Wetland buffer case study: Lake Broadwater

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Introduction

The Queensland Buffer Planning Guideline (Guideline DERM 2011) describes a method to design a buffer for a wetland. The method is based on the wetland's environmental values[1] and the pressures that are likely to impact the wetland from adjacent land uses. This case study provides an example of how to apply the guideline. It provides general guidance and should not be used prescriptively for other wetland buffers as application of the guideline will vary depending upon the circumstances and the site. The final recommended buffer is based on known existing or potential pressures. If other pressures are likely to occur, the buffer required may change. Professional expertise should be sought to incorporate local information and site-specific issues.

Designing an effective wetland buffer can be a complex process taking into consideration many factors, including the wetland's characteristics, the wetland type, environmental values, location, surrounding land uses, and the current and future pressures and impacts on the wetland. The guideline describes a wetland buffer design method (Figure 1 on page 6) which recognises two distinct areas — a wetland support area and a separation area.

Identifying and prioritising the unique wetland environmental values (WEVs) of a target wetland is fundamental to designing the wetland support area (the wetland's core). The separation area, which surrounds the wetland support area, is determined by identifying and conducting a risk assessment of the direct pressures to the WEVs (such as adjacent land uses), prioritising these pressures, and then estimating the area required to buffer the wetland and its WEVs from these pressures.

While wetland buffers should be viewed as an important part of managing wetlands, not all direct pressures can be mitigated by the wetland support and separation buffer areas. Therefore, it is essential to use a holistic, integrated landscape management approach and consider a range of management strategies as potential solutions to issues affecting wetlands and the broader landscape. For instance, if the connectivity of the wetland to the surrounding environment has been adversely affected there are only limited issues which can be addressed by an adequate wetland buffer, which will by its nature only be able to address local issues. For example, wetlands connectivity in the broader landscape cannot be fully addressed through the application of a site-specific wetland buffer.

Lake Broadwater with water. Photo: EHP

[1] The guideline uses environmental values in the broadest term, not as defined in the Environmental Protection Regulation 2008 which has a more limited definition of environmental values.

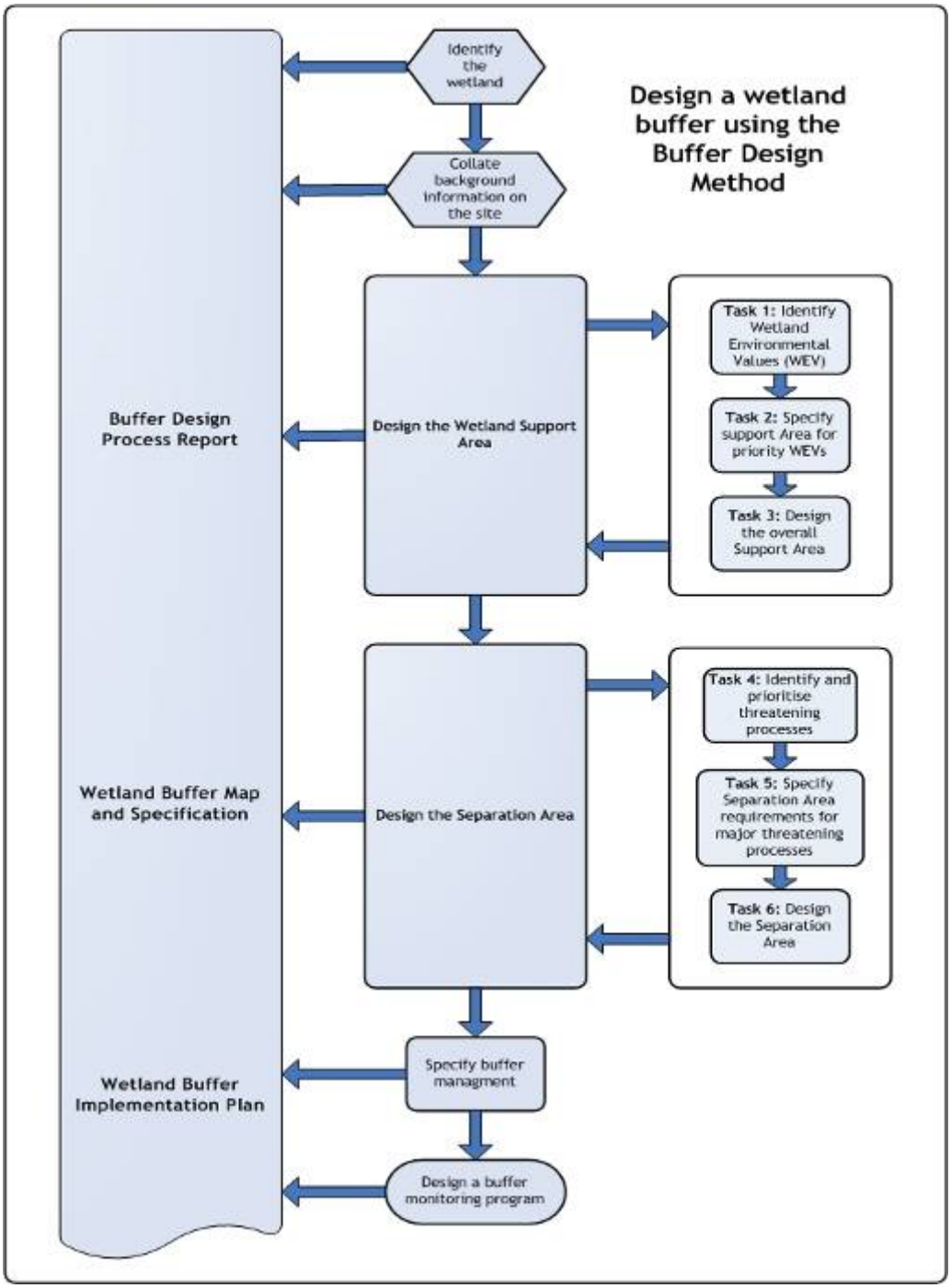


Figure 3 – Wetland buffer design process (DERM 2011)

About the site

Location, tenure and management

Bioregion:	Brigalow Belt
Catchment:	Condamine-Balonne
Local Government Area:	Western Downs Regional Council
Tenure:	National Park Lot 69 DY1009

Lake Broadwater is approximately 25 kilometres south-west of Dalby on the Darling Downs (Figure 2 on page 8). Located in the Lake Broadwater Conservation Park (established in 1994) and the Recreation Reserve (established in 2004), it is adjacent to the Lake Broadwater Resources Reserve (established in 1980) and lies within one of the most intensively cultivated agricultural districts in Queensland. The conservation park is managed primarily by the park's trustee - the Western Downs Regional Council. Some aspects such as weed and feral animal control and prescribed burns are conducted in association with the Queensland Parks and Wildlife Service.

Lake Broadwater Overflow after rain in March 2010. Photo: EHP

Stakeholders and partners

As the only large, naturally occurring lake on the Darling Downs, Lake Broadwater is of interest to many groups for its natural and recreational values. These include:

- Lake Broadwater Natural History Association
- Condamine Alliance (natural resource management body)
- Western Downs Regional Council
- Queensland Parks and Wildlife Service (QPWS)
- Department of Environment and Heritage Protection (EHP), formerly Department of Environment and Resource Management (DERM).

In 2010, the Lake Broadwater Natural History Association, QPWS and DERM participated in a workshop to identify the values of Lake Broadwater Conservation Park. The results of the workshop will be used by QPWS to manage the conservation park as well as contributing to this case study.

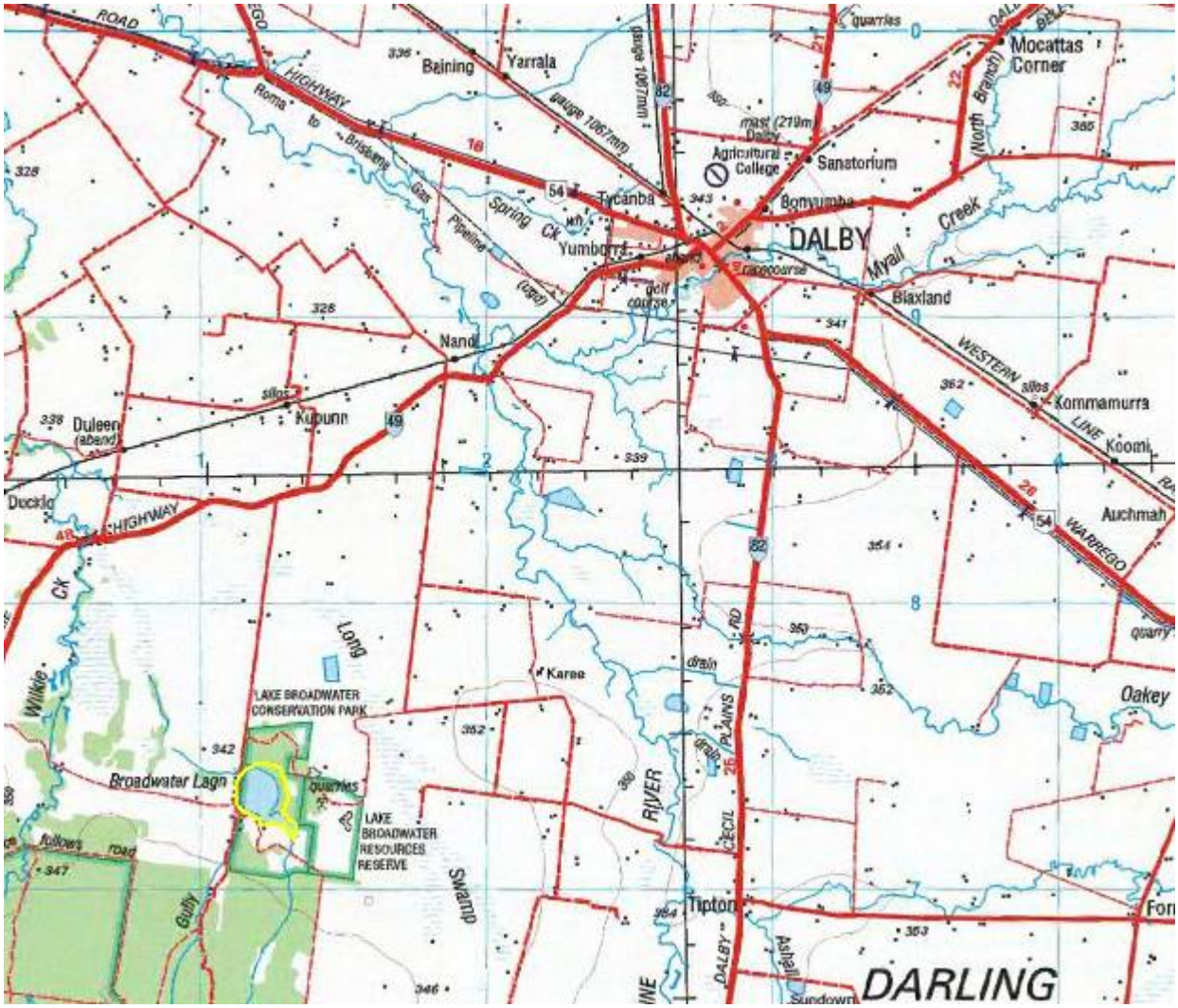


Figure 4 – Lake Broadwater Conservation Park and associated recreation reserve and resources reserve are located approximately 25 km south-west of Dalby. Lake Broadwater is shown in yellow.

Wetland description

Lake Broadwater is a naturally occurring, seasonal/intermittent, shallow, freshwater wetland. It covers approximately 350 hectares within the 1212 hectares Lake Broadwater Conservation Park. Open water is mapped as lacustrine (lake) under the Queensland wetland mapping (DERM 2012a) and as Regional Ecosystem 11.3.27a (DERM 2012b). A palustrine wetland fringes the lacustrine area, mapped as 11.3.27d (DERM 2012b). It is characterised by the presence of *Eucalyptus camaldulensis* (river red gum). Adjoining the palustrine fringe are areas that contain wetland regional ecosystems (1–50 per cent wetland mosaic units). They are part of two endangered ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Lake Broadwater's catchment is approximately 6000 hectares (Figure 3 below). Although the wetland is located in a district with high intensive agriculture the land use within the lake's catchment is low intensity, mainly conservation, grazing on native vegetation and forestry (Figure 4 on page 10). Coal seam gas wells and associated evaporation ponds are located in the upper catchment. Land tenure is principally conservation or freehold (Figure 5 on page 10).

Vegetation surrounding the wetland is diverse and includes remnant and high-value regrowth vegetation communities including cypress pine (*Callitris glaucophylla*), popular box (*Eucalyptus populnea*), bulloak (*Casuarina leuhmannii*), piliga grey box (*Eucalyptus woollsiana*) and grasslands communities. Figure 6 on page 11 and Table 1 on page 12 provide more details on the regional ecosystems within the catchment and their status.

