TAYLOR BURRELL BARNETT

MURRAY RIVER COUNTRY ESTATE
OUTLINE DEVELOPMENT PLAN

NOVEMBER 2007

prepared for: **Murray Riverside Pty Ltd**

prepared by: **Taylor Burrell Barnett**
Town planning and design

in association with: **Dennis Price Miller**
Douglas Partners
Ecoscape
Gresley Abas - Architects
Hames Sharley
JDA Consulting
MP Rogers
Plan E
Ray Bird & Associates
Transcore
ED Art

MURRAY RIVER COUNTRY ESTATE OUTLINE DEVELOPMENT PLAN

NOVEMBER 2007

Prepared for: **Murray Riverside Pty Ltd**

Prepared By: **Taylor Burrell Barnett Town Planning and Design**
187 Roberts Road
SUBIACO WA 6008
Phone: 9382 2911 Fax: 9382 4586
admin@tbbplanning.com.au

In association with:
Dennis Price & Miller
Douglas Partners
Ecoscape
Gresley Abas – Architects
Hames Sharley
JDA Consulting
MP Rogers
Plan E
Ray Bird & Associates
Transcore
Ed Art

DOCUMENT HISTORY AND STATUS

Printed	1/11/2007 2:34:00 PM
Last Saved	1/11/2007 2:27:00 PM
Job No.	03/148
Author	Emma Jeffcoat
Document Version	Rev 5

Revision	Date Issued	Reviewed by	Approved by	Date Approved
Rev 0	13.01.06			13.01.06
Rev 1	1.11.06	Emma Jeffcoat		
Rev 2	23.01.07	Sarah Toman	Sarah Toman	23.01.07
Rev 3	19.02.07	Sarah Toman	Sarah Toman	19.02.07
Rev 4	16.10.07	Sarah Toman	Sarah Toman	16.10.07
Rev 5	01.11.07	Sarah Toman	Sarah Toman	01.11.07

Consultant Inputs

Consultant	Means of Transmittal	Date of Transmittal
Dennis Price & Miller		13.01.06
Douglas Partners		
Ecoscape		
Hames Sharley		
Gresley Abas – Architects		
JDA Consulting		
MP Rogers		
Plan E		
Ray Bird & Associates		
Transcore		

TABLE OF CONTENTS

APPENDICES

FIGURES

1.0 INTRODUCTION

This report has been prepared on behalf of Murray Riverside Pty Ltd, by Taylor Burrell Barnett and the following team of specialist consultants:

- Dennis Price & Miller
- Douglas Partners
- Ecoscape
- Gresley Abas – Architects
- Hames Sharley
- JDA Consulting
- MP Rogers;
- Plan E;
- Ray Bird & Associates
- Transcore
- Ed Art

Hereafter referred to as the 'Outline Development Plan' (ODP), this report has been prepared to guide the development of Lot 331 Pinjarra Road and Lot 9008 Sunset Circle, Pinjarra (known as the 'Murray River Country Estate'), a partially constructed residential subdivision on the southern banks of the Murray River. Eight stages of the estate have previously been approved for subdivision, this ODP applies to the balance of the estate.

1.1 Purpose

Outline Development Plans are forward-planning documents prepared to provide an overarching scheme for the development or redevelopment of land. ODPs address broad land use and infrastructure matters, and establish the general principals, land uses and design layout to guide the unfolding of a development. ODPs are often a precursor to more detailed site and precinct planning.

This ODP has been prepared in accordance with clauses 6.8.5 and 6.8.6 of the Shire of Murray Town Planning Scheme No. 4 to facilitate the urbanisation of the land. The ODP recommends the preferred:

- pattern of land use;
- network and hierarchy of roads;
- public open space network; and
- servicing strategy for the development.

1.1.1 Agency Approval

This report will be submitted to the Shire of Murray for the approval of the Council in accordance with clauses 6.8.7 and 6.8.8 of the Shire's Town Planning Scheme No. 4 and subsequently forwarded to the Western Australian Planning Commission for its endorsement.

Once endorsed, the Outline Development Plan will become the reference document for future subdivision and development within the Estate.

1.2 ODP Land

The ODP land is located within the greater Peel Region approximately 75 kilometres southeast of the Perth Central Area, 15 kilometres southeast of Mandurah and approximately 3 kilometres northwest of the Pinjarra town site (**refer Figure 1**). The land is within the municipal boundaries of the Shire of Murray.

