Department of Water
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Riparian condition of the Yilgarn River: Caroline Gap to Hines Hill

Waterway assessment in the zone of ancient drainage

Water resource management series

Report No. WRM 49
February 2008

Department of Water
Government of Western Australia

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Funded by
the Avon Catchment Council, the Government of Western Australia
and the Australian Government through the Natural Heritage Trust
and the National Action Plan for Salinity and Water Quality

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This report was prepared by Kate Gole, Natural Resource Management Officer, Department of Water, Swan–Avon Region.

All photographs have been taken by Kate Gole unless otherwise stated.

Cover photo: Mallee woodland fringing a small playa lake in Mournucking Nature Reserve (Photo: S. Mehmet)

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Abbreviations

ACC	Avon Catchment Council
ANDA	Avon Natural Diversity Alliance
AWC	Avon Waterways Committee
DAF	Department of Agriculture and Food
DEC	Department of Environment and Conservation
EEI	Engineering Evaluation Initiative
NAP	National Action Plan for Salinity and Water Quality
NRM	Natural resource management
RRP	River recovery plan
SPA	Saltland Pastures Association
WDE	Wheatbelt Drainage Evaluation
WWF	WWF-Australia

Executive summary

Management of water resources in the Avon River basin is a high priority under the Avon Catchment Council's natural resource management (NRM) strategy and investment plans (Avon Catchment Council, 2005 a, b). Through the Avon Rivercare project, the Department of Water has begun to investigate the riparian condition and management needs of waterways in the Avon River basin within the zone of ancient drainage. The Lower Yilgarn River project is the second of these waterway assessments, following on from the Salt River study (Department of Water, 2008).

The Lower Yilgarn River study area extends from the Caroline Gap, where the Yilgarn and Lockhart rivers converge, upstream to Hines Hill Nature Reserve, and includes the channels and salt lakes of the Yilgarn River and its floodplain.

The purpose of the Lower Yilgarn waterway assessment is to investigate its current condition, identify threatening processes and propose management recommendations for improving its condition. Sources of advice and funding are also identified to enable the implementation of the proposed management recommendations.

The key management issues in the study area are:

- increasing salinity and waterlogging in the valley floor
- loss of riparian vegetation fringing the waterway and its tributaries
- impedance of flood flows by road crossings
- increased stream flow causing erosion and sedimentation in tributaries
- pest species degrading riparian vegetation
- stock access
- lack of corridors linking areas of remnant vegetation
- fire risk
- dumping of rubbish in floodplain areas.

Of these, the most crucial are increasing salinity levels and waterlogging in the valley floor. These are processes that need to be managed at a catchment scale through partnerships between landholders, all levels of government and non-government agencies.

Information gained through the Yilgarn River waterway assessment will be used by waterway managers including the Avon Catchment Council, Department of Water, Department of Environment and Conservation, Avon Waterways Committee, local shires and landholders to plan and set priorities for the future management of the waterway.

Kate Gole, Natural Resource Management Officer
Department of Water, Swan–Avon Region
Northam District Office

1 Introduction

1.1 Avon River basin

The Avon River is one of Western Australia's major river systems, draining approximately 120 000 km^2 from Dalwallinu in the north, Southern Cross in the north-east and Lake King in the south-east.

There are four main sub-catchments within the Avon River basin including:

- The Yilgarn River catchment, which drains an area of approximately 55 900 km^2. It originates north-east of Southern Cross from Lake Seabrook and Lake Deborah and flows to the south-west past Merredin to its confluence with the Lockhart River at the Caroline Gap, south of Kellerberrin.
- The Lockhart River catchment, which drains an area of approximately 32 400 km^2. It originates at Lake Magenta, south of Newdegate, and flows north-west through Kondinin, Corrigin and Bruce Rock to the Caroline Gap. The catchment also includes the Pingrup River, which originates at Chinocup Lake south of Lake Grace, and the Camm River, which originates at Lake King.
- The Mortlock River system, which drains an area of approximately 16 770 km^2. It consists of the Mortlock River, Mortlock River North, Mortlock River East and Mortlock River South and joins the Avon River at Northam.
- The Avon River catchment, which drains an area of approximately 15 500 km^2. It includes the Salt River, Avon River South Branch, Dale River, Mackie River, Toodyay Brook, Brockman River and Wooroloo Brook catchments.

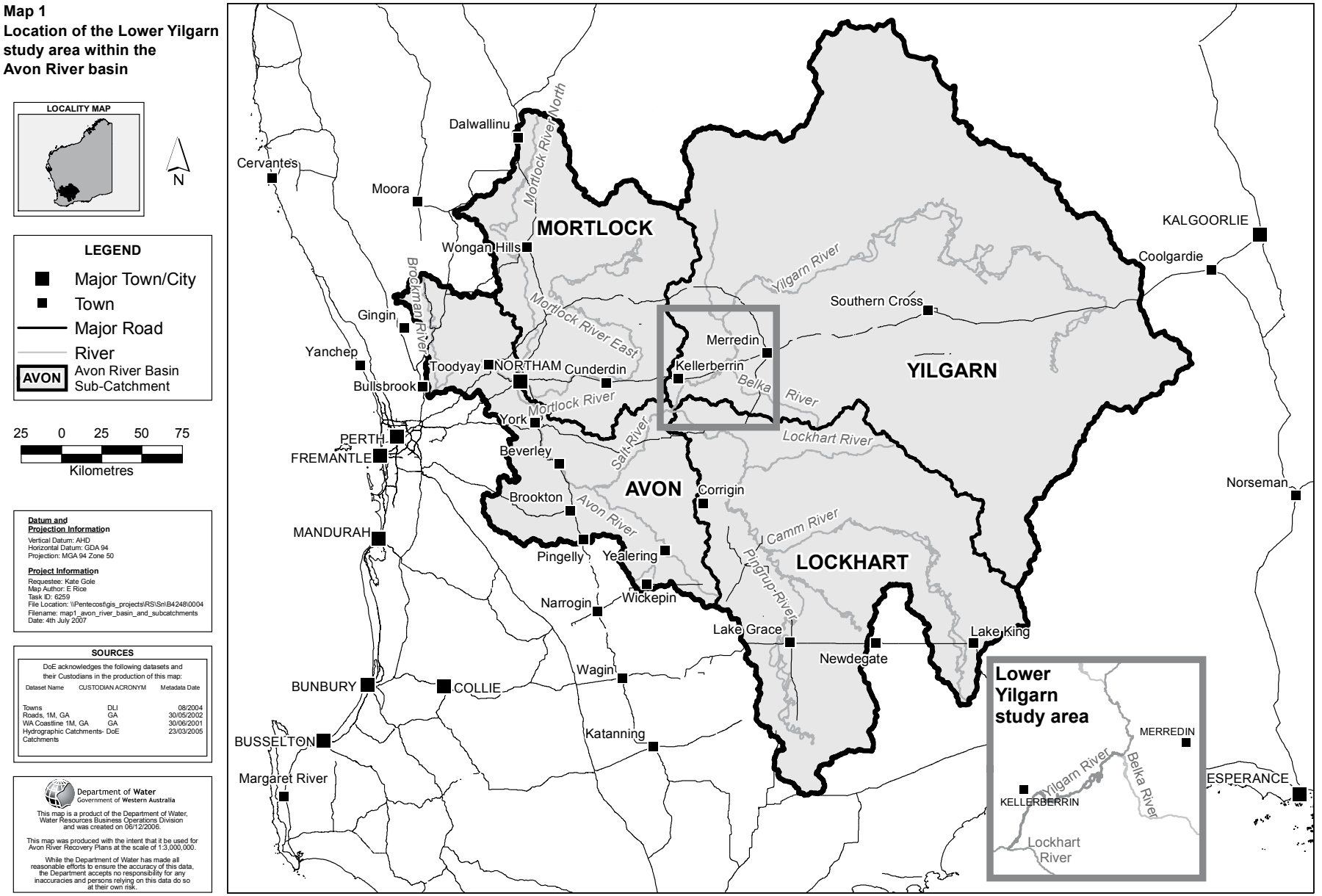
Map 1 shows the major sub-catchments of the Avon River basin and the location of the Lower Yilgarn study area.

1.2 Managing natural resources in the Avon River basin

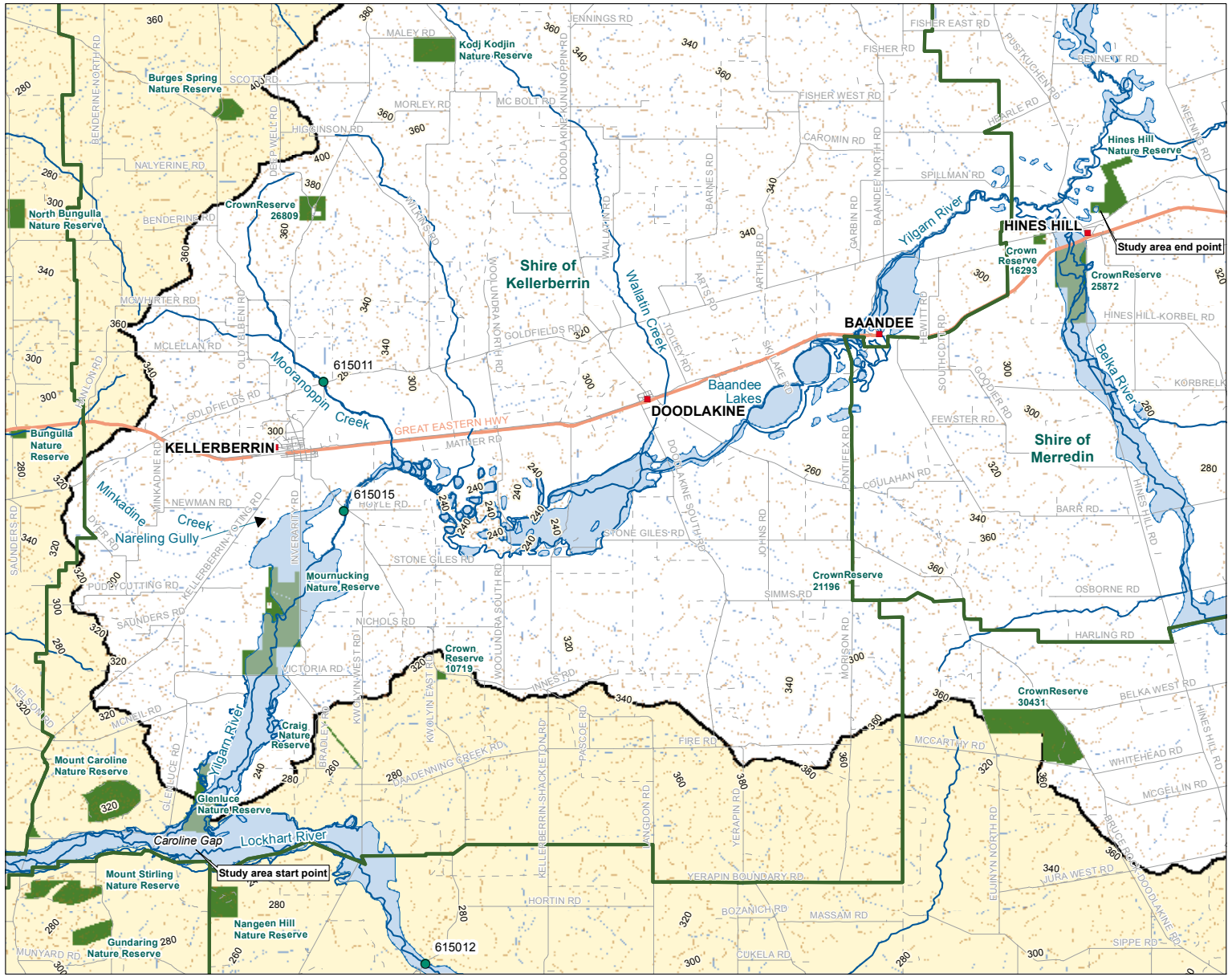
The Avon Catchment Council (ACC) is the peak natural resource management (NRM) body in the diverse Avon River basin. The ACC has recently completed the *Avon River Basin NRM Strategy* (Avon Catchment Council, 2005a) and *Avon Investment Plan* (Avon Catchment Council, 2005b), which provide direction and identify priorities for investment into actions to bring about change in the condition of water, land, vegetation and other landscape assets.

Supporting the Avon NRM Strategy, the Ballardong NRM Working Group (2006) has completed *Ballardong Noongar Budja: Healthy Country – Healthy People* which presents the Noongar perspective on caring for Country and involving the Ballardong people in NRM in the Avon River basin.

Map 1
Location of the Lower Yilgarn study area within the Avon River basin



Map 2
Lower Yilgarn River study area



Legend

Road network
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- Main Roads
- Local Roads
- Tracks

River network
- Major Waterway
- Lakes

Boundaries
- Yilgarn River Catchment
- LGA Boundary
- Nature Reserves

Other
- Contours
- Rabbit proof fence
- Towns
- Gauging Stations

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

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Map Author: Tom Lee
Task ID:
Filename J:\Rs\sn\b4148\0004
Date:5th July 2007

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Dataset Name-CUSTODIAN ACRONYM-Metadata Date
Towns - DLI - 08/08/2004
Road Centrelines - DLI - 01/05/2004
Hydrography, heirachy - DOE - 13/04/2005
Local Govt Authorities - DLI - 08/07/2004

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

Management of water resources, including waterways and lakes, is a high priority. Through the Avon Rivercare Project, the Department of Water has initiated a project to investigate the riparian condition and management needs of waterways in the Avon River basin within the zone of ancient drainage. The Lower Yilgarn study is the second of these waterway assessments, following on from the Salt River study (Department of Water, 2008).

1.3 Aims of the Lower Yilgarn waterway assessment

The main aim of the Lower Yilgarn River study is to gain an understanding of the current riparian condition of the Lower Yilgarn River in order to:

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

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

2 Nature of the Lower Yilgarn River study area

2.1 Lower Yilgarn River study area

The Yilgarn and Lockhart rivers converge at the Caroline Gap, in the vicinity of the granite domes of Mt Caroline and Mt Stirling. Downstream, the Salt River and Yenyening Lakes form the connection between the salt lake chains in the broad valleys of the zone of ancient drainage in the east and the rejuvenated Avon River in the west.

The study area for this project includes the channels and salt lakes of the Yilgarn River and its floodplain from the Caroline Gap to Hines Hill Nature Reserve, approximately 60 km upstream. Map 2 shows the location of the study area.

2.2 Nature of the Lower Yilgarn River landscape

2.2.1 Landscapes and soils

The Yilgarn River system lies within the zone of ancient drainage. The broad valley floors are characterised by salt lakes (playas); braided, discontinuous channels bordered by lunettes (wind-blown sediment deposits) and flat to undulating saline plains (Commander et al., 2001). These landscape features correspond to the Merredin, Baandee, Nangeenan and Belka surfaces shown in Figure 1 (Lantzke, 1992).

Very gentle slopes, corresponding to the Collgar landscape unit, fringe the broad, alluvial floodplain above which the long hillslopes with the hard-setting sandy loams of the Booraan unit occur (Lantzke, 1992; McArthur, 1991).

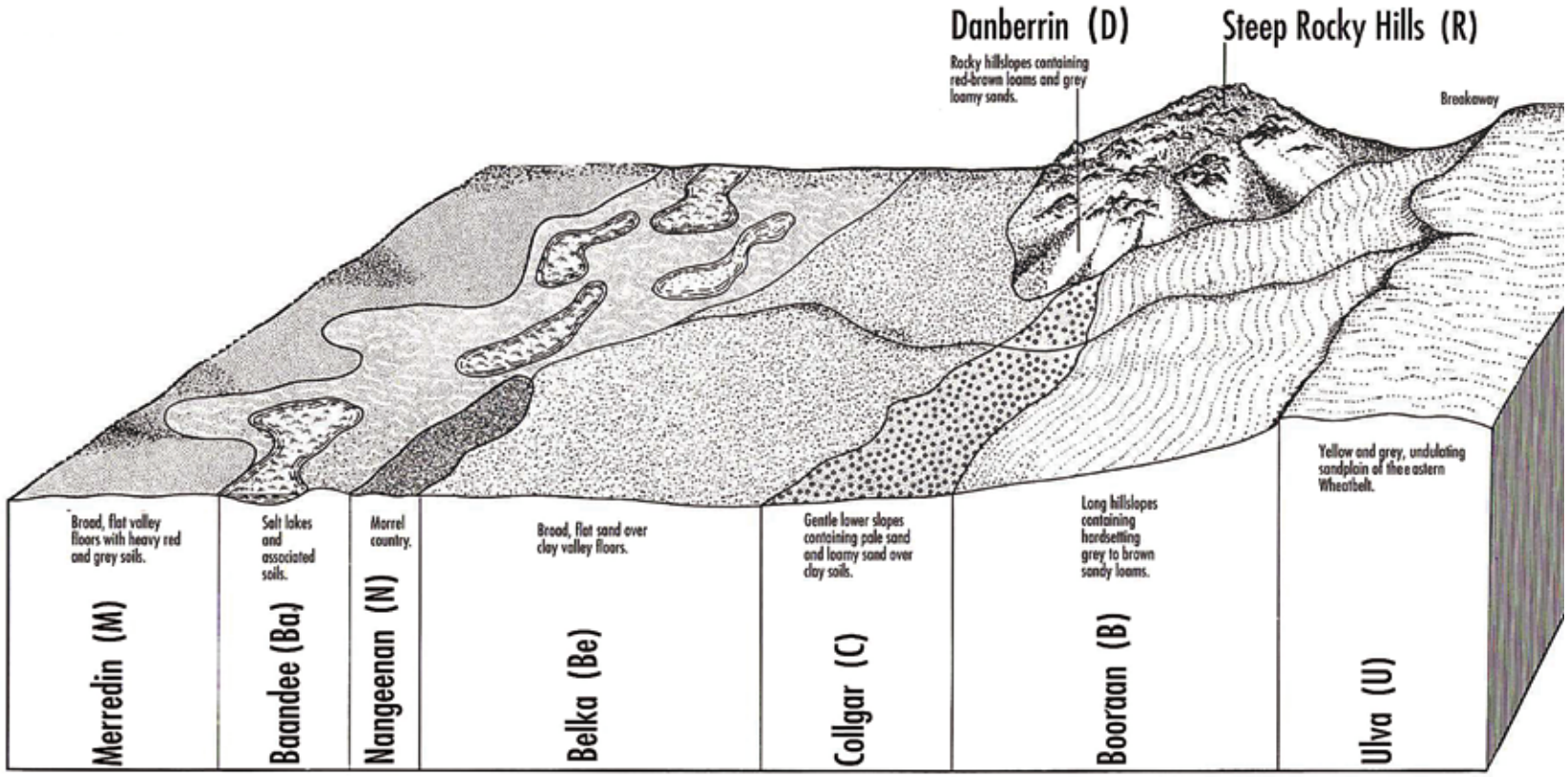
The Ulva landscape unit is an undulating sandplain above lateritic breakaways. This unit is all that remains of the old lateritic profile that once covered the entire landscape. The Booraan and Collgar units are formed from the dissection of this surface (Lantzke, 1992; McArthur, 1991).

