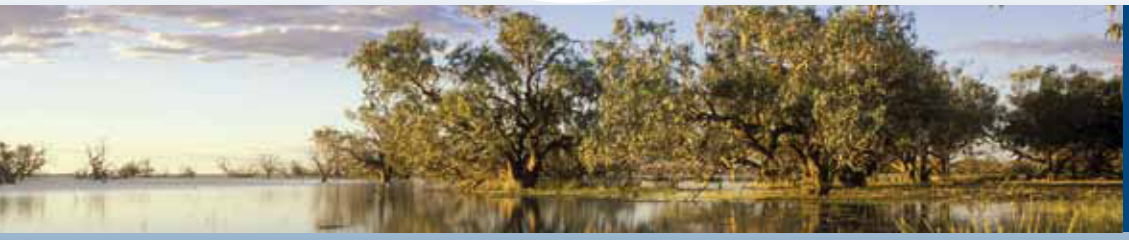
Aquatic ecosystems toolkit



CASE STUDY 1: Lake Eyre Basin

Based on work undertaken by Ms Jennifer Hale and Dr Shane Brooks
for the Aquatic Ecosystems Task Group

2012

Part 1 Identifying High Ecological Value Aquatic Ecosystems (HEVAE)
1.2 Identifying HEVAE

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This case study is based on trials of the draft Guidelines for Identifying High Ecological Value Aquatic Ecosystems, and the draft Aquatic Ecosystem Delineation and Description Guidelines. The final reports from these trials are as follows:

Hale, J. (ed.) (2010). Lake Eyre Basin High Conservation Aquatic Ecosystem Pilot Project. Report prepared for the Aquatic Ecosystems Task Group and the Department of Environment, Water, Heritage and the Arts. Jennifer Hale, Kinglake.

Hale, J., and Brooks, S. (2011). *Trialling the guidelines for the delineation of High Ecological Value Aquatic Ecosystems (HEVAE) in the Lake Eyre Basin (LEB)*. Report prepared for the Aquatic Ecosystems Task Group and the Department of Sustainability, Environment, Water, Population and Communities. Jennifer Hale, Kinglake.

These reports are available on request from the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

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Front page: Lake Goyder, part of a network of lakes and swamps that fill from Cooper Creek in north-east South Australia (Peter Canty)

The ERP's role in the identification of potential HEVAE was to:

- provide advice on decisions made regarding the method
- augment the application of attributes and criteria for the identification of HEVAE, and provide advice on the data and knowledge to delineate HEVAE by the input of expert opinion.

1.2 Identifying HEVAE

Step 4 Assign attributes to chosen spatial unit

a. Selection of criteria

At the time the trial was undertaken, there were six HEVAE criteria: diversity, distinctiveness, vital habitat, evolutionary history, naturalness and representativeness. These were the criteria that were applied in this trial.

b. Selection of attributes

Information on aquatic ecosystems and species is unevenly distributed (both spatially and temporally) across the LEB drainage division. Information available for this trial of the HEVAE process was limited further by resource and time constraints, such that only data that was readily available in a spatial format could be utilised. In an attempt to supplement this limited data, attributes were developed that allowed for expert opinion and/or local knowledge to act as an input to the process.

Consideration was given to finding scientifically defendable attributes, and care was taken to avoid 'double-dipping' i.e. including similar measures across several criteria. Additional attributes for macroinvertebrates, fossils, aquatic ecosystem extent, priority species and vital habitat were suggested, however these were not able to be implemented for this trial because of data or resource constraints. The selected attributes are listed in Table 2.

Aquatic ecosystem-dependent species

A list of native species in the LEB considered to be dependent on aquatic ecosystems was developed for use in applying attributes. The concept of 'aquatic ecosystem-dependent species' was strictly applied to fauna species and applied only to those that were fully aquatic (e.g. fish) or those that were considered dependent on aquatic ecosystems for a significant part of their lifecycles (e.g. waterbirds). A broader definition of aquatic ecosystem dependence was applied to flora species and included all species that were reliant on inundation.

There were some limitations on the application of this list. No invertebrate species were included in the systematic analysis, only vertebrates. The preparation of a list of vascular plants was hampered in some states by lack of access to appropriate experts, the difficulty of the task itself, and a lack of knowledge about inundation dependence. Defining 'dependence' was also a limiting factor.

c. Development of metrics

The rationale and data requirements for the selected metrics are detailed in Table 2.

d. Compile and assign data

A geo-database template containing fields for each attribute was populated with an application of the attributes, not the raw data/species records, which remained with jurisdictions. In the majority of cases, the process was limited to readily available, spatially stored information held in jurisdictional databases. The exceptions to this were attributes derived from national datasets (e.g. River Disturbance Index) and attributes populated by expert opinion and local knowledge (e.g. waterbird breeding). The completed database from each jurisdiction was integrated into a single geo-database that contained the outputs of attribute application as well as scoring and weighting.

Table 2 **Attributes and metrics used to identify potential HEVAE in the Lake Eyre Basin, and their rationale and data requirements**

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
Criterion 1: Diversity: The asset exhibits exceptional diversity of species or habitats, and/or geomorphological features/processes.		
1A DIVERSITY OF AQUATIC ECOSYSTEM TYPE		
Metrics: • number of aquatic ecosystem types within an assessment unit (referential to the entire basin) • number of aquatic ecosystem types within an assessment unit (referential to SWMA).	Biodiversity is often considered in terms of species richness and species evenness (Purvis & Hector 2000). However, in the LEB there is a lack of data on species across the landscape, limiting the application of a biodiversity criterion. When data on species richness or types of species are lacking, but the habitat preferences of the species of interest are known, it is possible to use the diversity of aquatic ecosystem types as a surrogate for the diversity of species supported by these systems. The attribute is assessed in two ways: referential to the entire basin, and referential to the adopted regionalisation. This takes into account the natural variability of diversity across the landscape, and ensures significant aquatic ecosystems in naturally low diversity areas are represented in the identification of potential HEVAE.	Populated with spatially derived data—there are two major data requirements for the application of this attribute: an aquatic ecosystem classification applied across the LEB (Step 2) and a regionalisation (Step 3).

Channel country near Goyders Lagoon, South Australia (Paul Wainwright & DSEWPaC)

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
1B DIVERSITY OF NATIVE AQUATIC ECOSYSTEM-DEPENDENT SPECIES (ALL REFERENTIAL TO A REGION)		
Metrics: • number of fish species (referential to SWMA) • number of waterbird species (referential to the basin) • number of reptile species (referential to basin and IBRA) • number of amphibian species (referential to basin and IBRA) • number of mammal species (referential to basin and IBRA) • number of woody perennial plant species (referential to basin and IBRA) • number of non-woody plant species (referential to basin and IBRA).	This attribute directly assesses species richness, with different groups of flora and fauna considered separately. The attribute only considers aquatic ecosystem-dependent biota to ensure potential HEVAE are identified on the basis of aquatic ecosystem significance. This was particularly important considering that all attributes are applied to assessment units, not to individual aquatic ecosystems, which could lead to significant terrestrial environments and species being identified. The application of attributes based on species records is always problematic, because of uneven sampling effort resulting in a high degree of spatial and temporal disparity in data (Butcher, Hale & Cottingham 2007, Maddock & Du Plessis 1999). However, it was considered important to test this attribute to determine how strongly sample bias affected the application at the assessment unit scale and to explore scoring and weighting options that may ameliorate biases because of uneven sampling effort. Similar to Attribute 1A, this measure is applied referential to the entire basin and to the region to ensure that comparable systems are compared, and ecosystems with naturally low species richness are not excluded from the process. Therefore, fish were considered referential to SWMA (catchments) to account for longitudinal connectivity; waterbirds that disperse widely across the drainage division (and the continent) were considered referential to the LEB; all remaining species groups were considered to be strongly influenced by climate and geomorphology and were considered referential to IBRA bioregions.	Populated with point data of species records (presence/absence only)—this attribute requires the identification of aquatic ecosystem-dependent species as well as species records for the LEB. (Note that aquatic macroinvertebrates were considered, however, there was insufficient data at an adequate taxonomic resolution to apply this attribute.)

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
1C DIVERSITY OF AQUATIC ECOSYSTEM VEGETATION TYPES (QUEENSLAND ONLY)		
Metrics: • number of aquatic ecosystem vegetation types within an assessment unit (referential to IBRA region).	Prioritisation based on higher biological organisation levels, such as vegetation communities, can help overcome some of the shortfalls associated with sample bias in species-level data by using data at a scale for which uniform information is available across the landscape (Maddock & Du Plessis 1999). Conservation of vegetation communities is likely to benefit species indirectly (including known ones) as well as capturing diversity in function and natural processes (Noss & Harris 1986).	A 200 m buffer surrounding the areas used to delineate the riverine typology and wetland typology was used to identify the 'aquatic ecosystem' vegetation. This data was sourced from the Remnant Ecosystem Mapping v6b. Queensland was the only jurisdiction with maps of aquatic ecosystem vegetation types (from mapped regional ecosystems) and able to apply this attribute.

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
Criterion 2: Distinctiveness: The asset is a rare/threatened or unusual aquatic ecosystem; and/or supports rare/threatened species/communities and/or exhibits rare or unusual geomorphological or hydrological features/processes and/or environmental conditions, and is likely to support unusual assemblages of species adapted to these conditions.		
2A THREATENED SPECIES		
Metrics: • accumulated scores based on the presence of aquatic ecosystem-dependent threatened species (referential to the LEB)—a scoring system was developed by the TWG (ratified by the ERP) based on the level of listing (international to regional) as follows: – IUCN/EPBC: critically endangered = 5; endangered = 4; vulnerable = 3; near threatened = 2 – State/Territory: critically endangered = 4; endangered = 4; vulnerable = 2; near threatened = 1	Threatened species (and communities) are a common feature in the identification of high ecological value ecosystems (terrestrial and aquatic) and feature in most international schemes e.g. Ramsar Convention on Wetlands, World Heritage Convention, International Union for Conservation of Nature. It is important to recognise that this attribute suffers from the same sampling biases of Attribute 1B. Species are only scored once per assessment unit at the highest relevant level.	Populated with point data of species records (based on presence only, not abundance). This attribute requires identification of aquatic ecosystem-dependent threatened species at the international, national and regional (jurisdictional) scales, as well as species records. Although the use of known habitat preferences of threatened species was considered, this was not possible because of the level of understanding associated with habitat preferences of threatened species, and information on the spatial distribution of those habitats across the LEB.

