sites within 15 metres (equivalent to half a pixel) of a wetland non-wetland boundary was calculated and found to be high relative to the total number of samples. Of the 98 incorrectly mapped survey sites, 46 were located within 15 metres of the mapped wetland/non-wetland boundary. This relatively high proportion of survey sites close to boundaries was a result of our stratified sampling design which generated a larger number of sites within 1000 metres of wetland/non-wetland boundaries. Terrestrial (non-wetland) areas located further than 1000 metres from wetland boundaries were not sampled. If an assumption is that incorrectly mapped survey sites are correct if they are within 15 metres (half a pixel) of the mapped wetland/non-wetland boundary, the overall accuracy (number of observed agreements) is estimated to be higher, at 79.02 % (Table 3).

Wetland boundaries are difficult to map, particularly within landscapes that support semi-permanent wetland types. It is expected that semi-arid wetland vegetation and plant indicator species such as occur in the Lachlan River Catchment expand and contract in extent through wetter and drier phases; it is likely this expansion and contraction through time also explains some of the disagreement between the observed wetland/non-wetland status of survey sites compared to the mapped boundaries.

Table 4 Accuracy assessment of wetland/non wetland boundaries

1. Raw values (e.g. no adjustment to account for pixel size)

		Predicted (mapped)		
		Wetland	Non-wetland	Total
Observed (field survey)	Wetland	121	31	152
	Non-wetland	67	167	234
	Total	188	198	386

Number of observed agreements: 288 (74.61% of the observations)

Number of agreements expected by chance: 194.1 (50.28% of the observations)

Kappa = 0.489

SE of kappa = 0.044

95% confidence interval: from 0.404 to 0.575

2. Assumption that predicted correct if the correctly predicted boundary is mapped with +/-15 metres of the observed location, i.e. all values are for the adjusted case (wetland boundaries +/-15 metres)

		Predicted (mapped)		
		Wetland	Non-wetland	Total
Observed (field survey)	Wetland	131	21	152
	Non-wetland	60	174	234
	Total	191	195	386

Number of field observations within +/-14 metres of mapped wetland/non-wetland boundary = 46 (out of total 386 observations)
 Number of observed agreements: 305 (79.02% of the observations)
 Number of agreements expected by chance: 193.4 (50.11% of the observations)
 Kappa = 0.579
 SE of kappa = 0.041
 95% confidence interval: from 0.500 to 0.659

The results for the accuracy assessment of wetland vegetation structure classes are shown in Table 5. Some field sites could not be reliably allocated to a PCT, so structure was not recorded and these sites were excluded from this analysis.

Overall accuracy (number of observed agreements) is 70.24%. Note there is no adjustment for effect of pixel size on accuracy measures. As is the case above for wetland/non-wetland boundaries, many of the observed pixel values are expected to occur within 15 metres of the wetland vegetation class boundaries, and this likely explains at least some of the error.

Table 5 Accuracy assessment of wetland vegetation structural classes

		Predicted (mapped)				Total
		Non-wetland	Wetland forest/ woodland	Wetland shrubland	Wetland grassland/ sedge/herb/ aquatic	
Observed (field survey)	Non-wetland	167	38	14	9	228
	Wetland forest/ woodland	19	87	5	3	114
	Wetland shrubland	5	2	5	1	13
	Wetland grassland/ sedge/ herb/ aquatic	7	1	7	3	18
	Total	198	128	31	16	373

Number of observed agreements: 262 (70.24% of the observations)
 Number of agreements expected by chance: 162.0 (43.43% of the observations)
 Kappa = 0.474
 SE of kappa = 0.038
 95% confidence interval: from 0.399 to 0.549