The steep rocky hills of the Danberrin unit include the red-streaked granites of Mt Caroline and Mt Stirling, which together define the Caroline Gap, and numerous other outcrops including Kellerberrin Hill and Totadgin Rock (Lantzke, 1992; McArthur, 1991).

2.2.2 Broad vegetation communities

The Lower Yilgarn River study area falls within the Mt Caroline vegetation system of the Avon botanical district (Beard, 1980). Soil types, landscape features and vegetation associations within the catchment are closely linked.

The lakes themselves tend to be bare of vegetation and fringed by salt-tolerant species such as samphire (*Halosarcia* species), saltbush (*Atriplex* species) and



SOIL LANDSCAPE UNIT	Merredin	Baandee	Nangeenan	Belka	Collgar	Danberrin	Steep Rocky Hills	Booraan	Ulva
MAJOR SOIL TYPES	Red-brown sandy loam over clay valley soil. Red clay valley soil. Grey clay valley soil Grey to brown cracking clay.	Salt lake and channels. Soils fringing the salt lakes.	Powdery surfaced calcereous soil.	Deep sandy surfaced valley soil. Shallow sandy surfaced valley soil.	Loamy sand over clay	Rocky red-brown loamy sand/sandy loam. Brownish grey granitic loamy sand. Red-brown doleritic clay loam.	Steep rocky hill soils.	Sandy loam over clay. Shallow hardsetting grey sandy loam over clay. Loamy sand over clay.	Yellow gradational loamy sand. Deep yellow sand. Pale sand over gravel/loamy sand. Deep pale sand. Shallow mottled zone. Deep yellow acid sand.
VEGETATION	Salmon gum Gimlet	Barley grass Bluebush Saltbush Samphire Bare ground	Morrel	Salmon gum York gum White gum Gimlet	Mallee species	York gum Jam Sheoak White gum Salmon gum	Jam York gum Sheoak White gum	Salmon gum White gum Mallee Gimlet	Banksia Sandplain pear Tammar Sandplain mallee Woodjil Flame grevillea Christmas tea

Figure 1 *Soil landscape units of the zone of ancient drainage (adapted from Lantzke, 1992)*

Photo 1 Eucalypt *woodland and* Melaleuca *shrubland growing within the floodplain (Photo S: Mehmet)*

bluebush (*Maireana* species). Bordering the lakes are flats dominated by *Melaleuca* thickets grading into woodlands of York gum (*Eucalyptus loxophleba*), salmon gum (*Eucalyptus salmonophloia*), gimlet (*Eucalyptus salubris*) and morrel (*Eucalyptus longicornis*) over *Melaleuca* species and succulents. Vegetation associations growing on the lunettes vary, but often mallee woodlands can be found growing just above the salt flats (Beard, 1980).

Dominating the loamy sand-over-clay soils associated with the gentle lower slopes above the broad valley floors, are woodlands of York gum (*Eucalyptus loxophleba*), salmon gum (*Eucalyptus salmonophloia*) and gimlet (*Eucalyptus salubris*) over jam (*Acacia acuminata*) and sheoak (*Allocasuarina* species). Higher on the slopes, the hard-setting, sandy loams are associated with salmon gum (*Eucalyptus salmonophloia*), wandoo (*Eucalyptus wandoo*) and gimlet (*Eucalyptus salubris*) woodlands over a sparse understorey of Acacia species (Beard, 1980).

The upland sandplain soils are dominated by highly diverse kwongan communities, characterised by acorn banksia (*Banksia prionotes*), sandplain woody pear (*Xylomelum angustifolium*) and sheoak (*Allocasuarina* species) over an open middlestorey of a wide variety of species, including *Hakea, Acacia, Melaleuca* and *Leptospermum* species. Tamma (*Allocasuarina campestris*) thickets with scattered wandoo (*Eucalyptus wandoo*) occur on the laterite breakaways (Beard, 1980).

The granite outcrops support low, open woodlands of York gum (*Eucalyptus loxophleba*) over *Acacia* and sheoak (*Allocasuarina* species) shrubland with an understorey of grasses and annual herbs. Pockets of soil on the slopes and summits of the outcrops support a range of sedges and herbs, including *Borya* species, under jam (*Acacia acuminata*) and *Grevillea* species (Beard, 1980).

2.2.3 Post-clearing changes to vegetation communities

While the Lower Yilgarn River is naturally saline, excess surface and groundwater resulting from widespread clearing has fragmented remnant vegetation and increased waterlogging and salinity levels across the floodplain. The native riparian vegetation is adapted to natural waterlogging and salinity levels; however, the increased salinity and frequency of inundation has lead to a decline in vegetation condition and caused deaths in some areas.

The field survey showed that the most degraded vegetation communities tend to occur where there are few or no lunettes or where the lunettes are relatively small and low (less than 1 m above the lake bed). In these areas vegetation condition has declined significantly and the original shrublands have been replaced with salt-tolerant species. The vegetation in the best condition tends to occur where lunettes are relatively large or high (more than 1 m above the lake bed) or on the edge of the floodplain. In these areas vegetation is still in relatively good condition and *Melaleuca* shrublands and mallee communities still occur.

2.3 Hydrology and water quality

The Lower Yilgarn River receives streamflow from upstream, groundwater seepage and numerous tributaries including:

- Minkadine Creek
- Nareling Gully
- Mooranoppin Creek
- Wallatin Creek
- Belka River.

The gradient along the lower Yilgarn River is very low. For the study area (from the Caroline Gap to Hines Hill) it has been calculated at 0.32 m/km (Figure 2). Beard (1999) calculated the gradient as 0.38 m/km, from the catchment boundary beyond Lake Seabrook to the confluence with Salt River at the Caroline Gap, which is similar to the 0.35 m/km calculated by Salama (1997) for the distance downstream from Lake Baandee. A key feature of this grade is that it is interrupted by large, relatively flat salt lakes which store large volumes of water before they fill and overflow. The total lake storage volume in the Yilgarn has been estimated at 3150 GL (Ruprecht et al., 2004).

The low gradient and the nature of the waterway, with braided, disconnected channels punctuated with salt lakes, means that the river does not flow as one linked system unless major summer rainfall events or prolonged, wet winters occur.

Annual average rainfall across the study area is approximately 330 mm and is highly seasonal, with approximately 70% of the annual total falling between April and September (Australian Bureau of Meteorology, 2007), and highly variable between years.

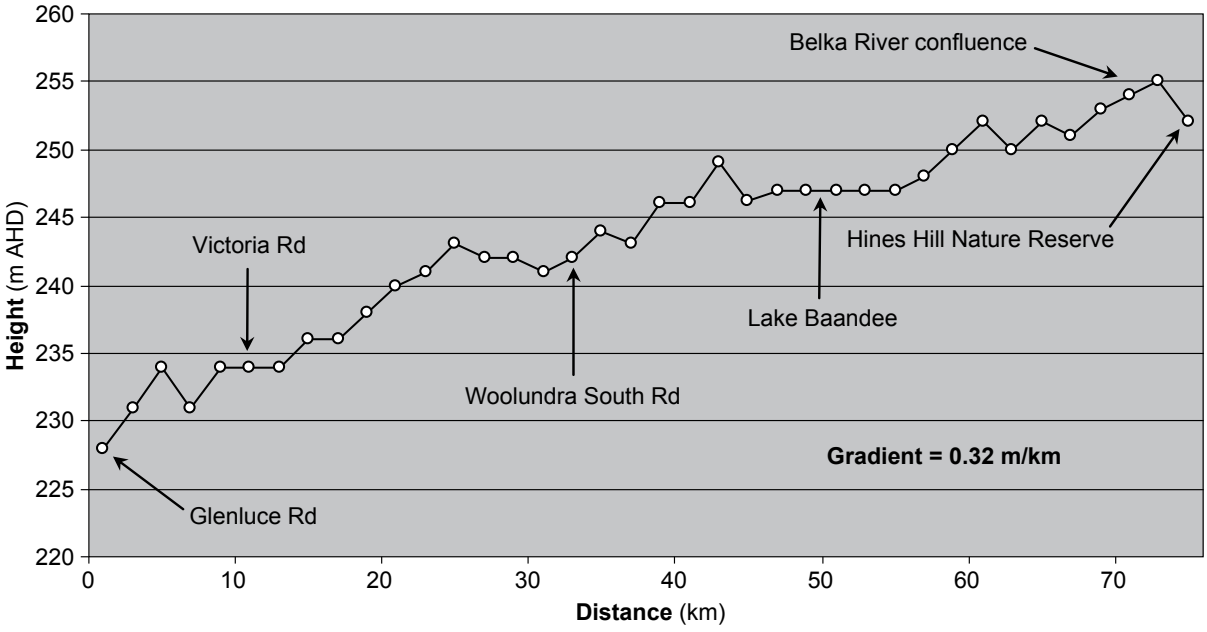


***Figure 2** Gradient along the Lower Yilgarn River from the Caroline Gap to Hines Hill*

The low gradient of the valley floor, geomorphology of the waterway, particularly storage in salt lake chains, and rainfall variability results in highly variable streamflow in the Yilgarn River.

There are two Department of Water gauging stations within the study area. The Gairdners Crossing gauging station was constructed on the Yilgarn River near Kellerberrin in 1976. Between 1976 and 2004, the total annual discharge has varied from zero to almost 54 GL (Figure 3a).

The Mooranoppin Rock gauging station was constructed on Mooranoppin Creek near Kellerberrin in 1975 as the 82.5 km^2 catchment represented a typical, small Wheatbelt catchment. Between 1975 and 2004, the total annual discharge has varied from zero up to just under 5 GL (Figure 3b).

Between 1993 and 2002, the Yilgarn River contributed an average of 4 GL of annual flow to Yenyening Lakes and an annual salt load of 64 kt (kilotonnes), an amount equivalent to 64 000 tonnes. During that time, annual flow varied from 0–29 GL and salt load from 0–377 kt (Mayer et al., 2005).

Sampling between 1981 and 1988 indicates that Mooranoppin Creek tends to be fresher than the Yilgarn River. During this period, salinity ranged between approximately 3400 mg/L Total Dissolved Salts (TDS) to approximately 21 500 mg/L TDS in Mooronoppin Creek compared with a range of 7300 mg/L TDS to approximately 47 300 mg/L TDS in the Yilgarn River. A salinity classification is included in Appendix 1.

Recent sampling undertaken by the Department of Water in 2006, as part of the Avon River Catchment Water Quality and Monitoring Program, supports this trend. At the Mooranoppin Creek gauging station TDS ranged from 18 139 to 21 196 mg/L and from 21 262 to 108 497 mg/L at Gairdners Crossing.

Limited nutrient sampling has been undertaken at the Gairdners Crossing gauging station. These have been snapshot samples, which only indicate nutrient concentrations on the day of sampling and therefore make it difficult to draw conclusions about long-term trends. The available results are detailed in Appendix 1 along with a summary of water quality data from the gauging station to date.

At the Gairdners Crossing gauging station total nitrogen ranged from 0.5–3.7 mg/L (10 samples collected between 27 July 1994 and 31 January 2006) and total phosphorus from 0–0.1 mg/L (10 samples collected between 24 September 1996 and 30 January 2006).

At Gairdners Crossing, pH ranged from 6.2 (slightly acidic) to 8.9 (slightly alkaline) with an average of 7.5 (neutral). Again, these are snapshot samples, which indicate pH on the day of sampling and therefore it is difficult to draw conclusions about long-term trends.

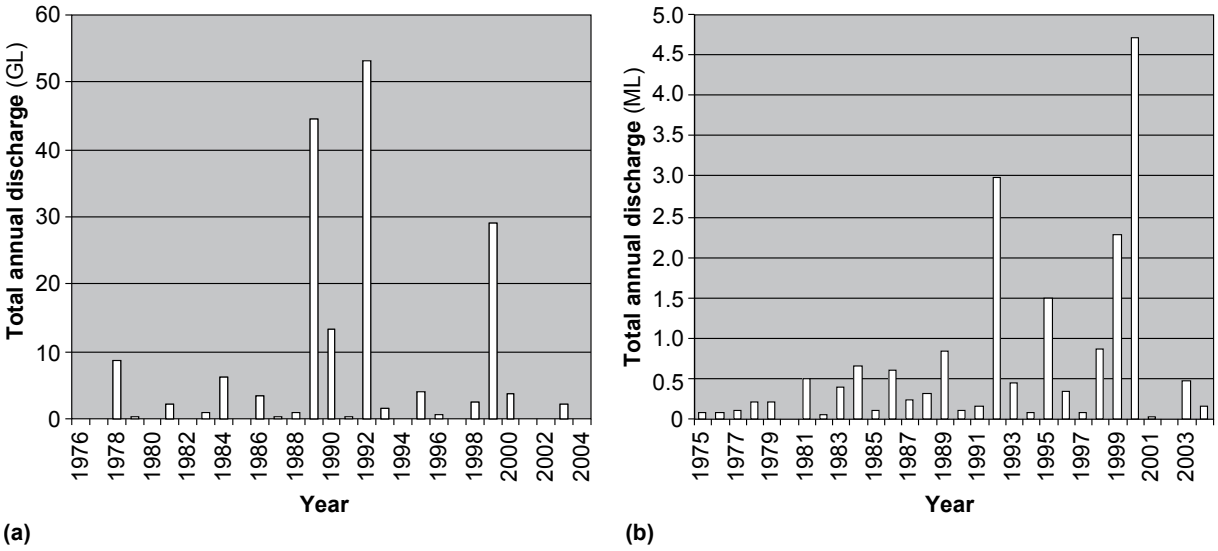


Figure 3 *Total annual discharge measured at (a) Gairdners Crossing gauging station 615015 on the Yilgarn River (b) Mooranoppin Rock gauging station 615011 on Mooranoppin Creek*

2.4 Land tenure

The majority of the land in the Lower Yilgarn River floodplain is freehold land used for agricultural purposes, although there are also a number of Crown reserves within, or close to the floodplain. These reserves are vested for a variety of purposes (Table 1).

Table 1 Crown reserves in proximity to the floodplain

Reserve name	Reserve number	Vesting	Size (ha)	Proprietor	Date vested
Glenluce NR	CR 26266 & CR 25112	Conservation	245	DEC	1962
Mournucking NR	CR 24897	Conservation	696	DEC	1958
	CR 35538	Sand quarry	8	SoK	1978
	CR 32086	Sewerage disposal	44	SoK	1973
Lake Baandee	CR 27145	Recreation	322	SoK	1964
	CR 13701	Recreation	21	SoK	2000
	CR 38514	Parklands	130	SoM	1983
	CR 16293	Conservation	21	DEC	1916
	CR 39249	Gravel, rubbish disposal	51	SoM	1992
	CR 28290	Rubbish disposal	4	SoM	1992
	CR 25872	Conservation		DEC	1961
Hines Hill NR	CR 23795	Conservation		DEC	1953

Abbreviations: NR – Nature Reserve, CR – Crown Reserve, DEC – Department of Environment and Conservation, SoK – Shire of Kellerberrin, SoM – Shire of Merredin

2.5 Post-clearing changes to naturally saline waterways

While naturally saline waterways still retain many natural, social, heritage and economic values, they are under increasing pressure from threats resulting from widespread land clearing.

2.5.1 Changes in hydrology

Land clearing in the Wheatbelt has been widespread, with 7.4 per cent of the pre-European extent of native vegetation remaining in the Shire of Kellerberrin and 11.8 per cent in the Shire of Merredin (Shepherd et al., 2002).

The pre-clearing vegetation pattern persists in the upper landscape; however, the remnant vegetation is now highly fragmented and in the valley floors a number of threats, including increasing salinity and waterlogging, continue to modify these communities.

With clearing, the water balance has changed to one of reduced annual evaporation and increased runoff and groundwater recharge. Runoff through and into river valleys has increased five-fold and increased groundwater recharge is filling deep sedimentary materials and bringing highly saline water to the surface (Davis, 2004; Hatton et al., 2003).

Prior to clearing, virtually all of the annual rainfall was evaporated or transpired and during dry periods the vegetation drew on groundwater. There was little surface runoff and there were few defined drainage lines in areas that now have well-defined streamlines (Davis, 2004; Hatton et al., 2003).

Before widespread land clearing, salt lakes generally contained water for several months through late winter and spring, although they occasionally flooded in summer or autumn from cyclonic rain. Salinity levels tended to be low when the lakes filled and increased as the lakes dried (Halse et al., 2003). Increased surface runoff and groundwater discharge resulting from land clearing means that salt lakes are now wetter for much longer periods of the year.

2.5.2 Acidification

Increased discharge of acidic groundwater is another post-clearing threat to Wheatbelt wetlands and waterways that has only been recognised recently. While surface waters, on average, tend to be neutral to alkaline (pH 7–8), groundwaters in the eastern Wheatbelt valleys, and other areas with abundant salt lakes, can be acidic with pH readings less than 4.5 (Rogers and George, 2005). With watertables continuing to rise in these areas, there is a threat of increasing interaction of acidic groundwaters with surface environments.

Acidic groundwaters discharge naturally through seeps and into waterways. However, activities such as deep drainage and groundwater pumping can accelerate discharge rates (Fitzpatrick et al., 2005).

The causes of the acidification are only broadly known. The majority of acid in groundwaters is due to a process called ferrolysis (or iron hydrolysis), where high concentrations of dissolved iron react with oxygen in the atmosphere producing iron precipitates (commonly iron oxy-hydroxides) and acidic hydrogen ions (Fitzpatrick et al., 2005; Gray, 2001).

$$2Fe^{2+} + \tfrac{1}{2}O_2 + 5H_2O \Leftrightarrow 2Fe(OH)_3 + \mathbf{4H^+}$$

Ferric ions + oxygen + water ⇔ Iron oxy-hydroxide + acid

In many groundwaters in the Wheatbelt this appears to have occurred already, possibly because of recent rises in groundwater levels due to land clearing. However, further acidification is also possible when shallow groundwaters with high concentrations of dissolved iron are exposed to the air by drainage or groundwater pumping.

Another source of acidity is the oxidation of pyritic materials in soils, where sulphide-containing materials are exposed to air releasing significant amounts of sulphuric acid (Fitzpatrick et al., 2005; Gray, 2001). The high concentrations of dissolved iron that now exist in many groundwaters may be the result of pyrite oxidation in deep, underlying sediments during previous climatic periods.

$$2FeS_2 + 7O_2 + 2H_2O \Leftrightarrow 2Fe^{2+} + 4SO_4^{2-} + \mathbf{4H^+}$$

Pyrite + oxygen + water ⇔ Ferric ions + sulphuric acid

However, the contribution of this process to groundwater acidity, prior to drainage, is unclear since the release of such acidity is generally thought to occur after drainage. Shallow pyritic materials are likely to occur in many low-lying areas around salt lakes and waterways. The construction of drains through such areas will cause oxidation and the subsequent release of acid from such materials.

Few plant and animal communities are adapted to acidic conditions. Secondary acidification poses a significant threat to biodiversity, both in aquatic and riparian ecosystems. Low pH waters can leach high concentrations of naturally occurring heavy metals, such as aluminium, cobalt, copper, zinc and lead from soils (Fitzpatrick et al., 2005), which can be transported to, and accumulate in, aquatic environments.