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
2B PRIORITY SPECIES		
Metrics: • number of priority aquatic ecosystem-dependent species in each assessment unit (referential at the Basin Scale).	Although threatened species are captured in Attribute 2A, it was recognised that threatened species' listings lag behind current knowledge and occur at a scale greater than the LEB. As such it is likely that species significant within the LEB may not be afforded the importance they deserve. From this, priority species were nominated by jurisdictions (and the ERP) and considered separately. Priority species (both flora and fauna) are defined as per the Queensland Biodiversity Planning Assessments (BPA) guidelines, where the species: • is endemic (to LEB) • is experiencing or is suspected of experiencing a population decline • has experienced a significant reduction in its distribution or has a naturally restricted distribution within the relevant catchment • is a small population and threatened by loss of habitat or • is at its distribution limit or is a disjunct population.	Populated with point data of species records (presence/absence only). Required a list of aquatic ecosystem-dependent species, nominated priority species, and species records.
2C MIGRATORY BIRD SPECIES (EAST ASIAN–AUSTRALASIAN FLYWAY)		
Metrics: • number of migratory bird species in each assessment unit.	Migratory species are considered a priority in conservation planning and are recognised under the EPBC Act, and in international agreements to which Australia is a party e.g. JAMBA, CAMBA, ROKAMBA. Only species that are part of the East Asian–Australasian Flyway were included. This limited the species to those that are true international migrants and excluded species such as ibis and egrets that are migratory in other areas of the globe, but are residents in the Australian context.	Populated with point data of species records (presence/absence only). Required a list of waterbird species that are part of the East Asian–Australasian Flyway, and species records.

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
2D DISTINCTIVE, RARE OR THREATENED GEOMORPHIC, HYDROLOGICAL OR ECOLOGICAL FEATURE (INCLUDING THOSE IMPORTANT FOR EVOLUTIONARY HISTORY)		
Metrics: • features were nominated by states and territories, with location, description and justification for nomination (see Step 6)	Spatiotemporal bias in data and the generally low level of data available within the LEB reduces confidence in the ability for any assessment method to identify all high ecological areas. Data poor areas will inevitably be scored lower than those that are data rich. Nomination of high ecological value areas through a qualitative expert assessment provides a means of accounting for data-poor areas, and a reality check against the application of criteria via data-based process. However, it is important to maintain the integrity of the quantitative trial assessment methodology separate from the qualitative nomination of sites. Attribute 2D has therefore been used as an overlay on the quantitative assessment to test the validity of assessment units scores. The following scenarios may arise: 1. assessment units scored 'high'/'very high' in agreement with nominations—increasing confidence in the assessment methodology; 2. assessment units that experts believed should have scored 'high'/'very high' but did not—highlighting potential shortcomings in the assessment methodology or datasets 3. assessment units that scored 'high'/'very high' but experts either did not believe warranted high-ecological-value status, or were previously unaware of any high ecological values—highlighting potential shortcomings in the assessment methodology, datasets or knowledge of ecological values in certain areas.	Populated through reference to literature, non-spatial datasets, expert opinion, and local knowledge.
2E THREATENED AQUATIC ECOLOGICAL COMMUNITY		
Metrics: • number of EPBC Act-listed threatened ecological communities.	As with threatened species, threatened ecological communities provide an input of data that has already been identified as a high priority through other processes. It also allows for the capturing of groups of species (such as macroinvertebrates) not able to be included as individual species.	Populated with point data of community records (presence/absence only)—distribution data for aquatic ecosystem-dependent EPBC Act-listed threatened ecological communities in the LEB.

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
2F CONSERVATION STATUS OF AQUATIC REGIONAL ECOSYSTEMS (QUEENSLAND ONLY)		
Metrics: • scored as follows: – endangered = 4 – of concern = 3 – not of concern = 2 – none present = 1.	Regional ecosystems are communities of vegetation that are consistently associated with a particular combination of geology, land form and soil in a bioregion. The Queensland Herbarium has mapped the remnant extent of regional ecosystems for much of the state using a combination of satellite imagery, aerial photography and on-ground studies. Each regional ecosystem has been assigned a conservation status which is based on its current remnant extent (how much of it remains) in a bioregion. Regional ecosystems are declared in the QLD Vegetation Management Regulation 2000 and are classified as: • Endangered if: – the area of remnant vegetation for the regional ecosystem is less than 10% of the pre-clearing extent of the regional ecosystem or – the area of remnant vegetation for the regional ecosystem is 10% to 30% of the pre-clearing extent of the regional ecosystem and less than 10 000 ha. • Of concern if: – the area of remnant vegetation for the regional ecosystem is 10% to 30% of the pre-clearing extent of the regional ecosystem or – the area of remnant vegetation for the regional ecosystem is more than 30% of the pre-clearing extent of the regional ecosystem and less than 10 000 ha. • Not of concern if: – the area of remnant vegetation for the regional ecosystem is more than 30% of the pre-clearing extent of the regional ecosystem and more than 10 000 ha.	Populated with a 200 m buffer of the wet areas used within the typology assessments (riverine and non-riverine) of the Remnant Ecosystem Mapping for Queensland.

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
Criterion 3: Vital Habitat: An asset provides vital habitat for flora and fauna species if it supports unusually large numbers of a particular natural species; and/or maintenance of specific species at critical life cycle stages; and/or key/significant refugia times of stress.		
3A WATERBIRD ABUNDANCE		
Metrics: • presence of significant waterbird populations (nominally > 20 000).	Waterbirds are one of the few groups of fauna for which large amounts of data have been collected over relatively long time frames. This attribute (and scoring) is consistent with the two criteria related to waterbirds for identifying wetlands of international importance under the Ramsar Convention. Here, however, in the absence of consistent repeated waterbird counts, single maximum abundance has been used, rather than the stricter standard of 'regularly supports' required under the Ramsar Convention. Productivity is a key ecological function of aquatic ecosystems and particularly important in the boom and bust cycles of temporary wetlands in arid Australia. While a direct measure for productivity is difficult to apply, waterbird abundance may act as a surrogate for productivity, with large numbers of waterbirds (as predators) arriving at wetlands following inundation to take advantage of the high productivity.	Populated primarily by expert opinion—requires abundance data on waterbirds.
3B SIGNIFICANCE OF SITE FOR WATERBIRD BREEDING (LARGE COLONIAL BREEDING EVENTS)		
Metrics: • breeding efforts scored as follows: – ≥10 000 pairs = 4 – 1000–10 000 pairs = 3 – 100–1000 pairs = 2 – < 100 pairs = 1	This attribute addresses the critical life stage of breeding for waterbirds. This is particularly relevant for the LEB, where waterbirds breed opportunistically in response to large scale flood events (Roshier, Robertson & Kingsford 2002).	Populated by breeding records augmented by expert opinion—requires abundance measures of nesting waterbirds.
3C REFUGIA		
Metrics: • presence of permanent and near-permanent waterbodies: – permanent refuge—not known to ever dry out (Silcock 2009, category P) – near-permanent refuge: only dries out in moderate-to-severe droughts (Silcock 2009, categories AP and ID).	The arid landscape of the LEB is characterised by a large number of temporary wetland systems that are inundated from periods of minutes to months or even years (Roshier et al. 2001; Knighton & Nanson 1994). Between these large flood events, surface water is limited across the landscape and permanent waterholes and springs act as refuges for aquatic species (Sheldon, Boulton & Puckridge 2002; Carini, Hughes & Bunn 2006).	Populated based on known water regimes (Silcock 2009) augmented by local knowledge.

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
Criterion 4: Evolutionary History: Exhibits features or processes and/or supports species or communities which are important in demonstrating key features of the evolution of Australia's landscape, riverscape or biota, especially in a world context.		
4A ENDEMIC SPECIES.		
Metrics: • accumulated scores based on the presence of endemic species in the assessment unit—scored* as follows: – endemic to the assessment unit = 3 – endemic to the Surface Water Management Area = 2 – endemic to the LEB drainage division = 1. *Species is only scored once per assessment unit at the highest relevant level.	A focus on endemic species is common in conservation priority setting (Myers et al. 2000; Olson 1998). There is also evidence that endemic species can act as a surrogate for broader species conservation in the absence of complete species richness data (Bonn, Rodrigues & Gaston 2002; Lamoreux et al. 2006).	Populated with point data of species records (presence/absence only)—required identification of endemic species at the drainage division and catchment scales (primarily made by expert opinion), and species records.

Pelicans on the banks of the Diamantina River, South Australia (Paul Wainwright & DSEWPaC)

CRITERION, ATTRIBUTES & METRICS	RATIONALE	DATA REQUIREMENTS
Criterion 5: Naturalness: The ecological character of the aquatic ecosystem is not adversely affected by modern human activity.		
RIVER DISTURBANCE INDEX		
Metrics: • Mean Catchment Disturbance Index • Mean Flow Regime Disturbance Index.	The River Disturbance Index (RDI) uses data on human disturbances at the catchment and stream scale to rate streams in terms of naturalness (Stein, Stein & Nix 1998). The RDI consists of a number of sub-indices and has been applied across all of Australia. In terms of the LEB HEVAE trial, two sub-indices (each the result of several factors) were selected as indicative of 'naturalness' at the assessment unit scale: • Catchment Disturbance Index (CDI) includes consideration of settlements, infrastructure, land use and point sources of pollution • Flow Regime Disturbance Index (FRDI) includes consideration of impoundments, flow diversions and levee banks. Although weeds and pest animals are considered significant threats to aquatic ecosystems in the LEB, there was inconsistent data across the drainage division to include a measure of these disturbances at this time. Similarly, land use and land tenure data was not in the appropriate format across all jurisdictions for use as a surrogate for disturbance.	Data is available as an ArcGIS database from Geoscience Australia that contains the CDI and FRDI for all river segments in the Australian 1:250 000 topographic layer. The CDI and FRDI for each assessment unit were calculated as the mean value for all river segments within each unit.
Criterion 6: Representativeness: The asset is an outstanding example of an aquatic ecosystem class to which it has been assigned, within a drainage division. **Applied as a filter at the end of the process to capture rare aquatic ecosystem types.**		
Metrics: • filter to ensure that all aquatic ecosystem types are captured in the HEVAE process.	In order to apply representativeness to the identification of HEVAE in the LEB, the 'best' (highest ecological value) examples of each aquatic ecosystem type were selected for inclusion in the identified HEVAE assessment units. This was applied after all other scoring was completed. Any aquatic ecosystem type not represented in the top ranking assessment units was identified and the highest ranking assessment unit containing this aquatic ecosystem type was elevated into the top rankings.	Wetland typology and mapping consistent across the basin.

Step 5 Apply the assessment process and identify units of high ecological value

a. Apply the criteria

Scoring

Consistent with similar aquatic ecosystem prioritisation systems in Australia e.g. CFEV (DIPWE 2007); AquaBAMM (Clayton et al. 2006); South Australia River Murray Prioritisation (Butcher, Hale & Cottingham 2007), attributes and criteria were not scored absolutely, but assigned to ranked categories:

- very high (score = 4)
- high (score = 3)
- medium (score = 2)
- low (score = 1), and
- null (score = unknown or 0).

The inclusion of the fifth level (null) was made on the understanding that differentiation between 'zero' (attribute known not to occur within the assessment unit) and a true null (it is unknown if an attribute occurs within an assessment unit) is important. The former should ideally be included in the 'low' category and the latter identified as a data deficiency that may require additional monitoring or investigation. However, for the LEB HEVAE trial, it was not possible to distinguish between null and zero because some of the source databases did not make this distinction.

There are a number of different methods that potentially could be used to set the thresholds for each of the four scored categories (very high, high, medium and low). This trial used the AquaBAMM approach (mean of the highest three scores divided by four e.g. if the mean of the top three scores = 10, then the categories are: very high >7.5; high >5 to 7.5; medium = 2.5 to 5; low = <2.5).

