Department for Environment and Heritage

Wetland Mapping

Channel Country bioregion, South Australia

Government of South Australia

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Channel Country bioregion, South Australia.

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EXECUTIVE SUMMARY

The South Australian Channel Country bioregion occupies an area of 56,000km^2 and is located in the far north-eastern corner of South Australia. The Cooper Creek, Diamantina River and to a lesser extent the Georgina River are the iconic desert channels in the study area. They support an internationally exceptional suite of ephemeral and semi-permanent wetlands of varying sizes and inundation frequencies. These systems are recognised both nationally and internationally as unique, largely unregulated water resources which support systems of high biodiversity and endemism (Reid and Gillen, 1988).

The Channel Country is an extensive natural irrigation system in the centre of the world's driest populated continent (White, 2001). The wetlands of the Channel Country are unique because their regime is determined by remote rainfall events in Queensland and is sourced as 'overland flow' when major channels flood. The presence of water in the arid dunefield environment of the Strzelecki Desert is quite exceptional aesthetically and ecologically, and could not be sustained by localised rainfall alone.

The Cooper Creek is probably the longest and most important dryland river in Australia and one of the largest inwardly draining catchments in the world (Kingsford, Curtin and Porter, 1999). An icon within the Cooper Creek catchment is the cluster of semi-permanent and episodic fresh-water wetlands known as the Coongie Lakes. Together with a portion of the Cooper Creek, they were listed as a wetland of international importance under the Ramsar Convention on Wetlands in 1987. In 2005, the core wetlands were afforded further protection when the Coongie Lakes National Park was proclaimed. The Cooper Creek supports a range of wetland types, including fresh and saline lakes, swamps, floodplains, flood outs and waterholes.

Flooding occurs because the region is close to Lake Eyre, the terminal point in an inwardly draining system. It shows extreme temporal and spatial variability, but is regular enough to maintain the heterogeneity of water dependent ecosystems in the bioregion. Unregulated flooding inundates different parts of the landscape for varying amounts of time, and in doing so supports a diverse assemblage of vegetation communities with the capability to maintain a rich array of taxa. Regionally, the water dependent ecosystems are of enormous interest yet poorly understood.

Close monitoring of the area is not easily achievable due to the remoteness and the size of the bioregion. Remotely sensed data captured by satellite has demonstrated the capability of delineating environmental information in a cost effective and time saving manner. Landsat has been used extensively for such a purpose, and was used during this project to further our spatial understanding of the inundation frequencies and extents of the wetlands in the bioregion. In order to achieve this purpose, a methodology derived by Knight (2004) and applied to standing water body mapping in Queensland was used.

The results indicated the paucity of permanent water bodies in the bioregion and support the notion that the wetlands are heavily dependent on both localised and non-localised flooding events to sustain their biodiversity. Although the maximum extent of the flood events mostly reflected the highest flow event, it accounted for the variability in each extent. Importantly, the frequency of inundation improves our understanding about the way in which the landscape floods, and improves upon the vague classifications that have been applied at smaller scales in the past.

Landsat imagery proved to be a good comprise between spatial resolution and cost, and due to its non-complexity, methods can be replicated easily in the future, and in other regions, to validate temporal changes

1.0 INTRODUCTION

1.1. Cooper Creek

The Cooper Creek is Australia's largest braided stream and inland floodplain (Roberts, 1996). It stretches for some 1,523km, rising in the Warrego Range in Queensland and terminating at the north-eastern corner of Lake Eyre. The floodplains of the Cooper cover 103,000km^2 but only 35,000 km^2 of these fall within South Australia (Kotwicki, 1986) (Figure 1.1). The floodplain area in South Australia includes the Coongie Lakes and Strzelecki floodplains but excludes Lakes Blanche, Callabonna, Frome and Gregory of the Strzelecki system (Graetz, 1980).

The Cooper Creek exhibits two distinct phases of its morphology in South Australia. The river crosses the Queensland-South Australian border as a single riverine channel that is largely ephemeral, but it contains a number of deep semi-permanent waterholes. Further to the west and northwest, the channel becomes less defined as it morphs into shallow lakes and floodplains and it loses its singular definitive path. Closer to Lake Eyre the channel re-forms and the system becomes riverine.

Although the Cooper is the largest of the Lake Eyre Basin (LEB) watercourses, it rarely flows into Lake Eyre, reaching it only 11 times since 1890 (Andrews, 1999) or once in ten years.

1.2. Diamantina River

The Diamantina River is a braided channel which travels 720km with a mean slope of 27cm/km., before reaching the northern border of South Australia. It originates north-west of Longreach on the northern slopes of the Finacune Range east of Selwyn.

Eighty kilometres south of the border lies Goyders Lagoon (Figure 1.1), an extensive ephemeral wetland covering 1300kms^2. From this point on, the drainage gradient flattens further to 14cm/km (Bonython, 1963). At the south-western edge of this large basin, Eyre Creek (known as the Georgina upstream) joins from the west. The Diamantina has an average annual inflow volume to Lake Eyre of 2.4km^3 (65% of the total flow) compared to the Cooper with an average contribution of only 0.63km^3 (16%). (Nanson *et al* 1998). The total catchment area of the Diamantina is 365,000km^2 (Kotwicki, 1986).

The Marree Soil Conservation Board (1996) describe the limited nature of the Diamantina floodwaters in comparison with the Cooper mentioning that one major distinguishing feature is the absence of interweaving dune and floodplain systems

1.3. Georgina River

The Georgina River flows along the eastern edge of the Simpson Desert and joins the Diamantina River on the south-western edge of Goyders Lagoon (Figure 1.1.), the catchment covers an area of 205,000km^2. The length of the main channel is 1,130km, with a mean slope of 19cm/km (Kotwicki, 1986). There are no flow-monitoring devices along the Georgina at present, so the volumetric contribution made to flood waters in Goyders Lagoon is unknown. Isolated heavy rainfall has been known to cause flooding along the Georgina whilst the Diamantina has remained dry. It appears that there are some areas of wetland close to the confluence of the Georgina and Diamantina which are inundated more regularly than the mapping suggests. The local land managers later supported this assertion.

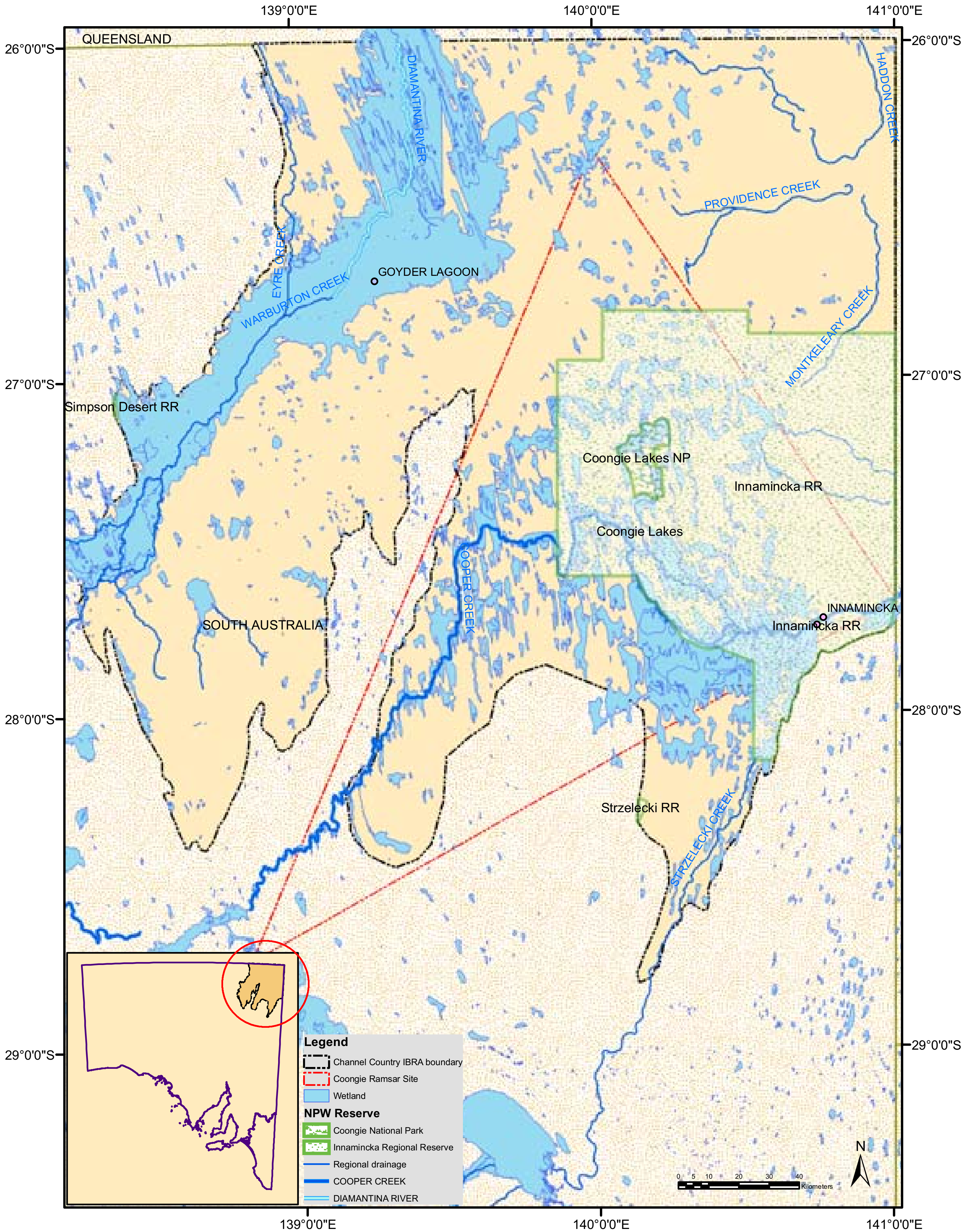

Figure 1.1. Located in the far north-eastern corner of the South Australia, the Channel Country bioregion contains two large ephemeral river systems (The Cooper Creek and the Diamantina River) and their associated wetlands.

1.4. Why are the wetlands in the Channel Country significant?

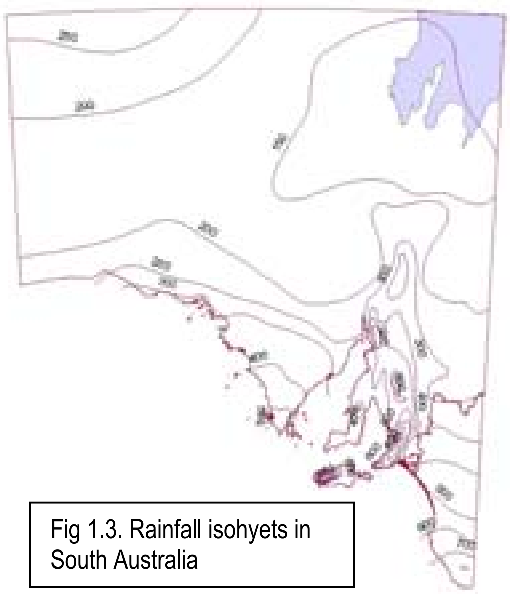

Fig 1.3. Rainfall isohyets in South Australia

The Channel Country occupies a niche in the core of arid Australia. Median annual rainfall is of the order of 100-150mm (Figure 1.4), and inter-annual variability is extreme, both spatially and temporally (Kotwicki, 1986). Rainfall is less frequent than adjacent areas in Queensland because it is situated more centrally on the Australian continent. Tropical incursions are more infrequent and have less vigour as latitudes increase. Ordinarily such rainfall would not support a suite of semi-permanent wetlands.

Following drought, at its driest, the entire bioregion can be completely devoid of surface water, except for waters captured by artificial means (Mollemans, *et al*, 1984). At the other extreme, prolonged heavy rainfall in the northern parts of the catchment, supplemented by local heavy rainfall can create vast flood conditions similar to those seen in 1974 and 2000. Following the 1974 event, it was suggested by Mollemans, *et al.* (1984) that 75% of the Cooper Creek environmental association was comprised of wetland habitat. This estimation is calculated using a definition that prescribes all areas inundated to a depth d 2m a wetland.

The rainfall deficiency is compensated intermittently by flows from the Cooper, Georgina, Eyre, and Diamantina as they pass through the bio-region. These flows originate many hundreds of kilometres upstream in places such as the Desert Uplands (Qld), Barkley Tablelands (NT and Qld) and the Great Dividing Range (Qld), and follow the shallow gradient that terminates below sea level (-15m) at Lake Eyre. The frequency and intensity of these flows is highly variable.

The Channel Country is distinct from outlying bioregions in the LEB because it is located centrally and southerly, at a point where the major tributaries begin to converge. The volume of flow delivered by each tributary peaks at this point in the basin and during a significant flood major channels cannot confine the flow. A significant proportion of the wetland communities in the Channel Country exist because of 'over-bank' flows.

Over time the repetitious effects of inundation are reflected by a change in the composition and structure of the flora to reflect a community that is better adapted to deal with inundation. The scale of adaptation is a reflection of the frequency of inundation or habitat modification. Inundated areas may take many months or years to fully dry depending on their connectivity with other water features and their morphology. The draw down is determined by factors such as soil moisture deficit, substrate, mean daily temperatures, evaporation rate, rainfall, and duration since previous inundation and so on.

The wetlands of the Channel Country are unique because they would not exist without intermittent flow from one or more of the major tributaries in the basin. Rainfall does not sustain wetlands in an environment that presents such climatic extremes.

The unregulated and largely pristine nature of the region presents few compromises to the ecology or ecological processes in the region. When conditions dictate, the wetlands are highly productive at a range of trophic levels at an order of magnitude above the potential of regulated riverine wetland systems. Waterbirds in particular, use the shallow wetlands (and the abundant food resources) to undertake large-scale breeding events, the likes of which are not seen elsewhere on the continent at these latitudes.

