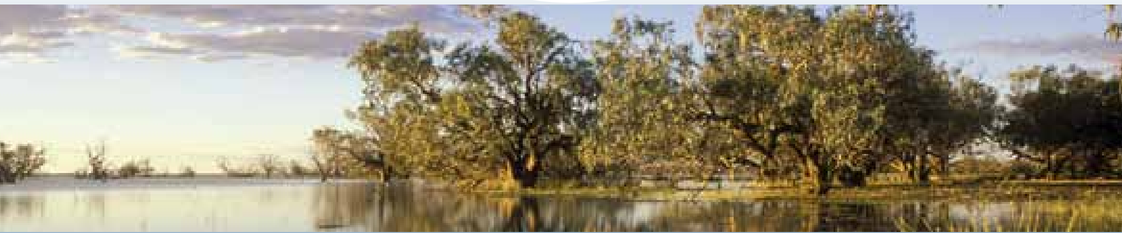
Aquatic ecosystems toolkit



CASE STUDY 1:
Lake Eyre Basin

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

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Authors/endorsement

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.

Endorsed by the Standing Council on Environment and Water, 2012.

These trials were undertaken during the time when guidance on the identification, delineation and description of aquatic ecosystems was an area of active policy development. The work informing the contents of this publication was carried out under budgetary and time restraints, resulting in limited ability to incorporate all available datasets and information into the process.

Citation

Aquatic Ecosystems Task Group (2012). Aquatic Ecosystems Toolkit. *Case Study 1: Lake Eyre Basin*. Department of Sustainability, Environment, Water Population and Communities, Canberra.

The publication can be accessed at <**http://www.environment.gov.au/water**>

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

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Abbreviations

AETG	Aquatic Ecosystems Task Group
ANAE	Australian National Aquatic Ecosystems (Classification Scheme)
AquaBAMM	Aquatic Biodiversity Assessment Mapping Methodology
AWRC	Australian Water Resources Council
CAMBA	China–Australia Migratory Bird Agreement
CDI	Catchment Disturbance Index
CFEV	Conservation of Freshwater Ecosystem Values Framework
DEM	Digital Elevation Model
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EFZ	Ecological Focal Zone
EPBC	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
ERP	Expert Reference Panel
GAB	Great Artesian Basin
Geofabric	Australian Hydrological Geospatial Fabric
HCVAE	High Conservation Value Aquatic Ecosystems
HEVAE	High Ecological Value Aquatic Ecosystems
IBRA	Interim Biogeographic Regionalisation of Australia
IUCN	International Union of Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
LEB	Lake Eyre Basin
NCB	National Catchment Boundaries
NRETAS	Department of Natural Resources, Environment, The Arts and Sport (Northern Territory)
RDI	River Disturbance Index
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SWMA	(Australian) Surface Water Management Areas
TWG	Technical Working Group

Introduction

Draft components of the national Aquatic Ecosystems Toolkit, developed by the Aquatic Ecosystems Task Group (AETG), were trialled in the Lake Eyre Basin. Trial application of module 3 was undertaken by a multijurisdictional team, led by Jennifer Hale, and module 4 by Jennifer Hale and Shane Brooks.

The base information developed and collated was done so within time and resource constraints and with regard to the objectives of the High Ecological Value Aquatic Ecosystems (HEVAE) trial and the HEVAE 'Framework' as it was at that time. Therefore, while the ancillary outcomes of this project such as the aquatic ecosystem mapping may be fit for the purpose of this trial, they should not be considered final products.

Note that at the time the trial was undertaken:

The terminology 'High Conservation Value Aquatic Ecosystems' (HCVAE) was still in use. However, to reflect the change in name to 'High Ecological Value Aquatic Ecosystems', the term HEVAE has been used in this case study, consistent with the other toolkit documents.

Module 3: Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE) was known as the HEVAE Framework.

There were six HEVAE criteria; 'evolutionary history' has since been incorporated into 'distinctiveness'.

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

Kaporilya Springs, Northern Territory (Diane Conrick)

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

1.1 Groundwork before identifying HEVAE

Whilst the Lake Eyre Basin (LEB) covers 15 percent of Australia, it is remote and poorly studied compared with similarly sized drainage divisions. The LEB spans four state/territory boundaries (Figure 1), and information collected prior to this project was not consistent or comprehensive across the whole basin. Before applying Module 3 *Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE)*, preliminary work was required to integrate existing data sets, to provide a basin-wide information base.

Step 1 Identify purpose

The purpose of the assessment was to test the draft HEVAE Framework, and draft delineation guidelines, (which have now been developed into Module 3: *Guidelines for Identifying HEVAE*, and Module 4: *Aquatic Ecosystem Delineation and Description Guidelines*, respectively) in the Lake Eyre Basin.

Step 2 Map and classify aquatic ecosystems

A consistent and comparable classification of aquatic ecosystems was required to apply a number of the HEVAE criteria (particularly ‘diversity’ and ‘representativeness’). Two typologies were developed, one for riverine and one for non-riverine aquatic ecosystems. This trial pre-dated the Australian National Aquatic Ecosystem (ANAE) Classification Scheme, however the principles of the ANAE Classification Scheme were used to identify aquatic ecosystem types.

Non-riverine (lacustrine/palustrine) aquatic ecosystems were defined as those that are not connected to a mapped drainage channel, or are substantially wider than the channel (e.g. a lake fed by a river). Riverine ecosystems were defined as all aquatic ecosystems and deepwater habitats within a channel that are naturally or artificially created, periodically/continuously contain moving water, or form a connecting link between two bodies of standing water.

A set of key classification attributes that each jurisdiction could apply were identified for both non-riverine and riverine systems (Table 1).

The application of the classification system was based predominantly on existing data sources. However, in order to minimise the number of systems that were classified as 'unknown' due to a lack of information on one or more attribute, defaults based on stated assumptions were used. Defaults were, in the absence of evidence or knowledge to the contrary:

- fresh
- non-permanent
- riverine systems were considered channels
- groundwater source was considered unconfined.

The final output was mapping of non-riverine aquatic ecosystems into 27 possible categories, and riverine ecosystems into 32 categories, based on combinations of attributes (e.g. lowland/floodplain/surface water/non-permanent/fresh).

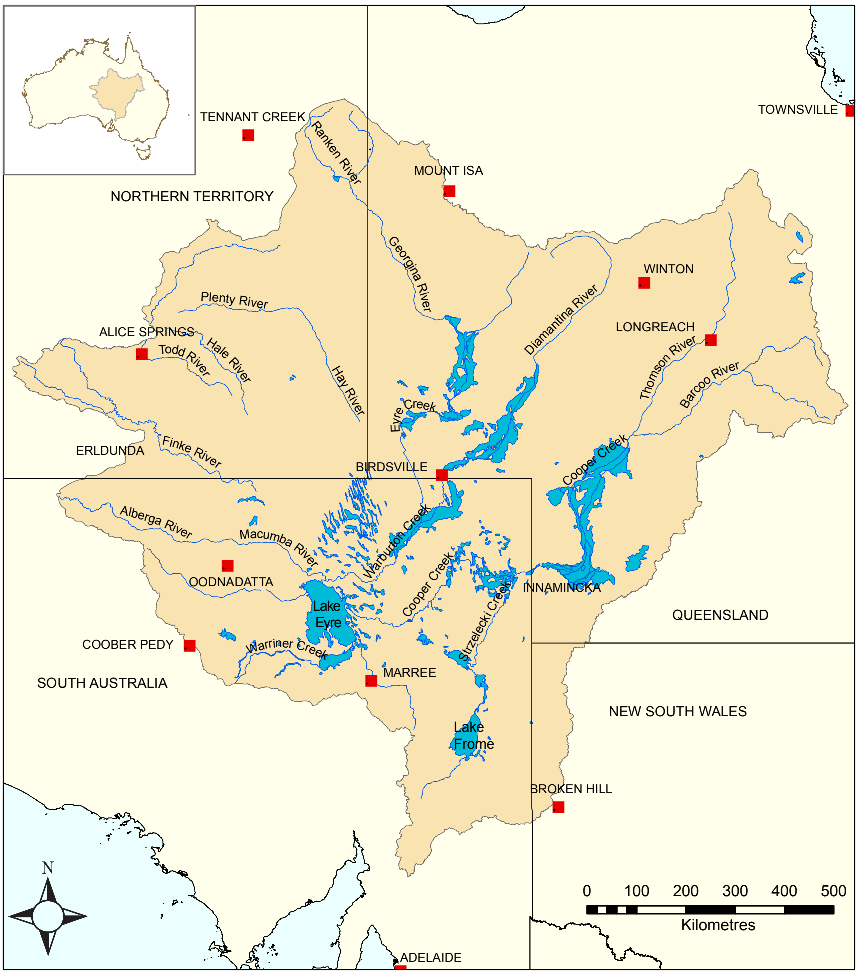


Figure 1 **Map of the Lake Eyre Basin drainage division showing major river systems and jurisdictional boundaries**

Table 1 Key attributes used to classify non-riverine and riverine aquatic ecosystems across the Lake Eyre Basin

ATTRIBUTE	DESCRIPTION	NON-RIVERINE/ RIVERINE
Landform: Upland Lowland	Based on a measure of roughness applied across the basin using the 9 second Digital Elevation Model.	Non-riverine & riverine
Dominant water source: Groundwater Surface water	The 'groundwater' attribute is applied to those aquatic ecosystems that have been identified in mapping or expert panel review as being fed predominately by groundwater (e.g. springs). The 'surface water' attribute covers all wetland systems that have not been identified as having characteristics that would indicate they are predominately groundwater fed. A sub-category of artesian versus unconfined aquifer sources was applied to separate deep-water aquifer-fed systems from surficial groundwater systems.	Non-riverine & riverine
Connectivity: Floodplain Non-floodplain	Floodplains are defined in this trial* as (The National Committee on Soil and Terrain, 2009[1]): 'alluvial plains characterised by frequently active erosion and aggradation by channelled or overbank stream flow. Unless otherwise specified "frequently active" is to mean that flow has an Average Recurrence Interval of 50 years or less.' The non-floodplain category covers the remaining systems that may receive some flow from local watershed creeks but are only very rarely or very minimally influenced by true river systems. The 'non-floodplain' (spring) category includes all mapped springs.	Non-riverine
Connectivity: Channel Waterhole Spring	Channel—water mostly flowing if present but may persist for a few days as shallow water after flow stops. Waterhole—water remains after flow stops for periods of weeks through to permanent. Spring—aquifer discharge feature on bank or bed of watercourse or very close on adjacent cliff; discharge may be intermittent and may rarely produce surface flows (i.e. a seepage spring).	Riverine
Water regime: Near-permanent Non-permanent	Near-permanent—defined as those waterbodies that hold water for >70% of the time. Non-permanent—defined as those waterbodies that hold water for <70% of the time.	Non-riverine & riverine
Water type: Fresh Saline	Adoption of the Queensland wetland mapping definition where fresh is <3 ppt and saline >3 ppt. In the context of the LEB, the attribute is applied based on the average conditions within the wetland (i.e. the wetland may become more saline as it dries, but is considered fresh if for the majority of the time it holds water, salinity is <3 ppt). However, few aquatic ecosystems contained salinity data. In these cases salinity was identified through expert opinion or defaulted to fresh.	Non-riverine & riverine

* Note this definition differs somewhat from the one used in the ANAE Classification Scheme (Module 2), which defines floodplains as 'areas that are intermittently inundated by the lateral overflow of riverine, lacustrine or palustrine systems, by direct precipitation, or by groundwater'.

1 The National Committee on Soil and Terrain (2009). Australian Soil and Land Survey Field Handbook, Third Edition, CSIRO Land and Water, Canberra.

Step 3 Determine scale, r egionalisation, and spatial units

The scale, regionalisation and spatial units relevant to the LEB HEVAE trial are illustrated in Figure 2.

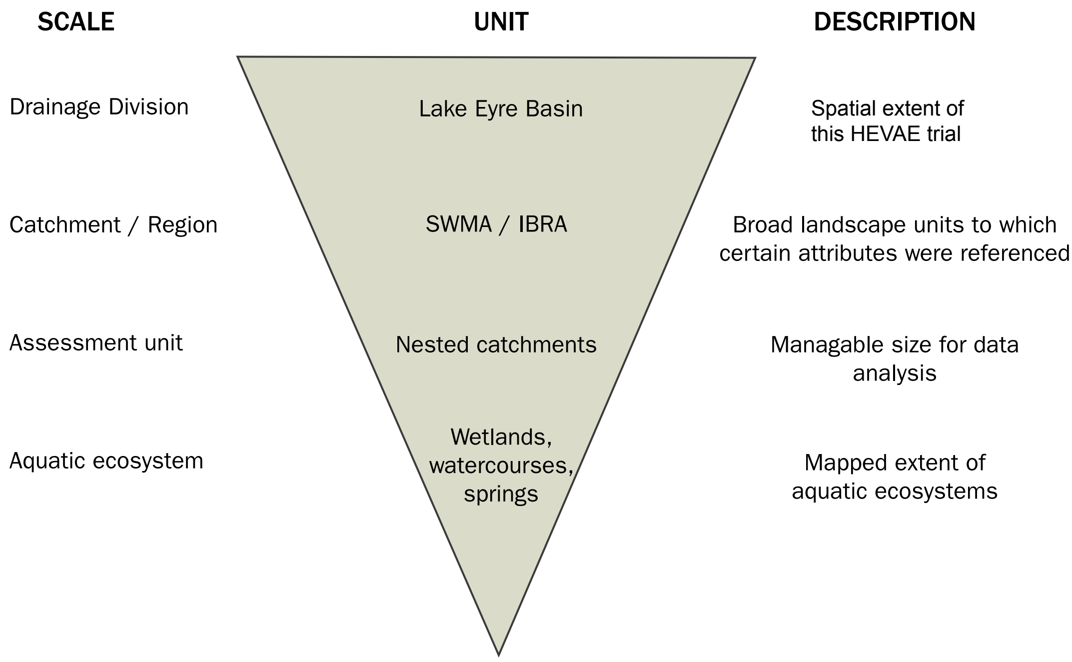


Figure 2 Spatial scales used in the LEB HEVAE trial

a. Determine scale and regionalisation

The LEB drainage division boundary was defined by the Australian Water Resources Council (AWRC) in the 1960s, and this boundary has been formally recognised in the LEB Agreement process. However, in 2005, Duguid et al. documented the need for a major boundary change associated with the catchment of the Karinga Creek and flow along the creek into the Finke River. Subsequently, Geoscience Australia has re-mapped major river basin and drainage division boundaries across Australia using a digital terrain model. This is part of a new Australian Hydrological Geospatial Fabric (Geofabric). A near-final draft of the revised drainage division boundaries was obtained for use in the LEB HEVAE trial. Queensland, South Australia and NSW chose to use the old boundary because of its official status under the LEB Agreement, and because they had data already organised according to that boundary, while the Northern Territory chose to use the new boundary.

Selection of an appropriate regionalisation for use at broader scales proved problematic, and three options were considered: river catchments, Interim Bioregionalisation of Australia (IBRA), and a regionalisation based on landscape form and function (a modified form of IBRA that accounted for the major hydro-geomorphic types and landscape processes occurring in the LEB).

The project's Technical Working Group (TWG) and Expert Reference Panel (ERP) (see Expert knowledge input (below) decided that more than one regionalisation scheme could be selected for application to different aspects of the HEVAE criteria. Two existing regionalisations (Figures 3a and b) were selected that had broad applicability to aquatic ecosystem attributes:

- Aquatic based regionalisation—Australian Surface Water Management Areas (SWMA) (with a further split in South Australia to Lake Frome and Western Rivers). SWMA provide a broad stratification on aquatic ecosystem characteristics and account for both longitudinal and lateral connectivity. They were used specifically for identification of endemic species at the sub-basin scale as well as for referencing diversity of aquatic ecosystems and species richness of fish.
- Geomorphic and climate-based regionalisation—Interim Bioregionalisation of Australia (IBRA) was selected for referencing attributes that are known to vary with climate and geomorphology across the basin (e.g. plant and amphibian species richness).

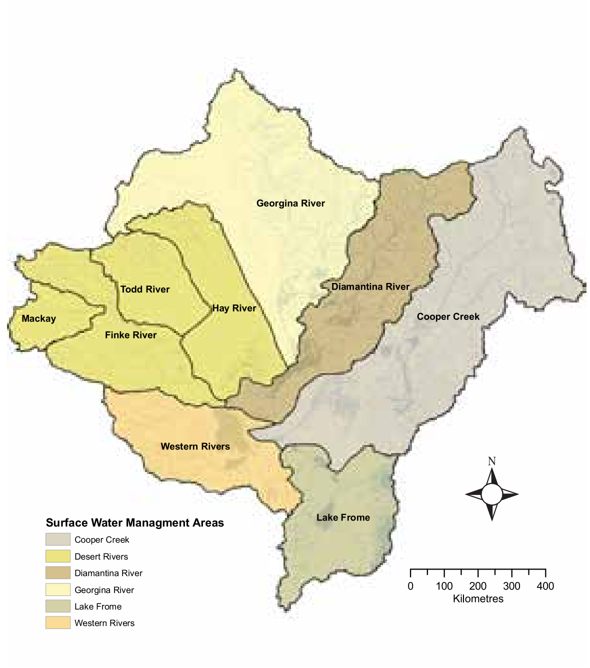


Figure 3a Surface Water Management Areas (SWMA) in the Lake Eyre Basin

Figure 3b Interim Bioregionalisation of Australia (IBRA) regions within the Lake Eyre Basin

b. Select spatial units

A top-down catchment-based approach was used to identify HEVAE, by assigning data to assessment units rather than individual wetlands, waterholes or river reaches. This approach partially overcame the problem of sample bias and uneven distribution of data between aquatic ecosystems in the LEB. While the systematic description or delineation of important aquatic ecosystems within the assessment units was not possible, assessment units that had a high probability of containing one or more HEVAE could be identified. In some instances an assessment unit could also meet the HEVAE criteria because of the presence of more than one disconnected aquatic ecosystem.