Weighting

As criteria 1, 2 and 3 comprise multiple attributes, it was necessary to combine them to acquire a categorical score for each criterion. It was recognised that not all attributes (or metrics) may contribute equally to the ecological value of aquatic ecosystems in the LEB, so it was agreed that attributes would be weighted on ecological reasoning (Table 3). However, in recognition that assigning weights is not an exact science, sensitivity analyses were conducted to determine the effect of weightings on the final outcome.

The attributes within a criterion were summed according to the agreed weighting (Table 3) and the AquaBAMM scoring method reapplied to the summed outcome to provide categorical scores for each of the criteria.

Redundancy

A correlation analysis of all attributes was undertaken to identify redundant variables. Following the method of Chadderton et al. (2004) attributes that are highly correlated and for which a functional relationship is well understood can be identified as potentially redundant and a decision made about excluding them from future assessments. However, the results of the correlation analyses indicated that no attributes were strongly correlated (r-squared <0.5), suggesting that all attributes contributed differently to the identification of assessment units with a high probability of containing an HEVAE.

Table 3 Agreed weightings for attributes

CRITERION	ATTRIBUTE	WEIGHTING	RATIONALE
1. Diversity	1A Diversity of aquatic ecosystems	Number of aquatic ecosystems x 2	Aquatic ecosystem diversity relates to diversity of habitat. Increased habitat diversity may act as a surrogate for species diversity (including species for which there are no records).
	1B Diversity of native aquatic species	Fish x 2	Obligate aquatic species, for which records will be only for aquatic ecosystems.
		Waterbirds x 1	No weighting
		Reptiles, amphibians x 0.5	Some members of these species groups are reliant on aquatic ecosystems for only a short part of their lifecycle.
		Mammals x 0.2	Only one aquatic ecosystem-dependent mammal species present in the LEB, was weighted down to make comparable to species richness of other species groups.
		Woody plants x 1	No weighting
		Non-woody plants x 1	No weighting
2. Distinctiveness*	2A Threatened species	Accumulated score x 1	No weighting
	2B Priority species	Number of priority species x 0.5	Priority species were nominated by TWG/ERP members but have not gone through the rigorous procedure for listing of threatened species.
	2C Migratory waterbirds	Number of species x 1	No weighting
	2E Threatened ecological communities	Presence of threatened ecological community x 2	Ecological communities can support a number of species. This was considered significant especially for endemic macroinvertebrate species in the Great Artesian Basin springs that were not captured elsewhere in the process.
3. Vital habitat	3A Waterbird breeding	Accumulated score x 1	No weighting
	3B Waterbird abundance	Presence of significant numbers of waterbirds x 1	No weighting
	3C Refugia	Score for presence of permanent or near-permanent water x 2	Permanent water sources are rare in the LEB landscape and significant for supporting abundance and diversity of aquatic species.

*Note that attribute 2D—distinctive, rare or threatened geomorphic, hydrological or ecological feature (including those important for evolutionary history)—is not scored and is added to C2 directly. Therefore it is not considered here.

Aggregation of assessment units

The LEB has many large aquatic ecosystems, spanning several assessment units e.g. Lake Eyre spans 23 assessment units. For some attributes, such as waterbird abundance, this was considered to be a problem as they should be applied at the scale of the aquatic ecosystem and not a fragment of it. As this case study was a trial of the method, this part of the assessment was somewhat trial and error.

To test the effect that aggregation had on the outcome, attributes were applied to aggregated and non-aggregated assessment units in the South Australian portion of the LEB, with thresholds re-calculated for each. For the majority of sites, the aggregation did not make a significant difference to the identification of high-ranking assessment units. Aggregated areas that were ranked highly almost always contained a smaller unit that also ranked highly, indicating that the site would have warranted further investigation in the process of delineating HEVAEs.

The lack of difference between aggregated and non-aggregated catchments highlights the robust nature of the scoring of attributes in the LEB, whereby the process identifies the same high-ranking areas regardless of the spatial scale used. Although, in this instance, the aggregation of catchments did not significantly alter the results, this may not be the same case in all situations.

b. Identify HEVAE

The following discussion relates to the HEVAE criteria as they were applied in the Lake Eyre Basin trial. Note that the criteria may have changed in subsequent iterations of the Guidelines for Identifying HEVAE. Refer to Module 3 of the Aquatic Ecosystems Toolkit for the current criteria.

Red Cabbage Palm (Livistona mariae) beside the Finke River, Palm Valley, Finke Gorge National Park (Diane Conrick)

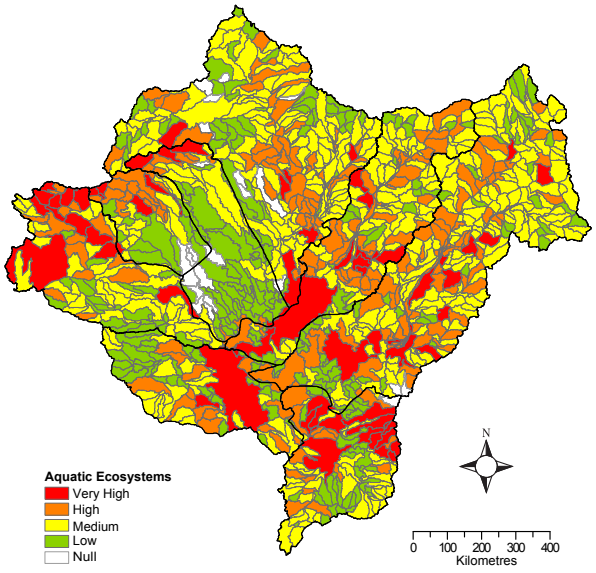
Criterion 1: Diversity

Description	The asset exhibits exceptional diversity of species or habitats, and/or geomorphological features/processes.
Attributes	1A. Diversity of aquatic ecosystem type 1B. Diversity of native aquatic ecosystem-dependent species (all referential to a region) 1C. Diversity of aquatic ecosystem vegetation types (Queensland only)

A total of 147 assessment units (approximately 14 percent) were afforded a 'very high' categorical score in at least one attribute for Criterion 1 (Figures 5a to h). Thresholds for different species groups across different regions varied significantly, and thresholds within species groups also varied considerably across regions. Whether this is a true reflection of variance in diversity across the LEB or more strongly influenced by sample effort is unknown.

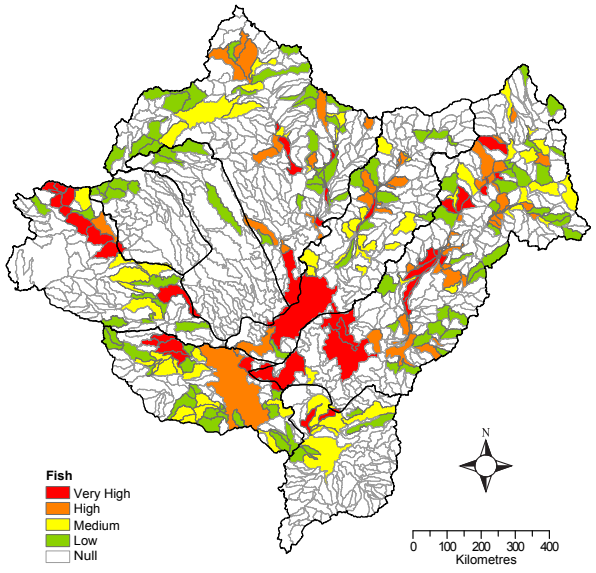
Combining and weighting the attributes resulted in 23 assessment units in the highest category (Figure 6a). A sensitivity analysis with no species weightings reduced this to 13 assessment units, which included two additional units not identified as 'very high' in the weighted assessment (Figure 6b). There was a strong positive correlation between the weighted and non-weighted scores (r-squared = 0.942) indicating that there was little difference between weighted and non-weighted outcomes (Figures 6a, b).

Attribute 1C could only be implemented in the Queensland portion of the LEB. However, analysis with and without Attribute 1C indicated that the attribute did not meaningfully add to the identification of HEVAE in the LEB.



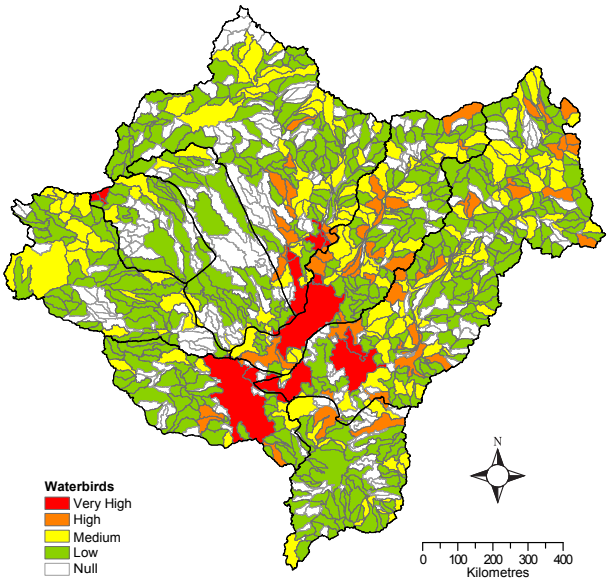
THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	10 to 15	7 to 9	4 to 6	1 to 3
Cooper Creek	9 to 12	6 to 8	3 to 5	1 to 2
Desert Rivers	7 to 9	5 to 6	3 to 4	1 to 2
Diamantina	9 to 12	6 to 8	3 to 5	1 to 2
Georgina	9 to 12	6 to 8	3 to 5	1 to 2
Lake Frome	7 to 9	5 to 6	3 to 4	1 to 2
Western Rivers	9 to 11	6 to 8	4 to 5	1 to 3

Figure 5a Attribute 1A—Diversity of aquatic ecosystems



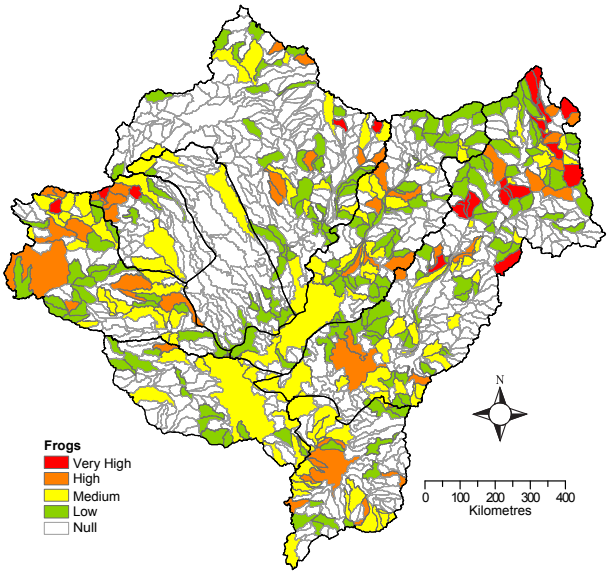
THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Cooper Creek	10 to 14	7 to 9	4 to 6	1 to 3
Desert Rivers	7 to 9	5 to 6	3 to 4	1 to 2
Diamantina	9 to 12	6 to 8	3 to 5	1 to 2
Georgina	8 to 10	5 to 7	3 to 4	1 to 2
Lake Frome	4 to 5	3	2	1
Western Rivers	7 to 10	5 to 6	3 to 4	1 to 2