1.5. Wetland definition

The Biodiversity Conservation Unit, Parks and Wildlife Service, Northern Territory developed the 'Wetlands' definition that has been adopted for the purposes of this project. (cited in Duguid, A., Barnetson, J., Clifford, B., Pavey, C., Albrecht, D., Risler, J. and McNellie, M. (2005). It is not dissimilar from the definition used by the Environmental Protection Agency (Qld) for the purposes of concurrent wetlands mapping. Both definitions are adapted from the 'Ramsar wetland definition' and place more emphasis on the characterisation of ephemeral wetland systems.

Wetland definition for this project (Arid Wetlands, NT)

Wetlands are areas of permanent or temporary surface water or waterlogged soil. They may be dry for decades but inundation or waterlogging must be re-occurring and of sufficient duration to be used by macroscopic plants and animals that require such conditions during their lifecycles. They may be natural or artificial, with still or running water that can be fresh or saline. In the inland they may be any depth or size.

The wetland definition used for this project uses the floral composition of a community as a diagnostic primary indicator. In the absence of water, it is the bio-indicator which best reflects the inundation history. If a vegetation community establishes because the substrate is intermittently wet or if there is some dependence on the substrate being irregularly inundated, such that a species would disappear if the inundation regime changed, then this is a wetland. A single inundation event does not prescribe wetland status.

Common language definition

Wetland is a term that can mean different things to different people. This definition is based on an international agreement and includes waterholes, rivers, swamps, clay pans, flood plains, salt lakes and springs. It also includes artificial wetlands such as dams.

Wetlands in the arid regions of South Australia range enormously in size from vast salt lakes to small spring fed pools. A few hold permanent water but most of the wetlands are dry most of the time. One of the distinguishing features is that following rain, wetlands continue to hold water after the surrounding landscape has dried out; either above the ground or in waterlogged soil.

Within the context of this project, 'wetlands' are the places where plant and animal assemblages are dependent on the landscape being permanently or intermittently wet. The wetting cycle is unique, in the sense that it's driven primarily by floodwaters and more infrequently by sporadic localised rainfall. Despite the unpredictable hydrological regime, antecedent events demonstrate that the mean flooding interval is regular enough to maintain the viability of perennial plant communities.

1.6. Wetland characteristics

In-channel waterbodies are common along both the Cooper and Diamantina. Often termed 'waterholes', they are places in the creekbed with deep bottoms and impervious soils that harbor water for longer than the neighbouring creek bed. As points of low elevation in the channel profile, they retain water for an indeterminate but often-lengthy period after the channel has dried. Knighton and Nanson (2000), describe them as self-maintaining scour features, of fixed position and contemporary origin. Further, their stability of location is due to the low stream power that is generated during flooding and the high boundary resistance caused by indurated alluvial terraces. Cullyamurra Waterhole is one example of a waterhole that retains water permanently, because of its depth and ability to minimise water losses to the soil profile.

Research by Capon (2003) suggests that the landscape effects of flood history have a stronger influence on plant community composition in frequently flooded areas while local factors (such as rainfall, soil-type, and elevation) appear to be more significant at low flood frequencies. The perennial plant species observed in arid zone wetlands are often described as stress tolerators because they have adaptations to survive prolonged inundation and extensive drying. The duration of both is highly variable. Lignum (*Muehlenbeckia florulenta*) is a very common coloniser of flood-plains and ephemeral lake beds in the study area, it persists through drought with dormant stems. When favourable conditions prevail the production of leaves and flowers commences and the plant begins actively growing.

Annual grasses and forbs exhibit a different but equally successful reproductive strategy. Their aim is to germinate, grow rapidly, reproduce and complete their life cycles between flood events. Seeds remain dormant in the soil until germination is triggered in response to the wetter conditions following floodwater recession. The apparent simplicity is highly successful because reproduction is prioritised over longer time survival.

The permanence of wetlands within the Channel Country is strongly influenced by the following attributes.

x **Topography/geomorphology**
Wetlands are shaped by the erosive qualities of wind and water. The rate at which this happens is determined by the location of the wetland relative to other landscape features, and the ability of neighbouring landforms to influence erosive forces. The substrate reflects the ability of a wetland to retain water following inundation.

x **Hydrology/Water regime**
Permanency, velocity and peak flow all affect the physical shape of the wetland to varying degrees. The delivery and permanency of water determines the structure and composition of plant communities.

Generalised classification based on biophysical characteristics is a common objective during wetland inventory. Examples of classification descriptors include ‘palustrine’ or ‘riverine’. However, the classification process does appear to have some limitations when applied to the temporally variable ephemeral wetland systems such as those encountered during this project. Such wetlands are likely to fall into two or possibly three categories as they move through a continuum from dry to maximum flooded extent and then back to dry. Wetland classification was not a part of this project since analyses were based predominantly on remotely sensed data.

1.7. Important wetland sites within the Channel Country bioregion.

Coongie Lakes Ramsar Site

The Coongie Lakes Ramsar site has an area of 19,800 km^2 and was designated in 1987 recognising the complex ephemeral and semi-permanent freshwater wetland system and the importance of the unregulated desert river, the Cooper Creek. The site also proves to be one of the ecologically richest wetland areas in Australia (ANCA, 1996).

One of the unique attributes of the site is the incongruous presence of wetlands in an arid dunefield dominated environment. The wetlands consist of a vast network of braided channel systems, internal deltas, waterholes, freshwater lakes, swamps and flooded woodlands. These habitats support the most diverse assemblages of species in the North East of south Australia. Bird (75 species, 36 breeding), frog (8 species), fish (13 sp.), aquatic invertebrate (>80 sp.) and plant communities (>350 sp.)

The most significant feature of the Coongie Lakes environment is the main channel and lake system for a number of reasons (Reid, J. and Gillen J. 1988).

- Its naturalness, beauty and setting in the surrounding arid landscape
- The absence of regulation of flow along a major river such as the Cooper Creek
- The range (temporal and spatial) of aquatic habitats represented in the district, from major permanent channels to large ephemeral lakes, densely vegetated swamps and temporarily inundated marshy floodouts.
- The diverse and abundant fauna it supports, including endemic and threatened species.
- The near natural functioning of the aquatic ecosystem, little changed by the impacts of human activities.

Coongie Lakes National Park

In June 2005 a core biodiversity area within Innamincka Regional Reserve known colloquially as the 'Coongie Lakes', (266km^2.) was declared a National Park. The listing recognised the outstanding biodiversity and cultural values of the semi-permanent wetlands and the iconic status of the Cooper Creek catchment.

Goyder's Lagoon

This vast wetland area of 1300km^2 fed by the Diamantina River contains a number of permanent waterholes such as Koonchera and Andrewilla and a large ephemeral floodplain wetland. The floristic variability within the lagoon is a consequence of a complex historical pattern of inundation. It supports a range of ecotypes that have the ability to support a diverse assemblage of plants and animals in both wet and dry states.

- Goyder's Lagoon delimits the eastern boundary of the Eyrean avifaunal barrier (Puckridge, J.T. *et al*. 1999), and as such, forms habitat for species at the extreme northern and southern limits of their range. E.g. Grey Grass-wren *Amytornis barbatus*.
- The fish fauna of Goyder's Lagoon is composed almost entirely of native species and differs in composition from the Coongie Lakes fauna.
- The gibber plains along the eastern flanks of the lagoon support a diverse mammal assemblage, including the stronghold of the South Australian population of the endangered Kowari, *Dasycercus byrnei*.
- Has an interaction between hydrological regime and geomorphology which create boom-bust conditions of magnitude, amplitude and regularity dissimilar to other river systems, notably unlike the Cooper Creek and Coongie Lakes system. (Puckridge, J.T *et al*. 1999).
- The greatest range of biological diversity is to be found on the lagoon's margins, especially where different landforms coexist.

Waterholes (Depositional zones in river courses)

As areas of concentration of critical moisture and nutrients, these areas act as refugia for terrestrial and aquatic organisms. The inundation frequency of these waterholes varies from permanent to ephemeral, however there are numerous examples of semi-permanent waterholes in the bioregion that play a significant ecological role within the broader functioning of the landscape because water is commonly the scarcest of resources.

Andrewilla and Koonchera waterholes were found to contain the largest number of individuals and greatest number of taxa of macro invertebrate fauna during a biological survey of Goyder's Lagoon (Puckridge, J.T *et al*. 1999). Regardless of habitat type, waterholes that are intermediate in the range of flooding frequency exhibit excellent biological diversity because flooding is a form of ecological 'disturbance'.

2.0 RESULTS

Five satellite images timed to capture the landscape at different stages of inundation were viewed independently and then aggregated to show independent wetland extents and the frequency of inundation. (A more detailed explanation of the methods can be found in section two of this document (technical discussion).)

This investigation provides us with quantitative spatial data to explain the extents and inundation frequencies of wetland habitats within the bioregion. Previously, waterbodies have been mapped using a generic classification called 'subject to inundation'; independent of any temporal understanding that would indicate how ecologically significant the habitat is likely to be.

Table 2.1 Areal wetland extents, as determined by the Landsat imagery.

Reach	Area (km^2)
Cooper Creek	3679
Diamantina River	5918
Autonomous wetlands (localised rainfall)	998
Coongie Lakes Ramsar Site	3919

2.1. Coongie Lakes Ramsar Site

The wetland area determined by this project is 3919km^2, or 17% of the Ramsar site area.

2.2. Coongie National Park

The wetland area inside Coongie National Park is 110.5 km^2 or 41% of the National Park area.

2.3. Permanent water bodies

It is difficult to apply 'permanent' status to any of the waterbodies in the Channel Country given the variability associated with the water supply. However, a small number of wetlands were inundated during all five events, including a dry scene. If not permanent, these features hold water for much longer than surrounding landscape features and are highly significant as refuge sites for fauna.

Cooper Creek, area of permanent /semi permanent wetlands - 18.46km^2.
Diamantina River, area of permanent/semi permanent wetlands - 12.86km^2.

2.4. Plant communities associated with wetlands in the Channel Country

Flood pulses of variable size and duration are likely to be important in maintaining a heterogeneous mosaic of plant communities of differing composition and structure throughout the floodplain landscape. An examination of the similarities between vegetation mapping and the inundation frequencies of wetlands shows that the temporary presence of water contributes significantly to the perennial and annual floral diversity of the bioregion. Further, the spatial patterning of vegetation correlates well with the temporal presence of water, and once outside an established zone of inundation, soil characteristics change rapidly and dictate a different vegetation assemblage.

Reid and Gillen (1988) defined wetland vegetation associations in the Coongie Lakes district based on cluster analysis of random and permanent sites as defined by perennial species (Table 2.2). Annual species are more difficult to document because their appearance is triggered by increases in soil moisture and longevity is controlled by the duration of a flood.

Table 2.2 Floodplain and Riverine communities indicative of Channel Country wetlands.

Floodplain complex	**Association**
	Halosarcia indica, Sclerolaena intricata
	Muehlenbeckia florulenta, Sclerolaena intricata, Atriplex velutinella
	Eragrostis australasica
	Muehlenbeckia florulenta, Chenopodium auricomum, Sclerolaena patenticuspis
	Intergrade
	Sclerolaena intricata / Sclerolaena bicornis, Muehlenbeckia florulenta
	As above with *Maireana coronata*
	Sclerolaena calcarata, Scleroleana intricata
	Stemodia floribunda, Crinum flaccidum, Osteocarpum acropterum
	Atriplex eardleyi, Sclerolaena intricata
	Eragrostis dielsii +/- Sclerolaena lanicuspis, Malcocera albolanata
	Sporobolus mitchelli
	Marsilea drummondi
Riverine complex	
	Eucalyptus coolabah, Sclerolaena intricata +/- Atriplex velutinella
	Depauperate version of the aboove
	Eucalyptus coolabah, Muehlenbeckia florulenta +/- Eucalyptus camaldulensis + Acacia stenophylla / Acacia salicina

3.0 DISCUSSION

3.1. Effects of wetting and drying on wetland plant community composition.

In frequently flooded zones, plant community composition is thought to be determined predominantly by abiotic factors and is usually dominated by hydrophytic species which exhibit flood tolerance or annual species which can complete their life cycles between inundation events. The latter are often referred to as ruderals. The dominating influence of water in determining patterns of association has been stated by Beadle (1981) – 'In the semi arid and arid zones, soil nutrients are of relatively minor importance in determining vegetation patterns, water availability being the most important factor controlling the communities'.

Frequently flooded areas are characterised by high species richness and total cover and significantly higher cover of annual monocots. Species with known flood tolerance include *Muehlenbeckia florulenta* (Polygonaceae) and *Chenopodium auricomum* (Marsileaceae) in the shrub plant group, *Marsilea drummondi* (Marsileaceae) in the perennial forb plant group and *Eleocharis* spp. (Cyperaceae) in the perennial monocot plant group.

Inundation frequency plays a significant role in the cover of a given species at a specific site. Queensland bluebush (*Chenopodium auricomum*) for example is more abundant at sites that have a medium flood frequency compared with a high flood frequency (Capon, 2003). This distribution may reflect the capacity of this species to survive minor but not major flooding. These areas can support a suite of plant species capable of withstanding inundation for long periods of time.

To better understand how different plant species respond to inundation events, Capon (2003) undertook a study which measured changes in cover in three different zones across the floodplain (these three areas represented a 1 in 2, 1 in 5 and 1 in 10 year flooding frequency). Perennial shrubs, of which *Muehlenbeckia florulenta* and *Chenopodium auricomum* were the most common, exhibited the highest cover in the 1 in 5 year inundation frequency. Annual monocots, best represented by members of the Cyperaceae family showed a general trend of increasing cover during wet phases and decreasing cover during drying cycles which was most significant in the 1 in 2 year flood frequency zone. Perennial monocots (Poaceae for example), behaved somewhat differently; the increase in cover with wetting and decrease with drying was significant only in the 1 in 10 year frequency zone. This finding suggested that the Poaceae species were better adapted for dry conditions.
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3.2. Hydrology

All watercourses within the Channel Country are ephemeral, and seasonally and annually very variable (DNR, 1997). The extremes of zero flow and flooding are important to the functioning of the system: the drying phases for nutrient cycling and system productivity, and the flood events maintain important wetland and lake systems as well as floodplain productivity (Young, 1999).

