



# Ecological Character of Lake Disappointment

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Final Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands



# Ecological Character of Lake Disappointment

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## EXECUTIVE SUMMARY

Lake Disappointment lies in the northern Little Sandy Desert (Trainor IBRA subregion), 138 km south of Telfer and 285 km east of Newman. The lake has an area of 150,000 ha. In addition to the large playa area of Lake Disappointment itself, the claypans, riparian communities and dunefields surrounding the lake may be considered to belong to the Lake Disappointment system.

Lake Disappointment is listed as a Nationally Important Wetland. The southern part of Lake Disappointment lies within the proposed Lake Disappointment Nature Reserve, which was first listed in the Environmental Protection Authority Red Book recommendations for Conservation Reserves 1975-1993. The reserve is yet to be approved or gazetted.

The main inflow to Lake Disappointment is via Savory Creek, which has headwaters south of Newman in the Pilbara. Savory Creek flows into the north-western side of Lake Disappointment. The lake is also fed by smaller ephemeral creeks feeding in from the west and east and by direct precipitation.

When dry, the lakebed of Lake Disappointment is covered by a white crust of salt crystals. After flooding, lake water quickly becomes hypersaline. Numerous episodically filled claypans occur around the lake. Those between dune swales associated with the lake are mostly saline, whereas those farther away are fresh.

Reward Minerals Limited is currently scoping the feasibility of mining potash from Lake Disappointment. The mining tenement covers 60,886 ha (40%) of the lakebed and mining is expected to continue for 30 years. It is intended to extract potash from lake brine using infrastructure (trenches and/or production bores) located in the north-western part of the lake and on the adjacent shoreline and dune systems. This report summarises the biological values of Lake Disappointment and its surrounds, with emphasis on aquatic values.

Despite being a Nationally Important Wetland, the frequency and extent of flooding at Lake Disappointment are not well documented. The presence of water in the lake after only moderate monsoonal rainfall in early 2016, as well as in 2013 and 2015, suggests that some inundation occurs at least every few years. There is also a permanent pool in Savory Creek immediately before it discharges into the lake.

Twenty-nine species of waterbirds were recorded at Lake Disappointment and its surrounds during surveys between 2012 and 2016, with many species recorded only outside the lake. Four migratory shorebirds listed under the Commonwealth legislation have been recorded (Sharp-tailed Sandpiper, Red-necked Stint, Common Greenshank and Marsh Sandpiper); while records of the endemic Banded Stilt probably have greatest conservation significance. The Banded Stilt has been recorded breeding at Lake Disappointment on several occasions, including in 2013 and 2015. Between 8,000 and 10,000 Banded Stilts were present when the lake was surveyed in early 2016. The critical issues for breeding success of Banded Stilts are islands on which to breed (these occur in the central sections of the lake) and a period of lake inundation lasting several months. Lake Disappointment also appears to be part of a national network of arid zone wetlands used by Banded Stilts.

A small amount of aquatic invertebrate surveying was done in 2004 and more intensive survey was conducted in late 2015 and early 2016 when, in addition to sweep sampling, hatching trials were conducted using samples of lakebed. A total of 76 species were collected from Lake Disappointment and surrounding waterbodies, with 10 species at the lake itself, 15 species in Savory Creek and 66 species in surrounding claypans.

Diatoms were also sampled in early 2016 (although from fewer sites than invertebrates and with greater focus on the lake). Altogether, 20 species being collected with 18 species found in Lake Disappointment, four species at Savory Creek and 13 species in claypans.

Taken together, information on waterbirds, aquatic invertebrates and diatoms suggest that Lake Disappointment itself has relatively low biological values, except for its role for Banded Stilts, and is perhaps best equated with one of the large natural salt lakes in the south-west. In addition to the occasional breeding events by Banded Stilts on islands in Lake Disappointment at least one new species of ostracod occurs in the lake and it is possible that new species of diatom are also present. The biological values of Lake Disappointment are mostly limited by the high salinity of the lake when it floods, although high salinity is the characteristic leading to use of the lake by Banded Stilts.

The Lake Disappointment system appears to have relatively high values as an arid zone group of wetlands because of use by a greater range of waterbird species and the occurrence of several new invertebrate species in the surrounding claypans. It is possible that a significant proportion of the aquatic invertebrate community of temporary waterbodies of north-western desert areas occurs in the Lake Disappointment system, although this is speculative because of the poor level of knowledge of desert wetlands.

Flora survey in the riparian and dunefield communities in the Lake Disappointment system identified seven vegetation communities including various hummock grasslands and open low woodlands on dunefields, open herb communities on claypans and samphire heath on the lake edge. These communities contain at least 208 species. No species on the Threatened species list is present but the undescribed *Tecticornia* sp. Sunshine Lake is a Priority 1 species and three species regarded as conservation significant occur on the lake edge (*Tecticornia* sp. nov. A, *Tecticornia* sp. nov. B and *Tecticornia* aff. *calyptrata*). The samphire communities on the shoreline of Lake Disappointment (that comprise these four *Tecticornia* species) are classed by regional ecologists as a "vulnerable" (VU) ecosystem (May & McKenzie 2001).

Fauna surveys recorded 142 native and five introduced vertebrate species (excluding waterbirds). This includes five species of frog, 50 species of reptile, 69 species of bird and 18 native mammals (including 8 species of bat). No threatened species was collected but four priority species were recorded (Lake Disappointment Gecko, Unpatterned Robust Lerista, Australian Bustard, Northern Marsupial Mole). One species listed as vulnerable under commonwealth legislation was recorded (Princess Parrot), as well as five migratory species including four shorebirds and the Rainbow Bee-eater. Both the Lake Disappointment Gecko and the Lake Disappointment Dragon (which has local conservation significance) use the shoreline of Lake Disappointment. Other listed species principally use dunefields except for the four shorebirds.

It is considered that the biological values of Lake Disappointment have been sufficiently characterised to assess overall biological value of the lake and its surroundings. Environmental impact assessment of proposed mining may require additional information but the information requirements will be dependent on the details of the proposed mining and the expected changes to the lake environment.

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## 1. INTRODUCTION

### 1.1. Location

Lake Disappointment is in the northern Little Sandy Desert (Trainor IBRA subregion), 138 km south of Telfer and 285 km east of Newman (**Error! Reference source not found.**). The nationally listed wetland has an area of 150,000 and comprises dunefield, riparian and claypan communities (there are large areas of Desert Oak *Casuarina decasneana* on the western side; margins support samphire communities, islands and dunes mainly *Plectrachne schinzii* and *Triodia pungens*, with *Acacia* and *Grevillea* shrubs) (Lynch 1995).

### 1.2. Tenure, treaties, legislation or regulations

Lake Disappointment is within a Schedule 1 Area under the Environmental Protection (Clearing of Vegetation) Regulations 2004 (**Error! Reference source not found.**). The southern extremity of the Potash Project is in the proposed Lake Disappointment Nature Reserve (EPA Red Book recommendation 1975-1993) (**Error! Reference source not found.**).

Lake Disappointment occurs within aboriginal land owned by the Martu community. The Martu hold native title rights and the right to control access. There are a number of exclusion zones identified for heritage reasons, including all areas within 100m of any of the islands in Lake Disappointment.

### 1.3. National listing

Lake Disappointment has been listed in the Directory of Important Wetlands in Australia (DIWA) (Environment Australia 2001) under two criteria:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.

DIWA recognises Lake Disappointment as containing two types of inland (category B) wetlands:

- Seasonal and irregular rivers and streams (category B2)
- Seasonal/intermittent saline lakes (category B8)

Seasonal, freshwater claypans also exist around Lake Disappointment and these are best treated as belonging to category B6 (Seasonal/intermittent freshwater lakes (> 8 ha), floodplain lakes) although some pans are <8 ha in area.

### 1.4. Objectives of report

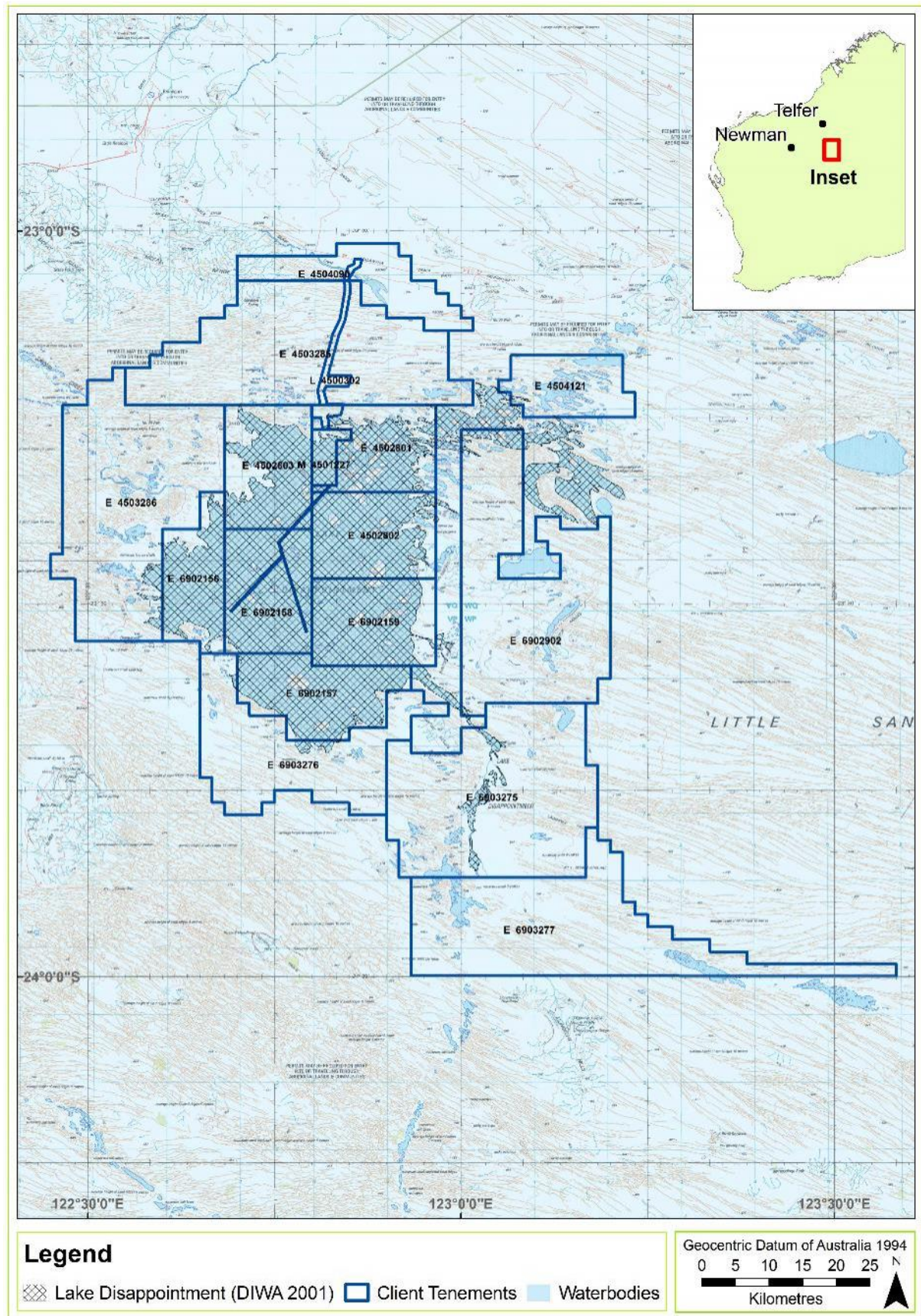
Reward Minerals Limited (Reward) is currently scoping the feasibility of mining potash from Lake Disappointment (the Project). The expected life of the Project is 20 years and it is proposed to cover an area of approximately 150,000 ha, of which 60,886 ha is in Lake Disappointment (40% of the lake). It is intended to extract potash from lake brine using infrastructure (trenches and/or production bores) located in the north-western part of the lake and on the adjacent shoreline and dune systems

Reward asked Bennelongia to characterise the environmental values of Lake Disappointment, namely, to characterise the aquatic biota and identify and describe the key ecological and biophysical attributes of the system based on published information, consultant reports and studies undertaken specifically for the Project.