Figure 5b Attribute 1B—Number of fish species



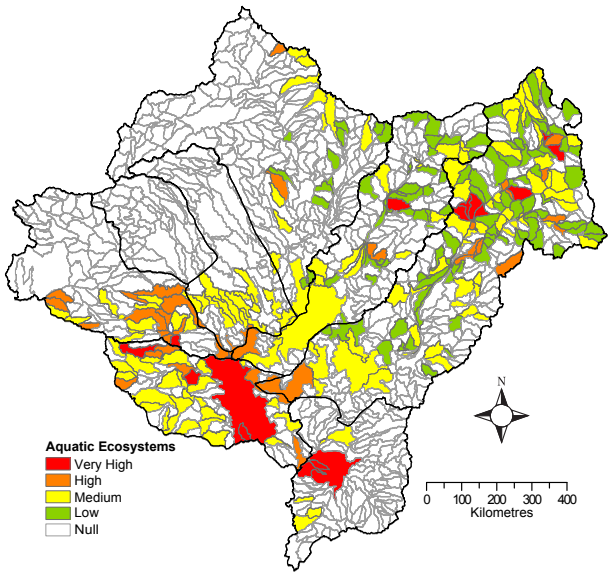
THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	58 to 91	37 to 57	19 to 36	1 to 18

Figure 5c Attribute 1B—Number of waterbird species



THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	10 to 14	7 to 9	4 to 6	1 to 3
Broken Hill Complex	3		1	
Burt Plain	2			
Channel Country	10 to 14	7 to 9	4 to 6	1 to 3
Desert Uplands	8 to 11	6 to 7	3 to 5	1 to 2
Finke	4	3	2	1
Flinders Lofty Block	4 to 5	3	2	1
MacDonald Ranges	7 to 9	5 to 6	3 to 4	1 to 2
Mitchell Grass Downs	7 to 9	5 to 6	3 to 4	1 to 2
Mount Isa Inlier	4 to 6	3	2	1
Mulga Lands	5 to 11	3 to 4	2	1
Simpson Strzelecki DF	4 to 5	3	2	1
Stony Plains	4 to 5	3	2	1
Tanami	No records			

Figure 5e Attribute 1B—Number of frog species



THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	4 to 5	3	2	1
Broken Hill Complex	No records			
Burt Plain	No records			
Channel Country	4 to 5	3	2	1
Desert Uplands	4 to 5	3	2	1
Finke	2	1		
Flinders Lofty Block	3	2	1	
MacDonald Ranges	No records			
Mitchell Grass Downs	4	3	2	1
Mount Isa Inlier	2	1		
Mulga Lands	2	1		
Simpson Strzelecki DF	2	1		
Stony Plains	3	2	1	
Tanami	No records			

Figure 5d Attribute 1B—Number of reptile species

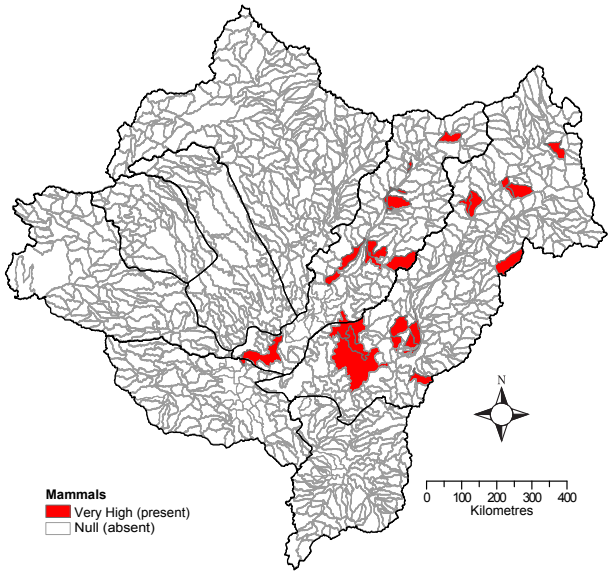
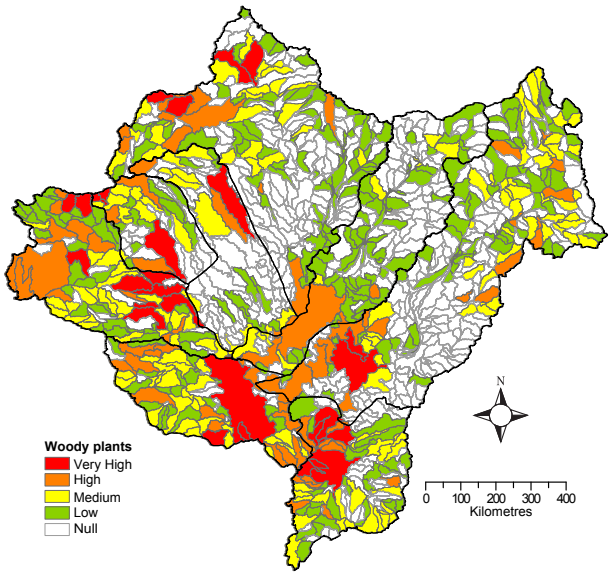
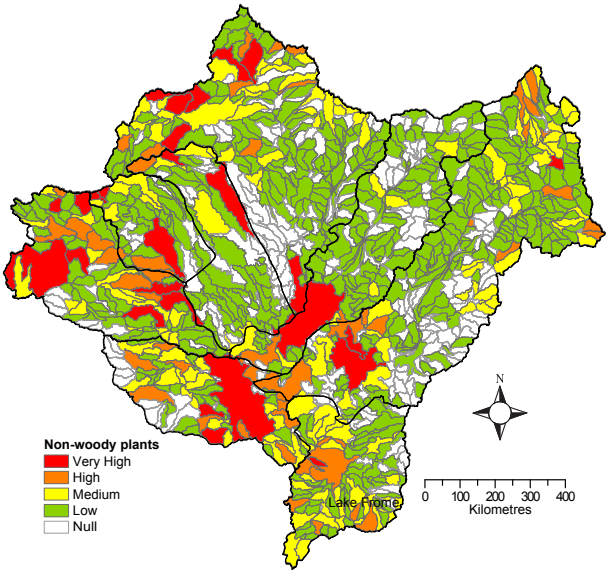


Figure 5f Attribute 1B—Presence of mammal (water rat)



THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	11 to 14	7 to 10	4 to 6	1 to 3
Broken Hill Complex	4	3	2	1
Burt Plain	5 to 6	4	2 to 3	1
Channel Country	11 to 14	7 to 10	4 to 6	1 to 3
Desert Uplands	5 to 6	4	2 to 3	1
Finke	6 to 8	4 to 5	2 to 3	1
Flinders Lofty Block	7 to 10	5 to 6	3 to 4	1 to 2
MacDonald Ranges	10 to 14	6 to 9	3 to 5	1 to 2
Mitchell Grass Downs	7 to 11	5 to 6	3 to 4	1 to 2
Mount Isa Inlier	4	3	2	1
Mulga Lands	2		1	
Simpson Strzelecki DF	8 to 12	6 to 7	3 to 5	1 to 2
Stony Plains	8 to 12	6 to 7	3 to 5	1 to 2
Tanami	4	3	2	1

Figure 5g Attribute 1B—Number of woody plant species



THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	98 to 151	66 to 97	33 to 65	1 to 32
Broken Hill Complex	23 to 41	15 to 22	8 to 14	1 to 7
Burt Plain	48 to 77	32 to 47	16 to 31	1 to 15
Channel Country	94 to 126	63 to 93	32 to 62	1 to 31
Desert Uplands	47 to 71	31 to 46	16 to 30	1 to 15
Finke	55 to 84	37 to 54	19 to 36	1 to 18
Flinders Lofty Block	46 to 83	31 to 45	16 to 30	1 to 15
MacDonald Ranges	76 to 124	51 to 75	26 to 50	1 to 25
Mitchell Grass Downs	62 to 96	41 to 61	21 to 40	1 to 20
Mount Isa Inlier	11 to 17	8 to 10	4 to 7	1 to 3
Mulga Lands	4 to 7	3	2	1
Simpson Strzelecki DF	93 to 151	62 to 92	32 to 61	1 to 31
Stony Plains	79 to 116	53 to 78	27 to 52	1 to 26
Tanami	39 to 84	26 to 38	13 to 25	1 to 12

Figure 5h Attribute 1B—Number of non-woody plant species

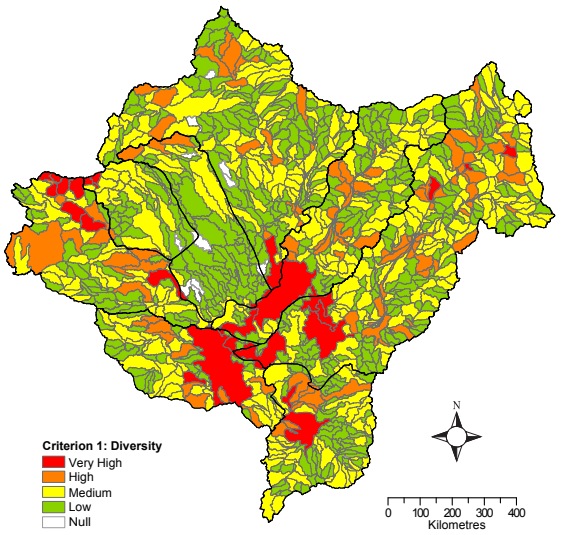


Figure 6a Diversity attributes combined and weighted

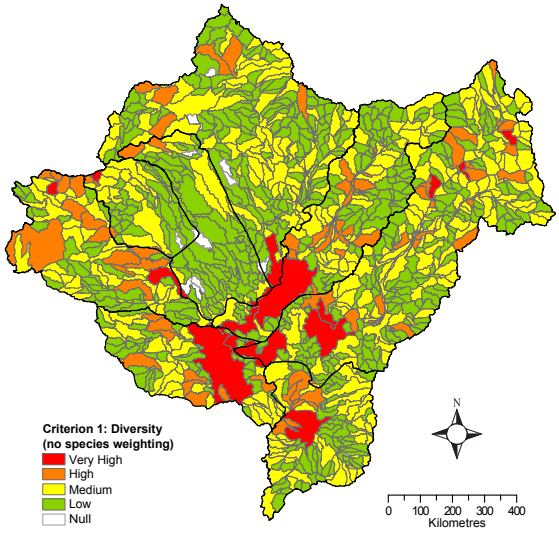


Figure 6b Diversity attributes combined not weighted

Criterion 2: Distinctiveness

Description	The asset is a rare/threatened or unusual aquatic ecosystem; and/or supports rare/threatened species/communities and/or exhibits rare or unusual geomorphological or hydrological features/processes and/or environmental conditions, and is likely to support unusual assemblages of species adapted to these conditions.
Attributes	2A. Threatened species 2B. Priority species 2C. Migratory bird species (East Asian–Australasian Flyway) 2D. Distinctive, rare or threatened geomorphic, hydrological or ecological feature (including those important for evolutionary history) 2E. Threatened aquatic ecological community 2F. Conservation status of aquatic regional ecosystems (Queensland only)

A total of 134 assessment units (approximately 13 percent) were afforded a 'very high' categorical score in at least one attribute of Criterion 2 (Figures 7a–d). Combining and weighting attributes resulted in 35 assessment units in the highest category (Figure 8) and a sensitivity analysis with no weightings did not appreciably alter the outcomes, with a strong positive correlation between weighted and unweighted scores (r-squared = 0.813).

