Wetland Conservation in the Jerdacuttup-Ravensthorpe area, WA

Management of the Lake Shaster and Jerdacuttup Wetland Suites: Assessment and Recommendations

A report produced by Green Skills for the South Coast Natural Resource Management Team

By Wetland Project Officer Tim Frodsham

July 2007

– southcoastnrm.com.au –
Funded by the Western Australian and Australian Governments through the joint National Action Plan for Salinity and Water Quality programme and the Natural Heritage Trust.

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Cover Photograph: Aerial view of Lake Shaster (T. Frodsham) January 2007

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Do you have any comments or feedback you would like to give?

This report is intended to generate community discussion as to the most effective management practices that can be incorporated into the catchment planning activities of Shaster Jerdacuttup system.

If you have any comments on the recommendations provided in this report, we would like to hear from you. Comments can be directed to:

Tim Frodsham
Wetlands Project Manager
P.O. Box 577, Denmark W.A. 6333
Tel: (08) 9848 1019
Fax: (08) 9848 2061
Email timfrodsham@greenskills.green.net.au
Web www.greenskills.green.net.au
Mobile: 0437 617 292

Executive summary

Twenty five wetlands between Hopetoun and Oldfield Estuary on the south coast of Western Australia were assessed for waterbird use, condition and potential threats. Of these 15 held at least some water after five successive years of less than average annual rainfall. Electrical conductivity of wetlands' water ranged from 11.6-164.1 mS/cm (Chapman, 2007:1). Wetlands carried varying levels of total phosphorus and total nitrogen. Wetland size was between 6 and 1,203 ha. According to the Ramsar classification most wetlands are inland saline lakes and/or inland wooded swamps. Functional classification and waterbird utilisation is determined by salinity and water level both of which change with time. One wetland is a coastal estuary. Forty nine waterbird species including all ducks known from south-western Australia, eight species of trans-equatorial migrants and one threatened species were recorded. Three native species of inland fish were recorded (Chapman, 2007:1).

Some wetlands appear to be exhibiting stress in the form of paperbark deaths due to water logging caused by increased run-off from their catchments in land cleared for agriculture. In some cases recent intensive rainfall events may be a cause of water logging. Other threats to wetlands are weed invasion, and for two wetlands there is a potential threat from sub-division development. A variety of other biological threats are also mentioned, including the potential indirect environmental threats of mining on the wetlands, as well as direct land sub-division development pressures. The threat of groundwater level changes to these wetlands is also considered. In spite of these threats, most of the wetlands are in very good condition and collectively they provide habitat, including summer refugia, for more than half the species of waterbirds recorded in South-western Australia. Some effects of an intensive rainfall event in January 2007 are reported (Chapman, 2007:1).

1.0 Introduction

The following report provides an inventory of current information and an appraisal of the state of Shaster Jerdacuttup wetland system situated approximately 30 km west of Denmark in Western Australia. Appendix 1 shows the location of the wetlands in relation to sub catchments land tenure and river systems. The report is intended to be viewed as part of our ongoing understanding of this wetland system. It covers; how it originated, what processes are operating within the system, the values of the wetland, and whether these values are threatened. Where threats to the health or habitat value of the wetland have been identified specific management recommendations are made to mitigate these.

2.0 Project Background

During 1999, the Water and Rivers Commission (now subsumed into Department of Environment and Conservation (DEC)) initiated a regional survey and evaluation of the wetlands of the entire South Coast Region between Walpole and Esperance. The survey for the south coast region was conducted by the V and C Semeniuk Research Group in 1998.

The objectives of the report were the:

- Identification of wetland regions.
- Classification of wetlands into consanguineous suites
- Identification of wetlands of significance.
- Identification of significant wetlands which are at risk.

The regional survey and evaluation of wetlands is part of a broader wetland conservation project being undertaken by the DoE and community group Green Skills. This project is a partnership program that has funded 12 wetland management plan projects since 1999. These are detailed below:

Table 1. Wetland Management Plan Projects since 1999

Wetland Suite	Location	Completed
Manypeaks/Pabelup	Bremer Bay	1999
Corimup	Manypeaks	2000
Mortijinup lakes	Esperance	2000
Mills Lake	Ongerup	2001
Coobidge Creek/Lake Gore	Esperance	2001
Coomalbidgup swamp	Esperance	2002
Unicup	Upper Kent River catchment	2002
Moates/Gardner lakes	Two Peoples Bay	2003
Roberts Swamp	Grass Patch, Nth Esperance	2003
Boyatup swamp	Cape Le Grand, Esperance	2004
Balicup	North Stirlings	2005
South of the Stirlings	South Stirling-Wellstead	2005
Owingup Swamp	Denmark	2006
Benje Benjenup Lake	Esperance	2006

During 2005, the South Coast Natural Resource Management (SCNRM) [formerly South Coast Regional Initiative Planning Team (SCRIPT)], in consultation with the South Coast community and regional stakeholders developed *Southern Prospects*, the investment plan for the South Coast regional natural resource management strategy.

Under this *Investment Plan* wetland management was considered a priority activity and consequently an expanded wetland program has been amongst the first to be funded, ensuring a continuation of the current wetland partnership program with Green Skills being directly contracted to SCRIPT to deliver the project outcomes.

Funding from the Federal Government Natural Heritage Trust (NHT) and the National Action Plan (NAP) provided through SCNRMhas been secured to provide limited on ground support for wetland fencing, revegetation and strategic earthworks (Hopkinson 2003).

The aim of the wetland project is to focus on catchment areas for the suites of significant or outstanding priority wetlands which have been identified, and develop and implement wetland management plans alongside existing catchment activities. The catchments for these systems are highly variable in flow. The catchment boundaries for Jerdacuttup Lakes appear in Appendix 2, at the back of this report. Photographs are referred as 'plates' throughout this document, and appear in Appendix 6. Locations of wetlands surveyed by Andy Chapman appear on his aerial photomaps, in Appendix 10.

3.0 Definitions and classifications of wetlands

It is first necessary to describe and define wetlands.

The definition of a wetland adopted by the Ramsar convention is:

> *Areas of marsh, fen, peatland or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.*

Similarly the convention provides a classification of wetlands based on whether they are marine/ coastal, inland or artificial with each of these categories sub-divided on vegetative or permanence criteria. This classification is in Appendix 4. Both the definition and classification were adopted by ANCA (1996) and for consistency are used in this assessment.

The following classifications were recognised for this assessment:

- A6 – *Estuarine waters; permanent waters of estuaries and estuarine systems of deltas*
- B8 – *Seasonal/intermittent saline lakes*
- B14 – *Freshwater swamp forest, seasonally flooded forest, wooded swamps on inorganic soils*

The 'B' designation indicates 'inland wetland', this disparity is explained in section 4.0. The term 'samphire' is used as a collective term for unidentified chenopods of the genera *Halosarcia* and *Sarcocornia.* Table 2 indicates salinity criteria from George *et al.* (1996) except that 'hypersaline' was not defined, that are used in this assessment.

Table 2: Salinity criteria used in assessment

Salinity	Total Soluble Salts (mg/l)	Approximate Electrical Conductivity equivalent (mS/cm)
Fresh	<500	<0.9
Marginal	500-1 500	0.9-2.7
Brackish	1 500-5 000	2.7-9.0
Saline	5 000-35 000	9.0-63.0
Hypersaline	>35 000	>63.0

4.0 Location, land tenure and land use

The Jerdacuttup – Shaster wetlands are located on a narrow coastal strip to 10 km wide on the south-east coast of Western Australia between the town of Hopetoun and the Oldfield Estuary, a distance of approximately 80 km. All wetlands are within crown reserves that confer some amount of statutory protection. Appendices 1 and 2 show the relative locations of each system (also see plates 1 and 2). With the exception of the recreation reserves around the Oldfield Estuary all wetlands not currently reserved for conservation are proposed as additions to either Jerdacuttup Lakes or Shaster Lake nature reserves or stand alone nature reserves in the South Coast Regional Management Plan (CALM 1991). While this enables some legislative safeguarding to the wetlands themselves, the minor sub-catchments are on the Jerdacuttup Plain which has been 90-95% cleared for agricultural production on lands held in private freehold title (see Appendix 3). Land was released here initially in the early 1960s and most clearing was completed by the mid 1970s. Mining is now a significant land use on the Jerdacuttup Plain and may have implications for groundwater management, which are referred to here.

The catchment of the Jerdacuttup River has an area of 232 000 ha of which 30% has been cleared; as such it remains one of the least cleared river catchment on the south coast with 81% of the linear extent of its riparian vegetation in good-excellent condition (DOE 2004). The catchment of the Oldfield River has an area of 248 000 ha of which approximately 30% has been cleared. The condition of the riparian vegetation has not been assessed.

