Government of **Western Australia**
Department of **Water**

Waterway assessment for the Lockhart River: Lake Kurrencutten to the Camm River confluence

Water resource management series
Looking after all our water needs

Report no. WRM 55
December 2008

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Department of Water

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Executive summary

Management of water resources in the Avon River basin is a high priority under the Avon Catchment Council's *Avon River basin natural resource management (NRM) strategy* and investment plans. Through the Avon Rivercare Project, the Department of Water has initiated a project to investigate the riparian condition and management needs of waterways in the Avon River basin within the zone of ancient drainage. The Lockhart River project is the fourth of these waterways assessments, following the Salt River, lower Yilgarn River and lower Lockhart River studies.

The Lockhart River extends from near Lake Biddy in the south, flowing in a general north-westerly direction until it converges with the Salt River at the Caroline Gap, south of Kellerberrin. This study has focussed on the section of the Lockhart River between Lake Kurrenkutten and its confluence with the Camm River, south-east of Kondinin.

The purpose of this waterway assessment is to investigate its current condition by recording a snap-shot survey of ten remnants in the Lockhart River catchment, identifying threatening processes and proposing management recommendations for improving its condition.

The key management issues identified in the study area are:

- increased salinity, higher watertable and longer periods of inundation in the valley floor
- loss of fringing riparian vegetation, especially around the edges of the larger lakes
- further clearing, including for sand extraction
- impedance of flood waters by road crossings
- pest species degrading riparian vegetation
- stock access, particularly causing soil erosion
- weed invasion
- lack of corridors linking areas of remnant vegetation
- fire risk
- rubbish dumping in floodplain areas.

Of these, the most damaging is the hydrological change (increased salinity, higher watertable and longer periods of inundation) experienced in the valley floors. Management of these processes needs to be at a catchment scale, through partnerships between landholders, all levels of government and non-government agencies.

Information gained through the Lockhart River waterway assessment will be used

by waterway managers including the Avon Catchment Council, Department of Water, Department of Environment and Conservation, Avon Waterways Committee, local shires and landholders to plan and prioritise for the future management of the waterway.

1 Introduction

1.1 Avon River basin

The Avon River is one of Western Australia's major river systems, draining approximately 120 000 km^2 from Dalwallinu in the north, Southern Cross in the north-east and Lake King in the south-east, entering the ocean at Fremantle after a name change to the Swan River.

There are four main subcatchments within the Avon River basin including:

- the Yilgarn River catchment, which drains an area of approximately 55 900 km^2. It originates north-east of Southern Cross from Lake Seabrook and Lake Deborah and flows to the south-west past Merredin to its confluence with the Lockhart River at the Caroline Gap, south of Kellerberrin
- the Lockhart River catchment, which drains an area of approximately 28 400 km^2. It originates around the locality of Lake Biddy, near Newdegate, and flows north-west through Kondinin, Corrigin and Bruce Rock to the Caroline Gap. The catchment also includes the Pingrup River, which originates at Chinocup Lake south of Lake Grace, and the Camm River, which originates at Lake King
- the Mortlock River system, which drains an area of approximately 16 770 km^2. The Mortlock River system consists of the Mortlock River, Mortlock River North, Mortlock River East and Mortlock River South, and joins the Avon River at Northam
- the Avon River, which drains an area of approximately 15 500 km^2, and includes the Salt River, Avon River South Branch, Dale River, Mackie River, Toodyay Brook, Brockman River and Wooroloo Brook catchments.

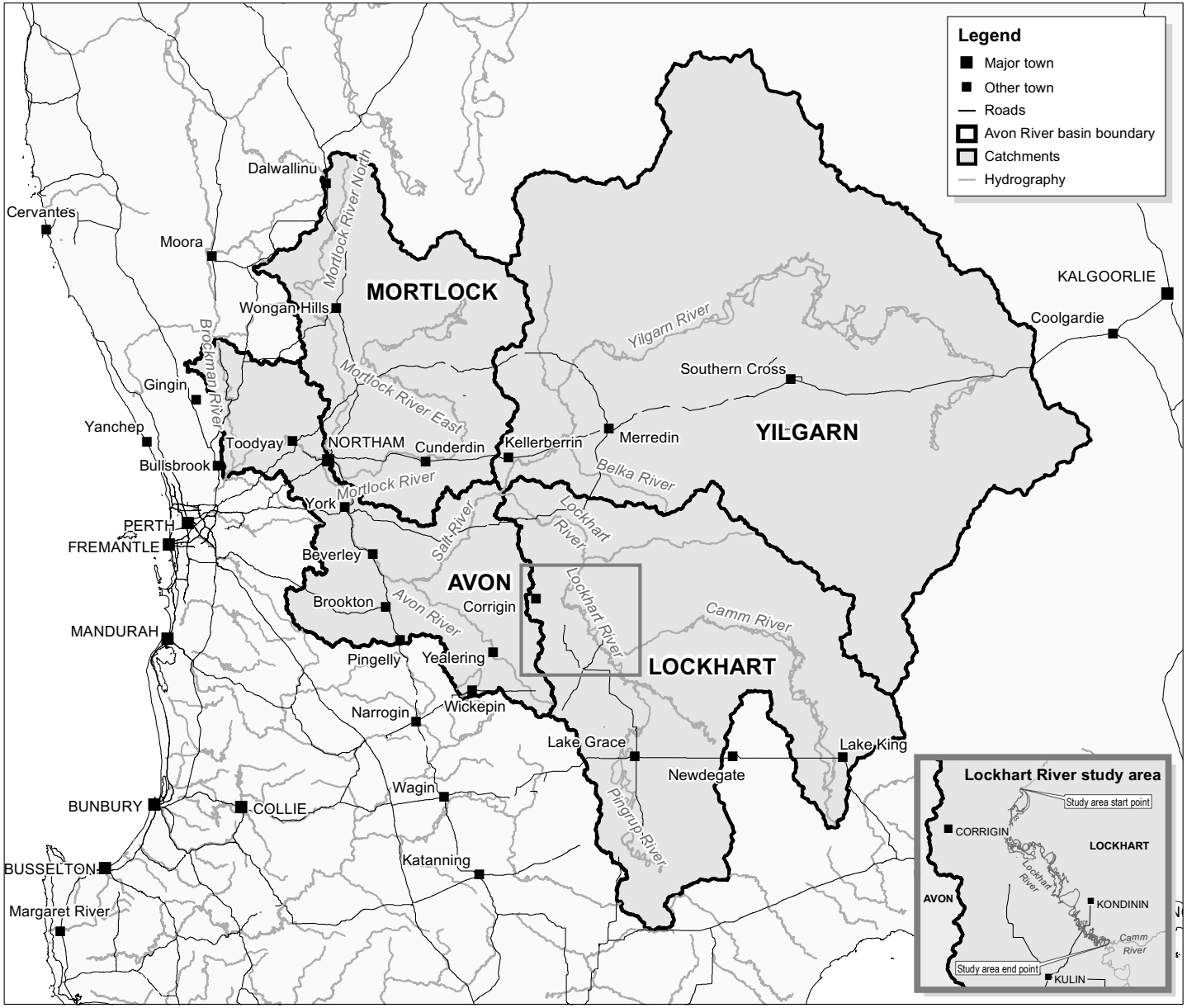
Map 1 shows the major subcatchments of the Avon River basin and the location of the Lockhart River study area.

1.2 Managing natural resources in the Avon River basin

The Avon Catchment Council (ACC) is the peak NRM body in the diverse Avon River basin. The ACC has completed the *Avon River basin NRM strategy* (Avon Catchment Council 2005) and updated the *Avon investment plan* (Avon Catchment Council 2006), which provide direction and identify priorities for investment into actions to bring about change in the condition of water, land, vegetation and other landscape assets.

Supporting the Avon NRM Strategy, the Ballardong NRM Working Group has completed Ballardong Nyungar Budja: *'Healthy Country – Healthy People'* (2006) which presents the Nyungar perspective on how to care for the Country and how to

Map 1
Location of the Lockhart River study area within the Avon River basin



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involve the Ballardong people in the Avon NRM region.

The Avon Natural Diversity Alliance (ANDA) was formed to facilitate the delivery of projects from the *Avon Investment Plan*. The Department of Water, Department of Environment and Conservation (DEC), Greening Australia Western Australia (GAWA) and WWF-Australia (WWF) are working in partnership with ACC to deliver a range of natural diversity projects.

Management of water resources, including waterways and lakes, is a high priority. Through the Avon Rivercare Project, the Department of Water has initiated a project to investigate the riparian condition and management needs of waterways in the Avon River basin within the zone of ancient drainage. To date there have been five waterway assessments completed on reaches of the Salt, Yilgarn and Lockhart rivers.

1.3 Aims of the Lockhart River waterway assessment

The main aims of the Lockhart River study are to:

- describe the nature of the waterway and floodplain
- identify and describe areas of riparian vegetation and areas of remnant vegetation closely linked to riparian vegetation
- identify threatening processes impacting on waterway health.

The information will lead to an understanding of the current riparian condition of the Lockhart River from Lake Kurrenkutten to the Camm River confluence in order to:

- provide river managers with information on the current condition of the Lockhart River to aid in decision-making processes
- provide landholders with information on best practice waterways management.

Information gained through the assessment of the Lockhart River will be used by waterway managers such as Department of Water, DEC, ACC, Avon Waterways Committee (AWC), landholders and local Shires to plan and prioritise for future management.

1.4 Nature of the Lockhart River study area

1.4.1 Lockhart River study area

The Lockhart River originates near the locality of Lake Biddy, near Newdegate, and flows north-west past Kondinin, Corrigin and Bruce Rock to the Caroline Gap, south of Kellerberrin. There it converges with the Yilgarn River and becomes the Salt River, although the reach of the Lockhart from the Caroline Gap to Lake Jilakin may also be known as the Salt River (Leoni and Murphy White 2005). The Lockhart River

Map 2
Lockhart River study area

N

0 2 4 6
Kilometres

Legend

Towns
- Town

Road network
- Highway
- Main road
- Local road
- Track

Waterways
- Major waterway
- Minor waterway
- Lakes

Boundaries
- Nature reserve
- Local government authorities
- Lockhart River catchment

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SOURCES

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Road Centrelines - Landgate - 2007
Hydrography, Linear (Hierarchy) - DoW - 2007
Local Govt Authorities - Landgate - 2004

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Study area start point

Study area end point

Red Lake Nature Reserve
Shire of Bruce Rock
Shire of Narembeen
Crown Reserve 14014
Crown Reserve 38567
Lake Kurrenkutten
Crown Reserve 30324
Billericay Nature Reserve
Crown Reserve 46116
Corrigin
Shire of Corrigin
Crown Reserve 15057
Lockhart River
Crown Reserve 19832
Bendering Nature Reserve
Paperbark Nature Reserve
Shire of Kondinin
Wedgengully Nature Reserve
Gorge Rock Nature Reserve
Morton Nature Reserve
Kondinin
Kondinin Lake
Kondinin Lake Nature Reserve
Stretton Road Nature Reserve
Kondinin Salt Marsh Nature Reserve
Camm River
Kulin Road Nature Reserve
Crown Reserve 16560
Shire of Kulin
Kulin
Jilakin Lake
Crown Reserve 18698
Sparks Road Nature Reserve
Crown Reserve 16281

MULVAHY RD
HEALEY RD
CHEETHAMS RD
SOUTH KUMMININ RD
BILBARIN RD
SORENSONS RD
BABAKIN-CORRIGIN RD
PARSON RD
HAYES RD
KONDININ-NAREMBEEN RD
NAREMBEEN RD
CORRIGIN-NAREMBEEN RD
BROWN RD
MALONES RD
CORRIGIN-WOGERLIN RD
SEDGWICK RD
GEORGE RD
BILLERICAY RD
PLEASS RD
DRY WELL RD
HEAL RD
BRUCE ROCK-CORRIGIN RD
MARTIN RD
NAMBADILLING RD
GIBSON RD
PONTIFEX RD
DICKINSON RD
PRUDEN RD
GNERKADILLING RD
CROSSLAND RD
CONNELLY RD
BENDERING RD
BENDERING RESERVE RD
DILLING RD
FULWOOD RD
HILLS RD
BENDERING HALL RD
DE GRUCHY RD
SCHULTZ RD
ROGERS RD
REED RD
BONDS RD
KOORIKIN RD
HARTLEY RD
BARTLETT RD
NOTTING-KARLGARIN RD
BULLARING-GORGE ROCK RD
GRAHAM RD
OLD KULIN RD
CORRIGIN-KONDININ RD
CEMETERY RD
THOMPSON RD
DAVIES RD
KONDININ LAKE RD
WILLIAMS-KONDININ RD
SLOANS RD
KONDININ-HYDEN RD
CARLSON RD
MIDDLETON RD
JAMES RD
KULIN ROCK RD
YOUNG RD
BAILEY RD
DOYLES RD
CORRIGIN-KULIN RD
GRAHAM RD
LANGE RD
FREEBAIRN RD
GNARMING RD
FOTHERINGHAME RD
CARMODY RD
RABBIT PROOF FENCE RD
YEALERING-KULIN RD
CLAYTON RD
PRATER RD
DAVIES RD
TARIN ROCK RD
JILAKIN ROCK RD
PAPERBARK RD
KULIN RD
SPARKS RD
JITARNING RD
NOTLEY RD
DANDAGIN RD
KULIN-HOLT ROCK RD

catchment also includes the drainages of the Pingrup and Camm rivers.

The study area includes the salt lakes, channels and floodplain of the Lockhart River from South East Hedges Road, just downstream from Lake Kurrenkutten, upstream approximately 60 km to the confluence with the Camm River, close to Gnarming Road East.

Ten survey sites have been selected by the Department of Water to represent the range of riparian landscapes present on this section of the Lockhart River.

Map 2 shows the location of the study area and the survey sites are shown on maps 3a and 3b.

1.4.2 Nature of the Lockhart River landscape

Landscapes and soils

The Avon River basin forms part of the Great Plateau of Western Australia, with ancient crystalline rocks that have weathered to form deep (10-30 m) and shallow soils. The rocks are mostly granitic surrounded by gneisses, with dolerite dyke intrusions. The valleys are extensively in-filled with unconsolidated sediments.

The Lockhart River lies within the zone of ancient drainage and is characterised by a landscape of very low relief with sluggish drainage through salt lakes systems in broad valley floors 5-8km wide. Crests and slopes are typically duplex soils with some gravels, originally vegetated with mallee eucalypts interspersed with scattered heath. Lower slopes and valley floors are typically sandy and loamy duplexes, usually with sodic and calcareous subsoil, and were originally vegetated by woodlands. Electrical conductivity of local groundwater in the south-east lakes subregion is commonly 4000 mS/m. Regional groundwater is often hypersaline and neutral to acidic (Galloway 2004; Lantzke 1992).

Hatton *et al* (2003) have described the Lockhart River as having a very low gradient, with significant discharges unlikely except in extreme rainfall events. A key feature of the grade of the Lockhart River, and others, is that it is interrupted by large, essentially flat salt lakes that disperse water from one to another as they fill and overflow. These systems do not flow as one linked system except in extreme events, with the Lockhart River system having significant flood storage that leads to major discontinuities of the waterway.

This interrupted flow may have implications for waterway management as lakes may hold and concentrate, through evaporation, poor quality water or toxins, which may cause local problems before being released to the waterway and flushed downstream in the next flood event.

Broad vegetation communities

The Lockhart River study area occupies an area within the Hyden system of the Roe botanical district (Beard 1980). The landscape is very gently undulating with wide flat valleys and long gentle slopes rising to broad uplands, usually capped with laterite and sand. The soils are variable and the vegetation is highly mosaic in structure and composition. The characteristic catena of the Hyden System is heath and thicket on upland sandplains, mallee on the slopes, mallee with patches of woodland on upper valley soils, woodland on lower valley soils and a mosaic of woodland, shrubland and samphire in saline areas.

Beard (1980)[1] has mapped the valley floors, including the salt lakes and samphire flats as succulent steppe, having a mosaic of eucalypts, dominated by yorrell (*Eucalyptus yilgarnensis*) and Kondinin blackbutt (*E. kondininensis*), teatree (probably *Melaleuca* species) and samphires (*Halosarcia* species).

The lower valley soils have woodland of salmon gum (*E. salmonophloia*) and gimlet (*E. salubris*): these occupy both sides of the valley floors from the southern end of Lake Kondinin northwards, and on the western side of the valley floors south of Lake Kondinin.

East of this area, to the south of Lake Kondinin, is described as *E. transcontinentalis* and *E. subangusta* mallee with patches of salmon gum and gimlet woodland.

Upland vegetation is described as scrub heath (undifferentiated kwongan communities) and *Allocasuarina campestris* thicket.

Post-clearing changes to vegetation communities

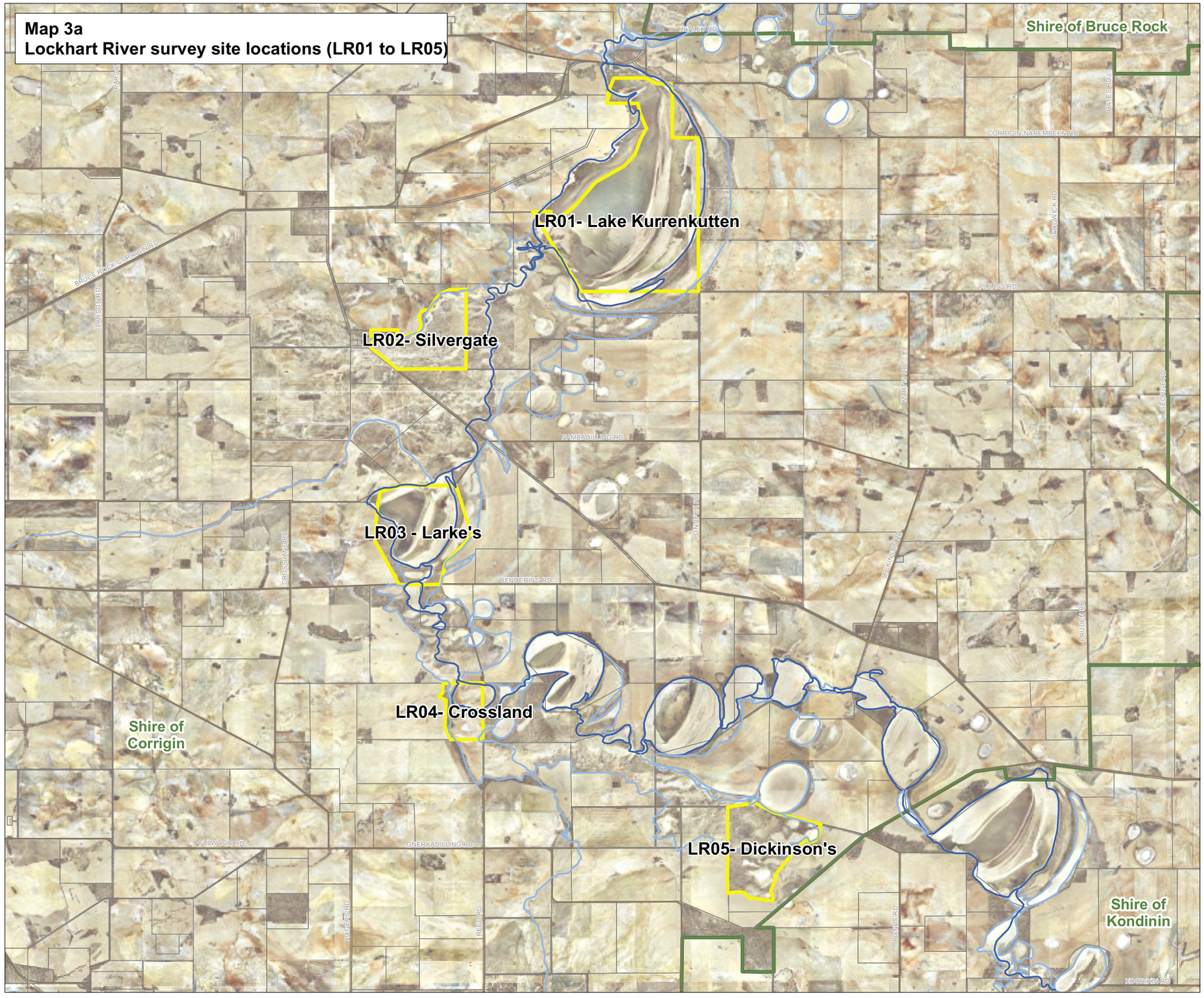
This study has sites located in three local government authority areas. Five sites are located in the Shire of Corrigin, four in Kondinin and one in Kulin.

Clearing has been extensive in all three shires, particularly Corrigin, where only 4.9 per cent of the pre-European vegetation remains. This compares with Kondinin, with 13.1 per cent remaining and Kulin, with 12 per cent, which are close to the overall Avon value of 13.5 per cent (Shepherd, Beeston & Hopkins 2002).

Further degradation of the existing vegetation has occurred since clearing, mainly as a result of grazing or hydrological change.

[1] Several of the botanical names used by Beard have changed since his report was published. Yorrell, at the time of writing, was the common name of *Eucalyptus gracilis*, but now refers to *E. yilgarnensis*. It is possible that *E. myriadena*, which looks similar to yorrell and was first described in 1981, may also be included as yorrell. Samphires were known as *Arthrocnemum* species: they are now mostly *Halosarcia* species. *E. redunca* (in the Wheatbelt) now refers to various species, but is presumed to be *E. subangusta*.

Map 3a
Lockhart River survey site locations (LR01 to LR05)



Legend

- Major watercourse
- Minor watercourse
- Survey sites
- Main road
- Local road
- Track
- Cadastre
- Local government authorities
- Corrigin aerial imagery, 2001

N

0 1 2 3
Kilometres

LOCALITY MAP

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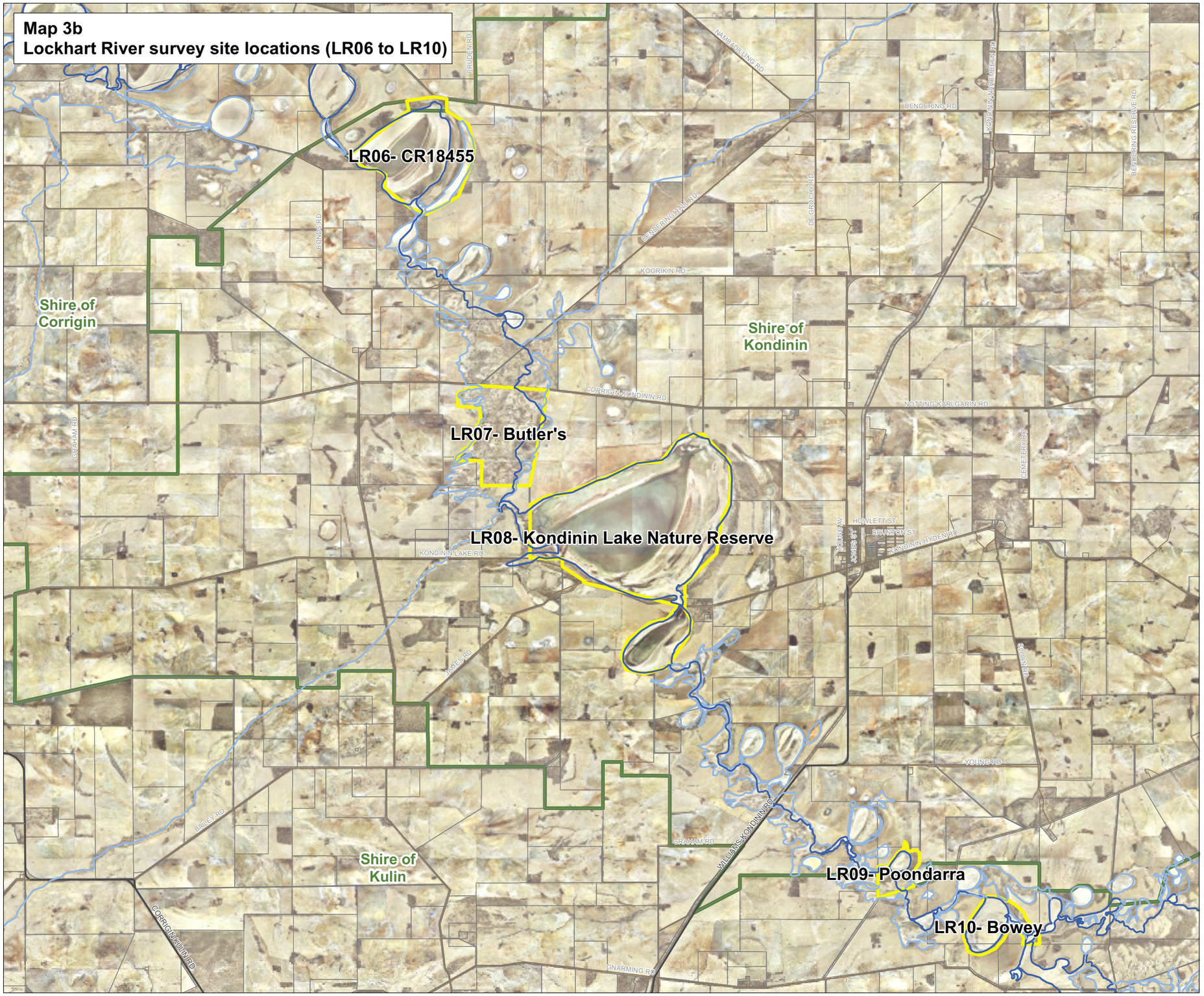
Map 3b
Lockhart River survey site locations (LR06 to LR10)



Legend

- Major watercourse
- Minor watercourse
- Survey sites
- Main road
- Local road
- Track
- Cadastre
- Local government authorities
- Corrigin aerial imagery, 2001

N

0 1 2 3
Kilometres

LOCALITY MAP

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Projection: MGA Zone 50

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Hydrography, Linear (Hierarchy) - DoW - 2007
Local Government Authorities - Landgate - 2004

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Although the Lockhart River was naturally saline, clearing has lead to a rise in the watertable, increased periods of inundation and an increase in salinity. The naturally salt-tolerant native vegetation has struggled to adapt to these changes, leading to a decline in vegetation condition and plant death in some areas.