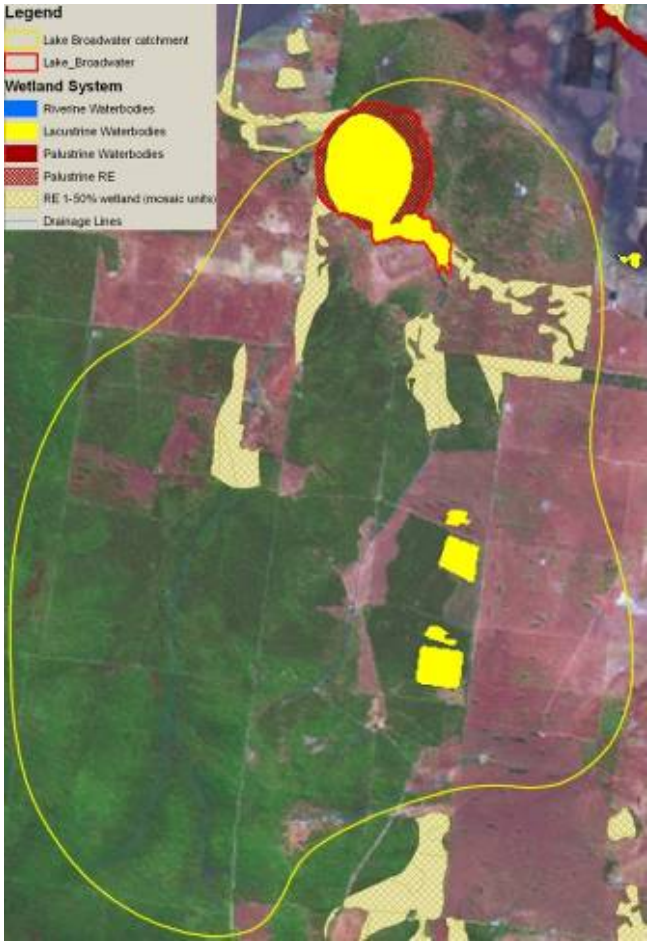


Figure 3 – Lake Broadwater catchment and wetland systems

Figure 4 – Land use within Lake Broadwater catchment (QNRW 1999)

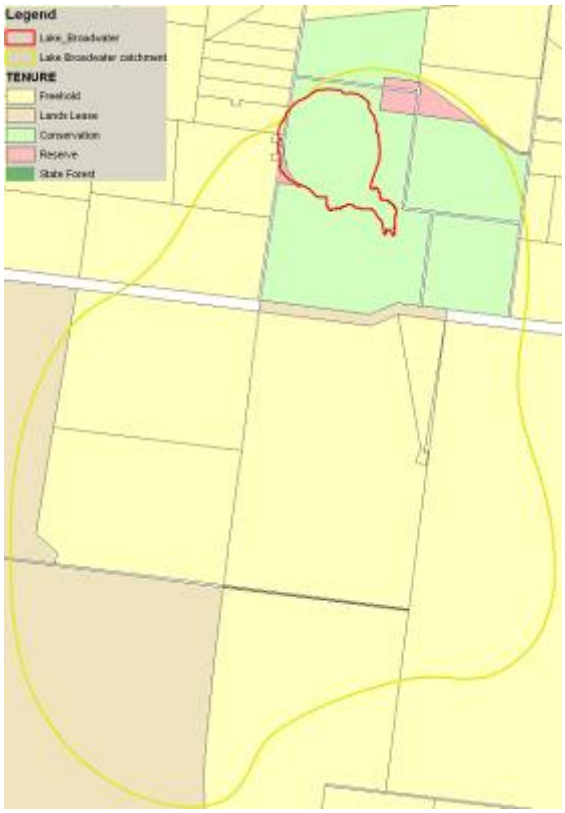


Figure 5 – Land tenure within the catchment (DERM 2011)

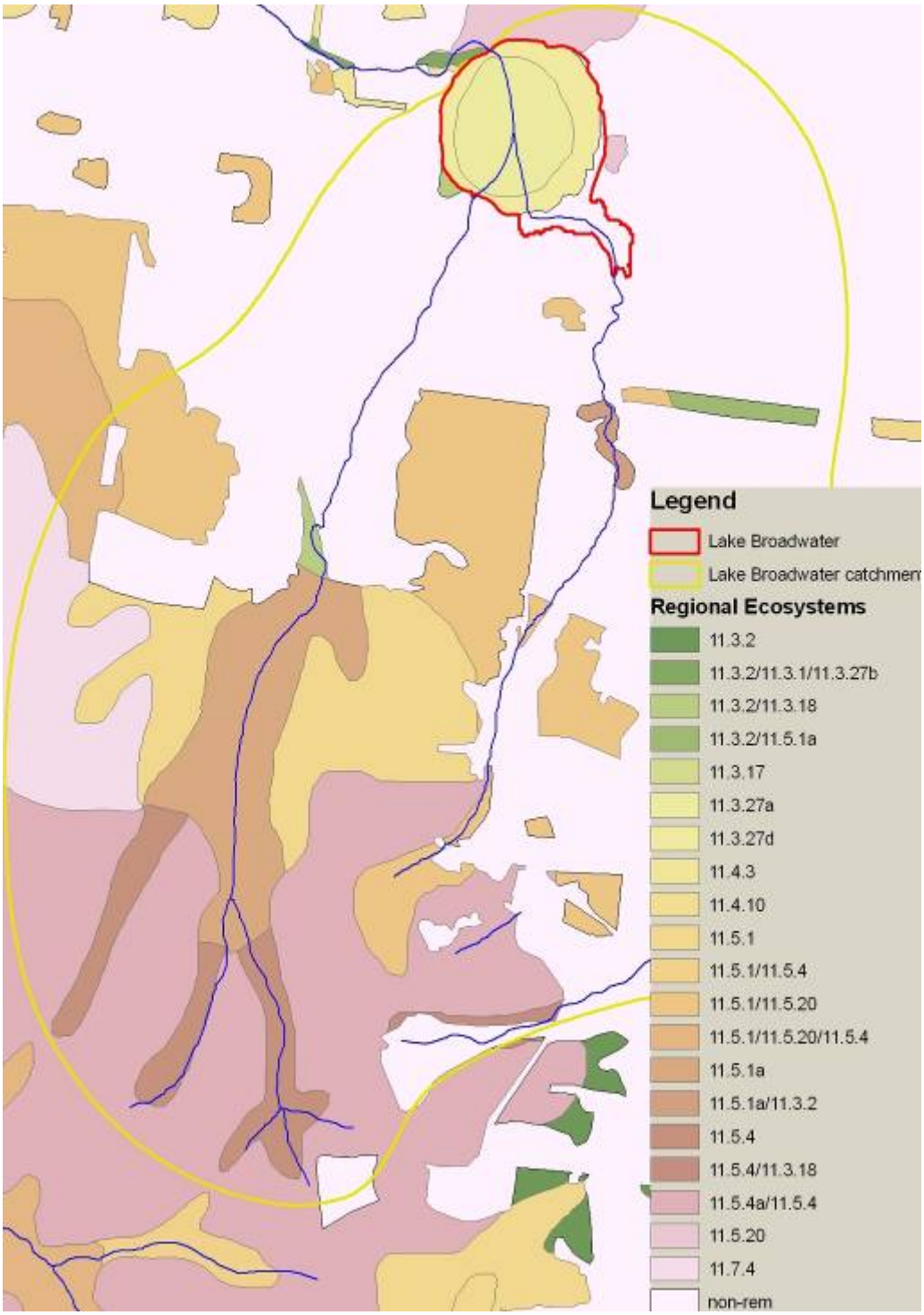


Figure 6 – Regional ecosystems within the catchment (Queensland Herbarium 2009)

Table 1 – Description of regional ecosystems within the catchment

Regional ecosystem	Description	VMA class	Wetland system
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Of Concern	
11.3.2/11.3.1/11.3.27b	*Eucalyptus populnea* woodland on alluvial plains/*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains/lacustrine wetland (e.g. lake). Vegetation ranges from open water +/- aquatics and emergents such as *Potamogeton crispus*, *Myriophyllum verrucosum, Chara spp.*, *Nitella spp*, *Nymphaea violacea, Ottelia ovalifolia*, *Nymphoides indica*, *N. crenata*, *Potamogeton tricarinatus*, *Cyperus difformis*, *Vallisneria caulescens* and *Hydrilla verticillata*. Often with fringing woodland, commonly *Eucalyptus camaldulensis* or *E. coolabah* but also a wide range of other species including *Eucalyptus platyphylla*, *E. tereticornis*, *Melaleuca spp.*, *Acacia holosericea* or other *Acacia spp*. Occurs on billabongs no longer connected to the channel flow	Of Concern/ Endangered / Least Concern	1-50%
11.3.2/11.3.18	*Eucalyptus populnea* woodland on alluvial plains/ *Eucalyptus populnea*, *Callitris glaucophylla*, *Allocasuarina luehmannii* shrubby woodland on alluvium	Of Concern/ Least Concern	1-50%
11.3.2/11.5.1a	*Eucalyptus populnea* woodland on alluvial plains/ *Eucalyptus populnea* woodland with *Allocasuarina luehmannii* low tree layer	Of Concern/ Least Concern	
11.3.17	*Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains	Of Concern	
11.3.27a	Lacustrine wetland (e.g. lake). Vegetation ranges from open water +/- aquatics and emergents such as *Chara spp.*, *Nitella spp.*, *Myriophyllum verrucosum*, *Nymphaea violacea*, *Pyrgillus javanicus*, *Potamogeton crispus*, *P. tricarinatus*, *Ottelia ovalifolia*, *Vallisneria caulescens* and *Nymphoides indica*, a narrow fringing woodland commonly dominated by *E. camaldulensis* or *E. coolabah* but also a range of other tree species may be present. Larger ephemeral - permanent water bodies (lakes)	Least Concern	Lacustrine
11.3.27d	Palustrine wetland (e.g. vegetated swamp). *Eucalyptus camaldulensis* and/or *E. tereticornis* woodland. A range of sedges and grasses occur in the ground layer including *Fimbristylis vagans*, *Myriophyllum striatum*, *Nitella pseudoflabellata* and *Pseudoraphis sp*. Occurs fringing large lakes	Least Concern	Palustrine
11.4.3	*Acacia harpophylla* and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains	Endangered	1-50%
11.5.1	*Eucalyptus crebra*, *Callitris glaucophylla*, *Angophora leiocarpa*, *Allocasuarina luehmannii* woodland on Cainozoic sand plains/remnant surfaces	Least Concern	
11.5.1/11.5.4	*Eucalyptus crebra*, *Callitris glaucophylla*, *Angophora leiocarpa*, *Allocasuarina luehmannii* woodland on Cainozoic sand plains/remnant surfaces / *Eucalyptus crebra*, *Callitris glaucophylla*, *C. endlicheri*, *E. chloroclada*, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands	Least Concern/ Least Concern	
11.5.1/11.5.20	*Eucalyptus crebra*, *Callitris glaucophylla*, *C. endlicheri*, *E. chloroclada*, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands/*Eucalyptus moluccana* and/or *E. microcarpa*/ *E. pilligaensis* +/- *E. crebra* woodland on Cainozoic sand plains	Least Concern/ Least Concern	
11.5.1/11.5.20/11.5.4	*Eucalyptus crebra*, *Callitris glaucophylla*, *C. endlicheri*, *E. chloroclada*, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands/*Eucalyptus moluccana* and/or *E. microcarpa*/*E. pilligaensis* +/- *E. crebra* woodland on Cainozoic sand plains/*Eucalyptus*	Not of Concern/ Least Concern/ Least Concern	

Regional ecosystem	Description	VMA class	Wetland system
	crebra, *Callitris glaucophylla*, *C. endlicheri*, *E. chloroclada*, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands		
11.5.1a	*Eucalyptus populnea* woodland with *Allocasuarina luehmannii* low tree layer	Least Concern	
11.5.1a/11.3.2	*Eucalyptus populnea* woodland with *Allocasuarina luehmannii* low tree layer/*Eucalyptus populnea* woodland on alluvial plains/*Eucalyptus populnea* woodland with *Allocasuarina luehmannii* low tree layer	Least Concern/ Of Concern	1-50%
11.5.4	*Eucalyptus crebra*, *Callitris glaucophylla*, *C. endlicheri*, *E. chloroclada*, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands	Least Concern	
11.5.4/11.3.18	*Eucalyptus crebra*, *Callitris glaucophylla*, *C. endlicheri*, E. chloroclada, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands/*Eucalyptus populnea*, *Callitris glaucophylla*, *Allocasuarina luehmannii* shrubby woodland on alluvium	Least Concern/ Least Concern	
11.5.4a/11.5.4	*Callitris glaucophylla* +/- *Eucalyptus spp. and Corymbia spp.* woodland/*Eucalyptus crebra*, *Callitris glaucophylla*, *C. endlicheri*, *E. chloroclada*, *Angophora leiocarpa* on Cainozoic sand plains/remnant surfaces. Deep sands	Least Concern/ Least Concern	
11.5.20	*Eucalyptus moluccana* and/or *E. microcarpa*/ *E. pilligaensis* +/- *E. crebra* woodland on Cainozoic sand plains	Least Concern	
11.7.4	*Eucalyptus decorticans* and/or *Eucalyptus spp.*, *Corymbia spp.*, *Acacia spp.*, *Lysicarpus angustifolius* on lateritic duricrust	Least Concern	
Non-rem	Non-remnant vegetation		

The lake goes through cycles of wetting and drying, occasionally overflowing. Only minor inflows of water have occurred between 2003 and March 2010 when it refilled, further inflows have been recorded since 2010. The lake was last recorded as being at full capacity in December 2003 and July 2012.

