



Riparian Habitat Values Assessment of the Diamantina River Catchment; Lake Eyre Basin, South Australia

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Natural Resources Management Board



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Diamantina River channel May 2014, Warburton River - Tinnie Landing waterhole April 2016

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1 Executive Summary

The Diamantina River catchment in South Australia consists of a number of dryland rivers and creeks, including the Diamantina River, Warburton River and Kallakoopah Creek. Their ecological, cultural and economic value is significant providing reliable sources of water during drought conditions and connectivity pathways during more favourable periods. Reliable sources of water provide vital drought refuge for a variety of biota and are at the core of traditional, historic and contemporary human activity in the region.

This river system contains permanent and semi-permanent waterholes and associated floodplain areas such as Goyder Lagoon. Most of Goyder Lagoon can be described as a broad open floodplain with a complex microtopography that includes scours and lignum swamps. There are a few waterholes around the lagoon edges and none in its main area. These floodplains are highly important productive zones for pastoralism and important sites for biodiversity that provide stability and valuable water sources in a system characterised by high variability and aridity.

This project investigated the ecological; cultural; economic and bio-physical values of permanent and semi-permanent waterholes across the South Australian section of the Diamantina River catchment. It also provides a qualitative assessment of the pressures and threats on these ecosystems. The project is focussed at the landscape-scale and takes a holistic approach to addressing the issues relating to biodiversity conservation and land use. This riparian habitat values assessment approach provides a basis for identifying ecological importance, investment prioritisation and management priorities through greater understanding of the present and potential impacts facing these important natural assets.

A number of waterholes, ranging in persistence from permanent to semi-permanent waterbodies and saline pools, were selected to provide a representative sample from four management reaches identified during the broader Channel Country Project. These management zones were based on channel flow distribution; floodplain connectivity; aquatic refuge value; and geomorphological characteristics.

Management reaches identified as four distinct zones:

1. **Diamantina main channel** – South Australian border to Goyder Lagoon (includes Andrewilla and Yammakira Waterholes – 2 important and highest ranked aquatic refuges)
2. **Goyder Lagoon** – from Andrewilla and Yammakira distributary channels to commencement of the Warburton River channel
3. **Warburton - Kallakoopah** – commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path
4. **Eyre Creek** – South Australian border to Goyder Lagoon

For each waterbody, the **Riparian Habitat Values Assessment** process consisted of four key components containing information of **site description and environmental setting** (i.e. site location; use zone; conceptual understanding; waterbody depth; elevation; and vegetation association with a list of recorded plant species); **ecosystem values** (i.e. riparian plant and habitat diversity; hydrological value; water quality; cultural site importance; aquatic refuge importance); **threats** (i.e. weeds, pest animals, surface and groundwater abstraction); and **pressures** (i.e. infrastructure development; visitor impacts; soil disturbance, total grazing pressure); **riparian condition assessment** (structural and spatial integrity; nativeness; age structure; and leaf / debris litter); and **riparian habitat summary** (i.e. ecological aquatic refuge importance ranking; riparian condition rating; connectivity value; restoration potential; investment priority and management priorities. The assessment was conducted using a field-based, qualitative assessment approach.

Presently, the Diamantina-Warburton River system in SA is an unregulated system and an important biodiversity corridor. It is critical natural flow and connectivity patterns are maintained to ensure healthy ecosystem function. This work also contributes to addressing Water Affecting Activities (WAA) and Water Allocation Planning (WAP) for the SA Arid Lands NRM region.

The key findings from this habitat values assessment study emphasises the importance of the Diamantina reach (Management Unit 1) that includes Andrewilla and Yammakira waterholes which provide high ecological value aquatic refuges within the SA section of the Diamantina River catchment. Findings emphasised there is low tourist visitation rates and negligible mining activity consequently infrastructure development affecting riverine waterholes and floodplain environments is currently low. There is moderate to high impact on vegetation structure from stock grazing and feral herbivore activity at some waterholes. The system is generally well managed, weed infestation is low and feral animal control is on-going maintaining relatively low numbers of invasive species.

The cultural significance of permanent waterholes, such as Andrewilla and Yammakira, elevates their importance ranking and is the foundation of many Dreaming stories. It is hoped a combined approach to their management is a key legacy of the project whereby Traditional Owners actively participate in research, monitoring and management decisions and activities.

With no large-scale hydrological modifications, the Diamantina and Warburton River wetlands are resilient systems that depend on maintenance of natural flow regimes; absence of flow modification and water abstraction; and variable flooding frequencies. Flooding is a major disturbance, providing the key driver for species dispersal, recruitment and regeneration, nutrient flow and generally re-setting human induced impacts on ecosystem structure and function. Maintaining strategic weed and pest animal management programs; reducing total grazing pressure; and managing recreational visitor impacts on accessible and well-used waterholes is a key factor in maintaining the integrity of these wetlands.

There is a unique opportunity to maintain the Diamantina catchment in South Australia as a relatively 'natural' aquatic ecosystem due to its current state and condition and land-use priorities. This opportunity is not available in many other major inland river systems where modifications to natural flow and water diversions have severely altered the ecological functioning of these systems. The waterholes and wetlands of the Diamantina River catchment must be valued and a vigilant eye kept on its sustainable management through mitigating against threats and pressures and continuing to gain a greater understanding of its ecological functioning, system dynamics and cultural importance through ongoing research and community collaboration.

1.1 Recommendations

- Undertake further research and monitoring and expand the number of sites investigated to include under-represented research areas such as Eyre Creek sites; the lower Warburton including Kalaweerina Creek wetlands at the confluence of the Macumba and Kallakoopah Creek with Kati-Thanda-Lake Eyre; sites in the eastern overflow region including Gumborie Creek; sites along Kallakoopah Creek; and most importantly greater coverage of Goyder Lagoon wetland.
- Use the proposed Management Zones to inform management decisions including water affecting activity assessments.
- Develop best practice grazing management strategies at key permanent and semi-permanent waterholes and trial grazing management strategies at high value sites in partnership with stakeholders (i.e. Pastoralists and Traditional Owners)
- Establish a monitoring site at the D-split site to improve understanding of a 'reference site' habitat and use this as a benchmark for riparian habitat recovery projects (e.g. grazing management exclusion zone).
- Develop best practice design and construction for infrastructure development at riverine and floodplain environments.

2 Introduction

The Georgina-Diamantina (G-D) catchment is an extensive freshwater system covering a large portion of central and south-west Queensland forming one of the major river systems of the Lake Eyre Basin (LEB). The catchment is influenced by highly variable and unpredictable rain events that have a major influence on flow patterns and ecosystem responses in the lower section of the catchment in South Australia.

The study area is the southern downstream extent of the Georgina-Diamantina River catchment, located in the far north-east of South Australia (Fig1). The lower reaches of the Diamantina River includes the Warburton River and Kallakoopah Creek. The Diamantina-Warburton River system in South Australia covers an area of approximately 31 500 km² from the South Australian-Queensland border to Kati Thanda- Lake Eyre. Eyre Creek brings streamflow from the Georgina catchment into the north-western side of Goyder Lagoon and forms the junction between the Diamantina and Georgina catchments.

The main land use is pastoralism and the fertile floodplains of the Warburton River and Goyder Lagoon support a healthy cattle grazing industry. The outback experience attracts large numbers of visitors travelling the Birdsville Track, however, there are limited opportunities to interact with the main river systems due to limited access points to river frontages.

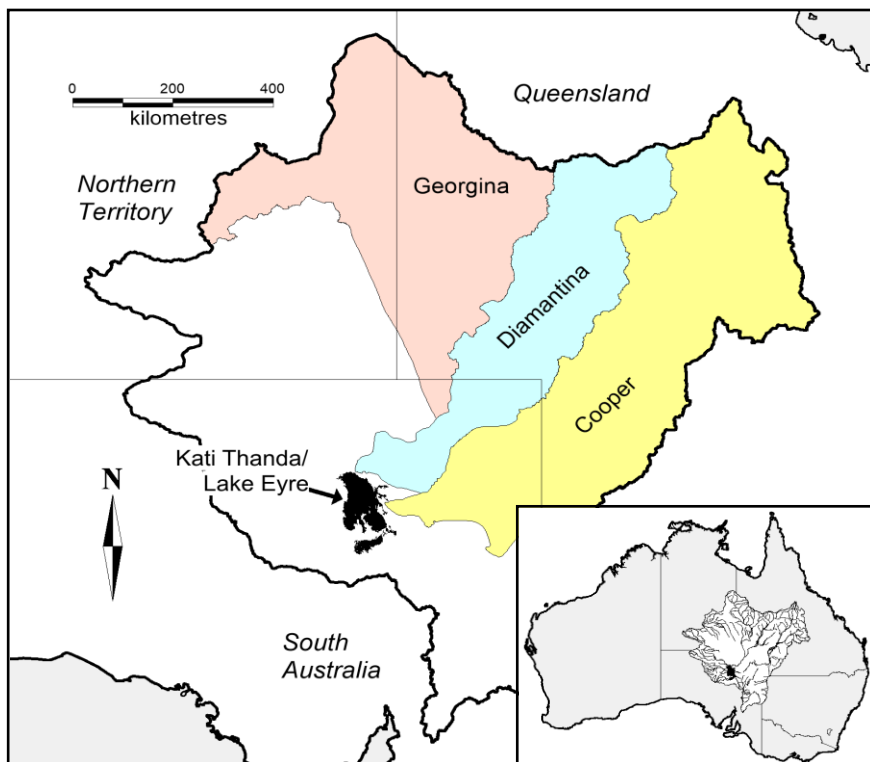


Figure 1 Map of Lake Eyre Basin

The geomorphology of the Diamantina-Warburton River System varies between channelised sections downstream of Birdsville and Warburton River, and the vast floodplain of Goyder Lagoon. Andrewilla and Yammakira Waterholes are the deepest and most permanent waterholes in this section of reach. Goyder Lagoon is an ecologically significant and economically important wetland habitat supporting large numbers of waterbirds when inundated and extensive forage for cattle production.

2.1 Project background and aims

This Riparian Habitat Values Assessment report is one component of a broader project supported by the South Australian Arid Lands (SAAL) Natural Resources Management (NRM) Board titled *Improving habitat condition and connectivity in SA's channel country* referred to as the 'Channel Country Project'. Funding was provided by the Australian Government. The project time frame was from July 2013 to June 2017.

The 'Channel Country Project' implemented a holistic approach to data gathering and analysis through a multi-disciplined project team structure to improve understanding of the Diamantina River, Warburton River and Kallakoopah Creek and associated wetlands in South Australia. This landscape scale approach provides a means of assessing a broad range of habitats and aims to not only assess biodiversity issues but also address issues relating to local business enterprises (pastoralism; tourism; conservation, mining & exploration); the challenges of climate change; and the health and social benefits of the environment. This report is one component of this assessment. The range of investigations included coolibah (*Eucalyptus coolabah*) recruitment, distribution and autecology; hydrological monitoring and assessment; geomorphological assessment; cultural/social landscape assessments; aquatic ecology (fish monitoring); terrestrial ecology assessments of plants, soils and birds; and riparian habitat values and condition assessment.

The main focus of this report was to document the values and assess the ecological character of high value aquatic ecosystems using a qualitative habitat values assessment protocol with particular focus on permanent and semi-permanent waterholes along the SA section of the Diamantina-Warburton River system.

Wetlands have high biodiversity and conservation value. They are also highly valued for their economic, aesthetic, cultural and recreational values. Healthy wetlands also add to the capital value of a grazing property due to the environmental services they provide for pasture and grazing requirements. Understanding and acknowledging the environmental and economic benefits of wetlands is vitally important. For this reason an understanding of the values associated with their ecological function, natural processes and vulnerability is critically important.

The riparian habitat values assessment of the Diamantina-Warburton River System improves the current inventory of wetland assessments. The key aims of this work are to:

- Collect qualitative data on the ecological, cultural, and economic values of a representative sample of waterbodies to create a basis for investment priority, restoration potential and importance rating
- Identify threats and pressures to the system and identify management implications
- Contribute to Water Affecting Activities (WAA) assessment procedures and to inform Water Allocation Planning (WAP) in the SA Arid Lands NRM region

2.2 Diamantina-Warburton River description

Flow patterns in the Diamantina River are highly variable, unregulated and driven by monsoonal summer rainfall in the upper catchment area of Queensland. Large flood events are typically associated with these climatic monsoonal events with varying degrees of flood extent and flow volumes. The Diamantina River flows approximately 900 km from central Queensland to Lake Eyre North and is the major contributor of floodwaters to Kati Thanda-Lake Eyre. It flows through the characteristic broad expanses of the Channel Country in Queensland to form a single channel as it enters South Australia. It then flows into the broad floodplain of Goyder Lagoon to subsequently form the Warburton River. The Georgina River connects to the Diamantina-Warburton River System via Eyre Creek entering at Goyder Lagoon. Eyre Creek is a major tributary of the Georgina River catchment that contributes flow into Goyder Lagoon on average every five years.

Downstream of Birdsville the system flows through four pastoral stations and at its lower section Kalamurina Wildlife Sanctuary. The system is unregulated and although riparian habitat and vegetation has been impacted through historic grazing pressures the system is relatively intact. The Diamantina catchment in South Australia has two important permanent waterholes Andrewilla and Yammakira both feeding into the vast Goyder Lagoon. The region is subject to extreme droughts with the median annual rainfall ranging from 150-250mm in the SA sections of the catchment.

The Diamantina River splits into two main channels upstream of the north eastern boundary of Clifton Hills and Pandie Pandie. A short distance after entering Clifton Hills Station both channels merge into the network of minor channels and swamps at Goyder Lagoon. The Georgina river floodplain intersects the Diamantina floodplain at the downstream part of Goyder Lagoon from this point the watercourse forms the Warburton River channel and floodplain that flows to Kati Thanda-Lake Eyre. Coolibah, Broughton willow (*Acacia salicina*), whitewood (*Atalaya hemiglauca*) and Queensland bean tree (*Bauhinia gilva*) are

the dominant tree species found lining the channels forming a thin riparian vegetation corridor along the river and waterholes and the more frequently inundated floodouts. Lignum (*Duma florulenta*) is the main shrub species and is ubiquitous along the entire Diamantina-Warburton channel system creating a dense understorey at some locations providing streambank stabilising vegetation by lining the channels and waterhole edges. Lignum is also common on the floodplain together with old man saltbush (*Atriplex nummularia*), and Queensland bluebush (*Chenopodium nummularia*) with some floodplain areas supporting dense stands of canegrass (*Zygochloa paradoxa*). Ruby saltbush (*Enchylaena tomentosa*) is another main perennial understorey species common along the entire length of the Diamantina-Warburton. There is a proliferation of unpalatable goathead (*Sclerolaena bicornis*) and other disturbance species such as large pigweed (*Portulaca intraterranea*) and caltrop (*Tribulus eichlerianus*) at heavily grazed sites

2.3 Key findings overview

The key findings emphasise the importance of the channelised Diamantina reach that includes Andrewilla and Yammakira waterholes. These waterholes feed into Goyder Lagoon, a significant wetland providing important habitat for large concentrations of waterbirds during flood events. These systems contribute the greatest ecological value in terms of aquatic refuge and waterbird breeding sites within the SA section of the Diamantina River catchment due to permanency, depth and consistent annual flow conditions. The cultural values associated with permanent waterholes also elevate their importance ranking.

The system is self-regulating (in terms of available forage) with a high degree of variability ranging from wet periods with extensive flooding and extremely hot dry periods. The system is generally well managed and feral animal control is on-going contributing to the low numbers of invasive species. Heavy stock grazing, both historically and more recently, has impacted some waterholes with modification to riparian vegetation structure an adverse consequence.

Grazing impacts have occurred in the vicinity of more permanent water sources on the Diamantina and Warburton River. For example, the sandy clay soils associated with Andrewilla waterhole are susceptible to erosion and the loss of perennial vegetation cover has resulted in extensive areas of moderate to severe scalding in the vicinity of this waterhole. Project findings emphasised there was moderate to high impact on vegetation structure from stock grazing and feral herbivore activity with all sites showing some degree of grazing pressure with slightly over half (13 of 22 sites) in the low to moderate range and the other 9 sites rated as having moderate to high total grazing pressure.

Tourism and recreation activity is seasonal with few access points to river frontages, consequently tourist visitation rates are low. There is also negligible mining activity. Consequently infrastructure development affecting waterhole and floodplain environments and natural flow regimes is currently low reducing external pressures on the system at the landscape scale. However, the region is increasingly becoming popular with tourists seeking an 'outback' experience and exploration activities are slowly gathering momentum.

With no large-scale hydrological modifications, the Diamantina and Warburton River wetlands depend on maintenance of natural flow regimes, absence of flow modification and water abstraction and variable flooding frequencies. Flooding is a major natural disturbance, providing the key driver for species dispersal, recruitment and nutrient exchange and generally re-setting human induced impacts and pressures on these ecosystems

Maintaining weed and feral animal control strategies and managing grazing pressure and recreational impacts on accessible and well-used waterholes is a key factor in maintaining the integrity of these waterholes and wetlands.

2.4 Site selection and conditions encountered

Site locations were selected based on spatial distribution along the system representative of key aquatic refuges, permanence, wetland type, condition and hydrological connectivity. This study aimed to assess the bio-physical, ecological, social and cultural values of waterbodies located the length of the SA section of the Diamantina River catchment. The project will provide an improved understanding and help address the current lack of knowledge of the Diamantina River catchment.

A number of waterholes ranging from permanent and semi-permanent waterbodies and saline pools were selected to provide a representative sample from 4 management reaches identified during the broader Channel Country Project. These management zones were based on flow distribution; floodplain connectivity; aquatic refuge value; and geomorphological characteristics.

Table 1 Sites, associated management zones and features

Wetland Site	Management Unit / reach	Persistence / flow frequency	Cease to flow depth (m)
Andrewilla WH	Diamantina main channel	Permanent / annual	6.00
Burt WH	Goyder Lagoon	Semi-permanent / annual	0.80
Cliff Camp WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	0.80
Cowarie Crossing	Warburton - Kallakoopah	Semi-permanent / 1-2 years	2.00
D-split	Diamantina main channel	Permanent / annual	7.35
Double Bluff WH	Diamantina main channel	Permanent / annual	1.35
Goyder Lagoon WH	Goyder Lagoon	Semi-permanent / annual	2.10
Kalamunkinna WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	1.00
Koonchera WH	Goyder Lagoon	Permanent / annual	1.75
Kuncherinna WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	2.60
Mia Mia WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	0.50
Mona Downs	Warburton - Kallakoopah	Semi-permanent / 1-2 years	2.15
Pelican WH	Goyder Lagoon	Semi-permanent / 1-2 years	2.60
Stony Point WH	Warburton - Kallakoopah	Semi-Permanent / 1-2 years	2.40
Tepamimi WH	Eyre Creek	Bore-fed / 5 years	2.10
Tinnie Landing	Warburton - Kallakoopah	Semi-permanent / 1-2 years	2.25
Ultoomurra WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	2.20
Wadlarkaninna WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	1.50
Windmill WH	Diamantina main channel	Permanent / annual	3.00
Yammakira WH	Diamantina main channel	Permanent / annual	6.00
Yellow WH	Warburton - Kallakoopah	Semi-permanent / 1-2 years	0.50
Yelpawaralinna WH	Goyder Lagoon	Semi-permanent / 1-2 years	2.40



Figure 2 Project assessment sites

The Channel Country project followed 2 years of marked La Nina episodes in the Diamantina catchment from 2010-2012 where there was above average rainfall and extensive regional flooding. By the beginning of 2012 extreme dry conditions were experienced and by the start of the project sampling period in April 2014, conditions were extremely dry. During the third year of sampling, in May 2016, the region experienced above average rainfall and moderate regional flooding. The middle year sampling (2015) was average with dry conditions prevailing. These variable weather patterns enabled assessments to occur during major hydrological and ecological changes that regularly take place in LEB Rivers and record the responses associated with extremely dry conditions; extensive rain events; and periodic seasonal and intermittent flooding. The extensive flooding and rainfall in the latter stages of the project made access to some sites difficult and, therefore, fewer sites were able to be assessed, including Eyre Creek waterholes and Goyder Lagoon sites.

Across the four Management Zones 22 sites were comprehensively assessed over three sampling periods (April-May 2014, April-May 2015, and April-May 2016). Their importance ranking as ecological aquatic refuges; condition rating; connectivity value; restoration potential; and investment priority were determined. Waterholes surveyed included deep waterhole aquatic refuges usually located within main channels that receive annual flow; main channel waterholes of varying cease to flow depths (CTFD), salinity levels and inundation / flooding frequencies; off-channel waterholes that connect with the main channel during larger flooding events; and outer floodplain waterholes that receive flow less regularly.

2.5 Identified management zones

Management zones were based on channel flow distribution; floodplain connectivity; aquatic refuge value; and geomorphological characteristics.

Management reaches identified as 4 distinct zones:

1. Diamantina main channel – SA border to Goyder Lagoon includes Andrewilla and Yammakira Waterholes – 2 important and highest ranked aquatic refuges – receives an annual flow
2. Goyder Lagoon – from Andrewilla and Yammakira distributary channels to commencement of the Warburton River channel- receives flow annually
3. Warburton - Kallakoopah – commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path – receives flow approximately every 1-2 years – less frequent for Kallakoopah Creek
4. Eyre Creek – South Australian border to Goyder Lagoon - receives flow on average every 5 years

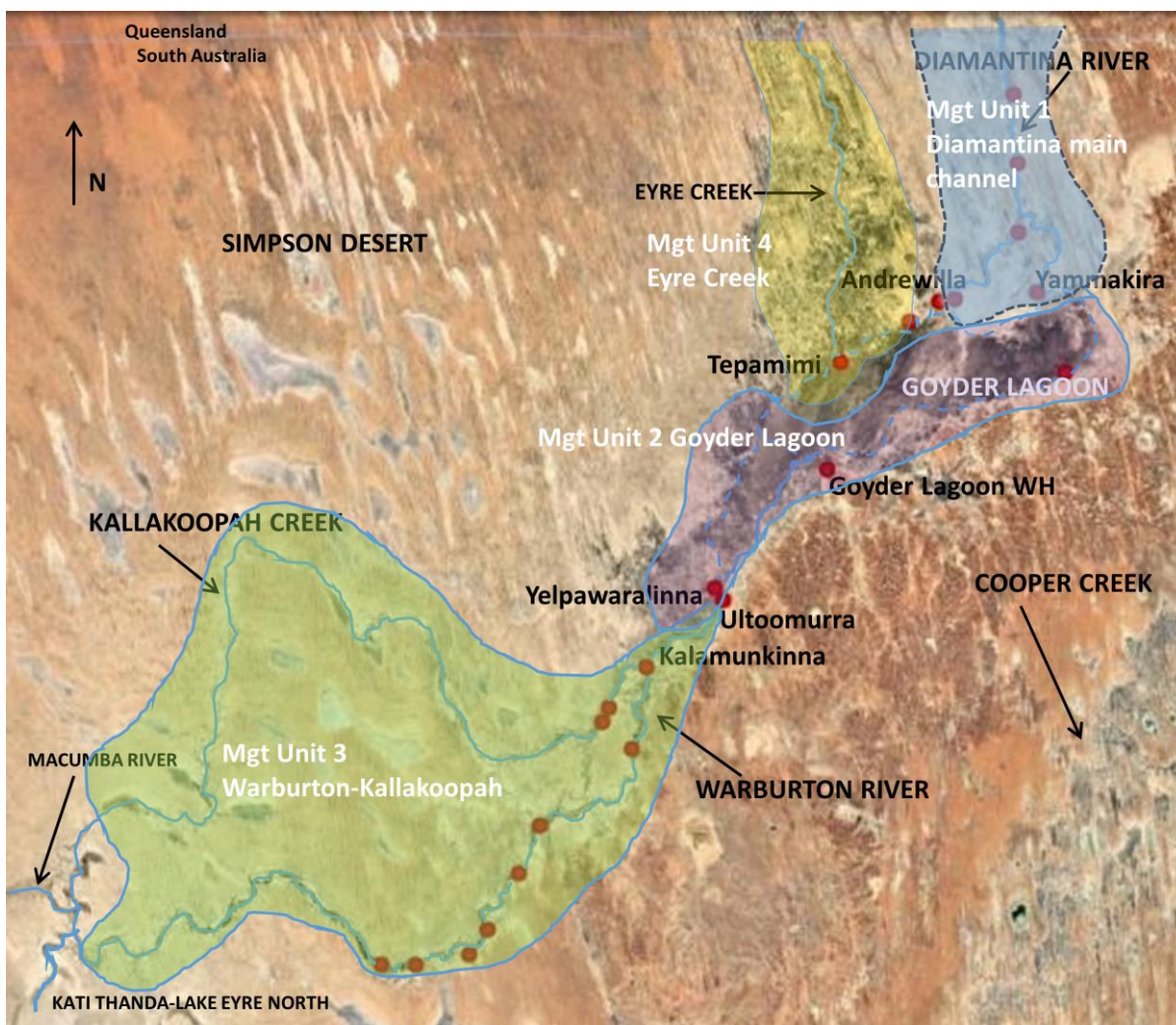


Figure 3 Management Zones

2.6 Riparian habitat values assessment

The Diamantina and Warburton River wetlands have high conservation value. Goyder Lagoon is a vast floodout network of braided and anastomosing channels and floodplain that has high conservation value, yet is poorly researched and understood. These wetlands are also highly desirable for their aesthetic, cultural and recreational values. Healthy wetlands also add to the capital value of a grazing property for the environmental services they provide for pasture and grazing requirements.

Assessing the natural, cultural and economic values associated with riparian habitats is a valuable investment in understanding and protecting these key natural assets. It provides a basis to manage and protect biodiversity and identify changes in vegetation structure over time. It also assists in strategic natural resource management decision making, investment prioritisation and tracking the effectiveness of protection and restoration activities.

Together with this baseline data, identification and assessment of current and potential threats and pressures and identification of management implications are provided. These pressures include increasing tourism activity; invasive species (buffel grass, prickly bushes; feral pigs, cane toads, gambusia, goldfish, rabbits and camels); cattle grazing impacts along riparian zones particularly the well-watered permanent waterholes; potential increase in infrastructure development through exploration, mining and pastoralism activities (tracks; bores; bridges; levees); soil disturbance; climate change scenarios; and water extraction and regulation of natural flow regimes in upper Queensland reaches.

Riparian vegetation is a key component of the Channel Country particularly perennial, long-lived structural canopy species, such as coolibah. The episodic establishment of these species after the recession of large floods is an important process linked to variable and natural hydrological regimes (flooding) where extensive seedling recruitment would normally be expected to occur. The structural complexity of riparian zones is linked to the presence or absence of perennial plant species (particularly coolibah) and species that form upper canopy, mid-stratum, lower stratum and ground layer cohorts. This contributes to ecosystem functioning through providing suitable habitat and nesting sites for birds; food and shelter for terrestrial fauna; conditions suitable for nutrient production and transfer; and amenable seed germination conditions. Maintaining structural vegetation integrity provides connectivity pathways along river systems and adjoining wetlands and floodplains and serve as corridors for movement through arid zones.

Generally, Diamantina and Warburton River riparian ecosystems were assessed to be in good to moderate condition apart from a few heavily impacted waterholes. An improved understanding of the ecological condition of high priority waterbodies is critical to balance their environmental needs against current and future demand for water resource and riparian habitat use. The attributes used to assess riparian ecosystem condition involve assessment of structure; function; and plant species richness.

2.7 Summary of key threats and pressures

- Water resource development (i.e. potential for upstream irrigation, flow diversions and dams) affecting natural flow and the variable hydrological regime.
- Overgrazing through total grazing pressure (including invasive herbivores) causing loss of vegetation cover, increased erosion, and destabilisation of stream bank integrity leading to a reduction in riparian plant and habitat diversity.
- Weed invasions establishing permanent populations from upper reaches in Queensland and moving into South Australia impacting and modifying the natural biotic systems.
- Increased feral animal populations, such as feral pigs and camels; and increase in aquatic pest species (e.g. gambusia, goldfish, sleepy cod) affecting native fish assemblages; potential cane toad infestation from upper reaches in Queensland and moving into South Australia impacting native fauna populations and modifying the natural biotic systems
- Climate change scenarios that may cause an increase in temperature leading to increased evaporation, longer drought conditions, reduced periods of inundation, higher intensity flood sequences and a decrease in waterhole permanency.

- Infrastructure development such as tracks, levee banks, bridges and roads impeding connectivity, natural flow and inundation, and movement of aquatic species.
- Recreation and tourism activity causing impacts at waterhole sites through compaction and trampling and removal of firewood leading to loss of groundcover and increased soil disturbance potentially causing an increase in invasive weed species and disturbance to terrestrial fauna habitat and nesting bird habitats.
- Contamination and pollution of aquatic ecosystems, mainly from extractive mining industries, leading to impacts on biota and organic grazing enterprises due to exposure to toxicants and hydrocarbons.
- High nutrient concentrations causing excessive algal growth and anoxic conditions detrimental to aquatic species.
- Unsustainable resource use such as illegal fishing or over fishing causing loss of source populations of adult breeding fish and turtles from permanent waterholes.

3 Methods

3.1 Background

The methodology for this study is adapted from the Riverine Vegetation Indicator Protocol for river health (DEWHA 2009). The work provides a summary of values, threats and pressures at a number of permanent and semi-permanent waterhole and wetland environments. A desirable outcome in investing in a values assessment protocol is to gain a better understanding of the ability of natural aquatic ecosystems to “resist” unfavourable conditions and bounce back (resilience) when conditions are favourable.

The first step in prioritising assets for management and investment is to focus on the appropriate scale for an improved biodiversity outcome and to provide an assessment of the ecological, cultural and economic values associated with these assets. The assessments and results are placed within a landscape context due to the relatively unmodified ecosystems of this arid zone river system. Information presented will in particular assist the development of management priorities. This process aims to provide the capacity to rapidly and cost-effectively assess and report on an aquatic ecosystem site. This process is also easily repeatable over time.

Prioritisation for investment is targeted at sites that have the highest value as an aquatic ecosystem refuge within the catchment as well as those that have the greatest recoverability potential in relation to current management regimes, investment and intervention. Sites that are heavily impacted may have a low priority for investment due to their reduced recovery potential. Sites that are ecologically intact may also have a lower priority for investment due to current environmental conditions, landuse and management systems. The ecological importance ranking is the key assessment component and provides a guide for long-term management and protection of these natural resources.

3.2 Methodology

The assessment protocol used in this study has been adapted from work previously conducted in the SA Arid Lands region at a number of other catchments, e.g. Gawler Ranges (Jenkins et al 2011); Flinders Ranges (White & Scholz 2008; McNeil et al 2011); Neales Catchment (Scholz & Deane 2011); and Cooper Creek Catchment (Mancini 2013). This allows for a consistent monitoring and reporting framework across the SAAL region with a focus on the management and prioritisation of aquatic ecosystem assets and a sound basis for investment decision-making for on-ground management. This work also contributes to addressing Water Allocation Planning (WAP) and Water Affecting Activities (WAA) objectives. Water affecting activities include impeding flow and draining or discharging into natural watercourses or floodplains.

Assessments were conducted along one bank of each waterhole to determine the current condition and extent of riparian habitat. Traverses of approximately two kilometres along the waterbody riparian zone were undertaken to collate data using the rapid appraisal process. Field survey and assessment criteria are detailed in the assessment sheets (see Appendix A).

3.3 Summary of assessment criteria

There are 4 main components to the Riparian Habitat Values Assessment protocol (RHVAP):

- Site Description and Environmental Setting
- Ecosystem Values, Threats and Pressures
- Riparian Condition Assessment
- Riparian Habitat Summary (*i.e. Ecological Importance Ranking; Ecological Condition Rating; Connectivity Value; Investment Priority; Restoration Potential, and Management Priorities*)

The assessment protocol uses a qualitative ‘score card’ approach in assessing ecosystem values, threats and pressures, riparian condition, recovery potential and investment priority. Attribute tables are populated with colour coded ‘ranking scores’.

Site Description and Environmental Setting

This outlines details of site location features (i.e. type of waterbody; use zone; size/area, conceptual understanding, recent rainfall and inundation events, depth of waterbody, elevation, and vegetation association); a comprehensive plant list is also included.