5.0 Indigenous History and Land Use

The name "Jerdacuttup" is a Noongar Aboriginal term meaning: "a bird to its head". This refers to the shape of the river. Jerdacuttup spring sits to the west of Jerdacuttup lakes. There is some oral history associated with this name, as discussed in the Jerdacuttup River Action Plan (2004:iii):

> *"...I must tell you about this Jerdacuttup River. We understand this to be an aboriginal name. Well it smacks of aboriginality, but it is not aboriginal. 'Jerda' is. The proper name of that river or the proper Aboriginal name of the river is 'Jerda Carte'. It was a name made of two words: 'Jerda', for a great big bird, let us say a black swan with a long neck and 'Carte' being the Aboriginal name for 'head' so it means 'a bird to its head'.... you will see ahead of you, this great, huge long lake into which the Jerdacuttup pours. This is the body of the bird ...see the eastern end of that lake, and it's a great long, narrow lake... like the body of a black swan ... there, you come to the breast of the bird, with the neck taking off...on the other side...We'll call it 'Jerdacuttup' – which is the correct name for us– and we'll let 'Jerda Carte' go back to the dreamtime."* as told in *'Stories from the past – some recollections of WA's pioneers'.*
> **William Peter Coleman (1900-1982)**
>
> *Bill Coleman was an Aboriginal descendant [Nyoongar mother and Irish father], born at Geordie Soak on the Jerdacuttup River. (from* Jerdacuttup River Action Plan, Water And Rivers Commission, Water Resource Management Series Report No Wrm 43, June 2004

It is understood that south coastal Nyoongar Aboriginal people in this area were highly mobile nomadic groups and tended to migrate within inter-connecting sub-tribal boundaries stretching between around Denmark and areas extending east of Esperance to around Cape Arid. The people of the area around the Jerdacuttup and Shaster Lakes would have found rich pickings, especially in the seasonal abundance of trans-equatorial migrant shorebirds and wader birds in these wetlands. The Nyoongar Aboriginal family that inhabited this area was the Wadjari. The Wadjari covered an area from near West Mt Barren, east to Shoal Cape, north to Lake Grace and east of Lake King (Tindale NB, Aboriginal Tribes of Australia, 1974). Some contemporary Noongars (specifically, the Roberts clan) with strong traditional connections to the region refer to themselves as Wilomin Noongar. Wilo = curlew, therefore literally curlew-like (Kim Scott, *pers comm*, 2007)

Their capability as land managers was governed by the prudent use of fire for game hunting, strict population control to limit the amount of energy demanded from areas of shifting carrying capacity for human beings, a culture of sharing, and an acute awareness of subtle symbols that pointed to varying food availability in fluctuating seasons. Wallaby and Kangaroo would have been abundant in this area, as would have shellfish, and riparian fish that were ensnared in stone traps. Tubers of certain plants were certainly eaten, along with various invertebrates and native bee honey.

The first Europeans to make contact with the area in 1802 were the crew of Matthew Flinders' survey ship, the *Investigator,* as it charted the southern coastline.

By the 1820s the whalers and sealers from Van Diemen's Land, who hunted in the southern ocean, knew of the shelter which the Hopetoun area offered. It is believed that this area may have been a semi-permanent occupation site for sealers from this point on, and that they had contact with Aboriginal people in the area.

In 1841 Edward John Eyre passed through the area in late June, 1841, after traversing the Nullarbor Plain from Adelaide. Eyre and his Aboriginal companion Wylie travelled very close to the present site of Hopetoun. He recorded that he spent a night at the Jerdacuttup Lakes east of Hopetoun and the following night stayed by Culham Inlet. John and Alexander Forrest passed through there in 1868 to explore for a route to South Australia for stock transport.

In the late 1860s, the area experienced the arrival of the Dunn brothers. John Dunn first prepared for pastoral occupation on a piece of land they would name 'Cocanarup'. Along with the Phillips River, this place name has been historically associated with massacres of aboriginal people who lived in the area. John Dunn himself was killed by local Aborigines in an alleged payback killing in 1880. His grave is located on Cocanarup Road, west of Ravensthorpe.

The novel *Benang*, by Kim Scott (1999), is a semi-fictional biographical account of the homicidal racial conflict in this area, characterising much of the early history of Aboriginal tensions with the Dunn's and other families in the area. Today, it is said that Aboriginal people stay away from Ravensthorpe, or do not stay long, if it cannot be avoided.

Gail Yorkshire Selby, a Noongar elder, now living in Esperance was referred as a contact for verbal of Aboriginal history of the area. Unfortunately, this person was unavailable to contribute to this report.

The Department of Indigenous Affairs' Aboriginal heritage enquiry system was able to come up with a variety of locations of sites and heritage surveys in the area, and these appear in Appendix 5.

Ann Williams (*pers comm*, 2006) reports of an Aboriginal Midden south of Springdale Road near the T junction with Coxall Road, Munglinup in a second line of sand dunes close to a fresh water spring. Reserve 32338. The coordinates are unavailable. At the junction of the Jerdacuttup River and the South coast highway, there is 'scar' left from a white ochre area that is thought to be used by Aboriginal people, presumably for ceremonial purposes (Anne Williams, *pers comm*, 2006). Also on the Carlingup Road's intersection of the Jerdacuttup river there exists a gnamma [water] hole, as well as remains of flint cutting tools (DEC, 2004:2:3). Grinding stones have been said to be found periodically by farmers in the district. There are also similar sites on the Woodenup Creek which also flows into the Jerdacuttup River. Gnamma holes also said to exist near the junction of Fence Rd and South Coast Highway (Anne Williams, *pers comm*, 2007).

6.0 Jerdacuttup - Shaster wetlands

6.1 Climate

The climate of the area is classified as 'dry Mediterranean' by Bagnouls & Gaussen (1957), cited by Beard (1981). 'Mediterranean' recognises that on average most rainfall is in winter; 'dry' indicates that there are 5-6 dry months per year according to this system. This classification fails to recognise that the most intensive rainfall events are usually in summer from either decaying tropical cyclones or complex upper atmosphere interactions between cold fronts and moist tropical air. It is these that usually re-charge wetlands, cause vigorous river flow and flooding (See Plate 1). Evaporation data are few for the south coast, Hodgkin (1997) estimated that for Culham Inlet, 10 km west of Hopetoun, the evaporation is about 1 mm to 100 mm for the six months November-April. On the basis of this figure these swamps and lakes could be expected to lose about 1,000 mm over this period, without any input flow, due to evaporation (Chapman, 2007:2).

Wetlands everywhere are influenced by previous rainfall and this applies particularly to areas of variable and unpredictable rainfall such as the Ravensthorpe Shire, where the coefficient of variability of rainfall is higher than anywhere else on the south coast between Cape Leeuwin and Esperance (Chapman 2003). Rainfall data have been collected at Hopetoun since 1901 where the annual mean and median rainfall are 504.3 and 502.8 mm respectively. The highest and lowest annual rainfall figures are 736.8 and 281.8 mm for 1971 and 2002 respectively. The highest ever monthly rainfall was 329.9 mm in May 1988, more than 250 mm fell in less than 24 hours. Rainfall events of this intensity have an enormous influence on wetlands, with the capacity to determine not only waterbird use but sediment transport, erosion and vegetative changes. In less episodic and drastic contexts, the function of wind in aerating bacteria and benthic invertebrate energy production also has a profound influence on the productivity of wetland systems (see Plate 2).

Five less than average rainfall years preceded this assessment. Annual rainfall figures for 2002, 2003, 2004 and 2005 were 281.8 (-44.1%), 493.2 (-2.2%0, 477.8 (-5.2%) and 466.9 mm (-7.4%) respectively with percentage departure from the mean in brackets. For 2006 the annual rainfall at Hopetoun was 403.8 mm, a departure from the mean of –19.9%.

Following completion of fieldwork, an intensive rainfall event over 4th to 5th January 2007 caused by the convergence of ex tropical cyclone 'Isobel' and a mid level trough filled most wetlands and bought local flooding, road damage and significant stock losses. Over the period 3rd to 6th January rainfall at the following centres was; Hopetoun 106.0 mm, Ravensthorpe (upper Jerdacuttup River catchment) 151.4 mm, Cheadanup (upper Oldfield River catchment) 204.4 mm and Esperance 191.6 mm.

6.2 Geology and Hydrology

In general terms most of these lakes and swamps occupy a relatively small section of some 80 km of coastline which is internally drained between two major rivers – the Phillips and the Oldfield that drain both the Yilgarn Plateau and the Bremer Basin externally i.e. into the sea (see Plate 3). There are important consequences of the curtailed drainage of the Jerdacuttup River and minor creeks the Yallobup and Collu-collup The Jerdacuttup is a classic and unusual example of the terminal progression of an estuary to a coastal lagoon; it has been barred from the sea for a probable 6,000 years (Hodgkin & Clark 1990). See Plate 4. It is unusual because all other south coast inlets which have long (>50 km) rivers still have occasional contact with the sea.

Most lakes and swamps examined in this assessment are sandwiched in a narrow band some 3 km wide parallel to the coastline between Quarternary aeolian and marine sediments of sand, clay and limestone on the seaward side and Archaen rocks to the landward. See Plate 5. Aeolian sediments include sands raised into dunes to 12 m high. On the landward side the Archaen granitoid gneisses and migmatites are only occasionally exposed along the northern shores of these lakes and swamps. The lakes and swamps themselves, when dry, have exposed alluvial sediments of clay and silty clay. Further to the north, most of the Jerdacuttup Plain which drains into these lakes and swamps, is underlain by Tertiary sediments of the Pallinup Siltstone including siltstones, sandstones and claystones which were deposited, along with a lot of salt, when the sea extended inland further than it does at present. Some 90-95% of the Jerdacuttup Plain has been cleared for agricultural production (Plate 6).

Between the Culham and Oldfield inlets two catchment divides are recognised by Johnson (1998), one associated with the Jerdacuttup River extends well inland to the Swan-Avon drainage and the other which includes the lakes and swamps of this assessment, extends only inland to Jerdacuttup Road. The latter is divisible into seven sub-catchments associated with Yallobup and Collu-collup creeks and other un-named minor drainages. (See map accompanying (Johnson 1998)). Of these the Yallobup sub-catchment is perhaps best known; it has an area of 23 700 ha of which 95% has been cleared. Bores established in 1986 indicate that groundwater in the vicinity of Middle Road is between <1m and <2m from the surface. These data are from Platt (1997). Resulting from this and the fact that groundwaters are rising at between 0.1 and 0.3 m per year e.g. Short (1997) is the observation that some lakes and swamps here now contain increased volumes of water of higher salinity over longer periods of time than they did prior to agricultural settlement. Elsewhere on the Jerdacuttup Plain the depth to groundwater is considerably greater than that indicated above. More recently Massenbauer (2007) indicated that the median depth to groundwater in the Ravensthorpe agricultural zone is 2.9 m and that it will take 25-70 years for salinity to reach its potential expression here (Chapman, 2007:3).

The depth to groundwater for the coastal plain is 5-15 m along a very narrow coastal strip and 0-5 m adjacent to lakes and swamps. Groundwater salinity here is 7 000 – 14 000 mg/l TDS (Johnson 1998). The approximate electrical conductivity equivalent to these data is 13 – 26 mS/cm using the conversion of x550 from George *et al.* (1996).