This report provides a summary of the values of the Lake Disappointment system, with a focus on aquatic values. Some survey work and hatching trials were undertaken to improve the level of information on aquatic invertebrate and diatoms inhabiting the system.

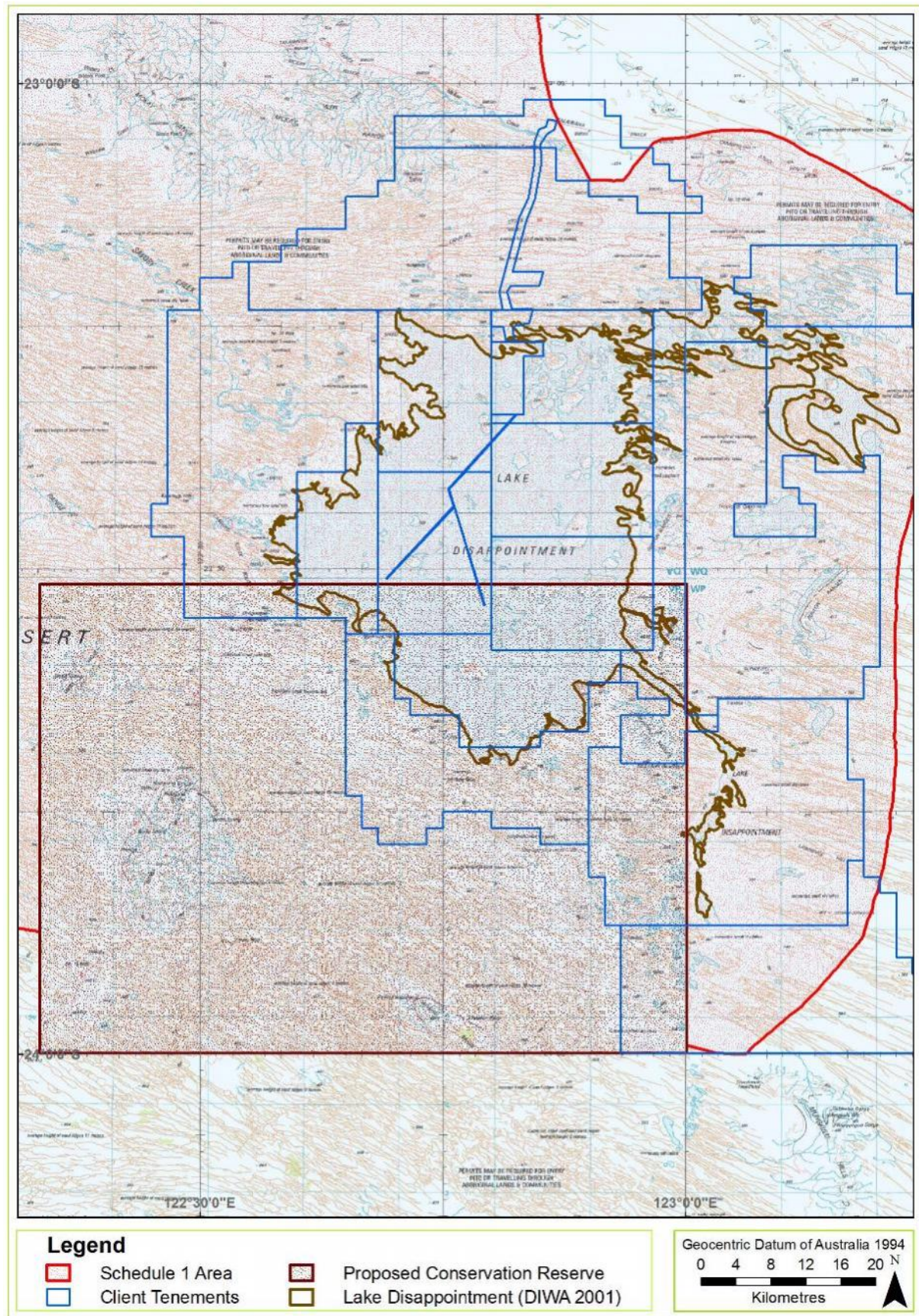
The report does not attempt to assess the likely impact of the Project other than through some general comments on lake values.





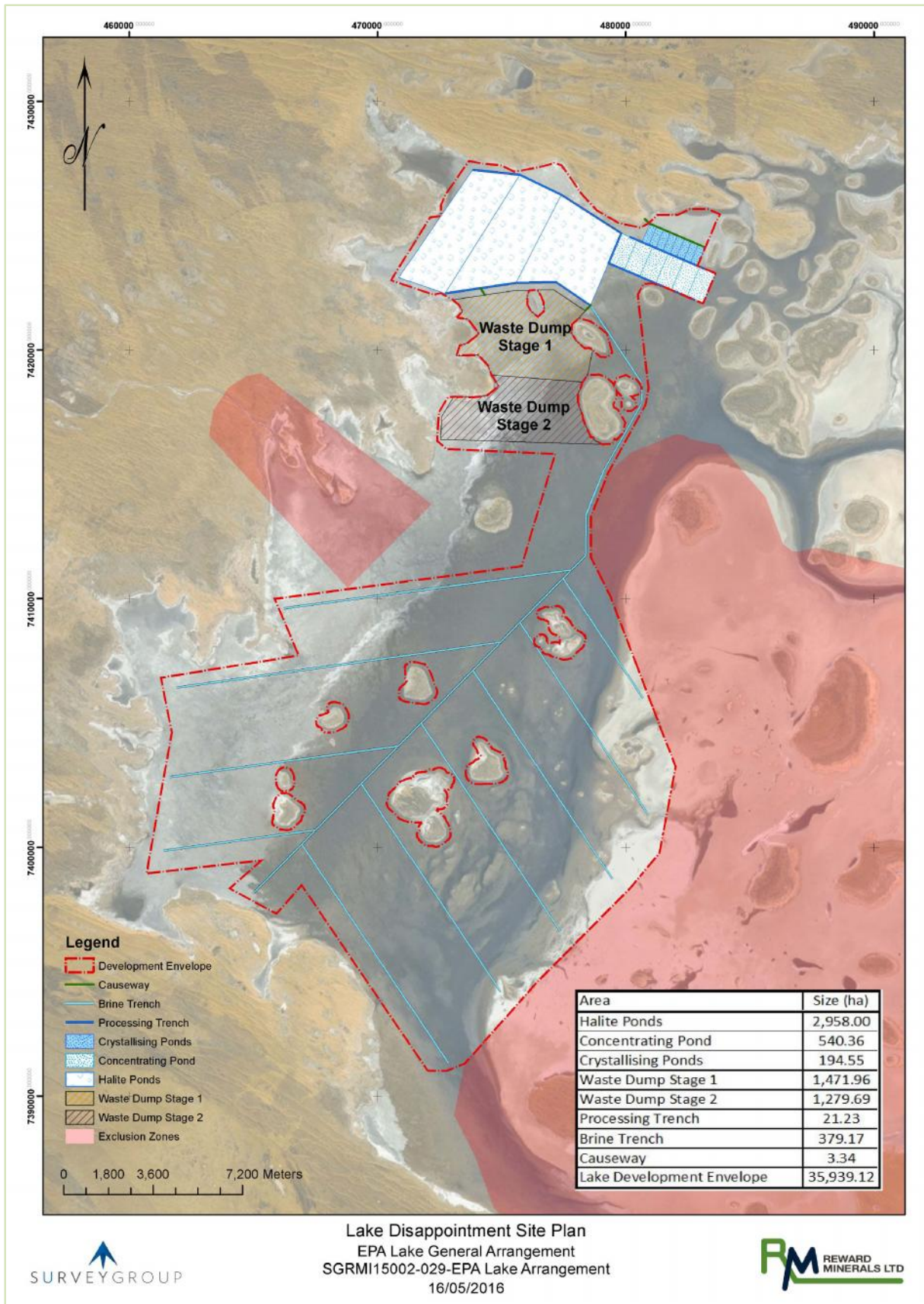
**Figure 1.** Location of Lake Disappointment and Reward's tenements at the lake.





**Figure 2.** Regional map of Lake Disappointment showing the Proposed Conservation Reserve and extent of the Schedule 1 area.





**Figure 3.** Site plan at Lake Disappointment, showing area of brine trenches and heritage area exclusion zones.

## 2. CLIMATE

The nearest Bureau of Meteorology (BoM) weather station to Lake Disappointment is Parnngurr (Site 13043; 50 km north) and has very limited data. Telfer Aero is nearby with records from 1974 (Site 13030; 175 km north), as is Nifty Copper Mine (Site 4103; 210 km north-north west) with irregular records from 1997. Two further stations, Noreena Downs (Site 4026; 280 km north-west; open 1911) and Ethel Creek (Site 5003; 250 km west-north west; open 1907), have relatively complete records over a century and were used to analyse broader weather patterns (see below).

In summary, Lake Disappointment experiences a typical desert climate with very high day-time summer temperatures (45 °C and above) and freezing winter nights. Annual rainfall is highly variable but has a long-term mean of approximately 200 mm, mostly from tropical cyclones or monsoonal rain in summer (see Figure 3).

## 3. AQUATIC ENVIRONMENT

Lake Disappointment is one of the larger playa lakes in Western Australia and is the lowest point of the Little Sandy Desert. It lies within an endorheic catchment that is 600 km by 500 km (Beard 2005). Using Semeniuk's (1987) classification, the lake is a megascale, irregular sump land with numerous microscale to macroscale islands. The lake bed consists of poorly consolidated saline lacustrine sediments (clay, silt, sand and gypsum). The surrounding area is composed of mixed aeolian-lacustrine silt, sand and kopi forming longitudinal dunes trending east-west, interspersed with minor salt lakes and claypans. Dunes on the lake form islands rising 5 to 18 m above the bed.