Three significant aspects of hydrological behaviour that influence flooding parameters and response (Walker *et al*. 1995) are:

1. Flood pulse concept – an increase followed by decrease in discharge. Each flood pulse has a complex character with unique patterns of magnitude, timing duration, rate of rise and fall and frequency. Pulses are generally influenced by location of rain, timing and magnitude of merging tributary flows (Young, 1999).

2. Flow history (previous sequence of pulses) and variability. Antecedent conditions influence how the flood moves through the system and how it is dispersed at the end of the system. Floodplain vegetation

condition and the wetness of different parts of the floodplain, including the water level in lakes, are very important (Young, 1999).

3. Flow regime (long term generalisation of flow behaviour). Flow drives sediment transport and so shapes the river channel and nutrient status that drives the riverine food webs (Young, 1999).

4.0 SUMMARY

In an environment where there is no predictable rainfall, and where much of the water supply arrives from remote rainfall events further north, the wetlands of the Channel Country are highly significant. The Cooper and Diamantina catchments remain two of the best examples of unregulated ephemeral wetland systems at national and international scales.

The mapping has many useful ecological and management related applications, particularly when used in conjunction with other spatial data. The strong positive correlation between species richness and inundation frequency was previously well understood, however the spatial extents and inundation frequencies of the wetlands, particularly of floodplain wetlands, were relatively unknown.

The extents and inundation frequencies associated with these wetlands, particularly those in the Diamantina catchment, have not been well studied in the past because of their remote location and the difficulties associated with acquiring data.

This project identified water features of varying inundation frequencies along with their maximum extents and helps to explain broader flooding patterns in the bioregion. The use of Landsat TM to resolve flooding patterns produced data with excellent spatial resolution that has improved upon the accuracy of work completed by other authors in the bioregion. With the exception of some feature-mixing, wetlands were accurately identified using the methods described.

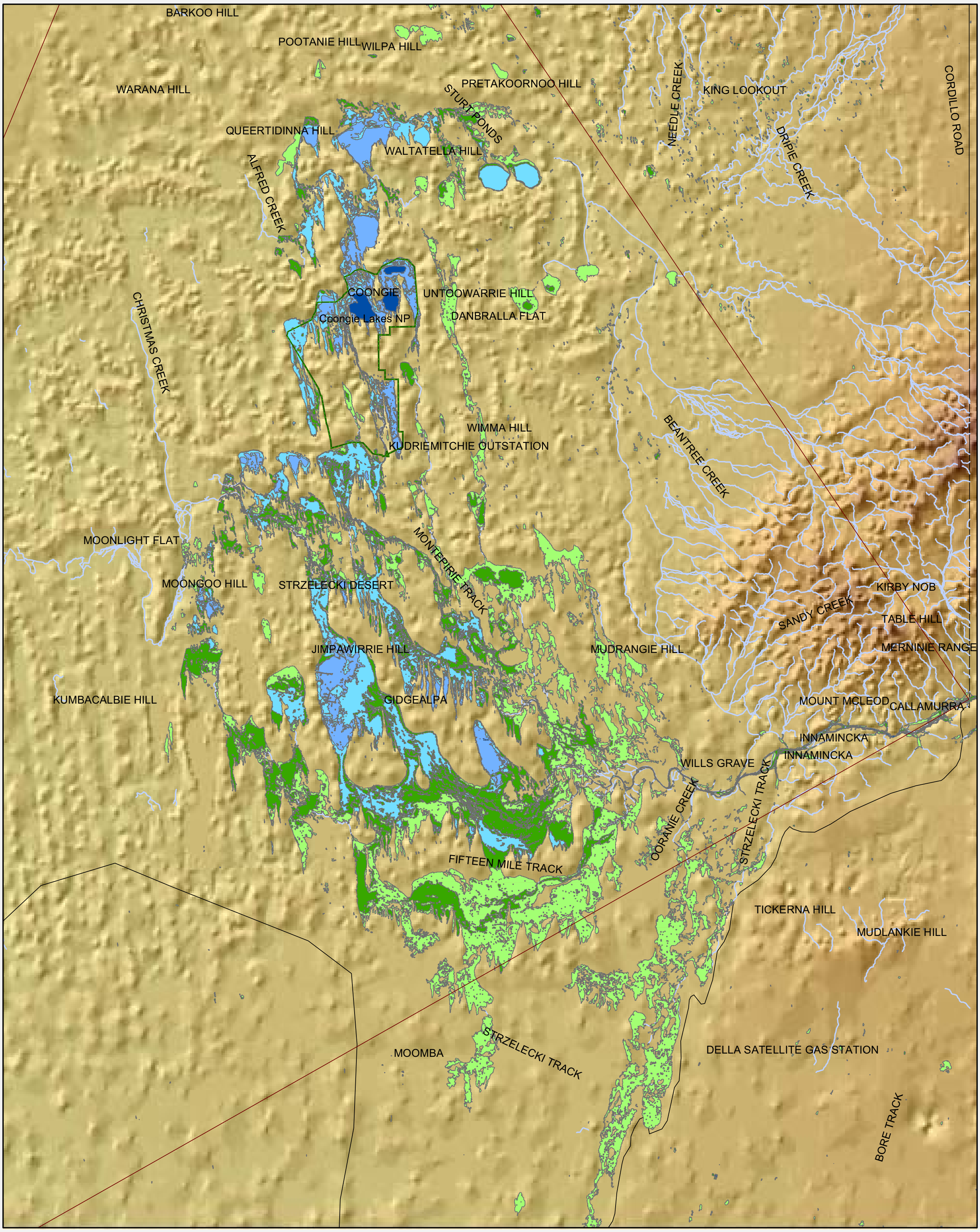
Permanent water-features are culturally and ecologically highly significant, but relatively uncommon. Their contribution to the broader suite of ephemeral wetland types is now more obvious and their relative scarcity in this arid landscape must be appreciated.

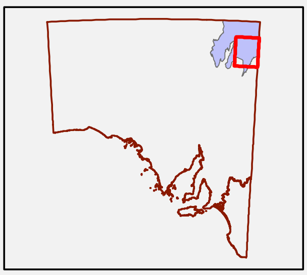
The wetland area figures realised by this project are highly conservative when compared with similar estimations by other authors. Large discrepancies between these figures and other work exist because of the imprecise nature of the wetland definition, the coarse resolutions used in the past, and subsequent debate about the inclusion and definition of floodplain wetlands.

Further work

Although there have been significant advances to the methods in which spatial data is collected in the current study, our ecological understanding of wetlands, particularly ephemeral systems, remains constrained in most localities by a severe lack (or complete absence) of base-line information. The Channel Country bioregion still requires wetland inventory work, a process that involves the collation and/or collection of core information for wetland management. Spatial datasets such as the wetlands mapping are valuable tools that can be integrated with other spatial data to rationalise sampling procedures during the wetland inventory process.

The Cooper Creek catchment boundary differs in areal extent from the Channel Country bioregional boundary, and as such, the extreme western section of the Cooper Creek (surrounding its confluence with Lake Eyre) was not mapped during this project. Remote sensing of the ephemeral wetlands along the eastern and northeastern corner of Lake Eyre would be a valuable addition to the Channel Country mapping.





Frequency of inundation - Cooper Catchment Wetland Mapping

Legend

Frequency of inundation - 5 events

GRID_CODE

- Wet 5 of 5 events
- Wet 4 of 5 events
- Wet 3 of 5 events
- Wet 2 of 5 events
- Wet 1 of 5 events
- Coongie National Park boundary
- Geo250k_Drainage
- TOPO.Geo250k_Roads

Produced by Land Managment Branch - Wetlands
Department for Environment and Heritage
1 Richmond Road, Keswick, SA
Web:www.environment.sa.gov.au/biodiversity

Data Source (Reference to data sources)

Projection Transverse Mercator
Compiled May 2006
Datum Geocentric Datum of Australia, 1994

Government of South Australia
Department for Environment and Heritage

0 3 6 12 18
Kilometers

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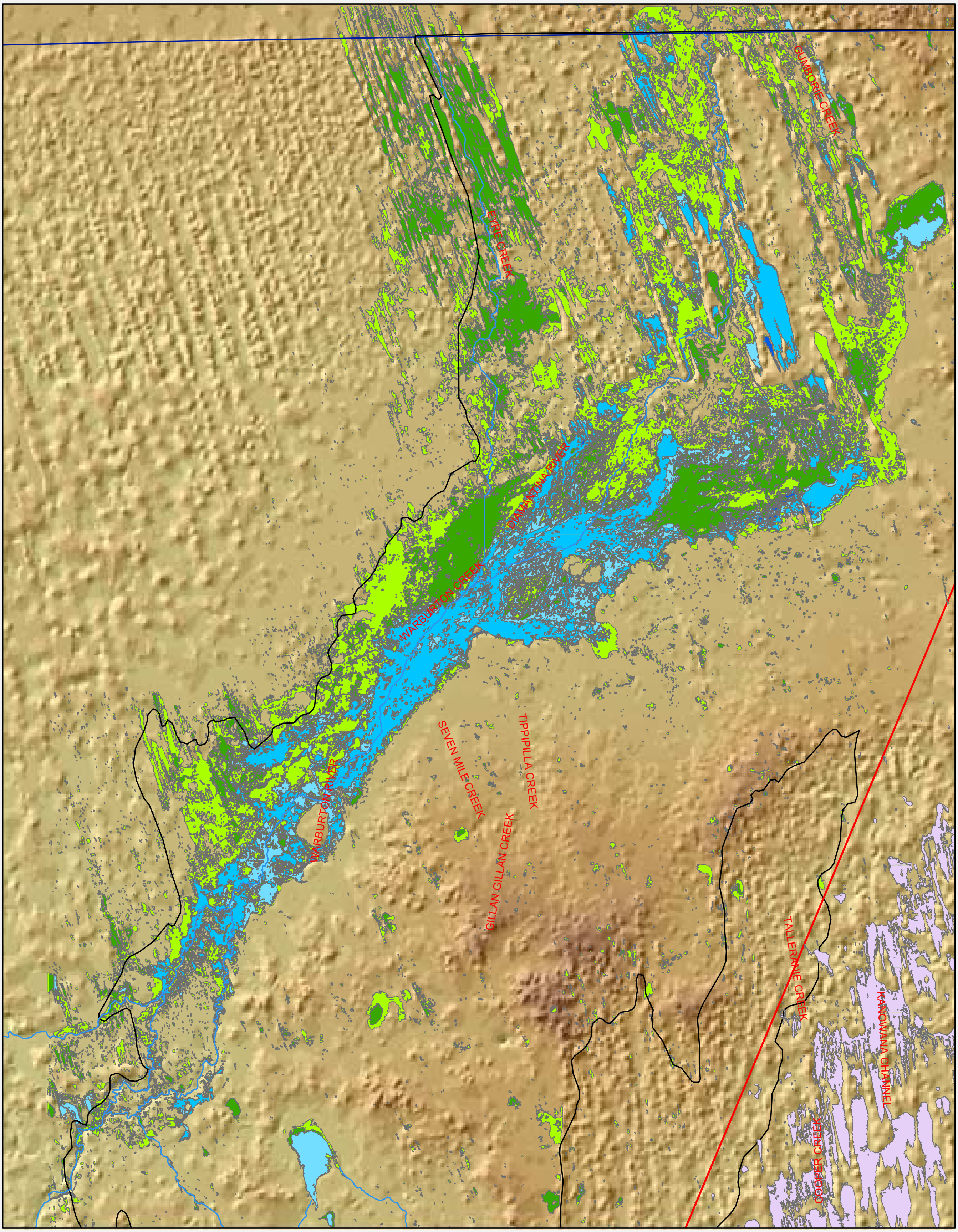
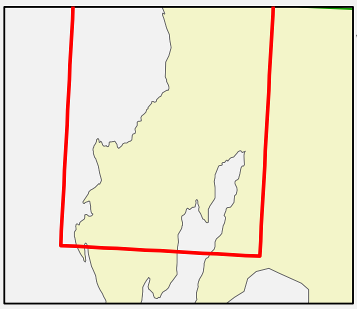




Frequency of inundation
Wetlands - Diamantina River, SA

Legend

Frequency of Inundation_5 events

Wetlands

- Wet 5 of 5 events
- Wet 4 of 5 events
- Wet 3 of 5 events
- Wet 2 of 5 events
- Wet 1 of 5 events