2.5.3 Impacts on fringing vegetation

The long history of naturally saline lakes and waterways in the south-west of Western Australia has led to the evolution of a rich diversity of saline-adapted flora and fauna. The threat to these species posed by secondary salinisation is often discounted because species are perceived to be salt-tolerant (Halse et al., 2003).

Increased salinity and waterlogging, changes in hydroperiod, increased nutrient loads and acidification have wrought changes to the fringing and aquatic vegetation and their associated fauna.

As well as an increase in depth and duration of waterlogging, secondary salinisation has had a significant effect on the ecology of saline wetlands and waterways. Plant communities adjacent to naturally saline wetlands and waterways have adapted to seasonal fluctuations in salinity and waterlogging levels. The presence of permanent, saline groundwater close to the surface under valley floors and adjacent slopes has caused a decline in vegetation health, changed the species composition of vegetation communities and affected regeneration rates.

Prior to the changes resulting from land clearing and secondary salinisation, wetlands were covered by sheoak (*Allocasuarina* species), paperbark (*Melaleuca* species) and tea tree (*Leptospermum* species), forming a dense canopy over low shrubs. Many wetlands supported beds of rushes and sedges and some had aquatic vegetation, such as nardoo (*Marsillea* species) (Sanders, 1991).

Increasing waterlogging and salinity levels have lead to the death of fringing vegetation. Salt- and waterlogging-tolerant species, including samphire (*Halosarcia* species), have colonised large areas, where previously they were restricted to small patches. Saline-adapted aquatic plants (*Ruppia* and *Lepilaena* species) have replaced the freshwater nardoo (*Marsillea* species) (Sanders, 1991). Sharp rush (*Juncus acutus*) has replaced native rush and sedge species, invading saline and waterlogged areas on the edges of the floodplain, tributaries and groundwater seeps.

2.5.4 Impacts on aquatic communities

Generally, the species richness of macroinvertebrate communities decreases with increased salinity; however, the trend is not always that simple. Changes in hydrology, in combination with other threats such as greater nutrient loads, acidification, sedimentation and simplified vegetation communities, has also significantly influenced the biota of saline waterways (Pinder et al., 2005; Timms, 2005; Halse et al., 2003).

As salinities increase, the aquatic vegetation communities dominated by salt-tolerant submerged macrophytes, such as *Ruppia* and *Lepilaena*, give way to phytoplankton-dominated communities and then to benthic microbial mat-dominated communities characterised by cyanobacteria and halophilic (salt-tolerant) bacteria (Strehlow et al., 2005; Davis et al., 2003).

The biodiversity of aquatic fauna appears to be strongly linked to the type of aquatic vegetation present in the wetland. A richer and more abundant macroinvertebrate fauna tends to be associated with wetlands containing submerged aquatic vegetation. Therefore, as salinity increases and drives changes in aquatic vegetation communities, there tends to be a simplification of the macroinvertebrate community with a flow-on effect to other fauna in the food web (Strehlow et al., 2005; Davis, 2004).

3 Waterway assessment method

This section describes the method used to assess the condition of the Lower Yilgarn River. The method was developed by the Department of Water to gain an understanding of current riparian condition and management needs of waterways in the zone of ancient drainage (Department of Water, 2007).

In the context of this study, riparian condition is the current condition of the riparian vegetation compared to a pristine state with all vegetation layers intact, no impacts from threatening processes and all natural processes operating.

3.1 Site selection

Given the size of the floodplains in the zone of ancient drainage, which can be kilometres wide, the waterway assessment method relies on information collected at a number of representative sites.

For the Yilgarn River assessment, 10 survey sites were selected. Sites were selected that met one or more of the following criteria:

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

Sites were selected using a number of tools, including aerial photography, cadastral information, anecdotal information and a ‘reconnaissance’ survey of the study area.

The locations of the 10 study sites within the Lower Yilgarn River study area are shown on Maps 3a and 3b and described in the appropriate site report in Appendix 3.

3.2 Recording of survey information

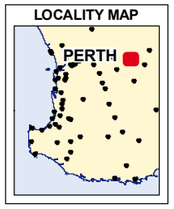
To ensure consistency, information collected during the site surveys was recorded on a survey form (see Appendix 2). Information collected for the 10 sites surveyed during the Lower Yilgarn River waterway assessment is summarised in Appendix 3.

3.2.1 Floodplain features

Floodplain features define the physical nature of the waterway and give indications of habitat and potential management issues.

Natural and constructed features within the floodplain are identified including playa lakes, channel form, lunettes, tributaries, drains and dams.

Map 3a
Lower Yilgarn survey sites LYR01 to LYR04



LEGEND

- Survey sites
- Towns
- Highway
- Main road
- Local road
- Track
- Major watercourse
- Minor watercourse
- Cadastre
- Local Government Authorities

N

0 1 2 3

Kilometres

Datum and Projection Information

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

Project Information

Requested by: Kate Gole
Map Author: Tom Lee
Task ID: 6632
Filename J:\Rs\sn\b4148\0004
Date: 5th July 2007

SOURCES

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

Dataset Name - CUSTODIAN ACRONYM - Metadata Date
Towns - DLI - 08/08/2004
Road Centrelines - DLI - 01/05/2004
Cadastre - DLI - 01/05/2005
Hydrography, heirachy - DOE - 13/04/2005
Local Govt Authorities - DLI - 08/07/2004

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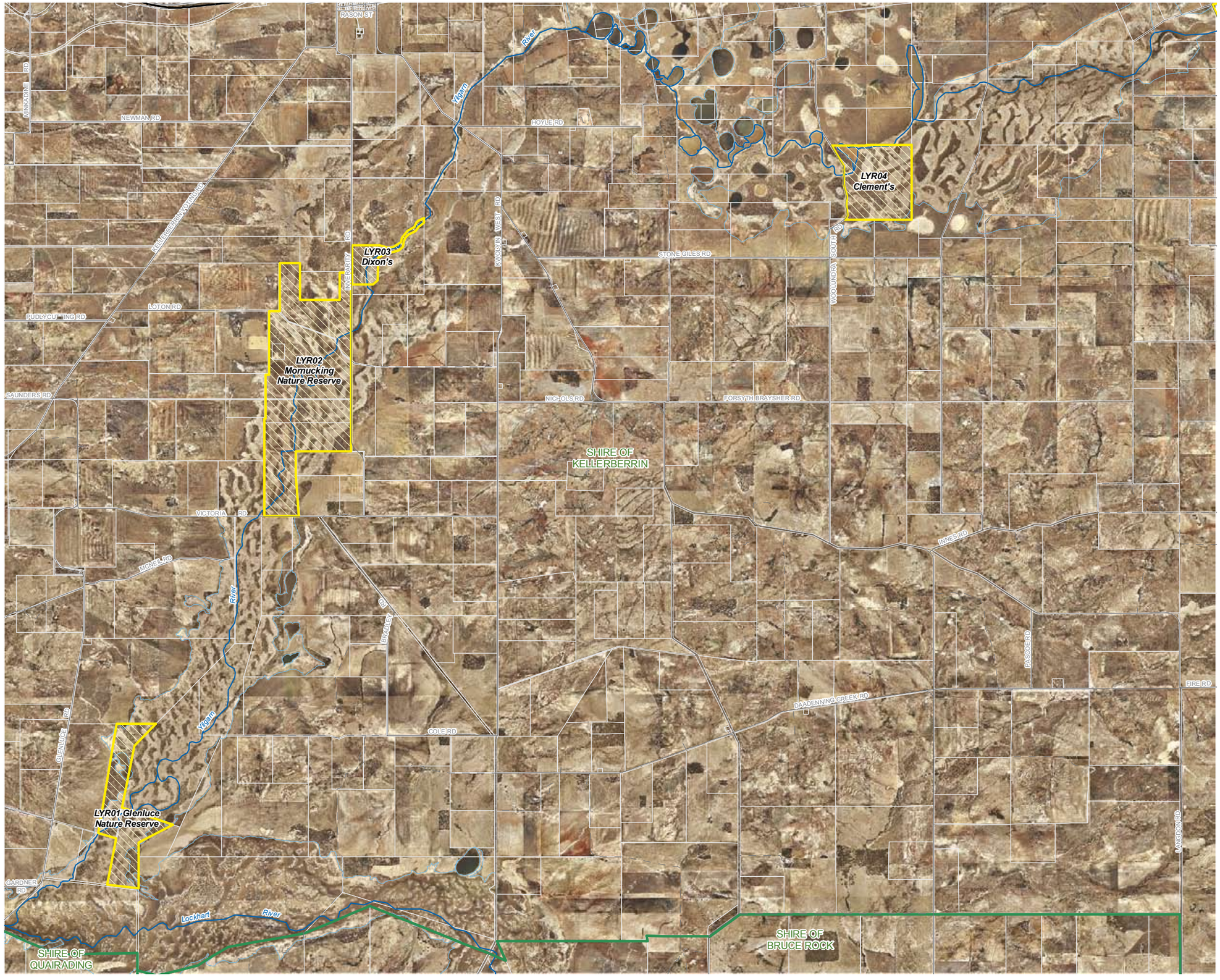
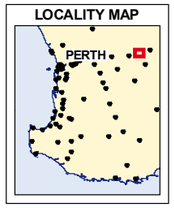
2007 Year of Hydrography
Celebrating over 100 years of water measurement in WA



Map 3b
Lower Yilgarn survey sites LYR05 to LYR10



LEGEND

- Survey sites
- Towns
- Highway
- Main road
- Local road
- Track
- Major watercourse
- Minor watercourse
- Cadastre
- Local Government Authorities

N

0 1 2 3

Kilometres

Datum and Projection Information

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

Project Information

Requested by: Kate Gole
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2007 Year of Hydrography
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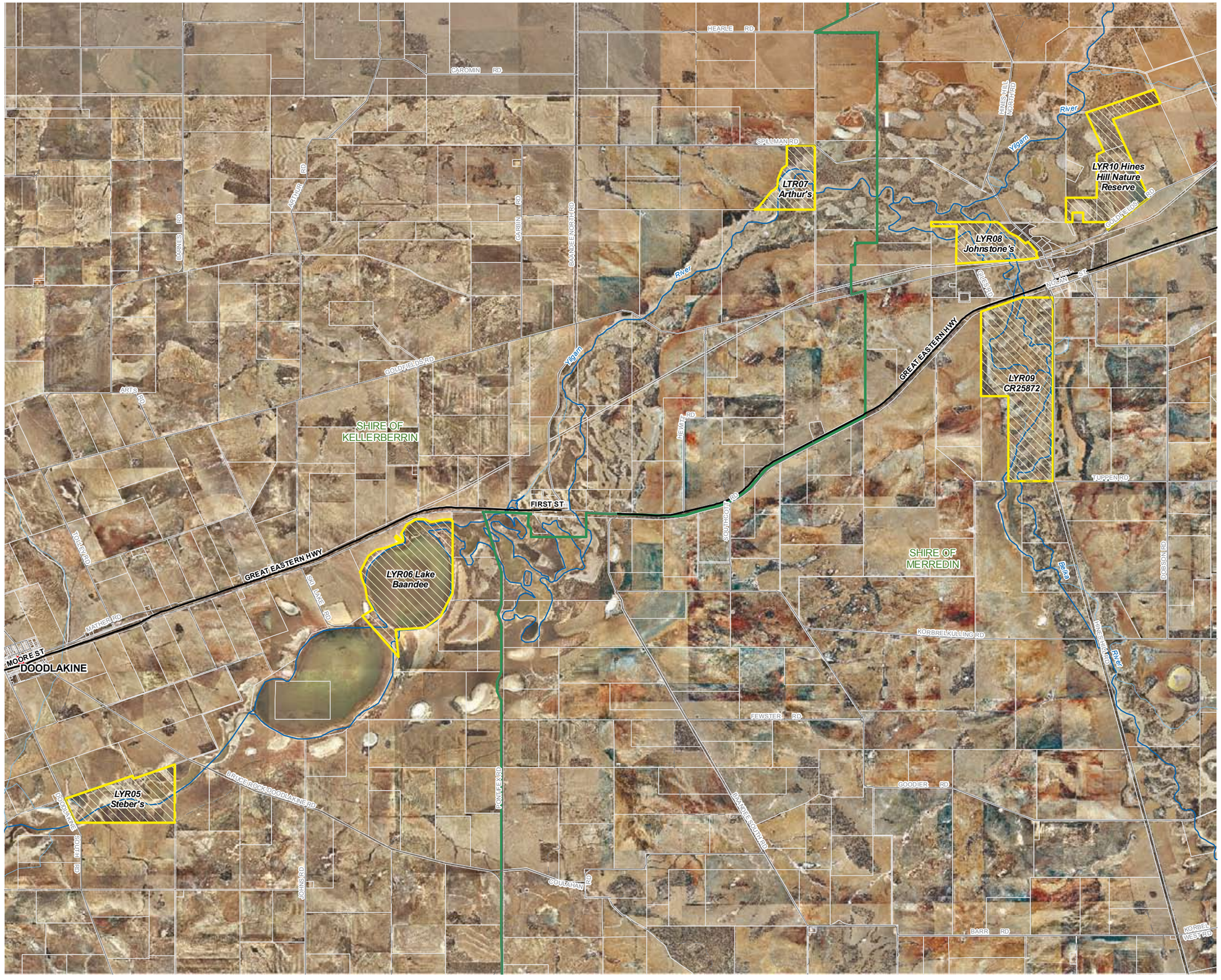

3.2.2 Description of the riparian vegetation

Healthy, undisturbed riparian vegetation is important to waterway health. The plant species that comprise the fringing vegetation are very diverse and, together with the many species of insects, birds and mammals that this vegetation shelters, riparian ecosystems contain significant biodiversity. Fringing vegetation also drops leaf litter and small twigs into the water. As well as providing habitat for aquatic animals, this litter is an important part of the aquatic food web.

A comparison of the current condition and structure of riparian vegetation to a pristine reference state indicates how waterway condition has changed over time. Identification of threatening processes impacting on vegetation condition gives an indication of why vegetation condition and structure has changed, and how it might change in the future.

The description of riparian vegetation has been adapted and modified from relevant sections of the *Bushland plant survey* methodology developed by Keighery, 1994. The method was initially developed to document vegetation communities on the Swan Coastal Plain to provide information needed for decisions on the conservation status of bushland areas and for determining management priorities. The survey method does not require a high level of technical knowledge and can be easily modified for use in regions other than the Swan Coastal Plain (Keighery, 1994).

Pre-European vegetation types

Beard vegetation associations (Hopkins et al, 2001; Beard 1980), evidence collected during the surveys and anecdotes from landholders are used to gain an understanding of the original vegetation type(s) at each survey site. This information gives an indication of what the original vegetation may have looked like and helps to assign the vegetation condition rating. For example, if there is evidence that the site was once dominated by *Melaleuca* shrubland and now only supports *Halosarcia* herblands, it is a strong indication that vegetation condition has declined significantly.

Beard vegetation associations have been mapped at regional scales for the whole of Western Australia. Where information about more localised vegetation mapping and surveys is available, these sources can also be used to provide information on the original vegetation types and condition.

Vegetation structure and cover

For each vegetation layer present within the site, an estimation of crown cover is used to record plant cover. Crown cover is the total area under an imaginary line bounding the extremities of all plants in each layer. To simplify the estimation of cover, cover classes are used rather than trying to determine an exact percentage.

The dominant species in each layer are identified and, if more than three species dominate, the layer is described as mixed.

Vegetation condition

The percentage of the survey site that falls within each condition category is recorded. Due to the presence of revegetated areas within several survey sites, an additional category was added to those adapted from Keighery 1994.

The vegetation condition rating (Table 2) is related to vegetation structure, the impact of disturbance on each vegetation layer and the ability of the community to regenerate. Photographs illustrating the different vegetation condition ratings are included in Appendix 3.

Linked to the vegetation condition rating is a description of disturbance factors and the degree of threat they pose; this enables us to gain an understanding of why vegetation condition has declined. Examples include salinity and waterlogging, clearing, weed invasion, fires, feral animals and stock access.

Table 2 Vegetation condition (adapted from Keighery, 1994)

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

Species presence

Native and introduced plant species are also identified, as an indication of species diversity, to identify potential species for riparian revegetation and to identify potential management issues. Where plants cannot be identified to species or genus level they are identified as, for example ‘unidentified shrub species’. Regeneration of overstorey and middlestorey species is also noted as the ability of the vegetation community to regenerate is part of the vegetation condition rating.

It must be noted that extensive flora surveys are not undertaken. Like other information collected as part of the surveys, the species lists for each site represent a snapshot of the species present at the time of the survey and it is highly likely that plant species occur within each site that are not identified during the survey.

3.2.3 Links to protected remnant vegetation

In highly fragmented landscapes the remaining remnant vegetation acts as a living link between adjacent habitats, allowing fauna and flora to move around the landscape.

The approximate distance and direction to areas of protected remnant vegetation within 10 km is recorded for each site. Protected remnant vegetation includes nature reserves and Crown reserves vested for conservation purposes.

3.2.4 Aquatic vegetation

Aquatic ecosystems in Wheatbelt lakes are characterised either by salt-tolerant submerged macrophyte communities, phytoplankton-dominated communities or benthic microbial mat-dominated communities. The biodiversity of aquatic macroinvertebrates seems strongly linked to the type of aquatic vegetation present. A richer, more abundant macroinvertebrate fauna tends to be associated with submerged macrophyte communities, such as those characterised by *Ruppia* and *Lepilaena* species (Strehlow et al., 2005; Davis, 2004).

In the absence of long-term macroinvertebrate monitoring within the study area, the type of aquatic vegetation present at each site is identified, where possible, as an indication of the relative abundance of the macroinvertebrate fauna.

3.2.5 Water quality data

Where possible, water quality data, including pH, salinity and temperature, is collected. With the exception of lakes, water quality is only sampled when water is flowing. Data collected during the survey is a ‘snapshot’ of water quality at the time of sampling and cannot be used to make comments on long-term trends.

3.2.6 Management

Information is collected on any current management activities, such as fencing, revegetation and groundwater and surface water management. Any issues in need of management, such as weed control, revegetation and surface water management, are also identified.

3.2.7 Fauna species

Native and introduced fauna species are identified, with a focus on identifying bird species. Birds are easier to find and identify than many other native fauna species. They are a major component of most ecosystems and are sensitive to many kinds of disturbance (Birds Australia, 2005).

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

It must be noted that extensive fauna surveys are not undertaken as part of the survey. Like other information collected as part of the surveys, the species lists for each site represent a snapshot of the species present at the time of the survey and it is highly likely that species occur within each site that are not identified during the survey.

3.3 How is the information that is collected used?

In Chapter 4, the information collected during the surveys is used to:

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

4 Main findings and management recommendations

This chapter presents the main findings from the surveys along with management recommendations and possible sources of advice and funding for their implementation.

4.1 Vegetation condition

There have been significant changes to the original vegetation communities associated with the Lower Yilgarn River study area. Widespread clearing, and the subsequent increase in salinity and associated waterlogging, have altered the original vegetation communities and continue to degrade the remnant valley floor vegetation.

Information from mapping of the pre-European vegetation communities (Hopkins et al., 2001; Beard, 1980), observations made during the field surveys and anecdotal information from landholders indicates that the playa lakes and floodplain were once fringed with samphire (*Halosarcia* species) flats grading into *Melaleuca* and tea tree (*Leptospermum* species) thickets and *Eucalypt* woodlands characterised by York gum (*Eucalyptus loxophleba*), salmon gum (*Eucalyptus salmonophloia*), gimlet (*Eucalyptus salubris*) and morrel (*Eucalyptus longicornis*).