Threatened species were assigned not simply on the basis of number of species, but weighted according to the level of listing.

There was insufficient knowledge and resources to nominate priority species for South Australia and New South Wales, however, the low weighting attributed to priority species reduced the impact of this in the combined criterion attribute score.

For Attribute 2E there was only one aquatic ecosystem-dependent nationally listed threatened community in the LEB: 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin'. This was therefore scored on the basis of presence (very high) and absence (null).

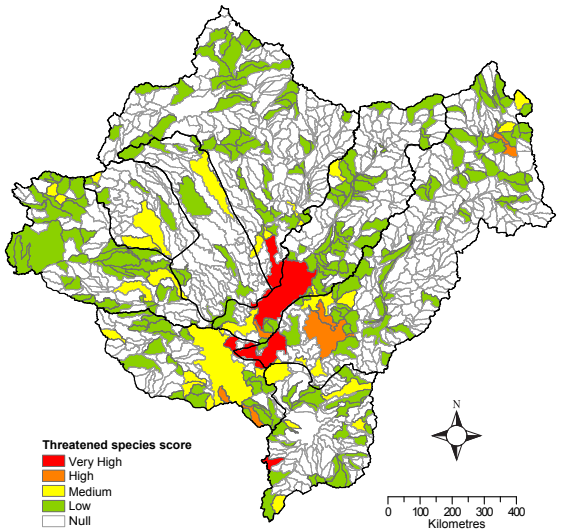


Figure 7a Attribute 2A—Threatened species

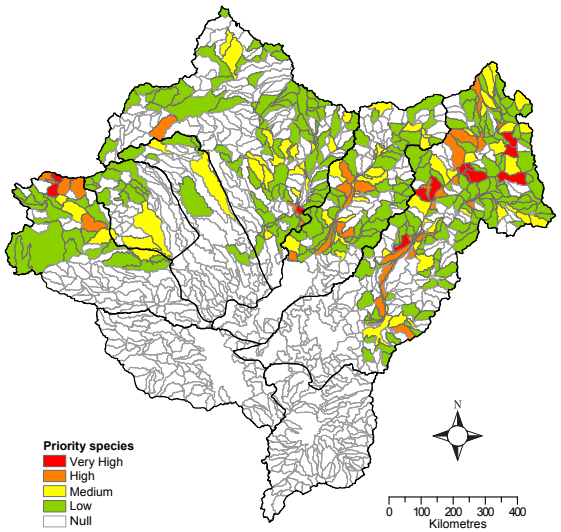


Figure 7b Attribute 2B—Priority species

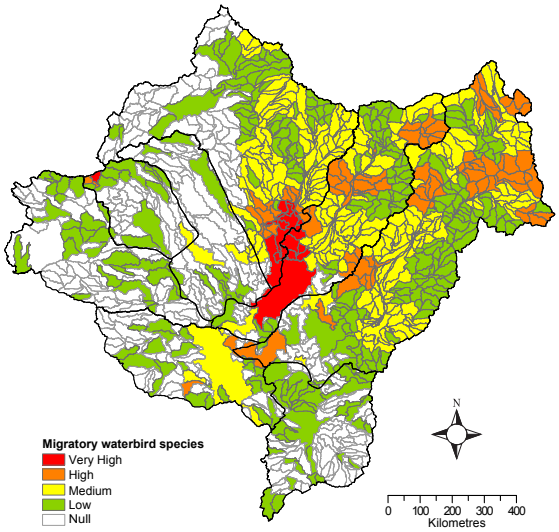


Figure 7c Attribute 2C—Migratory waterbirds

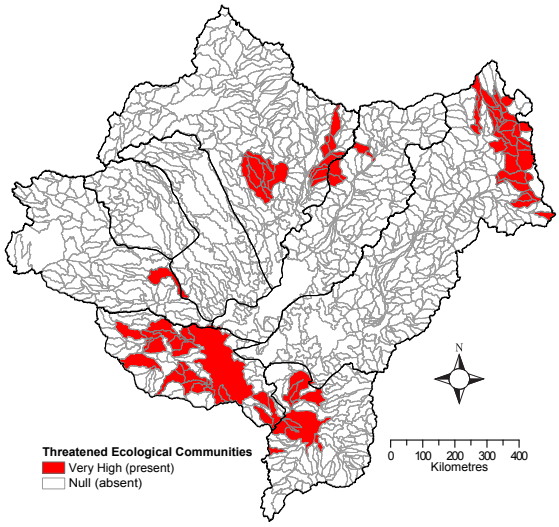


Figure 7d Attribute 2E—Presence of the threatened ecological community of the GAB springs

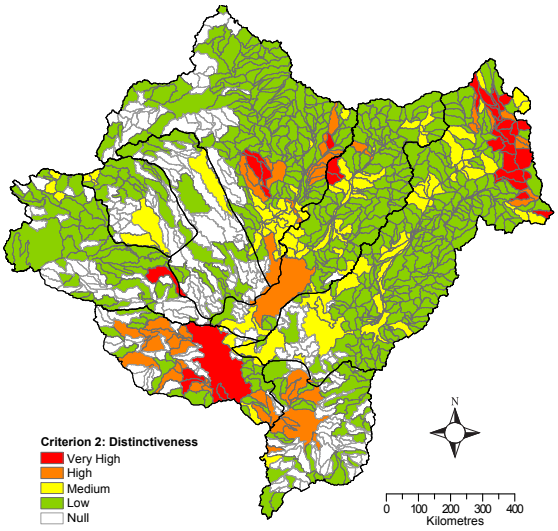


Figure 8 Distinctiveness attributes combined and weighted

Criterion 3: Vital Habitat

Description	An asset provides vital habitat for flora and fauna species if it supports unusually large numbers of a particular natural species; and/or maintenance of specific species at critical life cycle stages; and/or key/significant refugia at times of stress.
Attributes	3A. Waterbird abundance 3B. Significance of site for waterbird breeding (large colonial breeding events) 3C. Refugia

A total of 263 assessment units (approximately 24 percent) were afforded a 'very high' categorical score in at least one attribute of Criterion 3 (Figures 9a–c). Combining and weighting attributes resulted in 13 assessment units in the highest category (Figure 10). A sensitivity analysis with no weightings did not appreciably alter the outcomes, with a relatively strong positive correlation between weighted and unweighted scores (r-squared = 0.79).

The available information for waterbird abundance (populated by expert knowledge and published literature) allowed this attribute to be scored by presence/absence only. Waterbird breeding was populated from a single dataset (Reid[2], unpublished) and covers only a small portion of the LEB. The information used for both of these attributes cannot be considered complete.

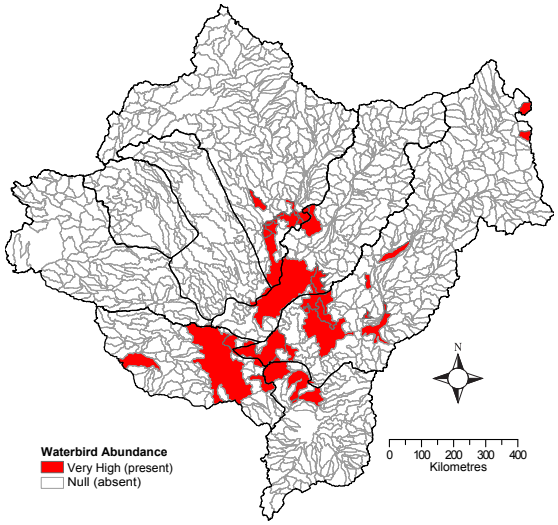


Figure 9a **Attribute 3A—Waterbird abundance (presence of large numbers of waterbirds)**

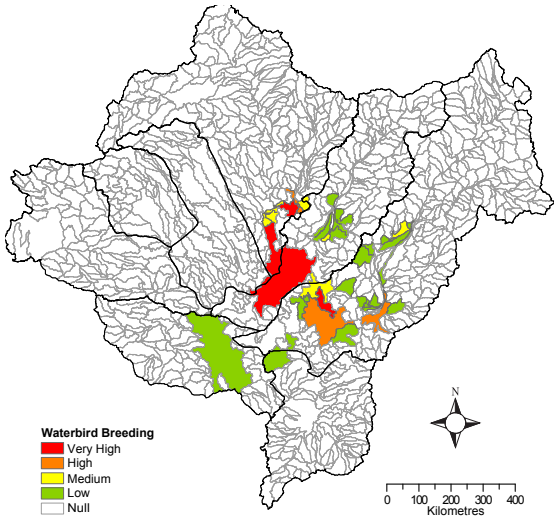


Figure 9b **Attributes 3B—Waterbird breeding**

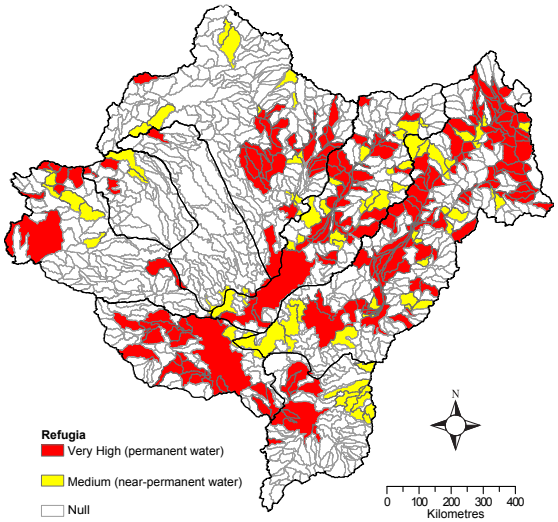


Figure 9c **Attribute 3C—Refugia (presence of permanent water = very high; near permanent water = high)**

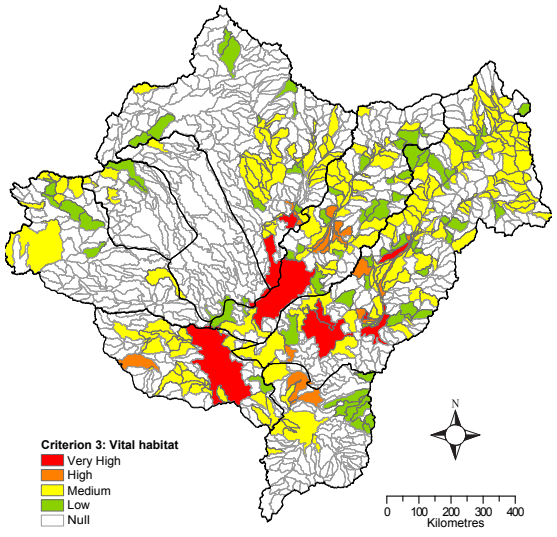


Figure 10 **Vital habitat attributes combined and weighted**

2 Julian Reid (Fenner School of Environment and Society, Australian National University).

Criterion 4: Evolutionary History

Description	Exhibits features or processes and/or supports species or communities, which are important in demonstrating key features of the evolution of Australia's landscape, riverscape or biota, especially in a world context.
Attributes	4A. Endemic species

Four assessment units were afforded a 'very high' categorical score in this attribute (Figure 11), with endemic species recorded in a total of 183 assessment units.

