Aquatic Conservation Assessment using AquaBAMM

for the riverine and non-riverine wetlands of the Lake Eyre and Bulloo Basins

Summary Report and
Flora, Fauna and Ecology Expert Panel Report
Version 1.1

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Summary Report

Version 1.1

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Cover photo: View of Cooper Creek, Windorah, Southwest Queensland provided by Gary Cranitch, © Qld.Museum 2015.

Please note the cover photo on this report was change in 2023. There were no other modifications to the report.

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Methodology
ASFB	Australian Society for Fish Biology
ASL	Above Sea Level
CAMBA	China–Australia Migratory Bird Agreement
CIM	criteria, indicators and measures used in AquaBAMM
DERM	Department of Environment and Resource Management.
DIWA	Directory of Important Wetlands Australia
DNRM	Department of Natural Resources and Mines
DSITI	Department of Science, Information Technology and Innovation
EHP	Department of Environment and Heritage Protection
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
GIS	Geographic Information System
IBRA	Interim Biogeographic Regionalisation for Australia
IQQM	Integrated water Quantity and Quality simulation Model
JAMBA	Japan–Australia Migratory Bird Agreement
LEBB	Lake Eyre and Bulloo Basins
NCA	*Nature Conservation Act 1992*
QHFD	Queensland Historical Fauna Database
QLUMP	Queensland Land Use Mapping Program
QMDB	Queensland Murray-Darling Basin
Ramsar	Ramsar Convention on Wetlands
RE	Regional Ecosystem
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SOR	State of the Rivers
WMG	Wetland Management Group
WWF	World Wide Fund for Nature

1 Introduction

The Aquatic Biodiversity Assessment and Mapping Methodology (AquaBAMM; Clayton et al. 2006) was developed to assess the conservation value of wetlands across Queensland. It is a comprehensive and scientific method that uses available data and expert knowledge to identify relative wetland biodiversity values within a specified study area (usually a catchment). The product of applying the AquaBAMM is an aquatic conservation assessment (ACA) for a nominated geographic area.

AquaBAMM is a robust and objective conservation assessment method which uses criteria, indicators and measures founded upon a large body of national and international literature. The AquaBAMM criteria, each of which may have a variable number of indicators and measures, include naturalness aquatic, naturalness catchment, diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity, and representativeness.

ACAs undertaken using the AquaBAMM provide a non-social, non-economic, and tenure independent assessment of aquatic biodiversity values at a user-defined scale. ACA results include a rich array of baseline ecological information, and an overall assessment of wetland conservation value (AquaScore), easily interrogated using a Geographic Information System (GIS). ACAs may be useful as an independent product, supporting natural resource management and planning processes, or as a foundation upon which a variety of additional environmental elements (e.g. risks, threats) can be added (i.e. an early input to broader triple-bottom-line decision-making processes).

An ACA can have application in:

- determining priorities for protection, regulation or rehabilitation of wetlands and other aquatic ecosystems
- on-ground investment in wetlands and other aquatic ecosystems
- contributing to impact assessment of large-scale development (e.g. dams)
- water resource and strategic regional planning processes
- providing input to broader social and economic evaluation and prioritisation processes.

The Department of Environment and Heritage Protection (EHP) has completed ACAs for the riverine, non-riverine and spring wetlands of the Lake Eyre and Bulloo Basins (LEBB). This project was commenced in 2010 by the former Department of Environment and Resource Management. The results presented here build upon this work using up-to-date data and by applying the AquaBAMM to springs.

The LEBB study areas consists of the parts of the Lake Eyre Basin (Georgina River, Diamantina River, and Cooper Creek catchments) and Bulloo River catchment situated within Queensland. A separate ACA has been completed for each of the four catchments.

A map of the four LEBB ACA study areas is provided in Figure 1.

This report should be read in conjunction with the flora, fauna and ecology expert panel report (EHP 2016b).

1.1 Study area

The four LEBB study areas cover approximately 562,176km^2 (>30% of Queensland) of arid and semi-arid landscapes in the south–western part of Queensland (Figure 1). They consist of the parts of the Lake Eyre Basin (Georgina River, Diamantina River and Cooper Creek catchments) and Bulloo River catchment situated within Queensland. The parts of the catchments extending into other states were excluded because of an inherent lack of data and the amount of time required to source and retrofit existing data.

The Georgina River, Diamantina River, and Cooper Creek catchments form part of the Lake Eyre Basin, the largest endorheic[1] basin in Australia occupying over 1.2 million square kilometres and approximately one-sixth of the continent. The Lake Eyre Basin has some of the most variable and unpredictable flow regimes on earth (Walker et al. 1995; Kingsford 2006) and contains some of the world’s last large river systems to remain unregulated and minimally human-impacted (Costello et al. 2004). Pisanu et al. (2015) recently assessed the conservation risk of the wetlands of this region, based on IUCN criteria, and found it to be of Least Concern.

The Bulloo River catchment is located directly to the east of the Lake Eyre Basin. It was included in this project because it made practical sense as it is the only river catchment west of the Queensland Murray–Darling Basin (QMDB) and east of the Cooper Creek catchment. The Cooper Creek and Bulloo, Diamantina and Georgina Rivers

[1] Endorheic—a closed drainage basin that retains water and allows no outflow to other external bodies of water, such as rivers or oceans, but converges instead into lakes or swamps (permanent or seasonal) that equilibrate through evaporation.

are all great Australian icons and amongst the last remaining near-natural desert river systems in the world.

The LEBB incorporates areas from seven IBRA bioregions including the whole of the Channel Country, parts of Mitchell Grass Downs and Desert Uplands, and lesser parts of the Simpson/Strzelecki Dune fields, Mount Isa Inlier, Brigalow Belt South and the Mulga Lands. It is roughly the same size as the Queensland Murray–Darling Basin, though is dryer and contains considerably less surface water.

The climate of the LEBB is highly variable ranging from dry-monsoonal in the north, to arid–temperate in the south. This area is hotter than most other areas of Australia with maximum temperatures in many areas exceeding 45°C and places such as Birdsville having maximum temperatures of over 49°C. Some centres can also experience temperatures below -2°C. Average annual rainfall and evaporation rates are 125mm (range 45 to 760mm) and 3.5m respectively (Australian Bureau of Meteorology 2011).

Much of the LEBB is comprised of parts of Sturts Stony, Strzelecki and Tirari deserts. These deserts are the origin of much of the airborne dust in the Southern Hemisphere. Over the last 60 million years or so, the climate of this basin has changed from wet to arid. All of the rivers in Cooper Creek, Diamantina and Georgina River basins flow towards Lake Eyre which is 15m below sea level. Other significant lakes include Lake Frome, Lake Yamma Yamma and Lake Hart. Major protected areas include Lake Eyre National Park, Strzelecki Regional Reserve, Witjira National Park, Sturt National Park, Diamantina Lakes/Astrebla National Park and Simpson Desert National Park.

The LEBB is sparsely populated with the major urban centres being Quilpie, Thargomindah, Blackall, Barcaldine, Longreach, Windorah, Winton, Birdsville, Boulia and Camooweal. The area contains significant mineral deposits including opals, coal, phosphate, gypsum, uranium, oil and natural gas. In fact, mining and petroleum industries comprise the greatest economic activity in region.

Grazing of native vegetation is the main land-use in the LEBB covering the majority of total land area. The development of the pastoral industry has affected the integrity of LEBB ecosystems, although the harsh and changeable climate has resulted in relatively low stocking rates and lower impacts when compared to other areas such as the Murray–Darling Basin (Ford 1995).

The main threatening processes in the LEBB include total grazing pressure in riparian areas, changes in hydrology, invasion by exotic and translocated native species, and changes to water quality and quantity (Pisanu et al. 2015). Another emerging threat to biodiversity is a reduction in the volume, height and frequency of flood waters due to climate change.

LEBB wetlands and associated riparian vegetation are regarded as critical for the maintenance of local and regional biodiversity because of their role in providing wildlife corridors and habitat. The processes threatening these values should be actively managed to minimise threats and to ensure that wetland ecological systems are maintained or improved. The management of LEBB wetlands is complicated by the fact that the Lake Eyre Basin crosses three states and one territory. The Lake Eyre Basin Intergovernmental Agreement was set up in 2001 to facilitate sustainability and the minimisation of cross-boundary impacts in the Lake Eyre Basin.

The LEBB is unique in Australia's arid zone for its high concentration of vast wetland habitats (Ford 1995) and highly specialised groundwater dependent ecosystems. In fact, the LEBB contains some of the most extensive and variable habitats in Australia ranging from broad open water areas to shrub swamps, tall open grasslands, woodlands, sedgelands and ephemeral forblands (Ford 1995; Jaensch 2009). Extensive flood-dependent swamp networks are also situated on the Georgina, Diamantina and Cooper floodplains. Other significant wetland systems include shallow drainage lines, artesian mound springs, waterholes, overflow swamps and flood-outs.

Food resources in these arid systems are generated from light and terrestrial organic carbon inputs (Long & Humphery 1997). Turbid dryland streams such as the Cooper Creek often feature a highly productive bath-tub ring of algae restricted to the shallow littoral margins which can result in metabolic activity one or two orders of magnitude greater than for temperate flowing streams (Bunn & Davies 1999; Bunn et al. 2003). Beyond the photic zone primary production is not significant (Bunn et al. 2003). These riverine conditions have led to a highly specialised but not very diverse riverine ecology with a low diversity of aquatic invertebrates and similar effects on fish species diversity and abundance (Long & Humphery 1997; Bailey 2001). Combined with the isolation of an essentially closed system such features have resulted in the evolution of genetically distinct lineages of aquatic fauna (e.g. Musyl & Keenan 1992; Hammer et al. 2007).

Particularly distinct to the LEBB are extensive dryland river systems characterised by low gradients throughout their course, internal drainage (rather than flowing to the sea), wide floodplains (up to 80km wide in the Cooper Creek), extensive anastomosing channels, large transmission losses and extremely high flow variability (Ford 1995; Costelloe et al. 2004).

The Channel Country refers to floodplains in the mid to lower reaches of the three anastomosed[2] river systems along the Cooper Creek, Georgina and Diamantina Rivers. On average, these areas receive less than 250 mm of rainfall per annum (Jaensch 2009), and during dry periods contain permanent and semi-permanent waterholes characterised by low salinity, high turbidity levels and low visual clarity (Ford 1995, Long & Humphery 1997) that provide refugia for a range of species.

Following significant rains in the northern parts of Queensland (i.e. seasonal monsoon/cyclones) the LEBB transforms from an extremely arid environment to one with volumes of water, bursting into life with grasses, wildflowers, fish, birds and many other forms of life. Massive water flows down the large watercourses create a vast natural flood irrigation system that drives ecosystem processes (and pastoral productivity) and a spectacular ‘boom’ in biological production (Jaensch 2009). Vast swamp and channel networks appear throughout the floodplains providing temporary habitat for wetland fauna. In the lower reaches of the river systems, prolonged overbank flow allows the transfer of energy between the channel and floodplain zone causing the lateral migration of organisms (Sheldon et al. 2003; Leigh et al. 2010). In fact, many flora and fauna have been shown to be uniquely adapted to the irregular rainfall and flooding events experienced by the LEBB. The boom/bust cycle of the region is also central in maintaining ecological connectivity between wetland habitats across timeframes of tens to hundreds of years.

Parts of the LEBB are also known to contain habitat for rare and threatened plant and animal species, or species of conservation concern, such as migratory bird species listed under international conventions. For example, the intermittently flooded shallow swamps and lake systems throughout the region provide a rich habitat for waterbirds including migratory shorebirds. The waterbirds arrive and typically breed in less than a year before bust (drought) conditions return (Jaensch 2009). Hence, the wetlands of the LEBB appear to provide the engine-room of recruitment events for entire populations of highly mobile species (Jaensch 2009). Migrant bird species, such as sharp-tailed sandpiper, use drying wetlands during northward migration to Asian breeding grounds (Barter & Harris 2002, NLWRA 2002).

Spectacular concentrations of waterbirds occur in terminal lakes once the floodplains have dried out. Over 80 species having been recorded in the Channel Country floodplains with surveys documenting huge numbers, e.g. >3 to 4 million individuals during the 2000 and 2001 flood events (Costelloe et al. 2004). Wetlands in the LEBB are recognised nationally and internationally as important for supporting large colonies of breeding waterbirds (White 2001; Costelloe et al. 2004, Jaensch 2009).

Most of the surface water in the LEBB is found in waterholes along the river systems. These areas provide important habitat for fish and turtle species, some of them threatened, and several of which have restricted distributions. For example, some of these species, while widely distributed when the rivers are flowing, are spatially restricted to wetlands that act as refugia during dry times. LEBB waterholes are also known to contain turtle species yet to be fully described.

Twenty nine wetlands within the LEBB are recognised as having national significance due to their biological and conservation value or uniqueness. For example, supplied by floods of the Cooper Creek, Queensland’s largest inland ephemeral lake, Lake Yamma Yamma, is a large fresh water body which fills to capacity about once every 25 to 30 years supporting internationally recognised populations of plumed whistling-ducks, sharp-tailed sandpipers, and Australian pelicans. Other ecologically and geologically significant wetlands include Lake Buchanan and Lake Galilee.

A distinct hydrological component of the LEBB is the deep artesian groundwater systems which operate almost entirely independent of shallower surface water alluvial aquifers (Armstrong 1990). In fact, water emanating from deep artesian groundwater has resulted in numerous spring wetlands which provide specialised habitats of high intrinsic conservation value (Fensham & Fairfax 2003; Fensham et al. 2007). For example, LEBB springs have been recoded as providing habitat for at least seven endemic snails from one genus, a number of undescribed ostracods, amphipods and other invertebrates (Ponder 1986), and a number of endemic flora species (Fensham et al. 2007). Some fish species in the LEBB are totally restricted to mound spring habitats critical for their survival. The Edgbaston Springs within the Springsure Supergroup contain two and possibly three endemic species of fish including the endangered redfin blue eye *Scaturiginichthys vermeilipinnis* which occurs in only several small springs. The cracking clay soils and surrounding grasslands also support a high diversity of large elapid snakes, several endemic reptile species, and very high densities of a number of grassland birds, small distinctive marsupials and reptiles.

[2] Anastomosed - networked into irregularly branching and reconnecting veins or fused together in a vein-like network.

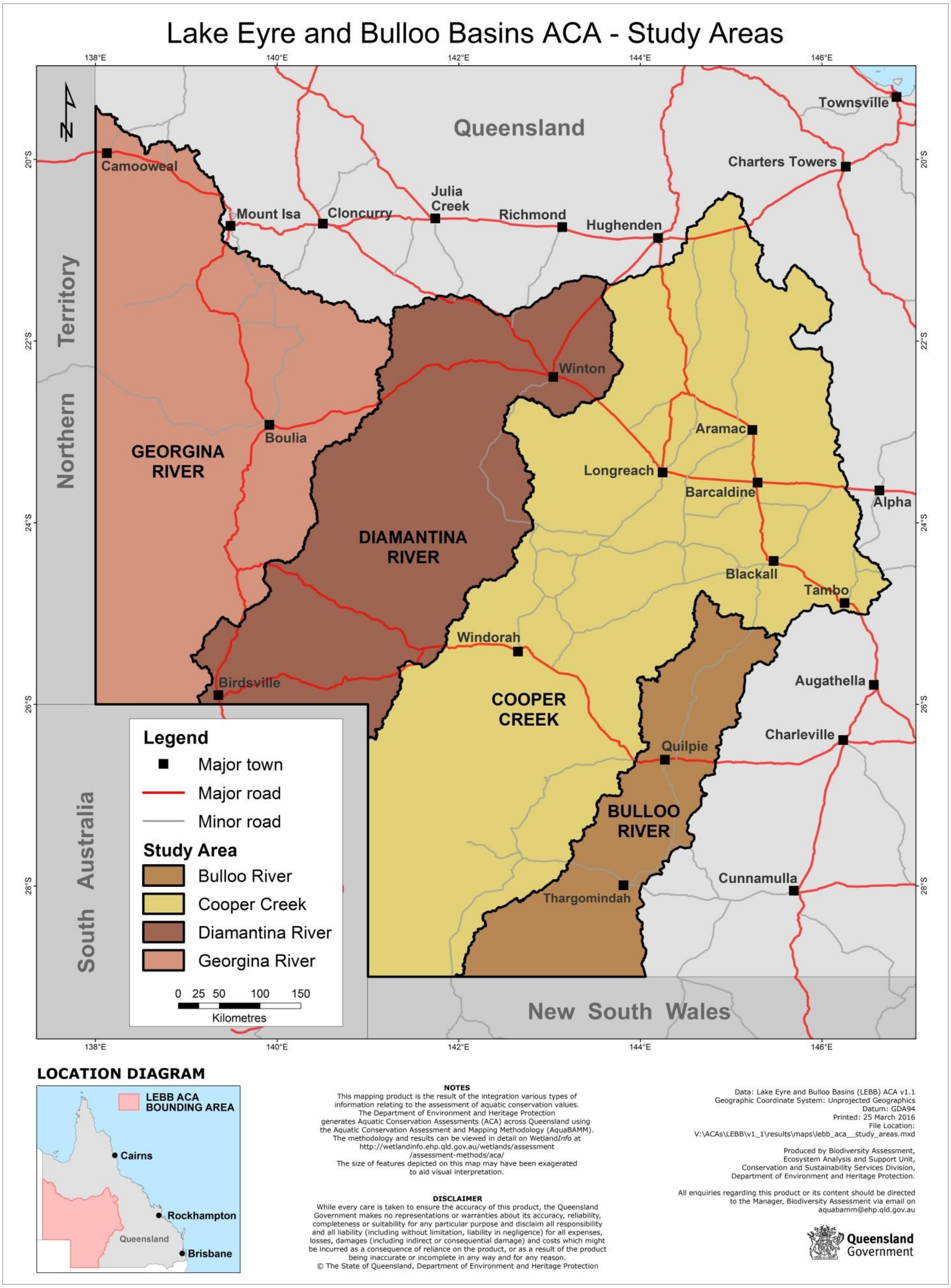


Figure 1. Study areas of the Lake Eyre and Bulloo Basins Aquatic Conservation Assessment project

2 Methods and Implementation

2.1 AquaBAMM

The LEBB ACAs were undertaken using AquaBAMM (Clayton et al. 2006). Published in 2006, the AquaBAMM has since been revised to incorporate measures for non-riverine wetlands and minor changes to the AquaBAMM database tool including revisions to the filter table.

2.2 Spatial units

In implementing an ACA individual mapping units must first be defined to which conservation values can be assessed and assigned. This section describes the spatial units used for each riverine and non-riverine assessment.

2.2.1 Riverine

Spatial units for the riverine assessments were based on large scale (small area) subsections. Subsections attempt to capture areas of similar surface hydrology and processes at a size that balances reporting needs with data availability. LEBB ACA subsections were created using a 1 second digital elevation model, Source Catchments (http://ewater.org.au/products/ewater-source/for-catchments/), and an average planning unit size of 750km^2. Final tidying up of the subsections included merging smaller subsections (<200km^2) and splitting subsections larger than 3,000km^2.

The LEBB riverine assessments included a total of 447 subsections ranging in area from 20,736 to 297,803ha with an average area of 125,767ha. These subsections were also used for selected measure calculations as part of the non-riverine assessments.

2.2.2 Non-riverine wetlands

In Queensland the Queensland Herbarium (the Department of Science, Information Technology and Innovation(DSITI) uses the Wetland Mapping and Classification Methodology (EPA 2005) to map the location, extent and attributes of wetlands across the state. Spatial units for the non-riverine assessments were drawn from this data (Queensland Wetland Data (Version 4.0)). Only natural (H1) or slightly modified (H2M1, H2M2, H2M3, H2M5) wetlands were included. Refer to the Wetland Mapping and Classification Methodology (EPA 2005) for more information on hydrological modifiers.

The LEBB non-riverine assessments included 29,650 palustrine or lacustrine wetland regional ecosystems/waterbodies and 819 springs. The non-riverine spatial units ranged in area from 0.5 to 337,814ha with an average area of 101ha.

2.2.3 Major wetlands

Using Queensland Wetland Data as the base layer for the non-riverine spatial units presented a unique challenge regarding wetland size within the LEBB. For example, several of the non-riverine wetlands associated with Channel Country flood-outs ended up being larger than their coincident subsections. This is important because subsections are used to define the area-of-influence around each non-riverine spatial unit when calculating certain AquaBAMM measures.

A new technique was implemented to ensure all non-riverine wetlands retained a one-to-one relationship with their containing subsections. Importantly, this approach avoided the need to increase the minimum size of all subsections maintaining relatively small spatial units for the riverine assessments.

For the LEBB non-riverine assessments major wetlands were defined as those:

1. with an area > 5000ha
2. that extend over at least three subsections
3. that cannot easily be assigned to a single subsection.

Amalgamations of subsections, called super-subsections, were defined for all major wetlands. In allocating subsections to a major wetland, intersecting subsections were selected and dissolved to cover the entire wetland; intersecting subsections were defined as those that:

- contained at least 10% of the major wetland area
- had at least 25% of their area covered by the major wetland.

The major wetlands defined as part of the non-riverine assessments are shown in Figure 2.

2.2.4 Springs

In previous ACAs springs were included as a value of any containing non-riverine wetlands. Struck by the abundance and importance of springs within the LEBB, this project sought to directly assess the aquatic conservation values of spring wetlands. This project (LEBB ACAs v1.1) is the first time the AquaBAMM has been applied to spring wetlands. A point geometry type shapefile containing the spring results has been included in the final LEBB ACA release package.

For this project springs were defined as discrete (i.e. <1 ha) hydrological features where groundwater discharges to the land surface. Spring spatial units were sourced from the point data published with the Queensland Wetland Data (Version 4.0). Only unmodified (HYDROMOD = ‘H1’) and active-modified (HYDROMOD = ‘H2M4’) non-riverine springs were assessed. Dormant springs (HYDROMOD = ‘H2M4a’) were omitted as they are currently inactive. The five riverine springs in the LEBB study areas were also excluded. A total of 819 springs were assessed as part of the LEBB ACAs. Each spring point was assigned a unique spatial unit ID (SPUNITID) and an area of zero.

Springs were implemented as a district *wetland system type* within the non-riverine AquaBAMM tool databases compiled for each study area. To achieve this spatial units were stratified by *wetland system type* (i.e. stratum 1 = spring wetlands, stratum 2 = non-riverine wetlands). Stratifying in this way allowed different threshold types and/or threshold values to be used for each *wetland system type* within the AquaBAMM databases. Using stratification in this way allowed multiple ACAs to be run within the same AquaBAMM database reducing the data handling and computational overhead.

Implementing spring ACAs within the non-riverine AquaBAMM database should be viewed as an intermediary between the previous approach used to assess spring values and a totally separate ACA for springs using the AquaBAMM. The latter may require additional work including the creation of both criteria, indicators and measures (CIM) and a filter table specifically tailored to springs. This may also involve the modification and/or addition of new AquaBAMM measures including some related to Connectivity and Representativeness. Both of these were beyond the scope and timeframes of the current project.

For the LEBB spring ACAs input data values for measures not available or applicable to springs were left blank in the non-riverine AquaBAMM databases. Doing so effectively turned these measures off leaving the corresponding AquaBAMM results (i.e. AquaScores, criterion and indicator ratings) unaffected. One consequence of this is that the dependability scores produced by the database may underestimate a spring's actual data richness.

The total number and area of spatial units within each LEBB ACA study area is shown in Table 1.

Table 1. Selected study area statistics including the size and number of spatial units

Study area	Study area code	Catchment area (ha)	Number of non-riverine spatial units	Number of spring spatial units	Area of non-riverine spatial units (ha)	Number of riverine spatial units	Area of riverine spatial units (ha)
Bulloo River	ul	5,199,099	6,360	24	283,459	42	5,199,099
Cooper Creek	cp	24,452,253	9,180	375	1,115,598	189	24,452,253
Diamantina River	di	11,847,669	4,903	300	761,999	89	11,847,669
Georgina River	ge	14,718,588	9,207	120	844,753	127	14,718,588
	Total	56,217,609	29,650	819	3,005,809	447	56,217,609

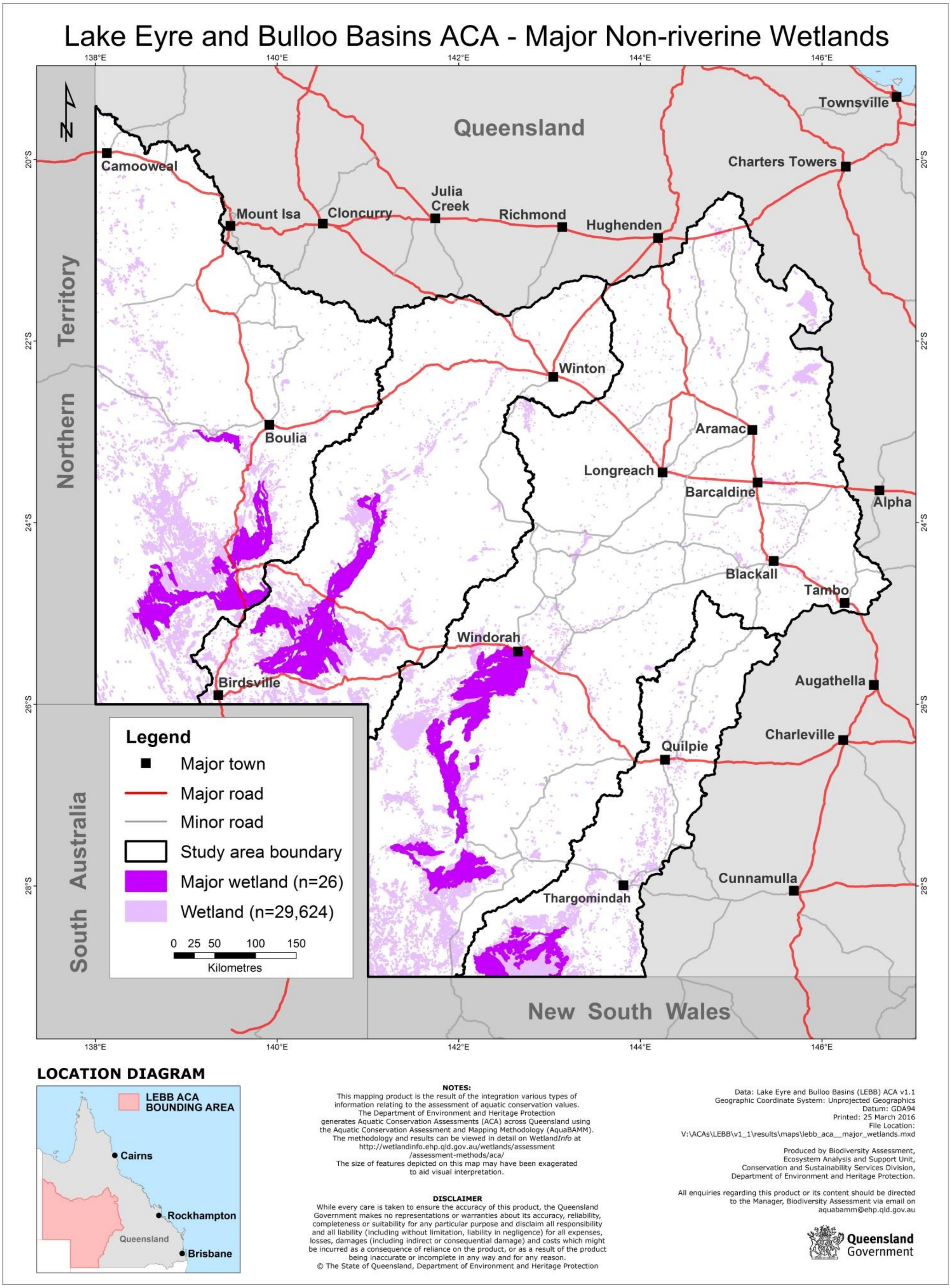


Figure 2. Major non-riverine wetlands of the Lake Eyre and Bulloo Basins

2.3 Assessment parameters

The CIM implemented for each LEBB ACA are outlined in Table 2. A different CIM list was used for the riverine and non-riverine (including springs) assessments.

This list was developed from the default list of criteria, indicators and measures provided by Clayton *et al.* (2006). The default CIM list is not mandatory and instead provides a 'starter set' for consideration when setting up the assessment parameters for a new ACA.

Table 2. Criteria, indicators and measures (CIM) used for each non-riverine, riverine and spring ACA

Criteria and Indicators	Measures		Riverine	Non-riverine	Spring
1 Naturalness aquatic					
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland	Y	Y	Y
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	Y	Y	Y
	1.1.3	Presence of exotic invertebrate fauna within the wetland	Y	Y	Y
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	Y	Y	Y
1.2 Aquatic communities / assemblages	1.2.1	SOR[1] aquatic vegetation condition	Y		
1.3 Habitat features modification	1.3.1	SOR[1] bank stability	Y		
	1.3.2	SOR[1] bed & bar stability	Y		
	1.3.3	SOR[1] aquatic habitat condition	Y		
	1.3.4	Presence/absence of dams/weirs within the wetland	Y		
	1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	Y	Y	Y
1.4 Hydrological modification	1.4.2	% natural flows — modelled flows remaining relative to predevelopment	Y		
	1.4.5	Hydrological disturbance/modification of the wetland (e.g. as determined through EHP wetland mapping and classification)		Y	Y
2 Naturalness catchment					
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	Y	Y	Y
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses	Y		
	2.2.2	Total number of REs relative to preclear number of REs within buffered riverine wetland or watercourses	Y		
	2.2.3	SOR[1] reach environs	Y		

Criteria and Indicators	Measures		Riverine	Non-riverine	Spring
	2.2.4	SOR[1] riparian vegetation condition	Y		
	2.2.5	% area of remnant vegetation relative to pre-clear extent within buffered non-riverine wetland: 500m buffer for wetlands >= 8ha, 200m buffer for smaller wetlands		Y	Y
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	Y	Y	Y
	2.3.2	% "grazing" land-use area	Y	Y	Y
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	Y	Y	Y
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	Y	Y	Y
3 Diversity and richness					
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	Y		
	3.1.2	Richness of native fish	Y	Y	Y
	3.1.3	Richness of native aquatic dependent reptiles	Y	Y	Y
	3.1.4	Richness of native waterbirds	Y	Y	Y
	3.1.5	Richness of native aquatic plants	Y	Y	Y
	3.1.6	Richness of native amphibians (non-riverine wetland breeders)		Y	Y
	3.1.7	Richness of native aquatic dependent mammals	Y	Y	Y
3.2 Communities/ assemblages	3.2.2	Richness of REs along riverine wetlands or watercourses within a specified buffer distance	Y		
3.3 Habitat	3.3.1	SOR[1] channel diversity	Y		
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR[1] sub-section)	Y	Y	Y
	3.3.3	Richness of wetland types within the sub-catchment	Y	Y	Y
4 Threatened species and ecosystems					
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA[2], EPBC[3]	Y	Y	Y
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species — NCA[2], EPBC[3]	Y	Y	Y
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA[2], EPBC[3]	Y	Y	Y

Criteria and Indicators	Measures		Riverine	Non-riverine	Spring
5 Priority species and ecosystems					
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[4], World Wide Fund for Nature (WWF), etc.)	Y	Y	Y
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	Y	Y	Y
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[5] / CAMBA[6] / ROKAMBA[7] agreement lists and/or Bonn Convention)	Y	Y	Y
	5.1.4	Habitat for significant numbers of waterbirds	Y	Y	Y
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	Y	Y	Y
6 Special features					
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	Y	Y	Y
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	Y	Y	Y
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	Y	Y	Y
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study		Y	Y
7 Connectivity					
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/or 6	Y		
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criterion 5 and/or 6	Y		
8 Representativeness					
8.1 Wetland protection	8.1.1	The percent area of each wetland type within Protected Areas.		Y	Y
8.2 Wetland uniqueness	8.2.1	The relative abundance of the wetland management group to which the wetland type belongs within the catchment or study area (management groups ranked least common to most common)		Y	Y

Criteria and Indicators	Measures		Riverine	Non-riverine	Spring
	8.2.2	The relative abundance of the wetland management group to which the wetland type belongs within the subcatchment (management groups ranked least common to most common)		Y	Y
	8.2.3	The size of each wetland type relative to others of its management group within the catchment or study area		Y	Y
	8.2.4	The size of each wetland type relative to others of its type within a subcatchment		Y	Y
	8.2.6	The size of each wetland type relative to others of its type within the catchment or study area		Y	Y

[1] SOR—State of the Rivers

[2] NCA—Nature Conservation Act 1992 (Queensland)

[3] EPBC—Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

[4] ASFB—Australian Society for Fish Biology

[5] JAMBA—Japan–Australia Migratory Bird Agreement

[6] CAMBA—China–Australia Migratory Bird Agreement

[7] ROKAMBA—Republic of Korea–Australia Migratory Bird Agreement

2.4 Stratification

AquaBAMM makes provisions for study areas to be stratified in any manner deemed ecologically appropriate. Stratification mitigates the effects of data averaging across large study areas, and is particularly important where ecological diversity and complexity is high.

Study area stratification for application to one or more AquaBAMM measures is not mandatory for a successful assessment. An example where stratification may be appropriate is fish diversity where fewer species inhabit the upland zone compared to lowland floodplains. For measure datasets where there is an equal probability of scoring across a range of values throughout the study area stratification is unwarranted. To date, the use of stratification in completed ACAs has been based on elevation (e.g. 150m ASL for coastal catchments and 400m ASL for catchments west of the Great Dividing Range in the Murray–Darling Basin) or bioregional boundaries.

Stratification was considered as part of the LEBB ACA expert panel process. The LEBB catchments have three broad geomorphic zones: headwaters, central braided channels and the channel country distributaries leading to a terminal lake (Lake Eyre or Bulloo Lake). The fauna panel members agreed that while there is geomorphic variation, and consequently distinct ecosystems within these broad zones, biologically there was no imperative to stratify ACA measure calculations for species (fish, frogs and birds). For example, genetically there is little difference between fish populations in lowland areas to the headwater streams indicating genetic connectivity within a catchment. Lake Eyre was considered by the panel to represent a barrier to genetic transfer between catchments in the Lake Eyre Basin, however this is outside of the LEBB ACA study areas. The Cooper Creek system is centrally located which is also reflected in genetic diversity of several groups of organisms (fish, molluscs).

After careful consideration the expert panel decided not to stratify the LEBB study areas.

2.5 Datasets

Typically, an ACA using AquaBAMM draws on a range of datasets with varying formats and data types. Data sources generally include published scientific documents and unpublished data (grey literature) such as data collected by various Queensland Government departments (e.g. Queensland Museum, Queensland Herbarium, etc.). In addition, data derived from one or more expert panel workshops is incorporated into every ACA. Expert knowledge is used to inform a range of measures within criteria 5 to 7, and to assign relative ranks and weights to individual AquaBAMM indicators and measures (Clayton et al. 2006).

Three expert panel workshops (flora, fauna, ecology) were held in Brisbane during late November and early December, 2010 as part of the LEBB ACA. The panels were comprised of individuals with expertise in local aquatic and riparian flora, aquatic fauna and/or wetland ecology.

The findings from the LEBB ACA expert panel process are reported in the accompanying expert panel report (EHP 2016b).

2.6 ACA wetland management groups (WMG)

The Queensland Wetlands Program (see http://wetlandinfo.ehp.qld.gov.au/wetlands) identifies attributes addressing characteristics of lacustrine and palustrine wetlands at increasingly specific scales (continental, ecosystem, landscape, and local). These attributes can be used to develop wetland typologies aimed at classifying wetlands into types or groups useful for wetland management, monitoring and regulation.

Through expert consultation, and an iterative process of reality checking with the mapping, a series of wetland habitat types has been developed that are broad enough to cover Queensland, while allowing the identification and grouping of key wetland ecological and physical processes across the broad climatic zones of Queensland (EHP 2016c). As wetlands are spatially and temporally diverse, this typology also allows for combining wetland habitat types which may be found within an individual wetland (e.g. a lacustrine waterbody may have a palustrine fringe). Wetland habitat types are subsequently called wetland management groups for the purposes of an ACA.

2.7 Measure implementation

Each ACA may have a different combination of assessment parameters (refer to section 2.3) and draw on a different combination of source datasets. Implementation of these measures can be complex so comprehensive implementation tables are maintained throughout the implementation process.

A description of how each measure was implemented is provided in Table 3 (riverine) and Table 4 (non-riverine).

Table 3. Riverine measure implementation table

Measure	Description	Implementation	Primary data sets used	Threshold type
1.1.1	Presence of 'alien' fish species within the wetland	An expert panel list of alien fish species found in riverine freshwater wetlands was used to calculate this measure. Species records were compiled from corporate databases. A subsection that had one or more alien fish species recorded (point records or site based lists, >=1975, precision <= 2000m) received a presence negative result (-2). No score was allocated to any spatial unit (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Presence Negative
1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	An expert panel list of exotic aquatic plants was used to calculate this measure. A subsection that had one or more exotic species recorded (point records or site based lists, >=1950, precision <= 2000m) from within its boundaries received a score of -2. No score was allocated to any spatial unit (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Presence Negative
1.1.3	Presence of exotic invertebrate fauna within the wetland	An expert panel list of exotic invertebrate fauna found in riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more exotic invertebrate fauna species recorded (point records or site based lists, >=1975, precision <= 2000m) from within its boundaries received a score of -2. No score was allocated to any spatial unit (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Presence Negative

Measure	Description	Implementation	Primary data sets used	Threshold type
1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	An expert panel list of feral/exotic vertebrate fauna found in riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more feral/exotic vertebrate species recorded (point records or site based lists, ≥1975, precision ≤ 2000m) from within its boundaries received a score of -2, which was then attributed to all spatial units in the subsection. No score was allocated to any spatial unit (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Presence Negative
1.2.1	SOR aquatic vegetation condition	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers) The SOR score (%) for the AQUVEG field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending
1.3.1	SOR bank stability	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers). The SOR score (%) for the BSTAB field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending
1.3.2	SOR bed & bar stability	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers). The SOR score (%) for the B_B field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending
1.3.3	SOR aquatic habitat condition	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers). The SOR score (%) for the AQUHAB field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending

Measure	Description	Implementation	Primary data sets used	Threshold type
1.3.4	Presence/absence of dams/weirs within the wetland	A SOR subsection that had one or more instream dams or weirs located within its boundaries received a score of one. SOR subsections without instream dams or weirs received no score and this measure was thresholded as presence negative.	The Department of Natural Resources and Mines (DNRM) — Dams and Weirs	Presence Negative
1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	Using the remnant and preclear vegetation version 8, the percentage area occupied by remnant riverine wetland types (R) was calculated as a proportion of pre-clear R in each subsection.	Regional ecosystem remnant and preclear mapping. REDD v9 database to obtain the riverine R type wetlands	Quartile Continuous Ascending
1.4.2	% natural flows — modelled flows remaining relative to predevelopment	Spatial units were assigned a score (one to four) based on expert knowledge (DNRM) of the LEBB catchment hydrology.	Expert Knowledge, DNRM IQQM	Categorical Cullen (2003) Heritage Rivers (AquaScore: >=95 = 4; >=85 = 3; >=67 = 2; <67% = 1)
2.1.1	Presence of exotic terrestrial plants in the assessment unit	An expert panel list of exotic plants found within the riparian zone of streams and wetlands was used to calculate this measure. A subsection that had one or more exotic species recorded (point records or site based lists, ≥1950, precision ≤2000m) from within its boundaries received a score of one. No score was allocated to any spatial unit (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Presence Negative
2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses	Pre-clear, RE, and study area feature classes were intersected. Study area by study area, the intersection product was intersected with the river buffers. Areas of all polygons were calculated, then percentages of remnant/preclear within the river buffers was calculated into the output table.	DSITI RE and preclear mapping v9. River buffers derived from NRM rivers line features	Quartile Continuous Ascending
2.2.2	Total number of REs relative to preclear number of REs within buffered riverine wetland or watercourses	Using the pre-clear x RE x study area intersection product from 2.2.1, the numbers of distinct REs and pre-clear RE's in each subsection's river buffers were recorded into a table, then divided one by the other. The percentages were copied to the measure's output table.	DSITI RE and preclear mapping v9. River buffers derived from NRM rivers line features	Quartile Continuous Ascending

Measure	Description	Implementation	Primary data sets used	Threshold type
2.2.3	SOR reach environs	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers). The SOR score (%) for the RENV field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending
2.2.4	SOR riparian vegetation condition	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers). The SOR score (%) for the RIPVEG field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending
2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	“Agricultural” land-use included (Queensland Land Use Mapping Program (QLUMP) secondary categories) intensive animal production, intensive horticulture, cropping, perennial horticulture, plantation forestry, irrigated cropping, irrigated perennial horticulture, irrigated seasonal horticulture and reservoir/dam. These land-use types were allocated an agriculture attribute and a % area was calculated for agricultural areas within each subsection. Thresholding applied the average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Descending
2.3.2	% "grazing" land-use area	“Grazing” land-use included (QLUMP secondary categories) grazing natural vegetation. These land-use types were allocated a grazing attribute and a % area was calculated for grazing areas within each subsection. Thresholding applied the average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Descending
2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	“Vegetation” land-use included (QLUMP secondary categories) managed resource protection, nature conservation, other minimal use, production forestry, estuary/coastal waters, lake, marsh/wetland, river. These land-use types were allocated a vegetation attribute and a % area was calculated for vegetation areas within each subsection. Thresholding applied the average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Ascending

Measure	Description	Implementation	Primary data sets used	Threshold type
2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	"Settlement" land-use included (QLUMP secondary categories) manufacturing and industrial, mining, residential, services, transport and communication, utilities, waste treatment and disposal, and channel/aqueduct. These land-use types were allocated a settlement attribute and a % area was calculated for settlement areas within each subsection; this value was then applied to each spatial unit within the subsection. Thresholding applied the average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Descending
3.1.1	Richness of native amphibians (riverine wetland breeders)	A list of native amphibians (riverine wetland breeders) was identified in the SEQ fauna expert panel. Using point records (>=1975 and a precision <2000m), an identity was run against subsections> to determine species richness in each. No score was allocated to any spatial unit that had an absence of amphibians (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.2	Richness of native fish	An expert panel list of fish dependent on freshwater streams for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000 m were included. A subsection was attributed with the number of fish species it contained. No score was allocated to any subsection that had an absence of species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.3	Richness of native aquatic dependent reptiles	An expert panel list of reptiles dependent on streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2000m were included. A subsection was attributed with the number of reptile species it contained. No score was allocated to any subsection that had an absence of species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.4	Richness of native waterbirds	An expert panel list of waterbirds dependent on streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2000m were included. A subsection was attributed with the number of waterbird species it contained. No score was allocated to any subsection that had an absence of species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.5	Richness of native aquatic plants	An expert panel list of aquatic and semi-aquatic plants (macrophytes) was used to calculate this measure. Records ≥1950 and a precision ≤2000m were included. A subsection was attributed with the number of species records it contained. No score was allocated to any spatial unit (subsection) that had an absence of species (i.e. they were treated as a missing value).	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Continuous Ascending or Categorical

Measure	Description	Implementation	Primary data sets used	Threshold type
3.1.7	Richness of native aquatic dependent mammals	An expert panel list of mammals dependant on freshwater streams for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000m were included. A subsection was attributed with the number of species records it contained. No score was allocated to any spatial unit (subsection) that had an absence of species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.2.2	Richness of REs along riverine wetlands or watercourses within a specified buffer distance	Due to the lack of suitable ordered stream network, major watercourses were selected by name (Cooper Creek, Thomson River, Bulloo River, Gegina River, Diamantina River, Barcoo River, Hamilton River, Eyre Creek, Burke River, Towerhill Creek, Mulligan River, Trens Creek, Alice River, Okena Creek, Pollygammon Creek, Warri Warri Creek, Moonah Creek, Cottonbush Creek, Ernestina Creek, Western River, Mayne River, Landsbough Channel, Landsbough Creek, Farrars Creek, Wilson River, Mackunda Creek, Gumbo Gumbo Creek, Moble Creek, Middleton Creek, Cadell Creek, Warburton Creek, Wokingham Creek, Paravituari Creek) and buffered by 200m. Remaining watercourses were buffered by 50m. The number of remnant regional ecosystems was calculated for each spatial unit.	Queensland Herbarium Remnant Vegetation Mapping (Ver. 9.0, 2015) Drainage Network —-creeks (QLD) [Enterprise GIS]	Quartile Continuous Ascending
3.3.1	SOR channel diversity	SOR data only exists within the Cooper. Process was to intersect the SOR subcatchments with the Cooper subsections (not identical) and remove the SORSS_G94_ numbers 607,687,740,754 (long skinny polygons along Thompson and Barcoo Rivers). The SOR score (%) for the CHDIV field for each spatial unit was directly incorporated into the analysis, through taking the minimum for the intersected layer, any values for study areas other than Cooper.	DERM State of the Rivers	Quartile Continuous Ascending
3.3.2	Richness of wetland types within the local catchment (e.g. SOR subsection)	The number of different wetland habitat types (based on TYPE_RE field—a concatenation of wetland class, hydromodifier, water regime, salinity modifier and WETRE fields from the QWM data) was calculated for each subsection. Threshold values were calculated based on the average of the three highest weighted richness scores (by subsection). To be allocated, the [SPUNITID] and its associated subsections, had to match those identified in the Wethabitat x subsection intersect. Any that were missed were assigned to the subsection that occupied the maximum area of the non-riverine spatial unit.	Queensland Wetland Data (v4.0), LEBB ACA subsections	Quartile Continuous Ascending

Measure	Description	Implementation	Primary data sets used	Threshold type
3.3.3	Richness of wetland types within the subcatchment	The number of different wetland habitat types (based on TYPE_RE field—a concatenation of wetland class, hydromodifier, water regime, salinity modifier and WETRE fields from the QWM data) was calculated for each subcatchment, and subsequently applied to all subsections already allocated to that sub-catchment (each subcatchment is made up of one or more subsections). Threshold values were calculated based on the average of the three highest weighted richness scores (by subcatchment). To be allocated, the [SPUNITID] and its associated sub-catchment, had to match those identified the Wethabitat x sub-catchment intersect. Any that were missed were assigned to the sub-catchment that occupied the maximum area of the non-riverine spatial unit.	Queensland Wetland Data (v4.0), LEBB ACA subsections	Quartile Continuous Ascending
4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act	A list of rare or threatened (NCA or EPBC) riverine aquatic ecosystem dependent fauna species identified by the expert fauna panel was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to the subsection.	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species Quartile - Continuous Ascending: Min. species count = 2

Measure	Description	Implementation	Primary data sets used	Threshold type
4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species - NCA Act, EPBC Act	A list of rare or threatened (NCA or EPBC) riverine aquatic ecosystem dependent flora species identified by the expert fauna panel was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to the subsection.	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2
4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA Act, EPBC Act	The Regional Ecosystem Biodiversity Status was used to score spatial units. The WETRE (previously WB_RE) field in the RIVERINE polygons in the Queensland Wetlands Mapping version 1.3 was used to identify the associated REs for each spatial unit. Endangered REs scored a four, Of Concern REs scored a three, No Concern at Present REs scored a two and spatial units without a RE category (i.e. “water”) scored one. Where a spatial unit had several polygons of differing REs, the maximum RE score was assigned to the spatial units. (de-concatenation code was used to separate these).	Queensland Wetland Data (v4.0), LEBB ACA subsections	Categorical - Endangered = 4 Of Concern = 3 Least Concern = 2 No RE = 1
5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, etc.)	An expert panel derived list of priority riverine aquatic ecosystem dependent fauna species was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to the riverine subsection.	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2

Measure	Description	Implementation	Primary data sets used	Threshold type
5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	An expert panel derived list of priority riverine aquatic ecosystem dependent flora species was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to the riverine subsection.	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2
5.1.3	Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA/ CAMBA/ ROKAMBA agreement lists and/or Bonn Convention)	An expert panel derived list of migratory species dependent on riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to the riverine subsection.	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2
5.1.4	Habitat for significant numbers of waterbirds	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Presence Positive, User Defined or Categorical
5.2.1	Presence of 'priority' aquatic ecosystem	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Presence Positive, User Defined or Categorical

Measure	Description	Implementation	Primary data sets used	Threshold type
6.1.1	Presence of distinct, unique or special geomorphic features	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Presence Positive, User Defined or Categorical
6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Presence Positive, User Defined or Categorical
6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	No Ramsar sites exist in LEBB. Spatial units that had interaction with the mapped boundaries of Directory of Important Wetlands Australia (DIWA) were identified and these spatial units were allocated a score of three. No score was allocated to spatial units that were not identified as significant by such methods (i.e. they were treated as a missing value).	DIWA	Categorical
7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6	The connectivity value of spatial units upstream from a special feature identified (and implemented) in Expert Panel Measures 5.1.4, 6.3.1 and calculations for 6.3.2 scored in this measure. Every spatial unit above a particular special feature was scored with the upstream adjoining spatial units to a special feature being scored a four, the next closest spatial units received a score of two and the remainder above a special feature were scored a one. The spatial unit having the special feature located within it was not given a score because it has already received a score in criterion five or six. Where a spatial unit had more than one calculation, the maximum value was incorporated.	Riverine Expert Panel Measures 5.1.4 and 6.3.1 and calculations for 6.3.2 (DIWA), Australian Hydrological Geospatial Fabric	Presence Positive, User Defined or Categorical
7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	The connectivity value of spatial units that contained the special features identified in the non-riverine ACA for measure 6.3.2 and 6.3.3 was assessed. Subsections (spatial units) that contained features identified in the non-riverine GBR ACA Version 1.2 (only those with a conservation rating of four), were given a value of four.	Non Riverine Measure 6.3.2 and Expert Panel Measure 6.3.3 that scored a 4, Australian Hydrological Geospatial Fabric	Presence Positive, User Defined or Categorical

Data extraction dates:

CORVEG — point records data extracted 02/07/2015

ParkInfo — pest species point records on estates extracted 27/08/2015

WildNet — point records extracted 14/08/2015

Queensland Historical Fauna Database — point records extracted 27/08/2015

Table 4. Non-riverine (including springs) measure implementation table

Measure	Description	Implementation	Primary datasets used	Threshold type
1.1.1	Presence of 'alien' fish species within the wetland	**Non-riverine wetlands** An expert panel list of alien fish species found in non-riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more alien fish species recorded (point records or site based lists, ≥1975, precision ≤ 2000m) from within its boundaries received a measure score of -2 which was then attributed to all the spatial units in this subsection. No score was allocated to any spatial unit where the associated subsection had an absence of exotic species (i.e. they were treated as a missing value). **Springs** An expert panel list of exotic fish dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Presence Negative
1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	**Non-riverine wetlands** An expert panel list of exotic aquatic plants was used to calculate this measure. A subsection that had one or more exotic species recorded (point records or site based lists, ≥1950, precision ≤2000m) from within its boundaries received a measure score of -2 which was then attributed to all the spatial units in this subsection. No score was allocated to any spatial unit that had an absence of exotic species (i.e. they were treated as a missing value). **Springs** An expert panel list of exotic flora dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Presence Negative
1.1.3	Presence of exotic invertebrate fauna within the wetland	**Non-riverine wetlands** An expert panel list of exotic invertebrate fauna found in non-riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more exotic invertebrate fauna species recorded (point records or site based lists, ≥1975, precision ≤ 2000m) from within its boundaries received a measure score of -2, which was then attributed to all spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of exotic species (i.e. they were treated as a missing value).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Presence Negative