Ecosystem Values, Threats and Pressures

An assessment of the ecosystem values, threats and pressures for each waterbody is provided consisting of 15 attributes. These provide a comprehensive summary of key influences and features that provide a baseline summary and can be easily re-assessed to monitor changes over time.

Ecosystem Values

Riparian plant diversity; riparian habitat diversity; hydrological value; water quality (salinity); cultural site importance; uniqueness; key aquatic refuge.

Ecosystem Threats

Weeds, pest animals, surface and groundwater abstraction, nutrients.

Ecosystem Pressures

Infrastructure development; tourism; camping and recreation activity; bank stability and soil disturbance (e.g. trampling, erosion); and total grazing pressure.

Riparian Condition Assessment

This assessment considered five indicators of site condition for native vegetation cover and quality:

Spatial integrity: Ranks integrity of riparian vegetation associations within riparian areas. This includes:

- *Lateral connectivity* - the width of riparian vegetation (as defined by inundation dependent species);
- *Longitudinal continuity* - continuous cover of dominant stratum along the channel; and
- *Connectedness* of the riverine vegetation to other areas of native vegetation (riparian or terrestrial).

Nativeness: Ranks riparian vegetation based on the proportion of 'nativeness' relating to non-native and high threat species and the abundance of non-native and high threat species in different strata.

Structural integrity: Ranks number of strata represented in riparian vegetation based on a 'best on offer' community.

Age structure: Ranks age structure of riparian vegetation for each strata present (juveniles, sub-adults, and adults). Cover of canopy species. Presence (or abundance) of different age stages. Presence (or abundance) of large old trees.

Debris: Ranks amount of debris within riparian vegetation based on a 'best on offer' community. Abundance of fallen logs. Presence (or abundance) of standing dead trees and cover of litter.

Riparian Habitat Summary

For each site **Ecological Aquatic Refuge Importance Ranking**; **Riparian Condition Rating**; **Connectivity Value**; **Restoration Potential**; **Investment Priority**; and **Management Priorities** are provided.

- **Ecological / Aquatic Refuge Importance Ranking**: Value of waterbody as a critical refuge rated high, moderate, low
- **Riparian Condition Rating**: Riparian habitat condition rated high, moderate, or degraded
- **Connectivity Value**: Value of riparian habitat to facilitate species dispersal and recruitment rated high, moderate, low
- **Restoration Potential**: Riparian recovery potential rated high, moderate, low
- **Investment Priority**: Investment according to condition, importance ranking and current management rated high, moderate, low
- **Management priorities**: Management interventions rated high, moderate, low

4 Results and discussion

4.1 Overview

Twenty two sites were assessed. Generally ecological riparian condition was rated as good for nine sites with four sites of 22 rated low due to past and current grazing pressure. The remaining nine sites were rated moderate. In particular the importance of Andrewilla and Yammakira Waterholes was emphasised due to their permanency, depth and importance as drought refuge waterholes. A number of waterholes have been assessed to have a significant grazing management issue that can be attributed to long-term and historic grazing pressure. Continued recovery of these areas will depend on conservative stocking rates and opportunistic spelling to improve leaf litter and groundcover; enable natural vegetation recruitment; and annual and perennial species establishment. These sites include Andrewilla, Yammakira, Goyder Lagoon Waterhole, Burt, Double Bluff, Koonchera, Tepamimi, Yelpawaralinna, Mona Downs and Kuncherinna waterholes.

Recreation and tourist activity was found to be minimal at all study sites due to the limited access to the Diamantina and Warburton main channels and associated waterholes. Vegetation responses such as coolibah germination and recruitment were lower than expected with coolibah seedlings largely absent at most of the grazed sites. Presently the system is not greatly impacted by any serious weed infestations; however, Buffel Grass (*Cenchrus ciliaris*) poses a serious future threat if control is not implemented where outbreaks occur. Athel Pine (*Tamarix aphylla*) has re-established at one site however there was no evidence of any new recruits or spread along the watercourse.

Feral animal numbers were moderate with rabbit activity, camels and feral pigs present at some sites. There was minimal new infrastructure or development impeding natural flow on channels or floodplains.

4.2 Reference areas

There were few areas assessed that provide 'reference' conditions due to the long-term grazing history in the region. It is therefore difficult to gauge long-term grazing impact and recovery in the frequently inundated areas of floodplains and well-watered, more permanent and semi-permanent waters where cattle tend to congregate. This means that 'reference' areas are not available and only 'best on offer' sites can be used to determine trends in habitat and vegetation condition.

Riparian zones are typically the most heavily vegetated sites, forming a thin vegetated corridor that receives frequent inundation providing suitable conditions for seed germination as well as flushing processes lowering soil salinities and maintaining fresher groundwater for plant growth. There are few riparian sites that have not been disturbed from grazing pressure and therefore are in varying states of recovery depending on current stocking rates, grazing regimes, and presence / absence of total grazing pressure from cattle, rabbits and camels. A recovery trajectory would be expected at waterhole sites where there is less intensive grazing, however, most permanent and semi-permanent waterholes are not totally fenced off from grazing and therefore it is difficult to gauge recovery.

The Kalamurina sites offer an insight into a recovery trajectory due to destocking and absence of cattle graze. However rabbits are present in large enough numbers to contribute to grazing pressure that may impact seedling recruitment.

A site that offered a 'best on offer' 'reference' type condition was at Diamantina-split (D-split). This site has had minimal recent cattle grazing, in contrast to the adjoining paddock, and with low rabbit activity demonstrates obvious signs of recovery. The recovery is probably over a timeframe of 40-50 years with previous tree removal for fence posts a significant disturbance. Plant species richness was not high, however, the site was stable and provided a good example of structural vegetation integrity with high percentage leaf litter and woody debris; and high mid-stratum vegetation and tree canopy cover. Consequently, this rich habitat supported a rare bird with identification of a spotted bowerbird that was thought to be extinct in SA. The site was located on an inner meander bend with expected higher productivity due to higher deposition and deeper soil profiles found on these deposition zones and consequently a wider riparian corridor supporting greater lateral vegetation extent.

Areas of low disturbance are important from a regional conservation perspective as they may contain comprehensive assemblages of plant species and important riparian habitat for a range of animal and bird species. They provide examples of recovery and 'reference' conditions that contribute to ecosystem resilience.

It is recommended this site is nominated as a 'reference site', fenced from grazing, grazing strategies implemented and monitoring continued to provide valuable baseline data on plant, bird, and terrestrial species presence and absence and use this site as a benchmark for riparian habitat recovery projects.



Figure 4 High value riparian habitat showing good structural vegetation and high percentage woody debris and leaf litter cover at D-split waterhole, Diamantina River

4.3 Survey findings

The findings of this study are based on observations and attribute data that provide an overview of the values associated with a range of riparian sites. These attributes are assessed qualitatively and will primarily reflect total grazing pressure, presence of introduced plant and animal species, visitor impacts and infrastructure development, e.g. tracks; culverts and levees. It was clear from the values assessment surveys that grazing pressure is a prime determinant of riparian condition around waterholes in the Diamantina River catchment.

Organic matter cover (including leaf litter and woody debris) is an effective visual indicator of waterhole condition as it influences riparian vegetation integrity; water quality; sedimentation; and bank erosion. It is important to note that bare areas do not infer grazing pressure as there will be a shear zone or bare area adjacent to the watercourse at some locations with only a few groundcover species present. Naturally bare areas are also common due to natural salinity gradients and during dry periods at sites with deep cracking clays or at small channels back from the main channel or waterhole.



Figure 5 Riparian vegetation and streambank shear zone exposing banks to natural flow events

As an overview all management reaches were assessed as being in a generally acceptable condition and reflects the effectiveness of current management practices. Although it must be noted the permanent waterholes, river channels and associated floodplains are regarded as 'sacrifice zones' subjected to more intensive grazing pressure. Vegetation changes associated with historical grazing has had an influence across the sites, however, it is difficult to make objective judgments regarding the current condition of riparian habitats due to lack of data describing conditions prior to existing land use.

The most discernible and widespread impact was 'moderate to high' grazing impacts to riparian vegetation at some sites, particularly the more permanent waterholes. Project findings emphasised this with all sites showing some degree of grazing pressure with slightly over half (13 of 22 sites) in the low to moderate range and the other 9 sites rated as having moderate to high impact on vegetation structure from stock grazing and feral herbivore activity.

The riverine vegetation associated with the Diamantina and Warburton is dominated by coolibah with decreasing canopy and tree height down the system to Kati Thanda-Lake Eyre. The associated floodplains are more sparsely vegetated, with coolibah the dominant tree species. Surveys emphasised groundcover is dominated by Ruby saltbush (*Enchylaena tomentosa*) the mid-stratum understorey by Broughton willow (*Acacia salicina*), *A. stenophylla* (cooba); and lignum (*Duma florulenta*). In the upper reaches of the system where there is more regular freshwater inflow the upper stratum comprises coolibah and Queensland beantree (*Bauhinia gilva*).

Lignum typically occurs on cracking or heavy clay soils of floodplains or wetlands prone to periodic inundation, as well as forming fringing corridor vegetation beside major and minor drainage lines. On account of its wide distribution; local dominance; distinctive character; importance as habitat; and providing streambank stability, Lignum is considered one of the most significant floodplain shrubs in arid river systems.

At Andrewilla and Kuncherinna Waterholes, lignum and ground cover and litter was heavily reduced due to past and more recent cattle activity. Soils were heavily impacted with loss of surface soil structure and lack of groundcover potentially exposing the site to further erosion and increased soil loss.

The majority of the waterbodies in the upper Diamantina reaches; at the Kallakoopah sites; and Goyder Lagoon management zone sites were fresh with salinities generally <500EC ($\mu\text{S}/\text{cm}$). These waterbodies were sampled at near to cease to flow depths, the waterholes did not show high salinities and were relatively fresh due to being flushed by recent flows and filled by localised rainfall events. The lower Warburton had higher salinities grading to hyper-saline conditions due to intermittent flood pulses concentrating salts during flow events. As the water levels recede and there are no flood pulses through the system

salinities increase. This is due to very low water levels not flushing salts through the system and higher evaporation rates increasing salt levels (Costelloe et al 2004).

The influence of grazing as a source of disturbance on vegetation structure, age class and density was evident at sites where there was recent stock access and feral herbivore activity. Grazed sites featured little or no regeneration of tree and shrub species as well as severe impacts on mid and lower stratum vegetation.

The study identified a number of sites, i.e. Mona Downs; Kuncherinna; Andrewilla, Yammakira and Tepamimi waterholes where perennial vegetation were grazed and sub adults and adults were heavily damaged and trampled. During the recruitment phase of coolibahs, usually after wet periods, it is important sites where there are new cohorts of germinated coolibah, these are protected from trampling and grazing to allow for seedling establishment to occur. In the arid zone, riparian ecosystem impacts may take many years to recover. The loss of important structural species such as coolibah from these regeneration events will not be fully realised until the surviving adults die off. Also other habitat values provided by canopy species such as wood hollows and submerged woody debris will be lost.

4.4 Cattle grazing

The floodplains and associated waterholes of the Diamantina system have greater productive capacity and therefore carrying capacity compared to the stony country. Generally cattle tend to prefer feed produced on stony country and unless fenced off, typically move from the floodplain to graze on the stony country when forage is available. The area has had intensive historic grazing over many years with thousands of cattle being watered on stock routes for over 100 years.

Suppressed recruitment of perennial vegetation particularly keystone species such as coolibah is a regional issue. It is more likely widespread regeneration will occur with suitable seasonal conditions and regional flooding events combined with low rabbit numbers and conservative grazing practices. Therefore, it is essential conservative grazing management strategies are maintained in order to facilitate the establishment of juveniles through to mature age stands. This may include opportunistic spelling or light stocking particularly following major flooding events to facilitate regeneration and recruitment of perennial species.

It is important that grazing management strategies take into account total grazing pressure when determining stocking rates in paddocks. This means areas where there are large feral herbivore numbers a lower stocking rate should be applied before feral animal control takes place.

4.5 Feral animal impacts

Rabbits

Rabbits are found in all land types, however, they are most prevalent in sand dune and sand plain country and gypsum stony country. Rabbit numbers increase on floodplain country following successive flood and good rainfall seasons. During the assessment period (2014-16) there was a steady increase in activity as the conditions improved with flooding and localised rain events in 2015 and 2016. It is evident Rabbit Haemorrhagic Disease Virus (RHDV), previously known as rabbit calicivirus, and probably myxomatosis over the wetter summer months, has had a major effect on their numbers. There were low numbers observed and only limited areas where active warrens were detected. Low rabbit numbers has meant that total grazing pressure, particularly in sandy country and at waterholes has been reduced. Rabbit grazing is considered responsible for suppressing the regeneration of many tree and shrub species. Coolibah seedling recruitment and juveniles were absent from most sites assessed, however, this must be viewed in the context of total grazing pressure as the most southern sites where grazing has been removed had moderate coolibah recruitment although these were sites preferred for rabbit habitat.

Camels

Camels were in low numbers throughout the study area due to recent large feral herbivore culls taking place on a regular basis. There were typically camels present in the north western areas of Clifton Hills (near Yelpawaralinna, Andrewilla and Tepamimi) and southern areas on Kalamurina (Cliff Camp) as they periodically move in from the Simpson Desert. There was clear

evidence of heavy grazing and damage particularly to perennial tree and shrub species, e.g. Bignonia emubush (*Eremophila bignoniiflora*) and whitewood. A small group was observed at Cliff Camp during the assessment, however, camel numbers were considered to be low during this time. As part of managing total grazing pressure, areas and waterholes prone to build up of camels should be monitored and control programs undertaken on a regular basis to ensure numbers are maintained at low levels.

Feral pigs

Feral pig activity increased as the seasons improved from low evidence of activity in 2014 to greater numbers observed in 2015-2016. This corresponds with conditions becoming wetter and as larger areas were inundated for longer periods. Goyder Lagoon, Andrewilla and Pandie channel waterholes had the highest feral pig activity observed. Where there is good cover and good water supplies numbers will increase and populations sustained. Feral pig control measures through aerial shooting programs as the system dries up will maintain lower population numbers.

4.6 Boredrains

Tepamimi waterhole is the site of an open artesian bore drain with a controlled bore head producing free flowing water into cooling ponds and along a bore drain into the waterhole. Removing or reducing the free flowing of artesian water into bore drains should be a key management goal. A potential lowering of water pressure in the local region is a concern and a policy of piping water to tanks and troughs in a closed system is a priority. The disadvantage of an open bore drain system is the difficulty in regulating grazing pressure from stock and feral animals particularly when the bore drain flows into a waterhole maintaining an artificial permanent water supply such as at Tepamimi.

The bore at Tepamimi is discharging into a short drainage line and into the waterhole maintaining an artificial wetland. This has promoted the proliferation of gambusia also known as mosquito fish (*Gambusia holbrooki*) and together with this permanent water regime could have serious implications for the aquatic biota which is adapted to wetting and drying cycles associated with irregular flooding. The water discharged into the waterhole may also contain high levels of total dissolved solids such as bicarbonates that may be causing the dieback observed in coolibahs on the edge of the waterhole.

It is recommended the bore drain at Tepamimi is decommissioned preventing flow into the waterhole and water use is restricted and maintained as a water-tight delivery system.

4.7 Wildlife conservation

Koonchera Dune, Koonchera waterhole and surrounding wetland, south-east of Goyder Lagoon, are areas recognised for their importance for wildlife and Aboriginal heritage value. Several species of conservation significance are found in this area including the kowari and grey grass wren. Grey grass wrens are found in the lignum and old man saltbush in the vicinity of Koonchera waterhole. It has a restricted distribution and is rated a vulnerable species nationally and in South Australia. It is important Koonchera is managed appropriately to maintain this population.

The Diamantina – Warburton floodplain and channel country includes the vast network of channels and swamps of Goyder Lagoon. This is an important area for wildlife conservation and in good seasons and due to its size and productivity level supports large numbers of waterbirds.

It is recommended further research and long-term monitoring is implemented to monitor changes in flooding frequency and vegetation responses in the face of changing climatic scenarios

4.8 Aquatic refuges

The upstream floodplain of the Diamantina as it enters Clifton Hills Station provides important aquatic refuge and wildlife habitat particularly as a refuge during extended dry periods. Waterholes such as Andrewilla and Yammakira are regarded as permanent and receive annual flow maintaining their permanent aquatic refuge status compared to the more intermittent and

semi-permanent waterholes on the outer floodplains and lower Warburton sites that become hypersaline when the system dries out.

4.9 Management of Diamantina-Warburton River waterholes and wetlands

The Diamantina and Warburton River system is characterised by the highly variable and unpredictable nature of the hydrological regimes of flooding and inundation. This is influenced by periodic rain events in the upper catchment in Queensland. The Diamantina is a dryland river that experiences episodic large floods and extended low or no flow periods. More permanent waterholes are found to persist during dry periods in wide and deeper sections of river channel and usually provide refuge during prolonged dry conditions for a range of aquatic species (Knighton & Nanson 1994).

The persistence of a refuge waterhole is the length of time it contains water in the absence of flow and, therefore, determines the maximum survival time of aquatic biota that resides in it, e.g. fish, aquatic macrophytes, turtles and some macro-invertebrates. It is important to understand the factors which affect waterhole persistence for each management unit. The benefits to understanding persistence of waterbodies provides valuable information to identify key permanent waterbodies that can be managed for stock grazing and to predict changes in persistence under modified flow regimes, for example, flow regulation in the upper Diamantina-Warburton River catchment in Queensland; or climate change scenarios.

The refuge waterholes assessed in this project in the Diamantina main channel are characterised by their larger, deeper and greater complexity. This complexity equates with greater hydrological persistence that supports the relatively larger number of aquatic species in refuge waterholes. Permanent refuge waterholes are significant and important habitats defined to be those that persist for at least 18-24 months in the event that they do not receive inflow during a flood season. To retain water for two years, such waterholes need cease to flow depths (CTFD) of greater than four metres depending on their location so that they are capable of withstanding large annual losses due to evaporation (1.3m–3.0m/year). Long term refuges also require annual inundation events so that the absence of inflow for an entire flood season is a rare occurrence that does not compromise its refuge capacity (Costelloe et al 2004).

For example, Andrewilla waterhole receives annual flow with a cease to flow depth (CTFD) of 6m therefore maintains permanency, whereas Ultoomurra waterhole on the Warburton is considered a semi-permanent waterhole with a CTDF of 2.2m receiving flow every 1-2 years.

During dry periods refuge habitats become reduced and disconnected as pools dry up. Some may be hundreds of kilometres apart in large dry-land rivers such as the Diamantina. These are significant ecological sites that during dry periods are further subjected to intense pressures from stock access and potentially water extraction. These influences have the potential to reduce the habitat quality and their capacity to provide resilience mechanisms for the survival and support of aquatic biota populations.

Andrewilla and Yammakira are permanent waterholes that have long term persistence and do not lose their ability to support aquatic biota during times of environmental stress. These are the key permanent waterholes in the Diamantina catchment in SA and support a representative assemblage of aquatic species for that catchment, including the freshwater turtle. They are classified as 'Ark-type' aquatic refuges that provide habitat conditions where species are able to avoid the impacts of climatic disturbances, such as drought, and are able to recolonise at the landscape / catchment scale. (Robson et al 2008).

Development of artificial barriers (culverts, flood mitigation barriers, crossings etc) have the potential to reduce connectivity between aquatic refuge areas and other parts of the system (e.g. floodplains). This loss of connectivity can reduce the potential for recolonisation from refuges to the remainder of the system and may greatly reduce the capacity for natural recovery causing potential extinctions or a decline in species diversity through reducing long-term viability of populations.

There are several management strategies for arid zone wetlands and aquatic refuge sites. Some sites may require temporarily or permanently removing grazing and conducting weed and feral animal control programs. Other sites may require maintaining 'least disturbance' pressure to facilitate the natural recovery process .

4.10 Key principles for managing aquatic ecosystems

- Maintaining riparian vegetation and lateral connection with floodplain ecosystems
- Management of aquatic refuges within a catchment / landscape scale context
- Visitor management
- Feral animal and weed management and control
- Prioritisation and importance ranking of aquatic refuges
- Monitoring of the function of aquatic refuges after disturbance
- Maintain flow regimes at natural levels and cycles
- Identify aquatic refuges that are adaptive to landscape and climate change



Figure 6 Inside Track – a surface water flow diversion forming a depression channel dewatering the surrounding landscape

4.11 Results for prioritisation

Investment priority is linked to the likely success of recoverability and restoration influenced by the ecological priority ranking; potential threats and pressures; and management regimes currently in place for that site.

Key aquatic refuge and ecological importance ranking is based on its current condition rating; its role as an aquatic refuge; and representativeness as a key aquatic refuge site in the system.

Riparian condition ranking is primarily a measure of vegetation in terms of structural and spatial integrity and measured against the five criteria describing vegetation condition; including *spatial integrity*; *nativeness*; *structural integrity*; *age structure*; *woody debris & leaf litter*.

Connectivity value is rated according to the ability of the habitat to facilitate species dispersal and recruitment.

4.12 Summary of the 22 wetland sites

Table 2 Summary of the field assessments and investment prioritisation

Wetland Site	Aquatic refuge importance	Riparian Condition	Connectivity Value	Restoration Potential	Investment Priority
Andrewilla WH	HIGH	MODERATE	HIGH	MODERATE	HIGH
Burt WH	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
Cliff Camp WH	MODERATE	HIGH	MODERATE	HIGH	HIGH
Cowarie Crossing	MODERATE	HIGH	HIGH	MODERATE	MODERATE
D-split	HIGH	HIGH	HIGH	HIGH	HIGH
Double Bluff WH	HIGH	MODERATE	HIGH	HIGH	HIGH
Goyder Lagoon WH	HIGH	MODERATE	HIGH	MODERATE	HIGH
Kalamunkinna WH	MODERATE	HIGH	HIGH	MODERATE	MODERATE
Koonchera WH	HIGH	MODERATE	HIGH	HIGH	HIGH
Kuncherinna WH	MODERATE	LOW	MODERATE	LOW	MODERATE
Mia Mia WH	MODERATE	HIGH	MODERATE	HIGH	MODERATE
Mona Downs	MODERATE	LOW	MODERATE	LOW	MODERATE
Pelican WH	MODERATE	HIGH	MODERATE	HIGH	MODERATE
Stony Point WH	MODERATE	HIGH	HIGH	MODERATE	MODERATE
Tepamimi WH	HIGH	LOW	MODERATE	MODERATE	HIGH
Tinnie Landing	MODERATE	HIGH	MODERATE	HIGH	HIGH
Ultoomurra WH	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
Wadlarkaninna WH	MODERATE	HIGH	MODERATE	HIGH	HIGH
Windmill WH	MODERATE	MODERATE	HIGH	MODERATE	MODERATE
Yammakira WH	HIGH	MODERATE	HIGH	MODERATE	HIGH
Yellow WH	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
Yelpawaralinna WH	MODERATE	LOW	MODERATE	LOW	HIGH

Key to rating criteria: HIGH  MODERATE  LOW 

Management Unit (MU); Diamantina main channel (MU1); Goyder Lagoon (MU2); Warburton River (MU3); Eyre Creek (MU4); KWS = Kalamurina Wildlife Sanctuary; WH = waterhole

5 Summary and recommendations

5.1 Summary

This study has provided an overview of the biophysical, economic and cultural values associated with the Diamantina-Warburton River system in SA and will contribute to addressing Water Affecting Activities (WAA) and Water Allocation Planning (WAP) for the SA Arid Lands NRM region. This provides greater certainty in decision-making and clarity in managing these important natural resources.

There is a unique opportunity to maintain the Diamantina catchment in South Australia as a relatively 'natural' aquatic ecosystem due to its current state and condition. This opportunity is not available in many other major inland river systems where modifications to natural flow and water diversions have severely altered the ecological functioning of these systems. The waterholes and wetlands of the Diamantina River catchment must be valued and a vigilant eye kept on its sustainable management through mitigating against threats and pressures and continuing to gain a greater understanding of its ecological functioning, system dynamics and cultural importance through ongoing research and community collaboration.

5.2 Recommendations

- Undertake further research and monitoring and expand the number of sites investigated to include under-represented research areas such as Eyre Creek sites; the lower Warburton including Kalaweerina Creek wetlands at the confluence of the Macumba and Kallakoopah Creek with Kati-Thanda-Lake Eyre; sites in the eastern overflow region including Gumborie Creek; sites along Kallakoopah Creek; and most importantly greater coverage of Goyder Lagoon wetland.
- Use the proposed Management Zones to inform management decisions including water affecting activity assessments.
- Develop best practice grazing management strategies at key permanent and semi-permanent waterholes and trial grazing management strategies at high value sites in partnership with stakeholders (i.e. Pastoralists and Traditional Owners)
- Establish a monitoring site at the D-split site to improve understanding of a 'reference site' habitat and use this as a benchmark for riparian habitat recovery projects (e.g. grazing management exclusion zone).
- Develop best practice design and construction for infrastructure development at riverine and floodplain environments.

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7 Appendix A

7.1 Riparian habitat assessment scoring system

The prioritisation for investment of Diamantina-Warburton River waterbodies requires evaluating which ecosystems have the greatest contribution and value as an aquatic ecosystem refuge within the catchment and those that have the greatest recoverability potential in relation to management investment and intervention. This assessment is based on a qualitative decision support protocol adapted from DEWHA 2009. This provides a consistent, easily repeatable, rapid assessment methodology and enables a comparison between the different assessment sites. Refer to section on 'Methods' for a summary of assessment criteria.

Table 3 Attribute table for Ecosystem Values

Ecosystem Values						
1	2	3	4	5	6	7
Riparian Plant Diversity	Riparian Habitat Diversity	Hydrological Value	Water Quality Salinity	Cultural Heritage Site	Uniqueness	Key Aquatic Refuge
'Best on offer'. All strata present. No introduced plants HIGH VALUE	All strata present – high diversity HIGH VALUE	Permanent HIGH VALUE	< 800 EC Fresh	HIGH VALUE	Only 'type' in catchment HIGH VALUE	High value site in catchment – permanent HIGH VALUE
Least disturbed plant assemblages - all strata present Some introduced species MODERATE to HIGH VALUE	All strata present and >3 habitat features MODERATE to HIGH VALUE	Semi-Permanent MODERATE to HIGH VALUE	800 - 2500 EC Sub-saline MODERATE to HIGH	MODERATE to HIGH VALUE	Same 'type' in catchment MODERATE to HIGH VALUE	High value refuge during drought – Semi-permanent MODERATE to HIGH VALUE
1 strata reduced / missing - (No WONS) Vegetation cover >50% MODERATE VALUE	All strata present with 3 habitat features MODERATE VALUE	Seasonal MODERATE VALUE	2,500 – 10,000EC Saline	MODERATE VALUE	Same 'type' in sub-catchment MODERATE VALUE	Seasonal MODERATE VALUE
2 strata reduced / missing Vegetation cover <50% MODERATE to LOW VALUE	One strata missing and <3 habitat features MODERATE to LOW VALUE	Ephemeral MODERATE to LOW VALUE	10,000 – 34,000 EC Saline – Saline - Hyper-saline	MODERATE to LOW VALUE	Same 'type' in sub-catchment MODERATE to LOW VALUE	Ephemeral pool MODERATE to LOW VALUE
2-3 strata missing / reduced Vegetation cover <25% LOW VALUE	Two or more strata missing and/or one habitat feature LOW VALUE	Intermittent LOW VALUE	> 34,000 EC Hyper-saline	LOW VALUE	Same 'type' in stream reach LOW VALUE	Intermittent waterbody LOW VALUE

VALUE rating system

Riparian Plant Diversity

HIGH VALUE ('reference' or best on offer)

Naturally occurring intact native plant species assemblages as expected for the habitat assessed. All strata present - typically coolibah overstorey with a range of native mid-stratum and understorey vegetation at different age classes (juvenile; sub-adult; & adult). No WONS (Weeds of National Significance) present. Riparian bank vegetation cover in-tact with minimal cover loss.

MODERATE to HIGH

Slightly reduced riparian plant assemblages. Least disturbed with all strata present. Vegetation largely native trees over predominately native understorey. No WONS present but typically includes some introduced species.

MODERATE

Loss of plant diversity due to heavy grazing pressure. Perennial species recruitment reduced. Vegetation is reduced from natural assemblages expected for the habitat assessed with 1 strata missing or greatly reduced. Comprising predominately native vegetation with some introduced and naturalised species present. No WONS present. Bank vegetation cover typically 50% or greater.

MODERATE to LOW

Loss of plant diversity due to heavy grazing pressure. Perennial species recruitment reduced. Vegetation showing obvious change from natural assemblages with at least 2 strata missing or greatly reduced. Comprising some trees at the riparian zone that is dominated by introduced plants. Extent of the vegetated bank cover <50%.

LOW

Very low tree cover present with often few or only 1 or 2 scattered trees that occur as small patches over an understorey dominated by introduced plants. Extent of the poorly vegetated bank cover typically <25% with 2 or more strata missing or greatly reduced.

Riparian Plant Diversity
'Best on offer' - all strata present. No WONS (Weeds of National Significance) present HIGH VALUE
Least disturbed plant assemblages - all strata present. No WONS (Weeds of National Significance). Some introduced species MODERATE to HIGH VALUE
Vegetation reduced – 1 strata missing or reduced (No WONS present) – vegetation cover >50% MODERATE VALUE
At least 2 strata greatly reduced or missing - vegetation cover <50% MODERATE to LOW VALUE
Very low tree cover with 2 or 3 strata greatly reduced / missing – vegetation cover <25% LOW VALUE

Riparian Habitat Diversity

HIGH VALUE ('best on offer')

A high range of riparian habitat features (at least 5) including flood runners; distributary channels; deep pools; inner meander bends or point bars; overhanging vegetation; tree hollows; in-stream snags; submerged logs. All strata present and typically well vegetated with expected range of plant assemblages.

MODERATE to HIGH

Good range of riparian habitat features (3-4) including flood runners; distributary channels; deep pools; meander bends; overhanging vegetation; tree hollows; submerged logs. All strata present.

MODERATE

Moderate range of riparian habitat features (2-3) present including flood runners; distributary channels; deep pools; meander bends; overhanging vegetation; tree hollows; submerged logs. One strata missing or greatly reduced.

MODERATE to LOW

Few riparian habitat features present (1-2) including flood runners; distributary channels; deep pools; meander bends; overhanging vegetation; tree hollows; submerged logs. At least 2 strata missing or greatly reduced.

LOW

Low range of riparian habitat features present (0-1) including flood runners; distributary channels; deep pools; meander bends; overhanging vegetation; tree hollows; submerged logs. 2 or more strata missing or greatly reduced.

Riparian Habitat Diversity
'Best on offer' – high range of riparian habitat features (at least 5) - all strata present HIGH VALUE
Good range of riparian habitat features (3-4) - all strata present MODERATE to HIGH VALUE
Moderate range of riparian habitat features (2-3) - 1 or 2 strata missing or greatly reduced MODERATE VALUE
Low number of riparian habitat features (1-2) - at least 2 strata missing or greatly reduced MODERATE to LOW VALUE
Low range of riparian habitat features present (0-1) - very low tree cover with 2 or more strata missing LOW VALUE

Hydrological Value

HIGH VALUE

Permanent waterhole. Persistence and depth confirmed through hydrological records and aquatic species presence (turtles, water rats & freshwater mussels). Permanence influenced by depth, flow frequency, loss processes and groundwater interactions. Waterholes classed as permanent when CTFD (cease to flow depth) at least 3-4 metres and receives annual flow. Very high channel / floodplain connectivity value for ecosystem function and species dispersal.

MODERATE to HIGH

Semi-permanent waterhole – almost permanent. Receives water from rainfall and regional flows on a regular basis. High channel / floodplain connectivity value for ecosystem function and species dispersal.

MODERATE

Seasonal waterhole - depending on extent of local and regional flow events– frequently dry becoming a series of saline pools. Waterbody may persist over longer periods of time due to depth and groundwater discharge. Moderate channel / floodplain connectivity value for ecosystem function and species dispersal.