It should be noted that insufficient knowledge within the project team existed to consider endemic flora for South Australia and New South Wales, and the effect this had on the scores is unknown. Additionally, there was a strong view from the ERP that endemic macroinvertebrates (e.g. in mound springs) should have been included, but there was insufficient data to do so in this trial.

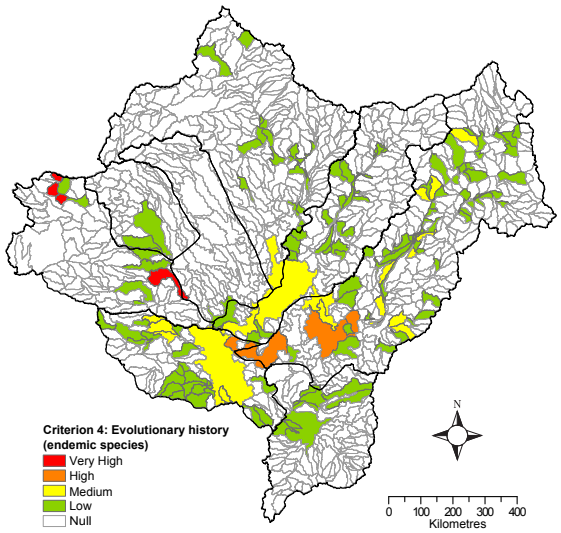


Figure 11 Evolutionary history—endemic species

Simpsons Gap, Northern Territory (Diane Conrick)

Criterion 5: Naturalness

Description	The ecological character of the aquatic ecosystem is not adversely affected by modern human activity.
Attributes	5A. River Disturbance Index

Two metrics (each the result of several factors) of the Rivers Disturbance Index (Stein, Stein & Nix 1998) were selected as indicative of 'naturalness':

- Catchment Disturbance Index (CDI)—includes consideration of settlements, infrastructure, land use and point sources of pollution
- Flow Regime Disturbance Index (FRDI)—includes consideration of impoundments, flow diversions and levee banks.

However, application of these was difficult and the outcomes did not differentiate assessment units well (Figures 12a and b). The River Disturbance Index is a national dataset and the LEB is comparatively undisturbed and 'natural' when considered at a national scale. The Flow Disturbance Index indicated that 97.5 percent of assessment units were 'very high' (most natural/least disturbed) and while there was a better spread of the data for Catchment Disturbance Index (23 percent scored as 'very high'), it was considered by the TWG and ERP to be of little use in identifying HEVAE in the LEB, because it did not represent a true indication of naturalness at the site scale.

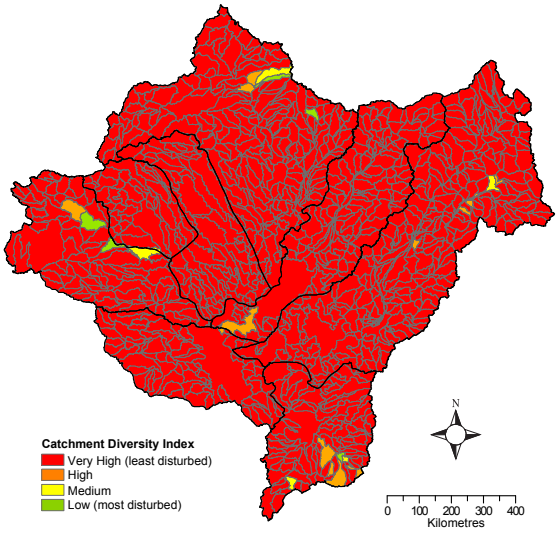


Figure 12a Mean Flow Disturbance Index

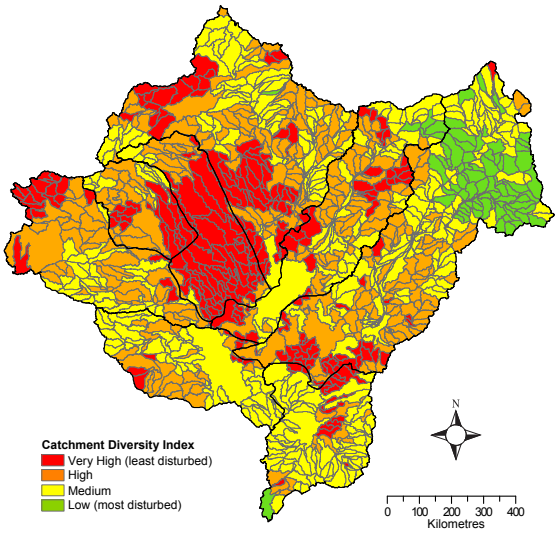


Figure 12b Mean Catchment Disturbance Index

Criterion 6: Representativeness

Description	The asset is an outstanding example of an aquatic ecosystem class to which it has been assigned, within a Drainage Division.
Attributes	Filter to ensure that all aquatic ecosystem types are captured in the HEVAE process.

The aquatic ecosystems present in the assessment units that scored 'very high' in one or more criteria (criteria 1 to 4) were compared to all aquatic ecosystem types recorded within the LEB.

A total of 20 non-riverine aquatic ecosystem types and 17 riverine types were mapped in the LEB. Of these, all non-riverine types and 14 river types were accounted for in the top-ranking assessment units. The riverine types that were not represented in the high-ranking assessment units were:

- lowland, waterhole, groundwater, permanent, fresh (type 4)—which occurred in nine assessment units
- upland, waterhole, groundwater, permanent, fresh (type 20)—which occurred in two assessment units
- upland, waterhole, groundwater, permanent, saline (type 25)—which occurred in a single assessment unit.

The highest-ranking assessment units that contained these 'missing' aquatic ecosystem types were elevated to a high-ranking status and included in the top ranking assessment units.

Thresholds

Whilst the HEVAE identification guidelines recommend the use of a filter table to determine thresholds and priorities, that recommendation was not available at the time of this case study. Much thought was put into exploring the issue, which in turn informed the development of the HEVAE identification guidelines. This section will present the findings of the assessment only.

Given that there was no specified purpose in this trial for the identification of HEVAE, there is a clear argument for considering the criteria separately allowing for weighting to be tailored to specific program needs. In terms of broad ecological value, the ERP considered criteria 1 to 4 were equally important and no weighting suggested. However, it was considered that ecological value increased with increasing criteria met (i.e. an assessment unit which scored 'very high' in two or three criteria had a greater potential for containing a HEVAE than an assessment unit that ranked highly in only one criterion).

The draft HEVAE guidelines, at the time of this assessment, stated that an aquatic ecosystem only had to meet one criterion in order to be identified as a HEVAE, and threshold values had not been determined. As a result, the report ranked assessment units from the highest probability of containing a HEVAE (i.e. scored 'very high' in each of the criteria 1 to 4), to the lowest probability of containing a HEVAE (scored 'low' in criteria 1 to 4). As this was a trial of the HEVAE guidelines, with limitations in time and resources, a priority list was not produced, except to identify those assessment units that scored 'very high' in one or more criteria.

It was also decided that the attributes for criterion 5 (naturalness) do not indicate a high probability of the presence of HEVAE within an assessment unit in the LEB. As a result, criterion 5 was not considered in the analysis.

Identified HEVAE

Two assessment units scored 'very high' in three categories. This comprised the assessment unit that contained Lake Eyre, which scored 'very high' for criteria 1, 2 and 3; and the assessment unit that contained Dalhousie Springs, which scored 'very high' for criteria 1, 2 and 4. Seven assessment units scored 'very high' in two criteria and 49 assessment units scored 'very high' in one criterion (criteria 1 to 4) (Figure 13). An additional three assessment units were elevated to the high-ranking category because of the presence of unique or rare wetland types not represented through the application of the criteria (e.g. Lake Galilee). Table 4 lists all the assessment units that scored 'very high' in at least one criterion (in order of the assessment unit identifier).

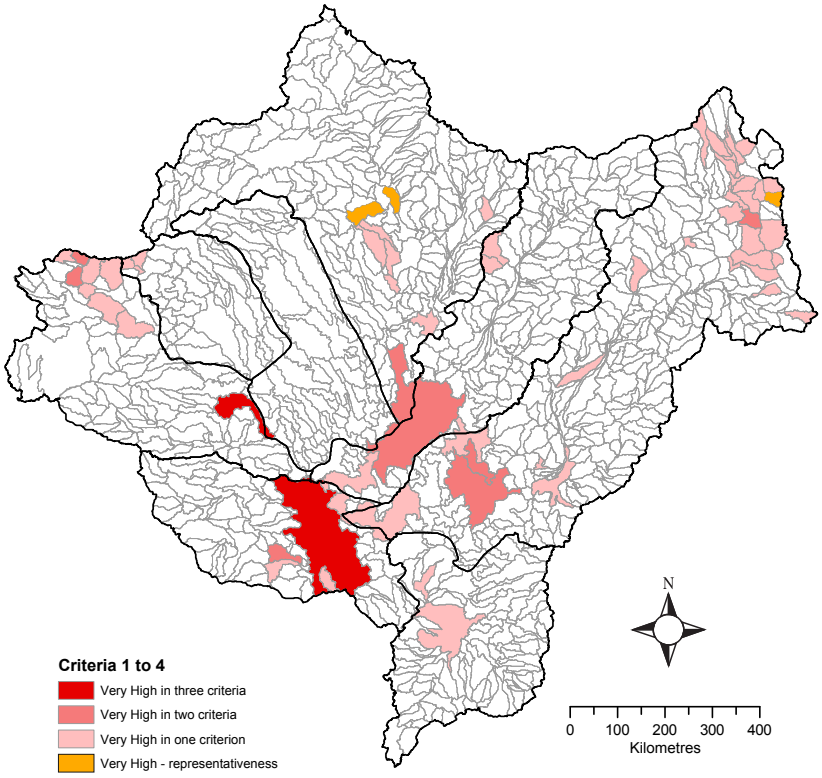


Figure 13 **Assessment units that scored 'very high' in at least one criterion (criteria 1 to 4) or contained representative wetland types**

Table 4 **Summary of assessment units that scored very high in at least one criterion (C1 to C4). 'Very high' scores shaded**

ASSESSMENT UNIT	KNOWN AQUATIC ECOSYSTEMS WITHIN ASSESSMENT UNIT	SCORE FOR CRITERIA			
		C1	C2	C3	C4
1000	Coongie Lakes	High	Very High	Medium	
1001	Cullyamurra Waterhole	Very High	Medium	Very High	High
1002	Coongie Lakes	Very High	Medium	Very High	Medium
1003	Goyders Lagoon	Very High	High	Very High	Medium
1007	Lake Eyre	Very High	Very High	Very High	Medium
1008	Lake Frome, Lake Frome mound springs	High	Low	Very High	Medium
3502		Very High	High	Medium	
3693	Barcaldine Springs Super Group	Medium	Very High	Medium	
3745		Medium	Very High	Medium	
3824	Barcaldine Springs Super Group	Medium	Very High	Medium	
3858		Medium	Very High	Medium	