Measure	Description	Implementation	Primary datasets used	Threshold type
		Springs An expert panel list of exotic invertebrate fauna dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2 km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).		
1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	**Non-riverine wetlands** An expert panel list of feral/exotic vertebrate fauna found in non-riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more feral/exotic vertebrate species recorded (point records or site based lists, ≥1975, precision ≤ 2000m) from within its boundaries received a measure score of -2, which was then attributed to all spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of exotic species (i.e. they were treated as a missing value). **Springs** An expert panel list of exotic vertebrate fauna dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Presence Negative
1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	Using the remnant and pre-clear vegetation version 9, the percentage area occupied by remnant non-riverine wetland types (P, L) was calculated as a proportion of pre-clear P and L in each subsection. Based on the subsection with the highest area of overlap against the <non-riverine_spatialunits>, percentage value for the dominant subsection was applied.	Regional ecosystem remnant and preclear mapping. REDD v9 database to obtain the riverine R type wetlands	Quartile Continuous Ascending
1.4.5	Hydrological disturbance/modification of the wetland (e.g. as determined through EPA wetland mapping and classification)	Score spatial units according to their modification code. H1 = 4; H2M1, H2M2 and H2M3 = 2; H2M5 = 1	Queensland Wetland Data (v4.0), LEBB ACA subsections	Categorical
2.1.1	Presence of exotic terrestrial plants in the assessment unit	An expert panel list of exotic plants found within the riparian zone of streams and wetlands was used to calculate this measure. A subsection that had one or more exotic species recorded (point records or site based lists, ≥1950, precision ≤2000m) from within its boundaries received a measure score of -2, which was then attributed to all spatial units in the subsection. No score was allocated to any spatial unit where the	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Presence Negative

Measure	Description	Implementation	Primary datasets used	Threshold type
		associated subsection had an absence of exotic species (i.e. they were treated as a missing value).		
2.2.5	% area of remnant vegetation relative to preclear extent within buffered non-riverine wetland: 500 m buffer for wetlands ≥ 8 ha, 200 m buffer for smaller wetlands	Each <non-riverine_spatialunit> was buffered by 500m buffer for wetlands >= 8ha, 200m buffer for smaller wetlands. A multiring buffer was used as it allowed for the exclusion of the wetland itself from the analysis. The remnant and pre-clear vegetation mapping was then intersected with area calculated. De-concatenating the RE_LABEL and PC_LABEL, The area of each value with a valid RE vegetation code was calculated to get the total area occupied by RE for pre-clear and remnant. The percentage of remnant to pre-clear was calculated and applied to each <non-riverine_spatialunits> feature.	QLD Herbarium Remnant Vegetation mapping and preclear mapping v9 / QLD wetlands mapping	Quartile Continuous Ascending
2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	“Agricultural” land-use included (QLUMP secondary categories) intensive animal production, intensive horticulture, cropping, perennial horticulture, plantation forestry, irrigated cropping, irrigated perennial horticulture, irrigated seasonal horticulture and reservoir/dam. These land-use types were allocated an agriculture attribute and a % area was calculated for agricultural areas within each subsection; this value was then applied to each spatial unit within the subsection. Spatial units that extend across subsections have already been allocated to a subsection based on the maximum area. Average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Descending
2.3.2	% "grazing" land-use area	“Grazing” land-use included (QLUMP secondary categories) Livestock grazing, grazing natural vegetation. These land-use types were allocated a grazing attribute and a % area was calculated for grazing areas within each subsection; this value was then applied to each spatial unit within the subsection. Spatial units that extend across subsections have already been allocated to a subsection based on the maximum area. Average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Descending
2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	“Vegetation” land-use included (QLUMP secondary categories) managed resource protection, nature conservation, other minimal use, production forestry, estuary/coastal waters, lake, marsh/wetland, river. These land-use types were allocated a vegetation attribute and a % area was calculated for vegetation areas within each subsection; this value was then applied to	DSITI QLUMP	Quartile Continuous Ascending

Measure	Description	Implementation	Primary datasets used	Threshold type
		each spatial unit within the subsection. Spatial units that extend across subsections have already been allocated to a subsection based on the maximum area. Average of the 3 highest weighted % scores (by subsection).		
2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	“Settlement” land-use included (QLUMP secondary categories) manufacturing and industrial, mining, residential, services, transport and communication, utilities, waste treatment and disposal, and channel/aqueduct. These land-use types were allocated a settlement attribute and a % area was calculated for settlement areas within each subsection; this value was then applied to each spatial unit within the subsection. Spatial units that extend across subsections have already been allocated to a subsection based on the maximum area. Average of the three highest weighted % scores (by subsection).	DSITI QLUMP	Quartile Continuous Descending
3.1.2	Richness of native fish	**Non-riverine wetlands** An expert panel list of fish dependent on non-riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000m were included. A subsection was attributed with the number of fish species it contained. This value was then attributed to all the spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of species (i.e. they were treated as a missing value). **Springs** An expert panel list of fish dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.3	Richness of native aquatic dependent reptiles	**Non-riverine wetlands** An expert panel list of reptiles dependent on non-riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000m were included. A subsection was attributed with the number of reptile species it contained. This value was then attributed to all the spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of species (i.e. they were treated as a missing value). **Springs** An expert panel list of reptiles dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical

Measure	Description	Implementation	Primary datasets used	Threshold type
		buffer area was attributed to the relevant spring. Scoring methodology is the same as or non-riverine wetlands (see above).		
3.1.4	Richness of native waterbirds	**Non-riverine wetlands** An expert panel list of waterbirds dependent on non-riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000m were included. A subsection was attributed with the number of waterbird species it contained. This value was then attributed to all the spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of species (i.e. they were treated as a missing value). **Springs** An expert panel list of naïve waterbirds dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.5	Richness of native aquatic plants	**Non-riverine wetlands** An expert panel list of aquatic and semi-aquatic plants was used to calculate this measure. Records ≥1950 and a precision ≤2000m were included. A subsection was attributed with the number of native aquatic / semi-aquatic species it contained. This value was then attributed to all the spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of species (i.e. they were treated as a missing value). **Springs** An expert panel list of aquatic and semi-aquatic plants dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Continuous Ascending or Categorical

Measure	Description	Implementation	Primary datasets used	Threshold type
3.1.6	Richness of native amphibians (non-riverine wetland breeders)	**Non-riverine wetlands** An expert panel list of amphibians dependent on non-riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000m were included. A subsection was attributed with the number of species it contained. This value was then attributed to all the spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of species (i.e. they were treated as a missing value). **Springs** An expert panel list of native amphibians dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.1.7	Richness of native aquatic dependent mammals	**Non-riverine wetlands** An expert panel list of mammals that are dependent on non-riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records ≥1975, precision ≤ 2000m were included. A subsection was attributed with the number of mammal species it contained. This raw score was then attributed to all the spatial units in the subsection. No score was allocated to any spatial unit where the associated subsection had an absence of species (i.e. they were treated as a missing value). **Springs** An expert panel list of native mammals dependent on spring ecosystem was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Continuous Ascending or Categorical
3.3.2	Richness of wetland types within the local catchment (e.g. SOR subsection)	An identity was run on <non-riverine_wethabitats> where the [HYDROMOD] was H1, H2M2, H2M3, H2M8 against <subregions>. A list of unique [TYPE_RE] values was counted for each subsection. To be allocated, the [SPUNITID] and its associated subsections, had to match those identified in the Wethabitat x subsection intersect. Any that were missed were assigned to the subsection that occupied the maximum area of the non-riverine spatial unit. Assign to each non-riverine spatial unit the number of TYPE_REs present in the subsection allocated to it based on maximum area.	Queensland Wetland Data (v4.0), LEBB ACA subsections	Quartile Continuous Ascending

Measure	Description	Implementation	Primary datasets used	Threshold type
3.3.3	Richness of wetland types within the subcatchment	An identity was run on <non-riverine_wethabitats> where the [HYDROMOD] was H1, H2M2, H2M3, H2M8 against <subregions>. A list of unique [TYPE_RE] values was counted for each subsection. To be allocated, the [SPUNITID] and its associated subsections, had to match those identified in the Wethabitat x subsection intersect. Any that were missed were assigned to the subsection that occupied the maximum area of the non-riverine spatial unit. Assign to each non-riverine spatial unit the number of TYPE_REs present in the sub-catchment allocated to it based on maximum area.	Queensland Wetland Data (v4.0), LEBB ACA subsections	Quartile Continuous Ascending
4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act	**Non-riverine wetlands** A list of rare or threatened (NCA or EPBC) non-riverine aquatic ecosystem dependent fauna species identified by the expert fauna panel was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to all the spatial units in the subsection **Springs** A list of rare or threatened (NCA or EPBC) spring ecosystem dependent fauna species identified by the expert fauna panel was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2count = 2
4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species - NCA Act, EPBC Act	**Non-riverine wetlands** A list of rare or threatened (NCA or EPBC) non-riverine aquatic ecosystem dependent flora species identified by the expert flora panel was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to all the spatial units in the subsection.	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous

Measure	Description	Implementation	Primary datasets used	Threshold type
		Springs A list of rare or threatened (NCA or EPBC) spring ecosystem dependent flora species identified by the expert flora panel was used to generate the records dataset. Springs were buffered by 2 km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).		Ascending: Min. species count = 2
4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA Act, EPBC Act	The Regional Ecosystem Biodiversity Status was used to score spatial units. The WETRE (previously WB_RE) field in the wetland mapping was used to identify the associated REs for each spatial unit. Endangered REs scored a four, Of Concern REs scored a three, No Concern at Present REs scored a two and spatial units without a RE category (i.e. “water”) scored one. Where a spatial unit had several polygons of differing REs, the maximum RE score was assigned to the spatial units. (De-concatenation code was used to separate these).	Queensland Wetland Data (v4.0)	Categorical Endangered = 4 Of Concern = 3 Least Concern = 2 No RE = 1
5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, etc.)	**Non-riverine wetlands** An expert panel derived list of priority non-riverine aquatic ecosystem dependent fauna species was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to all the spatial units in the subsection. **Springs** An expert panel derived list of priority spring ecosystem dependent fauna species was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2
5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	**Non-riverine wetlands** An expert panel derived list of priority non-riverine aquatic ecosystem dependent flora species was used to generate the records dataset. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four)	Flora species records from DSITI databases — WildNet, Herbrecs, Corveg and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2

Measure	Description	Implementation	Primary datasets used	Threshold type
		was then attributed to all the spatial units in the subsection **Springs** An expert panel derived list of priority spring ecosystem dependent flora species was used to generate the records dataset. Springs were buffered by 2km to capture records. Any record within the buffer area was attributed to the relevant spring. Scoring methodology is the same as for non-riverine wetlands (see above).		2 species = 4 3 species = 4 Four or more species: Quartile Continuous Ascending: Min. species count = 2
5.1.3	Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA / CAMBA / ROKAMBA agreement lists and/or Bonn Convention)	An expert panel derived list of migratory species dependent on non-riverine wetlands for all or part of their lifecycles was used to calculate this measure. Records were intersected with <subsections> to determine species richness in each. The measure value (four—highest; three; two; no data) was determined by thresholding species richness raw scores. The threshold type to determine the measure value depended on the maximum number of species for any particular subsection in a catchment. The measure value (two to four) was then attributed to all the spatial units in the subsection.	EHP QLD Historical Fauna Database (QHFD), DSITI WildNet, and Expert Panel	Dependent on the number of species Max. 1 species Presence Positive Max. 2 species User Defined: 1 species = 3 2 species = 4 Max. 3 species User Defined: 1 species = 2 2 species = 4 3 species = 4 Four or more species Quartile Continuous Ascending: Min. species count = 2
5.1.4	Habitat for significant numbers of waterbirds	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Categorical
5.2.1	Presence of 'priority' aquatic ecosystem	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Categorical
6.1.1	Presence of distinct, unique or special geomorphic features	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panel	Categorical
6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert Panels	Categorical

Measure	Description	Implementation	Primary datasets used	Threshold type
6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	No Ramsar sites exist in LEBB. Spatial units that had interaction with the mapped boundaries of Directory of Important Wetlands Australia (DIWA) were identified and these spatial units were allocated a score of three. No score was allocated to spatial units that were not identified as significant by such methods (i.e. they were treated as a missing value).	DIWA	Categorical
6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Biodiversity Planning Assessments (BPAs) and other documented reports external to the ACA process	Categorical
8.1.1	% area of each wetland type within Protected Areas.	The EPA Estates (CP, FR, NC, NP, NS, RR, SF and TR) and nature refuge data was used to calculate the % area of each wetland habitat type (based on TYPE_RE field—a concatenation of wetland class, water regime, salinity modifier and WETRE fields from the QWM data) located within these protected areas. The thresholds from Sattler & Williams (1999). >10% = 1; >4% = 2; >1% = 3; <1% = 4. The minimum % area was used for individual wetlands with more than one wetland habitat type to account for habitats less protected.	Queensland Wetland Data (v4.0), QPWS Estates Layer	Continuous Descending (Sattler & Williams 1999) (>10% = 1; >4% = 2; >1% = 3; <1% = 4)
8.2.1	The relative abundance of the wetland management group to which the wetland type belongs within the catchment or study area (management groups ranked least common to most common)	Each wetland habitat is assigned a wetland management group (WMG), assigned via the Wetland Habitat Typology. Then a count of each WMG is conducted across the whole study area. Each Wetland Habitat polygon will be assigned a score based on the abundance of the WMG. The maximum value will be assigned to a spatial unit where it contains two or more WMGs (based on the wetlands habitat polygons it contains). The maximum conservation rating is associated with the lowest frequency so the wetland habitat from the WMG with the lowest frequency was attributed to spatial units with more than one WMG.	Queensland Wetland Data (v4.0)	Logarithmic (User Defined >100 =1, <=100 = 2, <=10 = 3, 1 = 4)
8.2.2	The relative abundance of the wetland management group to which the wetland type belongs within the subcatchment (management groups ranked least common to most common)	Each wetland habitat is assigned a WMG, assigned via the Wetland Habitat Typology. Then a count of each WMG is conducted across the subcatchments (there are typically several subcatchments within a study area). Each Wetland Habitat polygon will be assigned a score based on the abundance of the WMG it belongs to within a subcatchment. The maximum value will be assigned to a spatial unit where it contains two or more WMGs (based on the wetlands habitat polygons it contains). The maximum conservation rating is associated with the lowest frequency so the wetland habitat from the WMG with the lowest frequency was	Queensland Wetland Data (v4.0)	Logarithmic (User Defined >100 =1, <=100 = 2, <=10 = 3, 1 = 4)

Measure	Description	Implementation	Primary datasets used	Threshold type
		attributed to spatial units with more than one WMG.		
8.2.3	The size of each wetland type relative to others of its management group within the catchment or study area	Each wetland habitat is assigned a WMG, assigned via the Wetland Habitat Typology. This measure is based on an area calculation of each wetland habitat polygon within a WMG. The resulting list of area values for a WMG across a whole study area is quartiled (thresholds applied using the average of the three maximum values). When there are two or more values for a spatial unit, the spatial unit will receive the score of the highest scoring wetland habitat polygon it contains The maximum conservation rating is associated with the largest wetland habitat polygon within each WMG.	Queensland Wetland Data (v4.0)	Categorical
8.2.4	The size of each wetland type relative to others of its type within a subcatchment	Each wetland habitat is assigned a WMG, assigned via the Wetland Habitat Typology. This measure is based on an area calculation of each wetland habitat polygon within a WMG. The resulting list of area values for a WMG across a subcatchment area is quartiled (thresholds applied using the average of the three maximum values). When there are two or more values for a spatial unit, the spatial unit will receive the score of the highest scoring wetland habitat polygon it contains. The maximum conservation rating is associated with the largest wetland habitat polygon within each WMG.	Queensland Wetland Data (v4.0)	Categorical
8.2.6	The size of each wetland type relative to others of its type within the catchment or study area	Area calculation of wetland habitat polygons across whole study area based on the wetland habitat type (based on TYPE_RE field—a concatenation of wetland class, water regime, salinity modifier and WETRE fields from the QWM data). Each wetland habitat type in each study area (usually with multiple wetland habitat polygons) is then quartiled and thresholded. Based on the thresholds a categorical value is attributed to the wetland habitats. Where a spatial unit only contains one wetland habitat, the categorical value is directly attributed. When there are two or more values for a spatial unit, the spatial unit will receive the score of the highest scoring wetland habitat polygon it contains. The maximum conservation rating is associated with the largest wetland habitat polygon within each TYPE_RE group in the study area.	Queensland Wetland Data (v4.0)	Categorical

Data extraction dates:

CORVEG—point records data extracted 02/07/2015

ParkInfo—pest species point records on estates extracted 27/08/2015

WildNet—point records extracted 14/08/2015

Queensland Historical Fauna Database—point records extracted 27/08/2015

2.8 Weights and Ranks

The importance of each AquaBAMM measure may vary in terms of its individual significance and contribution to its respective Indicator. To account for this variability AquaBAMM uses weights when combining individual measure scores to calculate an overall indicator score.

Similarly, the importance of each AquaBAMM indicator may vary in terms of its individual significance and contribution to its respective criterion. For example, unadjusted indicator scores perform in a similar way to other 'measures of central tendency' (e.g. average) in that outlying measure values are de-emphasised. This may be undesirable in conservation values assessments as extreme values can be important regardless of the distribution of other values. To account for this, AquaBAMM uses ranks to adjust indicator scores increasing the influence of the highest ranked indicator.

Panel members and project officers attending the expert panel workshops (see Section 2.5) were asked to weight measures and rank indicators based on ecological significance and preferred contribution to the conservation values of LEBB wetlands. While other methods may exist for eliciting weights and ranks from experts, the increased benefit of using these methods were considered small relative to the extra time and complexity required.

2.8.1 Weighting of measures

Measures were weighted according to their importance to an indicator and based on the following rules:

- At least one measure within each indicator must be weighted 10 which is the highest weighting.
- Other measures within each indicator were weighted relative to the weighting of 10 assigned in the first step.
- It was okay to have different measures with the same weight (i.e. all measures could be weighted 10).
- Some indicators only had one measure and had already been given a weighting of 10.
- Measures shouldn't be weighted down because of the quality or lack of data for that measure.

Weights from all respondents were averaged and reviewed with particular attention to averages having a high variance. A decision was made to use measure weights averaged across all study areas to improve statistical reliability.

Table 5 and

Table 6 list the weights used for each AquaBAMM measure.

Table 5. Measure weights used for the riverine ACAs

Maximum weight is 10.

Criteria and Indicators	Measure	Measure description	Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland	10
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	7.8
	1.1.3	Presence of exotic invertebrate fauna within the wetland	8.8
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	9.4
1.3 Habitat features modification	1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	10
1.4 Hydrological modification	1.4.5	Hydrological disturbance/modification of the wetland (e.g. as determined through EPA wetland mapping and classification)	10
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.5	% area of remnant vegetation relative to preclear extent within buffered non-riverine wetland: 500m buffer for wetlands >= 8Ha, 200m buffer for smaller wetlands	10
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	10
	2.3.2	% "grazing" land-use area	7.6
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	5.9
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	7.6
3 Diversity and richness			
3.1 Species	3.1.2	Richness of native fish	10
	3.1.3	Richness of native aquatic dependent reptiles	8
	3.1.4	Richness of native waterbirds	8.9
	3.1.5	Richness of native aquatic plants	9.2
	3.1.6	Richness of native amphibians (non-riverine wetland breeders)	9.3
	3.1.7	Richness of native aquatic dependent mammals	7.2
3.3 Habitat	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	7.1
	3.3.3	Richness of wetland types within the sub-catchment	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent	9.6

Criteria and Indicators	Measure	Measure description	Weight
		fauna species — NCA, EPBC Act	
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species — NCA, EPBC Act	10
4.2 Communities/assemblages	4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA, EPBC Act	10
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc.)	9.5
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	10
	5.1.3	Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA / CAMBA / ROKAMBA agreement lists and/or Bonn Convention)	8.5
	5.1.4	Habitat for significant numbers of waterbirds	8
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10
6 Special features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	10
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	9.5
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	9.4
8 Representativeness			
8.1 Wetland protection	8.1.1	The percentage of each wetland type within Protected Areas	10
8.2 Wetland uniqueness	8.2.1	The relative abundance of the wetland management group to which the wetland type belongs within the catchment or study area (management groups ranked least common to most common)	7.3
	8.2.2	The relative abundance of the wetland management group to which the wetland type belongs within the subcatchment or estuarine/marine zone (management groups ranked least common to most common)	7.3
	8.2.3	The size of each wetland type relative to others of its management group within the catchment or study area	10
	8.2.4	The size of each wetland type relative to others of its type within a subcatchment (or estuarine zone)	7.1
	8.2.6	The size of each wetland type relative to others of its type within the catchment or study area	7.3

Table 6. Measure weights used for the non-riverine (including spring) ACAs

Maximum weight is 10.

Criteria and Indicators	Measure	Measure description	Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland	8.3
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	7.2
	1.1.3	Presence of exotic invertebrate fauna within the wetland	10
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	7.2
	1.2.1	SOR aquatic vegetation condition	10
1.3 Habitat features modification	1.3.1	SOR bank stability	6.4
	1.3.2	SOR bed & bar stability	6.2
	1.3.3	SOR aquatic habitat condition	8
	1.3.4	Presence/absence of dams/weirs within the wetland	10
	1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	6.3
1.4 **Hydrological modification**	1.4.2	**Percent natural flows — modelled flows remaining relative to predevelopment**	**10**
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.1	% area of remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses	10
	2.2.2	Total number of REs relative to preclear number of REs within buffered riverine wetland or watercourses	7.0
	2.2.3	SOR reach environs	6.5
	2.2.4	SOR riparian vegetation condition	7.8
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	9.3
	2.3.2	% "grazing" land-use area	10
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	5.6
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	6.9
3 Diversity and richness			
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	9.3
	3.1.2	Richness of native fish	10
	3.1.3	Richness of native aquatic dependent reptiles	7.7

Criteria and Indicators	Measure	Measure description	Weight
	3.1.4	Richness of native waterbirds	8.6
	3.1.5	Richness of native aquatic plants	7.9
	3.1.7	Richness of native aquatic dependent mammals	7.2
3.2 Communities/ assemblages	3.2.2	Richness of REs along riverine wetlands or watercourses within a specified buffer distance	10
3.3 Habitat	3.3.1	SOR channel diversity	8.4
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	6.3
	3.3.3	Richness of wetland types within the sub-catchment	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act	9.6
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species — NCA, EPBC Act	10
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA, EPBC Act	10
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc.)	9.5
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	10
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA / CAMBA / ROKAMBA agreement lists and/or Bonn Convention)	8.3
	5.1.4	Habitat for significant numbers of waterbirds	8.0
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10
6 Special Features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	9.3
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	10
7 Connectivity			
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criterion five and/or six	8.8
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the	10

Criteria and Indicators	Measure	Measure description	Weight
		spatial unit	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criterion five and/or six	10

2.8.2 Ranking of indicators

Panel members and project officers attending the workshops ranked indicators within each criterion. Indicators were ranked according to their importance to a criterion and based on the following rules:

- At least one indicator within each criterion must be ranked one which is the highest ranking.
- The other indicators were ranked within each criterion relative to the ranking of one assigned in the first step.
- It was okay to have different indicators with the same ranking (i.e. all indicators may be ranked one).
- Indicator should not be ranked down because of the quality or lack of data for that indicator.

Ranks from all respondents were averaged and reviewed with particular attention to averages having a high variance. A decision was made to use indicator ranks averaged across all study areas to improve statistical reliability.

Table 7 and

Table 8 list the ranks used for each AquaBAMM indicator.

Table 7. Indicator ranks used for the riverine ACAs

Maximum rank is one.

Criterion	Indicator	Rank
1 Naturalness aquatic		
1.1	Exotic flora/fauna	1
1.2	Aquatic communities/assemblages	1
1.3	Habitat features modification	1
1.4	Hydrological modification	2
2 Naturalness catchment		
2.1	Exotic flora/fauna	2
2.2	Riparian disturbance	3
2.3	Catchment disturbance	4
3 Diversity and richness		
3.1	Species	1
3.2	Communities/assemblages	1
3.3	Habitat	1
4 Threatened species and ecosystems		
4.1	Species	1
4.2	Communities/assemblages	2
5 Priority species and ecosystems		
5.1	Species	1
5.2	Communities/assemblages	2
6 Special features		
6.1	Geomorphic features	3
6.3	Habitat	2
7 Connectivity		
7.1	Significant species or populations	1
7.3	Floodplain and wetland ecosystems	2

Table 8. Indicator ranks used for non-riverine (including spring) ACAs

Maximum rank is one.

Criterion	Indicator	Rank
1 Naturalness aquatic		
1.1	Exotic flora/fauna	1
1.3	Habitat features modification	2
1.4	Hydrological modification	3
2 Naturalness catchment		
2.1	Exotic flora/fauna	2
2.2	Riparian disturbance	2
2.3	Catchment disturbance	3
3 Diversity and richness		
3.1	Species	1
3.3	Habitat	1
4 Threatened species and ecosystems		
4.1	Species	1
4.2	Communities/assemblages	2
5 Priority species and ecosystems		
5.1	Species	1
5.2	Communities/assemblages	1
6 Special features		
6.1	Geomorphic features	3
6.3	Habitat	2
8 Representativeness		
8.1	Wetland protection	2
8.2	Wetland uniqueness	1

2.9 Conservation value categories

AquaBAMM calculates a final score of aquatic conservation value, called an AquaScore, for each spatial unit within a study area. The AquaScore ratings include 'Very High', 'High', 'Medium', 'Low' or 'Very Low', and are generally relative within a study area.

The following descriptions provide a summary of the general characteristics of each AquaScore.

Very High wetlands

These wetlands generally have very high values across all criteria (aquatic naturalness, catchment naturalness, diversity and richness, threatened species, special features, connectivity, representativeness), or very high representativeness values in combination with very high aquatic naturalness, catchment naturalness or threatened species values. They may also be wetlands nominated by an expert panel as containing special features or very high flora, fauna and/or ecological values regardless of values across other criterion.

High wetlands

These wetlands are mainly those that have very high aquatic naturalness or representativeness values in combination with high or very high values for threatened species or diversity and richness. Combinations of very high or high values among most criteria may also result in a 'High' AquaScore.

Medium wetlands

These wetlands have varied combinations of high and medium values among the criteria.

Low wetlands

These wetlands have limited aquatic and catchment naturalness values and generally varied combinations of medium and low values among the other criteria. These wetlands do not contain special features.

Very Low wetlands

These wetlands have very limited or no aquatic and catchment naturalness values and they lack any other known significant value. They may also be wetlands that are largely data deficient across the AquaBAMM measures. These wetlands do not contain special features.

2.10 Filter tables

The AquaBAMM uses a filter table to assign an AquaScore to each spatial unit. Filter tables consists of a series of ordered decisions made up of unique combinations of criterion ratings and corresponding AquaScores.

When undertaking an ACA filter tables (i.e. riverine filter table, non-riverine filter table, estuarine filter table, etc.) are reviewed and, if necessary, refined to ensure all unique criterion combinations are captured and assigned an appropriate AquaScore. The following filter table refinements were undertaken as part of the LEBB ACAs:

- Decisions10a, 11a, 20a, 20b, 25a, 26c, 30b, and all criterion 7 ratings from decisions 0, 1, 2, 6, 7 were deleted from the default non-riverine filter table. These decisions related to criterion 7 (connectivity) which was not used in the non-riverine assessments.
- Decision 27 in the default non-riverine filter table was moved above decision 3 changing its order number from 30 to 3. All subsequent decisions were shifted down one order in the filter table. This change prevented a small number of spatial units from being triggered by decisions with a lower AquaScore further up the filter table.
- The wording of several decisions was changed to make them more explicit. For example, when a criterion rating was listed in isolation (i.e. Criterion 7 = 'Medium'), all higher ratings for the criterion (i.e. 'High' and 'Very High') were added. Changing the default expressions in this way prevented the possibility of unique criterion combinations falling through to decisions with a lower AquaScore further down the filter table. This change was made to both riverine and non-riverine filter tables.

No new filter table decisions were created as part of the LEBB ACAs.

2.11 Dependability and data richness

The AquaBAMM uses a dependability score to provide information about the richness of data for each spatial unit within a study area. Dependability scores are calculated at the criterion and AquaScore level.

All criterion ratings and AquaScores should be interpreted in conjunction with the corresponding dependability scores as these provide an overall indication of the amount of data available for each spatial unit. For example, dependability can be used to indicate the potential for and AquaScore to change (upgrade or downgrade) with the addition of new data. For example, spatial units with low dependability and a 'Very Low' AquaScore should be used with caution as the result may be due to a lack of data rather than a lack of values. Dependability scores can also provide an indication of where additional survey work may be required and which, once completed, may or may not change an AquaScore.

Dependability scores range from 0 to 1 and are calculated as a fraction representing the number of measures with data for a particular spatial unit out of the total number of measures used in the assessment. Dependability is calculated as follows:

$$\text{Dependability} = \frac{\text{No. of measures with data (count)}}{\text{Total no. of measures (count)}}$$

2.12 Transparency of results and limitations

Despite presentation as a single AquaScore, ACAs produce results at a number of levels. For example, after running the AquaBAMM tool ACA results are available at the AquaScore, criterion, indicator, measure and raw data levels (Figure 3. Interrogating the non-riverine ACA results for spatial unit cp_w08532 in a GIS environment.). All results are available to the user through the use of user-defined queries inside a GIS or other database application (i.e. Microsoft Excel). Results may be interrogated at one or more levels in an almost infinite number of combinations. This transparency of results provides the ACA end user (e.g. scientists, resource managers and conservation organisations) with a unique level of flexibility for ACA interrogation, interpretation and presentation. This data access and interrogation flexibility is important as it enables investigation of different data contributions to the overall conservation value, investigation of missing data, and an ability for users to tailor the ACA output for a particular purpose. Links between the ACA results and GIS facilitate this and constitute the complete ACA results release package.

The intent of an ACA is not only to evaluate aquatic ecological and conservation values, but just as importantly, to identify variability in these values. It was noted during the initial runs of the LEBB riverine assessments that results were displaying a poor spread of AquaScores especially across the Georgina and Diamantina study areas. After careful investigation it became apparent that criterion 7 (connectivity), and in particular AquaBAMM measure 7.1.2, was disproportionately influencing the riverine results. Criterion 7 contained three measures including two (7.1.1, 7.1.2) with very high scores across the majority of spatial units, and another (7.3.1) with 'No Data' across the majority of spatial units.

This issue of AquaScores being driven by high scoring measures within criterion containing few measures was also identified as part of an independent sensitivity analysis (Robinson & Jackie 2009) and is a known limitation of the AquaBAMM. There is a necessary trade-off between the inclusion of measures in an assessment and the assessments ability to detect variability in wetland values across a study area. As a consequence, measures that score highly across all spatial units and which have an undue influence on the results are sometimes omitted from the underlying assessment parameter sets. For the riverine assessments, removing AquaBAMM measure 7.1.2 had the desired effect of decreasing the influence of criterion 7 and increasing the overall variability of AquaScores across the study areas. For this reasons measure 7.1.2 was not used in the riverine ACAs.

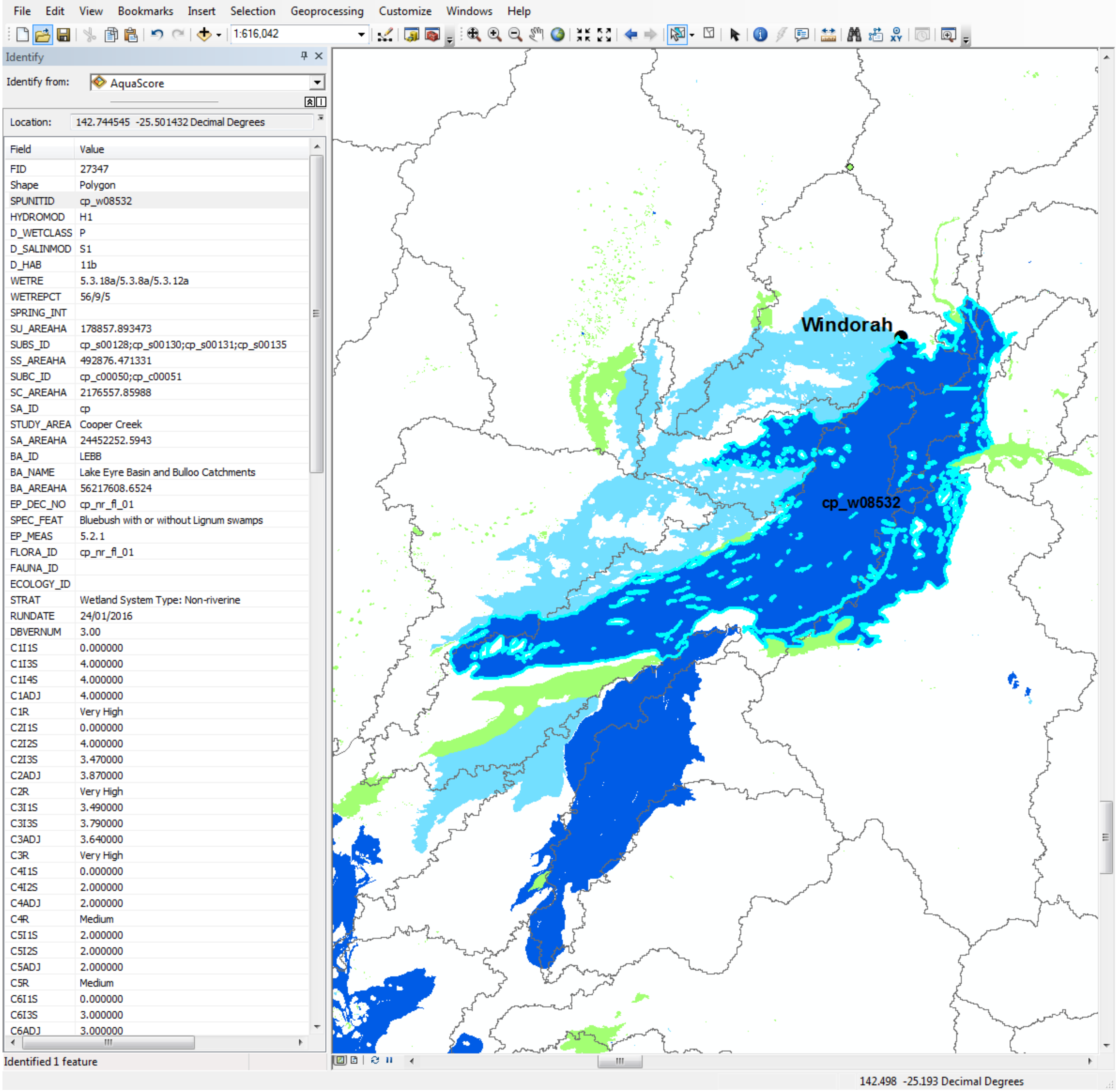


Figure 3. Interrogating the non-riverine ACA results for spatial unit cp_w08532 in a GIS environment.

3 Results

3.1 Riverine results

Aquatic conservation assessments were conducted for the riverine wetlands within each study area. The figures and tables shown below provide a summary of the results. Table 9 provides a combined summary of AquaScore results from all four study areas. Figure 5 and Figure 5 map the AquaScore results by riverine spatial unit and buffered drainage lines. Figure 6 maps the criterion ratings contributing to the AquaScores. Table 10 and Table 11 provide summary charts of the riverine results at the AquaScore and criterion level for each study area. Refer to the CIM list in Table 2 for the details of each criterion.

AquaScores

- 52.5% of riverine spatial units received an AquaScore of ‘Very High’ or ‘High’. This equated to approximately 55% of the total LEBB area.
- With the exception of the Cooper Creek catchment, more than 55% of each study area received an AquaScore of ‘Very High’ or ‘High’.
- 75% of the Bulloo River catchment received an AquaScore of ‘Very High’ or ‘High’.
- In the Bulloo River, Cooper Creek and Diamantina River catchments less than 10% of their area scoring ‘Low’ or ‘Very Low’ AquaScore. The Georgina catchment had 12.1% of area scoring ‘Low’.

Criterion Ratings

- Criterion 1 (Naturalness Aquatic): 71.2% of all spatial units scored ‘Very High’ or ‘High’ for criterion 1. This result is consistent with the relatively high naturalness of aquatic systems within the LEBB.
- Criterion 2 (Naturalness Catchment): 63.5 % of all spatial units scored ‘Very High’ for criterion 2. This equated to just under 60% of the total LEBB area. The majority of spatial units given a ‘Low’ criterion 2 rating were located in the north–eastern part of the Cooper Creek catchment.
- Criterion 4 (Threatened Species and Ecosystems): ‘Very High’ or ‘High’ criterion 4 ratings applied to 68.2% of the spatial units indicating that most riverine subsections contained either threatened species or ecosystems.
- Criterion 6 (Special Features): 33.3% of riverine spatial units contained special features. 27.7% of these were rated as having ‘High’ or ‘Very High’ conservation values.
- Criterion 7 (Connectivity): approximately 40% of all riverine spatial units displayed ‘High’ and ‘Very High’ ratings for connectivity. Only 15% of riverine spatial units within the LEBB were assessed as having no connectivity values.

Table 9. Riverine AquaScore summary statistics

AquaScore	Number of Spatial Units	Percent of Spatial Units (%)	Area (ha)	Area (%)
Very High	71	16	9,297,922	17
High	163	36	21,586,299	38
Medium	170	38	21,306,194	38
Low	38	9	3,443,136	6
Very Low	5	1	584,057	1
Total	447		56,217,609	

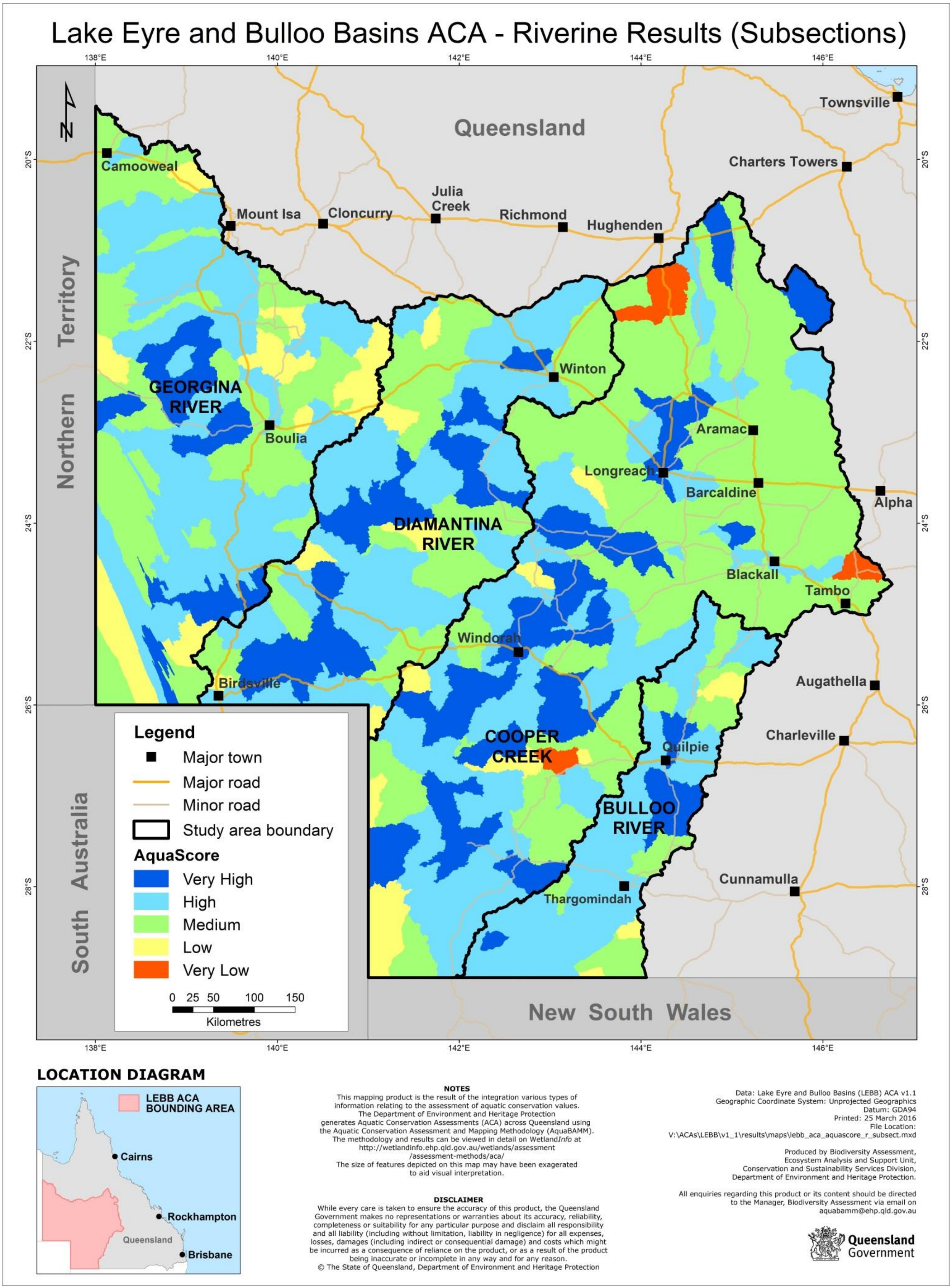


Figure 4. Riverine AquaScores for each study area

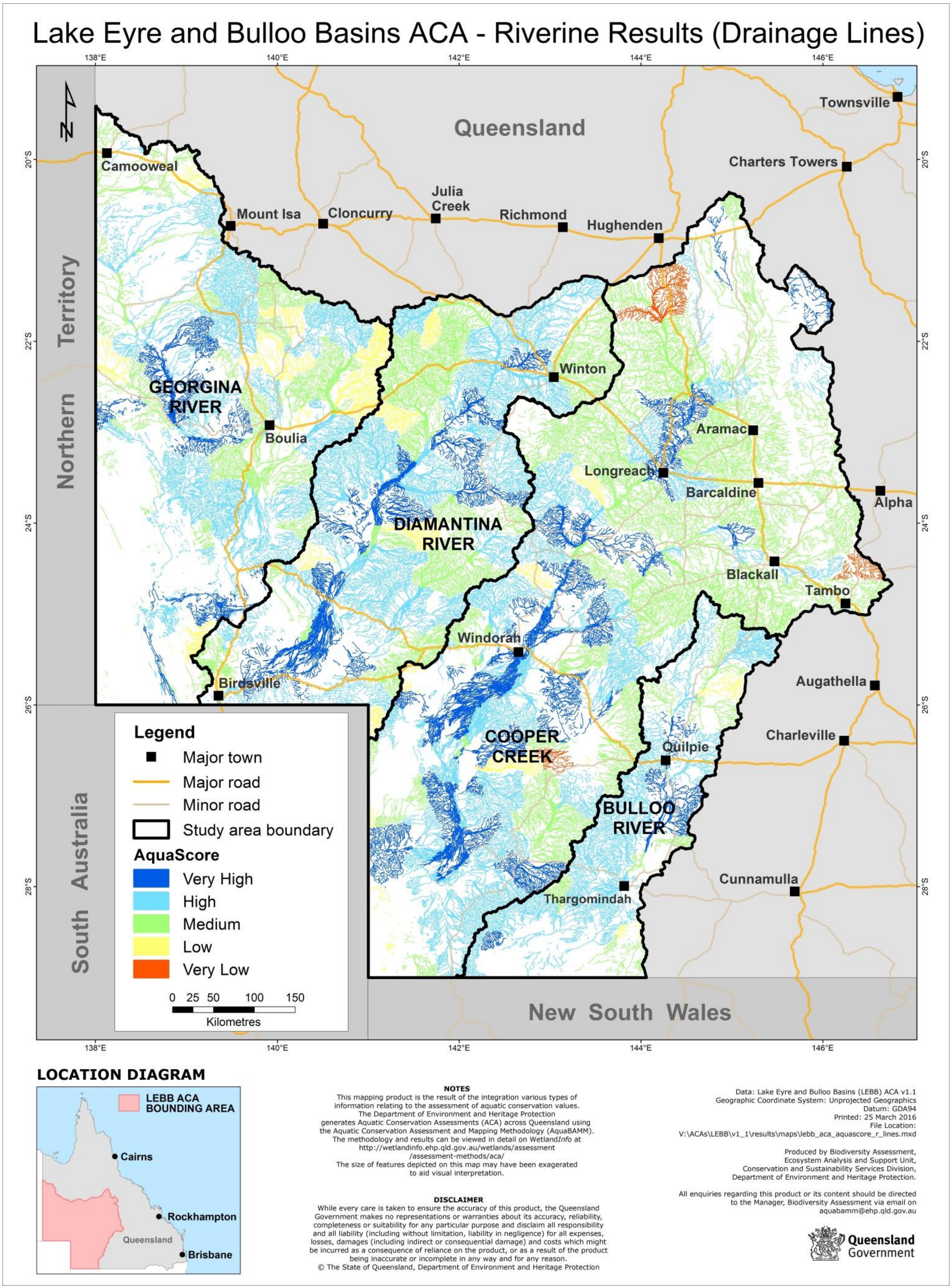


Figure 5. Riverine AquaScores for each study area coloured by drainage line

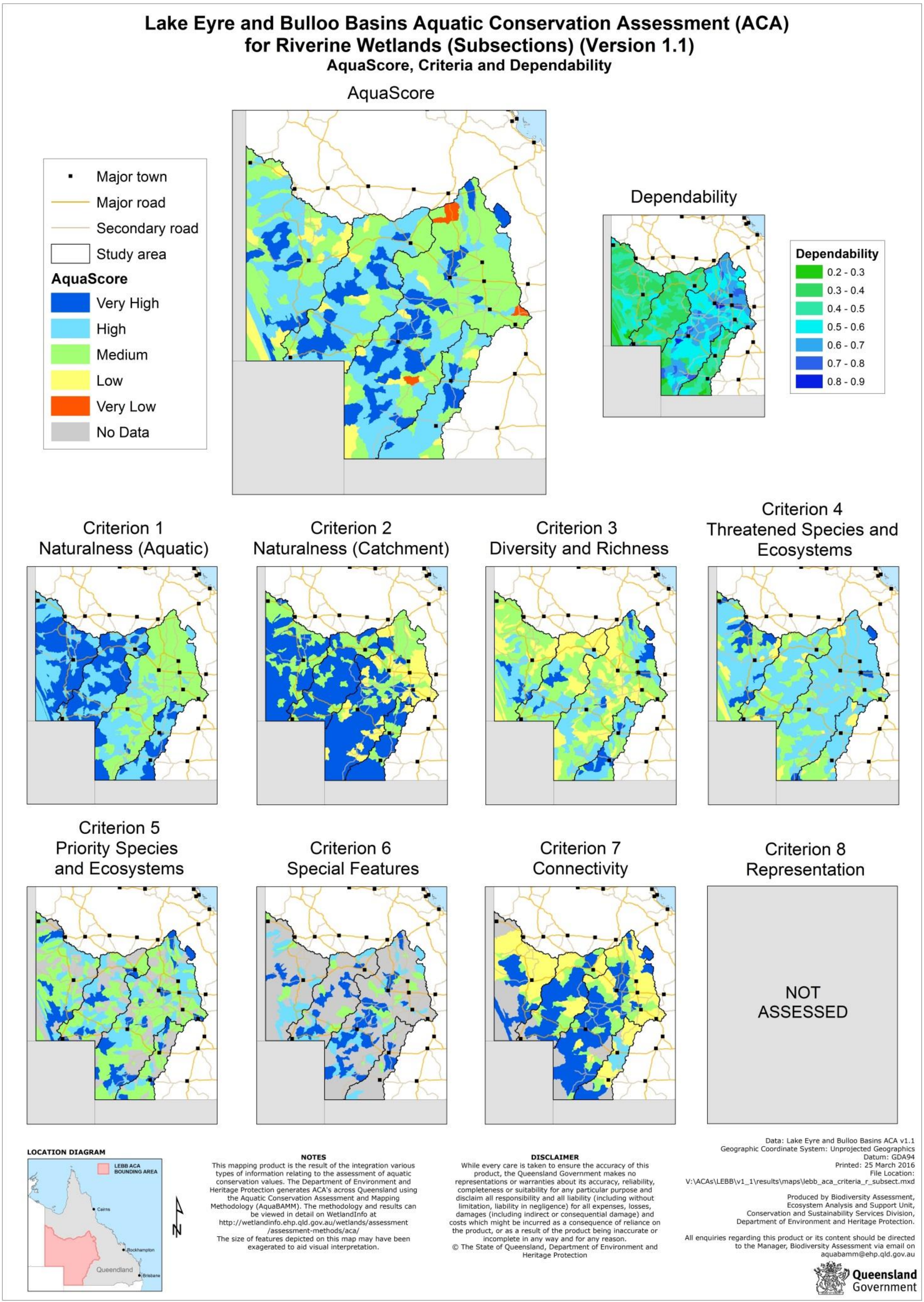
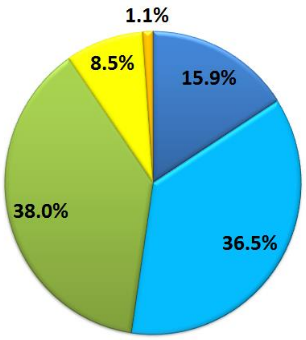
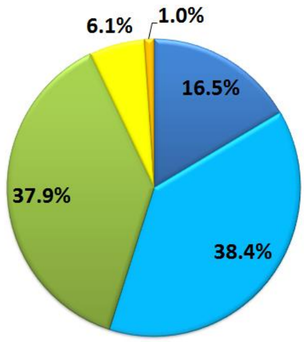
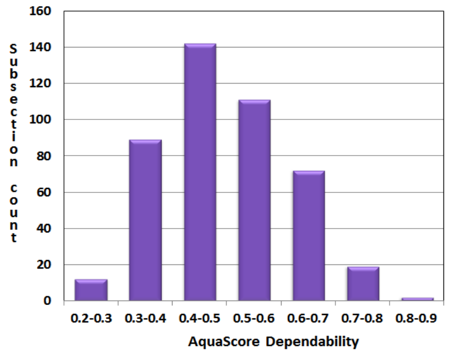
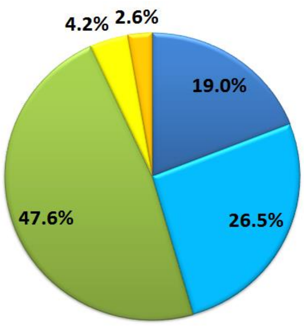
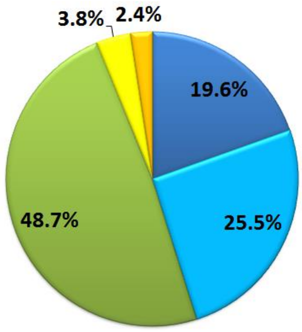
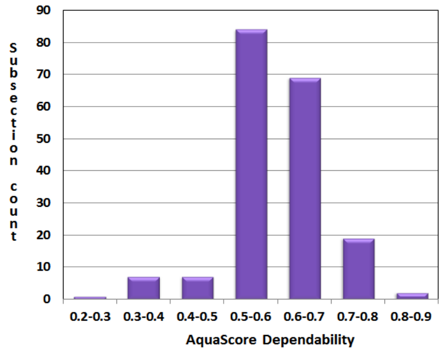
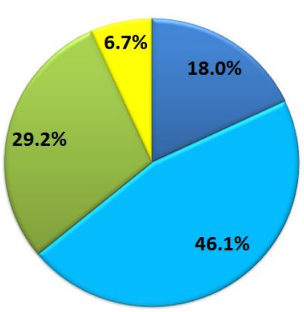
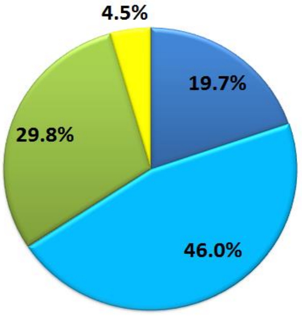
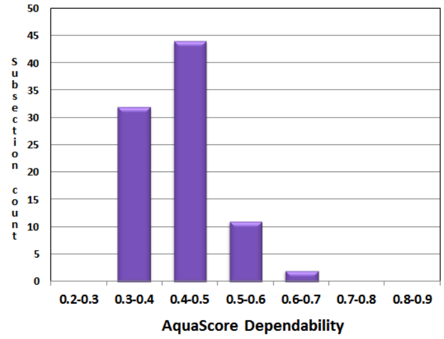
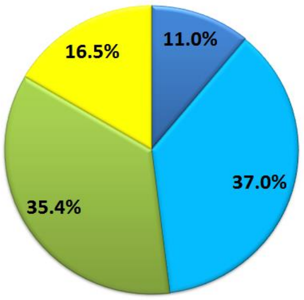
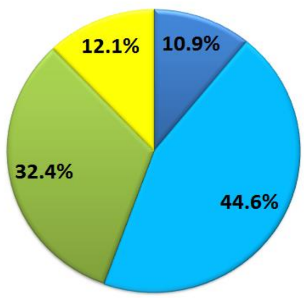
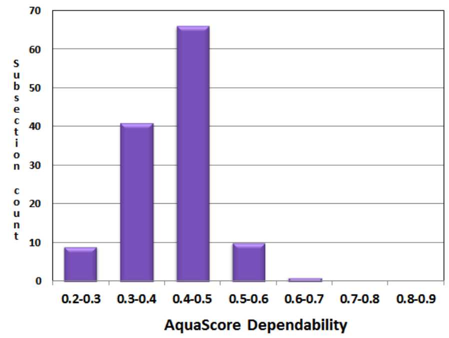