6.3 Groundwater Depth and Quality

The AgBores database has records of 255 groundwater monitoring bores within the study area (see Figure 16, (DAFWA, 2006:21), and 145 of these have recent measurements of groundwater depth and E_C (Department of Agriculture 2005b). Depth to groundwater is variable, ranging from ground level to deeper than 24 m with a median and average depth of 2.9 m and 4.6 m respectively. Groundwater E_C is generally saline (median value of 3,200 mS/m) although it ranges from 60 to 8,700 mS/m. The median groundwater E_C is lowest in the Esperance Sandplain Zone and highest in South-eastern Zone of Ancient drainage (Table 3), reflecting the differences in salt storage, rainfall, and soil type in the two zones. Soil landscape zone descriptions are outlined in DAFWA (2006:11).

Table 3: Groundwater depth and E_C in monitoring bores within the soil-landscapes zones (from DAFWA, 2006:21)

Soil-landscape zone	No. of Bores	Depth to groundwater below ground level (m)			Groundwater EC (mS/m)		
		Min	Max	Median	Min	Max	Median
243	13	<1	24	3	100	7,100	4,100
244	10	<1	24	3	<90	6,100	3,300
245	5	<1	24	2	<90	5,200	1,300
250	3	<1	12	4	2,300	8,700	5,100

(b) Electrical conductivity (mS/m) categories are: <90 (fresh); 90–270 (marginal); 270–900 (brackish); 900–5,500 (saline); >5,500 (highly saline); 5,300 (seawater).

7.0 Description of wetland suites

Details of wetlands assessed are in Appendix 7 – 'Wetlands Assessed, their location, type, land tenure and presence of water'. Numbers in descriptions below are field numbers in Appendix 7. Dimensions are maxima rather than suggesting all lakes and swamps are square or oblong (Chapman, 2007). The maps with numbered locations of these wetlands are featured in Appendix 10: Jerdacuttup Wetland Suite – Wetlands assessed and numbered Lake Shaster Wetland Suite' – Wetlands assessed and numbered (from Chapman, 2007, Figures 1a and 1b.)

7.1 Dunns Swamp suite

This suite consists of the distinctive and well known Dunns Swamp as well as a poorly defined (and incorrectly classified) area of 'perennial swamp' to the East (Chapman, 2007:5). See Plate 7.

Dunns Swamp (#1) has maximum dimensions of 700x250 m with an area of approximately 16 ha. Wetland classification B8, B14. The inner littoral vegetation is mature *Meleleuca cuticularis* woodland to 8 m in a zone approximately 25 m wide, approximately half of which was inundated at the time of assessment. Where not inundated understorey species include *Gastrolobium bilobum, Acacia subcaerulea, A. cyclops, A. crassiuscula* to 2-3 m with *Carpobrotus virescens* and *Threlkeldia diffusa* groundcover. The outer littoral zone has *Eucalyptus occidentalis* to 15 m which overlaps *Meleleuca cuticularis*, understorey species are *Labichea lanceolata, Spyridium globulosum, Rhagodia preissei, Dianella revoluta* and *Billardieria fusiformis*. There are noticeable and unexplained deaths of *Gastrolobium bilobum, Acacia crassiuscula* and *Kennedia nigricans* at the inner-outer littoral zone vegetation interface. Drainage into the swamp is from the north west across a low lying dry swampy area from a low limestone hill to the west of the Ravensthorpe-Hopetoun Road. In addition an area identified as 'subject to inundation' on CG 628 on the Hopetoun 1:50 000 map, north of the airstrip has turned saline and will be contributing to increasing salinity of the lake. Paperbark deaths are abundant and pronounced here (Plate 8). There has been past paperbark fence post cutting (Chapman, 2007).

Since 1996 depth of Dunns Swamp has varied from approximately 2.0 m during July 2000 when E_C was 7.01 mS/cm to approximately 0.2 m during January 1996 when E_C was 93.7 mS/cm. The highest E_C value of 143.5 was during December 2003 when depth was approximately. 0.4 m (Chapman, 2007:5).

Weeds present were bridal creeper, boxthorn, scotch thistle, blackberry nightshade and fleabane.

Two smaller, dry swamps (#2,3) approximately 3-4 km ESE of Dunns were assessed. Although they are quite discrete entities on aerial photography and on the ground they are mapped on the 'Hopetoun' 1:50 000 map as part of a much larger area of 'perennial swamp' Each has maximum dimensions of approximately 350x250 m and an area of approximately 12 ha. Both are classified B8. Both have very similar vegetation and old nests of either cormorants or egrets from a previous flood event, they are more abundant at #3 (Plate 9). Both have abundant and pronounced Paperbark deaths though there is regeneration to 1.5 m at both (Plate 10), in the few places where paperbarks have not died they are to 5 m with understorey species *Acacia cyclops, A. pulchella, Rhagodia preissei Westringia rigida* and un-identified sedges (Plate 11). A low sandy ridge with *Eucalyptus occidentalis* to 5 m growing in the straggly 'coastal' habit with *Labichea lanceolata* and *Spyridium globulosum* separates the swamps. There is no recognisable coordinated drainage into these swamps. There has been past paperbark fence post cutting (Chapman, 2007:5).

A low limestone ridge vegetated with *Eucalyptus platypus* var. *heterophylla, E. falcata, E. ?micranthera* and *E. angulosa* confines these swamps to the south.

7.2 Jerdacuttup Lakes Suite

This suite consists of Jerdacuttup Lakes both west and east, a particularly important deep and brackish swamp adjacent to Southern Ocean East Road and two constellations of small, swamps one to the east of Jerdacuttup Lake East and the other between the two main lakes.

Jerdacuttup Lake West (#4) is the former estuary of the Jerdacuttup River which has been cut off from the sea for a probable 6 000 years (Hodgkin & Clark 1990). The lake has maximum dimensions of 5 000 x 2 500 m, an area of 1203 ha of which 606 ha is open water and 597 ha is vegetated (Halse *et al.* 1993). See Plate 4. On the southern side is a band of samphire to 300 m wide as the inner littoral vegetation (Plate 12), the outer littoral zone here is a band of medium age *Melaleuca cuticularis* to 5m with understorey of *Rhagodia preissei, Frankenia* sp. and *Carpobrotus virescens*. On the north shore the inner littoral zone is much narrower at 10-20 m wide with samphire, *Carpobrotus virescens, Acacia subcaerulea* and *Persoonia* sp. The outer littoral vegetation is medium aged *Melaleuca cuticularis* to 5 m between 200-300 m wide, very large areas of which have been killed (Plate 13). Where windblown ridges of sediment have established along the shore there are two cohorts of *M. cuticularis* regeneration, one to 2.5 m and one to 4.0 m. The Jerdacuttup River enters the lake via a narrow channel through dense samphire vegetation. River flood velocity and sediment deposition are mitigated by an extensive *Eucalyptus occidentalis* swamp between the river and the lake (Chapman, 2007:5).

Weeds observed were scotch thistle and fleabane, both were very scarce along the north shore. Rabbits and the Mediterranean snail were present on sandy soils on the south side.

Jerdacuttup Lake west has been monitored for depth, salinity and waterbirds present by DEC since 1979. Depth has varied from NIL during parts of the dry years 1983,84 & 85 to 4.5 m in September 1989. Salinity has ranged from 50-400 ppt over the period 1980-85 (Jaensch *et al.* 1988). Assuming 50-400 ppt *should* be 5-40 ppt, the approximate E_C equivalent is 9-73 mS/cm.

Wetlands #5,6,7 and 8 form part of a constellation of small swamps between Jerdacuttup Lakes West and East which are all embedded in an extensive low open forest of *Melaleuca cuticularis* to 5m which is incorrectly identified as 'perennial swamp' on the Jerdacuttup 1:50, 000 sheet. Numbers 7 & 8 are discrete entities although they are mapped as the western extremities of Jerdacuttup Lake east. All are quite small and oval except for #7 which is elongated.

Number 5 is approximately 600 x 400 m and approximately 20 ha, classified B14 it was a brackish wooded swamp with mature *Melaleuca cuticularis* to 8 m. A disused Swan's nest was present. Mature *M. cuticularis* are not exhibiting signs of water logging stress. Drainage is from un-named creek which drains Jerdacuttup Plain north to Middle Road which probably formerly drained primarily into Jerdacuttup Lake east (see Discussion). This wetland is one of a kind in this assessment as it is the only wooded swamp type without an open water surface (Plate 11).

Tracks cut on this low lying section of ground have also had the effect of acting as extensions to the surface waters of these wetlands when flooded. See Plate 14.

Number 6 is approximately 300 x 250 m and approximately 7 ha, classified B8 it had a bare, dry bed with dead, immature *Melaleuca cuticularis* over the bed as well as some peripheral deaths.

Number 7 is approximately400 x 75 m and is approximately 10 ha. Classified B8, it had a largely bare surface with remnant hypersaline water and peripheral swards of *Wilsonia humilis.*

Number 8 is approximately 400 x 250 m and approximately 15 ha, classified B8, it had an open water surface with the beginning of peripheral *Melaleuca cuticularis* deaths (Chapman, 2007:6).

Jerdacuttup Lake East (#9) is approximately 3 300 x 2 200 m and approximately 240 ha, classified B8, it had a bare, dry surface at the time of assessment. (See Plate 15). Inner littoral vegetation along the south shore is dense, vigorous samphire with some *Melaleuca cuticularis* regeneration to 1.5 m. There were only few signs of deaths of mature plants. Outer littoral vegetation was an extensive low open forest of *Melaleuca cuticularis* to 5 m approximately 500 m wide with occasional *Eucalyptus occidentalis* and an abundance of *Acacia* sp. #1 in the understorey. This lake was probably formerly fed by two creeks, one unnamed referred to above and the other locally known as Yallobup Creek. It is hypothesised that this drainage has been curtailed by sedimentation of the main lake in recent geological time, and the drainage diverted into smaller, peripheral lakes and swamps. However following intensive rainfall events in the upper catchment e.g. in January 2000, there appears to be continuity between Jerdacuttup River, both Jerdacuttup Lakes and the minor watercourses (Chapman, 2007:6).