ASSESSMENT UNIT	KNOWN AQUATIC ECOSYSTEMS WITHIN ASSESSMENT UNIT	SCORE FOR CRITERIA			
		C1	C2	C3	C4
4020		Very High	Low	Medium	Low
4069	Barcaldine Springs Super Group	Medium	Low	Very High	Low
4240		Very High	High	Medium	Low
4254	Lake Huffer, Lake Barcoorah, Barcaldine Springs Super Group	Medium	Very High	Medium	
4264	Lake Galilee	Medium	Very High	Medium	
4293	Barcaldine Springs Super Group	Medium	Very High	Medium	
4321	Barcaldine Springs Super Group	High	Very High	Medium	
4417	Lake Huffer, Lake Barcoorah, Barcaldine Springs Super Group	High	Medium	Very High	Low
4472	Springvale Springs Super Group, Georgina waterholes, Melaleuca viminalis saltpans	Very High	Medium	Medium	
4578	Barcaldine Springs Super Group	High	Very High	Medium	Low
4612	Edgbaston Springs, Lake Mueller	Very High	Very High	Medium	Low
4714	Barcaldine Springs Super Group	Medium	Very High	Medium	
4766	Toko Gorge and waterholes	Medium	Very High	Medium	
4774		High	Very High	Medium	Low
4777	Mulligan River Springs	Medium	Very High	Medium	
4779	Glen Helen Area Mound Springs	Very High	Medium	Medium	Very High
4827	Springvale Springs Super Group	High	Very High	Medium	Low
4893	Black Gin Creek, Thompson River confluence, Thomson, Barcoo waterholes	High	Very High	Medium	
4913	Mulligan River Springs; Mulligan River–Wheeler Creek Junction.	Medium	Medium	Very High	
5002	Upper Finke River Refugia–NW Finke headwaters (Razorback to Two Mile Waterhole)	Medium	Very High	Medium	
5003	Upper Todd River catchment (including Alice Springs)	Low	Very High	Medium	Low
5009	Barcaldine Springs Super Group	High	Medium	Medium	Very High
5030	Barcaldine Springs Super Group	Medium	Very High	Medium	
5060	Springvale Springs Super Group	Medium	Very High	Medium	
5081		Medium	Very High	Medium	Low
5088	Upper Finke River Refugia	Medium	Very High	Medium	

ASSESSMENT UNIT	KNOWN AQUATIC ECOSYSTEMS WITHIN ASSESSMENT UNIT	SCORE FOR CRITERIA			
		C1	C2	C3	C4
5089	Thomson, Barcoo waterholes	High	Very High	Medium	
5093	Hugh River Refugia–Hugh River Headwaters, Chewings Springfed Pools	Medium	Very High	Medium	
5094	Todd River Refugia–Roe Creek and Laura Creek headwaters, Ilparpa Claypans and Conlans Lagoon	Very High	Medium	Medium	Low
5123	Barcaldine Springs Super Group	Very High	Medium	Medium	Medium
5171	Palm Valley Area Springs	Very High	Medium	Low	Very High
5268	Mulligan River Springs	Medium	Very High	Medium	
5354	Finke Gorge below Ellery Creek junction, Boggy Hole and Running Waters	Medium	High	Very High	Medium
5358	Group of freshwater springs, including Cobbs Spring	Very High	Medium	Medium	Medium
5466	Mid-Finke Waterhole Refugia (Central Finke River from Cave Hole to Brumby Waterhole)	Very High	Low	Medium	
5623	Mid-Finke Waterhole Refugia (Idracowra–Karinga Creek junction)	Low	Very High	Medium	
5631	Truno Freshwater Spring	Very High	Medium	Medium	Medium
5678	Lake Koolivoo, Cawallrie Waterhole	Very High	Medium	Medium	Medium
6039	Cooper Creek Overflow Swamps, Windora (DIWA site)	Very High	Medium	High	Medium
6455	Dalhousie Springs	Very High	Very High	Medium	Very High
6994	Southern Simpson Desert, Ephemeral wetlands	High	Very High	Medium	Low
7035	Lower Cooper and Warburton waterholes	High	Medium	Very High	
7201		Medium	Very High	Medium	
7359	Lower Cooper and Warburton waterholes	High	Very High	Medium	Medium
8008	Lake Eyre Mound Springs	Very High	Very High	Medium	Low
8169	Lake Eyre Mound Springs	Very High	Medium	Medium	High
8180	Lake Frome mound springs	High	Medium	Very High	Low
8223	Lake Eyre Mound Springs	High	Very High	Medium	Medium
4373		High ranking due to rare wetland type			
4438	Lake Galilee	High ranking due to rare wetland type			
4544	Georgina River Refugia, Toko waterholes	High ranking due to rare wetland type			

Step 6 Validate identified HEVAE

It is quite probable that in data poor areas such as the LEB, there is a possibility that some high ecological value aquatic ecosystems will not be identified. Jurisdictions were asked to nominate 'distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history)' within their portion of the LEB. While this is considered as an attribute under criterion 2 (Distinctiveness) it was also a means of accounting for data poor areas within the LEB, and a reality check of the identified high-scoring assessment units.

Nominations from jurisdictions were laid over the highest ranking assessment units and reviewed by the ERP. A summary of the outcomes of this process for each jurisdiction is as follows.

New South Wales (NSW)

No nominations were made by NSW because there was insufficient information/knowledge to suggest HEVAE within this area. This was consistent with the data-based scores, which did not identify any high-ranking assessment units within NSW.

Northern Territory (NT)

Sixteen places were nominated in the NT, some of which comprised of a number of aquatic ecosystems (Table 5, Figure 14). Of the sixteen, eight were in the top rankings of the data-based process, occurring in an assessment unit which scored a 'very high' in at least one criterion (Criterion 1 to Criterion 4). Additionally, the Georgina River Refugia were located within an assessment unit that was considered high ranking because of a rare aquatic ecosystem type

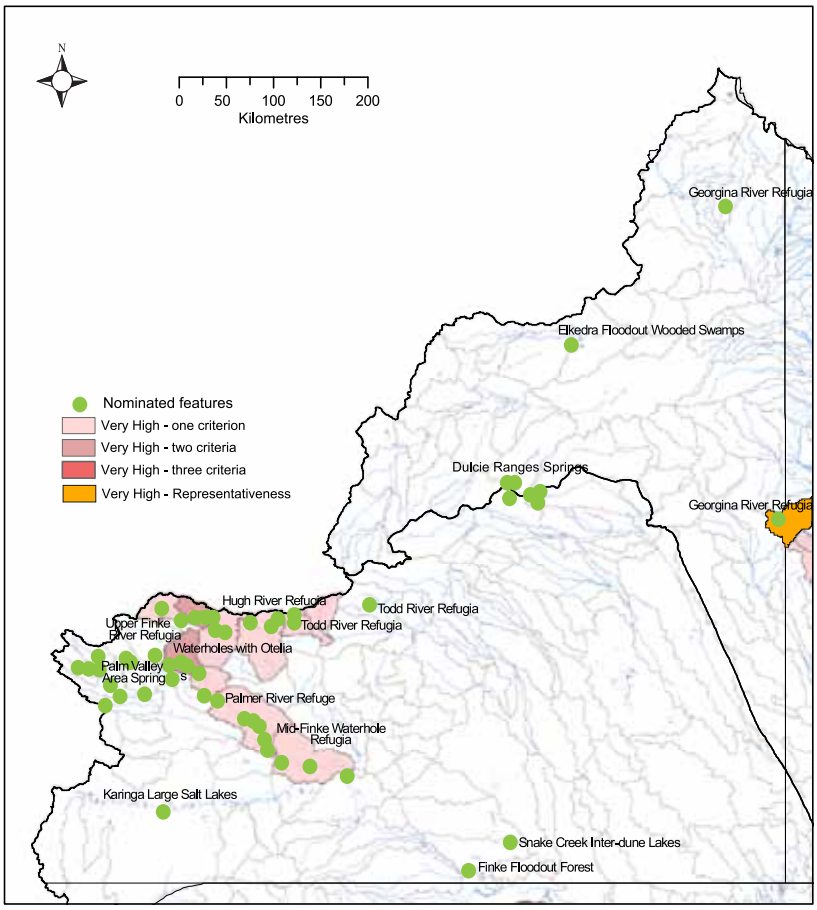


Figure 14 **Nominated distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from the Northern Territory, together with high-ranking assessment units**

(upland, waterhole, groundwater, permanent, fresh) (Criterion 6). Five of the seven remaining nominated aquatic ecosystems were within assessment units that scored high for diversity, but poorly in other criteria.

Elkedra Floodout Wooded Swamps and Finke Floodout Forests were nominated, in part because of the rarity of wooded wetlands in the NT portion of the LEB. This was not identified through the data-based process, as the aquatic ecosystem typology did not include vegetation as an attribute. As a consequence, the rarity or uniqueness of these aquatic ecosystems was not recognised.

There was strong support from the ERP for the inclusion of the Finke Floodout Forest as a HEVAE, with its hydrological importance as a recharge area for GAB springs considered to add to the value of this site. The role of an aquatic ecosystem in maintaining the values of other aquatic ecosystems is not recognised under the HEVAE criteria. This perhaps contributed to this system not being identified as high ecological value through the data-based process.

All seven assessment units that were not identified through the data-based process, but contained nominated high ecological value aquatic ecosystems were data poor. The majority of records were for flora species with few records for other biota. These systems should be afforded a high priority for future on-ground investigations to determine their true ecological value.

Table 5 **Nominations for distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from the NT, together with the outcomes of the scoring**

SITE	OUTCOME OF SCORING
Elkedra Floodout Wooded Swamps	High for C1 (diversity) but Low or Null for C2, C3, C4
Finke Floodout Forest	High for C1 (diversity) but Low or Null for C2, C3, C4
Georgina River Refugia	High for C1 (diversity) but Low or Null for C2, C3, C4. However, high ranking because of a rare aquatic ecosystem type
Glen Helen Area Mound Springs	Very High for C1 (diversity) and C4 (evolutionary history)
Hugh River Refugia	Very High for C1 (diversity)
Karinga Large Salt Lakes	High for C1 (diversity) but Low for C2 (distinctiveness), Medium for C3 (vital habitat), Null for C4 (evolutionary history)
Mid-Finke Waterhole Refugia	Very High for C1 (diversity)
Palm Valley Area Springs	Very High for C1 (diversity) and C4 (evolutionary history)
Palmer Catchment	Medium for C1 and Low or Null for C2, C3, C4
Palmer River (Finke System) Refuge	Medium for C1 and Low or Null for C2, C3, C4
Todd River Refugia	Very High for C1 (diversity)
Upper Finke River Refugia	Very High for C1 (diversity) and C4 (evolutionary history)
Waterholes with Ottelia	Very High for C1 (diversity) and C4 (evolutionary history)
Chewings Springfed Pools	Very High for C1 (diversity) and C4 (evolutionary history)
Dulcie Springfed Pools	High for C1 (diversity) but Low or Null for C2, C3, C4
Snake Creek Inter-dune Lakes	High for C1 (diversity) but Low or Null for C2, C3, C4

Note that some nominations span multiple assessment units; scoring represents the highest ranks recorded.