1.4.3 Hydrology and water quality

Salinity in the Lockhart River main valley is approaching equilibrium and the area affected by salinity is not expected to expand significantly (Leoni & Murphy-White 2005).

Between 1987 and 2004, saline areas at Pithara (on a tributary of the Mortlock River North) and Beacon (on a tributary of the Yilgarn River) increased by 163 per cent and 92 per cent respectively. Between 1988 and 2003 the saline area at Narembeen (at a site on the Wakeman Creek, a major tributary to the Lockhart River) increased by 12.7 per cent (van Dongen, 2005). While two of these sites are well outside of the study area, all three sites fall within the zone of ancient drainage and salinity trends in tributary valleys of the Lockhart River are likely to be similar. Therefore, it is expected that salinity in the Lockhart tributary valleys has not reached equilibrium and is likely to increase.

There is very little gradient in the Lockhart River: Beard (1999) calculated the total fall of the 170 km-long Lockhart system to be 41 m, a gradient of 0.24 m/km. A key feature of this grade is that it is interrupted by large, relatively flat salt lakes (such as Lake Kurrencutten and Kondinin Lake) which store large volumes of water before they fill and overflow. The low gradient and high storage capacity within the floodplain means that the waterway does not flow as one linked system unless there is a major summer rainfall event or a prolonged, wet winter occurs.

The Department of Water's Northam office undertakes water quality monitoring at sites across the Avon River basin. Under the Avon River Catchment Water Quality and Nutrient Monitoring Program fortnightly sampling is undertaken at 33 sites when the waterways are flowing and an annual snapshot event is undertaken at 296 sites in September.

The only Lockhart River sampling site included in the fortnightly sampling run is located at Kwolyin Hill, downstream from the study area however four snapshot sites fall within the study area (Table 1). There is not enough data to indicate water quality trends however at the time of sampling the results show that salinity ranged from highly saline to hypersaline, total nitrogen was moderate, total phosphorus was low and pH ranged from slightly acidic to moderately alkaline (Department of Water, undated).

Table 1 Water quality results for the 2006 and 2007 Avon River basin water quality snapshot

Site code	Site name	Location	Sampling year	Total dissolved salts (mg/L)	Total nitrogen (mg/L)	Total phosphorus (mg/L)	pH
LL22B	Lake Kurrencutten	Lake Kurrencutten	2006	16 527	1.30	0.020	10.17
			2007	82 782	–	–	8.42
LL27	Woolgning tributary	Kondinin Lake Rd	2006	35 877	1.30	<0.005	5.00
			2007	–	–	–	–
LL28A	Lockhart River	Lake Kondinin inflow	2006	23 346	1.10	0.009	9.29
			2007	–	–	–	–
LL29	Lockhart River	Kulin-Kondinin Rd	2006	30 955	1.20	0.019	9.32
			2007	–	–	–	–

Source: Department of Water, undated

1.4.4 Land tenure

The majority of the land in the Lockhart River study area is freehold land and used for agriculture, however there are a number of Crown reserves within or close to the floodplain. In most cases these reserves are salt lakes, although their vesting varies. Reserves that are vested for conservation and located within, or close to, the floodplain of the study area are shown in Table 2.

Table 2 Crown reserves close to the floodplain in the study area.

Site name	Name	Approx. distance and direction (km)	Size (ha)
Kurrenkutten (LR01)	Red Lake Nature Reserve	7km NE	54
	CR17299	3km NW	34
	CR14014	6km NW	38
	CR38507	6km W	42
	CR23263	9km S	67
	CR21194	10km S	230
Silvergate (LR02)	CR30324 (Lake Kurrenkutten)	5km NE	897
	CR38507	3.5km NW	42
	CR14014	7km N	38
	CR17299	6km NE	34
	CR23263	6km S	67
	CR21194	8km SW	230
	CR14101	10km SW	208

Site name	Name	Approx. distance and direction (km)	Size (ha)
Larke's (LR03)	CR17299	2km S	34
	CR30324 (Lake Kurrenkutten)	9km NE	897
	CR21194	4.5km SE	230
	CR14101	7km SE	208
	CR15057	9.5km E	80
Crossland (LR04)	CR23263	2.5km N	67
	CR21194	2.5km NE	230
	CR15057	9km NE	80
	Paperbark Nature Reserve	7.5km SE	120
	CR14101	5km E	208
Dickinson's (LR05)	CR23263	8km NW	67
	CR21194	5km NW	230
	CR14101	3km NE	208
	CR15057	5km NE	80
	Paperbark Nature Reserve	2.5km S	120
CR18455 (LR06)	CR21194	9.5km NW	230
	CR14101	7km NW	208
	CR15057	5km N	80
	Paperbark Nature Reserve	6km SW	120
Butler's (LR07)	Paperbark Nature Reserve	9km NW	120
	Kondinin Lake Nature Reserve	4.5km SE	1492
	CR10772	8.5km S	188
Kondinin Lake NR (LR08)	CR10772	8km SW	188
Poondarra (LR09)	Kondinin Salt Marsh Reserve	10km E	2240
Bowey's (LR10)	Kondinin Salt Marsh Reserve	7km E	2240

1.4.5 Post-clearing changes to naturally saline waterways

Naturally saline waterways still retain many natural, social, heritage and economic values. However these are under increasing pressure from threats arising from widespread land clearing.

Changes in the water balance

Land clearing has been extensive throughout the Wheatbelt, with only 13.5 per cent of pre-European vegetation extent remaining. Two of the three shires that this section of the Lockhart River pass through have a similar proportion of vegetation remaining (Kondinin 13.1 per cent and Kulin 12 per cent), with Corrigin only having 4.9 per cent remaining (Shepherd, Beeston & Hopkins 2002).

The remaining vegetation is now highly fragmented. Many of the threats facing this vegetation, including hydrological change, continue to modify these communities.

Prior to clearing, most of the rainfall intercepted would have been utilised by the vegetation, including drawing on reserves of groundwater over the summer. There was little surface runoff and it is likely that there were few well defined drainage lines in areas that are now streams (Davis 2004; Hatton, Ruprecht & George 2003).

After clearing, the pattern of rainfall use has changed to winter use only in areas with annual crops and pastures, and increased runoff. This has allowed runoff to increase fivefold and groundwater to recharge, filling deep sedimentary materials and bringing highly saline water to the surface (Davis 2004; Hatton, Ruprecht & George 2003).

Prior to clearing it is likely that salt lakes generally contained water for several months through winter and spring, although cyclonic rain occasionally filled the lakes in summer or autumn. Salinity levels would have been relatively low when the lakes were filled and increased as the lakes dried (Halse, Ruprecht & Pinder 2003). Increased runoff and groundwater discharge as a result of land clearing now means that the lakes are wetter for longer periods.

Salinity along the main Lockhart River channel is approaching equilibrium and the area within the main valley affected by salinity is not expected to significantly expand. However, additional salinisation is expected to occur in the tributary valleys and converge into the main valleys. These flat areas will be more prone to lateral expansion of salinity due to poor surface drainage and waterlogging (Leoni & Murphy-White 2005).

Acidification

Although surface water tends to be neutral to alkaline (pH 7-8), groundwaters in the eastern Wheatbelt and other areas with abundant salt lakes can be acidic, with pH readings of less than 4.5 (Rogers & George 2005).

The causes of groundwater acidification are poorly understood, however it is believed that high concentrations of dissolved iron in the groundwater, which reacts with oxygen in the atmosphere and causes iron precipitates and acidic hydrogen ions, is the cause of most acidification (Fitzpatrick et al. 2005).

While there is a low risk of increasing groundwater acidification in the South-

east Lakes subregion of the Avon River basin (McConnell et al. 2005), with rising watertables there is a threat of increasing interaction of acidic groundwater with surface environments. Deep drainage and groundwater pumping can also accelerate discharge rates and the mixing of acidic groundwater and more neutral surface waters.

There are some naturally acidic lakes in the Wheatbelt however secondary acidification still poses a significant threat to biodiversity, both in aquatic and riparian ecosystems. Low pH waters can leach high concentrations of naturally-occurring heavy metals such as aluminium, cobalt, copper, zinc and lead from soils (Fitzpatrick *et al*. 2005), which can be transported to, and accumulate in, aquatic environments.

Impacts on fringing vegetation

Saline lakes and waterways are a natural feature of the Western Australian landscape, and have lead to a high diversity of salt-adapted flora and fauna.

However, increased salinity and waterlogging, changed periods of inundation, increased nutrient loads and acidification have affected fringing and aquatic vegetation and their associated fauna.

Secondary salinisation has altered the environmental conditions of the fringing vegetation, which, prior to these changes, were adapted to fluctuating salinity and water levels. Now, permanent saline groundwater close to the surface has caused a decline in vegetation health and has changed the composition of vegetation communities.

Prior to clearing, wetlands would have had sheoak (*Allocasuarina* and *Casuarina* species), paperbark (*Melaleuca* species) and teatree (*Leptospermum* species) forming a dense canopy over low shrubs. Many wetlands would have had beds of sedges and rushes, with some having aquatic vegetation (Sanders 1991).

Increased salinity and waterlogging have lead to the death of much of the fringing vegetation, with salt and waterlogging-tolerant species colonising large areas: these would have previously been restricted to small patches. Samphire (*Halosarcia*) species have commonly replaced much of the fringing vegetation in the Wheatbelt.

Impacts on aquatic communities

Generally, species richness of aquatic macroinvertebrate communities decreases with increasing salinity. This is not always a linear relationship, and changes in hydrology and water condition can also significantly affect these communities. Altered communities are relatively homogenous, having similar composition throughout, compared with freshwater or naturally saline wetlands (Pinder *et al*. 2004).

The type of aquatic vegetation present changes with increasing salinity. Freshwater plants are first replaced by salt-tolerant submerged macrophytes, such as *Ruppia*

and water-mat *Lepilaena* species. As salinity increases, these are replaced with phytoplankton-dominated communities, then with benthic microbial mat-dominated communities characterised by cyanobacteria (blue-green algae) and halophilic (salt-tolerant) bacteria. This simplification tends to have a flow-on effect to other fauna in the food chain (Davis 2004; Strehlow *et al*. 2005).

2 Waterway assessment method

The method used for the waterway assessment has been developed by the Department of Water to gain an understanding of the current riparian condition and management needs of waterways in the zone of ancient drainage (Department of Water 2007a).

Vegetation condition was assessed using the methodology of Keighery (1994), which compares the current vegetation condition with the equivalent vegetation in pristine condition, with all structural layers intact, no impacts from threatening processes and all natural processes operating. All individual site assessments, included in Appendix 1, include a table of the Keighery bushland condition scores.

2.1 Site selection

Given the size of the floodplains in the zone of ancient drainage, which can be kilometres wide, the waterway assessment methodology relies on information collected at a number of representative sites rather than surveying the whole reach.

Ten survey sites were selected by the Department of Water from this section of the Lockhart River. These sites were selected to represent one or more of the following criteria:

- represented the full range of geomorphic features within the study area, for example salt lakes, areas of braided channels and areas with more defined channels
- had high environmental, social and/or cultural value, including nature reserves and lakes used for water-skiing
- contained vegetation communities in good or degraded condition.

Sites were selected using a number of tools, including aerial photography, cadastral information, anecdotal information and reconnaissance survey.

The locations of the study sites are included in Maps 3a and 3b, with descriptions of individual sites included in the relevant site report in Appendix 1.

2.2 Recording of survey information

To ensure consistency, information for each site was recorded on a standard survey form, which is included in Appendix 2.

2.2.1 Floodplain features

Floodplain features define the physical nature of the waterway and give indications of

habitat and potential management issues.

Natural and constructed features within the floodplain are identified, including playa lakes, channel forms, lunettes, tributaries, drains and dams. A list of definitions is included in the glossary, with illustrations of floodplain and channel forms available in Water and Rivers Commission Report No. RR17 (2002), which is available online.

2.2.2 Description of the riparian vegetation

Healthy undisturbed vegetation has an important role in maintaining waterway health. The wide array of plant species that comprise the fringing vegetation and their accompanying animal species, including birds, mammals, reptiles, frogs and invertebrates, have significant biodiversity value. The fringing vegetation also plays a significant role in providing habitat, including shade and shelter from exposed root systems, and food resources for aquatic ecosystems.

A comparison of the current condition and structure of riparian vegetation to its pristine state indicates how waterway condition has changed over time. Identification of threatening processes that have impacted on vegetation condition give an indication of why these changes have occurred, and how the vegetation may change in the future.

The Keighery bushland condition assessment method (Keighery 1994) used for this survey, which was originally designed to assess vegetation on the Swan Coastal Plain and determine management priorities, has been adapted for use in this area. The method does not require a high level of technical knowledge; however experience with a range of vegetation condition for each vegetation type will ensure more accurate allocation of condition type and allow the assessment to be more repeatable.

Pre-European vegetation types

Beard vegetation associations (Beard 1980; Shepherd, Beeston & Hopkins 2002), evidence collected during the survey and anecdotes from landholders are used to gain an understanding of the original pre-European vegetation at each site. Together, this information gives an indication of what the vegetation would have been like before clearing, and assists with assigning a vegetation condition score. As an example, a site which was once salmon gum woodland but is now a saltbush and bluebush shrubland, would indicate that the condition of this vegetation has declined significantly.

The Beard vegetation associations listed on the site survey report sheets are as mapped by Beard as the pre-European vegetation, and do not indicate that this vegetation still exists on the site.

Vegetation structure and cover

Vegetation structure is the plant form in each stratum, or layer, present in each vegetation community. Vegetation structures are combined with plant species names

to form a description of the vegetation community (vegetation association).

Crown cover, which can be described as the amount of shade, expressed as a percentage that each plant stratum would cast if the sun was directly overhead. To simplify the estimation of cover, cover classes are used rather than an actual percentage, which are then ascribed to a description: *closed* for 70–100 per cent vegetation cover, *open* for 30–70 per cent vegetation cover, *sparse* for 10–30 per cent vegetation cover and *very open* for 2–10 per cent vegetation cover. Vegetation with less than 2 per cent overall cover is not assessed.

A simplified version, omitting shrub height descriptions but retaining details of each stratum, of Muir (1977) vegetation descriptions are used throughout this report. Up to three dominant species are included in each stratum, however if more than three species are dominant, the stratum is described as ‘mixed’.

For each site assessed, an overall cover of each stratum (trees, mallees, shrubs etc) is included. This is a composite value estimated from all vegetated areas of the site, and does include a vegetation structure with an overall cover of <2 per cent if that structure occurs as a vegetation community. Bare areas, including lake beds, are not included in the overall cover estimate for the site.

Individual cover values for each vegetation association are included in the description for that vegetation.

Vegetation condition

Vegetation condition is assessed against an adapted version of the Keighery bushland condition scores (Keighery 1994), shown in Table 3 below. An additional category has been added to account for areas of revegetation.

Table 3 Vegetation condition scores, as adapted from Keighery (1994)

Condition	Description
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted
Pristine	No obvious signs of disturbance
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species
Very Good	Vegetation structure altered, obvious signs of disturbance
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management
Completely degraded	Vegetation structure no longer intact and the areas is without/almost without native species

An estimated overall percentage of the vegetated areas of each survey site that falls into each vegetation condition category is included in the site survey assessments in Appendix 1, which also include vegetation condition maps for each survey site. Note that only vegetated areas can be assessed for vegetation condition. Bare areas, as occur in salt lakes and stream channels, cannot be assessed for vegetation condition, unless there is evidence that vegetation used to occur there. Therefore it is likely, in these salinised and silted landscapes, that the percentage of the site that is *completely degraded* is always underestimated as we have no way of assessing aquatic vegetation that formerly existed when conditions were less saline.

Examples of each vegetation condition are shown in Appendix 3.

Vegetation condition is linked to disturbance factors, which are listed for each site, with the degree of threat they pose. Common disturbance factors which lead to a decline in vegetation condition include salinity and waterlogging (which, when combined, can be described as hydrological change), clearing, weed invasion, fires, feral animals and stock access.

Species presence

Plant species, both native and introduced, are also identified. This gives an indication of the plant species diversity present on each site, and may identify a potential species for riparian revegetation or potential management issues.

Where a plant cannot be identified to species level, that species is identified to the greatest level of certainty possible, which may be genus or family and described as ‘species’ instead of a full dichotomous name. ‘Species’ is abbreviated to ‘sp.’ for a single species and ‘spp.’ for more than one (plural) species. Particular attention was made to identifying the dominant plants used in the vegetation description.

Extensive flora surveys were not undertaken and only common plants were listed. This gives a snapshot of species present, but not a full flora inventory.

Plant names quoted in this report are correct at the time of writing, and are sourced from FloraBase (Western Australian Herbarium & Department of Environment and Conservation 2008) for scientific names and occasional common names, Bennett (1991) and Lefroy, Hobbs & Atkins (1991) for common names of native plants, and Hussey *et al* (2007) for common names of weeds.

2.2.3 Links to protected remnant vegetation

The approximate distance and direction to protected remnant vegetation within 10 km of each site is recorded (Table 2). Protected vegetation includes nature reserves and crown reserves vested for conservation purposes.

Links between remaining remnant vegetation is particularly important in a highly fragmented site like the Western Australian Wheatbelt. These links allow for fauna

and flora movement around the landscape.

2.2.4 Aquatic vegetation

Aquatic vegetation in the Wheatbelt is usually salt-tolerant submerged macrophyte communities, phytoplankton communities or benthic microbial mat-dominated communities. The diversity of macroinvertebrates present are often linked to the type of aquatic vegetation present, with higher diversity often associated with submerged macrophyte communities (Davis 2004; Strehlow *et al*. 2005).

Where aquatic vegetation was identified as present, the type was identified if possible.

2.2.5 Water quality data

Where lake or flowing water was accessible, water quality data (pH, salinity and temperature) was collected. Data collected during the survey is a 'snapshot' of water quality at the time of sampling and cannot be used to make comments on long-term trends.

2.2.6 Management

Information on current management activities such as fencing, revegetation and groundwater and surface water management, was collected. Any issues identified as requiring management were noted.

2.2.7 Fauna species

Extensive fauna surveys were not undertaken as part of this assessment, however where observed, these were noted. Fauna was observed either directly (by sight or sound) or indirectly (by the presence of scats, track or diggings).

Fauna observations provide a snapshot of species present, and are unlikely to provide a comprehensive list of species. This was especially true as hot and windy conditions were experienced at the time of survey and birds were often not moving, making observation and identification difficult.

The focus was on identifying bird species present as they are easier to find and identify than other types of fauna, they are a major component of most ecosystems and are sensitive to many kinds of disturbance (Birds Australia 2005).

Where possible, birds were classified as remnant-dependent or priority species, based on a classification used by Greening Australia Western Australia (2004) as an indication for the importance of the remnant for birds.

Fauna names used in this report are accurate at the time of writing and are taken from FaunaBase (Western Australian Museum 2008).

2.3 How is the information that is collected used?

In Section 4, the information collected during the survey is used to:

- draw conclusions about current riparian conditions
- identify issues impacting on current conditions
- make recommendations for management
- draw links to existing projects and programs within the Avon River basin that can aid waterways managers to improve the conditions of the Lockhart River.

3 Main findings and management recommendations

The results for each survey site, including maps of vegetation condition, are presented in Appendix 1.

While it cannot be confirmed, it is generally considered that the number of samphire species present on each site may indicate the time since the area has become suitable for colonisation by *Halosarcia* spp. Thus, while samphires were generally not identified to species, an estimate of number of species on each site was made.

3.1 Vegetation condition

There were no areas of *pristine* condition vegetation surveyed.

LR03 (Larke's) and LR05 (Dickinson's) were the only sites surveyed with any *excellent* condition vegetation. Both of these were woodlands on lower valley slopes rather than in the valley floor, and neither are grazed by livestock.

Very good and *good* condition vegetation tended to occur on the raised areas (lunettes and sandbars) within the valley floor. Higher lunettes with an elevation of over a metre tended to have vegetation in better condition than low lunettes, although this was not universal. Grazing also influenced the condition, with livestock grazing affecting soil surface condition and weed cover, which were contributing factors in assessing vegetation condition.

Most of the vegetation surveyed was in *degraded* or *completely degraded* condition. Virtually all low-lying floodplain vegetation was degraded, with most being samphire (*Halosarcia* spp.) dominated. Areas with sparse samphire and dead sticks, which indicate a former shrubby, probably *Melaleuca* spp. dominated vegetation, were assessed as *completely degraded*, as was vegetation that clearly had not included samphire in its pre-European state. Dense areas of samphire, without or only few dead sticks, or other species amongst the samphire, were assessed as *degraded.* These areas, prior to clearing, may have already had samphire present although likely at lower densities.

Sites illustrating the various conditions are displayed in Photos A3.1–A3.6 in Appendix 3.

Areas without any vegetation were not assessed for vegetation condition. This included playa lakes and bare stream channels, which have undoubtedly become more degraded since clearing, but not in terms of terrestrial vegetation.

An estimate of the area of vegetation in each vegetation condition category is shown in Figure 1 below. Although this figure is an estimate, based on an estimate

of percentage of each condition in each remnant and an estimate of the proportion of vegetated area in each remnant, it clearly shows that most of the vegetation surveyed in the study area is in degraded or completely degraded condition. In most cases, the vegetation has been assessed as degraded or completely degraded because of the loss of native species, which have either not been replaced by anything (largely bare areas formerly supporting vegetation), or have been replaced by salt-tolerant species (where they probably would not have been present or only at low densities) or weeds.

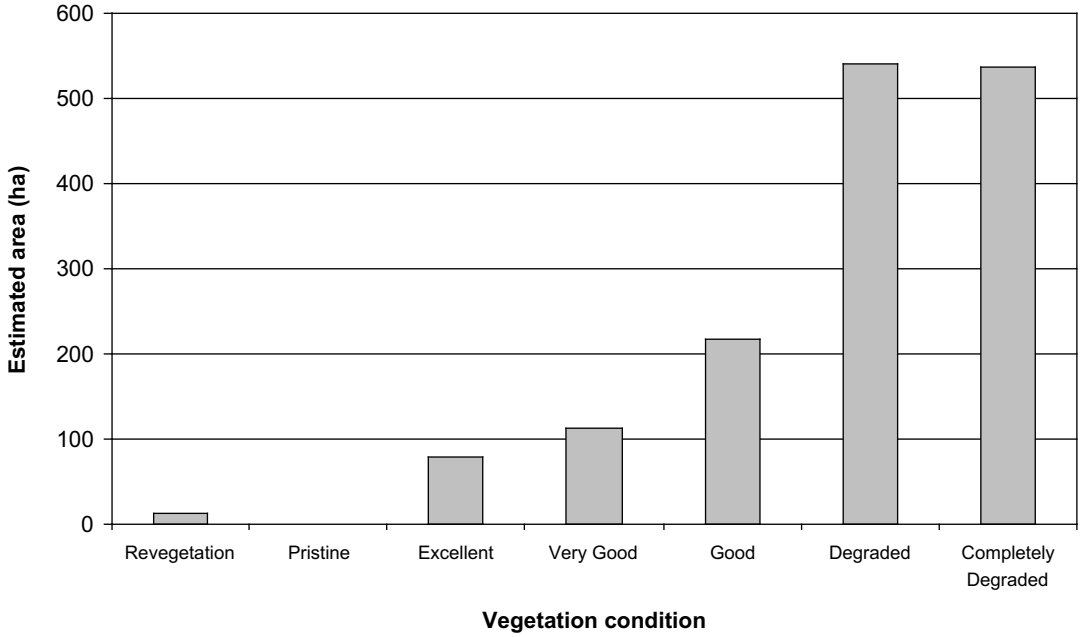

Figure 1 Estimated area of vegetation surveyed within each vegetation condition rating.

The amount of *degraded* and *completely degraded* vegetation present in the lower part of the landscapes indicates that significant changes affecting vegetation condition have occurred within the Lockhart River system. Increases in salinity, changes to the watertable and changes to period of inundation, all a result of widespread clearing for agriculture, are the most obvious causes of change.

Prior to clearing, the pre-European vegetation in these low-lying areas was mostly samphire (*Halosarcia* spp.) fringing the playa lakes and channels and on the flatter areas of the floodplain (Beard 1980; Shepherd, Beeston & Hopkins 2002). Slightly further upslope were woodlands, often yorrell (*Eucalyptus yilgarnensis,* but also probably including *E. myriadena*), and Kondinin blackbutt (*E. kondininensis*) over teatree (which may refer to *Melaleuca* spp. or *Leptospermum* spp.) and samphire. Slightly further upslope again were a variety of woodlands, including salmon gum (*E. salmonophloia*), gimlet (*E. salubris*), York gum (*Eucalyptus loxophleba* subsp. *loxophleba*), or wandoo (*E. capillosa*), or mallee scrub.

Most of these vegetation types (except wandoo, which was not seen at all in this area) are still present, although often degraded, with many dead trees and shrubs present.

3.2 Management issues

Management issues impacting on the Lockhart River, as identified from the site surveys, are:

- increased salinity, higher watertable and longer periods of inundation in the valley floor
- loss of fringing riparian vegetation, especially around the edges of the larger lakes
- further clearing, including for sand extraction
- impedance of flood waters by road crossings
- pest species degrading riparian vegetation
- stock access, particularly causing soil erosion
- weed invasion
- lack of corridors linking areas of remnant vegetation
- fire risk
- rubbish dumping in floodplain areas.

The most challenging issues to address, and requiring the most management, are hydrological in nature (salinity, watertables, inundation). Implementing many of these management recommendations has multiple benefits. For example, fencing tributaries, excluding livestock and revegetation along the Lockhart River and tributaries will improve bank stability, reduce sedimentation, improve water quality and contribute to biodiversity conservation by facilitating the distribution of flora and fauna through the landscape.