Number 10 is adjacent to Southern Ocean East Road, it is approximately 500 x 400 m and approximately 20 ha, classified B8, B14 it had inundated woodland and open water surface at the time of assessment. Inner littoral vegetation is mature *Melaleuca cuticularis* woodland to 6m all of which was inundated. Outer littoral vegetation is *Eucalyptus platypus* var. *heterophylla* with the parasitic climber *Cassytha* sp. *Acacia rostellifera, Rhagodia preissei, Persoonia* sp. and *Enchylaena tomentosa* (Chapman, 2007). Weeds present were fleabane and a yellow flowering thistle. Mediterranean Snails were present. Drainage is from Yallobup Creek which probably formerly drained primarily into Jerdacuttup Lake East.

Numbers 11 & 12 are part of a constellation of small dry swamps east of Jerdacuttup lake east which are embedded in low *Melaleuca cuticularis* shrubland to 3 m with little if any understorey. Number 11 is approximately 500 x 300 m and 10 ha with samphire and *Wilsonia humilis* as inner littoral vegetation and a bare lake surface, #12 is 400 x 300 and approximately 10 ha with similar zonation except that *W. humilis* extends over the lake surface (Chapman, 2007:6).

7.3 Jerdacuttup Lake East Suite

Two wetlands adjacent to Mason Bay Road were assessed. Number 13 is approximately 600 x 500 m and 30 ha, classified B8, B14 it had inundated woodland and open water surface at the time of assessment. See Plate 16. Inner littoral vegetation was mature *Melaleuca cuticularis* woodland to 6m with some regeneration to 2 m on the inner side, there were very few if any deaths. Outer littoral vegetation was *Acacia cyclops* and *Melaleuca thyoides* with *Scirpus nodosus* understorey, there were occasional *Eucalyptus occidentalis* and *E. incrassata* on the western side. Weeds present were fleabane and a yellow flowering thistle.
Drainage is from 'Little Yallobup Creek' which drains cleared land and originates on CGs 794 and 799 between Springdale and Middle Roads (Chapman, 2007:7).

Number 14 is approximately 650 x 450 m and 30 ha, classified B8 although it is really one of a kind of the wetlands assessed as a steep sided, dry 'limestone sunkland'. Its formation is probably due to ground subsidence due to leaching out of carbonate by percolating rainwater as described by Johnson (1998). The littoral vegetation is sparse in the extreme, comprising stunted *Melaleuca cuticularis* to 1.5 m and the sedge *Lepidosperma gladiatum*. Two small limestone island residuals are interesting as they harbour plants that have almost certainly never been burnt, one has senescent *Melaleuca pentagona* and *Eucalyptus falcata* and the other stunted *Melaleuca cuticularis*. Drainage is probably local and centripetal. See Plate 17.

7.4 Shaster System – West Suite

Three wetlands were assessed, one a large, dry lake north west of Starvation Boat Harbour and two small, coastal, hypersaline lakes west of here. See Plate 18. Number 15 is approximately 1 100 x 1 000 m and 90 ha, classified B8, B14. Inner littoral vegetation was a band of samphire, *Sarcocornia quinqueflora* and one unidentified species. Outer littoral vegetation was *Melaleuca cuticularis* to 6 m with *Gahnia trifida* understorey. There was some *Melaleuca cuticularis* regeneneration to 1.5 m between the inner and outer zones. There were no deaths. A weed present was fleabane, it was scarce. Rabbits were present. Drainage is from a minor creek entering from the north west from uncleared coastal vegetation (Chapman, 2007:7).

Numbers 16 and 17 were two of a kind, unlike any other lakes in this assessment on account of both their hypersalinity and narrow coastal orientation. Number 16 is approximately 400 x 100 m and 6 ha, classified B8. Inner littoral vegetation was *Carpobrotus virescens, Sporobolus virginicus, Wilsonia humilis* and *Threlkeldia* sp. Outer littoral vegetation was stunted *Melaleuca cuticularis* to 2 m with *Melaleuca lanceolata* to 3 m replacing the former as the dominant littoral plant. Number 17 is approximately 1 200 x 200 m and 30 ha, classified B8. Littoral vegetation was very similar to #16 except that on the north shore wind pruned *Acacia cyclops* and *Calothamnus quadrifidus* largely replace *Melaleuca lanceolata*. Both lakes are confined to the south by high vegetated dunes and to the north by a low limestone ridge. Drainage is probably local and centripetal. Both lakes provide hooded plover habitat including the possibility of breeding as one immature bird was present with one pair (Chapman, 2007:7).

7.5 Shaster System – Dorrinup Suite

Two large wetlands east of the rabbit proof fence were assessed. Number 18 is approximately 650 x 650 m and 30 ha, classified B8, B14 it had inundated littoral woodland and expansive open water surface at the time of assessment. See Plate 19. Inner littoral vegetation was mature *Melaleuca cuticularis* to 10 m with *Acacia cyclops, A. crassiuscula, A.* sp. #1, *Spyridium globulosum* understorey over samphire and *Scirpus nodosus* where not inundated. Paperbarks have in the past been extensively cut over, including some by axe, for fence construction and maintenance. There were very few paperbark deaths here and there was regeneration to 1.5 m in the inner littoral zone. A weed, fleabane was present but scarce. Drainage is from three small creeks entering from the north west that originate in cleared land north of Springdale Road and traverse uncleared vegetation before entering the lake. Two of the three coalesce into a wide channel at the rabbit proof fence; the channel has two species of samphire *Halosarcia halocnemoides* and *Sarcocornia quinqueflora* and *Frankenia* spp. with *Melaleuca brevifolia* to 3 m either side of the creek (Chapman, 2007:7).

A low, sandy ridge with *Labichea lanceolata* to 1.5 m, *Jacksonia* sp. and sedges separates #18 and 19 which is approximately 1 000 x 500 m and 50 ha, classified B8 it was dry at the time of assessment. Inner littoral vegetation was samphire and *Threkeldia* sp., outer littoral vegetation was *Melaleuca cuticularis* to a maximum of 7 m, most was approximately 3 m. There were very few paperbark deaths here. Drainage is probably over flow from #19. There is some limestone outcropping in the lake (Chapman, 2007:8).

7.6 Shaster system – Parriup suite

This suite comprises six small – medium sized lakes to the west of Lake Shaster and south of Bedford Harbour Road (Plate 20). Of these only two were assessed due to access difficulties, both had water in them at the time of assessment. Number 20 is approximately 300 x 250 m and 8 ha, classified B8. Inner littoral vegetation is *Melaleuca cuticularis* to 3 m with *Gahnia trifida* understorey in the outer zone. There are very few Paperbark deaths. Number 21 is approximately 800 x 650 m and 40 ha, classified B8. Inner littoral vegetation was *Melaleuca cuticularis* to 5 m with some deaths.

This lake has been subject to Department of Environment and Conservation monitoring of salinity, depth and waterbird use since September 2000, depth maxima of 1.48 and 1.47 m were recorded in September 2001 and 2005 respectively (Jim Lane, *pers comm.,* 2006). Drainage into both these is from Collu-collup Creek, most of whose drainage is from cleared land. Lake #21 may be more affected by water logging than #20 and therefore exhibiting more paperbark deaths because it is in more direct contact with the Collu-collup drainage (see Plate 19). Other lakes in this suite were dry at the time of assessment with the possible exception of the largest lake that is the most south-westerly (Chapman, 2007:8).

7.7 Lake Shaster

Lake Shaster (#22) is approximately 5 000 x 2 000 m with an area of 479 ha of which 111 ha is vegetated, the remainder being either bare or open water surface when full (Halse *et al.* 1993a). Vegetation at the water mark includes the samphires *Halosarcia pergranulata* and *H. syncarpa* and *Wilsonia humilis* and *W. backhousei* (Halse *et al.* 1993a). Inner littoral vegetation was *Melaleuca cuticularis* to 7m or *M. brevifloia* (noting that here the latter is the most abundant Paperbark) over *Gahnia trifida*. Outer littoral vegetation was *Acacia cyclops* to 3 m and *Callitris drummondii* to 2m.

The lake was monitored by Department of Environment and Conservation between November 1979 and November 1991, depth maxima of 1.13 and 1.10 m were recorded in September of 1986 and 1989 respectively. Monitoring was discontinued due to difficulties of access (Jim Lane, *pers comm*). Plate 21 shows the defunct tidal gauge.

Drainage into the lake is via two small, unnamed creeks one at either end of the lake, both have most of their catchments in land cleared for agriculture north of Springdale Road. See Plates 22 and 23. In spite of both these creeks having water in them, the lake itself was quite dry and not exhibiting any paperbark deaths. There are numerous small exposures of a granitoid rock – migmatite along the north shore. The most massive of these is 'Dingo Rock' where the eastern most creek enters the lake. As well as having some granite inhabiting plants e.g. (*Acacia lasiocalyx*) the rock has small freshwater pools with *Baumea articulata* (Chapman, 2007:8).

7.8 Oldfield Estuary

The Oldfield Estuary is the only wetland of its kind in this assessment, it is classified A6 (Plate 3). Described as a sediment filled former river valley by Hodgkin & Clark (1989) this estuary is more typical than Jerdacuttup or Shaster Lakes of a south coast estuary as it has contact with the sea every 3-4 years. The estuary is 8 km long; it is the terminal point of the Oldfield River which is 95 km long and has a 248 000 ha catchment, of which only 30% has been cleared (Craig 1998). The catchment has been classified as a 'focus catchment', and the Oldfield River and its tributary the Munglinup River are considered 'priority waterways' on account of their wide vegetated corridors. These provide valuable habitat and enable the ongoing river maintenance processes of nutrient flux, shading, bank stability and litter input (see Cummins, 1974).

Geomorphology and vegetation of the estuary have been described by Hodgkin & Clark (1989) and Craig (1999) respectively and the vertebrate fauna and flora of the catchment by Hickman & Sanders (2002). Water quality including nutrients were sampled extensively in the Oldfield River during 1997/98 by the Department of Water and are available at http://portal.water.wa.gov.au. These data do indicate elevated nutrient enrichment with some total nitrogen and total phosphorus levels well in excess of recommended maxima. The vegetation survey identified one threatened plant species *Hopkinsia adscendens* and 32 introduced species including the invasive grasses annual and perennial veldt and bridle creeper which is abundant for some 1.5 km downstream of Springdale Road crossing (Chapman, 2007:8).

