Trip Report: DBCA Lake Carnegie Reconnaissance 1-8 October 2019

Michael Coote - Principal Coordinator, Wetlands Section Policy, Biodiversity and Conservation Science

Adrian Pinder - Program Leader, Ecosystem Science, Biodiversity and Conservation Science

Robert Davis - Botanist, Plant Science and Herbarium, Biodiversity and Conservation Science

Bart Huntley – Remote Sensing and Spatial Analysis Program.

Introduction

Lake Carnegie is a large (120 km in length, 20 km at widest point), elongate, shallow, saline, internally draining basin on the southern edge of the Little Sandy Desert. The lake is located 920 km north-east of Perth, 210 km east of Wiluna and within the Local Government Area of Wiluna (Figure 1). It is described as a megascale, irregular sumpland with numerous microscale to macroscale islands. At its south-east end, the lake becomes a discontinuous series of microscale to macroscale sumplands and channels. It is fringed by extensive and geomorphologically complex areas of floodplains, claypans, creek lines and a small number of springs. The geology is described as overlying sandstone formations of the Capricorn Orogen in the west and Officer Basin in the east. Lake Carnegie has formed in a largely infilled alluvial valley of a major palaeodrainage which connected with Lake Wells and flowed northwards into Lake Disappointment and out to the ocean along the Oakover River. The lake-bed is an expanse of lacustrine clay and silt with sand, salt and gypsum. Mixed aeolian dunes of gypsum and quartz sand form numerous circular or crescentic islands and marginal lake deposits.

The median and mean annual rainfall at nearby Carnegie Station are 170 mm and 193 mm respectively, mostly falling in January-March. Lake Carnegie is episodically filled from surface inflow from numerous creeks including Kulele, Charles Wells, Wongawol and Banjo creeks to the western end; Miningarra and Fourteen Mile creeks from the south; Sholl, Anne and Brockman creeks from the north; and Windidda Creek to the eastern end. Lake water is probably fresh initially, becoming saline as lake-bed salt-crust dissolves and water evaporates. Inundation patterns have been revealed using Landsat data (see Appendix 3).

Lake Carnegie Tenure

The Tarlka Matuwa Piarku Aboriginal Corporation (TMPAC) is the Prescribed Body Corporate that holds exclusive possession native title rights and interests on trust for the Wiluna Native Title Holders including “the right to have access to, maintain and protect places, and areas and objects of importance” within the Wiluna determination area (WRD2017/001). This exclusive possession area includes Lake Carnegie (LC) which is approximately 244,737 ha. Former pastoral leases Lorna Glen and Earaheedy are known to the Martu People as Matuwa and Kurrara Kurrara, respectively, and were collectively declared an Indigenous Protected Area (IPA) in 2015 (MKK IPA) by the Commonwealth Government. The land tenure is currently recognised as unallocated crown land.

Lake Carnegie was assessed in 2005 as meeting Section 5 of the Aboriginal Heritage Act 1972 and placed on the Register of Sites maintained by the now Department of Planning, Lands and Heritage (DPLH) (site ID 25671, mythological, and male access only). Lake Carnegie is extremely significant to Martu traditional owners.

Background to the October 2019 field trip

Lake Carnegie is listed in the Commonwealth Directory of Important Wetlands in Australia as the Lake Carnegie System (WA032) and is known to be significant for black swan (Cygnus atratus) breeding and a major habitat for other waterfowl.

There have been very few biological studies of Lake Carnegie and its surrounds. The last survey of waterbirds was conducted in August 1999 by Stuart Halse and Grant Pearson (then with Department of Conservation and Land Management) (Appendix 4). Just over 10000 birds were counted, including 6500 grey teal and 467 black swan (with 114 broods observed). The central area of Lake Carnegie was about 1/3 inundated at the time.

Lane et al. (1980) undertook an aerial survey of waterbirds in September 1980, recording about 1000 breeding pairs of black swan, 1000s hardhead and 1000s of banded stilt on the main salt lake, but also noted hundreds of ducks and some other waterbirds on a smaller peripheral lake. Interestingly, the only significant rain in the vicinity of Lake Carnegie in 1980 was in February (248 mm at Lorna Glen and 193 mm at Prenti Downs) with additional falls in late autumn and winter (47.5 mm in May at Lorna Glen and 112 mm over the period April to July at Prenti Downs). An earlier survey by Tom Riggert and colleagues in March 1967 recorded 2500 Australian shelduck, 2000 black swan and 500 black duck, plus 1000s stilt. These birds were mostly in the smaller wetlands away from the main lake area. This survey was preceded by 162 mm in January and 205 mm in February at Carnegie Station, and 8 and 250 mm respectively at Wongawol Station. Data from these two surveys are provided as Appendix 4.

Lake Carnegie is also largely unknown floristically. Prior to the trip there were only 96 plant taxa recorded in Florabase from the vicinity of Lake Carnegie and only 44 of these from near the lake itself.