Photo 2 *Degraded vegetation on the edge of a low lunette in Mournucking Nature Reserve (Photo: K. Gole)*

Photo 3 *Vegetation in excellent condition on the edge of the floodplain in Crown Reserve 25872 (Photo: K. Gole)*

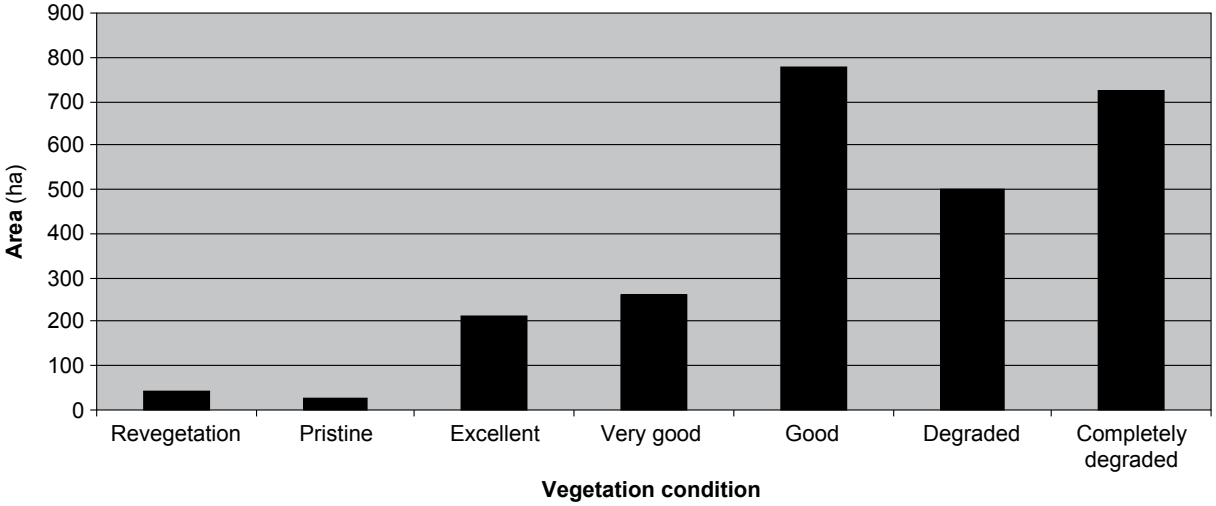

***Figure 4** The area of vegetation surveyed within each vegetation condition rating*

The field survey showed that the most degraded vegetation communities tend to occur where there are few or no lunettes or where the lunettes are relatively small and low (less than 1 m above the lake bed). In these areas vegetation condition has declined significantly and the original shrublands are being replaced with salt-tolerant species. The vegetation in the best condition tends to occur where lunettes are relatively large or high (more than 1 m above the lake bed) and on the edge of the floodplain. In these areas vegetation is still in relatively good condition and *Melaleuca* shrublands and mallee communities still occur.

Some remnants are in very good to pristine condition (Figure 4). These are generally the vegetation communities on the higher and/or larger lunettes and the *Eucalypt* woodlands on the edge of the floodplain. The one pristine remnant is protected within Glenluce Nature Reserve. Most of the other good quality vegetation is also within protected areas; however, there are significant areas of good quality vegetation on private lands.

Most of the surveyed vegetation is degraded or completely degraded (Figure 4). In these areas, the original vegetation is being replaced by species tolerant of higher salinities and waterlogging levels, resulting in the simplification of the vegetation communities.

4.2 Management issues

Management issues impacting on the Lower Yilgarn River identified from the site surveys are:

- increasing salinity and waterlogging in the valley floor
- loss of riparian vegetation fringing the floodplain and tributaries
- impedance of flood flows by road crossings
- increased stream flow causing erosion and sedimentation in tributaries
- pest species degrading riparian vegetation

Photo 4 *Eucalypt woodland in excellent condition in Crown Reserve 25872 (Site LYR09) on the Belka River (Photo: K. Gole)*

Photo 5 *A completely degraded area of the floodplain, where only dead branches remain of the original vegetation (Photo: S. Mehmet)*

- stock access
- lack of corridors linking areas of remnant vegetation
- fire risk
- dumping of rubbish in floodplain areas.

Management recommendations addressing these issues are detailed below. Many of these recommendations have multiple benefits. For example, revegetating and fencing tributaries of the Yilgarn River will improve bank stability, reduce sedimentation, improve water quality and contribute to biodiversity conservation by facilitating the distribution of flora and fauna through the landscape.

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

4.3 Salinity and waterlogging

Increasing salinity levels and waterlogging are the most significant threats in the Yilgarn River floodplain.

Research has shown that different approaches need to be taken for different types of salinity impacts, depending on catchment characteristics and the types of assets that are impacted – land, water, biodiversity or infrastructure. There is no ‘one-size-fits-all’ approach and not all management strategies are suitable for all situations.

A good example of this approach is the Wallatin/O’Brien Catchment Demonstration Initiative (CDI). The CDI is a project to plan and implement actions to tackle salinity at a catchment scale. It aims to demonstrate salinity management practices to recover saline land, reduce salinity risk and allow for the profitable use of saline areas. A number of projects are being implemented across the catchment including:

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

The following sections give a brief overview of some of the options for salinity management, including engineering works and revegetation. In the engineering options section, details are provided about two major programs, the Engineering Evaluation Initiative (EEI) and Wheatbelt Drainage Evaluation (WDE). Both programs are evaluating engineering options for the Wheatbelt and findings from the programs may influence salinity management in the Yilgarn River catchment.

4.3.1 Engineering options

Increasing numbers of land managers are considering engineering works, including deep drainage, groundwater pumping and surface water management, to reduce waterlogging problems and lower soil salinities.

There are widely differing opinions about the scale at which engineering options should be implemented. Some consider that all water should be retained 'on-farm' while others consider that significant arterial drainage networks, including deep drains and groundwater pumping, should be used for eventual discharge to the ocean.

Pressure for widespread implementation of engineering options is matched by concerns about downstream impacts (particularly from regional arterial drainage schemes) on water quality, changes to the natural hydroperiod and increased flood risk; and their impacts on natural waterway values and built assets, such as roads.

It is within this context that the EEI and WDE programs were developed. The ACC has also developed the Yilgarn Integrated Salinity Management Project to demonstrate salinity management specifically in the Yilgarn catchment.

Engineering evaluation and implementation in the Wheatbelt

The EEI and the WDE aim to evaluate the suite of issues associated with implementing engineering solutions to salinity in the Wheatbelt. These programs are being delivered under the National Action Plan for Salinity and Water Quality (NAP) through partnerships between government departments, catchment groups, research bodies and regional NRM groups, including the ACC.

The EEI program (December 2002 to June 2007) is focused on finding and demonstrating better ways to implement engineering to tackle salinity without damaging the environment and focuses on the:

- evaluation of engineering options, such as deep drainage, groundwater pumping and surface water management, at farm scale
- social, economic and environmental aspects of regional arterial drainage
- downstream impacts of drainage and safe disposal options.

The WDE program (July 2005 to June 2008) changes the focus from a science-based drainage evaluation under the EEI to a planning phase for drainage as part of broader catchment water management. It uses learnings from EEI projects in the following four main implementation areas:

1 Drainage management and governance, which will provide greater certainty to regional NRM groups, drainage proponents and state government as to how catchment and regional scale drainage projects may be implemented.

2 Regional drainage evaluation, which will provide a framework from which catchment and farm scale drainage can occur.

3 Catchment feasibility studies, investigating drainage options for priority catchments including the Yenyening Lakes catchment.

4 Wetland assessment, which involves the classification of potential receiving environments (Ruprecht et al., 2004).

Yilgarn Integrated Salinity Management Project

The Yilgarn Integrated Salinity Management Project was developed by the ACC to demonstrate integrated salinity management solutions in the Yilgarn catchment, including deep drainage, which reduce drain volumes and improve water quality for downstream receiving environments.

Deep drainage

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

Groundwater pumping

Groundwater pumping can be an effective method of disposing of saline water. It is most effective in soils with lighter textures that drain water more freely and leach salts more quickly.

Surface water management

Surface water management uses earthworks, such as grade and interceptor banks, shallow drainage channels and dams, to capture surface runoff and subsurface flow higher in the landscape, reducing recharge to valley floors. Harvested water is usually relatively fresh and can be used for farm water supply. Techniques such as modified tillage, perennial crops and revegetation can be used in conjunction with engineered structures to manage recharge.

Earthworks are used extensively in the Yilgarn River catchment for surface water management. Fresher flows are captured in dams for on-farm use but significant amounts of saline surface water continue to be directed into tributaries and into the Yilgarn River. Due to low gradients and flows impeded by road crossings, this excess surface water is likely to contribute to waterlogging problems in the valley floor.

4.3.2 Revegetation

Revegetation options for salinity management involve planting recharge and/or discharge areas. At a local scale, the re-introduction of perennials is effective in reducing groundwater recharge. However, there is less evidence that revegetation is an effective and economically viable strategy at a catchment scale, unless most or all of the catchment is revegetated. Using perennial plants to reduce recharge remains a challenge and research efforts are focusing on developing new perennial options that are profitable in their own right, as well as having an impact on water table levels (Pannell and Ewing, 2006; Ruprecht et al., 2004; Hatton, 2002).

The overall aim of revegetation to improve soil productivity and lower water tables can be achieved in a number of ways. Planting local native species for salinity control on either recharge or discharge areas can also have benefits for conservation and biodiversity. Planting species that can be harvested for timber or used as fodder crops can have economic benefits.

Perennial plants have benefits beyond recharge control. Depending on the species, they can play a vital role in controlling soil erosion, act as wind breaks to protect stock and crops, have biodiversity benefits and add value to the property. Revegetated landscapes also have improved aesthetics.

Biodiversity plantings

Planting local native species for conservation and biodiversity is discussed in Section 4.7.

Commercial plantings

There are a number of perennial species suitable for planting on Wheatbelt recharge areas including various *Eucalypt* species, tagasaste (*Chamaecytisus prolifer*), *Acacia* species, *Melaleuca* species and sandalwood (*Santalum spicatum*). All of these species have economic benefits, either from harvesting of wood or use as fodder.

Site conditions, such as waterlogging, salinity, fertility and acidity, largely determine the species selection for discharge areas. Slightly to moderately saline sites are suitable for saltland pasture. Saltbush (*Atriplex*) and bluebush (*Maireana*) species are commonly planted for saltland pasture. Understorey plants such as puccinellia (*Puccinellia ciliata*) and tall wheat grass (*Thinopyrum elongatum*) have also successfully been introduced into saltland pastures to increase the nutritional value of the fodder (Pannell and Ewing, 2006; Barrett-Lennard and Malcolm, 1995). However, these grasses can become weeds very easily and native grasses should be used where possible. Appendix 5 provides some details on species that may be suitable for the Yilgarn River catchment.

Saltland pastures can provide valuable feed for maintaining stock condition during the feed gap in summer and autumn. The protein content varies between species but

tends to be quite high (10–22%). However, most species are relatively low on energy and high in salt and higher quality forage also needs to be provided, either from supplementary feeding, crop stubbles in adjacent paddocks or the establishment of salt-tolerant understorey species (Pannell and Ewing, 2006; Phelan, 2004; Barrett-Lennard and Malcolm, 1995).

4.3.3 Recommendations for the management of salinity and waterlogging

Salinity and waterlogging are processes that need to be managed at a catchment scale. Given this, and the fact that salinity management needs to be tailored for different salinity impacts, the following general management recommendations are proposed:

- The detention of surface water, water quality permitting, higher in the catchment to slow recharge to valley floors.
- Revegetation of tributaries to slow movement of surface water on to valley floors without increasing flood risk.
- Evaluation of commercial revegetation options, including agroforestry and saltland pasture.
- Identification of recharge areas, such as sand lenses, suitable for revegetation for local watertable control, with either local native or commercial species.
- Groundwater and surface water quality and quantity to continue to be monitored as part of ongoing water quality monitoring programs.

4.4 Impedance of flows by road crossings

Low gradients and complex geomorphology contribute to slow flows through the Lower Yilgarn River study area. Road crossings can add significantly to this problem, exacerbating waterlogging problems across the floodplain. Road crossings are major control points for flood flows. As well as physically impeding surface flows, sub-surface compaction to create a stable road base interferes with sub-surface flows, further contributing to ponding problems.

There are 14 road crossings within the Yilgarn River study area: Glenluce Rd, Victoria Rd, Inverarity Rd, Kwolyin West Rd, Woolundra South Rd, Badgetopping South Rd, Innes Rd, Doodlakine South Rd, Bruce Rock–Doodlakine Rd, Pontifex Rd, Great Eastern Hwy (at Baandee Lakes and Hines Hill Lakes), Baandee North Rd, Goldfields Rd and Hines Hill North Rd.

Inverarity Rd is the only road crossing where ponding is known to be degrading upstream vegetation; however, there are a number of crossings where there is little or no vegetation and ponding may still be occurring.

Woolundra South Rd, Badgetopping South Rd, Innes Rd and Pontifex Rd act as causeways, with all flows flooding over the road. These roads are not considered to cause ponding problems. All other road crossings have adequate culverts.

Photo 6 *Culverts under Great Eastern Hwy at Baandee Lakes (Photo: S. Mehmet)*

Photo 7 *Badgetopping Rd South crossing (Photo: S. Mehmet)*

4.4.1 Recommendations for the management of flood flows

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

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

4.5 Tributaries

Tributaries have gradients that far exceed that of the Yilgarn River (Table 3). When tributaries reach the broad, flat floodplain they tend to spread out through shallow, undefined channels. Most tributaries are degraded and have significant erosion and sedimentation problems.

Table 3 Gradients for selected tributaries of the Lower Yilgarn River

Tributary name	**Relief** (m AHD)	**Length** (km)	**Gradient** (m/km)
Minkadine Creek	240–270	8.0	3.75
Nareling Gully	240–280	5.9	6.78
Mooranoppin Creek	240–330	16.3	5.52
Wallatin Creek	250–320	27.5	2.55
Belka River*	250–260	14.0	0.71
Lower Yilgarn River**	**228–252**	**74.0**	**0.32**

* *To Karbel West Rd*

** *Spot heights derived from Land Monitor digital elevation model. All other heights sourced from contour information.*

Most tributaries are linked to networks of contour or grade banks and some have been modified to carry saline surface flows away more quickly. In some cases, alternative channels have been cut to define the confluence with the floodplain and reduce localised flooding.

Tributaries can be managed to improve bank stability and reduce sediment loads, as well as provide benefits for biodiversity, without increasing flood risk.

Fencing and revegetation with local native species would have many benefits. Plant roots physically bind banks together, so revegetation would increase bank stability and reduce erosion. Fringing vegetation would also slow the velocity of runoff entering tributaries from surrounding paddocks, not only reducing erosion but also filtering out sediment and nutrients.

Riffles could be installed to reduce flow velocity and encourage sediment deposition, such as the riffle installed on O'Brien Creek as part of the Wallatin CDI project.

Given that many tributaries carry excess surface water diverted by contour or grade banks, retaining some of this surface water higher in the catchment would also reduce erosion and reduce waterlogging problems in the valley floor.

4.5.1 Recommendations for tributary management

To reduce erosion and sedimentation problems and increase the value of tributaries as landscape links between areas of remnant vegetation, the following recommendations are proposed:

- Revegetation of the riparian zones of tributaries with local native species to provide corridors linking areas of remnant vegetation higher in the landscape with riparian areas.
- Improvement of bank stability to reduce bank erosion and sedimentation, through revegetation with local native species.
- Revegetated areas to be fenced to control stock access.
- Installation of riffles, where appropriate, to reduce flow velocity and trap sediments before they reach the floodplain.

Photo 8 *Erosion and sedimentation problems in a reach of Mooranoppin Creek (Photo: S. Mehmet)*

4.6 Management of remnant vegetation

Like much of the Wheatbelt, remnant vegetation in the Yilgarn River catchment is highly fragmented and remains in patches of varying size, shape and condition on both private and public lands.

Floodplain vegetation communities have been significantly altered by the combined effects of land clearing, salinity and waterlogging. In many areas the original *Melaleuca* and *Leptospermum* shrublands are being replaced with salt-tolerant species.

Connectivity between remnants is very important to allow species to disperse across the landscape. All of the survey sites, with the exception of Steber's (Site LYR05) and Lake Baandee (Site LYR06), have protected remnants within a radius of 10 km.

In some areas, the remaining riparian vegetation is closely linked to large areas of good quality, protected remnant vegetation. Glenluce and Mournucking nature reserves are linked by floodplain vegetation. Glenluce Nature Reserve is closely linked to Mt Caroline and Mt Stirling nature reserves, through good quality vegetation within the Salt River floodplain. In other areas, the links are more fragmented due to the altered nature of the riparian vegetation and lack of vegetation along tributaries and road reserves.

Remnant vegetation within Crown reserves vested for conservation is protected; however, where good quality remnant vegetation remains on private land it needs to be protected and, if possible, linked to nearby remnants. Examples in the study area are vegetation communities within Clement's (Site SR04) which are in good to very good condition, contain a wide variety of plant species and have links to other good quality remnants.

4.6.1 Recommendations for remnant vegetation management

To manage remnant vegetation, including riparian vegetation, and improve landscape linkages to facilitate the distribution of fauna and flora in the Yilgarn River catchment, the following recommendations area are proposed:

- Fence good quality remnant vegetation to exclude stock and allow natural regeneration.
- Undertake control of priority pest species.
- Identify areas on private land that can be revegetated to create or strengthen links between good quality remnants.
- Investigate reconstruction of landscape links on public lands, such as road reserves.

4.7 Riparian revegetation

Revegetating floodplain areas with local native species has a number of benefits including:

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

Revegetation projects, whether large or small, need to be practical and realistic to establish and maintain, especially in altered landscapes. Rising groundwater and salinity levels, declining water quality and changes to the natural hydroperiod mean that some local native species may not be suitable for revegetation in some areas. Plant species selected for revegetation projects need to be suited to the current site conditions.

Some factors to take into consideration when planning revegetation could include budget, the objectives of the revegetation project, position of the site in the landscape, soil condition, water quality and weed species and cover.

Appendix 6 lists some species considered suitable for revegetation projects in the Yilgarn River catchment. The list includes species found during the survey and those known to be local native species suited to saline waterways.

4.7.1 Recommendations for riparian revegetation

To create or strengthen links with good quality riparian and bushland remnants, the following recommendations are proposed:

- Investigate riparian areas to be revegetated with local native species.
- Fence areas of good quality riparian vegetation to exclude stock and promote natural regeneration.
- Fence revegetated areas to exclude stock.

4.8 Fencing and stock access

In some areas, stock have access to the Yilgarn River floodplain for several months of the year during the summer and autumn feed gaps to graze on saltbush, in conjunction with stubble from surrounding paddocks. In areas where remnant woodlands and shrublands remain, stock are likely to be impacting on natural regeneration. Additionally, manure is likely to be adding to nutrient loads in tributaries and the main waterway.