It lies within a broad alluvial plain and derives its water supply principally from rainfall entering the lake via two ephemeral streams—Surveyor's Gully to the south-east and Broadwater Gully from the south-west, and from low energy overland flow (run-off) from the surrounding flat area. The lake overflows to the north-west through the Broadwater Overflow into Wilkie Creek which drains northwards into the Condamine River.

Groundwater is unlikely to play a major role—the lake appears to be primarily a surface water feature. Groundwater vulnerability mapping (Stenson 2002) indicates the area has a moderate to low water vulnerability but the mapping is coarse.

Figure 7a – Satellite image of Lake Broadwater.

Figure 7b – Mapped wetland areas overlayed on the satellite image. Yellow denotes lacustrine wetlands, red denotes the palustrine component and the beige areas to the north-west, west and south-west of the lake denote the 1–50% wetland mosaic adjacent to Lake Broadwater. Source: Wetland*Info* KML maps (Queensland wetland mapping 2012, version 3.0) powered through Google Earth.

Legislative requirements

The requirements of the *Vegetation Management Act 1999* (VMA), Regional Vegetation Management Code and the Regrowth Vegetation Code only apply to freehold and leasehold land outside the Lake Broadwater Conservation Park. However, to demonstrate the buffer design method for this case study, it has been assumed that the VMA and Regrowth Vegetation Code apply to the whole site based on leasehold tenure. The requirements are summarised in Table 2 on page 15.

Other legislation may apply for specific activities.

Table 2 – Legislative requirements

Wetland/vegetation area	Buffer distance	Justification	Legislation/code
RE 11.3.27 (lacustrine and palustrine wetland)	200 m	Lake Broadwater is a 'natural significant wetland'	Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions – version 2
Watercourse	Clearing cannot occur less than 50 m from each high bank	Watercourse of stream order 1 or 2	Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions – version 2
11.4.3		Remnant vegetation that is an Endangered regional ecosystem	Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions – version 2
11.3.2/11.3.18		Remnant vegetation that is an Of Concern regional ecosystem	Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions – version 2
11.3.27, 11.5.20, 11.8.17/11.5.20		Remnant vegetation that is a Least Concern regional ecosystem	Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions – version 2
11.4.3, 11.3.2/11.3.18, 11.5.1/11.5.20 and parts of 11.3.27, 11.8.20,	Clearing does not occur within essential habitat	Essential habitat	Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions Version 2
Wetland	Not in or within 100 m of wetland	High-value regrowth vegetation containing Endangered regional ecosystems	Regrowth Vegetation Code Version 2
Regrowth	More than 500 m from high-value regrowth	High-value regrowth vegetation containing Endangered regional ecosystems	Regrowth Vegetation Code Version 2
Regrowth	More than 500 m from high-value regrowth	High-value regrowth vegetation containing Of Concern regional ecosystems	Regrowth Vegetation Code Version 2
Regrowth	Not in or within 100 m of wetland	High-value regrowth vegetation that is a Least Concern regional ecosystem	Regrowth Vegetation Code Version 2
Broadwater outflow	20 m from defining bank	Endangered remnant vegetation, stream order 2	Regrowth Vegetation Code Version 2
Broadwater Gully inflow	10 m from defining bank	Of Concern high-value regrowth, stream order 1	Regrowth Vegetation Code Version 2
Surveyors Gully inflow	10 m from defining bank	Of Concern high-value regrowth, stream order 1	Regrowth Vegetation Code Version 2

Areas regulated by the VMA have been mapped and combined as shown in Figure 8 on page 16. It demonstrates that much of the Lake Broadwater Conservation Park is remnant vegetation, remnant watercourses, significant wetlands, high-value regrowth and the distances defined in codes where clearing is not acceptable for most purposes.

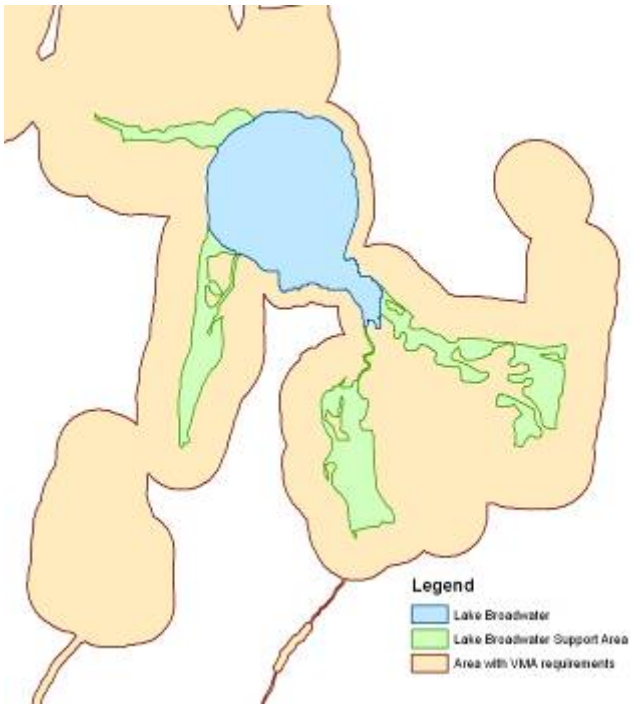


Figure 8 – Area with clearing requirements under VMA

Conceptual models

The two wetland conceptual models that best describe this wetland are the coastal/subcoastal non-floodplain soil lake and coastal/subcoastal non-floodplain tree swamp for the lacustrine and palustrine components respectively (see at <http://wetlandinfo.derm.qld.gov.au/wetlands/ScienceAndResearch/ConceptualModels.html>).

However, a specific conceptual model has been developed for Lake Broadwater and is available on Wetland*Info* at <http://wetlandinfo.derm.qld.gov.au/wetlands/ScienceAndResearch/ConceptualModels/case-study.html>.

Prepared in conjunction with this case study, it describes Lake Broadwater's four phases (wetting, full, drying and dry), its connections with the landscape, biological features, nutrient cycling and food webs in more detail than the generic conceptual models. Figures 9 and 10 on page 17-18 demonstrate the full phase and nutrient cycling respectively.

Dry Lake Broadwater with dead carp stranded as the lake dried out. Photo: EHP

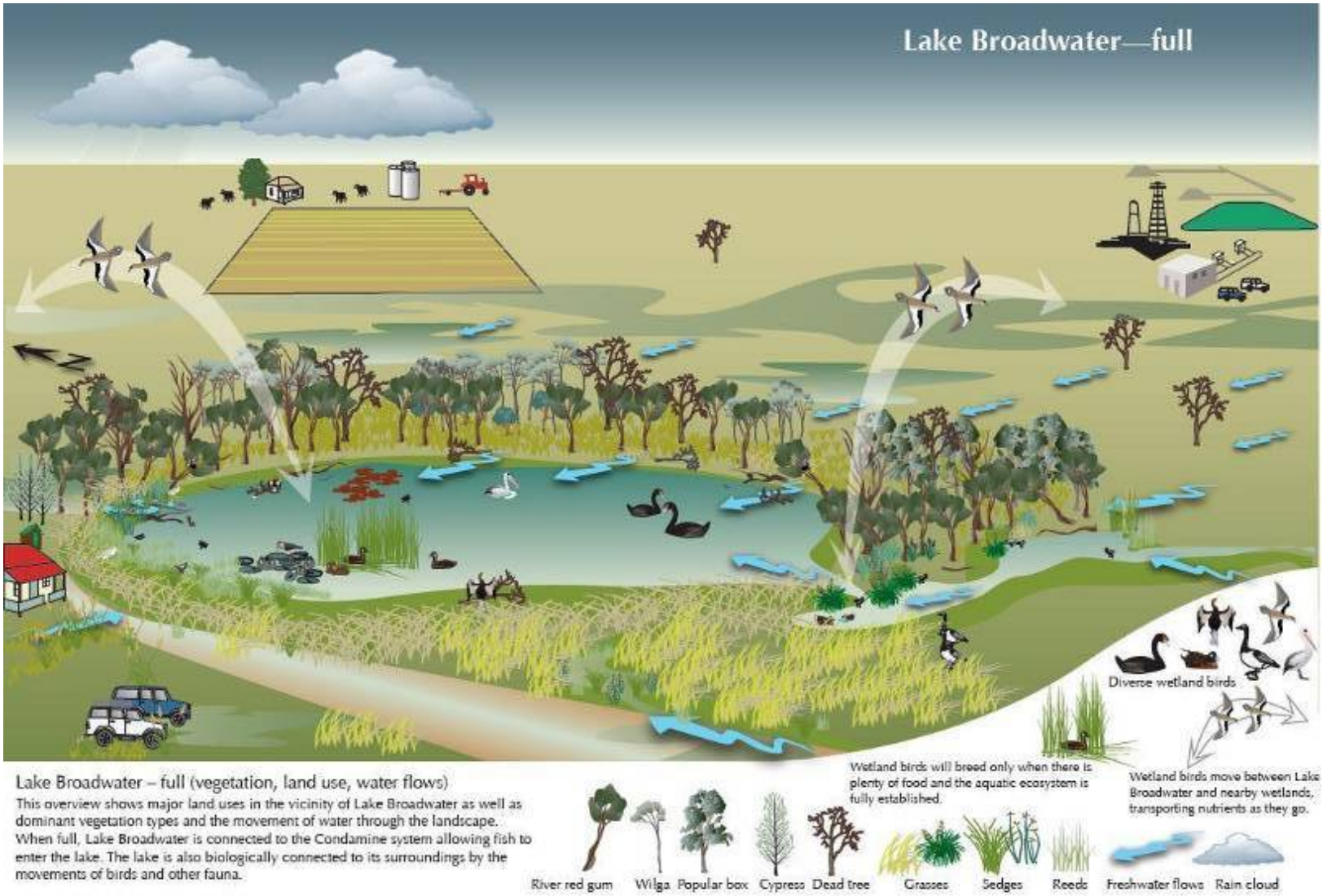


Figure 9 – A conceptual model of Lake Broadwater in its full phase. Source: DERM 2010