7.9 Oldfield Estuary east suite

This suite comprises three wetlands, two of which (#24,25) are in Lake Shaster nature reserve and one which is in private property. Number 24 is approximately 650 x 500 m and 25 ha, classified B8, it had only very shallow water and was mainly bare lake bed at the time of assessment. Inner littoral vegetation was *Halosarcia halocnemoides* which in places was heavily infested with weeds Scotch thistle and Maltese cockspur. Outer zonation was *Melaleuca cuticularis* to 6m with some *M. brevifolia* over *Spyridium globulosum* and *Dodonaea* sp. There were very few paperbark deaths. Drainage is overflow from #25.

Between #24 and #25 was open *Melaleuca cuticularis* over *Gahnia trifida.* The latter is approximately 1 200 x 1 000 m and 95 ha. Inner littoral vegetation was mature *Melaleuca cuticularis* to 8 m most of which was inundated. *Threlkeldia diffusa* was present as an understorey where this was not the case. On the north west side is a belt of *Eucalyptus occidentalis* to 7 m within the lake but on a low ridge exhibiting the coastal multi-stemmed habit. Fence posts have been cut from here and formerly the lake was used for water skiing (Brigette Wallefeld, *pers comm*). There were few paperbark deaths. Drainage is via a small creek entering from the north east that originates in cleared land (Chapman, 2007:9).

8.0 Soils

A survey of the Jerdacuttup - Shaster system was conducted in 1969 by the Department of Agriculture to assess its value as agricultural land (Malcolm, Jones and Fallon, 1969). The findings indicated that around 2000 acres, 800 ha, of the swamp would be suitable for clearing, draining and used for agriculture, although this never happened. Soil samples were taken at varying depths along several transects. The samples were then analysed by the Government Chemical Laboratories for a number of attributes including salinity, pH, moisture retention, and nutritional status. The report concluded that the soil underlying the swamp was:

> "…an essentially uniform area of soil with a typical soil profile of a thin layer of fibrous organic material overlying 2 to 4 ft of organic clay resting on sand. The clay contains a significant amount of diatomaceous remains and sponge spicules."

9.0 Biological – Characteristics

The only detailed biological study of the area covered by this assessment is the biological survey of the Oldfield catchment by Hickman & Sanders (2002). The only wetland work is the depth gauging and waterbird usage surveys conducted by Department of Environment and Conservation at Jerdacuttup Lake, Lake Shaster and Parriup North Lake. These commenced in 1979 and are referred to in section 8 of this report. Dunns Swamp, Jerdacuttup Lake, Lake Shaster, Oldfield Estuary and associated wetlands are rated as 'wetlands of subregional significance' in May & McKenzie (2002). In addition, Dunns Swamp and 'Mason Bay Road Lake' (wetland #13 in this assessment) were collected for invertebrates and measured for water quality parameters as part of the biodiversity survey of agricultural lands under the salinity action plan (see Keighery *et al.* 2004). Birds Australia have searched without success for the western ground parrot (*Pezoporus wallicus*) in Lake Shaster Nature Reserve (Chapman, 2007:11).

9.1 Water quality

Data for these appear in Appendix 8: 'Surface water quality parameters for selected wetlands'. Data reported in this assessment reveal that salinity as indicated by its surrogate electrical conductivity (E_C) is the most widely variable parameter pertinent to these wetlands; it varies temporally, spatially and at the micro scale. At the time of assessment the highest and lowest E_C values were 164.1 and 11.6 mS/cm respectively. Data for Dunns Swamp indicate a temporal variation over ten years from 7.01 to 143.5 mS/cm (see: Appendix 8). Micro scale variation is evident in the salinity stratification of Jerdacuttup Lake; on 25 November 2006 in still conditions the surface E_C was 82.0 mS/cm, two weeks later when high winds had mixed the water column the E_C was 115.1 mS/cm (Chapman, 2007:10)

Other water quality parameters in Appendix 8 indicate that at the surface in late spring-early summer waters are well oxygenated with a dissolved oxygen range 7.19-16.48 mg/l. Unpublished data from elsewhere in the vicinity of these wetlands indicate that dissolved oxygen like salinity can be highly stratified with high surface values and anoxic conditions in the lower water column. All waters are alkaline with a pH range 7.67 - 9.17, they are quite warm during daylight hours with a temperature range of 20.5-25.8 ^{0}C and clear with turbidity <10-20 NTUs. Total phosphorus ranged from 0.10-0.50 mg/l and total nitrogen from 1.87-5.86 mg/l. These are very high nutrient levels well in excess of the upper limits of 0.1 mg/l and 0.75 mg/l for total P and total N respectively (EPA data cited by George *et al.* 1996). Instrumentation used by Andy Chapman to collect this data appears in Plate 7.

9.2 Vegetation

The vegetation has been described in general terms by Beard (1981) as the Fanny Cove vegetation system, a division of the Eyre Botanical District. The system is described as occupying a narrow littoral plain on a young land surface of Quarternary sands on which both dunes and small, shallow lakes, swamps and closed estuaries are prominent features. Distinctive plant communities within the system are *Banksia speciosa* tall shrublands, *Eucalyptus platypus* var. *heterophylla* low woodlands, tall and mature stands of *Melaleuca lanceolata* and various species of hardy wind-pruned mallees including *Eucalyptus angulosa, E. falcata, E. incrassata* and *E. preissiana* which collectively often have a vigorous and diverse understorey (Chapman, 2007). See also Plate 24, which gives a visual reference to understorey plant community in the Quarternary sands in wetland #5, of the Jerdacuttup lake West system. The only detailed site account of the vegetation is that of Craig (1999) for the Oldfield Estuary which also included an account of weed invasion.

More recently the vegetation/landform complex has been described as Esperance 2 – Recherche subregion of the Interim Biogeographical Regionalisation of Australia (IBRA) in a recent biodiversity audit of the 53 biogeographical subregions in WA (see May & McKenzie 2002).

Melaleuca cuticularis is the dominant plant associated with these wetlands, as indicated in Plate 25. Elsewhere in WA it grows from Perth to and Israelite Bay, and occurs as either a low shrub or quite stately tree to 12 m (Holliday 2004). During this assessment it was present from immature regeneration < 1 m to mature trees to 8 m of unknown age. It was present in large stands of completely dead medium height trees e.g. on the north and western shore of Jerdacuttup Lake West (refer to Plate 13) as well as in large areas of healthy low forest e.g. in the vicinity of wetlands #5,6,7,8 (as Plate 25). At Jerdacuttup Lake on low wind driven banks of sediment immature trees were present in areas where otherwise all medium height plants were dead (Plate 13). Mature trees develop aerial roots that seem to resist the effect of prolonged inundation, as shown in Plate 26. Observations from elsewhere suggest that waterlogged soil or inundation beyond an unknown critical period rather than salinisation *per se* is the cause of premature death for *Melaleuca cuticularis.* Interpretation of these data may provide some insights into both natural and anthropogenic factors affecting this species and its wetland habitats. Land to the east of the lake was most likely cleared in the 1960s and has regrown since that time.

9.3 Birds

No waterbirds were recorded from dry wetlands. A total of 49 species were recorded of a possible 90 waterbird species, including trans-equatorial migrants but excluding seabirds, which are listed by Storr (1991) for South-western Australia. With 31 species Oldfield Estuary had more than any other, due to both its large size and different habitats as well as it having previously attracted the attention of ornithologists as it is readily accessible. Two wetlands had only one species. The mean number per wetland was 11. Family *Anatidae* which includes ducks, geese and black swan was best represented with 12 species. With the exception of a few vagrants from northern Australia this includes all ducks recorded in South-western Australia. Most duck species were recorded from a broad suite of wetlands, only two blue-billed duck and hardhead were confined to particular wetlands.

Families *Scolopacidae* and *Chradriidae* which include most wading birds had 11 species, eight of which are trans-equatorial migrants visiting south-western Australia from the northern hemisphere during the northern hemisphere winter. Sandpiper are such birds (Plate 27). These are subject to protection by international treaty as well as Western Australian legislation. Only one threatened species, hooded plover was recorded including a presumed breeding record. It is currently classified as P4 a 'taxa in need of monitoring' and is subject to a management plan (Raines 2002). With only the exception of the family *Anhingidae* (the 'darters'), all other waterbird families recorded in WA were represented. The thirty five species recorded in littoral vegetation of these wetlands is a relatively small sub-set of the terrestrial bird fauna of the wetland environs (see Appendix 9: Waterbirds of the Jerdacuttup Shaster Wetlands and Vertebrate Species). This is because although the littoral vegetation offers structural complexity and the 'edge effect' favoured by birds, it is usually neither dense nor floristically diverse (Chapman, 2007:3).

9.4 Waterbird usage of Jerdacuttup / Shaster wetlands

Of 25 wetlands assessed 15 held water even if it was only a few centimetres deep and hypersaline; all of these had at least one species recorded. No waterbirds were recorded from dry wetlands. A total of 49 species were recorded of a possible 90 waterbird species, including trans-equatorial migrants but excluding seabirds, which are listed by Storr (1991) for south-western Australia. With 31 species Oldfield Estuary had more than any other, due to both its large size and different habitats as well as it having previously attracted the attention of ornithologists as it is readily accessible. Two wetlands had only one species; the mean number per wetland was 11.

Family *Anatidae* which includes ducks, geese and black swan was best represented with 12 species. With the exception of a few vagrants from northern Australia this includes all ducks recorded in south-western Australia. Most duck species were recorded from a broad suite of wetlands, only two blue-billed duck and hardhead were confined to particular wetlands (Chapman, 2007:9). See also Plate 27.