MODERATE to LOW

Ephemeral waterhole – regularly dry. Waterbody persists for short periods after rain and flow events. Low channel / floodplain connectivity value for ecosystem function and species dispersal.

LOW

Intermittent waterhole – annually dry. Waterbody persists for short periods and streams normally cease flowing for extended periods each year. Minimal connectivity value.

Hydrological Value
Permanent HIGH VALUE
Semi-Permanent MODERATE to HIGH VALUE
Seasonal MODERATE VALUE
Ephemeral MODERATE to LOW VALUE

Hydrological Value

Intermittent LOW VALUE

Water Quality – salinity (EC – $\mu\text{S}/\text{cm}$)

HIGH: Fresh <800 EC

Freshwater streams and waterholes likely to be naturally very turbid.

MODERATE to HIGH: Sub-saline 800-2,500 EC ($\mu\text{S}/\text{cm}$)

Water likely to be naturally turbid and well oxygenated with little indication of eutrophication

MODERATE: Saline 2500-10,000 EC ($\mu\text{S}/\text{cm}$)

Water quality average with some turbidity and suspended solids.

MODERATE to LOW: Saline-Hyper-saline 10,000-34,000 EC ($\mu\text{S}/\text{cm}$)

Water quality insignificant and generally saturated with dissolved oxygen; high salinities associated with clearer, coloured water.

LOW: Hyper-saline >34,000EC ($\mu\text{S}/\text{cm}$)

Poor water quality with generally saturated dissolved oxygen; higher salinities associated with clear, coloured water and lower turbidity.

Water Quality

Salinity (fresh – hyper-saline)

EC units expressed in micro-Siemens/cm at 25°C ($\mu\text{S}/\text{cm}$)

1000 EC = 1000 $\mu\text{S}/\text{cm}$ = 1mS/cm = 1dS/m = 640 ppm

< 800 EC Fresh HIGH

800 - 2500 EC Sub-saline MODERATE to HIGH

2,500 –10,000 EC Saline MODERATE

10,000 – 34,000 EC Saline - Hyper-saline MODERATE to LOW

> 34,000 EC - Hyper-saline LOW

Cultural Heritage Site (Physical, Customary & Natural)

HIGH VALUE

High level of cultural heritage value associated with the site (e.g. Physical Heritage – Aboriginal artefacts and occupation sites, historic buildings, ruins and infrastructure; early explorers. Customary Heritage – site associated with traditional knowledge, stories, myths, legends; Natural Heritage – significant natural physical and biological features and landscapes, e.g. paleontological sites, threatened plant and animal species habitat, reserve systems e.g. National Parks).

MODERATE to HIGH

Good examples of cultural heritage associated with the site, such as evidence of physical; customary & natural heritage values

MODERATE

Some evidence of cultural heritage value e.g. occupation sites with some artefacts present; historic ruins; infrastructure e.g. old stockyards present

MODERATE to LOW

Low level evidence of cultural heritage value associated with the site

LOW

No significant evidence of cultural heritage value remaining or associated with the site

Cultural Heritage Site (Physical, Customary & Natural)
HIGH VALUE High level of cultural heritage value associated with the site
MODERATE to HIGH VALUE Good examples of cultural heritage associated with the site
MODERATE VALUE Some evidence of cultural heritage value
MODERATE to LOW VALUE Low level evidence of cultural heritage value
LOW VALUE No significant evidence of cultural heritage value

Uniqueness

HIGH VALUE

Only 'type' example in sub-catchment at sub-regional level i.e. South Australian section of Diamantina River catchment) including all 4 Management Zones. Best example of an aquatic refuge due to permanency and refuge qualities. Supports a range of flora and fauna and exhibits a range of geomorphological and hydrological features and environmental conditions providing vital habitat at times of environmental stress

MODERATE to HIGH

Similar 'type' example in sub-catchment at sub-regional level including all 4 Management Zones – other permanent or semi-permanent aquatic refuges are present.

MODERATE

Similar 'type' example in sub-catchment at sub-regional level including all 4 Management Zones – other semi-permanent aquatic refuges are present.

MODERATE to LOW

Similar 'type' example in management unit.

LOW

Similar 'type' in stream reach.

Uniqueness
Only 'type' example in sub-catchment at sub-regional level HIGH VALUE
Similar 'type' example in sub-catchment at sub-regional level and Management Zones – permanent MODERATE to HIGH VALUE
Similar 'type' example in sub-catchment at sub-regional level and Management Zones- semi-permanent MODERATE VALUE
Similar 'type' example in Management Unit MODERATE to LOW VALUE
Similar 'type' example in stream reach LOW VALUE

Key Aquatic Refuge
HIGH VALUE

Permanent waterhole - usually classified as an 'Ark-type' refuge - supports a range of fauna and flora during times of environmental stress e.g. drier conditions over extended periods of time

MODERATE to HIGH

Semi-permanent waterhole - persists for 12-18 months - supports a range of fauna and flora during times of stress over prolonged periods

MODERATE

Semi-permanent waterhole - seasonal, persists for <12 months - supports a low range of aquatic fauna and flora during drier periods over a limited period of time.

MODERATE to LOW

Ephemeral waterbody - quickly dries out and provides minimal support to biodiversity during prolonged dry periods

LOW

Intermittent waterbody - has minimal aquatic refuge capacity during times of environmental stress

Key Aquatic Refuge
Highest value sites in catchment - permanent HIGH VALUE
High value refuge during drought - semi-permanent to near permanent MODERATE to HIGH VALUE
Semi-permanent waterbody - seasonal MODERATE VALUE
Ephemeral waterbody MODERATE to LOW VALUE
Intermittent waterbody LOW VALUE

Table 4 Attribute table for Ecosystem Threats

Ecosystem Threats			
8	9	10	11
Weeds	Pest Animals (terrestrial & aquatic)	Surface & Ground water abstraction	Nutrients
Absent	Absent	Absent	Absent
PRESENT - LOW LEVEL. No WONS - 1-2 perennial weeds present	Present - low level activity evident LOW	Present - low level	Low level
No WONS - 1-4 perennial weeds MODERATE	Present - some activity evident MODERATE	Present - moderate level	Moderate level
MODERATELY HIGH LEVEL. No WONS - 1-5 perennial weeds present	Present - moderate level MODERATE	Present moderate - high level	Moderate to high level
WONS weeds present	Present - high level HIGH	Present - high level	High level

Weeds

ABSENT

Absent – no WONS species observed at the site

PRESENT – LOW LEVEL

Low level – no WONS present; some introduced species present at low density levels (1-2 species)

PRESENT - MODERATE LEVEL

Moderate level - no WONS present; some introduced species present at moderate density levels (1-4 species)

PRESENT - MODERATE to HIGH LEVEL

Moderately high level - no WONS present; some introduced species present at moderate to high density levels (1-5 species)

PRESENT – HIGH LEVEL

High level - WONS species present and some introduced species present at high density levels (1-5 species)

Weeds
ABSENT
LOW LEVEL
MODERATE LEVEL
MODERATE to HIGH LEVEL
HIGH LEVEL - WONS weeds present

Pest Animals (terrestrial and aquatic)

ABSENT

Absent – no observed indicators of recent feral animal activity or aquatic pest species present.

PRESENT – LOW LEVEL

Low level – recent activity evident- impacts minimal. Aquatic pest species present in low concentrations.

PRESENT - MODERATE LEVEL

Moderate level - recent activity evident and/or feral animals observed – impacts not severe. Aquatic pest species present in moderate numbers.

PRESENT - MODERATE to HIGH LEVEL

Moderately high level – recent activity evident and/or feral animals observed - impacts widespread. Aquatic pest species present in high numbers.

PRESENT – HIGH LEVEL

High level - feral animals present and severe damage observed to vegetation and riparian areas. High concentrations of aquatic pest species present with possible displacement of native fish species.

Pest Animals
ABSENT
LOW LEVEL
MODERATE LEVEL

Pest Animals
MODERATE to HIGH LEVEL
PRESENT - HIGH LEVEL

Surface & Groundwater Abstraction

ABSENT

Absent – no infrastructure present or water abstraction activities observed

PRESENT – LOW LEVEL

Low level – solar pump and/or water extraction infrastructure present not actively in use

PRESENT – MODERATE LEVEL

Moderate level – solar pump and infrastructure – operating

PRESENT - MODERATE to HIGH LEVEL

Moderately high level – capped bores, regulated bores

PRESENT – HIGH LEVEL

High level – free flowing, unregulated bores, bore drains flowing into waterholes; solar pumps operating

Surface & Groundwater Abstraction
ABSENT
LOW LEVEL
MODERATE LEVEL
MODERATE to HIGH LEVEL
PRESENT - HIGH LEVEL

Nutrients

ABSENT

Absent – freshwater streams no indicators showing elevated nutrient levels

PRESENT – LOW LEVEL

Low level – some evidence of eutrophication causing aquatic plant growth

PRESENT – MODERATE LEVEL

Moderate level – water quality shows obvious signs of eutrophication and aquatic plant growth

PRESENT - MODERATE to HIGH LEVEL

Moderately high level – fair water quality with nutrients present at high concentrations with corresponding high levels of aquatic plant growth e.g. filamentous algae; *Persicaria* (Knotweed)

PRESENT – HIGH LEVEL

High level – poor water quality – nutrients at high concentrations with high aquatic plant productivity

Nutrients
ABSENT
LOW LEVEL
MODERATE LEVEL
MODERATE to HIGH LEVEL
PRESENT - HIGH LEVEL

Table 5 Attribute table for Ecosystem Pressures

Ecosystem Pressures			
12	13	14	15
Infrastructure (e.g. tracks, flow diversions)	Tourism camping & recreation activity	Bank stability, soil disturbance	Total Grazing Pressure
Absent	Absent	Absent	Absent
Low level	Present – low level activity - controlled management	Present – low level	Low level
Low – moderate level	Present – some activity – no on-site management	Present – moderate level	Low – moderate level
Moderate – high level	Present - moderate level	Present moderate – high level	Moderate – high level
Present – high level	Present – high level – high impact	Present – high level	High level

Infrastructure development

ABSENT

Absent – no obvious development impacting site

PRESENT – LOW LEVEL

Low level – no significant disturbances, some infrastructure present e.g. dams, tracks, yards

PRESENT - MODERATE LEVEL

Moderate level – obvious signs of development e.g. tracks, outbuildings, flow diversions, dams, levees, culverts, bridges causing some disruption to normal ecosystem function and flow regimes

PRESENT - MODERATE to HIGH LEVEL

Moderately high level – extensive signs of development e.g. tracks, buildings, flow diversions, dams, bridges, culverts causing significant disruption to normal ecosystem function and flow regimes

PRESENT – HIGH LEVEL

High level – major impacts on natural flow regimes and ecosystem function due to human activities

Infrastructure development (e.g. tracks, flow diversions)
ABSENT
LOW LEVEL
MODERATE LEVEL
MODERATE to HIGH LEVEL
PRESENT - HIGH LEVEL

Tourism, camping & recreation activity

ABSENT

Absent – no recent evidence of tourism/recreation activity, campfires or wood collection

PRESENT – LOW LEVEL

Low level – some evidence of past and recent recreation / tourism activity including campfires, wood collection. Not causing serious damage.

PRESENT - MODERATE LEVEL

Moderate level – some evidence of past and recent recreation / tourism activity including campfires, wood collection. Not causing serious damage. Off-site or controlled management

PRESENT - MODERATE to HIGH LEVEL

Moderately high level – evidence of campfires and excessive firewood collection causing noticeable impacts and damage to habitat; no on-site management

PRESENT – HIGH LEVEL

High level – evidence of campfires and excessive firewood collection causing severe impacts and damage to habitats; no on-site management

Tourism, camping & recreation activity
ABSENT
LOW LEVEL
MODERATE LEVEL Off-site or controlled management
MODERATE to HIGH LEVEL no on-site management
PRESENT - HIGH LEVEL

Bank stability, soil disturbance

ABSENT

Minimal evidence of destabilised banks, erosion points or loss of groundcover. System stable.

LOW LEVEL

Evidence of destabilised banks, erosion points or loss of streambank vegetation and groundcover - naturally occurring or human induced. System stable.

MODERATE LEVEL

Evidence of destabilised banks, erosion points or loss of streambank vegetation and groundcover. Gullyng active or historic. Streambank slumping due to naturally occurring and / or human induced factors. System generally stable.

MODERATE to HIGH LEVEL

Active gullyng to 1m deep and / or major streambank slumping due to naturally occurring and / or human induced factors. Evidence of destabilised banks, erosion points forming and loss of streambank vegetation and groundcover. System unstable.

HIGH LEVEL

Major erosional processes with active gullyng >1m deep. Excessive streambank slumping due to naturally occurring and / or human induced factors. System unstable.

Bank stability, soil disturbance
ABSENT
LOW LEVEL
MODERATE LEVEL
MODERATE to HIGH LEVEL
PRESENT - HIGH LEVEL

Total Grazing Pressure

ABSENT

Absent – no observed grazing from domestic stock and introduced animals

PRESENT – LOW LEVEL

Low level – some grazing and browse evident not causing serious damage to perennial vegetation

PRESENT - MODERATE LEVEL

Grazing present with damage to perennial vegetation and potential impacts on recruitment

PRESENT - MODERATE to HIGH LEVEL

Grazing present at moderately high levels – recruitment of perennials and groundcover species impacted

PRESENT – HIGH LEVEL

Serious grazing impacts clearly observed – extensive damage to perennial vegetation and groundcover and minimal recruitment of perennials

Total Grazing Pressure
ABSENT
LOW LEVEL
MODERATE LEVEL
MODERATE to HIGH LEVEL
PRESENT - HIGH LEVEL

Table 6 Key to the rapid assessment of riparian habitat condition

	Largely Unmodified	Slightly Modified	Moderately Modified	Substantially Modified	Severely Modified
16. SPATIAL INTEGRITY	Little evidence of broad-scale loss of native vegetation	Width reduced by up to 1/3 and/or some breaks in continuity	About 50% of expected native vegetation remains, either in strips or patches	Only small patches of well-separated native vegetation remains	Little or no remaining native vegetation
17. NATIVENESS (perennials)	Vegetation predominately native, few weeds no 'high threat' (WONS) species	Introduced species present not dominating any strata, no 'high threat' (WONS) species	One or more strata dominated by exotic species, 'high threat' (WONS) species present	Most strata dominated by exotic species, 'high threat' (WONS) species abundant	Few native species remaining, cover dominated by exotic species
18. STRUCTURAL INTEGRITY	Number of strata and cover within each strata is 'best on offer'	Cover within one stratum 50% lower or higher than what is expected	One stratum missing and/or cover within remaining stratum 50% lower or higher than 'best on offer'	More than one stratum completely altered from 'best on offer' (lost or <10% remaining)	Structure completely altered from 'best on offer'
19. AGE STRUCTURE	Dominant strata 'best on offer' level of cover - at least 3 age classes present (juvenile, sub-adult, adults)	Reduced cover (75-50%) of dominant strata present. Only two age classes present	Reduced cover (75-50%) of dominant strata present, Only one age class present	Reduced cover (<50%) of dominant strata, and only one age class present	Dominant strata mostly absent
20. WOODY DEBRIS & LEAF LITTER	Quantity and cover is 'best on offer' and /or as expected for the site	Evidence of unnatural loss of debris (e.g. stock trampling of leaf litter; firewood collection)	Loss of leaf litter and debris. Quantity and cover 50% below what is expected	Significantly low quantities of debris and leaf litter cover present. Cover at 75% below what is expected.	Debris and leaf litter mostly absent or with little or no living vegetation

KEY 1: Riparian Habitat Condition Attributes

(for each indicator refer to appropriate column in Table for assessment criteria)

Spatial Integrity:

Ranks integrity of riparian vegetation associations within riparian areas. This includes:
Lateral connectivity - the width of riparian vegetation (as defined by inundation dependent species);
Longitudinal continuity - continuous cover of dominant stratum along the channel; and
Connectedness of the riverine vegetation to other areas of native vegetation (riparian or terrestrial).

Nativeness:

Ranks riparian vegetation based on the proportion of 'nativeness' relating to non-native and high threat species and the abundance of non-native and high threat species in different strata.

Structural Integrity:

Ranks number of strata represented in riparian vegetation based on a 'best on offer' community.

Age Structure:

Ranks age structure of riparian vegetation for each of the strata present (juveniles, sub-adults, and adults)
Cover of canopy species. Presence (or abundance) of different age stages. Presence (or abundance) of large old trees.

Woody Debris & Leaf Litter:

Ranks amount of debris within riparian vegetation based on a 'best on offer' community. Abundance of fallen logs. Presence (or abundance) of standing dead trees and cover of litter.

Table 7 Riparian Habitat Summary

PARAMETER	RATING		
ECOLOGICAL IMPORTANCE	HIGH	MODERATE	LOW
RIPARIAN CONDITION RATING	HIGH	MODERATE	LOW
CONNECTIVITY VALUE	HIGH	MODERATE	LOW
INVESTMENT PRIORITY	HIGH	MODERATE	LOW
RESTORATION POTENTIAL	HIGH	MODERATE	LOW
MANAGEMENT PRIORITIES	HIGH	MODERATE	LOW

For each site **Ecological Importance Ranking; Riparian Condition Rating; Connectivity Value; Investment Priority; Restoration Potential**, and **Management Priorities** are provided.

Ecological Aquatic Refuge Importance Ranking: Value of waterbody as a critical refuge rated high, moderate, low
Riparian Condition Rating: Riparian habitat condition rated either high, moderate, or degraded
Connectivity Value: Value of riparian habitat to facilitate species dispersal and recruitment, rated high, moderate, low
Restoration Potential: Riparian recovery potential rated high, moderate, low
Investment Priority: Investment according to condition, importance ranking and current management – rated high, moderate, low
Management priorities: Management interventions rated high, moderate, low

8 Appendix B

8.1 Survey results

Site 1: Andrewilla Waterhole, Clifton Hills Station

Site information

Site: Andrewilla Waterhole – Diamantina River

Management unit:

MANAGEMENT UNIT 1: Diamantina Main Channel

Diamantina Channel to Goyder Lagoon including Andrewilla & Yammakira Waterholes

Easting / Northing: -26°32'29.99"S (26.541664) 139°15'14.93"E (139.254147)

Date assessed: 7th May 2014; 13th May 2015; 7th May 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 14km from Diamantina River channel to Goyder Lagoon. Bankfull width approx. 70-80m, up to 120m in some sections.
- **Conceptual understanding:** In-channel permanent waterhole - 'Ark-type' aquatic refuge.
- **Recent rainfall / inundation events:** 80mm recorded in January 2015; receives annual flow.
- **Depth:** Cease to flow depth (CTFD): 6m.
- **Elevation:** ~ 32m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	<i>Aeschynomene indica</i> ; <i>Ipomoea diamantinensis</i>
Lower: Understorey - (grasses, forbs & misc)	<i>Amyema preissii</i> ; <i>Einadia nutans ssp. eremaea</i> ; <i>Lysiana exocarpi ssp exocarpi</i> ; <i>Malva preissiana</i> ; <i>Malvastrum americanum var americanum</i> ; <i>Nicotiana velutina</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Setaria jubiflora</i> ; <i>Sida ammophila</i> ; <i>Tribulus eichlerianus</i> ; <i>Zygophyllum simile</i>
Mid: Shrubs (low to tall shrubs)	<i>Abutilon fraseri</i> ; <i>Abutilon halophilum</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Hibiscus krichauffianus</i> ; <i>Duma florulenta</i> ; <i>Sclerolaena bicornis</i> ; <i>Senna artemisioides ssp. Filifolia</i>
Mid: Small Trees (<5m)	<i>Acacia oswaldii</i> ; <i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Atalaya hemiglaucula</i> ; <i>Eremophila bignoniiflora</i> ; <i>Eremophila longifolia</i> ; <i>Santalum lanceolatum</i>
Upper: Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 30



Andrewilla Waterhole – assessment area



Reduced riparian shrub layer and groundcover



Scalding on clay flats adjacent to waterhole



Heavily grazed riparian zone



Overhanging vegetation – riparian habitat feature

Ecosystem Values, Threats and Pressures

Andrewilla Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Heavy grazing pressure has resulted in low recruitment of perennials, reduced shrub layer and heavily impacted groundcover.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Range of riparian habitat features present, including flood runners; distributary channels; deep pools; overhanging vegetation; tree hollows; submerged logs.	QUALITATIVE SURVEY
3.	Hydrological Value	HIGH	Significant permanent waterhole. Cease to flow depth (CTFD) 6m. Receives annual flow. An important site for aquatic species recruitment, dispersal and channel / floodplain connectivity.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum EC 190 (µS/cm). Receives annual flow maintaining fresh water and low salinity able to support majority freshwater flora and fauna. High turbidity.	EC Tester METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	HIGH	High rating for Natural, Customary & Physical heritage values. High Aboriginal cultural significance; evidence of numerous occupation sites and stone artefacts. Important aquatic refuge site for native biota.	QUALITATIVE SURVEY
6.	Uniqueness	HIGH	Permanent refuge waterhole – large size and depth to 6m (CTFD). One of the deepest and most permanent waterholes in the region.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	HIGH	Size, permanence, & key biota (turtles, native fish) make this site a critical 'Ark-type' aquatic refuge.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT MODERATE	Range of feral animals observed, including feral pigs, rabbits, camels, cats. Impacts not severe. No introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – some eutrophication promoting aquatic plant growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	Station tracks leading into waterhole. Good accessibility to site due to proximity to Inside Track	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	LOW LEVEL	Camping and firewood collection observed.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	MODERATE LEVEL	Some disturbance observed on the alluvial plain adjacent to the channel. Erosion points formed with loss of lignum cover at the streambank edge due to stock accessing the waterhole.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
15.	Total Grazing Pressure	MODERATE to HIGH LEVEL	Heavy grazing pressure evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials. Presence of disturbance species and low species richness in understorey.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some reduction and modification to the lignum cover through stock accessing the waterhole.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weed (WONS) species present.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Reduction in understorey and shrub layer due to grazing pressure.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover of Coolibahs – juvenile and sub-adult class mostly absent due to grazing pressure.	Observation
20. Terrestrial woody debris and leaf litter	MODERATELY MODIFIED	Loss of leaf litter cover - reduced through stock trampling. Woody debris reduced.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Andrewilla Waterhole is located in the Diamantina floodplain and channel country (Diamantina Land System). It is an important aquatic refuge waterhole approximately 14km in length and is one of the deepest and most persistent waterholes on the Diamantina River in South Australia. The western channel of the Diamantina flows into Andrewilla Waterhole and discharges into the extensive Goyder Lagoon wetland. The waterhole consists of a thin vegetated riparian corridor and is lined with, coolibah (*Eucalyptus coolabah*); Queensland bean tree (*Bauhinia gilva*); Broughton willow (*Acacia salicina*); River cooba (*Acacia stenophylla*); whitewood (*Atalaya hemiglauc*); emu-bush (*Eremophila bignoniiflora*); native plum (*Santalum lanceolatum*); and lignum (*Duma florulenta*). The waterhole and floodplain has been heavily impacted by grazing and subjected to very high grazing pressure over a long period of time. Lignum has been heavily impacted and reduced in extent where there is access to the waterhole. There is a proliferation of unpalatable goathead (*Sclerolaena bicornis*) and other disturbance species such as large pigweed (*Portulaca intraterranea*) and caltrop (*Tribulus eichlerianus*). There was little evidence of any coolibah recruitment. Grazing impact has occurred in the vicinity of more permanent water sources on the major Diamantina Channels. The sandy clay soils adjacent to the more permanent waterholes such as Andrewilla are susceptible to erosion and the loss of perennial vegetation cover has resulted in extensive areas of moderate to severe scalding in the vicinity of this waterhole. There are numerous old tree hollows providing nesting habitat for birds. The riparian vegetation corridor is narrow at 5-10m. Andrewilla is an important refuge waterhole and warrants revised grazing management to enable natural restoration processes to stabilise the site. Further soil loss exposing the hard clay pan will reduce the likelihood of this occurring. It is a significant Aboriginal heritage site with evidence of numerous campsites, stone implements and artefacts and has high importance to the Wangkangurru Yarluyandi people.

Measures to assist stabilisation and recovery in the floodplain country are an important consideration. This may include opportunistic spelling or light stocking particularly following major flooding events along the waterhole to facilitate regeneration and recruitment of perennial species, particularly coolibahs. Other considerations include de-stocking the paddock before stock become concentrated and as other waterholes dry up and control of feral pigs and camels to prevent build up of numbers and an increase in grazing pressure.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	HIGH	Permanent waterhole classed as an 'Ark-type' aquatic refuge. Has high ecological and aquatic importance providing critical refuge during times of environmental stress.
Riparian Condition Rating	MODERATE	Heavily impacted from grazing pressure. Perennial vegetation damaged with little recruitment evident.
Connectivity Value	HIGH	Permanent aquatic refuge and extensive waterhole in overall length and size - high value for connectivity and species recruitment and dispersal.
Restoration Potential	MODERATE	Restoration potential is a longer-term proposition due to historic grazing pressure, soil compaction, loss of ground-cover and leaf litter, and deposition of fine clay particles making it more difficult for vegetation to naturally establish.
Investment Priority	HIGH	High ecological importance therefore implementing grazing management and pest species control measures are critical.
Management priorities	HIGH	Undertake regular monitoring, investigate and implement conservative grazing management strategies to facilitate the recruitment and establishment of perennial vegetation; implement pest animal control measures as required.

Site 2: Burt Waterhole, Clifton Hills Station

Site information

Site: Burt Waterhole – Goyder Lagoon floodplain

Management unit:

MANAGEMENT UNIT 2: Goyder Lagoon

From Andrewilla and Yammakira distributary channels to commencement of the Warburton River channel

Easting / Northing: -26°35'15.99"S 139° 09'03.23"E

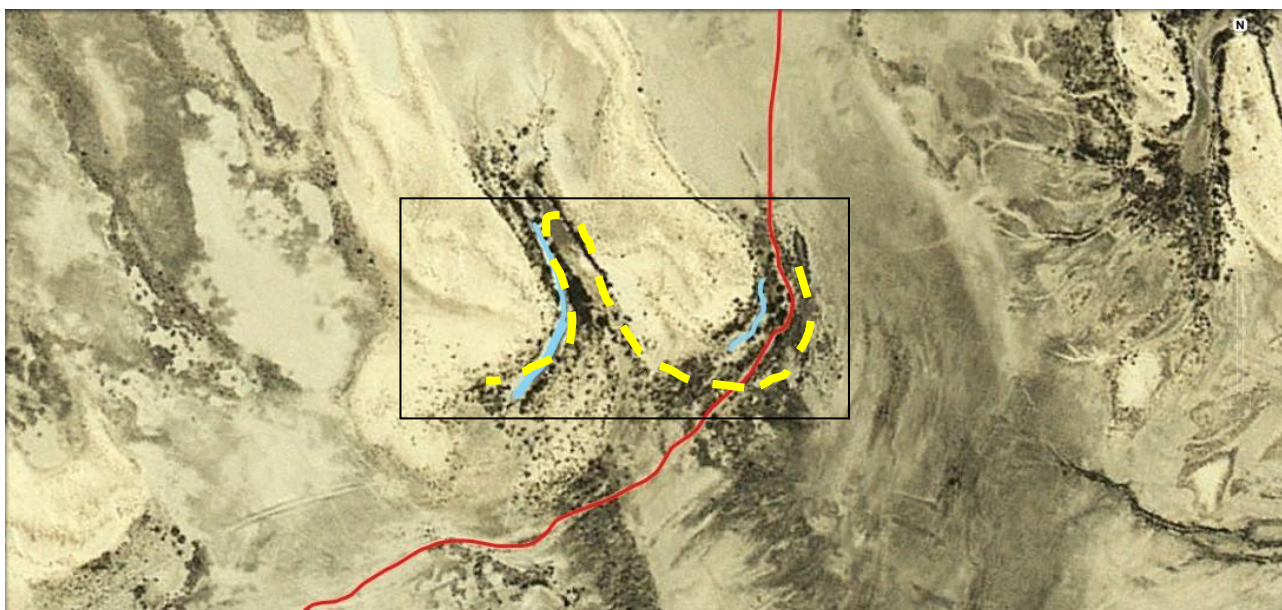
Date assessed: 13th May 2015

Description of feature assessed:

- **Feature type:** Floodplain waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 80m. Bankfull width approx. 28-30m.
- **Conceptual understanding:** Semi-permanent waterhole.
- **Recent rainfall / inundation events:** 80mm recorded in January 2015. Receives annual flow.
- **Depth:** Cease to flow depth (CTFD): 0.8m.
- **Elevation:** ~ 29m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amyema preissii</i> ; <i>Centipeda cunninghamii</i> ; <i>Cyperus difformis</i> ; <i>Eragrostis tenellula</i> ; <i>Eragrostis confertiflora</i> ; <i>Glinus lotoides</i> ; <i>Ipomoea polymorpha</i> ; <i>Marsilea drummondii</i> ; <i>Portulaca intraterranea</i> ; <i>Pseudognaphalium luteoalbum</i> (Syn. <i>Helichrysum luteoalbum</i>); <i>Solanum esuriale</i> ; <i>Sphaeranthus indicus</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus eichlerianus</i> ; <i>Teucrium racemosum</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Einadia nutans ssp. eremaea</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Eremophila bignoniiflora</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 26



Burt Waterhole – assessment area

Inside Track



Burt Waterhole riparian vegetation – highly turbid water



Reduced understorey & mid-stratum layer

Ecosystem Values, Threats and Pressures

Burt Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Heavy grazing pressure has resulted in low recruitment of perennials, reduced shrub layer and heavily impacted groundcover.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE	Range of riparian habitat features including overhanging vegetation and flood runners. Some areas of understorey heavily degraded with major vegetation loss.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Semi-permanent waterhole on Goyder Lagoon floodplain. Cease to flow depth 0.8m. Receives annual flow. Important floodplain connectivity value for species dispersal and recruitment.	QUANTITATIVE HYDROLOGICAL MONITORING

	Indicator	Value	Description	Confidence
4.	Water Quality – salinity	FRESH	Maximum salinity 342 EC (µS/cm). High turbidity	Ec Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Physical heritage value. Aboriginal cultural significance; evidence of occupation sites and stone tools in nearby dunes.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	Semi-permanent waterhole. Same 'type' in sub-catchment	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Size and depth makes this site moderately important as a semi-permanent aquatic refuge.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed; no introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Evidence of feral horses and rabbits. Low impact. No introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Elevated nutrient levels e.g. N & K –source probably faecal. Some algal growth observed.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	MODERATE LEVEL	Waterhole adjacent to Inside Track, near holding yards and tank.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	MODERATE LEVEL	Close to Inside Track. Increased visitor access. No controlled management.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	MODERATE to HIGH LEVEL	Riparian zone heavily trampled. Low gradient banks, some soil disturbance at waterhole edge. Nearby clayey ridge heavily eroded.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE to HIGH LEVEL	Heavily grazed and impacted site particularly along waterhole edge with distinct browse line evident. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Reduction and modification to the lignum cover.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weed species present.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Reduction in understorey and shrub layer.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover of Coolibahs – juvenile and sub-adult class mostly absent.	Observation

Indicator	Value	Description	Confidence
20. Terrestrial woody debris and leaf litter	MODERATELY MODIFIED	Loss of leaf litter cover reduced through stock trampling. Woody debris reduced.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Burt Waterhole is located in the Diamantina floodplain / channel country (Diamantina Land System) on the north-western edge of Goyder Lagoon. The waterhole is semi-permanent with an annual flow frequency and is filled during larger flood events. The waterhole persists for 6-8 months without in-flow and is approx. 80m in length. The floodplain and sandy country in the vicinity of Burt Waterhole was in reasonable condition with stable soil surfaces, however, at the waterhole there was extensive soil disturbance and groundcover loss. The waterhole is close to stockyards and the Inside Track. It is lined with coolibah (*Eucalyptus coolabah*), Broughton willow (*Acacia salicina*), emu bush (*Eremophila bignoniiflora*) and lignum (*Duma florulenta*). Leaf litter and debris is substantially reduced. On the adjacent Burt Ridge hard claypan areas have extensive erosion, whereas on the nearby sandhills vegetation cover is in good condition and tree and shrub communities are in mixed-age stands.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides aquatic habitat in the outer floodplain.
Riparian Condition Rating	MODERATE	Heavily impacted from grazing pressure. Perennial vegetation damage with little recruitment evident.
Connectivity Value	MODERATE	Outer floodplain waterhole – semi-permanent aquatic refuge provides habitat for species dispersal and recruitment.
Restoration Potential	MODERATE	Recovery of the site will likely occur over a long-term period due to current condition and land-use.
Investment Priority	MODERATE	Medium importance ranking due to ecological condition and aquatic refuge ranking.
Management priorities	MODERATE	Investigate and implement grazing management strategies to enable recovery of the site, undertake regular monitoring and pest species management.

