2. About the Basin

2.1 Location and global context

The Lake Eyre Basin covers around 1.2 million square kilometres of inland Australia and encompasses significant portions of the Northern Territory, Queensland and South Australia (Figure 1). The Basin comprises almost one sixth of the Australian continent (compared with one seventh covered by the Murray-Darling Basin) and is one of the world’s largest internally draining (i.e. endorheic) river basins. Kati Thanda – Lake Eyre, the large ephemeral lake system into which many of the Basin’s rivers occasionally drain, is the world’s fourth largest terminal lake and additionally contains Australia’s lowest point, 15.2 m below sea level.

The Basin forms a major part of Australia’s outback rangelands which comprise a diverse range of relatively undisturbed ecosystems characterised by a highly variable and arid climate. Numerous ecological and cultural features occur within the Basin that are unique and of significance both nationally and internationally. In addition to Kati Thanda – Lake Eyre itself, these include the Coongie Lakes in South Australia listed under the Ramsar Convention on Wetlands of International Importance. The Basin also contains numerous artesian springs which comprise unique aquatic ecosystems and biodiversity.

2.2 Riverine landscapes

Except for some relatively low ranges in the west (MacDonnell Ranges) and south (Flinders Ranges), the Lake Eyre Basin is low-lying and flat. The eastern portion of the Basin is dominated by several large river systems (the Cooper, Diamantina and Georgina) that arise in central Queensland and the eastern Northern Territory and develop into extensive braided channel networks before constricting and terminating in Kati Thanda – Lake Eyre. These rivers exist for much of the time as series of disconnected waterholes but are also associated with vast floodplains and a wide range of floodplain wetlands including swamps, claypans and ephemeral lakes (Figure 1). Upland areas in these catchments comprise a mixture of grasslands, stony and gibber plains and acacia woodlands with occasional, but significant, artesian springs.

In the western section of the Basin there are extensive areas of sandy desert with less well defined drainage systems. However there are also some significant river systems including the Finke, Todd and Hay catchments which drain much of the north-western portion of the Basin (Figure 1). Riverine features in these catchments include creeks, floodplains, ephemeral lakes and swamps occurring within a broader landscape of sand plains, stony gibber plains and dune fields. The Lake Frome and Western Rivers region makes up the southern and south-western portion of the Basin, of which the main rivers are the Neales, Macumba and Frome (Figure 1). Several significant creeks (the Margaret, Warriner and Strzelecki) also occur in this region as well as numerous large salt lakes (Kati Thanda – Lake Eyre and Lake Frome) embedded in the surrounding desert. Within this south-western region, only the Neales and Macumba lie within the Lake Eyre Basin Agreement Area (Figure 1).

2.3 Climate and hydrology

The climate of the Lake Eyre Basin is one of hot dry summers with mild winters in the north and cold winters in the south. Mean daily temperatures range from over 30 °C during summer months in the north to below 12 °C during winter in the south, with maximum daily temperatures frequently exceeding 40 °C during summer and daily minimums falling below 6 °C in winter (Bureau of Meteorology 2015).

Mean annual rainfall across the Basin is relatively low, ranging from around 500 mm in the north and east to below 200 mm in the centre. Rainfall occurs mainly during the summer months in both the north and south but is twice as high on average in the north due to the influence of the northern monsoon and tropical cyclones. Winter rainfall occurs in the south in relation to mid-latitude frontal lows but tends to be rare in the north. Rainfall throughout the Basin is highly variable between years, and is strongly influenced by changes in sea surface temperatures in nearby oceans (Bureau of Meteorology 2015). Periods of drought are characteristic and tend to be longer and more severe than might be expected in many arid and semi-arid regions because of the higher than average inter-annual rainfall variability (McMahon et al. 2005). Compared with other arid parts of the world, the Basin experiences high rainfall variability, around 65% higher than equivalent arid regions (McMahon et al. 2005).

Rivers in the Basin are among the most hydrologically variable in the world (Puckridge et al. 1998) and are, on average, about twice as variable as those from other arid zones (Finlayson & McMahon 1988). Periods of low or no flow are common throughout the Basin with about 50% of rivers and creeks ceasing to flow around 67% of the time (McMahon et al. 2005). Under such conditions, aquatic habitat is mainly restricted to persistent waterholes, although a few small sections of some creeks and rivers appear likely to have permanent flows fed by groundwater springs.