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9.5 Fish use of Jerdacuttup Shaster wetlands

Three native species are known from these wetlands. Black bream was recorded from Jerdacuttup Lake and wetland #25 where live fish were present. Swan River goby were present in Dunns Swamp in February 2000 (D. Morgan & A.Chapman, unpublished data) and were recorded in two small un-named creeks flowing into Lake Shaster during the present assessment. Spotted minnow was present where Yallobup Creek crosses Springdale Road in February 2000 (D. Morgan & A. Chapman, unpublished data). Unlike elsewhere in South-western Australia introduced fish species are not present. Three native species of inland fish were recorded (Chapman, 2007:12). All three fish species that utilise these wetlands are adaptive opportunists as opposed to specialists in that they are can withstand high salinity and they are euryphagic feeders. Typically, arid zone fish will utilise flooding to temporarily occupy and breed in habitat that would normally be unavailable to them. Spotted minnow for example is only permanently present in Jerdacuttup River and Yallobup Creek, following flooding it will migrate well upstream to spawn in both of these systems. The significance of these wetlands to these fishes is that following flooding they provide connectivity between populations that are normally isolated from each other by either dry lakes or lakes whose salinity exceeds the physiological tolerance of the fishes.

9.6 Yallobup Creek and Jerdacuttup River Catchment

The Jerdacuttup and Shaster Wetlands' catchments cover an area of greater than 232 000 ha. Much of the Upper Catchment, an area of about 30% of the above, has been cleared for agriculture, with about 81% of the linear extent of the riparian vegetation remaining as remnant vegetation. This vegetation has been described as being good to excellent condition (DEC, 2004). Water level monitoring in the Upper Catchment indicate that the highly saline groundwater is rising but data is lacking to clearly indicate exactly by how much and where levels of rise are most accelerated. Land degradation issues in this catchment are typical of other areas on the south coast but with differing levels of threat: water logging, salinisation, sub-surface soil acidity, soil compaction, soil structure decline, feral species control, weeds, and water repellency.

9.7 Yallobup Creek and Jerdacuttup River

The lower Jerdacuttup River is in good condition with a thick buffer of native riparian vegetation. There are some areas with trees overhanging the river. Although unlike riparian vegetation in areas of higher rainfall, they do not provide shade to keep water cooler and restrict the growth of algal blooms. This is useful when flows may hold high nutrient levels from overspill starting on agricultural land. Nonetheless the abundance of riparian plants in and on the Jerdacuttup River act as an buffer to nutrients by slowing the water flow, reducing its force, and allowing particulate matter to embed itself, as seen in Plate 28. Nutrients there are taken up by downstream plants. Yallobup Creek does not have such a good condition report, with larger proportions of riparian vegetation being cleared, and 95% of its original vegetation removed (Platt, 1997: 10).

Riparian vegetation also gives habitation for many species of animals. Some may live out their entire life cycle within this zone other utilise it temporarily. Continuous stretches of riparian vegetation may provide corridors for the movement of animals which avoid crossing open ground.

Another important role of riparian vegetation is the stabilisation of stream banks by their roots. Penn (1999) refers to the skeleton of intermeshed roots within the stream embankment:

> *Human ingenuity could not build a better structural support system for [a] river valley, and this natural system maintains itself indefinitely, at no cost to the human community.*

The Jerdacuttup River is a series of shallow pools behind rock barriers and fallen trees. These act to oxygenate water flowing over their surface during winter months. In summer when flow slows or ceases altogether these pools will gradually become de-oxygenated due to increases in water temperature, with warm water holding less oxygen than colder water (Penn

1999) and the consumption of organic matter by aerobic microbes. The snags are also important as habitat for a variety of wildlife. Larger organisms such as cormorants need such places where they may perch and spread their wings to dry (Penn, 1999).
Smaller organisms find either shelter or may consume the woody material directly or feed upon algae which grow upon its surface. Another important feature of such pools is that they provide permanent fresh water for native animals during the summer months.

In 2004 the Department of Environment and Conservation (DEC) carried out an assessment of the stream foreshore condition for the Jerdacuttup River. Sections of the foreshore were assessed and graded based on a system developed by Luke Penn (1999). In general terms the system grades the river foreshore condition through 4 major categories A, B, C, D with each of these being further divided into 3 sub-categories. Thus there is a scale with 12 stages from A1 pristine to D3 – Drain. It was found that of the 53 km of the lower Jerdacuttup River, 81% was considered to be in A grade (excellent condition), while 14% is in good (B grade) condition with some signs of weeds, and 5% was showing signs of weeds, tree deaths, sedimentation and erosion (C grade). The 2004 DEC report states indications of early stage system stresses – particularly in the duration of the rivers wetting cycle and water logging – and there are localized areas of degradation which could benefit from remediation. It refers to suite of management actions for fencing, revegetation, crossing construction, weed management, and mitigating fire threats.

10.0 Threats

A variety of threats are listed below. They are many, and vary in the continuum of seriousness.

10.1 Salinity

Today, the Jerdacuttup - Shaster wetland systems are considered brackish, with variable salinity conditions during winter. A dramatic increase to salinity levels within the swamp system could lead to large scale losses of freshwater riparian species such as *Baumea*. The extensive floodplain areas spilling out over the wetlands during peak rainfall events can provide habitat for a large number of birds and aquatic organisms, as seen in Plate 4. Shortly after desiccation, there would be both a loss of habitat and of the organisms which drive nutrient cycling processes within the wetlands until such time till more salt tolerant fringing vegetation establishes itself. Most of the salt water entering the Jerdacuttup lakes comes from the mid-to upper catchment which is characterised by increasingly saline rising groundwater tables. It should be noted that the Jerdacuttup Lakes were temporarily once part of an estuarine system that is continually in the process of evolving given the dynamic milieu of increasingly rapid climate change and concomitant sea level rise. From the other side, there is the ongoing process of salinity becoming increasingly significant from groundwater transfer into these wetland systems. As stated recently, it will take 25-70 years for salinity to reach its potential expression here (Chapman, 2007:3).

10.2 Weeds

There are a number of weed species present in the Lower Jerdacuttup - Shaster catchment which have the potential to infest disturbed areas of the riparian zone and to potentially enter the swamp system. The following weeds in the Jerdacuttup River foreshore survey (DEC, 2004) were cited: (Bridal creeper *(Asparagus asparagoides),* Pimpernel (*Anagallis arvensis*), black nightshade (*Solanum nigrum*), barley grass (*Hordeum* sp.), saffron thistle (*Carthamus lanatus*), mallow (*Malva parviflora*), Turnip weed (*Rapistrum rugosum*), Maltese cockspur, (*Centaurea melitensis*), cape weed (*Arctotheca calendula*), pimpernel (Anagallis arvensis), common peppercress (*Lepidium africanum*), wild oat (*Avena barbata*) African boxthorn (*Lycium ferocissimum*), wild rye (*Elymus cinereus, Elymus spp*.), wild oats (*Avena barbata*, *Avena fatua*), storksbill (*Pelargonium austral)*, canola (Brassica napus), mallow, common peppercress*(Lepidium virginicum*), and an unidentified white-flowering *Brassica*.

Weeds are thought to threaten the health or habitat value of wetlands and river systems through a variety of mechanisms. Typically weed infested areas are dominated by a few species in comparison to native vegetation and so do not provide the full range of habitats, food sources and nesting or dwelling sites. Risk of fire may be heightened particularly in the case of annual and perennial grasses. Weeds may inhibit the generation of native seedlings and affect nutrient cycling (Hopkinson 2005). It should be noted that weeds are frequently species which are colonisers of bare or disturbed ground (Gillespie, 2006). In natural succession it is often grasses which are the first to appear after disturbance. Slowly, over time shrubs and finally tree species will take over. Only after very long periods of time do we once again find the full complement of native species. Weeds are rarely the cause of the loss of habitat. In managing for weeds great care needs to be taken to avoid or minimise activities which lead to the baring of soil or disturbance of the soil profile. Weeds may also play an important role on some sites where they are the only plants holding soil together and thus minimising erosion and the subsequent problems further down the catchment.

According to present knowledge, a roadside weed survey has not been conducted (Jenny Chambers, *pers comm*, 2007).

10.3 Blue Gums

Recently, there has been small shift from the traditional agriculture of the catchment towards a greater percentage of tree crops, particularly blue gums (*E. Globulus*). This trend though, is not nearly as important as the more widespread prevalence of *E. Globulus* and other timber plantations in the Esperance area, and even more so in the Great Southern region. The main limiting factor to timber production in this area is the distance from markets. The number concerns listed belowwith this Bluegums elsewhere are germane for any future growth in the Ravensthorpe –Jerdacuttup agricultural zone;

- Blue gums have the potential to become weeds and replace native western Australian trees in the landscape.
- Plantations are also reported to be *refugia* for some feral animals including pigs (Green Skills 2002).
- Large scale plantings may lead to changes in the water balance of the catchment.
- Insecticides used in current plantations management practices are known to be extremely toxic to nutrient cycling capacities of macro invertebrates in rivers, lakes and estuaries.

10.4 Phytophthora cinnamomi

Phytophthora dieback is a disease caused by the soil-borne microscopic water mould *Phytophthora cinnamomi*. It is thought to have originated in Asia, where it may have been introduced from some 200 hundred years ago. *Phytophthora cinnamomi* attacks the roots of many native plants severely reducing their ability to transport water and nutrients (Carter 2004). There are many susceptible species present within the Jerdacuttup - Shaster system catchment, (particularly along road reserves) such as *Banksias*, *Xanthorrhoea spp*, and *Macrozamias*. Generally these occur along the sandy ridge lines of the old swamp system. Loss of susceptible species in these areas would severely impact on the wildlife due to loss of food sources, habitat and nesting sites. The many informally created beach access tracks for off-road vehicles are also considered to be a conduit for dieback in the area. See Plate 29. Dieback has been recorded on Mason's Bay Road, and on Fence Rd.

10.5 Nutrients

Nutrients from predominantly agricultural land pose a threat to aquatic systems by changing the nutritional status of the water bodies and sediments. Native species adapted to low levels of nutrients or their influx in organic form may conversely be poorly adapted to live in the new regime. Imbalances of nitrogen and phosphorus may lead to algal blooms or favour introduced aquatic species. The two major nutrients leaching from agricultural lands are likely to be Phosphorus and Nitrogen. Phosphorus may be carried into the river on organic particles to which it attaches, adsorbs. It may also move within the water body as Phosphorus ions. Nitrogen may enter as Ammonium ions but be quickly converted by bacteria into Nitrates and Nitrite, in which forms it is most readily taken up by plants.