Site 3: Cliff Camp Waterhole, Kalamurina Wildlife Sanctuary

Site information

Site: Cliff Camp Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°53'08.90"S 137°56'23.45"E

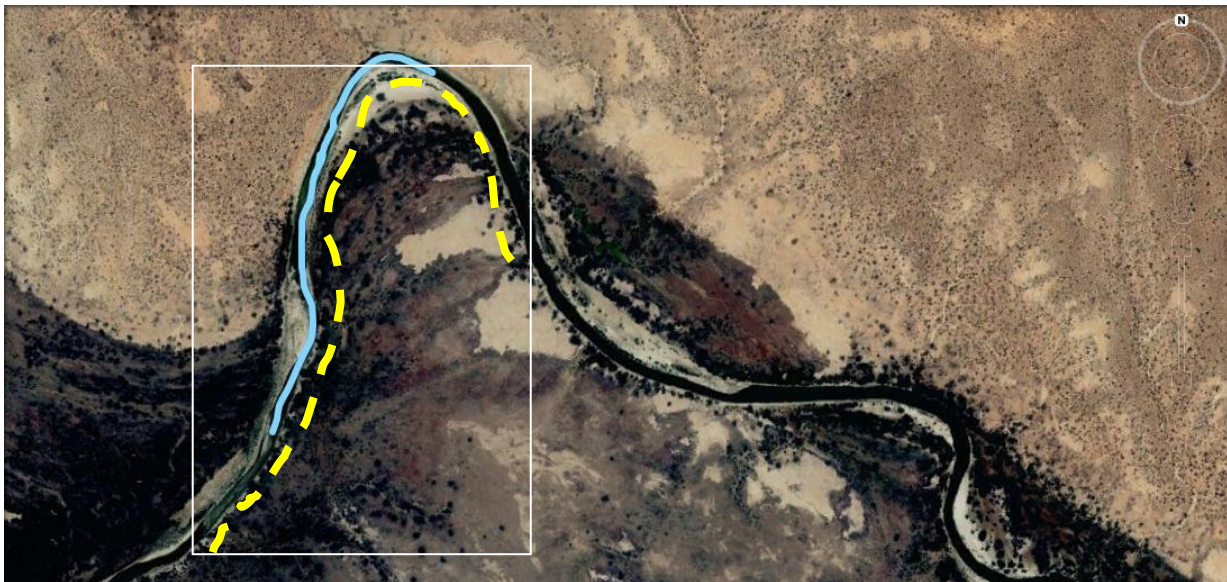
Date assessed: 30th April 2015

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Conservation
- **Size / Area:** Waterhole length approx. 500m. Bankfull width approx. 40m.
- **Conceptual understanding:** In-channel semi-permanent saline waterhole.
- **Recent rainfall / inundation events:** 100mm recorded at Kalamurina HS in January 2015.
- **Depth:** Cease to flow depth (CTFD): 0.8m.
- **Elevation:** ~ 2 m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Amyema preissii</i> ; <i>Cucumis melo</i> ; <i>Cynodon dactylon</i> ; <i>Cyperus gymnocaulos</i> ; <i>Helichrysum apiculatum</i> ; <i>Lavatera plebeia</i> ; <i>Nicotiana velutina</i> ; <i>Portulaca intraterranea</i> ; <i>Tribulus eichlerianus</i>
Shrubs (low to tall shrubs)	<i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Sclerolaena intricate</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 15



Cliff Camp waterhole assessment area



Cliff Camp Waterhole – channel morphology



Saline pool and riparian vegetation corridor



Dry conditions with groundcover of *Portulaca*



Sparse riparian vegetation - low species richness

Ecosystem Values, Threats and Pressures

Cliff Camp Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Low recruitment of perennials. Depauperate compared to other sites on the Warburton. High % cover of disturbance species.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Range of riparian habitat features present including flood runners; inner meander bends; overhanging vegetation; tree hollows; and submerged logs. All strata present.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole – frequently dry becoming a series of saline pools. Cease to flow depth (CTFD) 0.8m. Groundwater discharge maintains saline pools through drier periods.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	LOW	During site visits maximum 35000 EC (µS/cm) - Hypersaline pool	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE to HIGH	Physical and Natural Heritage value. Fossil site has significant scientific importance. Only a small number of stone artefacts found at the site.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Important habitat for salt tolerant fish species and dispersal once system connectivity occurs after flooding. Similar 'type' example in sub-catchment at sub-regional level.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Semi-permanent waterhole – seasonal, persists for <12 months - supports a low range of aquatic fauna and flora during times of stress over a limited period of time.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Camels present. Recent rabbit activity with active warrens. Gambusia present recorded in low numbers.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW	Some algal growth observed. No stock grazing therefore deemed to have low nutrient levels.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW	Well maintained tracks leading into the site. Good maintenance and management of track network.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Low visitor use area. Mainly used for scientific research. No major impacts observed due to effective management practices at campsites.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
14.	Bank stability, soil disturbance	PRESENT MODERATE LEVEL	Active erosion gullies forming on high, steep banks where vegetation is sparse.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	PRESENT LOW LEVEL	Low level with some herbivore browse evident. No major impacts. Destocking has contributed to recovery of site.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	LARGELY UNMODIFIED	Little evidence of broad-scale loss of native vegetation.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weeds present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Reduced with low species diversity in shrub layer – mid-stratum and groundcover.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Low recruitment of perennial species e.g. coolibahs.	Observation
20. Terrestrial woody debris and leaf litter	LARGELY UNMODIFIED	Good leaf litter and debris cover with a 'no campfire' policy in place.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Cliff Camp Waterhole is located on the Warburton River in country dominated by sandhills and flats of the Tirari Desert (Tirari Land System). This country includes channels and floodplains of the Warburton dominated by coolibah (*Eucalyptus coolabah*) and Broughton willow (*Acacia salicina*) with an understorey of lignum (*Duma florulenta*) and native grasses. Plant species assemblages are lower than expected for the habitat assessed and compared to other lower Warburton sites. Unpalatable goathead (*Sclerolaena bicornis*), an indicator of disturbance, was noted in the adjacent floodplain area. The site has low species diversity correlating with higher salinity and lower flooding frequency. The site is in recovery from historic heavy grazing pressure. Current management of camels and rabbits will also assist the natural recovery process.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the lower Warburton River system.
Riparian Condition Rating	HIGH	Site is recovering from extensive historical grazing pressure.
Connectivity Value	MODERATE	Provides habitat for salt tolerant species and dispersal after flooding.
Restoration Potential	HIGH	Current management will enhance recovery potential – removal of stock grazing has improved vegetation recovery rate.
Investment Priority	HIGH	Important natural heritage site warrants consideration for management investment.
Management priorities	MODERATE	Under sound management regime – maintain feral animal control measures and camping protocols currently in place.

Site 4: Cowarie Crossing (Kirrianthana Waterhole), Cowarie Station

Site information

Site: Cowarie Crossing (Kirrianthana Waterhole) – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -26°36'33.57"S 138°18'24.31"E

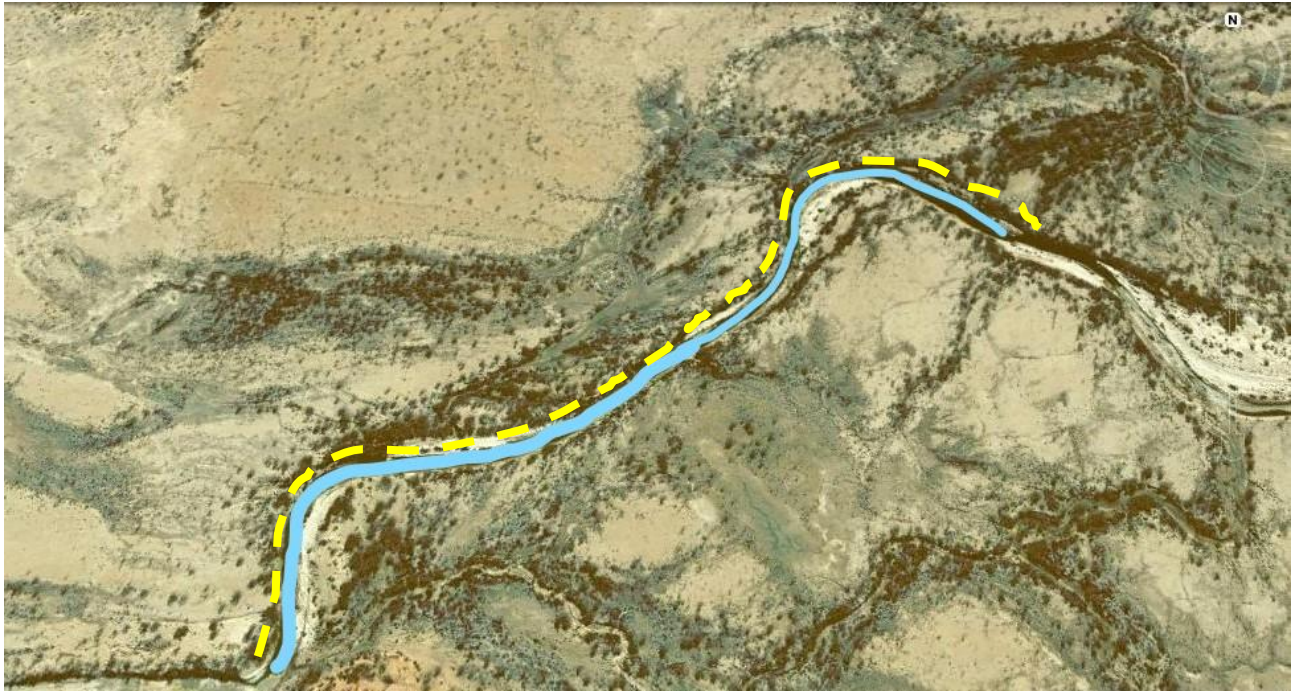
Date assessed: 13th May 2014; 28th May 2015; 2nd May 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 2.5km measured between the inflow channels of the Derwent River. Average channel width approx. 25m.
- **Conceptual understanding:** In-channel semi-permanent waterhole
- **Recent rainfall / inundation events:** 180mm in early January 2016
- **Depth:** Cease to flow (CTFD): 2.0m
- **Elevation:** ~ 8.5 m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Boerhavia dominii</i> ; <i>Brassica tournefortii</i> ; <i>Dactyloctenium radulans</i> ; <i>Einadia nutans ssp. eremaea</i> ; <i>Eriochloa australiensis</i> ; <i>Eragrostis dielsii var dielsii</i> ; <i>Haloragis aspera</i> ; <i>Malva preissiana</i> ; <i>Phyllanthus lacunellus</i> ; <i>Portulaca intraterranea</i> ; <i>Sclerolaena bicornis</i> ; <i>Tetragonia tetragonioides</i> ; <i>Trianthema triquetra</i>
Shrubs (low to tall shrubs)	<i>Atriplex nummularia</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 19



Cowarie Crossing – Kirrianthana Waterhole – assessment area



Warburton River saline clearer water less turbid



Riparian habitat feature - submerged log



Old Man saltbush (*Atriplex nummularia*)



Good riparian vegetation cover

Ecosystem Values, Threats and Pressures

Cowarie Crossing – Kirrianthana Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Coolibah recruitment absent. Each stratum represented - mid-stratum and groundcover layer reduced.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	All strata present with some loss of vegetation cover. Range of riparian habitat features including flood runners; distributary channels; meander bends; point bars; overhanging vegetation; tree hollows; submerged logs, deep pools.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Semi-permanent waterhole provides important connectivity value with Derwent & Warburton Creeks	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	LOW	During site visits maximum 257000 EC (µS/cm). Hyper-saline.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Physical Heritage value. Some evidence of Aboriginal occupation. Cowarie creek crossing of the Warburton River.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	Similar 'type' example in sub-catchment at sub-regional level including all 4 Management Zones – other permanent or semi-permanent aquatic refuges are present in the system	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole supports a range of fauna and flora.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	MODERATE	Rabbit activity observed. Gambusia present in low numbers.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	No water extraction activities observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW	Water quality shows signs of eutrophication e.g. algal growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW	Station tracks leading into waterhole. Site near to river crossing.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	MODERATE	Low visitor use area. Some camping and firewood removal.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
14.	Bank stability, soil disturbance	MODERATE	De-stabilised banks, vegetation loss and streambank slumping due to naturally occurring factors. System generally stable.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	LOW LEVEL	Grazing not causing major damage to perennial vegetation.	QUALITATIVE SURVEY

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	LARGELY UNMODIFIED	Lateral and longitudinal connectivity of riparian vegetation intact. Lignum cover not heavily impacted.	Observation
17. Nativeness	LARGELY UNMODIFIED	Mainly native vegetation no high threat weeds present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Each stratum well represented with some loss of mid-stratum layer.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Lack of recruitment of coolibahs.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Some evidence of loss of leaf litter cover. Firewood collection has depleted level of woody debris extent.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Cowarie Crossing waterhole is located north of where the Derwent Creek connects with the Warburton River. The waterhole is located in the Warburton land system comprising channels, floodplains and associated sand dunes with coolibah, Broughton Willow, river cooba and lignum lining the waterhole. Grazing has not significantly impacted the waterhole although there was a lower than expected level of coolibah recruitment and some impacts to lignum cover at the streambank edge. The waterhole persists for up to 12 months and turns very salty without inflow. The connectivity with the Derwent is a vector for gambusia to move into the Warburton Channel from the source population at Mungerannie wetland.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the lower Warburton River system.
Riparian Condition Rating	HIGH	Good spatial vegetation coverage along riparian zone. Lignum cover slightly modified, low recruitment of perennial vegetation.
Connectivity Value	HIGH	Connectivity with Derwent and Warburton - enables species dispersal.
Restoration Potential	MODERATE	Recovery potential rated moderate due to site not under heavy stress and relatively intact.
Investment Priority	MODERATE	Current management is maintaining the site.
Management priorities	HIGH	Grazing management considerations to enhance recovery of the site and promote perennial vegetation recruitment. Maintain feral animal control strategies as required.

Site 5: D-Split – Diamantina Channel, Pandie Pandie Station

Site information

Site: Diamantina Split (D-split) – Diamantina River

Management unit:

MANAGEMENT UNIT 1: Diamantina Main Channel

Diamantina Channel to Goyder Lagoon including Andrewilla & Yammakira Waterholes

Easting / Northing: -26°24'17.86"S 139°23'52.55"E

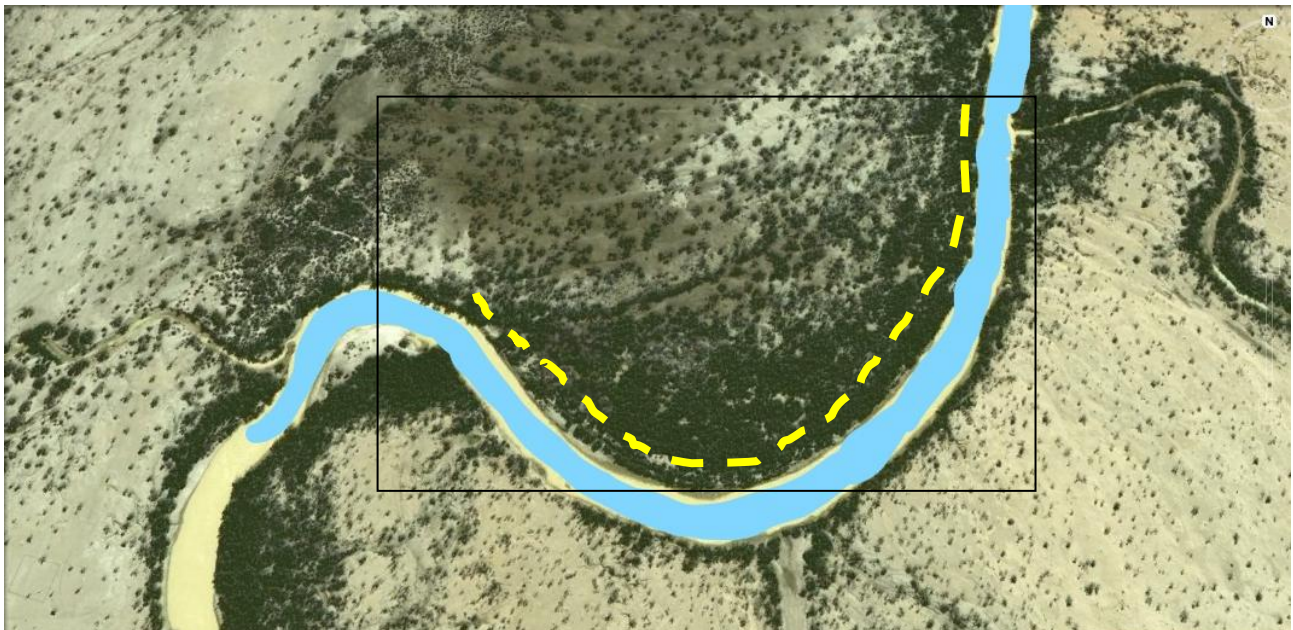
Date assessed: 8th May 2014; 12th May 2015; 6th May 2016

Description of feature assessed:

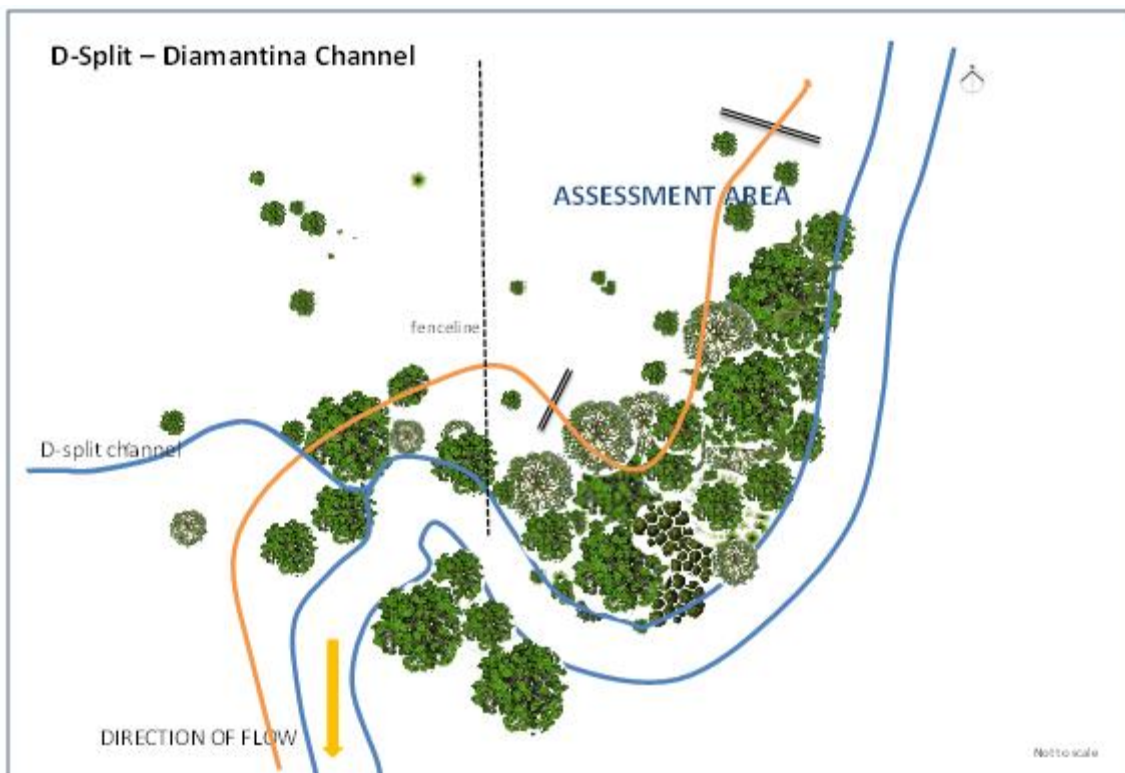
- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole forms part of the main channel that connects with Yammakira Waterhole. Bankfull width approx. 50m.
- **Conceptual understanding:** In channel permanent waterhole - 'Ark-type' aquatic refuge.
- **Recent rainfall / inundation events:** 80mm recorded in area in January 2015; receives annual flow.
- **Depth:** Cease to flow depth (CTFD): 7.4m
- **Elevation:** ~ 36.5m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	<i>Persicaria attenuate</i>
Understorey - (grasses, forbs & misc)	<i>Amyema preissii</i> ; <i>Boerhavia coccinea</i> ; <i>Cucumis argenteus</i> ; <i>Cucumis melo</i> ; <i>Cyperus bulbosus</i> ; <i>Lysiana exocarpi</i> ssp <i>exocarpi</i> ; <i>Nicotiana velutina</i> ; <i>Panicum</i> sp.; <i>Portulaca intraterranea</i> ; <i>Setaria jubiflora</i> ; <i>Tribulus eichlerianus</i> ; <i>Zygophyllum simile</i>
Shrubs (low to tall shrubs)	<i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i> ; <i>Solanum nigrum</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Atalaya hemiglauc</i> ; <i>Eremophila bignoniiflora</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 23



D-split – Diamantina Channel Split



High level structural vegetation cover at deposition zone on an inner meander bend



Diamantina Channel with intact lignum cover



Best on offer 'reference' condition vegetation cover



Grazed area on other side of fenced 'reference' area



Good leaf litter cover – lightly grazed 'reference' zone

Ecosystem Values, Threats and Pressures

D-Split Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	HIGH	Moderate species diversity.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	HIGH	All strata present. Multiple habitat features including: flood runners; distributary channels; deep pools; overhanging vegetation; tree hollows; and high number of in-stream snags with mainly silty / clay substrate. Site at inner meander bend, increased riparian vegetation cover.	QUALITATIVE SURVEY
3.	Hydrological Value	HIGH	Receives flow annually. Permanent waterhole. Cease to flow depth (CTFD) 7.5m. Site where Diamantina splits to form the western distributary channel. Important for species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum EC 270 (µS/cm). Receives annual flow maintaining fresh water and low salinity able to support majority freshwater flora and fauna. Turbidity naturally high.	EC Tester SALINITY METER
5.	Cultural Heritage Site	HIGH	High rating for natural and physical heritage values. Spotted Bowerbird observed – important riparian habitat supporting rare bird sighting.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
6.	Uniqueness	HIGH	Permanent 'Ark-type' refuge waterhole – large size and depth to 7.5m – deepest and most permanent waterhole in this reach of Diamantina River.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	HIGH	Size, permanence, and key biota (native fish and presence of turtles) make this site a critical 'Ark-type' refuge.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Feral pig activity observed at relatively low level. Low impact. Recent rabbit activity.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Some evidence of eutrophication e.g. algal or aquatic plants present.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	ABSENT	No major development observed.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Remote site – no visitor impact.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	ABSENT	Minimal evidence of destabilised banks, erosion points or loss of groundcover through trampling. System stable.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	LOW	Low level – some grazing and browse evident not causing serious damage to perennial vegetation.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	UNMODIFIED	Little evidence of broad-scale loss of native vegetation.	Observation
17. Nateness	UNMODIFIED	Vegetation predominately native, few weeds and no 'high threat' (WONS) species.	Observation
18. Structural Integrity	UNMODIFIED	Number of strata and cover within each stratum is 'best on offer'. Good mid-stratum layer and canopy cover.	Observation
19. Age Structure	MODERATELY MODIFIED	Dominant strata with 'best on offer' level of cover and at least three age classes present (juvenile, sub-adults and adults).	Observation
20. Terrestrial woody debris and leaf litter	UNMODIFIED	Good leaf litter cover. Low grazing levels has allowed build up of a deep litter layer and debris.	Observation

Refer Appendix A for interpretation of scoring system

Summary

The Diamantina Split site (D-split) is located along the Diamantina-Pandie Channel in Diamantina floodplain and channel country (Diamantina Land System). The assessment site is located near where the main channel splits into a small distributary channel (the Andrewilla flow channel) eventually connecting with Andrewilla waterhole (western flow path) and onto Goyder

Lagoon. On the eastern flow path the main channel connects with Yammakira waterhole and eventually Goyder Lagoon. D-split and other deep holes along the Diamantina-Pandie channel emphasise their considerable persistence in the absence of flow. The D-split site is one of the deepest and most persistent waterholes on the Diamantina reach in South Australia with a cease to flow depth measured at 7.4m. The site is situated on an inner meander bend with elevated productivity and consequently higher percentage cover of upper and mid strata vegetation. Coolibah (*Eucalyptus coolabah*), whitewood (*Atalaya hemiglauc*), bean tree (*Bauhinia gilva*) and Broughton willow (*Acacia salicina*) are the dominate tree species with an understorey of lignum (*Duma florulenta*) and native grasses. The channel receives annual flow and flooding typically follows monsoonal rain in the upper catchment in south-west Queensland.

The site was divided by a boundary fence showing high impact grazing pressure on one side and 'reference' condition on the other. For the purposes of this report the relatively in-tact higher productive site is assessed with reference to the impacted heavily grazed site. This 'reference' site is water-point and grazing remote with currently only minimal stock grazing occurring. Consequently leaf litter cover was exceptionally high and a good indicator of the biomass production at the site that can occur without intensive stocking and trampling. A spotted bowerbird thought to be extinct in South Australia was recorded at the site. (J. Reid, pers. Comm. 2015) which elevates the importance of these sites as key refuges for not only aquatic but also terrestrial animals and avifauna. Feral pig control is an on-going management consideration due to the permanent water and suitable habitat conditions. Maintaining present low stocking rates in the paddock before heavy grazing of perennials and groundcover occurs will maintain the integrity of the site. Maintaining feral animal control strategies to keep feral pig numbers under control will also prevent potential deterioration and loss of this important 'reference' site.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	HIGH	Near 'reference' or 'best on offer' site. Inner meander bends on rivers usually support highly productive ecosystems providing high quality habitat for bird and terrestrial species.
Riparian Condition Rating	HIGH	Good vegetation cover and site is in good condition due to low stocking rates.
Connectivity Value	HIGH	Deep permanent waterhole - receives an annual flow and provides habitat in the event of low flow scenarios – high value aquatic ecosystem providing connectivity pathways for species dispersal.
Restoration Potential	HIGH	Previous timber removal for fencing and lightning strikes causing fire damage is evident. The site has recovered from these disturbances. Restoration potential is high due to minimal recent disturbance, ecosystem stability and present low stocking rates and grazing impacts.
Investment Priority	HIGH	In order to maintain the integrity of the site investment priority is high. High ecological importance therefore high investment priority.
Management priorities	HIGH	Consider a stock exclusion zone and monitor recovery of site. Maintain feral animal control strategies e.g. feral pig control.

Site 6: Double Bluff Waterhole, Pandie Pandie Station

Site information

Site: Double Bluff Waterhole – Diamantina River

Management unit:

MANAGEMENT UNIT 1: Diamantina Main Channel

Diamantina Channel to Goyder Lagoon including Andrewilla & Yammakira Waterholes

Easting / Northing: -26°15'49.68"S 139°23'48.04"E

Date assessed: 11th May 2015; 6th May 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 1.5km. Bankfull width approx. 40-45m
- **Conceptual understanding:** In channel permanent waterhole - 'Ark-type' aquatic refuge
- **Recent rainfall / inundation events:** 80mm recorded in February 2015. Annual regional flow.
- **Depth:** Cease to flow depth (CTFD): 1.4m
- **Elevation:** ~ 38 m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amaranthus grandiflorus</i> ; <i>Amyema preissii</i> ; <i>Boerhavia burbridgeana</i> ; <i>Cucumis melo</i> ; <i>Lysiana exocarpi ssp exocarpi</i> ; <i>Lysiana subfalcata</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Setaria jubiflora</i> ; <i>Teucrium racemosum</i>
Shrubs (low to tall shrubs)	<i>Abutilon sp.</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Atalaya hemiglauca</i> ; <i>Eremophila bignoniiflora</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 21



Double Bluff waterhole – assessment area



Leaf litter cover under established Coolibah



Double Bluff waterhole riparian corridor vegetation

Ecosystem Values, Threats and Pressures

Double Bluff Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Coolibah recruitment absent. Each stratum represented - mid-stratum and groundcover layer reduced.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	All strata present with some loss of vegetation cover. Multiple habitat features including: overhanging vegetation; flood runners; tree hollows; in-stream snags.	QUALITATIVE SURVEY
3.	Hydrological Value	HIGH	Receives annual flow maintaining permanency status. Cease to flow depth (CTFD) 1.35m shallow pool providing important connectivity value.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum EC 270 (µS/cm). Receives annual flow maintaining fresh water and low salinity able to support majority freshwater flora and fauna. High turbidity.	EC Tester SALINITY METER
5.	Cultural Heritage Site	MODERATE	Natural & Physical heritage value. Nearby old stockyards. Aboriginal stone artefacts present, with evidence of campfires and hearths.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	One of a series of permanent pools along this section of the Diamantina channel.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	HIGH	This site is one of a series of permanent / semi-permanent pools along the Pandie - Diamantina River Channel. An important aquatic refuge.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Rabbit and camel activity at the site. No gambusia or goldfish detected.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	ABSENT	No evidence of elevated nutrient levels.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	Station tracks and nearby stockyards.	QUALITATIVE SURVEY
13.	Tourism, camping activity	PRESENT LOW LEVEL	Remote site no recent activity. Some firewood removal and evidence of camping.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	LOW LEVEL	Some disturbance observed and loss of lignum cover at the streambank edge. Some erosion points formed from stock access to channel.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	PRESENT MODERATE LEVEL	Mid-stratum reduced and perennials grazed. Moderate grazing pressure evident with perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some loss of vegetation cover and connectivity with floodplain.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weeds present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Good canopy upper stratum vegetation structure along riparian corridor. Some loss of mid-stratum and groundcover layer	Observation
19. Age Structure	SLIGHTLY MODIFIED	Recruitment of coolibah absent.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Some damage by cattle trampling and firewood removal.	Observation

Summary

Double Bluff waterhole is located along the Diamantina-Pandie Channel in the Diamantina floodplain and channel country (Diamantina Land System). The site is near stockyards and has historic grazing pressure over a long period of time that has impacted perennial vegetation cover with reduction of mid-stratum and groundcover layers. The narrow fringing upper stratum vegetation is largely intact and provides important nesting habitat particularly in larger established coolibahs. It is a shallow waterhole with a cease to flow depth measured at 1.35m and is considered permanent due to receiving annual flow. Coolibah, whitewood, bean tree and Broughton willow are the dominate tree species with an understorey of lignum and native grasses. Flooding typically follows monsoonal rain in the upper catchment in south west Queensland. Reducing stock numbers before heavy grazing of perennials and groundcover is impacted will improve condition of the site. A suggested measure is to facilitate an increase in perennial vegetation cover and stability of soil surfaces through opportunistic spelling, particularly following significant rainfall events to encourage the establishment of perennials.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	HIGH	Although not a deep waterhole has relatively high importance due to permanency – receives annual flow.
Riparian Condition Rating	MODERATE	Over grazing has resulted in impacts to vegetation structure and floodplain vegetation. Nearby stockyards have supported more intensive grazing pressure over a long period of time at this site.
Connectivity Value	HIGH	Provides connectivity value during annual flow events. Is one of several pools that persist along the Diamantina - Pandie channel.
Restoration Potential	HIGH	The site has good canopy vegetation structure and is considered a good site for restoration, recovery and recruitment of perennials in conjunction with conservative stocking and grazing strategies.
Investment Priority	HIGH	A suitable site to undertake long term monitoring of vegetation responses to different grazing strategies, therefore, has scope for investment prioritisation.
Management priorities	HIGH	Undertake regular monitoring, investigate and implement conservative grazing management strategies to facilitate the recruitment and establishment of perennial vegetation, e.g. coolibahs; implement pest animal control measures as required.