4.8.1 Recommendations for fencing

The following recommendations are proposed:

- Fence good quality remnant vegetation to be fenced to exclude stock and to allow natural regeneration.
- Fence revegetation to exclude stock.
- Fence tributaries to exclude stock and improve bank stability.

4.9 Pest species

Introduced plant species were noted at eight of the survey sites. No weed species were seen at Glenluce Nature Reserve (Site LYR01) or Arthur's (Site LYR07). A total of 16 introduced plant species were identified. Common weeds include slender ice plant (*Mesembryanthemum nodiflorum),* wild oats (*Fatua avena*) and barley grass (*Hordeum leporinum*). Many areas are too salty and waterlogged for weed species to cause significant problems. The woodland areas on the edge of the floodplain are more vulnerable to weed invasion.

Rabbits (*Oryctolagus cuniculus*) and foxes (*Vulpes vulpes*) are very common pest species in the Wheatbelt and signs of both species were seen in almost all survey sites.

A full list of the introduced flora and fauna species identified during the survey is detailed in Appendix 4. This list is not complete, and it is highly likely that there are species that are present in the local area that were not recorded.

4.9.1 Recommendations for the management of pest species

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

- Map the occurrence of priority pest species to identify priority areas for their control.
- Manage the pressure from rabbit (*Oryctolagus cuniculus*) grazing on private and public lands through a coordinated baiting program.

4.10 Flora and fauna

Although the landscape within the Yilgarn River catchment is highly fragmented there is a high diversity of species within the remnant vegetation. One hundred and forty-five native plant species were identified during the surveys. Some of these species are shown in Photos 9 to 14.

A total of 30 bird species were identified during the surveys. The most common species are Australian ringneck (*Barnardius zonarius*), commonly known as the Twenty-eight parrot, Galah (*Eolophus roseicapilla*) and Willy wagtail (*Rhipidura leucophrys*). These are all species whose main habitat is in farmland areas.

Photo 9 *One of the 11* Melaleuca *species found during the site surveys (Photo: K. Gole)*

Photo 10 *Sticky hopbush (*Dodonaea viscosa*), one of the variety of species growing in the woodlands on the edge of the floodplain (Photo: K. Gole)*

Photo 11 Templetonia *species (Photo: K. Gole)*

Photo 12 *Round-leaf pigface (*Disphyma crassifolium*), a very common groundcover species within the floodplain (Photo: K. Gole)*

Photo 13 *Two of the common samphire species that grow within the floodplain (Photo: K. Gole)*

Photo 14 *A salt-tolerant herb growing on the edge of a lunette (Photo: K. Gole)*

Priority species are those that have been identified as being at threat of local extinction if remnant vegetation is lost or degraded (Greening Australia Western Australia, 2004). Priority species identified during the surveys include rufous whistler (*Pachycephala rufiventris*), red-capped robin (*Petroica goodenovii*), spiny-cheeked honeyeater (*Acanthagenys rufogularis*) and white-winged fairy-wren (*Malarus leucopterus*).

Remnant-dependent species are those likely to decline in number if remnant vegetation is lost or degrades (Greening Australia Western Australia, 2004). Species identified during the surveys include yellow-rumped thornbill (*Acanthiza chrysorrhoa*), white-browed babbler (*Pomatostomus temporalis*) and Horsfield's bronze-cuckoo (*Chalcites basalis*).

In broad terms, the presence of these species indicates that remaining remnant vegetation, including bushland and riparian vegetation, is important on both local and regional scales for bird habitat.

A full list of the flora and fauna species identified during the survey is detailed in Appendix 4. This list is not complete, and it is highly likely that there are species that are present in the local area that were not recorded.

4.10.1 Recommendations for flora and fauna conservation

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

- Identification of priority areas (on both private and public lands) for the reconstruction of landscape links between areas of remnant vegetation.
- Revegetation for fauna and flora conservation to include local native middlestorey and understorey species.
- Retention of fallen logs and branches within remnants to provide fauna habitat, especially for birds and reptiles.
- Eradication of introduced plant species and their replacement with local native species.

4.11 Fire risk

The main threat is from stubble fires on farmland. In most areas, access to the floodplain area for fire fighting is relatively good. Through the *Bush Fires Act 1954* and any local government fire plans, landholders are responsible for maintaining fire breaks on private land. DEC maintains fire breaks and fire access tracks on DEC-managed lands adjacent to private property (Department of Conservation and Land Management, 2005).

4.12 Rubbish

Several rubbish dumps were identified within the floodplain during the survey, including old fencing materials and household rubbish. Rubbish in river environments is unsightly; however, most materials do not pose a significant threat. Dumping of chemicals and oils, and the containers used to store them, does pose a threat to the river environment and should be avoided.

4.12.1 Advice for rubbish management

Under Western Australia's *Litter Act 1979* dumping of rubbish on Crown lands, such as road reserves, council lands and nature reserves, is illegal and can be reported to the local shire or DEC office.

Clean, empty containers used to store crop production and on-farm animal health chemicals, can be disposed of through the *drumMUSTER* program. For more details, including collection points and the date of the next scheduled collection, contact the Shire of Kellerberrin on (08) 9045 4006 or the Shire of Merredin on (08) 9041 2379.

5 Glossary

Acid(ic)	See pH.
Alkaline	See pH.
Alluvial	Transported by water flow processes, for example alluvial plain.
Alluvium	Sediment deposited by flowing water.
Aquifer	A layer of rock or soil capable of receiving, storing and transmitting quantities of water.
Catchment	The area of land which intercepts rainfall and contributes the collected water to a common point through surface and groundwater.
Confluence	Flowing together or intermingling; for example, where a tributary joins the main river channel.
Discharge	Volumetric outflow rate of water, typically measured in cubic meters per second. Applies to both groundwater and surface water.
Discharge area or zone	Area where groundwater discharges to the surface.
Ecosystem	A biological community of interacting organisms and their physical environment.
Floodplain	Broad, flat, low lying area of land within the valley floor that is inundated during a 100-year flood. Includes the floodfringe and floodway.
Flood – 100 year	The 100-year flood has a statistical probability of occurring, on average, once every 100 years. The 100-year flood level is the contour to which this flood will rise.
Floodfringe	The area of the floodplain, outside of the floodway, which is affected by flooding.
Floodway	The river channel and portion of the floodplain which forms the main flow path for flood waters once the main channel has overflowed.
Geomorphology	The study of the origin, characteristics and development of landforms.
Gigalitre (GL)	1000 000 000 litres or 1 million cubic metres or 1 million kilolitres (kL).

Groundwater	Water which occupies the pores and crevices of rock or soil.
Hydrology	The study of water, its properties, distribution and utilisation, on and below the earth's surface.
Kilolitres (kL)	1000 litres or one cubic metre.
Kilotonne (kt)	1000 000 kilograms or 1000 tonnes.
Macroinvertebrates	Aquatic invertebrates (animals without backbones) that are retained on a 0.25 mm mesh net and are therefore big enough to be seen with the naked eye.
Natural resource management	The ecologically sustainable management of the land, water, air and biodiversity resources for the benefit of existing and future generations.
Nutrient load	The amount of nutrient (usually nitrogen and/or phosphorus) reaching a waterway over a given time period from its catchment area.
pH	The concentration of hydrogen ions in solution that indicates the acidity or alkalinity in water. A pH value of 7 is neutral, above 7 is alkaline and below 7 is acidic.
Recharge	Volumetric inflow rate of water to an aquifer, typically measured in cubic metres per second.
Recharge area or zone	An area through which water percolates to replenish (recharge) an aquifer. Unconfined aquifers are recharged through rainfall. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Remnant vegetation	An area of vegetation remaining after a major disturbance, such as land clearing.
Riparian zone	The riparian zone includes the floodplain and adjacent verge. The width of the riparian zone varies greatly, from tens of metres to kilometres, depending on the type of waterway and its catchment.
Riparian vegetation	Vegetation growing within the riparian zone.
River basin	The area drained by a waterway and its tributaries (see catchment).
Runoff	Water that flows over the soil surface when rainfall is greater than the infiltration capacity of the soil. Flow in waterways results from rainfall runoff.

Salinity	A measure of the total soluble (dissolved) salts in water. Commonly measured in terms of Total Dissolved Solids (TDS), in milligrams per litre (mg/L), or Electrical Conductivity, in millisiemens per metre (mS/m) or millisiemens per centimetre (mS/cm). Water resources are classified as fresh, marginal, brackish or saline on the basis of salinity. Refer to Appendix 1 for a salinity classification in relation to sea water.
Salinisation	An increase in the concentration of soluble salts in soil or water.
Sediment load	The amount of sediment reaching a waterway over a given time period from its catchment area. Also refers to the amount of sediment being transported by a waterway.
Surface water	Water flowing or held in waterways.
Tributary	A waterway that flows into a larger waterway.
Verge	Upland area adjacent to the floodplain.
Water quality	The physical, chemical and biological measures of water.
Waterlogging	Excess water close to the soil surface.
Watertable	Saturated level of unconfined groundwater. Wetlands in low lying areas may be surface expressions of groundwater.
Waterway	Surface water bodies, including streams, rivers, lakes, wetlands, estuaries, coastal lagoons and inlets. Can be seasonally or permanently inundated.

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Appendix 1 Water quality data for the Gairdners Crossing gauging station

Total nitrogen and total phosphorus concentrations at the Department of Water's Gairdners Crossing gauging station 615015 on the Yilgarn River

Date collected	**Total N** (mg/L)	**Classification**	**Total P** (mg/L)	**Classification***
24 September 1996	1.1	Moderate	0.1	Low/Moderate
3 September 1998	1.6	Moderate	0.1	Low/Moderate
22 March 1999	0.7	Low	0.1	Low/Moderate
20 May 1999	1.3	Moderate	0.1	Low/Moderate
20 July 1999	2.4	High	0.0	Low
24 January 2000	3.7	Very high	0.1	Low/Moderate
31 July 2001	0.5	Low	0.0	Low
18 February 2003	1.8	Moderate	0.1	Low/Moderate
2 August 2004	1.2	Moderate	0.1	Low/Moderate
30 January 2006	0.7	Low	0.1	Low/Moderate

** Refer to nutrient classification table below*

Nutrient classification

Classification	**Total nitrogen concentration** (mg/L)	**Total phosphorus concentration** (mg/L)
Extreme	> 4	> 0.5
Very high	3–4	0.3–0.5
High	2–3	0.2–0.3
Moderate	1–2	0.1–0.2
Low	< 1	< 0.1

Salinity classification with a comparison to sea water

Classification	**mg/L**	**mS/m**	**mS/cm**	**grains/gallon**
Fresh	0–550	0–100	0–1	0–38
Marginal	550–1100	100–200	1–2	38–77
Brackish	1100–5000	200–900	2–9	77–346
Low saline	5000–11 000	900–2000	9–20	346–770
High saline	11 000–30 000	2000–4500	20–45	770–1733
Hyper-saline	30 000–88 000	4500–12 200	45–122	1733–4697
Sea water	**35 000**	**6363**	**64**	**2450**

Summary of water quality and streamflow data for the Department of Water's Gairdners Crossing gauging station 615015 on the Yilgarn River

Variable	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last reading
Acidity ($CaCO_3$)	mg/L	4.5	4.5	4.5	1	24 Jan 00	24 Jan 00
Acidity to pH 8.3 ($CaCO_3$)	mg/L	18.0	18.0	18.0	1	02 Aug 04	02 Aug 04
Ag (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Al (sol)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Al (tot)	mg/L	0.1	0.1	0.1	1	09 July 98	09 July 98
Al (unfilt undig)	mg/L	0.2	0.2	0.2	1	02 Aug 04	02 Aug 04
Alkalinity (CO_3–CO_3)	mg/L	0.0	5.0	1.0	19	05 June 81	18 Aug 88
Alkalinity (CO_3–$CaCO_3$)	mg/L	1.0	1.0	1.0	1	24 Jan 00	24 Jan 00
Alkalinity (HCO_3–$CaCO_3$)	mg/L	23.0	23.0	23.0	1	24 Jan 00	24 Jan 00
Alkalinity (HCO_3–HCO_3)	mg/L	3.0	198.0	65.3	19	05 June 81	18 Aug 88
Alkalinity (tot) ($CaCO_3$)	mg/L	2.5	162.4	55.7	21	05 June 81	02 Aug 04
As (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
B (unfilt undig)	mg/L	1.8	1.8	1.8	1	02 Aug 04	02 Aug 04
Ba (unfilt undig)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Br (unfilt undig)	mg/L	39.0	39.0	39.0	1	02 Aug 04	02 Aug 04
C (sol org) {DOC}	mg/L	8.4	15.0	11.8	4	09 July 98	02 Aug 04
Ca (sol)	mg/L	120.0	832.0	405.9	22	05 June 81	02 Aug 04
Ca (unfilt undig)	mg/L	500.0	500.0	500.0	1	02 Aug 04	02 Aug 04
Cd (sol)	mg/L	0.0	0.0	0.0	2	02 Aug 04	02 Aug 04
Cl (sol)	mg/L	1615.6	27500.0	9149.7	42	29 July 76	02 Aug 04
Colour (TCU)	TCU	8.0	47.0	26.7	3	20 May 99	24 Jan 00
Colour (hazen)	Hu	17.0	50.0	29.0	3	30 Mar 78	23 Aug 78
Colour (true)	Hu	5.0	75.0	20.0	118	05 June 81	22 Mar 99
Cond comp 25°C (lab)	µS/m	750000.0	4400000.0	2575000.0	2	31 July 01	02 Aug 04
Cond uncomp (in situ)	µS/m	663000.0	6710000.0	2969642.9	14	20 July 95	30 Jan 06
Cond uncomp (lab)	µS/m	439000.0	6730000.0	2722142.0	162	29 July 76	02 Aug 04
Cr (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Cs (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Cu (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
F (sol)	mg/L	0.8	0.8	0.8	1	02 Aug 04	02 Aug 04
Fe (sol)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Fe (tot)	mg/L	0.1	0.8	0.4	4	22 July 92	24 Jan 00
Fe (unfilt undig)	mg/L	0.3	0.3	0.3	1	02 Aug 04	02 Aug 04
Hardness (tot) ($CaCO_3$) {Ca+Mg}	mg/L	1325.2	8809.9	4247.1	20	05 June 81	09 July 98
Hg (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
K (sol)	mg/L	30.0	120.0	75.0	2	24 Jan 00	02 Aug 04
K (tot)	mg/L	42.0	173.0	97.9	20	05 June 81	09 July 98
Mg (sol)	mg/L	170.0	1730.0	764.3	22	05 June 81	02 Aug 04
Mn (sol)	mg/L	0.2	0.2	0.2	1	02 Aug 04	02 Aug 04
Mn (tot)	mg/L	0.1	1.3	0.5	4	22 July 92	24 Jan 00

Variable	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last reading
Mn (unfilt undig)	mg/L	0.4	0.4	0.4	1	02 Aug 04	02 Aug 04
Mo (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
N (sum sol ox) {NOx-N, TON}	mg/L	0.0	0.5	0.2	6	24 Sept 96	02 Aug 04
N (tot kjel) {TKN}	mg/L	0.3	1.6	1.0	4	24 Sept 96	20 May 99
N (tot) {TN, pTN}	mg/L	0.5	3.7	1.5	10	24 Sept 96	30 Jan 06
NO_2-N (sol)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
NO_3 (sol)	mg/L	1.0	7.0	2.5	19	05 June 81	18 Aug 88
NO_3-N (sol)	mg/L	2.3	2.3	2.3	1	24 Jan 00	24 Jan 00
Na (sol)	mg/L	1800.0	14800.0	6706.8	22	05 June 81	02 Aug 04
Ni (sol)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Ni (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
O–DO	mg/L	5.9	9.6	8.6	4	03 Sept 98	18 Feb 03
O–DO%	%	69.2	84.5	76.9	2	13 Aug 04	30 Jan 06
O–DO (in situ)	mg/L	5.1	10.6	7.9	4	20 July 99	30 Jan 06
P (tot) {TP, pTP}	mg/L	0.0	0.1	0.1	10	24 Sept 96	30 Jan 06
Pb (sol)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Pb (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
S(2-) (sol)	mg/L	570.0	570.0	570.0	1	09 July 98	09 July 98
SO_4 (sol)	mg/L	360.0	1700.0	1030.0	2	24 Jan 00	02 Aug 04
SO_4 (tot)	mg/L	482.0	2280.0	1229.6	19	05 June 81	18 Aug 88
SiO_2 (sol react)	mg/L	0.2	6.0	2.8	21	05 June 81	02 Aug 04
SiO_2-Si (sol react)	mg/L	2.8	2.8	2.8	1	24 Jan 00	24 Jan 00
Suspended solids (EDI)	mg/L	20.2	546.7	121.3	8	27 Feb 78	22 Mar 78
Suspended solids (ETR)	mg/L	38.8	38.8	38.8	1	14 Mar 78	14 Mar 78
Suspended solids <63u (gulp)	mg/L	120.0	482.3	246.6	8	08 July 83	18 Feb 03
Suspended solids <63u (pump)	mg/L	263.0	765.0	514.0	2	05 Aug 85	05 Mar 86
TDSalts (sum of ions)	mg/L	7246.0	47298.0	21764.4	19	05 June 81	18 Aug 88
TDSolids (evap @180°C)	mg/L	30000.0	30000.0	30000.0	1	02 Aug 04	02 Aug 04
TSS	mg/L	16.0	140.0	92.0	3	31 July 01	30 Jan 06
Th (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Turbidity	NTU	0.6	1650.0	85.8	105	03 Aug 78	30 Jan 06
U (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
V (unfilt undig)	mg/L	0.5	0.5	0.5	1	02 Aug 04	02 Aug 04
Water level (SLE)	m	10.0	11.0	10.3	137	27 Feb 78	13 Aug 04
Water level (SLE) (maximum)	m	10.4	10.4	10.4	1	19 Aug 87	19 Aug 87
Water level status	(none)	0.0	0.0	0.0	116	27 Feb 78	18 Feb 03
Water temperature (in situ)	°C	7.0	34.4	17.8	92	29 July 76	30 Jan 06
Water temperature (test)	°C	17.5	25.2	23.9	163	29 July 76	02 Aug 04
Zn (sol)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Zn (unfilt undig)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
pH	(none)	6.2	8.9	7.5	102	03 Aug 78	30 Jan 06
pH (in situ)	(none)	6.4	9.0	8.0	5	31 Aug 83	26 July 00

Summary of water quality and streamflow data for the Department of Water's Mooronoppin Rock gauging station 615011 on Mooronoppin Creek