Two available datasets with delineations of catchments were investigated both based on digital elevation models (DEM):

- the recently developed National Catchment Boundaries (NCB) nested catchments that are being beta tested by the Bureau of Meteorology for the Geofabric (based on the Pfafstetter technique)

- the 500-square-kilometre nested catchments data set provided by the Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC).

The NCB nested catchments were rejected as the variability in area of 'catchments' within any given level was considered too great for the LEB HEVAE trial, and there were instances where boundaries did not align with on-ground knowledge of the TWG members. As a consequence, the 500-square-kilometre nested catchments data set provided by DSEWPaC was selected as an appropriate scale for the assessment units. This resulted in approximately 1100 units across the LEB.

Each jurisdiction further customised these catchments as necessary to balance objective boundaries derived from a DEM and ecologically meaningful units of an appropriate size. The process resulted in 1035 assessment units across the LEB ranging in size from 82 to 29 000 square kilometres, with a median size of approximately 1000 square kilometres (Figure 4).

To apply the attributes for criteria (see Step 4b), each assessment unit needed to be ascribed to a SWMA and IBRA region. Overlaying of the boundaries of assessment units with each of the regionalisations indicated that a large number of assessment units spanned a regional boundary. To address this, a '50 percent' rule was applied whereby the assessment units were ascribed to the region in which more than 50 percent of its area lay.

The intersection of the drainage division with the IBRA regions resulted in an imperfect fit, and a number of IBRA regions were dissected by the drainage division boundary. There were several small areas of IBRA regions that lay predominantly outside the LEB, which contained too few assessment units (less than three) for meaningful, referential evaluations to be made. As a consequence, assessment units in these small, partial IBRA regions were subsumed into adjoining IBRA regions for the purpose of referential evaluations.

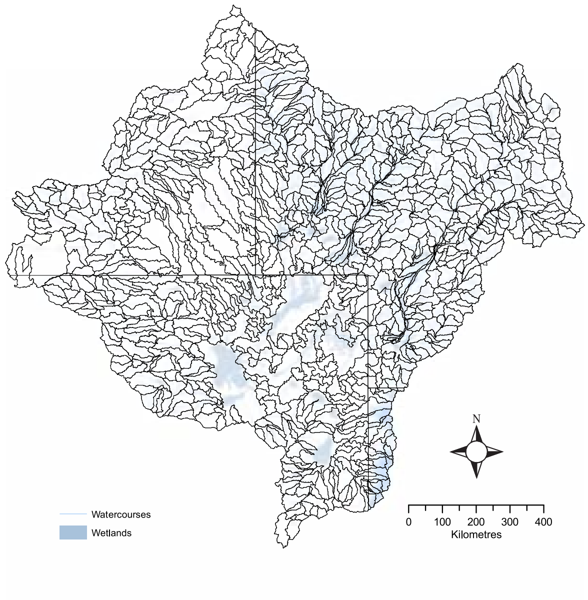


Figure 4 Assessment units in the LEB using the 500-square-kilometre nested catchments data set

Expert knowledge input

The Technical Working Group (TWG) comprising representatives from the NSW, Northern Territory, South Australia, Queensland and Australian governments was established to conduct the HEVAE trials. The TWG worked in collaboration with scientific experts from government and research organisations (the Expert Reference Panel).

The Expert Reference Panel (ERP) was assembled for both the HEVAE identification and delineation trials. The ERP comprised of scientists with expertise in a range of relevant fields (including hydrology, geomorphology, fish, waterbirds, vegetation, macroinvertebrates) and local knowledge and experience in the LEB. The ERP met with the TWG twice during the HEVAE identification trial and once during the delineation trial, and also contributed expert knowledge out of session.

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.

<table>
<tr><th>CRITERION, ATTRIBUTES & METRICS</th><th>RATIONALE</th><th>DATA REQUIREMENTS</th></tr>
<tr><td colspan="3">2F CONSERVATION STATUS OF AQUATIC REGIONAL ECOSYSTEMS (QUEENSLAND ONLY)</td></tr>
<tr><td>Metrics:
• scored as follows:
– endangered = 4
– of concern = 3
– not of concern = 2
– none present = 1.</td><td>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.</td><td>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.</td></tr>
</table>

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)

<table>
<tr><th>CRITERION, ATTRIBUTES & METRICS</th><th>RATIONALE</th><th>DATA REQUIREMENTS</th></tr>
<tr><td colspan="3">Criterion 5: Naturalness: The ecological character of the aquatic ecosystem is not adversely affected by modern human activity.</td></tr>
<tr><td colspan="3">RIVER DISTURBANCE INDEX</td></tr>
<tr><td>Metrics:
• Mean Catchment Disturbance Index
• Mean Flow Regime Disturbance Index.</td><td>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.</td><td>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.</td></tr>
<tr><td colspan="3">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.</td></tr>
<tr><td>Metrics:
• filter to ensure that all aquatic ecosystem types are captured in the HEVAE process.</td><td>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.</td><td>Wetland typology and mapping consistent across the basin.</td></tr>
</table>

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)

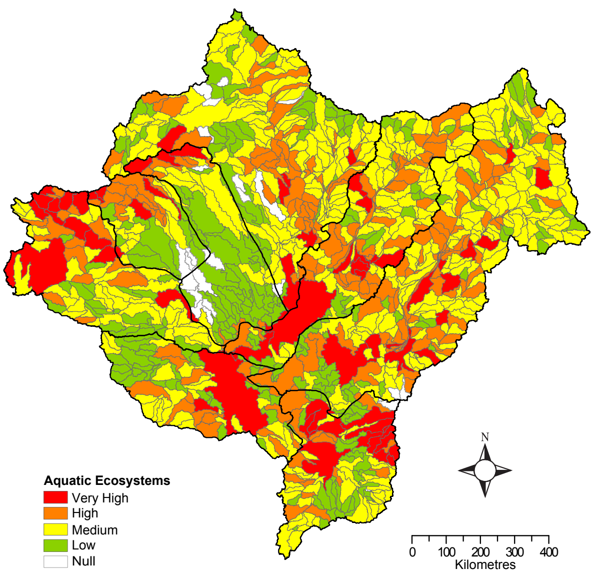
Criterion 1: Diversity

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.

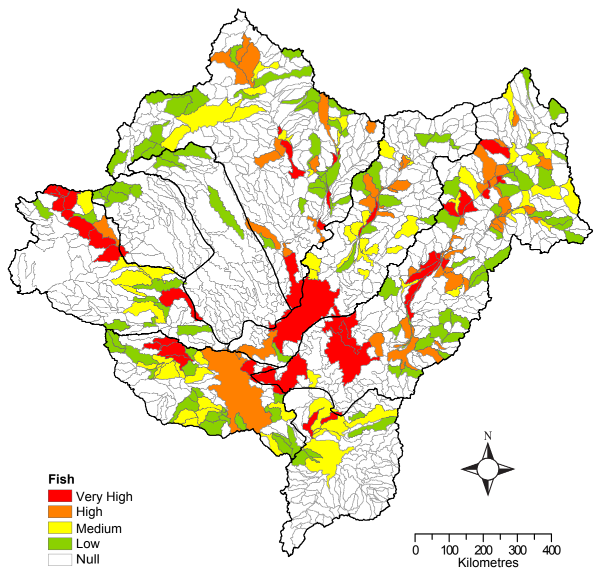
Combining and weighting the attributes resulted in 23 assessment units in the highest category (Figure 6a). A sensitivity analysis with no species weightings reduced this to 13 assessment units, which included two additional units not identified as 'very high' in the weighted assessment (Figure 6b). 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.



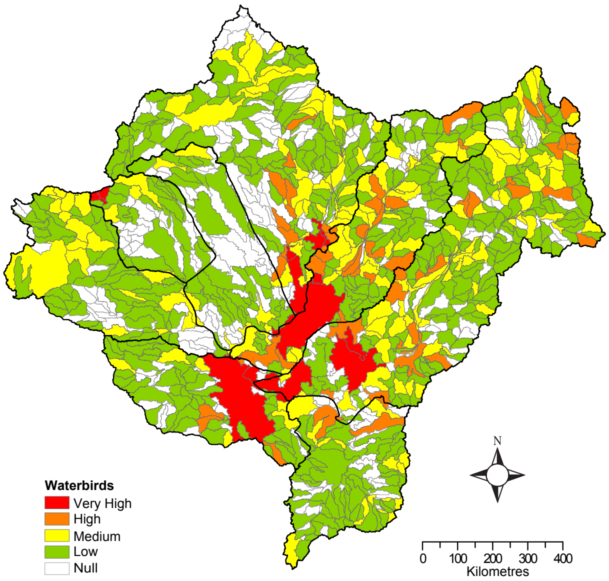
THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Lake Eyre Basin	10 to 15	7 to 9	4 to 6	1 to 3
Cooper Creek	9 to 12	6 to 8	3 to 5	1 to 2
Desert Rivers	7 to 9	5 to 6	3 to 4	1 to 2
Diamantina	9 to 12	6 to 8	3 to 5	1 to 2
Georgina	9 to 12	6 to 8	3 to 5	1 to 2
Lake Frome	7 to 9	5 to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



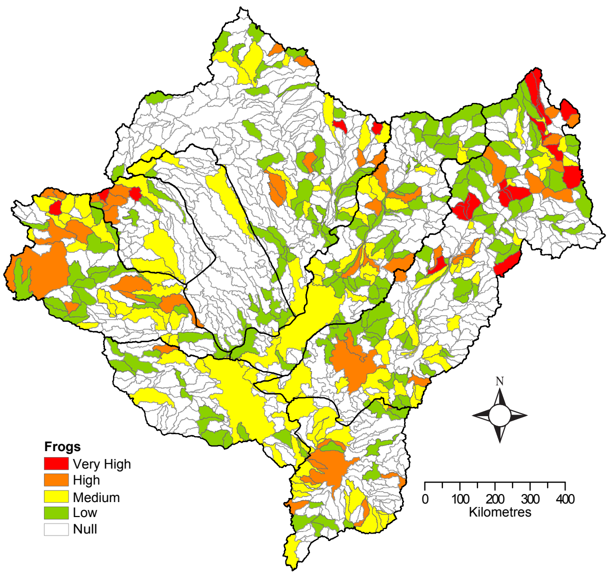
THRESHOLD VALUES				
Region	**Very High**	**High**	**Medium**	**Low**
Cooper Creek	10 to 14	7 to 9	4 to 6	1 to 3
Desert Rivers	7 to 9	5 to 6	3 to 4	1 to 2
Diamantina	9 to 12	6 to 8	3 to 5	1 to 2
Georgina	8 to 10	5 to 7	3 to 4	1 to 2
Lake Frome	4 to 5	3	2	1
Western Rivers	7 to 10	5 to 6	3 to 4	1 to 2

Figure 5b Attribute 1B—Number of fish species



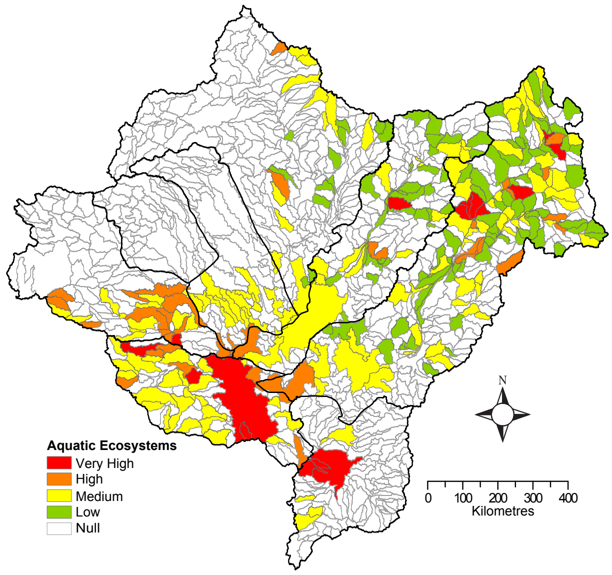
THRESHOLD VALUES				
Region	Very High	High	Medium	Low
Lake Eyre Basin	58 to 91	37 to 57	19 to 36	1 to 18

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

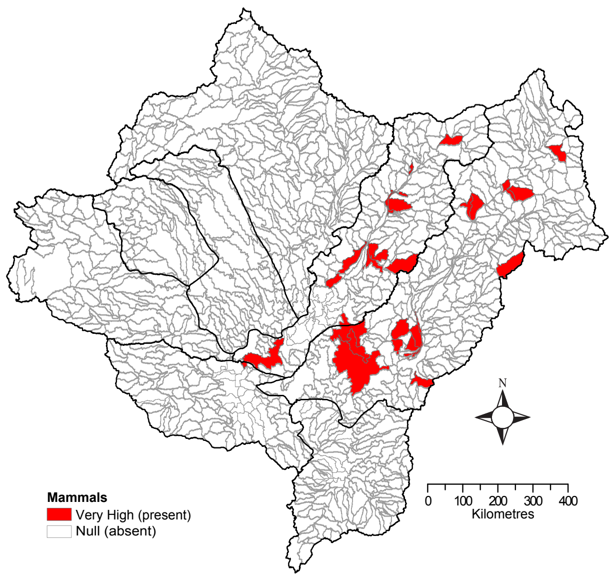
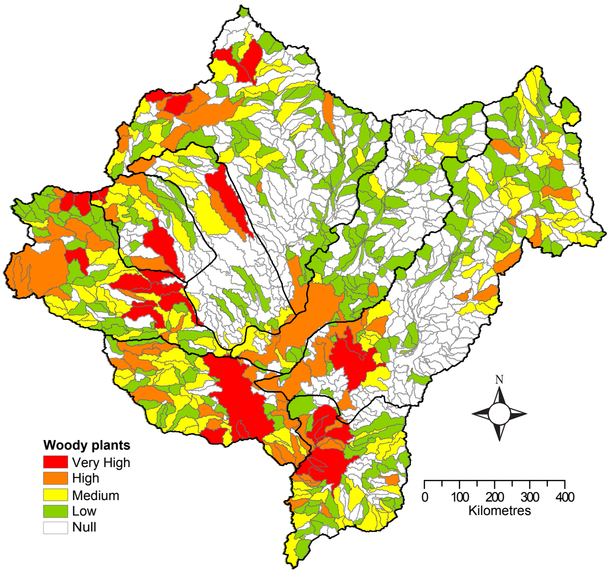
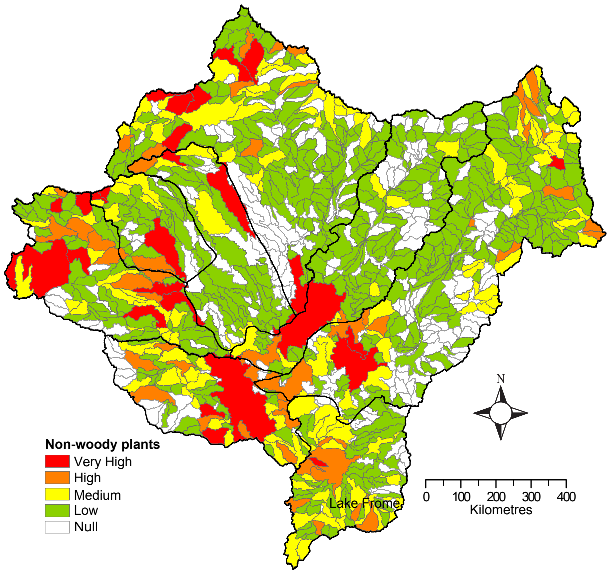


Figure 5f Attribute 1B—Presence of mammal (water rat)



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

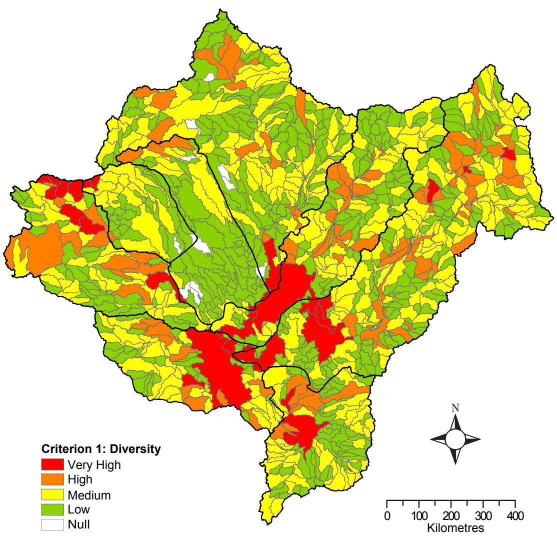


Figure 6a Diversity attributes combined and weighted

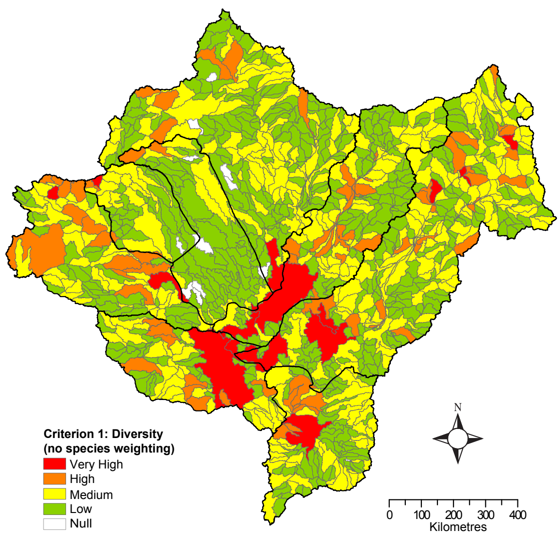


Figure 6b Diversity attributes combined not weighted

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).