The extent of the ODP area is shown on **Figure 2**. A legal description of the ODP land is provided below.

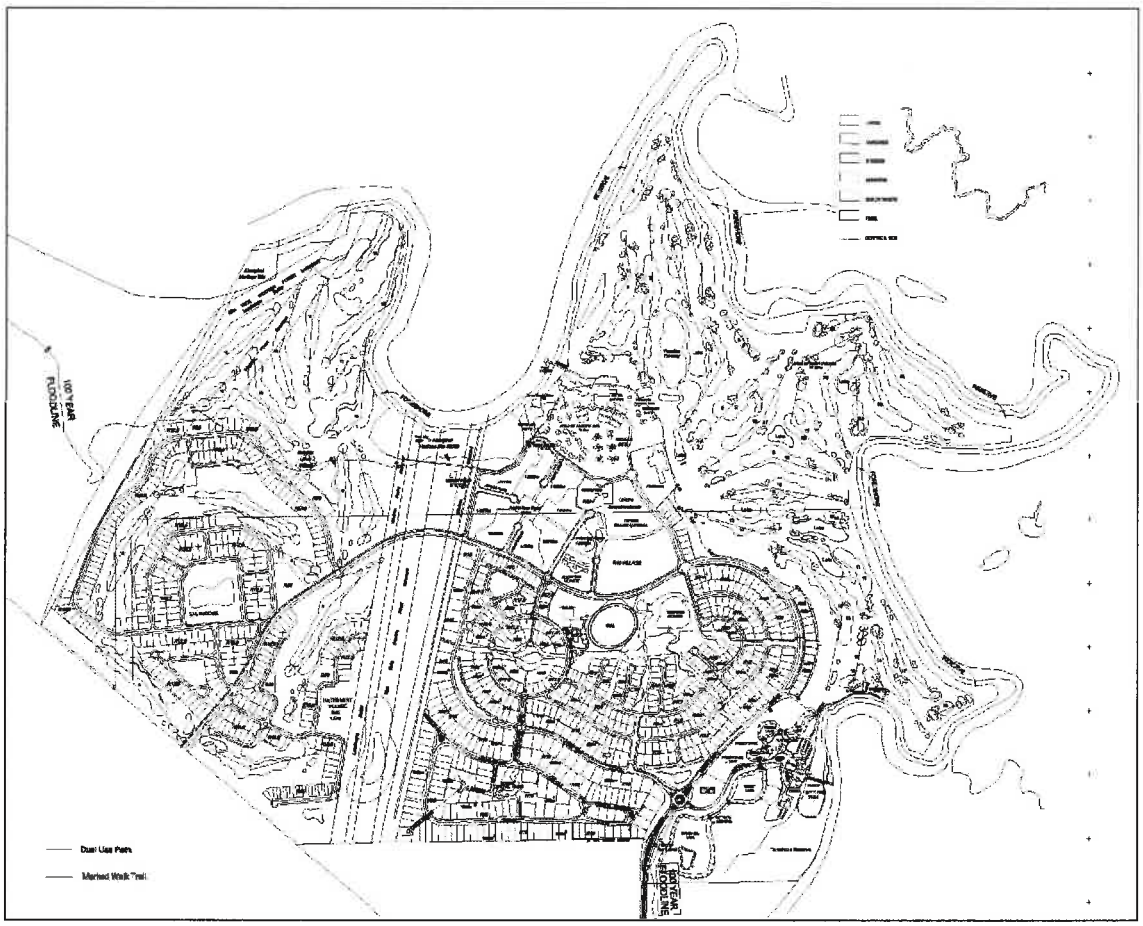
Table 1: Legal Description

Lot	Description	Vol/Folio	Area
Lot 9008	Sunset Circle, Pinjarra	2641/195	172.597 ha
Lot 331	Pinjarra Road, Pinjarra	2143/897	157.9025 ha
Total:			**330.4995 ha**