Figure 6. Riverine criterion ratings for each study area

Table 10. Riverine AquaScore percentages and dependability counts by study area

Catchment	AquaScore by % of spatial units	AquaScore by % of total area of spatial units	AquaScore dependability
All Very High High Medium Low Very Low			
Cooper Creek Very High High Medium Low Very Low			
Diamantina River Very High High Medium Low Very Low			
Georgina River Very High High Medium Low Very Low			

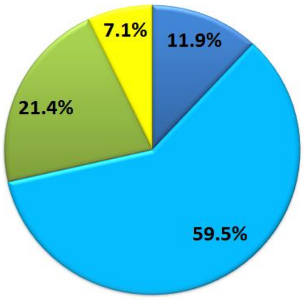
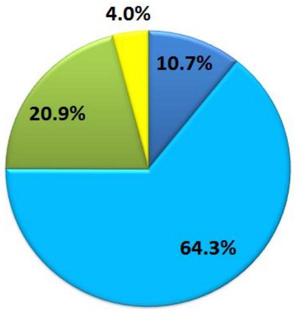
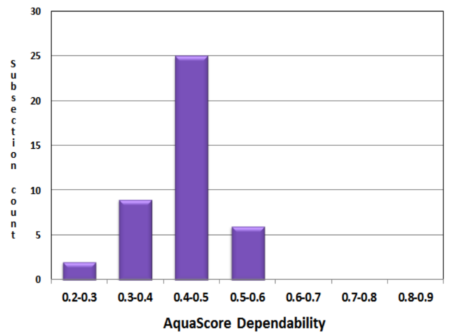
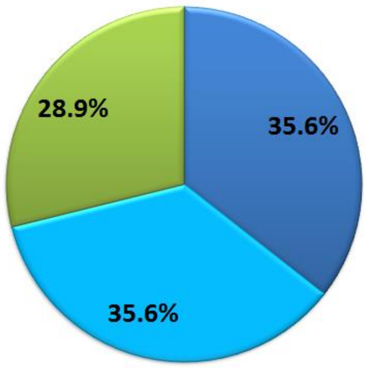
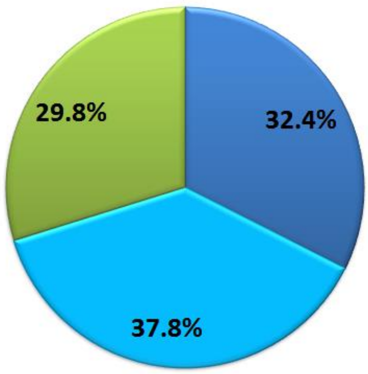
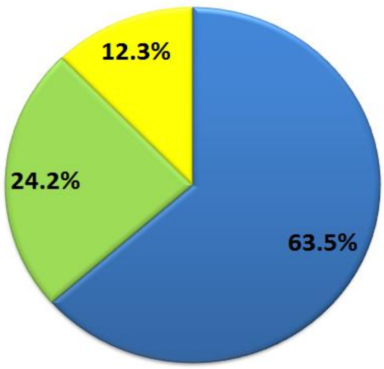
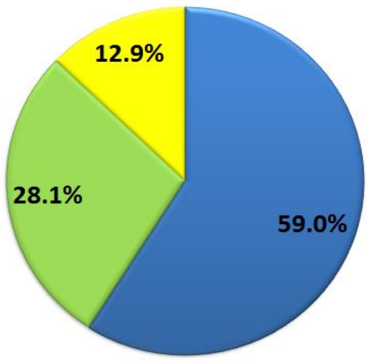
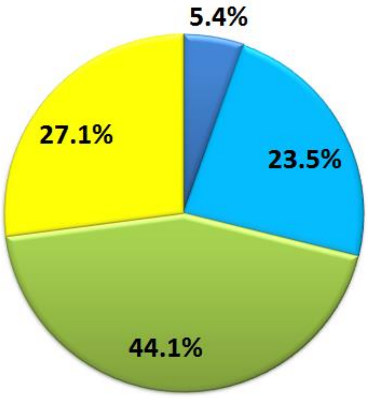
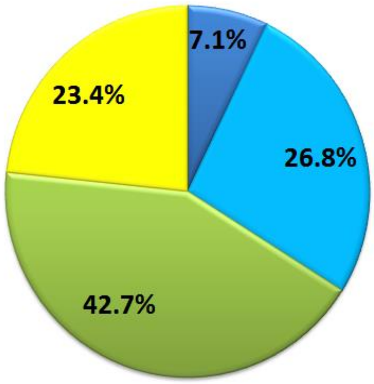
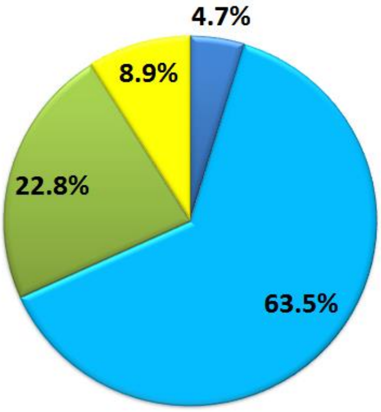
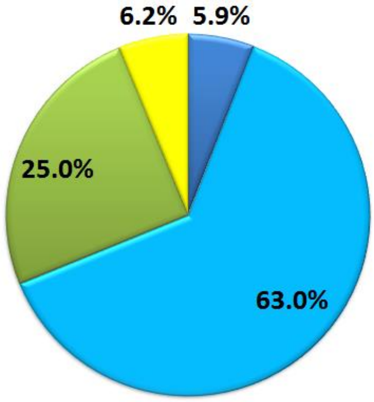
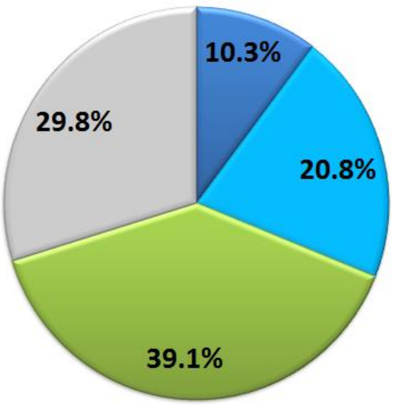
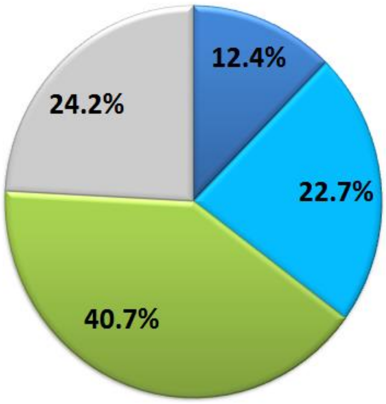
Catchment	AquaScore by % of spatial units	AquaScore by % of total area of spatial units	AquaScore dependability
Bulloo River Very High High Medium Low Very Low			

Table 11. Riverine AquaScore percentages by criterion and study area

Criteria	Criteria scores by % of spatial units	Criteria scores by % of total area of spatial units
Criterion 1 Very High High Medium Low No data		
Criterion 2 Very High High Medium Low No data		

Criteria	Criteria scores by % of spatial units	Criteria scores by % of total area of spatial units
Criterion 3 Very High High Medium Low No data		
Criterion 4 Very High High Medium Low No data		
Criterion 5 Very High High Medium Low No data		

<table>
<tr><th>Criteria</th><th>Criteria scores by % of spatial units</th><th>Criteria scores by % of total area of spatial units</th></tr>
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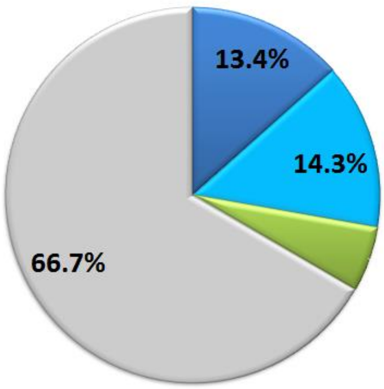
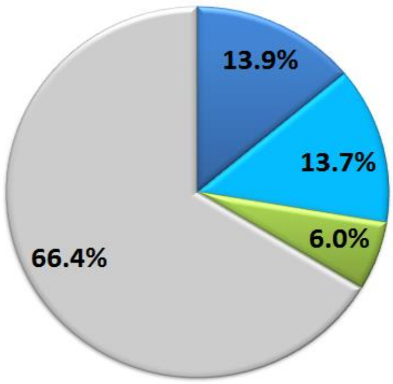
Medium
Low
No data</td><td></td><td></td></tr>
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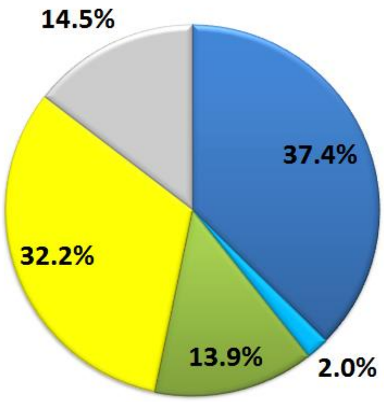
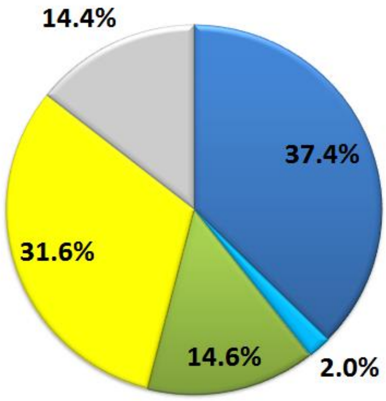
High
Medium
Low
No data</td><td></td><td></td></tr>
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3.2 Non-riverine results

Aquatic conservation assessments were conducted for the non-riverine wetlands within each study area. The figures and tables shown below provide a summary of the results. Table 12 provides a combined summary of AquaScore results from all four study areas. Figure 7 maps the AquaScore results by non-riverine spatial units. Figure 8 maps the criterion ratings contributing to the AquaScores. Table 13 and Table 14 provide summary charts of the non-riverine results at the AquaScore and criterion level for each study area. Refer to the CIM list in Table 2 for the details of each criterion.

AquaScores

- Similar AquaScore results were returned for non-riverine spatial units across all study areas.
- The larger than normal size of a small number of wetlands (major wetlands) within the LEBB resulted in the AquaScores and criterion ratings displaying different results when interpreted by count as opposed to area.
- Overall, 21.5% of the LEBB wetlands received and AquaScore of ‘Very High’ or ‘High’. This equated to approximately 78.2% of the total LEBB wetland area. Across all catchments at least 56% of total wetland area received and AquaScore of ‘Very High’ or ‘High’.
- High numbers of non-riverine wetlands (66.5% - 89.9%) across all catchments received an AquaScore of ‘Medium’.
- 4.6% of non-riverine wetlands in the Georgina catchment receive a ‘Low’ AquaScore.
- 2.5% of non-riverine wetlands in the Cooper catchment received a ‘Very Low’ AquaScore.

Criterion Ratings

- Criterion 1 (Naturalness Aquatic): High numbers (45.8%) of non-riverine wetlands received a criterion 1 rating of ‘Very High’. This is consistent with the relatively high naturalness of aquatic habitats within the LEBB. The high number of ‘Medium’ wetlands (45.8%) was primarily due to the presence of exotic species (i.e. indicator 1).
- Criterion 2 (Naturalness Catchment): the spread of criterion 2 ratings was strongly favoured toward ratings of ‘Very High’ and ‘High’; this alludes to the relative intactness of areas surrounding LEBB wetlands.
- Criterion 3 (Diversity and Richness): approximately 50% of the ‘High’ and ‘Very High’ ratings for criterion 3 were associated with the species and community richness (i.e. indicator 1 and 2). This is not surprising as the importance of waterholes as refugia and the boom-bust nature of LEBB ecosystems means there is a tendency for data collection to focus on individual wetlands or events. As species lists were tailored to each system types (i.e. riverine versus non-riverine), a larger number of non-riverine species records were available compared to the riverine ones.
- Criterion 4 (Threatened Species and Ecosystems): most non-riverine wetlands in the LEBB appear to contain threatened species or ecosystems.
- Criterion 5 (Priority Species and Ecosystems): most non-riverine wetlands in the LEBB appear to contain priority species or are known to act as habitat for significant bird populations.
- Criterion 6 (Special Features): 5.5% of non-riverine wetlands were identified as containing special features. This equated to 57.6% of the total LEBB wetland area.

Table 12. Non-riverine AquaScore summary statistics

AquaScore	Number of Spatial Units	Percent of Spatial Units (%)	Area (ha)	Area (%)
Very High	2,275	7	1,797,745	60
High	4,265	14	553,396	18
Medium	23,089	76	645,100	21
Low	528	2	7,965	<1
Very Low	312	1	1,603	<1
Total	30,469		3,005,809	

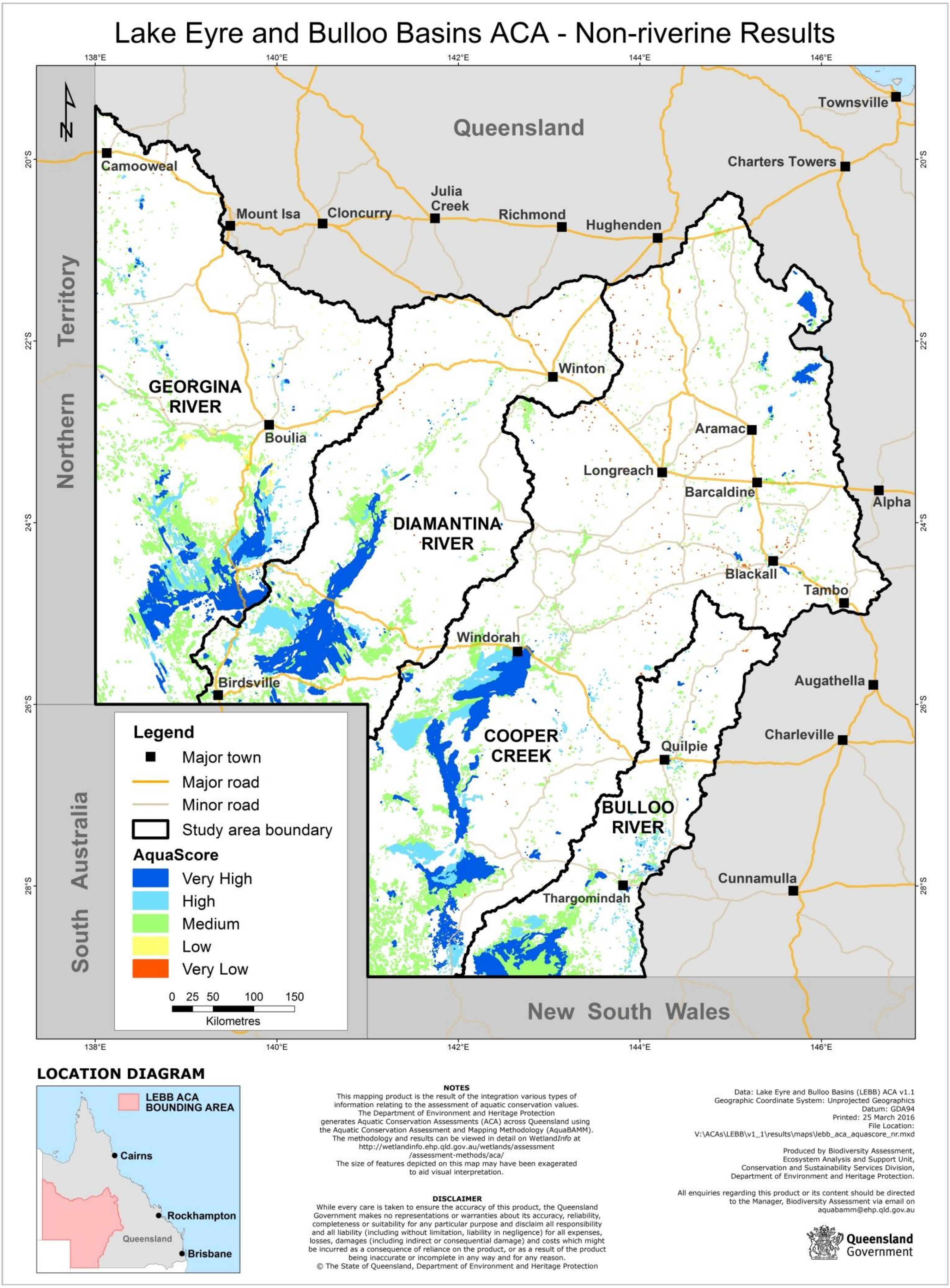


Figure 7. Non-riverine AquaScores for each study area

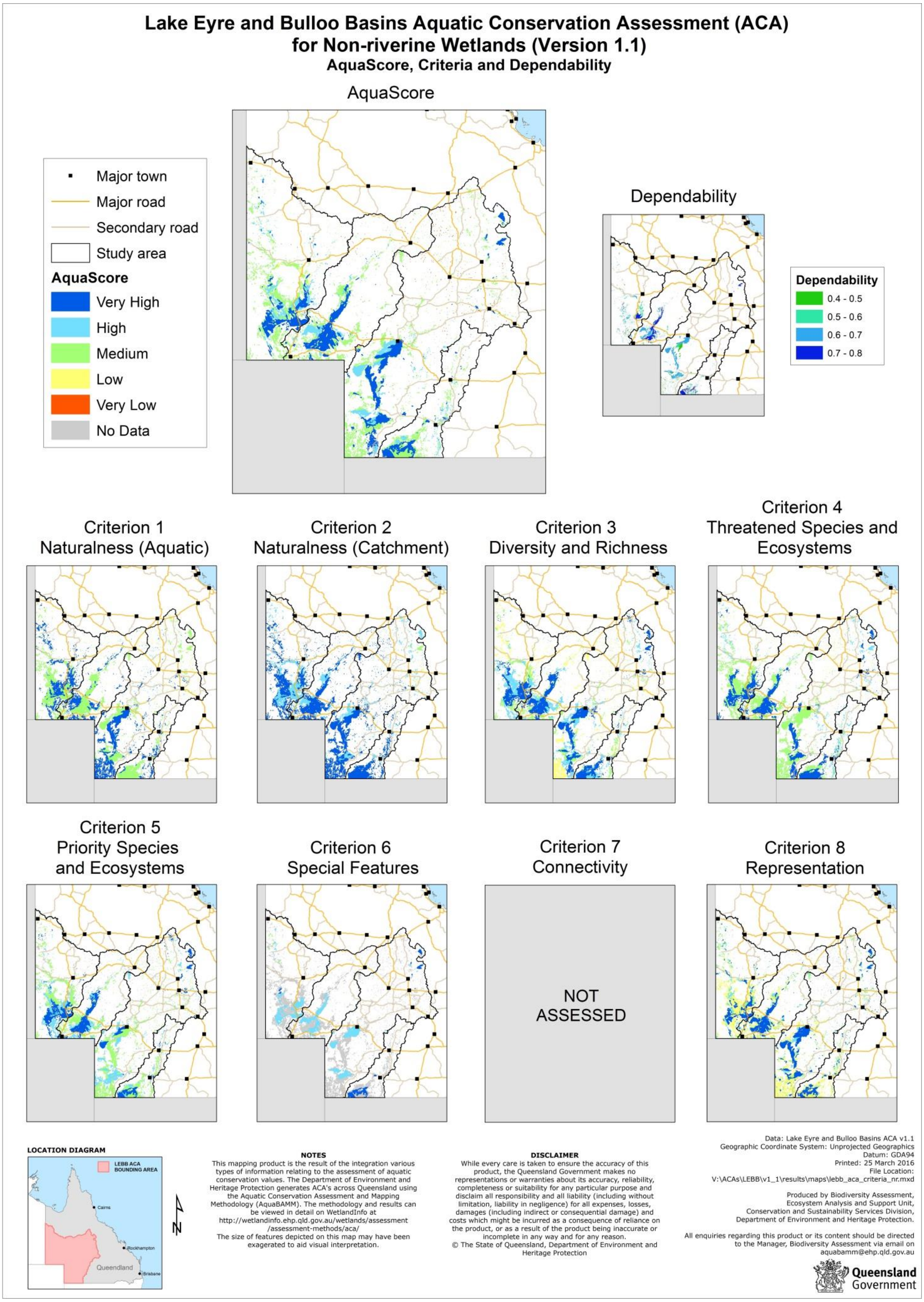
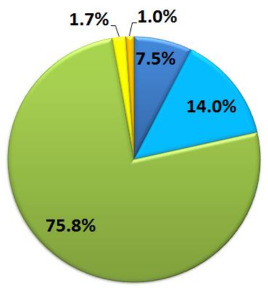
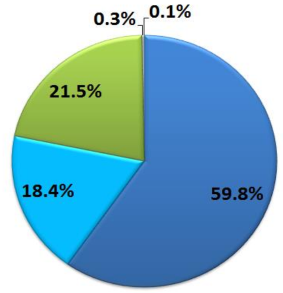
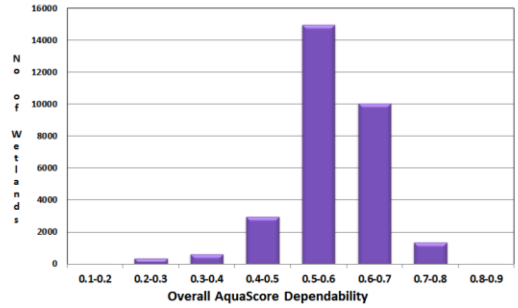
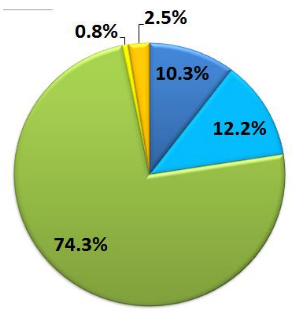
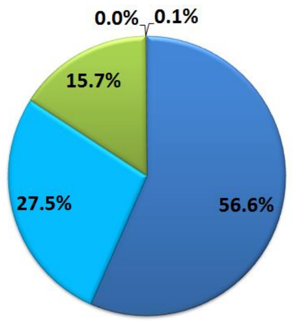
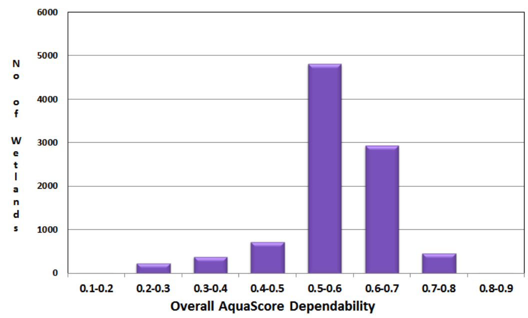


Figure 8. Non-riverine criterion ratings for each study area

Table 13. Non-riverine AquaScore percentages and dependability counts by study area

<table>
<tr><th>Catchment</th><th>AquaScore by % of spatial units</th><th>AquaScore by % of total area of spatial units</th><th>AquaScore dependability</th></tr>
<tr><td>All
Very High
High
Medium
Low
Very Low</td><td></td><td></td><td></td></tr>
<tr><td>Cooper Creek
Very High
High
Medium
Low
Very Low</td><td></td><td></td><td></td></tr>
<tr><td>Diamantina River
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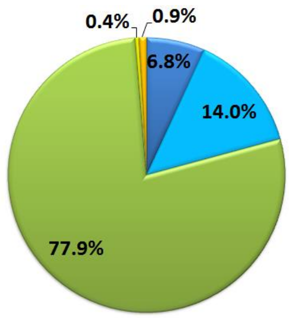
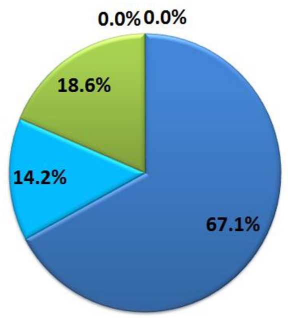
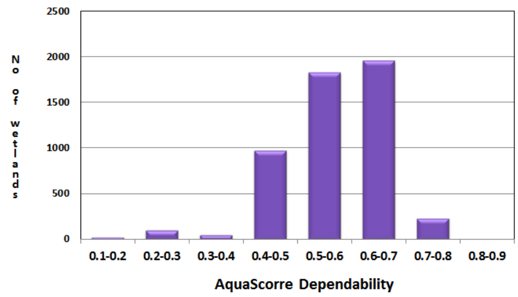
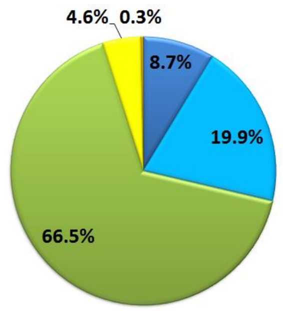
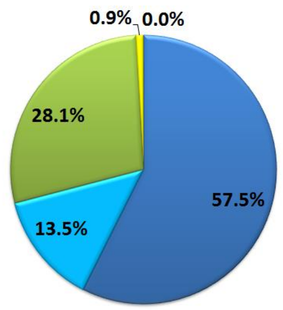
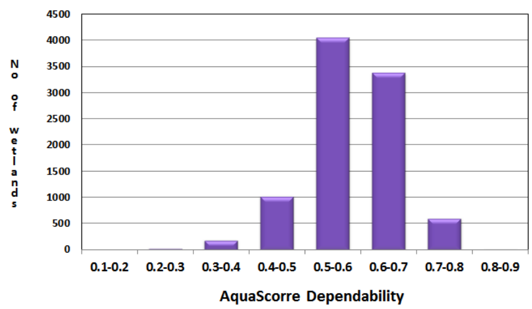
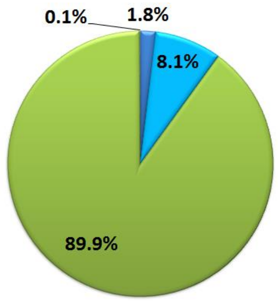
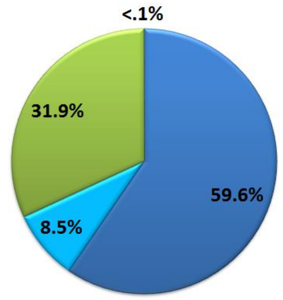
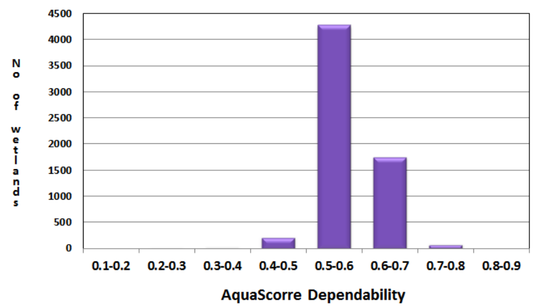
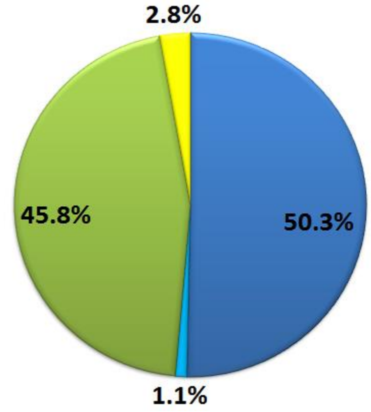
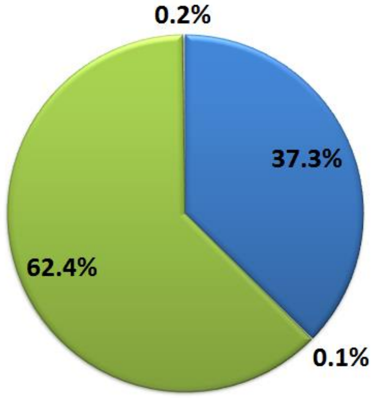
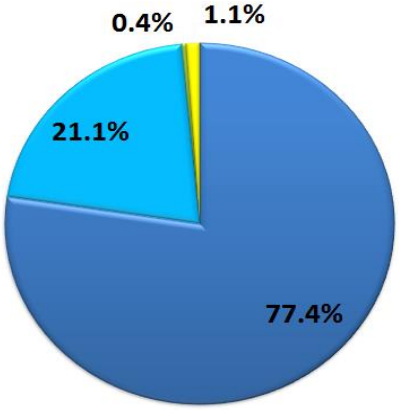
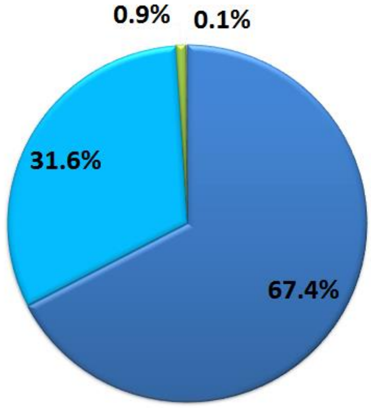
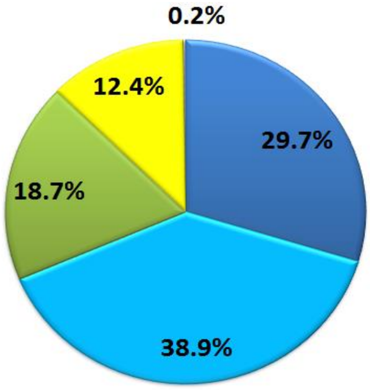
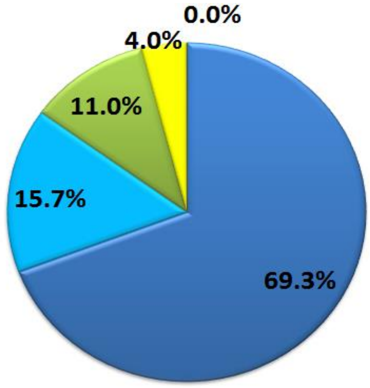
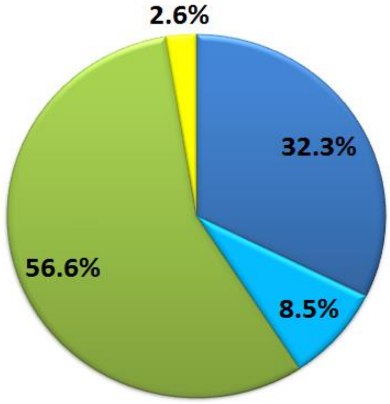
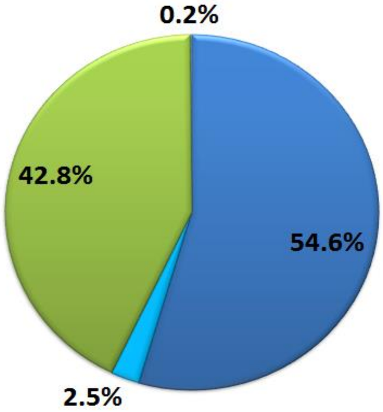
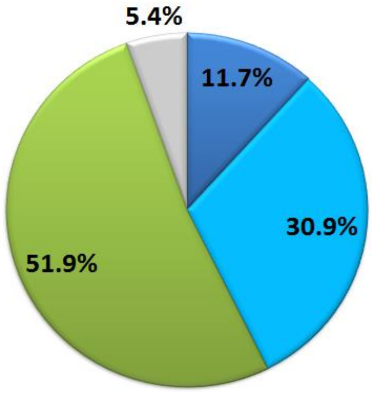
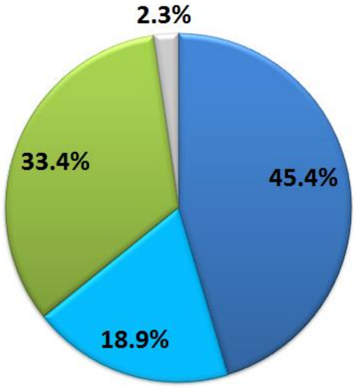
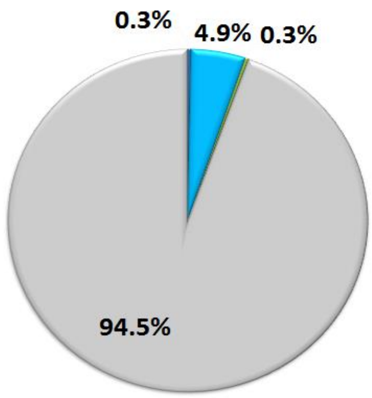
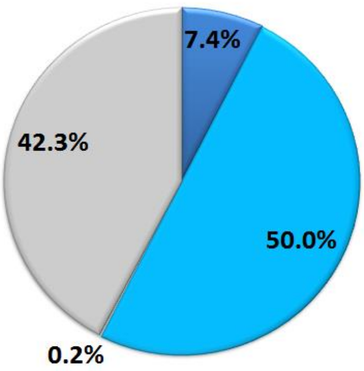
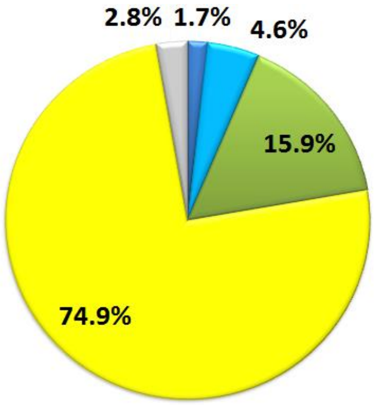
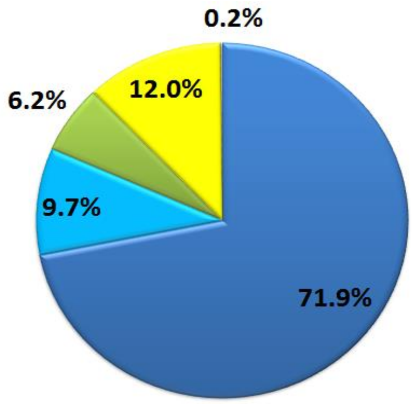
High
Medium
Low
Very Low</td><td></td><td></td><td></td></tr>
<tr><td>Georgina River
Very High
High
Medium
Low
Very Low</td><td></td><td></td><td></td></tr>
<tr><td>Bulloo River
Very High
High
Medium
Low
Very Low</td><td></td><td></td><td></td></tr>
</table>

Table 14. Non-riverine AquaScore percentages by criterion and study area

Criteria	Criteria scores by % of spatial units	Criteria scores by % of total area of spatial units
Criterion 1 Very High High Medium Low No data		
Criterion 2 Very High High Medium Low No data		
Criterion 3 Very High High Medium Low No data		

Criteria	Criteria scores by % of spatial units	Criteria scores by % of total area of spatial units
Criterion 4 Very High High Medium Low No data		
Criterion 5 Very High High Medium Low No data		
Criterion 6 Very High High Medium Low No data		

Criteria	Criteria scores by % of spatial units	Criteria scores by % of total area of spatial units
Criterion 8 Very High High Medium Low No data		

3.3 Spring results

Aquatic conservation assessments were conducted for the spring wetlands within each study area. The figures and tables shown below provide a summary of the results. Table 15 provides a combined summary of AquaScore results from all four study areas. Figure 9 maps the AquaScore results by spring spatial units. Figure 10 maps the criterion ratings contributing to the AquaScores. Table 16 and Table 17 provide summary charts of the spring results at the AquaScore and criterion level for each study area. Refer to the CIM list in Table 2 for the details of each criterion.

AquaScores

- 87.5% of springs received an AquaScore of ‘Very High’ or ‘High’. Virtually all springs in the Diamantina catchment received an AquaScore of ‘Very High’.
- The ‘Very High’ AquaScores for springs appears to be primarily derived from these springs exhibiting ‘Very High’ criterion ratings for at least four criteria.
- There was no ‘Low’ and only one ‘Very Low’ AquaScore for springs.

Criterion Ratings

- More than 90% of springs received ‘Very High’ ratings for criteria 1(Naturalness Aquatic), 2 (Naturalness Catchment) and 4 (Threatened Species and Ecosystems). This is indicative of the relatively high naturalness of the catchments and aquatic systems surrounding springs, and the importance of springs as habitat for threatened species or ecosystems.
- Criterion 3 (Diversity and Richness): 72% of springs returned ‘Very High’ or ‘High’ ratings for criterion 3. This is indicative of relatively high species diversity within LEBB spring ecosystems.
- Criterion 5 (Priority Species and Ecosystems): approximately 64% of springs were identified habitat for priority species including migratory birds.
- Criterion 8 (Representativeness): approximately 79% of springs scored a ‘Medium’ or ‘Low’ AquaScore for criterion 8 indicating they are reasonably well represented within protected areas (55% of springs) and/or are in a wetland management group that is reasonably abundant within the catchment.

Table 15. Spring AquaScore summary statistics

AquaScore	Number of Spatial Units	Percent of Spatial Units (%)
Very High	522	63.7
High	193	23.6
Medium	103	12.6
Low	0	0
Very Low	1	0.1
Total	819	100

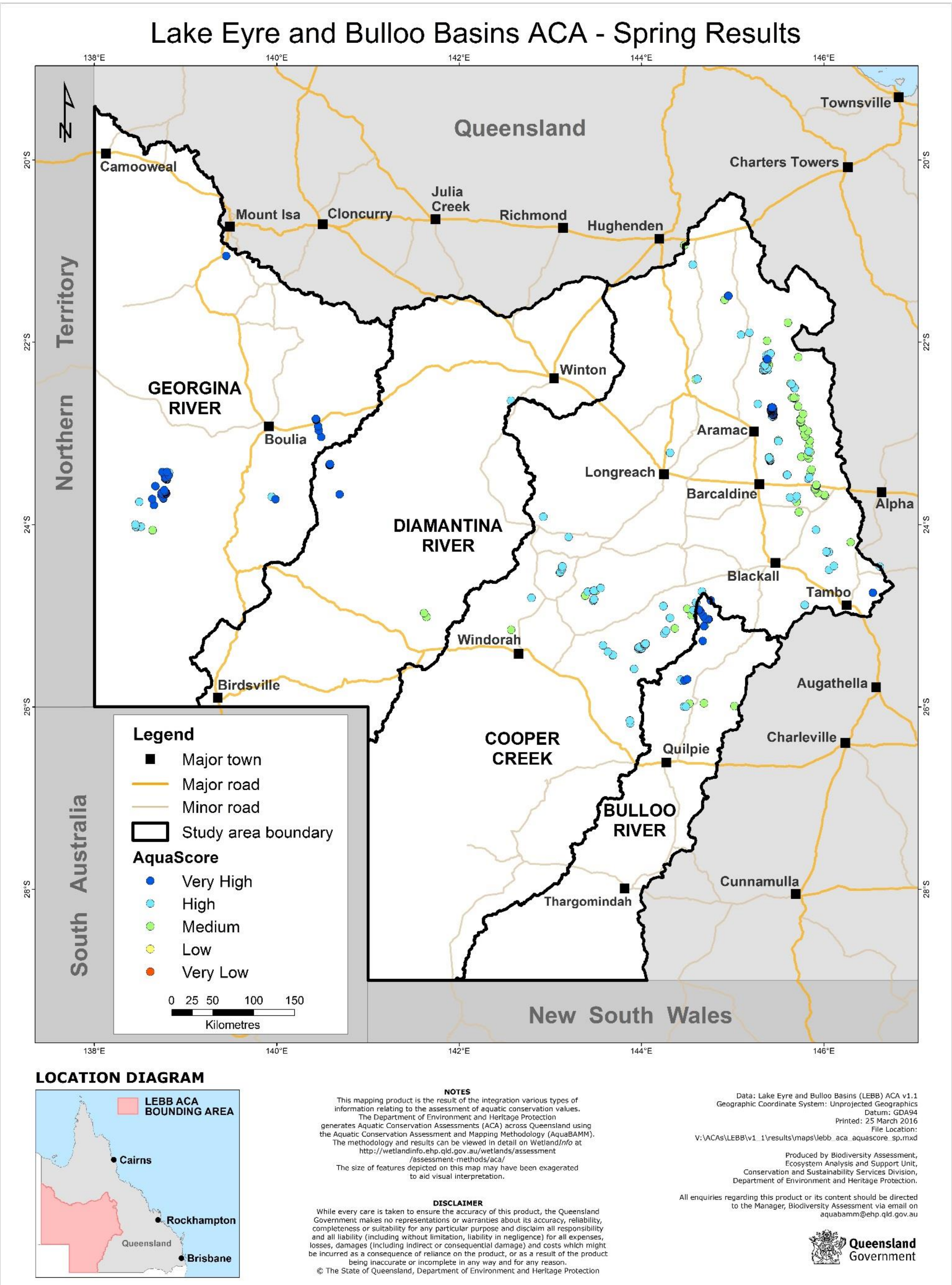


Figure 9. Spring AquaScores for each study area

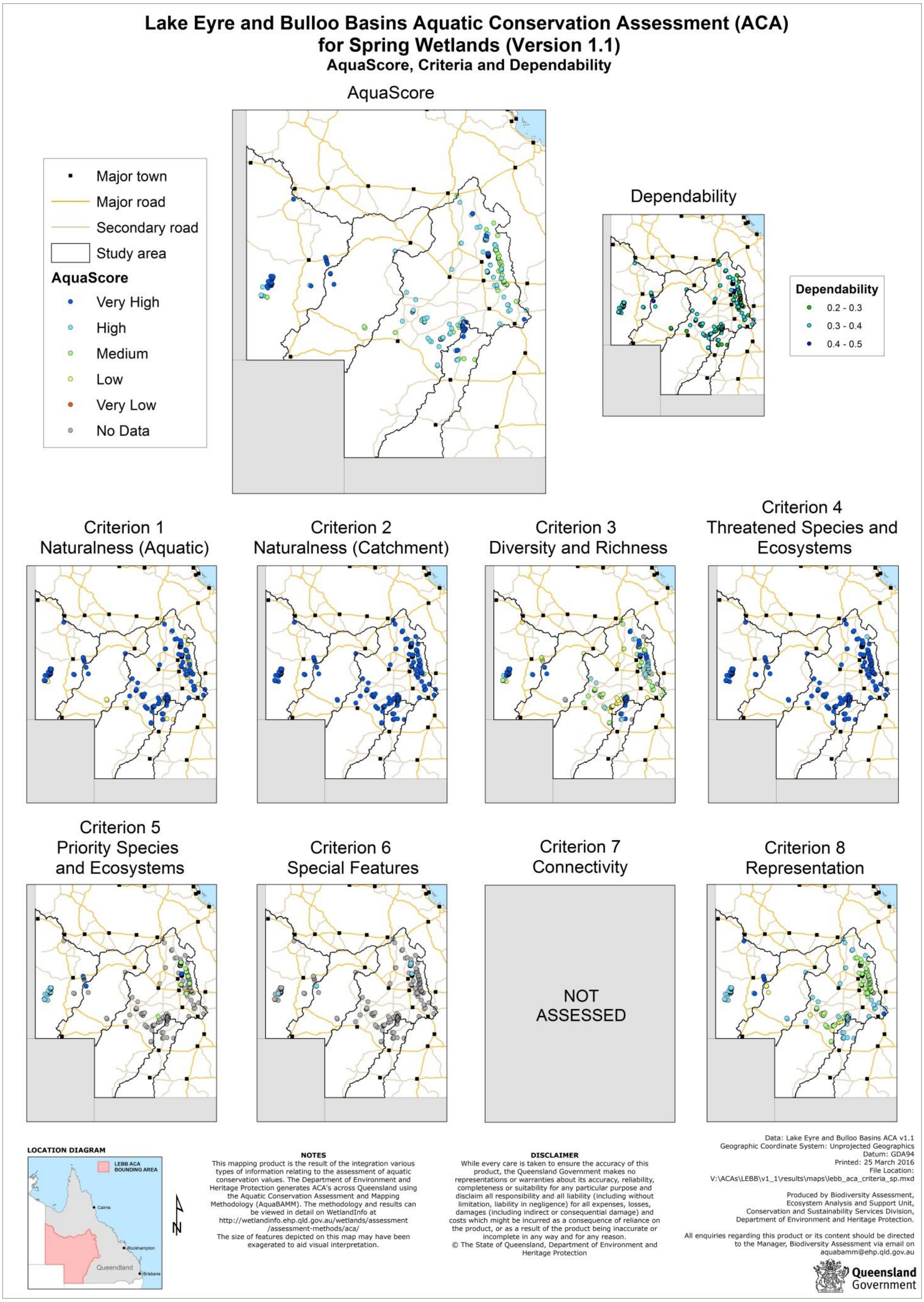
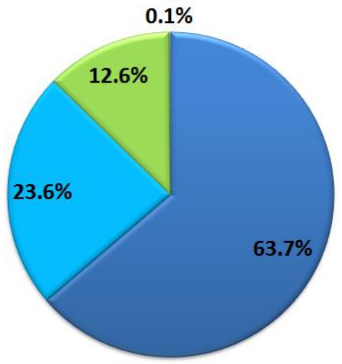
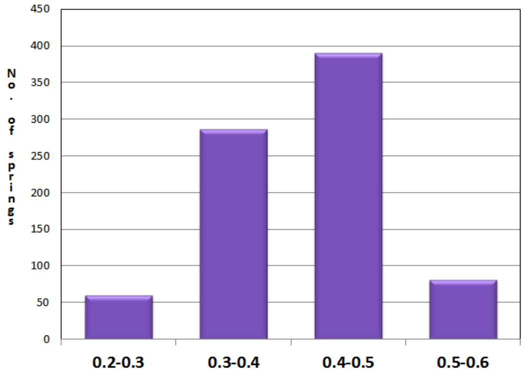
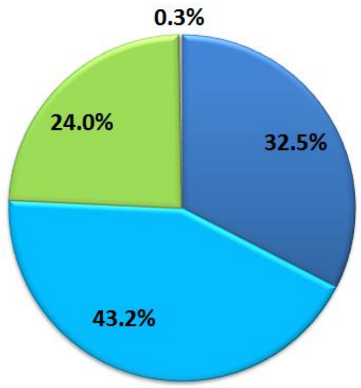
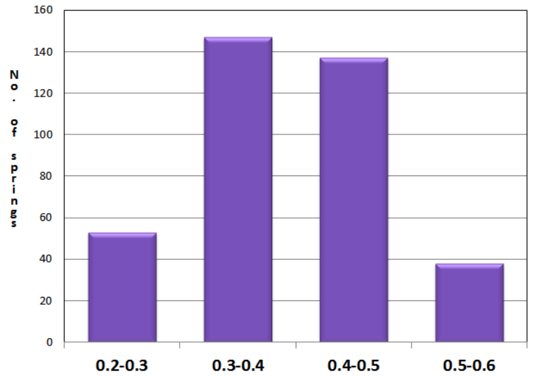
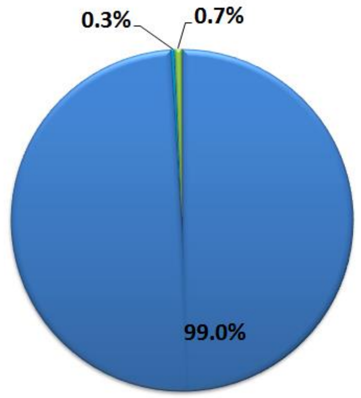
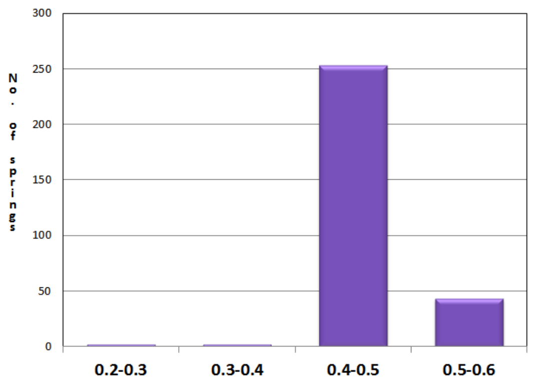


Figure 10. Spring criterion ratings for each study area

Table 16. Spring AquaScore percentages and dependability counts by study area

Catchment	AquaScore by % of spring spatial units	AquaScore dependability
All Very High High Medium Low Very Low		
Cooper Creek Very High High Medium Low Very Low		
Diamantina River Very High High Medium Low Very Low		

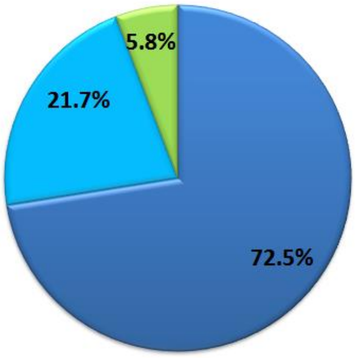
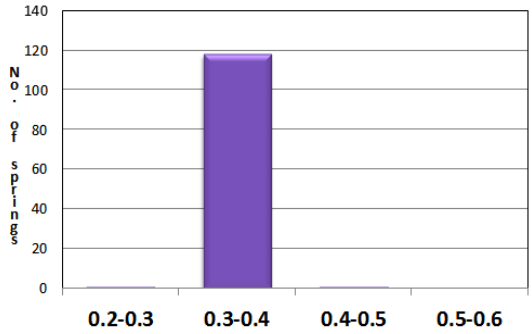
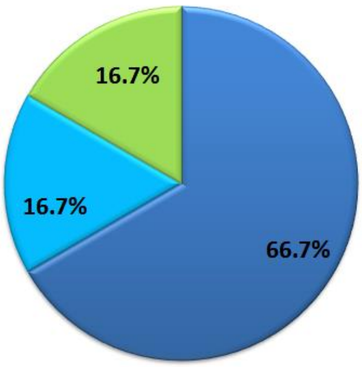
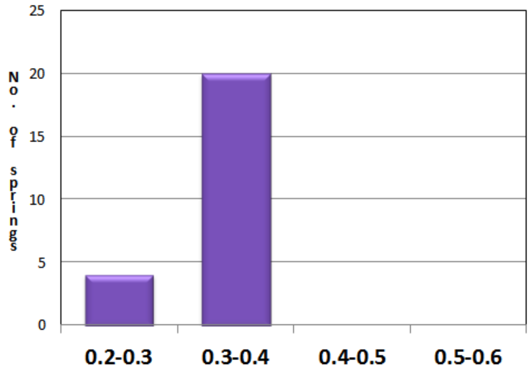
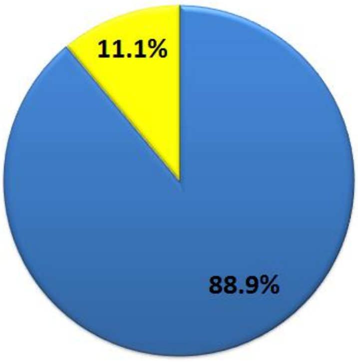
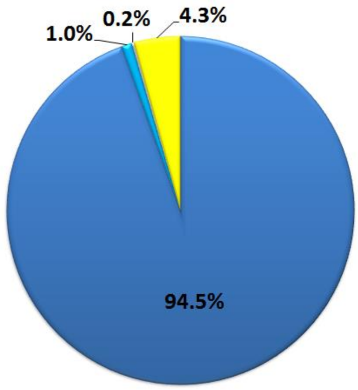
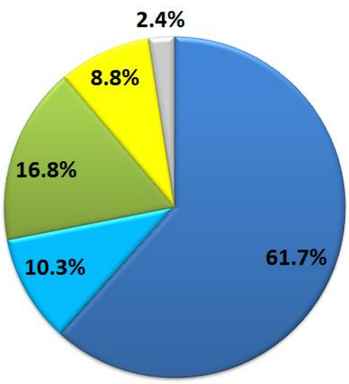
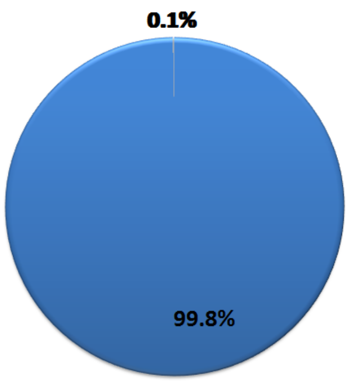
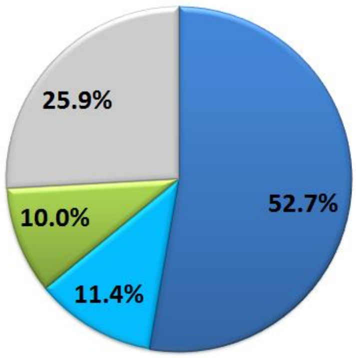
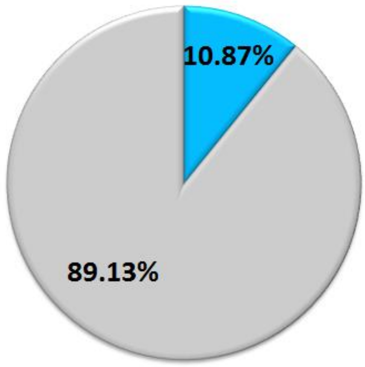
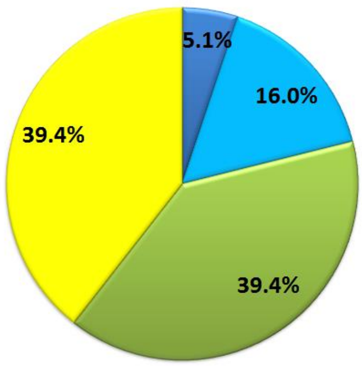
Catchment	AquaScore by % of spring spatial units	AquaScore dependability
Georgina River Very High High Medium Low Very Low		
Bulloo River Very High High Medium Low Very Low		

Table 17. Spring AquaScore percentages by criterion and study area

Criteria	Criteria scores by % of spatial units
Criterion 1 Very High High Medium Low No data	
Criterion 2 Very High High Medium Low No data	
Criterion 3 Very High High Medium Low No data	
Criterion 4 Very High High Medium Low No data	

Criteria	Criteria scores by % of spatial units
Criterion 5 Very High High Medium Low No data	
Criterion 6 Very High High Medium Low No data	
Criterion 8 Very High High Medium Low No data	

4 Field Truthing

Field truthing of ACA results is important to test the validity of the results and if necessary undertake any data corrections prior to a final running of the assessment.