Lake Disappointment lies within a major palaeochannel, the Disappointment Palaeoriver and Beard (2005) suggests this represents a palaeoriver that drained into Rudall River via Savory Creek, with the connection to Rudall River being disrupted in the Miocene by one or more factors including tectonic movement, a slight uplift of ridges to the north and sinking of the lake basin. This resulted in Lake Disappointment becoming a terminal basin within an internally flowing catchment. This has led to the development of a large, hypersaline brine reservoir under the lake because of prolonged concentration by evaporation (Pendragon 2014).

The few active tributaries that drain into Lake Disappointment are ephemeral and dry nearly all the time, except for Savory Creek, the headwaters of which stretch 300 km west to Capricorn (15 km south-east of Newman). The lake probably receives subsurface flow from drainage lines that are obscured by sand (Beard 2005) and, possibly, from the numerous surrounding claypans that hold water for brief periods after rain.

### 3.1. Savory Creek

Savory Creek contains a large sand bar at its junction with Lake Disappointment, which has resulted in formation of a large permanent pool along the creek.

While fresh in its headwaters, Savory Creek becomes saline east of the McFadden Ranges and the permanent pool at Lake Disappointment is hypersaline. Lake Disappointment may possibly be fresh immediately after substantial rain, although it is more likely to be brackish, and then becomes hypersaline as stored salt dissolves and the system dries.

The water at the permanent pool of Savory Creek in late January 2016 was clear on top of dark green to brown water obscuring salt or halite crystals on the floor. The creek is brown when flowing, but settles to clear in pools (A.A. Burbidge pers. comm.; P.J. Fuller pers. comm.; E.A. & R.J. Gard pers. comm.). At all sites in 2016 the lake water was crystal clear and saline (probably hypersaline).

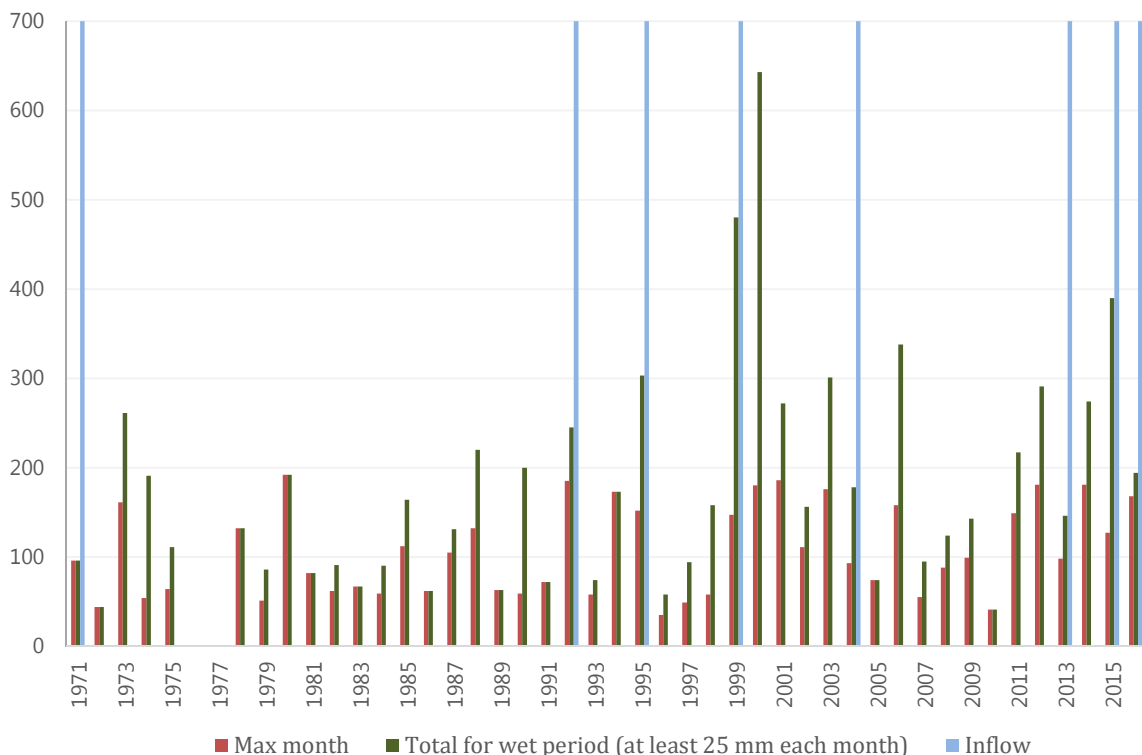
### 3.2. Flooding of Lake Disappointment

There is evidence of surface water being present in Lake Disappointment for short periods in six of the last 50 years. The years are 1971, six months in 1992 (Lynch 1995), 1995, several months after a cyclone

in 1999 (satellite imagery), 2004 (Pendragon 2014), 2013 (Earth Observatory 2013; see Appendix B), 2015 and 2016 (Figure 3). Rainfall records of maximum monthly rainfall and the total rainfall during the 'wet period' each year at Bulloo Downs in the headwaters of Savory Creek do not correlate well with inflow events, particularly in the case of 1971 and, to a lesser extent, 2013. This may be a reflection of the spatial patchiness of cyclonic and monsoonal rainfall in the eastern Pilbara and Great Sandy Desert, whereby major rainfall events in the Savory Creek catchment east of Bulloo Downs were not recorded. It may also reflect that some flood events occur through local rainfall at Lake Disappointment and inflow from other tributaries than Savory Creek. The flooding in 2013 appears to have resulted from rainfall to the north and east of Lake Disappointment, with little evidence of much flooding at that in the Pilbara to the west (Appendix B).

The rainfall records also suggest that flooding of Lake Disappointment has been more frequent in the past 25 years than the previous 50 years (not all shown in Figure 4). This is supported by records of inflow at the lake, although the increased number of records of inflow may merely be an indication of better record keeping.

Under the climate regime of the past 25 years, there appears to be some flooding of Lake Disappointment every two or three years. While not all flooding can be related to rainfall at Bulloo Downs (as already pointed out), there is probably a high chance of some flow into Lake Disappointment via Savory Creek whenever the total rainfall of the annual wet period at Bulloo Downs is >200 mm, especially if the rainfall for one month in the period is >150 mm. On this basis, it is possible Lake Disappointment also received inflow in 1973, 1980, 2000, 2001, 2003, 2011, 2012 and 2014 (Figure 3). Flooding was extensive through the Pilbara and Great Sandy Desert in 2000 (Halse *et al.* 2005) and Pedler *et al.* (2012) suggest Lake Disappointment held water in 2012.



**Figure 4.** Rainfall at Bulloo Downs in upper Savory Creek and known years of lake inflow. 06, 09, 26A, 26B).

### 3.3. Physico-chemistry

Water chemistry data show that the shallow groundwater brine underlying the lake is super saturated with salt ions and slightly acidic. There is little quantified information on the pattern of salinity as the

lake floods and water dries back but in May 2016 surface water from earlier rain that year freshened from >160,000 to <26,000 mg/L after 67 mm on the 6 and 7 May 2016,. Water chemistry was not measured during sampling for invertebrates in 2015 or 2016 but the lake was saline to taste.

## 4. BIOTA

### 4.1.1. Vegetation

Lake Disappointment has a variable fringe of riparian samphire vegetation, with encroaching dune swales supporting hummock grassland or mixed shrubs over grassland. The dune habitat is present on several islands within the lake; these lakes also have a fringe of samphire.

The riparian samphire community is also present at numerous seasonally inundated claypans around the main lake (see Appendix G). No species on the Threatened species list is present but the undescribed *Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) is a Priority 1 species and three species regarded as conservation significant occur in the riparian zone around Lake Disappointment (*Tecticornia* sp. nov. A, *Tecticornia* sp. nov. B and *Tecticornia* aff. *calyptrata*) (Botanica 2014). *Tecticornia* aff. *calyptrata* is also considered to be of conservation significance and is presently undergoing taxonomic review by staff of the Western Australian Herbarium to confirm whether it is a distinct taxon. The samphire community of Lake Disappointment is classified as a vulnerable ecosystem by regional ecologists (May and McKenzie 2001). The extent of samphire can be seen from aerial survey photos taken in 2016 (Appendix G).

### 4.1.2. Phytoplankton

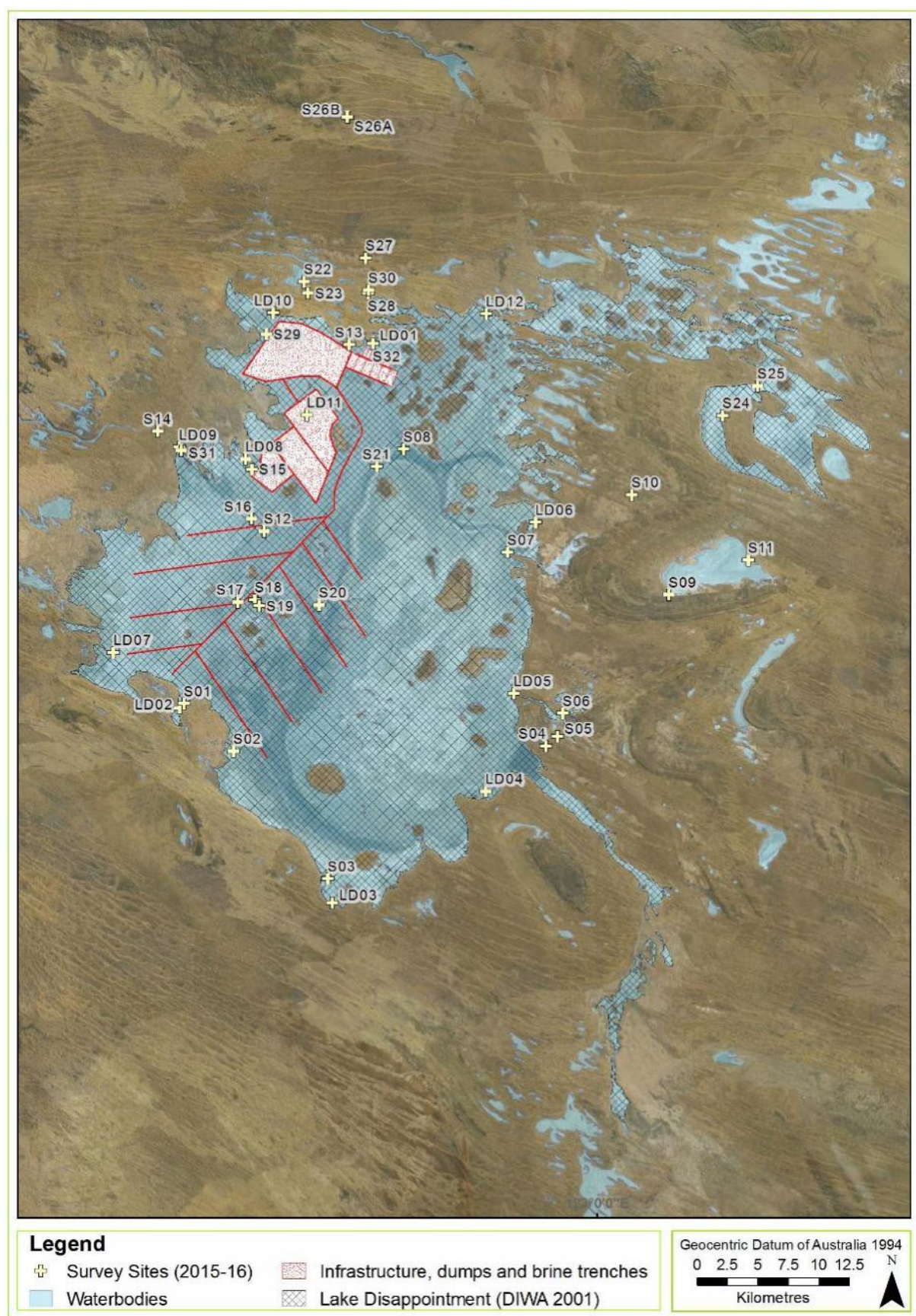
Diatoms are a group of single-celled algae characterised by being enclosed in a pair of overlapping silica sheaths that are usually bilaterally symmetrical. Diatoms are sensitive to water quality and are frequently used in bio-monitoring programs. Eleven diatom samples were collected on the 26 and 27 January 2016 by scraping a small amount of the surface of the lake bed into a vial of ethanol. These samples were identified by Prof. Peter Gell, Federation University Australia.