These, and other management issues, are discussed below.

Implementation of these management recommendations will be through partnerships between waterways managers including Department of Water, DEC, ACC, AWC, landholders, local Shires and community groups using a wide variety of funding sources.

3.3 Salinity and waterlogging

Increasing salinity levels and waterlogging, including increased periods of inundation (hydroperiod), are the most significant threats in the Lockhart River floodplain. These changed conditions have already had a significant impact on the Lockhart River floodplain and have affected vegetation condition, water quality, infrastructure and farm economics.

Research has shown that different approaches are required for different types of salinity impacts, and there is no ‘one-size-fits-all’ solution or management that is suitable for all situations.

An example of an integrated approach to managing salinity at a catchment scale is the Wallatin/O'Brien Catchment Demonstration Initiative (CDI), located near Kellerberrin in the Yilgarn River catchment. The CDI is a project to plan and implement actions to tackle salinity at a catchment scale. It aims to demonstrate salinity management practices to recover saline land, reduce salinity risk and allow for the profitable use of saline areas. A number of projects are being implemented across the catchment including:

- investigation of groundwater yields and salinity from sand seams in the valley floor
- establishment of saltland pastures in the valley floor
- planting deep-rooted fodder crops in recharge areas
- construction of a deep drain
- upgrading of a culvert on O'Brien Creek to reduce localised flooding and sedimentation problems
- surface water management
- revegetation of riparian zones.

The following sections give a brief overview of some options for salinity management, including engineering works and revegetation.

3.3.1 Engineering options

Increasing numbers of land managers are considering engineering works, including deep drains, groundwater pumps and surface water management, to reduce waterlogging and lower soil salinity.

There are widely differing opinions regarding the scale at which engineering options should be implemented. One point of conjecture is the eventual fate of the discharge water, with some favouring containment on-farm, whilst others consider significant arterial drainage networks should be established for the eventual disposal of discharge into the ocean.

The Lockhart River catchment, in general, consists of low gradient slopes (less than three degrees gradient), the surface drainage is poor and the risks associated with slow or impeded water movements are increased (Leoni & Murphy-White 2005).

This lack of gradient is likely to impose restrictions on engineering solutions to reduce the affects of salinity and waterlogging.

Notices of intent (NOI) to construct deep drains or pump groundwater are a legal requirement under the *Soil and Land Conservation Act 1945* (WA) and must be submitted to the Commissioner for Soil and Land Conservation. Recent changes to the *Environmental Protection Act 1986* (WA), which prevent environmental harm

due to inappropriate disposal of drainage waters, must also be considered prior to groundwater pumping.

The Department of Agriculture and Food (DAFWA) has developed a set of best management practice standards for conservation earthworks. These publications outlines design criteria, suitable conditions for construction and placement, planning considerations, legal aspects, environmental aspects and operation and maintenance and construction guidelines for various eartherworks, including grade banks, grassed waterways and drains (Department of Agriculture, various).

Engineering evaluation and implementation in the Wheatbelt

The Engineering Evaluation Initiative (EEI) was a state government commitment to deliver better engineering approaches to managing salinity in the Wheatbelt. The main object of the EEI was to review current knowledge on engineering options to mitigate dryland salinity and clarify 'best practice' by establishing demonstration sites for a range of engineering options.

The EEI had three main programs:

- evaluation of specific engineering options, including groundwater pumping, siphon and relief bores, deep drains and surface water management
- safe disposal, including natural disposal sites and engineered disposal/re-use
- regional drainage planning.

Information on the EEI is available through the Department of Water website <www.water.wa.gov.au>

The Wheatbelt Drainage Evaluation (WDE) was established in 2005 as part of the National Action Plan for Salinity and Water Quality, and is due for completion in June 2008. Although the focus of the WDE is on the Yenyening and Yarra Yarra catchments, other parts of the project include a review of Wheatbelt drainage governance and management, a study of options for treatment of acidic groundwater discharge and a project to classify Wheatbelt wetlands.

The WDE project may have implications for water management in the Lockhart catchment, especially as it is upstream from Yenyening.

Deep drainage

Deep drains collect and transport groundwater, and at times surface water, across the landscape to detention basins or into natural wetlands and waterways. They are typically used where the natural drainage system is unable to remove excess water and salt and the resultant waterlogging and salinity have a significant impact on agricultural production.

Deep drains are most effective where they are constructed to intercept the watertable, allowing groundwater to flow into the drain from the surrounding saturated soil. They are also more effective where they intercept more permeable soils (such as clay overlying permeable saprolite, sandy sediments and clays with preferred pathways such as sand seams) and where the groundwater recharge rate (the rate at which water reaches the watertable) is lower than the drainage rate (Department of Water, 2007b; Leoni & Murphy-White 2005).

Prior to constructing deep drains, it is important to consider drain design and the safe disposal of discharge waters to prevent downstream impacts on the environment, farmland, water supplies and infrastructure such as roads and bridges. If deep drains are to also conduct surface water, they must be designed to do so.

Groundwater pumping

Groundwater monitoring bores in the Lockhart River catchment have all yielded highly saline water (up to 8 000 mS/m) (Leoni & Murphy-White 2005).

Groundwater pumping to manage salinity aims to remove groundwater from the aquifer, maximising the drop in the watertable level while minimising the volume of groundwater that is pumped. Once the groundwater level has dropped, it stops discharging to the soil surface and into waterways and reduces the impacts of salinity and waterlogging (Department of Environment, 2004).

The effectiveness of groundwater pumping in lowering the watertable depends mainly on the characteristics of the aquifer and is also influenced by the number of bores that are installed. It is generally considered to be more effective on lighter-textured soils, where water and salts drain more quickly. Groundwater pumping can be very expensive but may be more economic than other engineering strategies in protecting high-value assets. As with the construction of deep drains, it is important to consider the safe disposal of the pumped groundwater to prevent downstream impacts (Leoni & Murphy-White 2005; Department of Environment 2004).

Surface water management

Surface water management uses earthworks, such as grade and interceptor banks, shallow drainage channels and dams, to capture surface runoff and subsurface flow higher in the landscape, to reduce recharge in valley floors.

Surface runoff is usually relatively fresh and can be intercepted and used to improve farm water supplies.

3.3.2 Revegetation

Revegetation can be used in a variety of ways to either intercept surface flows or utilise soil water reserves, thus reducing discharge, and for biodiversity and

conservation reasons.

Strategic revegetation can be used to:

- reclaim hillside seeps and sandplain seeps by planting upslope, thus reducing groundwater recharge and discharge downslope
- provide linkages in the landscape between areas of remnant vegetation, which may then be used as wildlife corridors
- reduce soil erosion on stream banks, especially when combined with fencing and stock exclusion
- filtering sediments and nutrients from surface flow
- provide buffers between existing vegetation and farmland, including intercepting agricultural sprays
- for biodiversity, agricultural and commercial reasons.

Biodiversity plantings

Planting local native species for biodiversity and conservation includes planting corridors of plants to provide linkages in the landscape and to provide buffers between remnant vegetation and farmland. Many local native species are suitable for revegetation, and planting a diverse range of plants, both in species and form (e.g trees, shrubs, grasses and herbs) provides a greater biodiversity benefit.

There are local species that are suitable for most conditions found in the catchment: a list of suggestions is found in Appendix 4.

Commercial plantings

There are a wide range of species suitable for commercial plantings on recharge areas in the Wheatbelt. These include *Eucalyptus* species, including oil mallee species, tagasaste (*Chamaecytisus palmensis*), *Acacia* species, *Melaleuca* species and sandalwood (*Santalum spicatum*), all of which have economic benefits either as a commercial crop for wood, brush or seed, or as fodder.

Commercial plantings in slightly saline to moderately saline discharge areas include saltland pastures, usually saltbush (*Atriplex* spp.) and bluebush (*Maireana* spp.). Understorey plants including puccinellia (*Puccinellia ciliata*), which is tolerant of waterlogging but less tolerant of salinity, and tall wheatgrass (*Thinopyrum elongatum*) are both planted to increase the nutritional value of saltland pastures.

There are some limitations associated with commercial plantings including potential placement of the crops in terms of soil types and site conditions (including water logging, salinity, fertility, and soil acidity), oil mallees are dependent on processing plants becoming established, there is only a small market for broombush fencing, and the time taken for these to become an economic proposition.

Appendix Five contains a list of plants suitable for saltland grazing.

3.3.3 Recommendations for the management of salinity and waterlogging

Salinity and waterlogging are processes that require management at a catchment scale.

A variety of general management recommendations are proposed to allow for tailoring of solutions to various problems, including:

- retention of surface water higher in the catchment, if suitable, to slow recharge in the valley
- revegetation along tributaries to slow movement of surface water onto the valley floor without increasing flood risk, and to trap sediment before it reaches the lower slopes, to reduce sedimentation of the river (which impedes river flow)
- evaluation of revegetation options, including agroforestry and saltland pastures
- identification of recharge areas that are suitable for revegetation for local watertable control
- groundwater and surface water quality and quantity to continue to be monitored as part of ongoing water quality monitoring programs.

3.4 Impedance of flows by road crossings

Approximately 0.12 percent of main roads and 2 percent of local roads in the greater Lockhart River catchment are within low-lying areas and may be susceptible to flooding, waterlogging and salinity. The annual cost of repairs and maintenance due to salinity of these roads was assessed in 2003 as $20 000 per kilometre for main roads and $6 600 per kilometre for local roads (Leoni & Murphy-White 2005).

Additional costs would apply to repairing roads washed away or damaged by flood events.

Low gradients contribute to slow streamflow through the Lockhart River. Narrow road crossings may impede river flow and lead to ponding, exacerbating local waterlogging problems. Additionally, subsurface compaction to create a stable road base interferes with sub-surface flows, further contributing to ponding problems.

There are several road crossings within the Lockhart River study area, including Williams-Kondinin Road (also known as Kulin-Kondinin Road), Kondinin Lake Road, Corrigin-Kondinin Road, Koorikin Road, Bonds Road, Bendering Road, Nambadilling Road and Bruce Rock-Corrigin Road.

Not all of these road crossings were examined for evidence of impedance of water flows, however the Kondinin Lake Road crossing has been washed away in the last two major floods (local landholder pers. comm.), and deep gullies on the upstream

side of the Lockhart River at the Corrigin –Kondinin Road crossings were observed (in Site LR07).

It is unlikely that any of the road crossings restrict flow during normal rainfall years, however during flood events they appear to cause impedance of water flow, resulting in structural damage to the roads. It is possible that ponding may occur after flood events. However, in most cases there is little vegetation that may be affected by any ponding if it does occur.

3.4.1 Recommendations for the management of flood flows

It is the nature of waterways in the zone of ancient drainage to retain water in the valley floors, including the lakes along the waterway, however road crossings may contribute significantly to localised flooding. The recommendations proposed for flood management are to:

- evaluation of road crossings in terms of flood risk
- analysis of costs and benefits associated with upgrading pipes and culverts to increase water flow through road crossings where significant flooding problems are evident.

3.5 Tributaries

It is recognised that additional salinisation is expected to occur in the tributary valleys that lie perpendicular to and converge into the main valleys in the Lockhart River, due to poor surface drainage and waterlogging (Leoni & Murphy-White 2005).

It was observed during the field survey that most tributaries are not well defined, and tend to be broad flat expanses covered with samphire (*Halosarcia* spp.). Exceptions occurred if the tributaries entered a salt lake: these tended to be more well-defined. All tributaries and the main channel and lakes, except site LR07, showed signs of sedimentation and silting.

All tributaries would benefit from revegetation using local native species and fencing from grazing. The plant roots would bind the soil and plant stems would slow the velocity of water flow into the tributary, decreasing water erosion and reducing sedimentation. Rocks or logs placed in the channel may also slow the velocity of water flow by providing a riffle effect.

An example of the difference native vegetation makes to a tributary can be seen in the aerial photograph of Site LR03 (Larke's) where a tributary flows from the west towards Lake Pickersgill. The stream is visible in the paddock as a white saline line, which almost disappears and becomes indistinct when it enters the woodland. There is now some revegetation along this streamline, which may have had an influence on salinity and sedimentation, however hydrology at this location may also be confounded by the presence of a dolerite dyke.

3.5.1 Recommendations for tributary management

To reduce soil erosion and sedimentation and increase the value of tributaries as landscape links, the following recommendations are proposed:

- revegetation along tributaries using native local species to provide corridors linking areas of remnant vegetation higher in the landscape with riparian areas
- revegetation with local native species to improve bank stability thus reducing soil erosion and sedimentation
- fence tributaries to avoid damage to the soil surface by livestock
- installation of riffles, where appropriate, to reduce flow velocity and trap sediments before they reach the floodplain.

3.6 Management of remnant vegetation

The Western Australian Wheatbelt is a highly fragmented landscape, with remnant vegetation occupying only a small proportion of its previous extent. The size, shape and condition of patches of remnant vegetation varies considerably in both private and public lands.

There have been significant changes in the composition of remnant vegetation since clearing, particularly in the floodplain where many species have since disappeared, like *Melaleuca* and *Leptospermum* species, which have been replaced with salt-tolerant species like *Halosarcia*. Changes in salinity and waterlogging are the main cause, however other effects of land use change, like grazing, may also be a factor.

Connections between remnants are very important to allow species to disperse across the landscape. In most cases there is linkage remaining along the Lockhart River, although this is often degraded and narrow, especially in the central part of the study area where the main channel lies along an east west axis. However there is far less linkage between the river and remnants higher in the landscape.

Remnant vegetation on public land vested for conservation is protected from clearing, but is not immune from degradation due to environmental conditions including salinity and waterlogging. Two of the study sites are vested for conservation (Lake Kurrenkutten Nature Reserve LR01 and CR 18455 LR06), and one is vested for recreation and conservation (Lake Kondinin Nature Reserve LR08). Additionally, one of the privately owned remnants (Dickinson's LR05) is protected under a conservation covenant, which will prevent clearing under current and future ownership.

Excellent condition vegetation was only observed on two sites, Dickinson's LR05 and Larke's LR03, both of them privately owned and neither of which are grazed.

3.6.1 Recommendations for remnant vegetation management

To manage remnant vegetation and improve landscape linkages in the Lockhart River catchment, the following recommendations are proposed:

- *good* or better condition vegetation should be fenced to exclude livestock grazing
- strategic enhancement of remnant vegetation by planting tree and shrub seedlings within the remnant, if the causes of degradation have been reduced sufficiently to consider that the seedlings could survive but natural regeneration has not occurred
- encourage landholders to value their remnant vegetation and suggest a suitable conservation covenant scheme for better condition vegetation
- rabbit control should be undertaken, particularly if a fire is experienced in remnant vegetation, to allow natural regeneration of plant species
- plant buffers of vegetation along the edges of remnant vegetation, either mixed native species or species suitable for saltland grazing; to provide a buffer between the remnant and agricultural activities
- identify areas of private land that can be revegetated to create or enhance links between the remnant vegetation
- prevent future sand extraction
- investigate reconstruction of landscape links along public lands, such as road reserves.

3.7 Riparian vegetation

Riparian vegetation in the Lockhart River catchment is mainly samphire (*Halosarcia* spp.), however there are various combinations of *Eucalyptus* spp. woodlands occurring on lunettes and occasional areas where the previously common *Melaleuca* spp. shrublands still survive.

Revegetating floodplain areas with local native species can have a number of benefits, including:

- localised salinity control
- conservation and biodiversity benefits
- filtering and removing nutrients and sediment from surface runoff
- improved aesthetics.

Appendix 4 includes several species that are suitable for revegetation in the Lockhart catchment, however it is especially important to tailor selection of revegetation species in riparian areas to the current site conditions. It must be taken into account that increased salinity, waterlogging, changed periods of inundation, reduced water

quality and weed cover have altered, and will continue to alter, site conditions. Time and budget constraints, including the costs of fencing and seedlings, are also factors to consider in choice of revegetation projects.

3.7.1 Recommendations for riparian vegetation

Recommendations to enhance the condition of riparian vegetation, and to create and strengthen environmental linkages between good quality riparian areas and other remnant vegetation, are suggested below:

- encourage natural regeneration and reduce soil degradation and erosion of riparian areas by using fences to exclude livestock
- investigate riparian areas suitable for revegetation with local native species
- consider strategic revegetation within riparian remnants, including planting on lunettes to replace plants killed by recent floods
- fence revegetated areas to exclude livestock
- prevent future sand extraction from lunettes
- consider planting saltland grazing species adjacent to fenced riparian areas.

3.8 Fencing and stock access

Significant areas in the greater Lockhart River catchment have been affected by soil degradation, including 62 per cent of the catchment affected by subsurface compaction, 53 per cent by soil structure decline, 50 per cent by subsurface acidification, 46 per cent by wind erosion and 44 per cent by water repellancy (Leoni & Murphy-White 2005). Although not all of these soil degradation hazards affect the floodplain and there is no data in this publication to separate the floodplain from other landscape areas, it is clear that some of these hazards are relevant to the floodplain.

Soil structure decline, wind erosion of fine soil particles and water erosion were all observed in the floodplain and are all exacerbated by livestock trampling.

Many areas surveyed were grazed by livestock for part of the year, particularly summer and autumn to fill the feed gap at that time. Damage to the soil surface, which leads to erosion, was observed, which compounds the soil structural decline that has resulted from increased salinity. Natural regeneration is also likely to be affected by livestock grazing. Faeces and urine are likely to be adding to the nutrient loads in the waterways. An example of this was seen in LR03 (Larke's), where samphire appears to have been killed as a result of being smothered by an algal bloom after the last floods (Photo 1).

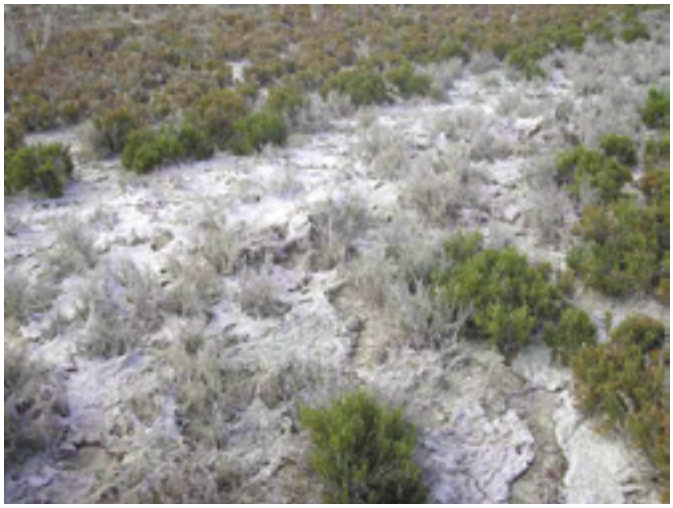

Photo 1
Samphire killed after being smothered by an algal bloom (Larke's LR03)

3.8.1 Recommendations for fencing

The following recommendations are proposed:

- *good* or better quality vegetation is fenced to exclude livestock grazing and allow natural regeneration
- areas where soil degradation is observed should be fenced to exclude livestock grazing to prevent further degradation and erosion
- revegetation should be fenced
- tributaries and lunettes associated with lakes should be fenced to exclude livestock and improve bank and dune stability.

3.9 Pest species

Introduced animal pest species are very common in the Wheatbelt. Rabbits (*Oryctolagus cuniculus*) were present on all sites. Signs of foxes (*Vulpes vulpes*) were commonly observed, however they are likely to be present in all remnants, as are feral cats (*Felis catus*), of which there were no observations.

Introduced plant pests (weeds) were present on all sites: 25 species were identified during the field survey. While there were no serious weeds as declared under the *Agriculture and Related Resources Protection Act 1976* (WA), there was one weed listed as high risk by the *Environmental Weed Strategy of Western Australia* (CALM 1999): wild turnip *Brassica tournefortii*.

However, field observations have indicated the most serious and common weeds to be slender iceplant (*Mesembryanthemum nodiflorum*), red brome (*Bromus rubens*), annual ryegrass (*Lolium rigidum*), silver grass (*Vulpia myuros*) and coast barbgrass (*Parapholis incurva*). Weed species are often a result of soil disturbance, and their presence often reduces natural regeneration of native species. Slender iceplant

and coast barbgrass are indicators of a salinising landscape, and will persist in salty situations.

A list of all pest species encountered during the field survey can be found in Appendix 6.

3.9.1 Recommendations for the management of pest species

The following recommendations for the management of pest species are proposed:

- monitor and manage rabbit and fox populations by using a co-ordinated baiting program on both private and public lands
- target local rabbit populations after a fire in remnant vegetation to allow natural regeneration
- remove weeds from an area prior to revegetation by proper soil preparation and weed control in the year before planting.

3.10 Flora and fauna

Eighty four commonly occurring native plants were identified during the field survey. Whilst this is not a high number, it is only for commonly occurring plants and is not a complete flora list, nor does it identify many genera to species level (including *Halosarcia,* of which there were approximately six species, and many of the native grasses which did not have the seeds required for identification at the time of survey). Common species included samphires (*Halosarcia* spp.), saltbushes (*Atriplex* spp, particularly *A. paludosa*), ruby saltbush (*Enchylaena tomentosa*), rhagodia *(Rhagodia preissii*), and round pigface (*Disphyma crassifolium*), with salmon gum (*Eucalyptus salmonophloia*) the most common eucalypt.

Thirty one bird species were identified during the field survey, however this did not include a large mixed-species flock of waterbirds on Lake Kurrenkutten that were too far away to be identified. It should be noted that the field survey occurred in November during a period of particularly hot and windy weather, and in several sites there were very few birds observed.

The most common birds encountered were the Australian ringneck parrot, also known as the twenty-eight parrot (*Platycercus zonarius*), the Australian pipit (*Anthus australis*) and crested pigeon (*Ocyphaps lophotes*), all of which are common farmland species.

Three priority bird species, a fairy wren species (*Malurus* sp.), red-capped robin (*Petroica goodenovii*) and jacky winter (*Microeca fascinans*) were observed. Priority birds are those that will be lost from the landscape if nothing is done to protect and enhance their habitat (Greening Australia Western Australia 2004). The jacky winter is also described as a declining species by Saunders and Ingram (1995).

Several thornbill species (*Acanthiza* spp.), the grey butcherbird (*Cracticus torquatus*), singing honeyeater (*Lichenostomus virescens*), striated pardalote (*Pardalotus striatus*), weebill (*Smicrornis brevirostris*) and white-browed babbler (*Pomatostomus superciliosus)* are described as remnant dependent, which indicates that they are likely to decline in number if remnant vegetation is lost or degrades (Greening Australia Western Australia 2004).

The presence of these species indicates that the remaining remnant vegetation, including riparian vegetation, is important for bird habitat.

The only native mammal observed was the western grey kangaroo (*Macropus fuliginosus)*, which is described as *abundant* in Strahan (1995). It was observed, or signs of its presence were seen, on every site.

Only three reptiles were observed: the bobtail (*Tiliqua rugosa*) was the most common, with the western blue tongue (*Tiliqua occipitalis*) and black-headed monitor (*Varanus tristis)* on one site each.

A full list of native flora and fauna species is found in Appendix 6.

3.10.1 Recommendations for flora and fauna conservation

The following recommendations for the conservation of native flora and fauna are proposed:

- fencing from grazing and preservation of areas of *good* or better condition vegetation, as these are likely to have the most plants and native animal species
- identify areas suitable for revegetation to provide links between areas of good quality remnant vegetation
- use local native species, including trees, understorey and groundcover plants, where possible and appropriate for revegetation
- retain fallen logs and branches within remnants to provide habitat for birds and reptiles
- avoid moving loose sheets of granite from exposed rocks as these provide habitat for reptiles
- plant buffer areas of revegetation beside remnant vegetation to protect the remnant from agricultural chemical sprays
- control weeds adjacent to the remnant, and within if possible
- eradication of pest animal species.

3.11 Fire risk

Remnant vegetation can be threatened by fires originating from stubble fires or by lightning strikes. It is unlikely that samphire vegetation will burn, however woodlands

and shrublands are vulnerable.

Through the *Bush Fires Act 1954* (Government of Western Australia) and local government fire plans, landholders are responsible for maintaining fire breaks on their property, with DEC responsible for fire breaks and fire access tracks on DEC-managed land.

3.12 Rubbish

Several areas of rubbish dumping were observed during the field survey. In most cases the dumps were of old fencing material and building material which, while unsightly, do not pose an environmental hazard.

Dumping of chemicals, chemical containers, household refuse, fuels and oils or vehicles may pose a threat to the environment, especially in waterways where pollutants can be spread through the environment.

Any dumped rubbish may be washed downstream during a flood event and may be hazardous if it blocks water flow, therefore dumping of any rubbish in or close to waterways should be prevented.

3.12.1 Advice for rubbish management

Under the Western Australian *Litter Act 1979* (Government of Western Australia), dumping rubbish on Crown lands, including road reserves, council lands and nature reserves, is illegal and can be reported to the local Shire or DEC office.

Clean, rinsed empty farm chemical containers can be disposed of through the *drumMuster* programme. Corrigin, Kondinin and Kulin shire councils all participate in *drumMuster*, and should be contacted for details.