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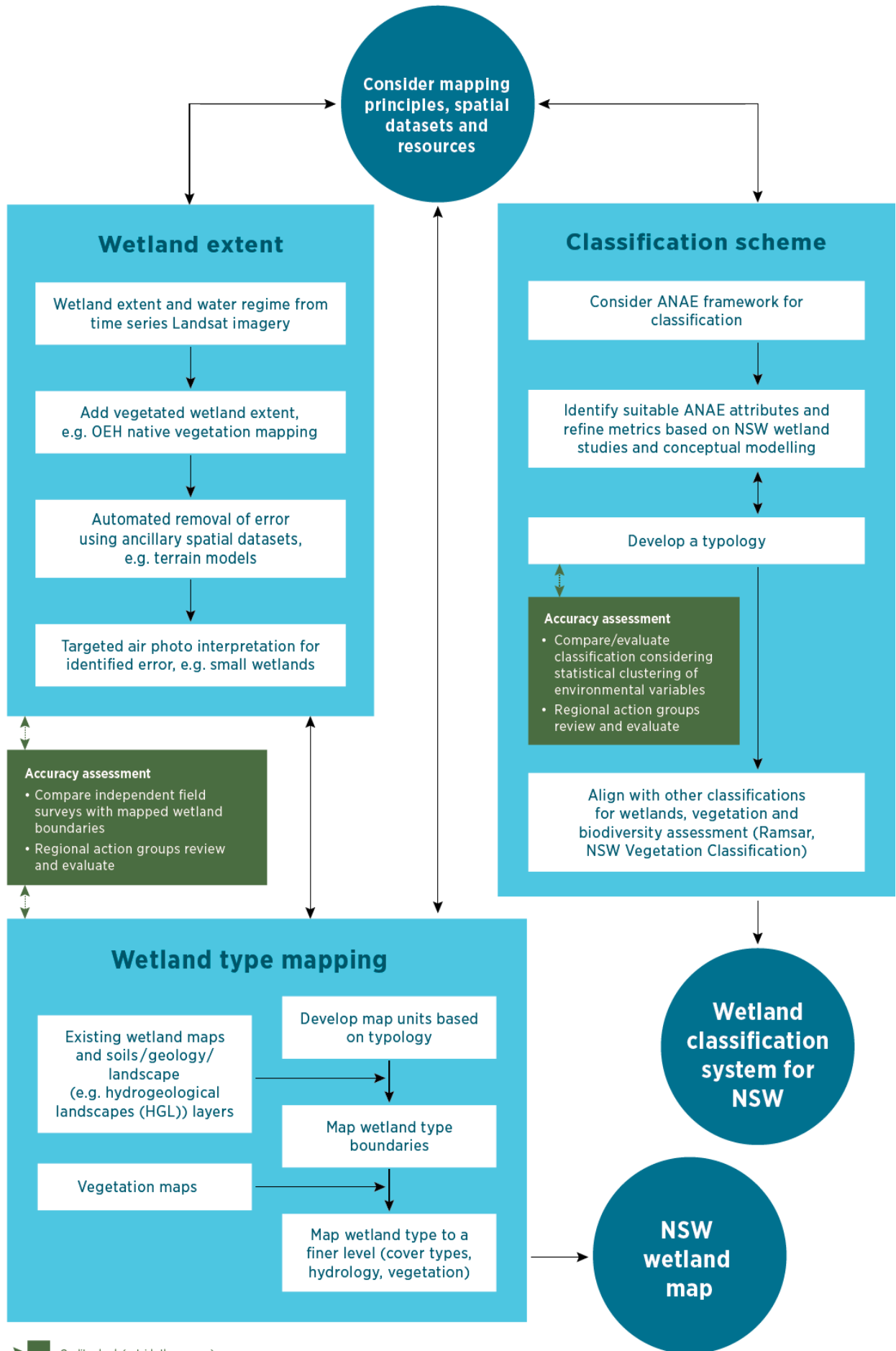
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Appendix A – Mapping and classification approach or framework