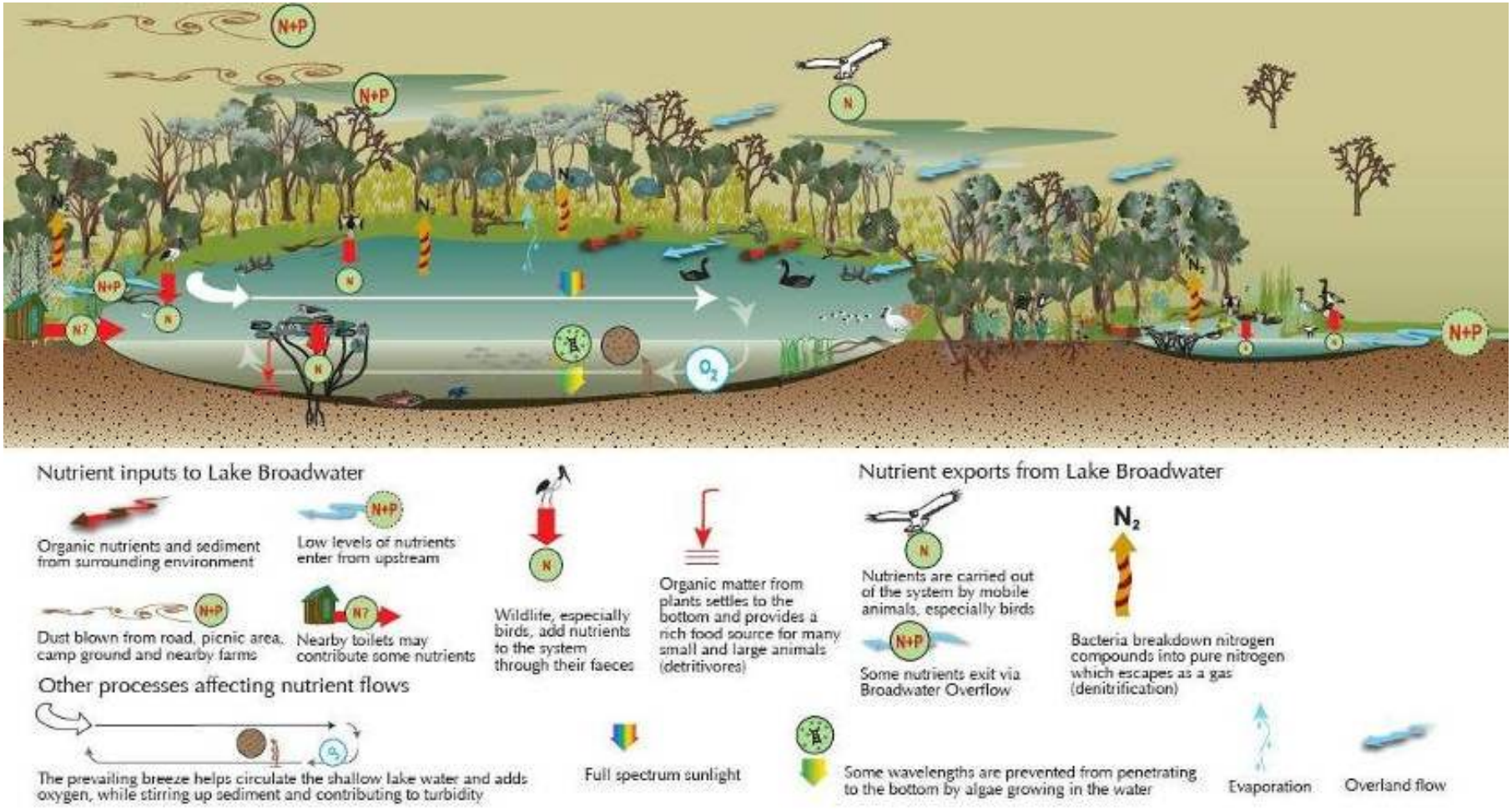


Figure 10 – Nutrient cycling in Lake Broadwater. Source: DERM 2010

Aquatic Conservation Assessment

An Aquatic Conservation Assessment (ACA) was conducted by DERM (Fielder, Davidson and Barrett 2011) using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) (Clayton et al 2006) for riverine and non-riverine wetlands. In an assessment of conservation values of wetlands in the Queensland Murray-Darling Basin, Lake Broadwater scored 'High'. The ACA score is an objective assessment of conservation/ecological values based on criteria, indicators and measures within a catchment. The score is relative to other wetlands in the catchment.

Scores for each criteria used in determining the ACA score are detailed in Table 3 below and were used in the identification of WEVs. Further information is available from <http://wetlandinfo.derm.qld.gov.au/wetlands/SupportTools/AssessmentMethods/AquaBAMM/murray_darling.html>

Table 3 - Criteria contributing to the ACA score for Lake Broadwater

Criteria	Criteria score	Measure
Naturalness aquatic	Very high	Exotic flora/fauna
		Aquatic communities/assemblages
		Hydrological modification
Naturalness catchment	Very high	Exotic flora/fauna
		Riparian disturbance
		Catchment disturbance
		Flow modification
Diversity and richness	Very high	Species
		Habitat
Threatened species and ecosystems	Medium	Species
		Communities/assemblages
Priority species and ecosystems	Very high	Species
		Ecosystems
Special features	High	Geomorphic features
		Ecological processes
		Habitat
		Hydrological modification
Representativeness	High	Wetland protection
		Wetland uniqueness

Ecological significance

Lake Broadwater is identified as a wetland of High Ecological Significance (HES) in Queensland using the Areas of Ecological Significance (AES) Mapping Methodology. For more information on the methodology and its purpose see <http://www.derm.qld.gov.au/environmental_management/land/natural_resource_management/ecological-significance-mapping.php>.

A Directory of Important Wetlands in Australia

Lake Broadwater is listed in A Directory of Important Wetlands in Australia 2010 <http://www.environment.gov.au/water/topics/wetlands/database/diwa.html>. It meets four of the six criteria for inclusion:

- It is a good example of a semi-permanent freshwater lake in the Darling Downs/Brigalow Belt region where this wetland type is rare.
- It plays an important ecological or hydrological role in the natural functioning of a major wetland complex.
- It is important habitat for animals at vulnerable stages of their life cycle.
- It supports native plants, animals and ecological communities considered endangered or vulnerable at the national level.

Guideline suitability

Lake Broadwater has been identified as a significant wetland through a number of processes as detailed above. Specifically it:

- is listed in A Directory of Important Wetlands in Australia 2010
- is mapped as a wetland of High Ecological Significance (HES)
- scored 'High' in the ACA for Queensland Murray-Darling Basin
- contains Endangered and Of Concern Regional Ecosystems
- supports wetland dependent species listed as endangered, near threatened, and vulnerable
- is a wetland within a conservation park.

Task 1: Identify and prioritise wetland environmental values (WEVs)

Lake Broadwater is a well-known and studied wetland in the Darling Downs area so a great deal is known about the lake's characteristics and WEVs.

Consultation

A number of people were involved in a workshop determining the WEVs identified for Lake Broadwater. Conservation values, priority WEVs, threats to those values and management of Lake Broadwater Conservation Park were discussed with representatives from :

- Lake Broadwater History Association, who have long-term knowledge of the lake
- Queensland Parks and Wildlife service staff with both operational (on-ground) and planning/management expertise
- DERM staff with background or interest in fauna, flora and wetland ecology.

In addition to the workshop, existing literature and a site visit were used for a desktop analysis of the WEVs. The combined results are summarised in Table 4 below.

Table 4 - Wetland environmental values of Lake Broadwater

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
Wetland processes	Hydrological processes	• Lake goes through complete wetting and drying cycles resulting in changes in habitats from more terrestrial to more aquatic species composition over time. Much of the mapped wetland area is dry for extended periods of time. Water supply is principally from direct rainfall, water inflow from Broadwater and Surveyor's Gully and overland flow. Groundwater is unlikely to play a major role—the lake appears to be primarily a surface water-fed feature. Groundwater vulnerability mapping (2002) indicates the area has a moderate–low/moderate water vulnerability but the mapping is coarse. Water is fresh but the nutrient and chemical composition changes between wet and dry periods (i.e. more concentrated when lake level is low). • Only minor inflows of water have occurred between 2003 and March 2010 when it refilled, further inflows have been recorded since 2010. The lake was last recorded as being at full capacity in December 2003 and July 2012. • Maintainance of natural hydrological processes in terms of drying and filling are recognised as being critical to the integrity of Lake Broadwater (A Directory of Important Wetlands in Australia 2010, Draft Lake Broadwater Management Plan (unpublished) 1999).	H	1
	Food webs	• Food webs at Lake Broadwater reflect a natural state due to the relatively low use of the area and the lake's ephemeral nature. • The physical features associated with Lake Broadwater, particularly during wet times, are fundamental to the dynamic character of its terrestrial and aquatic food webs (an example of a typical aquatic chain would be algae/phytoplankton → freshwater crustaceans → fish larva → carnivorous fish → sea eagle). • Different food web elements dominate the wetland system depending on the wet/dry conditions of the lake at any	H	2

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
		time. These can change extremely rapidly with the inflow of water. • A feature of ephemeral lake systems is that seeds and eggs of species are able to tolerate periods of dormancy so that regeneration can occur when conditions are suitable. • This value is intrinsically linked to the nutrient cycling WEV (see below).		
	Physical habitat	• Lake Broadwater's physical habitats and characteristics vary greatly between wet and dry cycles. Species inhabiting or utilising the wetland are limited by and adapted for these cycles (for example water level requirements for egg laying and provision of habitat during juvenile life stages). • Lake Broadwater is a shallow lake thought to have been formed when high energy stream flow from the Condamine River gouged a depression in a weak area of soil. Later flows maintained and deepened the depression. • The soils of the lake and surrounding area are Quaternary alluvium. A gravel ridge curves around the northern and eastern parts of the lake. A new, small sand bank appears to be forming on the eastern side of the lake. • The small, localised sub-catchment encircling the lake, mirrors climatic events in the surrounding Condamine catchment. • During its formation, vegetation around the lake would have trapped silt and led to the creation of levee banks around the lake. The vegetation would have stablised the shape of the lake. • Mature river red gums (*Eucalyptus camaldulensis*) that characterise the palustrine component of the wetland are regarded as an indicator of the lack of changes to the lake's high water shoreline. Saplings that establish during dry periods are killed off when the lake fills. • Soils around the lake tend to be predominantly duplex soils, characterised by a sandy/loamy surface horizon and a clear boundary to clay subsoil. There may also be small areas of deep cracking clays. In most areas the soils are poorly drained. • The topography of the lake – its natural shape and depth is essential to maintaining its environmental values. Deepening or shallowing the lake would change the local hydrology, altering food webs, species composition and other characteristics.	H	5
	Nutrient cycling	• Nutrients in the wetland result from the generation or trapping of organic and inorganic materials. This can occur through internal sources such as those associated with food web dynamics (see section above) or through external sources such as nutrient inflow into the lake from the surrounding landscape. • Nutrients also leave the lake through similar mechanisms to how they entered — through water flow, animal movements and processes such as denitrification and volatilisation. • The ephemeral nature of the lake allows nutrient dynamics (inflow and outflow) to 'reset' during each wet/dry cycle. • Lake Broadwater wetlands are a 'self-starting' system, i.e. the nutrient cycling process functions and fluctuations over time are primarily natural.	H	2
	Sediment trapping and stabilisation	• Lake Broadwater does not appear to perform a major sediment trapping and stabilisation function. It was previously thought that siltation was a foreseeable threat to the lake itself but a comparison of the current shoreline with historic mapping indicates that there is no real	M-L	

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
		evidence for this. This is probably because of the presence of buffering vegetation in the surrounding landscape (both in the conservation park itself and outside it), the low energy waters entering the wetland area, and the relative stability of the soils in surrounding areas. • The vegetation of the wetland system and surrounding area assists in maintaining the water quality of the lake area, as well as slowing water flow. Slow flows allow larger debris (such as rocks and logs) and possibly larger sediment particles to settle before entering the lake — leaving lighter particles such as fine organic matter for transport.		
Conservation significance	Diversity	• Lake Broadwater wetlands are extremely diverse in terms of physical characteristics, functions, species and habitat types (see below sections — Threatened species and ecosystems; Priority species and ecosystems). These characteristics vary temporally (with the wetting and drying cycle) and spatially. The wetland system supports at least five wetland communities: - open water - seasonally rich emergent vegetation - fringing grass/sedge vegetation - river red gum - dry lake bed vegetation. • Vegetation surrounding the wetland is also diverse and includes both remnant and high-value regrowth vegetation and vegetation communities, composed of cypress pine (*Callitris glaucophylla)*, poplar box (*Eucalyptus populnea)*, bulloak (*Casuarina luehmannii*), pilliga grey box (*Eucalyptus woollsiana)* and grasslands. • Both large numbers and diverse fauna and flora species are associated with the lake. This has been well documented in Lake Broadwater: the natural history of an inland lake and its environs (Scott 1988). It includes descriptions of the algae, macrofungi, lichens, mosses, ferns, flowering plants, aquatic and terrestrial invertebrates, fish, frogs, reptiles, birds and mammals of the area. • Recent records show that the following species are associated with the lake: - more than 21 species of frog, of which 11 are wetland indicator species (WIS) - 56 species of reptile (5 are WIS — three turtles and two snake species) - 12 species of freshwater fish (some are considered pest species) - 31 species of mammals (one is a WIS) - at least 222 species of bird including a wide range of waterbirds associated with the open water (e.g. grebes, pelicans, cormorants and ducks) and margins (e.g. herons, ibis, spoonbills, plovers, dotterels and sandpipers). At least 10 of the 36 migratory bird species recognised by the EPBC Act have been identified at the lake. Threatened and priority species are listed in the sections below. • The Aquatic Conservation Assessment (ACA) conducted by DERM for the Condamine-Balonne catchment within the Murray-Darling Basin provided an assessment of aquatic conservation values for riverine and non-riverine wetlands. Lake Broadwater is considered 'Very High' in terms of overall conservation significance based on the following	H	3