At least 20 diatom species were collected in the samples (**Error! Reference source not found.**, Figure 4). Most of the species collected are typical of hypersaline waters and similar to the flora common in shallow salines in inland, eastern Australia (Peter Gell pers. comm.). Several species are aerophilous and can exist on wet soil or halite in deep water (e.g. *Hantzschia* spp., *Luticola mutica*). There was no evidence in the 2016 samples of malformations (teratological forms) commonly caused by very high salinity or pollutants, although there is a lot of evidence of valve dissolution that can come with high concentrations of sodium and high or low pH.

*Luticola mutica* can be abundant in eutrophic situations, but here its abundance in one sample probably reflects a capacity to withstand very shallow conditions. Several taxa are described as 'aff.' which refers to the fact that they have morphological affinity to a well-known species known from overseas. There has been very little taxonomic work of Australian diatoms from dryland/saline systems and the names provided should be viewed as preliminary.

The diatom richness at Lake Disappointment was 6.6 species per sample, which is slightly above that recorded at Lake Carey (4.8 species per sample; Gregory *et al.* 2009) and well above that at Lake Maitland (1.6 species per sample; Outback Ecology 2007) (**Error! Reference source not found.**). The average richness per sample at Lake Eyre South (Blinn 1991) could not be calculated as species per sample are not provided, but it appears to be richer than the other three lakes in **Error! Reference source not found.**





**Table 1.** Diatoms taxa recorded at Lake Disappointment in 2016.

Taxa	Site and Location											Total
	Lake Disappointment							SC	Claypans			
	3	7	13	15	24	25	29	14	6	22	23	
<i>Amphora borealis</i>		48			1	2		36	13	1		101
<i>Amphora coffeaeformis</i>		13							6			19
<i>Amphora micrometra</i>		2			2	18			5	8		35
<i>Hantzschia amphioxys</i>	2	7	11		1					6	2	29
<i>Hantzschia</i> aff. <i>Petitiana</i>		65	26	32	98	107	12	6	138	126	6	616
<i>Luticola mutica</i>			1						20			21
<i>Luticola nivalis</i>									1			1
<i>Navicula</i> aff. <i>duerrenbergiana</i>		2										2
<i>Navicula</i> aff. <i>egregia</i>											1	1
<i>Navicula incertata</i>		9	11		80	29	27			7		163
<i>Navicula</i> aff. <i>minuscula</i>		1										1
<i>Navicula perminuta</i>		18			10	13	7			5		53
<i>Navicula</i> aff. <i>recens</i>		3	5		5		4			6		23
<i>Navicula</i> aff. <i>salinicola</i>		28			5	34	13		2	38		120
<i>Navicula</i> aff. <i>tenelloides</i>		10					2			4		16
<i>Nitzschia gracilis</i>								97				97
<i>Nitzschia palea</i>							3			1		4
<i>Nitzschia</i> aff. <i>pellucida</i>				6			2	1	2	5	1	17
<i>Mitschlia</i> sp. 1	2											2
<i>Sellaphora</i> sp.				2		4					2	8
Total Abundance ( $\bar{x}$ =120.8)	4	206	54	40	202	207	70	140	187	207	12	1329
Total Species ( $\bar{x}$ =6.6)	2	12	5	3	8	7	8	4	8	11	5	

SC Savory Creek.

**Table 2.** Diatom richness of selected Australian lakes.

Lake	Richness	Samples
Lake Disappointment <sup>1</sup>	≥20	11
Lake Maitland <sup>2</sup>	9	17
Lake Carey <sup>3</sup>	≥43	37
Lake Eyre <sup>4</sup>	33	10

<sup>1</sup> This study; <sup>2</sup> Outback Ecology 2007; <sup>3</sup> Gregory *et al.* 2009; <sup>4</sup> Blinn 1991.

#### 4.1.3. Aquatic Invertebrates

The term aquatic invertebrates covers a diverse array of invertebrates found living in water. Many insect species are found in water only during their larval stages (chironomid midges) or live in water but breathe at the surface (beetles). Crustaceans and some other groups are entirely aquatic and often have drought-resistant eggs to enable persistence of the species during periods of drought.

Aquatic invertebrates at Lake Disappointment and surrounding pans were surveyed in January 2016 when water was present by sampling with a sweepnet with mesh sizes of both 53 and 250 µm or by hatching invertebrates from samples of lakebed sediments. Samples were collected at 22 sites in January and one site in February 2016 (Appendix A, Figure 4). Lake bed sediments were collected at 12 sites in December 2015 by Botanica and one site in February 2016. Aquatic invertebrate samples were elutriated onsite to reduce the amount of debris retained in the sample and then were preserved in 100% ethanol.

Lake sediment samples were dried at 40°C in the laboratory before being placed in large Alfoil containers. De-ionised water was added to the containers. If sediment was saline, sufficient water was added to bring the salinity to 5 g/L; if sediment was fresh 7 cm of water was added. Water level was



maintained for three weeks and small samples of water (plus visible animals) were pipetted out every second day to check on the development of hatched animals.

Sweep net samples were sorted in the laboratory under dissecting microscopes. Aquatic invertebrates from the sweepnet samples (and also the re-flooded sediment) were identified to species level using published keys for described species and the characters in keys to distinguish undescribed species, which were then provided with an informal voucher name. Identifications of some rotifers and cladocerans were confirmed by Dr Russell Shiel and identifications of some anostracans were confirmed by Prof. Brian Timms. Both are taxonomic specialists in the relevant groups of aquatic invertebrates.

At least 78 species of aquatic invertebrates were collected from Lake Disappointment and surrounding claypans in 2015-2016. Twenty-two of these species were hatched from re-flooded sediment samples (Appendix D), with 10 of the species found in 12 re-flooded samples from Lake Disappointment itself. The single re-flooded sample from a claypan hatched 14 species. Protozoans were ubiquitous in the re-flooded samples and the rotifer *Proales* sp. was found in most of the re-flooded Lake Disappointment samples.

Sweep net samples collected 69 species of aquatic invertebrates (Appendix E). The most frequently occurring taxon in sweep samples was Nematoda sp. (treated here as a single species but probably more). Six species were collected from Lake Disappointment. One of these species, the salt lake copepod *Meridiacyclops* sp., was collected only from Lake Disappointment, while the other five species also occurred in saline claypans. Overall the fauna of claypans was dominated by rotifers and crustaceans, with insects comprising only 25% of the species in sweep samples.

Several of the species collected at Lake Disappointment or in surrounding claypans appear to be known currently only from Lake Disappointment. These are the two rotifers *Brachionus* cf. *ibericus* and *Brachionus* cf. *rotundiformis* from Lake Disappointment near the mouth of Savory Creek and the conchostracan *Eulimnadia* n. sp. B01, the ostracod *Bennelongia* sp. BOS564 and the copepod *Boeckella* sp. B01 (which belongs to the *B. triarticulata* complex) from surrounding claypans. These species are unlikely to be restricted to the Lake Disappointment area and it is expected that, as more wetlands are surveyed, the species will be shown to have wider distributions.

Opportunistic sampling of aquatic invertebrates at Lake Disappointment (and probably the pool in Savory Creek) in 2004 by the Department of Parks and Wildlife collected six species. These were the cladoceran *Daphnia* sp., ostracod *Diacypris dictyote*, anostracan *Parartemia laticaudata*, Nematoda, beetle larva *Hydrochus* sp. and chironomid larva that were probably *Tanytarsus barbitarsis* (Alan Clarke pers. comm.). Two of these species (*Diacypris dictyote* and *Hydrochus* sp.) were not re-collected in 2015-2016, meaning at least eight species of aquatic invertebrates are known from Lake Disappointment itself and 80 species are known from Lake Disappointment and surrounding claypans.

The eight species known from Lake Disappointment itself comprise a relatively small list compared with that from Lake Torrens (27 species, Table 3) and Lake Eyre (17 species). Lake Disappointment was about 15 cm deep and saline when sampled, although two of the species were hatched in hyposaline water at 5 g/L. In contrast, Lake Torrens was  $\leq 20$  g/L for the first five months after flooding, with multiple inflow events, and its salinity then rose steady to supersaturated conditions during the next five months. Salinity at Lake Eyre rose steadily over 12 months from 25 g/L to supersaturated conditions. While Lakes Torrens and Eyre were sampled across a year during major flood events, Lake Disappointment was sampled less intensively during a 'small' flood event when the extent of flooding was sufficiently small that water was being driven across the lake by wind and inundation of the lakebed was intermittent.

Aquatic invertebrate sampling at Weelarranna Salt Marsh, in the Pilbara 290 km west of Lake Disappointment, yielded 14 species in 2004 when its salinity was 38 g/L and its depth was about 16 cm (Pinder *et al.* 2010). In surveys of the well studied Lake Carey and its surrounds in the Yilgarn, 600 km

south of Lake Disappointment, 107 species were collected in four surveys over 14 months (Timms *et al.* 2006). This richness was largely attributable to most claypans being fresh. The species list for Lake Carey was not directly obtainable from Timms *et al.* (2006) but the authors report this lake had moderately different species composition in March-April 2003 when up to 40cm deep with salinity ranging from 13 to 62 g/L than when very shallow and with salinity of 55 to 230 g/L in 1998-1999. Similarly, in a large flood, Lake Disappointment would be likely to have a larger species list than currently documented.