TOPO_250k_Drainage

Major watercourse

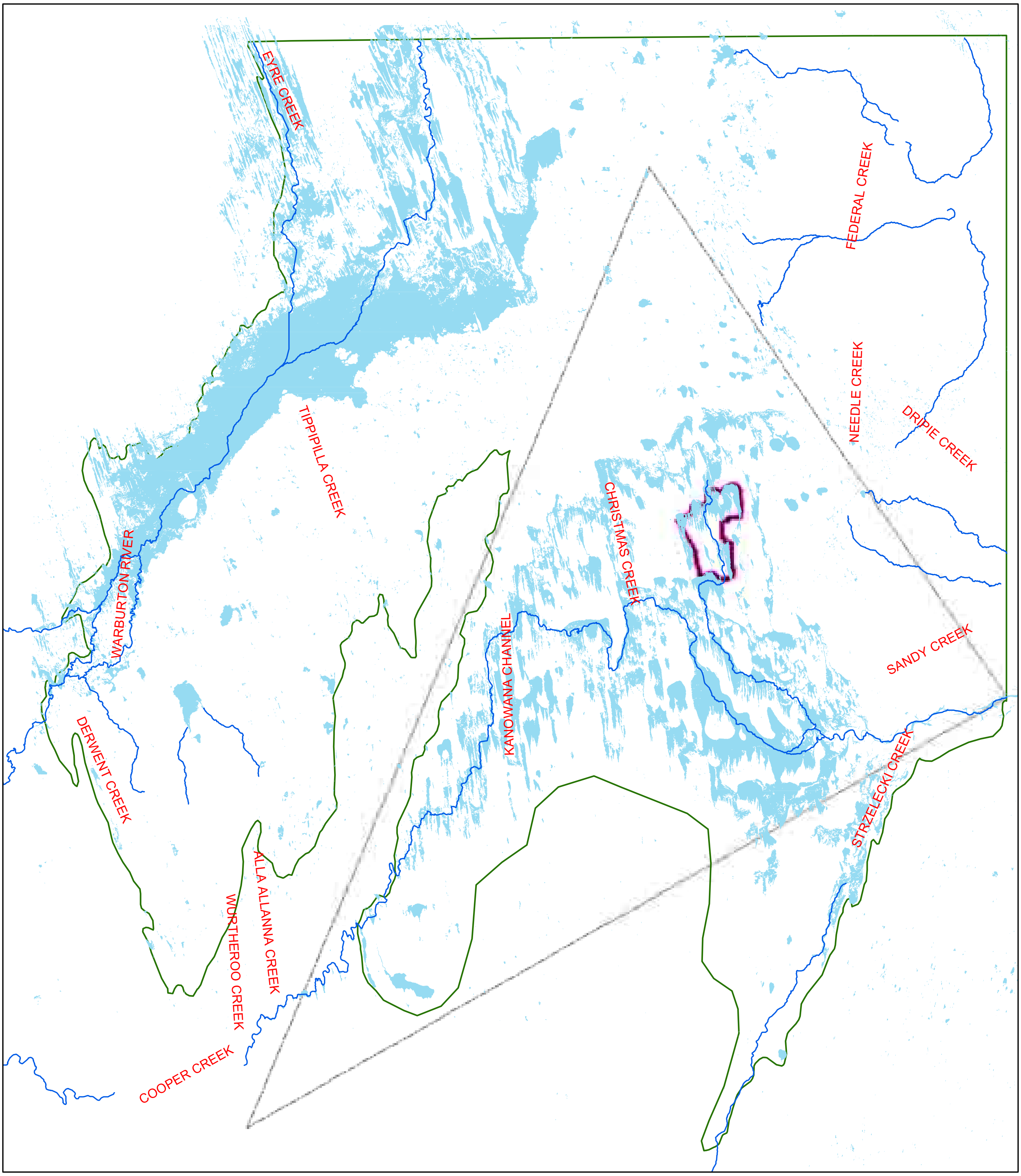
Produced by	Land Managment Branch - Wetlands Department for Environment and Heritage 1 Richmond Road, Keswick, SA Web: www.environment.sa.gov.au/biodiversity
Data Source	(Reference to data sources)
Projection	Transverse Mercator
Compiled	May 2006
Datum	Geocentric Datum of Australia, 1994

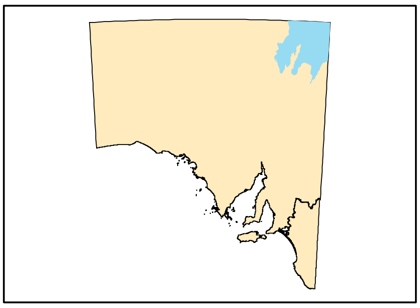
Government of South Australia
Department for Environment and Heritage

0 4 8 16 24 32 Kilometers

File ID : J:\GISworkspace\Biodiversity\BioConsStrat\PWainwright\Channel Country WI\Final\DIA-5yr_FINALmxd.mxd User ID : pwainwright

Wetland Extent, Channel Country, South Australia





Legend

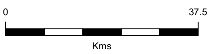
Major watercourses

Wetlands - maximum extent

Coongie NP

Coongie Lakes Ramsar Site

Channel Country IBRA region



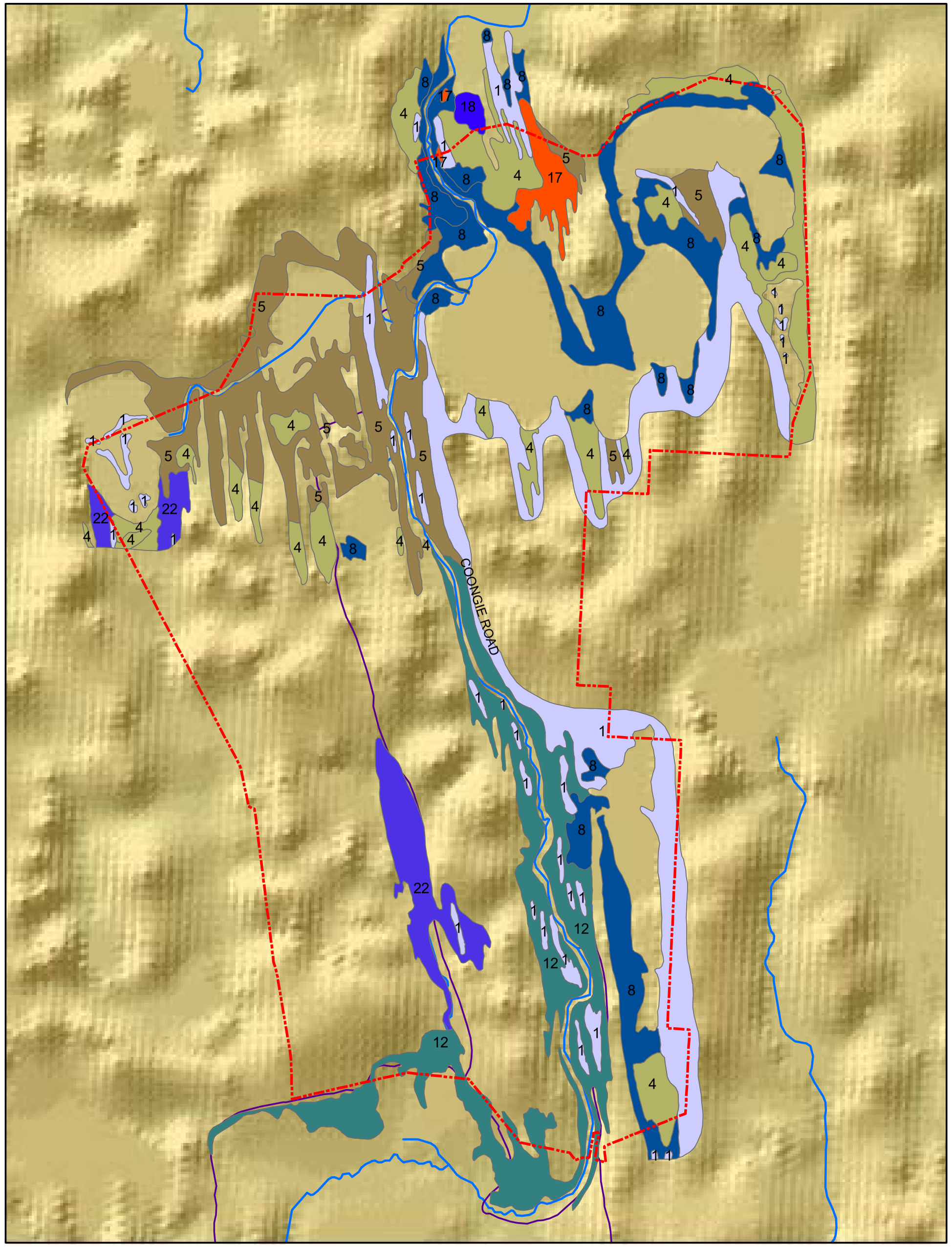
Produced by Land Management Branch
Department for Environment and Heritage
1 Richmond Road, Keswick SA
Web: www. environment.sa.gov.au

Data Source (Reference to data sources)

Projection Transverse Mercator
Compiled 19 May 2006
Datum Geocentric Datum of Australia, 1994

Government of South Australia
Department for Environment and Heritage

File ID : J:\GISworkspace\Biodiversity\BioConsStrat\PWainwright\Channel Country WI\Final\mxds\Max_extent_path98_six_path97_five_water_.mxd User ID : pwainwright



Coongie National Park - Cooper Creek
Vegetation Mapping

0 1 2 4 6
Kilometers

Legend

Coongie National Park boundary

Woodland

22 (22) *Eucalyptus coolabah, +/- Eucalyptus camaldulensis, Acacia stenophylla, Acacia salicina over Muehlenbeckia florulenta* Woodland

12 (12) *Eucalyptus coolabah over Sclerolaena intricata, +/- Atriplex velutinella* Open Woodland

Shrubland

1 (1) *Acacia ligulata over Triodia basedowii* Tall Very Open Shrubland

7 (7) *Atriplex nummularia ssp. nummularia, Halosarcia indica* Shrubland

8 (8) *Muehlenbeckia florulenta, Sclerolaena intricata, Atriplex velutinella* Shrubland

18 (18) *Chenopodium auricomum* Open Shrubland

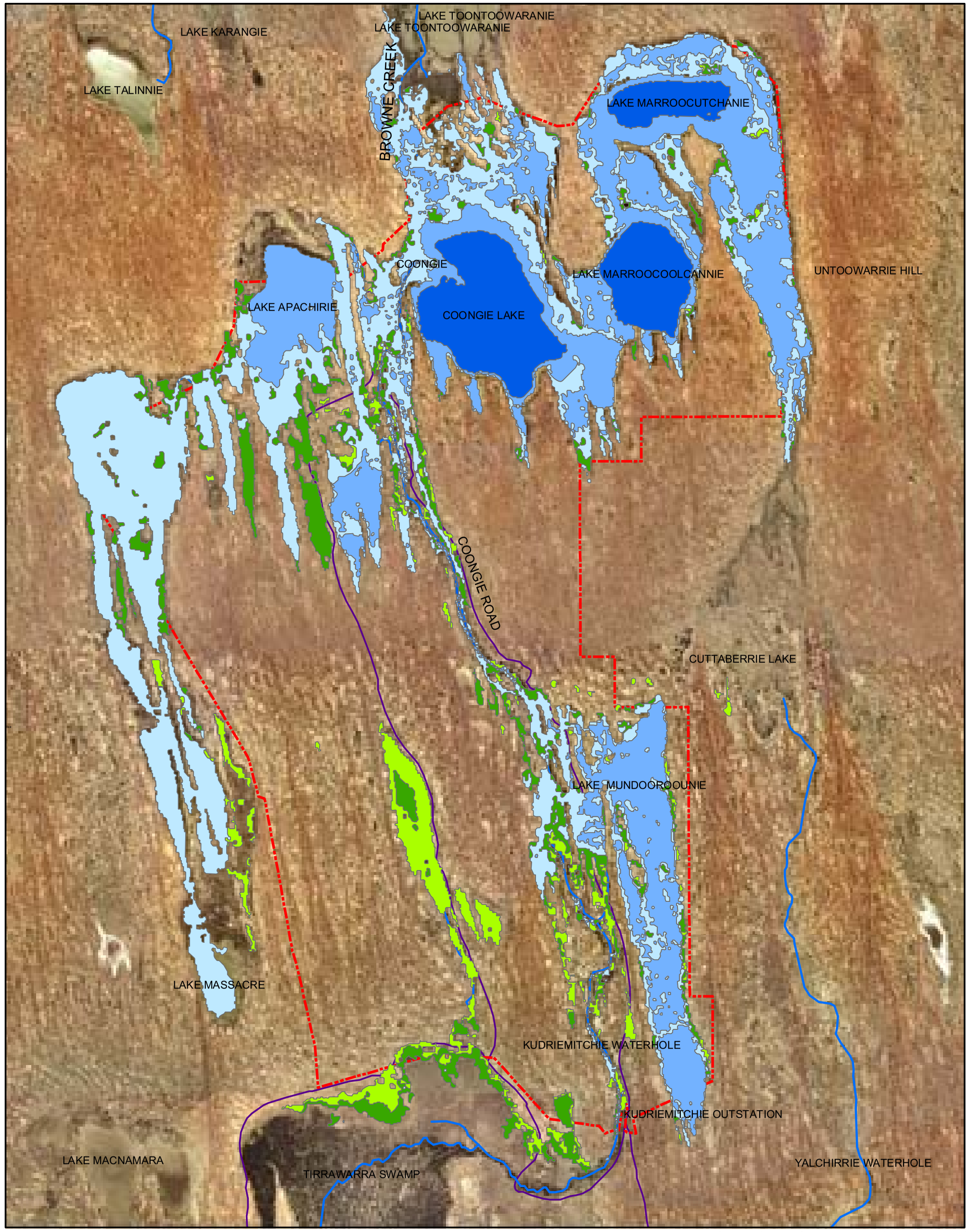
5 (5) *Halosarcia indica, Sclerolaena intricata* Low Shrubland

Grassland

17 (17) *Sporobolus mitchellii* Tussock Grassland

Herbland

4 (4) *Sclerolaena intricata* Open Herbland



Coongie National Park (Cooper Creek)
Wetland Mapping

0 1 2 4 6
Kilometers

Legend

Coongie National Park boundary
Road
Geo250k Drainage

Wetlands - Frequency of Inundation

Wet 5 of 5 events
Wet 4 of 5 events
Wet 3 of 5 events
Wet 2 of 5 events
Wet 1 of 5 events

Produced by: Land Management Branch - Wetlands (DEH)
Department for Environment and Heritage
GPO Box 1047, Adelaide, SA 5001
www.environment.sa.gov.au

Data Source: All topographic data supplied by Environmental Information (EI). DEH.

Projection/Datum: MGA 54/ GDA 54

Compiled: May 2006

File ID : J:\GIS\workspace\Biodiversity\BioConsStrat\PWainwright\Channel Country WI\Final\mxds\Wetlands_CoongieNP.mxd User ID : pwainwright

PART TWO - TECHNICAL DISCUSSION

1.0. DATA

1.1. Selection of imagery

The South Australian Department of Water, Land and Biodiversity Conservation (DWLBC) collect surface water data from a network of flow meters across the State and store it in a database known as the 'Surface Water Archive' (DWLBC, 2004). This database was used to guide the selection of imagery using known flood volumes at flow metres located on the Diamantina River (Birdsville) and the Cooper Creek (Cullyamurra Waterhole) (Tables 1.1 and 1.3). The flood events quite intentionally, show variability in peak amplitude, total volume and peak date such that we could better understand the patterns of flooding under different hydrological regimes. The flow events associated with each river remain completely independent of one another. The area was divided along the satellite paths covered by Paths 97 – 99.