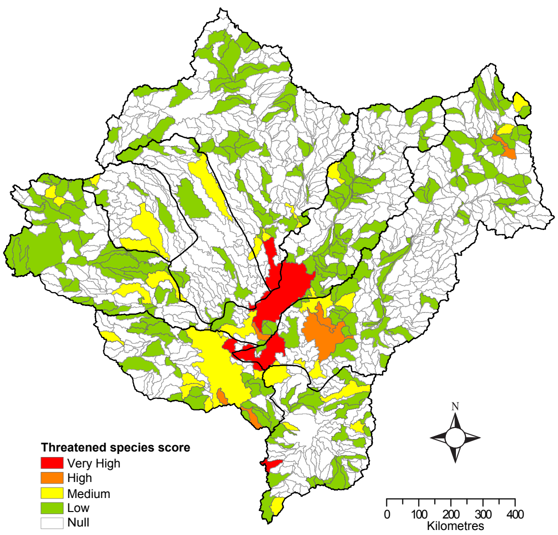


Figure 7a Attribute 2A—Threatened species

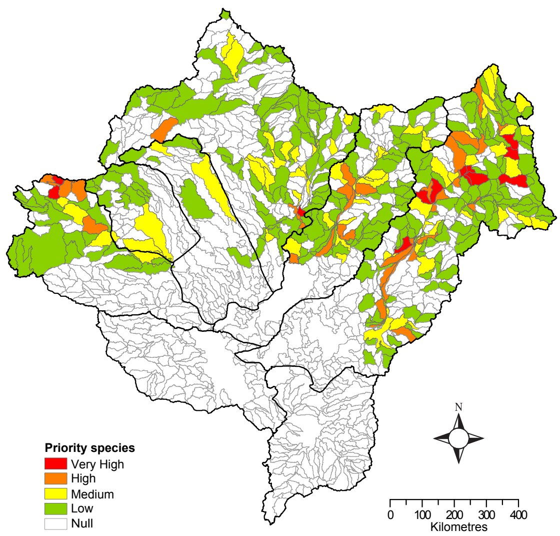


Figure 7b Attribute 2B—Priority species

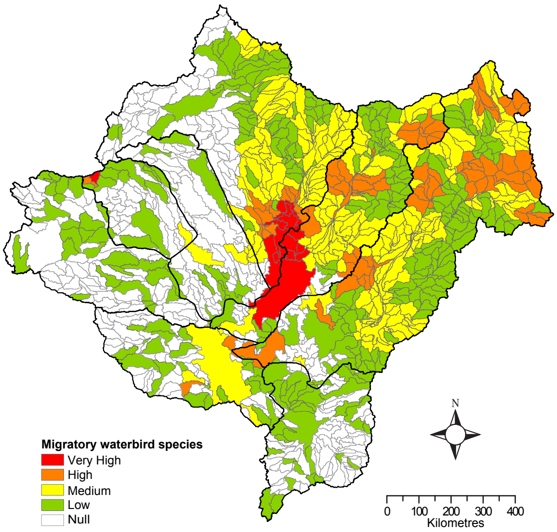


Figure 7c **Attribute 2C—Migratory waterbirds**

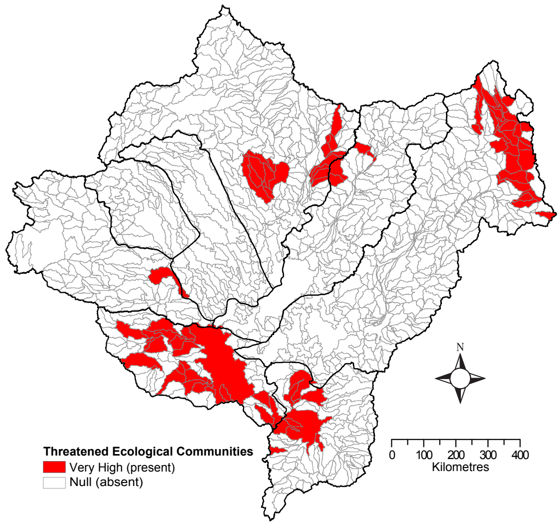


Figure 7d **Attribute 2E—Presence of the threatened ecological community of the GAB springs**

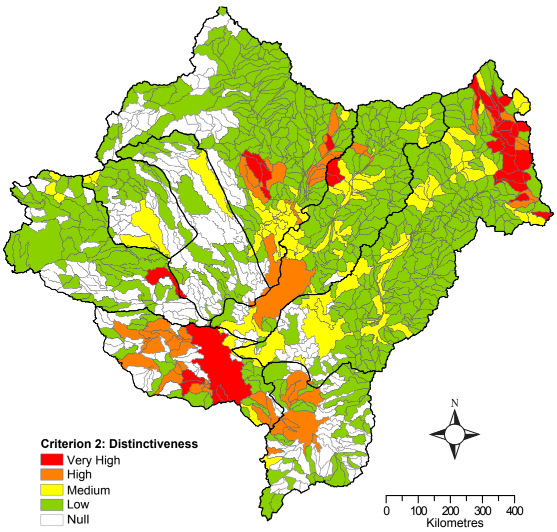


Figure 8 Distinctiveness attributes combined and weighted

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.

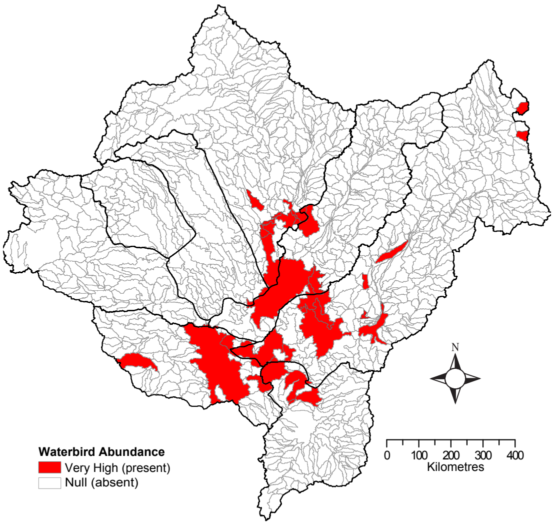


Figure 9a Attribute 3A—Waterbird abundance (presence of large numbers of waterbirds)

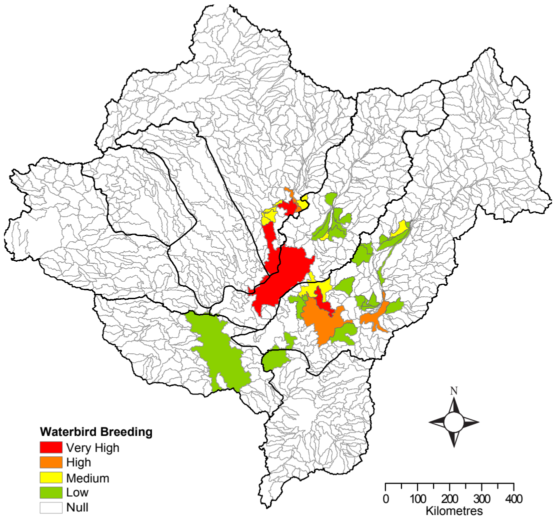


Figure 9b Attributes 3B—Waterbird breeding

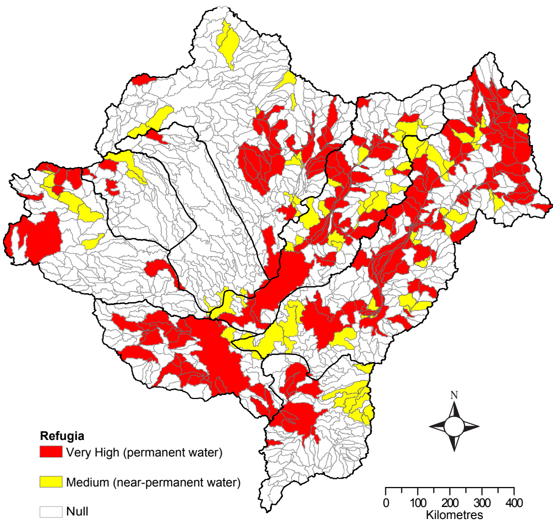


Figure 9c Attribute 3C—Refugia (presence of permanent water = very high; near permanent water = high)

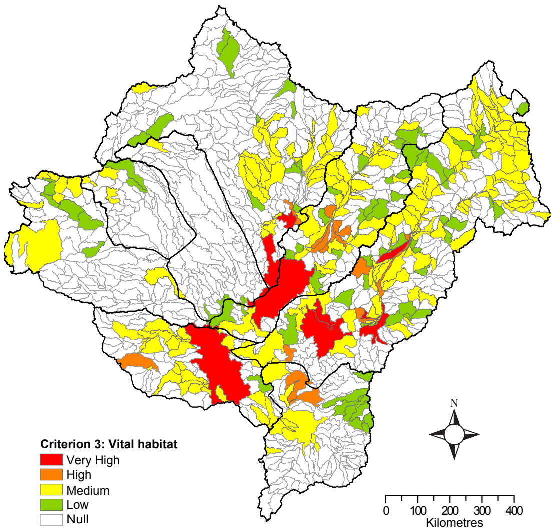


Figure 10 Vital habitat attributes combined and weighted

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.

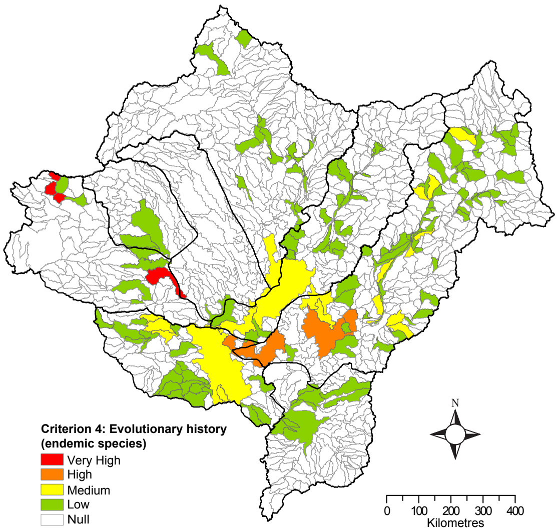


Figure 11 Evolutionary history—endemic species

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.

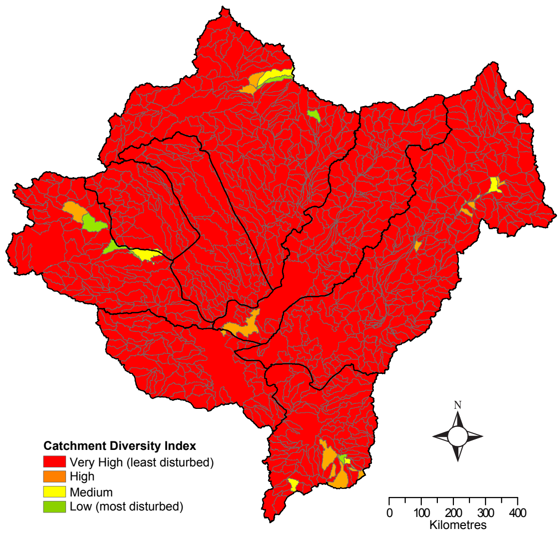


Figure 12a Mean Flow Disturbance Index

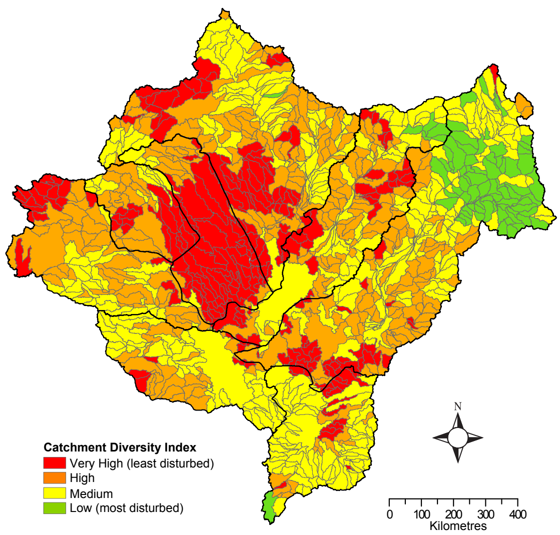


Figure 12b Mean Catchment Disturbance Index

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).

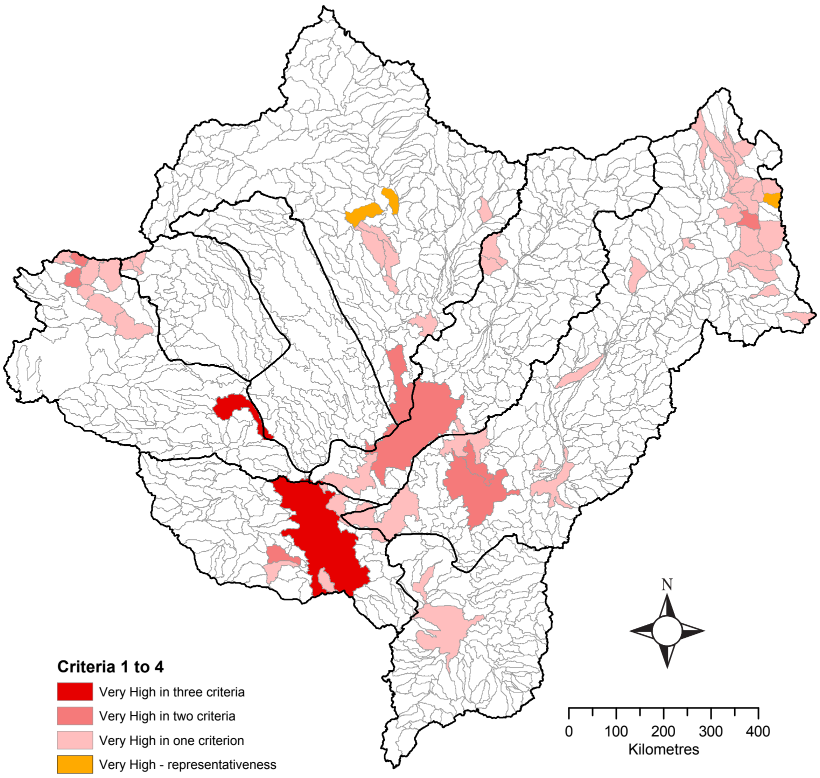


Figure 13 Assessment units that scored 'very high' in at least one criterion (criteria 1 to 4) or contained representative wetland types

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

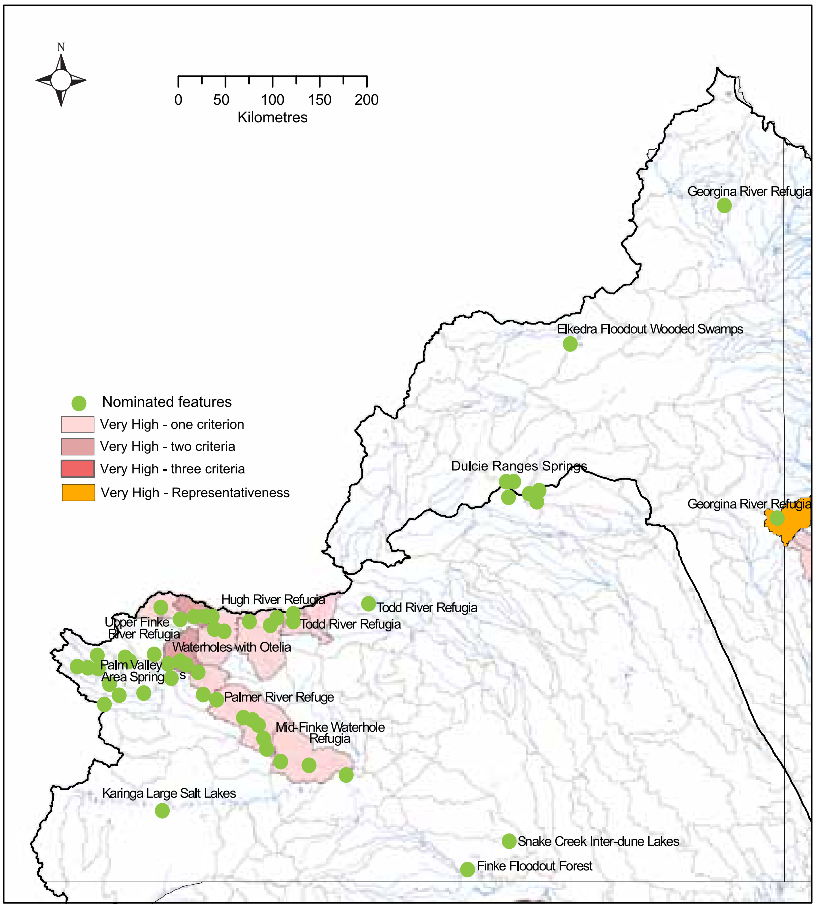


Figure 14 **Nominated distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from the Northern Territory, together with high-ranking assessment units**

(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.