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
		ratings and attributes: - **Non-riverine** (for the lacustrine and palustrine mapped wetland): Very High—naturalness (aquatic); diversity and richness; priority species and ecosystems; special features High—threatened species and ecosystems, representativeness Medium—naturalness (catchment). - **Riverine** (for the Broadwater Creek and Surveyor's Gully inflows, and the Broadwater Overflow): Very High—diversity and richness; priority species and ecosystems; special features High—naturalness (aquatic), naturalness (catchment), threatened species and ecosystems Medium—connectivity.		
	Naturalness	• Lake Broadwater's ACA score for the naturalness aquatic criteria was 'Very High' based on measures for presence/absence of: - 'alien' fish species within the wetland - exotic aquatic and semi-aquatic plants within the wetland - feral/exotic vertebrate fauna (other than fish) within the wetland. • Lake Broadwater is primarily a natural wetland due to the fact that it is left to respond to wet/dry events without major management intervention. In this way the system 'resets' itself periodically and reasonably frequently (for example, pest fish are not maintained in the system for extended periods of time so damage to the natural water quality and food webs are not sustained in the long term). • While the lake and its surrounds can be used for recreational purposes (see the category Activities below), the use of the open body of water is restricted to times when the lake is sufficiently full. This is infrequent. • There is some evidence of weeds in the vicinity of the lake (Green Panic [*Panicum maximum* var. trichoglume) and lippia) although these do not significantly impact on the wetland processes and values at the current time. • While no grazing is currently allowed in the park and boundary fences exist, there may be occasional intrusions into the park. There was no evidence of trampling by cattle or feral pigs when the site was visited (March 2010). QPWS staff confirmed that pest impact was minimal, and there are pest control programs in place.	H	4
	Special features	• The wetland is listed in A Directory of Important Wetlands in Australia 2010 as being a good example of a semi-permanent freshwater lake in the Darling Downs/Brigalow Belt Bioregion—an area where this wetland type is rare. • Lake Broadwater provides an important refuge for waterbirds (including migratory shorebirds) in this primarily agricultural landscape. • The lake provides habitat for a large range of species, and supports species at a critical stage of their life cycle (e.g. frogs, fish, and invertebrates). • Protection as a conservation park has allowed the lake to remain relatively natural allowing the wet/dry cycles to occur that are characteristic of this wetland type and critical to a number of species found there. This protection	H	7

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
		is extended to adjacent ecosystems (grasslands, bulloak and cypress pine) which are threatened by cultivation and agricultural use in the surrounding area. Indirectly, this extended protection also supports the naturalness and diversity of the wetland system. • The park and adjacent resources reserve contains areas of high-value regrowth vegetation which contribute to the naturalness and resilience of the wetland. • The lake is the subject of intense and longstanding interest by the Lake Broadwater History Association, who have been committed to the conservation of the lake and its surrounds. Lake Broadwater – the natural history of an inland lake and its environs was published in 1988, which included the results of a five-year ecological study of the area (including flora, fauna, soils, history, geomorphology etc). This was commissioned by the Australian Bicentennial Celebrations and provides an important resource to guide land managers.		
	Distinct or unique species	There is no particular species that would be considered distinct or unique to Lake Broadwater.	L	
	Representative-ness or unique habitat	• The wetland is listed in A Directory of Important Wetlands in Australia 2010 as being a good example of a semi-permanent freshwater lake in the Darling Downs/Brigalow Belt Bioregion—an area where this wetland type is rare. • Lake Broadwater's ACA score for the Representativeness criteria was 'High' based on measures for wetland protection and wetland uniqueness.	H	7
	Threatened species and ecosystems (including habitats)	• Nineteen species of near threatened and threatened flora and fauna are listed as being found at Lake Broadwater Conservation Park. Nine of these are more closely associated with ecosystems and habitats adjacent to the mapped wetlands (such as ecosystems containing Brigalow). The following eight species are associated with the wetlands themselves (*Queensland Nature Conservation Act 1992* [NCA] and *Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act) status provided): - rough collared frog (*Cyclorana verrucosa*) (Near Threatened, not listed) - cotton pygmy-goose (*Nettapus coromandelianus*) (Near Threatened, not listed) - freckled duck (*Stictonetta naevosa*) (Near Threatened, not listed) - black-necked stork (*Ephippiorhynchus asiaticus*) (Near Threatened, not listed) - Australian painted snipe (*Rostratula australis*) (Vulnerable, Vulnerable) - grey snake (*Hemiaspis damelii*) (Endangered, not listed) - *Eleocharis blakeana* (Near Threatened, not listed) - *Fimbristylis vagans* (Near Threatened, not listed). • The Lake Broadwater wetland system contains the following regional ecosystems (listed with *Vegetation Management Act 1999* [VMA) status, Biodiversity status and current representation in the protected estate listed respectively): - 11.3.27: Not of concern; Of concern; Low - 11.3.1: Endangered; Endangered; Low - 11.3.2: Of concern; Of concern; Low.	**H**	**6**

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
	Priority species and ecosystems	• The lake includes endangered ecological communities under the EPBC Act (as described above in Threatened Species and Ecosystems). • The western and southern part of the wetland is considered essential habitat under the VMA for the rough collared frog (*Cyclorana verrucosa*) and golden-tailed gecko (*Strophurus taenicauda*). • The lake provides habitat for the following bird species listed under one or more of the bilateral migratory bird agreements (JAMBA, CAMBA, ROKAMBA) or listed as a wetland indicator species (WIS) on Wetland*Info*: Australasian shoveler (*Anas rhynchotis*); white-throated needletail (*Hirundapus caudacutus*); cattle egret (*Ardea ibis*); glossy ibis (*Plegadis falcinellus*); white-bellied sea-eagle (*Haliaeetus leucogaster*); Pacific golden plover (*Pluvialis fulva*); Australian painted snipe (*Rostratula australis*); Latham's snipe (*Gallinago hardwickii*); black-tailed godwit (*Limosa limosa*); bar-tailed godwit (*Limosa lapponica*); common greenshank (*Tringa nebularia*); marsh sandpiper (*Tringa stagnatilis*); wood sandpiper (*Tringa Glareola*); red-necked stint (*Calidris ruficollis*); sharp-tailed sandpiper (*Calidris acuminate*); curlew sandpiper (*Calidris ferruginea*); ruff (*Philomachus pugnax*); Caspian tern (*Hydroprogne caspia*); Australian reed-warbler (*Acrocephalus australis*).	H	6
	Ecological connectivity	• When the lake is wet it forms hydrological connections with creeks, gilgai watercourses (Long Swamp to the east and north of the lake), riparian areas, and the local catchment (though overland flow). • Areas containing 1–50% wetland occur outside the lacustrine and palustrine wetland systems in the: - Broadwater Overflow (within and outside the conservation park) - recreation reserve area - along Broadwater Gully (patches inside and outside the conservation park) - Surveyor's Gully (outside the conservation park). These areas contain either remnant or high-value regrowth regional ecosystems. Two of these sites are part of the endangered EPBC Act listed threatened ecological community—the Weeping Myall Woodlands (as described above). The Broadwater Overflow area contains the endangered EPBC Act listed threatened ecological community Brigalow (*Acacia harpophylla* dominant and co-dominant) (also described above). • Biological connections through fish, bat and bird species particularly during wet periods. For example, migratory birds utilise Lake Broadwater as one of their re-fuelling sites, and during flood events the lake is connected to the Condamine River allowing the movement of fish species to the lake. Fish numbers fluctuate markedly and in extreme events European carp (*Cyprinus carpio*) can cause a decrease in water quality, an increase in turbidity, and a loss of aquatic plants and macroinvertebrates.	M-H	1
Material benefits from wetland ecosystems	Mitigation of impacts of climate change	• Has some role in sequestering and storing carbon due to the presence of vegetation (primarily trees)—this is a minor role. • Provides habitat or refugia for animals during extreme weather events—effects of climate change on this function of the ephemeral wetland system is unknown.	L-M	

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
	Coastal shoreline, bank stabilisation and storm protection	Not applicable.		
	Local climate regulation	No major effect—at times the lake provides a large expanse of shallow water which is vulnerable to evaporation (i.e. providing a local climate cooling effect).	L	
	Biological control of pest species and diseases, and support of predators of agricultural pests	Possible role as the lake does support a wide variety of frogs, fish and bird species. However, this is based on anecdotal information (e.g. during periods of inundation bony herring and glassfish eat mosquito larvae).	L	
	Trapping, storage and/or treatment of contaminants	Has the potential for this as it is a depression in the landscape. Also see WEV 'Sediment trapping and stabilisation' in the wetland processes section above.	M-L	
	Flood control	Provides temporary storage of local rainfall — the lake is shallow (4 metre maximum depth) and the land is relatively flat.	M-L	
	Primary production	Not used for this purpose.		
	Genetic resources	Yes, but currently not used for this purpose.	M-L	
Material products gained directly from wetlands	Water supply	Not used for these purposes.		
	Drinking water			
	Farm water supply			
	Irrigation			
	Stock watering			
	Industrial uses			
	Aquaculture			
	Wetland products (such as animal and plant material)			
Activities	Recreation	• Primary water-based recreation facility in the area, although the frequency of inundation and lake depth limit its use for water skiing, sailing, canoeing and swimming. Only the main body of the lake is used for these purposes as the neck area is described as a Special Habitat Protection Zone in the Draft Management Plan for the conservation park. • Lake and surrounding area are used for camping, picnicking, bushwalking, bird watching and wildflower viewing. • Activities are concentrated in, but not limited to, the recreation reserve area on the western side of the main water body area and the Wilga Campground to the north.	H	8
	Tourism	Has potential for this—exact uses and extent of use unknown.	H	8
	Education	The lake and its surrounding ecosystems have been extensively studied over the years by a range of individuals, conservation groups (Lake Broadwater Natural History Association, Queensland Wildlife Preservation Society) and other organisations (QPWS, Griffith University, Queensland Museum).	H	8
Cultural resources (including anthropological,	Indigenous cultural heritage	• Historically the lake provided water and a major camping site for the Barunggam people (southern and western side of the lake). • Scar trees and other artifacts (such as stone axes, cores,	M	

WEV category	WEV characteristic	Description of WEVs in relation to Lake Broadwater	Rating* (H/M/L)	Priority+ (1-8)
archaeological, historical, scientific, spiritual, visual, or sociological significance or value)		flakes, microliths, grinding dishes and pounders have been found in the area.		
	Non-indigenous cultural heritage	Several large pastoral holdings were established in the area (from 1840 onwards) including the St Ruth holding which included the lake area. Remains of the St Ruth Station dingo fence are evident near the lake's overflow area in the north-west.	M	

H=high, M=medium, L=low based on workshop results.
+ Priorities based on workshop results.

Priority WEVs

Fourteen priority WEVs were identified for Lake Broadwater. These were reduced to eight subgroups based on associations and/or overlap between individual values and development of individual wetland support areas.

The following are the priority WEVs for Lake Broadwater:

- hydrological processes and ecological connectivity
- food webs and nutrient cycling
- diversity
- naturalness
- physical habitat
- threatened species and ecosystems (including habitats) and priority species and ecosystems
- special features and representativeness or unique habitat
- recreation, tourism and education.

Task 2: Specify the individual wetland support area required for each priority WEV

Table 5 below lists the priority WEVs, a description of the support area role and the support area/distance or attributes required to protect the priority WEVs.

Table 5 – Support area requirements

Priority WEV	Support area role	Support area/distance estimate and other attributes
Hydrological processes and Ecological connectivity	Maintain natural hydrological processes (in terms of drying and filling) so that the natural ephemeral characteristics of the lake are maintained and the appropriate water flow regime reaches the site through existing channels. Maintain hydrological and ecological connectivity between wetland areas in the local landscape.	1–50% wetland mosaic units (Broadwater Gully and Surveyor's Gully) which slow and filter water into Lake Broadwater. 1-50% wetland mosaic of Broadwater Overflow to maintain connectivity to the Condamine River. Inflow and outflow watercourses where they are not part of the wetland mosaic areas. Delineation of these watercourses is not clear and they may move over time. However, an appropriate support area would be 10 m for Surveyors Gully and 20 m for Broadwater Gully and Broadwater Overflow, measured from each side of the defining bank or peak flow area—this may not be obvious and need to be estimated. This figure is based on the minimum stream protection zones required under the VMA Regrowth Vegetation Code and is consistent with the 5–10 m buffer estimated by Lovett, Price and Lovett (2003) for healthy riparian vegetation and in-stream health. Maintenance of the catchment plays a major part in maintaining the wetland's hydrology.
Food webs and nutrient cycling	Provide the setting for physicochemical and ecological processes that characterise the wetlands ephemeral nature and flora and fauna composition.	Support area as above Maintenance of the hydrological regime and water quality (in terms of naturalness) is important to this WEV. Intact vegetation within Lake Broadwater supports food webs and nutrient cycling.
Diversity	Provide the area necessary to support the wide range of species associated with the wetland systems.	Support area as above. Most local habitat requirements (in terms of breeding, feeding , nesting or dormancy) for the range of wetland species are fulfilled by Lake Broadwater (including the palustrine fringe)
Naturalness	Allow natural processes, including the ephemeral nature of the wetland to occur (such as hydrology, food webs and flora and fauna composition).	Support area as above.
Physical habitat	Maintain the physical characteristics of the wetland system to support life cycles of wetland-dependent species and natural processes.	Support area as above. Most habitat requirements (in terms of breeding, feeding, nesting or dormancy) for the range of wetland species would be fulfilled by the mapped wetland area — the palustrine fringe ranges from approximately 55 to 371 m around the circular part of the lake.
Threatened species and ecosystems (including habitats) and priority species and ecosystems	Provide and maintain quality, natural habitat for threatened or priority fauna and flora and habitats.	Support area as above. Species requirements are contained primarily within the areas containing water or close to water containing areas (i.e. in the palustrine fringing areas).
Special features and representativeness or	Allow natural processes including the ephemeral nature of the wetland to occur	Support area as above While the entire catchment plays a major part in

Priority WEV	Support area role	Support area/distance estimate and other attributes
unique habitat	(such as hydrology, food webs and flora and fauna composition)	maintaining the wetland's hydrology, the minimum support area for these WEVs needs to encompass the entire mapped area which includes the high water mark signified by river red gums and the 1–50% wetland mosaic units.
Recreation, tourism and education	Retain aesthetic qualities. Provide and maintain areas for managed public access and activities. Maintain the characteristics and wetland functions of educational interest. Note: this particular role relates to all of the other priority WEVs listed.	Support area as above to retain aesthetic qualities, characteristics and functions of educational interest, and for most of the public access uses (bushwalking, bird watching, picnicking etc). Current designated camping areas. Camping at Lake Broadwater is restricted to the recreation reserve which is contained largely within the mapped wetland area on the western side of the lake, and to Wilga Campground, which is located north of the lake. Walking tracks with little surface modification lead to the lake.