To account for complex flow extents, the Channel Country was divided into two sections that reflect the flow paths of the two major tributaries, the 'Diamantina River' and 'Cooper Creek'. Four targeted flood events and one 'dry scene' were selected for each of the regions. An additional scene for 'Cooper Creek' was later incorporated to capture the full extent of flooding along the lower Cooper Creek (Table 1.4) where it swings to the west intercepting path 98, the Diamantina River satellite path.

Cloud free Landsat 5 TM and 7 ETM+ images were acquired for each flood event per region (Figures 1.1 and 1.2). Images were available as determined by the repeat coverage interval of 16 days, and of that set, the intrusion of cloud rendered a sub-set unsuitable for classification.

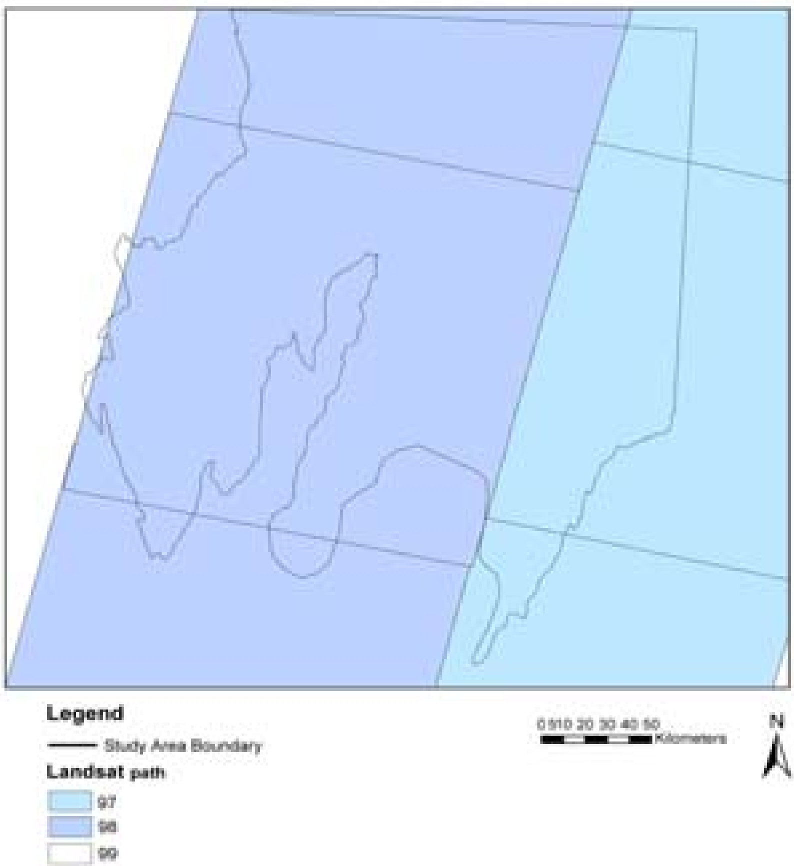


Figure 1.1. From a satellite's perspective, the bioregion is seen as a series of oblique paths containing 'scenes' which define a spatial area and allow data to be compared temporally.

Images were selected with the understanding that there is a considerable lag between the peak flow event at the gauging station and the maximum spatial extent of inundation. The date of each image trailed the peak flood event by a window of 14-28 days, depending upon the availability of cloud-free imagery (Tables 1.2 and 1.4).

When selecting imagery, every attempt was made to capture a range of floods of varying volumes from a 1 in 2 year to 1 in 10-15 year event. However, there are only a small selection within each range which are suitable for the purpose. Not all of the images are proportional in magnitude, so the difference between wetlands inundated in 1 of the 5 images compared with 2 of the 5 images is relative and not absolute.

To remove standing/permanent water from the analysis, a fifth image was acquired representing a dry period. The selection of 'Dry scene' images were determined by the length of time the surface water archive indicated 'zero flow' and the amount of water present in the image after visual inspection. The ACRES Digital Catalogue contained high quality 'quicklooks' using bands 7, 4,1 (R,G,B) which could be used for comparison.

An additional image was necessary to capture flooding events associated with the Cooper Creek which appear within the spatial extent of the Diamantina River image (west of the main branch-north west branch intersection). The Diamantina images cannot be used because their selection is timed to flooding events along the Diamantina and not the Cooper, although there may be concurrent flooding. An image representing a 1-10 year flood event was required because the frequency of inundation generally decreases as one moves closer to Lake Eyre.

Based on figures shown in the surface water archive and the amount of water present in the image, (ACRES Digital Catalogue containing high quality quicklooks with bands 7, 4,1 (R, G, B) (Figure 1) a cloud free Landsat 5 TM image on 15/08/1989 was chosen.

Table 1.1. Selected Flood data for the Diamantina River

	Period	Total Volume (ML)	Peak Date	Peak Volume (ML/day)
1	30/01/91-18/04/91	4,381,406	26/02/91	209,735
2	25/01/04-24/03/04	2,404,759	4/02/04	159,355
3	28/11/99-25/06/00	4,900,207	24/03/00	101,093
4	21/01/97-22/05/97	2,175,541	31/03/97	99,428

Table 1.2. Landsat imagery dates for the Diamantina River
(Path 98 Row 78-80 and Path 99 Row 79)

	Path 98	Path 99
Flood 1	13/03/91	20/03/91
Flood 2	1/03/04	5/02/04
Flood 3	17/05/00	8/05/00
Flood 4	01/05/97	24/05/97
Dry scene	10/01/00 for 98/78&79 30/03/00 for 98/80	17/01/00

Table 1.3. Selected Flood data for the Cooper Creek.

	Period	Total Volume (ML)	Peak Date	Peak Volume (ML/day)
1	8/03/89-4/09/89	4,609,549	09/06/89	155,176
2	16/12/99-27/07/00	3,657,575	16/04/00	75,328
3	12/02/04-13/04/04	1,081,561	17/02/04	45,271
4	22/02/91-1/06/91	1,626,074	3/04/91	38,441
5	8/03/89-4/09/89	4,609,549	09/06/89	155,176

*Data is recorded only when daily volume exceeds more than 1,000ml.

Table 1.4. Landsat Imagery dates for the Cooper Creek
(Path 97 and Path 98 Row 78-80)

	Path 97	Path98
Flood 1	20/06/89	
Flood 2	10/05/00	
Flood 3	11/04/04	
Flood 4	09/05/91	
Flood 5		15/08/89
Dry scene	07/02/04	

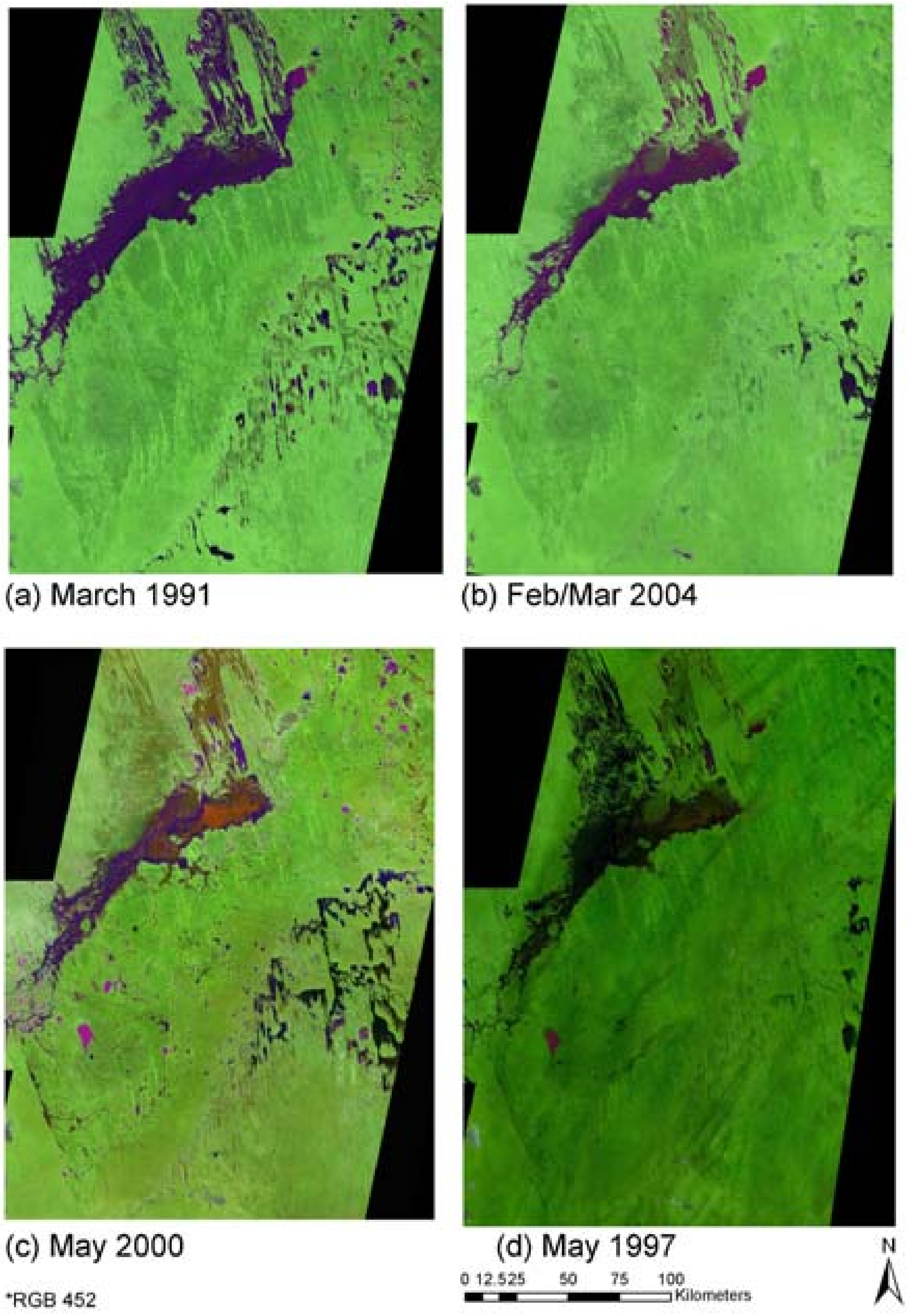


Figure 1.1. Cloud free Landsat Images associated with four selected flood events along the Diamantina River (Path 98 & 99)

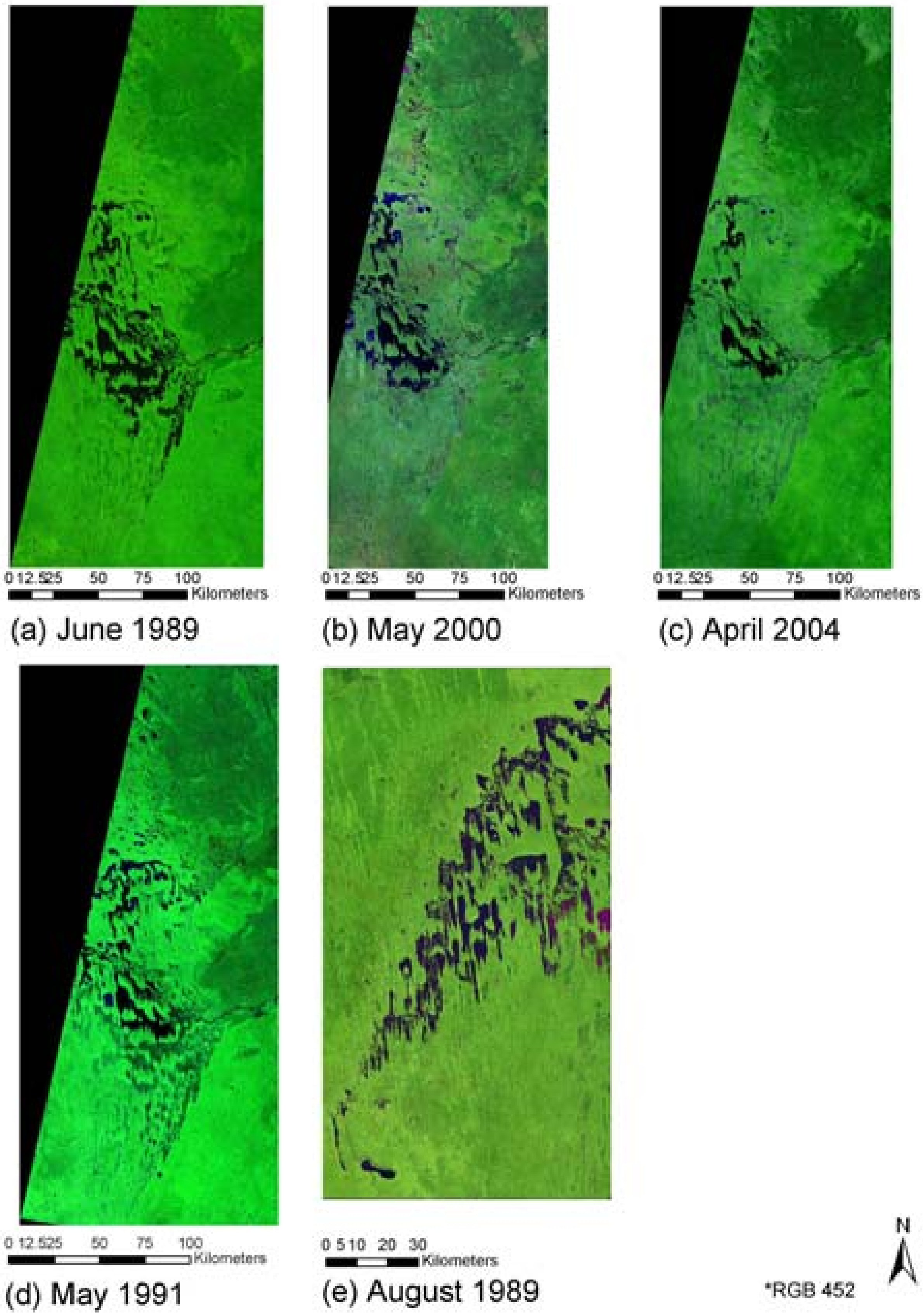


Figure 1.2. Cloudfree Landsat Images associated with four floods along Path 97 of the Cooper Creek and one image of Path 98 (August 1989).