Site 7: Goyder Lagoon Waterhole, Clifton Hills Station

Site information

Site: Goyder Lagoon Waterhole (Koondaritchinna) – Warburton River

Management unit:

MANAGEMENT UNIT 2: Goyder Lagoon

From Andrewilla and Yammakira tributary channels to commencement of the Warburton River channel

Easting / Northing: -26°53'21.92"S 138°57'47.96"E

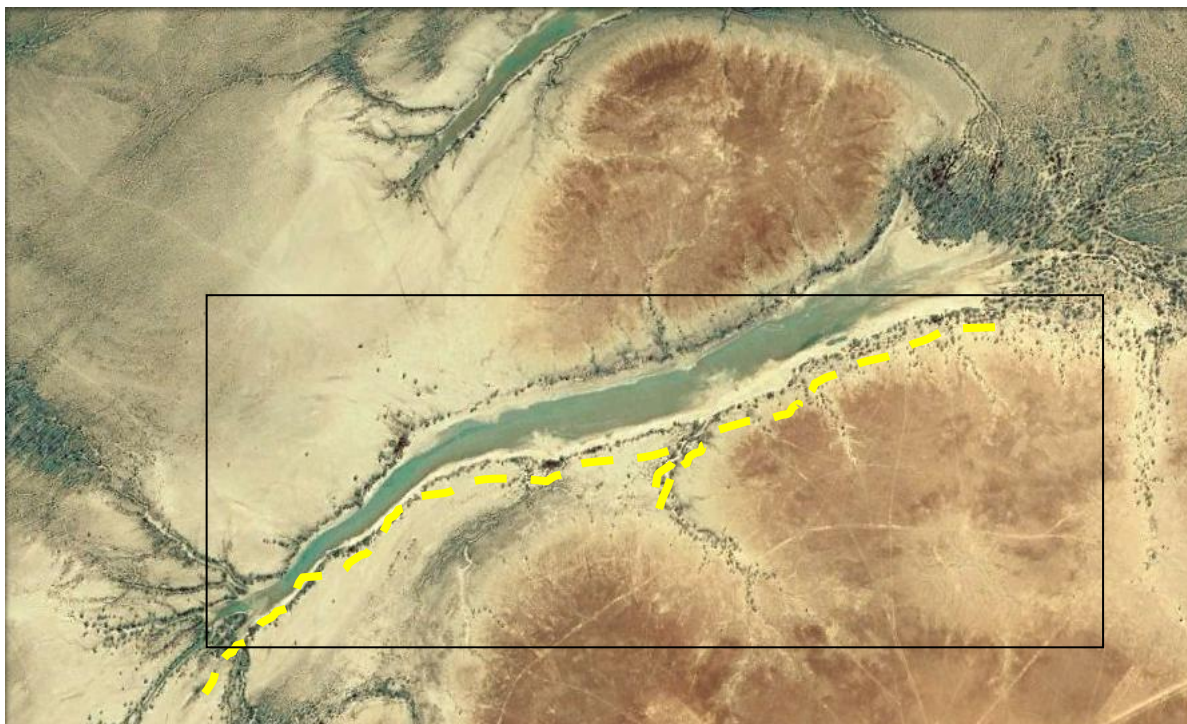
Date assessed: 1st May 2014; 8th May 2015

Description of feature assessed:

- **Feature type:** Off-channel riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 2.5km. Bankfull width approx. 70-80m, up to 120m in some sections.
- **Conceptual understanding:** Semi-permanent waterhole.
- **Recent rainfall / inundation events:** <20mm recorded early 2014; 80mm January 2015; received regional flow 2014-16.
- **Depth:** Cease to flow depth (CTFD): 2.1m
- **Elevation:** ~ 22m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	<i>Aeschynomene indica</i>
Understorey - (grasses, forbs & misc)	<i>Cressa cretica</i> ; <i>Goodenia fascicularis</i> ; <i>Trianthema triquetra</i> ; <i>Teucrium racemosum</i> ; <i>Marsilea drummondii</i> ; <i>Portulaca intraterranea</i> <i>Tetragonia tetragonioides</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Eremophila bignoniiflora</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 15



Low gradient waterhole receives runoff from nearby gibber **Reduced groundcover and shrublayer along riparian edge**



Large coolibah at waterhole edge



Stunted grazed mature coolibah on the outer riparian zone

Ecosystem Values, Threats and Pressures

Goyder Lagoon Waterhole (Koondaritchinna) – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Heavy grazing pressure has resulted in low recruitment of perennials, reduced shrub layer and heavily impacted groundcover.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE	Range of riparian habitat features including distributary channels; overhanging and submerged vegetation, tree hollows, and flood runners. All strata present although mid-stratum reduced. Some areas of understorey heavily degraded with major vegetation loss.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Semi-permanent waterhole – receives regular regional flows. Important waterhole for species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum 360 EC (µS/cm).	EC Tester SALINITY METER
5.	Cultural Heritage Site	MODERATE to HIGH	High rating for Physical Heritage values. Important Aboriginal cultural site. Numerous stone artefacts and hearths.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	Similar 'type' example in sub-catchment other semi-permanent aquatic refuges are present at the sub-regional level.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole – persists for 12-18 months and often receives regional flows. Provides waterbird habitat and good conditions for fish recruitment and dispersal.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial, aquatic)	PRESENT MODERATE	Evidence of camels and recent rabbit activity – low impact.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – some evidence of eutrophication; algal and aquatic plant growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW LEVEL	Station tracks leading into waterhole. Site relatively near to Inside Track.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	LOW LEVEL	Visitor use area. Site is often used for camping. Firewood supplies are low.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	LOW LEVEL	Soil trampling and disturbance evident from cattle and camel activity. Low gradient with numerous access points to waterhole.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE to HIGH	Heavy grazing pressure on perennial vegetation, coolibah, lignum and chenopodium. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Riparian vegetation consists of a thin margin along the waterhole edge – this is reduced due to historic grazing pressure.	Observation
17. Nativeness	UNMODIFIED	No weeds observed.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Reduced mid-stratum and groundcover. Lack of recruitment of perennials.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced due to grazing pressure – lack of juveniles and low recruitment of perennials.	Observation
20. Terrestrial woody debris and leaf litter	MODERATELY MODIFIED	Low leaf litter cover and debris probably from firewood collection and thin riparian edge vegetation.	Observation

Summary

Goyder Lagoon Waterhole (Koondaritchinna) is located on the margin of the river channel and floodplain country (Diamantina land system) and stony country (Koonchera land system). The waterhole, also known as Big Lagoon, is a large, shallow and wide waterhole which fills during moderate flood events and persists for approximately 12 months. The waterhole is approximately 2.5km in length with a cease to flow depth of 2.1m, a persistent although non-permanent waterhole. Because Goyder Lagoon waterhole holds water longer and is one of the more persistent water points on the floodplain it has had historically high grazing pressure subsequently the area has been impacted by grazing with a reduced cover of perennial grasses, and the shrub layer significantly reduced, with minimal to no coolibah recruitment. Queensland bluebush (*Chenopodium auricomum*) is also heavily grazed. The waterhole lies on the edge of a gibber plain and surface runoff probably contributes to its persistence. The waterhole is lined with a thin fringing vegetation of mature coolibahs. The waterhole has had long-term impacts from grazing with coolibahs showing stunted growth from repeated grazing. The site is an important Aboriginal site with numerous stone artefacts and evidence of fire hearths. Floodwaters often reach the waterhole, however, this may not occur on an annual basis.

A suggested measure is to facilitate an increase in perennial vegetation cover and stability of soil surfaces through periodic destocking or reducing stock numbers before cattle concentrate on the waterhole and heavy grazing of perennial vegetation occurs. Opportunistic spelling, particularly following significant rainfall events to encourage the establishment of perennials should also be considered. It is a significant Aboriginal heritage site that has importance to the Wangkangurru Yarluyandi Aboriginal community.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	HIGH	Semi-permanent waterhole provides important aquatic habitat during moderate flooding events. Important site for waterbirds.
Riparian Condition Rating	MODERATE	Impacted from long-term grazing pressure. Low recruitment of perennials evident.
Connectivity Value	HIGH	Connectivity with Diamantina main channel and Goyder Lagoon enables species dispersal; recruitment.
Restoration Potential	MODERATE	Recovery of the waterhole site will likely occur over a long-term period due to the extent of vegetation loss and soil disturbance.
Investment Priority	HIGH	Important natural heritage site warrants consideration of management investment.
Management priorities	HIGH	Undertake regular monitoring, investigate and implement conservative grazing management strategies to facilitate the recruitment and establishment of perennial vegetation, implement pest animal control measures as required.

Site 8: Kalamunkinna Waterhole, Cowarie Station

Site information

Site: Kalamunkinna Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°17'21.61"S 138°33'04.90"E

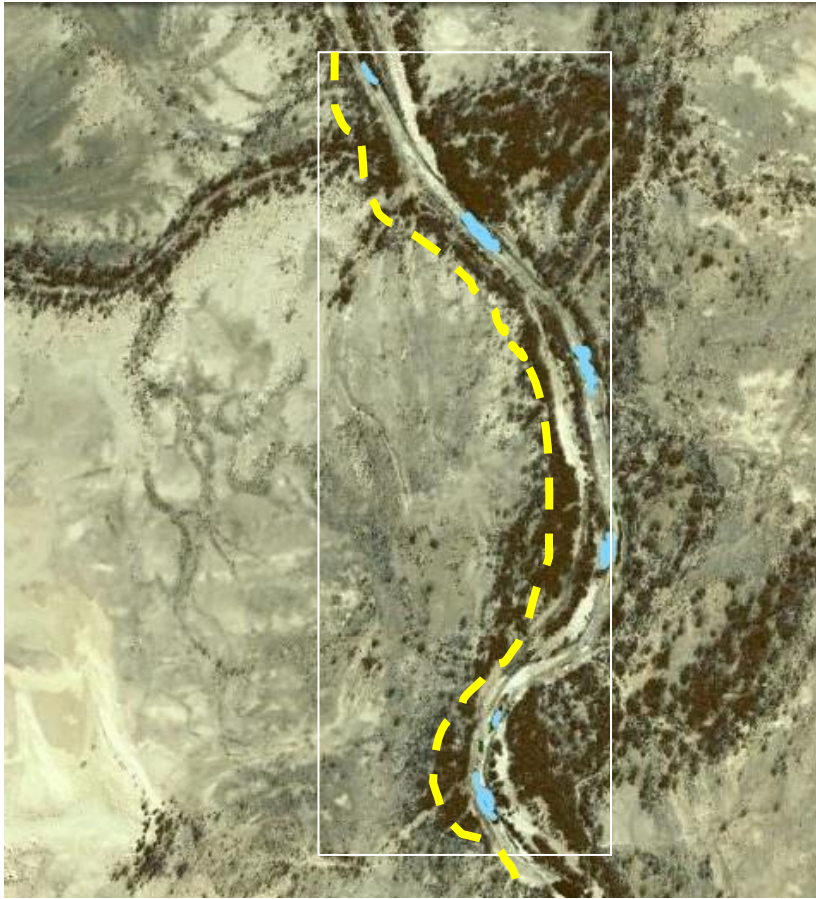
Date assessed: 10th May 2014; 4th May 2015

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 100m. Bankfull width approx. 24m.
- **Conceptual understanding:** In-channel small intermittent pools – highly saline
- **Recent rainfall / inundation events:** 100mm at Cowarie HS in early 2015
- **Depth:** Cease to flow (CTFD) depth: 1.0m
- **Elevation:** ~ 17m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland / lignum understorey

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Boerhavia dominii</i> ; <i>Cucumis melo</i> ; <i>Diplatia grandibractea</i> ; <i>Nicotiana velutina</i> ; <i>Portulaca intraterranea</i> ; <i>Phyllanthus lacunellus</i> ; <i>Solanum oligacanthum</i> ; <i>Teucrium racemosum</i> ; <i>Tetragonia tetragonioides</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 16



Kalamunkinna waterhole – assessment area



Riparian channel vegetation



Saline pool after Warburton channel and saline pool

Ecosystem Values, Threats and Pressures

Kalamunkinna Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for the habitat assessed. Low recruitment of perennials.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Good range of riparian habitat features including flood runners; distributary channels; overhanging vegetation; tree hollows; submerged logs; All strata present.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Semi-permanent waterhole. Cease to flow depth (CTFD) 1.0m. Receives water from regional flows. Site where Kallakooah connects with Warburton River. Important connectivity value for species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	LOW	During site visits maximum 148000 EC (µS/cm). Hyper-saline.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Physical Heritage value. Evidence of grinding stones.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	Similar 'type' example in sub-catchment at sub-regional level including all 4 Management Zones – other permanent or semi-permanent aquatic refuges exist.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Semi-permanent waterhole – seasonal, persists for <12 months - supports a low range of aquatic fauna and flora during drier periods.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Evidence of rabbits; camels; feral pigs in the area. Low level -low impact. Low numbers of gambusia present.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW LEVEL	Low level – some evidence of eutrophication e.g. algal or aquatic plant growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	ABSENT	Minor tracks no infrastructure near waterhole.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Remote access no evidence of recent camping or visitor impacts.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
14.	Bank stability, soil disturbance	LOW LEVEL	Evidence of destabilised bank and erosion points. Reduction in lignum cover at streambank edge. System stable.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE	Grazing present with damage to perennial vegetation and potential impacts on recruitment.	QUALITATIVE SURVEY

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some loss of vegetation continuity with floodplain. Longitudinal continuity of vegetation intact.	Observation
17. Nativeness	LARGELY UNMODIFIED	No significant weeds present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Mid-stratum layer reduced due to grazing pressure. Recruitment of coolibahs absent.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Reduced cover of Coolibahs – juvenile and sub-adult class mostly absent due to grazing pressure.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Reduced leaf litter layer by <20% through stock trampling	Observation

Refer Appendix A for interpretation of scoring system

Summary

Kalamunkinna Waterhole is located on the Warburton River at the junction of the Warburton and Kallakoopah reach. This country comprises channels, floodplains and associated sand dunes with coolibah, Broughton Willow, river cooba and lignum lining the waterhole (Warburton land system). Grazing impacts are moderate with a lower than expected level of coolibah recruitment and impact to lignum at the streambank edge. The waterhole is at the junction of the Kallakoopah providing connectivity with this desert creek system. Measures to assist stabilisation and recovery are an important consideration. This may include opportunistic spelling or light stocking particularly following major flooding events along the waterhole to facilitate regeneration and recruitment of perennial species, particularly coolibahs.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the Warburton River system.
Riparian Condition Rating	HIGH	Good spatial vegetation coverage along riparian zone. Lignum cover mostly intact. Low recruitment of perennials e.g. coolibahs.
Connectivity Value	HIGH	Connectivity with Kallakoopah Creek and Warburton River enables species dispersal.
Restoration Potential	MODERATE	Recovery potential rated moderate due to site not under heavy stress and relatively intact.
Investment Priority	MODERATE	Current management is maintaining the site.
Management priorities	HIGH	Stocking levels and grazing considerations to enhance recovery of the site and promote perennial vegetation recruitment.

Site 9: Koonchera Waterhole, Clifton Hills Station

Site information

Site: Koonchera Waterhole – Diamantina / Goyder Lagoon floodplain

Management unit:

MANAGEMENT UNIT 2: Goyder Lagoon

From Andrewilla and Yammakira tributary channels to commencement of the Warburton River channel

Easting / Northing: -26°41'21.47"S 139°30'20.00"E

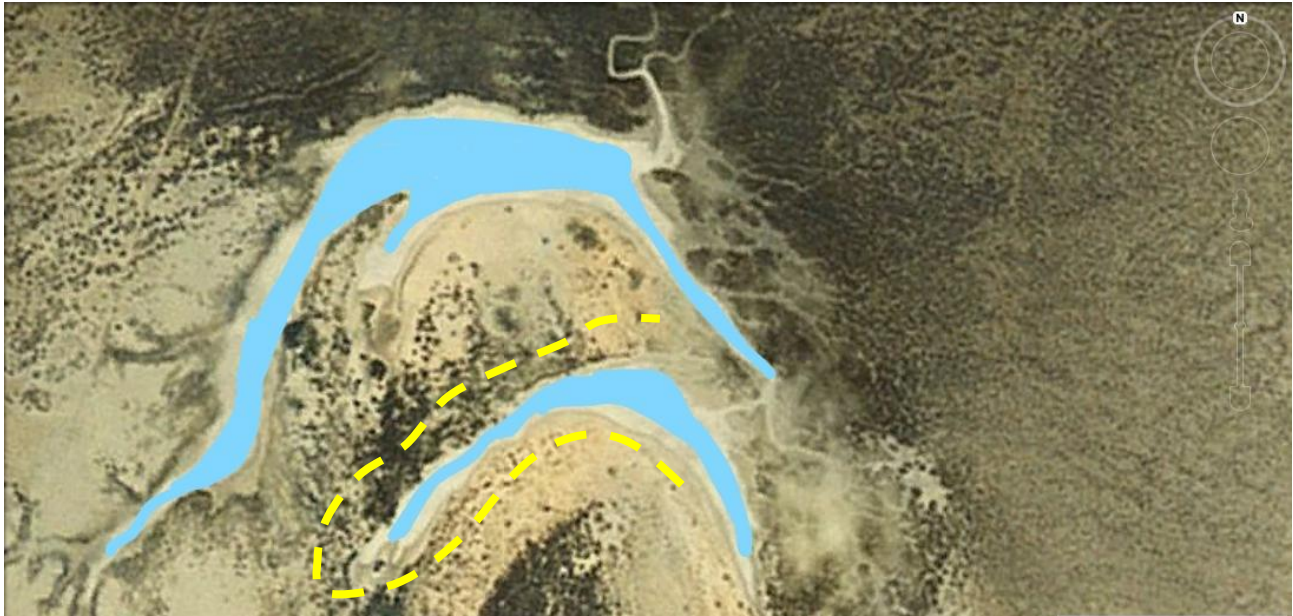
Date assessed: 3rd May 2014; 9th May 2015

Description of feature assessed:

- **Feature type:** Floodplain waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 600m. Bankfull width approx. 60-80m
- **Conceptual understanding:** Semi-permanent waterhole.
- **Recent rainfall / inundation events:** 80mm recorded in January 2015; receives annual flow.
- **Depth:** Cease to flow depth (CTFD): 1.75m
- **Elevation:** ~ 29 m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amyema preissii</i> ; <i>Boerhavia coccinea</i> ; <i>Citrullus lanatus</i> ; <i>Cyperus iria</i> ; <i>Dactyloctenium radulans</i> ; <i>Dysphania truncata</i> ; <i>Echinochloa crus-galli</i> ; <i>Einadia nutans ssp. eremaea</i> ; <i>Eragrostis basedowii</i> ; <i>Eragrostis setifolia</i> ; <i>Eriochloa australiensis</i> ; <i>Euphorbia wheeleri</i> ; <i>Ipomoea polymorpha</i> ; <i>Marsilea drummondii</i> ; <i>Malva preissiana</i> ; <i>Nicotiana velutina</i> ; <i>Paractaenum novae-hollandiae ssp. reversum</i> ; <i>Phyllanthus lacunellus</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Sesbania cannabina var cannabina</i> ; <i>Sonchus oleraceus</i> ; <i>Sauropus trachyspermus</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus eichlerianus</i> ; <i>Zygophyllum simile</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 35



Koonchera waterhole – assessment area



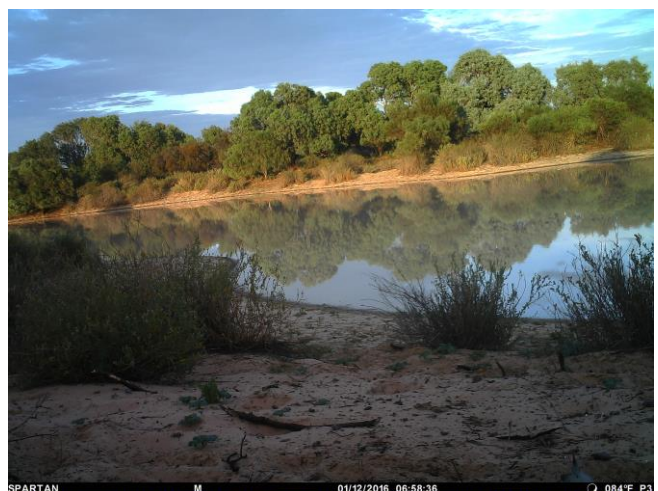
Thin riparian vegetation corridor



Australian bustard *Ardeotis australis* – Koonchera waterhole



Browse line on large Broughton willow



Riparian vegetation along waterhole

Ecosystem Values, Threats and Pressures

Koonchera Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE to HIGH	Slightly reduced riparian plant assemblages. Least disturbed with all strata present. Vegetation largely native trees over predominately native understorey. No WONS present but typically includes some introduced species.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	All strata present. Multiple habitat features including: deep pools, dune swales; flood runners.	QUALITATIVE SURVEY
3.	Hydrological Value	HIGH	Significant waterhole classified as semi-permanent to permanent. Cease to flow depth (CTFD) 1.75m. Receives annual flow. An important site for waterbirds, aquatic species recruitment, dispersal and channel / floodplain connectivity.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum EC 330 (µS/cm). Receives annual flow on a regular basis maintaining fresh water and low salinity.	EC Tester SALINITY METER
5.	Cultural Heritage Site	HIGH	High rating for Natural, Customary & Physical heritage values. High Aboriginal cultural significance; evidence of numerous occupation sites and stone artefacts. Important habitat for birds, fish.	QUALITATIVE SURVEY
6.	Uniqueness	HIGH	Important waterbird habitat and. Only type in sub-catchment – supports a range of fauna species and a good range of habitat features.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Permanent to semi-permanent waterhole - supports a range of fauna and flora during drier conditions over extended periods of time.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT MODERATE	No significant (WONS) weeds observed; four introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT MODERATE LEVEL	Feral pigs, cats, rabbits present at relatively low level with little observable impact. No introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & groundwater abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – some evidence of eutrophication causing aquatic plant growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	Low level – no significant disturbances, station tracks leading into waterhole. Accessible from Birdsville Track.	QUALITATIVE SURVEY
13.	Tourism, recreation and camping activity	PRESENT LOW LEVEL	Low level – some evidence of past and recent activity including campfires, wood collection.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
14.	Bank stability, soil disturbance	PRESENT LOW LEVEL	Some soil disturbance and loss of groundcover through trampling. System stable.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE to HIGH	Heavy grazing pressure evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some loss of vegetation along riparian edge.	Observation
17. Nativeness	LARGELY UNMODIFIED	No WONS species present.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Reduction in understorey and shrub layer due to grazing pressure	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover of Coolibahs – juvenile and sub-adult class mostly absent due to grazing pressure.	Observation
20. Terrestrial woody debris and leaf litter	MODERATELY MODIFIED	Loss of leaf litter cover reduced through stock trampling. Woody debris reduced.	Observation

Summary

Koonchera waterhole is located on the upstream channels of the Diamantina at the eastern margin of Goyder Lagoon floodplain (Diamantina Land System). The floodplain is frequently flooded during moderate flood events with Koonchera receiving an annual flow in most years. It is an important grazing area and is grazed in most years. The waterhole is an important waterbird habitat and supports large numbers when nearby Goyder Lagoon is in flood.

The site is often heavily grazed and attracts a large array of native and introduced fauna due to its near permanent water supply. Measures to assist stabilisation and recovery in the sand dune floodplain country are important. This may include opportunistic spelling or light stocking particularly following major flooding events at the waterhole to facilitate regeneration and recruitment of perennial species.

Other considerations include de-stocking the paddock before stock become concentrated and as other waterholes dry up and control of feral pigs to prevent build up of numbers. Koonchera is a significant site for Aboriginal people and requires sensitive management to maintain its natural and cultural values. The surrounding wetland and Koonchera Dune, south-east of Goyder Lagoon, are areas recognised for their importance for wildlife. Several species of conservation significance are found in this area including the kowari and grey grass wren.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	HIGH	Near permanent waterhole with high ecological and aquatic importance providing habitat for waterbirds and fish.
Riparian Condition Rating	MODERATE	Impacted from grazing pressure. Perennial vegetation damaged with little recruitment evident. Distinct browse.
Connectivity Value	HIGH	Floodplain waterhole – near-permanent provides habitat for fish species dispersal and recruitment. Important bird habitat.
Restoration Potential	HIGH	Recovery potential rated moderate due to site not under heavy stress and relatively intact.
Investment Priority	HIGH	High ecological importance therefore implementing grazing management and pest species control measures are important.
Management priorities	HIGH	Undertake regular monitoring, investigate and implement conservative grazing management strategies to facilitate the recruitment and establishment of perennial vegetation, e.g. coolibahs; implement pest animal control measures as required.

Site 10: Kuncherinna Waterhole, Cowarie Station

Site information

Site: Kuncherinna Waterhole – Kallakoopah Creek

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°22'16.70"S 138°27'57.11"E

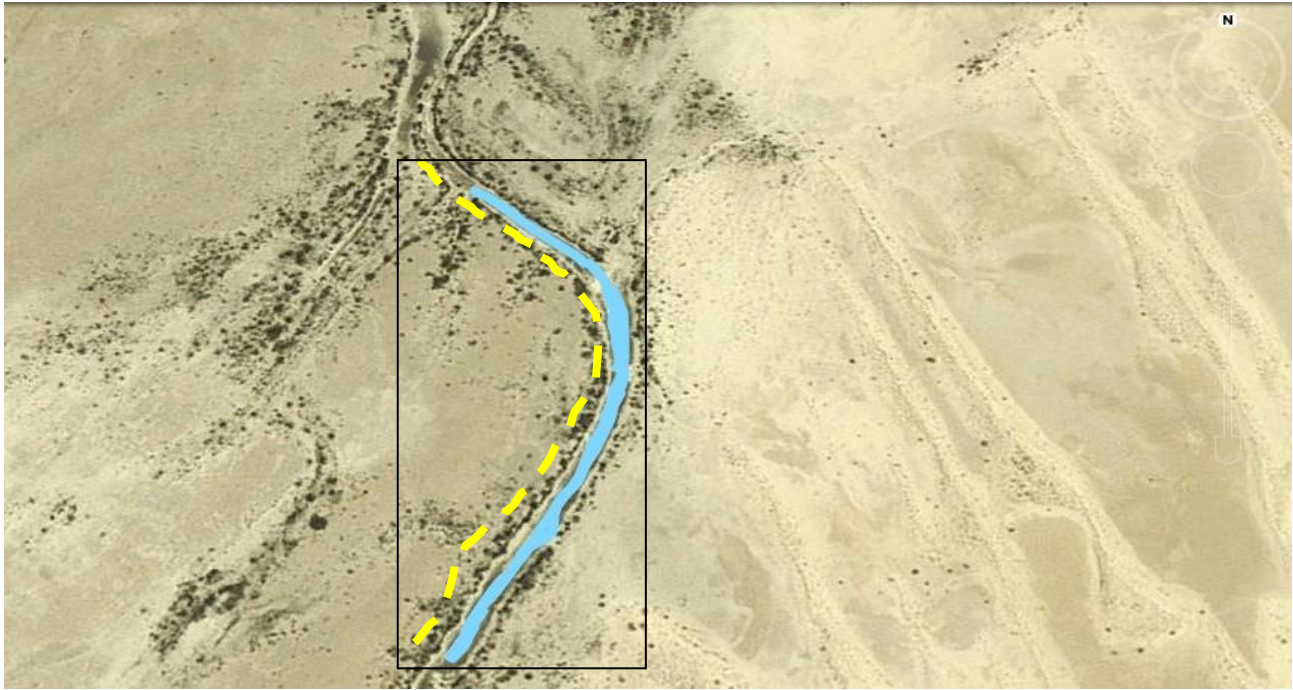
Date assessed: 11th May 2014

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 2.5km. Bankfull width approx. 40-50m.
- **Conceptual understanding:** Surface flow driven non-permanent waterhole.
- **Recent rainfall / inundation events:** 80mm recorded in area in February 2015; does not receive annual flow
- **Depth:** Cease to flow depth (CTFD): waterhole dry.
- **Elevation:** ~ 15m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Portulaca intraterranea</i> ; <i>Sclerolaena bicornis</i> ; <i>Stemodia florulenta</i>
Shrubs (low to tall shrubs)	<i>Atriplex nummularia</i> ; <i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 11



Kuncherinna waterhole – Kallakoopah Creek assessment area



Dry creek bed and thin riparian corridor vegetation



Exposed coolibah tree roots on riparian edge



Heavily grazed area near waterhole



Erosion areas on floodplain adjacent waterhole

Ecosystem Values, Threats and Pressures

Kuncherinna Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE to LOW	Low plant diversity. Heavily grazed. Perennial species recruitment reduced. Vegetation showing obvious change from natural assemblages with 2 strata greatly reduced (groundcover & mid-stratum layer). Extent of the vegetated bank cover <50%.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE	Moderate range of riparian habitat features (2-3) present including flood runners; distributary channels; tree hollows; submerged logs. One to two strata greatly reduced.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole - depending on extent of local and regional flow events– frequently dry becoming a series of saline pools. Moderate channel / floodplain connectivity value for ecosystem function and species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity		During site visits waterhole was dry	QUALITATIVE SURVEY
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Physical heritage value. Old stockyards nearby.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Same type in sub-catchment.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Similar 'type' example in sub-catchment at sub-regional level - other semi-permanent aquatic refuges are present.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT	Rabbits present. No introduced fish (gambusia or goldfish) recorded (site dry).	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients		Waterhole dry.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	Station tracks leading into waterhole. Stockyards nearby.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Relatively remote site – not a visitor use area.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	PRESENT MODERATE	Major disturbance observed heavy trampling and loss of lignum cover at the streambank edge. Some erosion points formed from stock access to channel.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	PRESENT HIGH LEVEL	Heavy grazing pressure evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Width reduced by up to 1/3 and/or some breaks in continuity.	Observation
17. Nativeness	UNMODIFIED	No WONS species present.	Observation
18. Structural Integrity	SUBSTANTIALLY MODIFIED	Reduced cover (75-50%) of dominant strata, and only one age class present FOR Coolibah layer.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover (75-50%) of dominant strata, and only one age class present.	Observation
20. Terrestrial woody debris and leaf litter	SUBSTANTIALLY MODIFIED	Significantly low quantities of debris and leaf litter cover present. Cover at 75% below what is expected.	Observation

Summary

Kuncherinna waterhole is located on the Kallakopah reach in flow path, floodplain country and associated sand dunes (Warburton land system) with channel vegetation mainly consisting of coolibah (*Eucalyptus coolabah*), Broughton willow (*Acacia salicina*), river cooba (*Acacia stenophylla*), and lignum (*Duma florulenta*). The waterhole receives intermittent flow depending on the extent of regional flows. Local rainfall can fill the waterhole with waterhole persistence low due to the shallow depth.

The waterhole was dry at the time of assessment but would probably have a fairly low cease to flow depth holding for less than a year after filling and without further inflow. The waterhole has been heavily impacted by grazing as evidenced by bare areas and scalded flats in the vicinity of the waterhole. This is largely as a result of the long grazing history in the vicinity of the waterhole. There is moderate gullying with reduced cover of perennials leading to soil loss; and proliferation of unpalatable goathead (*Sclerolaena bicornis*) noted along the riparian vegetation corridor. Lignum is heavily impacted and reduced in some sections due to stock repeatedly accessing the waterhole. There is extensive grazing of perennials and minimal groundcover remaining. Stem damage to Broughton willow is very evident due to prolonged grazing on the waterhole when there is little palatable feed available. Measures to assist stabilisation and recovery are an important consideration. This may include opportunistic spelling or light stocking particularly following major flooding events along the waterhole to facilitate regeneration and recruitment of perennial species, particularly coolibahs. Other considerations include de-stocking the paddock before stock become concentrated and as waterholes dry up.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Moderate importance as an aquatic refuge due to reliance on seasonal factors for connectivity with the Warburton.
Riparian Condition Rating	LOW	Heavily impacted from total grazing pressure. Perennial vegetation damage with little recruitment evident.
Connectivity Value	MODERATE	Important stepping stone waterhole for species dispersal into the Kallakopah reach when connected with the Warburton River.
Restoration Potential	LOW	Loss of habitat and vegetation cover integrity makes this site less likely to fully recover
Investment Priority	MODERATE	Medium importance. Investigating grazing strategies to facilitate recruitment of perennial vegetation in conjunction with feral animal control can be considered.
Management priorities	HIGH	Investigate and implement grazing management strategies to enable recovery of the site and undertake regular monitoring. Destocking when the waterhole becomes dry will reduce impacts on vegetation cover.