Glossary

Acid(ic)	See pH.
Alkaline	See pH.
Alluvial	Transported by water flow processes, for example ‘alluvial plain’.
Alluvium	Sediment deposited by flowing water.
Anabranching	Anabranching rivers are characterised by a network of diverging and converging channels separated by large, long-lived islands that are inundated only by floodwaters.
Aquifer	A layer of rock or soil capable of receiving, storing and transmitting quantities of water.
Braided river / channel	A braided river is characterised by numerous, interlaced channels that divide and rejoin around unstable bars and small islands.
Catchment	The area of land which intercepts rainfall and contributes the collected water to a common point through surface and groundwater.
Confluence	Flowing together or intermingling, for example where a tributary joins the main river channel.
Discharge	Volumetric outflow rate of water, typically measured in cubic metres per second. Applies to both groundwater and surface water.
Discharge area or zone	Area where groundwater discharges to the surface.
Ecosystem	A biological community of interacting organisms and their physical environment.
Floodplain	A broad, flat, low-lying area of land within the valley floor that is inundated during a 100-year flood. Includes the floodfringe and floodway.
Flood – 100 year	The 100-year flood has a statistical probability of occurring, on average, once every 100 years. The 100-year flood level is the contour to which this flood will rise.
Floodfringe	The area of the floodplain, outside of the floodway, that is affected by flooding.

Floodway	The river channel and portion of the floodplain which forms the main flow path for flood waters once the main channel has overflowed.
Geomorphology	The study of the origin, characteristics and development of landforms.
Gigalitre (GL)	1 000 000 000 litres or 1 million cubic metres or 1 million kilolitres (kL).
Gilgai	An area where the land surface is irregular with alternating mounds (puffs) and depressions (hollows) and is commonly referred to as ‘crab hole’ country. Gilgai microrelief is formed due to clay horizons shrinking and swelling with alternate drying and wetting cycles.
Groundwater	Water which occupies the pores and crevices of rock or soil.
Hydrology	The study of water, it’s properties, distribution and utilisation, on and below the earth’s surface.
Kilolitres (kL)	1000 litres or one cubic metre.
Kilotonne (kt)	1 000 000 kilograms or 1000 tonnes.
Macroinvertebrates	Aquatic invertebrates (animals without backbones) that are retained on a 0.25 mm mesh net and therefore big enough to be seen with the naked eye.
Natural resource management	The ecologically sustainable management of the land, water, air and biodiversity resources for the benefit of existing and future generations.
Nutrient load	The amount of nutrient (usually nitrogen and/or phosphorus) reaching a waterway over a given time period from its catchment area.
pH	The concentration of hydrogen ions in solution that indicates the acidity or alkalinity in water. A pH value of 7 is neutral, above 7 is alkaline and below 7 is acidic.
Recharge	Volumetric inflow rate of water to an aquifer, typically measured in cubic metres per second.
Recharge area or zone	An area through which water percolates to replenish (recharge) an aquifer. Unconfined aquifers are recharged through rainfall. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Remnant vegetation	An area of vegetation remaining after a major disturbance, such as land clearing.

Riparian zone	The riparian zone includes the floodplain and adjacent verge. The width of the riparian zone varies greatly, from 10s of metres to kilometres, depending on the type of waterway and its catchment.
Riparian vegetation	Vegetation growing within the riparian zone.
River basin	The area drained by a waterway and its tributaries (see Catchment).
Runoff	Water that flows over the soil surface when rainfall is greater than the infiltration capacity of the soil. Flow in waterways results from rainfall runoff.
Salinity	A measure of the total soluble (dissolved) salts in water. Commonly measured in terms of total dissolved solids (TDS) in milligrams per litre (mg/L), or electrical conductivity, in millisiemens per metre (ms/m) or millisiemens per centimetre (ms/cm). Water resources are classified as fresh, marginal, brackish or saline on the basis of salinity.
Salinisation	An increase in the concentration of soluble salts in soil or water.
Sediment load	The amount of sediment reaching a waterway over a given time period from its catchment area. Also refers to the amount of sediment being transported by a waterway.
Sp.	Species (singular), usually used when the plant or animal is identified to genus level but not identified to species level.
Spp.	Species (plural): a group of plants or animals of the same genus.
Surface water	Water flowing or held in waterways.
Tributary	A waterway that flows into a larger waterway.
Verge	Upland area adjacent to the floodplain.
Water quality	The physical, chemical and biological measures of water.
Waterlogging	Excess water close to the soil surface.
Watertable	Saturated level of unconfined groundwater. Wetlands in low-lying areas may be surface expressions of groundwater.
Waterway	Surface water bodies, including streams, rivers, lakes, wetlands, estuaries, coastal lagoons and inlets. Can be seasonally or permanently inundated.

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Appendix 1 Site survey reports

Site LR01 – Lake Kurrenkutten

General details	
Site name	Lake Kurrenkutten
Landholder	DEC
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	12-11-2007

Site description	
Landform	The site, which is confined to the Lake Kurrenkutten Nature Reserve boundary, consists mainly of a large salt lake, which was mostly open water and bare salt flats at the time of survey. There is samphire around the edges and on emergent sand banks, which run in series roughly parallel with the lake edges, particularly along the eastern side. There are some areas of woodland on low dunes (>1m height) around the lake with areas of samphire in the swales between the dunes. There are additional areas of vegetation not included within the site and therefore not surveyed, mostly on the eastern side of the Reserve. The Lockhart river enters the lake near the south-western corner of the reserve, and exits near the northern (narrower) end.
Site size	897 ha

Beard vegetation description (from pre-European vegetation associations)
Beard vegetation association 8: Medium woodland; salmon gum and gimlet
Beard vegetation association 125: Bare areas; salt lakes
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus salmonophloia, E. salubris, E. loxophleba, E. myriadena*
Mallees	<2%	*Eucalyptus* sp.
Shrubs	10-30%	*Halosarcia* spp, *Atriplex* spp.
Grasses	<2%	*Austrostipa elegantissima*
Herbs	10-30%	**Mesembryanthemum nodiflorum, Disphyma crassifolium, Sclerolaena diacantha*
Rushes and sedges	0	
Litter	2-10%	
Bare Ground	30-70%	
Rock outcrop	0	
Summary		
Bare ground, including the salt lake and water, accounts for most of the surface cover for the site. The lake edges and sand banks, and inlet channels on the south-eastern corner of the lake are fringed by several species of *Halosarcia* (samphire). The higher area near the northern end of the lake is very sparse salmon gum, gimlet and York gum woodland over very sparse hakea and saltbush shrubs. The dune area (lunettes) on the east of the lake is very sparse *Eucalyptus myriadena* woodland over sparse saltbush, with samphire in the swales. There are a few areas of mallee (not recorded as a vegetation unit due to their small size, as well as mostly being outside of the survey area) on some of the lunettes on the western side.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus salmonophloia, E. salubris* and *E. loxophleba* very sparse woodland over very sparse *Hakea kippistiana* and *Atriplex* sp. shrubs over open **Mesembryanthemum nodiflorum* herbs.
Vegetation 2	*Halosarcia* spp. sparse shrubland over sparse **Mesembryanthemum nodiflorum* and *Disphyma crassifolium* herbs.
Vegetation 3	*Eucalyptus myriadena* very sparse woodland over sparse *Atriplex* sp. shrubs over very sparse *Sclerolaena diacantha* herbs.

* Introduced species

Native species	
Scientific name	**Common name**
Atriplex holocarpa	Pop saltbush
Atriplex paludosa	Marsh saltbush
Austrostipa elegantissima	Feather spear-grass
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eucalyptus loxophleba	York gum
Eucalyptus myriadena	Eucalypt
Eucalyptus salmonophloia	Salmon gum
Eucalyptus salubris	Gimlet
Hakea kippistiana	Hakea
Halosarcia spp.	Samphire (several)
Lycium australe	Australian boxthorn, water bush
Melaleuca brevifolia	Paperbark
Melaleuca thyoides	Paperbark
Pittosporum angustifolium	Native apricot, native willow
Sclerolaena diacantha	Grey copper-burr

Weed species	
Scientific name	**Common name**
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Cotula bipinnata	Ferny cotula
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Pentaschistis airoides	False hair-grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	5
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	15
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	10
Completely Degraded	Vegetation structure no longer intact and the area is without/almost without native species	70

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish			
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk				Recreation			
Weed invasion		x		Point source discharge			
Stock access				Other			
Vehicle access			x				
Comments							
Hydrological change (changes in salinity, waterlogging and duration of waterlogging) is evident in dead shrubs, probably *Melaleuca* species, amongst the samphire, the poor condition of trees low in the landscape, and weeds dominated by Ice-plant. Weeds are common in samphire areas and on edges, especially the western edge. Rabbits are present but do not appear to be associated with weed increase.							

Links to protected areas of remnant vegetation
See Table 2

Management
The site, which is a nature reserve, is fully fenced from grazing and has firebreaks. Vegetation condition change is associated with the changed hydrological conditions of the river system: there are no management recommendations that are likely to reverse the condition change, and any management would need to be addressed at a catchment scale.

Fauna	
Scientific name	**Common name**
Birds	
Aquila audax	Wedge-tailed eagle
Cladorhynchus leucocephalus	Banded stilt
Manorina flavigula	Yellow throated miner
Ocyphaps lophotes	Crested pigeon
Platycercus zonarius	Australian ringneck parrot
Tadorna tadornoides	Mountain duck
	Unidentified waterbirds (several species)
Mammals	
Macropus fuliginosus	Western grey kangaroo
**Oryctolagus cuniculus*	Rabbit
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

- Water sampling of lake water (western side) produced pH 7.32 and water temperature of 34.6˚. The conductivity was in excess of the maximum range of the meter.
- There were lots of waterbirds on the lake, but most were too far away to get a sufficiently clear view for species identification.

Photo A1.1: LR01
Good condition vegetation association 1: Eucalyptus salmonophloia, E. salubris *and* E. loxophleba *very open woodland.*

Photo A1.2: LR01
Degraded condition vegetation association 2: Halosarcia *spp. sparse shrubland.*

Photo A1.3: LR01
Very good condition vegetation association 3: Eucalyptus myriadena *very open woodland.*

Map A1 Vegetation condition for survey site LR01 – Lake Kurrenkutten

Legend

Vegetation condition

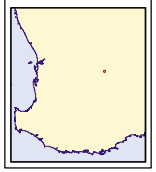
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 190 380 570 760

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
J:\gisprojects\Project\B_Series\B4148\0003\mxd\
Filename:
MapA1 Veg_cond_suvey site LR01.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

This map is a product of the Department of Water (Measurement and Water Information Branch), and was completed in August 2008.

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Site LR02 – Silvergate

General details	
Site name	Silvergate
Landholder	Ray and Danielle Norris
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	13-11-2007

Site description	
Landform	Most of the site is within the floodplain of a tributary of the Lockhart River, with only a small area along the northern edge on the lower valley slopes. The aerial photograph of the site indicates a dispersed stream flow across most of the site, with only one main channel at the break of slope near the northern side, which is in keeping with the virtually-flat nature of the floodplain. However, drains now direct much of the water eastwards towards Lake Kurrenkutten.
Site size	225 ha

Beard vegetation description
Beard vegetation association 1023; medium woodland; York gum, wandoo and salmon gum

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus salmonophloia, E. loxophleba*
Mallees	0	
Shrubs	30-70%	*Halosarcia* sp.
Grasses	<2%	*Eragrostis dielsii*
Herbs	2-10%	Mixed annual pasture species
Rushes and sedges	0	
Litter	2-10%	
Bare ground	30-70%	
Rock outcrop	0	
Summary		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus salmonophloia* and *E. loxophleba* subsp. *loxophleba* very sparse woodland over open mixed introduced herbs.
Vegetation 2	*Halosarcia* spp. open shrubland.
Vegetation 3	Mixed introduced open herbland.

Native species	
Scientific name	**Common name**
Acacia acuminata	Jam
Angianthus tomentosus	Camel-grass
Atriplex paludosa	Marsh saltbush
Atriplex semibaccata	Creeping saltbush
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Eucalyptus longicornis	Morrell
Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus myriadena	Eucalypt
Eucalyptus salmonophloia	Salmon gum
Halosarcia spp.	Samphire (few species)
Maireana brevifolia	Small-leaf bluebush
Salsola australe	Prickly saltwort, roly-poly
Santalum acuminatum	Quandong
Thryptomene sp.	Thyrptomene

Weed species	
Scientific name	**Common name**
Arctotheca calendula	Capeweed
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Erodium botrys	Corkscrews
Hordeum leporinum	Barley grass
Hypochaeris glabra	Flatweed
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Parapholis incurva	Coast barbgrass
Pentaschistis airoides	False hair-grass
Phalaris sp.	Canary grass
Plantago coronopus	Bucks-horn plantain
Sisymbrium orientale	Indian hedge mustard
Trifolium arvense	Hare's foot clover
Trifolium glomeratum	Cluster clover
Vulpia myuros	Silver grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	0
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	5
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	0
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	95

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish		x	
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion	x		
Drainage		x		Service corridors			
Clearing	x			Feral animals		x	
Fire risk				Recreation			
Weed invasion	x			Point source discharge			
Stock access	x			Other			
Vehicle access			x				
Comments							
Most of this site is floodplain and has been cleared, and probably cultivated. The floodplain has been colonised by samphire, where previously it would have been a salmon gum or morrell woodland: there are a few small 'islands' of this vegetation remaining. The northern side of the site is on the lower valley slopes and has a small area of cleared pasture and a small area of salmon gum and York gum woodland. There is a rubbish tip, mostly for vehicle dumping, within this woodland. The whole of the site is grazed, with the floodplain divided into smaller fenced paddocks.							

Links to protected areas of remnant vegetation
See Table 2

Management
The area is grazed despite it being fenced from the pasture area, although the fences are in poor condition. It is a management recommendation to exclude grazing to allow regeneration of native species and reduce soil erosion, and implement a measure of remnant vegetation management. There are several shallow drains directing surface water through the site: it is a management recommendation to widen these to allow greater flow of surface water, particularly on the northern side, although this should be done with the consent of the downstream neighbour. However it is not recommended to install deep drains as there is very little slope in this area and the water would ultimately be directed to flow into a nature reserve. Upslope revegetation (agroforestry), particularly along the eastern side of the northern edge, is recommended to reduce infiltration and surface flows, and reduce soil erosion. Saltland grazing species (saltbush, bluebush) may have a role on some of this site.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Cacatua roseicapilla	galah
Corvus coronoides	Australian raven
Platycercus zonarius	Australian ringneck parrot
Mammals	
Macropus fuliginosus	western grey kangaroo
**Oryctolagus cuniculus*	rabbit
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

- Current landholders have only owned the site for two years, therefore there is no history available.

Photo A1.4: LR02
Apart from a vehicle dump, this site is good condition vegetation association 1: Eucalyptus salmonophloia *and* E. loxophleba *subsp.* loxophleba *very sparse woodland on lower valley slope..*

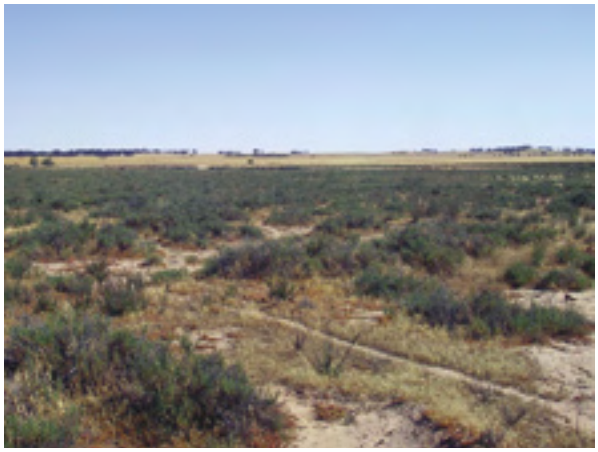


Photo A1.5: LR02
Completely degraded vegetation association 2: Halosarcia *spp. open shrubland on floodplain. This would have been woodland prior to clearing*

Photo A1.6: LR02
Small degraded patch within Vegetation 2, showing part of former composition prior to clearing.

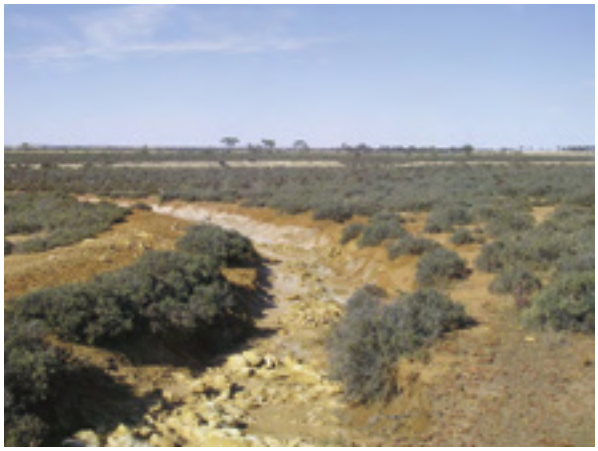
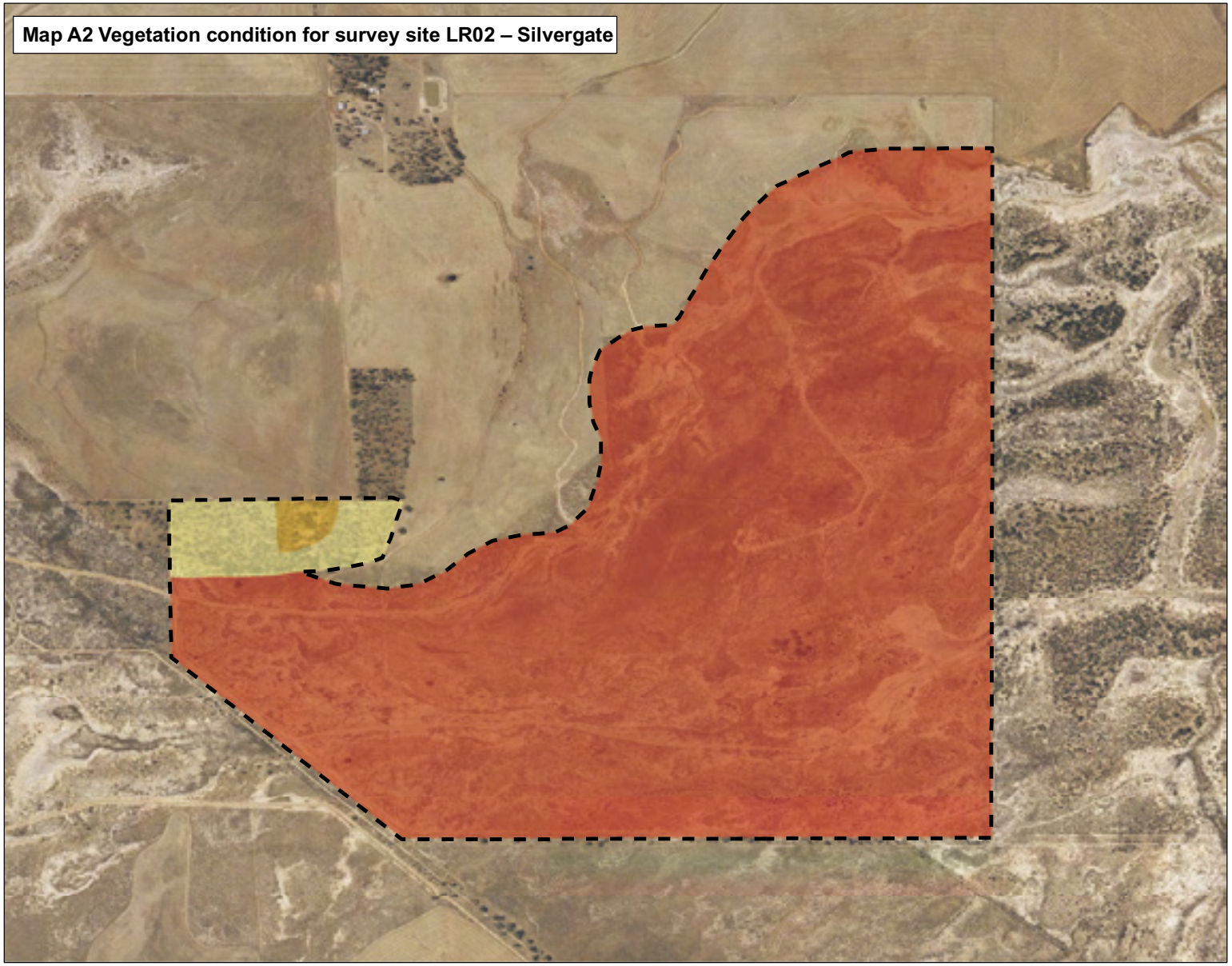


Photo A1.7: LR02
Surface drain on floodplain.

Map A2 Vegetation condition for survey site LR02 – Silvergate



Legend

Vegetation condition

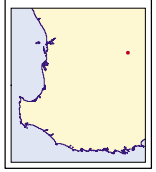
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 100 200 300 400

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
J:\gisprojects\Project\B_Series\B4148\0003\mxd\
Filename:
MapA2 Veg_cond_suvey site LR02.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

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Site LR03 – Larke's

General details	
Site name	Larke's
Landholder	Trevor and Christine Larke
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	12-11-2007

Site description	
Landform	The site is located within the Lockhart River floodplain and consists mostly of a seasonally wet playa lake (Pickersgill Lake, which held some water at the time of survey) and lunettes >1m high on the eastern and southern sides with trapped samphire wetlands and smaller lakes between the dunes. The western side is lower valley slope with 10-20 degree slope gradient, with some areas of exposed rock (granite and possibly dolerite, but not as outcrops) and gilgai on the flatter areas.
Site size	324 ha

Beard vegetation description
Beard vegetation association 125: Bare areas; salt lakes.
Beard vegetation association 959: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus loxophleba, Acacia acuminata, E. salubris, E. longicornis, E. myriadena*
Mallees	0	
Shrubs	10-30%	*Halosarcia* spp., *Atriplex* spp.
Grasses	<2%	*Austrostipa* spp., *Austrodanthonia* spp.
Herbs	2-10%	*Sclerolaena diacantha*
Rushes and sedges	0	
Litter	2-10%	
Bare ground	30-70%	
Rock outcrop	0	
Summary		
The lake fringes and low lying areas between the lunettes have samphire shrubland, up to approximately one metre elevation above the bare lake area. Above this, on the lunettes, is *Eucalyptus myriadena* woodland over *Hakea, Acacia* and *Rhagodia* spp. shrubs. In places the trees are dead. The slope on the western side of the lake is largely spp. shrubs. In places the trees are dead. The slope on the western side of the lake is largely York gum woodland with a native annual herb understorey and with small areas of exposed granite. There were patches of morrell and gimlet woodland on the redder loamy soil, presumably a result of dolerite intrusion.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus loxophleba* subsp. *loxophleba* very sparse woodland over *Acacia acuminata* sparse woodland over *Austrostipa* spp. very sparse grasses over *Waitzia acuminata* and *Rhodanthe manglesii* very sparse herbs.
Vegetation 2	*Eucalyptus longicornis* and *E. salubris* sparse woodland over *Atriplex paludosa* sparse shrubs.
Vegetation 3	*Halosarcia* spp. open shrubland.
Vegetation 4	*Eucalyptus myriadena* very sparse woodland over *Hakea preissii, Acacia nyssophylla* sparse shrubs over *Rhagodia preissii* very sparse shrubs over *Sclerolaena diacantha* very sparse herbs.

Native species	
Scientific name	**Common name**
Acacia acuminata	Jam
Acacia nyssophylla	Wait-a-while
Atriplex paludosa	Marsh saltbush
Austrodanthonia spp.	Wallaby grass
Austrostipa elegantissima	Feather spear-grass
Austrostipa spp.	Speargrass
Enchylaena tomentosa	Ruby saltbush
Eucalyptus longicornis	Morrell
Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus myriadena	Eucalypt
Eucalyptus salmonophloia	Salmon gum
Eucalyptus salubris	Gimlet
Hakea preissii	Needle tree
Halosarcia spp.	Samphire (several species)
Lycium australe	Australian boxthorn, water bush
Melaleuca brevifolia	Paperbark
Pittosporum angustifolium	Native apricot, native willow
Rhagodia preissii	Rhagodia
Rhodanthe manglesii	Pink sunray
Scaevola spinescens	Maroon bush
Sclerolaena diacantha	Grey copper-burr
Templetonia sulcata	Centipede bush
Waitzia acuminata	Orange immortelle

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oat
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Echium plantagineum	Paterson's curse
Ehrharta longiflora	Annual veldt grass
Mesembryanthemum nodiflorum	Slender ice-plant
Pentaschistis airoides	False hair-grass
Ursinia anthemoides	Ursinia
Vulpia myuros	Silver grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	50
Very good	Vegetation structure altered, obvious signs of disturbance	0
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	25
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	25
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	0

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk	x			Recreation			
Weed invasion		x		Point source discharge			
Stock access			x	Other			
Vehicle access		x					
Comments							
The low-lying areas associated with lake edges and the areas between the lunettes have been affected by salinity and waterlogging, although most of the shrub deaths are not recent. There is a line of dead samphire parallel to the lake edge that appears to have been smothered by an algal bloom associated with the most recent flood event (2006). There is a high fire risk in the woodland areas; however these are largely weed-free (and have never been grazed) so regeneration should not be a concern although rabbits may need to be controlled should a fire occur. The few weeds in the woodland are only along the paddock edge. There is a track on top fo the eastern dune with some weed invasion along it. There is some rubbish dumped on the western shore of the lake.							

Links to protected areas of remnant vegetation
See Table 2

Management
The area is fenced and has never been grazed. If the woodland is burnt, rabbit control may be necessary to allow regeneration to occur without hindrance. The low-lying areas have been affected by changes to salinity and waterlogging, however any management recommendations for this must be at a catchment scale. Although rubbish has been dumped on the edge of the lake, removal is not recommended. However general education of landholders regarding some of the hazards of waste dumped in waterways is recommended.

Fauna	
Scientific name	**Common name**
Birds	
Acanthiza spp.	Thornbills
Cacatua roseicapilla	Galah
Corvus coronoides	Australian raven
Cracticus nigrogularis	Pied butcher bird
Platycercus zonarius	Australian ringneck parrot
Rhipidura leucophrys	Willy wagtail
Mammals	
Macropus fuliginosus	Western grey kangaroo
**Oryctolagus cuniculus*	Rabbit
**Vulpes vulpes*	Fox
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

From discussions with landholders Colin (father, now retired) and Trevor Larke:

- The site, at least the woodland on the western side, has never been grazed.
- The 2006 floods caused a lot more tree deaths than the 2000 floods.
- Tree plantings to the north of Pickersgill Lake (not within the site) dried the soil profile within 2 years. Gimlet, York gum, Salt River gum and sheoak were planted.
- The whole of the lake system had a series of low-level aerial photographs taken in the 1970s. The fate of these photos is unknown.