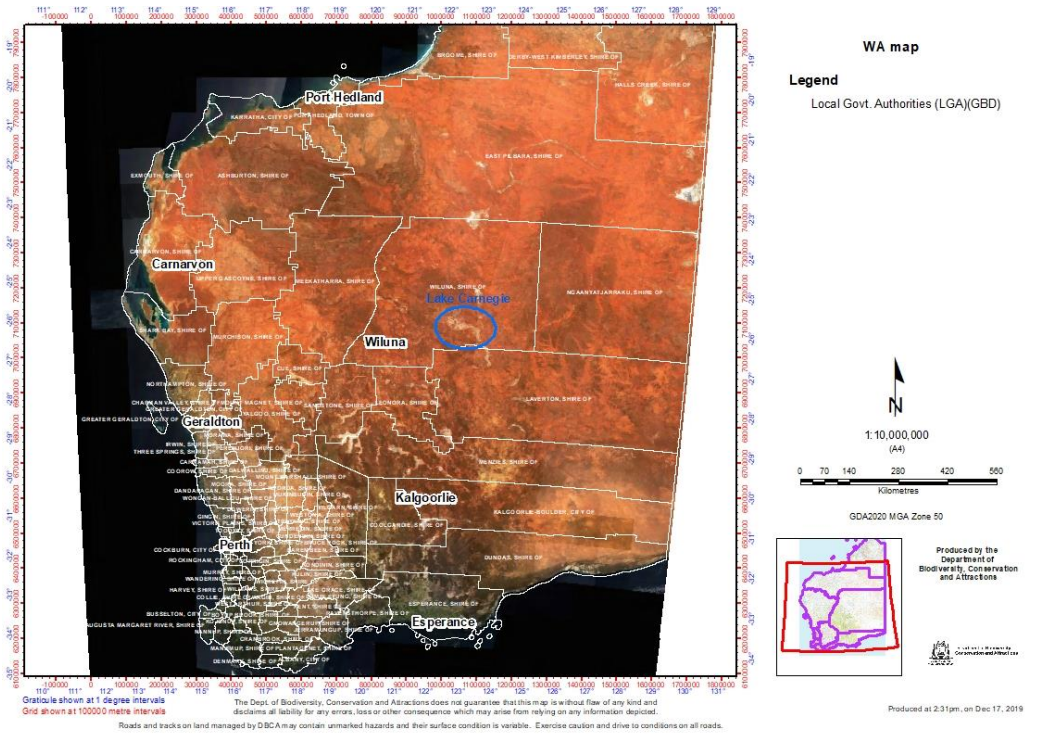

Figure 1. Satellite image of Western Australia showing location of Lake Carnegie

TMPAC have indicated their support for the nomination of Lake Carnegie under the International Convention on Wetlands, the Ramsar Convention. However, there is currently insufficient information about the wetland's biodiversity values, ecological and hydrological functioning, threats and management requirements to identify which of the nine Ramsar listing criteria the system supports and to produce the Ecological Character Description (ECD) that needs to accompany a nomination.

The reconnaissance trip was arranged after discussions between Jan Taylor (Land Services Unit) and Nigel Wessels (Goldfields Region) with Michael Coote and Adrian Pinder (Biodiversity and Conservation Science), about the potential for nominating Lake Carnegie as a Ramsar wetland. It was agreed that at the time of these discussions, that the salt lake and its peripheral wetland habitats were almost all dry and the data required to demonstrate listing criteria and produce an ECD cannot be collected without further biological survey effort following the wetland system receiving significant rains and at least partially filling. It would be possible to commence contact with the Commonwealth to gain in-principle support for preparing a nomination without a biological survey having taken place, but it was decided that staff responsible for preparing the relevant documentation needed to visit the wetland. Consequently, a reconnaissance trip was conducted in October 2019 to undertake preliminary investigations into the diversity and condition of wetland habitats and biodiversity present, feasibility of accessing the wetlands under wet conditions and to gain an understanding of the lake's values to the native title holders (Tarlka Matuwa Piarku Aboriginal Corporation (TMPAC)), and pastoral leaseholders. The trip also provided us with ideas on how to structure a biological survey should the opportunity arise and confirm that TMPAC supports the nomination of Lake Carnegie as a Ramsar listed site.

Trip details

Itinerary

1 Oct. Perth to Sandstone

2 Oct. Sandstone to Matuwa

3 Oct. Met senior TMPAC representative Allan Ashwyn and five younger male members, at Windidda homestead. Drove to claypans on the southern edge of the lake directly north of Windidda homestead, camped overnight.

4 Oct. On Windidda Station during day, including driving overland to a wetland that is reliably filled and retains water for longer periods than the main lake body (peripheral wetland 3), then accessed the main braided lake area on the Windidda/Prenti Downs boundary before driving to Prenti homestead and viewing the southern extent of the eastern braided section of the lake with Tim Carmody. Spent night at Prenti Downs homestead.

5 Oct. With Tim Carmody and TMPAC representatives, visited disturbance sites from Kalium exploration and claypans and braided channels on the north-west of the lake. Set two ARUs overnight in potential night parrot habitat. Returned to Prenti Downs homestead for night.

6 Oct. Collected ARUs and continued to drive around the northern side of the lake with TMPAC representatives, visiting a number of peripheral wetland habitats. Visited Mingol Pool on Wongawol Station. TMPAC then left us and we proceeded to Wongawol Station. No-one home at homestead so we went back to Windidda to camp where we camped near the salt lake. Set 2 ARUs up overnight.

7 Oct. Collected ARUs and walked over sand dunes to the salt lake, scoring a catena of vegetation types. Mike Coote ran out to the mushroom-shaped peninsula to visit some of the interdunal wetlands. Departed camp and drove to Wongawol Station. Spoke to station manager, who contacted the Snells (lessees) to get permission for us to explore the areas of river pools to the west of the lake. Visited one river pool but channels very dry. Departed Wongawol and drove to Matuwa for the night.

8 Oct. Matuwa to Perth.

Wetland areas visited

The main body of the open area of Lake Carnegie was accessed on Windidda Station north of the homestead – had to walk about 500 m over dunes from where we camped on the northern edge of a claypan. The eastern braided section of the salt lake was accessed at four points:

1. On the boundary fenceline between Windidda and Prenti Downs Station.
2. Along the track heading east of Prenti Downs homestead.
3. On the north-east side of the braided eastern section of the lake on Prenti Downs south of Toonil Pool.
4. 12km west of Toonil Pool, south of Freshwater Bore.