Variable	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last reading
Acidity ($CaCO_3$)	mg/L	4.5	4.5	4.5	1	24 Jan 00	24 Jan 00
Al (tot)	mg/L	0.1	0.1	0.1	1	10 July 98	10 July 98
Alkalinity (CO_3-CO_3)	mg/L	0.0	5.0	1.1	21	04 June 81	18 Aug 88
Alkalinity (CO_3-$CaCO_3$)	mg/L	1.0	1.0	1.0	1	24 Jan 00	24 Jan 00
Alkalinity (HCO_3-$CaCO_3$)	mg/L	100.0	100.0	100.0	1	24 Jan 00	24 Jan 00
Alkalinity (HCO_3-HCO_3)	mg/L	89.0	224.0	147.2	21	04 June 81	18 Aug 88
Alkalinity (tot) ($CaCO_3$)	mg/L	73.0	370.0	136.2	24	30 May 75	10 July 98
C (sol org) {DOC}	mg/L	21.0	43.0	29.8	3	10 July 98	18 Feb 03
Ca (sol)	mg/L	66.0	350.0	199.7	23	04 June 81	24 Jan 00
Cl (sol)	mg/L	1396.8	19186.0	5944.9	35	18 July 74	24 Jan 00
Colour (TCU)	TCU	69.0	180.0	114.7	3	21 July 99	24 Jan 00
Colour (hazen)	Hu	5.0	50.0	19.5	10	03 Aug 77	10 June 86
Colour (true)	Hu	5.0	125.0	51.3	411	30 May 75	02 Sept 98
Cond comp 25°C (lab)	µS/m	1850000.0	1850000.0	1850000.0	1	31 July 01	31 July 01
Cond uncomp (in situ)	µS/m	22500.0	3550000.0	1509735.3	17	27 July 94	30 Jan 06
Cond uncomp (lab)	µS/m	147800.0	9950000.0	2630659.8	463	30 May 75	24 Jan 00
Fe (tot)	mg/L	0.1	0.4	0.2	6	24 July 92	24 Jan 00
Hardness (tot) ($CaCO_3$) {Ca+Mg}	mg/L	590.0	3740.2	1913.1	24	30 May 75	10 July 98
K (sol)	mg/L	29.0	29.0	29.0	1	24 Jan 00	24 Jan 00
K (tot)	mg/L	18.0	99.0	51.9	22	04 June 81	10 July 98
Mg (sol)	mg/L	116.0	696.0	339.5	23	04 June 81	24 Jan 00
Mn (tot)	mg/L	0.0	0.1	0.0	6	24 July 92	24 Jan 00
N (sum sol ox) {NOx-N, TON}	mg/L	0.0	2.5	0.6	4	27 July 94	02 Sept 98
N (tot kjel) {TKN}	mg/L	1.3	2.8	2.0	3	27 July 94	02 Sept 98
N (tot) {TN, pTN}	mg/L	1.3	9.6	2.9	10	29 Aug 97	30 Jan 06
NH3-N/NH4-N (sol)	mg/L	0.1	0.1	0.1	1	27 July 94	27 July 94
NO3 (sol)	mg/L	1.0	25.0	9.8	21	04 June 81	18 Aug 88
NO3-N (sol)	mg/L	8.2	8.2	8.2	1	24 Jan 00	24 Jan 00
Na (sol)	mg/L	1010.0	6700.0	3167.4	23	04 June 81	24 Jan 00
O - DO	mg/L	6.1	9.1	7.3	3	02 Sept 98	18 Feb 03
O - DO %	%	77.4	80.0	78.7	2	12 Aug 04	30 Jan 06
O - DO (in situ)	mg/L	4.6	11.6	8.4	5	21 July 99	30 Jan 06
P (tot) {TP, pTP}	mg/L	0.0	0.4	0.1	11	27 July 94	30 Jan 06
PO4-P (sol react) {SRP, FRP}	mg/L	0.1	0.1	0.1	1	27 July 94	27 July 94
S(2-) (sol)	mg/L	271.0	271.0	271.0	1	10 July 98	10 July 98
SO_4 (sol)	mg/L	380.0	380.0	380.0	1	24 Jan 00	24 Jan 00
SO_4 (tot)	mg/L	235.0	1320.0	726.9	21	04 June 81	18 Aug 88
SiO_2 (sol react)	mg/L	7.0	17.0	12.5	22	04 June 81	10 July 98
SiO_2-Si (sol react)	mg/L	10.0	10.0	10.0	1	24 Jan 00	24 Jan 00
Suspended solids (gulp)	mg/L	1542.2	1542.2	1542.2	1	26 Aug 85	26 Aug 85

Variable	Unit	Minimum	Maximum	Average	No. of readings	First reading	Last reading
Suspended solids <63u (gulp)	mg/L	10.0	3198.6	559.8	29	08 July 83	18 Feb 03
Suspended solids <63u (pump)	mg/L	4.8	4109.3	257.6	193	13 July 85	27 Sept 87
TDSalts (sum of ions)	mg/L	3381.0	21509.0	10498.3	21	04 June 81	18 Aug 88
TDSolids (calc @180°C-by cond)	mg/L	12456.0	14602.0	13529.0	2	30 May 75	30 July 75
TSS	mg/L	2.0	140.0	64.5	4	25 July 00	30 Jan 06
Turbidity	NTU	1.0	1700.0	56.1	401	04 June 81	30 Jan 06
Turbidity (JCU)	JTU	25.0	25.0	25.0	2	30 May 75	30 July 75
Water level (SLE)	m	9.7	11.0	10.2	118	18 July 74	12 Aug 04
Water level (SLE) (maximum)	m	10.4	10.4	10.4	3	17 June 83	12 Nov 83
Water level status	(none)	0.0	0.0	0.0	97	03 Aug 77	18 Feb 03
Water temperature (in situ)	°C	5.6	27.8	14.5	89	18 July 74	30 Jan 06
Water temperature (test)	°C	17.9	25.2	24.6	463	30 May 75	31 July 01
pH	(none)	6.7	9.2	7.8	103	30 May 75	30 Jan 06
pH (in situ)	(none)	8.3	8.8	8.6	4	02 Sept 98	25 July 00

Appendix 2 Survey form

General details

Recorder's name: ……Survey date: ……

Site number: …… Site name: ……...

Landholder: …… Contact number: ……

Property address: ……

Site position in landscape

❒ Valley floor
❒ Valley slope
❒ Uplands
❒ Rocky outcrop

Floodplain features

Natural features:

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

Constructed features:

- ❒ Drain
- ❒ Dam
- ❒ Other ……

Vegetation description (from Keighery, 1994)

Beard vegetation association

Number	Description
8	Medium woodland; salmon gum and gimlet
125	Bare areas; salt lakes
141	Medium woodland; York gum, salmon gum and gimlet
356	Succulent steppe with open woodland; eucalypt over saltbush
631	Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire
694	Shrublands; scrub-heath on yellow sandplain banksia-xylomelum association in the Geraldton Sandplain and Avon Wheatbelt Region
951	Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over tea-tree thicket and samphire
955	Mosaic: shrublands; Scrublands; scrub-heath (SE Avon)/ Shrublands: *Allocasuarina campestris* thicket
1049	Medium woodland; wandoo, York gum, salmon gum, morrel and gimlet
1053	Shrublands; *Melaleuca uncinata* thicket with scattered York gum

Vegetation structure and cover (both native and weed species)

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

*Canopy cover class Very open 2–10% Sparse 10–30% Open 30–70% Closed 70–100%
**More than 3 dominant species described as mixed

Native species list

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

Regeneration ❒ Yes ❒ No Species: ……

Weed species list

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

Vegetation condition (from Keighery, 1994)

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

Disturbance factors affecting vegetation condition score

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

Linkages to protected remnant vegetation

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

Aquatic vegetation (if water is present)

Is the aquatic environment dominated by:

- ❒ Macrophytes
- ❒ Phytoplankton
- ❒ Benthic microbial mats

Disturbance factors impacting on in-stream functions

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

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

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

Evidence of management

❒ Revegetation
❒ Fencing
❒ Drainage
❒ Fire break control
❒ Weed control
❒ Surface water management
❒ Other:……

Ideas for management

Tick the appropriate boxes:
❒ Prescribed burning
❒ Firebreak control
❒ Fencing
❒ Erosion control
❒ Saltland grazing
❒ Agroforestry
❒ Remnant vegetation management
❒ Weed control
❒ Drainage
❒ Sediment management
❒ Surface water management
❒ Road crossing
❒ Other……

Fauna list

Photographs

Number	Description

Appendix 3 Survey site reports

Site LYR01 – Glenluce Nature Reserve

General details	
Site name	Glenluce Nature Reserve (Department of Environment and Conservation) Crown Reserve 26266
Surveyed by	Kate Gole
Survey date	28.11.2006

Site description	
Landform	This site is within the Lower Yilgarn floodplain, just upstream from the Caroline Gap where the Yilgarn and Lockhart rivers converge, and is characterised by a series of small, seasonally inundated playa lakes bordered by lunettes and linked by braided, discontinuous channels
Site size	Approximately 244.5 ha

Vegetation description

Beard vegetation association 141: Medium woodland; York gum, salmon gum and gimlet

Beard vegetation association 951: Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over tea-tree thicket and samphire

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	10–30%	*Melaleuca* species
Grasses	2–10%	Native species
Herbs	10–30%	*Halosarcia* species
Rushes and sedges	2–10%	Native species
Litter	2–10%	
Bare ground	10–30%	

Summary

The playas and channels are fringed with a diverse range of *Halosarcia* species grading into *Melaleuca* species shrublands with an understorey of *Atriplex* species and succulents, including *Carpobrotus* species and *Disphyma crassifolium*, on the lunettes. Bordering the floodplain is *Eucalypt* woodland with a diverse understorey of shrubs and herbs

Native species

Scientific name	Common name
Acacia species	Acacia (2 species)
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (3 species)
Austrostipa elegantissima	Feather speargrass
Austrostipa species	Grass

Native species	
Scientific name	**Common name**
Callistemon phoeniceus	Lesser bottlebrush
Carpobrotus species	Pigface
Cassytha species	Dodder
Disphyma crassifolium	Round-leaf pigface
Enchylaena tomentosa var *tomentosa*	Ruby saltbush
Eragrotis dielsii	Mallee lovegrass
Eucalyptus species	Eucalypt (3 species)
Exocarpos aphyllus	Leafless ballart
Hakea pressii	Needlebush
Hakea species	Hakea
Halosarcia species	Samphire (7 species)
Leptospermum species	Tea tree (2 species)
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Maireana species	Bluebush (1 species)
Melaleuca species*	Melaleuca (5 species)
Poacea species	Grass
Santalum acuminatum	Quandong
Sclerolaena species	2 species
Templetonia species	
	Unidentified shrubs (11 species)
	Unidentified herbs (4 species)

** Regeneration of overstorey species noted*

Weed species
No species present

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance	10
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	20
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	20
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	50

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

Comments

Most of the site is affected by salinity and waterlogging with samphire (*Halosarcia*) and saltbush (*Atriplex*) species dominating the understorey. There are several patches of remnant vegetation characterised by *Eucalypt* woodland in good to pristine condition.

Links to protected areas of remnant vegetation

Name	**Area** (ha)	**Approximate distance and direction from site**
Mt Caroline Nature Reserve	352	2 km W
Nangeen Hill Nature Reserve	178	3 km S
Mt Stirling Nature Reserve	223	4.5 km SW
Mournucking Nature Reserve	696	4.5 km N
Gundaring Nature Reserve	128	5.5 km SW
Crown Reserve 11024	22	6 km W

Management

The main management issues are salinity and waterlogging, which need to be addressed at a catchment scale. Fox and rabbit control would be beneficial.

Fauna

Scientific name	**Common name**
Birds	
Acanthagenys rufogularis	Spiny-cheeked honeyeater
Acanthiza chrysorrhoa	Yellow-rumped thornbill
Anthus australis	Richard's pipit
Artamus cinereus	Black-faced woodswallow
Barnardius zonarius	Australian ringneck
Chalcites basalis	Horsfield's bronze-cuckoo
Corvus coronoides	Australian raven
Eoloptus roseicapillus	Galah
Gymnorhina tibicen	Australian magpie

Fauna	
Scientific name	**Common name**
Birds	
Lichenostomus virescens	Singing honeyeater
Merops ornatus	Rainbow bee-eater
Ocyphaps lophotes	Crested pigeon
Pachycephala rufiventris	Rufous whistler
Petrochelidon species	Martin species
Petroica goodenovia	Red-capped robin
Psephotus haematonotus	Mulga parrot
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Degraded valley floor vegetation (Photo: K. Gole)

Site LYR02 – Mournucking Nature Reserve

General details	
Site name	Mournucking Nature Reserve (Department of Environment and Conservation) Crown Reserve 24897
Surveyed by	Kate Gole and Shenaye Mehmet
Survey date	03.11.2006

Site description	
Landform	This site is located within the Yilgarn River floodplain. There is a relatively well-defined main channel and a series of small, seasonally inundated playa lakes surrounded by lunettes. In one area of the reserve, there is a small playa lake surrounded by deep yellow sands
Site size	Approximately 696 ha

Vegetation description

Vegetation association 951: Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over tea-tree thicket and samphire

Vegetation association 1049: Medium woodland; wandoo, York gum, salmon gum, morrel and gimlet

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	10–30%	*Melaleuca* species
Grasses	2–10%	*Austrostipa* species
Herbs	10–30%	*Samphire* and *Atriplex* species
Rushes and sedges	2–10%	Native species
Litter	2–10%	
Bare ground	2–10%	

Summary

While there are some areas of bare ground, the playa lakes are mostly covered with various samphire (*Halosarcia*) species. The majority of the lunettes support sparse to open *Melaleuca* shrubland. The deep yellow sands support kwongan characterised by sandplain cypress (*Actinostrobus arenarius*) and sparse mallee (*Eucalyptus* species) woodlands.

** Regeneration of overstorey species noted*

Weed species	
Scientific name	Common name
Avena fatua	Wild oats

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition

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

Disturbance factors contributing to vegetation condition score

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

Comments

Salinity and waterlogging are impacting on vegetation in and immediately adjacent to the main flow pathways. There are a few tracks through the reserve and rubbish (including household items and car bodies) has been dumped in many adjacent areas.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Glenluce Nature Reserve	245	4.5 km S
Crown Reserve 10719	12	6 km E
Mt Caroline Nature Reserve	352	7.5 km SW

Management

There is good vehicle access via a number of tracks, which has allowed agricultural and household rubbish to be dumped in a number of locations. The amenity of the nature reserve would be improved by its removal.

Weed species have invaded the understorey adjacent to tracks and rubbish dumps and would benefit from control, particularly wild oats (*Avena fatua*).

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Richard's pipit
Artamus cinereus	Black-faced woodswallow
Chalcites basalis	Horsfield's bronze-cuckoo
Cheramoeca leucosternus	White-backed swallow
Coracina novaehollandiae	Black-faced cuckoo-shrike
Cracticus nigrogularis	Pied butcherbird
Eoloptus roseicapillus	Galah
Merops ornatus	Rainbow bee-eater
Ocyphaps lophotes	Crested pigeon
Psephotus haematonotus	Mulga parrot
Rhipidura leucophrys	Willy wagtail
	Honeyeater
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*

**Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)

Weaving, S. (1994)

Weaving, S. and Grein, S. (1994)

Samphire (Halosarcia species) flats grading into Melaleuca shrublands (Photo: K. Gole))

Eucalypt woodland in excellent condition fringing a small playa lake (Photo: S. Mehmet)

Site LYR03 – Dixon's

General details	
Site name	Dixon's (private property)
Surveyed by	Shenaye Mehmet and Paula Haro
Survey date	08.6.2007

Site description	
Landform	This site is within the valley floor and is characterised by a series of small, seasonal salt lakes and a series of relatively defined channels
Site size	Approximately 100 ha

Vegetation description

Beard vegetation association 951: Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over tea-tree thicket and samphire

Beard vegetation association 1053: Shrublands; *Melaleuca uncinata* thicket with scattered York gum

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus loxophleba*
Mallees	–	
Shrubs	10–30%	*Melaleuca* species, *Acacia* species
Grasses	10–20%	Native and weed species
Herbs	10–30%	*Halosarcia* species
Rushes and sedges	–	
Litter	2–10%	
Bare ground	30–70%	

Summary

The site is characterised by sparse *Eucalypt* woodland, including *Eucalyptus loxophleba*, and *Melaleuca* and *Acacia* shrubland with an understorey of salt-tolerant species, including *Atriplex, Halosarcia* and *Maireana* species.

Native species

Scientific name	Common name
Acacia species*	Acacia (3 species)
Aristida species	Kerosene grass
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (3 species)
Austrostipa elegantissima	Feather speargrass
Cassytha species	Dodder

Native species	
Scientific name	**Common name**
Chloris species	Windmill grass
Disphyma crassifolium	Round-leaf pigface
Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba	York gum
Exocarpos aphyllus	Leafless ballart
Hakea pressii	Needlebush
Halosarcia species	Samphire (14 species)
Leptospermum species	Tea tree
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Melaleuca species*	Melaleuca (5 species)
Poacea species	Grass (2 species)
Salsola tragus	Prickly saltwort
Sclerolaena species	
	Unidentified herbs (7 species)
	Unidentified shrubs (6 species)

* *Regeneration of overstorey species noted*

Weed species	
Scientific name	**Common name**
Carthamus lanatus	Saffron thistle
Mesembryanthemum nodiflorum	Slender iceplant
Poacea species	Grass (4 species)
Trifolium species	Clover
	Unidentified herb species (2 species)

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	30
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	20
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	50

Disturbance factors contributing to vegetation condition score

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

Comments

Salinity, waterlogging and ponding from the nearby road crossing (Inverarity Rd) are the main threatening processes with an impact on the site. Flow from upstream, runoff from the Kellerberrin townsite and relatively fresh sub-surface flow are all likely to be contributing to the ponding problem, which is exacerbated by the low gradient, height of the road and the insufficient culvert under Inverarity Rd. The vegetation close to Inverarity Rd is degrading with many stags (dead vegetation) present. A bank has been constructed along part of the channel to prevent waterlogging of cultivated areas. The landholder is keen to implement drainage to manage the salinity and waterlogging problems.

Anecdotal evidence suggests that the ‘main channel’ of the waterway is shifting to the south-east of its present course, encroaching on cultivated land.

Other factors impacting on vegetation condition include stock and vehicle access, invasion of agricultural weeds (including saffron thistle (*Carthamus lanatus*)), rubbish, the presence of a power line corridor through the site and feral animals.

Acacia plants are showing signs of an unidentified disease.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Mournucking Nature Reserve	696	Approximately 0.1 km W
Glenluce Nature Reserve	245	Approximately 9 km SW

Management

Significant areas of the site have been revegetated with local native species, including *Melaleuca* species and *Atriplex* species. A bank has been constructed along part of the channel to prevent waterlogging of cultivated areas. A firebreak along Inverarity Rd has been maintained.

The boundary fence is in poor condition however stock are only grazed intermittently and have limited access to the vegetation near the road.

Fauna	
Scientific name	**Common name**
Birds	
Artamus cinereus	Black-faced woodswallow
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. and Grein, S. (1994)
Weaving, S. (1994)

Bank constructed through Melaleuca *shrubland to alleviate waterlogging problems (Photo: S. Mehmet)*

Site LYR04 – Clement's

General details	
Site name	Clement's (private property)
Surveyed by	Kate Gole
Survey date	01.03.2007

Site description	
Landform	This site is located fully within the Yilgarn River floodplain and is characterised by a series of seasonal salt lakes and braided channels
Site size	Approximately 198 ha

Vegetation description

Beard vegetation association 631: Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire

Beard vegetation association 1053: Shrublands; *Melaleuca uncinata* thicket with scattered York gum

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	Mixed
Grasses	2–10%	*Aristida* and *Austrostipa* species
Herbs	20–30 %	*Halosarcia* species
Rushes and sedges	–	
Litter	2–10%	
Bare ground	10–30%	

Summary

There are several vegetation communities that occur on the lunettes within this site, including very open *Eucalypt* woodland with an understorey dominated by *Atriplex* species, *Eucalypt* woodland with a diverse middlestorey (including *Pittosporum angustifolium*, *Hakea presii* and *Exocarpos aphyllus*), *Melaleuca* shrubland and very open *Acacia* shrubland with an understorey dominated by *Aristida* species. All of these communities grade into *Halosarcia* herblands on the fringes of the salt lakes and channels.