From observations:

- Lichen was common in the woodland, indicating good soil condition and lack of salinity.
- There was a band of dead samphire around the main lake bed, which appears to have been smothered by a mat of algae resulting from the last flood event (2006).
- Gilgai were observed in the morrell / gimlet woodland.
- There has been some fencing and revegetation along the streamline flowing into the western side of the lake.
- Although there was water in the lake, there were no waterbirds.

Photo A1.8: LR03
Excellent condition vegetation association 1: Eucalyptus loxophleba *subsp.* loxophleba *very sparse woodland on lower valley slope.*

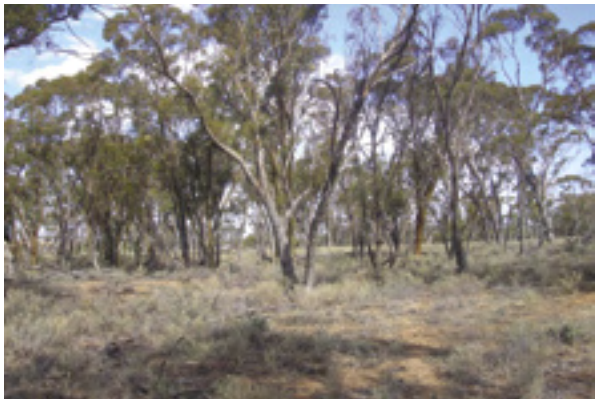


Photo A1.9: LR03
Excellent condition vegetation association 2: Eucalyptus longicornis *and* E. salubris *sparse woodland on lower valley slope.*

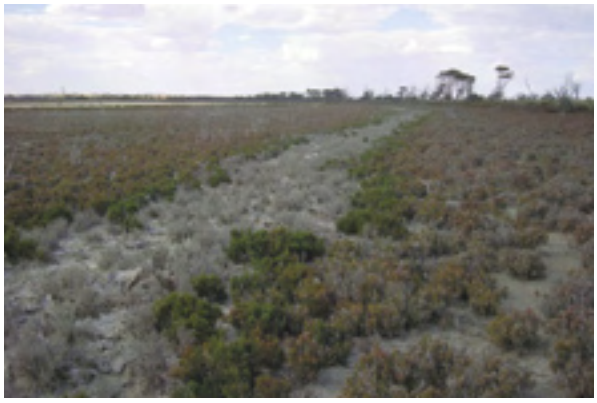
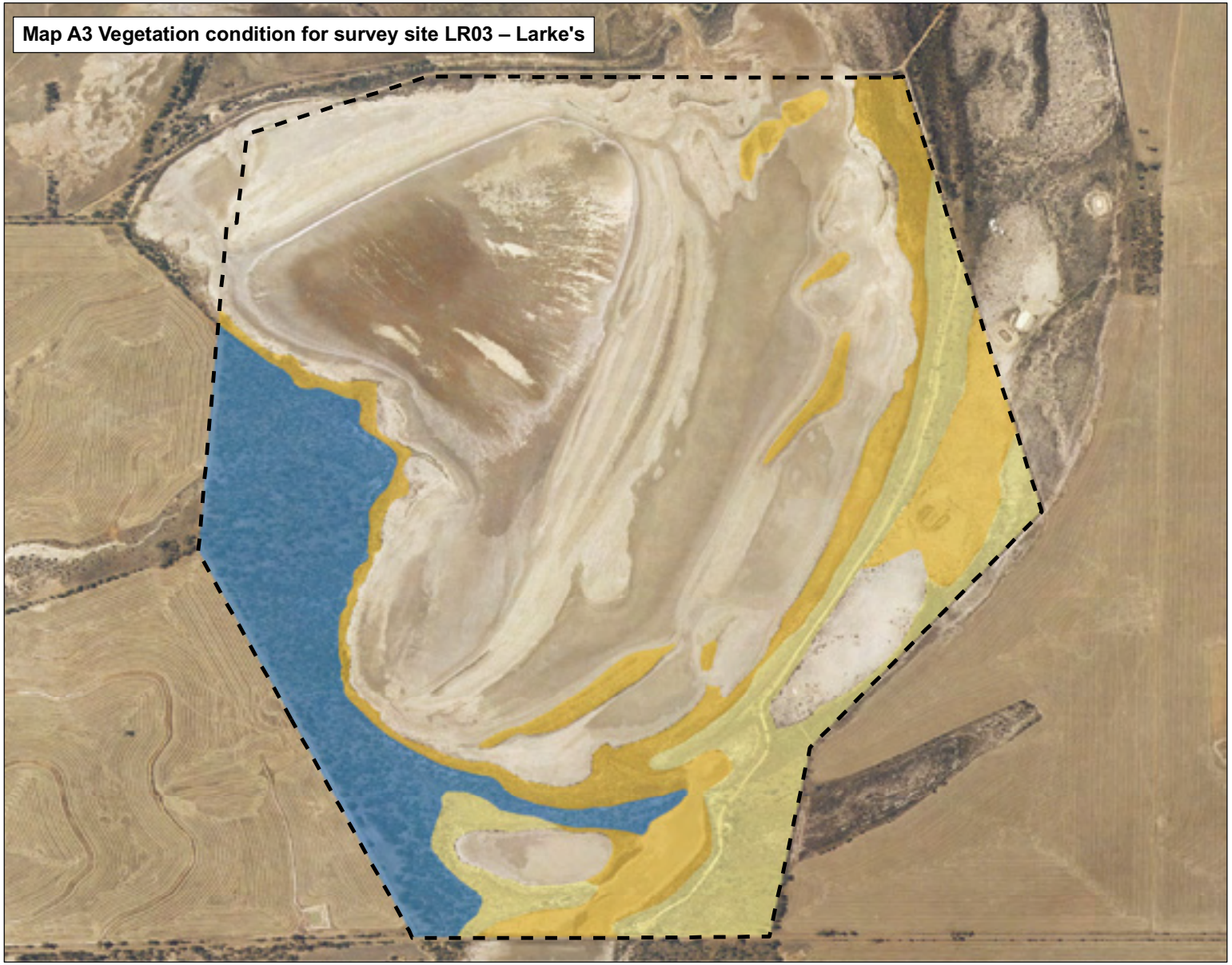


Photo A1.10: LR03
Degraded condition vegetation association 3: Halosarcia *open shrubland on floodplain. Note the line of dead samphire smothered by an algal mat and regeneration alongside.*

Photo A1.11: LR03
Good condition vegetation association 4: Eucalyptus myriadena *very sparse woodland on lunette.*

Photo A1.12: LR03
Rubbish dumped on the western side of Lake Pickersgill.

Map A3 Vegetation condition for survey site LR03 – Larke's



Legend

Vegetation condition

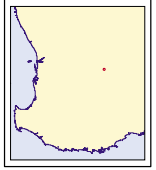
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 100 200 300 400

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
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Filename:
MapA3 Veg_cond_suvey site LR03.mxd
Date: August 2008

SOURCES

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Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

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Site LR04 – Crossland

General details	
Site name	Crossland
Landholder	Charles Crossland, leased to Tony and SueAnne Crossland
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	13-11-2007

Site description	
Landform	The site is within the floodplain of the Lockhart River. It consists of a dry playa lake with a raised lunette within the lake area and surrounding the lake, most of which are less than one metre elevation above the lake edge, and a wide bare drainage area with no distinctive channel south of this. The lake exits through a narrow channel north of the site.
Site size	93 ha

Beard vegetation description
Beard vegetation association 125: Bare areas; salt lakes.
Beard vegetation association 959: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	Mixed planted eucalypts
Mallees	0	
Shrubs	2-10%	*Halosarcia* spp.
Grasses	<2%	*Austrostipa* sp., *Eragrostis dielsii*
Herbs	2-10%	Mixed
Rushes and sedges	<2%	*Lomandra effusa*
Litter	2-10%	
Bare ground	70-100%	
Rock outcrop	0	
Summary		
The edges of the playa lakes and drainage line are samphire shrublands. The lunettes have very sparse woodland of jam over herbs. Most of the vegetated area of this site – the western edge of the playa lake and drainage area – is revegetation.		

Individual vegetation association descriptions	
Vegetation 1	Mixed *Eucalyptus* spp. open woodland (planted).
Vegetation 2	*Halosarcia* spp. very sparse shrubland over *Atriplex* and *Rhagodia* spp. very sparse shrubs.
Vegetation 3	*Acacia acuminata* very sparse woodland over *Lomandra effusa* very sparse sedges over mixed annual sparse herbs.

Native species	
Scientific name	**Common name**
Acacia acuminata	Jam
Atriplex paludosa	Marsh saltbush
Atriplex semibaccata	Creeping saltbush
Austrodanthonia spp.	Wallaby grass
Didymanthus roei	Didymanthus
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Gnephosis multiflora	Gnephosis
Hakea preissii	Needle tree
Halosarcia spp.	Samphire (4-5 species)
Lomandra effusa	Scented Matrush
Maireana brevifolia	Small-leaf bluebush
Maireana carnosa	Cottony bluebush
Podolepis canescens	Bright podolepis
Podotheca gnaphalioides	Golden long-heads
Rhagodia preissii	Rhagodia
Siloxerus pygmaeus	Siloxerus
Stylidium repens	Matted triggerflower

Weed species	
Scientific name	**Common name**
Arctotheca calendula	Capeweed
Avena fatua	Wild oat
Bromus rubens	Red brome
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Monoculus monstrosus	Stinking roger
Moraea setifolia	Thread iris
Ursinia anthemoides	Ursinia
Vulpia myuros	Silver grass

Revegetation species	
Scientific name	**Common name**
Acacia saligna	Orange wattle
Eucalyptus salmonophloia	Salmon gum
Eucalyptus sargentii	Salt River gum
Eucalyptus sp.	Eucalypt
Melaleuca cuticularis	Saltwater paperbark

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	70
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	0
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	10
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	10

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish		x	
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing	x			Feral animals		x	
Fire risk				Recreation			
Weed invasion			x	Point source discharge			
Stock access		x		Other			
Vehicle access							

Comments
Most of the vegetated area is revegetation, although there are signs of recent deaths in some of the trees. Areas of natural vegetation have been degraded by changes to salinity and waterlogging, however their condition, relative to other areas, is good: there are species other than *Halosarcia* present amongst the samphire. It is likely that much of the bare areas would have been vegetated in the past, however flood events have removed any evidence. Overall the site could be regarded as *degraded*.

Links to protected areas of remnant vegetation
See Table 2

Management
The revegetated area is fenced, however other fences are in poor condition and therefore the rest of the site may be grazed: it is recommended to not graze this area. Rabbit control would be an appropriate management recommendation as there appeared to be a significant amount of damaged caused by rabbit warrens on the lunettes. Any further site management involves hydrological issues that must be approached at catchment level.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Cracticus tibicen	Magpie
Lichenostomus virescens	Singing honey-eater
Macropus fuliginosus	Western grey kangaroo
Ocyphaps lophotes	Crested pigeon
Platycercus zonarius	Australian ringneck parrot
Smicrornis brevirostris	Weebill
Mammals	
**Oryctolagus cuniculus*	Rabbit
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

- Recent deaths of vegetation in lake islands observed.
- Recent deaths amongst revegetation observed.
- Adjacent to public land.
- No water on site.

Photo A1.13: LR04
Revegetation: mixed species vegetation association 1. Note that there have been several recent deaths of planted species.

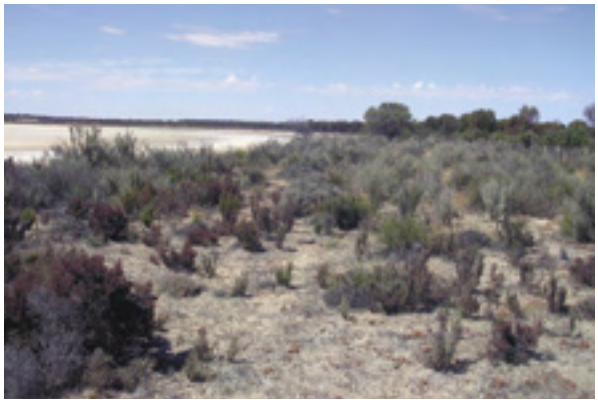


Photo A1.14: LR04
Good condition vegetation association 2: Halosarcia spp. very sparse shrubland. This stream edge vegetation was unusual for its high diversity of species.

Photo A1.15: LR04
Good condition vegetation association 3: Acacia acuminata very sparse woodland on lunette.

Photo A1.16: LR04
Completely degraded area on floodplain.

Photo A1.17: LR04
Completely degraded vegetation on floodplain.

Photo A1.18: LR04
Rubbish dump on edge of waterway.

Map A4 Vegetation condition for survey site LR04 – Crossland

Legend

Vegetation condition

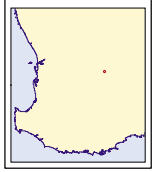
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 50 100 150 200

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
J:\gisprojects\Project\B_Series\B4148\0003\mxd\
Filename:
MapA4 Veg_cond_suvey site LR04.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

This map is a product of the Department of Water (Measurement and Water Information Branch), and was completed in August 2008.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:9,000 when printing at A4.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data' do so at their own risk.

Site LR05 – Dickinson's

General details	
Site name	Dickinson's (property name: Stoneley)
Landholder	PJ and KL Dickinson
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	13-11-2007

Site description	
Landform	This site is almost isolated from the Lockhart River. The northern part of the side is a wide expanse of floodplain associated with a tributary of the Lockhart. The site has a few playa lakes and several irregularly shaped low-lying areas between lunettes, which are mostly approximately 1m high although some are higher. There are no clear drainage channels. There is an area of woodland along the western and southern side on lower valley slope.
Site size	248 ha

Beard vegetation description
Beard vegetation association 8: Medium woodland; salmon gum and gimlet.
Beard vegetation association 959: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus salubris, E. salmonophloia*
Mallees	<2%	*Eucalyptus loxophleba* subsp. *gratiae, E. horistes*
Shrubs	10-30%	*Halosarcia* spp.
Grasses	<2%	*Eragrostis dielsii*
Herbs	2-10%	Mixed introduced
Rushes and sedges	<2%	*Lomandra effusa*
Litter	10-30%	
Bare ground	30-70%	
Rock outcrop	0	
Summary		
The northern part of the site is largely *Halosarcia* spp. shrubland, with emergent *Melaleuca* spp. on slightly raised areas. The southern part of the site is a series of low-lying areas of *Halosarcia* spp with dead sticks, presumably dead *Melaleuca* spp, and the occasional playa lake, some with water. There are raised dunes in irregular shapes between these low-lying areas: these have *Eucalyptus kondininensis* woodland with no understorey or mallee on them. The area near the south-western corner is *Eucalyptus salubris* and *E. salmonophloia* woodland with a shrub understorey on lower valley slopes.		

Individual vegetation association descriptions	
Vegetation 1	*Melaleuca brevifolia* very sparse shrubland over *Halosarcia* spp. sparse shrubland.
Vegetation 2	*Halosarcia* spp. sparse shrubland.
Vegetation 3	*Eucalyptus salubris* and *E. salmonophloia* very sparse woodland over *Melaleuca pauperiflora* and *Exocarpos aphyllus* very sparse shrubs over *Atriplex* sp. very sparse shrubs.
Vegetation 4	*Eucalyptus kondininensis* very sparse woodland.
Vegetation 5	*Eucalyptus loxophleba* subsp. *gratiae* and *E. horistes* very sparse mallee over *Olearia dampieri* subsp. *eremicola* and *Rhagodia* sp. very sparse shrubs over *Lomandra effusa* very sparse sedges over mixed introduced annual sparse herbs.

Native species	
Scientific name	**Common name**
Angianthus tomentosus	Camel-grass
Atriplex paludosa	Marsh saltbush
Atriplex sp.	Saltbush
Austrostipa elegantissima	Feather spear-grass
Austrostipa spp.	Speargrass
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Eucalyptus horistes	White flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus loxophleba subsp. *gratiae*	Lake Grace mallee
+ Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus myriadena	Eucalypt
+ Eucalyptus salmonophloia	Salmon gum
Eucalyptus salubris	Gimlet
Eucalyptus spathulata	Swamp mallet
Exocarpos aphyllus	Leafless ballart
Hakea preissii	Needle tree
+ Halosarcia spp.	Samphire (2 species)
Lomandra effusa	Scented matrush
Lycium australe	Australian boxthorn, water bush
Melaleuca brevifolia	Paperbark
Melaleuca lateriflora	Gorada
Olearia dampieri subsp. *eremicola*	Daisy-bush
Pittosporum angustifolium	Native apricot, native willow
Rhagodia preissii	Rhagodia
Santalum murrayanum	Bitter quandong
Templetonia sulcata	Centipede bush
Waitzia acuminata	Orange immortelle
+ Regeneration noted	

Weed species	
Scientific name	**Common name**
Avellinia michelii	Avellinia
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Cotula bipinnata	Ferny cotula
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Parapholis incurva	Coast barbgrass
Plantago coronopus	Bucks-horn plantain
Ursinia anthemoides	Ursinia

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	20
Very good	Vegetation structure altered, obvious signs of disturbance	15
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	35
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	20

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish			
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk	x			Recreation			
Weed invasion			x	Point source discharge			
Stock access			x	Other			
Vehicle access			x				

Comments

This site has been fenced under a remnant vegetation scheme, and has a conservation covenant on it. Stock grazing and subsequent weed invasion are therefore a low threat risk. A significant portion of the site (the woodland on the lower valley slopes) is in *excellent* condition: there are few weeds and the main species of eucalypts have seedlings regenerating, however the adult tree canopies are sparse with some signs of epicormic shoots. This indicates that there is some level of disturbance affecting this area. Fire is a significant risk in this woodland, although good regeneration is likely should this occur. Rabbit control may be necessary after any fire.

Salinity and water table changes are likely to be the disturbance factors in effect on this site. The lowest-lying areas are generally *completely degraded*, with *Halosarcia* spp. (only two species, indicating recent invasion by samphires) and dead sticks. Slightly higher, but still on the valley floor, is largely *Melaleuca brevifolia* shrubs over *Halosarcia* spp., which is in better condition: either (largely) *degraded* where the Melaleucas are dead or very sparse, or *very good* in areas with live Melaleuca.

Links to protected areas of remnant vegetation
See Table 2

Management
Fencing is the main management already undertaken on this site. Permanent clear firebreaks maintained from around this site, particularly adjacent to the woodland but outside of the fenced area, may be appropriate. Outside of the site, trees planted along the western edge, particularly towards the north, may be an appropriate management to reduce waterlogging on the floodplain. In more saline areas on the western side, saltland grazing may be an appropriate activity. Generally, activities that may be effective in reducing the effects of salinity or waterlogging must be conducted at a catchment scale, or in this case, on a subcatchment (tributary) scale.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Artamus cyanopterus	dusky woodswallow
Cacatua roseicapilla	galah
Coracina novaehollandiae	black-faced cuckoo-shrike
Cracticus nigrogularis	pied butcher bird
Cracticus tibicen	magpie
Neophema elegans	elegant parrot
Ocyphaps lophotes	crested pigeon
Platycercus zonarius	Australian ringneck parrot
Mammals	
Macropus fuliginosus	western grey kangaroo
**Oryctolagus cuniculus*	rabbit
**Vulpes vulpes*	fox
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

- This site is not on the main river channel. The northern part is connected to the floodplain of a tributary channel although the southern and western parts appear to be mostly internally drained.
- Some of the floodplain is in *very good* condition, with living Melaleucas.
- Fenced under a conservation covenant scheme. The vegetation was surveyed by Robyn Campbell.
- Some of the lakes on the southern side appear to have yellow water, and the salt deposits have a definite yellow hue.

Photo A1.19: LR05
Very good condition vegetation association 1: Melaleuca brevifolia *very sparse shrubland. This site was unusual in having living Melaleuca over samphire.*

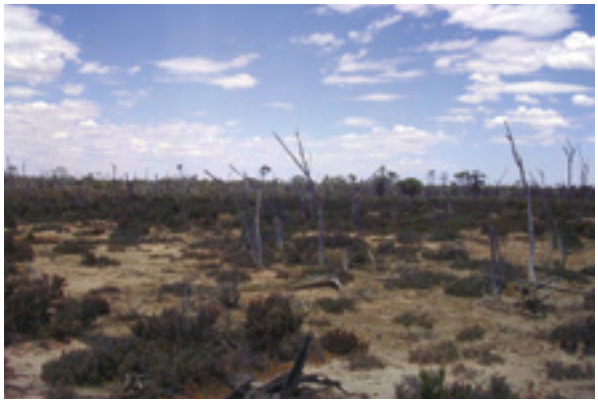


Photo A1.20: LR05
Degraded condition vegetation association 2: Halosarcia *sparse shrubland. This vegetation would have been similar to Vegetation 1 but is now degraded.*

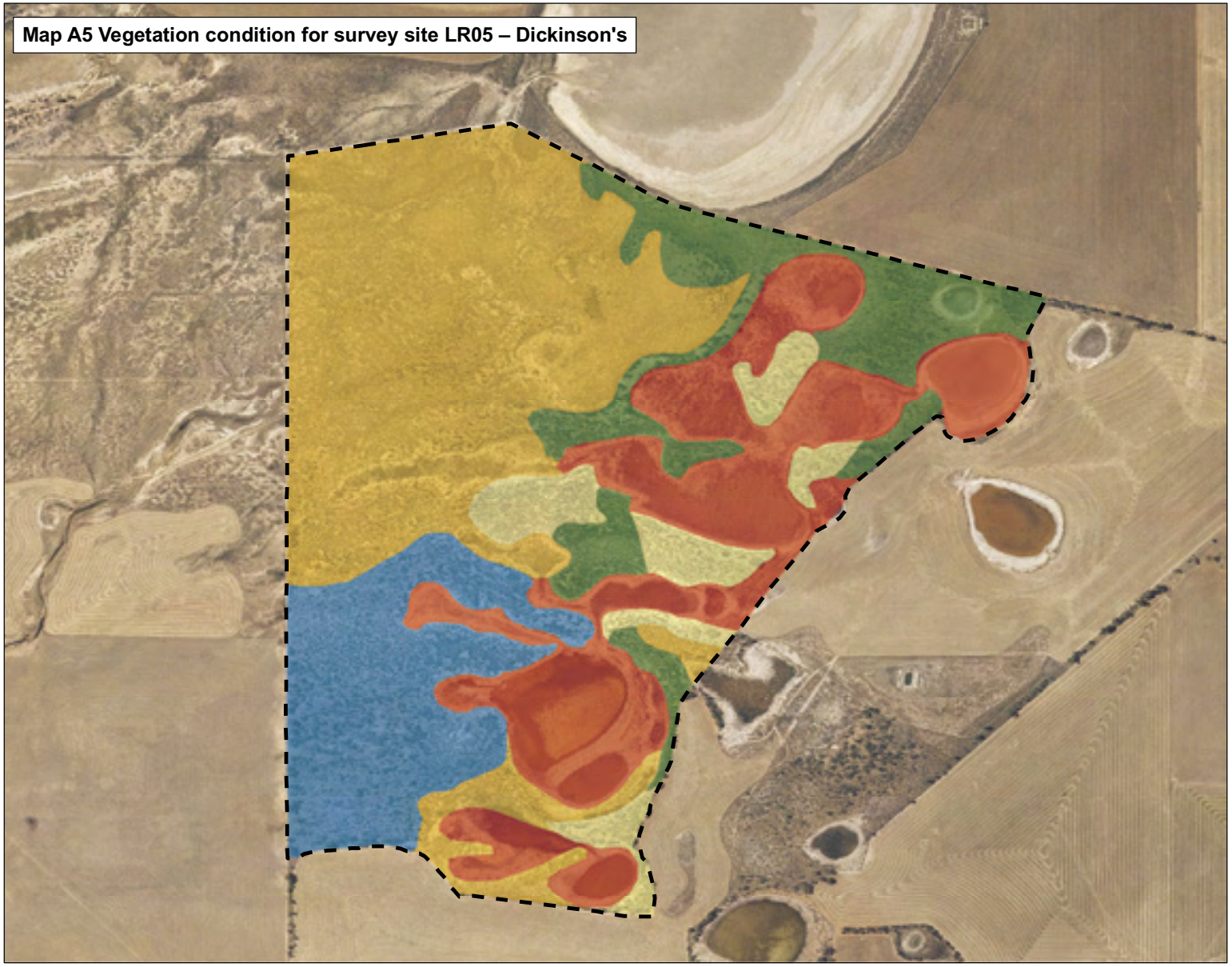
Photo A1.21: LR05
Excellent condition vegetation association 3: Eucalyptus salubris *and* E. salmonophloia *very sparse woodland on lower valley slope.*

Photo A1.22: LR05
Good condition vegetation association 4: Eucalyptus kondininensis *very sparse woodland on lunettes.*

Photo A1.23: LR05
Good condition vegetation association 5: Eucalyptus loxophleba *subsp.* gratiae *and* E. horistes *very sparse mallee on lunettes.*

Photo A1.24: LR05
Completely degraded condition lake.

Map A5 Vegetation condition for survey site LR05 – Dickinson's



Legend

Vegetation condition

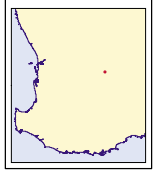
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 100 200 300 400

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
J:\gisprojects\Project\B_Series\B4148\0003\mxd\
Filename:
MapA5 Veg_cond_suvey site LR05.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

This map is a product of the Department of Water (Measurement and Water Information Branch), and was completed in August 2008.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:16,000 when printing at A4.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data' do so at their own risk.