Other wetland areas accessed were:

1. Complexes of claypans and low-lying vegetated flats north of Windidda homestead, within 0.5 to ~ 3km from the salt lake edge.
2. Two connected claypans approximately 5km north-west of Top Fourteen Mile Well on Windidda.

3. Internally draining dunal swale wetlands on Windidda with *Tecticornia* and some with fringing layer of *Melaleuca*. Similar dune swale wetland systems occur elsewhere on the lake.
4. Toonil Pool. A large claypan with *Tecticornia* fringes, connected to another smaller claypan by a broad channel.
5. An un-named claypan 1 km west of Freshwater Bore. Unusual in that it had grass (?*Eragrostis* or *Erinacine*) rather than *Tecticornia*.
6. Mingkul Pool. A semi-permanent river pool on Brockman Creek.
7. Marlanindie Pool on Wongawol Station at the western end of the lake.

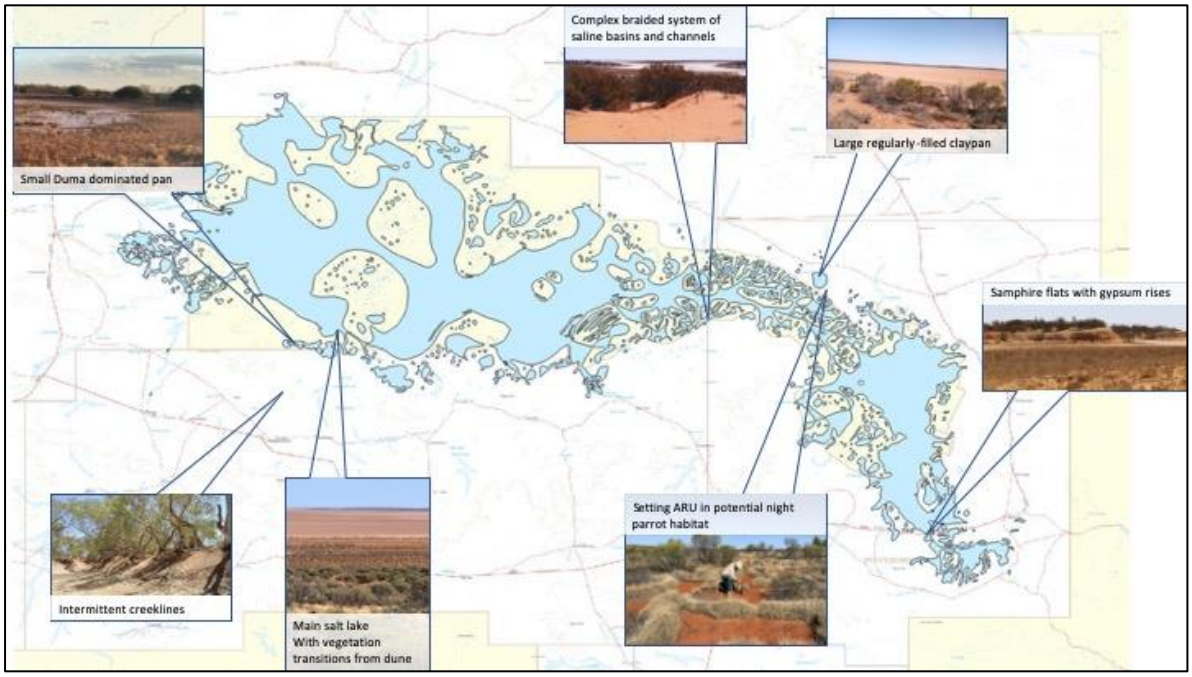

Figure 2. Example habitats visited during the field trip.

Trip documentation

During the trip, tracks were recorded using a combination of handheld GPS, SW Maps app on an android tablet and using the hema maps app on an iphone. GPS points were recorded where notes were made about landscape features, vegetation or other points of interest. These tracks and points are shown on Figure 3 and are available on request. Notes made at each GPS point are shown in the table in Appendix 5, along with references to associated photos (available on request).