As the LEBB cover a large area and field time was restricted, the project team decided to use a dual focus field truthing strategy. This was aimed at gathering as much information about the validity of initial results for this area. The two approaches adopted were:

1. validation of the draft results using key experts that have a good working knowledge of the Lake Eyre Basin
2. traversing the LEBB to field truth the results.

4.1 Expert validation

Prior to the field truthing trip, a decision was made to attempt to validate the results without the requirement for the project team to visit the area. Using scientific experts that have lived and researched in this area over an extended period of time gave a level of validation of the results which a field truthing trip would not have been able to provide. This recognises that any single short field trip would yield only a limited snapshot of the often highly seasonal values within an extensive study area.

Five experts were involved and all had the range of ecological processes expertise required to give a good evaluation of the ACA results. The five experts were:

- Roger Jaensch, Wetlands International, Brisbane (waterbirds and wetland ecology, fauna aquatic panel member)
- Dr Adam Kerezsy, Griffith University, Brisbane (fish ecology, aquatic fauna panel member)
- Chris Mitchell, Principal Conservation Officer, Queensland Parks and Wildlife Service (QPWS), Brisbane (management within the Lake Eyre Basin and National Parks acquisition since 1990, general expertise)
- Maree Rich, EHP, Longreach (field biologist, flora and fauna aquatic panel member)
- Jen Silcock, The University of Queensland/Queensland Herbarium, Brisbane (general, flora and ecology panel member).

Each was provided with A0 size maps of the catchment's draft riverine and non-riverine results. The following questions were asked to guide the experts through the review and to assist with identification of any potential errors in the results.

- Are there any very special wetlands, in your view, that have been rated lower than you would have expected?
- Are there any wetlands of low value (in your opinion) that should have been assigned a higher or lower AquaScore?
- Are there any wetlands of high value (in your opinion) that should have been assigned a higher or lower AquaScore?
- Are the wetlands rated 'Medium', what you expected to be 'Medium' rated wetlands?
- Are there any glaring (or otherwise) errors in the data? If so, please specify?
- Any other comments you might have.

Feedback was analysed by the project team and appropriate changes made. One of the valuable pieces of feedback was that springs values were undervalued, which led to the discovery of the fact that springs were not implemented. This was adopted and confirmed the value of this process.

4.2 Subsections traversed

The four catchments of the LEBB contain a total of 447 riverine subsections and 30,469 non-riverine wetland spatial units. From 9 July to 14 July, 2013 a total of approximately 2570km was driven on the following route: Thargomindah; The Dig Tree Reserve; Thargomindah; Quilpie; Windorah; Birdsville; Plant Camp; Bedourie; Boulia; Winton; Longreach; Barcaldine; Blackall; Charleville (Figure 11).

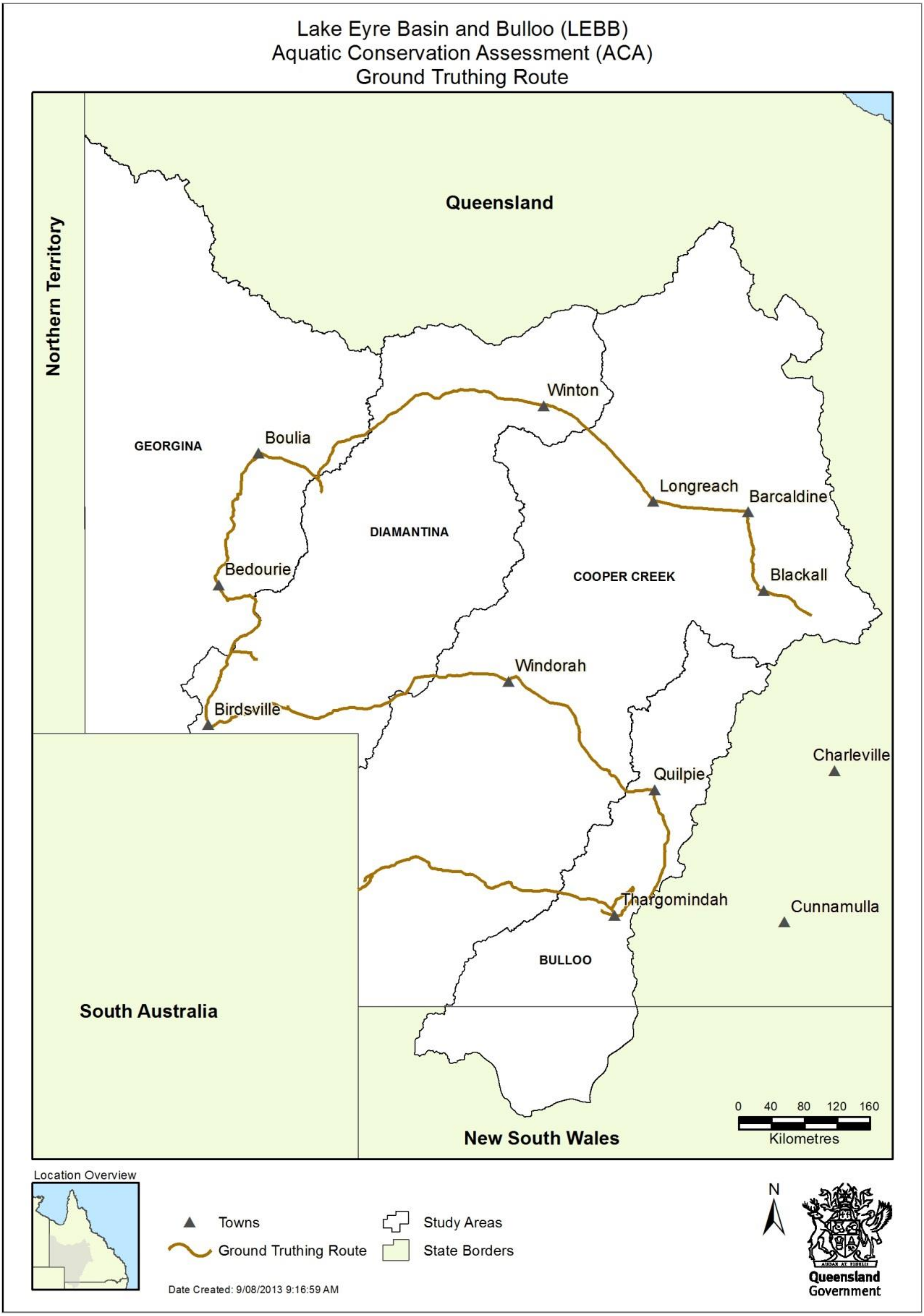


Figure 11. Route undertaken during field truthing exercise

Subsections were observed *en route* and either inspected from gazetted roads at junctions between the roads and the riverine systems. Photographs were taken at each of the sites stopped at. The size of the LEBB catchment area and the issue of accessibility accounted for the relatively small number of subsections and wetlands visited relative to the whole study area. This was found to be one of the major limitations of the field truthing exercise.

A total of 58 riverine subsections and 18 wetland spatial units across the four catchments were traversed by vehicle as part of the field truthing exercise (Table 18**,** Table 19 and Figure 11). This equated to 13% of the total riverine subsections and 0.06% of the non-riverine wetland spatial units in the LEBB study area.

Table 18. Riverine subsections traversed during field truthing by AquaScore

ACA study area	Very Low	Low	Medium	High	Very High	Total	%
Bulloo	0	0	0	6	5	11	19
Cooper	0	1	3	8	7	19	33
Diamantina	0	2	5	6	3	16	28
Georgina	0	1	1	7	3	12	21
TOTAL	0	4	9	27	18	58	100

Table 19. Non-riverine wetlands traversed during field truthing by AquaScore

ACA study area	Very Low	Low	Medium	High	Very High	Total	%
Bulloo	0	0	0	2	2	4	0.03
Cooper	0	0	4	3	0	7	0.06
Diamantina	0	0	1	2	1	4	0.04
Georgina	0	0	1	1	1	3	0.02
TOTAL	0	0	6	8	4	18	0.04

Despite the small percentage of subsections and wetlands traversed (relative to the whole study area), the exercise allowed the direct checking of numerous riverine and some non-riverine wetlands and covered a range of AquaScores (Table 18 and Table 19). As stated previously only 18 non-riverine wetlands were investigated, the majority of which were major wetlands, as the distances, logistics and time involved prohibited investigation of any more than this. Some images of subsections and non-riverine wetlands inspected during the field trip are provided in the following plates. These photographs represent a cross-section of the catchments and overall AquaScore.

Plate 1. Bulloo River where the Soonah Crossing Road intercepts it near Thargomindah, Bulloo River catchment (Photo: EHP).

This site (riverine subsection ul_s00020) is located along the Bulloo River, where the river crosses Soonah Crossing Road, a minor road 35km north–north–east of Thargomindah, in the Bulloo River catchment. This site supports thick riparian vegetation and there was much visible recruitment of eucalypts and yapunyah trees at the site. There were also river red gum trees present, as well as some sedges, and several bird species.

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Very High
C3 — Diversity and richness	Low
C4 — Threatened species and ecosystems	High
C5 — Priority species and ecosystems	No data
C6 — Special features	No data
C7 — Connectivity	Low
AquaScore	Medium
AquaScore dependability	37%

Plate 2. Un-named creek near Thargomindah on the Thargomindah–Dig Tree main road, Bulloo River catchment (Photo: EHP).

This un-named creek is 25km from Thargomindah along the Thargomindah to Dig Tree main road (riverine subsection ul_s00017), in the Bulloo River catchment.

Criterion	Score
C1 — Naturalness aquatic	High
C2 — Naturalness catchment	Medium
C3 — Diversity and richness	Very High
C4 — Threatened species and ecosystems	Medium
C5 — Priority species and ecosystems	Medium
C6 — Special features	No data
C7 — Connectivity	Low
AquaScore	High
AquaScore dependability	47%

Plate 3. Cooper Creek crossing on the Quilpie–Windorah road, Cooper Creek catchment (Photo: EHP).

This riverine subsection is situated where the road crosses Cooper Creek between Quilpie and Windorah. It is located approximately 225km north–west of Quilpie, and 11km east of Windorah, in the Cooper River Catchment (riverine subsection unit cp_s00128).

Criterion	Score
C1 — Naturalness aquatic	Medium
C2 — Naturalness catchment	Very High
C3 — Diversity and richness	High
C4 — Threatened species and ecosystems	High
C5 — Priority species and ecosystems	High
C6 — Special features	No data
C7 — Connectivity	Very High
AquaScore	High
AquaScore dependability	63%

Plate 4. Tralee Creek in Cooper Creek catchment (Photo: EHP).

This riverine site is part of Tralee Creek, close to Kyabra Creek, 80km east–south–east of Windorah on the Quilpie–Windorah main road (riverine subsection cp_s00129), in the Cooper Creek catchment.

Criterion	Score
C1 — Naturalness aquatic	High
C2 — Naturalness catchment	Very High
C3 — Diversity and richness	Medium
C4 — Threatened species and ecosystems	High
C5 — Priority species and ecosystems	No data
C6 — Special features	No data
C7 — Connectivity	Very High
AquaScore	High
AquaScore dependability	51%

Plate 5. Macfarlane Creek, off the Barcoo River, in the Cooper Creek catchment, between Blackall and Tambo (Photo: EHP).

This site is on Macfarlane Creek, a tributary of the Barcoo River, 52km west of Blackall on the Blackall–Tambo highway, in the Cooper Creek catchment (riverine subsection cp_s00106).

Criterion	Score
C1 — Naturalness aquatic	Medium
C2 — Naturalness catchment	Low
C3 — Diversity and richness	Low
C4 — Threatened species and ecosystems	Medium
C5 — Priority species and ecosystems	Medium
C6 — Special features	No data
C7 — Connectivity	Low
AquaScore	Medium
AquaScore dependability	60%

Plate 6. Middleton Creek in the Diamantina catchment (Photo: EHP).

This riverine subsection is located on Middleton Creek where the main road crosses the creek 160km west of Winton (riverine subsection di_s00018), in the Diamantina catchment.

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Very High
C3 — Diversity and richness	Low
C4 — Threatened species and ecosystems	High
C5 — Priority species and ecosystems	Medium
C6 — Special features	No data
C7 — Connectivity	Medium
AquaScore	Medium
AquaScore dependability	37%

Plate 7. Cadell Creek in the Diamantina River catchment (Photo: EHP).

Cadell Creek is a tributary of Mackunda Creek which flows into the Diamantina River and is located on the Boulia–Winton highway, approximately 218km east of Boulia (riverine subsection unit di_s00008), in the Diamantina River catchment.

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Medium
C3 — Diversity and richness	Low
C4 — Threatened species and ecosystems	High
C5 — Priority species and ecosystems	No data
C6 — Special features	No data
C7 — Connectivity	Low
AquaScore	Medium
AquaScore dependability	37%

Plate 8. Eyre Creek, half way between Birdsville and Boulia, in the Georgina River catchment (Photo: EHP).

This riverine subsection is close to the main road, approximately half way between Birdsville and Boulia (175km from either town), in the Georgina River catchment (riverine subsection ge_s00009).

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Medium
C3 — Diversity and richness	Very High
C4 — Threatened species and ecosystems	High
C5 — Priority species and ecosystems	High
C6 — Special features	High
C7 — Connectivity	Very High
AquaScore	High
AquaScore dependability	51%

Plate 9. An unnamed creek in the Georgina River catchment (Photo: EHP).

This unnamed multi-channelled creek off the Hamilton River is 88km east of Boulia on the Boulia–Winton main road (riverine subsection ge_s00123), in the Georgina River catchment.

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Medium
C3 — Diversity and richness	Low
C4 — Threatened species and ecosystems	Low
C5 — Priority species and ecosystems	No data
C6 — Special features	No data
C7 — Connectivity	Low
AquaScore	Low
AquaScore dependability	37%

Plate 10. Wetland, 3km west of Thargomindah, in the Bulloo River catchment (Photo: EHP).

This wetland is located approximately 3km west of Thargomindah (non-riverine spatial unit ul_w05120), in the Bulloo River catchment, on a minor road running west–north–west out of the town. This palustrine wetland is an arid/semi-arid floodplain lignum swamp.

Criterion	Score
C1 — Naturalness aquatic	Medium
C2 — Naturalness catchment	High
C3 — Diversity and richness	Very High
C4 — Threatened species and ecosystems	Very High
C5 — Priority species and ecosystems	Very High
C6 — Special features	No data
C8 — Representativeness	Low
AquaScore	Medium
AquaScore dependability	68%

Plate 11. Arid/Semi-arid floodplain lignum swamp the Cooper Creek catchment (Photo: EHP).

This palustrine wetland (non-riverine spatial unit cp_w05524) is located between Gooaghooheeny Billabong to the east and Cooper creek to the west. It is situated 190km west of Thargomindah on the main road in the Cooper Creek catchment. This wetland is an arid/semi-arid floodplain lignum swamp.

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Very High
C3 — Diversity and richness	Very High
C4 — Threatened species and ecosystems	Very High
C5 — Priority species and ecosystems	Medium
C6 — Special features	No data
C8 — Representativeness	Very High
AquaScore	Very High
AquaScore dependability	63%

Plate 12. Wetland, 30km north of Birdsville, in the Diamantina River catchment (Photo: EHP).

This wetland is 30km north of Birdsville on the Birdsville–Boulia main road (wetland spatial unit di_w00850) in the Diamantina River catchment. This site is an arid/semi-arid fresh non-floodplain lacustrine wetland.

Criterion	Score
C1 — Naturalness aquatic	Medium
C2 — Naturalness catchment	Very High
C3 — Diversity and richness	Medium
C4 — Threatened species and ecosystems	Very High
C5 — Priority species and ecosystems	Medium
C6 — Special features	No data
C8 — Representativeness	Medium
AquaScore	Medium
AquaScore dependability	61%

Plate 13. Bilpa Morea Claypan in the Diamantina River catchment (Photo: Lorraine Briggs, EHP).

Bilpa Morea Claypan covers an area of approximately 62 000ha, when full. The claypan is situated 121km north- east of Birdsville. This is an arid/semi-arid fresh non-floodplain lacustrine wetland. Bilpa Morea Complex plus eastern swamps is one of the fauna expert panel decisions (di_nr_fa_01, rating = 2), being an important waterbird habitat area (measure 5.1.4, habitat for significant numbers of waterbirds). Bilpa Morea is located in the Diamantina catchment (spatial unit di_w03089).

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	High
C3 — Diversity and richness	Very High
C4 — Threatened species and ecosystems	Medium
C5 — Priority species and ecosystems	Medium
C6 — Special features	High
C8 — Representativeness	Very High
AquaScore	High
AquaScore dependability	63%

Plate 14. A palustrine wetland near Eyre Creek in the Georgina River catchment, on the main road approximately half way between Birdsville and Boulia (Photo: EHP).

This palustrine wetland (non-riverine spatial unit ge_w09179) is located near Eyre Creek, approximately 200km north of Birdsville on the Birdsville–Boulia main road, in the Georgina River catchment. This wetland is an arid/semi-arid floodplain grass, sedge, herb (lignum) swamp.

Criterion	Score
C1 — Naturalness aquatic	High
C2 — Naturalness catchment	High
C3 — Diversity and richness	Medium
C4 — Threatened species and ecosystems	Medium
C5 — Priority species and ecosystems	Medium
C6 — Special features	No data
C8 — Representativeness	Very High
AquaScore	Medium
AquaScore dependability	55%

Plate 15. Wetland in Eyre Creek catchment in the Georgina River catchment (Photo: EHP).

This palustrine wetland is an arid/semi-arid floodplain lignum swamp (non-riverine spatial unit ge_w03740), in the Georgina River catchment.

Criterion	Score
C1 — Naturalness aquatic	Very High
C2 — Naturalness catchment	Medium
C3 — Diversity and richness	Very High
C4 — Threatened species and ecosystems	Medium
C5 — Priority species and ecosystems	High
C6 — Special features	No data
C8 — Representativeness	High
AquaScore	Medium
AquaScore dependability	63%

4.3 Field interpretation of ACA results

4.3.1 Ecological versus condition assessment

When looking at wetlands or subsections in a catchment and comparing them to their AquaScore, there is a strong tendency to focus on a subsection's condition. Wetland condition or health has been a major emphasis of aquatic assessment in Australia, such as the nationally agreed protocol of Monitoring River Health Initiative, Index of Stream Condition and Queensland State of the Rivers (Anderson 1993, Dunn 2000). However, several authors make a clear distinction between river health and ecological value of a river (Dunn 2000, Bennett et al. 2002, Chessman 2002). Wetland health data may inform an assessment of value, and usually does so where data are available, but is not interchangeable with it and the two are not necessarily correlated.

ACAs are primarily focussed on aquatic ecological or conservation value such that the condition contributes to, but does not solely determine a subsection's value. A subsection value is a composite of several criteria, indicators and measures. Of the measures used in these assessments, usually less than 10% are related to aquatic, riparian and/or catchment condition.

Consequently, when in the field, the successful interpretation of a subsection's conservation value is reliant on the observer to view condition in conjunction with other values whether seen or unseen.

4.3.2 Field truthing insights

Several lessons were gained from the field truthing exercise:

- The distance involved as well as the time available with this LEBB ACA limited the number of sites that could be investigated. An average of 12 sites a day was visited over the six days that data were collected making a total of 76 sites assessed.
- The non-riverine sites were particularly difficult to visit as they were few and far between relative to the riverine sites. Only 18 non-riverine sites were investigated during the field truthing exercise. However, when there are 30,000 wetlands that could never have been visited, the value of an expert validation process is apparent.
- During the field trip it became evident that the number of different criteria with data and the dependability of the data had a great influence on the final overall AquaScore for that particular subsection.
- It was difficult to see degradation of sites and subsections in the LEBB ACA study area as the landscape was more uniform than, for example, the Condamine ACA study area (part of the Queensland Murray–Darling Basin ACA), where degradation was much more noticeable and evident (Thrupp & Moffatt 2002).
- A range of values were observed through this process, and one of the larger indicators of values was the presence or lack of data for the subsection—dependability has large impact on the score for these catchments.

4.3.3 Confidence in the AquaScore

Conservation assessments of landscapes, by their very nature, apply ratings along a continuum. Hence, sites with extremes in values ('Very High' and 'Very Low') are relatively easy to recognise in the field compared to sites of intermediate value (e.g. 'Low', 'Medium' and 'High'). It is particularly difficult to distinguish between subsections rated as either 'Medium' or 'High'. Possible reasons for this difficulty whilst in the field included:

- insufficient datasets for some subsections to allow for a precise determination of conservation value
- the differences between subsections are real, but are not easily observed in the field because of hidden instream values
- often only a small part of a subsection can be seen and assessed in the field. For instance, smaller tributaries within a subsection unit may be devoid of values but the main channel may have significant values that increase the subsection's overall score.

A lack of data for some subsections is recognised as a limitation to any assessment. This limitation has been addressed in part by calculating a dependability score for each wetland. The dependability score is an important parameter when interpreting the AquaScore, or any other conservation value score from criterion or indicator level within the ACA. The lower the dependability score for a subsection means a lower confidence level the user will have in the conservation value. Conversely, the higher the dependability scores for a subsection, the more confident the user can be in the conservation value assigned to the subsection (Clayton et al. 2006).

In the end, wetlands or subsections are ecologically complex and field truthing must be undertaken with observer perspective driven strictly by the limitations of each ACA, such as scale, datasets, etc. With this approach, an indication of confidence in the accuracy of any ACA using AquaBAMM can be reached.

5 General Summary and Discussion

The AquaBAMM is a robust and comprehensive method for assessing the conservation values of Queensland's wetlands. This document describes the methods and results for a series of ACAs completed for the riverine, non-riverine and spring wetlands of the Lake Eyre and Bulloo Basins.

Overall, the LEBB ACAs resulted in:

- 52.5% of riverine, 21.5% of non-riverine (78% of non-riverine wetland area) and 87.5% of spring spatial units received an AquaScore of ‘Very High’ or ‘High’
- 10% of riverine spatial units and 3% of non-riverine spatial units (<1% of non-riverine wetland area) received an AquaScore of ‘Low’ or ‘Very Low’
- No spring spatial units received an AquaScore of ‘Low’
- Only one spring spatial unit received an AquaScore of ‘Very Low’.

The main factors contributing to these results appear to be:

- high aquatic and catchment naturalness across the four study areas
- variable spatial distributions of near threatened or threatened species within the LEBB region
- a high number of areas identified as critical habitat for waterbirds
- high endemism of spring flora and fauna.

Data for three of the AquaBAMM criteria were derived primarily from expert knowledge. Expert opinion was also used to moderate AquaBAMM results through the application of ranks and weights to each AquaBAMM indicator and measure.

Three expert panel workshops comprising individuals with expertise in LEBB aquatic and aquatic flora, aquatic fauna and wetland ecology were held in Brisbane late 2010. Experts were asked to nominate species adapted to, or dependent on, living in wet conditions for at least part of their life, and found either within or immediately adjoining a riverine, non-riverine or spring wetland. The experts nominated:

- thirty threatened or near threatened taxa, 73 priority and 20 migratory taxa dependent on the wetlands
- two-hundred and six native flora and 150 native fauna taxa dependent on the wetlands
- forty six exotic plant and animal taxa which may or may not be wetland dependent but are impacting on the values of LEBB wetlands.

Lists containing the individual taxa described above are provided in the accompanying LEBB expert panel report (EHP 2016b).

Experts were also asked to nominate areas containing special or unique features based on their ecology, geomorphology or hydrology. Sixty decisions describing special or unique wetland features were identified in the LEBB region (EHP 2016b). All but three of these decisions could be implemented as a special feature dataset. In addition, 25 areas containing either significant proportions of a single species breeding population (> one per cent for waterbirds), or high density concentrations of non-breeding waterbirds (e.g. one per cent of global population), were identified. Together, the special feature and significant waterbird habitat area datasets provide a comprehensive and unique data source.

The AquaBAMM affords relatively high conservation significance to wetlands containing special features or threatened and near threatened species records. Combined with a larger than normal size of spatial units within the LEBB this may have resulted in some wetlands receiving ‘Very High’ or 'High' AquaScores despite only part of the corresponding spatial unit containing the underlying values. Accordingly, all results should be interpreted in conjunction with the raw data assessed for each spatial unit. For example, users should refer to the descriptions of any intersecting special features as these may contain additional information concerning the specific geographical extent of the corresponding special features values.

Data scale and availability are additional factors to consider when interpreting ACA results. For example, AquaBAMM uses data collected for different purposes and at different times meaning the scale, currency, extent and completeness of input data can vary between measures. For example, State of Rivers data used in this project were restricted to the Cooper Creek and parts of the Bulloo Rivera study areas.

Issues related to data availability are common to all ACAs, with data completeness commonly influenced by factors such as research priorities, accessibility, research effort or search effort by enthusiasts. Overall, the LEBB ACAs assessed a total of 43 riverine and 38 non-riverine and spring measures which, in general, is lower than that used by the other ACAs completed for the state. One of the strengths of the AquaBAMM is that new data can be incorporated as it becomes available.

The AquaBAMM dependability score describes, for a particular spatial unit, the number of measures which have data relative to the total number of measure used in the assessment. Dependability scores do not influence or change the final AquaScore. In general, higher confidence should be afforded to results with more complete data when interpreting the LEBB ACA results. For example, for spatial units where data is limited, low AquaScores and criteria ratings should be interpreted in conjunction with the corresponding dependability scores. Dependability score may also be used to help target areas for future survey effort.

During this project several modifications were made to the ACA methodology in an attempt to accommodate the unique characteristics of the LEBB region. For example, this project introduced the concept of a ‘major wetland’ and ‘subsection amalgamations’ in an attempt to better represent the values of large non-riverine wetlands. In addition, the ‘variable thresholds approach’ proposed during the South East Queensland ACA was adopted providing more meaningful results for the species richness measures. Finally, the wording of several filter table decisions were modified to better capture the intent of the corresponding decisions.

Field truthing is an important part of the AquaBAMM and generally precedes any method or input data corrections and a final re-run for each assessment. For this project a combination of field truthing and direct engagement with local experts was employed to increase the reliability of results.

Aquatic conservation assessments undertaken using the AquaBAMM have now been completed for most of Queensland. ACA results provide a rich source of baseline wetland conservation/ecological information, and an overall assessment of relative aquatic conservation value, and are easily interrogated using GIS software.

The catchments of the LEBB are home to a variety of aquatic species and ecosystems including many that are rare, threatened or migratory. The LEBB also contains some of the world’s last large unregulated and minimally impacted river systems (Costello et al. 2004). The results presented here fill an important gap by providing critical information needed to support natural resource management, regional planning and environmental licensing and permitting decisions aimed at managing and protecting LEBB wetlands.

6 Recommendations

- Where possible, incorporate Lake Eyre Basin Rivers Assessment Monitoring Program data into the next versions of the LEBB ACAs.
- Measure 7.1.2 was removed from the riverine assessments. The next version of LEBB ACAs should attempt to re-include this measure. This may entail adding new filter table decisions to tease out the unique criteria combinations captured by decision 13.
- Explore the possibility of completing a totally independent assessment for springs. This may require the development of an assessment parameter set (i.e. CIM), including the addition or subtraction of AquaBAMM criteria, indicators and/or measures, specific to springs. This may also require new or the adaptation of existing connectivity and representativeness measures.
- Changes made to the filter table as part of the LEBB ACAs should be rolled into the default riverine and non-riverine filter tables for use in future ACAs.
- Explore avenues for reducing the size of large non-riverine spatial units as this will help apply values (i.e. special features) at a finer scale.
- Investigate the use of springs by broader terrestrial fauna groups (frogs, reptiles, birds and mammals) including taxa that impact on spring values.

7 References

Anderson, JR 1993, *State of the Rivers project—report 1: Development and validation of the methodology*, Report by AquaEco Services to Queensland Department of Primary Industries, Brisbane.

Armstrong, D 1990, Hydrology. In *Natural history of the North East Deserts*. eds Tyler, MJ, Twidale, CR, Davies, M, Wells, CB, Royal Society of South Australia, Adelaide.

Australian Bureau of Meteorology, 2011, Climate data online, accessed 17 May 2011, http://www.bom.gov.au/climate/data/.

Bailey, V 2001, *Western streams water quality monitoring project*, Department of Natural Resources and Mines, Brisbane.

Barter, MA, Harris, K 2002, Occasional Count No 6. Shorebird counts in the NE South Australia-SW Queensland region in September-October 2000, *The Stilt* 41, 44-47.

Bennett, J, Sanders, N, Moulton, D, Phillips, N, Luckacs, G, Walker, K, Redfern, F 2002, *Guidelines for protecting Australian waterways*, Land and Water Australia, Canberra.

Bunn, SE, Davies, PM 1999, Aquatic food webs in turbid, arid zone rivers: Preliminary data from Cooper Creek, Queensland. In *Free-flowing River: the Ecology of the Paroo River*, ed. Kingsford, RT, NSW National Parks and Wildlife Service, Sydney.

Bunn, SE, Davies, PM, Winning, M 2003, Sources of organic carbon supporting the food web of an arid zone floodplain river, *Freshwater Biology*, 48, 619-635.

Chessman, B 2002, *Assessing the conservation value and health of New South Wales rivers. The PBH (Pressure-Biota-Habitat) project*, New South Wales Department of Land and Water Conservation, Parramatta.

Clayton, PD, Fielder, DF, Howell, S, Hill, CJ 2006, *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment*, Environmental Protection Agency, Brisbane.

Costelloe, JF, Hudson, PJ, Pritchard, JC, Puckridge, JT, Reid, JRW 2004, *ARIDFLO Scientific Report: Environmental Flow Requirements of Arid Zone Rivers with Particular Reference to the Lake Eyre Drainage Basin*, Final report to South Australian Department of Water, Land and Biodiversity Conservation and Commonwealth Department of Environment and Heritage. School of Earth and Environmental Sciences, University of Adelaide, Adelaide.

Desert Channels Queensland Inc. 2004, *Our country: Our community. A community information paper for the Queensland section of the Lake Eyre Basin,* Desert Channels Queensland, Longreach.

Dunn, H 2000, *Identifying and protecting rivers of high ecological value*, Land and Water Resources Research and Development Corporation Occasional Paper 01/00.

EHP, 2016b. Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Lake Eyre and Bulloo Basins: Flora, Fauna and Ecology Expert Panel Report—Version 1.1. Brisbane: Department of Environment and Heritage Protection, Queensland Government.

EHP, 2016c. Queensland wetland classification method, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 31 May 2016,<http://wetlandinfo.ehp.qld.gov.au/wetlands/what-are-wetlands/definitions-classification/classification-systems-background/typology.html>.

EPA, 2005, *Wetland mapping and classification methodology—overall framework: A method to provide baseline mapping and classification for wetlands in Queensland, Version 1.2*, Environmental Protection Agency, Brisbane.

Fensham, RJ, Fairfax, RJ 2003, Spring wetlands of the Great Artesian basin, Queensland, Australia, *Wetland Ecology and Management*, 11, 343-362.

Fensham RJ, Ponder, W, Fairfax, RJ, 2007, *Recovery plan for the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*, Report to Department of the Environment, Water, Heritage and the Arts, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Ford, G 1995, *A survey and inventory of wetlands in the Channel Country, south-western Queensland*, Report to Australian Nature Conservancy. Queensland Department of Environment and Heritage, Toowoomba.

Hammer, MP, Adams, M, Unmack, PJ, Walker, KF 2007, A rethink on *Retropinna*: conservation implications of new taxa and significant genetic sub-structure in Australian smelts (Pisces: Retropinnidae), *Marine and Freshwater Research*, 58, 327-341.

Jaensch, R 2009, *Floodplain Wetlands and Waterbirds of the Channel Country*, South Australian Arid Lands Resource Management Board.

Kingsford, RT (ed) 2006, *Ecology of desert rivers*, University Press, Cambridge, United Kingdom.

Leigh, C, Sheldon, F, Kingsford, RT, Arthington, AH 2010, Sequential floods drive 'booms' and wetland persistence in dryland rivers: a synthesis, *Marine and Freshwater Research*, 61, 896-908.

Long, PE; Humphery, VE 1997, *Fisheries Study Lake Eyre Catchment: Thomson and Diamantina Drainages, December 1995*, Queensland Department of Primary Industries, Information Series QI97080.

Musyl, MK, Keenan, CP 1992, Population genetics and zoogeography of Australian freshwater Golden Perch, *Macquaria ambigua* (Richardson 1845) (Teleostei : Percichthyidae), and electrophoretic identification of a new species from the Lake Eyre Basin, *Australian Journal of Marine and Freshwater Research* 43, 1585-1601.

National Land and Water Resources Audit (NLWRA), 2002, *User Guide - Australian Natural Resources Atlas and Data Library*, National Land and Water Resources Audit, Canberra.

Pisanu, P, Kingsford, RT, Wilson, B, Bonifacio, R 2015, Status of connected wetlands of the Lake Eyre Basin, Australia, *Austral Ecology* 40, 460-471.

Ponder, WF 1986, Mound springs of the Great Artesian Basin. In *Limnology of Australia*, eds DeDeckker, P, Williams, WD, CSIRO, Australia and W. Junk, The Hague.

Robinson, W, Lee, J 2009, *AquaBAMM: sensitivity analysis using the Burnett River catchment results*, Report by University of the Sunshine Coast.

Thrupp, CL, Moffatt, DB 2002, *The ecological condition of floodplain wetlands in the Queensland Murray–Darling Basin, Australia*, Department of Natural Resources and Mines, Toowoomba.

Sheldon, F, Balcombe, S, Brunner, P Capon, S 2003, *Ecological and geomorphological assessment for the Georgina-Diamantina River Catchment. Stage 1 Ecological and geomorphological assessment*, Consultant report by the Centre for Riverine Landscapes, Griffith University, Brisbane.

Turpie, JK, Adams, JB, Joubert, A, Harrison, TD, Colloty, BM, Maree, RC, Whitfield, AK, Wooldridge, TH, Lamberth, SJ, Taljaard, S. and Van Niekerk, L. (2002) Assessment of the conservation priority status of South African estuaries for use in management and water allocation. Water SA 28: 191-206.

Walker, KF, Sheldon, F, Puckridge, JT 1995, A perspective on dryland river ecosystems, *Regulated Rivers: Research and Management* 11, 85-104.

White, IA 2001, *With Reference to the Channel Country, Review of available information,* Queensland Department of Primary Industries.

Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Lake Eyre and Bulloo Basins

Flora, Fauna and Ecology Expert Panel Report

Version 1.1

Queensland Government

Prepared by: Biodiversity Assessment, Conservation and Sustainability Services, and Biodiversity Services, Environmental Standards and Compliance, Department of Environment and Heritage Protection.

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Methodology
ASFB	Australian Society for Fish Biology
ASL	Above Sea Level
BAMM	Biodiversity Assessment and Mapping Methodology
BPA	Biodiversity Planning Assessment
CAMBA	China–Australia Migratory Bird Agreement
CIM	Criteria, indicators and measures (used in AquaBAMM)
DIWA	Directory of Important Wetlands Australia
EHP	Department of Environment and Heritage Protection
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
GAB	Great Artesian Basin
IBRA	Interim Biogeographic Regionalisation for Australia
JAMBA	Japan–Australia Migratory Bird Agreement
LEBB	Lake Eyre and Bulloo Basins
MGD	Mitchell Grass Downs bioregion
NCA	*Nature Conservation Act 1992*
QMDB	Queensland Murray–Darling Basin
QWS	Queensland Wetland System
Ramsar	Ramsar Convention on Wetlands
RE	Regional Ecosystem
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SOR	State of the Rivers
WWF	World Wide Fund for Nature

1 Introduction

The Department of Environment and Heritage Protection (EHP) has completed an assessment of the aquatic conservation values of wetlands within the Lake Eyre and Bulloo Basins (LEBB) using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton et al. 2006).

AquaBAMM is a robust and objective conservation assessment method which uses criteria, indicators and measures founded upon a large body of national and international literature. Aquatic conservation assessments undertaken using the AquaBAMM provide a non-social, non-economic, and tenure independent assessment of wetland biodiversity values within a specified study area (usually a catchment).

Three expert panel workshops (flora, fauna, and ecology) were held in Brisbane in 2010 as part of the LEBB ACA project. Experts were used to elicit data for a number of AquaBAMM measures and to assign ranks and weights to individual AquaBAMM indicators and measures (Clayton et al. 2006). The workshops were comprised of individuals with expertise in LEBB aquatic and riparian flora, aquatic fauna and/or wetland ecology.

This report describes the findings and recommendations from the expert panel process including any additional information provided by experts subsequent to the expert panel workshops. Terms of reference for the expert panel workshops are provided in Appendix A. Expert panel terms of reference.

The report should be read in conjunction with the results summary report (EHP 2016a).

2 Method

2.1 Study area

The four LEBB study areas cover approximately 562,176km^2 (>30% of Queensland) of arid and semi-arid landscapes in the south–western part of Queensland (**Error! Reference source not found.**). They consist of the p arts of the Lake Eyre Basin (Georgina River, Diamantina River and Cooper Creek catchments) and Bulloo River catchment situated within Queensland. The parts of the catchments extending into other states were excluded because of an inherent lack of data and the amount of time required to source and retrofit existing data.

The Georgina River, Diamantina River, and Cooper Creek catchments form part of the Lake Eyre Basin, the largest endorheic[1] basin in Australia occupying over 1.2 million square kilometres and approximately one-sixth of the continent. The Lake Eyre Basin has some of the most variable and unpredictable flow regimes on earth (Walker et al. 1995; Kingsford 2006) and contains some of the world's last large river systems to remain unregulated and minimally human-impacted (Costello et al. 2004). Pisanu et al. (2015) recently assessed the conservation risk of the wetlands of this region, based on IUCN criteria, and found it to be of Least Concern.

The Bulloo River catchment is located directly to the east of the Lake Eyre Basin. It was included in this project because it made practical sense as it is the only river catchment west of the Queensland Murray–Darling Basin (QMDB) and east of the Cooper Creek catchment. The Cooper Creek and Bulloo, Diamantina and Georgina Rivers are all great Australian icons and amongst the last remaining near-natural desert river systems in the world.

The LEBB incorporates areas from seven IBRA bioregions including the whole of the Channel Country, parts of Mitchell Grass Downs and Desert Uplands, and lesser parts of the Simpson/Strzelecki Dune fields, Mount Isa Inlier, Brigalow Belt South and the Mulga Lands. It is roughly the same size as the Queensland Murray–Darling Basin, though is dryer and contains considerably less surface water.

The climate of the LEBB is highly variable ranging from dry-monsoonal in the north, to arid-temperate in the south. This area is hotter than most other areas of Australia with maximum temperatures in many areas exceeding 45°C and places such as Birdsville having maximum temperatures of over 49°C. Some centres can also experience temperatures below -2°C. Average annual rainfall and evaporation rates are 125mm (range 45 to 760mm) and 3.5m respectively (Australian Bureau of Meteorology 2011).

Much of the LEBB is comprised of parts of Sturts Stony, Strzelecki and Tirari deserts. These deserts are the origin of much of the airborne dust in the Southern Hemisphere. Over the last 60 million years or so, the climate of this basin has changed from wet to arid. All of the rivers in Cooper Creek, Diamantina and Georgina River basins flow towards Lake Eyre which is 15m below sea level. Other significant lakes include Lake Frome, Lake Yamma

[1] Endorheic—a closed drainage basin that retains water and allows no outflow to other external bodies of water, such as rivers or oceans, but converges instead into lakes or swamps (permanent or seasonal) that equilibrate through evaporation.

Yamma and Lake Hart. Major protected areas include Lake Eyre National Park, Strzelecki Regional Reserve, Witjira National Park, Sturt National Park, Diamantina Lakes/Astrebla National Park and Simpson Desert National Park.

The LEBB is sparsely populated with the major urban centres being Quilpie, Thargomindah, Blackall, Barcaldine, Longreach, Windorah, Winton, Birdsville, Boulia and Camooweal. The area contains significant mineral deposits including opals, coal, phosphate, gypsum, uranium, oil and natural gas. In fact, mining and petroleum industries comprise the greatest economic activity in region.

Grazing of native vegetation is the main land-use in the LEBB covering the majority of total land area. The development of the pastoral industry has affected the integrity of LEBB ecosystems, although the harsh and changeable climate has resulted in relatively low stocking rates and lower impacts when compared to other areas such as the Murray–Darling Basin (Ford 1995).

The main threatening processes in the LEBB include total grazing pressure in riparian areas, changes in hydrology, invasion by exotic and translocated native species, and changes to water quality and quantity (Pisanu et al. 2015). Another emerging threat to biodiversity is a reduction in the volume, height and frequency of flood waters due to climate change.

LEBB wetlands and associated riparian vegetation are regarded as critical for the maintenance of local and regional biodiversity because of their role in providing wildlife corridors and habitat. The processes threatening these values should be actively managed to minimise threats and to ensure that wetland ecological systems are maintained or improved. The management of LEBB wetlands is complicated by the fact that the Lake Eyre Basin crosses three states and one territory. The Lake Eyre Basin Intergovernmental Agreement was set up in 2001 to facilitate sustainability and the minimisation of cross-boundary impacts in the Lake Eyre Basin.

The LEBB is unique in Australia's arid zone for its high concentration of vast wetland habitats (Ford 1995) and highly specialised groundwater dependent ecosystems. In fact, the LEBB contains some of the most extensive and variable habitats in Australia ranging from broad open water areas to shrub swamps, tall open grasslands, woodlands, sedgelands and ephemeral forblands (Ford 1995; Jaensch 2009). Extensive flood-dependent swamp networks are also situated on the Georgina, Diamantina and Cooper floodplains. Other significant wetland systems include shallow drainage lines, artesian mound springs, waterholes, overflow swamps and flood-outs.

Food resources in these arid systems are generated from light and terrestrial organic carbon inputs (Long & Humphery 1997). Turbid dryland streams such as the Cooper Creek often feature a highly productive bath-tub ring of algae restricted to the shallow littoral margins which can result in metabolic activity one or two orders of magnitude greater than for temperate flowing streams (Bunn & Davies 1999; Bunn et al. 2003). Beyond the photic zone primary production is not significant (Bunn et al. 2003). These riverine conditions have led to a highly specialised but not very diverse riverine ecology with a low diversity of aquatic invertebrates and similar effects on fish species diversity and abundance (Long & Humphery 1997; Bailey 2001). Combined with the isolation of an essentially closed system such features have resulted in the evolution of genetically distinct lineages of aquatic fauna (e.g. Musyl & Keenan 1992; Hammer et al. 2007).

Particularly distinct to the LEBB are extensive dryland river systems characterised by low gradients throughout their course, internal drainage (rather than flowing to the sea), wide floodplains (up to 80 km wide in the Cooper Creek), extensive anastomosing channels, large transmission losses and extremely high flow variability (Ford 1995; Costelloe et al. 2004).

The Channel Country refers to floodplains in the mid to lower reaches of the three anastomosed[2] river systems along the Cooper Creek, Georgina and Diamantina Rivers. On average, these areas receive less than 250 mm of rainfall per annum (Jaensch 2009), and during dry periods contain permanent and semi-permanent waterholes characterised by low salinity, high turbidity levels and low visual clarity (Ford 1995, Long & Humphery 1997) that provide refugia for a range of species.

Following significant rains in the northern parts of Queensland (i.e. seasonal monsoon/cyclones) the LEBB transforms from an extremely arid environment to one with volumes of water, bursting into life with grasses, wildflowers, fish, birds and many other forms of life. Massive water flows down the large watercourses create a vast natural flood irrigation system that drives ecosystem processes (and pastoral productivity) and a spectacular 'boom' in biological production (Jaensch 2009). Vast swamp and channel networks appear throughout the floodplains providing temporary habitat for wetland fauna. In the lower reaches of the river systems, prolonged overbank flow allows the transfer of energy between the channel and floodplain zone causing the lateral migration of organisms (Sheldon et al. 2003; Leigh et al. 2010). In fact, many flora and fauna have been shown to be uniquely adapted to the irregular rainfall and flooding events experienced by the LEBB. The boom/bust cycle of the

[2] Anastomosed - networked into irregularly branching and reconnecting veins or fused together in a vein-like network.

region is also central in maintaining ecological connectivity between wetland habitats across timeframes of tens to hundreds of years.

Parts of the LEBB are also known to contain habitat for rare and threatened plant and animal species, or species of conservation concern, such as migratory bird species listed under international conventions. For example, the intermittently flooded shallow swamps and lake systems throughout the region provide a rich habitat for waterbirds including migratory shorebirds. The waterbirds arrive and typically breed in less than a year before bust (drought) conditions return (Jaensch 2009). Hence, the wetlands of the LEBB appear to provide the engine-room of recruitment events for entire populations of highly mobile species (Jaensch 2009). Migrant bird species, such as sharp-tailed sandpiper, use drying wetlands during northward migration to Asian breeding grounds (Barter & Harris 2002, NLWRA 2002).

Spectacular concentrations of waterbirds occur in terminal lakes once the floodplains have dried out. Over 80 species having been recorded in the Channel Country floodplains with surveys documenting huge numbers, e.g. >3 to 4 million individuals during the 2000 and 2001 flood events (Costelloe et al. 2004). Wetlands in the LEBB are recognised nationally and internationally as important for supporting large colonies of breeding waterbirds (White 2001; Costelloe et al. 2004, Jaensch 2009).

Most of the surface water in the LEBB is found in waterholes along the river systems. These areas provide important habitat for fish and turtle species, some of them threatened, and several of which have restricted distributions. For example, some of these species, while widely distributed when the rivers are flowing, are spatially restricted to wetlands that act as refugia during dry times. LEBB waterholes are also known to contain turtle species yet to be fully described.

Twenty nine wetlands within the LEBB are recognised as having national significance due to their biological and conservation value or uniqueness. For example, supplied by floods of the Cooper Creek, Queensland's largest inland ephemeral lake, Lake Yamma Yamma, is a large fresh water body which fills to capacity about once every 25 to 30 years supporting internationally recognised populations of plumed whistling-ducks, sharp-tailed sandpipers, and Australian pelicans. Other ecologically and geologically significant wetlands include Lake Buchanan and Lake Galilee.

A distinct hydrological component of the LEBB is the deep artesian groundwater system which operates almost entirely independent of shallower surface water alluvial aquifers (Armstrong 1990). In fact, water emanating from artesian groundwater in the LEBB has resulted in numerous spring wetlands which provide specialised habitats of high intrinsic conservation value (Fensham & Fairfax 2003; Fensham et al. 2007). For example, LEBB springs have been recoded as providing habitat for at least seven endemic snails from one genus, a number of undescribed ostracods, amphipods and other invertebrates (Ponder 1986), and a number of endemic flora species (Fensham et al. 2007). Furthermore, some fish species in the LEBB are totally restricted to mound spring habitats critical for their survival. For example, the Edgbaston Springs within the Springsure Supergroup contain two and possibly three endemic species of fish including the endangered redfin blue eye *Scaturiginichthys vermeilipinnis* which occurs in only several small springs. The cracking clay soils and surrounding grasslands also support a high diversity of large elapid snakes, several endemic reptile species, and very high densities of a number of grassland birds, small distinctive marsupials and reptiles.