Site LR06 – Crown Reserve 18455

General details	
Site name	Crown Reserve 18455
Landholder	DPI
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	13-11-2007

Site Description	
Landform	The site is mostly a playa lake within the main stream channel of the Lockhart River, although the lake is north of the main flow channel, which is close to the southern edge of the lake. The lake itself has formed at the junction of the main river channel and a tributary entering from the north. The lake consists of a series of raised sandbars and dunes running approximately north-south and parallel with the eastern bank, with either bare salt scald areas or samphire in the lower areas and saltbush, sparse shrubs and (mostly dead) sparse trees on the highest lunette, which is over a metre high. The lunettes on the edge of the lake, which are greater than 2 m high, support very sparse woodland or mallee.
Site size	600 ha

Beard vegetation description
Beard vegetation association 125: Bare areas; salt lakes.
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus longicornis, Eucalyptus salubris*
Mallees	<2%	*Eucalyptus loxophleba* subsp. *gratiae*
Shrubs	10-30%	*Halosarcia* spp.
Grasses	<2%	*Aristida* sp.
Herbs	<2%	Mixed annual weeds
Rushes and sedges	0	
Litter	2-10%	
Bare ground	30-70%	
Rock outcrop	0	
Summary		
The lake itself consists of bare areas or expanses of *Halosarcia* spp on the slightly raised sand bars. The taller lunette within the lake has a very sparse shrubland of mixed species, with very sparse emergent (mostly dead) trees. The lunettes around the edge of the lake have *Eucalyptus salubris* or *Eucalyptus longicornis* woodland or *Eucalyptus loxophleba* subsp. *gratiae* mallee, all of which are weedy.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus salubris* very sparse woodland over *Melaleuca pauperiflora* sparse shrubs over *Lycium australe* and *Enchylaena tomentosa* very sparse shrubs over *Sclerolaena diacantha* very sparse herbs over very sparse mixed annual weeds.
Vegetation 2	*Eucalyptus loxophleba* subsp. *gratiae* sparse mallee over *Olearia dampieri* subsp. *eremicola* very sparse shrubs over *Aristida* sp. very sparse grasses over sparse mixed annual weeds.
Vegetation 3	*Eucalyptus longicornis* very sparse woodland over *Melaleuca pauperiflora* very sparse shrubs over *Lycium australe* and *Atriplex* sp. sparse shrubs over very sparse mixed annual weeds.
Vegetation 4	*Acacia nyssophylla* very sparse shrubland over *Lycium australe* and *Hakea kippistiana* very sparse shrubs over *Atriplex* sp. very sparse shrubs over very sparse mixed annual weeds.
Vegetation 5	*Halosarcia* spp. opens shrubland.

General details	
Site name	Crown Reserve 18455
Landholder	DPI
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	13-11-2007

Site Description	
Landform	The site is mostly a playa lake within the main stream channel of the Lockhart River, although the lake is north of the main flow channel, which is close to the southern edge of the lake. The lake itself has formed at the junction of the main river channel and a tributary entering from the north. The lake consists of a series of raised sandbars and dunes running approximately north-south and parallel with the eastern bank, with either bare salt scald areas or samphire in the lower areas and saltbush, sparse shrubs and (mostly dead) sparse trees on the highest lunette, which is over a metre high. The lunettes on the edge of the lake, which are greater than 2 m high, support very sparse woodland or mallee.
Site size	600 ha

Beard vegetation description
Beard vegetation association 125: Bare areas; salt lakes.
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus longicornis, Eucalyptus salubris*
Mallees	<2%	*Eucalyptus loxophleba* subsp. *gratiae*
Shrubs	10-30%	*Halosarcia* spp.
Grasses	<2%	*Aristida* sp.
Herbs	<2%	Mixed annual weeds
Rushes and sedges	0	
Litter	2-10%	
Bare ground	30-70%	
Rock outcrop	0	
Summary		
The lake itself consists of bare areas or expanses of *Halosarcia* spp on the slightly raised sand bars. The taller lunette within the lake has a very sparse shrubland of mixed species, with very sparse emergent (mostly dead) trees. The lunettes around the edge of the lake have *Eucalyptus salubris* or *Eucalyptus longicornis* woodland or *Eucalyptus loxophleba* subsp. *gratiae* mallee, all of which are weedy.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus salubris* very sparse woodland over *Melaleuca pauperiflora* sparse shrubs over *Lycium australe* and *Enchylaena tomentosa* very sparse shrubs over *Sclerolaena diacantha* very sparse herbs over very sparse mixed annual weeds.
Vegetation 2	*Eucalyptus loxophleba* subsp. *gratiae* sparse mallee over *Olearia dampieri* subsp. *eremicola* very sparse shrubs over *Aristida* sp. very sparse grasses over sparse mixed annual weeds.
Vegetation 3	*Eucalyptus longicornis* very sparse woodland over *Melaleuca pauperiflora* very sparse shrubs over *Lycium australe* and *Atriplex* sp. sparse shrubs over very sparse mixed annual weeds.
Vegetation 4	*Acacia nyssophylla* very sparse shrubland over *Lycium australe* and *Hakea kippistiana* very sparse shrubs over *Atriplex* sp. very sparse shrubs over very sparse mixed annual weeds.
Vegetation 5	*Halosarcia* spp. opens shrubland.

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	10
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	40
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	30
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	10

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing		x		Erosion			x
Drainage				Service corridors			
Clearing		x		Feral animals		x	
Fire risk			x	Recreation			
Weed invasion		x		Point source discharge			
Stock access			x	Other			
Vehicle access			x				
Comments							
The vegetation on the raised sand bars in the lake is most susceptible to hydrological change.							

Links to protected areas of remnant vegetation
See Table 2

Management
Changes to salinity and water tables are likely to be the disturbance factors that will have the most impact on vegetation on this site, however any management intervention that is likely to have an impact on this must be implemented on a catchment basis. The road crossing across the tributary to the north of this lake has a narrow culvert, however any ponding caused by this would not be on the site.

Fauna	
Scientific name	**Common name**
Birds	
Acanthiza spp.	Thornbills
Cacatua roseicapilla	Galah
Cracticus tibicen	Magpie
Lichenostomus virescens	Singing honey-eater
Microeca fascinans	Jacky winter
Neophema elegans	Elegant parrot
Ocyphaps lophotes	Crested pigeon
Platycercus zonarius	Australian ringneck parrot
Mammals	
Macropus fuliginosus	Western grey kangaroo
**Vulpes vulpes*	Fox

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

- There was no sign of surface salt on the raised sand bar in the lake.
- Crab claws were observed in the samphire.
- The lake is used for recreation when there is sufficient water as kayaks were observed near the lake outlet.
- The jacky winter was observed perching on a dead shrub which was emergent in samphire. It was an extremely hot, humid and windy day, just before a massive thunderstorm that caused localised flooding in Kondinin, and the bird was perched with spread wings.

Photo A1.25: LR06
Very good condition vegetation association 1: Eucalyptus salubris *very sparse woodland on lower valley slope.*

Photo A1.26: LR06
Good condition vegetation association 2: Eucalyptus loxophleba *subsp.* gratiae *very sparse woodland on lunette.*

Photo A1.27: LR06
Very good condition vegetation association 3: Eucalyptus longicornis *very sparse woodland on lunettes.*

Photo A1.28: LR06
Good condition vegetation association 4: Acacia nyssophylla *very sparse shrubland on lunette within lake bed. Note dead tree trunks, indicating this was formerly woodland.*

Photo A1.29: LR06
Degraded condition vegetation association 5: Halosarcia *spp. open shrubland on lake edge.*

Photo A1.30: LR06
Good condition vegetation on lunette.

Photo A1.31: LR06
Area of sand extraction and rubbish dumping near north-east corner of site.

Photo A1.32: LR06
Degraded condition vegetation on lake (background).

Map A6 Vegetation condition for survey site LR06 – Crown Reserve 18455

Legend

Vegetation condition

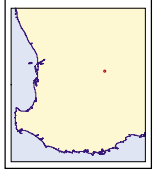
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 100 200 300 400

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
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Filename:
MapA6 Veg_cond_suvey site LR06.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

This map is a product of the Department of Water (Measurement and Water Information Branch), and was completed in August 2008.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:22,000 when printing at A4.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data' do so at their own risk.

Site LR07 – Butler's

General details	
Site name	Butler's
Landholder	Andrew Butler
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	15-11-2007

Site description	
Landform	The site is entirely within the floodplain of the Lockhart River. There are no distinct drainage lines anywhere on this site, with the site consisting of irregular areas of slightly raised land interspersed with lower-lying areas, generally with only approximately 30 cm elevation difference between the two. The higher areas support very sparse woodland or *Melaleuca* spp. shrubland, with the lower areas having samphire. There are some cleared areas scattered within the site which have been cultivated in the past. The site is divided into small holding paddocks.
Site size	435 ha

Beard vegetation description
Beard vegetation association 959: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.
Beard vegetation association 1023: Medium woodland; York gum, wandoo and salmon gum.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	<2%	*Eucalyptus loxophleba* subsp. *loxophleba*
Mallees	<2%	*Eucalyptus horistes*
Shrubs	10-30%	*Halosarcia* spp.
Grasses	<2%	*Eragrostis dielsii*
Herbs	10-30%	*Mesembryanthemum nodiflorum*
Rushes and sedges	<2%	*Lomandra effusa*
Litter	<2%	
Bare ground	30-70%	
Rock outcrop	0	
Summary		
The site is largely covered with *Halosarcia* spp. shrubs, including areas which have been cleared and cropped but have been invaded since the flood of 2006. Slightly raised areas have mostly *Melaleuca* and *Acacia* spp. shrublands, with woodlands confined to the highest elevations within the floodplain and sloping land on the edge of the site.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus loxophleba* subsp. *loxophleba* very sparse woodland over *Acacia nyssophylla* and *A. mackeyana* very sparse shrubs over *Rhagodia preissii* very sparse shrubs over *Lomandra effusa* very sparse sedges over *Carpobrotus modestus* and *Disphyma crassifolium* sparse herbs over *Eragrostis dielsii* very sparse grass.
Vegetation 2	*Halosarcia* spp. sparse shrubland.
Vegetation 3	*Melaleuca pauperiflora, M. acuminata* and *M. lateriflora* sparse shrubland over *Atriplex* spp. and *Maireana* spp. sparse shrubs over open introduced annual herbs.

Native species	
Scientific name	**Common name**
Acacia mackeyana	Wattle
Acacia nyssophylla	Wait-a-while
Angianthus tomentosus	Camel-grass
Atriplex hymenotheca	Saltbush
Atriplex paludosa	Marsh saltbush
Atriplex sp.	Saltbush
Austrostipa elegantissima	Feather spear-grass
Roycea spinescens	
Carpobrotus modestus	Inland pig face
Disphyma crassifolium	Feather spear-grass
Eragrostis dielsii	Mallee lovegrass
Eucalyptus horistes	White flowered mallee
Eucalyptus longicornis	Morrell
Eucalyptus loxophleba subsp. loxophleba	York gum
Eucalyptus salubris	Gimlet
Eucalyptus yilgarnensis	Yorrel
Frankenia sp.	Frankenia
Hakea preissii	Needle tree
+ Halosarcia spp.	Samphire (5-6 species)
Lomandra effusa	Scented matrush
Lycium australe	Australian boxthorn, water bush
Maireana brevifolia	Small-leaf bluebush
Melaleuca pauperiflora	Boree
Melaleuca acuminata	Paperbark
Melaleuca lateriflora	Gorada
Pittosporum angustifolium	Native apricot, native willow
Podolepis canescens	Bright podolepis
Rhagodia preissii	Rhagodia
Santalum murrayanum	Bitter quandong
Sclerolaena diacantha	Grey copper-burr
Stackhousia sp.	Stackhousia
Templetonia sulcata	Centipede bush
+ Regeneration noted	

Weed species	
Scientific name	**Common name**
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Cotula bipinnata	Ferny cotula
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Parapholis incurva	Coast barbgrass
Pentaschistis airoides	False hair-grass
Sisymbrium orientale	Indian hedge mustard
Vulpia myuros	Silver grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	10
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	55
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	25

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			x
Ponding from road crossing	x			Erosion			
Drainage			x	Service corridors			
Clearing			x	Feral animals			x
Fire risk				Recreation			
Weed invasion			x	Point source discharge	x		
Stock access	x			Other			
Vehicle access		x					

Comments

The whole site is flat with little relief, being the floodplain of the Lockhart River. In flood events water ponds on the site, thus salinity and waterlogging are the major threats, with the vegetation on the slightly raised areas at most risk (the lower areas are already *degraded* or *completely degraded*). There are two narrow culverts under the road on the northern (discharge) end of the site, thus ponding is also a threat, although this was not mentioned by the landholder as being an issue. There are small surface drains into the site from the adjacent paddocks, however they have only a small catchment area. Risk associated with these drains is low. However this site is the outlet from Lake Kondinin (point source discharge), which fills before overflowing onto this site, thus low water quality in the lake during flood events presents a high threat risk.

The site is divided into small holding paddocks which are used as summer grazing, so the threat to the vegetated raised areas is high.

There are several tracks through the site, which is on dispersive clay soil: driving on these tracks when they are wet presents a moderate risk of soil structural damage and, if followed by a flood, resultant silting.

Damage by stem borers was observed, thus plant disease may be introduced as a result of this damage. Damage by stem borers also indicates plant stress.

Links to protected areas of remnant vegetation
See Table 2

Management
The area is largely fenced from the adjacent paddock, therefore grazing is controlled. There are surface drains into the site. Management recommendations include fencing the vegetated raised areas, planting saltbush and bluebush for saltland grazing and increasing the culvert size along the road. Surface drains may improve the speed of water flow through the site and allow for faster drying of the soil after flood events, however the lack of gradient and suitable discharge site, as well as the dispersive clay soil on site (which would result in rapid erosion of soil banks and drain edges) would probably make surface drains unfeasible.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Aquila audax	Wedge-tailed eagle
Artamus cinereus	Black-faced woodswallow
Cacatua roseicapilla	Galah
Epthianura albifrons	White fronted chat
Lichenostomus virescens	Singing honey-eater
Neophema elegans	Elegant parrot
Ocyphaps lophotes	Crested pigeon
Grallina cyanoleuca	Peewee or magpie-lark
Platycercus varius	Mulga parrot
Platycercus zonarius	Australian ringneck parrot
Rhipidura leucophrys	Willy wagtail
Mammals	
Macropus fuliginosus	Western grey kangaroo
**Oryctolagus cuniculus*	Rabbit
Reptiles	
Tiliqua occipitalis	Western blue tongue
Tiliqua rugosa	Bobtail
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

From Jenny Browning (southern neighbour):

- 2000 flood filled Kondinin Lake very quickly (within 24 hours) and washed over the banks of the lake into the surrounding area. The flooded land couldn't be cropped for 2 years: the soil became smelly mud. There were many tree deaths as well as sand wash.
- 2006 flood filled Kondinin Lake more slowly and caused less damage and tree deaths, however it killed planted saltbush and *Melaleuca* spp. on lake banks. The vegetation is starting to come back.

From Andrew Butler (owner):

- Andrew has owned the land for approximately two years but is familiar with the site history.
- The site was included in one of the first farms in the district (Kondinin was first settled in 1908, and the farm would have been cleared in the 1910s). The old homestead site is still visible on the eastern edge of the site. The site was divided into several small holding paddocks and some areas were cleared and cropped. The

presumption is that the areas would have been only lightly wooded: trees are now confined to only a few small raised areas. The dam near the centre of the site (Plate A1.38) was used for stock and house water, however it is now dry and silted, and the soil surrounding the dam is saline and supporting samphire.

- The cleared areas are occasionally sown to oats but are currently mostly regenerated samphire on the lower-lying areas, which is a result of the 2006 floods which left the area wet for several months (the soil was still wet at seeding). The area is grazed, usually in Dec/Jan although there is less saltbush (*Atriplex*) than previously.
- The trees, mostly salmon gum and yorrel, and *Melaleuca* spp. have died recently (2006) as a result of sustained waterlogging (Plate A1.36).
- It takes about 125mm of rain to fill the lake to the point of overflow. The site is on the main channel but there are no distinct channels. It is a true floodplain – water just flows over the area. The clay soils absorb and retain moisture but are not suitable for dam construction due to their dispersive nature.

From field observation:

- The cleared areas appear to be mostly on the lower parts: these are now samphire, however the higher areas which were cleared are mostly ryegrass and ice-plant.
- Lichen is present on the ground in the wooded and shrubby areas on the higher rises, indicating lack of salinity on the soil surface.
- There are several dams scattered throughout the site however none appeared to hold water, possibly as a result of soil structural decline making the clay dispersive thus no longer able to hold water. Although these structures are called dams, it may be that they were actually soaks which have been deepened, with the spoil forming the dam walls – they do not all appear to have open inlet areas.
- Stock water is from troughs fed by scheme water.
- It appears that this site is on either an uplifted area or on a higher land surface that has resulted from a barrier created by a dolerite dyke. Reason 1: Kondinin Lake, which is only approximately 400m to the south, must fill completely before overflowing onto this site (the floodplain). Reason 2: The northern banks of Lake Kondinin are relatively steep in comparison with the other banks, which corroborates this observation. However rather than uplift, a barrier created by a possible dolerite dyke, which now forms the south-west / north-east aligned northern bank of the lake (the red soil shown in aerial photographs) may be the cause of this anomaly.

Photo A1.33: LR07
Very good condition vegetation association 1: Eucalyptus loxophleba *subsp.* loxophleba *very sparse woodland on slightly raised area on floodplain.*

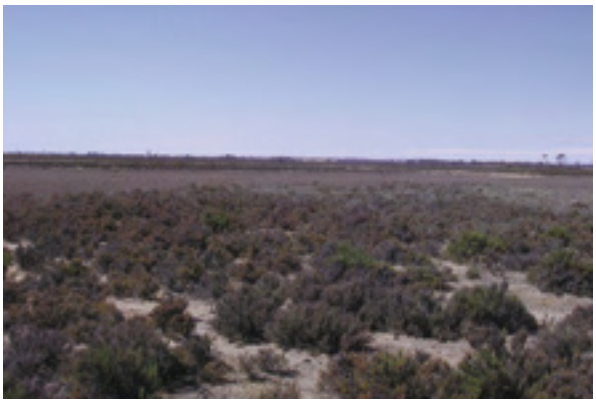


Photo A1.34: LR07
Degraded condition vegetation association 2: Halosarcia *spp. sparse shrubland on floodplain.*

Photo A1.35: LR07
Very good condition vegetation association 3: Melaleuca pauperiflora, M. acuminata *and* M. lateriflora *sparse shrubland on raised area of floodplain.*

Photo A1.36: LR07
Melaleuca shrubland on raised area of floodplain with recent deaths amongst living shrubs. Deaths were a result of 2006 floods.

Photo A1.37: LR07
Degraded condition Eucalyptus loxophleba *subsp. loxophleba woodland on lower valley slope.*

Photo A1.38: LR07
Dam (or soak) near centre of the site. This used to be the main water supply for the homestead and stock but is now dry and saline.

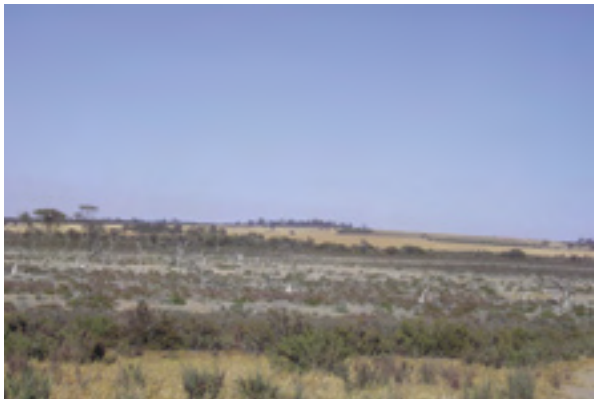
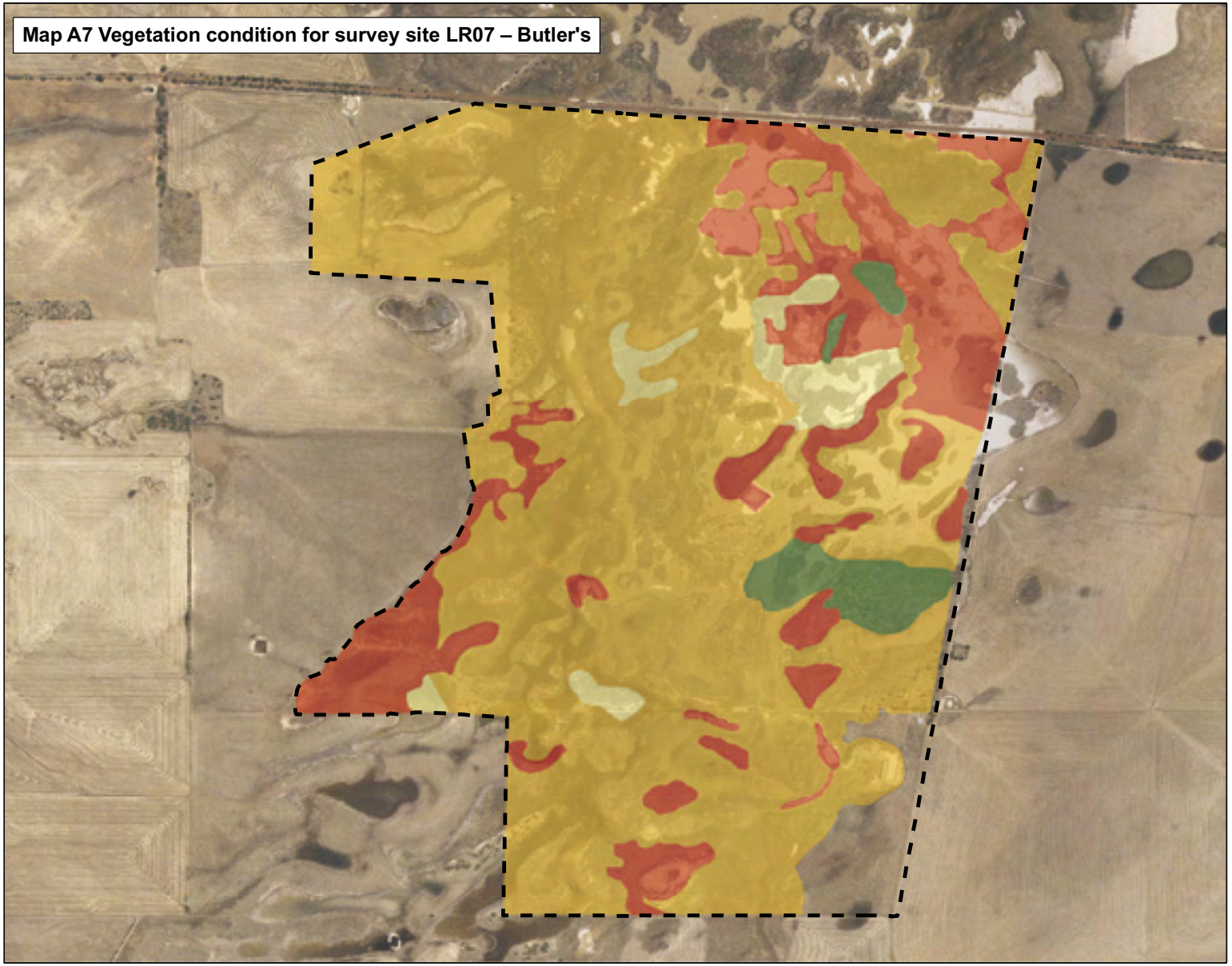


Photo A1.39: LR07
General view of floodplain with cleared area in foreground.

Map A7 Vegetation condition for survey site LR07 – Butler's



Legend

Vegetation condition

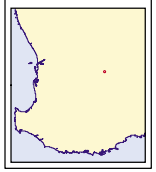
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 100 200 300 400

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
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Filename:
MapA7 Veg_cond_suvey site LR07.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
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Site LR08 – Kondinin Lake

General details	
Site name	Kondinin Lake
Landholder	DEC and Shire of Kondinin
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	14-11-2007

Site description	
Landform	Kondinin Lake (the site) has two largely bare playa lakes set in the main stream channel of the Lockhart River. The southern smaller lake has an inlet near the centre of the eastern shore and outlet on the northern end, and a very minor tributary on the south-eastern corner. The larger northern lake has the inlet on the south-eastern corner and the outlet on the western corner, and tributaries in from the north, south-west and west. The lake beds have parallel series of raised areas and lunettes, running parallel with the eastern shore (possibly including former shorelines). The lake banks on the north-western shore are steep, but other sides have shallower gradients and fringing vegetation, mostly samphire.
Site size	1684 ha

Beard vegetation description
Beard vegetation association 125: Bare areas; salt lakes.
Beard vegetation association 1023: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	<2%	*Eucalyptus loxophleba* subsp. *loxophleba, E. yilgarnensis, E. spathulata*
Mallees	0	
Shrubs	10-30%	*Halosarcia* spp.
Grasses	<2%	*Eragrostis dielsii*
Herbs	<2%	Mixed annuals
Rushes and sedges	0	
Litter	<2%	
Bare ground	70-100%	
Rock outcrop	0	
Summary		
The lake bed (on the raised banks) and around the edges of the lake is largely *Halosarcia* shrubland. There are very sparse emergent *Melaleuca brevifolia* around the lake edges, but not in the lake, although there are areas of dense sticks indicating that the *Melaleuca* was more plentiful in the past. There was a small area of living *Melaleuca* spp. shrubland on the banks of the southern lake. The lunettes around the northern lake have woodland of varying species.		