Native species	
Scientific name	**Common name**
Acacia species	
Aristida species	Kerosene grass
Atriplex species	Saltbush (1 species)
Austrostipa elegantissima	Feather speargrass
Dianella revoluta	Blueberry lily
Disphyma crassifolium	Round-leaf pigface
Enchylaena tomentosa var tomentosa	Ruby saltbush
Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba	York gum
Eucalyptus sargentii	Salt river gum
Eucalyptus species	Eucalypt (3 species)
Exocarpos aphyllus	Leafless ballart
*Hakea pressii**	Needlebush
Halosarcia species	Samphire (7 species)
Leptospermum species	Tea tree
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Melaleuca species*	Melaleuca (5 species)
*Pittosporum angustifolium**	Native willow
Ptilotus polystachyus	Prince of Wales feather
Rhagodia species	Rhagodia
Salsola tragus	Prickly saltwort
Santalum acuminatum	Quandong
Sclerolaena species	
Templetonia species	
	Unidentified shrubs (5 species)
	Unidentified herbs (6 species)

** Regeneration of overstorey species noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Bromus species	Brome grass
Mesembryanthemum nodiflorum	Slender iceplant
Solanum hoplopetalum	Thorny solanum (native but acting as a roadside weed species)

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

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

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

Comments
Salinity and waterlogging are having an impact on the vegetation at the fringes of the lunettes. Weed invasion is in isolated patches and rabbits and foxes are present. However, on the whole the vegetation within the site is in good to very good condition.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Mournucking Nature Reserve	696	Approximately 9 km W
Mooranoppin Nature Reserve	40	Approximately 9 km N

Fauna	
Scientific name	**Common name**
Birds	
No bird species seen during survey, probably due to strong winds at the time.	
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Remnant vegetation in good condition on a lunette (Photo: K. Gole)

Site LYR05 – Steber's

General details	
Site name	Steber's (private property)
Surveyed by	Shenaye Mehmet and Paula Haro
Survey date	07.06.2007

Site description	
Landform	This site is within the Yilgarn River floodplain and is characterised by seasonal salt lakes. A tributary drains into the floodplain within this site
Site size	Approximately 170 ha

Vegetation description

Beard vegetation association 631: Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	–	
Mallees	–	
Shrubs	–	
Grasses	2–10%	Native and introduced species
Herbs	70–100%	*Halosarcia* species
Rushes and sedges	–	
Litter	–	
Bare ground	10–30%	

Summary

The original *Melaleuca* shrubland has been entirely replaced with salt-tolerant species, including *Halosarcia*. Three individual *Eucalyptus loxophleba* are present within the site. All are dying. No regeneration of overstorey species was noted. In a few restricted areas agricultural weeds have invaded the understorey.

Native species	
Scientific name	**Common name**
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (4 species)
Chenopodiaceae species	
Disphyma crassifolium	Round-leaf pigface
Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba	York gum (3 dying trees)
Halosarcia species	Samphire (11 species)
Maireana brevifolia	Small leaf bluebush
Poacea species	Grass species
Salsola tragus	Prickly saltwort
	Unidentified shrubs (2 species)
	Unidentified herb species

No regeneration of overstorey species noted

Weed species	
Scientific name	**Common name**
Mesembryanthemum nodiflorum	Slender iceplant
Poacea species	Grass (3 species)
Trifolium species	Clover

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	100

Disturbance factors contributing to vegetation condition score

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

Comments

The site is highly degraded from rising salinity and waterlogging levels. The original *Melaleuca* shrubland has been entirely replaced with salt-tolerant species, including samphire (*Halosarcia*) species. Significant numbers of stags (dead trees) remain.

Other factors impacting on the vegetation condition include stock access, vehicle access, dumping of rubbish, invasion of agricultural weeds and feral animals.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
No reserves vested for nature conservation are located within 10 km		

Management

Existing fencing is in poor condition and is not stock proof. Stock are walked through the floodplain between properties on either side of the waterway.

The main threatening processes impacting on the site are salinity and waterlogging, which need to be managed on a catchment scale. The fencing could be replaced if stock are grazed in the floodplain.

Fauna	
Scientific name	**Common name**
Birds	
No bird species were recorded at this site, probably due to cold, windy weather at the time of the survey.	
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

*Samphire (*Halosarcia *species) flats (Photo: S. Mehmet)*

Site LYR06 – Lake Baandee

General details	
Site name	Lake Baandee
Surveyed by	Kate Gole and Shenaye Mehmet
Survey date	17.11.2006

Site description	
Landform	Lake Baandee is a significant salt lake within the Lower Yilgarn floodplain
Site size	Approximately 322 ha

Vegetation description
Beard vegetation association 125: Bare areas; salt lakes
Beard vegetation association 631: Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire

Vegetation structure and cover

Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	Mixed
Grasses	2–10%	Mixed native species
Herbs	2–10%	*Halosarcia* species
Rushes and sedges	–	-
Litter	2–10%	
Bare ground	70–100%	

Summary

Most of the site is dominated by a large playa lake which is fringed with *Melaleuca* shrublands and areas dominated by *Halosarcia* and *Atriplex* species.

Native species

Scientific name	**Common name**
Acacia species	Acacia (3 species)
Aristida species	Kerosene grass
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (4 species)
Austrostipa elegantissima	Feather speargrass
Carpobrotus species	Pigface
Cassytha species	Dodder
Disphyma crassifolium	Round-leaf pigface
Enchylaena tomentosa var tomentosa	Ruby saltbush
Eragrotis dielsii	Mallee lovegrass
Eucalyptus salmonphloia	Salmon gum
Eucalyptus salubris	Gimlet

Native species	
Scientific name	**Common name**
Eucalyptus species	Eucalypt (1 species)
Exocarpos aphyllus	Leafless ballart
Frankenia paucifolia	Sea heath
Hakea species	Hakea
Halosarcia species	Samphire (7 species)
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Maireana species	Bluebush (1 species)
Melaleuca species*	Melaleuca (7 species)
*Pittosporum angustifolium**	Native willow
Poacea species	Grass (3 species)
Ptilotus species	Mulla mulla
Salsola tragus	Prickly saltwort
*Santalum acuminatum**	Quandong
Sclerolaena species	1 species
Templetonia species	
Verticordia species	Verticordia
	Unidentified shrubs (6 species)
	Unidentified herbs (3 species)

* *Regeneration of overstorey species noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Hordeum leporinum	Barley grass
Asteraceae species	Daisy species

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

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

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

Comments

Most of the site consists of the bare ground of the salt lake. There is a narrow fringe of vegetation separating the lake from surrounding farm land, characterised by *Melaleuca* shrublands and samphire (*Halosarcia*) and saltbush (*Atriplex*). There are weeds invading the remnant vegetation along the vehicle tracks that circle the site. Lake Baandee is used for water skiing. There is small amount of erosion at the boat launch area.

Links to protected areas of remnant vegetation

None within 10 km radius

Management

Weed control, revegetation, erosion control on lake edge near boat launch

Fauna

Scientific name	**Common name**
Birds	
Barnardius zonaris	Australian ringneck
Lichenostomus virescens	Singing honeyeater
Cracticus torquatus	Grey butcherbird
Acanthiza chrysorrhoa	Yellow-rumped thornbill
Malarus species	Wren species
Ocyphaps lophotes	Crested pigeon
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)

Weaving, S. (1994)

Weaving, S. and Grein, S. (1994)

Lake Baandee outlet with completely degraded to degraded Melaleuca *shrublands on the adjacent lunettes (Photo: K. Gole)*

Water skiing boat launch (Photo: K. Gole)

Site LYR07 – Arthur's

General details	
Site name	Arthur's (private property)
Surveyed by	Shenaye Mehmet and Paula Haro
Survey date	28.05.2007

Site description	
Landform	This site is within the valley floor and is characterised by a series of seasonal salt lakes, bordered by lunettes. A tributary to the Yilgarn River flows through the site. A drain also discharges into the floodplain within the site
Site size	Approximately 100 ha

Vegetation description
Beard vegetation association 631: Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire
Beard vegetation association 1049: Medium woodland; wandoo, York gum, salmon gum, morrel and gimlet

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	10–30%	*Eucalyptus salubris, Eucalyptus longicornis*
Mallees	–	
Shrubs	30–70%	*Melaleuca* species
Grasses	2–10%	Native species
Herbs	10–30%	*Halosarcia* and *Atriplex* species
Rushes and sedges	–	
Litter	2–10%	
Bare ground	30–70%	

Summary

This site is characterised by sparse *Eucalypt* woodland, including *Eucalyptus salubris* and *Eucalyptus longicornis*, and open *Melaleuca* shrubland with a salt-tolerant understorey, including *Atriplex*, *Halosarcia* and *Maireana* species. The biological crust is intact within the woodland area.

Native species

Scientific name	Common name
Acacia species*	Acacia
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (4 species)
Callitris species	Cypress pine
Cassytha species	Dodder
Chenopodiaceae species	
Disphyma crassifolium	Round-leaf pigface
Enchylaena tomentosa var *tomentosa*	Ruby saltbush
Eragrotis dielsii	Mallee lovegrass

Native species	
Scientific name	**Common name**
Eucalyptus longicornis	Red morrel
Eucalyptus salubris	Gimlet
Eucalyptus species	Eucalypt (2 species)
Exocarpos aphyllus	Leafless ballart
Exocarpos sparteus	Broom ballart
Hakea pressii	Needlebush
Halosarcia halocnemoides	Shrubby samphire
Halosarcia species	Samphire (7 species)
Leptospermum species	Tea tree
Lycium australe	Australian boxthorn
Maireana amoena	Brittle bluebush
Maireana brevifolia	Small leaf bluebush
Melaleuca species*	Melaleuca (8 species)
Rhagodia drummondii	Lake fringe rhagodia
Salsola tragus	Prickly saltwort
Santalum acuminatum	Quandong
Sclerolaena species	2 species
Templetonia species	
	Unidentified shrubs (3 species)
	Unidentified herbs (4 species)

* *Regeneration of overstorey species noted, mostly on the lunettes. Not as evident in the woodland areas, which are grazed.*

Weed species	
Scientific name	**Common name**
No weed species recorded	

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	30
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	65
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	5

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

Comments

The *Melaleuca* shrublands within the site are being significantly impacted on by salinity and waterlogging. Stock access from the neighbouring property is impacting on the *Eucalypt* woodland, which is otherwise in good condition.

There is significant evidence of the presence of feral animals within the site, including rabbit warrens and fox dens.

There is some evidence of bank erosion affecting the drain, at least within the floodplain; however, there are no mobile sediment slugs present. General farm rubbish has been dumped or washed into the drain. It is likely that the drain is contributing nutrients to the main waterway. These are all upstream issues and difficult to manage within the site.

Links to protected areas of remnant vegetation

Name	**Area** (ha)	**Approximate distance and direction from site**
Crown Reserve 25872	407	Approximately 4.5 km SE
Hines Hill Nature Reserve	203	Approximately 5 km W

Management

A section of the tributary close to the floodplain has been revegetated. The fence along the edge of the floodplain is in good condition; however, the fence along Spillman Rd is in poor condition and not stock proof. Fire breaks have been maintained. A drain, constructed on the neighbouring property, discharges into the site.

The *Eucalypt* woodland bordering Spillman Rd is in good condition and would benefit from fencing to exclude stock.

Fauna

Scientific name	**Common name**
Birds	
Barnardius zonaris	Australian ringneck
Petroica goodenovia	Red-capped robin
Rhipidura leucophrys	Willy wagtail
	3 unidentified species

Fauna	
Scientific name	**Common name**
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

** Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation fringing a small playa lake (Photo: S. Mehmet)

Eucalypt *woodland (Photo: S. Mehmet)*

Site LYR08 – Johnstone's

General details	
Site name	Johnstone's (private property)
Surveyed by	Shenaye Mehmet and Paula Haro
Survey date	30.05.2007

Site description	
Landform	This site is within the valley floor and is characterised by a series of seasonal salt lakes, bordered by lunettes
Site size	Approximately 104 ha

Vegetation description
Beard vegetation association 631: Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus sargentii* and *Eucalyptus loxophleba*
Mallees	–	
Shrubs	10–30%	*Melaleuca* species
Grasses	2–10%	Mix of native and introduced species
Herbs	30–70%	*Halosarcia* species
Rushes and sedges	–	
Litter	2–10%	
Bare ground	30–70%	

Summary

This site is characterised by very open *Eucalypt* woodland, including *Eucalyptus sargentii* and *Eucalyptus loxophleba* and sparse *Melaleuca* shrubland with an understorey of salt-tolerant species, including *Maireana*, *Atriplex* and *Halosarcia*.

Native species

Scientific name	Common name
Acacia species	Acacia (3 species)
Aristida species	Kerosene grass
Atriplex species	Saltbush species
Austrostipa elegantissima	Feather speargrass
Borya species	Pincushions
Carpobrotus species	Pigface
Cassytha species	Dodder
Chenopodiaceae species	3 species
Dianella revoluta	Blueberry lily
Disphyma crassifolium	Round-leaf pigface
Dodonaea species	Hop bush

Native species	
Scientific name	**Common name**
Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba	York gum
Eucalyptus sargentii	Salt river gum
Exocarpos aphyllus	Leafless ballart
Hakea pressii	Needlebush
Halosarcia species	Samphire (13 species)
Lycium australe	Australian boxthorn
Lysiana casuarinae (on *Acacia* species)	Mistletoe
Maireana amoena	Brittle bluebush
Maireana brevifolia	Small leaf bluebush
Melaleuca species*	Melaleuca (4 species)
Pittosporum angustifolium	Native willow
Poacea species	Grass (3 species)
Rhagodia drummondii	Lake fringe rhagodia
Sclerolaena species	
Templetonia species	
	Mistletoe (on Melaleuca)
	Unidentified shrubs (7 species)
	Unidentified herbs (9 species)

* *Regeneration of overstorey species noted (only noted in a limited area)*

Weed species	
Scientific name	**Common name**
Poacea species	Grass species
Mesembryanthemum nodiflorum	Slender iceplant

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	80
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	20

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

Comments

The vegetation communities within the site are being significantly impacted on by salinity and waterlogging. A few species of agricultural weeds are present in the understorey. Stock have access to the site and may be impacting on regeneration.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Crown Reserve 25872	407	Approximately 1 km S
Hines Hill Nature Reserve	203	Approximately 1 km E

Management

The site is partly fenced and fire breaks are maintained.

The main threatening processes impacting on the vegetation are salinity and waterlogging, which need to be managed on a catchment scale. Fencing in poor condition may need to be replaced if stock are grazed within the site. Fencing would also give some protection to the remnant vegetation, especially if stock grazing is impacting on regeneration.

Fauna	
Scientific name	**Common name**
Birds	
Ocyphaps lophotes	Crested pigeon
Rhipidura leucophrys	Willy wagtail
	Wren
	3 unidentified species
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Completely degraded vegetation (Photo: S. Mehmet)

Eucalypt *woodland on the edge of the floodplain (Photo: S. Mehmet)*

Site LYR09 – Crown Reserve 25872

General details	
Site name	Crown Reserve 25872 (Department of Environment and Conservation)
Surveyed by	Kate Gole and Shenaye Mehmet
Survey date	21.11.2006

Site description	
Landform	This site is within the Lower Yilgarn floodplain, just upstream from the Caroline Gap where the Yilgarn and Lockhart rivers converge, and is characterised by a series of small, seasonally inundated playa lakes bordered by lunettes and linked by braided, discontinuous channels
Site size	Approximately 407 ha

Vegetation description

Beard vegetation association 141: Medium woodland; York gum, salmon gum and gimlet

Beard vegetation association 631: Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	10–30%	*Melaleuca* species
Grasses	2–10 %	Native species
Herbs	10–30%	*Halosarcia* and *Atriplex* species
Rushes and sedges	–	
Litter	2–10%	
Bare ground	10–30%	

Summary

The site is characterised by sparse *Eucalypt* woodland and *Melaleuca* shrubland with an *Atriplex* understorey grading into *Halosarcia* flats. Several of the lunettes have shrublands of *Callitris canescens* and *Pittosporum angustifolium*.

Native species

Scientific name	Common name
Acacia species	Acacia (1 species)
Amyema gibberula (on *Hakea* species)	Mistletoe
Amyema pressii (on *Hakea* species)	Wireleaf mistletoe
Aristida species	Kerosene grass
Atriplex species	Saltbush species
Austrodanthonia caespitosa	Common wallaby grass
Austrostipa elegantissima	Feather speargrass

Native species	
Scientific name	**Common name**
Callitris species*	Cypress pine
Carpobrotus species	Pigface (2 species)
Cassytha species	Dodder
Disphyma crassifolium	Round-leaf pigface
Dodonaea viscosa	Sticky hop bush
Enchylaena tomentosa var tomentosa	Ruby saltbush
Eragrotis dielsii	Mallee lovegrass
Eucalyptus species	Eucalypt (4 species)
Exocarpos aphyllus	Leafless ballart
Frankenia paucifolia	Sea heath
Hakea pressii	Needlebush
Hakea species	Hakea
Halosarcia species	Samphie (11 species)
Lycium australe	Australian boxthorn
Lysiana casuarinae (on *Exocarpus aphyllus*)	Mistletoe
Maireana amoena	Brittle bluebush
Maireana brevifolia	Small leaf bluebush
Melaleuca species	Melaleuca (4 species)
*Pittosporum angustifolium**	Native willow
Poacea species	Grass (3 species)
Ptilotus species	Mulla mulla (2 species)
Rhagodia species	Rhagodia
Santalum acuminatum	Quandong
Sarcozona praecox	Sarcozona
Templetonia species	
	Unidentified shrubs (14 species)
	Unidentified herbs (10 species)

* *Regeneration of overstorey species noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Limonium lobatum	Statice
Mesembryanthemum nodiflorum	Slender iceplant
Solanum hoplopetalum	Thorny solanum (native but acting as a roadside weed species)

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	10
Very good	Vegetation structure altered, obvious signs of disturbance	15
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	25
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	25
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	25

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

Comments

The vegetation communities fringing the salt lakes and channels within the site are being affected by salinity and waterlogging and the *Melaleuca* shrublands on some of the lower lunettes are at risk from salinity and waterlogging. There is some weed invasion from roadsides but these weeds are unlikely to spread due to salinity and waterlogging. Household rubbish has been dumped near several of the access tracks through the site.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Hines Hill Nature Reserve	203	Approximately 2.5 km NE
Nangeenan Nature Reserve	37	Approximately 9.5 lm E

Management

Weeds, including wild oats (*Avena fatua*), are invading the site from surrounding road verges; however, their spread is likely to be limited by saline and waterlogged conditions.