Foundation	Goals and objectives for mapping	Mapping & classification activities
<p>Our purpose</p> <ul style="list-style-type: none"> Improve on the previous statewide wetland map (Kingsford <i>et al.</i> 2003) for NSW by improving on the accuracy and scale. Build on existing classifications of wetlands and biodiversity information systems to better represent and provide information on the diversity of wetland types in NSW. Improve mapping and data to support regional to statewide approaches to wetland management and protection. 	<p>Overarching goal</p> <p>To produce a consistent map of wetland extent and type across NSW.</p> <p>Objectives</p> <ol style="list-style-type: none"> Provide end-users with the information and data they need for evidence based decision making for better managed wetlands. Identify and address knowledge gaps for NSW wetlands. 	<p>To address objectives</p> <ul style="list-style-type: none"> Provide statewide guidelines to improve consistency of mapping and classification of wetlands. Extend the methods developed in the pilot study across the state to produce a consistent statewide map of wetland extent and type. Identify and address key knowledge gaps for each region in relation to wetland extent and type. Include review and evaluation of map and classification products by Regional Advisory Groups. Report on accuracy of mapping products and provide guidelines for their scale-appropriate use. Align with other government programs related to biodiversity and monitoring. Make the data publicly available via a web-based portal.
<p>Our principles for mapping and classification</p> <ol style="list-style-type: none"> Mapping methods will delineate wetland types consistently across NSW. The methods and classification will align with and extend the Australian National Aquatic Ecosystem (ANAE) framework for mapping and classification. This will ensure compatibility with Commonwealth wetland initiatives and allow for flexibility to include information additional to that currently included in the ANAE framework. Mapping methods will also be compatible with wetland mapping programs in other states to avoid data compatibility issues across jurisdictional boundaries. Methods and the map product will build-on, support and align with existing OEH and other NSW Government programs as far as possible, including the NSW Native Vegetation Information Strategy, Environmental Water Management Program and the NSW Monitoring, Evaluation and Reporting Programs for Estuaries and Coastal Lakes, Rivers, and Groundwater. This will ensure that the project adds value to existing programs, avoids duplication of effort, creates efficiencies, and demonstrates responsible use of resources. The resulting spatial datasets will address the key knowledge gaps and provide information required by stakeholders, including supporting the development of variables to monitor statewide wetland extent over time. Methods must be fit for purpose, robust and repeatable. Map products will be released with guidelines on their scale-appropriate use. All map products will be released with a date, version number and metadata statement, consistent with NSW standards. Revisions may be published with subsequent versions and dates. Data will be made accessible and publicly releasable. Mapping methods will be predominantly desk-top based, as resources for field surveys are limited. The focus of field survey data collection will be to support the calibration and accuracy assessment of the desktop mapping method. 	<p>Definition of wetlands</p> <p>Areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle (<i>NSW Wetlands Policy 1.1, p.2</i>)</p> <p>Note: Mapping and classification for the proposed NSW Wetland Inventory will include surface water wetlands only. This will include wetlands fed by rainwater, rivers, groundwater and seawater. Estuarine wetlands are included, with boundaries and types determined according to the NSW Monitoring and Evaluation and Reporting Estuary Program and Framework. Marine wetlands including seagrasses outside the estuarine zone, and coral reefs, are excluded from the initial development of the statewide inventory. Karst systems are also excluded. For mapping purposes, areas of hydric soils (modified due to the presence of water) will be included as wetlands.</p> <p>KPI – How we measure success</p> <p>Measure and target</p> <ul style="list-style-type: none"> Satisfaction of governance groups 80% % of data made publicly available 80% % of NSW area mapped and classified 100% End-user satisfaction 80% % key stakeholders downloading data 50% 	<p>To address risks and threats</p> <ul style="list-style-type: none"> Communicate to end-users the intended use and limitations of the mapping products to address unrealistic expectations. Communicate the goal of the mapping and classification and broader NSW Wetland Inventory project. The goal of statewide mapping is to address the knowledge gap for consistent statewide wetland information, not to compile the best available mapping products across the state. Report progress to end users. Regularly collect, consider and address end-user feedback.



→ Quality check (outside the process)

Table 6 Definitions and scope as agreed through collaboration with technical working group representatives from the governance structure

Term	Agreed definition
Wetlands <i>NSW Wetlands policy DECCW (2010)</i>	Areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving. Examples of wetlands include lakes, lagoon estuaries, rivers, floodplains, swamps, bogs, billabongs, marshes, coral reefs and seagrass beds.
Wetland extent	<p>The project will adopt the ‘maximum extent’ through time and space approach to map wetland extent for wetlands that undergo wetting and drying cycles. This will include time series analysis of wetted areas, adopting water indices and ancillary datasets available through the imagery and remote sensing computing facility to include all wetlands present over the period for which we have a suitable Landsat archive (1987–2014).</p> <p>Not all wetland areas will be detected using Landsat imagery. Additional wetland areas will be identified using targeted approaches such as air photo interpretation, and use of existing fine scale vegetation mapping for small, mostly-wet, wetland types.</p>
Wetland type	Once wetland extent is determined, wetland areas will be further subdivided to represent wetland types. GIS methods and existing maps of vegetation, landscape units and terrain, in combination with the water regime information from Landsat analyses, will be used to group wetlands into classes with shared characteristics.
Accuracy assessment	Accuracy will be assessed by comparing the resulting wetland map with available independent ground survey data. We will produce a set of discrete multivariate statistics to measure the amount of agreement between the independent ground truthed dataset and the mapping dataset. This will include existing vegetation and soil survey data, and the collection of new field data to NSW standards. The results will be presented as error matrices. Error matrices will be included in the final report along with an interpretation and discussion of the results.
Mapping scale	<p>Previous state-wide wetland map (2003) was produced at 1:250,000 for inland areas, as only Landsat Multispectral Scanner (MSS) imagery (80m pixel size) was resourced for inland NSW at the time.</p> <p>With new technology and innovation, it is anticipated a semi-automated method using archived Landsat imagery will detect water at a scale of around 1:50,000 (i.e. from Landsat thematic mapper imagery with pixel size of 30 metres). Once the detection of water using the Landsat archive is completed, this study will further refine wetland boundaries by integrating higher resolution imagery and other spatial datasets.</p> <p>The map scale resulting from the pilot study methods will be evaluated and described in the final report, and included in metadata statements accompanying the map product.</p>