2.2 Panel composition

The expert panel was comprised of the persons listed in Table 1. It included individuals with expertise in the local aquatic dependent flora and fauna, and non-riverine and riverine wetland ecology including fish, macro invertebrates, water quality, hydrology, geomorphology and vegetation. Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

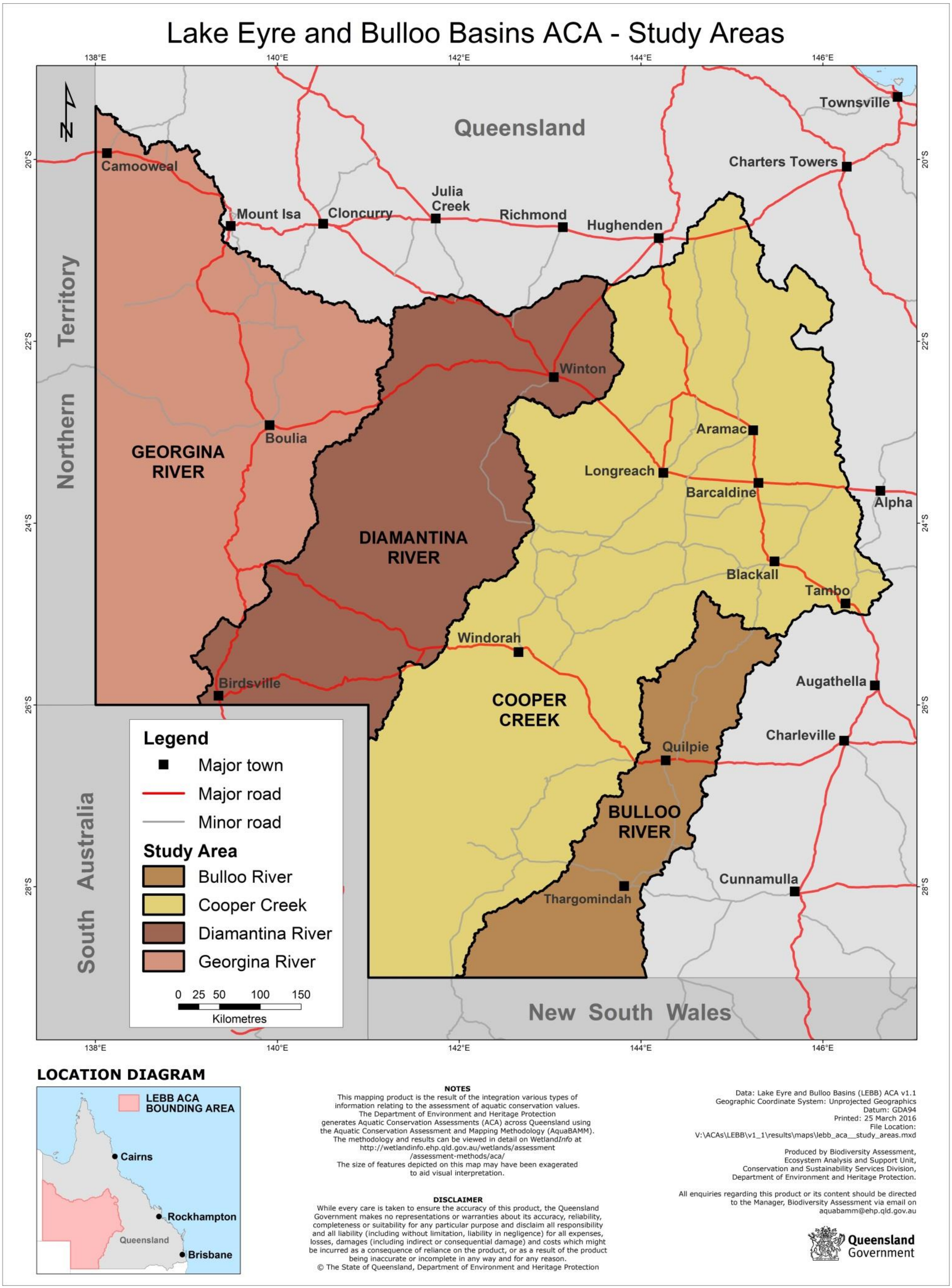


Figure 1. Study areas of the Lake Eyre and Bulloo Basins Aquatic Conservation Assessment project

Table 1. Composition and details of the LEBB ACAs expert panels

Name	Position / Organisation	Expertise
Aquatic Fauna Panel Members		
Dr David McFarland	DERM, Brisbane	Birds, ecology
Dr Stephen 'Harry' Balcombe	Griffith University	Fish
Dr James Fawcett	DERM, Brisbane	Fish, molluscs, genetics
Dr Adam Kerezsy	Griffith University	Fish
Julian Reid	ANU, Canberra	Waterbirds, ecology
Roger Jaensch	Wetlands International	Waterbirds and wetland ecology
Maree Rich	DERM, Longreach	Fauna
Dr Michael Tyler	Adelaide University	Frogs
Peter Long	DEEDI, Rockhampton	Fish
Dr Winston Ponder	Australian Museum, Sydney	Invertebrates
Dr Geoff Lundie-Jenkins	DERM, Toowoomba	Fauna
Charles Ellway	DERM, Toowoomba	Fish
Dr Peter Unmack	Consultant	Fish
Aquatic Flora Panel Members		
Jenny Silcock	University of Queensland and Qld Herbarium	Aquatic flora, springs
Maree Rich	DERM, Longreach	Botany
Bruce Wilson	DERM, Herbarium	Botany
Chris Pennay	DERM, Herbarium	Botany
Ronald Booth	DERM, Herbarium	Botany
Wetland Ecology Panel Members		
Anna Habeck	PhD student, wetland geomorphology	Geomorphology
Dr Rod Fensham	University of Queensland, Brisbane	Botany, springs ecology
Prof Gerald Nanson	University of Wollongong, NSW	Geomorphology
Dr Jerry Maroulis	University of Southern Queensland	Geomorphology
Bernie Cockayne	DERM, Rockhampton	Aquatic ecology
Bruce Wilson	DERM, Herbarium	Wetland ecology and botany
Dr Jon Marshall	DERM, Brisbane	Aquatic ecology, fish
Peter Negus	DERM, Brisbane	Water quality
Dr Ryan Woods	DERM, Brisbane	Fish
Vanessa Bailey	DERM, Longreach	Fish, wetland ecology

Name	Position / Organisation	Expertise
Cathy Mylrea	South West NRM Regional Body	Ecology

Shane Chemello, Wes Davidson, Clare Davies, Jason De Chastel, Geoff Lundie-Jenkins and Steven Howell provided technical support for the workshops. The aquatic flora panel was facilitated by Shane Chemello and the aquatic fauna and ecology panels were facilitated by Darren Fielder.

2.3 Workshop format

Three expert panel workshops were in held in Brisbane including a flora panel (3 November, 2010), a fauna panel (4 November to 5 November, 2010) and an ecology panel (8 December, 2010).The workshops used an interactive approach and ArcGIS Desktop software to display point records of species and their spatial distributions. Where necessary, a background of topographic maps, roads, rivers and other relevant datasets were used to help identify areas of interest. Additional supporting information on flora, fauna and ecology in the LEBB were also sourced from various technical reports. An overview of recommendations from the expert panel and the corresponding actions taken are provided in Appendix B. Overview of recommendations from the expert panel workshops and corresponding actions taken.

3 Flora

3.1 Near threatened and threatened flora

The panel identified 19 rare or threatened flora taxa relevant to the riverine and non-riverine wetlands of the LEBB (Table 2). Only species judged to be aquatic, semi-aquatic or riparian dependent and scheduled as near threatened, vulnerable, endangered, or critically endangered under the Queensland *Nature Conservation Act 1992* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* were considered.

Table 2 was updated to reflect status changes between when the expert panel workshop was convened in 2010 and preparation of this report in March 2016.

Point records for the listed species were used to pinpoint spatial units containing priority flora taxa to calculate scores for the AquaBAMM measure 4.1.2 (Presence of near threatened or threatened aquatic ecosystem dependent flora species).

Table 2. Aquatic dependent near threatened and threatened flora taxa in the LEBB study areas

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	NCA[2]	EPBC[3]	Panel Comments
Atriplex morrisii	saltbush		Y		V		Found in small depressions (like gilgai wetlands).
Chloris sp. (Edgbaston R.J.Fensham 5694)				Y	E		
Eragrostis fenshamii				Y	E		
Eriocaulon aloefolium				Y	E		
Eriocaulon carsonii	salt pipewort			Y	E	E	
Eriocaulon carsonii subsp. *carsonii*				Y	E	E	
Eriocaulon carsonii subsp. *orientale*				Y	E	E	
Eriocaulon giganticum				Y	E		
Eryngium fontanum			Y		E	E	
Fimbristylis sp. (Elizabeth Springs R.J.Fensham 3743)				Y	V		
Fimbristylis vagans	wandering fringe-rush	Y	Y		E		
Gunniopsis sp. (Edgbaston R.J.Fensham 5094)				Y	E		
Hydrocotyle dipleura				Y	V		Very restricted distribution.
Isotoma sp. (Elizabeth Springs R.J.Fensham 3676)				Y	E		
Isotoma sp. (Myross R.J.Fensham 3883)				Y	V		
Lawrencia buchananensis	blue bush		Y		V	V	Found at Lake Buchanan.
Myriophyllum artesium	spring milfoil			Y	E		
Sclerolaena walkeri			Y		LC	V	*Scleroleana walkeri* is known from floodplains, blue bush

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	NCA[2]	EPBC[3]	Panel Comments
							swamps and dry lake beds.
Sporobolus pamelae	spring grass			Y	E		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

[2] NCA—*Queensland Nature Conservation Act 1992*: E = endangered, V = vulnerable, NT = near threatened, LC = least concern.

[3] EPBC—Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: Ex = extinct, CE = critically endangered, E = endangered, V = vulnerable.

3.2 Priority flora

Priority taxa are defined as those not listed as critically endangered, endangered, vulnerable or near threatened in Queensland or Commonwealth legislation but are considered important by the expert panel for the integrity of local aquatic ecosystems as they exhibit one or more of the following priority attributes:

1. It forms significant macrophyte beds (in shallow or deep water).
2. It is an important/critical food source.
3. It is important/critical habitat.
4. It is implicated in spawning or reproduction for other fauna and/or flora species.
5. It is at its distributional limit or is a disjunct population.
6. It provides stream bank or bed stabilisation or has soil-binding properties.
7. It is a small population and subject to threatening processes.

The panel identified 35 priority flora taxa relevant to the riverine and non-riverine wetlands of the LEBB (Table 3). Only species judged to be aquatic, semi-aquatic or riparian dependent were considered.

Point records for the listed species were used to pinpoint spatial units containing priority flora taxa to calculate scores for the AquaBAMM measure 5.1.2 (Presence of aquatic ecosystem dependent 'priority' flora species).

Table 3. Aquatic dependent priority flora taxa in the LEBB study areas

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Priority Number[2]	Panel Comments
Cenchrus purpurascens	swamp foxtail grass			Y	5, 7	Only springs in study area. Discharge (GAB).
Chenopodium auricomum	Queensland bluebush		Y		3	
Cyclosorus interruptus				Y	5, 7	Newhaven Spring, south of Yaraka (only population in Lake Eyre Basin). Outcrop (Tertiary).
Duma florulenta	lignum	Y	Y		1, 2, 3, 4	Lignum usually forms significant stands where it occurs. It provides multiple benefits for fauna during dry periods as well as during inundation providing waterbird habitat.
Eleocharis pallens	pale spikerush	Y	Y		1, 3	*E. pallens* is known to form significant macrophyte beds providing habitat for numerous bird species (primarily for nesting). There are not large areas of it.
Eragrostis australasica	canegrass		Y		3	*E. australasica* (swamp cane grass) grows quite tall and is important for many faunal species including macroinvertebrates (e.g. shield shrimps), hopping mice and Forrest mouse during the dry. It could be considered as an important RE.
Eucalyptus camaldulensis	river red gum	Y	Y		2, 3, 6	*E. camaldulensis* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus camaldulensis subsp*. acuta*	river red gum	Y	Y		2, 3, 6	*E. camaldulensis* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus camaldulensis subsp*. arida*	river red gum	Y	Y		2, 3, 6	*E. camaldulensis* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus camaldulensis	river red gum	Y	Y		2, 3, 6	*E. camaldulensis* provides multiple fauna values including habitat, food

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Priority Number[2]	Panel Comments
subsp. *obtusa*						resources and stream bank stabilisation.
Eucalyptus coolabah	coolabah	Y	Y		2, 3, 6	*E. coolabah* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus largiflorens	black box	Y	Y		2, 3, 6	*E. largiflorens* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus ochrophloia	yapunyah		Y		2, 3, 6	*E. ochrophloia* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Fimbristylis ferruginea	West Indian fimbry			Y	5, 7	Restricted to GAB springs in Lake Eyre Basin/arid zone. Discharge (GAB).
Fimbristylis rara				Y	5, 7	Springvale super-group (including extinct springs) + Edgbaston Spring. Discharge (GAB).
Lemna trisulca	ivy leaf duckweed			Y	5, 7	Only at Myross in LEBB. Discharge (GAB).
Ludwigia peploides	water primrose	Y	Y			Common along most waterholes.
Melaleuca argentea	silver tea-tree	Y			2, 3, 6	
Melaleuca fluviatilis	silver-crowned paperbark	Y			2, 3, 6	
Melaleuca leucadendra	broad-leaved tea-tree	Y			2, 3, 6	
Melaleuca trichostachya	river paperbark	Y			2, 3, 6	
Melaleuca viminalis	red bottlebrush, Boulia callistemon, Boulia bottlebrush	Y	Y		5	A disjunct population is known from the Georgina River catchment.
Nymphaea georginae	Georgina waterlily	Y			7, 8	This species is likely under-collected in the LEBB. Endemic to the LEBB. Also occurs in the Thomson. Record available from Australian Virtual Herbarium.
Peplidium sp. (Edgbaston R.J. Fensham 3341)				Y	7, 8	Only recorded from Edgbaston, from a handful of springs. Very restricted.
Persicaria attenuata	hairy knotweed	Y	Y		1, 3, 6	Common along most waterholes.
Persicaria decipiens	slender knotweed	Y	Y		1, 3, 6	Common along most waterholes.
Persicaria lapathifolia	pale knotweed	Y	Y		1, 3, 6	Common along most waterholes.
Persicaria orientalis	princes feathers	Y	Y		1, 3, 6	Common along most waterholes.
Phragmites australis	common reed		Y	Y	3, 5, 7	Only GAB springs in study area. Discharge (GAB). *P. australis* provides important habitat for warblers, chats and insectivorous birds.

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Priority Number[2]	Panel Comments
Plantago gaudichaudii	narrow plantain			Y	5, 7	Elizabeth Springs LEBB. Discharge (GAB).
Schoenus falcatus				Y	5, 7	Only springs in study area. Discharge (GAB).
Spirodela punctata	spirodela duckweed			Y	5, 7	Only springs in study area. Discharge (GAB).
Stylidium velleioides	Mount Garnet stylidium			Y	5, 7	North Delta, north of Barcaldine. Outcrop (GAB).
Utricularia caerulea	blue bladderwort			Y	5, 7	Only springs in study area. Discharge (GAB).
Utricularia dichotoma	fairy aprons			Y	5, 7	Only springs in study area. Discharge (GAB).

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

[2] The priority number is the priority attribute each species exhibit.

3.3 Flora species richness

Flora species richness (total number of species) was calculated using wetland indicator species. The panel defined a 'wetland indicator species' to mean:

Species that are adapted to and dependent on living in wet conditions for at least part of their life and are found either within or immediately adjoining a riverine, non-riverine or estuarine wetland.

When applied to flora species this definition extends beyond the more traditional definition of submerged and floating aquatic plants as it includes plants inhabiting the littoral zone (water's edge) and plants that usually have 'wet feet' on the toe of the bank. This meaning was chosen because it was considered to best capture the intent of the AquaBAMM measure of species richness (3.1.5). The indicator is a measure of floristic richness of a particular spatial unit's aquatic environment, and hence, a broad definition will better depict the flora richness value at a given location.

The panel identified 206 flora wetland indicator species relevant to the riverine and non-riverine wetlands of the LEBB (Table 4). Taxa were accessed from the DERM corporate databases of WildNet and Herbrecs and from panel member records.

Point records for the listed species were used to a calculate wetland flora indicator species richness scores for the AquaBAMM measure 3.1.5 (Richness of native aquatic plants).

Table 4. Aquatic dependent native flora taxa in the LEBB study areas

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
Acacia stenophylla	belalie	Y	Y		
Aeschynomene indica	budda pea		Y		
Ammannia multiflora	jerry-jerry	Y	Y		
Atriplex lobativalvis			Y		Found in claypans.
Atriplex morrisii			Y		Found in small depressions (like gilgai wetlands).
Bergia ammannioides			Y		
Bergia pedicellaris			Y		
Bergia trimera			Y		
Bolboschoenus caldwellii		Y	Y		
Caldesia oligococca			Y		
Casuarina cunninghamiana	river oak	Y			
Casuarina cunninghamiana subsp. *cunninghamiana*		Y			
Cenchrus purpurascens				Y	
Centrolepis exserta		Y	Y		
Chenopodium auricomum			Y		
Chloris sp. (Edgbaston R.J. Fensham 5694)				Y	Only known from Edgbaston Spring. Very restricted distribution and rare.
Crinum flaccidum	Murray lily		Y		
Cyclosorus interruptus				Y	Newhaven Spring, south of Yaraka (only population in Lake Eyre Basin). Outcrop (Tertiary).
Cycnogeton dubius		Y	Y		

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
Cycnogeton procerus		Y	Y		
Cyperus alterniflorus		Y	Y		
Cyperus aquatilis		Y	Y		
Cyperus betchei		Y	Y		
Cyperus castaneus		Y	Y		
Cyperus concinnus		Y	Y		
Cyperus conicus var. *conicus*		Y	Y		
Cyperus dactylotes	tuber spike-rush	Y			
Cyperus difformis	rice sedge	Y	Y		
Cyperus exaltatus	tall flatsedge	Y	Y		
Cyperus flaccidus		Y	Y		
Cyperus gymnocaulos	spiny flatsedge		Y		
Cyperus haspan subsp. *haspan*		Y	Y		
Cyperus holoschoenus		Y	Y		
Cyperus iria			Y		
Cyperus javanicus		Y	Y		
Cyperus laevigatus		Y	Y		
Cyperus nervulosus		Y	Y		
Cyperus polystachyos var. *polystachyos*		Y	Y		
Cyperus procerus		Y	Y		
Cyperus pygmaeus	dwarf sedge	Y	Y		
Cyperus sanguinolentus		Y	Y		
Cyperus squarrosus	bearded flatsedge	Y	Y		
Cyperus vaginatus		Y	Y		
Cyperus victoriensis		Y	Y		
Dicranopteris linearis var. *linearis*			Y		
Diplachne fusca			Y		
Diplachne fusca var. *fusca*			Y		
Diplachne fusca var. *muelleri*			Y		
Drosera finlaysoniana			Y		

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
Drosera indica			Y		
Drosera peltata	pale sundew		Y		
Drosera spatulata			Y		
Duma florulenta	lignum	Y	Y		Lignum usually forms significant stands where it occurs. It provides multiple benefits for fauna during dry periods as well as providing waterbird habitat during inundation.
Echinochloa turneriana	channel millet		Y		
Eclipta prostrata	white eclipta		Y		
Elacholoma hornii			Y		Grows around the edge of small swamps in the desert. Also grows in small depressions. Only one record — at Wyandra airport (in the QMDB).
Elatine gratioloides	waterwort	Y	Y		
Eleocharis atropurpurea		Y	Y		
Eleocharis brassii		Y	Y		
Eleocharis pallens	wale spikerush	Y	Y		*E. pallens* is known to form significant macrophyte beds providing habitat for numerous bird species (primarily for nesting). There are not large areas of it.
Eleocharis philippinensis		Y	Y		
Eleocharis plana	ribbed spikerush	Y	Y		
Eleocharis pusilla	small spikerush	Y	Y		
Eleocharis spiralis		Y	Y		
Eragrostis australasica	canegrass		Y		*E. australasica* (swamp cane grass) grows quite tall and is important for many faunal species including macroinvertebrates, e.g. shield shrimps, and native rodents, e.g. hopping mice and Forrest mouse during the dry. It could be considered as an important RE.
Eragrostis fenshamii				Y	Known only from Bundoona Springs and Elizabeth Springs. Very restricted but abundant where it occurs; populations secure.
Eremophila bignoniiflora	eurah	Y	Y		
Eriocaulon aloefolium				Y	
Eriocaulon carsonii				Y	
Eriocaulon carsonii subsp. *carsonii*				Y	
Eriocaulon carsonii subsp. orientale				Y	
Eriocaulon cinereum		Y	Y		
Eriocaulon giganticum				Y	
Eriocaulon nanum		Y	Y		

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
Eriocaulon pygmaeum		Y	Y		
Eryngium fontanum			Y		
Eucalyptus camaldulensis	river red gum	Y	Y		
Eucalyptus camaldulensis subsp*. acuta*		Y	Y		
Eucalyptus camaldulensis subsp*. arida*		Y	Y		
Eucalyptus camaldulensis subsp*. obtusa*		Y	Y		
Eucalyptus coolabah	coolabah	Y	Y		*E. coolabah* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus largiflorens	black box	Y	Y		*E. largiflorens* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Eucalyptus microtheca	northern coolabah	Y	Y		
Eucalyptus ochrophloia	yapunyah		Y		*E. ochrophloia* provides multiple fauna values including habitat, food resources and stream bank stabilisation.
Fimbristylis aestivalis		Y			
Fimbristylis ferruginea				Y	Restricted to GAB springs in Lake Eyre Basin/arid zone. Discharge (GAB).
Fimbristylis littoralis		Y	Y		
Fimbristylis microcarya		Y	Y		
Fimbristylis nutans		Y	Y		
Fimbristylis rara				Y	Springvale super-group (including extinct springs) + Edgbaston Spring. Discharge (GAB).
Fimbristylis sp. (Elizabeth Springs R.J. Fensham 3743)				Y	Only recorded from four localities (Elizabeth Springs, Warra Spring, Big Moon Spring, Myross & Sulphur Spring, SA); taxonomy unresolved.
Fimbristylis vagans		Y	Y		
Fuirena ciliaris		Y	Y		
Fuirena incrassata		Y	Y		
Fuirena umbellata		Y	Y		
Glinus lotoides	hairy carpet weed	Y	Y		
Glossostigma cleistanthum			Y		
Glossostigma diandrum			Y		
Glycyrrhiza acanthocarpa	native liquorice		Y		
Gunniopsis sp. (Edgbaston R.J. Fensham 5094)				Y	Only known from two places on Edgbaston Spring — Measuring Spring and Big Spring; sparse in both

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
					places.
Hydrocotyle dipleura				Y	Very restricted distribution.
Isotoma sp. (Elizabeth Springs R.J.Fensham 3676)				Y	Elizabeth Springs. About 50 plants; currently in herbarium as *Isotoma fluviatilis*, but will be described as a new species (smaller in all parts than *I. fluviatilis*).
Isotoma sp. (Myross R.J. Fensham 3883)				Y	Myross / Edgbaston springs complex, <1000 plants in all known populations.
Juncus aridicola	tussock rush		Y		
Juncus continuus			Y		
Juncus polyanthemus			Y		
Juncus subsecundus			Y		
Juncus usitatus	common rush		Y		
Lawrencia buchananensis	blue bush		Y		Found at Lake Buchanan.
Leersia hexandra	swamp rice grass	Y	Y		
Lemna aequinoctialis	common duckweed	Y	Y		
Lemna trisulca				Y	Only at Myross in LEBB. Discharge (GAB).
Lepilaena bilocularis		Y	Y		
Leptochloa digitata	umbrella canegrass	Y	Y		
Limosella australis	mudwort	Y	Y		
Lipocarpha microcephala			Y		
Lomandra longifolia	long-leaf matrush	Y			
Lophostemon grandiflorus		Y			
Lophostemon grandiflorus subsp. riparius		Y			
Lophostemon suaveolens	swamp box		Y		
Ludwigia octovalvis	willow primrose	Y	Y		
Ludwigia peploides	water primrose	Y			Common along most waterholes.
Ludwigia peploides subsp. *montevidensis*		Y	Y		
Marsilea costulifera	narrow-leaved nardoo	Y	Y		
Marsilea drummondii	common nardoo	Y	Y		
Marsilea exarata	sway-back nardoo	Y	Y		
Marsilea hirsuta	hairy nardoo	Y	Y		

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
Marsilea mutica	shiny nardoo	Y	Y		
Melaleuca argentea	silver tea-tree	Y			
Melaleuca bracteata	river teatree	Y			
Melaleuca fluviatilis		Y			
Melaleuca leucadendra	broad-leaved tea-tree	Y			
Melaleuca linariifolia	snow-in summer	Y			
Melaleuca trichostachya		Y			
Melaleuca viminalis	red bottlebrush	Y	Y		A disjunct population is known from the Georgina River catchment.
Melaleuca viridiflora		Y			
Melaleuca viridiflora var. *viridiflora*		Y			
Monochoria cyanea		Y	Y		
Muehlenbeckia rhyticarya		Y	Y		
Murdannia graminea	murdannia	Y	Y		
Myriophyllum artesium				Y	
Myriophyllum gracile var. *lineare*		Y	Y		
Myriophyllum implicatum		Y	Y		
Myriophyllum verrucosum	water milfoil	Y	Y		
Najas tenuifolia	water nymph	Y	Y		
Nymphaea carpentariae		Y			
Nymphaea georginae		Y			This species is likely under-collected in the LEBB. Endemic to the LEBB. Also occurs in the Thomson River.
Nymphaea gigantea	giant waterlily	Y	Y		
Nymphoides aurantiaca		Y	Y		
Nymphoides crenata	wavy marshwort	Y	Y		
Nymphoides exiliflora		Y	Y		
Nymphoides geminata		Y	Y		
Nymphoides indica	water snowflake	Y	Y		
Oryza australiensis		Y	Y		
Panicum larcomianum		Y			
Paspalum distichum	water couch	Y	Y		

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
Peplidium sp. (Edgbaston R.J. Fensham 3341)				Y	Only recorded from Edgbaston, from a handful of springs. Very restricted.
Persicaria attenuata		Y	Y		Common along most waterholes.
Persicaria decipiens	slender knotweed	Y	Y		Common along most waterholes.
Persicaria lapathifolia	pale knotweed	Y	Y		Common along most waterholes.
Persicaria orientalis	princes feathers	Y	Y		Common along most waterholes.
Phragmites australis	common reed		Y	Y	Discharge (GAB). *P. australis* provides important habitat for warblers, chats and insectivorous birds.
Plantago gaudichaudii				Y	Elizabeth Springs LEBB. Discharge (GAB).
Platyzoma microphyllum	braid fern	Y			
Polygonum plebeium	small knotweed	Y	Y		
Potamogeton crispus	curly pondweed	Y	Y		
Potamogeton tricarinatus	floating pondweed	Y	Y		
Pseudoraphis spinescens	spiny mudgrass	Y	Y		
Ranunculus sessiliflorus var. *pilulifer*			Y		
Ranunculus sessiliflorus var. *sessiliflorus*			Y		
Rotala diandra		Y			
Rotala mexicana		Y			
Rotala occultiflora		Y			
Rumex crystallinus	shiny dock	Y			
Ruppia maritima	sea tassel	Y			
Schoenoplectus dissachanthus		Y	Y		
Schoenoplectus laevis		Y	Y		
Schoenoplectus lateriflorus		Y	Y		
Schoenoplectus subulatus		Y	Y		
Schoenoplectus tabernaemontani		Y	Y		
Schoenus falcatus				Y	Only springs in study area. Discharge (GAB).
Scleria rugosa		Y	Y		
Sclerolaena walkeri			Y		*Scleroleana walkeri* is known from floodplains, blue bush swamps and dry lake beds.
Sesbania cannabina			Y		
Sesbania cannabina var.			Y		

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	Panel Comments
cannabina					
Sesuvium portulacastrum	sea purslane		Y		
Sphaeromorphaea australis		Y	Y		
Spirodela punctata	thin duckweed			Y	Only springs in study area. Discharge (GAB).
Sporobolus pamelae				Y	
Sporobolus partimpatens				Y	Found on ground water scalds. Populations around springs.
Sporobolus virginicus	sand couch		Y		
Stylidium velleioides	Mount Garnet stylidium			Y	North Delta, north of Barcaldine. Outcrop (GAB).
Tecticornia indica			Y		
Tecticornia indica subsp. leiostachya			Y		
Tecticornia pergranulata			Y		
Tecticornia pergranulata subsp*. divaricata*			Y		
Tecticornia pergranulata subsp*. pergranulata*			Y		
Triglochin calcitrapum		Y	Y		
Trigonella suavissima			Y		
Typha domingensis	narrowleaf cumbungi		Y		
Utricularia aurea	golden bladderwort		Y		
Utricularia caerulea	blue bladderwort			Y	Only springs in study area. Discharge (GAB).
Utricularia dichotoma	fairy aprons			Y	Only springs in study area. Discharge (GAB).
Utricularia stellaris			Y		
Vallisneria annua			Y		
Xyris complanata	yellow-eye		Y		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

3.4 Exotic flora

The degree of infestation and abundance of an exotic plant at a particular locality was acknowledged by the panel as an important factor in determining the impact of an exotic flora species on LEBB wetland ecosystems. The panel recommended that only exotic plants that cause, or have the potential to cause, significant detrimental impact on natural systems within a riverine or non-riverine landscape be included used for the LEBB ACAs.

Abundance information and mapping of exotic species' extent was used instead of point records, where available, to flag the spatial units with exotic species present. Where only a point record is available for a location, then the record was used to identify the spatial units as having an exotic species present. Hence, an individual point record may or may not correspond to localities of dense weed infestations.

The panel identified 25 exotic flora taxa relevant to the riverine and non-riverine wetlands of the LEBB (Table 5).

Point records for the listed species were used to pinpoint spatial units containing exotic flora species to calculate scores for the AquaBAMM measures 1.1.2 (Presence of exotic aquatic and semi-aquatic plants within the wetland) and 2.1.1 (Presence of exotic terrestrial plants in the assessment unit).

Table 5. Exotic flora taxa impacting wetland values in the LEBB study areas

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	M 1.1.2	M 2.1.1	Panel Comments
Achyranthes aspera	chaff flower	Y	Y			Y	
Arundo donax	giant reed	Y	Y		Y		
Cenchrus ciliaris	buffel grass	Y	Y			Y	Serious threat to riverine areas.
Cryptostegia grandiflora	rubber vine	Y	Y			Y	Rubber vine is a weed of national significance and can be a serious issue for some areas of the LEBB.
Cynodon dactylon	couch	Y	Y		Y		
Cyperus aggregatus	inflatedscale flatsedge	Y	Y		Y		
Cyperus brevifolius	Mullumbimby couch	Y	Y		Y		
Cyperus compressus	poorland flatsedge	Y	Y		Y		
Cyperus involucratus	umbrella sedge	Y	Y		Y		
Cyperus rotundus	nutgrass	Y	Y		Y		
Cyperus tuberosus	nutgrass	Y	Y		Y		
Echinochloa colona	awnless barnyard grass	Y	Y		Y		
Echinochloa crus-galli	barnyard grass	Y	Y		Y		
Leucaena leucocephala subsp. *glabrata*	leucaena	Y	Y			Y	Leucaena was identified by the panel as a potentially significant weed. It is not established in the Lake Eyre Basin but should be watched as it has the potential to expand. Monitoring of the spread of this weed is required.
Leucaena leucocephala subsp. *leucocephala*	leucaena	Y	Y			Y	Leucaena was identified by the panel as a potentially significant weed. It is not established in the Lake Eyre Basin but should be watched as it has the potential to expand. Monitoring of the spread of this weed is required.
Parkinsonia aculeata	Jerusalem thorn	Y	Y			Y	Serious issue in LEBB.

Scientific Name	Common Name	R[1]	NR[1]	Sp[1]	M 1.1.2	M 2.1.1	Panel Comments
Persicaria glabra	denseflower knotweed	Y	Y			Y	
Polygonum aviculare	wireweed	Y	Y		Y		
Polypogon monspeliensis	annual beardgrass	Y	Y		Y		
Prosopis glandulosa var. *glandulosa*	honey mesquite	Y	Y			Y	
Prosopis pallida	algraoba	Y	Y			Y	
Prosopis velutina		Y	Y			Y	
Urochloa mutica	para grass	Y	Y		Y		
Vachellia nilotica	prickly acacia	Y	Y			Y	Prickly acacia is a serious issue for watercourses and non-riverine wetlands in the LEBB.
Xanthium occidentale	noogoora burr	Y	Y			Y	

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

3.5 Flora special features

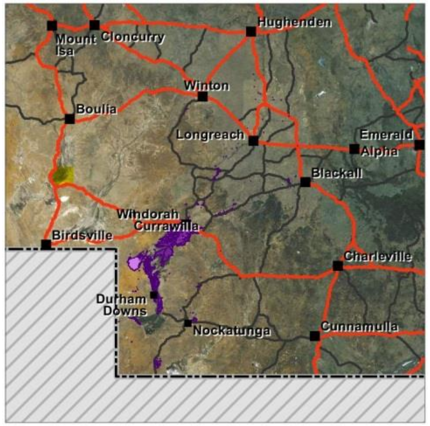
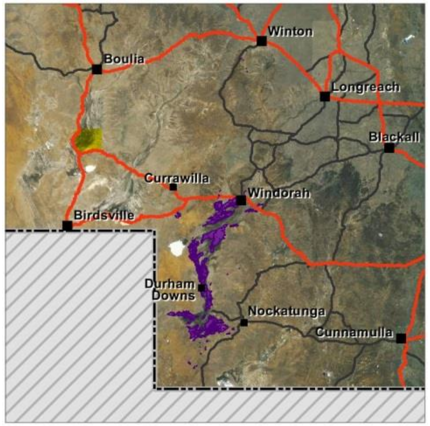
The panel identified 13 flora special features relevant to the riverine and non-riverine wetlands of the LEBB. Where a single special feature decision crossed a number of study areas, the decision has been duplicated for each study area. Each special feature was assigned a conservation rating between 1 (Low) and 4 (Very high). Areas having additional values, e.g. fauna or ecology, were consolidated and implemented as wetland ecology special features. Special feature decisions that were not able to be implemented due to a lack of readily available data or unconfirmed values are indicated with '_not_implemented' in the decision number column. No special features relating to springs were discussed.

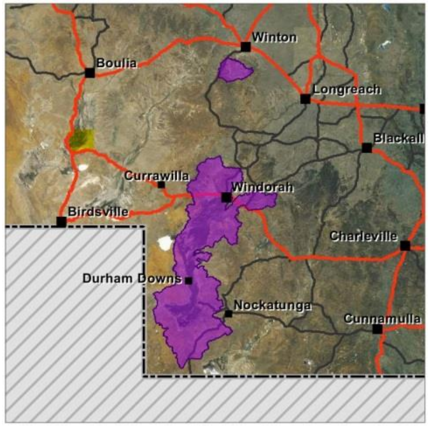
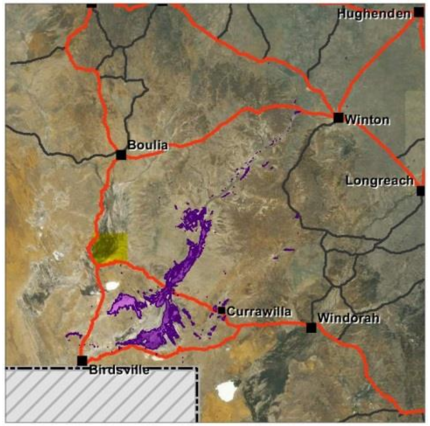
The riverine and non-riverine spatial units intersecting flora special features are listed alphabetically in Table 6.

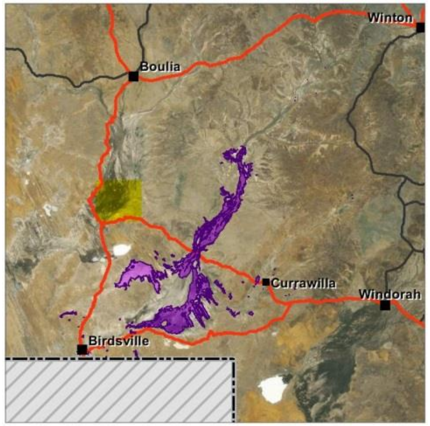
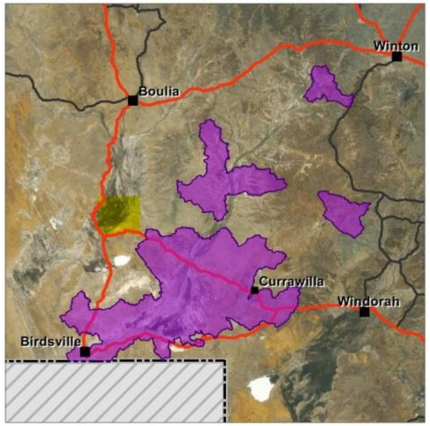
Flora special features were used to calculate scores for the AquaBAMM measure 5.2.1 (Presence of 'priority' aquatic ecosystem). This measure was used as the features selected were significant ecosystems with universal values that occur across several study areas rather than specific localities for which criterion 6 (Special features) measures might be more applicable.

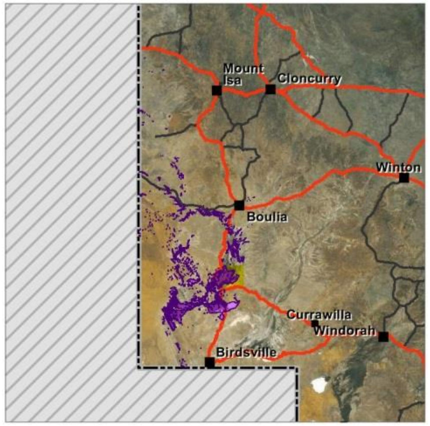
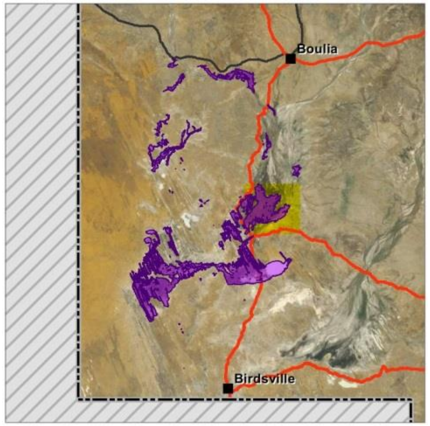
Table 6. Flora special features in the LEBB study areas

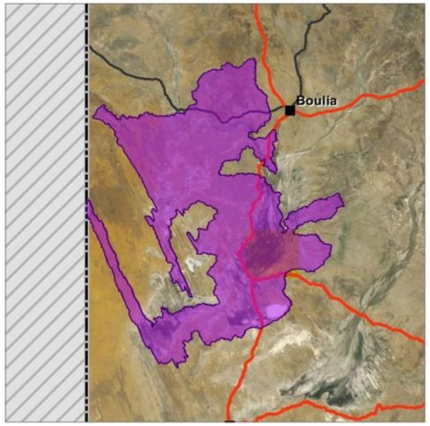
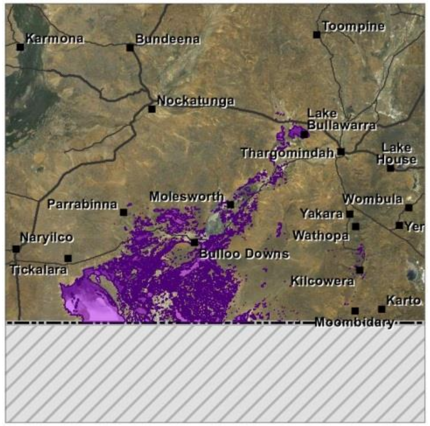
Table sorted by decision number which equates to alphabetically by study area code then riverine/non-riverine.

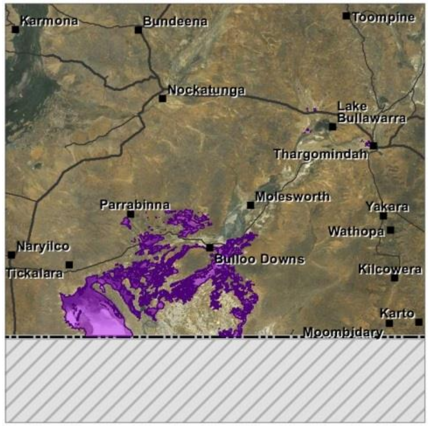
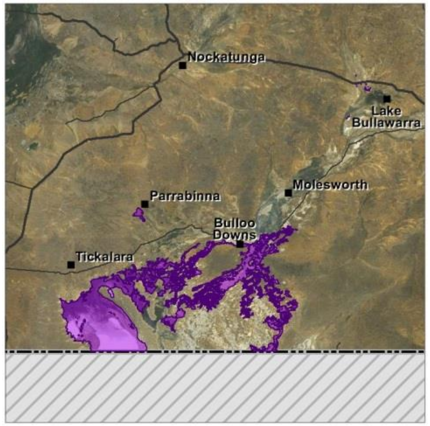
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_fl_01	Bluebush with or without lignum swamps		Cooper		Y	Bluebush with or without lignum swamps were identified as having significant flora and fauna values (though lesser value than wetlands of 5.3.13a\b and 5.3.16b). 5.3.12a/b: Palustrine wetland of *Chenopodium auricomum* open-shrubland sometimes with scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs. Occurs in swampy depressions on alluvial plains and on frequently flooded inter-dune flats and clay pans. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand. RE 4.3.24: *Chenopodium auricomum* +\- *Muehlenbeckia florulenta* open shrubland in swampy depressions within floodplains with braided channels.	5.2.1	2
cp_nr_fl_02	Lignum swamps		Cooper		Y	Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species (e.g. egrets, herons, ibis), and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a/b: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels or in depressions, lakes or larger claypans in dune systems.	5.2.1	3

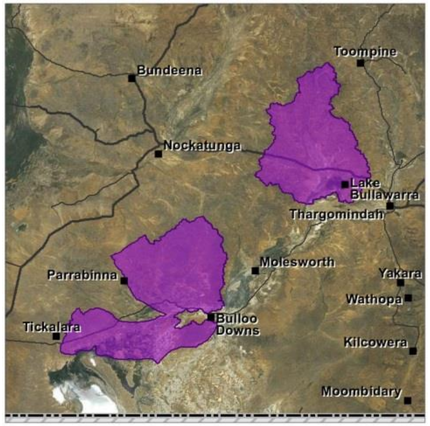
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_fl_01	Lignum swamps along channels		Cooper	Y		Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species, e.g. egrets, herons, ibis, and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels.	5.2.1	3
di_nr_fl_01	Bluebush with or without lignum swamps		Diamantina		Y	Bluebush with or without lignum swamps were identified as having significant flora and fauna values (though lesser value than wetlands of 5.3.13a\b and 5.3.16b). 5.3.12a/b: Palustrine wetland of *Chenopodium auricomum* open-shrubland sometimes with scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs. Occurs in swampy depressions on alluvial plains and on frequently flooded inter-dune flats and clay pans. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand. RE 4.3.24: *Chenopodium auricomum* +\- *Muehlenbeckia florulenta* open shrubland in swampy depressions within floodplains with braided channels.	5.2.1	2

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_nr_fl_02	Lignum swamps		Diamantina		Y	Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species (e.g. egrets, herons, ibis), and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a/b: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels or in depressions, lakes or larger claypans in dune systems.	5.2.1	3
di_r_fl_01	Lignum swamps along channels		Diamantina	Y		Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species, e.g. egrets, herons, ibis, and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels.	5.2.1	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_fl_01	Bluebush with or without lignum swamps		Georgina		Y	Bluebush with or without lignum swamps were identified as having significant flora and fauna values (though lesser value than wetlands of 5.3.13a\b and 5.3.16b). 5.3.12a/b: Palustrine wetland of *Chenopodium auricomum* open-shrubland sometimes with scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs. Occurs in swampy depressions on alluvial plains and on frequently flooded inter-dune flats and clay pans. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand. RE 4.3.24: *Chenopodium auricomum* +\- *Muehlenbeckia florulenta* open shrubland in swampy depressions within floodplains with braided channels.	5.2.1	2
ge_nr_fl_02	Lignum swamps		Georgina		Y	Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species, e.g. egrets, herons, ibis, and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a/b: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels or in depressions, lakes or larger claypans in dune systems.	5.2.1	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_r_fl_01	Lignum swamps along channels		Georgina	Y		Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species, e.g. egrets, herons, ibis, and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels.	5.2.1	3
ul_nr_fl_01	Bluebush with or without lignum swamps		Bulloo		Y	Bluebush with or without lignum swamps were identified as having significant flora and fauna values (though lesser value than wetlands of 5.3.13a\b and 5.3.16b). 5.3.12a/b: Palustrine wetland of *Chenopodium auricomum* open-shrubland sometimes with scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs. Occurs in swampy depressions on alluvial plains and on frequently flooded inter-dune flats and clay pans. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand. RE 4.3.24: *Chenopodium auricomum* +\- *Muehlenbeckia florulenta* open shrubland in swampy depressions within floodplains with braided channels.	5.2.1	2

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ul_nr_fl_02	Lignum swamps		Bulloo		Y	Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species, e.g. egrets, herons, ibis, and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a/b: Palustrine of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels or in depressions, lakes or larger claypans in dune systems.	5.2.1	3
ul_nr_fl_03	Cane grass swamps (Bulloo Lake)		Bulloo		Y	The Bulloo Lakes cane grass swamps area is bigger and more extensive area than anywhere else. It provides important habitat for waterbirds and grey grasswren (Bulloo subspecies). Part of recognised Bulloo Floodplain IBA (Dutson et al. 2009). A significant proportion extends into northern NSW. 5.3.16b — palustrine wetland of *Eragrostis australasica* open-grassland. Occurs on floodplains and floodplain lakes.	5.2.1	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ul_r_fl_01	Lignum swamps along channels		Bulloo	Y		Large lignum swamps provide important habitat for waterbirds, including breeding and feeding habitat especially for colonial waterbird species, e.g. egrets, herons, ibis, and for other fauna. These swamps are associated with river channels lined with river coolabahs. etc. 5.3.13a: Palustrine wetland of *Muehlenbeckia florulenta* open-shrubland sometimes with scattered low trees such as *Acacia stenophylla, A. victoriae, Eremophila bignoniiflora, Eucalyptus coolabah*. Occurs on floodplains in depressions or fringing channels.	5.2.1	3

[1] R — Riverine, NR — Non-riverine.

[2] Criteria, indicators and measures (used in AquaBAMM).

[3] Conservation rating between 1 (Low) and 4 (Very high).

4 Fauna

4.1 Near threatened and threatened fauna

The panel identified 11 near threatened or threatened fauna taxa relevant to the riverine and non-riverine wetlands of the LEBB (Table 7). Only species judged to be aquatic, semi-aquatic or riparian dependent and scheduled as near threatened, vulnerable, endangered, or critically endangered under the Queensland *Nature Conservation Act 1992* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* were considered.

Table 7 was updated to reflect status changes between when the expert panel workshop was convened in 2010 and preparation of this report in March 2016. Of the five taxa no longer listed as near threatened or threatened, only the freckled duck *Stictonetta naevosa* was added as a Priority taxon for listing in Table 8.

Point records for the listed species were used to pinpoint spatial units containing rare or threatened fauna taxa to calculate scores for the AquaBAMM measure 4.1.1 (Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act).

Table 7. Aquatic dependent near threatened and threatened fauna taxa in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	NCA[2]	EPBC[3]	Panel comments
Fish							
Chlamydogobius micropterus	Elizabeth Springs goby			Y	E	E	Highly restricted.
Chlamydogobius squamigenus	Edgbaston goby			Y	E	V	Highly restricted.
Scaturiginichthys vermeilipinnis	redfin blue eye			Y	E	E	Highly restricted.
Mogurnda sp. cf. *clivicola*	Flinders Ranges [Lake Eyre Basin] mogurnda	Y	Y		V	V	
Birds							
Amytornis barbatus barbatus	grey grasswren (Bulloo subsp.)	Y	Y		E	E	
Amytornis barbatus diamantina	grey grasswren (Diamantina subsp.)	Y	Y		NT	NT	
Botaurus poiciloptilus	Australasian bittern	Y	Y		E	E	
Calidris ferruginea	curlew sandpiper	Y	Y		E	CE	
Epthianura crocea	yellow chat	Y	Y		NT	NT	
Numenius madagascariensis	eastern curlew	Y	Y		E	CE	
Rostratula australis	Australian painted snipe	Y	Y		V	E	At least two known breeding sites in the Diamantina floodplain (Jaensch 2003, 2009b). Latter may have been a breeding site more than 50 years ago (Duncan-Kemp 1933). Suitable habitat is vast in these basins after floods.

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

[2] NCA—Queensland Nature Conservation Act *1992*: E = endangered, V = vulnerable, NT = near threatened, LC = least concern.

[3] EPBC—Commonwealth Environment Protection and Biodiversity Conservation Act *1999*: Ex= extinct, CE = critically endangered, E = endangered, V = vulnerable.

4.2 Priority fauna

The panel deliberated on all aquatic-dependent fauna species within the LEBB to identify priority fauna. Priority taxa are defined as those not listed as critically endangered, endangered, vulnerable or near threatened under Queensland or Commonwealth legislation but are considered important for the integrity of local aquatic ecosystems as they exhibit one or more of the following priority attributes:

1. It is endemic to the study area (>75% of its distribution is in the study area/catchment).
2. It has experienced, or is suspected of experiencing, a serious population decline.
3. It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
4. It is currently a small population and threatened by loss of habitat.
5. It is a significant disjunct population.
6. It is a migratory species (other than birds).
7. It is an iconic boom and bust species in an arid and semi-arid landscape.

4.2.1 Priority species

The panel identified 38 priority fauna taxa relevant to the riverine and non-riverine wetlands of the LEBB (Table 8). Of these, 23 were invertebrates (worm, molluscs, crustaceans and insects) and 15 were vertebrates (fish, amphibians, reptiles, birds and mammals).

Point records for the listed species were used to pinpoint spatial units containing priority fauna taxa to calculate scores for the AquaBAMM measure 5.1.1 (Presence of aquatic ecosystem dependent 'priority' fauna species).

Table 8. Aquatic dependent priority fauna taxa in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Priority number[2]	Panel comments
Invertebrates						
Velesunio spp.		Y	Y		1	Endemic to Cooper Creek as sp. B and sp. D (Baker et al. 2004).
Gabbia davisi			Y	Y	1, 4	
Gabbia fontana			Y	Y	1, 4	
Gabbia pallidula			Y	Y	1, 4	
Edgbastonia alanwillsi			Y	Y	1, 4	
Jardinella acuminata			Y	Y	1, 4	
Jardinella colmani			Y	Y	1, 4	
Jardinella coreena			Y	Y	1, 4	
Jardinella corrugata			Y	Y	1, 4	
Jardinella edgbastonensis			Y	Y	1, 4	
Jardinella eulo			Y	Y	1, 4	Border Paroo and Bulloo catchments.
Jardinella isolata			Y	Y	1, 4	
Jardinella jesswiseae			Y	Y	1, 4	
Jardinella pallida			Y	Y	1, 4	
Jardinella sp. 'Bundoona'			Y	Y	1, 4	Includes Australian Museum specimens AMS C.400130-33, AMS C.410721.