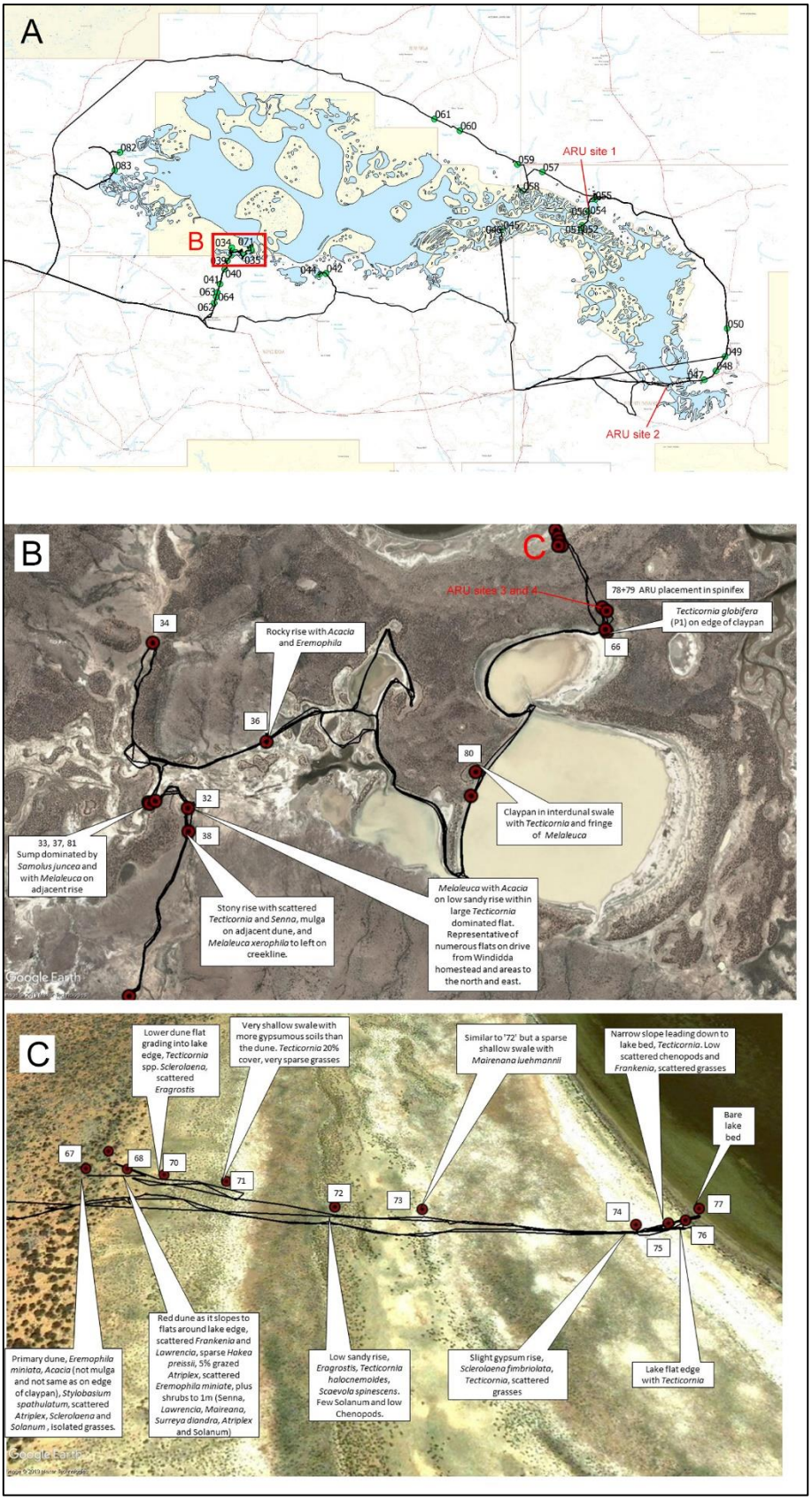

*Figure 3. **A**, Map of the Lake Carnegie area, showing our GPS track and the gps points recorded (see Appendix X for details); **B**, an area near the main lake (the red box in A) showing complex wetland geomorphology, with notes on vegetation complexes; **C**, Edge of the main lake showing a complex catena of vegetation communities in low rises and swales between the dunes and the lake bed (this area indicated by 'C' in the image above).*

Main Findings

- Lake Carnegie has a diverse range of wetland types that include the main water body, described as a megascale irregular sumpland with numerous islands and embayments, a braided system of sumplands and channels, claypans (that are fresh or saline, clear or turbid), interspersed within landscapes of gypsum rises, red sand dunes, interdunal swales, floodplains, creeks and rivers that include near permanent pools, some of which are likely intersecting groundwater flows. Some of these are shown in Figure 2 and Figure 3.

- There is a high diversity of vegetation communities across the varied wetland ecotypes and these would support a high diversity of flora following rains (Figure 3). These have been very poorly surveyed, with Florabase listing just 96 taxa in the area traversed during this trip, with 44 of those around the lake's immediate fringes. It would not be surprising if a floristic survey during wetter times would turn up novel taxa. Forty six species were collected during this trip (species list included below as Appendix 2) including a Priority 1 species *Tecticornia globifera* from a claypan 1km south of the main lake directly north of Windidda homestead (gps point 66). Of these, 38 had not previously been collected within the area we traversed during the trip, increasing the area's species list by 40% in a few days during a very dry period. Specimens of 25 species were lodged in the WA Herbarium.

- The reconnaissance trip confirmed that there are pressures on the natural processes, attributes and ecosystem services of the system as a result of pastoral activities, feral animals and more recent construction of causeways on the eastern end for increasing access around the system and mining activities. The presence of a large number of camels and horses are likely to be contributing, along with managed stock, to the degradation of the vegetation and channel bank morphology and increasing sedimentation in the system. The recent construction of causeways is likely to be contributing to altered flow paths and hydrology of the eastern braided end of the system. There has been recent construction of tracks and drill pads that remain unrehabilitated. Tim Carmody took us to one such site and we took georeferenced photographs of the disturbance. Two springs on Prenti Downs Station were in very poor condition. Windidda Spring had been extensively excavated to provide water for road construction by Tim Carmody. Well Spring was heavily grazed due to its proximity to a well and had numerous dead stock and camels.

- In some areas away from the lake, vegetation condition was poor, reflecting cattle grazing, feral animals, fire and the dry conditions during the last few years. This was especially the case along the northern side of the lake on Wongawol and Naminga Stations. River pools on the drainage channels flowing into the western end of Lake Carnegie were mostly dry or with very poor quality water (green and odorous). However, closer to the lake, at least on the southern side, the floodplains and wetland complexes, which would probably form the core of a Ramsar boundary, appear to be in moderate to good or even near natural condition.

- Previous waterbird surveys conducted in 1967 and 1980, indicated that the system is important for waterbird breeding and foraging (Appendix 1) and this was confirmed by anecdotal information from Allan Ashwyn and Tim Carmody (Prenti Downs). This will have to be confirmed through new surveys following a wetting event to meet requirements for criteria 3 and 4. The 1967 survey noted that most ducks were primarily on the smaller peripheral wetlands and this was supported by observations by Allan Ashwyn. Carmody indicated that he had seen Banded Stilt on the lake. This nomadic species breeds only when inland salt lakes fill, so conserving such salt lakes is important for that species.