10.6 Habitat loss

Habitat loss is one of the major threatening processes affecting native animals in the South coast of Western Australia. Kitchner (1982, cited in Bradshaw 2006) noted that of all animal groups studied, mammals have shown the greatest departure from their original richness since the fragmentation of the landscape of the south coast of Western Australia. Fragmentation of landscape and loss of habitat are listed as threatening processes for many endemic native species. Many catchments have only very small areas of native vegetation remaining and these are fragmented and degraded. Weeds encroach easily on disturbed areas and although they may provide some valuable habitat and food it is unlikely that they provide the same diverse suite of beneficial attributes as intact native vegetation. Fragmentation of ecological communities may lead to species loss where individuals are unable to move between key food supplies. The loss of key species within ecosystems results in a decline of the whole system. Habitat loss is not confined to the loss of flora species; frequent burning or removal of old logs may result in a lack of den sites for rare and endangered species. Roads and track building also leads to severance and division of habitat, and can impact on drainage. See Plate 30 for an example of this.

10.7 Feral Animals

Feral animals are considered a threat to native species due to competition for resources such as food and nesting and breeding sites. They may also impact directly consuming native animals or plants. In some cases they may carry transmissible disease or through their foraging behaviour disturb or destroy fragile habitats. There are few, if any, areas in the south west which have not felt the impact of these introduced species. At least 7 species of feral animal are thought to be present within the lower Jerdacuttup - Shaster Catchment and so pose some level of threat to the Jerdacuttup - Shaster wetland system. It should be noted that for many areas native species which may have been present 200 years ago are no longer there and that little or no scientific study has been carried out on the possible ecologically beneficial role that introduced predators may be having.

Pigs were first brought to Australia as a food source however escapees quickly established feral populations. Today Australia may have as many as 23 million feral pigs. Feral pigs are considered to be an agricultural and environmental menace. Their behaviour of wallowing and rooting around water courses and swamps is described as being responsible for destroying fringing vegetation, nesting sites and the habitat of several eastern states frogs such as the white-bellied frog, orange-bellied frog and the corroboree frog (Department of Environmental Heritage 2006).

Rabbits are considered to be a problem primarily as they compete for food with native species. In large numbers they may also interfere with an area's ability to rejuvenate after fire as they feed on young seedlings. Warrens may also lead to erosion of sandy soils particularly around the fringes of the swamp basin. Rabbits in Mediterranean climates reach sexual maturity earlier than those of the arid regions becoming sexually mature at around 7 months of age. In these environments females may produce upwards of 28 young per year with populations reaching their maximum during spring (Walton & Richardson (eds) 1989). So under suitable conditions rabbits populations are able to increase dramatically

The fox was brought to Australia in 1855 for hunting, within 100 years it had spread across the continent. The fox is thought to have played a major role in the decline of many populations of native animals. Foxes generally prey on small mammals but will eat birds, reptiles, insects and fruit if their preferred food is scarce. Both males and females are sexually mature at the age of one year. Litters, averaging four cubs, are born during August and September, and emerge from the den in late spring. Foxes are considered to be a severe impediment to small mammals re-establishing colonies. For example Quendas have become abundant again at Lake Magenta only after fox control programmes were initiated.

Feral cats are found throughout much of mainland Australia and are known to predate a large range of native animals from brush-tailed possums and bandicoots, through to the smaller marsupials such as dunnarts as well as birds, reptiles and macro-invertebrates. However, there appears to be no documented evidence of cats leading to the local extinction of any native species on the mainland (Nattrass 1993, and Walton & Richardson (eds) 1989).

E. Jones (in Walton & Richardson (eds) 1989), cites several studies where the full extent of native species one would expect to find in a particular habitat are present even where feral cats are prevalent. Nattrass (1993) also points out that in many areas the native predators such as quolls, *Dasyurus* spp, are no longer present and indicates that the feral cat may be playing the role of these predators in a sustainable manner. Both authors indicate that the role of the cat needs to be considered along with large scale ecological changes such as habitat loss and fragmentation. In some studies the major food source for feral cats appear to have been another introduced species the rabbit, which further complicates the dynamics between introduced and native fauna.

There are at least 7 introduced species of fauna present in the Jerdacuttup - Shaster catchment which may or may not be present here. The mouse *Mus musculus*, brown rat *Rattus norvegicus*, blackrat *Rattus rattus*, rabbit *Oryctolagus cuniculus*, fox *Vulpes vulpes*, cat *Felis catus*, and the pig *Sus scrofa*. Certainly there is evidence of foxes and rabbits and it is likely that mice, rats and cats are all present. Domestic horses occasionally visit the wetland but at this stage are not considered to be an issue due to low numbers.

10.8 Stock

Stock impact on wetlands and riparian zones through a number of mechanisms. Firstly they may trample plants and if using a site regularly denude it of any vegetation which then leads to erosion of stream banks and an increase in sediment loads and nutrients. They may also increase the nutrient load in the water body through their droppings. Stock can also help to spread weed seeds either through seeds being present in manure or carried on the animal. Management of stock in riparian zones if therefore critical to the health of the river and wetland system. See Plate 32.

10.9 Acid Sulphate Soils

Acid sulphate soils is the term given to soils which contain iron sulphides. In Western Australia the acid sulphate soils of greatest concern are those which formed after the last major sea level rise. Sammut and Lines-Kelly 1995 describe the formation of acid sulphate soils as being due to:

> Bacteria in organically rich waterlogged sediments converted sulphate
> from tidal waters and iron from sediments to iron disulfide (iron pyrite).
> When exposed to air, iron sulphides oxidise and produce sulphuric acid.

Acid sulphate soils are typically categorised as either "Potential" or "Actual" acid sulphate soil. Potential acid sulphate soils are those containing iron sulphides that are contained in an anaerobic environment such as being waterlogged. Actual acid sulphate soils on the other hand are those that have been exposed to the air and oxidation of the iron sulphides is producing sulphuric acid.

The exposure and subsequent oxidation of acid sulphate soils leads to many adverse environmental impacts both for agricultural land and natural ecosystems. Acid leaching from the soil profile may directly impact on aquatic life which typically requires a minimum pH of 6 to survive (Sammut and Lines-Kelly 1995). Fish exposed to highly acidic water are likely to suffer damage to gills and skin making them more prone to fungal infections and ulcerous diseases such as red spot. More subtle effects are reduced hatching and decline in growth rates (Sammut and Lines-Kelly 1995). At the moment, acid sulphate soils are not considered a major threat in the Jerdacuttup-Shaster wetland system.

10.10 Perennial Pastures

In an effort to address changed hydrological regimes, due to clearing of native vegetation, farmers are being encouraged to integrate deep rooted perennial species into their farming regimes. While this practice may deal with the rising, saline watertables there are management issues associated with their use. Species such as Kikuyu *Pennisetum clandestinum* have the capacity to become an environmental weed once they spread from agricultural land. Kikuyu may spread rapidly through low lying, wet areas of a catchment and so is considered a threat to creeks and wetlands. A study was undertaken by Green Skills to develop guidelines for the management of such species around environmentally sensitive areas. Management considerations and a number of control techniques are provided including buffers, barriers, bio-filters, fire, chemical control, slashing, utilisation of shade and nutrient management. Perennial pastures have an important role in the development of sustainable farming practices, however, careful management is required to avoid them becoming environmental weeds.

10.11 Biological poisons

The use of biological poisons impacts on all levels of the ecosystem. These chemicals persist in the environment accumulating in species at the top of the food chain. Peregrine falcons, as a top predator for example, are known to have experienced symptoms such as thin egg shells which may severely reduce their chances of successful breeding. Hopkinson (2003) states that the commonly used Dimethoate is known to be extremely toxic to aquatic fauna particularly macroinvertebrates such as gilgies and marron. Some landholders in the Yallobup Creek catchment have mentioned concerns regarding spray drift from 'di-cambrin', a locally used bio-cide. Changes in land use within the catchment that result in an increase in the use of biological poisons have the potential to impact upon the health of the Jerdacuttup River and the Jerdacuttup - Shaster wetland system.

10.12 Fire

Fire poses a serious threat to the flora and fauna of the Jerdacuttup - Shaster system wetland system. In general terms excessive fire may lead to the loss of fire sensitive plant species and fauna species that require vegetative communities which arise after long periods without fire. Loss of habitat appears to be the most limiting factor for endemic and local marsupial species as well as trans-equatorial migrant shorebirds because they have not persisted in areas where adequate dense cover is provided and fox/cat control measures are not undertaken (Bradshaw 2006). It has also been suggested that in an area where foxes and cats are likely to be present the most critical factor for certain local species' survival is availability of protection from predators through dense understorey (Morris et al. 2000, Paul 1999/1). Habitat may be optimal for approximately one decade after the ground layer regenerates, but some sites are used five decades after fire.

Large scale intense fires may kill fauna populations within the natural reserves around the Jerdacuttup – Shaster wetlands. Recruitment from other areas may be difficult or impossible given the fragmented state of remnant vegetation within the upper catchment. Loss of habitat, including suitable cover from predators and short term loss of nesting or breeding sites, may impose further stress on already threatened populations. Although there is no apparent threat imposed by acid sulphate soils, intense and frequent fire may pose a threat to areas and plant communities normally free from its impact. Particularly summer refugia for shorebirds and waterbirds. Reed beds and aquatic organisms will burn and through oxidation of their embodied iron sulphates ($Fe\ SO_4$), and there is subsequent production of highly acidic material. The combined effect of massive loss of habitat both in the water body and within the surrounding riparian communities could be disastrous for local populations of already marginalised marsupial species.