Streamflows in the major rivers of the Basin typically occur in response to heavy rainfall in their upper and mid-reaches, mainly during summer but occasionally in winter. In many cases, flows persist for relatively short periods (i.e. days to weeks) but, under wetter conditions, can last for many months, especially in the larger eastern rivers. In contrast to temperate and tropical rivers, flow volumes in these dryland rivers tend to decline with increasing distance downstream due to evaporation, infiltration into the soil, groundwater recharge and diversion to floodplains and wetlands (Knighton & Nanson 1994; McMahon et al. 2005; Duguid 2013).

As well as connecting isolated waterholes within river channels, periods of high river flow generate widespread flooding in much of the Basin which is promoted by the low gradient of the landscape and the occurrence of extensive channel networks, especially in south-west Queensland's channel country. These floods inundate a wide range of riverine wetlands including floodplains, swamps, and lakes. Most run-off in the Basin is generated by the north-eastern catchments of the Cooper and Diamantina. Inflows to Kati Thanda – Lake Eyre are mainly delivered by the Diamantina, reaching the lake about once every 2 years, followed by the western rivers (Macumba, Neales and Peake) around once every 4 years and then by the Cooper Creek about once every 6 years (McMahon et al. 2005).

Groundwater is also a significant component of the hydrology of the Basin and has a long history of use. The Great Artesian Basin underlies around 73% of the Basin (McMahon et al 2005); other groundwater provinces are also present, although none is as significant as
the Great Artesian Basin. Shallow unconfined groundwater is also likely to occur throughout the Basin, mostly in proximity to the alluvial sediments of the river systems.

2.4 Riverine ecosystems and biodiversity

The Lake Eyre Basin contains a high diversity of riverine ecosystems including a range of channels and waterholes, riparian woodlands, floodplain shrublands and grasslands, swamps, claypans and a wide variety of fresh and saline lakes. All of these habitats experience variable wetting and drying regimes, some of which are amongst the most unpredictable in the world (Puckridge et al. 1998). Plants and animals inhabiting these ecosystems typically display traits that allow them either to survive under these variable and extreme conditions or to escape from these in space (by moving between suitable habitats) or time (by persisting as dormant seeds or eggs). Consequently, hydrology has an overriding influence on the structure and function of riverine ecosystems in the Basin. Because of differences in degrees of hydrologic connectivity and the frequency, duration and magnitude of wetting, the Basin is characterised by a dynamic spatial mosaic of riverine ecosystems.

Aquatic and amphibious fauna inhabiting riverine ecosystems of the Basin include freshwater fish, turtles, frogs and a wide range of invertebrate animals such as freshwater crayfish, crabs and mussels. The Basin is also significant to waterbirds (Appendices 4 & 5). Many riverine sites within the Basin are amongst Australia’s most important sites for waterbird abundance and diversity (Kingsford & Halse 1998). Riparian habitats are also likely to provide habitats and drought refuges for terrestrial wildlife, including birds, reptiles and mammals, especially because complex woody vegetation is often restricted to areas fringing watercourses and wetlands.

2.4.1 Boom and bust ecology

Because of the high variability in rainfall and streamflow, aquatic habitats in the Lake Eyre Basin undergo long periods of drought punctuated by shorter periods of extensive hydrological connectivity, both along and between watercourses and their floodplains and adjacent wetlands. The diversity and productivity of riverine ecosystems strongly reflect these flood-dominated ‘boom’ and drought-dominated ‘bust’ conditions (Figures 2 & 3).

Boom periods are characterised by high levels of hydrologic connectivity in which ephemeral channels, floodplain wetlands and terminal lakes are filled. Inundated floodplains provide productive and diverse habitats in which fish breed and migrate prior to recession of flows. Many fish species in central Australia are capable of moving long distances during periods of flooding, and boom periods provide for connectivity between fish populations (Kerezy et al. 2013) as well as population growth (Puckridge et al. 2000). This movement of fish from refuge habitats facilitates breeding and recruitment, together with the dispersal of offspring and colonization of habitats unsuitable to support some species during the bust phase. Boom periods also provide significant breeding and feeding habitats for waterbirds, which sustain populations for long durations (Kingsford et al. 2013). Ecological responses to boom conditions may vary depending on their duration (e.g. one very large flood vs. several successive wet years) and extent (Duguid 2013).