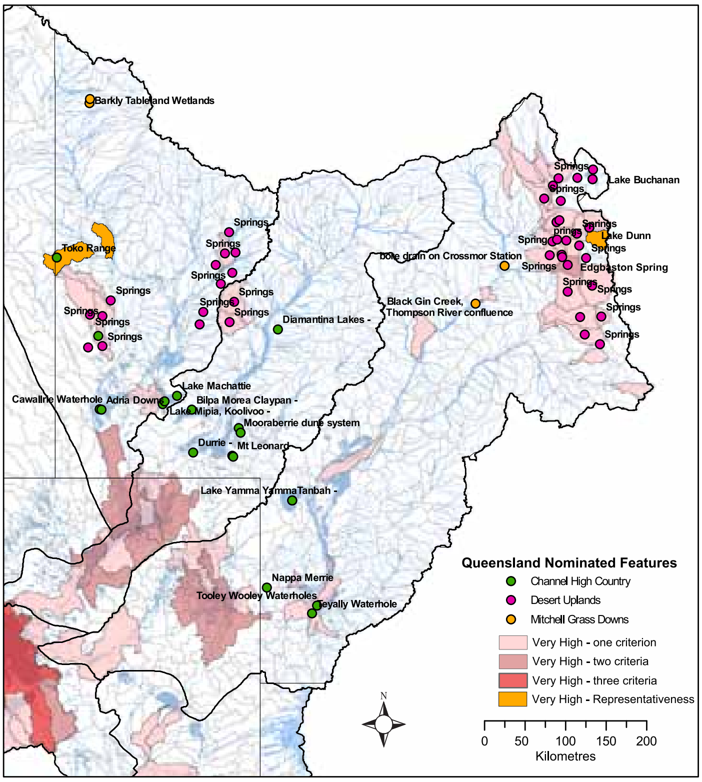


Figure 15 **Nominated distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from Queensland, together with high ranking assessment units**

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.

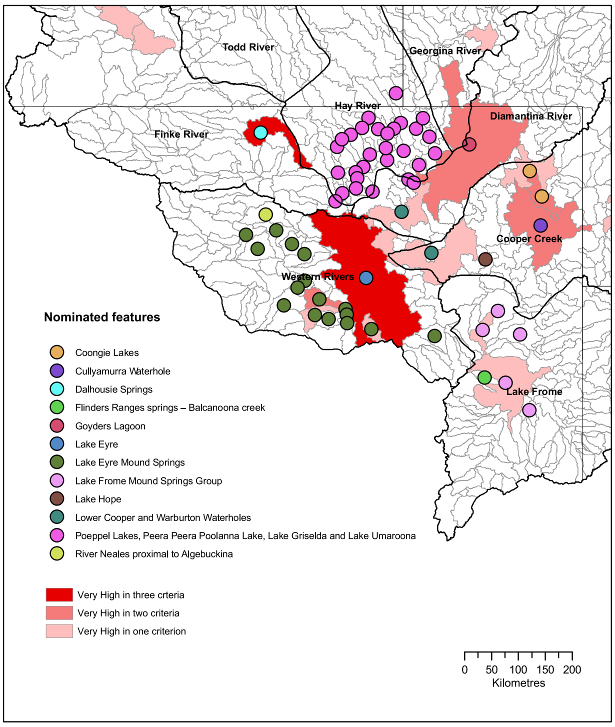


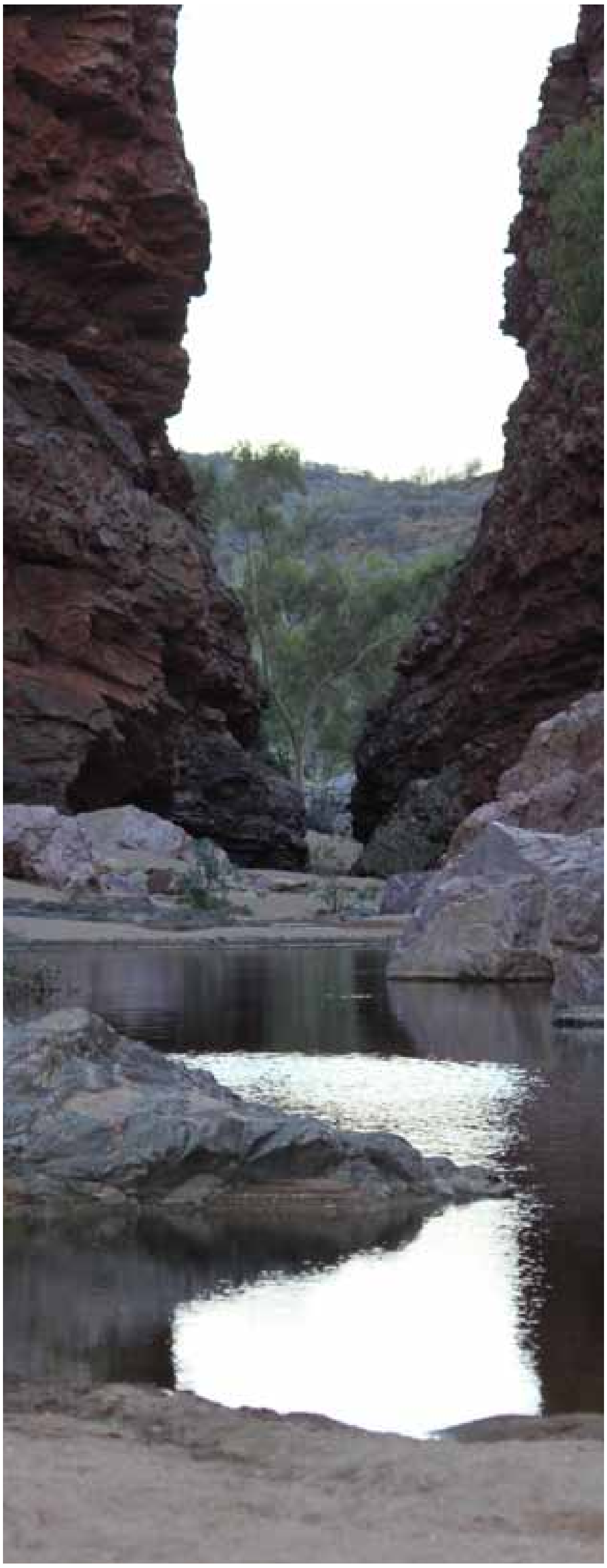
Figure 16 **Nominated distinctive, rare or threatened geomorphic, hydrological or ecological features (including those important for evolutionary history) from South Australia, together with high-ranking assessment units**

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



Simpsons Gap, Northern Territory (Diane Conrick)

Part 2: Aquatic ecosystem delineation and description

Draft guidelines for delineating aquatic ecosystems were trialled in the Lake Eyre Basin, on four sites identified through the trial of the HEVAE identification guidelines:

- Test Site 1: Assessment unit 6455 (contains Dalhousie Springs)
- Test Site 2: Assessment units 4264, 4293, 4438 (contains Lake Galilee)
- Test Site 3: Assessment units 1000, 1001, 1002 (contains Coongie Lakes)
- Test Site 4: Assessment units 4779, 5088, 5093, 5094 (contains Chewings Range spring-fed pools).

These four sites were selected (by negotiation with jurisdiction representatives) to cover a broad range of variables such as:

- aquatic ecosystems (i.e. springs, rivers, floodplains and lakes)
- jurisdictions (NSW, NT, QLD and SA)
- values (e.g. diversity of aquatic ecosystems, threatened species, endemic species, vital habitat)
- available data (i.e. both data poor and data-rich areas).

It should be noted that the selection of known and named aquatic ecosystems, rather than simply high-ranking assessment units, to some extent affected the outcomes of the delineation trial. The draft delineation guidelines specified that the identification and delineation of aquatic ecosystems should follow an objective approach from assessment unit to core element and Ecological Focal Zone (EFZ). The selection process for this trial decided *a priori* which aquatic ecosystems within the high-ranking units would be selected for delineation. While this did not affect the outcome for three of the trial sites, it made a significant impact for one (Test Site 2–Lake Galilee).

2.1 Assessment Unit 6455—Dalhousie Springs

Step 1 Identify/review values, aquatic ecosystem classification, and components and processes for the high ecological value aquatic ecosystems or assessment units

Assessment unit 6455 scored very highly for criteria 1 (Diversity), 2 (Distinctiveness) and 4 (Evolutionary History) (Table 8). In particular the assessment unit scored highly for:

- fish species (diversity and endemic)
- high diversity of plants and aquatic ecosystems
- endangered ecological community (the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin)
- refuge (permanent water).

Table 8 Outputs of LEB HEVAE trial for assessment unit 6455

CRITERIA	RANK	ATTRIBUTES	RANK
1. Diversity	Very High	Diversity of aquatic ecosystem type	Very High
		Diversity of native aquatic ecosystem-dependent spp. fish	Very High
		Waterbirds	Medium
		Reptiles	High
		Frogs	High
		Mammals	Null
		Woody plants	Very High
		Non-woody plants	Very High
		Diversity of aquatic ecosystem vegetation types (QLD only)	N/A
2. Distinctiveness	Very High	Threatened species	Moderate
		Priority species	Null
		Migratory bird species (East Asian–Australasian Flyway)	Low
		Threatened aquatic ecological community	Very High
		Conservation status of aquatic regional ecosystems (QLD only)	N/A
3. Vital habitat	Medium	Waterbird abundance	Null
		Significance of site for waterbird breeding (large colonial breeding events)	Null
		Refugia (permanent water)	Very High
4. Evolutionary History	Very High	Endemic species	Very High

Step 2 Identify the core elements

There were eight types of aquatic ecosystems within the assessment units; the values were associated with the permanent freshwater springs and associated wetlands in the Dalhousie Springs complex (T Gotch 2010, pers. comm., 14 December). The springs are populated by endemic fish species contributing to the very high scores for refugia, endemic species and diversity of fish species. They are groundwater fed and scored very high for the threatened aquatic ecological community of the Great Artesian Basin. The 'core elements' of this HEVAE were therefore defined as the springs in the Dalhousie Springs complex (Figure 17).

Step 3 Identify and summarise the critical components and processes

An ecological description was not undertaken as part of this trial, thus critical components and processes were not identified.

Step 4 Identify the ecological focal zones (EFZ) and delineate the overall EFZ

Available data layers that were assessed for the purpose of objectively delineating the ecological focal zone (EFZ) with comments on their applicability are provided in Figures 18 to 23.

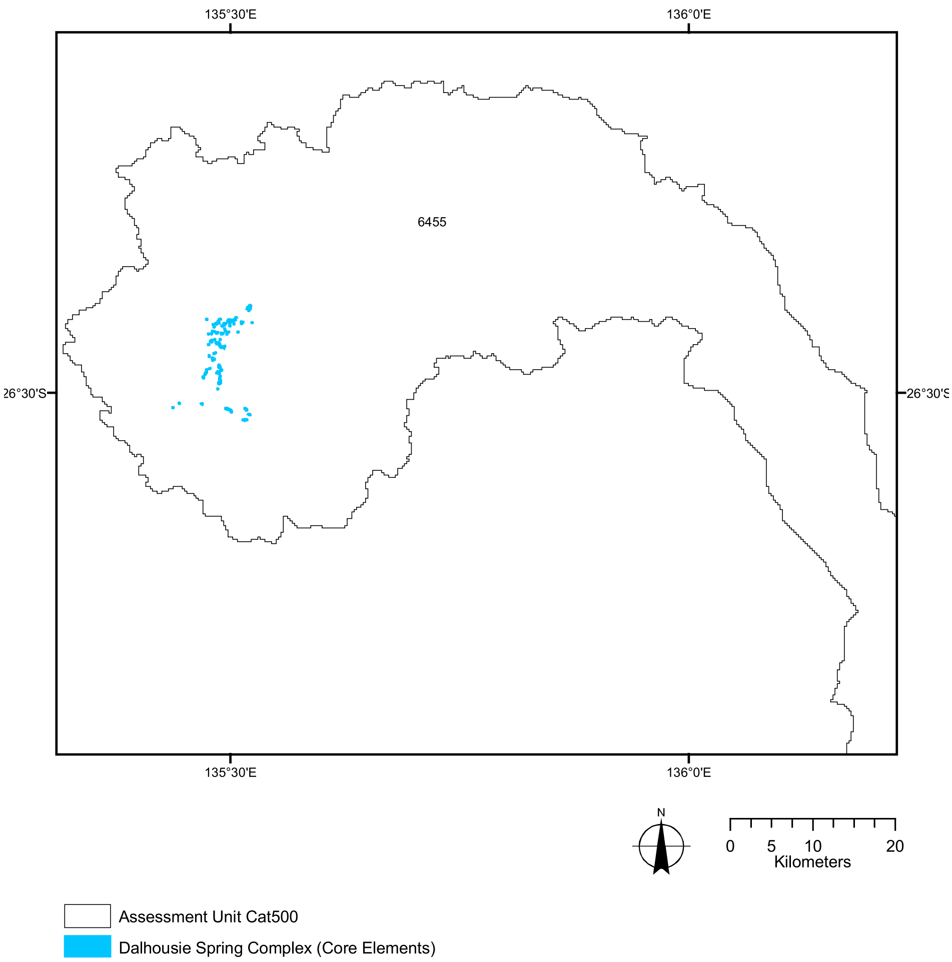


Figure 17 **Aquatic ecosystems that contribute significantly to the values of assessment unit 6455. These are the core elements to be used for delineating the ecological focal zone.**

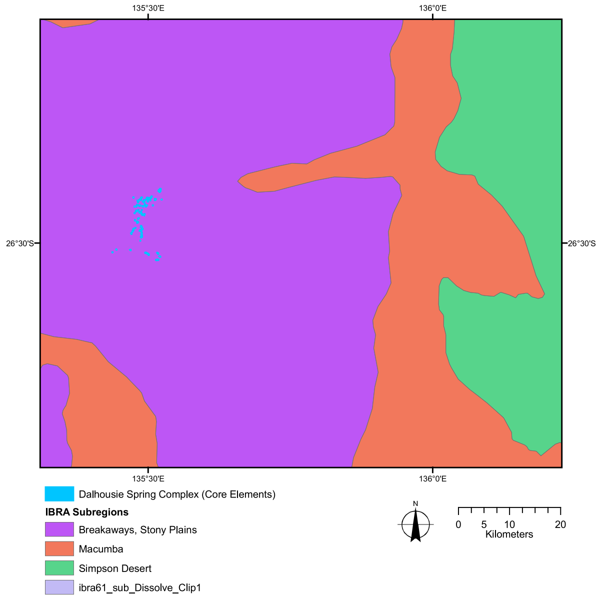


Figure 18 IBRA subregions surrounding the core elements identified within assessment unit 6455

Do not appear to align with any identifiable landscape features, geomorphic or ecological processes related to the core elements and were not considered useful to inform the process of defining the EFZ.

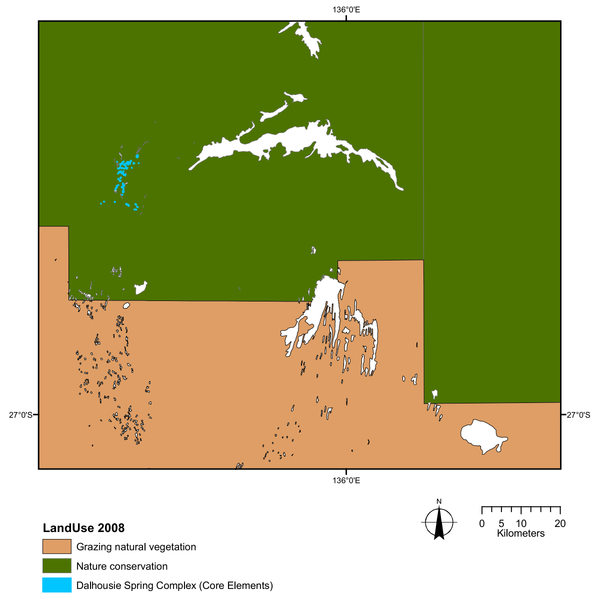


Figure 19 Land use surrounding the core elements identified within assessment unit 6455 (2008 Land Use)

Only distinguished two land uses operating at broad scales and neither are relevant to any ecologically meaningful boundaries that may inform the EFZ.

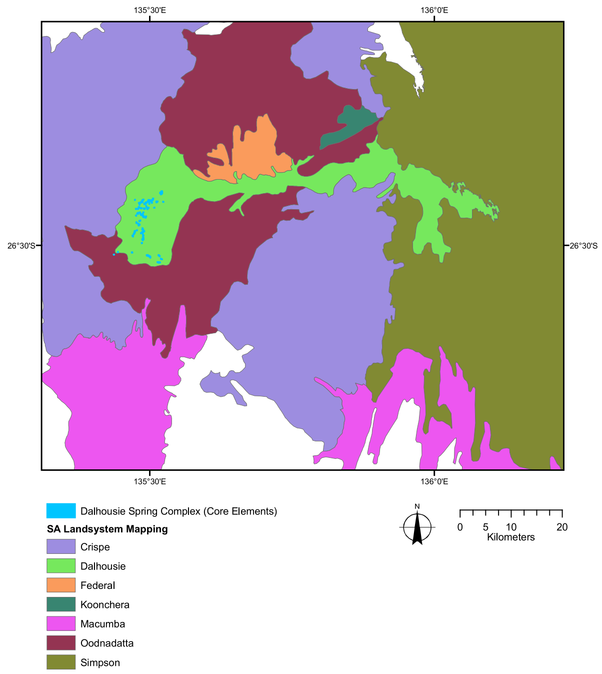


Figure 20 Land systems mapping of the area surrounding the core elements identified within assessment unit 6455 (South Australian Land System mapping)

The Dalhousie Land System contains the core elements and downstream drainage area. These downstream areas are predominantly dry salt and clay pans that do not contribute to the ecological values of the HEVAE and the Expert Reference Panel felt should be excluded from the EFZ.