Site 11: Mia Mia Waterhole, Kalamurina Wildlife Sanctuary

Site information

Site: Mia Mia Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°49'27.97"S 138°11'02.82"E

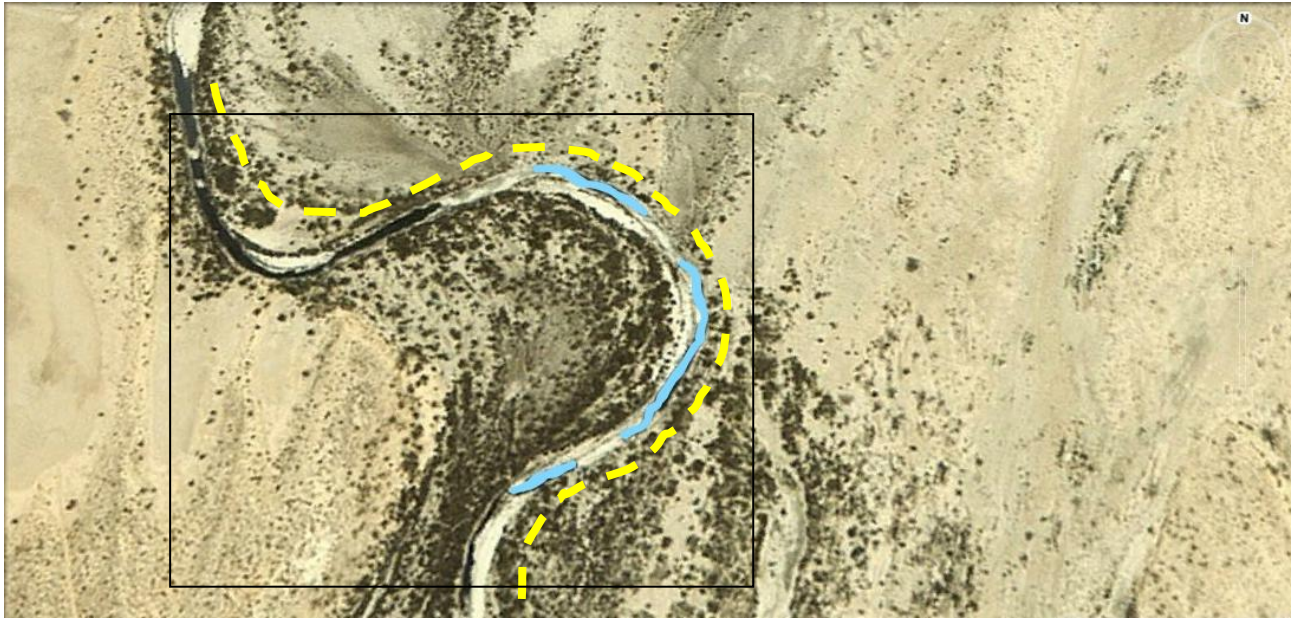
Date assessed: 2nd May 2015; 30th April 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Conservation
- **Size / Area:** Waterhole length approx. 1km. Bankfull width approx. 20-25m.
- **Conceptual understanding:** Surface flow driven semi-permanent waterhole.
- **Recent rainfall / inundation events:** 100mm recorded at Kalamurina HS in January 2015; 190mm January 2016.
- **Depth:** Cease to flow depth (CTFD): 0.5m
- **Elevation:** ~ 5m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amaranthus grandiflorus</i> ; <i>Boerhavia coccinea</i> ; <i>Boerhavia schomburgkiana</i> ; <i>Chloris pectinata</i> ; <i>Cucumis melo</i> ; <i>Cyperus gymnocaulos</i> ; <i>Dactyloctenium radulans</i> ; <i>Eragrostis dielsii</i> var. <i>dielsii</i> ; <i>Eriochloa crebra</i> ; <i>Goodenia glauca</i> ; <i>Rutidosia helichrysoides</i> ssp. <i>Helichrysoides</i> ; <i>Marsilea drummondii</i> ; <i>Nicotiana velutina</i> ; <i>Phyllanthus lacunellus</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Sauropus trachyspermus</i> ; <i>Sclerolaena intricata</i> ; <i>Sclerolaena bicornis</i> ; <i>Sida ammophila</i> ; <i>Sphaeromorphaea littoralis</i> ; <i>Sporobolus mitchellii</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus terrestris</i> ; <i>Trichodesma zeylanicum</i> var. <i>zeylanicum</i> ; <i>Triraphis mollis</i> ; <i>Teucrium racemosum</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Pterocaulon sphacelatum</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 34



Mia Mia waterhole – assessment area



Good leaf litter and ground cover along riparian corridor



Recovery of riparian vegetation



Streambank habitat features – fallen and submerged logs



Good riparian vegetation cover on streambank edge

Ecosystem Values, Threats and Pressures

Mia Mia Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Plant species assemblages as expected for the habitat assessed with increased species richness in lower stratum probably a response to recent rainfall event. All strata present - typically coolibah overstorey with a range of native mid-stratum and understorey vegetation at different age classes (juvenile; sub-adult; & adult). Minimal riparian vegetation cover loss.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	HIGH	High range of riparian habitat features including flood runners; distributary channels; deep pools; inner meander bends; overhanging vegetation; tree hollows; in-stream snags; submerged logs. All strata present and typically well vegetated with expected range of plant assemblages.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole – frequently dry becoming a series of saline pools. Cease to flow depth (CTFD) 0.5m.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	SALINE	During site visits maximum 8300 EC (µS/cm).	EC Tester SALINITY METER
5.	Cultural Heritage Site	MODERATE VALUE	Physical heritage value. Old stockyards nearby; and historic farming machinery.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Important habitat for salt tolerant fish species and dispersal once system connectivity occurs after flooding. Similar 'type' example in sub-catchment at sub-regional level.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Semi-permanent waterhole – seasonal, persists for <12 months - supports a low range of aquatic fauna and flora during drier periods over a limited period of time.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Evidence of recent rabbit activity. No introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	No water extraction activities observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW LEVEL	Elevated nutrient levels. Some evidence of eutrophication e.g. algal growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks)	PRESENT LOW LEVEL	Minor track leading into site. Nearby old stockyards.	QUALITATIVE SURVEY
13.	Tourism, camping, activity	ABSENT	Low visitor use area. Low impact camping.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	ABSENT	Minimal evidence of destabilised banks, erosion points or loss of groundcover through trampling. System stable.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
15.	Total Grazing Pressure	PRESENT LOW LEVEL	Low level with some herbivore browse evident. No major impacts. Destocking has contributed to recovery of site.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	LARGELY UNMODIFIED	Little evidence of broad-scale loss of native vegetation.	Observation
17. Nativeness	LARGELY UNMODIFIED	Vegetation predominately native, few weeds and no 'high threat' (WONS) species.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Cover within one stratum 50% lower or higher than what is expected.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Reduced cover (75-50%) of dominant strata present. Only two age classes present.	Observation
20. Terrestrial woody debris and leaf litter	LARGELY UNMODIFIED	Quantity and cover as expected for the site. Good leaf litter and debris cover with a 'no campfire' policy in place.	Observation

Summary

Mia Mia Waterhole is located on the Warburton River in the Tirari Desert (Tirari Land System). This country includes channels and floodplains of the lower Warburton. Dominate tree species are coolibah (*Eucalyptus coolabah*) and Broughton willow (*Acacia salicina*) with an understorey of lignum (*Duma florulenta*) and native grasses. The opposite side of the waterhole (not assessed) is situated on an inner meander bend where there would be expected elevated productivity and consequently higher percentage cover of upper and mid strata vegetation.

The site has lower perennial species richness in the upper stratum correlating with higher salinity and lower flooding frequency. Plant species assemblages are as expected for the habitat assessed with increased species richness in the lower stratum, mainly consisting of annual and ephemeral species, probably as a response to a significant localised rainfall event. Unpalatable goathead (*Sclerolaena bicornis*), an indicator of disturbance, was noted in the adjacent floodplain area, however, the site is in recovery from historic heavy grazing pressure and there is good species recruitment and the system is in a stable condition.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the lower Warburton River system.
Riparian Condition Rating	HIGH	Good recovery and vegetation cover at riparian zone.
Connectivity Value	MODERATE	Semi-permanent waterhole provides habitat for salt tolerant species and dispersal after flooding.
Restoration Potential	HIGH	Current management will enhance recovery potential – removal of stock grazing has improved vegetation recovery rate.
Investment Priority	MODERATE	Due to current management of feral animals and visitor control protocols there is a lower priority for interventions or investment.
Management priorities	MODERATE	Under sound management – maintain feral animal control measures and visitor management/camping protocols currently in place.

Site 12: Mona Downs Outstation, Cowarie Station

Site information

Site: Mona Downs – Kallakoopah Creek

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°23'59.77"S 138°27'02.88"E

Date assessed: 5th May 2015; 3rd May 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 1.5km. Bankfull width 30m.
- **Conceptual understanding:** In-channel non-permanent waterhole.
- **Recent rainfall / inundation events:** 80mm recorded in area in February 2015.
- **Depth:** Cease to flow depth (CTFD): 2.15m
- **Elevation:** ~ 15m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Boerhavia schomburgkiana</i> ; <i>Centipeda nidiformis</i> ; <i>Cucumis melo</i> ; <i>Cullen sp.</i> ; <i>Glinus lotoides</i> ; <i>Haloragis aspera</i> ; <i>Portulaca intraterranea</i> ; <i>Rumex crystallinus</i> ; <i>Salsola australis</i> ; <i>Sclerolaena bicornis</i> ; <i>Sclerolaena intricata</i> ; <i>Sphaeromorphaea littoralis</i> ; <i>Trianthema triquetra</i> ; <i>Teucrium racemosum</i> ; <i>Tetragonia tetragonioides</i>
Shrubs (low to tall shrubs)	<i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Tamarix aphylla</i> 23



Mona Downs Station waterhole – assessment area



Athel pine regrowth at Mona Downs Station ruins



Heavy grazing pressure along riparian edge

Ecosystem Values, Threats and Pressures

Mona Downs Outstation – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for the habitat assessed. Loss of plant diversity due to heavy grazing pressure. Perennial species recruitment and groundcover reduced.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE	Moderate range of riparian habitat features including flood runners; overhanging vegetation; tree hollows; submerged logs. One strata missing or greatly reduced.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole depending on flooding extent and local rain events. Cease to flow depth 2.15m.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visit (2015) maximum EC 300 (mS/cm). Recent rain event filled waterhole. High turbidity.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	HIGH	High rating for Physical heritage values. Mona Downs homestead ruins - historical importance. Stockyards nearby. Evidence of Aboriginal presence, numerous campfire sites and stone artefacts.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Similar 'type' example in sub-catchment at sub-regional level – other semi-permanent aquatic refuges present.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Semi-permanent waterhole – seasonal, persists for less than 12 months - supports a low range of aquatic fauna and flora during drier periods over a limited period of time.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT	Athel Pine (WONS) present at old Mona Downs Homestead (abandoned). Regeneration of existing stand previously controlled. No new cohorts	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT MODERATE LEVEL	Access point for large numbers of camels. Rabbits present.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	No water extraction activities observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW LEVEL	Low level – some evidence of algal growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW	Nearby outbuildings and tracks; stockyards.	QUALITATIVE SURVEY
13.	Tourism, camping, recreational activity	ABSENT	Low visitor use area.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	PRESENT	Some disturbance observed and loss of lignum cover at the streambank edge. Some erosion points formed from stock access to channel.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	HIGH	Heavy grazing pressure evidenced by perennials grazed and distinct browse. Low recruitment of perennials.	QUALITATIVE SURVEY

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Loss of understorey cover with some breaks in continuity along the waterhole and poor connectivity with floodplain vegetation.	Observation
17. Nativeness	MODERATELY MODIFIED	'High threat' (WONS) species present.	Observation
18. Structural Integrity	MODERATELY MODIFIED	One stratum missing and/or cover within remaining stratum 50% lower or higher than 'best on offer'	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover (75-50%) of dominant strata present, Only one age class present	Observation
20. Terrestrial woody debris and leaf litter	SUBSTANTIALLY MODIFIED	Significantly low quantities of debris and leaf litter cover present. Cover at 75% below what is expected.	Observation

Summary

Mona Downs is located on the Kallakoopah reach in channel, floodplain country and associated sand dunes (Warburton land system) with channel vegetation mainly consisting of coolibah (*Eucalyptus coolabah*), Broughton willow (*Acacia salicina*), river cooba (*Acacia stenophylla*), and lignum (*Duma florulenta*). The waterhole has a fairly shallow cease to flow depth (approximately 2.0m) and holds for less than a year after filling and without further inflow. It receives intermittent flow depending on the extent of regional flows. Local rainfall can fill the waterhole, however, persistence is low due to the shallow depth. The country in the vicinity of Mona Downs has been heavily impacted by grazing as evidenced by bare areas and scalded flats in the vicinity of the waterhole and Mona Downs Station ruins. This is largely as a result of the long grazing history in the vicinity of the waterhole.

There is moderate gullying with reduced cover of perennials leading to soil loss; and proliferation of unpalatable goathead (*Sclerolaena bicornis*) noted along the riparian vegetation corridor. Lignum is heavily impacted and substantially reduced in some sections due to stock repeatedly accessing the waterhole. There is moderate to high grazing of perennials including native plumbush (*Santalum lanceolatum*) and river cooba. Stem damage to Broughton willow is very evident due to prolonged grazing on the waterhole when there is little palatable feed available.

An outbreak of Athel Pine (*Tamarix aphylla*), coppicing from previously controlled mature trees, requires treatment at the old homestead ruins. There seems to be no new infestations along the channel. It is suggested this is carried out before further suckering and the vegetative formation of new stems and root systems occurs at the infestation site. A further measure is to facilitate an increase in perennial vegetation cover to stabilise soil surfaces by opportunistic spelling or light stocking.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Moderate importance as an aquatic refuge due to reliance on seasonal factors for connectivity with the Warburton.
Riparian Condition Rating	LOW	Heavily impacted from total grazing pressure. Perennial vegetation damage with little recruitment evident.
Connectivity Value	MODERATE	Provides some connectivity value for species dispersal into Kallakoopah reach.

Riparian Habitat Summary	Ranking	Comments
Restoration Potential	LOW	Heavy grazing over long-term has created loss of habitat and vegetation cover making this site less likely to fully recover.
Investment Priority	MODERATE	Medium importance. Investigating grazing strategies to facilitate recruitment of perennial vegetation in conjunction with feral animal control.
Management priorities	HIGH	Apply grazing strategies to enable recovery of the site. Destocking when required according to condition. Control and remove Athel Pine and monitor for any regrowth.

Site 13: Pelican Waterhole, Clifton Hills Station

Site information

Site: Pelican Waterhole – Andrewilla floodplain

Management unit:

MANAGEMENT UNIT 2: Goyder Lagoon

From Andrewilla and Yammakira distributary channels to commencement of the Warburton River channel

Easting / Northing: -26°32'42.04"S 139°13'09.15"E

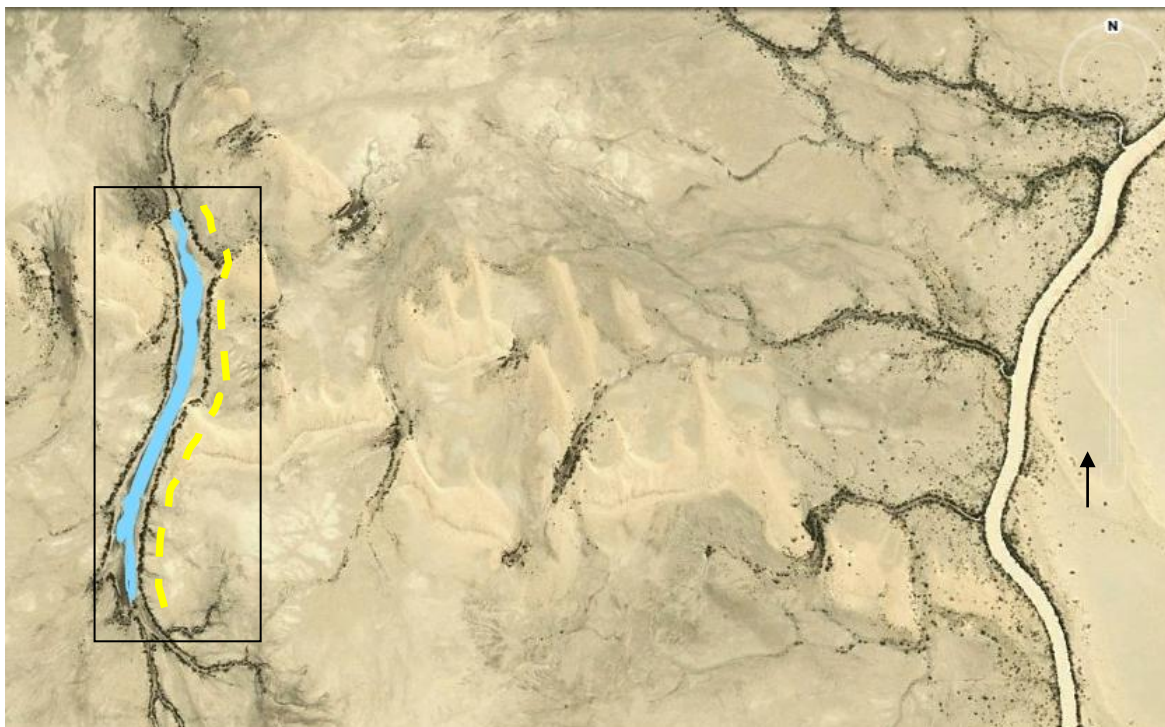
Date assessed: 12th May 2016

Description of feature assessed:

- **Feature type:** Floodplain waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 2km. Bankfull width approx. 80m.
- **Conceptual understanding:** Semi-permanent waterhole
- **Recent rainfall / inundation events:** 80mm recorded in area in January 2015.
- **Depth:** Cease to flow (CTFD) depth: 2.6m
- **Elevation:** ~ 32m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amaranthus mitchellii</i> ; <i>Ammannia multiflora</i> ; <i>Aristida holathera</i> var <i>holathera</i> ; <i>Boerhavia burbridgeana</i> ; <i>Cucumis melo</i> ; <i>Cullen australasicum</i> ; <i>Cyperus rigidellus</i> ; <i>Cyperus iria</i> ; <i>Dactyloctenium radulans</i> ; <i>Datura leichhardtii</i> ; <i>Diplachne fusca</i> ssp <i>meuelleri</i> ; <i>Enneapogon polyphyllus</i> ; <i>Eragrostis basedowii</i> ; <i>Eragrostis dielsii</i> var <i>dielsii</i> ; <i>Eragrostis setifolia</i> ; <i>Eragrostis tenellula</i> ; <i>Euphorbia dallachyana</i> ; <i>Euphorbia tannensis</i> ssp <i>eremophila</i> ; <i>Glinus lotoides</i> ; <i>Goodenia cycloptera</i> ; <i>Haloragis aspera</i> ; <i>Ipomoea polymorpha</i> ; <i>Lotus cruentus</i> ; <i>Marsilea drummondii</i> ; <i>Nicotiana velutina</i> ; <i>Panicum laevinode</i> ; <i>Phyllanthus lacunellus</i> ; <i>Portulaca intraterranea</i> ; <i>Pterocaulon sphacelatum</i> ; <i>Rutidosis helichrysoides</i> ssp <i>helichrysoides</i> ; <i>Salsola australis</i> ; <i>Sauropus trachyspermus</i> ; <i>Sclerolaena bicornis</i> ; <i>Sclerolaena diacantha</i> ; <i>Sclerolaena</i> sp; <i>Sesbania cannabina</i> var <i>cannabina</i> ; <i>Sida ammophila</i> ; <i>Sida cunninghamii</i> ; <i>Sporobolus mitchellii</i> ; <i>Stemodia florulenta</i> ; <i>Swainsona</i> sp; <i>Synaptantha tillaeacea</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus eichlerianus</i> ; <i>Triraphis mollis</i> ; <i>Urochloa praetervisa</i> ; <i>Urochloa piligera</i> ; <i>Verbena officinalis</i>
Shrubs (low to tall shrubs)	<i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Atalaya hemiglauca</i> ; <i>Eremophila bignoniiflora</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 57



Pelican waterhole assessment area



Pelican waterhole at cease to flow level



Riparian vegetation high understorey species richness



Riparian vegetation good groundcover vegetation and leaf litter cover – low shrub-layer species richness



Ecosystem Values, Threats and Pressures

Pelican Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE TO HIGH	Reduced mid-stratum layer. Good groundcover and lower stratum species richness.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE TO HIGH	Multiple habitat features including: overhanging vegetation; flood runners; distributary channel.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Receives flows at high flood levels. CTFD 2.6m	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	Maximum salinity 130 EC (µS/cm). High turbidity.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Evidence of cultural heritage value – stone artefacts present.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	Semi-permanent waterhole. Similar type waterholes are found in the sub catchment.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole persists for approx. 12months - provides habitat for aquatic species and waterbirds - riparian vegetation in good condition.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT MODERATE LEVEL	No significant (WONS) weeds observed; three introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Evidence of rabbits and camel activity.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW	Low level. Some algal growth observed.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW	Station tracks leading into waterhole. Site near to inside Track.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	No clear evidence. Site near to Inside Track and often dry; inaccessible when floodplain is inundated, therefore low visitor use.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	LOW	Some disturbance observed. Recent stock access to waterhole.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	PRESENT LOW LEVEL	Low grazing impact observed compared to nearby permanent Andrewilla waterhole.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some modification of vegetation and connectivity with the adjacent floodplain.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weeds present	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Reduced with low species diversity in shrub layer – mid-stratum.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Low recruitment of perennial species e.g. coolibahs.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Good leaf litter and debris cover.	Observation

Summary

Pelican waterhole is located in the Andrewilla floodplain (Diamantina Land System). It is semi-permanent holding water for up to 12 months situated in close proximity to the permanent Andrewilla waterhole. Subsequently grazing pressure is reduced at Pelican as cattle tend to congregate at Andrewilla when water dries up on the floodplain. This has led to high species richness in understorey species as noted in the high count of forbs and groundcover species. The waterhole is a good example of reduced grazing pressure and the potential for recovery and species recruitment if cattle are managed to assist stabilisation and recovery in floodplain country. Opportunistic spelling or light stocking particularly following major flooding events to facilitate regeneration and recruitment of perennial species and annual grasses and forbs, is a worthwhile consideration.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the Andrewilla floodplain – provides suitable habitat for species recruitment when inundated.
Riparian Condition Rating	HIGH	Site has recovered from previous grazing pressure with high level recruitment of groundcover forbs and grasses and increased leaf litter.
Connectivity Value	MODERATE	Seasonal waterhole depending on extent of regional flows. Moderate connectivity value.
Restoration Potential	HIGH	Vegetation recovery is evident with less stock grazing pressure compared to the nearby Andrewilla waterhole
Investment Priority	MODERATE	Important 'reference' site to compare lower grazing pressure with the more intensively grazed Andrewilla waterhole. Warrants long-term monitoring to gauge recovery potential.
Management priorities	HIGH	Undertake regular monitoring, investigate and implement conservative grazing management strategies to facilitate the recruitment and establishment of perennial vegetation and to maintain present species richness; implement pest animal control measures as required.

Site 14: Stony Point Waterhole, Cowarie Station

Site information

Site: Stony Point Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°27'18.36"S 139°31'05.39"E

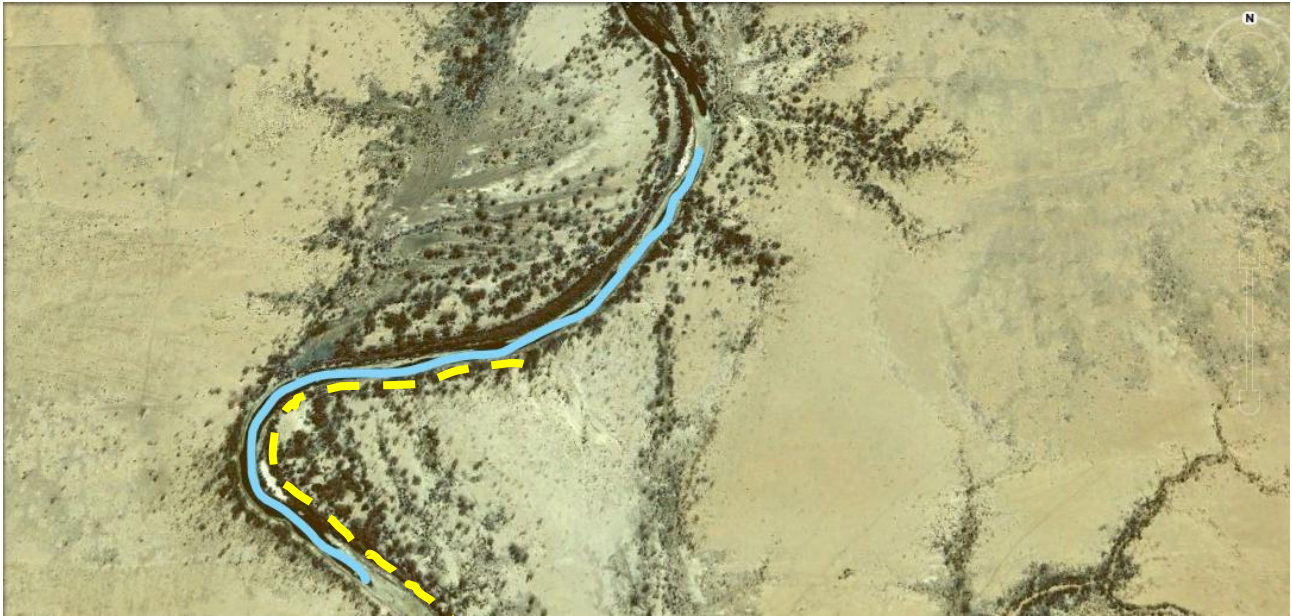
Date assessed: 12th May 2014; 3rd May 2015

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole extends for approx. 1.5km. Bankfull width approx. 25m.
- **Conceptual understanding:** In-channel semi-permanent waterhole.
- **Recent rainfall / inundation events:** 80mm recorded in area in February 2015.
- **Depth:** Cease to flow depth (CTFD): 2.4m
- **Elevation:** ~ 14m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Amaranthus mitchellii</i> ; <i>Amyema preissii</i> ; <i>Boerhavia coccinea</i> ; <i>Cyperus sp.</i> ; <i>Eragrostis sp.</i> ; <i>Malva preissiana</i> ; <i>Phyllanthus lacunellus</i> ; <i>Portulaca intraterranea</i> ; <i>Pterocaulon sphacelatum</i> ; <i>Salsola australis</i> ; <i>Sclerolaena bicornis</i> ; <i>Sida sp.</i> ; <i>Sporobolus sp.</i> ; <i>Swainsona sp.</i> ; <i>Trianthema triquetra</i> ; <i>Zygophyllum simile</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i> ; <i>Rhagodia spinescens</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Eremophila bignoniiflora</i> ;
Trees (5-15m)	<i>Eucalyptus coolabah</i> 25



Stony Point Waterhole – assessment area



Good vegetation cover along waterhole edge



Riparian zone - moderate grazing impacts – conditions dry



Open areas on sandy dune swales



Groundcover and shrub layer reduced along riparian zone

Ecosystem Values, Threats and Pressures

Stony Point Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE to HIGH	Slightly reduced riparian plant assemblages. Least disturbed with all strata present. Some reduction in groundcover and mid-stratum vegetation.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	All strata present. Multiple habitat features: inner meander bends; tree hollows; flood runners; and high number of in-stream snags.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Semi-permanent waterhole – almost permanent. Cease to flow depth 2.4m. Receives flow on a regular basis. High channel / floodplain connectivity value for species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	LOW	During site visits maximum EC 133000 (µS/cm). Hypersaline waterhole.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Some evidence of cultural heritage value e.g. occupation sites with some stone artefacts present.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Similar 'type' example in sub-catchment at sub-regional level – other semi-permanent aquatic refuges are present.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole - persists for 12-18 months - supports a range of fauna and flora during times of stress.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT	Evidence of rabbits; in the area. Low level -low impact. Low numbers of gambusia present.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW	Low level – some evidence of eutrophication e.g. algal or aquatic plant growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	ABSENT	Minor tracks no infrastructure near waterhole	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Remote access no evidence of camping or visitor impacts.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	LOW LEVEL	Evidence of destabilised bank and erosion points. Some reduction in lignum cover at streambank edge. System stable.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	LOW LEVEL	Low level – some grazing and browse evident not causing serious damage to perennial vegetation	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	LARGELY UNMODIFIED	Little evidence of broad-scale loss of native vegetation	Observation
17. Nativeness	LARGELY UNMODIFIED	No significant weeds present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	All strata represented with some reduction in groundcover and mid-stratum.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Recruitment of coolibahs absent.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Evidence of unnatural loss of leaf litter and debris	Observation

Refer Appendix A for interpretation of scoring system

Summary

Stony Point waterhole is located in the Warburton land system comprising channels, floodplains and associated sand dunes with coolibah (*Eucalyptus coolabah*); Broughton Willow (*Acacia salicina*), river cooba (*Acacia stenophylla*); and lignum (*Duma florulenta*) lining the waterhole. Grazing has not significantly impacted the waterhole although there was a lower than expected level of coolibah recruitment, some impacts to lignum cover at the streambank edge and a reduction in the mid-stratum layer. The waterhole has a cease to flow depth of approximately 2.4m and holds for less than a year after filling and without receiving further inflow. Salinities can be extremely high after flow ceases and the waterhole begins to dry out due to the interaction with saline regional groundwater. The country in the vicinity of Stony Point waterhole has been impacted by grazing as evidenced by bare areas and scalded flats near the waterhole caused largely as a result of the long grazing history with increased occurrence of unpalatable goathead (*Sclerolaena bicornis*) noted along the riparian vegetation corridor. Lignum is heavily impacted and reduced in some sections due to stock accessing the waterhole. A suggested approach is to facilitate an increase in perennial vegetation cover to stabilise soil surfaces by opportunistic spelling or light stocking.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the Warburton River system.
Riparian Condition Rating	HIGH	Good spatial vegetation coverage along riparian zone. Lignum cover mostly intact. Low recruitment of perennials e.g. coolibahs.
Connectivity Value	HIGH	Semi-permanent waterhole persists for approximately 12months providing connectivity value along the Warburton River.
Restoration Potential	MODERATE	Recovery potential rated moderate due to site not under heavy stress and relatively intact.
Investment Priority	MODERATE	Current management is maintaining the site.
Management priorities	HIGH	Stocking levels and grazing considerations to enhance recovery of the site and promote perennial vegetation recruitment.