2.0 METHODOLOGY

2.1. Radiometric and Geometric Corrections

Landsat 5 TM and 7 ETM+ images were radiometrically calibrated to compensate for changes in incident light due to different imagery acquisition times and to correct for changes in the sensor sensitivities on the satellites. These parameters are provided by the Australian Centre for Remote Sensing (ACRES) and the United States Government Service. Atmospheric corrections were not applied, because an accurate model of the atmosphere was not available, and the method was designed to detect relative changes, not absolute differences.

One image from each region was georectified using an orthophoto mosaic of 1:80000 scale aerial photography with an accuracy of +/-50m (horizontal). The other images in the region were georectified using the above now georectified images. All images were resampled during this process to a 25m pixel resolution.

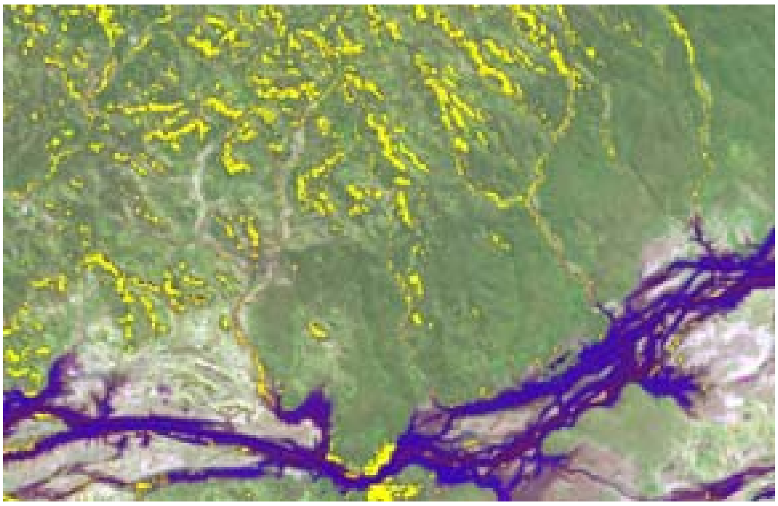
2.2. Shadow Effects

The Channel Country is mostly flat and 'uncomplicated' from a remote sensing perspective. Complex landforms in undulating terrain can cause shadow effects which may result in misclassifications during post processing. The probability of shadow effects in the bioregion due to the low topography of this environment was considered minimal. However, some shadow problems were encountered in an area north of Cullyamurra Waterhole (Fig 2.1a) where a plateau of relatively high elevation falls away and exposes some steep cliffs. The classified imagery showed 'wet' pixels high in the shadows created by the cliffs, but after consulting aerial photography and the pastoral managers we agreed that a mis-classification had occurred. Band 3, 4 and 5 thresholds (Knight 2004) (Fig 2.1d) were then applied to all images to remove the shadow effect.

2.1(a) Aerial photography – Cooper Creek and Cullyamurra Waterhole (Bottom left). Scale,1:80,000

2.1(b) RGB

2.1(c) Band 5 thresholds (Blue) and RGB 452



2.1(d). Band 3, 4 & 5 threshold (Yellow) and RGB 452

Figure 2.1. The sequence of four images above shows how the shadow effects north of Cullyamurra Waterhole were identified and removed using band 3, 4 and 5 thresholds

2.3. Image Classification

An ISOCLASS unsupervised classification method was used to classify the images. Water features were identified from the classified images, using the method that had been applied for the EPA Standing Water Body Mapping across Queensland (Knight 2004). This method employed the key water signature from Band 5 of Landsat, based on the assumption that the middle infrared spectrum is sensitive to the pure water signature. Moreover, the method is considered 'near-stationary' through time and can be applied repeatedly through time, although the accuracy of spectral signal may depend on satellite platform and age, and environmental and scene conditions potentially affect values (Knight 2004).

A multi-dimensional density slice with the additional use of Band 3 and 4 to exclude shadow and greenness effects was not applied for this project. Greenness effect was not apparent, probably due to the arid, low humidity conditions of the Channel Country.

The spectral characteristics of water, shallow water and swamp environments were separated during the classification to help resolve flooding patterns more closely. Deeper water absorbs more infra-red radiation and can be distinguished from shallow water (or damp substrate) by the amount of reflection emitted. Swamp areas were distinct from either of the water classes because they contained vegetation that was identified using Band 4 and associated near-infrared reflectivity.

Filters of Band 5 for water features, as suggested by Knight (2004) were as follows:

Band 5 Digital Numbers [1-16]: Deeper or more permanent water bodies

Band 5 Digital Numbers [17-32]: Shallow and more ephemeral water features.

Band 5 Digital Numbers [33-38] Swamp

As additional references, aerial photographs taken close to the dates of the Landsat images, band ratios of bands 2/5 and 5/4, and a band combination of RGB 452 separating water bodies from land were utilised in order to improve the accuracy at which water features were detected. After the images were analysed, it was possible to derive three datasets (provided in both raster and vectorised forms):

1. Permanent/semi-permanent water bodies

Areas which were classifed as 'water' or 'shallow water' in all scenes (including the dry scene) were extracted, and suspected to have a regime which was either permanent or very close to permanent.

2. The maximum extent

Represents the outer spatial boundary of the water signature when the temporal series of classified images were combined.

The water and shallow water class were employed and combined together here, as these two classes are regarded as conservative standing water (Knight, 2004) and only the presence of water was required for analyses from this point on.

3. Frequency of inundation

A pixel value was applied to each cell showing the relative inundation frequency. The pixel value denotes a unique inundation sequence (Tables 2.1 and 2.2). The number of inundation events that occurred in each cell were counted and interpreted into a frequency index showing a value between 1-

5. This value indicates how 'wet' or 'dry' the landscape is relative to other features in the study area (Table 5.1).

A matrix using pixel values between 1-63 was developed to show the inundation frequency associated with 6 images (Table 2.2). It must be noted that the area covered by all six images is the area of the additional image only, and not the entire area of path 98. Hence, none of the wetlands in the Diamantina catchment were inundated in all six events because the additional image was timed to a Cooper Creek flooding event.

Table 2.1. Frequency matrix developed for Cooper Creek (path 97) from the series of five Landsat images. A pixel value is allocated to each pixel based on its inundation frequency and inundation history.

The number of wet events from a maximum of five	Pixel Value	Epoch 1 1991	Epoch 2 1997	Epoch 3 2000	Epoch 4 2004	Dry scene
5	1	Y	Y	Y	Y	Y
4	2	Y	Y	Y	Y	**N**
	3	Y	Y	Y	**N**	Y
	4	Y	Y	**N**	Y	Y
	5	Y	**N**	Y	Y	Y
	6	**N**	Y	Y	Y	Y
3	7	Y	Y	Y	**N**	**N**
	8	Y	Y	**N**	**N**	Y
	9	Y	Y	**N**	Y	**N**
	10	Y	**N**	**N**	Y	Y
	11	Y	**N**	Y	Y	**N**
	12	Y	**N**	Y	**N**	Y
	13	**N**	Y	Y	Y	**N**
	14	**N**	Y	Y	**N**	Y
	15	**N**	Y	**N**	Y	Y
	16	**N**	**N**	Y	Y	Y
2	17	Y	Y	**N**	**N**	**N**
	18	Y	**N**	**N**	**N**	Y
	19	Y	**N**	**N**	Y	**N**
	20	Y	**N**	Y	**N**	**N**
	21	**N**	Y	Y	**N**	**N**
	22	**N**	Y	**N**	**N**	Y
	23	**N**	Y	**N**	Y	**N**
	24	**N**	**N**	Y	Y	**N**
	25	**N**	**N**	Y	**N**	Y
	26	**N**	**N**	**N**	Y	Y
1	27	Y	**N**	**N**	**N**	**N**
	28	**N**	Y	**N**	**N**	**N**
	29	**N**	**N**	Y	**N**	**N**
	30	**N**	**N**	**N**	Y	**N**
	31	**N**	**N**	**N**	**N**	Y

- Y= Flood occurrence, N= No flood occurrence

Table 2.2. Frequency matrix for path 98 developed from the series of six Landsat images. A pixel value is attributed according to the inundation frequency and inundation history.

The number of wet events from a maximum of six	Pixel Value	Epoch 1 1991	Epoch 2 1997	Epoch 3 2000	Epoch 4 2004	Epoch5 1989	Dry scene 2000
6	1	Y	Y	Y	Y	Y	Y
5	2	Y	Y	Y	Y	Y	**N**
	3	Y	Y	Y	**N**	Y	Y
	4	Y	Y	**N**	Y	Y	Y
	5	Y	**N**	Y	Y	Y	Y
	6	**N**	Y	Y	Y	Y	Y
	7	Y	Y	Y	Y	**N**	Y
4	8	Y	Y	Y	**N**	Y	**N**
	9	Y	Y	**N**	**N**	Y	Y
	10	Y	Y	**N**	Y	Y	**N**
	11	Y	**N**	**N**	Y	Y	Y
	12	Y	**N**	Y	Y	Y	**N**
	13	Y	**N**	Y	**N**	Y	Y
	14	**N**	Y	Y	Y	Y	**N**
	15	**N**	Y	Y	**N**	Y	Y
	16	**N**	Y	**N**	Y	Y	Y
	17	**N**	**N**	Y	Y	Y	Y
	18	Y	Y	Y	Y	**N**	**N**
	19	Y	Y	Y	**N**	**N**	Y
	20	Y	Y	**N**	Y	**N**	Y
	21	Y	**N**	Y	Y	**N**	Y
	22	**N**	Y	Y	Y	**N**	Y
3	23	Y	Y	**N**	**N**	Y	**N**
	24	Y	**N**	**N**	**N**	Y	Y
	25	Y	**N**	**N**	Y	Y	**N**
	26	Y	**N**	Y	**N**	Y	**N**
	27	**N**	Y	Y	**N**	Y	**N**
	28	**N**	Y	**N**	**N**	Y	Y
	29	**N**	Y	**N**	Y	Y	**N**
	30	**N**	**N**	Y	Y	Y	**N**
	31	**N**	**N**	Y	**N**	Y	Y
	32	**N**	**N**	**N**	Y	Y	Y
	33	Y	Y	Y	**N**	**N**	**N**
	34	Y	Y	**N**	Y	**N**	**N**
	35	Y	**N**	Y	Y	**N**	**N**
	36	**N**	Y	Y	Y	**N**	**N**
	37	Y	Y	**N**	**N**	**N**	Y
	38	Y	**N**	Y	**N**	**N**	Y
	39	**N**	Y	Y	**N**	**N**	Y
	40	**N**	Y	**N**	Y	**N**	Y
	41	**N**	**N**	Y	Y	**N**	Y
	42	Y	**N**	**N**	Y	**N**	Y
2	43	Y	Y	**N**	**N**	**N**	**N**
	44	Y	**N**	**N**	Y	**N**	**N**
	45	**N**	**N**	Y	Y	**N**	**N**
	46	**N**	Y	**N**	Y	**N**	**N**
	47	**N**	**N**	**N**	Y	Y	**N**

The number of wet events from a maximum of six	Pixel Value	Epoch 1 1991	Epoch 2 1997	Epoch 3 2000	Epoch 4 2004	Epoch5 1989	Dry scene 2000
2	48	Y	**N**	**N**	**N**	Y	**N**
	49	Y	**N**	**N**	**N**	**N**	Y
	50	**N**	Y	**N**	**N**	**N**	Y
	51	**N**	**N**	Y	**N**	**N**	Y
	52	**N**	**N**	**N**	Y	**N**	Y
	53	**N**	**N**	**N**	**N**	Y	Y
	54	**N**	Y	**N**	**N**	Y	**N**
	55	**N**	**N**	Y	**N**	Y	**N**
	56	Y	**N**	Y	**N**	**N**	**N**
	57	**N**	Y	Y	**N**	**N**	**N**
	58	Y	**N**	**N**	**N**	**N**	**N**
1	59	**N**	Y	**N**	**N**	**N**	**N**
	60	**N**	**N**	Y	**N**	**N**	**N**
	61	**N**	**N**	**N**	Y	**N**	**N**
	62	**N**	**N**	**N**	**N**	Y	**N**
	63	**N**	**N**	**N**	**N**	**N**	Y

2.4. Filter

The images were filtered using a majority filter that changes spurious pixels within a large single class to that class and enhances clumps. The filter was applied to each cluster of 3 x 3 pixels.

2.5. Data processing from raster format to vector format

The raster to vector conversion of this classified data included a routine for placing curves in the resulting boundary lines. The data was transformed from a 'staircase' appearance to a more natural looking curve shape which is normally associated with vector area data.

The original grid data was filtered to ensure that no pixel agglomerations were less than one hectare in size. This greatly reduced the number of polygons in the vector conversion. Arc/Info GIS commands were then used in both the filtering and curve generation processes.

After a grid to polygon conversion, the ‘Generalize’ command was applied to the vector data. The Douglas-Peucker algorithm with an extra function called the Bendsimplify parameter was specified using an integer number to apply a degree of curvature to the generalized lines. A low number such as two gives only a slight amount of curvature to the staircase data, but this means there is less chance of losing some of the smaller and narrow polygons caused by sliver complications. A high Bendsimplify parameter produced greater curvature and increased the possibility of some polygons being affected by slivers and other topology problems. Whichever simplification parameter is used, the data still had a jagged appearance, which was smoothed by using the Spline function. Superfluous vertexes and pseudo nodes were eliminated using the conventional running of the Generalize command as well as concatenation. The final phase of the data processing involved dealing with those polygons whose classifications have been lost. Most of these are tiny slivers that can be ignored, but it can happen to large polygons as well. A copy of the original staircase data or grid was placed in an ArcMap window for the operator to determine the classification values for large null value polygons (using the information icon). These values are then transferred from the staircase data to the curved polygon dataset. This is only practical for a few large polygons. All the remaining null polygons were then dissolved and merged with their most dominant neighbouring class.