1.3 Background

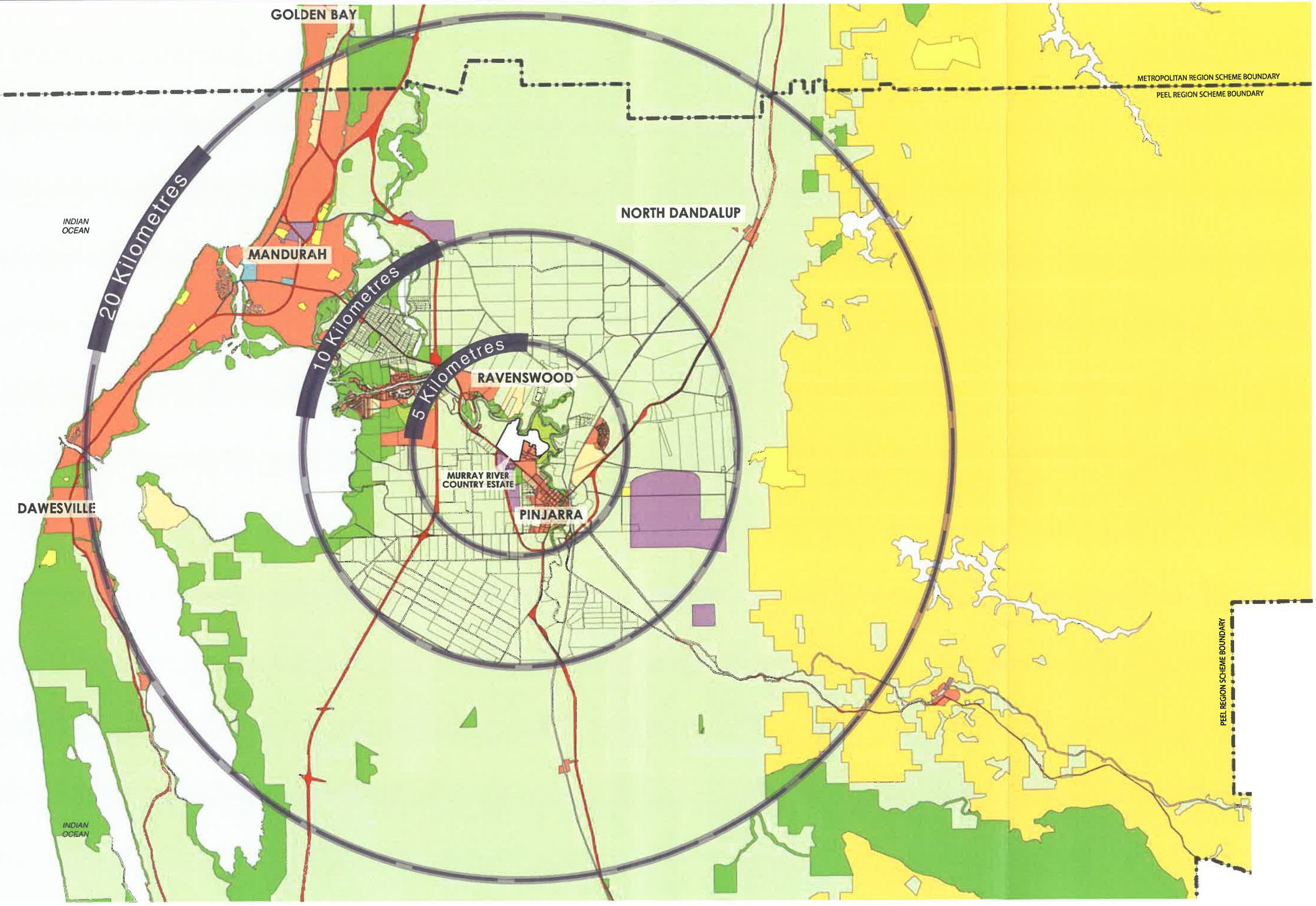
The Murray River Country Estate (MRCE) comprises (balance) Lot 9008 & Lot 331 Pinjarra Road, Ravenswood. Lot 9008 & lot 331 are zoned 'Special Development' under the Shire of Murray Town Planning Scheme No. 4. The land was included within the Special Development zone via Amendment No. 72, which was approved in August 1996. An Outline Development Plan was adopted over the land and proposed development for predominantly residential use based around a 44 hole golf course. The estate was marketed as 'Ravenswood Sanctuary', however the development syndicate went into receivership leaving the estate partially constructed.

Whilst the land is already appropriately zoned to allow for a range of residential and other complementary uses, the design offered by the Ravenswood Sanctuary ODP is outdated and does not reflect contemporary planning practices. Furthermore, the current owners do not intend to proceed with the entire 44 hole golf course. A copy of the approved ODP is shown in **Plan 1**, below.



Plan 1 – Approved Ravenswood Sanctuary Outline Development Plan

In short, the ODP does not reflect current planning practices or policies of the relevant government agencies. In support of this view, the following observations are made.



MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

REGIONAL LOCATION PLAN

2km 0m 2 4 6km

22 JAN 2007 | 03/148/FIG1

FIGURE 1

LEGEND

EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

Murray

River

212

331

9005

PINJARRA

ROAD

HIGHWAY

WESTERN

SOUTH

PINJARRA

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

OUTLINE DEVELOPMENT PLAN AREA

100m 0m 100 200 300 400m

22 JAN 2007 | 03/148/FIG2

FIGURE 2

The Ravenswood Sanctuary ODP:

- does not take full advantage of its Pinjarra Road frontage; neither in terms of giving a 'face' to the estate or in terms of the commercial benefits such exposure affords;
- does not promote place creation. In particular, there are no identifiable character precincts or nodes intended for the use of its permanent residents;
- is not site responsive and does not does not make best use of the site's environmental qualities;
- does not appear to offer a diversity of housing product and so has a narrow market focus;
- shows poor integration of land uses; and,
- represents an inefficient use of developable land.

It is further considered that the level of reporting undertaken in support of the previous ODP does not reflect the level required by today's standard. To address and resolve these perceived deficiencies, Taylor Burrell Barnett was commissioned by Murray Riverside Pty Ltd to undertake a comprehensive review of the Ravenswood Sanctuary ODP.

Taylor Burrell Barnett has approached the 'revised ODP' as an entirely new planning document, rather than simply a revision to the existing design. It should be recognised, however, that in the meantime, the existing Ravenswood Sanctuary ODP remains valid for the site - and under cover of that approval, subdivision has continued to occur concurrent to the review of the ODP. It should also be noted that care has been taken to ensure the new ODP blends appropriately with the existing development and in particular, the development interface between the old and new designs.

To coincide with a renewed approach to development of the site, the current developers have re-branded the estate as the 'Murray River Country Estate' (MRCE).

1.4 Report Format

This report comprises two distinct parts. Part 1 serves as an explanatory section that provides background, analyses the condition of the site and its surrounding context and explains the design and philosophy of the ODP. Part 2 provides the initiatives and specific requirements of the ODP.

Separation of the content into two parts will assist with implementation of the ODP, by ensuring it may be administered easily. As the initiatives and requirements may be read in isolation, the reader will be able to clearly and quickly identify what the requirements are for development of the land without needing to read the background. This will also ensure there is no confusion as to what the actual requirements are.

Due to the breadth of data that has been prepared in support of the ODP, only summaries of the various technical reports are contained in the main body of the ODP. Full copies of the following reports are appended:

Appendix 1	MRCE ODP Report – Environmental Section
Appendix 2	MRCE Wetland Assessment
Appendix 3	MRCE Groundwater Assessment
Appendix 4	MRCE Retail Potential
Appendix 5	MRCE ODP Servicing, Urban Water Management & Engineering Aspects

PART ONE

2.0 PROJECT PHILOSOPHY

The location of the Murray River Country Estate alongside the Murray River and its proximity to the Pinjarra town site provides an exceptional opportunity for urban development. The location affords the conveniences of urban living (being access to Pinjarra's shops, amenities, community and government facilities) whilst the Murray River setting provides tranquillity and a sense of being close to nature.

In preparing the ODP it was important that the site's unique locational qualities be optimised and promoted. Whilst many objectives were identified during the formative stages, the notion of *'bringing the River to the development'* was the over-arching objective that had significant bearing on the design outcome.

Below the overarching objective, the following four primary development objectives were identified:

- Celebration of the Murray River;
- Retention of Pinjarra's rural character;
- Traditional neighbourhood design; and
- Place making.

The development objectives are discussed further in the following sections.

2.1 Celebration of the Murray River

The northern perimeter of the development site abuts the Murray River Foreshore Reserve, which forms a natural boundary to the Estate.

With the development enjoying and close proximity to such a regional asset it provides a unique opportunity to incorporate nearly 9km of river frontage into the Estate. In doing so, the residents of the Estate will enjoy a range of benefits associated with a riverside setting, including:

- A high level of visual amenity,
- A sense of harmony with the environment;
- Various recreational opportunities;
- A point of community focus; and
- An abundance of flora and fauna.

The means by which the River environs may be incorporated into the Estate requires careful planning and design. During the formulation of the ODP it was recognised that 'access' (being the extent to which the river interfaces the development, either literally or figuratively) would play a leading role in the Estate's success in celebrating the Murray River.