It is clear from the above analysis that most of the WEVs associated with Lake Broadwater are reliant on Lake Broadwater itself and connected wetlands. Additionally, the watercourse inflows (Surveyor's and Broadwater Gully) and outflow (Broadwater Overflow) should be considered part of the support area for a range of WEVs, but primarily those relating to providing hydrological and ecological connectivity between mapped wetland areas. The suggested support area for the watercourses is 10–20 metres extending from each side of the defining bank (see Table 5 above).

The priority WEV related to public access conflicts with, or requires a different support area from, the other WEVs. These activities contrast strongly to the passive recreational activities that occur predominantly at this site and the more natural environmental values described for the wetland. Nevertheless, the ephemeral nature of the lake and generally low water levels limit how much the lake can actually be used for these purposes. As the natural WEVs associated with Lake Broadwater are the most significant, they are the values which will dictate the design of the wetland buffer.

It should be noted that some of the areas mapped as wetlands in the Queensland wetland mapping (the western side of Lake Broadwater and the 1–50 per cent mosaic wetlands that contain EPBC Act listed endangered ecological communities) lie outside the conservation park itself, on either the recreation reserve or on adjacent freehold properties. Where Broadwater Road dissects the palustrine component of Lake Broadwater on its western side, the freehold properties have been partially cleared.

The physical extremes of Lake Broadwater are infrequently inundated. The 55 to 371 metres palustrine component fringing the main body of lacustrine area and the neck area of the mapped lacustrine area (that is less likely to be inundated than the main body of the lake) provide important habitat for wetland indicator species, threatened and priority species at important stages of their lifecycle, as well as providing habitat for a diverse range of species that characterise Lake Broadwater even during dry times. These areas could be identified as support areas for the core lacustrine component of Lake Broadwater if they were not already considered as part of the lake.

Task 3: Design the overall support area

The individual support areas for Lake Broadwater's WEVs and an overall support area for the priority WEVs is shown diagrammatically in Figure 11 below.

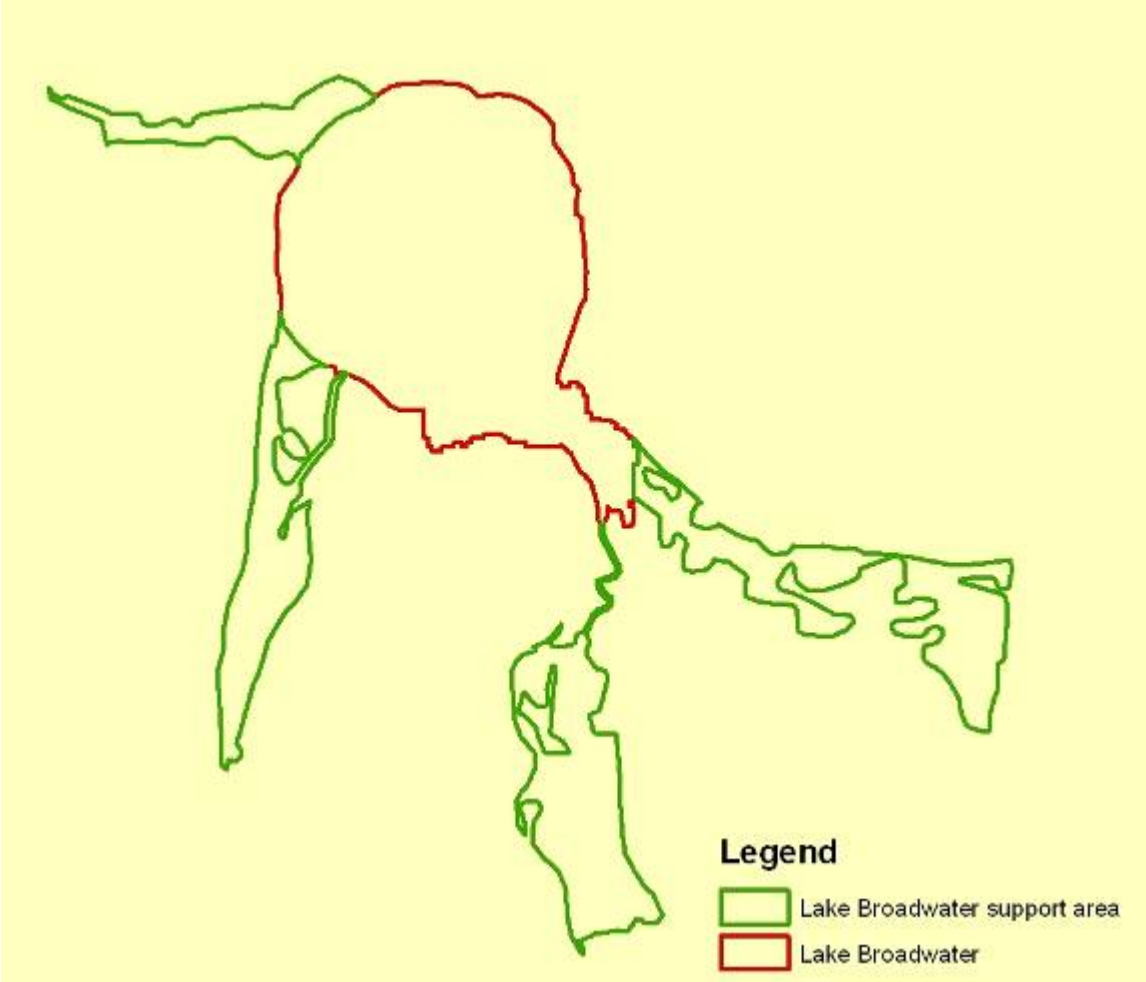


Figure 11 – Overall wetland support area

Task 4: Identify and prioritise pressures and impacts

For each priority WEV, Table 6 below lists potential threatening processes from within the wetland or externally; potential pressures to these values; and the overall risk to the priority WEVs. Each pressure is assessed for whether or not it can be addressed by a buffer. Where a buffer is not appropriate, the pressure is not considered further and the row in Table 6 is not coloured. Where the overall risk score is less than 7, the direct pressure is not considered a major direct pressure and is also not coloured. Where the overall impact risk is greater than 7, the pressure is a major direct pressure and the row is highlighted by being coloured.

Table 6 – Major direct pressures

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
Hydrological processes and ecological connectivity: complete wetting and drying cycle	Local hydrology	Altered hydrology	Increase in water extraction or diversion within catchment	Loss of sensitive species; change in species composition	Buffer; maintain current management and level of protection	5	1.5	7.5	Y
		Altered rate of rise and fall of water levels	Dredging for water-based recreational activities	Change in species composition; increased presence of alien species	Maintain current management and level of protection				N
	Local connectivity	Different connection regime with surrounding rivers and catchment	Modification of natural drainage pathways; removal of wetland and fringing zone vegetation	Change in community structure; reduction in biodiversity; reduced reproduction; reduced opportunity for reproduction and migration	Buffer; maintain current level of protection	5	1.5	7.5	Y

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
Food webs and nutrient cycling: depend upon wet/dry cycle	Nutrients	Increase in amount of nutrients entering wetland	Changes to catchment land use	Altered food webs; altered community structure	Buffer	5	1.5	7.5	Y
			Fire		Maintain fire management plan				N
	Pest species	Increase in pest weeds	Lippia (*Phyla canescens)* in the lake and Green Panic (*Panicum maximum* var. trichoglume) (a pasture grass) in the vicinity of the lake	Altered food webs; loss of naturalness; altered habitat; altered biodiversity; reduced species richness	Buffer	5	3	15	Y
	Pest species	Increased presence of carp (currently die when lake dries and only return when lake is connected downstream)	Changes to connectivity	Altered food webs; increased predation of native fish; reduced species richness	Maintain current management, level of protection and connectivity				N
	Aquatic sediments	Disturbance of lake bed	Dredging for water-based recreational activity	Reduced water clarity, increased sediment load; altered primary production	Maintain current management				N
		Disturbance by large number of carp	Increased period of wetness due to dredging	Reduced water clarity; altered primary production	Maintain current management				N

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
Diversity, naturalness ,threatened species and ecosystems (including habitats) and priority species and ecosystems, special features, representativeness or unique habitat	Bacteria/ pathogens	Bacteria / pathogens entering the wetland from septic systems, catchment run--off or recreational activities	Reduction in level of protection and increased recreational activities	Animal lesions, disease, kills; changes in species composition; loss of sensitive species	Buffer, maintain current management	4	1	4	N
	Biota removal/ disturbance	Activities that change the wetland form	Dredging for water-based recreational activity; high levels of inappropriate recreational activities	Change in community structure; increase in weeds; loss of individuals	Maintain current management				N
		Habitat loss	Clearing, human activity in and around the wetland	Change in community structure; increase in weeds; loss of individuals	Buffer, maintain current level of protection and management	5	1	5	N
	Conductivity	Large water release from impoundments	Failure of coal seam gas evaporation ponds	Increased salinity; plant and animal kills; loss of sensitive species	Buffer, maintain current level of protection and management, evaporation pond best management practice	4	1	4	N

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
	Local connectivity	Reduction in overland flow and water inflow	Impoundments, modification of natural drainage paths	Change in community structure; reduction in biodiversity; reduced reproduction; reduced opportunity for reproduction and migration	Buffer, maintain current level of protection and management	5	1	5	N
	Hydrology	Altered seasonality of water levels (wet for longer)	Dredging for water-based recreational activity	Change in species composition; increased presence of carp	Maintain current management				N
	Habitat removal	Modification of lake bed	Dredging for water-based recreational activity	Change in wetland habitat type extent; loss of sensitive species	Maintain current management and level of protection				N
		Vegetation clearing	Vegetation clearing, increased recreation activities						
	Nutrients	Blue-green algae blooms and nuisance growth of aquatic plants	Change in land use	Loss of sensitive species; altered community structure	Buffer, maintain current level of protection and management	4	1	4	N
	Organic matter	Increase in the amount of organic matter entering the wetland	Catchment run-off	Animal kills; loss of sensitive species; change in community structure	Buffer, maintain current management and level of protection	4	1	4	N

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
	Pest species	Increase in pest weeds	Lippia (*Phyla canescens)* in the lake and Green Panic (*Panicum maximum* var. trichoglume) (a pasture grass) in the vicinity of the lake	Loss of naturalness; altered habitat; altered biodiversity; reduced species richness	Buffer, maintain current management	5	2	10	Y
	pH	Acidic water entering a wetland	Failure of coal seam gas evaporation ponds	Change of water pH; loss of sensitive species especially fish and shellfish	Buffer, maintain current level of protection and management, evaporation pond best management practice	4	1	4	N
	Toxicants	Oil spills	Fuel and oil leaks from recreational boats	Animal and plant kills and disease; changed community composition; increased toxicant concentrations in biota	Maintain current management				N
	Aquatic sediments	Disturbance of lake bed	Dredging for water-based recreational activity	Reduced water clarity, increased sediment load; altered food webs	Maintain current management				N