Fauna	
Scientific name	**Common name**
Birds	
Acanthagenys rufogularis	Spiny-cheeked honeyeater
Aquila audax	Wedge-tailed eagle (breeding)
Cheramoeca leucosternus	White-backed swallow
Epthianura albifrons	White-fronted chat
Malarus species	Wren species
Ocyphaps lophotes	Crested pigeon (breeding)
Pachycephala rufiventris	Rufous whistler
Psephotus haematonotus	Mulga parrot
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Sparse Eucalypt *woodland in very good to excellent condition (Photo: K. Gole)*

*Samphire (*Halosarcia *species) flats bordering the 'main channel' through the floodplain (Photo: K. Gole)*

Site LYR10 – Hines Hill Nature Reserve

General details	
Site name	Hines Hill Nature Reserve (Department of Environment and Conservation) Crown Reserve 23795
Surveyed by	Kate Gole and Michael Kelly
Survey date	20.02.2007

Site description	
Landform	This site is within the Yilgarn River floodplain and is characterised by several small, seasonally wet salt lakes
Site size	Approximately 203 ha

Vegetation description
Beard vegetation association 141: Medium woodland; York gum, salmon gum and gimlet
Beard vegetation association 356: Succulent steppe with open woodland; eucalypt over saltbush

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus salubris*
Mallees	2–10%	*Eucalyptus* species
Shrubs	10–30%	*Melaleuca* species
Grasses	2–10%	*Avena fatua*
Herbs	2–10%	*Samphire* species
Rushes and sedges	–	-
Litter	2–10%	
Bare ground	10–30%	

Summary

The site is characterised by *Eucalypt* woodland with a very open understorey and sparse *Melaleuca* shrubland. Samphire (*Halosarcia*) species fringe the salt lakes, grading into shrublands dominated by *Melaleuca* species and also containing *Acacia* species and *Templetonia* species.

Native species

Scientific name	Common name
Acacia species	Acacia (2 species)
Atriplex species	Saltbush (1 species)
Austrostipa elegantissima	Feather speargrass
Enchylaena tomentosa var tomentosa	Ruby saltbush
Eucalyptus longicornis	Red morrel
*Eucalyptus salubris**	Gimlet
Eucalyptus species	Eucalypt (2 species)

Native species	
Scientific name	**Common name**
Halosarcia species	Samphire (5 species)
Leptospermum species	Tea tree (2 species)
Maireana brevifolia	Small leaf bluebush
Melaleuca species*	Melaleuca (3 species)
Salsola tragus	Prickly saltwort
Santalum acuminatum	Quandong
Sclerolaena species	
Templetonia species	
	Unidentified shrubs (9 species)
	Unidentified herbs (3 species)

Revegetation	
Atriplex species	Saltbush (1 species)
Eucalyptus species	
Melaleuca species	

** Regeneration of overstorey species noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Asteraceae species	Thistle species

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	-	20
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	50
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	20
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	10
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	

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

Comments

A percentage of the site has been cleared and subsequently revegetated. This area has a heavy weed burden, predominantly wild oats (*Avena fatua*). The weeds are restricted to this area and, at present, are not encroaching into the surrounding remnant vegetation. Plant deaths were noted, particularly *Templetonia* species and some of the *Melaleuca* species. In some cases, on the lunettes close to the salt lakes, these deaths seem to be linked to salinity and waterlogging.

Links to protected areas of remnant vegetation		
Name	**Area (ha)**	**Approximate distance and direction from site**
Crown Reserve 25872	407	Approximately 2.5 km SW
Nangeenan Nature Reserve	37	Approximately 7.5 km E

Management

Most of the reserve is fenced and the cleared area has been revegetated. There is an access track for the power lines which acts as a fire break along one edge of the reserve.

Management suggestions include the control of the wild oats (*Avena fatua*) in the revegetated area and maintenance of fire breaks around the perimeter of the reserve.

Fauna	
Scientific name	**Common name**
Birds	
Barnardius zonaris	Australian ringneck
Corvus coronoides	Australian raven
Eoloptus roseicapillus	Galah
Lichenostomus virescens	Singing honeyeater
Malarus leucopterus	White-winged fairy-wren
Mammals	
Macropus species	Kangaroo
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Melaleuca *shrublands in good to very good condition characterised most of the site (Photo: K. Gole)*

Valley floor vegetation on relatively high lunettes (Photo: K. Gole)

Appendix 4 Flora and fauna lists for the Lower Yilgarn River study area

Native plant species found during the survey*

Scientific name	Common name
Acacia species	Acacia (5 species)
Actinostrobus arenarius	Sandplain cypress
Allocasuarina species	
Amyema gibberula (on *Hakea* species)	Mistletoe
Amyema miquelii (on *Eucalyptus* species)	Stalked mistletoe
Amyema pressii (on *Hakea* species)	Wireleaf mistletoe
Aristida species	Kerosene grass
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (4 species)
Austrodanthonia caespitosa	Common wallaby grass
Austrostipa elegantissima	Feather speargrass
Austrostipa species	
Borya species	Pincushions
Callistemon phoeniceus	Lesser bottlebrush
Callitris species	Cypress pine
Carpobrotus species	Pigface (2 species)
Cassytha species	Dodder
Chenopodiaceae species	
Chloris species	Windmill grass
Clematis species	
Dianella revoluta	Blueberry lily
Didymanthus roei	
Disphyma crassifolium	Round-leaf pigface
Dodonaea species	Hop bush
Dodonaea viscosa	Sticky hop bush
Enchylaena tomentosa var tomentosa	Ruby saltbush
Eragrotis dielsii	Mallee lovegrass
Eucalyptus longicornis	Red morrel
Eucalyptus loxophelba	York gum
Eucalyptus salmonphloia	Salmon gum
Eucalyptus salubris	Gimlet
Eucalyptus sargentii	Salt river gum
Eucalyptus species	Eucalypt (5 species)
Exocarpos aphyllus	Leafless ballart
Exocarpos sparteus	Broom ballart
Frankenia paucifolia	Sea heath
Grevillea pritzelii	Black toothbrush
Hakea pressii	Needlebush
Hakea species	Hakea
Halosarcia halocnemoides	Shrubby samphire

Scientific name	Common name
Halosarcia lylei	Samphire
Halosarcia species	Samphire (17 species)
Leptospermum species	Tea tree (2 species)
Lycium australe	Australian boxthorn
Lysiana casuarinae (on *Exocarpus aphyllus*)	Mistletoe
Maireana amoena	Brittle bluebush
Maireana brevifolia	Small leaf bluebush
Maireana species	Bluebush (2 species)
Melaleuca species	Melaleuca (11 species)
Pittosporum angustifolium	Native willow
Poacea species	Grass (3 species)
Ptilotus polystachyus	Prince of Wales feather
Ptilotus species	Mulla mulla (2 species)
Rhagodia drummondii	Lake fringe rhagodia
Salsola tragus	Prickly saltwort
Santalum acuminatum	Quandong
Sarcozona praecox	Sarcozona
Sclerolaena species	2 species
Templetonia species	
Verticordia species	Verticordia (2 species)
	Unidentified shrubs (29 species)
	Unidentified herbs (10 species)
	Unidendified sedge

* *Plant list is not complete. There are likely to be species within each site that were not identified during the survey.*

Introduced plant species found during the survey*

Scientific name	Common name
Asteraceae species	Daisy species
Asteraceae species	Thistle species
Avena fatua	Wild oats
Bromus species	Brome grass
Carthamus lanatus	Saffron thistle
Hordeum leporinum	Barley grass
Limonium lobatum	Statice
Mesembryanthemum nodiflorum	Slender iceplant
Poacea species	Grass (4 species)
Solanum hoplopetalum	Thorny solanum (native but acting as a roadside weed species)

* *Plant list is not complete. There are likely to be species within each site that were not identified during the survey.*

Other plant lists for the general area
Beard, J.S. (1980)
Weaving, S. (1994)
Weaving, S. and Grein, S. (1994)

Native and introduced fauna species found during the survey*

Scientific name	Common name	Conservation status	Habitat type**
Birds			
Acanthagenys rufogularis	Spiny-cheeked honeyeater	Shrubland	Priority
Acanthiza chrysorrhoa	Yellow-rumped thornbill	Woodland	Remnant-dependent
Anthus australis	Richard's pipit	Farmland	Farmland
Aquila audax	Wedge-tailed eagle		
Artamus cinereus	Black-faced woodswallow		
Barnardius zonaris	Australian ringneck	Woodland	Farmland
Chalcites basalis	Horsfield's bronze-cuckoo	Woodland	Remnant-dependent
Cheramoeca leucosternus	White-backed swallow	Shrubland	Farmland
Colluricincla harmonica	Grey shrike-thrush	Woodland	Priority
Coracina novaehollandiae	Black-faced cuckoo-shrike	Woodland	Farmland
Corvus coronoides	Australian raven	Farmland	Farmland
Coturnix pectoralis	Stubble quail	Farmland	Farmland
Cracticus nigrogularis	Pied butcherbird	Woodland	Farmland
Cracticus torquatus	Grey butcherbird	Woodland	Remnant-dependent
Eoloptus roseicapillus	Galah	Woodland	Farmland
Epthianura albifrons	White-fronted chat	Farmland	Farmland
Gymnorhina tibicen	Australian magpie	Woodland	Farmland
Lichenostomus virescens	Singing honeyeater	Shrubland	Remnant-dependent
Malarus leucopterus	White-winged fairy-wren	Shrubland	Priority
Malarus species	Wren species	Shrubland	Priority
Merops ornatus	Rainbow bee-eater		
Ocyphaps lophotes	Crested pigeon	Farmland	Farmland
Pachycephala rufiventris	Rufous whistler	Woodland	Priority
Petrochelidon species	Martin species	Shrubland	Farmland
Petroica goodenovia	Red-capped robin	Woodland	Priority
Phaps chalcoptera	Common bronzewing	Woodland	Priority
Pomatostomus superciliosus	White-browed babbler	Shrubland	Remnant-dependent
Psephotus haematonotus	Mulga parrot	Farmland	Farmland
Rhipidura leucophrys	Willy wagtail	Woodland	Farmland
	Honeyeater		
Mammals			
Macropus species	Kangaroo		
Oryctolagus cuniculus	European wild rabbit	Introduced	
Vulpes vulpes	European red fox	Introduced	

* Plant list is not complete. There are likely to be species within each site that were not identified during the survey.

** Greening Australia Western Australia (2004)

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. and Grein, S. (1994)

Appendix 5 Examples of suitable species for saltland pasture

Species suitable for saltland pasture (Sourced from: Oversby, 2004; Phelan, 2004; Butler, 2001; Barrett-Lennard and Malcolm, 1995; Mitchell and Wilcox, 1994; Runciman and Malcolm, 1989)

Species name	Occurrence and use
Saltbush species	
Berry (creeping) saltbush *(Atriplex semibaccata)*	Grows on fine-textured, non-saline to moderately saline soils near salt lakes and in woodlands. Slightly salt tolerant and very drought tolerant. Is introduced easily by direct seeding or tubestock. Seeds can be readily harvested January to March. It is short-lived but regenerates easily. Must be managed carefully as it is palatable for sheep and prone to being eaten out. Local native species.
Swamp (river) saltbush *(Atriplex amnicola)*	Grows on a variety of soil types that are irregularly inundated and waterlogged. Very salt tolerant, moderately waterlogging (once mature) and moderately drought tolerant. Plants can be grown from tubestock, cuttings or direct seeded. Seed can be collected from December to February. Good forage for sheep (up to 10% crude protein) and recovers well from grazing. Local native species.
Wavy leaf saltbush *(Atriplex undulata)*	Grows on saline soils and is tolerant of waterlogging, but less so than swamp saltbush. Can be established through direct seeding and it self-seeds. Palatable for stock and recovers well from grazing. Not native to Western Australia.
Old man saltbush *(Atriplex nummularia)*	Grows on alkaline, moderately saline soils but is sensitive to waterlogging. Is not as palatable as other *Atriplex* species. Is long-lived and recovers from grazing but is brittle and easily damaged from trampling. Can be direct seeded or grown from tubestock but does not readily self-seed. Seed can be collected from September to October. Native species of semi-arid and arid southern and central Australia.
Grey saltbush *(Atriplex cinerea)*	Grows on saline seepages and is moderately tolerant of waterlogging. Grows best from cuttings but can be direct seeded. Its palatability for stock varies. Native species of coastal areas in southern Australia.
Samphire species	
Various species	Grow on a variety of highly saline soils. Very tolerant of salt and waterlogging. Can be grown from tubestock and cuttings or direct seeded and then allowed to spread naturally. Can survive moderate grazing but have high salt content so must be grazed in conjunction with crop stubbles or other feed sources. Sheep must also have access to fresh water.
Bluebush species	
Small leaf bluebush *(Maireana brevifolia)*	Grows on a wide variety of soil types on the drier end of the floodway and floodfringe. It is very tolerant of drought and salt-tolerant but only slightly tolerant of waterlogging. Plants can be grown from tubestock, direct seeded or self seeded. At up to 16% crude protein it is more palatable for sheep than *Atriplex* species and recovers well from grazing. Local native species.
Grass species	
Variety of native species	There are a number of summer-active native grass species considered suitable for pastures. They vary in palatability, nutrition and tolerance to saline conditions, waterlogging and grazing. Contact the Department of Agriculture and Food for more information.

Appendix 6 Examples of local native species suitable for revegetation

Local native species suitable for revegetating valley floors in the Yilgarn River catchment (sourced from Oversby, 2004; Mitchell and Wilcox, 1994; Lefroy et al. 1991)

Species name	Revegetation tips
Understorey	
Berry (creeping) saltbush *(Atriplex semibaccata)*	Grows on fine-textured, non-saline to moderately saline soils near salt lakes and in woodlands. Slightly salt tolerant and very drought tolerant. Is introduced easily by direct seeding or tubestock. Seeds can be readily harvested January to March. It is short-lived but regenerates easily.
Swamp (river) saltbush *(Atriplex amnicola)*	Grows on a variety of soil types that are irregularly inundated and waterlogged. Very salt tolerant, moderately waterlogging (once mature) and moderately drought tolerant. Plants can be grown from tubestock, cuttings or direct seeded. Seed can be collected from December to February.
Small leaf bluebush *(Maireana brevifolia)*	Grows on a wide variety of soil types associated with the drier floodways and floodfringes of saline waterways. Slightly tolerant of waterlogging and very tolerant of drought and salinity. Plants can be grown from tubestock or direct seeded, with seeds collected between December and March. Also self-seeds.
Lake fringe rhagodia *(Rhagodia drummondii)*	Grows on a variety of soil types, especially sandy soils, associated with salt lakes and saline waterways. Slightly tolerant of waterlogging and very tolerant of drought and salinity. Plants can be grown from tubestock or by direct seeding.
Spiny flat sedge *(Cyperus gymnocaulos)*	Grows on a variety of soil types associated with fresh to saline waterways, including floodways, seeps and lake edges, especially in disturbed areas or waterways with high nutrient levels. Moderately salt tolerant but does not tolerate inundation for very long. Can be propagated by transplanting stems or by direct seeding with seed collected in January to February; however, the most effective technique is to transplant the plantlets into damp soil.
Coast saw sedge *(Gahnia trifida)*	Grows on a variety of soils types associated with fresh to saline waterways including floodways, seeps, clay pans and lake edges. Moderately tolerant of waterlogging and very salt tolerant. Can be propagated successfully from creeping stems and less successfully by direct seeding, using seed collected between January and March.
Shore rush *(Juncus acutus)*	Grows on any moist soil type associated with brackish to saline waterways including floodways, seeps, swamps and lake edges. Very tolerant of waterlogging and salinity. Can be propagated successfully from creeping stems and by direct seeding, using seed collected between December and February.
Native marine couch *(Sporobolus virginicus)*	Grows on a variety of soil types but prefers lighter soils associated with fresh to moderately saline waterways including floodways and lake edges. Very tolerant to waterlogging and moderately salt tolerant. Easily propagated by transplanting creeping stems and also by direct seeding with seed collected from January to March.

Species name	Revegetation tips
Mallee lovegrass *(Erogrostis dielssii)*	Grows on a variety of soil types but prefers lighter soils associated with saline waterways including floodways and lake edges. Moderately tolerant to waterlogging, salinity and drought. Can be grown from tubestock or direct seeded.
Samphire species (*Halosarcia* species)	*Halosarcia* species grow on a variety of soil types associated with saline waterways, salt flats and lake edges. Very tolerant of salinity and waterlogging. Can be grown from tubestock, cuttings or direct seeded.
Middlestorey	
Grevillea paniculata	Grows on a variety of soil types, particularly sandy soils, associated with fresh floodfringes. Not tolerant of waterlogging or salinity. Can be grown from tubestock.
Needlebush *(Hakea preissii)*	Grows on many soil types, including grey clays, duplex soils and alluvial loams, associated with floodfringes, floodways and sand rises of saline waterways. Moderately salt and waterlogging tolerant. Can be grown from tubestock.
Jam *(Acacia acuminata)*	Grows on a variety of soil types, especially red loams, associated with fresh to slightly saline floodfringes and drier floodways. Slightly waterlogging and salt tolerant and very drought tolerant. Can be grown from tubestock or direct seeded with seeds collected from November to December.
Manna wattle *(Acacia microbotrya)*	Grows on a wide range of soil types associated with fresh to slightly saline floodways and floodfringes. Slightly waterlogging and salt tolerant. Can be grown from tubestock or direct seeded with seed collected from early October to December.
Broombush *(Melaleuca uncinata)*	Grows on a variety of soil types. Has a variable tolerance to waterlogging and salinity.
Lesser bottle brush *(Callistemon phoeniceus)*	Grows on a variety of soil types associated with fresh to saline floodways, floodfringes and winter wet depressions. Depending on the provenance, it has a high to moderate tolerance to waterlogging, salinity and drought. Plants can be grown from tubestock or direct seeded, using seed collected throughout the year.
Swamp sheoak *(Casuarina obesa)*	Suitable for a variety of floodway soils. Very salt and waterlogging tolerant. Plant tubestock or direct seed.
Overstorey	
York gum *(Eucalyptus loxophleba)*	Grows on a variety of soils associated with floodfringes and the drier ends of floodways. Does not tolerate waterlogging but some provenances are moderately salt tolerant. Can be grown from tubestock or direct seeded, using seed collected throughout the year.
Salmon gum *(Eucalyptus salmonophloia)*	Grows on red and brown duplex soils on the lower slopes and valley floors. Moderately tolerant of salinity.
Salt river gum *(Eucalyptus sargentii)*	Grows on a variety of soil types associated with salt lakes and saline waterways. Tolerates some waterlogging and is moderately to highly tolerant of salinity, depending on the provenance. Plants can be grown from tubestock or direct seeded. Seed can collected at any month from unopened mature fruit.

Species name	Revegetation tips
Gimlet *(Eucalyptus salubris)*	Grows on red and brown duplex soils on the lower slopes and valley floors. Moderately tolerant of salinity.
Morrel *(Eucalyptus longicornis)*	Grows on saline, fine-textured loams and clays on valley floors.
Yorrel *(Eucalyptus yilgarnensis)*	Grows on saline, fine-textured loams and clays on valley floors.

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