Site 15: Tepamimi Waterhole, Clifton Hills Station

Site information

Site: Tepamimi Waterhole – Eyre Creek

Management unit:

MANAGEMENT UNIT 4: Eyre Creek

South Australian border to Goyder Lagoon

Easting / Northing: -26°40'14.88"S 139°59'38.82"E

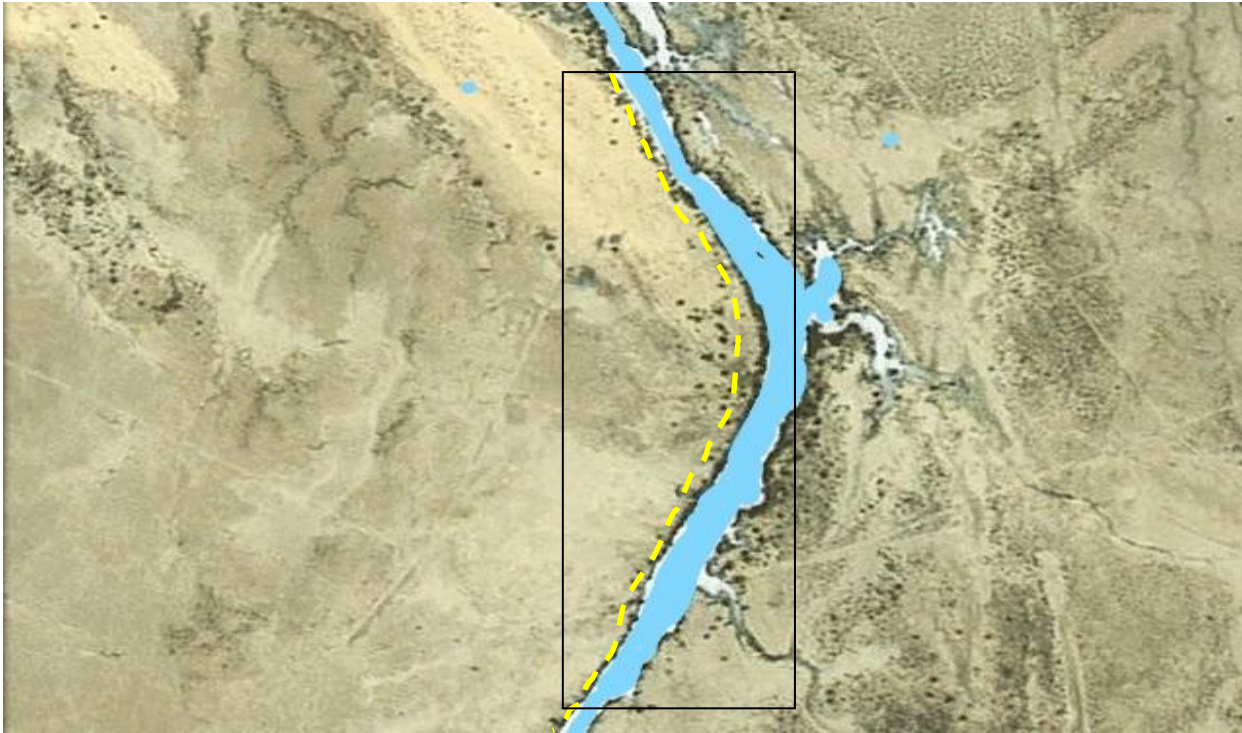
Date assessed: 6th May 2014

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** The waterhole extends for approx. 2km. Bankfull width up to 60m
- **Conceptual understanding:** Receives periodic flow from Eyre Creek non-permanent waterhole – currently bore-fed artificially permanent waterhole
- **Recent rainfall / inundation events:** 80mm recorded in area in February 2015
- **Depth:** Cease to flow depth (CTFD) 2.1m
- **Elevation:** ~ 25m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Nicotiana velutina</i> ; <i>Salsola australis</i> ; <i>Senecio lanibracteus</i> ; <i>Sonchus oleraceus</i> ; <i>Teucrium racemosum</i> ; <i>Typha australis</i>
Shrubs (low to tall shrubs)	<i>Acacia victoriae</i> ; <i>Atriplex nummularia</i> ; <i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Senna artemisioides</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Eremophila bignoniiflora</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 17



Tepamimi Waterhole – assessment area



Bore drain maintaining permanent waterhole



Heavy grazing pressure due to permanent water



Riparian vegetation at waterhole

Ecosystem Values, Threats and Pressures

Tepamimi Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Loss of plant diversity due to heavy grazing pressure. Perennial species recruitment reduced. Vegetation is reduced from natural assemblages expected for the habitat assessed lower than expected shrub and groundcover layer.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Good range of riparian habitat features present - flood runners; overhanging vegetation; tree hollows; submerged logs.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole dependent on regional flooding; frequently dry (presently permanent bore-fed). Cease to flow depth (CTFD) 2.1m. Moderate channel / floodplain connectivity value for ecosystem function and species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	MODERATE to HIGH: Sub-saline	During site visit maximum 1800 EC (µS/cm). Sub-saline groundwater – artesian borefed waterhole.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	HIGH	High rating for Physical, Natural & Customary heritage values. High Aboriginal cultural significance; numerous artefacts; site associated with traditional stories. Important aquatic refuge site for native biota due to present permanency status. Nearby stockyards.	QUALITATIVE SURVEY
6.	Uniqueness	HIGH	Only 'type' example in sub-catchment at sub-regional level.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Artificially permanent waterhole providing important drought refuge.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT HIGH LEVEL	Camel activity high impact to perennial vegetation. Rabbits present. Gambusia present in large numbers.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
10.	Surface & G/water Abstraction	PRESENT HIGH LEVEL	Free flowing bore and bore drain maintaining an artificial permanent waterhole. Solar pump present.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – some evidence of eutrophication causing aquatic plant growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT MODERATE LEVEL	Station tracks leading into waterhole. Bore pump, cooling ponds, tanks, water distribution, solar pump; nearby stockyards.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	MODERATE to HIGH LEVEL	Remote site few visitors. Moderately high level of firewood collection - firewood depleted.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	LOW LEVEL	Some disturbance to the waterhole with loss of lignum cover and damage caused from stock access.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE to HIGH	Heavy grazing pressure (camels), evidenced by perennials extensively grazed. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some reduction and modification to the lignum cover through stock accessing the waterhole.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weed (WONS) species present.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Reduction in understorey and shrub layer due to grazing pressure.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover of Coolibahs – juvenile and sub-adult class mostly absent due to grazing pressure.	Observation
20. Terrestrial woody debris and leaf litter	MODERATELY MODIFIED	Loss of leaf litter cover reduced through stock trampling. Woody debris reduced.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Tepamimi waterhole is located at the lower end of Eyre Creek near the junction with Goyder Lagoon in floodplain country of the Diamantina River channels and floodplains (Diamantina land system). The riparian vegetation mainly consists of coolibah (*Eucalyptus coolabah*), Broughton willow (*Acacia salicina*), river cooba (*Acacia stenophylla*), emu bush (*Eremophila bignoniiflora*) and lignum (*Duma florulenta*). The waterhole is fed from a free-flowing artesian bore maintaining its cease to flow depth of approximately 2.1m creating an artificial permanent water supply. The waterhole would normally receive in-flow through regional flooding 1 in every 5 years. This change to the natural water regime has resulted in the site being heavily impacted by camels seeking permanent water supplies, and generally an increase in grazing pressure from stock with a reduction of perennial vegetation at the riparian edge. Mature coolibahs are showing dieback due to the prolonged flooding and in effect are being drowned. There is a proliferation of *Gambusia* potentially impacting native fish stocks at Tepamimi and when connectivity occurs downstream at Goyder Lagoon and the Diamantina-Warburton reaches thus creating a source invasive species population.

Normally without this artificial water supply, stock are reliant on waterholes of the Georgina floodplain for stock water. These waterholes fill when the Georgina River floods into South Australia from south west Queensland. Due to water holding for approximately 12 months from regional flows down Eyre Creek Tepamimi waterhole and surrounding area is normally self-

regulating in terms of supporting grazing stock with water becoming limiting before floodplain and waterhole forage is depleted.

The waterhole has a fairly shallow cease to flow depth (approximately 2.1m) and would normally hold for less than a year after filling and without the present artificial water regime. The country in the vicinity of Tepamimi is heavily impacted by grazing as evidenced by bare areas in the vicinity of the waterhole. This is largely as a result of the long grazing history in the vicinity of the waterhole. There is moderate gullying with reduced cover of perennials leading to soil loss. Lignum is heavily impacted and reduced in some sections due to stock repeatedly accessing the waterhole. Rabbits are active and prolific in the area with numerous active warrens. Importantly replacing the open bore drain with a closed tank and trough system will improve stock management and reduce feral animal congregations if the waterhole is returned to its natural water regime and semi-permanent nature. Another suggested measure is to facilitate an increase in perennial vegetation cover to stabilise soil surfaces by opportunistic spelling or light stocking.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Normally semi-permanent - moderate importance. Receives flow on average every 5 years.
Riparian Condition Rating	LOW	Heavily impacted from grazing pressure. Perennial vegetation damaged with little recruitment evident. Site for gambusia recruitment and dispersal.
Connectivity Value	HIGH	Artificially permanent due to artesian bore - high value aquatic refuge - high value for connectivity and species recruitment and dispersal when receives flow down the Georgina.
Restoration Potential	MODERATE	Restoration potential is over the long-term once management of the open bore drain has occurred and a water-tight delivery system is installed.
Investment Priority	HIGH	High ecological and cultural importance therefore implementing grazing management and pest species control measures is required.
Management priorities	HIGH	Implement grazing management strategies (spelling paddock, seasonal de-stocking) to facilitate recruitment and establishment of perennial vegetation. Pest animal control as required. Close free-flowing bore to return waterhole to natural hydrology and flooding regime.

Site 16: Tinnie Landing Waterhole, Kalamurina Wildlife Sanctuary

Site information

Site: Tinnie Landing Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°53'27.34"S 139°01'10.14"E

Date assessed: 1st May 2015; 28th April 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Conservation
- **Size / Area:** Waterhole length approx. 600m. Bankfull width up to 25m.
- **Conceptual understanding:** In-channel semi-permanent waterhole.
- **Recent rainfall / inundation events:** 100mm recorded at Kalamurina HS in January 2015; 190mm January 2016.
- **Depth:** Cease to flow (CTFD) depth: 2.25m
- **Elevation:** ~ 5m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amaranthus grandiflorus</i> ; <i>Amyema preissii</i> ; <i>Austrobryonia micrantha</i> ; <i>Boerhavia schomburgkiana</i> ; <i>Crotalaria cunninghamii</i> ; <i>Cullen discolor</i> ; <i>Cyperus gymnocaulos</i> ; <i>Dactyloctenium radulans</i> ; <i>Eragrostis dielsii</i> var. <i>dielsii</i> ; <i>Eriochloa crebra</i> ; <i>Euphorbia porcata</i> ; <i>Ipomoea polymorpha</i> ; <i>Paractaenum novae-hollandiae</i> ssp. <i>reversum</i> ; <i>Phyllanthus lacunellus</i> ; <i>Portulaca intraterranea</i> ; <i>Rutidosia helichrysoides</i> ssp. <i>helichrysoides</i> ; <i>Salsola australis</i> ; <i>Sclerolaena diacantha</i> ; <i>Sclerolaena bicornis</i> ; <i>Sida ammophila</i> ; <i>Solanum nigrum</i> ; <i>Sphaeromorphaea littoralis</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus eichlerianus</i> ; <i>Trichodesma zeylanicum</i> var. <i>zeylanicum</i> ; <i>Triraphis mollis</i> ; <i>Teucrium racemosum</i> ; <i>Zygochloa paradoxa</i>
Shrubs (low to tall shrubs)	<i>Abutilon otocarpum</i> ; <i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 35



Tinnie Landing Waterhole assessment area



Well vegetated banks



Warburton Creek at Tinnie Landing site



Example of severe scalding and erosion – a legacy of vegetation removal

Ecosystem Values, Threats and Pressures

Tinnie Landing Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE to HIGH	Slightly reduced riparian plant assemblages. Least disturbed with all strata present. Vegetation largely native trees over predominately native understorey.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Good range of riparian habitat features including flood runners; deep pools; meander bends; overhanging vegetation; tree hollows; submerged logs. All strata present.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole - depending on extent of local and regional flow events– frequently dry becoming a series of saline pools. Cease to flow depth (CTFD) 2.25m. Waterbody may persist over longer periods of time due to depth and groundwater discharge. Moderate channel / floodplain connectivity value for ecosystem function and species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	MODERATE to LOW	During site visits maximum EC 26000 EC (µS/cm). Saline-Hyper-saline pool.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE to HIGH	Heritage value. Ringer's camp ruins.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to HIGH	Similar 'type' example in sub-catchment at sub-regional level - other permanent or semi-permanent aquatic refuges present.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole - persists for 12-18 months - supports a range of fauna and flora during times of stress over prolonged periods	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT	Some past feral pig activity observed at relatively low level with little observable impact. Recent rabbit activity, warrens active. Low number of gambusia present.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	No water extraction activities observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW LEVEL	Some evidence of eutrophication causing aquatic plant growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	MODERATE LEVEL	Moderate level of infrastructure e.g. tracks, flow diversions, levees, causing some impacts.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	LOW LEVEL	Low level – some evidence of past and recent recreation / tourism activity including campfires, wood collection.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
14.	Bank stability, soil disturbance	MODERATE to HIGH	Previous earthworks and impacts on natural flow regimes through levee bank construction. Major erosion gullies forming. Generally site is stable.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	LOW LEVEL	Low level – some grazing and browse evident not causing serious damage to perennial vegetation.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	LARGELY UNMODIFIED	Little evidence of broad-scale loss of native vegetation.	Observation
17. Nativeness	LARGELY UNMODIFIED	Vegetation predominately native, few weeds and no 'high threat' (WONS) species present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Cover within one stratum 50% lower or higher than what is expected	Observation
19. Age Structure	SLIGHTLY MODIFIED	Reduced cover (75-50%) of dominant strata present. Only two age classes present	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Historic firewood collection and evidence of campfires. Good leaf litter and debris cover with a 'no campfire' policy in place.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Tinnie Landing Waterhole is located on the Warburton River in the Tirari Desert (Tirari Land System). This country includes channels and floodplains of the lower Warburton dominated by coolibah (*Eucalyptus coolabah*) and Broughton willow (*Acacia salicina*). At the opposite side of the waterhole (not assessed) a large artificial embankment was constructed to apparently obstruct natural flooding at the inner meander bend. There is an extensive erosion site opposite this feature. Coolibah (*Eucalyptus coolabah*) and Broughton willow (*Acacia salicina*) are the dominate tree species with an understorey of lignum (*Duma florulenta*) and native grasses. The site has lower perennial species richness in the upper stratum correlating with higher salinity and lower flooding frequency. Plant species assemblages are as expected for the habitat assessed with increased species richness in the lower stratum, mainly consisting of annual and ephemeral species, probably as a response to a significant localised rainfall event. Unpalatable goathead (*Sclerolaena bicornis*), an indicator of disturbance, was noted in the adjacent floodplain area. The site is in recovery from historic heavy grazing pressure and there is good species recruitment and the system is in a stable condition.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the lower Warburton River system.
Riparian Condition Rating	HIGH	Site has recovered from extensive historical grazing pressure with good groundcover layer and debris and recruitment of perennials.
Connectivity Value	MODERATE	Provides habitat for salt tolerant species and dispersal after flooding.
Restoration Potential	HIGH	Current management will enhance recovery potential.
Investment Priority	HIGH	Important natural heritage site warrants consideration of management investment.
Management priorities	MODERATE	Under sound management regime – maintain feral animal control measures and visitor management protocols currently in place.

Site 17: Ultoomurra Waterhole, Clifton Hills Station

Site information

Site: Ultoomurra Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°09'14.44"S 138°43'36.71"E

Date assessed: 30th April 2014; 6th May 2015

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 250m. Bankfull width approx. 25-30m
- **Conceptual understanding:** In-channel semi-permanent waterhole
- **Recent rainfall / inundation events:** 25mm recorded early 2014; 80mm recorded January 2015.
- **Depth:** Cease to flow depth (CTFD): 2.2m
- **Elevation:** ~ 20m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Lysiana exocarpi ssp. exocarpi</i> ; <i>Nicotiana velutina</i> ; <i>Senecio lanibracteus</i> ; <i>Stemodia florulenta</i>
Shrubs (low to tall shrubs)	<i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 11



Ultoomurra waterhole - assessment area



Exposed roots of mature Coolibah



Warburton Creek channel



Riparian vegetation cover

Ecosystem Values, Threats and Pressures

Ultoomurra Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Perennial species recruitment reduced. Vegetation is reduced from natural assemblages expected for the habitat assessed – percentage cover of mid and lower stratum reduced.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE	Moderate range of riparian habitat features including flood runners; overhanging vegetation; tree hollows; submerged logs.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Semi-permanent waterhole. Cease to flow depth (CTFD) 2.2m. Seasonal waterhole - depending on extent of local and regional flow events– frequently dry becoming a series of saline pools. Waterbody may persist over longer periods of time due to depth and groundwater discharge. Moderate channel / floodplain connectivity value for ecosystem function and species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	LOW	During site visits maximum 85000 EC (µS/cm). Hypersaline pool.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Physical Heritage value. Some evidence of stone implements and artefacts.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Similar 'type' example in sub-catchment at sub-regional level other semi-permanent aquatic refuges are present.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole - persists for 12-18 months - supports a range of fauna and flora during times of stress over short periods	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Low level – recent activity evident - impacts minimal. Camel browse and rabbits present. Aquatic pest species (gambusia) present in low numbers.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	No water extraction activities observed.	QUALITATIVE SURVEY
11.	Nutrients	LOW LEVEL	Low level – some evidence of eutrophication causing aquatic plant growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW LEVEL	Station tracks leading into waterhole. Low level – no significant disturbance.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Absent – no recent evidence of tourism/recreation activity, campfires or wood collection.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	MODERATE	Some loss of lignum cover at streambank edge and groundcover generally. Erosion points formed from stock access to channel. System stable.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
15.	Total Grazing Pressure	MODERATE	Moderate grazing pressure evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Width reduced by up to 1/3 and/or some breaks in continuity of mid-stratum and lower – groundcover stratum	Observation
17. Nativeness	LARGELY UNMODIFIED	Vegetation predominately native, few weeds and no 'high threat' (WONS) species.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Cover within some stratum 50% lower than what is expected.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover (75-50%) of dominant strata present. Only two age classes present – low coolibah recruitment.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Evidence of unnatural loss of debris (e.g. stock trampling of leaf litter; firewood collection).	Observation

Refer Appendix A for interpretation of scoring system

Summary

Uloomurra waterhole is located in channel, floodplain country of the Diamantina River (Diamantina land system) between Sturts land system and gibber plains of the Koonchera land system. Channel vegetation mainly consists of coolibah (*Eucalyptus coolabah*), Broughton willow (*Acacia salicina*), river cooba (*Acacia stenophylla*), and lignum (*Duma florulenta*). The waterhole has a cease to flow depth of approximately 2.2m and holds for less than a year after filling and without receiving further inflow. Salinities can be extremely high after flow ceases and the waterhole begins to dry out due to the interaction with saline regional groundwater. The country in the vicinity of Uloomurra waterhole has been heavily impacted by grazing as evidenced by bare areas and scalded flats in the vicinity of the waterhole caused largely as a result of the long grazing history. There is moderate gullying with reduced cover of perennials leading to soil loss; and as noted along the riparian vegetation corridor lignum is heavily impacted and reduced in some sections due to stock accessing the waterhole. A suggested approach is to facilitate an increase in perennial vegetation cover to stabilise soil surfaces by opportunistic spelling or light stocking.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Has some importance as a refuge for salt tolerant species when system starts to dry out.
Riparian Condition Rating	MODERATE	Loss of groundcover and low recruitment of perennials but generally in reasonable condition.
Connectivity Value	MODERATE	Has some value for connectivity and dispersal along the Warburton channel.
Restoration Potential	MODERATE	Recovery of the site will occur through an adjustment of current management to increase perennial vegetation cover and recruitment.
Investment Priority	MODERATE	Moderate importance requires minimal intervention – maintain current management practice.
Management priorities	MODERATE	Investigate alternative grazing practices and stocking rates. Feral animal control as required.

Site 18: Wadlarkaninna Waterhole, Kalamurina Wildlife Sanctuary

Site information

Site: Wadlarkaninna Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°51'51.60"S 138°07'55.67"E

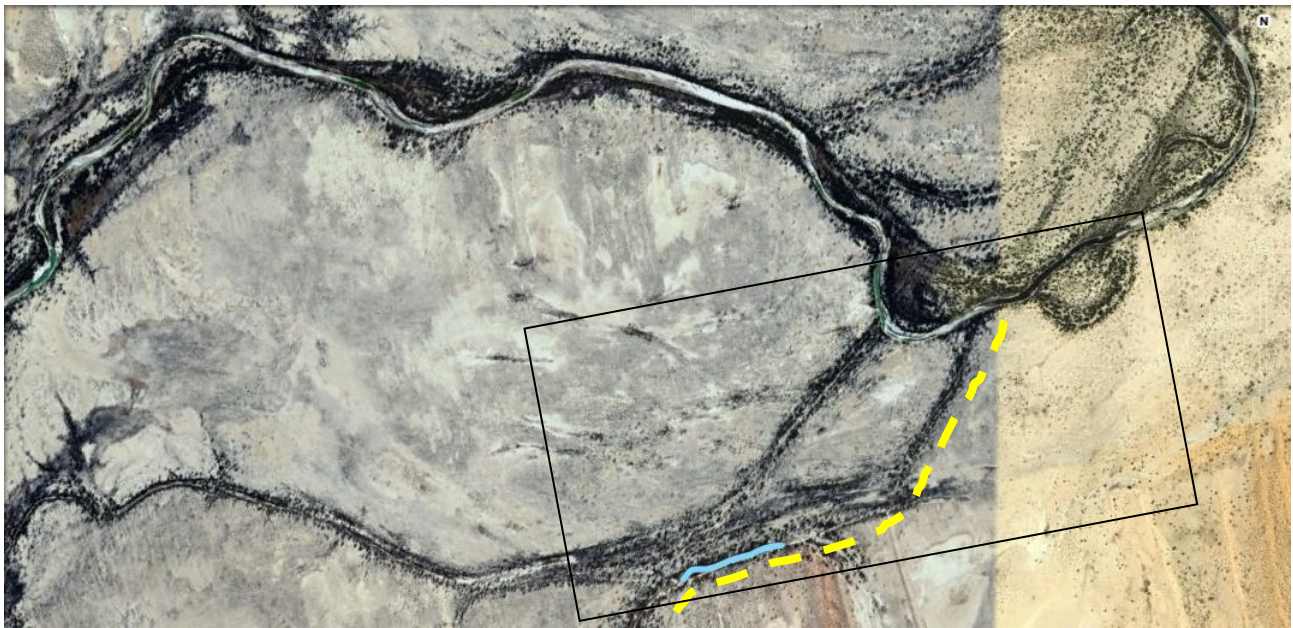
Date assessed: 29th April 2016

Description of feature assessed:

- **Feature type:** Floodplain waterhole
- **Use zone:** Conservation
- **Size / Area:** Waterhole length 600m. Bankfull width approx. 40m.
- **Conceptual understanding:** Off-channel semi-permanent saline waterhole.
- **Recent rainfall / inundation events:** 100mm recorded at Kalamurina HS in January 2015; 190mm January 2016.
- **Depth:** Cease to flow depth (CTFD): 1.5m
- **Elevation:** ~ 6m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Amaranthus grandiflorus</i> ; <i>Aristida contorta</i> ; <i>Brassica tournefortii</i> ; <i>Calotis hispidula</i> ; <i>Citrullus lanatus</i> ; <i>Commicarpus australis</i> ; <i>Dactyloctenium radulans</i> ; <i>Dysphania truncata</i> ; <i>Einadia nutans ssp. eremaea</i> ; <i>Eragrostis basedowii</i> ; <i>Eragrostis dielsii var. dielsii</i> ; <i>Euphorbia drummondii</i> ; <i>Euphorbia wheeleri</i> ; <i>Haloragis aspera</i> ; <i>Ipomoea polymorpha</i> ; <i>Lepidium phlebopetalum</i> ; <i>Phyllanthus lacunellus</i> ; <i>Polycalymma stuartii</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Sclerolaena diacantha</i> ; <i>S. bicornis</i> ; <i>Tragus australianus</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus eichlerianus</i> ; <i>Triraphis mollis</i> ; <i>Teucrium racemosum</i> ; <i>Tetragonia tetragonioides</i> ; <i>Zygophyllum howittii</i> ; <i>Zygophyllum simile</i>
Shrubs (low to tall shrubs)	<i>Atriplex sp.</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 37



Wadlarkaninna waterhole – assessment area



Riparian vegetation



Riparian vegetation cover

Ecosystem Values, Threats and Pressures

Wadlarkaninna Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Lower than expected mid-stratum vegetation cover. Low recruitment of coolibahs.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Multiple habitat features including: tree hollows; overhanging vegetation; distributary channels; flood runners; tree hollows. All strata present.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole (depending on extent of regional flows). Cease to flow depth (CTFD) 1.5m. Moderate connectivity value.	QUANTITATIVE HYDROLOGICAL MONITORING

	Indicator	Value	Description	Confidence
4.	Water Quality – salinity	FRESH	During site visits maximum 620 C (µS/cm).	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	HIGH	High level physical heritage value. Site of early explorer blaze tree.	QUALITATIVE SURVEY
6	Uniqueness	MODERATE	Habitat for fish species dispersal once system connectivity occurs after flooding. Similar 'type' example in sub-catchment at sub-regional level.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Semi-permanent waterhole – seasonal, persists for <12 months - supports a low range of aquatic fauna and flora during times of stress over a limited period of time.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; two introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT	Rabbit activity, warrens active. No introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	PRESENT LOW LEVEL	Poly pipe feeding into retention areas.	QUALITATIVE SURVEY
11.	Nutrients	MODERATE LEVEL	Moderate level – water quality shows signs of eutrophication and algal growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW	Well maintained tracks leading into the site. Good maintenance and management of track network.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Low visitor use area. Mainly used for scientific research. No major impacts observed due to effective management practices.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	PRESENT MODERATE	Some disturbance observed and loss of lignum cover at the streambank edge. Some erosion points forming.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	LOW	Low level with some herbivore browse evident. No major impacts. Destocking has contributed to recovery of site.	QUALITATIVE SURVEY

Site Condition

	Indicator	Value	Description	Confidence
16.	Spatial Integrity	LARGELY UNMODIFIED	Little evidence of broad-scale loss of native vegetation	Observation
17.	Nativeness	LARGELY UNMODIFIED	No major weeds present	Observation
18.	Structural Integrity	SLIGHTLY MODIFIED	Reduced with low species diversity in shrub layer – mid-stratum.	Observation

Indicator	Value	Description	Confidence
19. Age Structure	SLIGHTLY MODIFIED	Low recruitment of perennial species e.g. coolibahs.	Observation
20. Terrestrial woody debris and leaf litter	LARGELY UNMODIFIED	Good leaf litter and debris cover with a 'no campfire' policy in place.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Wadlarkaninna Waterhole is located on a floodplain flow path of the Tirari land system that includes channels and floodplains of the lower Warburton. Coolibah (*Eucalyptus coolabah*) and Broughton willow (*Acacia salicina*) are the main tree species with an understorey of lignum (*Duma florulenta*) and native grasses. The waterhole is sited on the lower Warburton on floodplain country on a distributary channel south of the main Warburton channel. The riparian vegetation corridor is in recovery phase after de-stocking. Plant species assemblages are as expected for the habitat assessed with increased species richness in the lower stratum, mainly consisting of annual and ephemeral species, probably as a response to a significant localised rainfall event. Unpalatable goathead (*Sclerolaena bicornis*), an indicator of disturbance, was noted in the adjacent floodplain area, however, the site is in recovery from historic heavy grazing pressure and there is evidence of species recruitment with the system in a stable condition. There is good recruitment of coolibahs with good stands of juvenile and mixed age stands.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Semi-permanent waterhole provides important aquatic habitat in the lower Warburton River system.
Riparian Condition Rating	HIGH	Site has recovered from extensive historical grazing pressure with high level recruitment of coolibahs and increased groundcover and leaf litter cover.
Connectivity Value	MODERATE	Seasonal waterhole (depending on extent of regional flows). Moderate connectivity value.
Restoration Potential	HIGH	Vegetation recovery is evident with removal of stock grazing pressure.
Investment Priority	HIGH	Important physical and natural heritage site warrants consideration of management investment.
Management priorities	MODERATE	Under sound management regime – maintain feral animal control measures and camping and science activity protocols currently in place.

Site 19: Windmill Waterhole, Pandie Pandie Station

Site information

Site: Windmill Waterhole – Diamantina River

Management unit:

MANAGEMENT UNIT 1: Diamantina Main Channel

Diamantina Channel to Goyder Lagoon including Andrewilla & Yammakira Waterholes

Easting / Northing: -26°07'24.09"S 139°23'11.54"E

Date assessed: 10th May 2014

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 1.5km. Bankfull width approx. 40-45m
- **Conceptual understanding:** Surface flow driven permanent waterhole.
- **Recent rainfall / inundation events:** 80mm recorded in January 2015; receives annual flow.
- **Depth:** Cease to flow depth (CTFD): 3.0m.
- **Elevation:** ~ 41m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Amyema preissii</i> ; <i>Lysiana exocarpi ssp exocarpi</i> ; <i>Pseudoraphis spinescens</i> ; <i>Setaria jubiflora</i>
Shrubs (low to tall shrubs)	<i>Diplatia grandibractea</i> ; <i>Duma florulenta</i> ; <i>Enchylaena tomentosa var. glabra</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Atalaya hemiglauca</i> ; <i>Eremophila bignoniiflora</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 13



Windmill waterhole - assessment area



Riparian vegetation



Diamantina River channelised section – steep banks

Ecosystem Values, Threats and Pressures

Windmill Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation is reduced from natural assemblages expected for this site. Coolibah recruitment absent. Mid-stratum and groundcover layer reduced.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	All strata present with some loss of vegetation cover. Multiple habitat features including: overhanging vegetation; flood runners; tree hollows; in-stream snags.	QUALITATIVE SURVEY
3.	Hydrological Value	HIGH	Receives annual flow maintaining permanency status. Cease to flow depth (CTFD) 3.0m provides important connectivity value.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum EC 250 (µS/cm). Receives annual flows maintaining fresh water and low salinity.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Natural & Physical heritage value. Nearby old stockyards and homestead.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	One of a series of permanent pools along this section of the Diamantina channel.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	HIGH	This site is one of a series of permanent / semi-permanent pools along the Pandie - Diamantina River Channel. An important aquatic refuge.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	ABSENT	No significant (WONS) weeds observed.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT LOW LEVEL	Rabbit and camel activity at the site. No gambusia or goldfish detected.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	No water extraction activities observed.	QUALITATIVE SURVEY
11.	Nutrients	ABSENT	No evidence of elevated nutrient levels.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	Station tracks leading into waterhole. Near to homestead.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	PRESENT LOW LEVEL	Low visitor use area.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	PRESENT LOW LEVEL	Some disturbance observed and loss of lignum cover at the streambank edge. Some erosion points formed from stock access to channel.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE	Moderate grazing pressure evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some loss of vegetation cover and connectivity with floodplain.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weeds present.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Good canopy vegetation structure along riparian edge with mid-stratum and groundcover layer relatively intact.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Recruitment of coolibah absent.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Vegetation impacts from cattle trampling and firewood removal.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Windmill waterhole is located along the Diamantina-Pandie Channel in the Diamantina floodplain and channel country (Diamantina Land System). The site is near the Pandie homestead and stockyards. The site has experienced grazing pressure over a long period of time that has impacted perennial vegetation cover with reduction of the mid-stratum and groundcover layers. The narrow fringing upper stratum vegetation is largely intact and provides important nesting habitat particularly in larger established coolibahs. It is a relatively deep waterhole with a cease to flow depth measured at 3.0m and is considered permanent due to receiving annual flow. Coolibah, whitewood, Queensland bean tree and Broughton willow are the dominate tree species with an understorey of lignum and native grasses. Flooding typically follows monsoonal rain in the upper catchment in south-west Queensland. Reducing stock numbers before heavy grazing of perennials and groundcover is impacted will improve condition of the site. A suggested measure is to facilitate an increase in perennial vegetation cover and stability of soil surfaces through opportunistic spelling, particularly following significant rainfall events to encourage the establishment of perennials.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Although not a deep waterhole has relatively high importance due to permanency – receives annual flow.
Riparian Condition Rating	MODERATE	Over grazing has resulted in impacts to vegetation structure and floodplain vegetation. Nearby stockyards have supported more intensive grazing pressure historically.
Connectivity Value	HIGH	Provides connectivity value during annual flow events. Is one of several pools that persist along the Diamantina River - Pandie channel.
Restoration Potential	MODERATE	Recovery of the site over a long-term period is possible. The site has had long-term grazing pressure however structural vegetation is relatively in-tact that will sustain recovery.
Investment Priority	MODERATE	Moderate importance requires minimal intervention – maintain current management practice.
Management priorities	MODERATE	Maintain sustainable stocking rates and present grazing regime.