- Parts of the lake fringes represent night parrot habitat, consisting of old ring forming spinifex in proximity to samphire communities and water points. Some of these areas were visited during the trip and audio recording units placed overnight at three locations – marked on Figure 3. The recordings are yet to be processed.
- Mingkul Pool is described as a permanent pool but was dry when visited. Allan Ashwyn commented that he had never seen it dry. The only remaining water we could see was a small (2 x 1 m) pool with a dying cow. Wongawol Station has constructed a turkey nest dam near the pool (south side of the Carnegie Road) and, while the dam was dry when visited, there was a pipeline running from the pool to the dam.

Implications for nomination of Lake Carnegie under the Ramsar Convention

The reconnaissance survey confirmed that Lake Carnegie is a representative example of a natural or near-natural large, elongated, shallow, saline, internally draining basin within the Gascoyne Biogeographic Region. While there is evidence of significant impacts from feral animals and potential hydrological alteration in the far eastern end of the system as a result of the construction of low causeways, it remains in near natural condition and meets Criteria 1 (Appendix 1).

The presence of habitat that is known to be suitable for the Night parrot *Pezoporus occidentalis*, which is listed as Endangered under the *Environmental Protection and Biodiversity Conservation* (EPBC) Act 1999 over the eastern third of the lake system raises potential for the site to meet Criteria 2 (Appendix 1) if the presence is confirmed.

There is a high diversity of vegetation communities across the varied wetland ecotypes and these would support a high diversity of flora following rains. These have been very poorly surveyed and the 46 species that were collected during the trip, which was a particularly dry period is indicative that the diversity of flora following rains will support the site meeting Criteria 3.

Bird surveys conducted in 1967 and 1980 show that Lake Carnegie is an important wetland system for waterbirds in WA and particularly the arid region of the state. If future surveys confirm the diversity and abundance of water birds that were observed in these early surveys, the site will also meet Criteria 3 and if the breeding of Banded stilts and Black swan are recorded again, the site will also meet Criteria 4 (Appendix 1).

The Australian Department of Environment and Energy (DEE) have been approached regarding a potential nomination of this site under the Ramsar Convention following further biological survey. The response from DEE indicated support for the nomination once further biological data is collected that will inform an assessment of listing criteria that are met. Acknowledgement was provided that nominations can only be finalised following the drafting of supporting documents, including a Ramsar Information Sheet with mapping of wetland types and boundaries, Ecological Character Description and a Management Plan for the area.

Acknowledgements

Thanks to Jan Taylor, Nigel Wessels and Tjokkie Pieterse for involving us in this work, assisting with logistics and liaison with Tarlka Matuwa Piarku Aboriginal Corporation (TMPAC) and the Matuwa caretakers. We very much appreciated Allan Ashwyn generously guiding us and sharing his deep knowledge of the area during the trip. Tim Carmody at Prenti Downs spent a day showing us around and discussing some of the management issues.

References

Lane. J, Munro, Fuller, Youngson (24-26 September 1980) Eastern goldfields: Aerial Survey of Waterbirds.

Appendix 1. Ramsar criteria

In order to be nominated under the Ramsar convention, DBCA are required to demonstrate that there is support from landowners and key stakeholder groups for the nomination and that the site supports values that are internationally significant in terms of ecology, botany, zoology, limnology or hydrology. The Ramsar Convention has nine criteria which relate to identifying sites that contain representative, rare or unique wetlands, or wetlands that are important for conserving biodiversity. For a site to be nominated it must satisfy one or more of the criteria:

Group A of the criteria: Sites containing representative, rare or unique wetland types	
	Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B of the criteria: Sites of international importance for conserving biological diversity	
Criteria based on species and ecological communities	**Criterion 2:** A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
	Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region*.
	Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Specific criteria based on waterbirds	**Criterion 5:** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
	Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.
Specific criteria based on fish	**Criterion 7:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
	Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Specific criteria based on other taxa	**Criterion 9:** A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

To be considered a priority for nomination, a site would need to support more than just Criterion 1, that of being representative, rare, or unique example of a natural or near-natural wetland found within the Gascoyne Biogeographic Region.

Appendix 2. Flora collected during survey

Polygonaceae	*Duma florulenta*
Asteraceae	RD 13044 *Senecio gregorii*
	Pimelea microcephala
Casuarinaceae	*Casuarina pauper*
Chenopodiaceae	*Mairena leuhmannii*
	Maireana globifera
	Maireana pyramidata
	Sclerolaena fimbriolata
	RD 13050a *Tecticornia globulifera* (P1)
	RD 13051a *Tecticornia halocnemoides*
	RD 13038 and 13030a *Tecticornia indica* subsp. *leiostachya* (site 54 and 35)
	RD 13039 *Tecticornia verrucosa* (site 54)
	RD 13029 *Tecticornia undulata* (site 35)
	RD 13030 *Tecticornia* sp. Dennys Crossing (site 35)
	RD 13049 *Tecticornia disarticulata*
Primulaceae	*Samolus juncea*
Goodeniaceae	*Scaevola spinescens*
Amaranthaceae	*Ptilotus obovatus*
	Surreya diandra
Malvaceae	*Lawrencia* sp.
Surianaceae	*Stylobasium spathulatum*
Proteaceae	RD 13028 *Hakea preissii*
	RD 13036 *Grevillea sarissa*
Loranthaceae	RD 13037 *Amyema gibberula* var. *tatei*
Scrophulariaceae	RD 13032 *Eremophila gilesii* subsp. *gilesii*
	RD 13033 *Eremophila cuneifolia*
	RD 13042 *Eremophila pantonii* (Pernti Homestead)
	RD 13043 Eremophila exilifolia

	RD 13050 *Eremophila glabra* subsp. *tomentosa*
	Eremophila miniata
Fabaceae	RD 13040 *Swainsona microphylla* (site 54)
	RD 13046 **Vachellia farnesiana* (Mingol Camp)
	Acacia ligulata
	Acacia cyperophylla
	Acacia tetragonophylla
	Acacia ramulosa
	Acacia pruinocarpa
	RD 13041 *Acacia sibulans*
	Melaleuca interioris
Myrtaceae	RD 13031 *Melaleuca xerophila*
	Eucalyptus gamophylla
	RD 13045 *Eucalyptus camaldulensis* subsp. *obtusa* (Mingol Camp)
Boraginaceae	RD 13047 *Heliotropivum ammophilum* (Mingol Camp)
Plantaginaceae	RD 13048 *Stemodia florulenta* (Mingol Camp)

Appendix 3. History of wetland inundation.