**Table 3.** Aquatic invertebrate richness at selected Australian salt lakes (and surrounds).

System	Overall richness	Lake richness	Lake salinity mg/L	Sites	Samples
Lake Disappointment <sup>1</sup>	80	8	saline	28	29
Lake Eyre <sup>2</sup>	17	17	25-273	1	15
Lake Torrens <sup>3</sup>	27	27	13-250	5	25
Lake Carey <sup>4</sup>	107	10+	55-230	31	66
Lake Weelarrana <sup>5</sup>	14	14	38	1	1

<sup>1</sup> This report; Clarke unpub.; <sup>2</sup> Williams and Kokkinn 1988; <sup>3</sup> Williams *et al.* 1998, <sup>4</sup> Timms *et al.* 2006; <sup>5</sup> Pinder *et al.* 2010

#### 4.1.4. Terrestrial Invertebrates

The terrestrial invertebrate fauna at Lake Disappointment is largely characteristic of the desert and appears to be relatively depauperate. Two pilot level surveys have documented the fauna and at least 14 species belonging to groups likely to have short ranges were recorded. These include seven scorpions, at least three pseudoscorpions, two mygalomorph spiders, one wolf spider, one isopod, one pupillid snail and a tiger beetle. Five of these species were identified as potential short-range endemics (SREs) and are only known to occur in the vicinity of Lake Disappointment but they occur in the widespread and continuous sand dune habitat (Phoenix 2013). Five species were also identified as potential salt lake specialists, including the tiger beetle (Volschenk 2016). The tiger beetle was observed by Bennelongia at many locations at Lake Disappointment in 2016, including claypans to the north and east of the lake.

#### 4.1.5. Vertebrate Fauna

Altogether five species of frogs, 50 reptile species, 18 mammal species, 98 bird species (though see below for waterbirds) have been collected in the vicinity of Lake Disappointment. The mammal list includes eight species of bat.

Twelve vertebrate species of conservation significance have been recorded around Lake Disappointment (or there is evidence of their occurrence). The species are listed in Table 4. The Woma Python (*Aspidites ramsayi*) occurs at Lake Disappointment but this northern population is not considered to be conservation significant, unlike the southwest population which has a P1 listing. It should also be noted that the migratory Marsh Sandpiper, Common Greenshank and Sharp-tailed Sandpiper are unlikely to use Lake Disappointment except in times of major floods. Instead these species utilise surrounding claypans.

#### Waterbirds

Twenty-nine species of waterbirds were recorded at Lake Disappointment and its surrounds during surveys between 2004 and 2016 (Table 5), with most species recorded only outside the lake. Four listed migratory shorebirds have been recorded (Table 4). The breeding by Banded Stilts at Lake Disappointment on several occasions, including in 2004 (Clarke *et al.* 2004), 2013 and 2015 (Botanica 2015), is probably the most conservation significant occurrence of waterbirds at Lake Disappointment and the surrounding claypans. Nevertheless, in a formal sense the occurrence of breeding by Banded Stilts has only local significance.

Between 8,000 and 10,000 Banded Stilts were present when Lake Disappointment was surveyed in early 2016. There appeared to be too little water for attempted breeding, although pre-mating displays were observed. The critical issues for breeding success of Banded Stilts are islands on which to breed (these occur in the central sections of the lake) and a period of lake inundation lasting several months.

**Table 4.** Conservation significant vertebrate species.

S5, migratory species; P2, poorly known, some on conservation land; P4, rare but not threatened.

Common name	Scientific name	WC Act	EPBC Act
Lake Disappointment Dragon	<i>Ctenophorus nguyarna</i>	local significance	
Lake Disappointment Gecko	<i>Diplodactylus fulleri</i>	P2	
Unpatterned Robust Lerista	<i>Lerista macropisthopus remota</i>	P2	
Northern Marsupial Mole	<i>Notoryctes caurinus</i>	P4	
Rainbow Bee-eater	<i>Merops ornatus</i>	S5	Migratory
Australian Bustard	<i>Ardeotis australis</i>	P4	
Princess Parrot	<i>Polytelis alexandrae</i>	P4,	Vulnerable
Common Greenshank	<i>Tringa nebularia</i>	S5	Migratory
Marsh Sandpiper	<i>Tringa stagnatilis</i>	S5	Migratory
Red-necked Stint	<i>Calidris ruficollis</i>	S5;	Migratory
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	S5	Migratory
Banded Stilt	<i>(Cladorhynchus leucocephalus)</i>	local significance	

**Table 5.** Waterbirds recorded at Lake Disappointment, Savory Creek and surrounding claypans.

Common name	Scientific name	Record dates
Freckled Duck	<i>Stictonetta naevosa</i>	2013, 2014 <sup>1</sup> ,
Australian Wood Duck	<i>Chenonetta jubata</i>	2013, 2014 <sup>1</sup> ,
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>	2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
Australasian Shoveler	<i>Anas rhynchos</i>	2014 <sup>1</sup> ,
Grey Teal	<i>Anas gracilis</i>	2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
Pacific Black Duck	<i>Anas superciliosa</i>	2013, 2014 <sup>1</sup> ,
Hardhead	<i>Aythya australis</i>	2013, 2014 <sup>1</sup> ,
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>	2013, 2014 <sup>1</sup> ,
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	2013, 2014 <sup>1</sup> ,
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
White-faced Heron	<i>Ardea novaehollandiae</i>	2013, 2014 <sup>1</sup> ,
White-necked Heron	<i>Ardea pacifica</i>	2013, 2014 <sup>1</sup> ,
Straw-necked Ibis	<i>Threskiornis spinicollis</i>	2013, 2014 <sup>1</sup> ,
Swamp Harrier	<i>Circus approximans</i>	2013, 2014 <sup>1</sup> ,
Brolga	<i>Grus rubicunda</i>	2013, 2014 <sup>1</sup> ,
Black-tailed Native Hen	<i>Gallinula ventralis</i>	2013, 2014 <sup>1</sup> ,
Eurasian Coot	<i>Fulica atra</i>	2013, 2014 <sup>1</sup> ,
Black-winged Stilt	<i>Himantopus leucocephalus</i>	2013, 2014 <sup>1</sup> ,
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	2004 <sup>3</sup> , 2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	2004 <sup>3</sup> , 2013, 2014 <sup>1</sup> , 2015 <sup>4</sup> , 2016 <sup>2</sup>
Red-capped Plover	<i>Charadrius ruficapillus</i>	2004 <sup>3</sup> , 2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
Black-fronted Dotterel	<i>Charadrius melanops</i>	2013, 2014 <sup>1</sup> ,
Red-kneed Dotterel	<i>Erythronyx cinctus</i>	2013, 2014 <sup>1</sup> ,
Banded Lapwing	<i>Vanellus tricolor</i>	2013, 2014 <sup>1</sup> ,
Common Greenshank	<i>Tringa nebularia</i>	2013, 2014 <sup>1</sup> ,
Marsh Sandpiper	<i>Tringa stagnatilis</i>	2013, 2014 <sup>1</sup> ,
Red-necked Stint	<i>Calidris ruficollis</i>	2004 <sup>3</sup> , 2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	2004 <sup>3</sup> , 2013, 2014 <sup>1</sup> , 2016 <sup>2</sup>
Gull-billed Tern	<i>nilotica</i>	2013, 2014 <sup>1</sup> ,

<sup>1</sup> Harewood 2014; <sup>2</sup> This study; <sup>3</sup> Clarke et al. 2004; <sup>4</sup> Botánica 2015.

## 5. VALUES OF THE LAKE DISAPPOINTMENT SYSTEM

The presence of water and its salinity are the primary constraints on aquatic life in the Lake Disappointment system.

The short period of shallow inundation that is associated with typical inflows at Lake Disappointment, combined with high salinity, limits the aquatic invertebrate fauna and diatom flora of Lake Disappointment itself to a few species that can tolerate these conditions and, in turn, makes the lake suitable breeding habitat for the Banded Stilt. The salinity of surrounding claypans also controls the aquatic invertebrate fauna and diatom flora present in these waterbodies. The fresher claypans are moderately speciose and it may be speculated that, taken together, they perhaps contain a significant proportion of aquatic invertebrates found in temporary waterbodies of north-western desert areas.

Given the large size of Lake Disappointment and the relatively small catchment area of Savory Creek, it is considered unlikely that Lake Disappointment ever undergoes the kind of flooding event that transforms Lake Eyre. However, in a wet year it may experience a similar pattern of flooding to that observed in Lake Torrens, where spectacular numbers of Banded Stilts have bred (Williams *et al.* 1998).

Taken together, information on waterbirds, aquatic invertebrates and diatoms suggest that Lake Disappointment itself has relatively low aquatic biological values and that its conservation values are perhaps more aesthetic than biological. However, the lake appears to be part of a national network of arid zone lakes important for the Banded Stilt and, perhaps, other species. This is best illustrated by a recent study in which a Banded Stilt released at Lake Eyre in 2012 travelled through Lake Disappointment on its way to south-west WA. Another bird flew to Shark Bay (Pedler *et al.* 2014). In terms of its standalone characteristics and values, Lake Disappointment is perhaps best equated with one of the large natural salt lakes in the south-west. The occasional breeding events by Banded Stilts on islands in the lake, which complements its network role, appears to be its highest value although at least one new species of ostracod occurs and, possibly, new species of rotifer and diatom are present.

The broader Lake Disappointment system, comprising the playa lake and surrounding claypans, has moderately high values for a desert wetland system because of the use of Savory Creek and the claypans by a range of waterbird species and the occurrence of several new freshwater invertebrate species. The terrestrial fauna values of Lake Disappointment and surrounding claypans is not considered here in detail, other than to point out that all desert wetland systems tend to be focal points for terrestrial species because of the greater availability of water and higher productivity around these systems than elsewhere in the desert.

The extensive samphire community on the lake foreshore at Lake Disappointment is an important value of the lake. This riparian community supports up to three new species of *Tecticornia*.

The proposed modifications on the lakebed associated with the Project may impact water flows, as well as affecting a small proportion of the samphire marsh surrounding the lake. Changed water flows may impact on the feeding of waterbirds at the lake and may also affect aquatic invertebrates adversely in areas experiencing the new water regime. Given the size of Lake Disappointment, however, it is unlikely that changes would affect more than a relatively small (and still to be fully defined) portion of the lake. The overall values of Lake Disappointment and the Lake Disappointment system are expected to remain unchanged.

It is considered that the information in this report and others commissioned by Reward (Phoenix 2013; Botanica 2014; Harewood 2014; Volschenk 2016) characterise the botanical and fauna values of Lake Disappointment sufficiently to assess overall biological value of the lake and its surroundings. Environmental impact assessment of proposed mining may require additional information but the information requirements will be dependent on the details of the proposed mining and the expected changes to the lake environment.

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## APPENDIX A. LOCATION OF SAMPLING SITES IN 2015-2016

Birds present were recorded at sites 01-32, except for site 27.