Queensland

Queensland nominated 40 areas, 32 springs and 1061 ephemeral wetlands as 'distinctive, rare or threatened geomorphic, hydrological or ecological feature (including those important for evolutionary history)'. These ranged from large areas such as the Simpson Desert, to small waterholes and springs. The ERP did not consider all Queensland-nominated features as HEVAE. There was doubt as to the validity of nominating such a large number of ephemeral wetlands, areas with predominantly terrestrial values and that not all spring systems were of equal high ecological value. In particular Edgbaston Springs was singled out by the ERP as a highly significant site and of high ecological value at the national level.

The large number of nominations precluded a full comparison with the data-based process. However, an assessment of nomination for which a point location was provided (excluding the 1061 ephemeral wetlands) indicated there was a good correlation with high-scoring assessment units particularly for spring systems (Table 6, Figure 15). The assessment unit that contained Edgbaston Springs scored 'very high' for Criterion 1 Diversity and Criterion 2 Distinctiveness.

Interestingly, the area in the middle reaches of the Diamantina River, including Diamantina Lakes did not score highly in the data-based process. There was strong support from the ERP for the inclusion of Diamantina Lakes as a HEVAE. However, the site spans 15 assessment units, many of which scored 'high' for species richness. Had these assessment units been aggregated and scores calculated on combined species richness, it might have been elevated in the ranking. In addition, the mid reaches of the Diamantina nominated as distinct features fell into the same SWMA and/or IBRA region as a number of high-ranking aquatic ecosystems (e.g. Goyders Lagoon, Toko Gorge) which may have lowered the comparative ranking of the nominated systems.

Similarly, areas such as Lake Buchanan were nominated as part of a suite of aquatic ecosystems in the desert uplands. While the assessment units that contained some of these wetlands were in the high-ranking categories (e.g. Lake Galilee and Lake Huffer) others were not. This would be potentially identified in the delineation and description process.

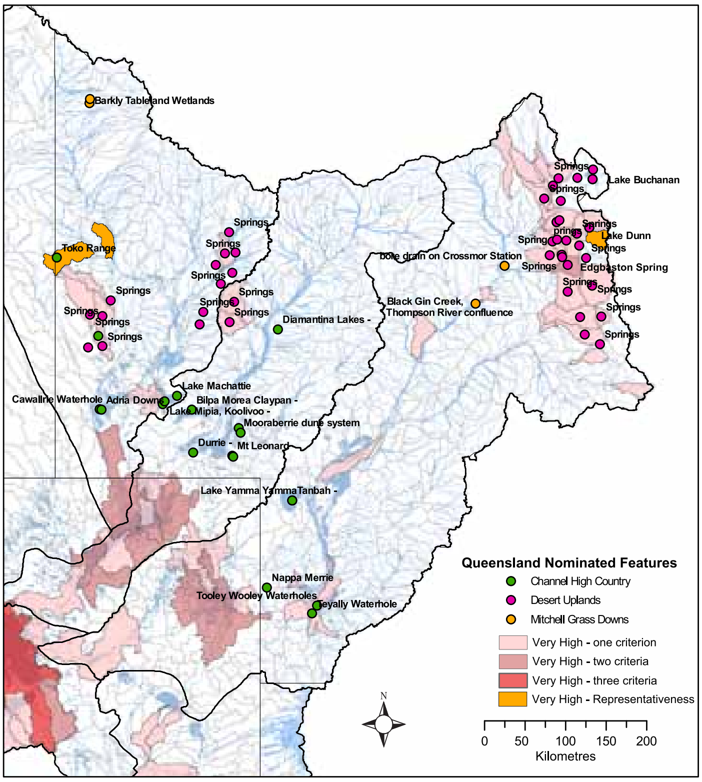


Figure 15 Nominated distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from Queensland, together with high ranking assessment units

Table 6 **Nominations for distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from Queensland, together with the outcomes of the scoring**

SITE	OUTCOME OF SCORING
Lake Buchanan	All medium or low
Edgbaston Springs	Very High C1 (diversity) and C2 (distinctiveness)
Lake Huffer and springs	Very High C2 (distinctiveness)
Lake Galilee	Very High C2 (distinctiveness)
Cauckingburra Swamp	Medium, Low or Null for all
Thirlestone Lakes	Medium, Low or Null for all
Lake Barcoorah	Very High C2 (distinctiveness), High C1 (diversity)
Lake Mueller	Very High C1 (diversity) and C2 (distinctiveness)
Lake Dunn	Very High C2 (distinctiveness)
Black Gin Creek, Thompson River confluence	Very High C1 (diversity)
Barkly Downs Wetlands	High C1 (diversity)
Barkly Tableland Wetlands	Medium, Low or Null for all
Wetlands—closed depressions with bluebush Eragostis setafolia and nardoo	Very High C2 (distinctiveness)
Georgina waterholes (permanent)	Very High C2 (distinctiveness)
Georgina waterholes (semi-permanent)	Mostly Low or Null
Melaleuca viminalis east of Boulia	Very High C2 (distinctiveness)
Thomson, Barcoo waterholes	Very High C1 (diversity)
bore drain on Crossmor Station	High C1 (diversity)
Adria Downs	High C1 (diversity)
Sandringham Dune Systems	Very High C1 (diversity) and C2 (distinctiveness)
Ethabuka	Very High C2 (distinctiveness)
Durrie	High C1 (diversity) and C3 (vital habitat)
Mt Leonard	High in C1 (diversity)
Diamantina Lakes	High in C1 (diversity)
Tanbah	High in C3 (vital habitat)
Bilpa Morea Claypan	Medium, Low or Null for all
Lake Yamma Yamma	High in C3 (vital habitat)
Lake Machattie, Lake Mipia, Koolivoo	High C1 (diversity), High in C2 (distinctiveness) and C3 (vital habitat)
Cawallrie Waterhole	Very High C3 (vital habitat)
Toko Range	Very High C2 (distinctiveness)
Mooraberrie dune system	High C1 (diversity) and C3 (vital habitat)
Southern Simpson Desert	Very High C3 (vital habitat) and High C4 (evolutionary history)
Simpson Desert	Very High C2 (distinctiveness)
Barcaldine Springs Super Group	Very High C1 (diversity) and C2 (distinctiveness)
Mulligan River Springs Super Group	Very High C2 (distinctiveness)
Springvale Springs Super Group	Very High C2 (distinctiveness)

Note that some nominations span multiple assessment units and scoring represents the highest ranks recorded.

Diamantina River, Monkira, Queensland (Diane Conrick)

South Australia

Thirteen places were nominated in South Australia, some of which comprised a number of aquatic ecosystems (Table 7, Figure 16). Of the thirteen, nine were in the top rankings of the database process, occurring in an assessment unit which scored a 'very high' in at least one criterion (criteria 1 to 4). The three of the four remaining nominated aquatic ecosystems were within assessment units that scored 'high' for at least one criterion, but poorly in other criteria. The final nominated site (Poeppel Lakes, Peera Peera Poolanna Lake, Lake Griselda and Lake Umaroona) was within very data poor assessment units with a large number of 'null' values.

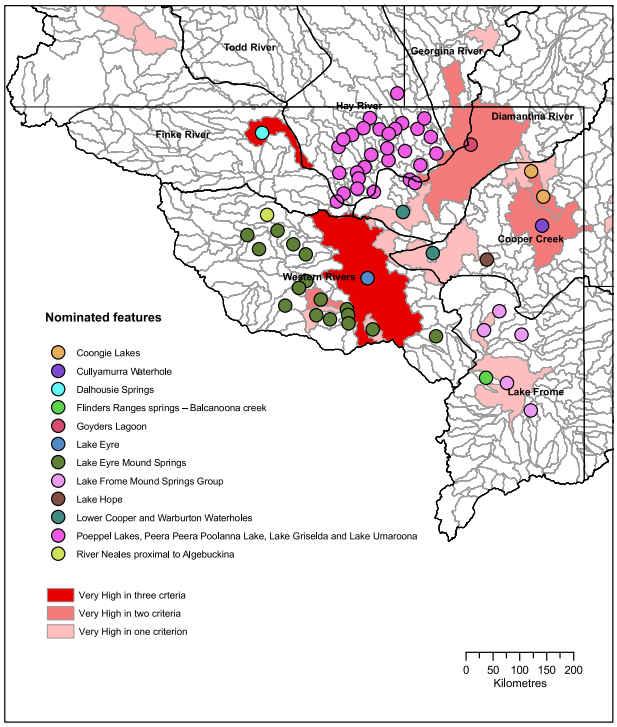


Figure 16 Nominated distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from South Australia, together with high-ranking assessment units

Algebuckina Waterhole was nominated based on the rarity of permanent water in the Western Rivers SWMA. The application of the attribute for refugia (vital habitat) was based on presence/absence data only and referential to the entire LEB. This was recognised as a compromise because of data and resource constraints and a more robust method based on extent, number and depth of waterholes, referential to the SWMA may have resulted in a higher score for the assessment unit containing this aquatic ecosystem.

Lake Hope and the Flinders Ranges Springs are located within SWMA/IBRA regions with other high-ranking assessment units. This may have comparatively decreased the scores for assessment units containing these two nominated features. The interdunal clay/salt pan features of Poeppel Lakes, Peera Peera Poolanna Lake, Lake Griselda and Lake Umaroona are extremely data poor and not well studied. These systems should be afforded a high priority for further investigation.

Table 7 **Nominations for distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from the South Australia, together with the outcomes of the scoring**

SITE	OUTCOME OF SCORING
Dalhousie Springs	Very High for C1 (diversity), C2 (distinctiveness) and C4 (evolutionary history)
Coongie Lakes	Very High for C1 (diversity) and C3 (vital habitat)
Goyders Lagoon	Very High for C1 (diversity) and C3 (vital habitat)
Lake Eyre	Very High for C1 (diversity), C2 (distinctiveness) and C3 (vital habitat)
Cullyamurra Waterhole	Very High for C1 (diversity) and C3 (vital habitat)
River Neales proximal to Algebuckina	High for C1 (diversity) and C2 (distinctiveness), Medium for C3 (vital habitat) and C4 (evolutionary history)
Lake Eyre Mound Springs	Very High for C1 (diversity) and C2 (distinctiveness)
Lake Frome Mound Springs Group	Very High for C1 (diversity)
Lower Cooper and Warburton waterholes	Very High for C1 (diversity), C2 (distinctiveness) and C3 (vital habitat)
Lakes Blanche, Callabonna and Frome	Very High for C1 (diversity)
Lake Hope	High for C3 (vital habitat), Medium for C1 (diversity), Low for C4 (evolutionary history) and Null for C2 (distinctiveness)
Flinders Ranges springs—Balcanoona Creek	High for C1 (diversity) and C2 (distinctiveness), Medium for C3 (vital habitat) and Low for C4 (evolutionary history)
Poeppel Lakes, Peera Peera Poolanna Lake, Lake Griselda and Lake Umaroona	Low or Null for C1, C2, C3 and C4