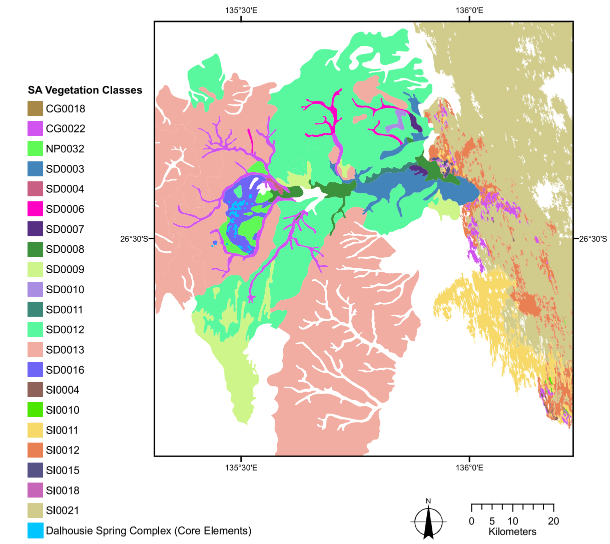


Figure 21 **Dominant vegetation classes in the area surrounding the core elements identified within assessment unit 6455 (South Australian vegetation ID mapping).**

The vegetation class SD0016 is the wetland vegetation that is fed directly from the springs and this may provide a suitable boundary for the EFZ given the values of the assessment unit are very tightly associated with the spring itself and the diversity of woody and non-woody plants in the adjacent vegetation.

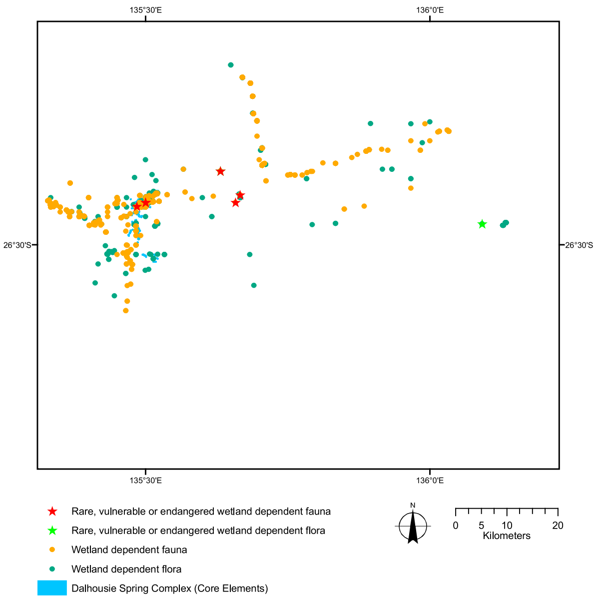


Figure 22 **Location of species records for wetland-dependent flora and fauna in assessment unit 6455.**
Stars indicate locations with species listed as rare, vulnerable or endangered in South Australia.
(Note: does not include fish, for which data was not available).

The locality of records for wetland-dependent species appear more strongly associated with the road network than with aquatic habitats reflecting strong sampler bias. Only six records for threatened wetland-dependent fauna were found, all being migratory bird species (SA could not supply location data for fish for this project). Only two records for threatened wetland-dependent plants were found and these were not associated with the core elements.

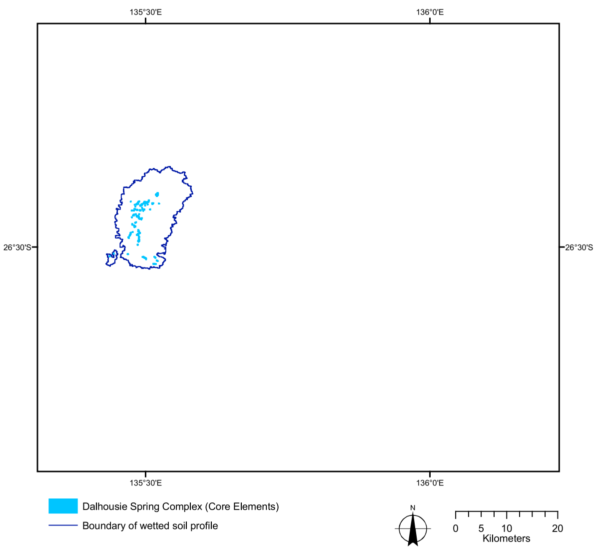


Figure 23 **Boundary of wetted soil profile surrounding the core elements identified within assessment unit 6455 as determined by 3 m airborne imagery 2010.**

Soil moisture provided by the springs underpins the distribution of the associated wetland habitats (expert opinion of Travis Gotch, SA Arid Lands NRM). The boundary of surrounding the springs was mapped in 2010 by Dr D. C. White at the University of Adelaide, as part of the 'Allocating water and maintaining |springs in the Great Artesian Basin' program (NWI 2008–2012).

As the values of this site were predominantly related to fish and permanent wetland features, it was determined that hydrology was the most important feature for identifying the EFZ. The delineation of the EFZ was informed by the expert opinion of Travis Gotch and is based on hydrology (i.e. equivalent to the wetted area around the springs). The ERP agreed that the boundary of the wetted soil profile provided an ecologically meaningful and objective method for determining the boundary of the EFZ for the core elements of the Dalhousie Springs complex (Figure 24).

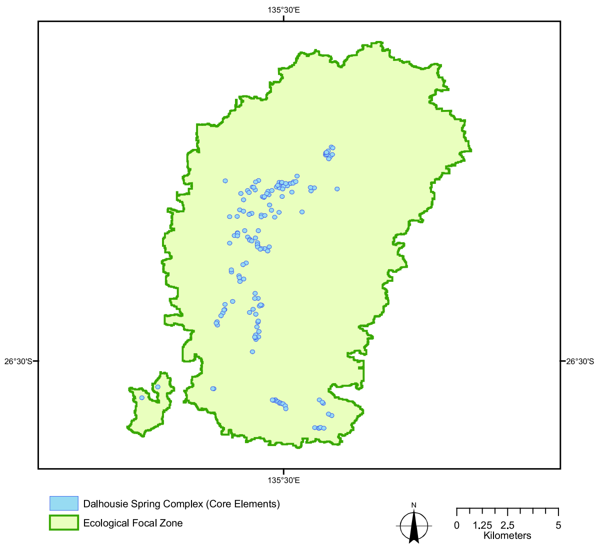


Figure 24 Delineated HEVAE ecological focal zone containing the Dalhousie Springs complex

Step 5 Identify/develop conceptual models

An ecological description was not undertaken as part of this trial, thus conceptual models were not identified or developed.

Step 6 Identify threats

An ecological description was not undertaken as part of this trial, thus threats were not identified.

Ormiston Gorge, Northern Territory (Diane Conrick)

Output—Aquatic Ecosystem Delineation Record Sheet

AQUATIC ECOSYSTEM DELINEATION RECORD SHEET	
Name of aquatic ecosystem	Dalhousie Springs
Date of delineation	January 2011
Purpose for delineation (e.g. water planning)	Case study
Ecosystem description	A supergroup of approximately 80 active Great Artesian Basin springs located in the Witjira National Park.
Ecosystem types	Lowland, non-floodplain, groundwater, permanent, fresh
Land use	Conservation (National Park)
Land tenure	National Park
Scale	HEVAE criteria were applied at the 500 km^2 nested catchment scale, site was delineated at the spring super group scale.
Experts involved	Travis Gotch (South Australia Arid Lands NRM)
Datasets used	Lake Eyre Basin Aquatic Ecosystem Mapping (2010) developed for the Lake Eyre Basin HEVAE Trial; held by SEWPaC (ERIN). Dalhousie Springs wetted soil profile (Dr D. C. White, University of Adelaide)
Gaps/limitations	Fish survey data was not made available to inform the process; species records showed a strong sampler bias and correlated with the road network; vegetation mapping was not available at a suitable resolution to inform the process.
HEVAE criteria met	■ Criteria 1 ■ Criteria 2 ☐ Criteria 3 ■ Criteria 4 ☐ Criteria 5 ☐ Criteria 6
Summary of Values	Criteria related: • fish species (diversity and endemic); • high diversity of plants; • high diversity of aquatic ecosystems; • endangered ecological community (the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin); and • refuge (permanent water). Identified by experts: • as above, plus endemic macroinvertebrates.
Description/ justification	As the values of this site were predominantly related to fish and permanent wetland features, it was determined that hydrology was the most important feature for identifying the EFZ. The delineation of the EFZ was informed by the expert opinion of Travis Gotch and is based on hydrology (i.e. equivalent to the wetted area around the springs).
Presence in other listing	☐ Ramsar ☐ World Heritage Areas ☐ Flyways ☐ EPBC threatened species.

2.2 Assessment Units 4264, 4293, 4438—Lake Galilee

Step 1 Identify/review values, aquatic ecosystem classification, and components and processes for the high ecological value aquatic ecosystems or assessment units

Lake Galilee spans three assessment units (4264, 4293 and 4438) which scored 'very highly' for criterion 2 (Distinctiveness), and waterbird abundance (attribute for criterion 3), amongst others (Table 9). A rare wetland type was identified within assessment unit 4438 (Riverine type 25—upland, waterhole, groundwater, permanent, saline). The high scores for 'distinctiveness' were driven by the threatened ecological community of the Great Artesian Basin springs. The springs are located in the periphery of the assessment units and not associated with Lake Galilee. Additionally, the rare wetland type (Riverine type 25) identified through the LEB HEVAE trial is most likely the product of mapping errors and those that knew the site well expressed doubt that it occurred in the site.

Members of the ERP indicated that Lake Galilee had a number of values that were not identified through the LEB HEVAE trial because of data deficiencies. In particular, they considered the site to have values associated with:

- waterbird feeding and breeding
- macroinvertebrates (rare species)
- rare and threatened vegetation types (regional ecosystems)
- geomorphic features (beaches on the north-western shoreline).

Table 9 Outputs of LEB HEVAE trial for assessment units 4264, 4293, 4438 (highest rank shown)

CRITERIA	RANK	ATTRIBUTES	RANK
1. Diversity	Medium	Diversity of aquatic ecosystem type	Low
		Diversity of native aquatic ecosystem-dependent spp. fish	Null
		Waterbirds	High
		Reptiles	Low
		Frogs	Medium
		Mammals	Null
		Woody plants	Low
		Non-woody plants	Low
		Diversity of aquatic ecosystem vegetation types (QLD only)	Very High
2. Distinctiveness	Very High	Threatened species	Low
		Priority species	Medium
		Migratory bird species (East Asian–Australasian Flyway)	Medium
		Threatened aquatic ecological community	Very High
		Conservation status of aquatic regional ecosystems (QLD only)	Very High
3. Vital habitat	Medium	Waterbird abundance	Very High
		Significance of site for waterbird breeding (large colonial breeding events)	Null
		Refugia (permanent water)	Very High
4. Evolutionary History	Very High	Endemic species	Low

Spatially displaying the expert-identified values for this site was not possible with the available data. No location data was provided for waterbird breeding, feeding and abundance nor are exact areas important to macroinvertebrate communities known. The important geomorphic features were visible on satellite imagery, but not at the resolution of the imagery available for publication.

Step 2 Identify the core elements

The delineation of core elements was based on existing wetland mapping and was informed by expert opinion. Core elements were considered to be the wetland polygons associated with the main body of the lake, but excluding inflowing channels (Figure 25). The focus on Lake Galilee reflects the expert derived values adopted by the ERP.

Step 3 Identify and summarise the critical components and processes

An ecological description was not undertaken as part of this trial, thus critical components and processes were not identified.

Step 4 Identify the ecological focal zones (EFZ) and delineate the overall EFZ

Available data layers that were assessed for the purpose of objectively delineating the ecological focal zone (EFZ) with comments on their applicability are provided in Figures 26 to 28.

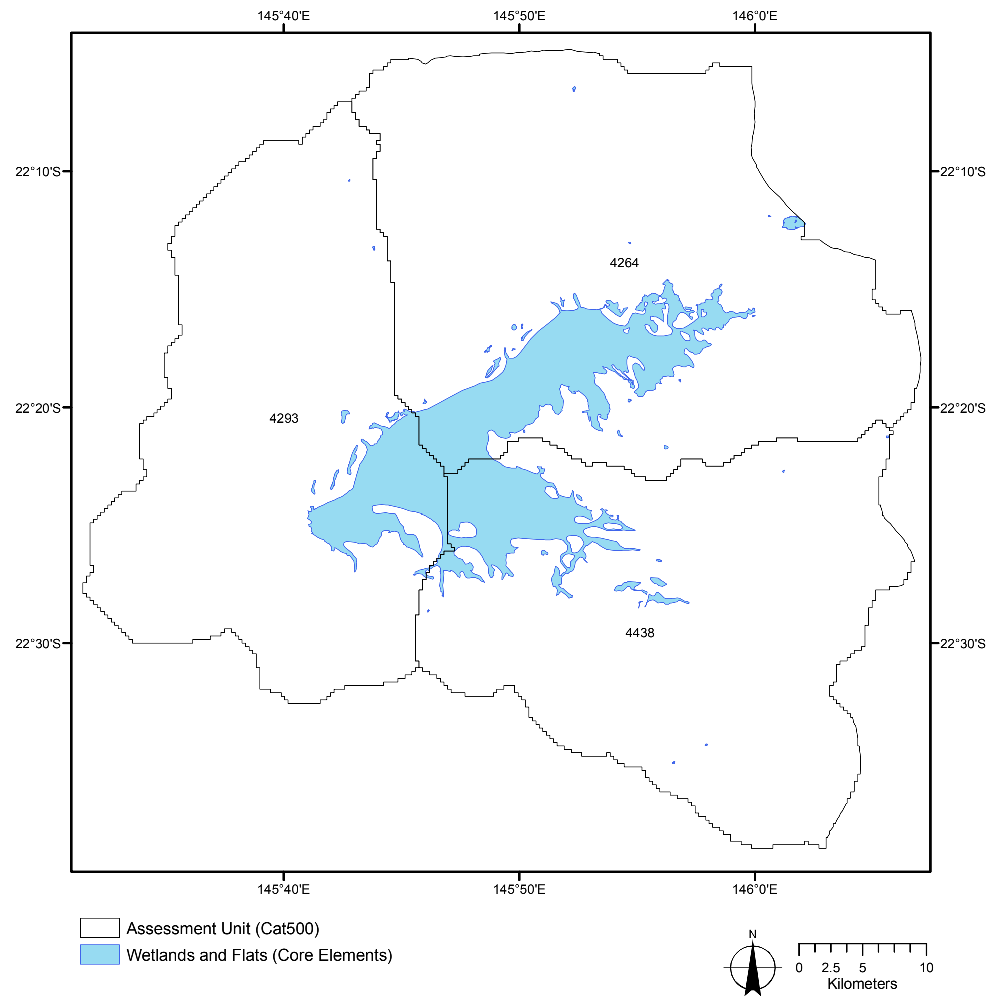


Figure 25 Aquatic ecosystems that contribute significantly to the values of assessment units 4264, 4293, and 4438. These are the core elements to be used for delineating the ecological focal zone.

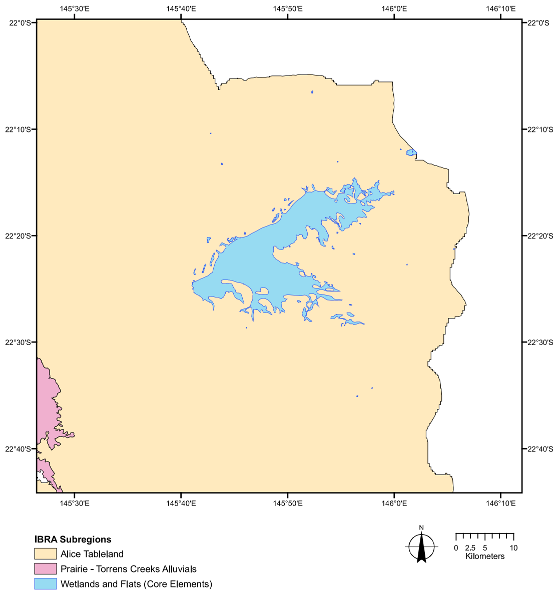


Figure 26 IBRA subregions surrounding the core elements identified within assessment units 4264, 4293, and 4438

Do not appear to align with any identifiable landscape features, geomorphic or ecological processes related to the core elements and were not considered useful to inform the process of defining the EFZ.

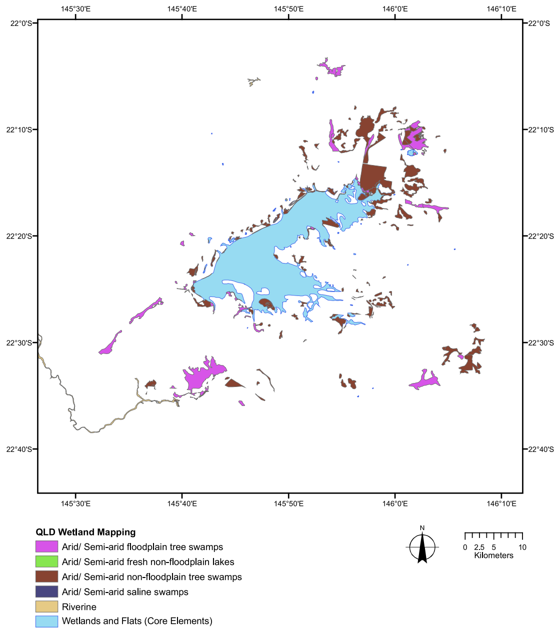


Figure 27 QLD Regional Ecosystem mapping surrounding the core elements identified within assessment units 4264, 4293, and 4438 (Wetland mapping and classification for Queensland 2009)

Only partial coverage associated with specific wetland types but does highlight the presence of tea-tree swamps in various locations around the fringes of Lake Galilee.