In contrast, bust phases are periods of drying without significant rainfall or flows
(Figures 2 & 3). Fish populations during these phases are limited to isolated persistent waterholes. These aquatic refuges play an important role in enabling aquatic organisms such as fish to survive in the Basin (Davis et al. 2013). Aquatic community composition shifts in these refuges with the duration of bust conditions as the volume of water and its quality declines with drying, influencing competition between species and causing mortality (Arthington et al. 2005). While most fish species in the Basin can tolerate high turbidity and low levels of oxygen, for instance, only a few can cope with extremely high salinity (McNeil et al. 2015).

Between these hydrologic extremes, smaller flows can also occur that connect local waterholes without overland flooding. By providing opportunities for dispersal, spawning and growth, these bridging flows may be critical for the persistence of some aquatic organisms and are also likely to be important in shaping ecological productivity (McNeil et al. 2015; Schmarr et al. 2015). Localised rainfall and low within-channel flows that occur following drought, for example, are important to the resilience of riverine biota and ecosystems (Figure 3). On some occasions, bust conditions shift immediately to boom conditions as high-flow events and widespread flooding occur (Bunn et al. 2006). In the eastern rivers of the Basin, bridging flows tend to be the most common flow event and may actually be more important for sustaining aquatic populations than boom and bust cycles.
(Cockayne et al. 2015).

Figure 3 Conceptual diagrams illustrating traits conferring resilience and resistance of fish communities in the Lake Eyre Basin through a boom and bust cycle (top) and ecological drivers of fish abundance and the role of refugia (bottom). Cullyamurra waterhole hydrograph (2008-2015) shown in blue.

NB. In top diagram, 1 – highly resilient species respond rapidly, less resilient species gradually; 2 – less tolerant species collapse rapidly, more tolerant species gradually.
2.5 People, settlements and land use

Approximately 60,000 people currently reside in the Lake Eyre Basin with over two million more visiting each year (Measham & Brake 2009). A significant portion of the population (~25,000) live in Alice Springs but most people are highly dispersed across the Basin between other major urban centres (Winton and Longreach), smaller towns (e.g. Barcaldine, Birdsville, Blackall and Oodnadatta), mining developments, homesteads and Aboriginal communities (e.g. Alpurrurulam and Nepabunna).

The Basin has a very long and continuous history of Aboriginal occupation demonstrated by a rich and complex culture that reflects the close ties between people and their country. The dreaming paths of Aboriginal nations across the Basin formed ceremonial routes along which goods and knowledge traveled, and these are still living and relevant today. Trade was not only seen as a method of sharing resources but as a form of cultural and social management and law. According to Watson (1983) the direction of the water formed the main trunk route for trade, which also flowed along other numerous river systems branching out from the main trunk. Aboriginal people moved throughout the Basin as conditions shifted, often capitalising on plant growth following floodplain inundation and relying on persistent waterholes during dry periods. Significant events in European settlement in Australia have also occurred in the Basin. It was traversed by many early explorers (Eyre, Sturt, Burke and Wills) as well as Afghan camel traders, and was the birthplace of numerous significant Australian institutions such as Qantas, the Labor Party and the Royal Flying Doctor Service. Seven sites located with the Basin are listed on the National Heritage List: Witjira – Dalhousie Springs; Elizabeth Springs; Burke, Wills, King and Yandruwandha National Heritage Place; Lark Quarry – Dinosaur Stampede National Monument; the Qantas Hangar (Longreach); Tree of Knowledge site (Barcaldine); and Hermannsburg Historic Precinct.

The Basin supports a range of land uses and industries but is dominated, in terms of area, by cattle grazing and to a lesser extent sheep, which together occupy over 80% of the Basin. However, mining, especially oil and gas extraction, represents the most economically significant land use (Measham & Brake 2009). Tourism is also important and growing with more than two million people visiting the Basin every year (Measham & Brake 2009). A relatively small proportion of the Basin’s land area is occupied by settlements and associated infrastructure. Conservation areas represent a further significant land use, encompassing around 11%, and providing a major focus for visitors. Significant protected areas include Kati Thanda – Lake Eyre National Park, Strzelecki Regional Reserve and Inamincka Regional Reserve. Most land in the Basin is leasehold (71%) with freehold only accounting for about 12% and Crown land a further 5% (Measham & Brake 2009). A relatively high proportion of land, compared with much of Australia, is owned by Aboriginal people with considerably more under Native Title claims, especially in the Northern Territory portion of the Basin.