Bart Huntley (Remote Sensing and Spatial Analysis Program) used Landsat data (band 5 near infrared) to determine the frequency and timing of hydroperiods for 3 areas of the main salt lake (west, middle and east) and five small peripheral wetlands over the period 14 Jan 1988 to 16 Sep 2019. These wetlands were chosen because, on Google Earth imagery, they seem to hold water when other wetlands are dry, except for peripheral wetland #4 which is one of numerous small pans between polygonal dunes. They are shown as polygons in Figure 4. R code for producing Figure 6 is available at https://github.com/AdrianMP62/LC_analyses_2019.git.

Some Landsat images had missing data which appear as white lines through the image (Figure 5). These missing data were counted as inundated where the wetland polygon was otherwise mostly inundated. Some inaccuracy in the timing of flooding and drying will result from some periods in the data where imagery was not available for several week at a time, largely due to cloud cover. On average, for the central area of the main lake an image was available every 21 days but there are intervals between these images that are larger than this which would introduce inaccuracies in the apparent timing of inundation events and their duration.

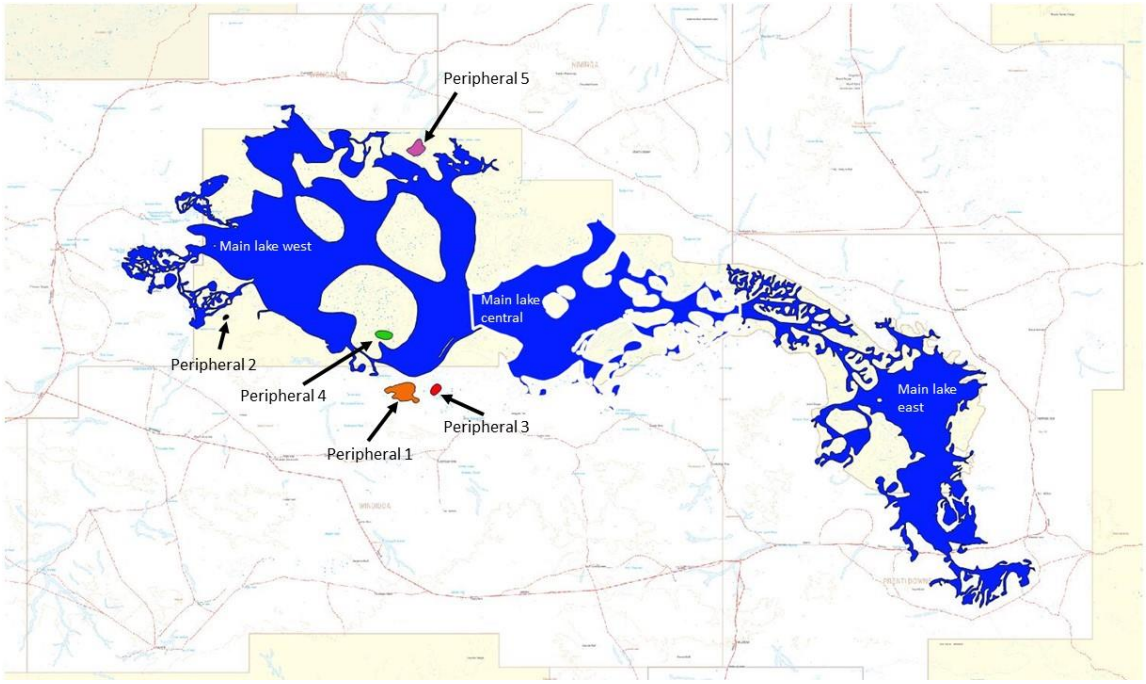

Figure 4. Wetlands used for remote sensing of inundation patterns, with the main salt lake areas (blue) divided into west, central and east and five other wetlands coloured as in Figure 6.

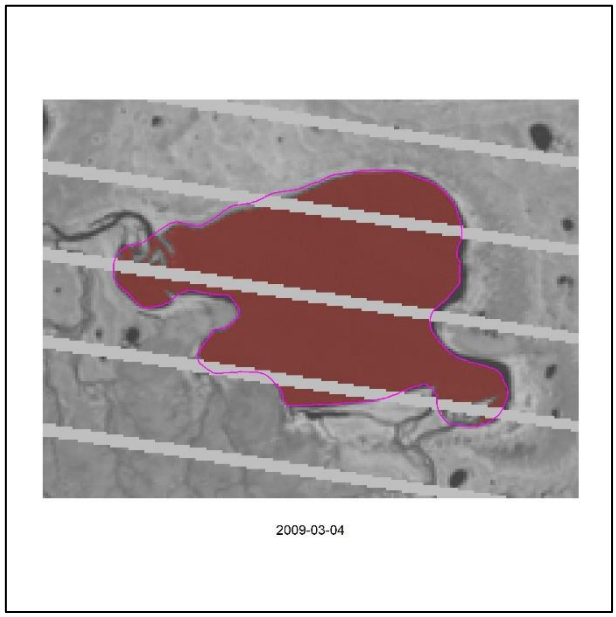

Figure 5. Landsat band 5 image of 'peripheral wetland 1' with area interpreted as inundated coloured red. White bands are missing data.