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
		Disturbance by large number of carp	Increased period of wetness due to dredging	Reduced water clarity; altered food webs	Maintain current management				N
Physical habitat	Habitat removal	Modification of lake bed	Dredging for water-based recreational activity	Change in wetland habitat type extent; loss of sensitive species	Maintain current management and level of protection				N
		Vegetation clearing	Vegetation clearing, increased recreation activities	Change in wetland habitat type extent; loss of sensitive species	Buffer, maintain current management and level of protection	5	1.5	7.5	Y
	Pest species	Increase in pest weeds	Lippia (*Phyla canescens)* in the lake and Green Panic (*Panicum maximum* var. trichoglume) (a pasture grass) in the vicinity of the lake	Loss of naturalness; altered habitat; altered biodiversity; reduced species richness	Buffer	5	2	10	Y

Priority WEV description*	Pressure categories	Direct pressure on WEV	Potential cause	Impact	Appropriate response	Impact rating (1–5)**	Likelihood (1,2,3)***	Impact overall risk****	Major direct pressure? (Y/N) *****
Recreation, tourism and education	Bacteria/ pathogens	Bacteria / pathogens entering the wetland from septic systems, catchment run-off or recreational activities	Reduction in level of protection and increased recreational activities	Infections, gastroenteritis, viruses	Buffer, maintain current management	4	1.5	6	N
	Biota removal/ disturbance	Activities that change the wetland form	Dredging for water-based recreational activity; high levels of inappropriate recreational activities	Change in community structure; increase in weeds; loss of individuals; loss of enjoyment	Maintain current management				N
	Conductivity	Large water release from impound-ments	Failure of coal seam gas evaporation ponds	Increased salinity; plant and animal kills; loss of enjoyment	Buffer, maintain current level of protection and management	4	1	4	N
	Litter (rubbish)	Increase in human made rubbish in wetland	Inappropriate recreational use	Loss of enjoyment	Buffer, maintain current level of protection and management	2	1	2	N
	Nutrients	Blue-green algae blooms and nuisance growth of aquatic plants	Change in land use, increased recreational use	Maintain current access for recreation	Buffer, maintain current level of protection and management	3	2	6	N
	Organic matter	Change in the amount of organic matter entering the wetland	Catchment run-off	Animal kills; loss of enjoyment	Buffer, maintain current level of protection and management	4	1	4	N
	Toxicants	Oil spills	Fuel and oil leaks from recreational boats	Animal and plant kills and disease; changed community composition; increased toxicant concentrations in biota; reduced enjoyment	Current level of protection and management				N

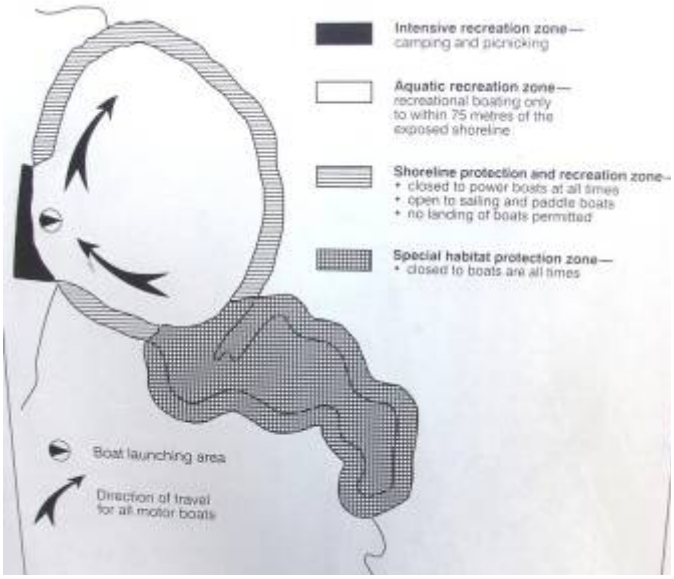
Note, in the above table:
* From Table 3; ** 1 = minimal, 3 = moderate, 5 = serious (integrates overall impact and vulnerability of wetland);
*** 1 = unlikely, 2 = quite likely, 3 = highly likely; **** Overall risk = vulnerability score x likelihood score; ***** Generally, a direct pressure with an overall risk score above 10 would be considered a major direct pressure. In this instance because of competing values, some direct pressures with a score above 7 have been included.

Buffer elements

Buffer elements are natural or artificial features or management actions that protect the wetland from direct pressures. For Lake Broadwater they are:

- conservation tenure
- designated camping areas
- aquatic recreation management by Western Downs Regional Council
- fire management by QPWS
- weed control by QPWS
- bird hide
- Water Resource Plan
- NCA, VMA and EPBC Acts.

The boat ramp area in the recreation reserve area. The sign board indicates the lake is closed due to low water levels —a common occurrence. Photo: EHP



Part of another sign board indicating the rules for boating and the zones associated with recreation at Lake Broadwater. Photo: EHP

Identified major direct pressures

Major direct pressures were identified based on whether their overall risk score was greater than 7. This was done to include pressures that had a high impact rating (5) but existing buffer elements reduced the likelihood (hence giving a lower risk score). The only major direct pressure identified based on the overall risk estimate, was an increase in pest weeds (lippia [*Phyla canescens*] in the lake and Green Panic [*Panicum maximum* var. trichoglume], a pasture grass, in the vicinity of the lake).

Lippia is a broadleaf perennial herb that may pose a threat to the Lake Broadwater wetland.

Lippia forms a dense mat like groundcover and is well established in the Darling Downs. Photos: DEEDI, 2010

Task 5: Specify the individual separation area requirements

Some major direct pressures require a similar response so they have been linked in Table 7 below. Literature was reviewed to determine appropriate separation areas/distance for each pressure.

Table 7 – Separation area required for major threatening processes

Separation area requirements				
Major direct pressure	**Response**	**Recommended management**	**Recommended separation area/distance**	**Comments/ justification**
Increase in pest weeds—lippia (*Phyla canescens)* in the lake and Green Panic (*Panicum maximum* var. trichoglume), a pasture grass, in the vicinity of the lake	Limit the spread of lippia and Green Panic, within and from areas outside Lake Broadwater	• Bare soil should be reduced to a minimum and competition by other plants encouraged. • Monitor the extent of intrusion into the wetland area. If mechanical or chemical removal is required it should be limited to small areas so that soil remains as undisturbed as possible. Advice should be sought should this be deemed necessary. • Where manual or chemical removal is required it should be conducted when water isn't present. Notes • Both are summer growing, drought tolerant species capable of regrowing quickly after rain events. • Lippia may be spread by floodwaters, seed dispersal, vehicles or birds. Green Panic may gradually extend its distribution by seeding and rooting from lower nodes.	100 m (Water & Rivers Commission 2000)	• The extent of lippia is currently relatively low but occurs within the mapped lacustrine and palustrine components of Lake Broadwater. • Lippia is recognised as a significant threat to wetlands and riparian areas; and is extremely difficult to control. • Lippia is not a declared plant under Queensland legislation but is recognised as a serious environmental weed. • Green Panic is a pasture crop. It is currently limited to the western portion of the lake, on the road side adjacent to the recreation reserve area within the palustrine component of Lake Broadwater.
Altered hydrology	Minimise the potential for changes to local hydrology of the wetland	• Maintain current level of protection • Allow ecological adjustments to changing water levels • Maintain naturally vegetated areas • Minimise soil disturbance	200 m (DNRW 2007)	Other references suggest buffers of 10-200 m
Different connection regime with catchment and rivers	Maintain connectivity with Condamine River and with catchment	• Maintain current level of protection • Any downstream works should not impede fish passage • Minimise disturbance to downstream beds	• 20 m stream order 2 • 10 m stream order 1 (DERM 2009b)	Width of the stream bed was estimated using aerial photos
Increase in amount of nutrients entering wetland	Control nutrients entering the wetland	• Maintain current level of protection • Minimise the potential for water pollution and non-natural changes in water quality (i.e. changes not related to the ephemeral nature of the wetland)	200 m (Western Australian Planning Commission 2005)	

Separation area requirements				
Major direct pressure	**Response**	**Recommended management**	**Recommended separation area/distance**	**Comments/ justification**
Habitat loss	Maintain naturally vegetated areas	Maintain current level of protection	200 m (DNRW 2007)	• Habitat removal is restricted under the VMA.
Reduction in overland flow and water inflow	Limit water extraction	Maintain current level of protection	200 m (DNRW 2007)	• Extended dry periods and the naturally low water depth restrict the use of the lake for water-based recreation.
Vegetation clearing	Maintain naturally vegetated areas	• Maintain current level of protection • Minimise soil disturbance and maintain the integrity of existing vegetation • Encourage natural revegetation where necessary • Maintain active relationships between the trustees of the Conservation Park and recreation reserve, QPWS and community groups so that the wetland is managed in a holistic way.	200 m (DNRW 2007)	• The wetland occurs within areas of remnant and high-value regrowth, and as a consequence habitat removal (clearing) is restricted (under the VMA). • The palustrine component occurs on the western side of Lake Broadwater Road and on adjacent properties that are not mapped as remnant vegetation. Therefore management options for this separation area are limited to community education.
High levels of or inappropriate recreational activities	Limit the impacts of recreation on WEVs identified for Lake Broadwater	• Maintain active relationships between the trustees of the conservation park and recreation reserve, QPWS and community groups so that the wetland is managed in a holistic way. • Maintain current limits on water-based activities to the western shore of the mapped wetland area (in the recreation reserve) and to the main body of the lake (to within 75 m of the exposed shoreline). • Restrict numbers using the lake for water-based recreation. • Only authorised vehicles should be allowed on the lake. • Monitor water quality, particularly if people are swimming in the lake (e.g. blue-green algae and faecal coliforms). • Restrict vehicle access to the boat ramp, designated roads and parking areas. • Encourage visitors to use designated walking tracks (to the bird hide, from Wilga campground etc.), and facilities within the recreation	30 m (Castelle et al 1994)	• Extended dry periods and the naturally low water depth restrict the use of the lake for water-based recreation but are important for other WEVs. • A draft management plan for the conservation park exists and provides guidance for both natural and recreational values. • A blue-green algae (*Cyanobacteria sp.*) outbreak has occurred in the past and is a potential threat to water-based recreation. These outbreaks may be a natural part of ephemeral wetland cycle.

Separation area requirements				
Major direct pressure	**Response**	**Recommended management**	**Recommended separation area/distance**	**Comments/ justification**
		reserve as much as possible to reduce impacts on natural values.		

Task 6: Design the overall separation area

The separation distances are summarised in Table 8 below and shown on Figure 12 on page 45. A separation distance of 200 metres is common for five major direct pressures and is also the largest separation distance. A GIS was used to overlay and compare each separation distance to determine the overall separation distance (Figure 12).

Table 8 – Summary of separation distances

Major direct pressure	Separation distance	Application
Increase in pest weeds	100 m	Lake Broadwater, support areas and streams
Altered hydrology Increase in nutrients entering wetland Habitat loss Reduction in overland flow Vegetation clearing	200 m	Lake Broadwater, support areas and streams
Different connection regime	• 120 m for stream order 2 • 30 m for stream order 1	Measured from stream line, using estimated width of stream bed. The support distance and separation distance for the watercourses were combined
Recreation and human impacts	30 m	Lake Broadwater and streams