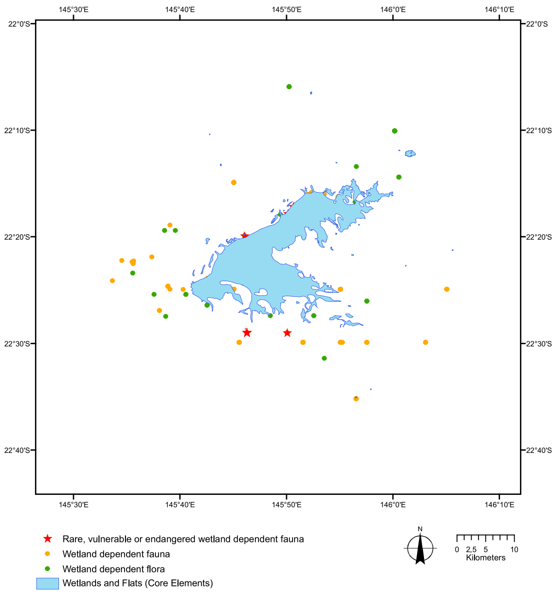


Figure 28 Location of species records for wetland-dependent flora and fauna in assessment units 4264, 4293, and 4438. Stars indicate locations with species listed as rare, vulnerable or endangered in Queensland

The locality of records for wetland-dependent species were for the most part not associated with Lake Galilee, nor other wetlands in the vicinity. All of the faunal records were migratory waterbirds and the recorded data may represent sites of access along the road network rather than associations with aquatic ecosystems. Only three sites had threatened wetland-dependent birds and no threatened wetland-dependent plants were recorded. These data were considered by the ERP to be too sparse and not closely related to the core element (Lake Galilee) and therefore not useful in delineating the lake's EFZ.

Because of the paucity of available data the EFZ was defined by expert opinion using wetland and vegetation mapping to delineate the wetland areas on the lake fringe and including a buffer to capture discernable alluvial features (Figure 29):

1. Small zone—[Core Elements]

This is the lake bed plus fringing palustrine wetlands plus bordering dunes. It equates to what might be considered wetland plus 'riparian' zone. However, in substantial areas this option does not extent beyond the wetland core area.

2. Core elements plus a buffer—[Option 1 EFZ]

A buffer has been added to include additional areas adjacent to the wetland proper where there was no buffer around the core area in the above option. The additional area is based on discernable alluvial/wetland-type features but where these features kept going, an arbitrary cutoff was utilised. The buffer can be several kilometres wide but as these lakes are themselves 20 to 35 kilometres wide/long it doesn't look out of scale.

3. Whole catchment—[Option 2 EFZ]

At the workshop there was discussion on including other alluvial or lake-related geomorphological features in the EFZ. In some cases these features have clear boundaries e.g. the fans clearly visible on the imagery to north-west of Lake Galilee and Buchanan, or the clay plains of the old lake bed (with partially cleared gidgee) clearly discernable to the north of Galilee, but in others they either didn't have clear boundaries or started to include most of the catchment. Therefore, the third option is the whole catchment. Obviously the whole catchment would not normally equate to the EFZ but is justified in this case as:

- the catchments are not large relative to the wetlands, and all drainage lines in the catchment feed directly into the lakes and thus would comply with the EFZ definition i.e. the area that supports the values of the core elements in terms of function and connectivity
- the catchments include mainly areas that would have been part of the old lake beds—there are a few areas of residuals in the catchments that would not have been the original lake beds but it wasn't sensible to exclude them.

Ecological focal zones were identified for each of the identified values. The EFZ for geomorphic features includes the beaches on the north-western shoreline (Figure 29). The EFZ for waterbirds and macroinvertebrate values could also be defined by surrounding terrestrial regional ecosystems (Figure 29). The EFZ for waterbirds includes Lake Buchanan and Cauckingburra Swamp (hereafter referred to as the Lake Buchanan complex) and includes the beaches and relevant regional ecosystems surrounding these wetlands (Figure 29). This EFZ was justified based on expert knowledge that birds that breed within the lake may use the Lake Buchanan complex as core feeding grounds and as such both feeding and breeding habitats were important for maintaining waterbird values (J Reid 2010, pers. comm., 14 December). Direct evidence of waterbird feeding at the Lake Buchanan complex is lacking, however, for the purposes of this trial the working group agreed to base the EFZ on the presumption of this being the case because:

- It generated the scenario where the potential EFZ for different values were at different spatial scales (i.e. the discrete nature of the geomorphic features versus the larger area required for waterbirds).
- It supported the concept of a disjunct EFZ.

The EFZ for Lake Galilee includes the regional ecosystems surrounding the lake, and a separate polygon at the Lake Buchanan complex including the regional ecosystems surrounding these features. The ERP recommended that the EFZs for each attribute be retained for informing future management of the site.

The delineation of this site could be improved by further interpretation and mapping. The use of finer scale vegetation mapping and/or satellite imagery may have been useful in providing a more objective delineation of the EFZ for this site.

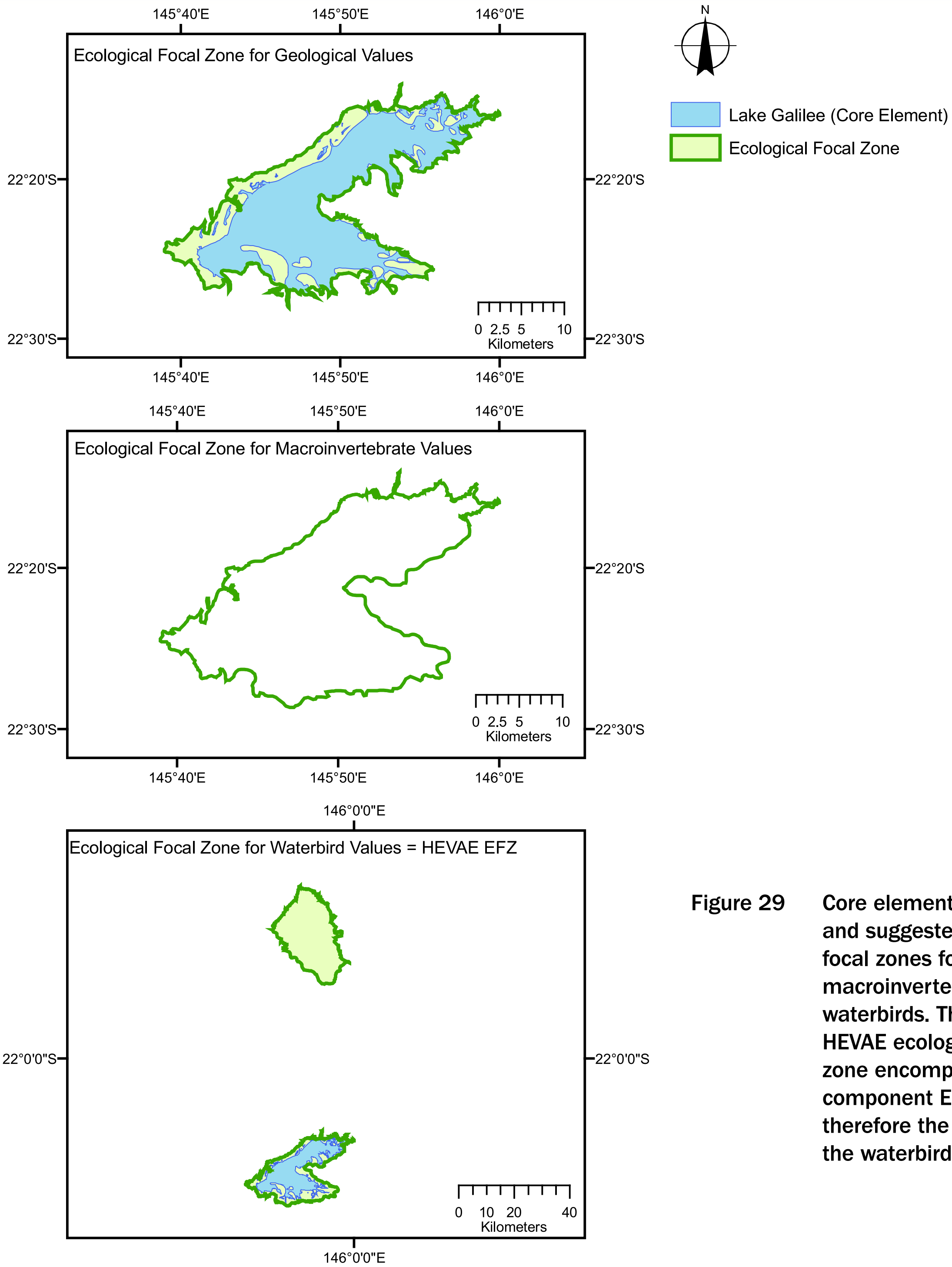


Figure 29 Core element (Lake Galilee) and suggested ecological focal zones for geology, macroinvertebrates and waterbirds. The delineated HEVAE ecological focal zone encompasses all component EFZ and is therefore the same as the waterbird EFZ

Step 5 Identify/develop conceptual models

An ecological description was not undertaken as part of this trial, thus conceptual models were not identified or developed.

Step 6 Identify threats

An ecological description was not undertaken as part of this trial, thus threats were not identified.

Output—Aquatic Ecosystem Delineation Record Sheet

AQUATIC ECOSYSTEM DELINEATION RECORD SHEET	
Name of aquatic ecosystem	Lake Galilee
Date of delineation	January 2011
Purpose for delineation (e.g. water planning)	Case study
Ecosystem description	Lake Galilee is a saline playa tectonic terminal lake in central Queensland. It is located in a shallow closed basin bordered by the Great Dividing Range to the west and north. Its catchment is internally draining, fed by some 20 seasonal streams.
Ecosystem types	Upland, non-floodplain, surface water, permanent, fresh Upland, non-floodplain, surface water, permanent, saline
Land use	Conservation (lake bed); agriculture (surrounding area)
Land tenure	Unallocated state land
Scale	HEVAE criteria were applied at the 500 km^2 nested catchment scale, site was delineated at the aquatic ecosystem scale (i.e. the lake and associated EFZ).
Experts involved	Julian Reid, (Australian National University)—waterbirds Brian Timms (University of New South Wales)—macroinvertebrates and geomorphology Bruce Wilson (QLD Department of Environment and Resource Management)—vegetation
Datasets used	Lake Eyre Basin Aquatic Ecosystem Mapping (2010) developed for the Lake Eyre Basin HEVAE Trial, held by SEWPaC (ERIN) QLD Regional Ecosystem Mapping (QLD DERM)
Gaps/limitations	The delineation of the HEVAE Lake Galilee was problematic for a number of reasons. Firstly, it was not identified through a strict application of the process as a potential HEVAE and so values associated with the site were informed predominantly by expert opinion (although the data for some attributes from the LEB HEVAE Trial supported the expert opinion). Secondly, none of the available data layers provided a clear delineation of the EFZ. Instead the delineation was informed almost exclusively by expert opinion and as such transparency was lost in the process. The delineation of this site could be improved by further interpretation and mapping. The use of finer scale vegetation mapping and/or satellite imagery may have been useful in providing a more objective delineation of the EFZ for this site.

HEVAE criteria met	☐ Criteria 1 ☐ Criteria 2 ☒ Criteria 3 (waterbird abundance) ☐ Criteria 4 ☐ Criteria 5 ☐ Criteria 6
Summary of values	Criteria related: • waterbird abundance. Identified by experts: • waterbird feeding and breeding • macroinvertebrates (rare species) • rare and threatened vegetation types (regional ecosystems) • geomorphic features (beaches on the north-western shoreline).
Description/ justification	Because of the paucity of available data the EFZ was defined by expert opinion using wetland and vegetation mapping to delineate the wetland areas on the lake fringe and including a buffer to capture discernable alluvial features. Ecological focal zones were identified for each of the identified values. The EFZ for geomorphic features includes the beaches on the north-western shoreline (as informed by Brian Timms). The EFZ for waterbirds and macroinvertebrate values could also be defined by surrounding terrestrial regional ecosystems (as informed by Bruce Wilson). The EFZ for waterbirds includes Lake Buchanan and Cauckingburra Swamp and includes the beaches and relevant regional ecosystems surrounding these wetlands (as informed by Julian Reid). This EFZ was justified based on expert knowledge that birds that breed within the lake may use Lake Buchanan and Cauckingburra Swamp as core feeding grounds and as such both feeding and breeding habitats were important for maintaining waterbird values (J Reid 2010, pers. comm., 14 December).
Presence in other listing	☐ Ramsar ☐ World Heritage Areas ☐ Flyways ☐ EPBC threatened species.

2.3 Assessment Units 1000, 1001, 1002—Coongie Lakes

Step 1 Identify/review values, aquatic ecosystem classification, and components and processes for the high ecological value aquatic ecosystems or assessment units

Coongie Lakes spans three assessment units (1000, 1001 and 1002) which scored very highly for criteria 1 (Diversity) and 3 (Vital Habitat) (Table 10). In particular the assessment unit scored highly for:

- aquatic ecosystem types (diversity, permanent water)
- fish (species richness, endemic species)
- waterbirds (species richness, abundance, breeding, threatened species)
- plant species richness.

Table 10 Outputs of LEB HEVAE trial for assessment units 1000, 1001, 1002 (highest rank shown)

CRITERIA	RANK	ATTRIBUTES	RANK
1. Diversity	Very High	Diversity of aquatic ecosystem type	Very High
		Diversity of native aquatic ecosystem-dependent spp. fish	Very High
		Waterbirds	Very High
		Reptiles	Medium
		Frogs	High
		Mammals	Very High
		Woody plants	Very High
		Non-woody plants	Very High
		Diversity of aquatic ecosystem vegetation types (QLD only)	Very High
2. Distinctiveness	Medium	Threatened species	High
		Priority species	Null
		Migratory bird species (East Asian–Australasian Flyway)	Medium
		Threatened aquatic ecological community	Null
		Conservation status of aquatic regional ecosystems (QLD only)	Not applicable
3. Vital habitat	Very High	Waterbird abundance	Very High
		Significance of site for waterbird breeding (large colonial breeding events)	Very High
		Refugia (permanent water)	Very High
4. Evolutionary History	High	Endemic species.	High

Step 2 Identify the core elements

The delineation of core elements was based on existing wetland mapping and was informed by expert opinion. Ephemeral floodplain wetlands dominate the landscape of assessment units 1000, 1001 and 1002, however, some values are linked directly to other ecosystem types (e.g. permanent waterholes with endemic fish populations give high values for refugia and endemic fish) and so all aquatic ecosystem types were considered to contribute to the values of the units. Based on expert opinion, the core elements were restricted to the main Cooper Creek drainage. Wetlands in the southern half of assessment unit 1001 associated with Strzelecki Creek flood infrequently and were less likely to be contributing to the values of this unit than wetlands of the Cooper Creek. The eastward boundary was drawn to exclude the stony rises which were considered to be part of a separate system. The core elements were therefore initially defined as all aquatic ecosystem types fed from Cooper Creek within the assessment units 1000, 1001 and 1002 (Figure 30).

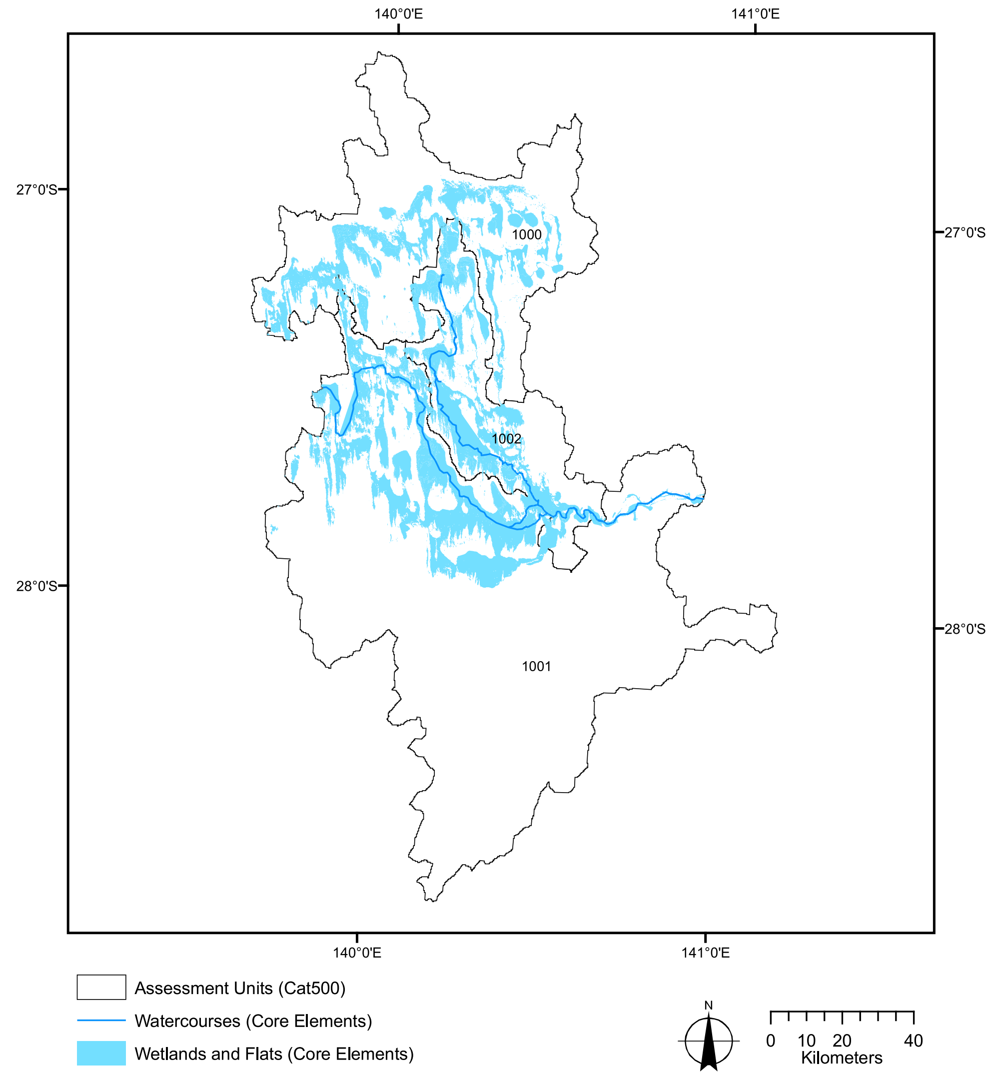


Figure 30 Aquatic ecosystems that contribute significantly to the values of assessment units 1000, 1001 and 1002.
These wetlands of the Cooper Creek drainage are the core elements to be used for delineating the ecological focal zone.