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Priority number[2]	Panel comments
Jardinella sp. AMS C.415845 (Myross)			Y	Y	1, 4	
Jardinella sp. AMS C.447677 (Warra)			Y	Y	1, 4	
Jardinella zeidlerorum			Y	Y	1, 4	Wilson Ponder to send through list to identify J. species details. Likely to be listed as endangered.
Glyptophysa sp. AMS C.381628			Y	Y	1, 4	
Gyraulus edgbastonensis			Y	Y	1, 4	Edgbaston endemic.
Larina lirata		Y			1	Susceptible to modification (hydrological).
Dugesia artesiana			Y	Y	1	
Branchinella buchananensis	Buchanan's fairy shrimp		Y		4, 5	Very restricted distribution, known only from one arid and semi-arid lake in Queensland and two lakes in north–west New South Wales, none of which are under protected land management. Threats to its survival in NSW include the gypsum extraction or other mining, which could disturb lake hydrology. Lake Buchanan may become a significant refuge for this species in the future (Gardiner 2010).
Fish						
Craterocephalus eyresii	desert hardyhead	Y	Y		1	
Craterocephalus stercusmuscarum	Edgbaston / Myross springs rainbowfish		Y	Y	1, 4	Undescribed taxon.
Macquaria ambigua	yellowbelly [including Lake Eyre yellowbelly, M. sp. B, Bulloo River yellowbelly]	Y	Y		1	
Neosiluroides cooperensis	Cooper Creek catfish	Y	Y		1	
Retropinna semoni	Australian smelt	Y	Y		1	This is recognised as an undescribed form of *Retropinna* that is endemic to the Cooper Creek system (Hammer et al. 2007).
Birds						
Anseranas semipalmata	magpie goose	Y	Y		2	Major decline in southern part of former range.
Biziura lobata	musk duck	Y	Y		2	There has been a population decline throughout the Murray–Darling Basin and the LEBB. Loss of breeding habitat is a concern as it requires good quality lignum habitat. Needs deep open water.
Chlidonias hybrida	whiskered tern	Y	Y		7	Iconic boom/bust species for semi-arid

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Priority number[2]	Panel comments
						environments. Breeding habitat is channel country rivers.
Erythrogonys cinctus	red-kneed dotterel	Y	Y		7	Iconic boom/bust species for semi-arid environments. Breeding habitat is channel country rivers.
Ninox connivens	barking owl	Y	Y		2	It is usually associated with riparian zones for inland catchments and is suspected to be in decline from a loss of habitat. From the Brigalow Belt South BPA (EPA 2008): Riparian areas in the Brigalow Belt are the stronghold of *N. connivens*. The species is declining westward from the coast and appears to be gone from the SEQ bioregion. Nesting is in large hollows in live eucalypts, such as river red gums. Threats include loss and fragmentation of habitat, particularly old growth eucalypts with suitable nesting and roosting hollows.
Oxyura australis	blue-billed duck	Y	Y			At the edge of its range.
Porzana fluminea	Australian spotted crake	Y	Y		7	Iconic boom/bust species for semi-arid environments. Breeding habitat is channel country rivers.
Stictonetta naevosa[3]	freckled duck	Y	Y		7	Iconic boom/bust species for semi-arid environments. Breeding habitat is channel country rivers.
Tribonyx ventralis	black-tailed native-hen	Y	Y		7	Iconic boom/bust species for semi-arid environments. Breeding habitat is channel country rivers.
Reptiles						
Emydura macquarii emmotti	Emmott's short-necked turtle	Y	Y		1	Endemic to the Cooper Creek and Bulloo River catchments. Abundant throughout, however, there are localised impacts from illegal drum net fishing which has affected various size classes in certain populations.

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

[2] The priority number is the priority attributes exhibited by each species.

[3] Previously listed as EVNT. Considered priority by Darren Fielder and David McFarland as part of 2016 revision.

4.2.2 Migratory species

In addition to the priority species identified above, the panel nominated migratory species for inclusion in measure 5.1.3. Only species listed under the Convention on Migratory Species (Bonn), Japan Australia Migratory Bird Agreement (JAMBA), the China Australia Migratory Bird Agreement (CAMBA), or Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) as significant fauna taxa were considered.

The definition for a migratory species adopted by the expert panel is:

Bird species that are dependent on wetland environments whose entire population or any geographically separate part of the population cyclically and predictably cross one or more national jurisdictional boundaries. This definition excludes those species listed as “nomadising” or “range extensions” and those travelling less than 100km.

The panel identified 20 migratory species relevant to the riverine and non-riverine wetlands of the LEBB (Table 9). Due to time constraints and a lack of information on taxon use of springs, no taxa were flagged for springs in this measure.

Point records for the listed species were used to pinpoint spatial units containing migratory taxa to calculate the scores for the AquaBAMM measure 5.1.3 (Habitat for, or presence of, migratory species).

Table 9. Migratory bird taxa, listed on international agreements, in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Agreements/Conventions
Charadrius veredus	oriental plover	Y	Y		JAMBA, ROKAMBA & Bonn
Pluvialis fulva	Pacific golden plover	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Glareola maldivarum	oriental pratincole	Y	Y		CAMBA, JAMBA & ROKAMBA
Chlidonias leucopterus	white-winged black tern	Y	Y		CAMBA, JAMBA & ROKAMBA
Actitis hypoleucos	common sandpiper	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Arenaria interpres	ruddy turnstone	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Calidris acuminata	sharp-tailed sandpiper	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Calidris ferruginea	curlew sandpiper	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Calidris melanotos	pectoral sandpiper	Y	Y		JAMBA, ROKAMBA & Bonn
Calidris ruficollis	red-necked stint	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Calidris subminuta	long-toed stint	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Gallinago hardwickii	Latham's snipe	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Gallinago megala	Swinhoe's snipe	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Limosa lapponica	bar-tailed godwit	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Limosa limosa	black-tailed godwit	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Numenius madagascariensis	eastern curlew	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Numenius minutus	little curlew	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Tringa glareola	wood sandpiper	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Tringa nebularia	common greenshank	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn
Tringa stagnatilis	marsh sandpiper	Y	Y		CAMBA, JAMBA, ROKAMBA & Bonn

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

4.3 Fauna species richness

Fauna species richness (total number of species) was calculated using wetland indicator species. The panel defined a 'wetland indicator species' to mean:

Species that are adapted to and dependent on living in wet conditions for at least part of their life and are found either within or immediately adjoining a riverine, non-riverine or estuarine wetland.

4.3.1 Fish richness

Georgina River

Waterholes in the Georgina catchment contain a suite of fish species common to the Lake Eyre Basin including bony bream, Hyrtl's tandan, silver tandan, desert rainbowfish, glassfish, yellowbelly, Welch's grunter, spangled perch and Barcoo grunter. In addition, waterholes in the Georgina catchment contain golden goby, banded grunter and the desert hardyhead. Most fish utilise ephemeral habitats after a flood, and migrate up to 300km to do so. In the case of hardyhead it could be >1000km if they come all the way from South Australia. Parapituri waterhole west of Boulia is promoted as a tourist destination and experiences high recreational fishing and should be monitored for unwanted translocated species (live bait). However, most Georgina waterholes receive little fishing pressure.

Diamantina River

Similar to the Georgina catchment, waterholes in the Diamantina catchment also contain a suite of fish species common to the Lake Eyre Basin (as listed above). Golden goby are only known from two specimens but they are most likely widespread. Following flooding, the desert hardyhead would also be widespread given their presence in the Georgina. From Diamantina Lakes north, the waterholes are very turbid and the river is biologically similar to the Cooper catchment. There is a significant data gap between the Diamantina Lakes and Birdsville. Permanent Diamantina waterholes like Hunter's Gorge and Old Cork experience moderate fishing pressure which might lead to unauthorised introductions. Smaller streams like the Mayne have similar fish assemblages to the Diamantina proper. In addition, limited sampling of rock holes in the dissected residuals in the central Diamantina reveal that they usually have one or two common species such as rainbowfish and spangled perch.

Cooper Creek

Similar to the Georgina and Diamantina catchments, waterholes in the Cooper catchment contain a suite of fish species common to the Lake Eyre Basin (as listed above). In addition, waterholes in the Cooper catchment contain carp gudgeons, Australian smelt and Cooper Creek catfish. These species are not known from other Lake Eyre Basin catchments, and Cooper Creek catfish is an endemic species. The presence of Cooper Creek catfish has been cited as a reason to give special mention to certain waterholes (e.g. Cullyamurra) but though endemic, they are widespread and occur in most permanent and some ephemeral areas. There is an isolated population of *Mogurnda* sp. in the Barcoo River near Blackall which is deserving of further investigation. Alien fish present in the Cooper Creek catchment include gambusia and goldfish. Gambusia threaten redfin blue-eye at Edgbaston Spring (Fensham et al. 2007), and also infest the large waterhole at Noccundra on the Wilson River. In recent years, goldfish have been turning up at Longreach and Stonehenge. Translocated fish in the Cooper Creek catchment include the Murray cod, Murray–Darling Basin yellowbelly, sleepy cod and silver perch. The extent of any impacts from these translocations is unknown. Large permanent waterholes in the Cooper receive a considerable amount of fishing pressure and therefore could be vectors for unauthorized translocations and disease. Examples of these waterholes include Currareva near Windorah, Coolagh, Avington and Oma on the Barcoo, and Longreach on the Thomson. Nearly all town waterholes or waterholes on a road crossing experience moderate to heavy recreational fishing pressure. The presence of alien fish species, translocated crayfish, translocated fish species, and the continued stocking of waterholes in the Cooper Creek catchment with farm-reared fingerlings indicates that this catchment is subjected to greater interference than the more western catchments.

Bulloo River

Generally, fish communities of the Bulloo River are poorly studied and require rigorous sampling, using multiple sampling techniques, across several years to account for temporal and spatial variation. Sampling would provide a greater understanding of what species are present and their distribution. From limited survey data, the fish assemblages appear to be very depauperate (near Quilpie and Thargomindah). Regularly caught species include bony bream, spangled perch, rainbowfish, yellowbelly, carp gudgeons and silver tandans. There are capture records for Welch's grunter and Barcoo grunter; however they are likely to be very rare in the catchment. Similarly, purple spotted gudgeons and catfish species are poorly understood in the Bulloo. Even *Ambassis* distribution, to some extent, can be very patchy.

Springs

Four species of native fish are known to inhabit artesian springs, three of which are listed as endangered. These very restricted species and the habitats that they occur in are considered areas of high conservation value.

The panel identified native 20 fish wetland indicator species relevant to the riverine and non-riverine wetlands of the LEBB (Table 10). Point records for the listed species were used to pinpoint spatial units containing native fish taxa to calculate species richness scores for the AquaBAMM measure 3.1.2 (Richness of native fish).

Table 10. Aquatic dependent native fish taxa in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Ambassis sp.	glassfish sp.	Y	Y		Include other *Ambassis* sp. *(mulleri)*. In Cooper, Diamantina and Georgina records from A. Kerezsy and J. Huey.
Craterocephalus eyresii	desert hardyhead	Y	Y		Waterholes in the Georgina catchment contain desert hardyhead. The first records of hardyhead are from 2009 and 2010, though it is likely they migrate long distances and have been patchily present all along. Hardyheads utilise ephemeral habitats after floods and migrate up to 300 km and possibly >1000 km if they recolonise from South Australia.
Craterocephalus stercusmuscarum	Edgbaston/Myross springs rainbowfish		Y	Y	Priority species — Edgbaston springs. Undescribed taxon.
Nematalosa erebi	bony bream	Y	Y		
Hypseleotris spp.	gudgeon sp. [including western, Midgley's and Lake's carp gudgeons]	Y	Y		*Hypseleotris* species grouped together (recommendation by expert panel).
Chlamydogobius micropterus	Elizabeth Springs goby			Y	
Chlamydogobius squamigenus	Edgbaston goby			Y	
Glossogobius aureus	golden flathead goby	Y	Y		
Melanotaenia splendida tatei	desert rainbowfish	Y	Y		
Macquaria ambigua	yellowbelly [including Lake Eyre yellowbelly, *Macquaria* sp. B, Bulloo River yellowbelly]	Y	Y		All yellowbelly species were grouped into *Macquaria ambigua*.
Neosiluroides cooperensis	Cooper Creek catfish	Y	Y		
Porochilus argenteus	silver catfish	Y	Y		Old genus name: *Neosilurus.*
Mogurnda sp. cf. *clivicola*	Flinders Ranges mogurnda	Y	Y		
Neosilurus hyrtlii	Hyrtl's catfish [inc. Bulloo false-spined catfish]	Y	Y		
Scaturiginichthys vermeilipinnis	redfin blue eye			Y	
Retropinna semoni	Australian smelt	Y	Y		The LEBB populations have been identified as an undescribed cryptic species (Hammer et al. 2007).
Amniataba percoides	barred grunter	Y	Y		
Bidyanus welchi	Welch's grunter	Y	Y		
Leiopotherapon unicolor	spangled perch	Y	Y		
Scortum barcoo	Barcoo grunter	Y	Y		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

4.3.2 Reptile richness

The panel identified one native reptile wetland indicator species relevant to the riverine and non-riverine wetlands of the LEBB (Table 11). Due to time constraints and a lack of information on taxon use of springs, no taxa were flagged for springs in this measure.

Point records for the listed species were used to pinpoint spatial units containing native reptile taxa to calculate scores for the AquaBAMM measure 3.1.3 (Richness of native aquatic dependent reptiles).

Table 11. Aquatic dependent native reptile taxa in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Comments and habitat type
Emydura macquarii emmotti	Emmott's short-neck turtle	Y	Y		Anecdotal evidence suggests turtles (*E. m. emmottii*) may be present in the Georgina (Costello et al. 2004). They have been recorded on Diamantina River as well with few records and lower numbers. Threatening processes include netting, as well as drum net fishing. Water extraction of permanent holes during drought years is also a threatening process for turtles (has led to local populations dying through over extraction).

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

4.3.3 Waterbird richness

The panel identified 103 native bird wetland indicator species relevant to the riverine and non-riverine wetlands of the LEBB (Table 12). Only bird species inhabiting freshwater wetland environments for part or all of their natural life functions were considered. Due to time constraints and a lack of information on taxon use of springs, no taxa were flagged for springs in this measure.

Point records for the listed species were used to pinpoint spatial units containing native bird taxa to calculate species richness scores for the AquaBAMM measure 3.1.4 (Richness of native waterbirds).

Table 12. Aquatic dependent native bird taxa in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Circus approximans	swamp harrier	Y	Y		
Haliaeetus leucogaster	white-bellied sea-eagle	Y	Y		
Haliastur sphenurus	whistling kite	Y	Y		
Pandion cristatus	eastern osprey	Y	Y		
Acrocephalus australis	Australian reed-warbler	Y	Y		
Ceyx azureus	azure kingfisher	Y	Y		
Anas castanea	chestnut teal	Y	Y		
Anas gracilis[2]	grey teal	Y	Y		
Anas rhynchotis	Australasian shoveler	Y	Y		
Anas superciliosa[2]	Pacific black duck	Y	Y		
Aythya australis[2]	hardhead	Y	Y		
Biziura lobata	musk duck	Y	Y		
Chenonetta jubata[2]	Australian wood duck	Y	Y		

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Cygnus atratus	black swan	Y	Y		
Dendrocygna arcuata	wandering whistling-duck	Y	Y		
Dendrocygna eytoni[2]	plumed whistling-duck	Y	Y		
Malacorhynchus membranaceus[2]	pink-eared duck	Y	Y		
Nettapus coromandelianus	cotton pygmy-goose	Y	Y		
Nettapus pulchellus	green pygmy-goose	Y	Y		
Oxyura australis	blue-billed duck	Y	Y		
Stictonetta naevosa[2]	freckled duck	Y	Y		
Tadorna tadornoides	Australian shelduck	Y	Y		
Anhinga novaehollandiae	Australasian darter	Y	Y		
Anseranas semipalmata	magpie goose	Y	Y		
Ardea ibis	cattle egret	Y	Y		
Ardea intermedia	intermediate egret	Y	Y		
Ardea modesta[2]	eastern great egret	Y	Y		
Ardea pacifica	white-necked heron	Y	Y		
Botaurus poiciloptilus	Australasian bittern	Y	Y		
Egretta garzetta	little egret	Y	Y		
Egretta novaehollandiae	white-faced heron	Y	Y		
Egretta picata	pied heron	Y	Y		
Ixobrychus dubius	Australian little bittern	Y	Y		
Ixobrychus flavicollis	black bittern	Y	Y		
Nycticorax caledonicus[2]	nankeen night-heron	Y	Y		
Charadrius ruficapillus	red-capped plover	Y	Y		
Charadrius veredus	oriental plover	Y	Y		
Elseyornis melanops	black-fronted dotterel	Y	Y		
Erythrogonys cinctus	red-kneed dotterel	Y	Y		
Pluvialis fulva	Pacific golden plover	Y	Y		
Vanellus miles	masked lapwing	Y	Y		
Vanellus tricolor	banded lapwing	Y	Y		
Ephippiorhynchus asiaticus	black-necked stork	Y	Y		

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Cisticola exilis	golden-headed cisticola	Y	Y		
Glareola maldivarum	oriental pratincole	Y	Y		
Stiltia isabella[2]	Australian pratincole	Y	Y		
Grus rubicunda	brolga	Y	Y		
Irediparra gallinacea	comb-crested jacana	Y	Y		
Chlidonias hybrida	whiskered tern	Y	Y		
Chlidonias leucopterus	white-winged black tern	Y	Y		
Chroicocephalus novaehollandiae	silver gull	Y	Y		
Gelochelidon nilotica	gull-billed tern	Y	Y		
Hydroprogne caspia	Caspian tern	Y	Y		
Amytornis barbatus barbatus	grey grasswren (Bulloo)	Y	Y		Grey grasswren could be argued to be wetland dependent species of the LEBB. Closely associated with, if not exclusively found in, vegetation that occurs in wetlands and presumably requires at least occasional inundation.
Amytornis barbatus diamantina	grey grasswren (Lake Eyre basin)	Y	Y		Grey grasswren could be argued to be wetland dependent species of the LEBB. Closely associated with, if not exclusively found in, vegetation that occurs in wetlands and presumably requires at least occasional inundation.
Megalurus gramineus	little grassbird	Y	Y		
Megalurus timoriensis	tawny grassbird	Y	Y		
Epthianura crocea	yellow chat	Y	Y		Yellow chat could be argued to be wetland dependent species of the LEBB. Closely associated with, if not exclusively found in, vegetation that occurs in wetlands and presumably requires at least occasional inundation. The yellow chat seems most often recorded in these natural wetlands after major floods, both in the drying phase and at residual lakes and on lakebeds for some months post-flood.
Melithreptus brevirostris	brown-headed honeyeater	Y	Y		
Melithreptus gularis	black-chinned honeyeater	Y	Y		
Melithreptus gularis laetior	black-chinned honeyeater (golden backed)	Y	Y		
Pelecanus conspicillatus[2]	Australian pelican	Y	Y		
Microcarbo melanoleucos	little pied cormorant	Y	Y		
Phalacrocorax carbo	great cormorant	Y	Y		
Phalacrocorax sulcirostris[2]	little black cormorant	Y	Y		

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Phalacrocorax varius	pied cormorant	Y	Y		
Platalea flavipes	yellow-billed spoonbill	Y	Y		
Platalea regia[2]	royal spoonbill	Y	Y		
Plegadis falcinellus[2]	glossy ibis	Y	Y		
Threskiornis molucca	Australian white ibis	Y	Y		
Threskiornis spinicollis[2]	straw-necked Ibis	Y	Y		
Podiceps cristatus	great crested grebe	Y	Y		
Poliocephalus poliocephalus	hoary-headed grebe	Y	Y		
Tachybaptus novaehollandiae	Australasian grebe	Y	Y		
Fulica atra[2]	Eurasian coot	Y	Y		
Gallinula tenebrosa	dusky moorhen	Y	Y		
Gallirallus philippensis	buff-banded rail	Y	Y		
Porphyrio porphyrio[2]	purple swamphen	Y	Y		
Porzana fluminea	Australian spotted crake	Y	Y		
Porzana pusilla	Baillon's crake	Y	Y		
Porzana tabuensis	spotless crake	Y	Y		
Tribonyx ventralis[2]	black-tailed native-hen	Y	Y		
Cladorhynchus leucocephalus	banded stilt	Y	Y		
Himantopus himantopus	black-winged stilt	Y	Y		
Recurvirostra novaehollandiae	red-necked avocet	Y	Y		
Rostratula australis	Australian painted snipe	Y	Y		
Actitis hypoleucos	common sandpiper	Y	Y		
Arenaria interpres	ruddy turnstone	Y	Y		
Calidris acuminata[2]	sharp-tailed sandpiper	Y	Y		
Calidris ferruginea	curlew sandpiper	Y	Y		
Calidris melanotos	pectoral sandpiper	Y	Y		
Calidris ruficollis	red-necked stint	Y	Y		
Calidris subminuta	long-toed stint	Y	Y		
Gallinago hardwickii	Latham's snipe	Y	Y		
Gallinago megala	Swinhoe's snipe	Y	Y		

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Limosa lapponica	bar-tailed godwit	Y	Y		
Limosa limosa	black-tailed godwit	Y	Y		
Numenius madagascariensis	eastern curlew	Y	Y		
Numenius minutus[2]	little curlew	Y	Y		In the LEBB it occurs widely on drying floodplain marshes and bare flats after major floods and also uses wetland pools for bathing, drinking and resting in hot weather. Most of the world population spends the non-breeding period in Australia. In the LEBB it has been recorded extensively and in high numbers — thousands to tens of thousands — since aerial and ground surveys of waterbirds began systematically in summer-autumn (and other seasons) in 2000. They are mainly recorded during January to April (especially in the last week of March and first week of April) with counts during (sometimes visible) return migration at either ground level or in aerial surveys totalling well over 1% of the flyway population size. Such 1% sites occur on the Diamantina floodplain between Monkira and Durrie, on the Georgina-Eyre floodplain between Glengyle and Muncoonie, and on the Diamantina-Warburton (South Australia) in the greater Goyders Lagoon complex.
Tringa glareola	wood sandpiper	Y	Y		
Tringa nebularia	common greenshank	Y	Y		
Tringa stagnatilis	marsh sandpiper	Y	Y		
Ninox connivens	barking owl	Y	Y		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

[2] LEBB floodplains are internationally significant for this taxon (>1% of world population breeds here) (Jaensch 2009a).

4.3.4 Amphibian richness

The panel identified 25 native amphibian wetland indicator species relevant to the riverine and non-riverine wetlands of the LEBB (Table 13). Due to time constraints and a lack of information on taxon use of springs, no taxa were flagged for springs in this measure.

Point records for the listed species were used to pinpoint spatial units containing native amphibian taxa to calculate species richness scores for the AquaBAMM measures 3.1.1 (Richness of native amphibians (riverine wetland breeders)) and 3.1.6 (Richness of native amphibians (non-riverine wetland breeders)).

Table 13. Aquatic dependent native amphibian taxa in LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Crinia deserticola	chirping froglet		Y		
Cyclorana alboguttata	greenstripe frog		Y		
Cyclorana cultripes	grassland collared frog		Y		
Cyclorana novaehollandiae	eastern snapping frog		Y		
Cyclorana platycephala	water holding frog		Y		
Cyclorana verrucosa	rough frog		Y		Presence in LEBB questionable.

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Litoria caerulea	green treefrog		Y		
Litoria electrica	buzzing treefrog		Y		
Litoria inermis	bumpy rocketfrog		Y		
Litoria latopalmata	broad palmed rocketfrog		Y		
Litoria pallida	pallid rocketfrog		Y		
Litoria peronii	emerald spotted treefrog	Y	Y		
Litoria rothii	Roth's treefrog		Y		
Litoria rubella	ruddy treefrog		Y		Taxonomic issues likely to be divided to multiple species. However retain as *L. rubella* for ACA.
Limnodynastes fletcheri	barking frog		Y		
Limnodynastes salmini	salmon striped frog		Y		
Limnodynastes tasmaniensis	spotted grassfrog		Y		
Limnodynastes terraereginae	northern banjo frog		Y		
Neobatrachus sudelli	meeowing frog		Y		
Notaden bennettii	holy cross frog		Y		
Notaden nichollsi	desert shovelfoot		Y		
Platyplectrum spenceri	desert burrowing frog		Y		
Uperoleia capitulata	big shouldered gungan		Y		
Uperoleia rugosa	chubby gungan		Y		
Uperoleia trachyderma	orange shouldered gungan		Y		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

4.3.5 Mammal richness

Only one mammal taxa was considered by the panel to be aquatic dependent for the LEBB ACAs (Table 14). Due to time constraints and a lack of information on taxon use of springs, no taxa were flagged for springs in this measure.

Point records for the listed species were used to pinpoint spatial units containing mammal taxa to calculate species richness scores for the AquaBAMM measure 3.1.7 (Richness of native aquatic dependent mammals).

Table 14. Aquatic dependent native mammal taxa in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Hydromys chrysogaster	water rat	Y	Y		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

4.4 Exotic fauna

Exotic fauna species found in or likely to invade LEBB wetlands were evaluated by the panel. Only species known or suspected to cause significant detrimental impact to wetland habitat values and/or native species were considered.

The panel identified 21 exotic fauna taxa relevant to the riverine and non-riverine wetlands of the LEBB (Table 15). This included one invertebrate (worm, molluscs, crustaceans and insects) and 20 vertebrate (fish, amphibians, reptiles, birds and mammals) species. Due to time constraints and a lack of information on taxon use of springs, no taxa were flagged for springs in this measure.

Point records for the listed species were used to pinpoint spatial units containing exotic fauna taxa to calculate scores for the AquaBAMM measures 1.1.1 (Presence of ‘alien' fish species within the wetland), 1.1.3 (Presence of exotic invertebrate fauna within the wetland) and 1.1.4 (Presence of feral/exotic vertebrate fauna (other than fish) within the wetland).

Table 15. Exotic fauna taxa impacting wetland values in the LEBB study areas

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Invertebrate					
Cherax quadricarinatus	redclaw crayfish	Y	Y		Redclaw occurs in the Cooper Creek catchment north of Longreach to south of Jundah (as far south as Stonehenge on the Thomson and Coolagh on the Barcoo). Records in the Georgina and Diamantina. It has only been around for the last decade and has come from Gulf catchments. Impacts unknown but this species may competitively exclude naturally-occurring blue-claw crayfish (‘yabbies’).
Amphibian					
Rhinella marina	cane toad	Y	Y		There are records from January and February 2010, 150 km south–west of Longreach. From property owners who answered a survey by Mike Tyler, there were toads as far south as Windorah. Their main pathway is coming down the Thomson River in the Cooper Creek catchment. Georgina, Diamantina and Bulloo are free of toads to the best of people’s knowledge.
Fish					
Bidyanus bidyanus	silver perch	Y	Y		There were some historically stocked silver perch in farm dams, primarily in Thomson and Cooper. However, there are no verified records.
Carassius auratus	goldfish	Y			
Gambusia holbrooki	mosquitofish	Y	Y		Known to impact on endemic fish taxa in certain springs.
Maccullochella peelii peelii	Murray cod	Y	Y		There are a number of records for Murray cod in the Thomson River near Longreach.
Macquaria ambigua ambigua	Murray–Darling golden perch	Y	Y		There were some historically stocked Murray yellow belly in farm dams, primarily in Thomson and Cooper. Use only records of stocked fish.
Oxyeleotris lineolatus	sleepy cod	Y	Y		
Perca fluviatilis	red fin	Y	Y		Redfin have been found 98km north–east of Innaminka at the South Australian border.
Mammal					

Scientific name	Common name	R[1]	NR[1]	Sp[1]	Panel comments
Bos indicus	zebu	Y	Y		
Bos spp.	cattle spp.	Y	Y		
Bos taurus	European cattle	Y	Y		
Camelus dromedarius	one-humped camel	Y	Y		
Capra hircus	goat	Y	Y		
Equus asinus	donkey	Y	Y		
Equus caballus	horse	Y	Y		Feral horses have caused significant impacts on springs.
Felis catus	cat	Y	Y		
Oryctolagus cuniculus	rabbit	Y	Y		There are many thousands of rabbits in the Bulloo River catchment.
Ovis aries	sheep	Y	Y		
Sus scrofa	pig	Y	Y		
Vulpes vulpes	red fox	Y	Y		

[1] R = Riverine, NR = Non-riverine, Sp = Spring.

4.5 Fauna special features

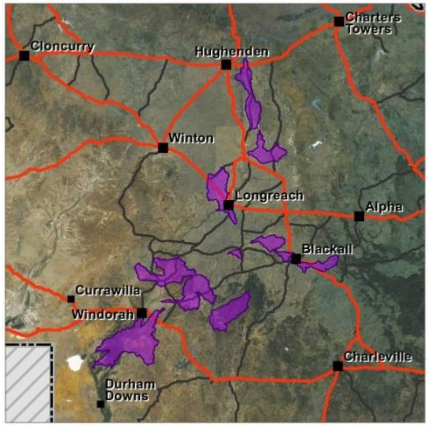
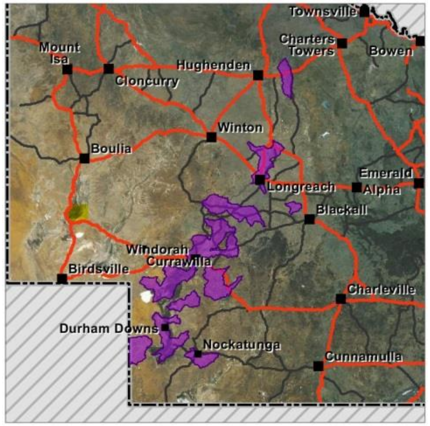
The panel identified 10 fauna special features relevant to the riverine and non-riverine wetlands of the LEBB. Where a single special feature decision crossed a number of study areas, the decision has been duplicated for each study area. Each special feature was assigned a conservation rating between one (Low) and four (Very High). Areas having additional values (e.g. flora, ecology) were consolidated and implemented as wetland ecology special features. Special feature decisions that were not able to be implemented due to a lack of readily available data or unconfirmed values are indicated with '_not_implemented' in the decision number column. No special features relating to springs were discussed.

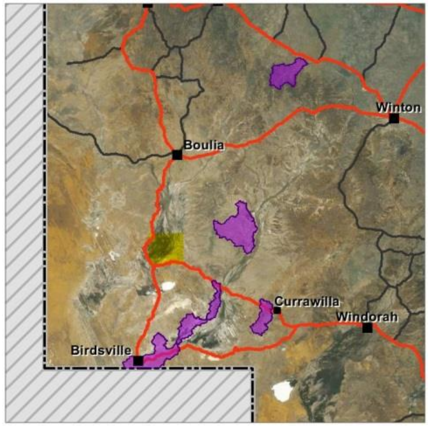
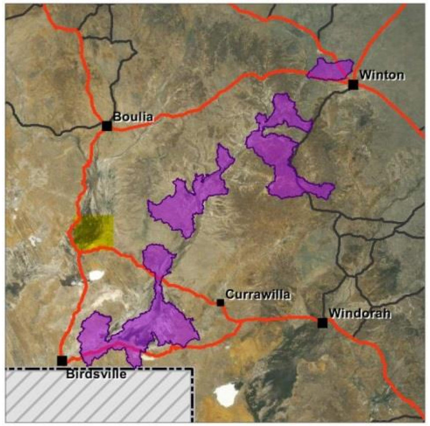
The riverine and non-riverine spatial units intersecting fauna special features are listed alphabetically in Table 16.

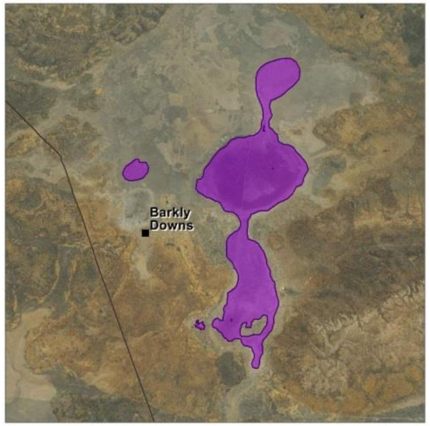
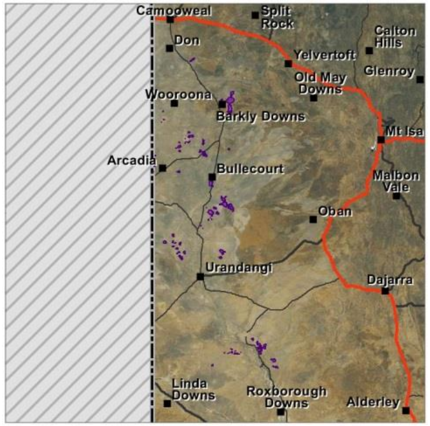
Fauna special features were used to calculate scores for the AquaBAMM measure 6.3.1 (Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)).

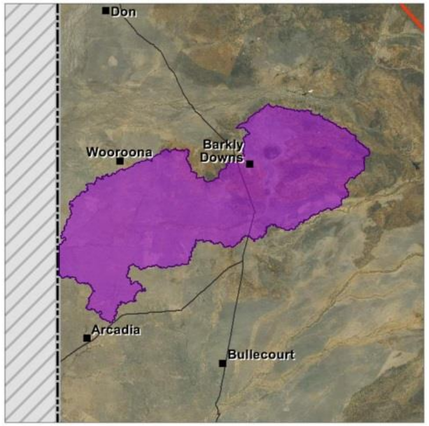
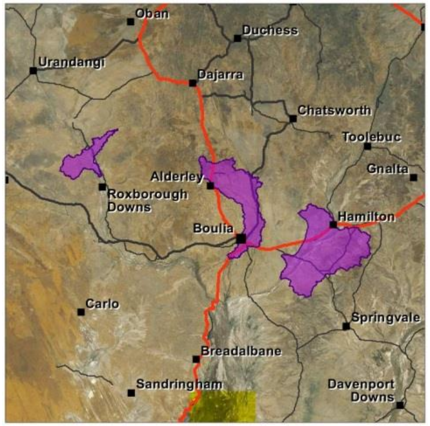
Table 16. Fauna special features in the LEBB study areas

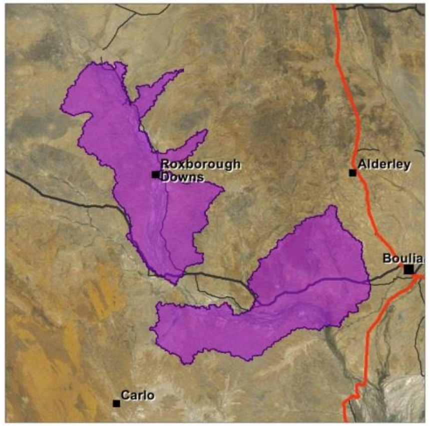
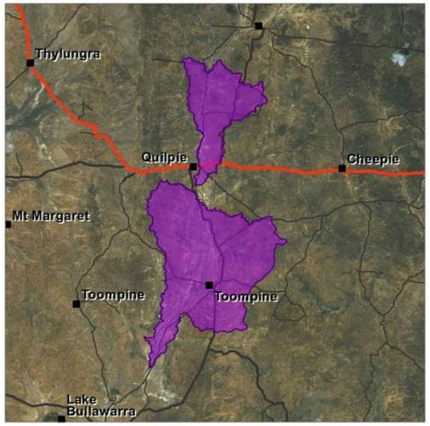
Table sorted by decision number which equates to alphabetically by study area code then riverine/non-riverine.

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_fa_06	Permanent waterholes — medium term		Cooper	Y		Waterholes present for 100% of the time for >50 years were considered to be regionally significant for sustaining in stream biota and ecological processes. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006). Critical to the systems.	6.3.1	3
cp_r_fa_07	Permanent waterholes — long term		Cooper	Y		Ecological processes in the LEBB work over vast timeframes of centuries or 1000's of years. The permanent waterholes (100% permanent >100 years) that never go dry over these longer timeframes are critically important to aquatic species persistence in these arid landscapes. They have a major influence on the genetic diversity and gene flow between river catchments. These waterholes act as refugia (Hamilton et al. 2005), e.g. metapopulation and genetics of the Cooper Creek turtle requires long time frames of persistence to sustain populations and species. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006).	6.3.1	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_r_fa_03	Permanent waterholes — medium term		Diamantina	Y		Waterholes present for 100% of the time for >50 years were considered to be regionally significant for sustaining in stream biota and ecological processes. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006). Critical to the systems.	6.3.1	3
di_r_fa_04	Permanent waterholes — long term		Diamantina	Y		Ecological processes in the LEBB works over vast timeframes of centuries or 1000's of years. The permanent waterholes (100% permanent >100 years) that never go dry over these longer timeframes are critically important to aquatic species persistence in these arid landscapes. They have a major influence on the genetic diversity and gene flow between river catchments. These waterholes act as refugia (Hamilton et al. 2005), e.g. metapopulation and genetics of the Cooper Creek turtle requires long time frames of persistence to sustain populations and species. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006).	6.3.1	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_fa_05	Barkly Downs wetlands		Georgina		Y	The panel noted that the Barkly Downs (property) wetlands contain some endemic molluscs, although fauna sampling has been done along the access road more than in the wetlands themselves. Only part of Barkly system that gets into Queensland. Important for wetland bird nesting (DERM 2009c).	6.3.1	3
ge_nr_fa_06	Barkly Tableland wetlands		Georgina		Y	Generally, a number of selected wetlands on the Barkly Tablelands contain important invertebrate values including endemic molluscs (DERM 2009c). More survey work is required to confirm possible values.	6.3.1	2

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_r_fa_01	Barkly Downs wetlands		Georgina	Y		The panel noted that the Barkly Downs wetlands contain some endemic molluscs, although fauna sampling has been done along the access road more than in the wetlands themselves. Only part of Barkly system that gets into QLD. Important for wetland bird nesting (DERM 2009c).	6.3.1	3
ge_r_fa_02	Permanent waterholes — medium term		Georgina	Y		Waterholes present for 100% of the time for >50 years were considered to be regionally significant for sustaining in stream biota and ecological processes. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006). Critical to the systems.	6.3.1	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_r_fa_03	Permanent waterholes — long term		Georgina	Y		Ecological processes in the LEBB works over vast timeframes of centuries or 1000's of years. The permanent waterholes (100% permanent >100 years) that never go dry over these longer timeframes are critically important to aquatic species persistence in these arid landscapes. They have a major influence on the genetic diversity and gene flow between river catchments. These waterholes act as refugia (Hamilton et al. 2005), e.g. metapopulation and genetics of the Cooper Creek turtle requires long time frames of persistence to sustain populations and species. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006).	6.3.1	4
ul_r_fa_02	Permanent waterholes — long term		Bulloo	Y		Ecological processes in the LEBB works over vast timeframes of centuries or 1000's of years. The permanent waterholes (100% permanent >100 years) that never go dry over these longer timeframes are critically important to aquatic species persistence in these arid landscapes. They have a major influence on the genetic diversity and gene flow between river catchments. These waterholes act as refugia (Hamilton et al. 2005), e.g. metapopulation and genetics of the Cooper Creek turtle requires long time frames of persistence to sustain populations and species. However, the panel cautioned that care is required for broad application of this decision as some wetlands have been modified through water extraction (Bunn et al. 2006).	6.3.1	4

[1] R — Riverine, NR — Non-riverine.

[2] Criteria, indicators and measures (used in AquaBAMM).

[3] Conservation rating between 1 (Low) and 4 (Very High).

4.6 Significant waterbird habitat areas

Considerable but incomplete data exists for population sizes of waterbirds that breed in Australia (Wetlands International 2006), with more complete data for waterbirds that breed in Asia but migrate to Australia (Bamford et al. 2008). For the LEBB there are many counts scattered across many sources, which can be used to identify species/populations occurring at one per cent levels in one or more study areas, thus identifying internationally important sites. Though not fully analysed or synthesised, the data now demonstrates that the wetlands in LEBB consistently support several millions of waterbirds during major flood events and thus are among the most important in Australia and of global significance (Jaensch 2009a).

For migratory waterbirds:

The LEBB is significant for sharp-tailed sandpiper (up to tens of thousands, multiple sites in most basins); little curlew (several sites in the Georgina and Diamantina) and white-winged black tern (Lake Yamma Yamma; and similar sites as for little curlew). It is also important for the Australian pratincole (several sites), which migrates to Indonesia.

For breeding waterbirds:

Population size estimates are less robust but for many species it seems clear that the LEBB holds far in excess of one per cent of species populations e.g. black-tailed native-hen, freckled duck, glossy Ibis, various ducks (Jaensch 2009a). The report by Reid et al. (2009) on the 2009 flood event supports this conclusion. Reports in the annual October aerial survey of Eastern Australia series (e.g. Porter & Kingsford 2009) reveal high post-breeding numbers related mainly to persistent lakes in these systems. Important sites include most of the persistent lakes as well as the major swampy floodplain reaches or terminal swamps of each of the four rivers. Breeding colonies occur in both swamps and lakes but the largest (apart from pelicans) are in the swampy floodplains.

Habitat for significant numbers of waterbirds fall into three categories: swampy floodplain complexes (at least seven in Queensland, each at times hosting in excess of 100,000 waterbirds); persistent lakes (at least eight, probably more than 10, depending on boundaries; post-breeding aggregations); and breeding colonies. Breeding colonies of waterbirds are inherently few and vulnerable, and are biodiversity/biomass hotspots in the landscape. There are at least 20 in the Georgina River, eight on the Diamantina River, 12 in the Cooper Creek and three in the (poorly studied) Bulloo River basin. They include some of the largest known, contemporary colonies of certain species (e.g. Australian pelican, royal spoonbill and glossy ibis). Lignum-belalie communities are especially important but are potentially threatened by inappropriate burning regimes (R. Jaensch, pers. comm.).

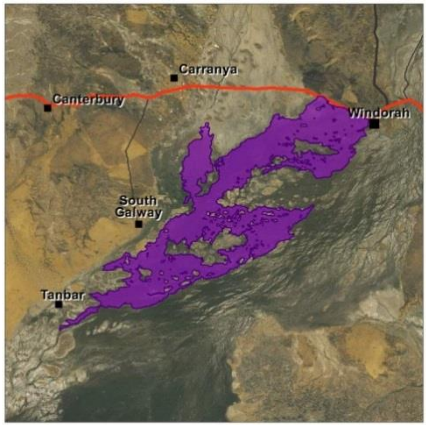
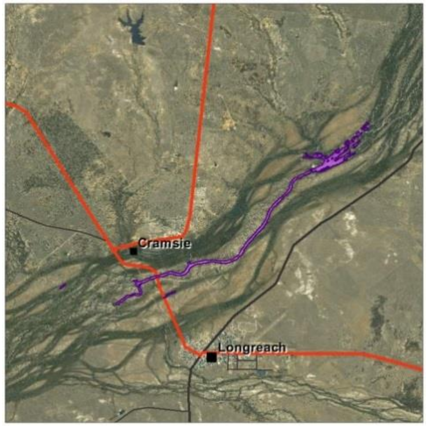
The panel identified the following two criteria for a wetland to be considered habitat for a significant number of waterbirds in the LEBB:

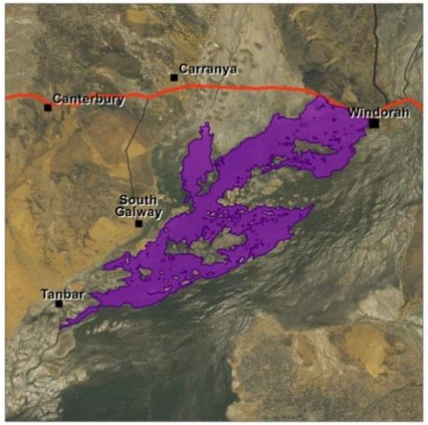
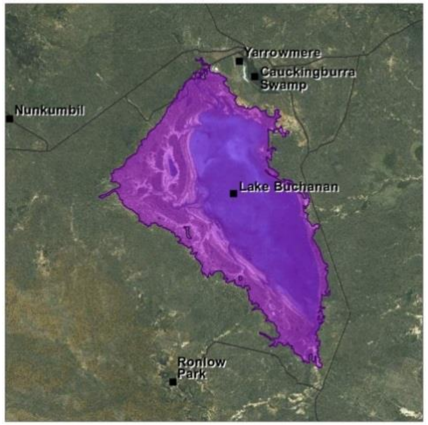
1. A significant proportion of the single species breeding population (> one per cent for waterbirds) occurs in the waterbody (see Ramsar criterion 6 for waterbirds).
2. High density concentrations of non-breeding waterbirds (multiple species) in the hundreds of thousands for identified wetland habitats (e.g. one per cent of global population).

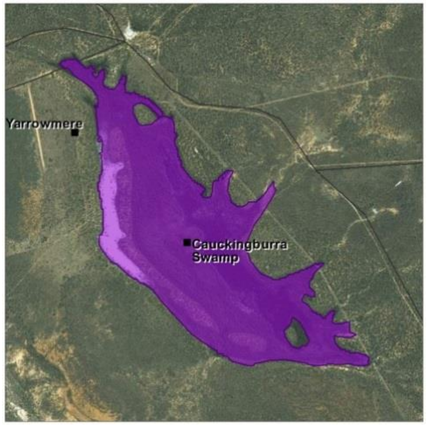
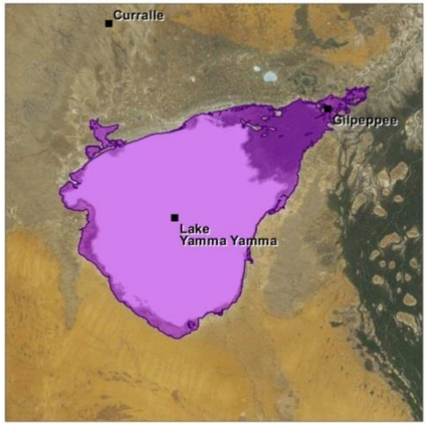
The expert panel identified 25 areas of significant waterbird habitat within the LEBB (Table 17). Riverine and non-riverine spatial units coincident with these wetlands were given a score of four under the AquaBAMM measure 5.1.4 (Habitat for significant numbers of waterbirds).

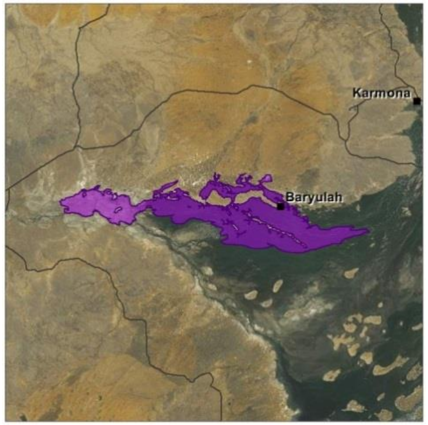
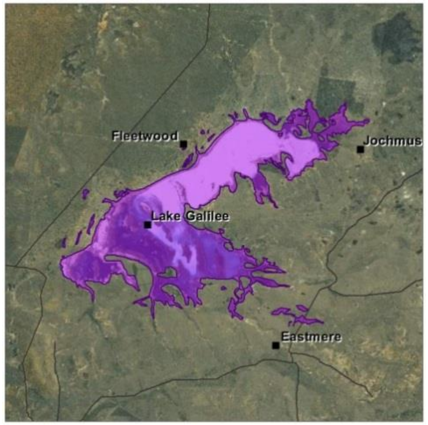
Table 17. Areas of significant waterbird habitat in the LEBB study areas

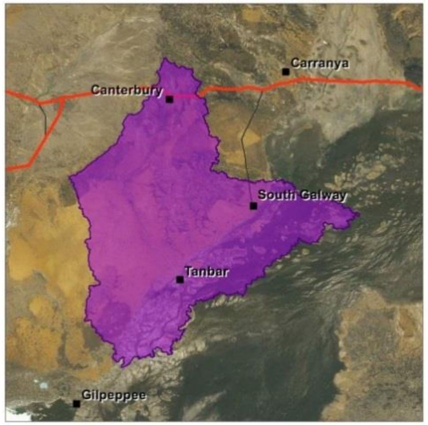
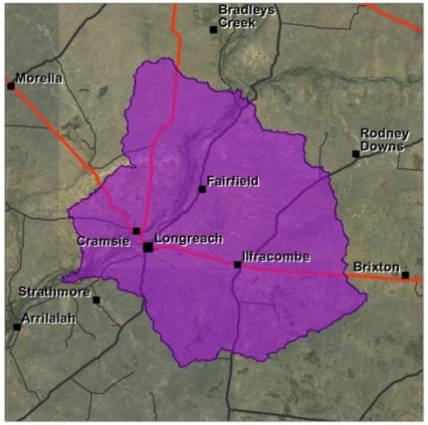
Table sorted by decision number which equates to alphabetically by study area code then riverine/non-riverine.