Site 20: Yammakira Waterhole, Clifton Hills Station

Site information

Site: Yammakira Waterhole – Diamantina River

Management unit:

MANAGEMENT UNIT 1: Diamantina Main Channel

Diamantina Channel to Goyder Lagoon including Andrewilla & Yammakira Waterholes

Easting / Northing: -26°31'37.84"S 139°26'28.35"E

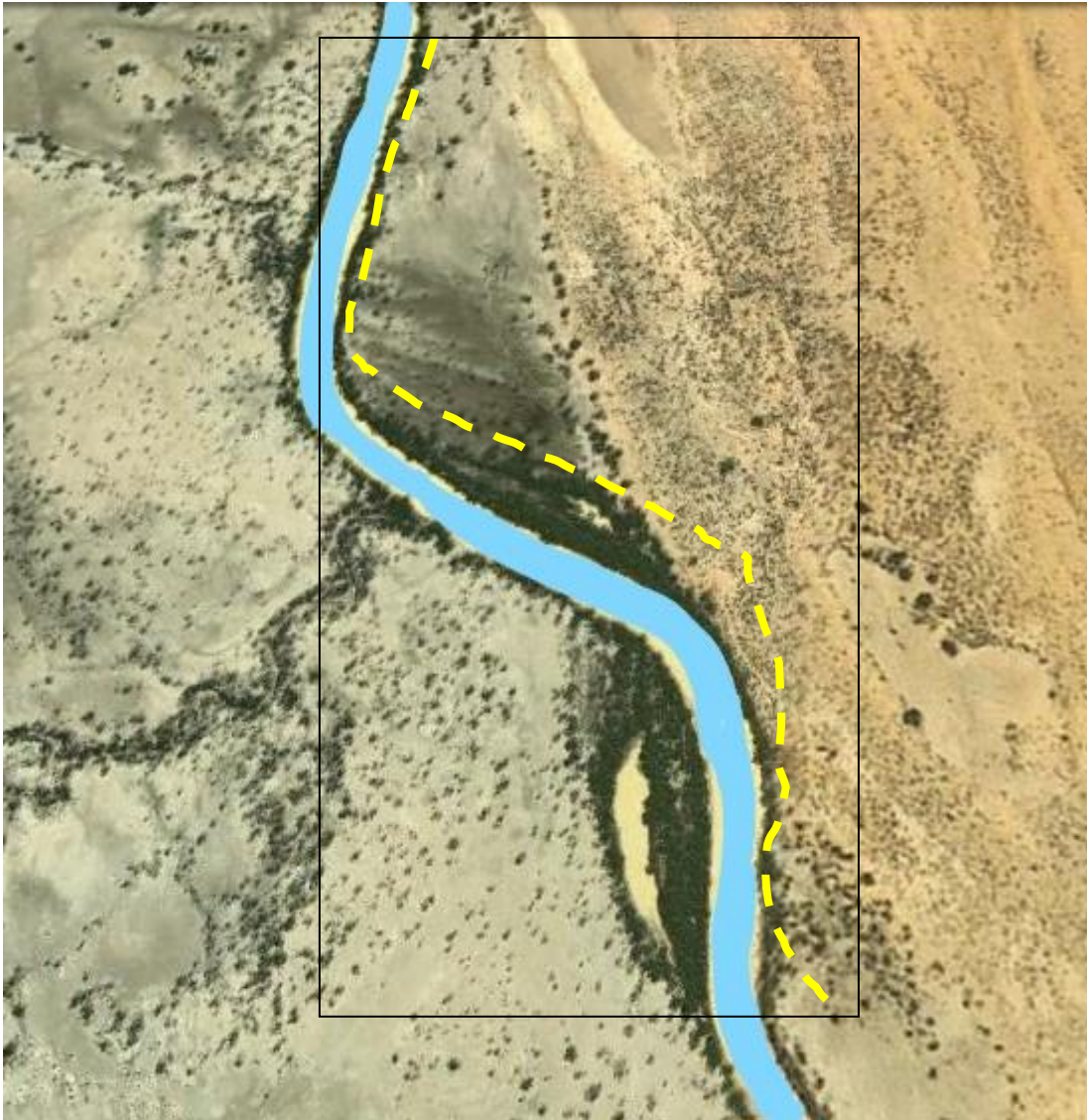
Date assessed: 4th May 2014; 10th May 2015

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 10km. Bankfull width 50m and up to 65m in some sections.
- **Conceptual understanding:** In-channel permanent waterhole - 'Ark-type' aquatic refuge.
- **Recent rainfall / inundation events:** 80mm recorded in January 2015; receives annual flow.
- **Depth:** Cease to flow depth (CTFD): 6m
- **Elevation:** ~ 34m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	<i>Persicaria attenuate</i>
Understorey - (grasses, forbs & misc)	<i>Boerhavia coccinea</i> ; <i>Lysiana exocarpi</i> ssp <i>exocarpi</i> ; <i>Malvastrum americanum</i> var <i>americanum</i> ; <i>Minuria rigida</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Senna artemisioides</i> ssp <i>quadrifolia</i> ; <i>Setaria jubiflora</i> ; <i>Solanum esuriale</i> ; <i>Solanum nigrum</i> ; <i>Tribulus terrestris</i> ; <i>Teucrium racemosum</i> ; <i>Zygophyllum simile</i>
Shrubs (low to tall shrubs)	<i>Abutilon halophilum</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Sclerolaena bicornis</i> ; <i>Senna artemisioides</i> ssp <i>quadrifolia</i> ; <i>Solanum chenopodium</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Atalaya hemiglauca</i> ; <i>Eremophila bignoniiflora</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> ; <i>Bauhinia gilva</i> 27



Yammakira Waterhole assessment area



Heavily grazed understorey and reduced groundcover layer



Site of Clifton Hills Homestead ruins

Ecosystem Values, Threats and Pressures

Yammakira Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation altered with some loss of diversity due to grazing pressure. Shrub layer and perennial species recruitment reduced.	QUANTITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	Range of riparian habitat features present including flood runners; distributary channels; deep pools; overhanging vegetation; tree hollows; submerged logs - reduced shrub layer and groundcover.	QUALITATIVE SURVEY
3.	Hydrological Value	HIGH	Significant permanent waterhole. Cease to flow depth (CTFD) 6m. Receives annual flow. An important site for aquatic species recruitment and dispersal and channel / floodplain connectivity.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum EC 190 (µS/cm). Receives annual flow maintaining fresh water and low salinity able to support majority freshwater flora and fauna. High turbidity.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	HIGH	High rating for Natural & Physical heritage. High Aboriginal cultural significance; evidence of numerous occupation sites. Old Clifton Hills Homestead ruins. Important refuge site for native biota.	QUALITATIVE SURVEY
6.	Uniqueness	HIGH	Permanent refuge waterhole – large size and depth to 6m (CTFD). One of the deepest and most permanent waterholes in this reach of Diamantina River.	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	HIGH	Size, permanence, and key biota (native fish, and presence of turtles) make this site a critical 'Ark-type' refuge.	QUANTITATIVE FISH SURVEY (SARDI 2014-16)
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; two introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT MODERATE	Recent rabbit activity, previous camel activity; no introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	PRESENT MODERATE	Water extraction pump operating.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – some eutrophication e.g., algal or aquatic plant growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	Station tracks leading into waterhole. Clifton Hills Outstation.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	No recent activity observed.	QUALITATIVE SURVEY

	Indicator	Value	Description	Confidence
14.	Bank stability, soil disturbance	LOW LEVEL	Historic erosion on adjacent sand dunes due to heavy stocking. Dunes highly eroded now stable. Some disturbance observed and loss of lignum cover at the streambank edge.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE to HIGH LEVEL	Heavy grazing pressure evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some reduction and modification to the lignum cover through stock accessing the waterhole.	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weed species present.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Reduction in understorey and shrub layer due to grazing pressure.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover of Coolibahs – juvenile and sub-adult class mostly absent due to grazing pressure.	Observation
20. Terrestrial woody debris and leaf litter	MODERATELY MODIFIED	Loss of leaf litter cover reduced through stock trampling. Woody debris reduced.	Observation

Summary

Yammakira Waterhole is located on the upstream channels of the Diamantina and the eastern section of Goyder Lagoon. It is approximately 10km in length and is one of the deepest (CTFD 6.0m) and most persistent waterholes on the Diamantina River in South Australia making it a significant large freshwater and permanent aquatic refuge. The floodplain in the vicinity of Yammakira is the most frequently flooded on Clifton Hills with an annual channel flow frequency replenishing the waterhole on the eastern flow path of the Diamantina and eventually discharging into Goyder Lagoon. It is a very important component of Clifton Hills pastoral production and provides good sources of forage even though local conditions may be dry.

The eastern flow path at the split of the Diamantina connects with Yammakira Waterhole and discharges into the extensive Goyder Lagoon wetland. The waterhole is lined with coolibah (*Eucalyptus coolabah*); Queensland bean tree (*Bauhinia gilva*), whitewood (*Atalaya hemiglauc*), Broughton willow (*Acacia salicina*), emu bush (*Eremophila bignoniiflora*) and lignum (*Duma florulenta*). The waterhole and adjacent sand dunes have been impacted by grazing and subjected to very high grazing pressure over many years.

The riparian vegetation is a thin corridor up to 10m wide and due to its permanency the waterhole provides important watering during dry periods. Tall shrubs such as whitewood, emu bush, and native plum (*Santalum lanceolatum*) are heavily grazed. Lignum has been heavily impacted in some areas. Leaf litter and debris is substantially reduced. There are numerous old tree hollows providing nesting habitat for birds. Yammakira is an important aquatic refuge waterhole and warrants controlled management to enable natural restoration processes to stabilise the site. A suggested measure is to facilitate an increase in perennial vegetation cover and stability of soil surfaces through periodic destocking or reducing stock numbers before cattle concentrate on the waterhole and heavy grazing of perennial vegetation occurs. Opportunistic spelling, particularly following significant rainfall events to encourage the establishment of perennials should also be considered. It is a significant Aboriginal heritage site that has importance to the Wangkangurru Yarluyandi Aboriginal community.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	HIGH	Permanent waterhole classed as an 'Ark-type' refuge – high ecological and aquatic importance providing critical refuge during times of environmental stress.
Riparian Condition Rating	MODERATE	Heavily impacted from historic grazing pressure. Perennial vegetation damage with little recruitment evident.
Connectivity Value	HIGH	Permanent aquatic refuge and extensive waterhole in overall length and size - high value for connectivity and species recruitment and dispersal.
Restoration Potential	MODERATE	Restoration potential is a longer-term proposition due to historic grazing pressure, soil compaction, loss of groundcover and litter, and deposition of fine clay particles making it more difficult for vegetation to naturally establish.
Investment Priority	HIGH	High ecological importance therefore implementing grazing management and pest species control measures are critical.
Management priorities	HIGH	Undertake regular monitoring, investigate and implement conservative grazing management strategies to facilitate the recruitment and establishment of perennial vegetation, e.g. coolibahs; implement pest animal control measures as required.

Site 21: Yellow Waterhole, Kalamurina Wildlife Sanctuary

Site information

Site: Yellow Waterhole - Warburton River

Management unit:

MANAGEMENT UNIT 3: Warburton - Kallakoopah

Commencement of Warburton Channel to Kati Thanda-Lake Eyre including Kallakoopah Creek flow path

Easting / Northing: -27°42'18.78"S 139°14'37.79"E

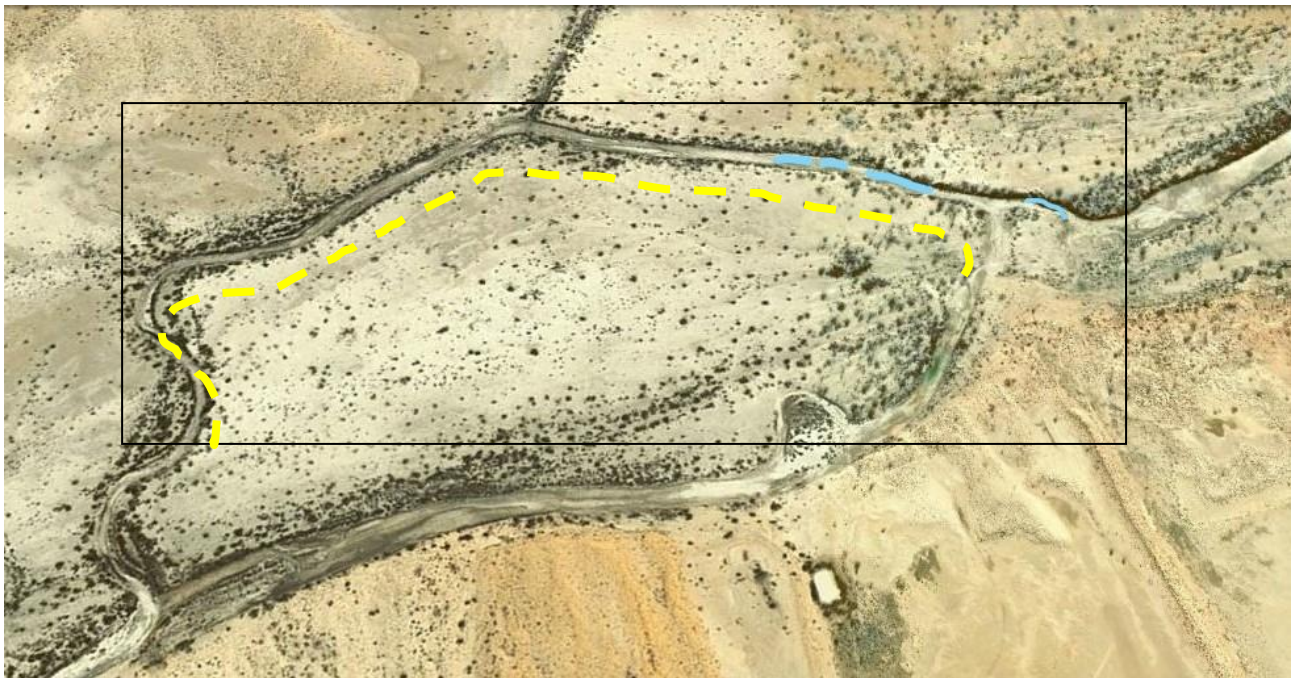
Date assessed: 15th May 2014; 2nd May 2016

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Conservation
- **Size / Area:** Waterhole length approx. 100m. Bankfull width up to 40m
- **Conceptual understanding:** In-channel semi-permanent waterhole / saline pool.
- **Recent rainfall / inundation events:** 60mm recorded May 2014; 180mm early January 2016
- **Depth:** Cease to flow (CTFD) depth: 0.5m
- **Elevation:** ~ 8m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced/naturalised)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Amaranthus grandiflorus</i> ; <i>Brassica tournefortii</i> ; <i>Commicarpus australis</i> ; <i>Dactyloctenium radulans</i> ; <i>Dysphania truncata</i> ; <i>Einadia nutans</i> ssp. <i>eremaea</i> ; <i>Eragrostis dielsii</i> var <i>dielsii</i> ; <i>Euphorbia wheeleri</i> ; <i>Gnephosis eriocarpa</i> ; <i>Ipomoea polymorpha</i> ; <i>Nicotiana velutina</i> ; <i>Othonna gregorii</i> (Syn. <i>Senecio gregorii</i>); <i>Paractaenum novae-hollandiae</i> ssp. <i>reversum</i> ; <i>Phyllanthus lacunellus</i> ; <i>Polycalymma stuartii</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Sauropus trachyspermus</i> ; <i>Sclerolaena diacantha</i> ; <i>Setaria jubiflora</i> ; <i>Sida</i> sp.; <i>Tragus australianus</i> ; <i>Trianthema triquetra</i> ; <i>Tribulus eichlerianus</i> ; <i>Triraphis mollis</i> ; <i>Tetragonia tetragonoides</i> ; <i>Zygophyllum simile</i>
Shrubs (low to tall shrubs)	<i>Acacia ligulata</i> ; <i>Acacia salicina</i> ; <i>Enchylaena tomentosa</i> var. <i>glabra</i> ; <i>Duma florulenta</i> ; <i>Senecio lanibracteus</i>
Small Trees (<5m)	
Trees (5-15m)	<i>Eucalyptus coolabah</i> 33



Yellow waterhole – assessment area



Erosion gully forming 2015



Increased erosion gullying 2016



Riparian corridor vegetation



Good debris and leaf litter cover

Ecosystem Values, Threats and Pressures

Yellow Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Vegetation reduced from natural assemblages expected for this site. Good response after recent rain event particularly ephemeral understorey species. Low recruitment of perennials.	QUANTITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE to HIGH	All strata present. Multiple habitat features including: tree hollows; overhanging vegetation; distributary channels; flood runners.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE	Seasonal waterhole (depending on extent of regional flows) becoming hyper-saline. Cease to flow depth (CTFD) 0.5m. Moderate connectivity value. Supports hyper-saline tolerant aquatic species	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	LOW	During site visits maximum 14000 EC (µS/cm). Hyper-saline pool.	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	MODERATE	Evidence of cultural heritage value: physical heritage with numerous stone artefacts present.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE to LOW	Similar 'type' in sub-catchment and management unit: Management Unit 3: Warburton – Kallakoopah	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE	Semi-permanent waterhole supports highly salt tolerant aquatic species.	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT MODERATE LEVEL	Recent rabbit activity evident, warrens active, fresh digging and dung heaps. Camels observed – under active control.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – no evidence of significant eutrophication e.g. algal or aquatic plant growth	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	PRESENT LOW LEVEL	No significant infrastructure – mainly station tracks and disused creek crossing.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	PRESENT LOW LEVEL	Site used for camping – low impact well managed site.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	MODERATE to HIGH LEVEL	Major gullying at one section of creek – active erosion point exacerbated by recent heavy rain event. Streambank erosion exposing tree roots extreme.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	LOW LEVEL	Low level with some herbivore browse evident. No major impacts. Destocking has contributed to recovery of site.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	SLIGHTLY MODIFIED	Some modification to the lateral vegetation connectivity with adjacent floodplain	Observation
17. Nativeness	LARGELY UNMODIFIED	No major weed infestations or WONS present. Naturalised species widespread.	Observation
18. Structural Integrity	SLIGHTLY MODIFIED	Mid-stratum reduced.	Observation
19. Age Structure	SLIGHTLY MODIFIED	Recruitment of perennials reduced.	Observation
20. Terrestrial woody debris and leaf litter	SLIGHTLY MODIFIED	Historic firewood collection. Good leaf litter and debris cover with a 'no campfire' policy in place.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Yellow Waterhole is located on the Warburton River in the Tirari Desert (Tirari Land System). This country includes channels and floodplains of the lower Warburton. Dominate tree species are coolibah (*Eucalyptus coolabah*) and Broughton willow (*Acacia salicina*) with an understorey of lignum (*Duma florulenta*) and native forbs and grasses.

The site has lower perennial species richness in the upper stratum correlating with higher salinity and lower flooding frequency. Plant species assemblages are as expected for the habitat assessed with increased species richness in the lower stratum, mainly consisting of annual and ephemeral species, probably as a response to significant localised rainfall events experienced in the region. The site is in recovery from historic heavy grazing pressure and there is good species recruitment.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Moderate aquatic refuge importance as a saline pool that persists for salt tolerant species.
Riparian Condition Rating	MODERATE	Historic landuse has impacted site – mid-stratum reduced with an active erosion gully. Low perennial vegetation recruitment (coolibahs)
Connectivity Value	MODERATE	Provides habitat for salt tolerant species for eventual dispersal when connectivity occurs.
Restoration Potential	MODERATE	Natural recovery processes on-going due to de-stocking – maintain large feral herbivore control and manage stock incursions appropriately.
Investment Priority	MODERATE	Currently under sound management and in order to maintain current recovery trajectory investment would be beneficial.
Management priorities	MODERATE	Maintain current management regime for feral animal control and visitor management.

Site 22: Yelpawaralinna Waterhole, Clifton Hills Station

Site information

Site: Yelpawaralinna Waterhole – Warburton River

Management unit:

MANAGEMENT UNIT 2: Goyder Lagoon

From Andrewilla and Yammakira tributary channels to commencement of the Warburton River channel

Easting / Northing: -27°07'44.96"S 138°42'30.09"E

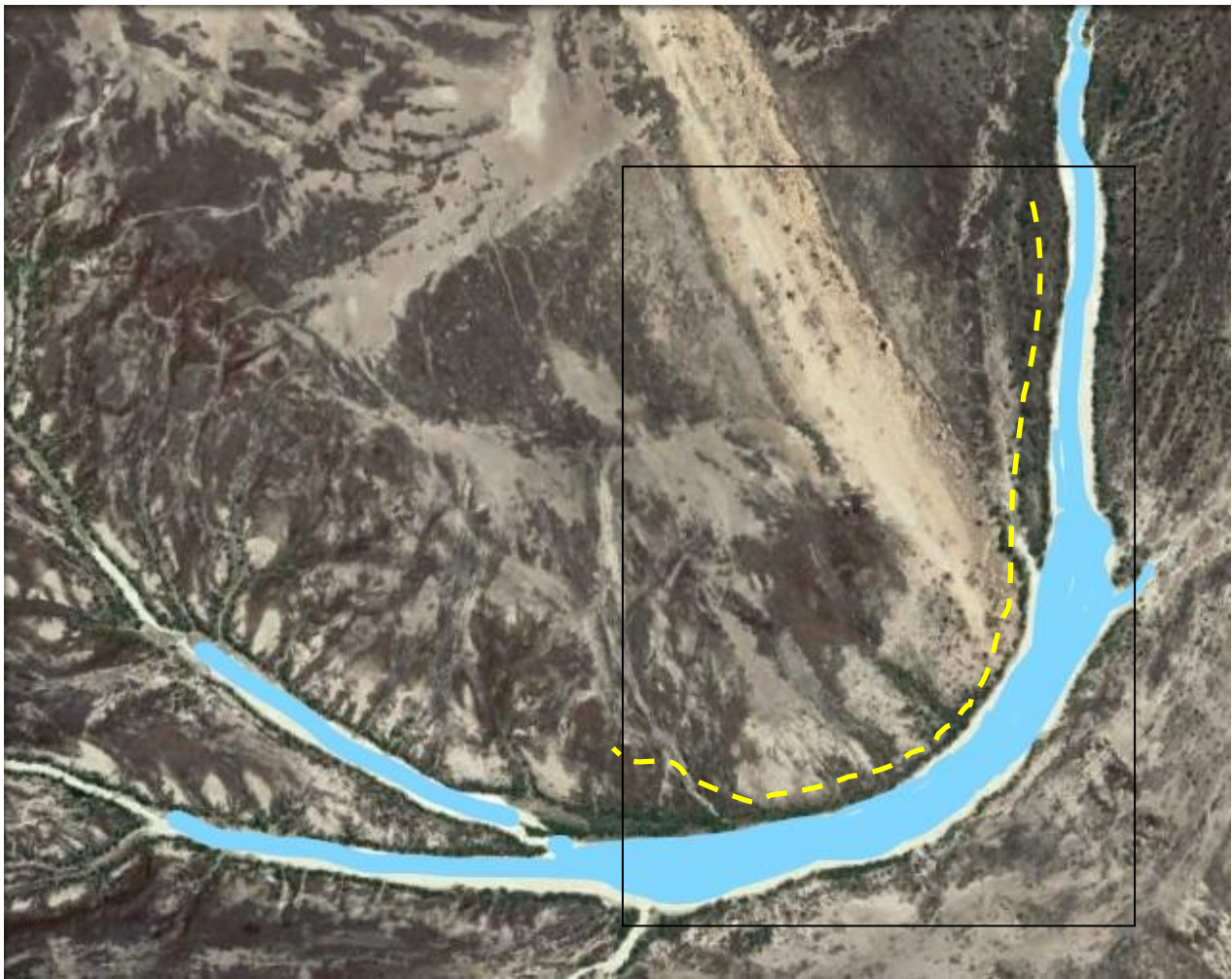
Date assessed: 7th May 2015

Description of feature assessed:

- **Feature type:** Riverine waterhole
- **Use zone:** Pastoralism
- **Size / Area:** Waterhole length approx. 3km. Bankfull width 120m-140m.
- **Conceptual understanding:** In-channel semi-permanent waterhole.
- **Recent rainfall / inundation events:** 25mm recorded early 2014; 80mm recorded in January 2015. Dries out on average every 3 years. Receives regional floods every 2 years.
- **Depth:** Cease to flow depth (CTFD): 2.4m.
- **Elevation:** ~ 22m
- **Vegetation association:** Coolibah (*E. Coolabah*) riparian open woodland

Plant list of perennial and annual species from J. Gillen 2015 vegetation survey (species in bold introduced)

Strata	Species
Aquatic/ semi-aquatic	
Understorey - (grasses, forbs & misc)	<i>Alternanthera nodiflora</i> ; <i>Amaranthus grandiflorus</i> ; <i>Boerhavia burbridgeana</i> ; <i>Calotis porphyroglossa</i> ; <i>Centipeda cunninghamii</i> ; <i>Cucumis melo</i> ; <i>Dactyloctenium radulans</i> ; <i>Eriochloa crebra</i> ; <i>Glinus lotoides</i> ; <i>Lysiana subfalcata</i> ; <i>Portulaca intraterranea</i> ; <i>Salsola australis</i> ; <i>Sclerolaena intricata</i> ; <i>Sclerolaena bicornis</i> ; <i>Sesbania cannabina var cannabina</i> ; <i>Trianthema triquetra</i> ; <i>Zaleya galericulata</i>
Shrubs (low to tall shrubs)	<i>Abutilon fraseri ssp fraseri</i> ; <i>Chenopodium auricomum</i> ; <i>Enchylaena tomentosa var. glabra</i> ; <i>Duma florulenta</i>
Small Trees (<5m)	<i>Acacia salicina</i> ; <i>Acacia stenophylla</i> ; <i>Bauhinia gilva</i> ; <i>Santalum lanceolatum</i>
Trees (5-15m)	<i>Eucalyptus coolabah</i> 26



Yelpawaralinna waterhole assessment area



Yelpawaralinna waterhole riparian vegetation



Riparian vegetation reduced

Ecosystem Values, Threats and Pressures

Yelpawaralinna Waterhole – ecosystem values, threats and pressures

	Indicator	Value	Description	Confidence
Ecosystem Values				
1.	Riparian plant diversity	MODERATE	Perennial species recruitment absent. Vegetation is reduced from natural assemblages expected for the habitat assessed – percentage cover of mid-stratum reduced.	QUALITATIVE SURVEY
2.	Riparian habitat diversity	MODERATE	Moderate range of riparian habitat features including flood runners; overhanging vegetation; submerged logs.	QUALITATIVE SURVEY
3.	Hydrological Value	MODERATE to HIGH	Semi-permanent waterhole. Cease to flow depth 2.4m. Seasonal waterhole - depending on extent of local and regional flow events– frequently dry. Moderate channel / floodplain connectivity value for ecosystem function and species dispersal.	QUANTITATIVE HYDROLOGICAL MONITORING
4.	Water Quality – salinity	FRESH	During site visits maximum 166 EC (µS/cm).	EC Tester SALINITY METER
5.	Cultural Heritage Site (Physical; Customary & Natural)	HIGH	High rating for Physical heritage values. Aboriginal cultural significance. Extensive shell midden site with numerous stone tools.	QUALITATIVE SURVEY
6.	Uniqueness	MODERATE	Similar 'type' example in sub-catchment at sub-regional level other semi-permanent aquatic refuges are present	QUALITATIVE SURVEY
7.	Key Aquatic Refuge	MODERATE to HIGH	Semi-permanent waterhole - persists for 12-18 months - supports a range of fauna and flora during times of stress over prolonged periods	QUALITATIVE SURVEY
Ecosystem Threats				
8.	Weeds	PRESENT LOW LEVEL	No significant (WONS) weeds observed; one introduced/naturalised species present.	QUALITATIVE SURVEY
9.	Pest Animals (terrestrial & aquatic)	PRESENT MODERATE to HIGH	High level of camel activity and impacts. No introduced fish (gambusia or goldfish) recorded.	QUALITATIVE SURVEY
10.	Surface & G/water Abstraction	ABSENT	None observed.	QUALITATIVE SURVEY
11.	Nutrients	PRESENT LOW LEVEL	Low level – some eutrophication causing aquatic plant growth.	QUALITATIVE SURVEY
Ecosystem Pressures				
12.	Infrastructure (e.g. tracks, flow diversions)	LOW LEVEL	Station tracks leading into waterhole. Low level – no significant disturbance.	QUALITATIVE SURVEY
13.	Tourism, camping, recreation activity	ABSENT	Remote site no recent activity observed.	QUALITATIVE SURVEY
14.	Bank stability, soil disturbance	MODERATE	Some disturbance observed and loss of lignum cover causing destabilisation of streambank edge.	QUALITATIVE SURVEY
15.	Total Grazing Pressure	MODERATE to HIGH	Heavy grazing pressure from camels evidenced by perennials grazed and distinct browse lines. Low recruitment of perennials.	QUALITATIVE SURVEY

Refer Appendix A for interpretation of scoring system

Site Condition

Indicator	Value	Description	Confidence
16. Spatial Integrity	MODERATELY MODIFIED	Width reduced by up to 1/3 and/or some breaks in continuity.	Observation
17. Nativeness	LARGELY UNMODIFIED	Vegetation predominately native, few weeds and no 'high threat' (WONS) species.	Observation
18. Structural Integrity	MODERATELY MODIFIED	Cover within one stratum 50% lower than what is expected – mid-stratum vegetation layer.	Observation
19. Age Structure	MODERATELY MODIFIED	Reduced cover (75-50%) of dominant strata present. Only two age classes present – coolibah juvenile recruitment absent.	Observation
20. Terrestrial woody debris and leaf litter	SUBSTANTIALLY MODIFIED	Significantly low quantities of debris and leaf litter cover from stock and feral camel activity. Cover at 75% below what is expected.	Observation

Refer Appendix A for interpretation of scoring system

Summary

Yelpawaralinna waterhole is located in channel, floodplain country of the Diamantina River (Diamantina land system). Flow into Yelpawaralinna occurs from the Warburton channel and by floodplain flow during larger flood events. Channel vegetation mainly consists of coolibah (*Eucalyptus coolabah*), Broughton willow (*Acacia salicina*), river cooba (*Acacia stenophylla*), and lignum (*Duma florulenta*). The waterhole has a cease to flow depth of approximately 2.2m and holds for less than a year after filling and without receiving further inflow.

The country in the vicinity of Yelpawaralinna waterhole has been heavily impacted by grazing and camel activity. There are open bare areas and scalded flats in the vicinity of the waterhole. Lignum is impacted and reduced in some sections due to stock accessing the waterhole. A suggested approach is to facilitate an increase in perennial vegetation cover to stabilise soil surfaces by opportunistic spelling or light stocking and feral camel control. This is an important cultural site for local Aboriginal people and warrants increased management and protection.

Riparian Habitat Summary	Ranking	Comments
Ecological / Aquatic Refuge Importance Ranking	MODERATE	Moderate importance as an aquatic refuge due to reliance on seasonal factors for connectivity with the Warburton.
Riparian Condition Rating	LOW	Heavily impacted from total grazing pressure. Perennial vegetation damage with little recruitment evident.
Connectivity Value	MODERATE	Has some value for connectivity and dispersal along the Warburton channel.
Restoration Potential	LOW	Heavy grazing and trampling over a long-term period has created loss of habitat and vegetation cover making this site less likely to fully recover.
Investment Priority	HIGH	High importance due to cultural site significance. Investigating grazing strategies to facilitate recruitment of perennial vegetation in conjunction with feral animal (camel) control.
Management priorities	HIGH	Apply grazing strategies to enable recovery of the site. Destocking when required according to condition. Maintain sustainable stocking rates and feral animal control as required. Protect Aboriginal heritage sites.