Governance of the Basin is challenged by the dispersion of the population, the vast areas and distances involved and the diversity of communities, ecosystems and concerns. While a great diversity of people inhabit the Basin, there is recognition amongst inhabitants of the importance of community and the critical connections between ecological, socio-economic and cultural spheres. What sets the Basin apart from the other similar flooded systems of the world – for example, the Okavango Delta in Botswana, the Southern Pantanal of Brazil, the Flooded Pampas of Argentina and Red
Creek in Wyoming, USA – is the ability of the community to maintain relatively unaltered natural systems for cattle grazing by resisting water diversions. There is widespread community recognition that human well-being and sustainable livelihoods in the Basin are dependent on the condition of its environment. Living under the variable and unpredictable conditions of the Basin also promotes a need for resilience and flexibility amongst both individuals and communities. Finally, there is growing acknowledgement that local issues can affect the whole Basin, and vice versa. For all these reasons, the Lake Eyre Basin Intergovernmental Agreement was established to promote the Basin’s sustainable management and to minimise cross-border impacts.

Figure 4 Land use in the Lake Eyre Basin 2010-2011. (source: Australian Bureau of Agriculture and Resource Economics and Sciences 2016; Ramsar site information from Department of Environment and Energy)
2.6 Key values

The Lake Eyre Basin is an internationally recognised Basin supporting a range of key values amongst the various communities and industries throughout the Basin. These key values are outlined below.

- The Basin is one of the largest internally draining river basin globally, and Lake Eyre – Kati Thanda is the fourth largest terminal lake on Earth. Rivers of the Basin are amongst the most hydrologically variable in the world, and unpredictable river flows are the key feature determining the health of communities and the environment.

- Hydrology has an overriding influence on the riverine ecosystems and the plants and animals inhabiting those systems in the Basin. Many plants and fish in these diverse aquatic ecosystems only occur in the Basin. Wetlands of the Basin are amongst the most significant on the continent for abundance and diversity of waterbirds and several, including Coongie Lakes have been recognised for their high natural values.

- Underneath most of the Basin, and extending beyond it, lies Australia’s largest groundwater resource, the Great Artesian Basin. This underground water is essential for the Great Artesian Basin springs, permanent wetlands that provide habitat for unique aquatic life forms in otherwise dry landscapes.

- There is a long and continuous Aboriginal history in the Basin, and a rich and complex culture that reflects thousands of years of living with and surviving highly variable conditions. The dreaming paths of Aboriginal nations across the Basin form ceremonial routes along which goods and knowledge originally flowed, and which are alive and relevant today.

- Grazing occupies the greatest area as a land use, although oil and gas extraction are the most economically significant. Conservation and heritage areas represent a further significant land use and provide a major focus for a growing tourism industry.

- The Basin supports diverse human communities. Around 60,000 people currently live in the Basin with over two million more visiting each year. Apart from Alice Springs, most people are dispersed in small towns, settlements, Aboriginal communities, mining developments and homesteads of great character. Several sites are on the National Heritage list, including the Dig Tree of Burke and Wills and the birthplace of Qantas, and events such as the Birdsville Races are of national prominence.

- The Lake Eyre Basin Intergovernmental Agreement was established as a result of community concern about potential intensification of development and negative consequences of the separate management of the Basin by four different governments. In 2015, community, scientists and natural resource management bodies working to implement the Lake Eyre Basin Intergovernmental Agreement were recognised when the 'Lake Eyre Basin Partnership' was awarded the Thiess International Riverprize. This 20-year partnership has focused on prevention rather than restoration, and has kept the rivers healthy while encouraging sustainable economic growth.

- The Basin stands out among the great flooded systems of the world because the
Channel Country is maintained in relatively unaltered character. The community has consistently argued for this outcome and demonstrated the ability to come together to achieve it. Through resistance to water diversions in upper catchments, the community has helped foster ongoing cattle grazing and tourism, and likewise has facilitated maintenance of the Basin’s environment in good condition.

Image 3 Coongie Lakes and the Northwest Branch inlet, Cooper Creek, South Australia, 2009. Photo: G Scholz

Image 4 Channel Country floodplain at Goyders Lagoon, Diamantina / Warburton, South Australia, 2009. Photo: G Scholz