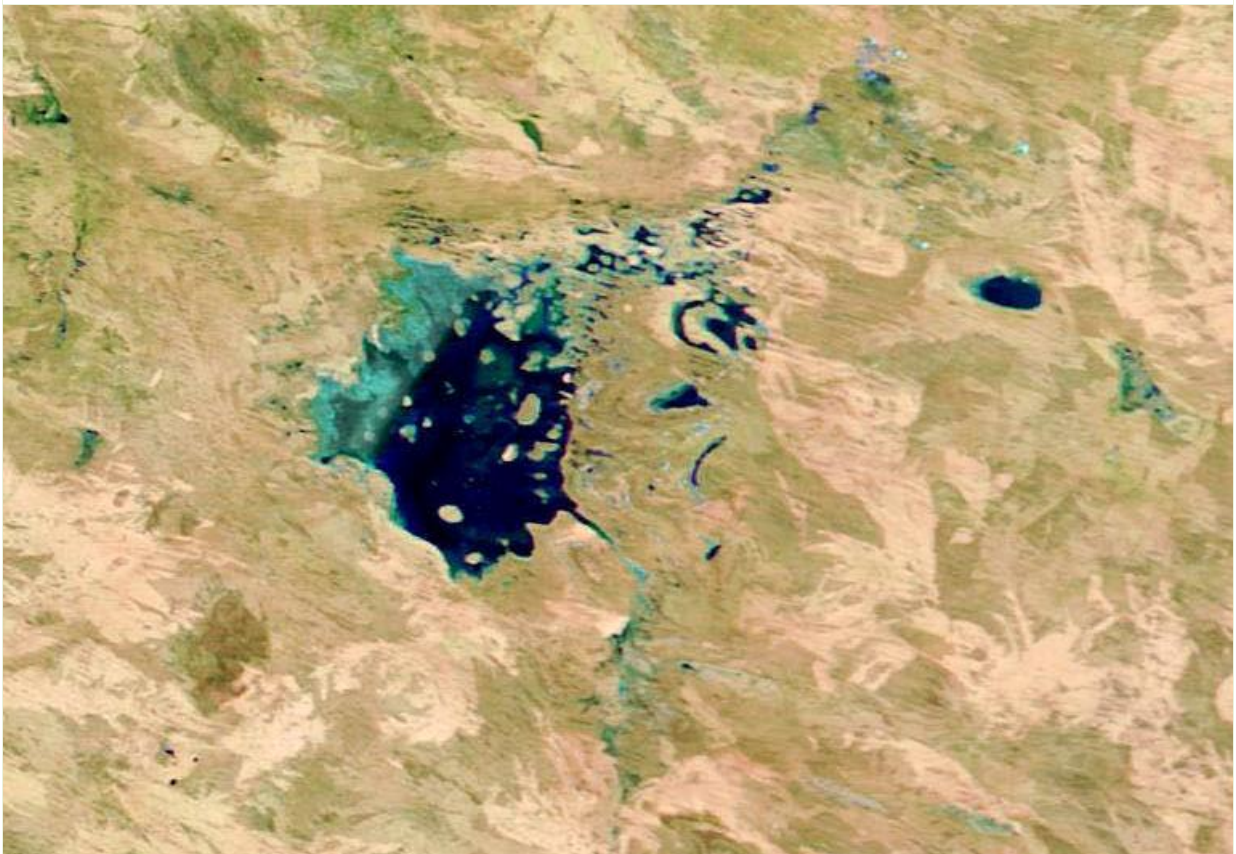
Survey Site	Latitude	Longitude	Collector	Sample(s)
LD01-WP182	-23.2802467525	122.819818071	Botanica 2015	Sediment hatching
LD02-WP187	-23.5516164359	122.663416221	Botanica 2015	Sediment hatching
LD03-WP188	-23.6965466024	122.786401558	Botanica 2015	Sediment hatching
LD04-WP189	-23.6138744118	122.910353921	Botanica 2015	Sediment hatching
LD05-WP190	-23.5411808947	122.932741208	Botanica 2015	Sediment hatching
LD06-WP191	-23.413787535	122.950326181	Botanica 2015	Sediment hatching
LD07-WP192	-23.5102132254	122.61038407	Botanica 2015	Sediment hatching
LD08-WP193	-23.3664508419	122.717190527	Botanica 2015	Sediment hatching
LD09-WP194	-23.3576554608	122.663750904	Botanica 2015	Sediment hatching
LD10-WP195	-23.2576596148	122.739456609	Botanica 2015	Sediment hatching
LD11-WP196	-23.3339232612	122.766619488	Botanica 2015	Sediment hatching
LD12-WP197	-23.258645406	122.910935356	Botanica 2015	Sediment hatching
Site 01	-23.5483360290527	122.6672239881	Bennelongia 2016	Sweep net
Site 02	-23.5839339718222	122.706921016797	Bennelongia 2016	Sweep net
Site 03	-23.6788420099765	122.782601974904	Bennelongia 2016	Sweep net; Diatoms
Site 04	-23.5801310185343	122.958584977313	Bennelongia 2016	<i>Bird observation only</i>
Site 05	-23.5730039700865	122.968188961967	Bennelongia 2016	Sweep net
Site 06	-23.5558889620006	122.972287964075	Bennelongia 2016	Sweep net; Diatom
Site 07	-23.43600503169	122.927935039624	Bennelongia 2016	Sweep net; Diatom
Site 08	-23.3593579754233	122.844099998474	Bennelongia 2016	Sweep net
Site 09	-23.46773003228	123.05758900009	Bennelongia 2016	Sweep net
Site 10	-23.3934900071471	123.027702989056	Bennelongia 2016	Sweep net
Site 11	-23.4418629761785	123.12154803425	Bennelongia 2016	<i>Invertebrate observation only</i>
Site 12	-23.4202169626951	122.731842007488	Bennelongia 2016	<i>Bird observation only</i>
Site 13	-23.2814879994839	122.800550982356	Bennelongia 2016	Diatom
Site 14	-23.345646020025	122.646624036133	Bennelongia 2016	Sweep net; Diatom
Site 15	-23.374078022316	122.72195697762	Bennelongia 2016	Sweep net; Diatom
Site 16	-23.4110289718955	122.721594041213	Bennelongia 2016	<i>Bird observation only</i>
Site 17	-23.4730040095746	122.710444014519	Bennelongia 2016	<i>Bird observation only</i>
Site 18	-23.4712599869817	122.724195029586	Bennelongia 2016	<i>Bird observation only</i>
Site 19	-23.4757660143077	122.727628005668	Bennelongia 2016	<i>Bird observation only</i>
Site 20	-23.4753370285034	122.776165008544	Bennelongia 2016	<i>Bird observation only</i>
Site 21	-23.3722800202667	122.822476029396	Bennelongia 2016	Sweep net
Site 22	-23.2346179895102	122.764246026054	Bennelongia 2016	Sweep net; Diatom
Site 23	-23.2430540397763	122.767361998558	Bennelongia 2016	Sweep net; Diatom
Site 24	-23.3343390002846	123.100883960723	Bennelongia 2016	Sweep net; Diatom
Site 25	-23.3124929945915	123.129023015499	Bennelongia 2016	Sweep net; Diatom
Site 26A	-23.1128389947116	122.799616986885	Bennelongia 2016	Sweep net
Site 26B	-23.1121560372412	122.799079958349	Bennelongia 2016	Sweep net
Site 27	-23.2169358841	122.814078089	Bennelongia 2016	<i>Bird observation only</i>
Site 27	unknown	unknown	Suzi Wild 2016	Sweep net; Hatching
Site 28	-23.2432790100574	122.815774027258	Bennelongia 2016	Sweep net
Site 29	-23.27366	122.73385	Bennelongia 2016	Sweep net; Diatom
Site 30	-23.240954	122.816293	Bennelongia 2016	Hand collection of scorpions
Site 31	-23.3601694444444	122.66535	Bennelongia 2016	<i>Bird observation only</i>
Site 32	-23.2808064777	122.819533751	Suzi Wild 2016	Sweep net

At Bennelongia sites, all birds present were recorded.

## APPENDIX B. SATELLITE IMAGERY OF NORTHERN WA IN MAY AND JUNE 2013



North western Australia June 2013



Lake Disappointment June 2013



## APPENDIX C. PHYSICO-CHEMISTRY DATA

Site LD00409; 7 December 2015; collected by Geoff Browne, Botanica.

SAMPLE ID	TDS (mg/L)	Ca(mg/L)	K(mg/L)	Mg(mg/L)	Na(mg/L)	SO4(mg/L)	Cl (mg/L)	pH
BRINE 7 LD5 BOTANICA 1/12/15	261658	595	2480	3344	89180	19110	146949	7.32
BRINE 8 LD9 BOTANICA 1/12/15	348653	270	9690	14610	98610	57900	167573	7.45

Surface water measurements in Lake Disappointment associated with rain event.

Sample ID	SG <sup>(1)</sup>	TDS <sup>(4)</sup> (mg/L)	Mg <sup>(3)</sup> (mg/L)	Cl <sup>(2)</sup> (mg/L)
LD1516 6/05/16 11:30am (Start-rain)	1.118	162357	1630	104750
LD1516 9/5/16, after rain	1.030	44352	1570	24000
Lake sample End of Causeway 9/5/16 9:00am	1.013	25612	1150	16400
LD1516 10/5/16 7:30am	1.026	39738	1450	22900
Causeway 10/5/16 8:30am	1.027	37148	1390	20700
Causeway 11/5/16 7:00am	1.029	39202	1450	21800
Causeway 12/5/16 7:30am	1.033	47411	1570	26200
Causeway 13/5/16 7:00am	1.034	56363	1690	30600
Causeway 14/5/16 7:30am	1.048	67866	1930	34900

NOTE:

(1) SG by pycnometer

(2) Chloride by AgNO<sub>3</sub> / Chromate titration

(3) Magnesium by EDTA /EBT titration

(4) TDS by gravimetric method

Groundwater salinity and chemistry reproduced from Pendragon (2014).