3.0. RESULTS

3.1. Water features

Individual flood extents (Figures 3.1 and 3.2) were selected to show spatial variability and were later combined to infer inundation frequencies. Also noticeable in some of the images (May 2000 along the Diamantina River for example) is concurrent flooding along the Cooper Creek.

The filters of Band 5 coincided with the results of the unsupervised classification and other references. Temporal consistency between scenes was also confirmed.

The filters of Band 5 seemed to overestimate both the water class and the shallow water class in some instances, this occurred most commonly when the reflectance in Band 4 identified the signature as water. It was assumed that emergent aquatic vegetation partially covered some of the shallow water environments, resulting in lower pixel values associated with Band 5.

Conversely, the results underestimated the shallow water class in some areas. These areas were classified as non-water features by the Band 5 filter, but they appeared to belong to the shallow water class in the band ratio and the RGB band combination. They also presented relatively similar spectral signatures to the shallow water class , although mean values were slightly higher. These areas may have contained shallow water as well as swamps (vegetated floodouts or floodplain). Consequently, these areas were also included in the 'Swamp class', as explained in the methodology.

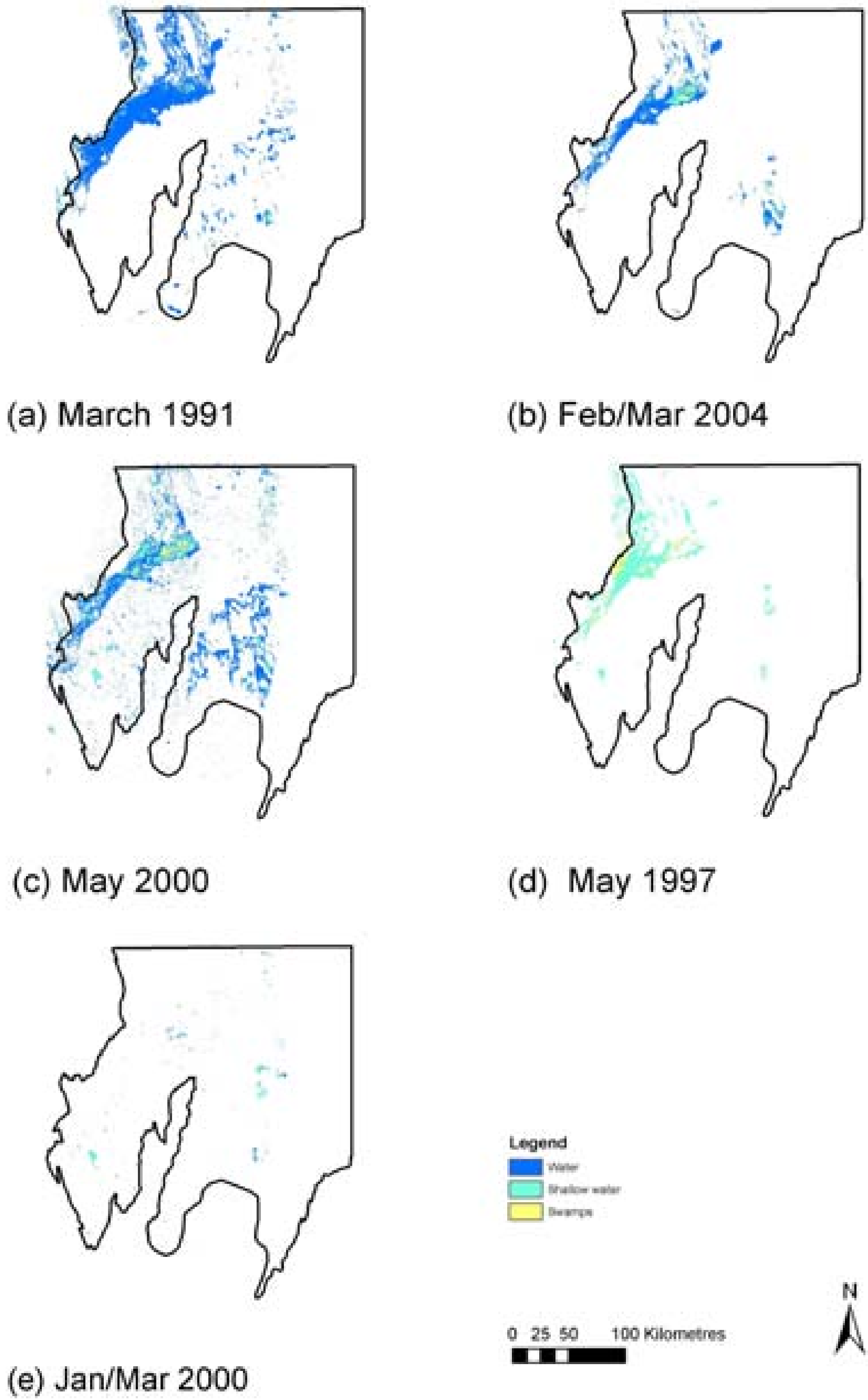


Figure 3.1. Classified images associated with the Diamantina River, showing the variability in size and feature class

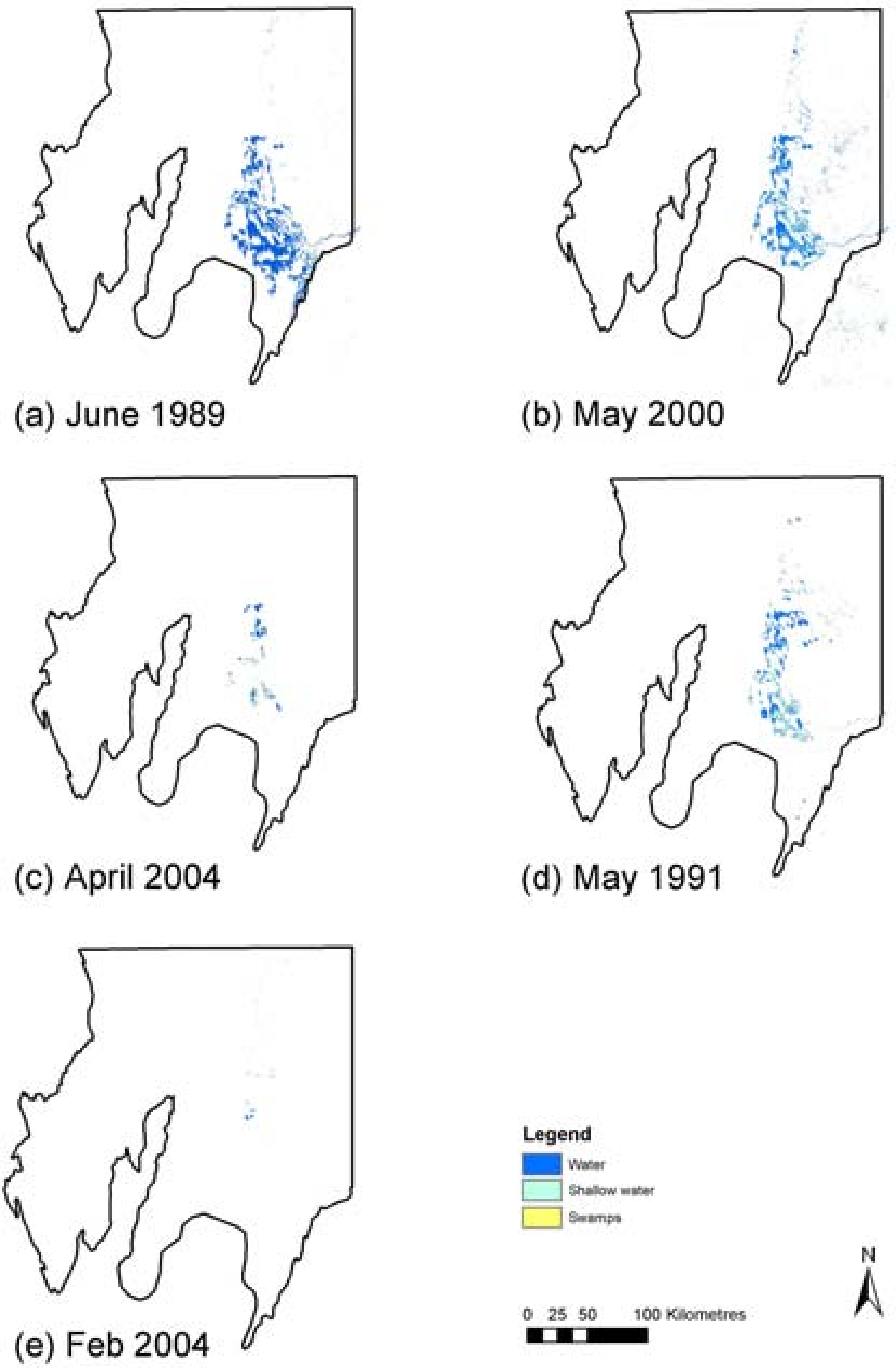


Figure 3.2. Classified images associated with the Cooper Creek showing the variability in size and feature class.

3.2. Maximum wetland extent.

The ‘maximum wetland extent’ refers to the outer spatial boundary identified by combining the data from the processed images (Tables 3.1 and 3.2). The term ‘maximum wetland extent’ is not intended to reflect the largest historical extent, rather, a boundary within which the flooding frequency is considered less than 1 in 15 years. This regime is frequent enough for the biota to become wetland adapted.

The results indicated the variability between flood extents, and suggest that spatial extent is not necessarily a function of total flood volume. Smaller floods with higher peak amplitudes inundated areas which remained dry during slower building but cumulatively larger floods. The extent of the 1991 flood on the Cooper Creek (Path 97) for example was larger than the 2000 event, despite lower total and peak volume. Several factors including flood period, time passage, flow rates and antecedent history may be attributed to this. In areal terms the maximum extent (Fig. 3.3) represents a wetland area of 10,595km^2 (18.6% of the bioregion).

Table 3.1 Areal wetland extents, as determined by the Landsat imagery.

Reach	Area (km^2)
Cooper Creek	3679
Diamantina River	5918
Autonomous wetlands (localised rainfall)	998
Coongie Lakes Ramsar Site	3919

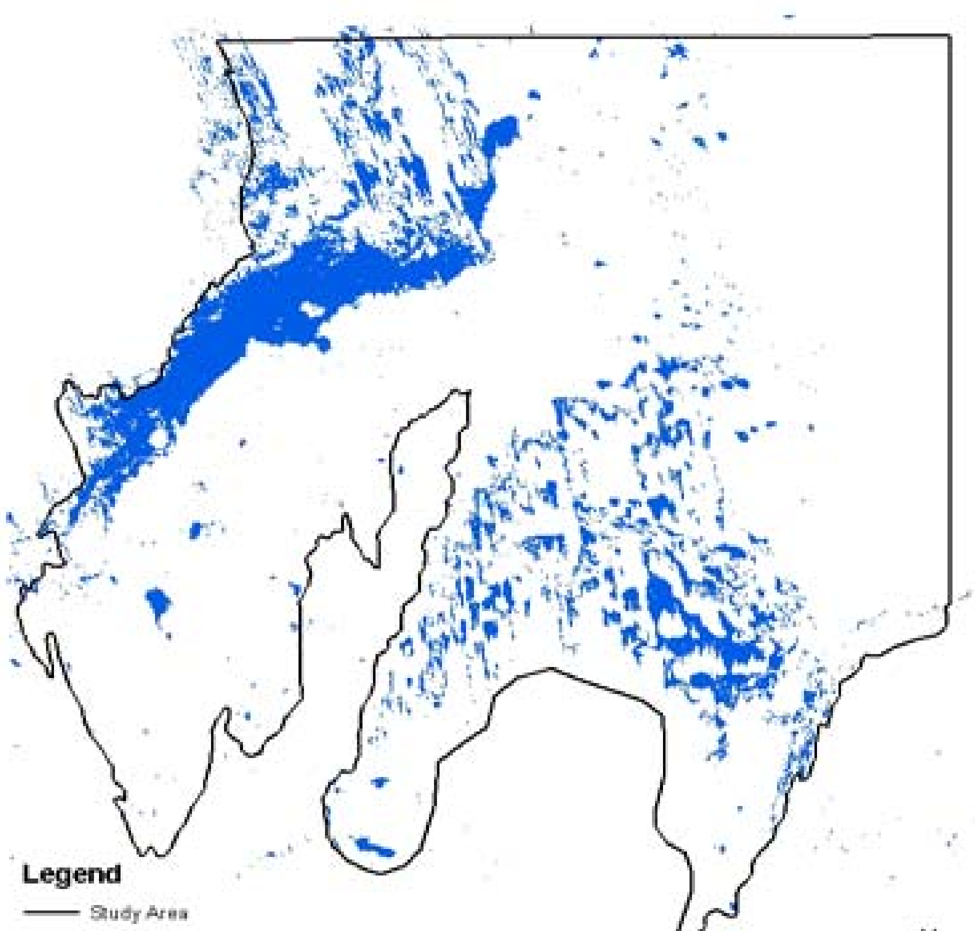


Figure 3.3 The maximum wetland extent represented by the series of Landsat images

3.3. Frequency of inundation

The frequency of inundation is a relative index indicating how often different parts of the landscape become wet. It is derived from a series of 5 images (4 floods of varying magnitudes and a dry scene). Importantly, the frequency of inundation data does not represent the same area as the maximum extent image because it did not include the additional aerial extent derived from an additional image that was acquired to help derive maximum extents. The size of the wetland area subject to these analyses is 9804km^2 compared with 10,595km^2 (maximum extent) (Figures 3.5 and 3.6)

Table 3.2. Inundation statistics

Frequency	Area represented	Cum. Area	Cum.%
Inundated during all 5 images	31km^2	31km^2	0.3
Inundated during 4 of the 5 images	1168km^2	1199km^2	12.2
Inundated during 3 of the 5 images	1157km^2	2356km^2	24.0
Inundated during 2 of the 5 images	2425km^2	4781km^2	48.7
Inundated during 1 of the 5 images	5023km^2	9804km^2	100

* Wetlands inundated in all images are likely to be permanent, but this cannot be assured with complete confidence because there were no 'longer duration' dry scenes available for comparison.