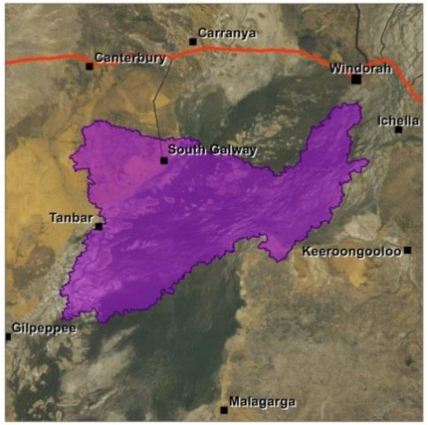
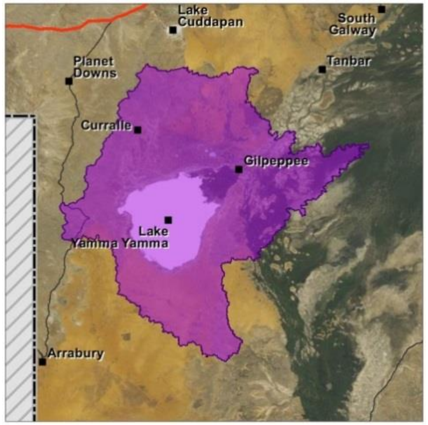
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_fa_01	Talpi and Corner Bores — Subset of DIWA Site south–west Windorah		Cooper		Y	Includes 10+ species with breeding records of egrets and ibis, particularly straw-necked ibis (> one per cent world population) and glossy ibis. Smaller numbers than other identified Cooper waterbird wetland complexes. Part of recognised Cooper Flooplain Below Windorah IBA (Dutson et al. 2009). Also supports migratory waterbirds (Blackman et al. 1999).	5.1.4	2
cp_nr_fa_02	Black Gin Creek, Thomson River Confluence — Non-riverine wetlands		Cooper		Y	Small egret colony. First flood-out in the system. Unique braided channels, associated lagoons that provide bird habitat. Flowering lignum and bluebush. Coolabah lined channels. Outlier of Channel Country. There has been removal of hollow trees used by nesting birds (DERM 2009b).	5.1.4	2

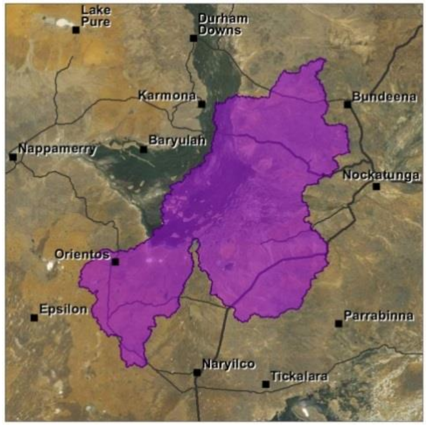
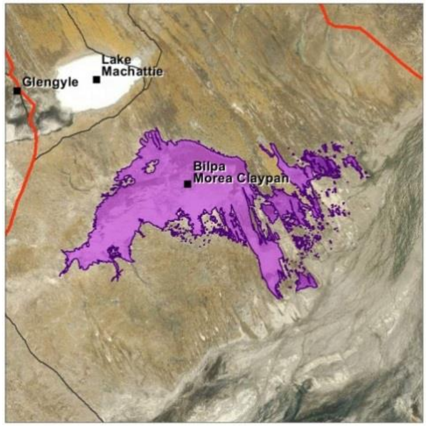
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_fa_03	Candue swamp on South Galway — Non-riverine wetlands		Cooper		Y	Significant location for colonial nesting waterbirds breeding events (100,000+ waterbird numbers). It is assumed that there is a preferential flow from the Cooper to keep the water ponded long enough (five to six months minimum). Part of recognised IBA (Dutson et al. 2009).	5.1.4	3
cp_nr_fa_04	Lake Buchanan — not including Caukingburra Swamp		Cooper		Y	Large numbers of non-breeding waterbirds including migratory shorebirds. Periodically important habitat and refuge for waterbirds (Blackman et al. 1999).	5.1.4	3

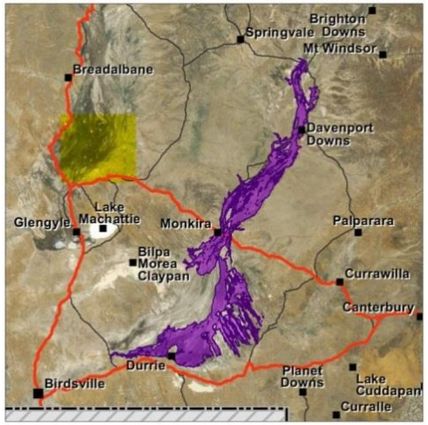
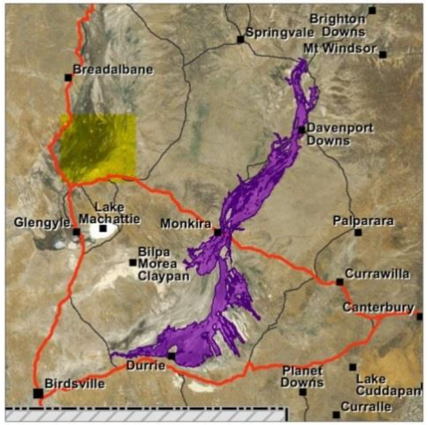
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_fa_05	Caukingburra Swamp		Cooper		Y	Colonial nesting waterbird species breeding site including cotton pygmy goose. Smaller area and densely vegetated. Best example of seasonal freshwater habitat in central Queensland, used by a diverse waterfowl fauna (Blackman et al. 1999).	5.1.4	3
cp_nr_fa_06	Swampy upstream parts of Lake Yamma Yamma — Non-riverine wetlands		Cooper		Y	Large numbers of waterbirds. 10 to 15 colonial nesting waterbird breeding species with large numbers of each. Contained >50,000 pelicans in 2009. Part of recognised Lake Yamma Yamma IBA (Dutson et al. 2009) for plumed whistling-duck and stopover for migrating sharp-tailed sandpipers. Lake Yamma Yamma is Queensland's largest inland ephemeral lake (Blackman et al. 1999).	5.1.4	4

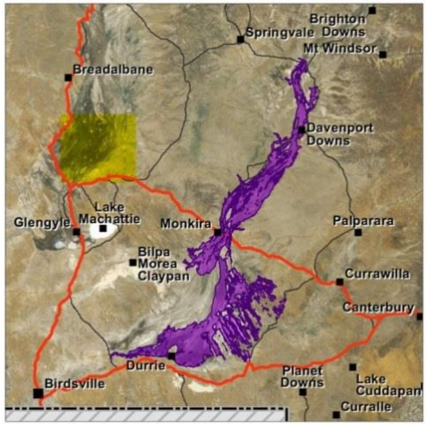
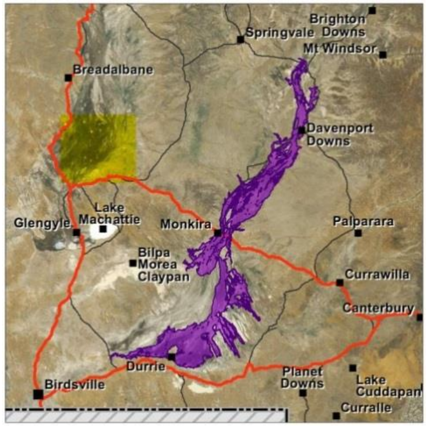
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_fa_07	Bilpa-Baryulah Complex		Cooper		Y	Large aggregations of waterbirds. 10 to 15 colonial nesting waterbird breeding species large numbers of each. During AridFlo project access to area refused and hence no data from that project. Historic data from 1930s+. Typical example of vast lignum swamp and large permanent waterholes, the latter providing significant refugial habitat for waterbirds throughout most of the year (Blackman et al. 1999).	5.1.4	4
cp_nr_fa_08	Lake Galilee		Cooper		Y	Range of colonial nesting waterbird species nesting, up to 10,000 pelicans. At non-nesting times can still support large populations of non-breeding birds. Part of recognised Lake Galilee IBA, particularly for freckled duck and grey teal (Dutson et al. 2009).	5.1.4	4

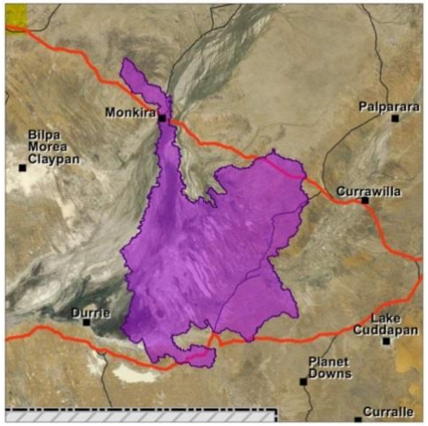
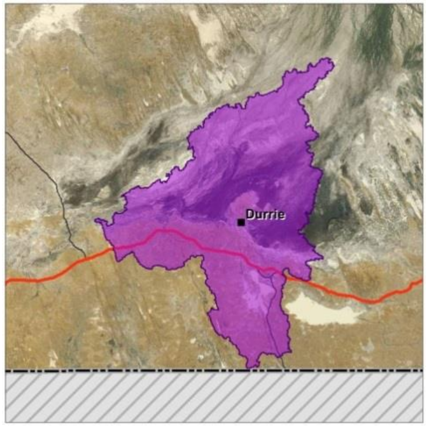
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_fa_01	Tanbar Waterhole		Cooper	Y		One of the largest white-necked heron colonies documented and up to 5,000 colonial nesting waterbirds — example of one of many similar waterholes in the Cooper, already captured by permanent waterhole decision. Information based on chance flight over this waterhole when colonies were present.	5.1.4	2
cp_r_fa_02	Black Gin Creek, Thomson River Confluence — Riverine wetlands		Cooper	Y		Small egret colony. First flood-out in the system. Unique braided channels, associated lagoons that provide bird habitat. Flowering lignum and bluebush. Coolabah lined channels. Outlier of Channel Country bioregion. There has been removal of hollow trees used by nesting birds (DERM 2009b).	5.1.4	2

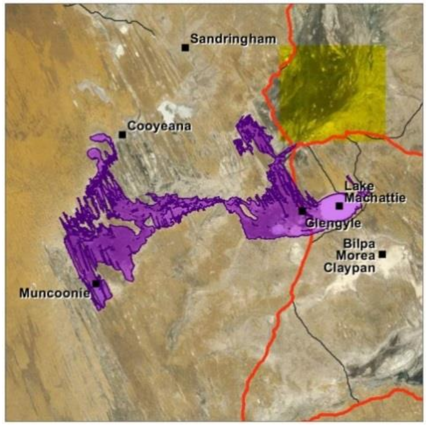
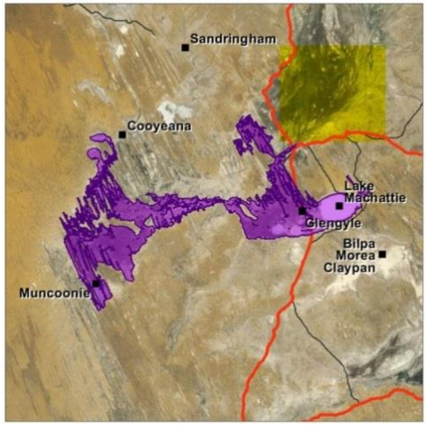
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_fa_03	Candue swamp on South Galway — Riverine wetlands		Cooper	Y		Significant location for colonial nesting waterbird breeding events (100,000+ waterbird numbers). It is assumed that there is a preferential flow from the Cooper to keep the water ponded long enough (5 to 6 months minimum). Part of recognised IBA (Dutson et al. 2009).	5.1.4	3
cp_r_fa_04	Swampy upstream parts of Lake Yamma Yamma — Riverine wetlands		Cooper	Y		Large numbers of waterbirds. 10 to 15 colonial nesting waterbird breeding species with large numbers of each. Contained >50,000 pelicans in 2009. Part of recognised Lake Yamma Yamma IBA (Dutson et al. 2009) for plumed whistling-duck and stopover for migrating sharp-tailed sandpipers. Lake Yamma Yamma is Queensland's largest inland ephemeral lake (Blackman et al. 1999).	5.1.4	4

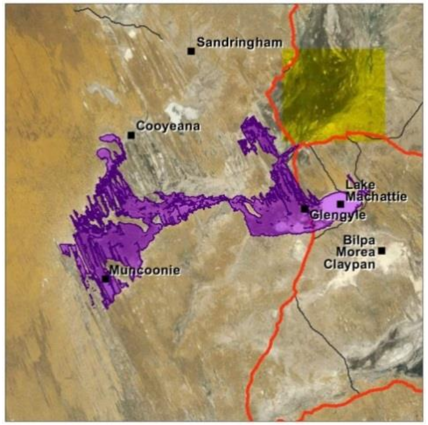
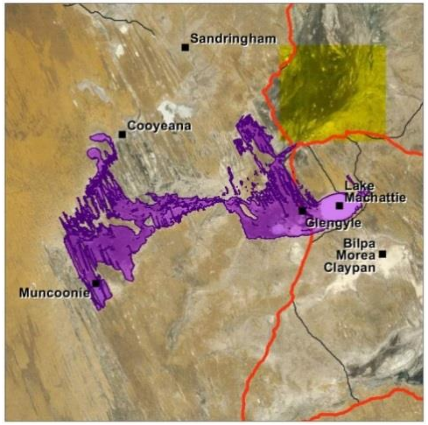
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_fa_05	Lower Cooper waterbird — Tooley Wooley Water Hole and Naryilco Complex		Cooper	Y		Large accumulations of waterbirds. Ten to 15 colonial nesting waterbird breeding species, large numbers of each. The permanent waterholes provide a significant resource in an otherwise arid region (Blackman et al. 1999). The Bilpa-Baryulah (‘Nappa Merrie’) to Tooley Wooley's Water Holes area is a significant waterbird breeding floodplain on the lower Cooper in Qld, but poorly researched (DERM 2009a). AridFlo was not granted permission to survey the Nappa Merrie portion in 2000, but historical accounts (Chenery 1921) attest to the large ibis-egret colonies there, and we (R. Jaensch & J. Reid) have observed colonial nesting waterbirds breeding there and on the Tooley Woolies in smaller flood years on the Cooper. This tract could be drawn to include the southern portions of the ‘Big Bend’, e.g. Yetally Waterhole, to capture all of the important waterbird breeding habitat in this district.	5.1.4	4
di_nr_fa_01	Bilpa Morea Complex plus eastern swamps		Diamantina		Y	Large numbers of birds, including shorebirds on Bilpa Morea. Data deficient.	5.1.4	2

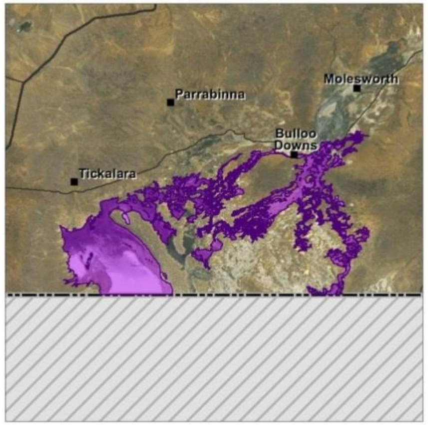
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_nr_fa_02	Crossdune swales — SE of Kingadurka — Mooraberrie Complex		Diamantina		Y	Diamantina preferentially fills swales leading to greater persistence of water. Up to 10,000 colonial nesting waterbirds and large breeding area for other waterbird species. Part of recognised Diamantina Floodplain IBA (Dutson et al. 2009).	5.1.4	3
di_nr_fa_03	DIWA site — Durrie East Swamps		Diamantina		Y	10,000s colonial nesting waterbirds breeding. Part of recognised Diamantina Floodplain IBA (Dutson et al. 2009). Waterholes are fringed by coolabah woodland and have backswamp areas of lignum. Lower lying areas of lignum also support sedge swamps of *Eleocharis* spp. and *Cyperus* spp. (Blackman et al. 1999). These fringing, seasonal shallow water areas and vast low lying lignum swamp provide habitat for a number of migratory wader species (Blackman et al. 1999).	5.1.4	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_nr_fa_04	Kingadurka-Mooraberrie Complex — Non-riverine wetlands		Diamantina		Y	Large breeding colonies of colonial nesting waterbirds. 100,000 plus breeding units. Equal to the Lake Machattie-Mipia complex as the most important waterbird breeding site in the Channel Country based on current knowledge. A highly significant tract of marginal floodplain\interdunal swale-swamp intermittent wetlands, that runs east and north of Durrie homestead, north to the Monkira-Mooraberrie boundary two breeding records of the vulnerable Australian painted snipe (DERM 2009a). Includes the Kingadurka and Milkra Waterholes and their associated swale wetlands. Kingadurka is the largest-known, mixed species colony of breeding waterbirds in the bioregion (estimated at around 45,000 pairs of egrets, spoonbills, ibises, night herons and cormorants) and supported this order of numbers post-flood in 2000 and 2009 with high numbers also in some intervening years. Milkra supports small \ moderate-sized breeding colonies of Australian pelican in an unusual habitat situation (on channel banks under trees). Part of recognised Diamantina Floodplain IBA (Dutson et al. 2009).	5.1.4	4
di_nr_fa_05	Durrie waterholes including adjacent palustrine swamps — Non-riverine wetlands		Diamantina		Y	50,000+ colonial nesting waterbirds breeding. Part of recognised Diamantina Floodplain IBA (Dutson et al. 2009). Significant threatened taxa include grey grasswren (Diamantina subspecies) (DERM 2009a).	5.1.4	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_r_fa_01	Kingadurka—Mooraberrie Complex - Riverine wetlands		Diamantina	Y		Large breeding colonies of colonial nesting waterbirds. 100,000 plus breeding units. Equal to the Lake Machattie-Mipia complex as the most important waterbird breeding site in the Channel Country based on current knowledge. A highly significant tract of marginal floodplain/interdunal swale-swamp intermittent wetlands, that runs east and north of Durrie homestead, north to the Monkira–Mooraberrie boundary. Two breeding records of the Vulnerable Australian painted snipe (DERM 2009a). Includes the Kingadurka and Milkra Waterholes and their associated swale wetlands. Kingadurka is the largest-known, mixed species colony of breeding waterbirds in the bioregion (estimated at around 45,000 pairs of egrets, spoonbills, ibises, night herons and cormorants) and supported this order of numbers post-flood in 2000 and 2009 with high numbers also in some intervening years. Milkra supports small/moderate-sized breeding colonies of Australian pelican in an unusual habitat situation (on channel banks under trees). Part of recognised Diamantina Floodplain IBA (Dutson et al. 2009).	5.1.4	4
di_r_fa_02	Durrie waterholes including adjacent palustrine swamps — Riverine wetlands		Diamantina	Y		50,000+ colonial nesting waterbirds breeding. Part of recognised Diamantina Floodplain IBA (Dutson et al. 2009). Significant threatened taxa include grey grasswren (Diamantina subspecies) (DERM 2009a).	5.1.4	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_fa_01	Lakes Torquinie and Mumbleberry		Georgina		Y	Massive numbers of birds — nonbreeding — after the floods — 100,000+. Kingsford et al (1992) found up to 85% of the freckled ducks counted in Eastern Australia occurred on Lakes Torquinie and Mumbleberry. Significant permanent waterholes used by range of waterbirds including red-necked avocets, and migrants such as sharp-tailed sandpipers (Blackman et al. 1999, Dutson et al. 2009). Part of recognised Lakes Muncoonie, Mumbleberry & Torquinie IBA (Dutson et al. 2009).	5.1.4	3
ge_nr_fa_02	Smith's waterhole and west		Georgina		Y	Prime colonial nesting waterbird breeding habitat — 50,000 colonial nesting waterbird breeding pairs.	5.1.4	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_fa_03	Muncoonie—Titheropatchie waterhole		Georgina		Y	More than ten thousand colonial nesting waterbirds — massive amounts of breeding by all 55 species of birds. Significant threatened taxa: Australian painted snipe and yellow chat (DERM 2009a). Part of recognised Lakes Muncoonie, Mumbleberry & Torquinie IBA (Dutson et al. 2009). Condition: Under threat from rabbit grazing. Long term rabbit monitoring site by DERM.	5.1.4	4
ge_nr_fa_04	Lake Machattie-Mipia Complex		Georgina		Y	More than one hundred thousand colonial nesting waterbirds in addition to 70,000 pelican pairs — equal to Kingadurka–Mooraberrie complex as the most important waterbird breeding area in the LEBB (Reid et al. 2009). Lakes Mipia and Koolivoo fill every year while Lake Machattie fills 1 in 3 years (Blackman et al. 1999). Several migratory birds have been recorded here (Blackman et al. 1999). Most significant waterbird breeding habitat in the Channel Country bioregion (DERM 2009a). Extensive lignum swamps provide habitat for grey grasswrens and pelican breeding sites. Part of recognised Lake Machattie area IBA (Dutson et al. 2009).	5.1.4	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ul_nr_fa_01	Bulloo Lake		Bulloo		Y	Three hundred thousand non-breeding waterbirds were seen in recent surveys and is a stronghold for grey grasswren subspecies. Also used by grey teal, freckled and pink-eared duck, and as stopover for migratory waders. Part of recognised Bulloo Floodplain IBA (Dutson et al. 2009). Lake Bulloo is dominated by low to tall, open to closed lignum with emergent river cooba *Acacia stenophylla* and coolabah with areas of swamp canegrass *Eragrostis australasica* and bluebush (Blackman et al. 1999). The lake is a vast area and is a significant terminal floodout of a major internal drainage basin (Blackman et al. 1999).	5.1.4	4

[1] R = Riverine, NR = Non-riverine.

[2] Criteria, indicators and measures (used in AquaBAMM).

[3] Conservation rating between 1 (Low) and 4 (Very High).

5 Ecology

5.1 Special Features

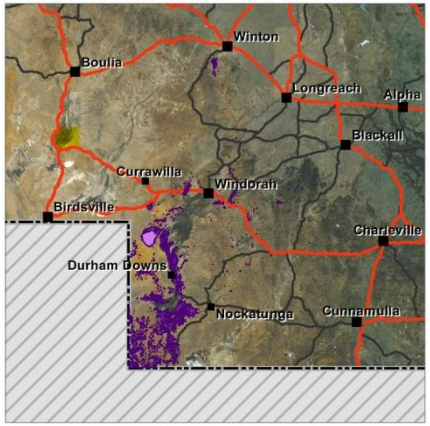
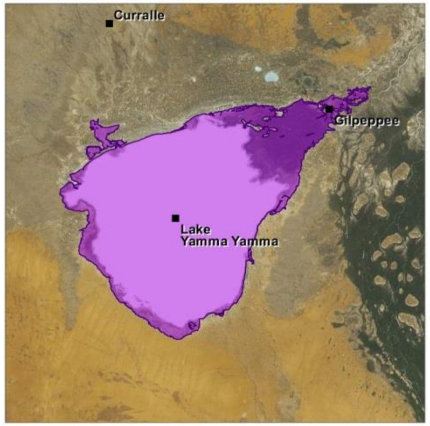
The panel identified 34 ecology special features relevant to the riverine and non-riverine wetlands of the LEBB. Where a single special feature decision crossed a number of study areas, the decision has been duplicated for each study area. Each special feature was assigned a conservation rating between one (Low) and four (Very High). Areas having additional values (e.g. flora, ecology) were consolidated and implemented as wetland ecology special features. Special feature decisions that were not able to be implemented due to a lack of readily available data or unconfirmed values are indicated with '_not_implemented' in the decision number column. Specific spring special features were not discussed but where identified were included as non-riverine decisions.

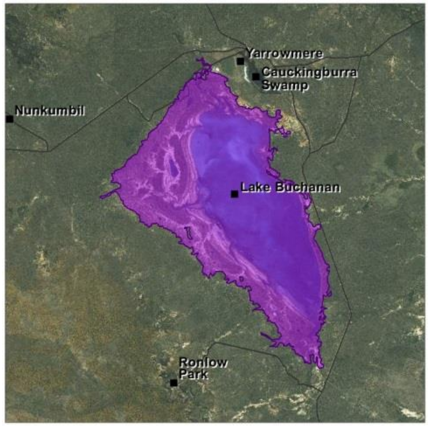
The riverine and non-riverine spatial units intersecting ecological special features are listed alphabetically in Table 18.

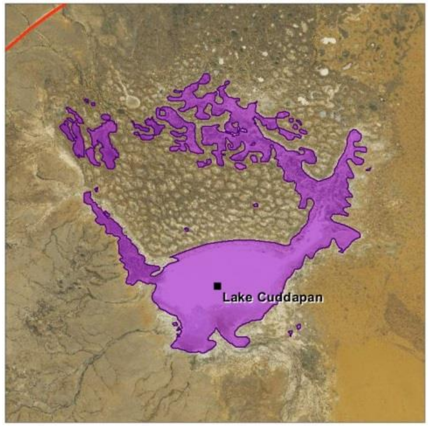
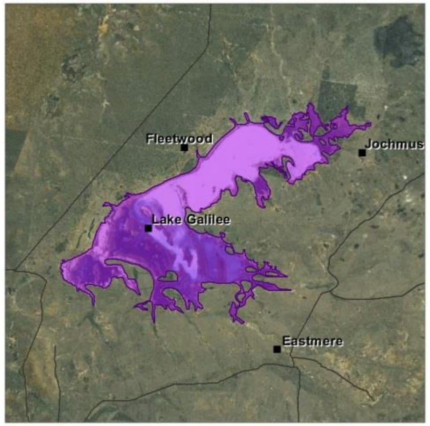
Ecology special features were used to calculate scores for the AquaBAMM measure 5.2.1 (Presence of 'priority' aquatic ecosystem), 6.1.1 (Presence of distinct, unique or special geomorphic features), 6.3.1 (Presence of distinct, unique or special habitat, including habitat that functions as refugia or other critical purpose), 6.3.3 (Ecologically significant wetlands identified through expert opinion and/or documented study), and 6.4.1 (Presence of distinct, unique or special hydrological regimes, e.g. spring fed stream, ephemeral stream or boggomoss).

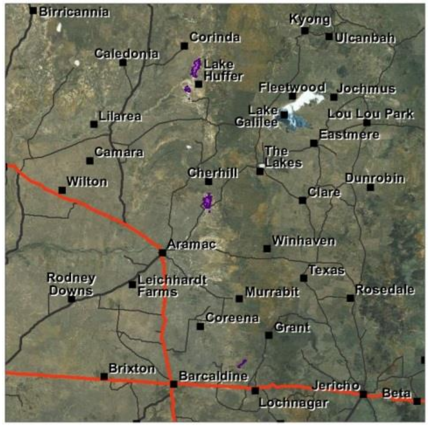
Table 18. Ecological special features in the LEBB study areas

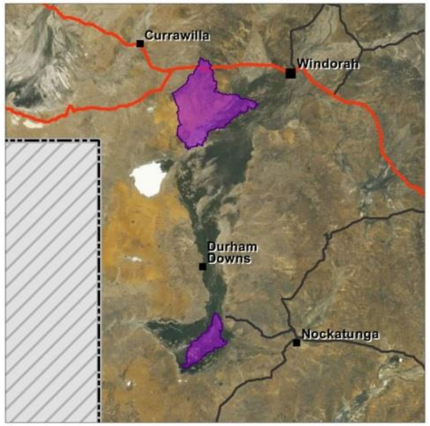
Table sorted by decision number which equates to alphabetically by study area code then riverine /non-riverine.

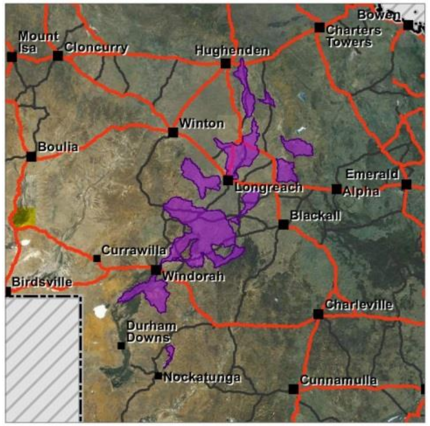
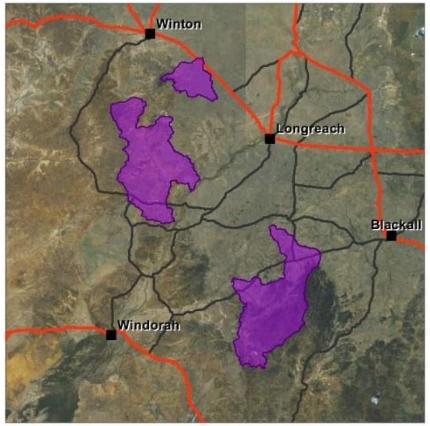
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_ec_02	Temporary claypan wetlands		Cooper		Y	A number of temporary claypan wetlands not fed by rivers have different biota adapted to different desiccation cycles e.g. fairy shrimp. For the majority of their time they are dry and are susceptible to cattle damage and woody debris removal. The REs associated with this decision are: 4.3.12b, d; 5.3.13b; 5.3.15a, b; 5.3.16a; 5.3.22a; 5.3.8b; 6.3.11; 6.3.11b.	5.2.1	3
cp_nr_ec_04	Lake Yamma Yamma		Cooper		Y	Lake Yamma Yamma is the biggest terminal lake in the Cooper Creek being an offshoot of the main stream. It receives water overflow from Cooper Creek in extreme flood years and contains extensive low grassland of *Sporobolus mitchellii* (Blackman et al. 1999). It is geomorphologically distinct and is an ecological desert being flat and bare for most of its time. Significant waterbird habitat, including breeding, intermittent richness species values (DERM 2009a). Scenically beautiful country that needs more survey work.	6.1.1	4

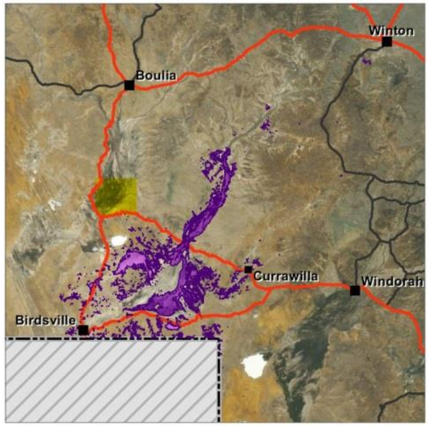
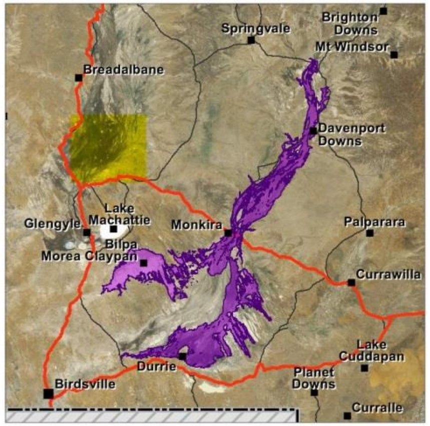
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_ec_05	Cooper Creek lacustrine wetlands — Lake Buchanan		Cooper		Y	Lake Buchanan usually contains water (salinity levels vary widely between sites and with time) for only a few months of the year. There are approximately 53 species of fauna (mostly insects and crustaceans) recorded from the lake and surrounding peripheral pools (Timms 1987). The fauna composition is predominantly endemics and is considered to be quite distinctive on a global level (Timms 1987). Area of concentration of flora with biogeographic interest. Includes concentrations of threatened and/or priority species and narrow endemic taxa. *Calotis sp*. (Lake Buchanan J.Kemp+ 3384H), *Dactyloctenium sp*. (Yarrowmere J.Kemp+ 3365H), *Dysphania plantaginella*, *Ipomoea sp*. (Lake Buchanan E.J.Thompson+ BUC2133), *Pterocaulon sp*. (Yarrowmere Station E.J.Thompson + BUC340), *Fimbristylis sp.* (Lake Buchanan V.J. Neldner 3362) (R), *Lawrencia buchananensis* (V) (DERM 2012a). Good example of large shallow, saline lake in closed drainage basin with relict beach structures, and important waterbird habitat (Blackman et al. 1999).	6.1.1 6.3.3	4, 4
cp_nr_ec_06	Cooper Creek lacustrine wetlands — Lakes Dunn and Huffer		Cooper		Y	Lakes Dunn and Huffer. This complex is confined within a land zone five surface. The complex includes a mapped lakebed, adjoining areas that are seasonally flooded, adjoining areas of non-wetland REs, and a small area of confined sand plain (DERM 2012b).	6.1.1 6.3.3	3, 3

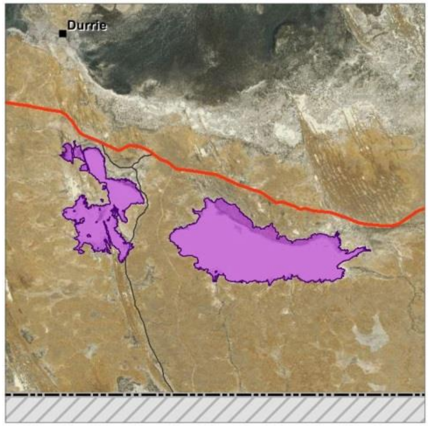
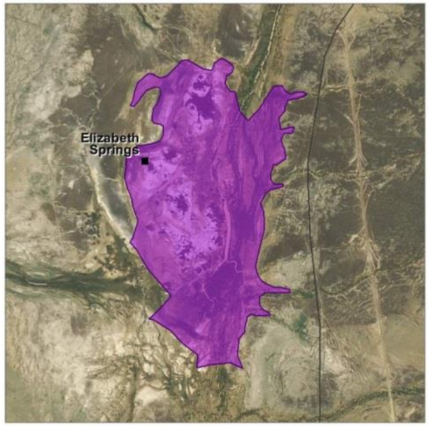
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_ec_07	Cuddapan swamp		Cooper		Y	Canegrass plain with swamp canegrass — waterbird habitat and potential habitat for grey grasswren. Cuddapan is a terminal playa lake (Blackman et al. 1999).	6.1.1 6.3.3	3, 3
cp_nr_ec_08	Cooper Creek lacustrine wetlands — Lake Galilee		Cooper		Y	Lake Galilee was identified as being significant waterbird habitat. It also meets the criterion for Ramsar wetland status, even though it is not listed. Part of recognised Lake Galilee IBA (Dutson et al. 2009). Its water quality is unique. This complex includes remnant vegetation associated with the lakebed, depressions and plains adjacent to and continuous with the lakebed, and dunes and weathered dunes that are continuous with the lakebed. Regional ecosystems that are mapped as part of the lake complex fall into one of four functional groups: lakebed, periodically inundated depressions and plains, adjoining dunes, inliers of non-wetland complex type (DERM 2012b). Rare lake type and periodically important breeding site for waterbirds (Blackman et al. 1999).	6.1.1 6.3.3	4, 4

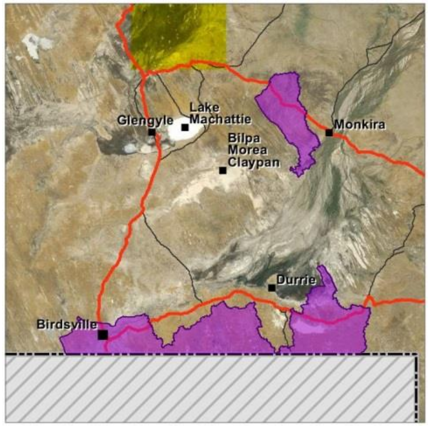
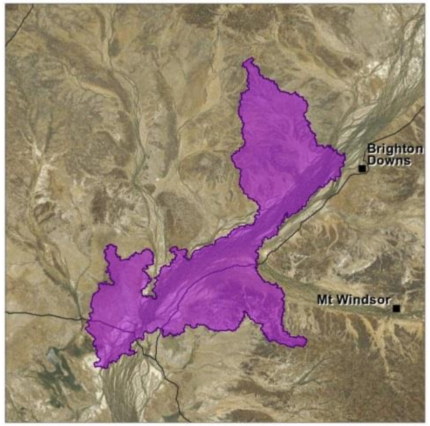
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_nr_ec_12	Non-riverine wetlands containing unmodified springs		Cooper		Y	The refugia nature of LEBB springs has resulted in distinct flora and fauna assemblages including highly specialised and endemic species. For example, recent studies have revealed LEBB springs to be evolutionary hotspots providing habitat for endemic plants, fish, snails and other invertebrates (Boyd 1990; Ponder 2002; Fensham and Fairfax 2003; Ponder 2003; Fensham and Price 2004; Fensham et al. 2004; Fairfax et al. 2007) as well as refugia for non-endemic native plants isolated by over 500 km from other populations (Fensham et al. 2004). Wetlands containing unmodified springs in the LEBB were considered to have very high intrinsic conservation value.	6.1.1	4
cp_nr_ec_13	Non-riverine wetlands containing modified springs		Cooper		Y	The refugia nature of LEBB springs has resulted in distinct flora and fauna assemblages including highly specialised and endemic species. For example, recent studies have revealed LEBB springs to be evolutionary hotspots providing habitat for endemic plants, fish, snails and other invertebrates (Boyd 1990; Ponder 2002; Fensham and Fairfax 2003; Ponder 2003; Fensham and Price 2004; Fensham et al. 2004; Fairfax et al. 2007) as well as refugia for non-endemic native plants isolated by over 500 km from other populations (Fensham et al. 2004). Wetlands containing modified springs in the LEBB were considered to have high intrinsic conservation value.	6.1.1	3

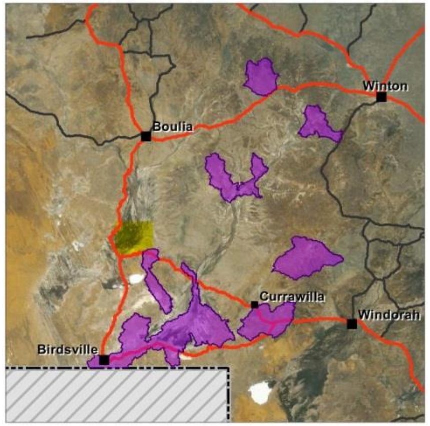
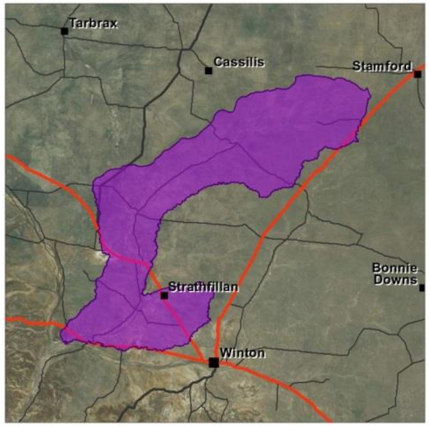
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_ec_01	Wilson's River		Cooper	Y		A dune dissected the Wilson River sometime in the past creating a barrier for aquatic species resulting in unique species assemblages. This is a geomorphic feature unique to the Cooper Creek catchment.	6.1.1	3
cp_r_ec_02	Wilson's Swamp, Tanbar and Eulbertie waterholes		Cooper	Y		The unique geomorphology of the sand dunes has created permanent water holes (Wilson's Swamp, Tanbar and Eulbertie waterholes).	6.1.1	3

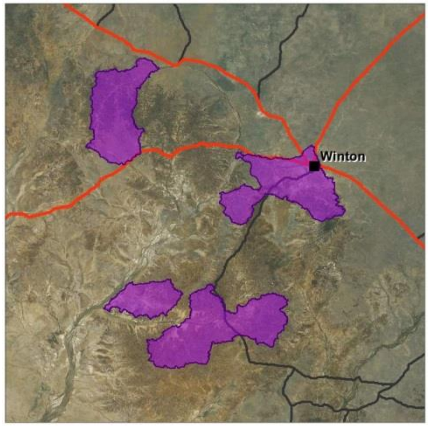
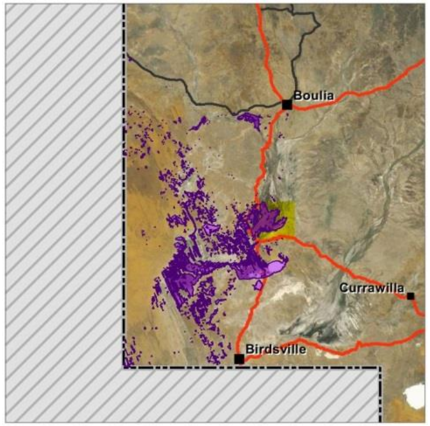
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
cp_r_ec_03	Semi-permanent waterholes (75%-99%, >50 years)		Cooper	Y		Semi-permanent waterholes (present 75%-99% of the time for >50 years) were considered by the expert panel as significant habitat features in the landscape. Connectivity between permanent waterholes is often maintained through less permanent waterholes acting as a conduit (lateral connectivity and longitudinal connectivity down the stream). The role that these waterholes play in the landscape depends on the wetness/season of the year. Distance from waterholes is important with respect to frequency of flooding.	6.3.1	2
cp_r_ec_04	Rockholes		Cooper	Y		The panel identified the significant values of permanent rockholes across the LEBB. These rain fed and isolated aquatic ecosystems sustain unique biota (similar to claypans with respect to uniqueness). Rockholes are mostly located in the upper catchment areas. These are also important for terrestrial wildlife and are also culturally significant. A point dataset collected by Jenny Silcock was used.	5.2.1	3

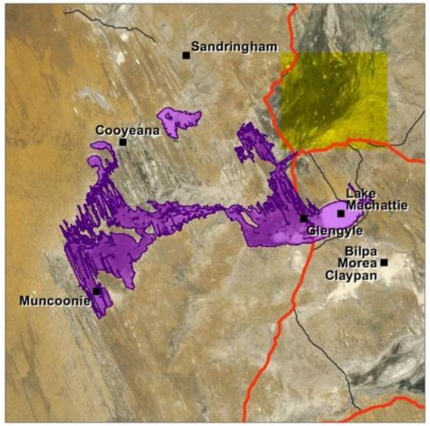
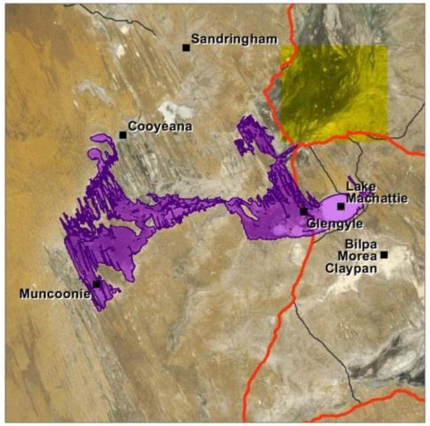
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_nr_ec_02	Temporary claypan wetlands		Diamantina		Y	A number of temporary claypan wetlands not fed by rivers have different biota adapted to different desiccation cycles e.g. fairy shrimp. For the majority of their time they are dry and are susceptible to cattle damage and woody debris removal. The REs associated with this decision are: 4.3.12b, d; 5.3.13b; 5.3.15a, b; 5.3.16a; 5.3.22a; 5.3.8b; 6.3.11; 6.3.11b.	5.2.1	3
di_nr_ec_03	Ephemeral lakes — Bilpa Morea claypan and associated wetland complex		Diamantina		Y	Bilpa Morea claypan is a very large wetland and is unique for that catchment (but not as unique as Makadi). Significant threatened taxa include bilby, kowari and other species (DERM 2009a).	6.1.1 6.3.3	3, 3

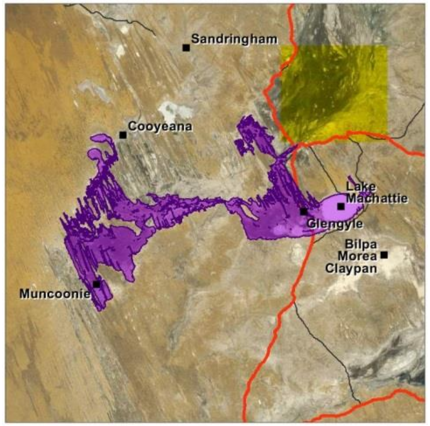
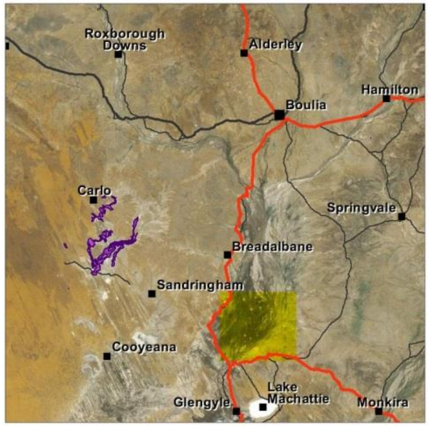
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_nr_ec_04	Moonda Lake		Diamantina		Y	Large lakes away from major watercourse with expanses of gibber country. Considered unique but more data required.	6.1.1 6.3.3	3, 3
di_nr_ec_06	Non-riverine wetlands containing unmodified springs		Diamantina		Y	The refugia nature of LEBB springs has resulted in distinct flora and fauna assemblages including highly specialised and endemic species. For example, recent studies have revealed LEBB springs to be evolutionary hotspots providing habitat for endemic plants, fish, snails and other invertebrates (Boyd 1990; Ponder 2002; Fensham and Fairfax 2003; Ponder 2003; Fensham and Price 2004; Fensham et al. 2004; Fairfax et al. 2007) as well as refugia for non-endemic native plants isolated by over 500 km from other populations (Fensham et al. 2004). Wetlands containing unmodified springs in the LEBB were considered to have very high intrinsic conservation value.	6.1.1	4

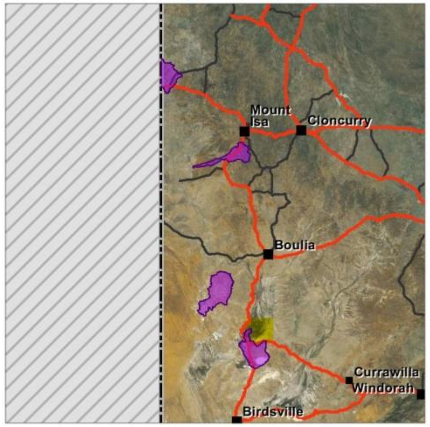
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_r_ec_01	Dunal waterholes		Diamantina	Y		Across the Diamantina and Cooper floodplains are dunal systems extending out of the mud layer. Where there are dunes close to each other, waterholes sometimes form. It is in these waterholes where most surface water penetrates into the sand sheets below. Water is also thought to recharge on the edge of dunes as well. This water in the sand sheets supports surrounding dunal vegetation during dry periods. These geomorphic sites are also culturally significant because it was often where aboriginal people congregated. Some dunes have clay pans in middle of them and are quite complex. Sand dunes also would likely absorb rainfall. This is one of three mechanisms to form waterholes (Knighton & Nanson 1994, Habeck-Fardy & Nanson 2014).	6.1.1	3
di_r_ec_02	Hunter Gorge		Diamantina	Y		Hunters Gorge, near Diamantina Lakes, is a unique geomorphic feature. It is where the Diamantina is confined by the surrounding geology. There is a strong interaction between the geology and vegetation with a diversity of geological features and riparian habitats. The water hole is very deep (>10 m) for the Diamantina system. Between Hunters Gorge and Wongeri additional geomorphic feature are ridge forming anabranches. Presence of threatened species, e.g. freckled duck, and used by migratory waterbirds (Blackman et al. 1999). Part of recognised Diamantina & Astrebla Grasslands IBA (Dutson et al. 2009), especially for straw-necked ibis and white-necked heron.	6.1.1	4

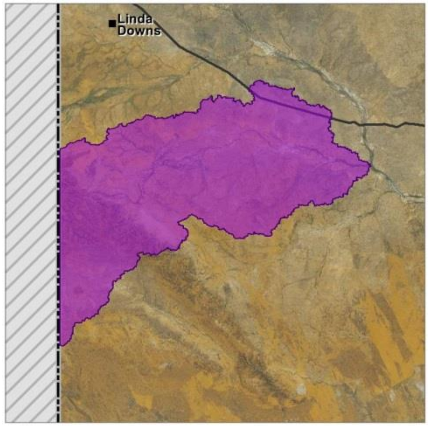
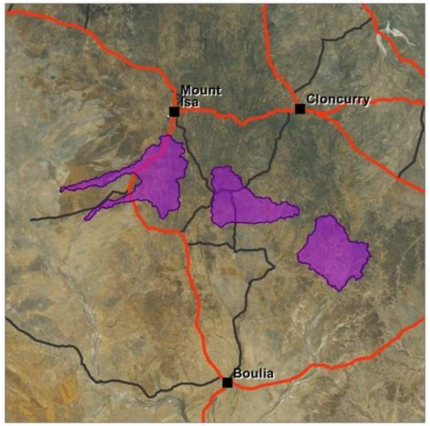
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_r_ec_03	Semi-permanent waterholes (75%-99%, >50 years)		Diamantina	Y		Semi-permanent waterholes (present 75%-99% of the time for >50 years) were considered by the expert panel as significant habitat features in the landscape. Connectivity between permanent waterholes is often maintained through less permanent waterholes acting as a conduit (lateral connectivity and longitudinal connectivity down the stream). The role that these waterholes play in the landscape depends on the wetness/season of the year. Distance from waterholes is important with respect to frequency of flooding.	6.3.1	2
di_r_ec_04	Wokingham Creek		Diamantina	Y		Wokingham Creek near Winton was identified by the panel as having a unique geomorphology particularly in relation to its location in catchment.	6.1.1	3

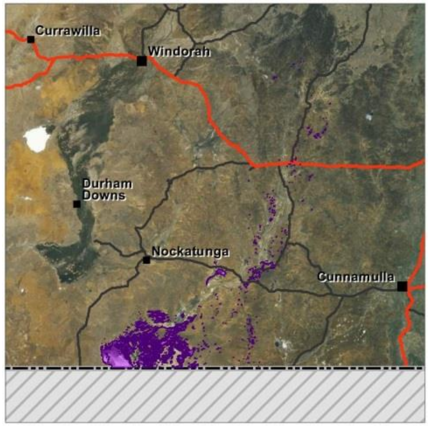
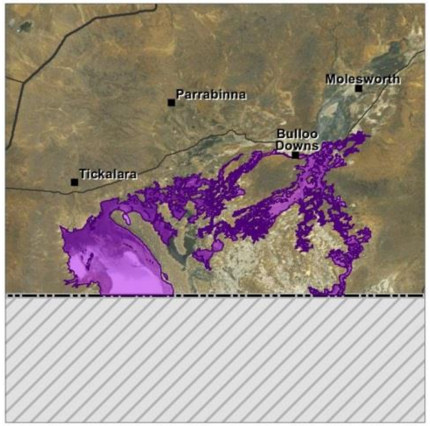
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
di_r_ec_05	Rockholes		Diamantina	Y		The panel identified the significant values of permanent rockholes across the LEBB. These rain fed and isolated aquatic ecosystems sustain unique biota (similar to claypans with respect to uniqueness). Rockholes are mostly located in the upper catchment areas. These are also important for terrestrial wildlife and are also culturally significant. A point dataset collected by Jenny Silcock was used. Limited sampling of rock holes in the dissected residuals in the central Diamantina reveal that they usually have one or two common fish species such as rainbowfish and spangled perch.	5.2.1	3
ge_nr_ec_02	Temporary claypan wetlands		Georgina		Y	A number of temporary claypan wetlands not fed by rivers have different biota adapted to different desiccation cycles e.g. fairy shrimp. For the majority of their time they are dry and are susceptible to cattle damage and woody debris removal. The REs associated with this decision are: 4.3.12b, d; 5.3.13b; 5.3.15a, b; 5.3.16a; 5.3.22a; 5.3.8b; 6.3.11; 6.3.11b.	5.2.1	3

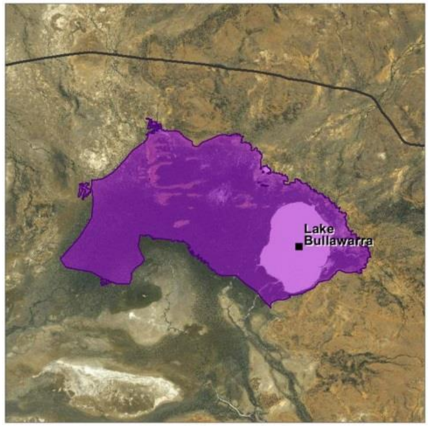
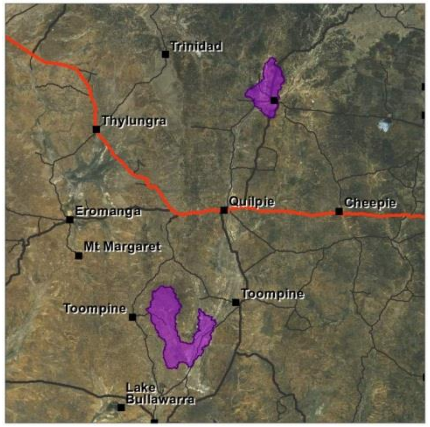
Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_ec_04	Georgina terminal lakes — Lake Phillipi, Mumbleberry and Torquinie		Georgina		Y	The terminal lakes of Phillipi, Mumbleberry and Torquinie (three lakes in total) have similar values to Lake Yamma Yamma, but smaller with desiccation resistant faunal assemblages. These lakes have a broad, low gradient floodplain within a large swamp and playa system, surrounded and intruded by sandhills (Blackman et al. 1999). Lake Torquinie is bounded by longitudinal dunes of the Simpson Desert. Mildly saline waterholes and lakes, except when first filled (fresh for short periods). Kingsford et al. (1992) found up to 85% of the freckled ducks counted in Eastern Australia occurred on Lakes Torquinie and Mumbleberry. Significant permanent waterholes used by range of waterbirds including migrants (Blackman et al. 1999). Part of recognised Lakes Muncoonie, Mumbleberry & Torquinie IBA (Dutson et al. 2009).	6.1.1 6.3.3	3, 3
ge_nr_ec_05	Ephemeral lakes — Muncoonie Lake and Lake Selicia		Georgina		Y	Muncoonie Lake and Lake Selicia are unique wetlands forming part of the swamp complex on the Georgina floodplain. Muncoonie Lakes fill about one year in ten and dry out within six months without top up. Waterholes in the area are generally saline, becoming more so as they dry. Supports freckled duck and number of internationally listed waterbird taxa (Blackman et al. 1999). Part of recognised Lakes Muncoonie, Mumbleberry & Torquinie IBA (Dutson et al. 2009).	6.1.1 6.3.3	3, 3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_ec_06	Ephemeral lakes — Lakes Machattie, Mipia and Koolivoo		Georgina		Y	Lake Machattie is a large lake that forms part of a massive swamp complex including lakes Mipia and Koolivoo on the Georgina floodplain. Lakes and associated floodplain, swamps and playas act as significant water resource in dry area (Blackman et al. 1999). Wildlife refugia, waterbird breeding habitat, grey falcon breeding records and grey grasswren (Diamantina subspecies) habitat (Blackman et al. 1999; DERM 2009a). Part of recognised Lake Machattie IBA (Dutson et al. 2009). Contains significant flora values, high diversity of chenopod communities and physically retains wet species even though it is not wet all the time.	6.1.1 6.3.3	3, 3
ge_nr_ec_08	Non-riverine wetlands containing unmodified springs		Georgina		Y	The refugia nature of LEBB springs has resulted in distinct flora and fauna assemblages including highly specialised and endemic species. For example, recent studies have revealed LEBB springs to be evolutionary hotspots providing habitat for endemic plants, fish, snails and other invertebrates (Boyd 1990; Ponder 2002; Fensham and Fairfax 2003; Ponder 2003; Fensham and Price 2004; Fensham et al. 2004; Fairfax et al. 2007) as well as refugia for non-endemic native plants isolated by over 500 km from other populations (Fensham et al. 2004). Wetlands containing unmodified springs in the LEBB were considered to have very high intrinsic conservation value.	6.1.1	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_nr_ec_09	Non-riverine wetlands containing modified springs		Georgina		Y	The refugia nature of LEBB springs has resulted in distinct flora and fauna assemblages including highly specialised and endemic species. For example, recent studies have revealed LEBB springs to be evolutionary hotspots providing habitat for endemic plants, fish, snails and other invertebrates (Boyd 1990; Ponder 2002; Fensham and Fairfax 2003; Ponder 2003; Fensham and Price 2004; Fensham et al. 2004; Fairfax et al. 2007) as well as refugia for non-endemic native plants isolated by over 500 km from other populations (Fensham et al. 2004). Wetlands containing modified springs in the LEBB were considered to have high intrinsic conservation value.	6.1.1	3
ge_r_ec_01	Semi-permanent waterholes (75%-99%, >50 years)		Georgina	Y		The semi-permanent waterholes were also considered by the expert panel as significant habitat features in the landscape. Connectivity between permanent waterholes is often maintained through less permanent waterholes acting as a conduit (lateral connectivity and longitudinal connectivity down the stream). The role that these waterholes play in the landscape depends on the wetness/season of the year. Distance from waterholes is important with respect to frequency of flooding.	6.3.1	2

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ge_r_ec_02	Toko Gorge		Georgina	Y		Toko Gorge is a unique, small gorge holding permanent water. It is listed on the national Directory of Important Wetlands. The gorge is of high aesthetic value and has been listed as an outstanding geomorphic feature (Blackman et al. 1999). Toko Gorge which has permanent or near-permanent water (possibly spring-fed) in gorge (DERM 2009b). This renders it an important and very isolated refuge water body. Its inaccessible nature means that it is largely unsurveyed. The area is culturally very significant.	6.1.1	4
ge_r_ec_03	Rockholes		Georgina	Y		The panel identified the significant values of permanent rockholes across the LEBB. These rain fed and isolated aquatic ecosystems sustain unique biota (similar to claypans with respect to uniqueness). Rockholes are mostly located in the upper catchment areas. These are also important for terrestrial wildlife and are also culturally significant. A point dataset collected by Jenny Silcock was used.	5.2.1	3

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ul_nr_ec_02	Temporary claypan wetlands		Bulloo		Y	A number of temporary claypan wetlands not fed by rivers have different biota adapted to different desiccation cycles e.g. fairy shrimp. For the majority of their time they are dry and are susceptible to cattle damage and woody debris removal. The REs associated with this decision are: 4.3.12b, d; 5.3.13b; 5.3.15a, b; 5.3.16a; 5.3.22a; 5.3.8b; 6.3.11; 6.3.11b.	5.2.1	3
ul_nr_ec_03	Bulloo Lake		Bulloo		Y	The Bulloo Lake is a large terminal lake that extends across the Queensland and NSW border. It provides significant habitat values, including extensive areas of lignum that are used by grey grasswren (Bulloo subspecies).	6.3.3	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
ul_nr_ec_04	Lake Bullawarra		Bulloo		Y	Lake Bullawarra is a broad, shallow playa lake surrounded by low gradient floodplains and low lying swamps with anastomosing channels (Blackman et al. 1999). When full the lake has a shallow open water area of some 1,000ha. It contains an outlier population of black box *Eucalyptus largiflorens* (Blackman et al. 1999).	6.3.3	4
ul_r_ec_01	Semi-permanent waterholes (75%-99%, >50 years)		Bulloo	Y		Semi-permanent waterholes (present 75%-99% of the time for >50 years) were considered by the expert panel as significant habitat features in the landscape. Connectivity between permanent waterholes is often maintained through less permanent waterholes acting as a conduit (lateral connectivity and longitudinal connectivity down the stream). The role that these waterholes play in the landscape depends on the wetness/season of the year. Distance from waterholes is important with respect to frequency of flooding.	6.3.1	2
nr_05_not_implemented	Floodplain areas experiencing extended flood regimes — high productivity	This decision was not implemented because of insufficient detail and time.	Cooper Bulloo Diamantina Georgina		Y	Floodplain areas where flood durations are prolonged resulting in increased productivity which is important for the boom/bust food web. During floods these areas stay connected for long periods (e.g. 50 days to six months).	6.4.1	4

Decision number	Special feature (name)	Location	Study area	R[1]	NR[1]	Values	CIM[2]	Con. rating[3]
nr_06_not_implemented	Floodplain areas experiencing extended flood regimes — low productivity	This decision was not implemented due to insufficient detail and time.	Cooper Bulloo Diamantina Georgina		Y	Floodplain areas where flood durations are prolonged resulting in low productivity which is important for the boom \ bust food web. During floods these areas stay connected for long periods (e.g. 50 days to six months).	6.4.1	3
nr_10_not_implemented	Cooper Creek floodplain recharge geomorphic features	This decision was not implemented due to insufficient detail and time.	Cooper		Y	Across the floodplain of the Cooper Creek are dunal systems extending out of the mud layer. Where there are dunes close to each other, waterholes sometimes form. It is in these waterholes where most surface water penetrates into the sand sheets below. Water is also thought to recharge on the edge of dunes as well. This water in the sand sheets supports surrounding dunal vegetation during dry periods. These geomorphic sites are also culturally significant because it was often where aboriginal people congregated. Some dunes have clay pans in middle of them and are quite complex. Sand dunes also would likely absorb rainfall. This is one of three mechanisms to form waterholes (Knighton & Nanson 1994, Habeck-Fardy & Nanson 2014).	6.1.1	2

[1] R = Riverine, NR = Non-riverine.