Individual vegetation association descriptions	
Vegetation 1	*Melaleuca brevifolia* and *M.* sp. sparse shrubland.
Vegetation 2	*Halosarcia* spp. sparse shrubland. Emergent very sparse *Melaleuca brevifolia*.
Vegetation 3	*Eucalyptus loxophleba* subsp. *loxophleba, E. yilgarnensis* and *E. spathulata* sparse woodland over *Olearia dampieri subsp. eremicola* and *Rhagodia preissii* very sparse shrubs over *Lomandra effusa* very sparse sedges over *Austrostipa* spp. very sparse grass over very sparse mixed introduced annual herbs.
Vegetation 4	*Eucalyptus spathulata* very sparse woodland over *Melaleuca hamata, M.* sp. and *Santalum murrayanum* very sparse shrubs over sparse *M.* sp. seedlings over *Eragrostis dielsii* and *Austrostipa* spp. very sparse grass.

Native species	
Scientific name	**Common name**
Acacia acuminata	Jam
Atriplex paludosa	Marsh saltbush
Atriplex semibaccata	Creeping saltbush
Austrostipa spp.	Speargrass
Carpobrotus modestus	Inland pig face
Casuarina obesa	Swamp sheoak
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus loxophleba subsp. loxophleba	York gum
Eucalyptus myriadena	Eucalypt
Eucalyptus salmonophloia	Salmon gum
Eucalyptus salubris	Gimlet
Eucalyptus spathulata	Swamp mallet
Exocarpos aphyllus	Leafless ballart
+ Halosarcia spp.	Samphire (5-6 species)
Lycium australe	Australian boxthorn, water bush
+ Melaleuca ?carrii	Paperbark
Melaleuca brevifolia	Paperbark
+ Melaleuca hamata	Broombush
Melaleuca lateriflora	Gorada
Olearia dampieri subsp. eremicola	Daisy-bush
Rhagodia preissii	Rhagodia
Santalum murrayanum	Bitter quandong
+ Regeneration noted	

Weed species	
Scientific name	**Common name**
Atriplex nummularia	Old man saltbush
Avena fatua	Wild oat
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Parapholis incurva	Coast barbgrass
Ursinia anthemoides	Ursinia
Vulpia myuros	Silver grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	5
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	70
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	20

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish		x	
Waterlogging	x			Plant disease			x
Ponding from road crossing	x			Erosion		x	
Drainage			x	Service corridors			x
Clearing			x	Feral animals		x	
Fire risk			x	Recreation		x	
Weed invasion			x	Point source discharge			x
Stock access			x	Other		x	
Vehicle access			x				

Comments

The disturbance factors threatening the vegetation on this site are largely associated with hydrological change: salinity increase, periods of waterlogging and ponding from the road crossing, which affects the southern lake. Other lesser disturbance factors include rubbish dumping and erosion caused by recreational activities, including ski boats on the lake. Sand has been extracted from many of the lunettes around the lake: this has degraded existing vegetation and further sand extraction on this site would almost entirely eliminate lunette vegetation.

Links to protected areas of remnant vegetation
See Table 2

Management
The culvert under the main road is narrow, relative to the size of the channel and has washed away in the last floods: this should be widened to avoid infrastructure (road) damage and allow free water flow. Although the site is a reserve, many of the surrounding fences separating the reserve from the farmland are in poor condition and should be improved. Sand extraction from the lunette areas should not occur. Although there is little vegetation, fire breaks around the woodland areas should be maintained. In the event of a fire, rabbit control would be required to allow regeneration of the woodlands.

Fauna	
Scientific name	**Common name**
Birds	
Corvus coronoides	Australian raven
Cracticus tibicen	Magpie
Cracticus torquatus	grey butcherbird
Grallina cyanoleuca	peewee or magpie-lark
Manorina flavigula	yellow throated miner
Ocyphaps lophotes	crested pigeon
Pardalotus striatus	striated pardalote
Platycercus varius	mulga parrot
Platycercus zonarius	Australian ringneck parrot
Pomatostomus superciliosus	white-browed babblers
Mammals	
Macropus fuliginosus	western grey kangaroo
**Oryctolagus cuniculus*	rabbit
Reptiles	
Tiliqua rugosa	bobtail
Varanus tristis	black-headed monitor
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

Observations:

- Water sampled from the tributary near the south-western corner of the lake had pH 7.99, and a water temperature of 30˚. The conductivity was in excess of the maximum range of the meter.
- Newly deposited sand was observed in the lunette area.
- *Santalum murrayanum* on the lunettes appear to be dying.
- *Melaleuca* spp. on lunettes are regenerating.
- Lake is used for waterskiing when full. There were remains of shelter areas on the edge of the lake.
- There were extensive areas of recently dead vegetation around the lake, but especially near the western end.
- Despite having (possibly) permanent water, no waterbirds were observed.
- The lake position appears to have moved to the west over time: there is a series of lakes in an arc and series of lunettes that probably were previously shorelines to the east of the north lake. The low-lying areas between these lunettes now supports bluebush (*Maireana brevifolia*), and closer to the current lake, samphire.
- The north-western shore of the lake is steep and the banks are tall in comparison to the other shorelines, although some areas around the southern lake also have tall, steep banks.

- The lake fills before overflowing, indicating that the water gets trapped here by higher land to the north. This may be due to land tilting and creating a barrier, or the barrier may have been a dolerite dyke (the soil is red on this northern side).

John Browning (owner of the land surrounding the southern lake):

- The 2006 floods brought in very salty water from the Jilakin system, further upstream on the Lockhart system, which killed many plants. Previous floods have been from the less-saline Hyden area (Camm River system).
- The road between the lakes has washed away during both of the most recent floods. The earlier bridge, which was built in the 1930s, allowed free flow of water but this was replaced with culverts some time before the 2000 flood. The culverts are not large enough to allow flood flow.

From Jenny Browning (owner of land to the west of the northern lake: these comments also included for site LR07):

- 2000 flood filled Kondinin Lake very quickly (within 24 hours) and washed over the banks of the lake into the surrounding area. The flooded land couldn't be cropped for 2 years: the soil became smelly mud. There were many tree deaths as well as sand wash.
- 2006 flood filled Kondinin Lake more slowly and caused less damage and tree deaths, however it killed planted saltbush and Melaleuca on lake banks. The vegetation is starting to come back.

From Andrew Butler (owner of LR07 to the north but whose main property is west of John Browning: these comments also included for LR07):

- It takes about 125mm of rain to fill the lake to the point of overflow.

Photo A1.40: LR08
Very good condition vegetation association 1: Melaleuca *spp. sparse shrubland on lunette of south lake.*

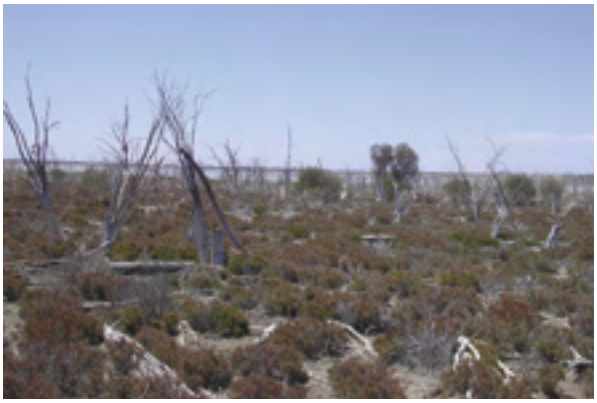


Photo A1.41: LR08
Degraded condition vegetation association 2: Halosarcia *spp. sparse shrubland with rare emergent* Melaleuca *spp. shrubs on lake edge.*

Photo A1.42: LR08
Very good condition vegetation association 3: Eucalyptus loxophleba *subsp.* loxophleba, E. yilgarnensis *and* E. spathulata *sparse woodland on lunette. This woodland has been cleared or degraded in most areas due to sand extraction.*

Photo A1.43: LR08
Very good condition vegetation association 4: Eucalyptus spathulata *very sparse woodland on lunette at lake edge. Note regenerating* Melaleuca *spp. shrubs.*

Photo A1.44: LR08
Tributary into the south-west corner of the north (main) lake. Note completely degraded condition of vegetation. This is near the site of water quality sample.

Photo A1.45: LR08
Good condition Eucalyptus *spp. woodland on lunette of southern lake.*

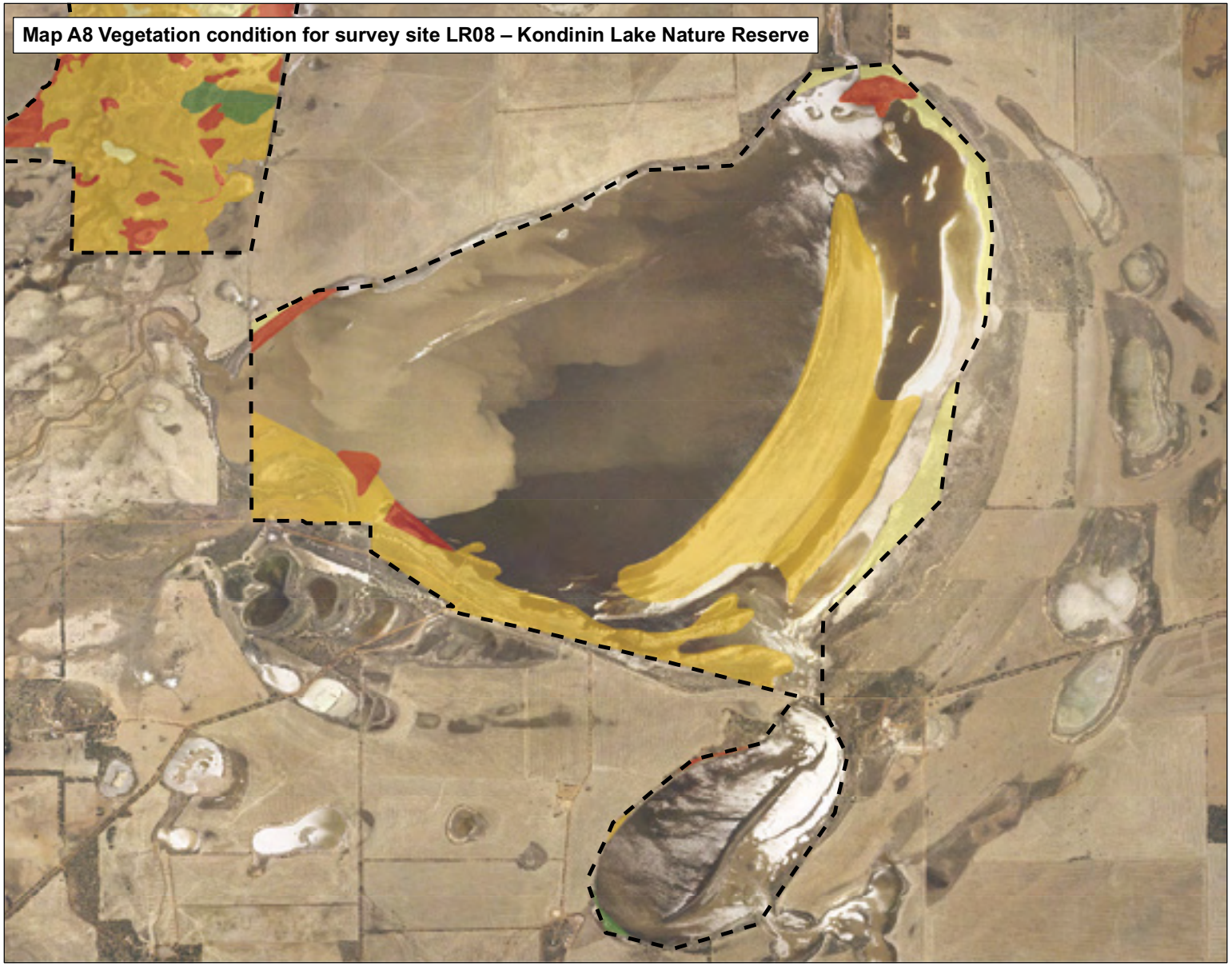
Photo A1.46: LR08
Recreation site on southern shore of main lake.

Photo A1.47: LR08
Recreation site on southern shore of main lake.

Photo A1.48: LR08
View over northern end of main lake.

Photo A1.49: LR08
View over northern end of main lake.

Map A8 Vegetation condition for survey site LR08 – Kondinin Lake Nature Reserve



Legend

Vegetation condition

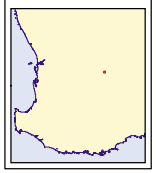
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 200 400 600 800

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
Filepath:
J:\gisprojects\Project\B_Series\B4148\0003\mxd\
Filename:
MapA8 Veg_cond_suvey site LR08.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

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Site LR09 – Poondarra

General details	
Site name	Poondarra
Landholder	John Young
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	14-11-2007

Site description	
Landform	The site is mostly within the floodplain of the Lockhart River, and includes the main flow channel, which is dispersed and not obvious, some lunettes and a dry playa lake. There is an area of lower valley slope to the east of the playa lake.
Site size	92 ha

Beard vegetation description
Beard vegetation association 131: Mosaic; Medium woodland: salmon gum and gimlet/mallee scrub, redwood and black marlock.
Beard vegetation association 959: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	<2%	*Eucalyptus spathulata*
Mallees	<2%	*Eucalyptus yilgarnensis*
Shrubs	2-10%	*Halosarcia* spp.
Grasses	0	
Herbs	2-10%	Mixed
Rushes and sedges	0	
Litter	2-10%	
Bare ground	70-100%	
Rock outcrop	0	
Summary		
The low lying areas within the floodplain are largely *Halosarcia* spp. shrublands, with *Eucalyptus spathulata* woodland and *Melaleuca* spp. shrubs on the lunettes, which are greater than one metre high. The raised areas of the lower valley slopes between playa lakes (they are not lunettes) have mallee with occasional emergent *Eucalyptus salmonophloia* and other species, or occasionally *Acacia acuminata*.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus spathulata* very sparse woodland over *Melaleuca lateriflora, M. hamata* and *M. acuminata* very sparse shrubs over sparse introduced annual herbs.
Vegetation 2	*Halosarcia* spp. very sparse shrubland over *Mesembryanthemum nodiflorum* very sparse herbs.
Vegetation 3	*Eucalyptus yilgarnensis* sparse mallee over *Templetonia sulcata* and *Lycium australe* very sparse shrubs over *Atriplex paludosa* very sparse shrubs.

Native species	
Scientific name	**Common name**
Acacia acuminata	Jam
Atriplex paludosa	Marsh saltbush
Austrostipa spp.	Speargrass
Didymanthus roei	Didymanthus
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Erymophyllum tenellum	
Eucalyptus loxophleba subsp. loxophleba	York gum
Eucalyptus salmonophloia	Salmon gum
Eucalyptus spathulata (sens lat)	Swamp mallet
Eucalyptus yilgarnensis	Yorrel
Exocarpos aphyllus	Leafless ballart
Halosarcia spp.	Samphire (3-4 spp.)
Lomandra effusa	Scented matrush
Lycium australe	Australian boxthorn, water bush
Melaleuca acuminata	Paperbark
Melaleuca hamata	Broombush
Melaleuca lateriflora	Gorada
Rhagodia preissii	Rhagodia
Santalum murrayanum	Bitter quandong
Scaevola spinescens	Maroon bush
Sclerolaena diacantha	Grey copper-burr
Templetonia sulcata	Centipede bush

Weed species	
Scientific name	**Common name**
Bromus rubens	Red brome
Hypochaeris glabra	Flatweed
Mesembryanthemum nodiflorum	Slender ice-plant
Parapholis incurva	Coast barbgrass
Pentaschistis airoides	False hair-grass
Spergularia marina	Salt spurry
Vulpia myuros	Silver grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	0
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	35
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	55
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	10

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish		x	
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			x
Drainage			x	Service corridors			
Clearing		x		Feral animals		x	
Fire risk		x		Recreation			
Weed invasion		x		Point source discharge			
Stock access	x			Other			
Vehicle access			x				

Comments

The site, like all others, is highly threatened by increases in salinity and rising watertables. Most of the site is already degraded, however there are a few lunettes with *good* condition vegetation that are under threat. The lower valley slope woodlands are less threatened by salinity and watertable change, however they are threatened by grazing causing soil degradation, weed invasion, increased fire risk, feral animals and rubbish dumping. As this area of woodland is privately owned it is possible that it may be cleared.

Links to protected areas of remnant vegetation

See Table 2

Management

The site is grazed, with soil structure altered by hooves, especially in the lunette areas. It is recommended that the site is fenced from grazing. Saltland grazing may be an appropriate management recommendation for the paddock area immediately north of the site boundary. Any management likely to impact on the main threats of salinity and watertables must be undertaken at a catchment level.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Artamus cinereus	Black-faced woodswallow
Coracina novaehollandiae	Black-faced cuckoo-shrike
Epthianura tricolor	Crimson chat
Lichenostomus virescens	Singing honey-eater
Platycercus zonarius	Australian ringneck parrot
Rhipidura leucophrys	Willy wagtail
Mammals	
Macropus fuliginosus	Western grey kangaroo
**Oryctolagus cuniculus*	Rabbit
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:

From discussion with owner John Young:

- He has been farming since 1945 but was resident before then and remembers the original house burning down in 1935 when the family was away on holiday. He has since retired: the farm is leased but he still lives on site.
- The area was cleared in the 1920s, mostly by Italian immigrants.
- He still has freshwater seeps in the sandplain north of this site.
- The southern boundary of the site is the original road to the reservoir (on a granite outcrop to the east) and was regularly used in the past, although not always passable in the wet.
- He remembers ‘dead sticks in the samphire’ from his earliest memories, therefore shrub deaths must have occurred before or rapidly after clearing.

From observation:

- A crab claw was found on site.
- Grazing is damaging soil structure.

Photo A1.50: LR09
Good condition vegetation association 1: Eucalyptus spathulata *very sparse woodland on lunette.*

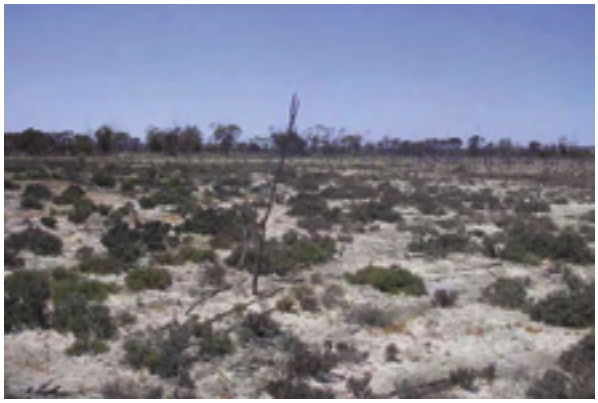


Photo A1.51: LR09
Degraded condition vegetation association 2: Halosarcia *spp. very sparse shrubland on floodplain.*

Photo A1.52: LR09
Good condition vegetation association 3: Eucalyptus yilgarnensis *sparse mallee on lower valley slope between lakes.*

Map A9 Vegetation condition for survey site LR09 – Poondarra

Legend

Vegetation condition

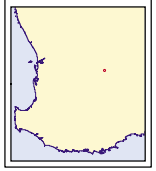
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 50 100 150 200

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
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Filename:
MapA9 Veg_cond_suvey site LR09.mxd
Date: August 2008

SOURCES

DoW acknowledges the following datasets and their Custodians in the production of this map:

Corrigin Aerial Imagery - Landgate - 2001
Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

Government of **Western Australia**
Department of **Water**

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Site LR10 – Bowey

General details	
Site name	Bowey
Landholder	John and Robbie Bowey
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date surveyed	14-11-2007

Site description	
Landform	The site consists of a large playa lake and a meandering stream channel and floodplain, with lunettes on the eastern and southern sides. The confluence of the Lockhart and Camm rivers occurs near the south-eastern corner of the site. There is a narrow strip of lower valley slope along the western edges of the stream channel and lake.
Site size	164 ha

Beard vegetation description
Beard vegetation association 8: Medium woodland; salmon gum and gimlet.
Beard vegetation association 125: Bare areas: salt lakes.
Beard vegetation association 959: Succulent steppe with sparse woodland thicket; yorrel and Kondinin blackbutt over teatree and samphire.

Overall vegetation structure and cover (for vegetated areas only)		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2-10%	*Eucalyptus yilgarnensis, E. kondininensis*
Mallees	<2%	*E. horistes, E. loxophleba* subsp. *loxophleba*
Shrubs	10-30%	*Melaleuca brevifolia, M. lateriflora, Halosarcia* spp.
Grasses	<2%	*Austrostipa* spp., *Eragrostis dielsii*
Herbs	2-10%	*Mesembryanthemum nodiflorum*
Rushes and sedges	<2%	*Lomandra effusa*
Litter	2-10%	
Bare ground	70-100%	
Rock outcrop	0	
Summary		
The vegetated part of the site consists of woodland of various combinations of species, usually including *Eucalyptus yilgarnensis,* on the valley slopes on the edges of the lake and river channel. The lunette on the eastern side of the lake also has *E. yilgarnensis* woodland, although this is occasionally replaced with *E. salmonophloia*, over chenopod shrubs. The lunettes on the eastern side of the stream channel have *E. horistes* or *E. loxophleba* subsp. *gratiae* mallee or, in the lower-lying areas, *Melaleuca* spp. shrubland. The lowest lying parts of the floodplain and lake edges have *Halosarcia* spp. shrublands.		

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus horistes* very sparse mallee over *Senna artemisioides* subsp. *filifolia* and *Olearia dampieri* subsp. *eremicola* very sparse shrubs over *Lomandra effusa* very sparse sedges.
Vegetation 2	*Halosarcia* spp. sparse shrubland over *Roycea spinescens* and *Mesembryanthemum nodiflorum* sparse herbs.
Vegetation 3	*Melaleuca brevifolia* and *M. lateriflora* very sparse shrubland over *Halosarcia* spp. very sparse shrubs over very sparse mixed annual herbs.
Vegetation 4	*Eucalyptus yilgarnensis* and *E. kondininensis* sparse woodland over *Rhagodia preissii* and *Atriplex paludosa* very sparse shrubs over *Austrostipa* spp. and *Austrodanthonia* spp. very sparse grass.
Vegetation 5	*Eucalyptus yilgarnensis* very sparse woodland over *Hakea kippistiana* open shrubs over *Halosarcia* spp. and *Maireana brevifolia* very sparse shrubs.

Native species	
Scientific name	**Common name**
Amphipogon strictus	Greybeard grass
Aristida contorta	Bunched kerosene grass
Atriplex paludosa	Marsh saltbush
Atriplex semibaccata	Creeping saltbush
Atriplex sp.	Saltbush
Austrodanthonia spp.	Wallaby grass
Austrostipa elegantissima	Feather spear-grass
Austrostipa spp.	Speargrass
Casuarina obesa	Swamp sheoak
Dianella revoluta	Blueberry lily
Disphyma crassifolium	Feather spear-grass
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Eucalyptus horistes	White flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	Morrell
Eucalyptus loxophleba subsp. *gratiae*	Lake Grace mallee
Eucalyptus salmonophloia	Salmon gum
Eucalyptus yilgarnensis	Yorrel
Exocarpos aphyllus	Leafless ballart
+ Hakea kippistiana	Hakea
Hakea preissii	Needle tree
+ Halosarcia spp.	Samphire (3-4 spp.)
Leptospermum erubescens	Roadside tea-tree
Lomandra effusa	Scented matrush
Maireana brevifolia	Small-leaf bluebush
Maireana sp.	Bluebush
Melaleuca brevifolia	Paperbark
Melaleuca cuticularis	Saltwater paperbark
Melaleuca lateriflora	Gorada
Melaleuca pauperiflora	Boree
Melaleuca thyoides	Paperbark
Olearia dampieri subsp. *eremicola*	Daisy-bush
Pittosporum angustifolium	Native apricot, native willow
Pogonolepis stricta	
Rhagodia drummondii	Rhagodia
+ Roycea spinescens	
Santalum murrayanum	Bitter quandong
Sclerolaena diacantha	Grey copper-burr
Senna artemisioides subsp. *filifolia*	Desert cassia
Waitzia acuminata	Orange immortelle
+ Regeneration noted	

Weed species	
Scientific name	**Common name**
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Hypochaeris glabra	Flatweed
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Morea setifolia	Thread iris
Parapholis incurva	Coast barbgrass
Pentaschistis airoides	False hair-grass
Ursinia anthemoides	Ursinia
Vulpia myuros	Silver grass

Other plant lists for the general area
Beard, JS (1980)
Grein, SB (1994)
Lefroy *et al* (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	10
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	50
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	35
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	5

Disturbance factors contributing to vegetation condition score							
	Level of threat				Level of threat		
Disturbance factor	H	M	L	**Disturbance factor**	H	M	L
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			x
Drainage				Service corridors			
Clearing		x		Feral animals	x		
Fire risk		x		Recreation			
Weed invasion	x			Point source discharge			
Stock access	x			Other			
Vehicle access		x					

Comments
The vegetation on this site has been degraded, and is still under threat of further degradation, mainly as a result of changes to salinity and the watertable. The site is grazed by sheep and a large population of rabbits, and these are factors in vegetation condition degradation and lack of regeneration, with soil surface disturbance leading to weed invasion. Clearing is a threat as the site is privately owned. There is a track along the southern and eastern edges of the lake which, along with the grazing by livestock, allows opportunity for weed invasion due to weed seed source and soil disturbance.

Links to protected areas of remnant vegetation
See Table 2

Management
Grazing exclusion and feral animal (rabbit) control are suggestions for management on this site. Any management recommendations for control of salinity and watertable change must be on a catchment scale.