Sample	Na	Cl	K	Ca	Mg	Br	SO4	pH	EC	TDS	Cl:SO4
UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		mS/cm	gm/L	
GP01-1	86800	135100	4680	607	4540	10	20700	6.1	462	277	6.5
GP01-2	89500	141400	4740	581	4280	10	20900	6.4	483	290	6.8
GP02-1	89500	133700	4460	620	3230	-5	20600	6.2	468	281	6.5
GP02-2	88200	134400	4400	588	3250	-5	21100	6.2	459	275	6.4
GP03-1	94100	145600	4450	561	4240	25	19700	6.6	484	290	7.4
GP03-2	92100	142100	4380	538	4290	20	20800	6.8	476	286	6.8
GP04-1	103000	166600	5470	398	8100	55	25600	6.4	544	326	6.5
GP04-2	106000	167300	5250	499	9100	55	28900	6.4	1050	630	5.8
GP05-1	112000	171500	5950	442	6860	60	24900	6.5	577	346	6.9
GP05-2	110000	177100	6690	369	7870	70	25100	6.5	578	347	7.1
GP06-1	113000	178500	6410	362	7690	70	26100	6.4	584	350	6.8
GP06-2	110000	177800	6470	357	7380	65	27500	6.6	585	351	6.5
GP07-1	109000	171500	5360	339	7980	90	29700	6.2	571	343	5.8
GP07-2	102000	163800	5040	371	8500	100	30000	6.6	548	329	5.5
GP08-1	106000	161700	5250	327	7500	50	32100	6.5	565	339	5
GP08-2	94100	151200	4390	415	6880	45	27600	6.7	511	307	5.5
GP09-1	84200	127400	4480	597	3850	-5	20900	6.5	439	263	6.1
GP09-2	89500	132300	4730	517	4620	10	23600	6.5	459	275	5.6
GP10-1	86200	131600	4570	541	4250	5	23300	6.3	445	267	5.6
GP10-2	88200	123900	4810	502	3830	5	25600	6.7	460	276	4.8
GP11-1	84200	130200	4790	535	5270	15	25300	6.3	446	268	5.1
GP11-2	84900	125300	4710	524	4830	10	25400	6.9	452	271	4.9
GP12-1	107000	165200	5560	408	6460	60	24600	6.1	463	278	6.7
GP12-2	102000	161000	5490	399	6620	55	24700	6.6	547	328	6.5
GP13-1	105000	173600	6720	379	8560	70	25100	6.5	573	344	6.9
GP13-2	104000	170800	7370	355	9910	70	26900	6.7	560	336	6.3
GP14-1	111000	177800	8670	175	9360	90	34200	6.6	616	370	5.2
GP14-2	103000	173600	8970	236	10800	90	33300	6.7	591	355	5.2
GP15-1	107000	171500	6450	315	7300	75	27800	6.7	574	344	6.2
GP15-2	105000	168700	6560	358	7580	75	27500	6.8	567	340	6.1
GP16-1	98000	153300	5020	447	5990	50	24400	7.1	552	331	6.3
GP16-2	101000	158900	5210	408	6280	50	25200	6.8	529	317	6.3
GP17-1	89500	136500	4500	576	3540	10	22100	6	456	274	6.2
GP17-2	90800	137200	4510	538	3480	10	22400	6.8	459	275	6.1
GP18-1	78900	121800	4390	634	3100	5	21100	6.3	429	257	5.8
GP18-2	83600	123900	4450	620	3170	5	20500	6.8	424	254	6
GP19-1	95400	147700	4680	446	5910	45	26000	7.1	505	303	5.7
GP19-2	96700	149800	4690	442	5790	45	25600	6.9	514	308	5.9
GP20-1	105000	168700	7030	334	9110	115	31200	6.7	584	350	5.4
GP20-2	104000	164500	6820	354	8450	105	30600	6.9	544	326	5.4
GP21-1	106000	175700	5360	464	7950	70	19300	6.8	567	340	9.1
GP22-1	78000	123900	3900	814	3400	25	18300	6.4	420	252	6.8
GP23-1	100000	153300	4690	493	6960	50	26100	6.7	524	314	5.9
GP24-1	103000	167300	5650	393	8930	60	26700	6.4	571	343	6.3
GP25-1	111000	177100	4510	494	7320	65	15900	6.1	596	358	11.1



Sample	Na	Cl	K	Ca	Mg	Br	SO4	pH	EC	TDS	Cl:SO4
GP26-1	105000	163800	5900	338	7250	60	30900	6.7	566	340	5.3
GP27-1	96700	150500	4620	437	5870	45	26100	6.7	524	314	5.8
GP28-1	98000	145600	4610	544	3870	10	20600	6.3	500	300	7.1
GP29-1	101000	154000	5220	369	5420	55	31200	6.4	539	323	4.9
GP30-1	97500	132300	4450	438	6050	50	29600	6.2	517	310	4.5
T1-1	110000	177800	5710	347	7690	60	26300	6.8	609	365	6.8
T1-2	109000	175000	5690	356	7630	65	26000	6.8	601	361	6.7
T2-1	105000	167300	5560	406	8000	60	26300	6.7	584	350	6.4
T2-2	104000	167300	5490	408	7930	60	26000	6.6	597	358	6.4
T3-1	107000	168000	6550	317	7390	75	27900	6.6	603	362	6
T3-2	107000	168000	6540	322	7370	75	28200	6.6	594	356	6
<b>Min</b>	<b>78000</b>	<b>121800</b>	<b>3900</b>	<b>175</b>	<b>3100</b>	<b>5</b>	<b>15900</b>	<b>6</b>	<b>420</b>	<b>252</b>	<b>4.5</b>
<b>Max</b>	<b>113000</b>	<b>178500</b>	<b>8970</b>	<b>814</b>	<b>10800</b>	<b>115</b>	<b>34200</b>	<b>7.1</b>	<b>1050</b>	<b>630</b>	<b>11.1</b>
<b>Average</b>	<b>99064</b>	<b>155025</b>	<b>5411</b>	<b>446</b>	<b>6407</b>	<b>48</b>	<b>25429</b>	<b>6.6</b>	<b>537</b>	<b>322</b>	<b>6.2</b>

Full Analysis and description of Boreholes refer to Global Groundwater, 2007. Analytical Methods - The solutions have not been treated other than by dilution. Na, K, Ca, Mg, SO4, B have been determined by Inductively Coupled Plasma (ICP) Optical Emission Spectrometry.

Li, U, I, Br have been determined by Inductively Coupled Plasma (ICP) Mass Spectrometry. Chloride in solution Cl has been determined colourimetrically. Sample density was determined by liquid pycnometry. Density was expressed in units of grams per cubic centimeter. pH has been determined by direct measurement with a pH meter. Conductivity has been determined by direct measurement with a conductivity meter. Total dissolved salts (TDS) have been calculated from conductivity measurements. Note GP\*\*-1 is from top metre, GP\*\*-2 is from base of open drill hole and may be composite sample.

## APPENDIX D. INVERTEBRATES COLLECTED FROM HATCHING TRIALS

Species collected are shown below in taxonomic sequence. Sites where they are collected have LD codes (i.e. LD1-LD12) except for Site 27.

		1	2	3	4	5	6	7	8	9	10	11	12	27
Taxonomy	Lowest ID													
Protozoa	Protozoa													
Animalia														
Rotifera														
Bdelloidea	Bdelloidea sp.													
Monogononta														
Flosculariacea														
Hexarthridae	<i>Hexarthra fennica</i>													
Ploima														
Brachionidae	<i>Brachionus cf. ibericus</i>													
	<i>Brachionus cf. rotundiformis</i>													
Euchlanidae	<i>Euchlanis dilatata</i>													
Lecanidae	<i>Lecane sp. s. str.</i>													
Lepadellidae	<i>Lepadella sp.</i>													
Notommatidae	<i>Cephalodella similis</i>													
Proalidae	<i>Proales sp.</i>													
Platyhelminthes														
Turbellaria	Turbellaria sp.													
Nematoda	Nematoda sp.													
Gastrotricha	Gastrotrichs sp.													
Arthropoda														
Branchiopoda														
Anostraca														
Branchiopodidae	<i>Parartemia sp.</i>													
Notostraca														
Triopsidae	<i>Triops australiensis australiensis</i>													
Cladocera	Cladocera sp. unident.													
Chydoridae	Chydoridae sp..													
Moinidae	Moinidae sp.													
Neothricidae	<i>Neothrix sp.</i>													
Ostracoda	Ostracoda sp. unident.													
Cyprididae	Nr <i>Heterocypris sp.</i> BOS560													
Maxillopoda														
Calanoida														
Centropagidae	<i>Boeckella sp. B01</i>													

## APPENDIX E. INVERTEBRATES COLLECTED FROM INVERTEBRATE SAMPLING 2016

		Site 02		Site 03		Site 05		Site 06		Site 08		Site 09		Site 10		Site 14		Site 21		Site 22		Site 23		Site 24		Site 25		Site 26A		Site 26B		Site 27		Site 28		
		LD		LD		CP		LD		LD		CP		CP		SC		LD		CP		CP		LD		LD		CP		CP		CP		CP		
Taxonomy	Lowest ID	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	Log	No.	
Protozoa	Protozoa																											4	10							
Animalia																												3	100							
Rotifera	Rotifera sp.					4	100																													
Bdelloidea	Bdelloidea sp.					2	50							2	10															1	1	1	1			
	Bdelloidea sp. 4:4											1	2																							
Monogononta																																				
Flosculariacea																																				
Hexarthridae	Hexarthra sp. B01					3	100																							2	200					
Testudinellidae	Testudinella sp.					1	2																					1	1							
	Testudinella sp. B01																																1	1		
Ploima																																				
Asplanchnidae	Asplanchna sieboldi																																1	1		
Brachionidae	Brachionus quadridentatus					1	1																													
	Brachionus sp.					1	1						1	5														3	100	2	50					
	Keratella australis																											1	1							
Euchlanidae	Euchlanis dilatata																																1	1		
	Euchlanis sp.					2	10																													
Lecanidae	Lecane aculeata																																1	1		
	Lecane ludwigii																											1	1							
	Lecane luna																																1	1		
	Lecane signifera					1	1																													
Lepadellidae	Lepadella ovalis																																	1	1	
Notommatidae	Cephalodella gibba																																	1	2	
Proalidae	Proales sp.																																3	100		
Synchaetidae	Polyarthra sp.																																			
Trichocercidae	Trichocerca sp.					2	50																					3	100	3	200					
																												2	10	1	2					
Platyhelminthes																																				
Turbellaria	Turbellaria sp.					2	10																								1	1				
Nematoda	Nematoda sp.			1	1	2	10					3	100	2	50	1	1			2	30	1	5	1	1	1	5	1	1	2	10	2	10			
Arthropoda																																				
Branchiopoda																																				
Anostraca	Anostraca sp. unident.											1	5	2	30					2	20					1	1				1	6				
Branchiopodidae	Parartemia laticaudata					1	2	2	20							2	33					1	1													
	Parartemia sp.									1	1							1	1																	
Thamnocephalidae	Branchinella affinis																												2	20						
	Branchinella proboscida					2	20																									1	7			
	Branchinella wellardi																												2	20						
Conchostraca																																				
Cyzicidae	Eocyclus nr argillaquus																												1	5						
	Eocyclus sp.																																1	3		
	Ozestheria nr packardi																															1	1			
	Ozestheria packardi					2	10																							3	20					