10.13 Mining

Mining has been mentioned by local catchment groups as a potential threat to this wetland system. Already, leachate from a disused copper mine in the area is thought to be an issue for the water quality for the Culham Inlet and the catchment from the defunct mine (Rod Daw, *pers comm*., 2007). Possible future threats that have been considered of the current Ravensthorpe Nickel Project (RNP), run by the mining company, BHP (see Plate 33) are: Silica dust, Sulphur dioxide as vented air pollution, potential groundwater pollution from leaks in tailings dams (see Plate 34), and herbicidal spray drift (Yallobup Catchment Group, May, 2006). Precedents for accidents have already been set. A small amount of seawater escaped from the first 19km of a broken underground pipe from the RNP's marine water desalination system, on a section of Mason's Bay Road. See Plates 35 and 36.

10.14 Global Warming

The Jerdacuttup - Shaster system, today a complex series of wetlands, was once part of a larger Holocene dune complex that looked very different to its present form. With sea levels expected to rise from rapid melting of polar ice caps and glaciers over the next few decades and centuries it is possible that Jerdacuttup River system will once more become joined to the Southern Ocean and transform into saline estuarine life, and eventually become inundated. In the medium term,(100 years to 1,000 years) there will be a transition from freshwater to salt tolerant species and from species which prefer static or seasonal water level fluctuations to those which are able to tolerate daily tidal fluctuations. Although in the medium term (50 years to 1000 years) another native riparian community will arise and be different to the brackish-freshwater system currently in place. It is with utmost irony that peri-urban coastal development pressures (another separate issue) prevail at such relatively remote locations as Dunn's Swamp and Culham Inlet, given the impending reality that soon the considerable human resources invested in them will become part of the future seabed. See Plate 37.

11.0 Conclusion

As previously mentioned, the Lake Shaster and Jerdacuttup wetland systems have a large area of bushland adjacent to the lake which have regrown after clearing some 40 years ago. Twenty five wetlands between Hopetoun and Oldfield Estuary on the south coast of Western Australia were assessed for waterbird use, condition and potential threats; of these 15 held at least some water after five successive years of less than average annual rainfall. Electrical conductivity of these wetlands' water ranged from 11.6-164.1 mS/cm and wetland size was between 6 ha and 1,203 ha. The fact that wetlands carried varying levels of total phosphorus and total nitrogen are also partly explained by the large variation in wetland size in the area (between 6ha and 1, 203 ha). (from Chapman, 2007:1).

All of the wetlands studied accorded to the Ramsar classification of most wetlands: they are inland saline lakes and/or inland wooded swamps. Salinity and water level both of which continuously change over time impact on waterbird utilisation. It is the nature of the changes at work and their severity which most negatively impacts on the ecology's capacity to adapt to this change. This suite of wetlands is unique in that only one of them is a coastal estuary. This reflects the flatness of hinterland and the relatively slower flow and lesser volume of the riparian systems capacities to discharge at a rate needed to form estuarine systems that are contiguous with the Southern Ocean. These systems are nonetheless clearly very bio-diverse. They contain 49 waterbird species including all ducks known from south-western Australia, as well as 8 species of trans-equatorial migrants.

Some of these wetlands are clearly beginning to exhibit stress in the form of paperbark deaths due to water logging caused by increased run-off from their catchments in land cleared for agriculture. In some cases recent intensive rainfall events may be a cause of water logging. Other threats to wetlands are weed invasion and for two wetlands there is a potential threat from sub-division development (Plate 37). In spite of these threats most wetlands are in very good condition and collectively they provide habitat, including summer refugia, for more than half the species of waterbirds recorded from south-western Australia. Recommendations follow, yet it is noteworthy that there is already a movement towards implementation, as will be discussed at the end of the next section.

12.0 Recommendations

It was initially pointed out that some wetlands appear to be exhibiting stress in the form of paperbark deaths due to water logging caused by increased run-off from their catchments in land cleared for agriculture. Groundwater investigations are recommended to ascertain connectivity of these wetlands to local and regional aquifers as there is little understanding of their contribution to water level changes in the above studied wetland systems. This is one of the strongest factors influencing littoral vegetation health, and subsequent waterbird utilisation and general habitat health. Equally, the potential threat from sub-division development has to be addressed (see Plate 37). A tabulated list of recommendations follows:

Table 4 – Site Specific Recommendations for the Jerdacuttup and Shaster wetland systems

Sites:	**Dunn's Swamp**
Issues/Threats:	As with Culham Inlet, there is peri-urban development pressure in the form of subdivision allotments being slated and prepared in the area. High waterbird use of this site will be under potential pressure (disturbance, introduction of feral predators –introduced cats, dogs). Drainage to these systems may also be affected- sediment loadings, increased pollution, etc).
Management recommendations	Further study to enable better understanding of the ecological dynamics of this system in its proximity to development. Good water sensitive development design will be required, here. Fencing of wetland reserve and fringing vegetation may be a useful strategy to deter predators. Also stronger controls of pets are suggested.
Specific site:	**Lower Jerdacuttup River**
Issues/Threats:	Tributaries to the main river feeding this system (Jerdacuttup River) are sometimes inadequately buffered. Specifically Sections of the Jerdacuttup River as it enters Jerdacuttup Lake East close to Springdale Rd (Lakes Entrance sub-division).
Management recommendations	Negotiate a fencing and revegetation project with the land manager for locations 37, 38 and 21. Encourage completion of a specific management plan for the foreshore reserve adjacent to the Lakes Entrance' sub-division. This should address storm water management, construction of walk trails to stop the proliferation of many trails, manage access points to the river, foreshore reserve demarcation, control and eradication of weed species. (DEC, 2004: 41)
Specific site:	**Jerdacuttup River and Yallobup Creek catchments**
Issues/Threats:	Fragmented bush corridors may not be able to act smoothly as area for local species to maintain viable habitat and transport between larger remnant patches of vegetation.
Management recommendations	Where practicable, key areas of remnant vegetation are linked by new bush corridors of local species.

Issues/Threats:	Recent breakage in the first 19kms of a desalination pipe from Mason's Point to the RNP mine site has lead to the spillage of an unknown but small amount of seawater directly into the groundwater systems.
Management recommendations	Landholders and other stakeholders to negotiate a 'no-accident' compensation clause with the RNP with respect to risk of groundwater pollution resulting from any activities of this particular mining infrastructure operation.
Issues/Threats:	Nearby nickel mining operations are said to pose perceived long term threats. Those that have been mentioned by local residents and other stakeholders' include: • Silica dust • Sulphur dioxide • Potential groundwater pollution from leaks in tailings dams. • Herbicidal spray drift.
Management recommendations	This issue to be addressed by the appropriate State agencies in conjunction with landholders and local NRM groups, especially in connection with wetlands.
Issues/Threats:	Weeds (especially African Love grass), is a threat to productive pasture, especially on roadside verges. Weeds in these areas represent fire risks in the form of increased fuel loads
Management recommendations	Hazard reduction burning to control fuel loads, particularly along road sides and fence lines. This to be followed up with other weed management strategies (glyphosphate, biological controls, etc).
Specific site:	**Roadside verges in Jerdacuttup River and Yallobup Creek catchments**
Issues/Threats:	*Phytophthora cinnamomi* has been seen as a threat in the catchment of the Jerdacuttup – Shaster lakes area, specifically along Springdale Road, Mason's Bay Rd and Fence Rd.
Management recommendations	*Phytophthora* control program to be implemented in the area. • Controlling dust on this road and other affected roads that increase the risk of further introduction. • washing soil from vehicles prior to entry to the area, • sourcing materials to be used in works from *P. cinnamomi*-free stock, • more effective sequencing and timing of vehicles travelling on affected roads. • Signage on roads • Monitoring of surrounding vegetation, particularly *P. cinnamomi* susceptible species. • Information to be provided to landholders on the threat posed by *P. cinnamomi*.
Specific site:	**Higher catchments and sub-catchments for Jerdacuttup River and Yallobup Creek**
Issues/Threats:	Salinity threat is relatively not unknown in the system (Pratt, 1998). E_c varies significantly in the downstream wetland systems
Management recommendations	Groundwater investigations are suggested to acquire greater clarity. Scoping for locations for this has already been undertaken by the Department of Agriculture and Food's regional hydrologist. Landholders encouraged to integrate deep rooted perennials into current farming systems.

Specific site:	**Oldfield River**
Issues/Threats:	Nutrient data indicate elevated nutrient enrichment with some total nitrogen and total phosphorus levels well in excess of recommended maxima for the Oldfield River.
Management recommendations	Fencing tributary waterways in sub-catchments to protect remnant vegetation from stock, and also engaging in re-vegetation of these waterways is necessary. Surface water management (construction of berms, swales and banks to slow water down and catch sediment and filter salt in peak flow events into wetlands).
Wetland:	**Lake Shaster**
Issues/Threats:	Some evidence of feral animals (foxes and rabbits).
Management recommendations	Fox baiting and rabbit control program to be implemented throughout this and other affected areas within the catchment.
Site:	**All Wetlands**
Issues/Threats:	Potential inundation of breeding grounds for threatened species – Hooded Plover. Change of nutrient status of wetland – algal blooms, loss of food and habitat sources for trans-equatorial migrant bird species.
Management recommendations	Water depth monitored over time. Ground water monitoring to be undertaken to ascertain groundwater influx rates to wetlands.
Issues/Threats:	Access tracks between wetlands and coastal dunes enable transmission of disease, weeds, vehicles, horses, feral animals.
Management recommendations	Blocking off some tracks, signage at track entrance advising of dieback threat, need to keep to track and appropriate care of wetland area. Revegetation with native species of bare or degraded foreshores. Install signage as a priority for all wetlands close to main roads, declaring dieback control zones.

As indicated in the conclusions, the effort to implement recommendations is already underway. There are a number of drainage systems in the mid-catchment of the Yallobup Creek system, and the Jerdacuttup River East which empty into Jerdacuttup Lake East, and West, respectively. Several of these mid-catchment creek lines are being scheduled for fencing and revegetation, for example on property location numbers 813, 814, and 800. More implementations of previously planned on-ground works are being carried out by other landholders, in conjunction with the peak NRM agency in the area, the Ravensthorpe Agricultural Initiative Network (RAIN). Scoping for a groundwater drilling and monitoring survey is already underway for the Jerdacuttup – Shaster wetlands (see Plate 38).

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