The results of this analysis are shown in Figure 6. These show largely coincident timing of inundation events across all eight wetland areas, but with significant differences in the extents of filling and duration of hydroperiods. In the main salt lake the central area fills for longer periods than the western and eastern areas of the lake, possibly indicating that it fills to greater depths. This is supported by the comment in Lane et al. (1980) that the western part of the main lake was dry when they surveyed waterbirds in Sep 1980 but that the central area was up to 1 metre deep.

The eastern part of the lake appears to fill to lesser extents (compared to the size of the polygon) but this is because the polygon used for the analysis includes large areas of raised land areas between the braided channels that would never be submerged. The central lake area has filled to more than 50% of its area on 19 occasions over the 31 year study period, but several of these fills have been short lived. There have been 14 events where the central area has been more than 25% inundated for longer than 100 days, with the longest hydroperiod being 336 days (March 2011 to Feb 2012), although a Jan 2017 to Apr 2018 event was 432 days other than briefly dropping below 25% in Oct 2017 (after 256 days). The current dry period, since May 2018, is not unusual, but have historically not lasted for much longer periods so a flood event is 'due'.

Rainfall preceding the larger fill events (> 100 days duration) in the central lake area has usually been 50 to 100mm in the preceding week to a month (based on rainfall measured at Carnegie Station) but has ranged from 24 mm to 192 mm. This requires more serious analysis to determine rainfall-inundation relationships.

Peripheral wetland 3, on the southern side of Lake Carnegie, appears to hold water for much longer than the other wetlands when it fills and has held water for as long as it has been dry over the 31 year study period. It seems to remain full for extended periods and then dry very quickly. The longest period with water was 3.5 years between 1999 and 2002. The wetland has had 24 fill events >50% (by area) but many of these have been very short-lived. This wetland is located on the edge of an alluvial fan associated with Fourteen Mile Creek which drains the Carclew Range south of Lake Carnegie. The fan may hold groundwater that is recharged from the associated creek and release this slowly and thus prolong the wetland's hydroperiod. The nearby peripheral wetland 1 has a much smaller catchment consisting of shorter creeks. While that wetland fills as frequently as peripheral wetland 3 it does not fill to the same extent relative to its total area (usually reaching much less than 100% full) and does not retain water for as long. Peripheral wetland 2 is very small but is fed by a creek draining nearby hills. It fills nearly as frequently as peripheral wetlands 1 and 3, but also has shorter hydroperiods than wetland 3.

Peripheral wetland 4 is the largest of numerous wetlands within a complex of polygonal dunes with very small local catchments. Compared to the other 4 peripheral wetlands this wetland has water much less frequently and only for very short-lived periods. Its situation in a dune field may mean that it has a relatively permeable substrate that preclude extended periods of inundation.

Peripheral wetland 5 is located on the northern edge of Lake Carnegie and is fed by ill-defined drainage lines to its north. This has had a similar number of inundation events as peripheral wetlands 1 to 3, but the timing of these is not as in sync as those southern wetlands and the hydroperiods seem somewhat shorter.