[2] Criteria, indicators and measures (used in AquaBAMM).

[3] Conservation rating between 1 (Low) and 4 (Very High).

5.2 Connectivity

The panel members were asked to develop and/or identify a set of principles that could be applied to determine relative connectivity scores for the riverine and non-riverine wetlands based on the existing AquaBAMM criterion for connectivity. The following sections focus on implementing the connectivity measures for riverine wetlands. Discussion on non-riverine wetland connectivity is recorded here where relevant.

5.2.1 Importance of connectivity

There was broad agreement by the panel that the concept of connectivity is important, and it is directly or indirectly linked to most facets of aquatic ecology, geomorphology and water quality. The scientific literature reviewed for the AquaBAMM program reflects this view. The ecological value of a particular reach of river is directly linked in quantity and quality to the movement both up and downstream (and between adjoining terrestrial lands) of resources such as water, sediment and debris and recruitment and distribution of species (Cullen 2003).

An inherent connectivity (or lack of connectivity in drier periods) is a significant feature of fresh waters. In arid-zone systems, and floodplains, the irregular flow regime and sporadic connectivity underpins the conservation of the in-stream and floodplain wetland biota such as the invertebrate assemblages (Sheldon et al. 2002; Leigh et al. 2010). Similarly, this relationship is evident for maintaining the health and productivity of end-of-river estuarine systems (Cullen 2003).

A largely unknown and unseen linkage occurs within the hyporheic zone between surface waters and groundwater ecosystems sustaining many endemic or relictual invertebrate fauna (Boulton et al. 2003).

5.2.2 Applying principles for measuring connectivity

The practicalities of measuring connectivity in a riverine environment are complex, making general principles difficult to develop and implement. Connectivity in its broadest meaning incorporates hydrological processes (quantity and quality, temporal and spatial variability), organism dispersal (barriers) and disturbances from natural sources. Connectivity can be bi-directional movements within a stream (e.g. fish passage), uni-directional contribution to a downstream spatial unit or special area, or lateral connectivity to floodplain wetlands or groundwater ecosystems. These aspects of connectivity combine to provide a matrix of competing and differing values from an ecological conservation viewpoint.

5.2.3 Fish passage — measure 7.1.2

There was some discussion regarding connectivity of fish passage during the aquatic fauna panel and the wetland ecology panel workshops. The panel recognised that the watercourses within the LEBB remain connected with few significant in-stream barriers. Cooper Creek is a good example of a river system being connected to its floodplain. In fact, without this link a number of ecosystem functions would start to fail, e.g. significant waterbird breeding events. Consequently, connectivity between the rivers and floodplain wetlands is an important function identified by the panel. In addition, the panel identified retaining permanent waterholes in the river as critical, allowing populations of aquatic fauna, e.g. fish, turtle, molluscs and crustaceans, to survive during drought conditions. The LEBB connectivity has not been as affected as the Murray–Darling Basin catchments or coastal systems. Due to connectivity maintenance in most areas of the LEBB, any break from in-stream barriers or levees could have detrimental effects on the overall survival of that part of the system.

Specifically regarding fish passage, the panels examined all aspects of this issue including barriers at the local and regional scale. Examples of local barriers included road culverts and road crossings that are likely to be barriers to dispersal during low flows and drought conditions. Regional barriers consisted of the larger weirs for town water supplies and are listed in Table 19. At Longreach, there are seven old weirs on various channels of the Thomson River which don't have a fishway, however due to the number of channels, medium flows are able to over top providing an alternative fish passage upstream. The main weir at Longreach has been built with an operational fishway. Despite this, the panels recognised that while most of the weirs in the Cooper Creek are drowned out in medium floods, their perceived impact during extended drier periods was considered to be relatively high for those weirs with a wall height > five metres. Thus the rules implemented for AquaBAMM measure 7.1.2 (Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit) in the subsections with weirs were: weirs >five metres = one conservation rating and weirs < five metres = three conservation rating.

In addition to the rules applied to the subsections with weirs present, the panel also recommended that all subsections above Barcaldine Weir be downgraded for 7.1.2 to receive a conservation value of one. This is because of the limited movement of yellowbelly above this weir. With the exception of subsections above Barcaldine Weir, subsections not containing any of the weirs listed in Table 19 received a conservation value of four.

Table 19. Licensed weirs in the Cooper Creek basin and their approximate wall heights and corresponding scores used for measure 7.1.2

Weir name	Approximate wall height (m)[1]	AquaBAMM Conservation rating (M7.1.2)
Oma	1	3
Ilfracombe	4 (wing wall)	3
Fairmount	5	1
Bimbah	2.5	3
Goodberry Hills	2.3	3
Main Weirs	4.5	3
Isisford Town	1.5 to 2	3
Lloyd Jones (Barcaldine Weir)	7	1
Stonehenge	1.5	3
Jericho	2	3

[1] DERM estimates from Longreach Office.

5.2.4 Connectivity of special features — measures 7.1.1 and 7.3.1

The panel members were also asked to develop principles for scoring connectivity for special features such as waterfalls, macrophyte beds, significant in-stream habitats, and other areas or features identified through expert opinion. This question primarily relates to uni-directional connectivity, i.e. quantity or quality of flow to a downstream special feature.

The principles for assessing connectivity values for special features (measures 7.1.1, 7.3.1) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton et al. 2006) was tabled at the panel workshop. The panel agreed that the “Model 4—Inverse exponential scoring of spatial units upstream” method could be implemented in the LEBB. This model is as follows:

This model uses the spatial units rather than a distance to determine how they are scored. Every contributing spatial unit above a particular special feature was logarithmically scored with the spatial units immediately upstream of a special feature being scored a four, the next adjoining upstream spatial units received a score of two and the remainder of spatial units above a special feature were scored a one. The spatial unit having the special feature located within it would not receive a score because it was already scored in criterion six (it may receive a score where it is upstream of another special feature). Where a spatial unit had more than one calculation (i.e. overlapping scores), the maximum value was incorporated.

This model better reflects the importance of spatial units immediately above a special feature by applying a logarithmic threshold to scoring. It is also an efficient and practical application of a complex issue. A disadvantage of this model is that it treats all special features (e.g. macrophyte bed, geomorphological feature, hydrological feature) equally where there may be reasons to differentiate between them. Also, this model can result in some variation of the real distances upstream of a special feature being scored.

The panel also recognised that there is some value that can be placed on downstream spatial units connected to special features e.g. some fish need to move downstream to breed. This approach was not applied in the assessment because further investigation is required to determine whether this model can be applied downstream based on the values in the LEBB.

5.3 Modelled natural flows — measure 1.4.2

Cullen (2003) proposed an Australian River Classification based solely on flow extractions from rivers (Table 20). He argued that flow diversion is the most important threatening process, and one that is easily understood and managed. Cullen (2003) believed a flow classification could be useful in water planning in Australia.

The flow extraction thresholds used for AquaBAMM measure 1.4.2 (Percent natural flows — modelled flows remaining relative to predevelopment) are shown in Table 20. These values represent broad-scale trends and were interpreted from LEBB flow data by DERM hydrologists. Spatial boundaries between classes necessarily approximate and identify areas of modified hydrology and developed the flow classes above. The percent natural flow class of the highest stream order within a spatial unit was assigned to all of the other streams within a spatial unit.

Table 20. Australian rivers classification

River class	% mean annual flow
Heritage River	>95%
Conservation River	85 to 95%
Sustainable Working River	67 to 85%
Managed Working River	<67%

5.4 Stratification

Study area stratification for application to one or more AquaBAMM measures is not mandatory for a successful assessment. AquaBAMM makes provisions for data to be stratified in any defined manner that is determined to be ecologically appropriate. Stratification mitigates the effects of data averaging across large study areas, and is particularly important where ecological diversity and complexity is high. An example where stratification may be appropriate is fish diversity where fewer species inhabit the upland zone compared to lowland floodplains. For measure datasets where there is an equal probability of scoring across a range of values throughout the study area, stratification is unwarranted. To date, the use of strata in completed ACAs has been based on elevation (e.g. 150m ASL for coastal catchments and 400 m ASL for catchments west of the Great Dividing Range in the Murray–Darling Basin) or bioregional boundaries.

Stratification was considered as part of the expert panel process. The LEBB catchments have three broad geomorphic zones: headwaters, central braided channels and the channel country distributaries leading to a terminal lake (Lake Eyre or Bulloo Lake). The fauna panel members agreed that while there is geomorphic variation, and consequently distinct ecosystems within these broad zones, biologically there was no imperative to stratify the ACA outputs for species (fish, frogs and birds). For example, genetically there is little difference between fish populations in lowland areas to the headwater streams indicating genetic connectivity within a catchment. Lake Eyre was considered by the panel to represent a barrier to genetic transfer between catchments in the Lake Eyre Basin, however this is outside of the overall LEBB study area. The Cooper Creek system is centrally located which is also reflected in genetic diversity of several groups of organisms (fish, molluscs).

After careful consideration the expert panel and the project team decided not stratify the LEBB study areas.

5.5 Groundwater dependent ecosystems — springs

A distinct hydrological component of the LEBB is the deep artesian groundwater systems which operate almost entirely independent of shallower surface water alluvial aquifers (Armstrong 1990). In fact, water emanating from deep artesian groundwater has resulted in numerous spring wetlands which provide specialised habitats of high intrinsic conservation value (Fensham & Fairfax 2003; Fensham et al. 2007). For example, LEBB springs have been recoded as providing habitat for at least seven endemic snails from one genus, a number of undescribed ostracods, amphipods and other invertebrates (Ponder 1986), and a number of endemic flora species (Fensham et al. 2007). Some fish species in the LEBB are totally restricted to mound spring habitats critical for their survival. The Edgbaston Springs within the Springsure Supergroup contain two and possibly three endemic species of fish including the endangered redfin blue eye *Scaturiginichthys vermeilipinnis* which occurs in only several small springs. The cracking clay soils and surrounding grasslands also support a high diversity of large elapid snakes, several endemic reptile species, and very high densities of a number of grassland birds, small distinctive marsupials and reptiles.

Struck by the abundance and importance of springs within the study areas, the expert panel expressed a strong desire to assess the conservation values of springs as part of the LEBB ACAs. The following sections describe key observations and suggestions made by experts (in session and out of session) and the final approach used to assess the conservation values of springs as part of this project.

5.5.1 Spring typology

The expert panels identified the following three distinct types of springs within the LEBB study areas:

1. tertiary springs, those springs located in basalt outcrops (subset of outcrop springs)

2. recharge springs, those springs located in sandstone outcrops (subset of outcrop springs)

3. discharge springs, surface expressions in the landscape that originate from the GAB (e.g. Edgbaston Springs).

The tertiary springs were considered to be unique because their water is derived from tertiary basalt substrates rather than GAB groundwater sources. They have a different set of fauna (stygofauna) and flora to other spring types because of the unique water chemistry, but are little known or understood. Recharge springs include those occurring on sandstone outcrops and which have different RE types (e.g. RE 6.7.18 in the top of the Diamantina) to the tertiary or basalt derived springs. These springs have a short resonance time from when the water enters an aquifer to its subsequent surface expression. The third type of spring, discharge springs, originate from GAB water sources and have the greatest levels of fauna and flora endemics. Consequently, these springs are usually of very high conservation significance depending on the available habitat, threats and local species.

An attempt was made to use this typology within the LEBB ACAs through incorporating this typology into criterion eight: Representativeness. This was not possible in this iteration of the LEBB ACAs and has been postponed to a later version.

5.5.2 Spring conservation ratings—measure 6.3.3

The expert panel recommended that an Aquatic Conservation Assessment for springs could rank spring spatial units according to the conservation scores assigned by Fensham and Fairfax (2005). For example, Fensham and Fairfax (2005) assessed the conservation priority of GAB springs using the using the following criteria:

1. Category 1a: These spring wetlands provide habitat for biota endemic to one spring complex.

2. Category 1b: These spring wetlands provide habitat for biota endemic to more than one spring complex.

3. Category 1c: These spring wetlands provide habitat for species listed under State or Commonwealth legislation (except *Callistemon* sp. Boulia (L. Pedley 5297) which is listed as vulnerable under the EPBC and has since been identified as the common species *C. viminalis*).

4. Category 2: These spring wetlands provide habitat for some isolated populations of plant species, or are outstanding examples of their type.

5. Category 3: Any spring of lower value than above that is relatively intact.

6. Category 4: Severely degraded by any threatening processes.

The expert panel suggested that Fensham and Fairfax (2005) scores be assigned to measure 6.3.3 as described in **Table** 21. The project team decided not implement this recommendation because the scores provided by Fensham and Fairfax (2005) incorporate criteria already captured by the CIM (Appendix C. Criteria, indicators and measures for the Lake Eyre and Bulloo Basins ACAs).

Table 21. Scores from Fensham and Fairfax (2005) and the corresponding measure 6.3.3 scores suggested by the expert panel

Fensham & Fairfax (2005) Score	AquaBAMM Measure 6.3.3 Score
4	1
3	2
2	3
1a,b,c	4

5.5.3 Springs implementation approach

In previous ACAs spring values have been included as a value of any containing non-riverine wetlands. Struck by the abundance and importance of springs within the LEBB region, the LEBB ACA project team sought to uniquely assess the aquatic conservation value of springs. This (LEBB ACAs v1.1) is the first time that the AquaBAMM has been applied to spring wetlands.

For the LEBB ACAs springs were defined as discrete (i.e. <1ha) hydrological features where groundwater discharges to the land surface. The spatial units used for springs were sourced from the point data contained within the Queensland Wetland Data (Version 4.0). Only unmodified (HYDROMOD = 'H1') and active-modified (HYDROMOD = 'H2M4') non-riverine springs were assessed. Dormant springs (HYDROMOD = 'H2M4a') were omitted as they are currently inactive. Five riverine springs within the LEBB study areas were also excluded. A total of 819 springs were assessed as part of the LEBB ACAs.

Each spring point was assigned a unique spatial unit ID (SPUNITID) and an area of zero. All spring spatial units were uniquely assessed using the AquaBAMM database tool. A point geometry-type shapefile containing the spring results has been included in the final LEBB ACAs release package.

Springs were implemented as a district *wetland system type* within the non-riverine AquaBAMM tool databases compiled for each study area. To achieve this spatial units were stratified by *wetland system type* (i.e. stratum 1 = spring wetlands, stratum 2 = non-riverine wetlands). Stratifying in this way allowed different threshold types and/or threshold values to be used for each *wetland system type* within the AquaBAMM databases. Using stratification in this way allowed multiple ACAs to be run within the same AquaBAMM database reducing the data handling and computational overhead.

Implementing spring ACAs within the non-riverine AquaBAMM database should be viewed as an intermediary between the previous approach used to assess spring values and a totally separate ACA for springs using the AquaBAMM. The latter will require additional work including the creation of both a CIM and filter table specifically tailored to spring wetlands. This may involve the modification and/or addition of new AquaBAMM measures including some related to Connectivity and Representativeness. Both of these were beyond the scope and timeframes of the current project.

For the LEBB spring ACAs input data values for measures not available or applicable to springs were left blank in the non-riverine AquaBAMM databases. Doing so effectively turned these measures off leaving the corresponding AquaBAMM results (i.e. AquaScores, criterion and indicator ratings) unaffected. One consequence of this is that the dependability scores produced by the database may underestimate a spring's actual data richness. However, given a known subset of AquaBAMM measures specific to springs, this limitation could be overcome by recalculating spring dependability scores in any database application.

5.5.3.1 Spring species measures

Some species are endemic to springs wetlands. To account for this, species records were assigned a corresponding *wetland system type* (i.e. riverine species, non-riverine species, and spring species). In contrast to non-riverine spatial units, species counts for springs consisted of the total number of unique spring species within a 2 km buffer of each spring spatial unit. Species were counted in this way to account for the varying geographical precision of the spring points, high spring species endemism, and the greater survey effort afforded to springs within the Great Artesian Basin (D. Fielder, pers. comm.).

5.5.3.2 Spring special features

Two new special feature decisions were created subsequent to the expert panel workshops with the aim of assigning value to any non-riverine wetland containing a spring. Specifically, all non-riverine spatial units coincident with a buffered "unmodified" spring (i.e. 'H1') were assigned a score of 4 for AquaBAMM measure 6.1.1 (Presence of distinct, unique or special geomorphic features); non-riverine spatial units coincident with a buffered "active — modified" spring were assigned a score of 3 for AquaBAMM measure 6.1.1 (Presence of distinct, unique or special geomorphic features). Springs were buffered by 100m to account for varying geographical precision of spring points in the Queensland Wetland Data.

Also, springs were not considered explicitly by the expert panel in terms of their special feature values. As a result, all non-riverine special features identified by the expert panel and coincident with a spring were applied to the corresponding spring spatial units unless the expert panel decision explicitly related to non-spring type special features values. To implement this all non-riverine special features coincident with a buffered spring were applied to the spring spatial unit. Once again a 100m spring buffer was used to account for varying geographical precision of spring points in the Queensland Wetland Data.

6 Weights and Ranks

The importance of each AquaBAMM measure may vary in terms of its individual significance and contribution to its respective indicator. To account for this variability AquaBAMM uses weights when combining individual measure scores to calculate an overall indicator score.

Similarly, the importance of each AquaBAMM indicator may vary in terms of its individual significance and contribution to its respective criterion. For example, unadjusted indicator scores perform in a similar way to other 'measures of central tendency' (e.g. average) in that outlying measure values are de-emphasised. This may be undesirable in conservation values assessments as extreme values can be important regardless of the distribution of other values. To account for this, AquaBAMM uses ranks to adjust indicator scores increasing the influence of the highest ranked indicator score.

Panel members and project officers attending the expert panel workshops were asked to weight measures and rank indicators based on ecological significance and preferred contribution to the conservation values of LEBB wetlands. While other methods may exist for eliciting weights and ranks from experts the increased benefit of using these methods were considered small relative to the extra time and complexity required.

6.1 Weighting of measures

Measures were weighted according to their importance to an indicator and based on the following rules:

- At least one measure within each indicator must be weighted 10 which is the highest weighting.
- Other measures within each indicator were weighted compared to the weighting of 10 assigned in the first step.
- It was okay to have different measures with the same weight (i.e. all measures could be weighted 10).
- Some indicators only had one measure and had already been given a weighting of 10.
- Measures shouldn't be weighted down because of the quality or lack of data for that measure.

Weights from all respondents were averaged and reviewed with particular attention to averages having a high variance. A decision was made to use measure weights averaged across all study areas to improve statistical reliability.

Table 22 and Table 23 list the weights used for all AquaBAMM measures used for the LEBB ACAs. A copy of the complete CIM list used for the LEBB ACAs is given in Appendix C. Criteria, indicators and measures for the Lake Eyre and Bulloo Basins ACA

Table 22. Measure weights used for the riverine ACAs

Maximum score is 10.

Criteria and indicators	Measure	Measure description	Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland	10
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	7.8
	1.1.3	Presence of exotic invertebrate fauna within the wetland	8.8
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	9.4
1.3 Habitat features modification	1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	10
1.4 Hydrological modification	1.4.5	Hydrological disturbance/modification of the wetland (e.g. as determined through EPA wetland mapping and classification)	10
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.5	% area of remnant vegetation relative to preclear extent within	10

Criteria and indicators	Measure	Measure description	Weight
		buffered non-riverine wetland: 500m buffer for wetlands >= 8Ha, 200m buffer for smaller wetlands	
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	10
	2.3.2	% "grazing" land-use area	7.6
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	5.9
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	7.6
3 Diversity and richness			
3.1 Species	3.1.2	Richness of native fish	10
	3.1.3	Richness of native aquatic dependent reptiles	8
	3.1.4	Richness of native waterbirds	8.9
	3.1.5	Richness of native aquatic plants	9.2
	3.1.6	Richness of native amphibians (non-riverine wetland breeders)	9.3
	3.1.7	Richness of native aquatic dependent mammals	7.2
3.3 Habitat	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	7.1
	3.3.3	Richness of wetland types within the sub-catchment	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act	9.6
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species — NCA, EPBC Act	10
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA, EPBC Act	10
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc.)	9.5
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	10
	5.1.3	Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA / CAMBA / ROKAMBA agreement lists and/or Bonn Convention)	8.5
	5.1.4	Habitat for significant numbers of waterbirds	8
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10
6 Special features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10

Criteria and indicators	Measure	Measure description	Weight
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	10
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	9.5
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	9.4
8 Representativeness			
8.1 Wetland protection	8.1.1	The percentage of each wetland type within Protected Areas.	10
8.2 Wetland uniqueness	8.2.1	The relative abundance of the wetland management group to which the wetland type belongs within the catchment or study area (management groups ranked least common to most common)	7.3
	8.2.2	The relative abundance of the wetland management group to which the wetland type belongs within the subcatchment or estuarine/marine zone (management groups ranked least common to most common)	7.3
	8.2.3	The size of each wetland type relative to others of its management group within the catchment or study area	10
	8.2.4	The size of each wetland type relative to others of its type within a subcatchment (or estuarine zone)	7.1
	8.2.6	The size of each wetland type relative to others of its type within the catchment or study area	7.3

Table 23. Measure weights used for the non-riverine (including spring) ACAs

Maximum score is 10.

Criteria and indicators	Measure	Measure description	Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland	8.3
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	7.2
	1.1.3	Presence of exotic invertebrate fauna within the wetland	10
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	7.2
	1.2.1	SOR aquatic vegetation condition	10
1.3 Habitat features modification	1.3.1	SOR bank stability	6.4
	1.3.2	SOR bed & bar stability	6.2
	1.3.3	SOR aquatic habitat condition	8
	1.3.4	Presence/absence of dams/weirs within the wetland	10
	1.3.7	% area of remnant wetland relative to preclear extent for each	6.3

Criteria and indicators	Measure	Measure description	Weight
		spatial unit	
1.4 **Hydrological modification**	1.4.2	Percent natural flows — modelled flows remaining relative to predevelopment	10
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.1	% area of remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses	10
	2.2.2	Total number of REs relative to preclear number of REs within buffered riverine wetland or watercourses	7.0
	2.2.3	SOR reach environs	6.5
	2.2.4	SOR riparian vegetation condition	7.8
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	9.3
	2.3.2	% "grazing" land-use area	10
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	5.6
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	6.9
3 Diversity and richness			
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	9.3
	3.1.2	Richness of native fish	10
	3.1.3	Richness of native aquatic dependent reptiles	7.7
	3.1.4	Richness of native waterbirds	8.6
	3.1.5	Richness of native aquatic plants	7.9
	3.1.7	Richness of native aquatic dependent mammals	7.2
3.2 Communities/ assemblages	3.2.2	Richness of REs along riverine wetlands or watercourses within a specified buffer distance	10
3.3 Habitat	3.3.1	SOR channel diversity	8.4
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	6.3
	3.3.3	Richness of wetland types within the sub-catchment	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act	9.6
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species — NCA, EPBC Act	10
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA, EPBC Act	10

Criteria and indicators	Measure	Measure description	Weight
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc.)	9.5
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	10
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA / CAMBA / ROKAMBA agreement lists and/or Bonn Convention)	8.3
	5.1.4	Habitat for significant numbers of waterbirds	8.0
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10
6 Special Features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	9.3
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	10
7 Connectivity			
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criterion 5 and/ or 6	8.8
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit	10
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criterion 5 and/or 6	10

6.2 Ranking of indicators

Panel members and project officers attending the workshops ranked indicators within each criterion. Indicators were ranked according to their importance to a criterion and based on the following rules:

- At least one indicator within each criterion must be ranked one which is the highest ranking.
- The other indicators were ranked within each criterion relative to the ranking of one assigned in the first step.
- It was okay to have different indicators with the same ranking (i.e. all indicators may be ranked one).
- Indicator should not be ranked down because of the quality or lack of data for that indicator.

Ranks from all respondents were averaged and reviewed with particular attention to averages having a high variance. A decision was made to use indicator ranks averaged across all study areas to improve statistical reliability.

Table 24 and

Table 25 list the ranks used for all AquaBAMM indicators for the LEBB ACAs. A copy of the complete CIM list used for the LEBB ACAs is given in Appendix C. Criteria, indicators and measures for the Lake Eyre and Bulloo Basins ACA

Table 24. Indicator ranks used for the riverine ACAs

Maximum rank is one.

Criterion	Indicator description	Rank
1 Naturalness aquatic		
1.1	Exotic flora / fauna	1
1.2	Aquatic communities/ assemblages	1
1.3	Habitat features modification	1
1.4	Hydrological modification	2
2 Naturalness catchment		
2.1	Exotic flora / fauna	2
2.2	Riparian disturbance	3
2.3	Catchment disturbance	4
3 Diversity and richness		
3.1	Species	1
3.2	Communities / assemblages	1
3.3	Habitat	1
4 Threatened species and ecosystems		
4.1	Species	1
4.2	Communities / assemblages	2
5 Priority species and ecosystems		
5.1	Species	1
5.2	Communities / assemblages	2
6 Special features		
6.1	Geomorphic features	3
6.3	Habitat	2
7 Connectivity		

Criterion	Indicator description	Rank
7.1	Significant species or populations	1
7.3	Floodplain and wetland ecosystems	2

Table 25. Indicator ranks used for non-riverine (including spring) ACAs

Maximum rank is one.

Criterion	Indicator	Rank
1 Naturalness aquatic		
1.1	Exotic flora / fauna	1
1.3	Habitat features modification	2
1.4	Hydrological modification	3
2 Naturalness catchment		
2.1	Exotic flora / fauna	2
2.2	Riparian disturbance	2
2.3	Catchment disturbance	3
3 Diversity and richness		
3.1	Species	1
3.3	Habitat	1
4 Threatened species and ecosystems		
4.1	Species	1
4.2	Communities / assemblages	2
5 Priority species and ecosystems		
5.1	Species	1
5.2	Communities / assemblages	1
6 Special features		
6.1	Geomorphic features	3
6.3	Habitat	2
8 Representativeness		

Criterion	Indicator	Rank
8.1	Wetland protection	2
8.2	Wetland uniqueness	1

7 References

Armstrong, D 1990, Hydrology, In *Natural history of the North East Deserts*. eds Tyler, MJ, Twidale, CR, Davies, M, Wells, CB, Royal Society of South Australia, Adelaide.

Bamford, M, Watkins, D, Bancroft, W, Tischler, G, Wahl, J 2008, *Migratory shorebirds of the East Asian — Australasian flyway: population estimates and internationally important sites*, Wetlands International — Oceania, Canberra.

Bailey, V 2001, *Western streams water quality monitoring project*, Department of Natural Resources and Mines, Brisbane.

Baker, AM, Sheldon, F, Somerville, J, Walker, KF, Hughes, JM 2004, Mitochondrial DNA phylogenetic structuring suggests similarity between two morphologically plastic genera of Australian freshwater mussels (Unionoida: Hyriidae), *Molecular Phylogenetics and Evolution* 32, 902-912.

Barter, MA, Harris, K 2002, Occasional Count No 6. Shorebird counts in the NE South Australia-SW Queensland region in September-October 2000, *The Stilt* 41, 44-47.

Blackman, JG, Perry, TW, Ford, GI, Craven, SA, Gardiner, SJ, De Lai, RJ 1999, *Characteristics of important wetlands in Queensland*, Environmental Protection Agency, Queensland.

Boulton, AJ, Humphreys, WF, Eberhard, SM 2003, Imperilled subsurface waters in Australia: Biodiversity, threatening processes and conservation, *Aquatic Ecosystem Health and Management* 6, 41-54.

Boyd, WE 1990, Mound Springs, In *Natural history of the North East Deserts*, eds Tyler, MJ, Twidale, CR, Davies, M, Wells, CB, Royal Society of South Australia, Adelaide.

Bunn, SE, Davies, PM 1999, Aquatic food webs in turbid, arid zone rivers: Preliminary data from Cooper Creek, Queensland. In *Free-flowing River: the Ecology of the Paroo River*, ed Kingsford, RT, NSW National Parks and Wildlife Service, Sydney.

Bunn, SE, Davies, PM, Winning, M 2003, Sources of organic carbon supporting the food web of an arid zone floodplain river, *Freshwater Biology*, 48, 619-635.

Bunn, SE, Thoms, MC, Hamilton, SK, Capon, SJ 2006, Flow variability in dryland rivers: boom, bust and the bits in between, *River Research and Applications* 22, 179-186.

Chenery, A 1921, Notes on birds met with during a visit to southwest Queensland, *South Australian Ornithologist* 6:37-40, 61-64, 82-86.

Clayton, PD, Fielder, DF, Howell, S, Hill, CJ 2006, *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment*, Environmental Protection Agency, Brisbane.

Costelloe, JF, Hudson, PJ, Pritchard, JC, Puckridge, JT, Reid, JRW 2004, *ARIDFLO Scientific Report: Environmental Flow Requirements of Arid Zone Rivers with Particular Reference to the Lake Eyre Drainage Basin*, Final report to South Australian Department of Water, Land and Biodiversity Conservation and Commonwealth Department of Environment and Heritage. School of Earth and Environmental Sciences, University of Adelaide, Adelaide.

Cullen, P 2003, The Heritage River Proposal — Conserving Australia's undamaged rivers. In *Aquatic Protected Areas. What works best and how do we know? Proceedings of the World Congress on Aquatic Protected Areas, Cairns, Australia — August 2002*, eds. Beumer, JP, Grant, A, Smith, DC, University of Queensland Printery, St Lucia, Queensland, Australia.

DERM, 2009a, *Biodiversity Planning Assessment, Channel Country Bioregion Fauna Expert Panel Report,* Western Region, Department of Environment and Resource Management.

DERM, 2009b, *Biodiversity Planning Assessment, Channel Country Bioregion Landscape Expert Panel Report,* Western Region, Department of Environment and Resource Management.

DERM, 2009c, *Biodiversity Planning Assessment, Mitchell Grass Downs Bioregion Landscape Expert Panel Report,* Western Region, Department of Environment and Resource Management.

DERM, 2012a, *Biodiversity Planning Assessment, Desert Uplands Bioregion Flora Expert Panel Report,* Central West Region, Department of Environment and Resource Management.

DERM, 2012b, *Biodiversity Planning Assessment, Desert Uplands Bioregion Landscape Expert Panel Report,* Central West Region, Department of Environment and Resource Management.

Desert Channels Queensland Inc. 2004, *Our country: Our community. A community information paper for the*

Queensland section of the Lake Eyre Basin, Desert Channels Queensland, Longreach.

Duncan-Kemp, AM 1933, *Our Sandhill Country*, Angus & Robertson, Sydney.

Dutson, G, Garnett, S, Gole, C 2009, *Australia's Important Bird Areas - Key sites for bird conservation*, Conservation Statement Number 15, Birds Australia, Melbourne.

EHP, 2016a. An Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Lake Eyre and Bulloo Basins: Summary Report—Version 1.1. Brisbane: Department of Environment and Heritage Protection, Queensland Government.

EPA, 2008, *Biodiversity Planning Assessment, Brigalow Belt South Fauna Expert Panel Report,* Southwest Region, Environmental Protection Agency.

Fensham, RJ, Fairfax, RJ 2003, Spring wetlands of the Great Artesian basin, Queensland, Australia, *Wetland Ecology and Management*, 11, 343-362.

Fensham, RJ, Fairfax, RJ 2005, *Great Artesian Basin Water Resource Plan — Ecological Assessment of GAB springs in Queensland*, Report for the Department of Natural Resources and Mines by the Queensland Environmental Protection Agency.

Fensham, RJ, Price, RJ 2004, Ranking spring wetlands in the Great Artesian Basin of Australia using endemicity and isolation of plant species, *Biological Conservation* 119, 41-50.

Fensham, RJ, Fairfax, RJ, Sharpe, PR 2004, Spring wetlands in seasonally arid Queensland: floristics, environmental relations, classification and conservation values, *Australian Journal of Botany* 52, 583-595.

Fensham RJ, Ponder, W, Fairfax, RJ 2007, *Recovery plan for the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*, Report to Department of the Environment, Water, Heritage and the Arts, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Ford, G 1995, *A survey and inventory of wetlands in the Channel Country, south-western Queensland*, Report to Australian Nature Conservancy. Queensland Department of Environment and Heritage, Toowoomba.

Gardiner, S 2010, *Wetland Management Profile, Arid and Semi-arid Lakes*, Queensland Wetlands Program http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/fact-sheets/profiles/new-profiles/29113-03-arid-lakes-web.pdf accessed 16 March 2016.

Habeck-Fardy, A, Nanson, GC 2014, Environmental character and history of the Lake Eyre Basin, one seventh of the Australian continent, *Earth-Science Reviews* 132, 39-66.

Hamilton, SK, Bunn, SE, Thoms, MC, Marshall, JC 2005, Persistence of aquatic refugia between flow pulses in a dryland river system (Cooper Creek, Australia), *Limnology and Oceanography* 50, 743-754.

Hammer, MP, Adams, M, Unmack, PJ, Walker, KF 2007, A rethink on *Retropinna*: conservation implications of new taxa and significant genetic sub-structure in Australian smelts (Pisces: Retropinnidae), *Marine and Freshwater Research*, 58, 327-341.

Jaensch, R 2003, Breeding by Australian Painted Snipe in the Diamantina Channel Country, south-western Queensland, *The Stilt* 45, 39-42.

Jaensch, R 2009a, *Floodplain Wetlands and Waterbirds of the Channel Country*, South Australian Arid Lands Resource Management Board.

Jaensch, R 2009b, Further records of Australian Painted Snipe *Rostratula australis* in the Lake Eyre Basin, Queensland, with evidence of breeding, *The Stilt* 56, 40-42.

Kingsford, RT (ed) 2006, *Ecology of desert rivers*, University Press, Cambridge, United Kingdom.

Kingsford, RT, Porter, JL, Levy, RF 1992, *An aerial survey of wetland birds in eastern Australia — October 1991*, Occasional Paper No. 12. NSW National Parks and Wildlife Service.

Knighton, AD, Nanson, GC 1994, Waterholes and their significance in the anastomosing channel system of Cooper Creek, Australia, *Geomorphology* 9, 311-324.

Leigh, C, Sheldon, F, Kingsford, RT, Arthington, AH 2010, Sequential floods drive ‘booms’ and wetland persistence in dryland rivers: a synthesis, *Marine and Freshwater Research*, 61, 896-908.

Long, PE; Humphery, VE 1997, *Fisheries Study Lake Eyre Catchment: Thomson and Diamantina Drainages, December 1995*, Queensland Department of Primary Industries, Information Series QI97080.

Musyl, MK, Keenan, CP 1992, Population genetics and zoogeography of Australian freshwater Golden Perch, *Macquaria ambigua* (Richardson 1845) (Teleostei : Percichthyidae), and electrophoretic identification of a new species from the Lake Eyre Basin, *Australian Journal of Marine and Freshwater Research* 43, 1585-1601.

National Land and Water Resources Audit (NLWRA), 2002, *User Guide - Australian Natural Resources Atlas and Data Library*, National Land and Water Resources Audit, Canberra.

Pisanu, P, Kingsford, RT, Wilson, B, Bonifacio, R 2015, Status of connected wetlands of the Lake Eyre Basin, Australia, *Austral Ecology* 40, 460-471.

Ponder, WF 1986, Mound springs of the Great Artesian Basin. In *Limnology of Australia*, eds DeDeckker, P, Williams, WD, CSIRO, Australia and W. Junk, The Hague.

Ponder, WF 2002, Desert Springs of the Great Artesian Basin, In *Conference Proceedings. Spring-fed wetlands: Important Scientific and Cultural Resources of the Intermountain Region*, eds Sada, DW, Sharpe, SE, http://wetlands.dri.edu/2002/ponder.pdf accessed 15 March 2016.

Porter, JL, Kingsford, RT 2009, *Aerial Survey of Wetland Birds in Eastern Australia - October 2009 Annual Summary Report*, University of New South Wales, Sydney.

Reid, JRW, Kingsford, RT, Jaensch, RP 2009, *Waterbird Surveys in the Channel Country Floodplain Wetlands, Autumn 2009*, Report by Australian National University, Canberra, University of New South Wales, Sydney, and Wetlands International — Oceania, Brisbane, for the Australian Government Department of Environment, Water, Heritage and the Arts.

Sheldon, F, Balcombe, S, Brunner, P Capon, S 2003, *Ecological and geomorphological assessment for the Georgina-Diamantina River Catchment. Stage 1 Ecological and geomorphological assessment*, Consultant report by the Centre for Riverine Landscapes, Griffith University, Brisbane.

Sheldon, F, Boulton, AJ, Puckridge, JT 2002, Conservation value of variable connectivity: aquatic invertebrate assemblages of channel and floodplain habitats of a central Australian arid-zone river, Cooper Creek, *Biological Conservation* 103, 13-21.

Timms, BV 1987, Limnology of Lake Buchanan, a tropical saline lake, and associated pools of North Queensland, *Australian Journal of Marine and Freshwater Research* 38, 877-884.

Walker, KF, Sheldon, F, Puckridge, JT 1995, A perspective on dryland river ecosystems, *Regulated Rivers: Research and Management* 11, 85-104.

Wetlands International, 2006, *Waterbird population estimates*, Wetlands International, Wageningen, The Netherlands.

White, IA 2001, *With Reference to the Channel Country, Review of available information,* Queensland Department of Primary Industries.

Appendix A. Expert panel terms of reference.

The terms of reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to inform a number of AquaBAMM criteria and their associated indicators and measures (Clayton et al. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the LEBB. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic Flora and Fauna Panels

The aquatic flora and fauna expert panels were established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to the riverine and non-riverine wetlands of the LEBB. The panels consisted of professionals with expertise relating to aquatic fauna and flora values.

The tasks undertaken by the panel included, but without limitation, the following:

1. Review relevant existing spatial data (species point records) and available information.
2. Provide advice on riverine and non-riverine threatened species, habitat and localities.
3. Provide advice on riverine and non-riverine priority species, habitat and localities.
4. Identify priority ecosystems or areas important for significant communities or species.
5. Provide advice on riverine and non-riverine ecosystem exotic species localities and abundance.
6. Weight measures relative to their importance for an indicator.
7. Rank indicators relative to their importance for a criterion.

Wetland Ecology Panel

The wetland ecology panel is established to provide expert advice based on experience and demonstrated scientific theory on natural geological or geomorphological and hydrological processes and issues of connectivity between aquatic systems within the LEBB.

The tasks undertaken by the panel included, but without limitation, the following:

1. Weight measures relative to their importance for an indicator.
2. Rank indicators relative to their importance for a criterion.
3. Identify areas of significant geomorphological, ecological or hydrological processes, or priority areas — special features.
4. Provide advice on biodiversity ‘hot-spots’ or areas of particular significance for species or communities.
5. Establish principles for applying the connectivity criterion (bi-directional, unidirectional and lateral directions) in the wetland ecosystems.

Appendix B. Overview of recommendations from the expert panel workshops and corresponding actions taken.

Comment from expert/s	Action taken	Name of expert/s
Specific subsections or wetlands should have a different AquaScore, and the area/extent of these subsections or wetlands may have varied according to various opinions.	Case by case assessment of AquaScores to determine the reasons for deviation was carried out and in the majority of cases no changes were made. Some of these types of issues were addressed through discussion in the dependability section of the summary report (EHP 2016a).	Roger Jaensch
Specific subsections or wetlands should have a different AquaScore. There were many suggestions of various areas having different AquaScores to the ones assigned to them (usually suggestions were to move them up a level, and sometimes down a level, though most comments of this type suggested that the level assigned be moved up a level).	The final AquaScore is linked to the ACA methodology and the data availability and because of these factors the suggested changes were not implemented.	Roger Jaensch
All of the Directory of Important Wetlands in Australia (DIWA) areas/wetlands should have a ‘very high’ AquaScore.	No action was required as DIWA areas/wetlands are included as a measure in this ACA.	Roger Jaensch
Queensland/New South Wales border has different AquaScores on either side due to the difference in availability of data in each State (especially in the Bulloo River catchment).	New South Wales was not included in this ACA.	Roger Jaensch, Chris Mitchell, Jen Silcock
Experts provided or referred to extra sources of data after the expert panel meetings were held.	Data sourced and applied as appropriate.	Roger Jaensch
The AquaScore outcomes/results generally look very reasonable.	Noted. No action taken.	Roger Jaensch
Higher ranked AquaScores are generally associated with more data being available than lower ranked AquaScores.	This comment is acknowledged, but no alterations were made. Dependability should be used in conjunction with all AquaScore values to help with interpretation.	Adam Kerezsky
There was much general discussion on the final ACA AquaScores and how these may be a good or not-so-good reflection of the actual ‘health’ of the riverine subsection or wetland.	This comment has been addressed and recognised and in the AquaBAMM methodology (Clayton et al. 2006) and discussed in the summary report (EHP 2016a).	Adam Kerezsky
There is some discrepancy between subsections/wetlands of one particular AquaScore in one catchment and them not lining up or having similar characteristics to subsections/wetlands of the same AquaScore in other adjacent or near-by river	This comment has been noted already in discussion of the AquaBAMM methodology. AquaScores within a catchment can be compared with one another, as they are scored relative to one another. However, AquaScores	Chris Mitchell

catchments.	cannot be accurately compared between different catchments, although the relativities will be the same ie very high is the highest value wetlands in any catchment assessed.	
The Great Artesian Basin (GAB) springs need to be mapped and ranked appropriately.	All non-riverine springs in the LEBB were assessed as part of this ACA. Springs spatial units were sourced from the QLD Wetlands Mapping (V4) data.	Jen Silcock
Certain floodplains (e.g. an extensive floodplain south of Quilpie) are not mapped at all.	Floodplains are not included in the Queensland Wetland System's (QWS) mapping, and therefore, are not included as wetlands in this ACA, as the QWS mapping was used as the base layer for the non-riverine component of this ACA.	Jen Silcock
An up-to-date database for springs was sent to DERM, with rankings already included.	There are difficulties associated with a point of truth layer for springs due to available time and expertise. Non-riverine springs from the QLD Wetlands Mapping (V4) data were used for this ACA.	Jen Silcock, Adam Kerezsy

Appendix C. Criteria, indicators and measures for the Lake Eyre and Bulloo Basins ACAs

An ACA CIM list describes the criteria, indicators and measures used as part of each ACA.

Master LEBB ACA CIM lists were developed from the default list of criteria, indicators and measures that may be considered when conducting an ACA using the AquaBAMM (Table 26). The default CIM list is not mandatory for any particular ACA however it provides a “starter set” for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criterion change, addition or deletion. However, AquaBAMM does allow the addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. Generally, modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

AquaBAMM measure numbers are hierarchical describing both the criterion and indicator of a particular measure. For example, the first number refers to a criterion, the second number to an indicator within a criterion, and the final number the individual measure.

Table 26 shows the master CIM used for each non-riverine, riverine and spring assessment.

Table 26. Criteria, indicators and measures (CIM) used for each non-riverine, riverine and spring ACA.

Criteria and indicators	Measure	Measure description	R[1]	NR[1]	Sp[1]
1 Naturalness aquatic					
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland	Y	Y	Y
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	Y	Y	Y
	1.1.3	Presence of exotic invertebrate fauna within the wetland	Y	Y	Y
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	Y	Y	Y
1.2 Aquatic communities / assemblages	1.2.1	SOR aquatic vegetation condition	Y		
1.3 Habitat features modification	1.3.1	SOR bank stability	Y		
	1.3.2	SOR bed & bar stability	Y		
	1.3.3	SOR aquatic habitat condition	Y		
	1.3.4	Presence/absence of dams/weirs within the wetland	Y		
	1.3.7	% area of remnant wetland relative to preclear extent for each spatial unit	Y	Y	Y
1.4 Hydrological modification	1.4.2	% natural flows - modelled flows remaining relative to predevelopment	Y		
	1.4.5	Hydrological disturbance/modification of the wetland (e.g. as determined through EHP wetland mapping and classification)		Y	Y
2 Naturalness catchment					

Criteria and indicators	Measure	Measure description	R[1]	NR[1]	Sp[1]
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	Y	Y	Y
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses	Y		
	2.2.2	Total number of REs relative to preclear number of REs within buffered riverine wetland or watercourses	Y		
	2.2.3	SOR reach environs	Y		
	2.2.4	SOR riparian vegetation condition	Y		
	2.2.5	% area of remnant vegetation relative to pre-clear extent within buffered non-riverine wetland: 500m buffer for wetlands >= 8Ha, 200m buffer for smaller wetlands		Y	Y
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	Y	Y	Y
	2.3.2	% "grazing" land-use area	Y	Y	Y
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	Y	Y	Y
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc.)	Y	Y	Y
3 Diversity and richness					
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	Y		
	3.1.2	Richness of native fish	Y	Y	Y
	3.1.3	Richness of native aquatic dependent reptiles	Y	Y	Y
	3.1.4	Richness of native waterbirds	Y	Y	Y
	3.1.5	Richness of native aquatic plants	Y	Y	Y
	3.1.6	Richness of native amphibians (non-riverine wetland breeders)		Y	Y
	3.1.7	Richness of native aquatic dependent mammals	Y	Y	Y
3.2 Communities/ assemblages	3.2.2	Richness of REs along riverine wetlands or watercourses within a specified buffer distance	Y		
3.3 Habitat	3.3.1	SOR channel diversity	Y		

Criteria and indicators	Measure	Measure description	R[1]	NR[1]	Sp[1]
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	Y	Y	Y
	3.3.3	Richness of wetland types within the sub-catchment	Y	Y	Y
4 Threatened species and ecosystems					
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act	Y	Y	Y
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species — NCA, EPBC Act	Y	Y	Y
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems — Herbarium biodiversity status, NCA, EPBC Act	Y	Y	Y
5 Priority species and ecosystems					
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc.)	Y	Y	Y
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	Y	Y	Y
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA / CAMBA / ROKAMBA agreement lists and/or Bonn Convention)	Y	Y	Y
	5.1.4	Habitat for significant numbers of waterbirds	Y	Y	Y
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	Y	Y	Y
6 Special features					
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	Y	Y	Y
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	Y	Y	Y
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	Y	Y	Y

Criteria and indicators	Measure	Measure description	R[1]	NR[1]	Sp[1]
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study		Y	Y
7 Connectivity					
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criterion 5 and/ or 6	Y		
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criterion 5 and/or 6	Y		
8 Representativeness					
8.1 Wetland protection	8.1.1	The percent area of each wetland type within Protected Areas.		Y	Y
8.2 Wetland uniqueness	8.2.1	The relative abundance of the wetland management group to which the wetland type belongs within the catchment or study area (management groups ranked least common to most common)		Y	Y
	8.2.2	The relative abundance of the wetland management group to which the wetland type belongs within the subcatchment (management groups ranked least common to most common)		Y	Y
	8.2.3	The size of each wetland type relative to others of its management group within the catchment or study area		Y	Y
	8.2.4	The size of each wetland type relative to others of its type within a subcatchment		Y	Y
	8.2.6	The size of each wetland type relative to others of its type within the catchment or study area		Y	Y

[1] R — Riverine, NR — Non-riverine, Sp — Spring.