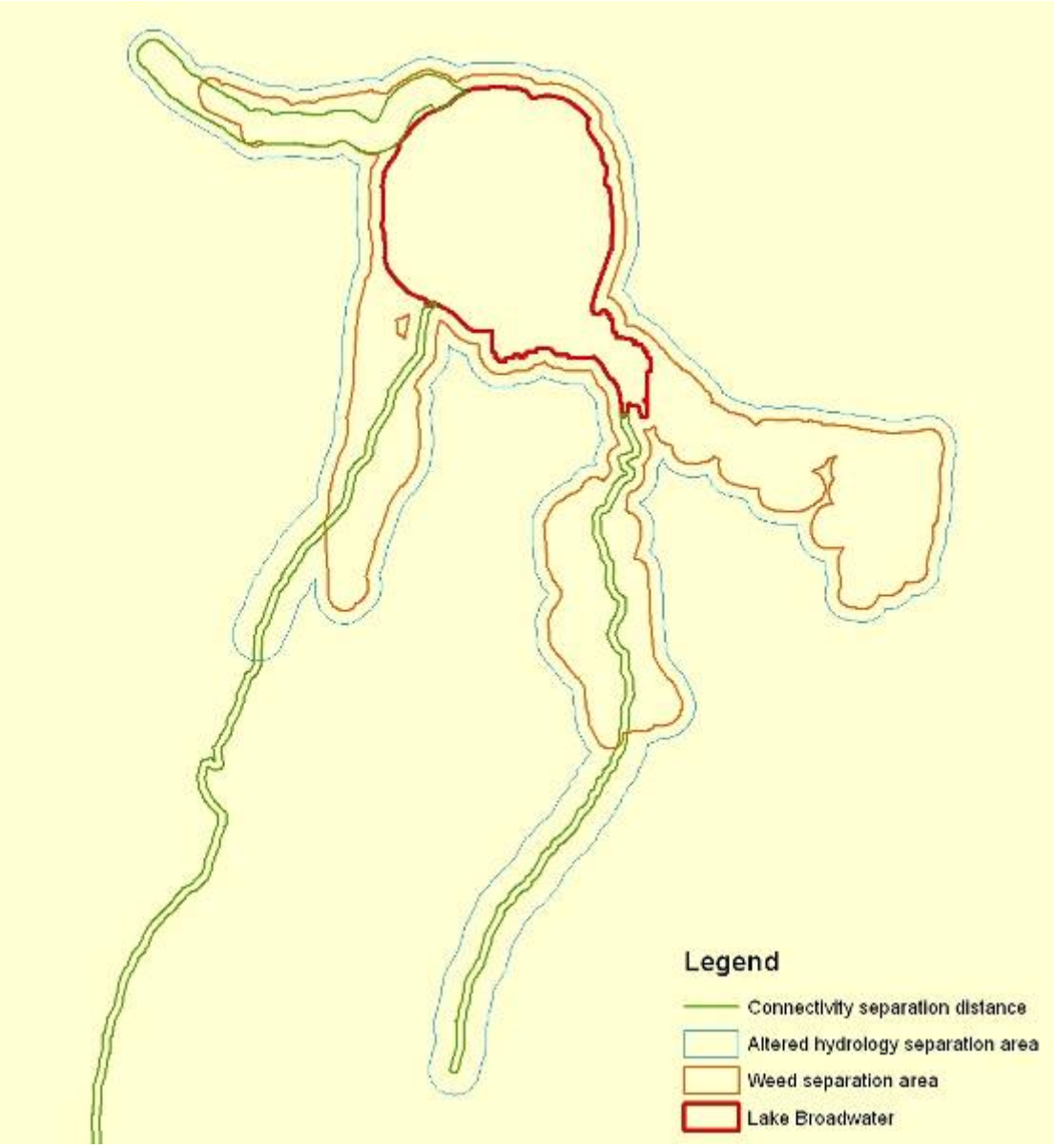


Figure 12 – Individual separation areas required to maintain the natural values of Lake Broadwater

Total wetland buffer distance

The total wetland buffer distance for Lake Broadwater consists of the overall support area and overall separation area as shown in Figure 13 below and described in Table 9 on page 47.

The support area includes areas mapped as containing wetlands (1-50 per cent wetland mosaic units) and 10–20 metre buffers around watercourses flowing into and out of Lake Broadwater. The separation area is 200 metres around Lake Broadwater and the wetland mosaic support area and 30–120 metres around watercourses.

Note that the total wetland buffer and part of the western side of Lake Broadwater are dissected by roads and occur over cleared freehold land limiting management options.

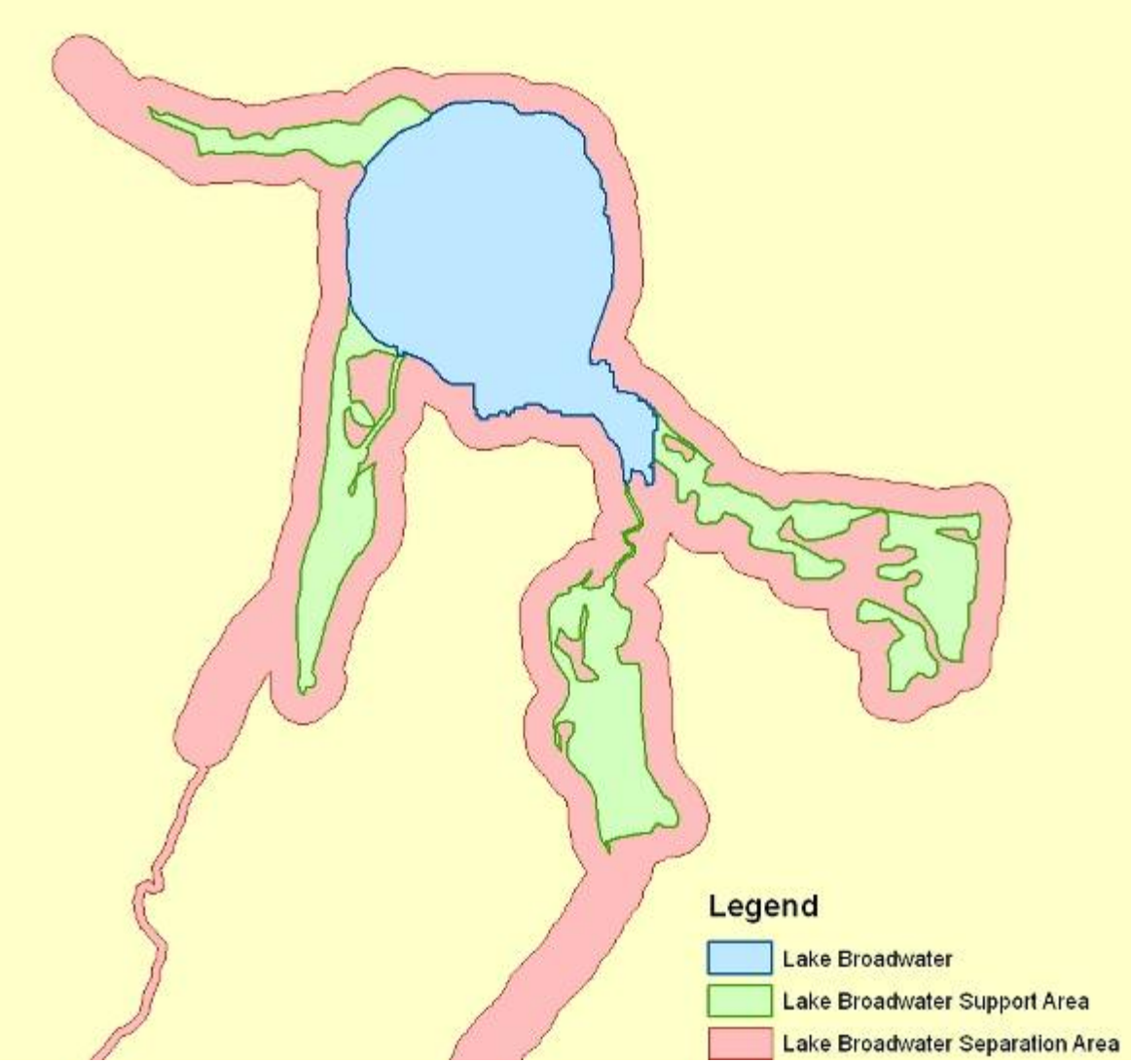


Figure 13 – Total buffer areas

Table 9 – Total buffer distances

Wetland component	Support distance	Separation distance	Total buffer distance
Lake Broadwater		200 m	200 m
1-50% wetland mosaic		200 m	200 m
Broadwater Overflow	20 m	120 m	120 m
Surveyor's Gully inflow	10 m	30 m	30 m
Broadwater Gully inflow	10 m	30 m	30 m

The Lake Broadwater Conservation Park, which encompasses more than the wetland itself, is managed primarily by Western Downs Regional Council. However, some aspects such as prescribed burns, weed and feral animal control are conducted in association with the QPWS. The wetland buffer also extends beyond the Conservation Park and Reserves (Figure 14 below).

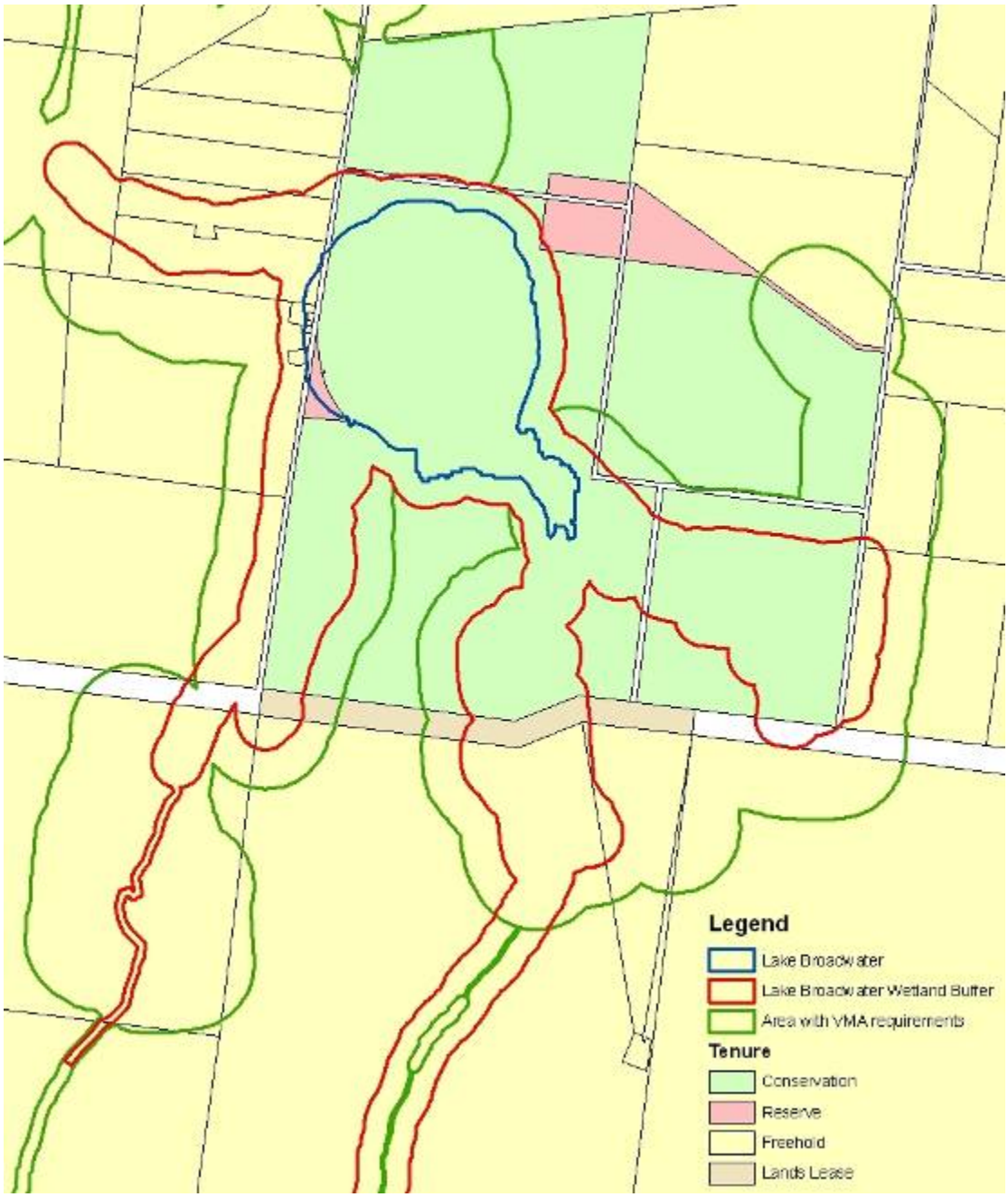


Figure 14 - Wetland buffer and VMA requirement areas

For the best overall outcome, the wetland needs to be managed by council and QPWS to maintain the unique and widely recognised values associated with Lake Broadwater in the long term.

Suggestions in relation to maintaining the integrity of the wetland buffer are provided in Table 7 on page 42. This includes but is not limited to:

- maintaining active relationships with key stakeholders to manage the wetland holistically
- monitoring and maintaining the integrity of existing vegetation and encouraging natural revegetation where necessary. This includes continuing to monitor the quality and distribution of river red gums (as currently performed by QPWS) which is an excellent indicator of the expansion and contraction of the lacustrine component of the wetland.
- monitoring the extent of lippia and other weed species intrusion into the wetland area and applying appropriate methods to reduce this threat
- limiting visitor numbers during periods when the lake is used for water-based recreation and monitoring water quality to ensure water quality meets human contact standards. While periodic water quality monitoring could be useful, interpretation is difficult (in the short term) as water quality variables change markedly between wet and dry times naturally. Any proposed water quality monitoring program needs a concerted and long-term commitment for results to be interpretable.
- monitoring numbers and impacts of feral pigs and managing them if necessary. They do not appear to be a current threat to wetland values of Lake Broadwater.
- undertaking periodic surveys of wetland indicator species which would help determine habitat requirements and use as well as if species diversity is being maintained, and if additional support areas for species-related WEVs would be appropriate.

The ephemeral nature of Lake Broadwater makes it inherently resilient to some threats. Existing and proposed monitoring projects by academic institutions (e.g. Griffith University's Centre for Innovative Conservation Strategies current project to 'quantify mesoscale variation in vegetation assemblages') should be encouraged and incorporated into management plans where appropriate. Wetland buffer WEVs, monitoring and management strategies need to be reviewed periodically and modified as necessary.

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