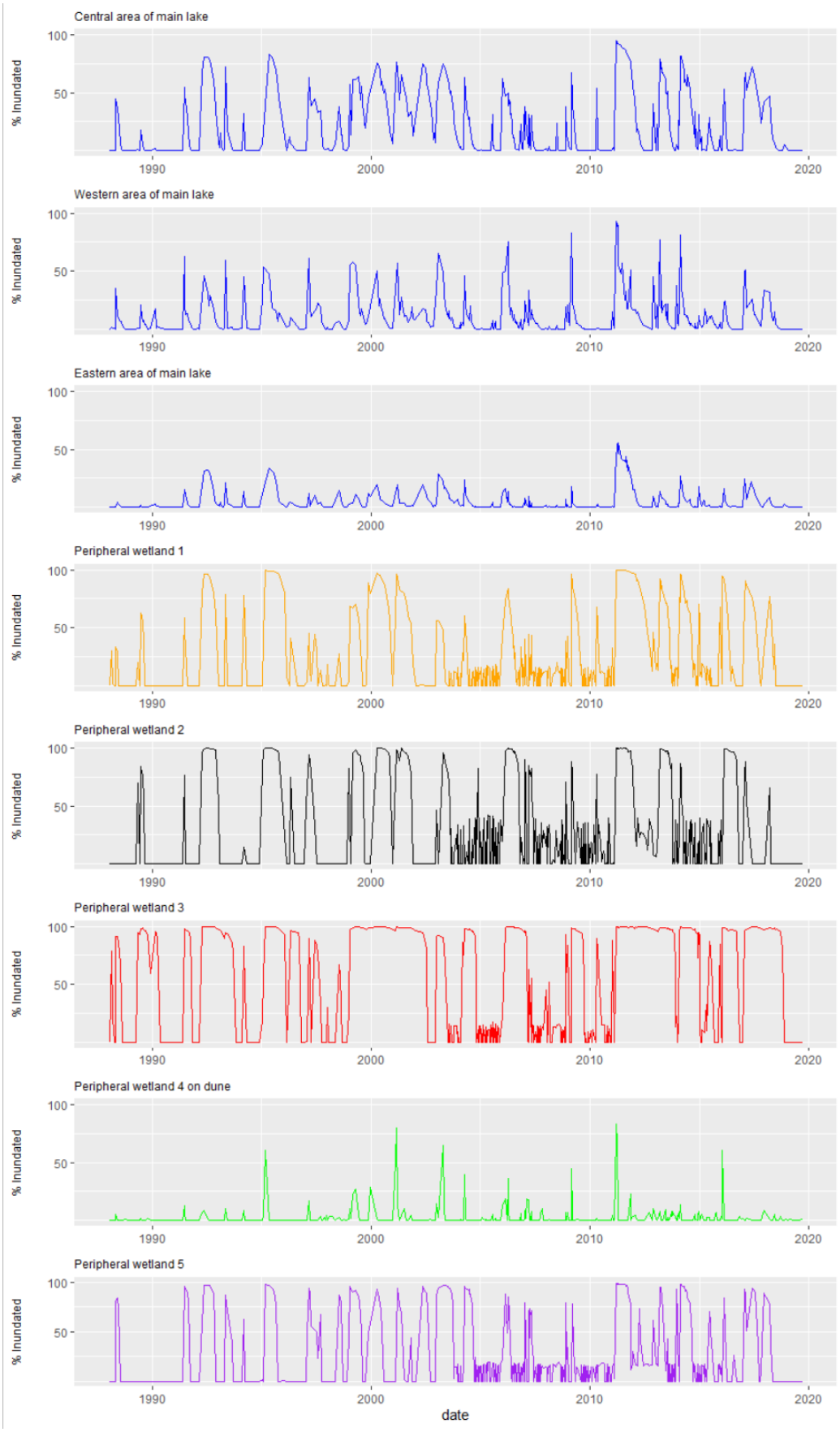

Figure 6. Inundation history of three areas of the main Lake Carnegie (central, western and eastern) and five peripheral claypans, based on analysis of Landsat band 5 data.

Appendix 4. Waterbird data

Data from Stuart Halse, aerial survey for August 1999. All counts from main lake area.

Birds were scattered across the open areas of the salt lake.

Species	Count	Number of broods
Black Swan	467	114
Black-winged stilts	25	
Australian shelduck	763	9
Pacific Black Duck	53	
Grey Teal	6531	
Unidentified wader	8	
Eurasian coot	142	
Australian Wood Duck	10	
Hoary-headed grebe	810	
Gull-gilled tern	15	
White-faced heron	11	
Pink-eared duck	362	
Freckled duck	20	
Hardhead	816	
Red-capped plover	15	
Red-necked avocet	10	
White-necked heron	3	
Silver gull	2	
TOTAL		

Excerpt - Aerial Survey of Goldfields waterbirds carried out on 25 Sep 1980 (Lane et. al. 1980).

Lake Carnegie - continuous water, appears to be up to 1 m deep. North-western corner west of a line from Mt. Alexandra to Mt. Hosken is dry.

- Black Swans - approx. 130 broods counted. Numerous nests with eggs.
- Estimate total number of black swan breeding pairs in vicinity of 1,000.
- Hundreds of free-flying individual black swans.
- Banded Stilt - Thousands
- Teal - Thousands. Broods seen.
- Hardhead – Thousands
- Shelduck : Tens seen. One brood seen.
- Shoveller – A few seen.

- Pied Stilt, Avocet, Gull-billed and Marsh Terns.

Lake on South Side of Lake Carnegie (25 km East of Federation Headland)

- Teal - 100+
- Hardhead – Hundreds
- Shelduck - Tens, plus one brood
- Black Swans - Tens of broods and nests with eggs.
- Coot, Pied Stilt, Wood Duck, White-necked Heron.

Note that this may be 'peripheral wetland 1' in Figure 4 above.

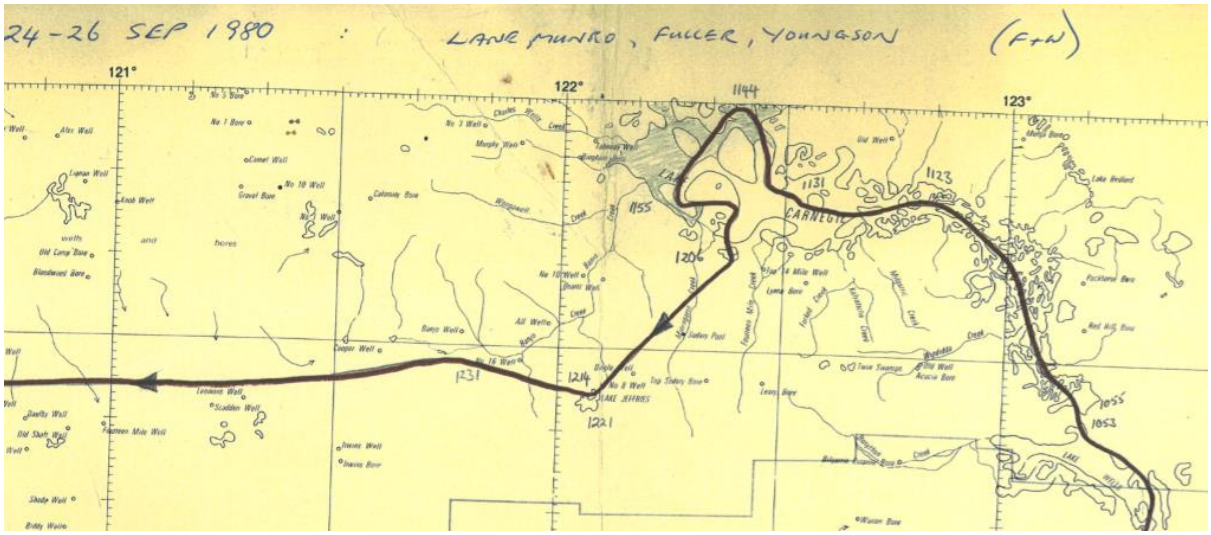

Figure 7. Aerial survey route of waterbirds, September 1980 Lane et. Al.

Data from an earlier unpublished aerial survey conducted by Tom Riggert and colleagues on 22 Mar 1967

Notes from this trip are

- Ducks were not in big groups but were scattered about the lake and seemed to favour pools away from the main lake that had clear water in them.
- Mountain duck 2 500
- Swans 2 000
- Black duck 500
- Teal 500
- Stilts - several thousand (identification of these was difficult).