Wetlands that were inundated during all five images have a permanent or semi-permanent regime (or at the very least, one which can sustain itself through a prolonged dry period) and represent 0.3% of the areal wetland extent (Table 3.2). These features include the semi-permanent lakes in the Coongie complex and permanent in-channel waterholes along the Cooper Creek and Diamantina River (Figure 3.6).

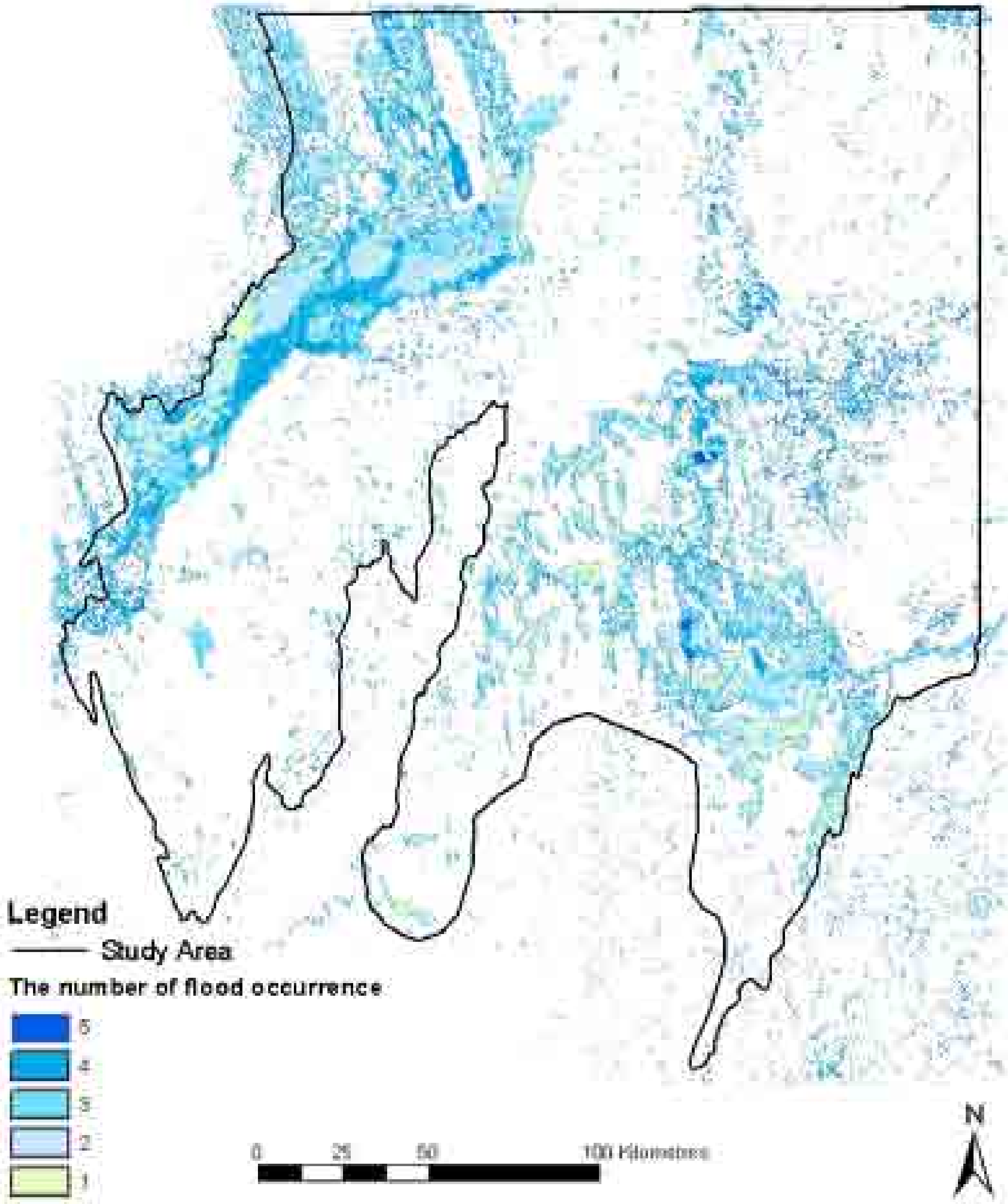


Figure 3.4. The frequency of inundation (flood frequency). Shading reflects the number of floods in which different parts of the landscape were wet. Dark blue areas, hence, are more frequently inundated than pale blue or green features.

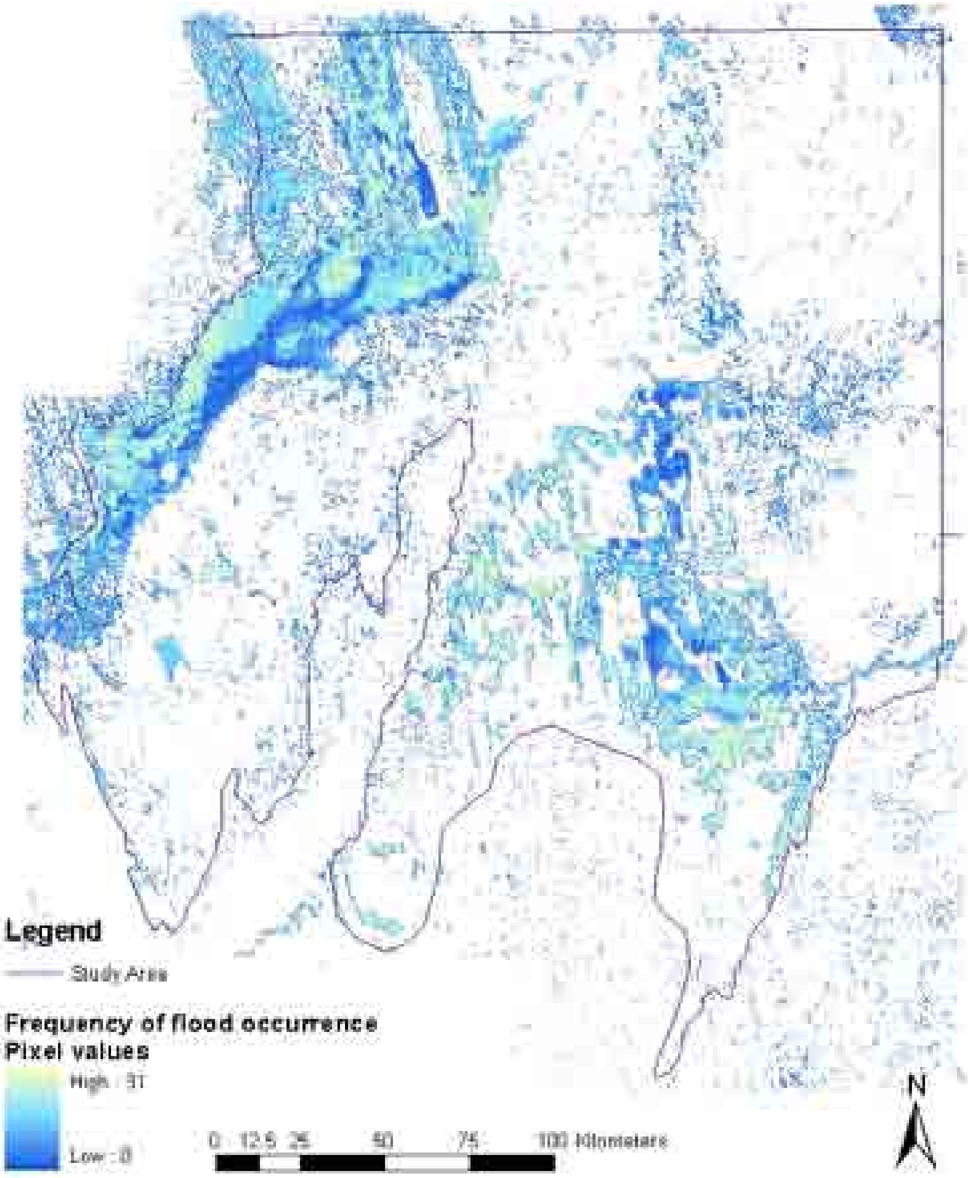


Figure 3.5. The frequency of inundation (pixel value). Water features have been allocated a pixel value between 1- 31, which correspond to a flood sequence shown in table 6.1. Lower pixel values are represented by dark blue.

3.4. Coongie Lakes Ramsar Site

The wetland area determined by this project is 3919km^2, or 17% of the Ramsar site area.

3.5. Coongie National Park

The wetland area inside Coongie National Park is 110.5 km^2 or 41% of the park area.

3.6. Permanent water bodies

It is difficult to apply 'permanent' status to any of the waterbodies in the Channel Country given the variability associated with the water supply. However, a small number of wetlands were inundated during all five events, including a dry scene (Figure 3.6). If not permanent, these features hold water for much longer than surrounding landscape features and are highly significant as refuge sites for fauna.

Cooper Creek, area of permanent /semi permanent wetlands - 18.46km^2 .
Diamantina River, area of permanent/semi permanent wetlands - 12.86km^2.

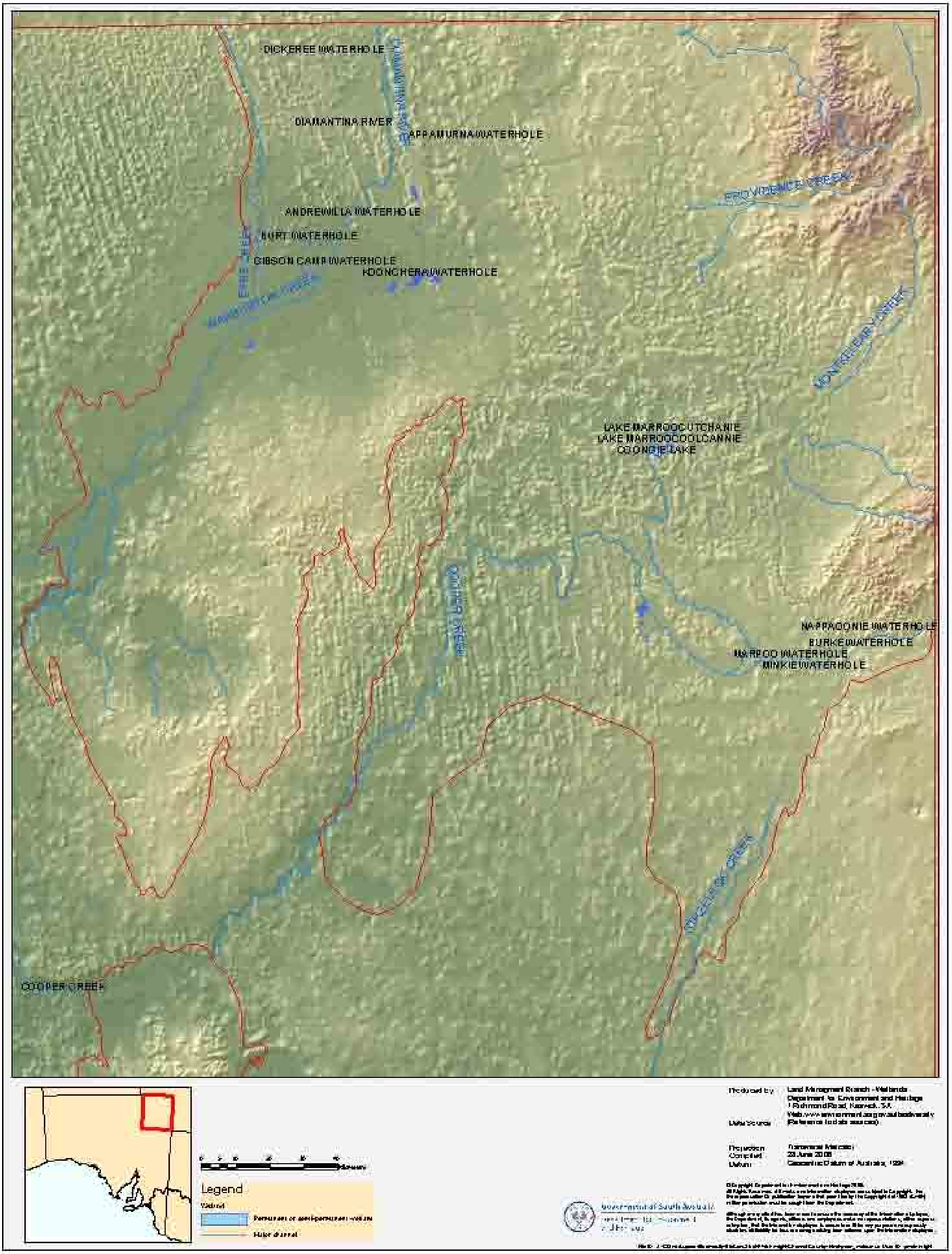


Figure 3.6. Wetlands which contained water in all of the images (indicating a regime which is permanent or semi-permanent).

4.0 GLOSSARY

Antecedent. Going before in time; prior; anterior; preceding; as, an event antecedent to the deluge; an antecedent cause.

Depauperate: Falling short of the natural size, from being impoverished or starved.

Endorheic: Internally draining

Hydrophyte : A plant that grows partly or wholly in water whether rooted in the mud, or floating without anchorage,

Heterogeneous: Differing in kind; having unlike qualities; possessed of different characteristics; dissimilar; -- opposed to homogeneous, and said of two or more connected objects, or of a conglomerate mass, considered in respect to the parts of which it is made up.

Ruderal: The ability to complete a life cycle between flood events

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