After delineation of the EFZ core elements were reassessed as all mapped aquatic ecosystems within the EFZ. Core elements for different values were proposed by the ERP as follows:

- core elements for fish equate to the area between Cullyamurra Waterhole and Coongie Lake
- core elements for aquatic ecosystem diversity include all aquatic ecosystems in the EFZ
- core elements for waterbirds include major waterholes and floodplains within the system.

However, despite the suggestion of different core elements for different values, it was not possible to delineate this with the available data. Firstly, data provided did not include the names for watercourses and wetlands and so the isolation of the core element for fish was problematic. In addition, the core elements for waterbirds were not described by the experts in sufficient detail for individual aquatic ecosystems to be identified.

Step 3 Identify and summarise the critical components and processes

An ecological description was not undertaken as part of this trial, thus critical components and processes were not identified.

Step 4 Identify the ecological focal zones (EFZ) and delineate the overall EFZ

Available data layers that were assessed for the purpose of objectively delineating the EFZ with comments on their applicability are provided in Figures 31 to 36.

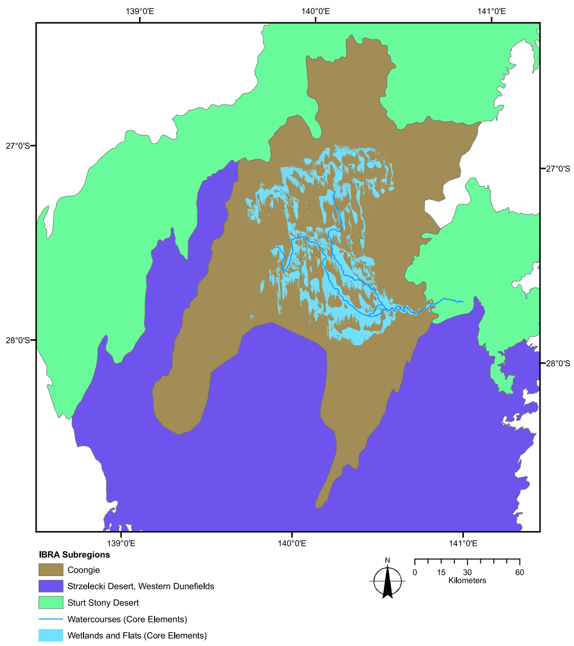


Figure 31 IBRA subregions surrounding the core elements identified within assessment units 1000, 1001 and 1002

The Coongie IBRA subregion encompasses all of the core elements. It also includes areas to the north and east of the Cooper Creek drainage, as well as the Strzelecki Creek system to the south that in the expert opinion of Julian Reid (2010, pers. comm., 14 December) are quite different (and more ephemeral) than the core elements in the Cooper Drainage. The western projection of the Coongie IBRA subregion contains the continuation of Cooper Creek and a similar landscape to the core elements of assessment units 1000, 1001 and 1002.

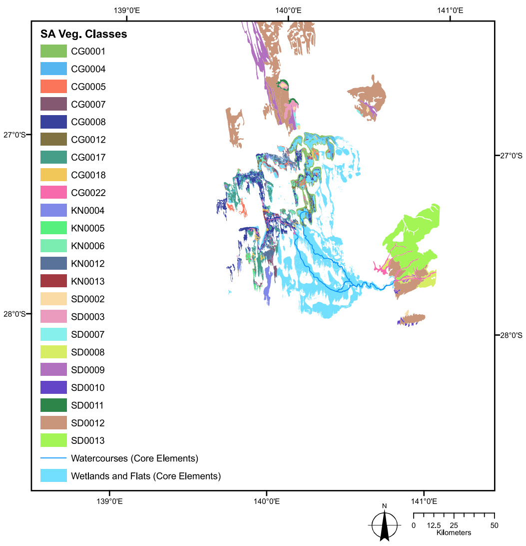


Figure 32 Dominant vegetation classes in the area surrounding the core elements identified within assessment units 1000, 1001 and 1002 (South Australian vegetation ID mapping)

Dominant vegetation type mapping is patchy, does not appear to relate to the core elements, and is not considered further in the determination of the EFZ.

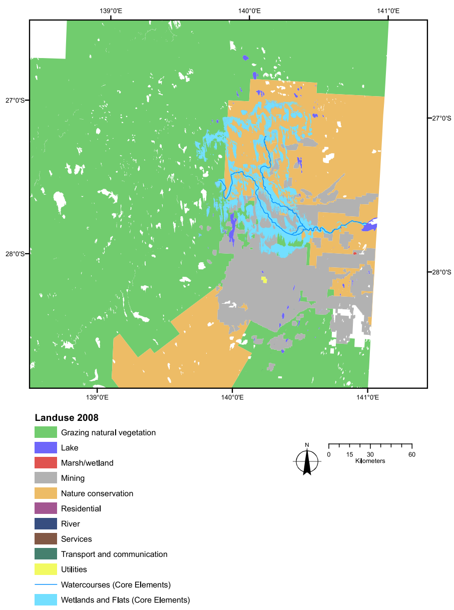


Figure 33 2008 land use surrounding the core elements identified within assessment units 1000, 1001 and 1002

The area of the core elements does not appear relevant to any ecologically meaningful boundaries that may inform the EFZ. Much of the area falls under large-scale mining and/or grazing leases, the boundaries of which do not relate to aquatic ecosystems. The 2008 Land Use layer includes some wetlands, but these are a small subset of wetland features found in other data layers.

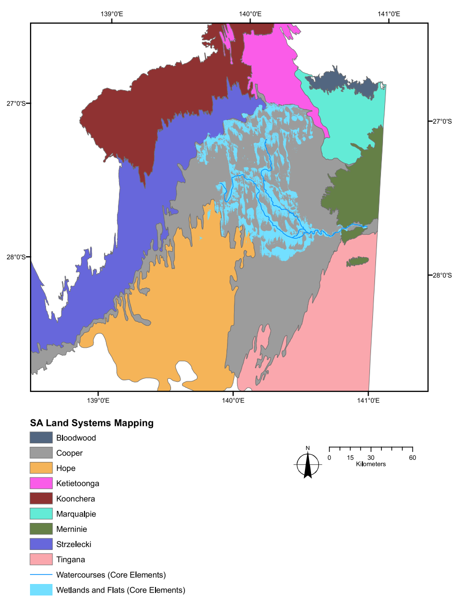


Figure 34 Land systems mapping of the area surrounding the core elements identified within assessment units 1000, 1001 and 1002

The Cooper Land System contains the core elements and downstream drainage area and may provide a good approximation of the EFZ for this HEVAE. The Strzelecki Creek system which was excluded by the Expert Reference Panel for being too ephemeral is also included, however digital elevation modelling (DEM) could be used to remove the Strzelecki Creek system from the Cooper Land System to give the EFZ. Given the apparent dominance of the drainage boundaries on the land system determination in this case it may be more sensible to just use DEM to define the EFZ.

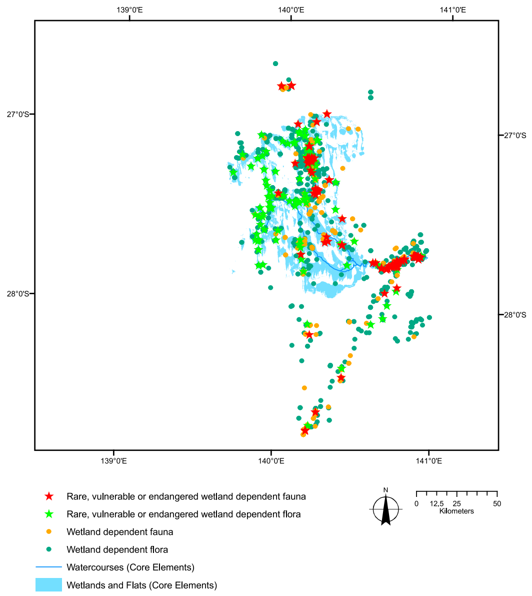


Figure 35 Location of species records for wetland-dependent flora and fauna in assessment units 1000, 1001 and 1002. Stars indicate locations with species listed as rare, vulnerable or endangered in South Australia

The locality of records for wetland-dependent species appear more strongly associated with the road network than with aquatic habitats, reflecting strong sampler bias. Only six records for threatened wetland-dependent fauna were found, all being migratory bird species (South Australia could not supply location data for fish for this project). Only two records for threatened wetland-dependent plants were found and these were not associated with the core elements.

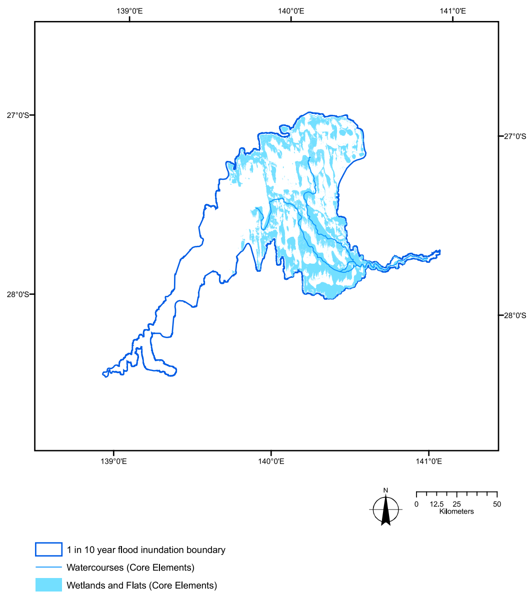


Figure 36 One in 10 year flood inundation limit for the lower Cooper Creek containing the core elements identified within assessment units 1000, 1001 and 1002

Widespread flooding of Cooper Creek is known to be a major driver of the ecological values exhibited by the core elements in this landscape. The Expert Reference Panel supported using the 1 in 10 year flood inundation extent as a potential EFZ. More infrequent flood frequencies (larger floods) could be used to define a larger EFZ though very infrequent flooding may be too stochastic to drive the values expressed by the core elements. The 1 in 10 flood frequency is probably an upper limit for supporting waterbird breeding and vegetation communities and therefore may represent a reasonable approximation to the EFZ.

The EFZ for this system (Figure 37) is based on hydrological connectivity and geomorphology. The EFZ boundary corresponds to the one in 10 year inundation extent of the Coongie Lake complex and extends from Cullyamurra Waterhole, following the Cooper flood out and lakes down to just below Lake Hope.

As the EFZ boundary extends beyond the original assessment units identified through the LEB HEVAE Trial the core elements were reassessed to include all aquatic ecosystems within the EFZ that contribute to the values of the HEVAE (as informed by expert opinion) (Figure 37).

The justification for the choice of one in 10 year inundation extent, as opposed to a one in 20 ARI or one in 100 ARI was not explicitly provided. It was the consensus of the Expert Reference Panel that one in 10 years seemed to be appropriate with respect to arid zone ecology, but more detail was not provided.

The use of flora and fauna records is of limited use in this case as it is strongly influenced by sampling bias. Improvements to the delineation of the Coongie Lakes HEVAE could be made if there was more comprehensive mapping of habitats from across the site. A combined vegetation and aquatic ecosystem map across the assessment units may have been useful in defining key habitat areas for waterbird feeding and breeding. However, as current vegetation mapping is at a relatively coarse resolution and does not extend across the entire site this was not feasible. Additionally, there are comprehensive waterbird data available for this site, although they are not currently in a spatial form that might provide indicators of diversity such as number of different feeding/breeding guilds and abundance (based on mean or maximum counts) for individual waterbodies within the Coongie Lakes. Whether this would be valuable in terms of delineating the HEVAE, however, is not known.

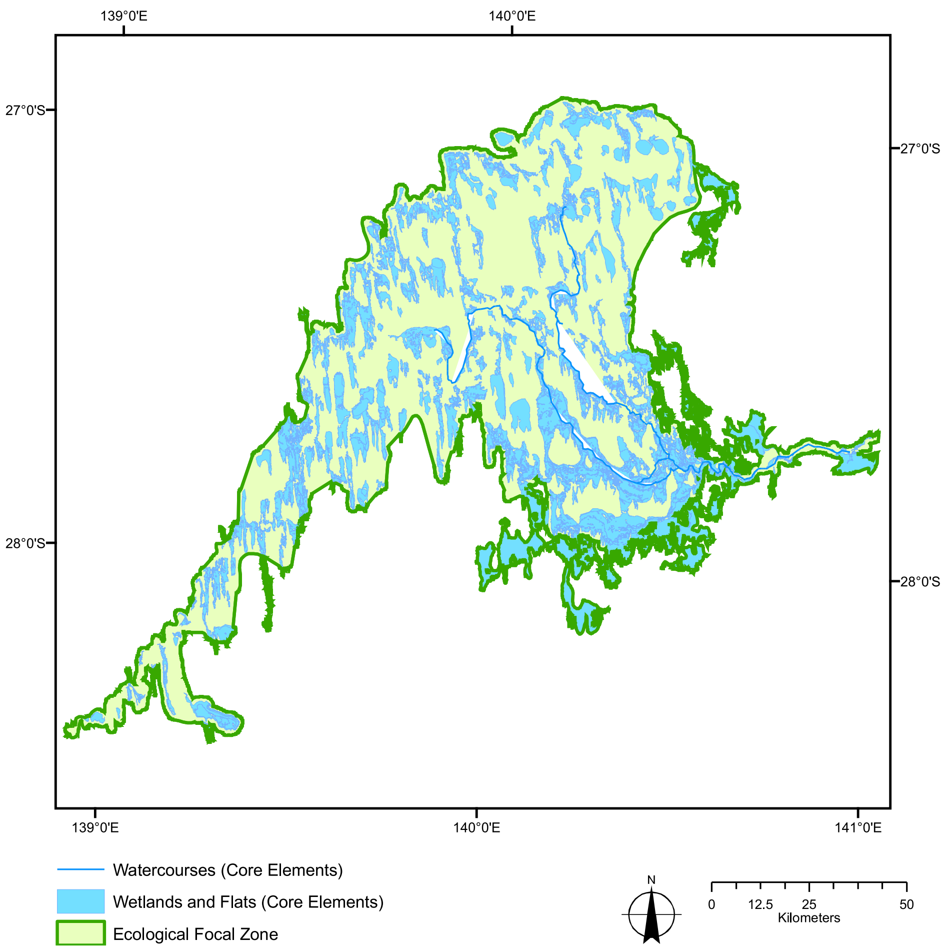


Figure 37 **Delineated HEVAE ecological focal zone containing Coongie Lakes and wetlands of the lower Cooper Creek**

Step 5 Identify/develop conceptual models

An ecological description was not undertaken as part of this trial, thus conceptual models were not identified or developed.

Step 6 Identify threats

An ecological description was not undertaken as part of this trial, thus threats were not identified.

Output—Aquatic Ecosystem Delineation Record Sheet

AQUATIC ECOSYSTEM DELINEATION RECORD SHEET	
Name of aquatic ecosystem	Coongie Lakes
Date of delineation	January 2011
Purpose for delineation	Case study
Ecosystem description	Coongie Lakes is a system of lakes, streams and floodplain of the Cooper Creek system from the South Australian–Queensland border downstream to Lake Hope (Lake Pando). It includes the north-west branch of Cooper Creek, the northern overflow and their many waterholes and terminal lakes covering an area of approximately 1.9 million hectares.
Ecosystem types (dominant types)	Non-riverine: • lowland, floodplain, surface water, non-permanent, fresh • lowland, non-floodplain, surface water, non-permanent, saline. Riverine: • lowland, channel, surface water, non-permanent, fresh • lowland, waterhole, surface water, permanent, fresh.
Land use	Conservation
Land tenure	National Park
Scale	HEVAE criteria were applied at the 500 km^2 nested catchment scale, site was delineated at the aquatic ecosystem scale (i.e. the floodplain and associated EFZ).
Experts involved	Julian Reid (Australian National University)—waterbirds.
Datasets used	Lake Eyre Basin Aquatic Ecosystem Mapping (2010) developed for the Lake Eyre Basin HEVAE Trial; held by SEWPaC (ERIN). Coongie Lakes 1 in 10 year flood inundation mapping (provided by SA Department of Environment and Natural Resources).
Gaps/limitations	Expert opinion and local knowledge provided by Julian Reid (independent waterbird expert) informed the choice of a suitable data layer for the delineation of the EFZ and identification of core elements within. The EFZ corresponded to the 1 in 10 year inundation flood extant, with upstream and downstream extent determined by geomorphology. However, the justification for the choice of 1 in 10 year inundation extent, as opposed to a 1 in 20 ARI or 1 in 100 ARI was not explicitly provided. It was the consensus of the Expert Reference Panel that 1 in 10 years seemed to be appropriate with respect to arid zone ecology, but more detail was not provided.