Fauna	
Scientific name	**Common name**
Birds	
Acanthiza spp.	Thornbills
Accipiter fasciatus fasciatus	Brown goshawk
Anthus australis	Australian pipit
Corvus coronoides	Australian raven
Cracticus torquatus	Grey butcherbird
Lichenostomus virescens	Singing honey-eater
Malurus sp.	Fairy wren
Manorina flavigula	Yellow throated miner
Ocyphaps lophotes	Crested pigeon
Pardalotus striatus	Striated pardalote
Petroica goodenovii	Red-capped robin
Platycercus zonarius	Australian ringneck parrot
Podargus strigoides	Tawny frogmouth
Pomatostomus superciliosus	White-browed babblers
Mammals	
Macropus fuliginosus	Western grey kangaroo
**Oryctolagus cuniculus*	Rabbit
* Introduced species	

Other fauna lists for the general area
Grein, SB (1994)
Lefroy *et al* (1991)

Notes:
Paddock spoil (straw and rabbit scats) was observed high on the banks of the lake: this appeared to be deposited as a result of the floods rather than washed down as a result of surface runoff.

The lower lying (floodplain) areas amongst the lunettes, which were *Melaleuca* spp. shrublands, had high proportions of recently deceased shrubs and have now been colonised by samphire, probably as a result of the 2006 floods.

Photo A1.53: LR10
Very good condition vegetation association 1: Eucalyptus horistes *very sparse mallee on lunette between river confluences.*

Photo A1.54: LR10
Good condition vegetation association 2: Halosarcia *spp. sparse shrubland on floodplain. The samphire on the floodplain varied from good to completely degraded condition.*

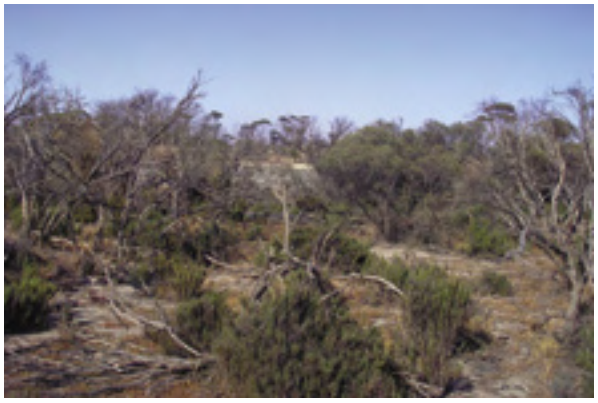


Photo A1.55: LR10
Degraded condition vegetation association 3: Melaleuca brevifolia *and* M. lateriflora *very sparse shrubland on low-lying area adjacent to floodplain. Note recent shrub deaths.*

Photo A1.56: LR10
Very good condition Eucalyptus yilgarnensis *and* E. kondininensis *sparse woodland on lower valley slope.*

Photo A1.57: LR10
Good condition vegetation association 5: Eucalyptus yilgarnensis *very sparse woodland on lower valley slope adjacent to lake edge.*

Photo A1.58: LR10
Degraded condition woodland on southern edge of the lake.

Map A10 Vegetation condition for survey site LR10 – Bowey

Legend

Vegetation condition

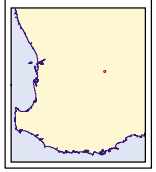
- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

N

0 100 200 300 400

Metres

LOCALITY MAP



Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Vishnu Nallan
Task ID: 6957
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Filename:
MapA10 Veg_cond_suvey site LR10.mxd
Date: August 2008

SOURCES

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Vegetation condition – DoW – 2008
WA Coastline – DoW – July 2006

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Department of **Water**

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Appendix 2 Standard survey form

General details

Recorder's name: …… Survey date: ……...

Site number: …… Site name……

Landholder: …… Contact number: ……..

Property address: ……...

Site position in landscape

❒ Valley floor
❒ Valley slope
❒ Uplands
❒ Rocky outcrop

Floodplain features

Natural features:

- ❒ Salt lakes (playas)
  - ❒ Permanent water
  - ❒ Seasonally wet
- ❒ Braided channel
  - ❒ Discontinuous
  - ❒ Continuous
- ❒ Lunettes (dunes)
- ❒ Tributary

Constructed features:

- ❒ Drain
- ❒ Dam
- ❒ Other……

Vegetation description (from Keighery, 1994)

Beard vegetation association

Number	Description
8	Medium woodland; salmon gum and gimlet
125	Bare areas; salt lakes
131	Mosaic; Medium woodland: salmon gum and gimlet/Shrublands: mallee scrub, redwood and black marlock
959	Succulent steppe with sparse woodland thicket; yorrell and Kondinin blackbutt over teatree and samphire
1023	Medium woodland; York gum, wandoo and salmon gum

Vegetation structure and cover (both native and weed species)

Vegetation layer	Canopy cover class*	Dominant species**
Trees		
Mallees		
Shrubs		
Grasses		
Herbs		
Rushes and sedges		
Litter		
Bare ground		
Rock outcrop		

*Canopy cover class (where canopy cover refers to the total area under an imaginary line bounding the extremities off all plants in each layer):

Very open 2-10% Sparse 20-30% Open 30-70% Closed 70-100%

**More than 3 dominant species described as mixed

Native species list

Record number of species if all species cannot be identified by name

Regeneration ❒ Yes ❒ No Species: ……

Weed species list

Record number of species if all species cannot be identified by name

Vegetation condition (from Keighery, 1994)

Condition	Description	% of site
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	

Disturbance factors affecting vegetation condition score

Disturbance factor	Threat level		
	High	Medium	Low
Salinity			
Waterlogging			
Ponding from road crossing			
Drainage			
Clearing			
Fire risk			
Weed invasion			
Stock access			
Vehicle access			
Rubbish			
Plant disease			
Erosion			
Service corridors			
Feral animals			
Recreation			
Point source discharge			
Other			

Linkages to protected remnant vegetation (from aerial photography)

Site name	Area (ha)	Approximate distance and direction from site

Aquatic vegetation (if water is present)

Is the aquatic environment dominated by:

❒ Macrophytes ❒ Phytoplankton ❒ Benthic microbial mats

Water depth and quality observations

Any data or observations on variation in water depth? Evidence – debris, water marks, salt deposits etc.

Any data or observations on water quality? (i.e. discoloured water, debris, algal blooms).

Disturbance factors impacting on in-stream functions

Disturbance factor	Threat level		
	High	Medium	Low
Salinity			
Change in hydroperiod			
Drainage			
Clearing of fringing veg			
Sediment			
Rubbish			
Point source discharge			
Recreation			
Other			

Water quality data (channels, wetlands, drains, tributaries)

Sample number	pH	Conductivity (mS/cm)	Temperature (ºC)	Location

Evidence of management

Tick the appropriate boxes:

- ❒ Revegetation
- ❒ Fencing (also need to complete fencing section below)
- ❒ Drainage
- ❒ Fire break control
- ❒ Prescribed burning
- ❒ Weed control
- ❒ Surface water management
- ❒ Other: ……

Ideas for management

Tick the appropriate boxes:

- ❒ Prescribed burning
- ❒ Firebreak control
- ❒ Fencing
- ❒ Erosion control
- ❒ Saltland grazing
- ❒ Agroforestry
- ❒ Remnant vegetation management
- ❒ Weed control
- ❒ Drainage
- ❒ Sediment management
- ❒ Surface water management
- ❒ Road crossing
- ❒ Other……

Fauna list

Photos (veg associations, landscape units, floodplain features etc)

Number	Description

Appendix 3 Vegetation condition photographs

Photo A3.1
Excellent condition woodland, Dickinson's (LR05 Vegetation Association 3).

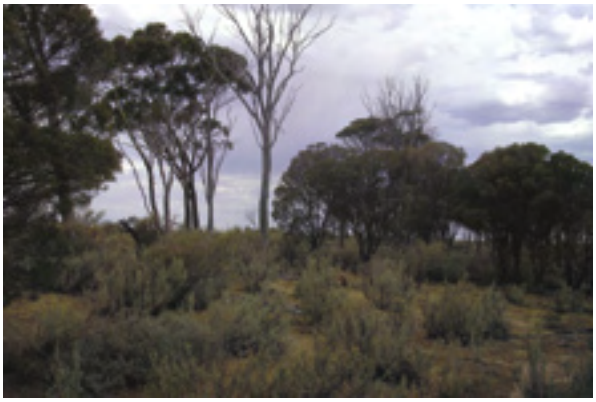


Photo A3.2
Very good condition vegetation, CR18455 (LR06 Vegetation Association 3).

Photo A3.3
Good condition vegetation, Crossland (LR04 Vegetation Association 2)

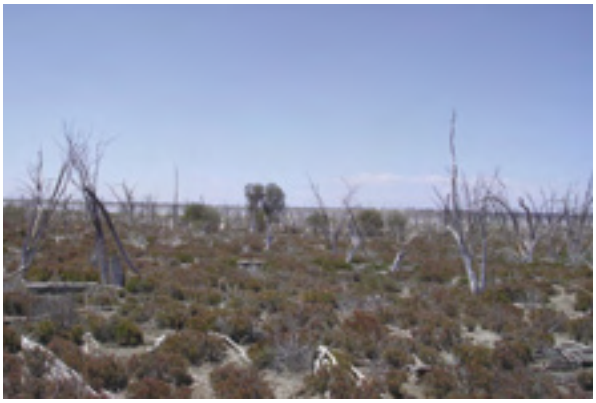


Photo A3.4
Degraded condition vegetation, Kondinin Lake Nature Reserve (LR08 Vegetation Association 3).

Photo A3.5
Completely degraded vegetation, Dickinson's (LR05)

Photo A3.6
Completely degraded vegetation (formerly woodland), Silvergate (LR02 Vegetation Association 2).

Appendix 4 Examples of local native species suitable for revegetation

Table A4 Examples of local species suitable for revegetation in valley floors in the Lockhart catchment.

Inclusion in this table does not guarantee availability of seed or tubestock for revegetation, nor success of establishment.
Information is sourced from Oversby (2004), Mitchell & Wilcox (1994), Lefroy, Hobbs & Atkins (1991) and observations during the field survey.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
Understorey									
Atriplex amnicola (river saltbush)	Very	Moderate (when mature)	Moderate	Yes	Yes	Yes		Dec-Feb	
+ *Atriplex semibaccata* (creeping saltbush)	Slightly	Not	Very	Yes	Yes			Jan-Mar	Grows naturally near salt lakes and in woodlands. Short-lived but regenerates well.
Cyperus gymnocaulos (spiny flat-sedge)	Moderate	Short periods		Yes		Yes		Jan-Feb	Grows in a wide variety of soils, including floodways, seeps and lake edges, especially in disturbed areas with high nutrient levels.
+ * *Eragrostis dielsii* (mallee lovegrass)	Moderate	Moderate	Moderate	Yes	Yes				Prefers lighter soils.
Gahnia trifida (coast saw-sedge)	Very	Moderate		Low success		Yes		Jan-Mar	Grows in a wide variety of soil types, including floodways, clay pans and lake edges.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ * *Halosarcia species* (samphire)	Various	Very	Very			Yes	Yes	Yes	
+ *Maireana brevifolia* (small-leaf bluebush)	Yes	Slightly	Very	Yes	Yes		Yes	Dec-Mar	Grows naturally on drier parts of floodplain.
+ *Rhagodia drummondii* (lake fringe rhagodia)	Very	Slightly	Very	Yes	Yes				Grows in a wide variety of soils, especially sand.
Sporobolus virginicus (native marine couch)	Moderate	Very		Yes		Yes		Jan-Mar	Prefers lighter soils
Midstorey									
+ *Acacia acuminata* (jam)	Slightly	Slightly	Very	Yes	Yes			Nov-Dec	Grows in a wide variety of soil types.
Acacia microbotrya (manna wattle)	Slightly	Slightly		Yes	Yes			Oct-Dec	Grows in a wide variety of soil types.
Callistemon phoeniceus (lesser bottlebrush)	High-Mod	High-Mod	High-Mod	Yes	Yes			All year	Grows in a wide variety of soil types.
Grevillea paniculata	Not	Not			Yes				Suitable for fresh flood fringes
+ * *Hakea kippistiana*									Found naturally regenerating on the edge of salt lakes.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ *Hakea preissii* (needle tree)	Moderate	Moderate			Yes				Grows in many soil types.
Melaleuca adnata									Grows in floodplains
+ *Melaleuca acuminata*									Grows in floodplains
+ *Melaleuca brevifolia*									Grows in floodplains
+ *Melaleuca cuticularis* (saltwater paperbark)									Grows in saline floodplains and on the edge of lakes.
+ * *Melaleuca hamata* (broombush)									One of the Broombush Melaleucas (formerly included with *M. uncinata*). Found near the edge of salt lakes.
+ *Melaleuca thyoides*									Grows on the edge of salt lakes.
Melaleuca uncinata (Broombush)	Variable	Variable							Grows in a wide variety of soil types.
Overstorey									
+ *Casuarina obesa* (swamp sheoak)	Very	Very		Yes	Yes				Grows in many soil types.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ *Eucalyptus horistes* (white flowered mallee)									Grows on dunes near salt lakes and waterways. Includes the mallee formerly called *Eucalyptus hypochlamydea*.
+ *Eucalyptus kondininensis* (Kondinin blackbutt)									Prefers loamy soils near salt lakes.
+ *Eucalyptus longicornis* (morrel)									Grows in saline fine-textured loams and clays on valley floors
+ * *Eucalyptus loxophleba* (York gum)	Some moderate	Not		Yes	Yes			All year	Grows in many soil types. Both mallee (subsp. gratiae) and tree (subsp. loxophleba) suitable.
+ *Eucalyptus myriadena*									Similar in appearance to yorrell. Prefers clay soils near salt lakes.
+ * *Eucalyptus salmonophloia* (salmon gum)	Moderate	Not							Grows in loams and duplex soils on lower slopes and valley floors.
+ *Eucalyptus salubris* (gimlet)	Moderate								Grows in loams and duplex soils on lower slopes and valley floors.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ *Eucalyptus sargentii* (Salt River gum)	Mod-High	Some		Yes	Yes			All year	Grows in a wide variety of soils associated with salt lakes and saline waterways.
+ *Eucalyptus spathulata* (swamp mallet)									Grows close to salt lakes
+ *Eucalyptus yilgarnensis* (yorrell)									Grows in saline fine-textured loams and clays on valley floors

+ species found during field survey

** natural regeneration observed during field survey*

Appendix 5 Examples of species suitable for saltland pasture

Table A5 Examples of species suitable for saltland pasture.

Sourced from Oversby (2004), Phelan (2004), Butler,(2001), Barrett-Lennard & Malcolm (1995), Mitchell & Wilcox (1994) and Runciman & Malcolm (1991).

Species	Origin	Tolerance			Propagation				Seed harvested	Notes
		Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings	Self-seeding		
Saltbush										
Atriplex amnicola (river saltbush)	Local	Very	Moderate (when mature)	Moderate	Yes	Yes	Yes		Dec-Feb	Good forage with up to 10 per cent protein. Recovers well from grazing.
Atriplex cinerea (grey saltbush)	WA	On saline seeps	Moderate		Yes		Yes			Palatability varies
Atriplex nummularia (old man saltbush)	Australia	Moderate	Sensitive		Yes	Yes			Sep-Oct	Not as palatable as other species, brittle and easily damaged by trampling.
Atriplex semibaccata (creeping saltbush)	Local	Slightly	Not	Very	Yes	Yes			Jan-Mar	Short-lived but regenerates well. Very palatable and prone to being eaten out.
Atriplex undulata (wavy-leaf saltbush)	Introduced	Yes	Moderate		Yes			Yes		Palatable. Recovers well from grazing.
Samphire										

Species	Origin	Tolerance			Propagation				Seed harvested	Notes
		Salt	Waterlogging	Drought	Direct seeding	Tubestock	Cuttings	Self-seeding		
Halosarcia species (samphire)	Various	Very	Very			Yes	Yes	Yes		Can survive moderate grazing. Highly saline, therefore sheep must have access to fresh water and graze in conjunction with stubble or other sources.
Bluebush										
Maireana brevifolia (small-leaf bluebush)	Local	Yes	Slightly	Very	Yes	Yes		Yes	Dec-Mar	Good forage with up to 16 per cent protein, very palatable. Recovers well from grazing.
Grasses										
Various grass species	Various	Various	Various	Various						A number of summer active grasses are available: contact the Department of Agriculture and Food for details. Includes Tall Wheatgrass and Pucinellia.

Appendix 6 Flora and fauna lists

Table A6.1 Native plant species found during the survey.

Species	Common name
Acacia acuminata	Jam
Acacia mackeyana	Wattle
Acacia nyssophylla	Wattle
Acacia saligna	Orange wattle
Amphipogon strictus	Greybeard grass
Angianthus tomentosus	Camel-grass
Aristida contorta	Bunched kerosene grass
Atriplex holocarpa	Pop saltbush
Atriplex hymenotheca	Saltbush
Atriplex paludosa	Marsh saltbush
Atriplex semibaccata	Creeping saltbush
Atriplex sp.	Saltbush
Austrodanthonia spp.	Wallaby grass
Austrostipa elegantissima	Feather speargrass
Calandrinia eremaea	Twining purslane
Carpobrotus modestus	Inland pig face
Casuarina obesa	Swamp sheoak
Dianella revoluta	Blueberry lily
Didymanthus roei	Didymanthus
Disphyma crassifolium	Round pig face
Enchylaena tomentosa	Ruby saltbush
Eragrostis dielsii	Mallee lovegrass
Eremophila lehmanniana	Poverty bush
Erymophyllum tenellum	
Eucalyptus horistes	White flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	Morrel
Eucalyptus loxophleba subsp. *gratiae*	Lake Grace mallee
Eucalyptus loxophleba subsp. *loxophleba*	York gum

Species	Common name
Eucalyptus myriadena	Eucalypt
Eucalyptus salmonophloia	Salmon gum
Eucalyptus salubris	Gimlet
Eucalyptus sargentii	Salt River gum
Eucalyptus sp.	Eucalypt
Eucalyptus spathulata	Swamp mallet
Eucalyptus yilgarnensis	Yorrell
Exocarpos aphyllus	Leafless ballart
Frankenia sp.	Frankenia
Gnephosis multiflora	Gnephosis
Hakea kippistiana	Hakea
Hakea preissii	Needle tree
Halosarcia spp.	Samphire (total 5-6 species)
Leptospermum erubescens	Roadside tea-tree
Lomandra effusa	Scented matrush
Lycium australe	Australian boxthorn, water bush
Maireana brevifolia	Small-leaf bluebush
Maireana carnosa	Cottony bluebush
Maireana sp.	Bluebush
Melaleuca ?carrii	Paperbark
Melaleuca acuminata	Paperbark
Melaleuca brevifolia	Paperbark
Melaleuca cuticularis	Saltwater paperbark
Melaleuca lateriflora	Paperbark
Melaleuca pauperiflora	Boree
Melaleuca thyoides	Paperbark
Olearia dampieri subsp*. eremicola*	Daisy-bush
Pittosporum angustifolium	Native apricot, native willow
Podolepis canescens	Bright podolepis
Podotheca gnaphalioides	Golden long-heads
Pogonolepis stricta	
Ptilotus polystachyus	Prince of Wales feather
Rhagodia drummondii	Rhagodia

Species	Common name
Rhagodia preissii	Rhagodia
Rhodanthe manglesii	Pink sunray
Roycea spinescens	
Salsola australe	Prickly saltwort, roly-poly
Santalum acuminatum	Quandong
Santalum murrayanum	Bitter quandong
Scaevola spinescens	Maroon bush
Sclerolaena diacantha	Grey copper-burr
Senna artemisioides subsp. *filifolia*	Desert cassia
Siloxerus pygmaeus	Siloxerus
Stackhousia sp.	Stackhousia
Stylidium repens	Matted triggerflower
Templetonia sulcata	Centipede bush
Thryptomene sp.	Thryptomene
Waitzia acuminata	Orange immortelle

Table A6.2 Weed species found during the survey

Species	Common name
Arctotheca calendula	Capeweed
Avellinia michelii	Avellinia
Avena fatua	Wild oat
Brassica tournefortii	Wild turnip
Bromus rubens	Red brome
Cotula bipinnata	Ferny cotula
Echium plantagineum	Paterson's curse
Ehrharta longiflora	Annual veldt grass
Erodium botrys	Corkscrews
Hordeum leporinum	Barley grass
Hypochaeris glabra	Flatweed
Lolium rigidum	Annual ryegrass
Mesembryanthemum nodiflorum	Slender ice-plant
Monoculus monstrosus	Stinking roger
Morea setifolia	Thread iris

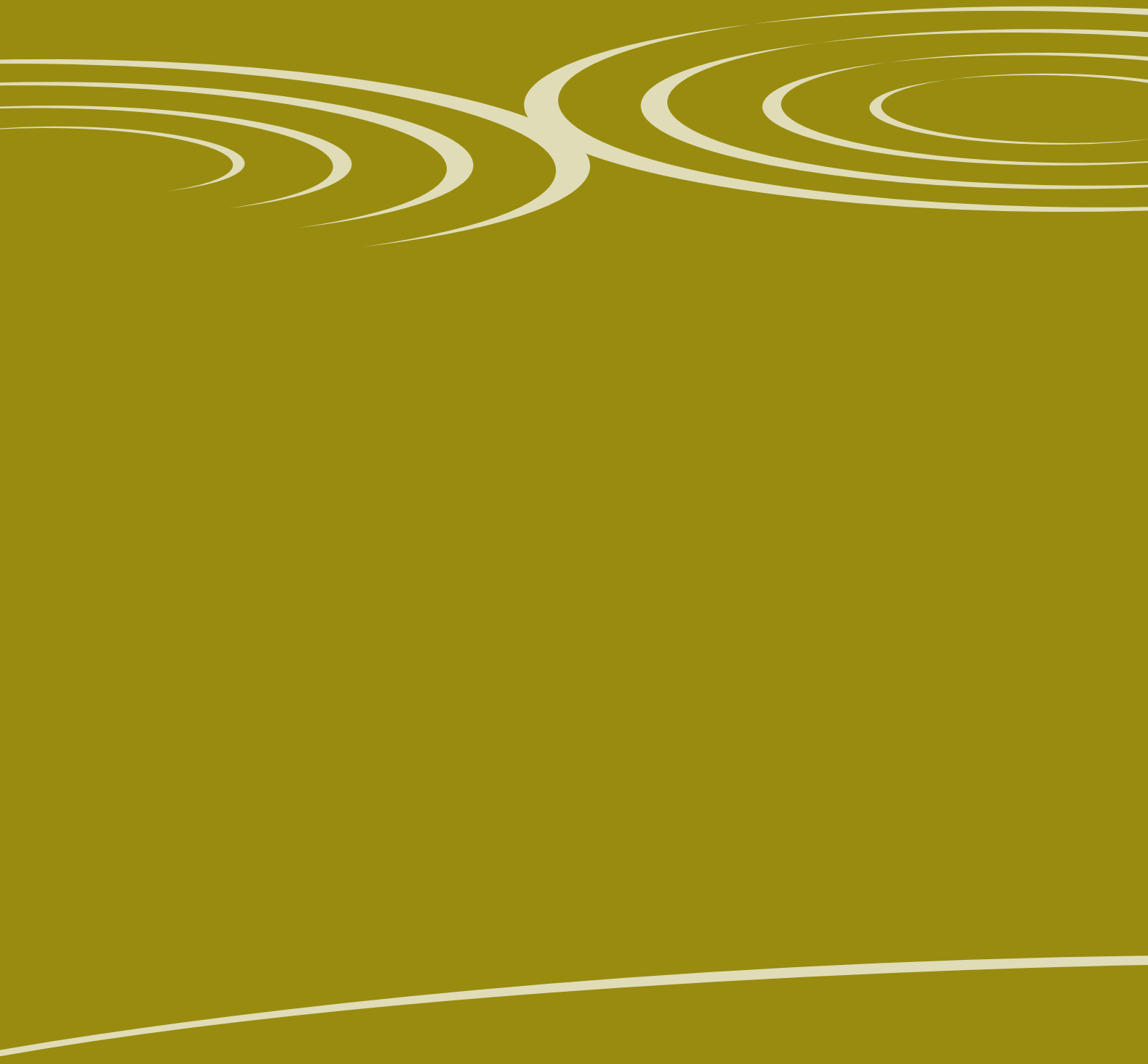
Species	Common name
Parapholis incurva	Coast barbgrass
Pentaschistis airoides	False hair-grass
Phalaris sp.	Canary grass
Plantago coronopus	Bucks-horn plantain
Sisymbrium orientale	Indian hedge mustard
Spergularia marina	Salt spurry
Trifolium arvense	Hair's foot clover
Trifolium glomeratum	Cluster clover
Ursinia anthemoides	Ursinia
Vulpia myuros	Silver grass

Note: Species used for revegetation are not included in these lists.

Table A6.3 Birds found during the survey

Species	Common name
Acanthiza spp.	Thornbills
Accipiter fasciatus fasciatus	Brown goshawk
Anthus australis	Australian pipit
Aquila audax	Wedge-tailed eagle
Artamus cinereus	Black-faced woodswallow
Artamus cyanopterus	Dusky woodswallow
Cacatua roseicapilla	Galah
Cladorhynchus leucocephalus	Banded stilt
Coracina novaehollandiae	Black-faced cuckoo-shrike
Corvus coronoides	Australian raven
Cracticus nigrogularis	Pied butcher bird
Cracticus tibicen	Magpie
Cracticus torquatus	Grey butcherbird
Epthianura albifrons	White fronted chat
Epthianura tricolor	Crimson chat
Grallina cyanoleuca	Peewee or magpie-lark
Lichenostomus virescens	Singing honey-eater
Malurus sp.	Fairy wren
Manorina flavigula	Yellow throated miner

Microeca fascinans	Jacky winter
Neophema elegans	Elegant parrot
Ocyphaps lophotes	Crested pigeon
Pardalotus striatus	Striated pardalote
Petroica goodenovii	Red-capped robin
Platycercus varius	Mulga parrot
Platycercus zonarius	Australian ringneck parrot
Podargus strigoides	Tawny frogmouth
Pomatostomus superciliosus	White-browed babblers
Rhipidura leucophrys	Willy wagtail
Smicrornis brevirostris	Weebill
Tadorna tadornoides	Mountain duck



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