		Site 02	Site 03	Site 05	Site 06	Site 08	Site 09	Site 10	Site 14	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26A	Site 26B	Site 27	Site 28
Limnadiidae	<i>Eulimnadia</i> n. sp. B01														1	1		
Diplostraca																		
Chydoridae	<i>Alona</i> sp.			2	12													
	<i>Australospilus</i> cf. <i>elongatus</i>			1	2											1	2	
	<i>Pseudomonospilus</i> <i>diporus</i>			1	5													
Daphniidae	Daphniidae sp.							1	1									
Moinidae	<i>Moina</i> sp. B01															1	1	
	<i>Moina</i> cf. <i>micrura</i>			2	50										2	20	2	23
	<i>Moina</i> sp. B03														3	30	2	15
	<i>Moina</i> sp. B04														1	1		
	<i>Moina</i> sp. B05																1	6
Neothricidae	<i>Neothrix</i> sp.			1	2													
Sididae	<i>Diaphanosoma</i> sp.															1	5	
(blank)	Cladocera sp. unident.														4	50		3 100
Notostraca																		
Triopsidae	<i>Triops australiensis australiensis</i>						1	1	2	30		2	30	1	1	2	20	
Ostracoda	Ostracoda sp. unident.							1	1								2	10
Popocopida																		
Cypridae	<i>Bennelongia</i> sp. BOS565			2	10										3	15	1	3
	<i>Cypretta</i> sp.			1	2			1	1									
	<i>Cyprinotus kimberleyensis</i>								1	2			1	4				
	<i>Diacypris</i> sp.								1	2								
	Nr <i>Heterocypris</i> sp. BOS560					1	3				1	1						
	<i>Ilyodromus</i> ? <i>dikrus</i>			2	10													
	<i>Strandesia</i> sp. BOS564			2	10													
Limnocytheridae	<i>Limnocythere</i> sp.			1	1													
Maxillopoda																		
Calanoida																		
Centropagidae	<i>Boeckella</i> sp. B01			2	10												2	14
	<i>Calamoecia baylyi</i>			2	10										2	10	3	100
Cyclopoida																		
Cyclopidae	<i>Apocyclops dengizicus</i>	3	100				3	100		2	15		2	25	1	1	1	1
	<i>Meridiecylops</i> sp.			1	2													
	<i>Metacyclops</i> sp.														3	20	1	9
	Cyclopoida sp.			1	1						1	1						
Insecta																		
Coleoptera																		
Dytiscidae	<i>Bidessini</i> sp.																1	5
	<i>Eretes australis</i>						1	1				1	3		1	1	1	2
Hydrophilidae	<i>Enochrus elongatus</i>																1	1
	<i>Laccobius zeitzi</i>								2	23								
Diptera																		
Ceratopogonidae	<i>Culicoides</i> sp.								3	20		1	4					
	<i>Dasyhelea</i> sp.								3	20								
Chironomidae	Chironomini sp.						1	1										
	<i>Microchironomus</i> sp.																1	2
	<i>Polypedilum nubifer</i>																1	2

		Site 02	Site 03	Site 05	Site 06	Site 08	Site 09	Site 10	Site 14	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26A	Site 26B	Site 27	Site 28
	<i>Tanytarsus barbitarsis</i>								1	1								
	<i>Tanytarsus fuscithorax/semibarbitarsis</i>																1	1
Muscidae	Muscidae sp.		1	3			1	3	1	4								
Stratiomyidae	Stratiomyidae sp.								1	1								
Hemiptera																		
Corixidae	<i>Micronecta</i> sp.																1	2
Notonectidae	<i>Anisops</i> sp.														1	1	1	1
	<i>Anisops stali</i>																1	1
Odonata																		
Coenagrionidae	<i>Ischnura heterosticta heterosticta</i>																1	2
Hemicorduliidae	<i>Hemicordulia tau</i>						1	1									1	1
Libellulidae	<i>Orthetrum caledonicum</i>																1	1

## APPENDIX F. WATERBIRD OBSERVATIONS IN JANUARY 2016.

Site	Area	Species
3	Lake Disappointment south in Proposed Nature Reserve	4 Red-necked Stint
4	Fresh claypan SE. of Lake Disappointment	2 Red-necked Avocet
5	Fresh claypan SE. of Lake Disappointment	1 Red-necked Avocet 2 Pink Eared Duck 6 Grey Teal
12	Middle of Lake Disappointment	200 Banded Stilt
14	Savory Creek	2 Grey Teal 1 Little Pied Cormorant
15	Middle of Lake Disappointment	2 Grey Teal
16	Middle of Lake Disappointment	4 Red Necked Stint
17	Middle of Lake Disappointment	10 Banded Stilt
18	Middle of Lake Disappointment	50 Banded Stilt
19	Middle of Lake Disappointment	50 Banded Stilt
20	Middle of Lake Disappointment	50 Banded Stilt
21	NW. heritage area	Around 8000 Banded Stilt
25	NE. extension of Lake Disappointment	Footprints of 100s of Banded Stilt
27	Claypan N. of Lake Disappointment	1 Sharp-tailed Sandpiper 2 Red-necked Avocet
31	Mouth of Savory Creek	1 x Little Pied Cormorant 1 x Grey Teal

## APPENDIX G. PHOTOS OF THE LAKE DISAPPOINTMENT SYSTEM (JANUARY 2016)



Lake Disappointment west, a spit covered with samphire



Lake Disappointment west, a broad shore with samphire and a little spinifex





Lake Disappointment west, a broad shore covered with samphire



Lake Disappointment north-east, samphire on lake bed and pockets of samphire behind defined shore with hummock grassland





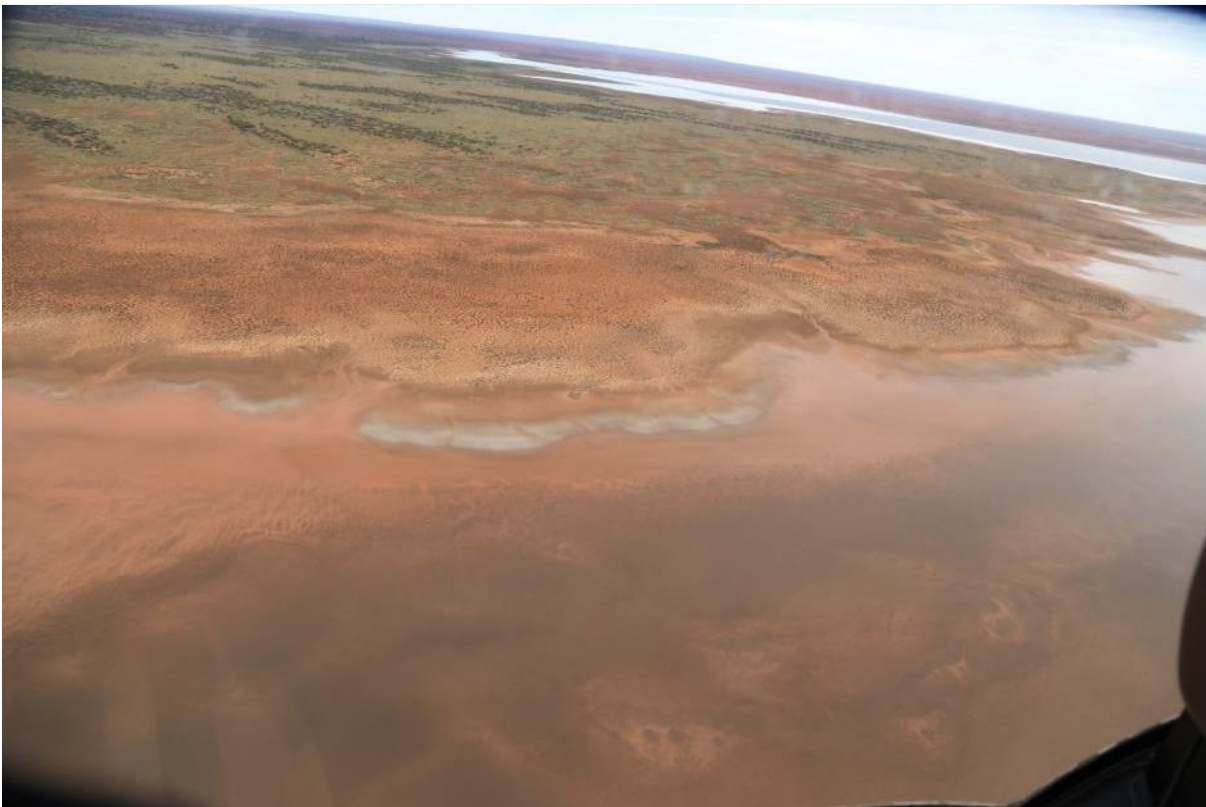
Lake Disappointment south-west, a defined shore of hummock grassland with occasional pockets of samphire



Lake Disappointment west, a broad shore of samphire



Lake Disappointment, Savory Creek inlet with defined islands of spinifex separated by samphire banks



Lake Disappointment north east, a broad shore of samphire moving gradually into hummock grassland





Lake Disappointment north, a broad cove with a defined shore on right with small samphire fringe and large samphire community in upper area



Lake Disappointment north shore, a cove covered by samphire that has a strongly defined shore upper left versus a broadly defined shore bottom left to upper right





Lake Disappointment, an island with a small, reasonably defined shore and small samphire fringe



Lake Disappointment, an island with a defined shore and sparse samphire community



Lake Disappointment south-west, a broad shore of mixed samphire and hummock grassland



Lake Disappointment southern shore with a partially defined shore and very little samphire





A broad channel in the south of Lake Disappointment with little to no samphire on the gypsum island or shore on the left



A section of the southern Lake Disappointment shore with little to no samphire



A broad channel south-east of the gypsum island in Lake Disappointment with little to no samphire



South-east shore of Lake Disappointment with a small shore and very sparse samphire



The large raised area in the south-east of Lake Disappointment has islands with some samphire fringe



A strongly defined shore of Lake Disappointment with a small samphire fringe





A strongly defined shore of Lake Disappointment with a very small samphire fringe



Claypans north of Lake Disappointment between swales with samphire





Claypans north of Lake Disappointment between swales with samphire



A claypan north of Lake Disappointment between swales covered by samphire





North-east extension of Lake Disappointment has a broadly defined shore of samphire backed by spinifex



North-east extension of Lake Disappointment has some areas with bare lake bed, a broad samphire fringe around islands and hummock grasslands on the periphery





A section of the northern shore of Lake Disappointment (bottom) has a defined shore with little samphire and a cove (above) is completely covered in samphire



North-east extension of Lake Disappointment with large areas of samphire abutting defined edges of sand and spinifex





Low lying areas between sand ridges north-east of Lake Disappointment with abundant samphire communities



North-east extension of Lake Disappointment – large areas of samphire upto defined shores of islands





Low lying areas between sand ridges north-east of Lake Disappointment with abundant samphire communities



Low lying areas between sand ridges north-east of Lake Disappointment with abundant samphire communities





North-east extension of Lake Disappointment – large areas of samphire upto defined shores of islands



North-east extension of Lake Disappointment – large areas of samphire upto broad shore and sand dunes





North-east extension of Lake Disappointment – large areas of samphire up to defined shores of islands



North-east extension of Lake Disappointment – large areas of samphire up to broad shore and sand dunes





Claypan north of Lake Disappointment – dominated by samphire, surrounded by sand ridges with spinifex