AQUATIC ECOSYSTEM DELINEATION RECORD SHEET	
Gaps/limitations	While the notion of identifying different core elements for different values was explored, this could not be translated into a mapping product. This was due both to insufficient data resolution and availability as well as knowledge gaps with respect to the ecology of the system. Improvements to the delineation of the Coongie Lakes HEVAE could be made if there was more comprehensive mapping of habitats from across the site. A combined vegetation and aquatic ecosystem map across the assessment units may have been useful in defining key habitat areas for waterbird feeding and breeding. However, as current vegetation mapping is at a relatively coarse resolution and does not extend across the entire site this was not feasible. In addition, there are comprehensive waterbird data available for this site, although they are not currently in a spatial form that might provide indicators of diversity such as number of different feeding/ breeding guilds and abundance (based on mean or maximum counts) for individual waterbodies within the Coongie Lakes. Whether this would be valuable in terms of delineating the HEVAE, however, is not known.
HEVAE criteria met	■ Criteria 1 ☐ Criteria 2 ■ Criteria 3 ☐ Criteria 4 ☐ Criteria 5 ☐ Criteria 6 Other criteria: Ramsar criteria 1, 2, 3, 4, 5, 6.
Summary of Values	Criteria related: • aquatic ecosystem types (diversity, permanent water) • fish (species richness, endemic species) • waterbirds (species richness, abundance, breeding, threatened species) • plant species richness. Identified by experts: As above.
Description/ Justification	The EFZ for this system is based on hydrological connectivity and geomorphology (informed by Julian Reid with agreement by Expert Reference Panel members). The EFZ boundary corresponds to the 1 in 10 year inundation extent of the Coongie Lake complex and extends from Cullyamurra waterhole, following the Cooper flood out and lakes to just below Lake Hope.
Presence in other listing	■ Ramsar ☐ World Heritage Areas ☐ Flyways ■ EPBC threatened species.

2.4 Assessment Units 4779, 5088, 5093, 5094—Chewings Range spring-fed pools

Step 1 Identify/review values, aquatic ecosystem classification, and components and processes for the high ecological value aquatic ecosystems or assessment units

Chewings Range spring-fed pools span four assessment units: 4779, 5088, 5093 and 5094, which scored very highly for criteria 1 (Diversity) and 4 (Evolutionary History) (Table 11). In particular the assessment units scored highly for:

- fish species (diversity and endemic)
- high diversity of plants
- high diversity of aquatic ecosystems
- refuge (permanent water).

Table 11 Outputs of LEB HEVAE trial for assessment units 4779, 5088, 5093 (highest rank shown)

CRITERIA	RANK	ATTRIBUTES	RANK
1. Diversity	Very High	Diversity of aquatic ecosystem type	Very High
		Diversity of native aquatic ecosystem-dependent spp. fish	Very High
		Waterbirds	Medium
		Reptiles	Null
		Frogs	High
		Mammals	Null
		Woody plants	Very High
		Non-woody plants	Very High
		Diversity of aquatic ecosystem vegetation types (QLD only)	Not applicable
2. Distinctiveness	Medium	Threatened species	Low
		Priority species	Very High
		Migratory bird species (East Asian–Australasian Flyway)	Low
		Threatened aquatic ecological community	Null
		Conservation status of aquatic regional ecosystems (QLD only)	Not applicable
3. Vital habitat	Medium	Waterbird abundance	Null
		Significance of site for waterbird breeding (large colonial breeding events)	Null
		Refugia (permanent water)	Very High
4. Evolutionary History	Very High	Endemic species.	Very High

Step 2 Identify the core elements

This region of the Northern Territory has very little standing water limited to a small number of isolated spring systems. Core elements were defined as the point location of springs provided by Angus Duguid from the NT Department of Natural Resources, Environment, The Arts and Sport (NRETAS) (Figure 38). The wetted extent of most springs has not been mapped. The springs are an important source of permanent and near-permanent water in an otherwise arid landscape. The high scores for endemic species and refugia are attributed to fish living in the spring-fed pools. However, there are also endemic macroinvertebrates within these springs (A Duguid 2010, pers. comm.) that were not included in the LEB HEVAE Trial. The springs have low discharge volumes and resultantly small areas of surface water (typically less than 50 m in the channel) that supports clearly dependent 'riparian' vegetation.

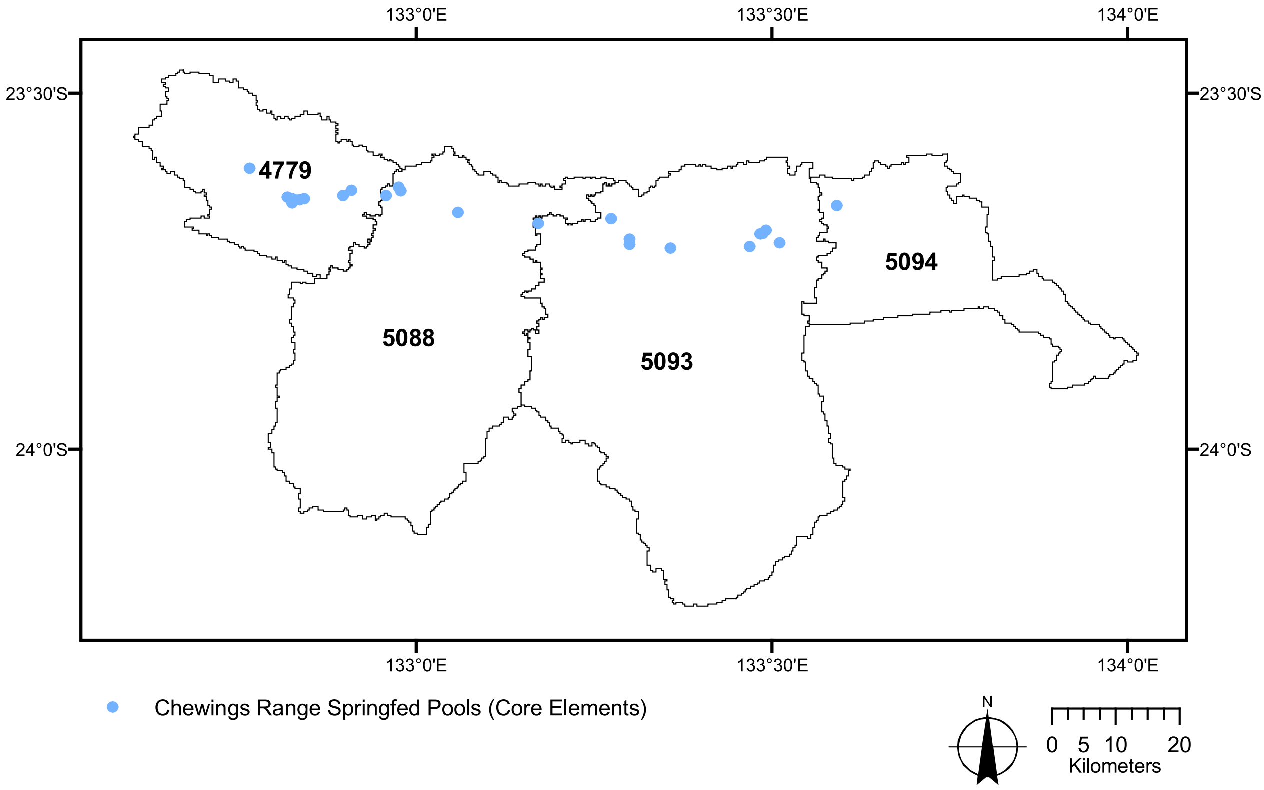


Figure 38 Aquatic ecosystems that contribute significantly to the values of assessment units 4779, 5088, 5093 and 5094.
The Chewings Range spring-fed pools are the core elements to be used for delineating the ecological focal zone.

Step 3 Identify and summarise the critical components and processes

An ecological description was not undertaken as part of this trial, thus critical components and processes were not identified.

Step 4 Identify the ecological focal zones (EFZ) and delineate the overall EFZ

Available data layers that were assessed for the purpose of objectively delineating the EFZ with comments on their applicability are provided in Figures 39, 40.

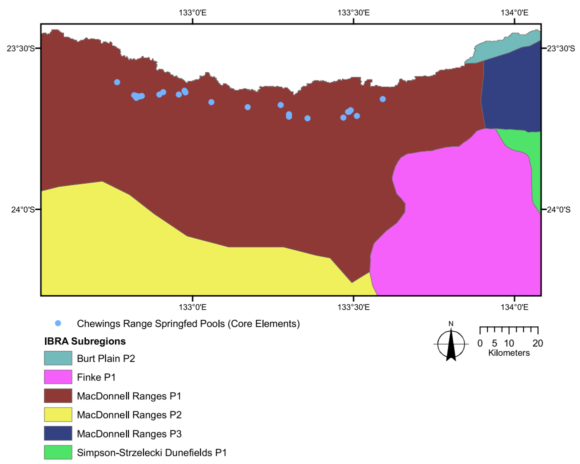


Figure 39 IBRA subregions surrounding the core elements (Chewings Range spring-fed pools) identified within assessment units 4779, 5088, 5093 and 5094

The core elements (the Chewing Ranges spring-fed pools) are highly constrained habitats that support values immediately within and adjacent to the pools and extending downstream no more than a few hundred meters (50m typical). The MacDonnell Ranges P1 IBRA subregion encompasses the core elements but is at a much larger scale than the potential EFZ for the springs.

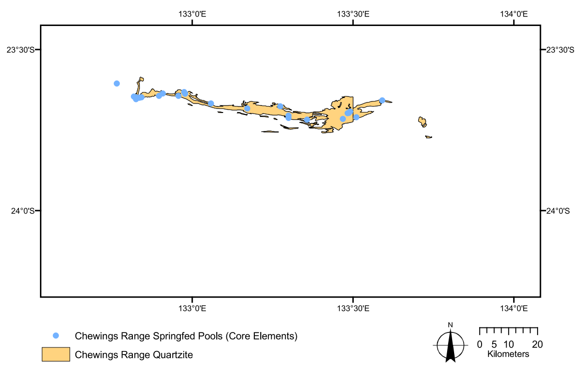


Figure 40 Distribution of the Chewings Range quartzite formation (Digital Geology of the Northern Territory)

The 1:250 000 map series was used to delineate the extent of the Chewings Range quartzite formation. The Chewings Range is a tall range and rainfall generated by orographic uplift yields both runoff and infiltration through cracks in the quartzite formation. The springs arise from fractures in the Chewings Range quartzite along drainage lines. The extent of the quartzite formation provides a geological basis for defining the extent of the EFZ.

The delineation of the EFZ was informed by expert opinion. Twenty-six individual springs were identified. Two alternative approaches for defining the EFZ were considered:

- Define an EFZ individually for each spring. The springs are isolated both longitudinally within the same drainage line, and across the multiple channels that drain the Chewings Ranges. The key ecological values are constrained to the pools (fish) and wetted-soil perimeter that supports relic ferns, the endemic *Acacia dolichophylla* and river red gums. The EFZ for each spring could be delineated using high-resolution aerial photography where the riparian zone is typically clearly visible and distinct from the surrounding landscape. Imagery to date has not been digitised and mapping the EFZ in this manner was beyond the scope of this trial.
- Define an EFZ that encompasses all springs as a complex. Using the extent of the Chewings Range quartzite formation as the basis for the EFZ (Figure 41) includes important infiltration and recharge areas in the HEVAE. Following the delineation process one core element, Possum Spring to the far west of the spring group, was not located within the EFZ defined by the Chewings Range quartzite. The identification of core elements was reconsidered after the EFZ was delineated. This single spring is therefore not considered to be a core element of the HEVAE.

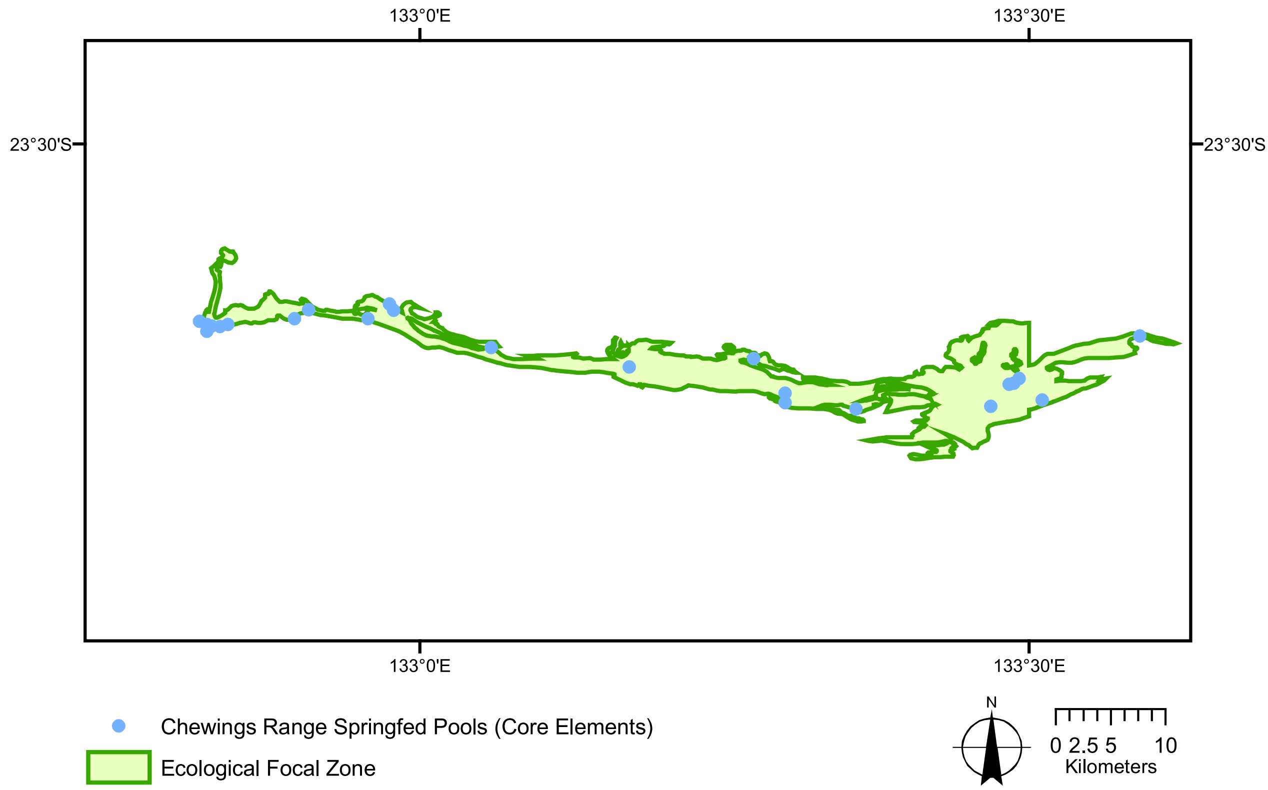


Figure 41 Delineated HEVAE ecological focal zone containing Chewings Range spring-fed pools

Step 5 Identify/develop conceptual models

An ecological description was not undertaken as part of this trial, thus conceptual models were not identified or developed.

Step 6 Identify threats

An ecological description was not undertaken as part of this trial, thus risks were not identified.

Output—Aquatic Ecosystem Delineation Record Sheet

AQUATIC ECOSYSTEM DELINEATION RECORD SHEET	
Name of aquatic ecosystem	Chewings Range spring-fed Pools
Date of Delineation	January 2011
Purpose for delineation (e.g. water planning)	Case study
Ecosystem description	Chewings Range spring-fed pools are a system of springs within drainage lines that incise the quartzite of the tall steep range. They have low discharge volumes, resulting in small areas of surface water and clearly dependent 'riparian' vegetation.
Ecosystem types	Upland, non-floodplain, surface water, non-permanent, fresh
Land use	Unknown
Land tenure	Unknown
Scale	HEVAE criteria were applied at the 500 km^2 nested catchment scale, site was delineated at the aquatic ecosystem scale (i.e. the springs and associated EFZ).
Experts involved	Angus Duguid (NRETAS).
Datasets used	Lake Eyre Basin Aquatic Ecosystem Mapping (2010) developed for the Lake Eyre Basin HEVAE Trial; held by SEWPaC (ERIN). Digital Geology of the Northern Territory. 1:250 000 map series. Location data for springs (x, y coordinate only) from Angus Duguid (NRETAS).
Gaps/limitations	This site in particular suffers from a paucity of data and ecological understanding. The delineation of this site could certainly be improved with greater field-collected data from the site. Little is known of the springs, and sampling has been limited. Satellite or aerial imagery may have helped inform the process, but a greater knowledge and understanding of this unusual system is required before delineation of the HEVAE could be completed with confidence. In particular, the location and extent of the recharge zone for the springs would perhaps be a better indication of the EFZ than the geology selected. In addition, the likely distribution of Acacia dolichophylla using buffered drainage lines to a set distance from the Chewings Range is another possibility that could be explored.
HEVAE criteria met	■ Criteria 1 ☐ Criteria 2 ☐ Criteria 3 ■ Criteria 4 ☐ Criteria 5 ☐ Criteria 6

AQUATIC ECOSYSTEM DELINEATION RECORD SHEET	
Summary of values	Criteria related: • fish species (diversity and endemic) • high diversity of plants • high diversity of aquatic ecosystems • refuge (permanent water). Identified by experts: • relict flora and fauna
Description/ justification	Expert opinion and local knowledge provided by Angus Duguid (NRETAS) informed the choice of a suitable data layer for the delineation of the EFZ and identification of core elements within. The EFZ corresponded to Chewings Range quartzite and the core elements were the springs within this EFZ.
Presence in other listing	☐ Ramsar ☐ World Heritage Areas ☐ Flyways ☐ EPBC threatened species.

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Australian Government

Lake Eyre Basin case study: WAT227.0512