Access may involve development directly interfacing with the River, or the establishment of view corridors toward the river. In the more referential sense it may be conveyed in a theme demonstrated through landscaping works or public art, reminding the user that the River is within reach.

There are numerous methods by which the river may be referenced, however the guiding principle is to maximise and strengthen the relationship between all land uses within the Estate and the Murray River. Planning for this will produce a considerable public equity outcome, a key component of a socially sustainable community.

2.2 Retention of the Pinjarra's Rural Character

It is understood that Pinjarra was established in 1830 and is one of the oldest towns in Western Australia. With its fertile soils and pastures, it quickly attracted settlers. Today Pinjarra retains an air of peace and tranquillity, largely because its hinterland remains undeveloped and rural landholdings continue to predominate.

The charge for the consultant team has been to prepare an ODP for an Estate that pays homage to the former use of the site and its history, and to weave the environmental assets through the development whilst achieving the appropriate level of urbanism demanded by a growing population.

The Outline Development Plan, and subsequent phases of subdivision, will therefore recognise and celebrate the presence of the Murray River, views back to the Darling Scarp and existing vegetation & wetlands.

2.3 Traditional Neighbourhood Design

As part of the project brief, and in keeping with contemporary design practices in Western Australia, the Murray River Country Estate Outline Development Plan is designed in accordance with the principle recommendations of Liveable Neighbourhoods (LN).

Liveable Neighbourhoods is the current benchmark for community design in Western Australia. Whilst upholding the principles of LN is considered a responsible path for any developer, it is particularly relevant in the context of the MRCE because the urban form promoted by LN is already expressed in the neighbouring historic settlement of Pinjarra. There is an opportunity to establish a link between the ODP area and of the urban form that dominates the neighbouring town site of Pinjarra.

2.4 Place Making

People are on one level diverse and unique. On another level we have physiological and psychological needs that are universal. People like to wait where they can watch what is going on, they like to feel the sun on a winter's day or find shade out of the midday sun. They get uncomfortable when a stranger stands too close in a small space but gather close to friends to laugh and talk and exchange ideas. These fundamentals are so powerful that they have shaped great cities for millennia. Cities that have relegated people second to industry, transport or private greed have all failed to develop a rich diverse and sustainable urban ecology. In time they have either reinvented themselves as people cities or become redundant. Cities that have created places that support people's daily needs and reinforce and celebrate life's events have flourished over centuries.

Over the past two decades Perth has rediscovered and reinvested in many of its most important major places. One example is inner city Perth. People have moved back in, spaces have been made more pleasant to pedestrians, new trees shade benches and cafes spill out wherever there is enough space on the footpath. There is a new energy in places like inner city Perth and many smaller traditional centres across Western Australia.

There is also, however, a half century's worth of suburbs designed for the motor car where local centres provide little for the local community and shops are vacant or in decline. Place making reasserts the importance of outcomes - stronger and healthier communities, vibrant and successful businesses and the environment in balance with the city. Place making brings together the experts that develop and administer strategies, the people who control finances, those that have technical know-how and those that understand local issues. These specialists work together in an interactive process where each idea is tested and evaluated in an iterative process.

The objective of place making has played an important role in the approach to the design of the ODP, which strives to create a sense of place to MRCE for residents and visitors alike.

3.0 STATUTORY & POLICY FRAMEWORK

3.1 Regional Zoning

The majority of ODP land is zoned 'Urban' under the Peel Region Scheme (PRS). The northern and eastern extremities of the site are zoned 'Private Recreation' under the PRS. (Refer to **Figure 3**)

The boundary between the 'Urban' zone and the 'Private Recreation' zone generally corresponds with the previously intended golf course and the land use configuration proposed under the former Ravenswood Sanctuary ODP.

3.2 Shire of Murray Town Planning Scheme No. 4

The ODP land is zoned 'Special Development' under the Shire of Murray Town Planning Scheme No. 4 - District Zoning Scheme. (Refer to **Figure 4**)

The 'Special Development' zone is intended to facilitate extensive development in accordance with an approved Outline Development Plan. The Murray River Country Estate ODP has been prepared to support the future development of the subject land, in accordance with clauses 6.5.3 and 6.8 of TPS No. 4.

3.2.1 *Proposed Zoning under proposed Shire of Murray Town Planning Scheme No. 5*

The Shire of Murray is currently in the process of reviewing Town Planning Scheme No. 4 and it is anticipated that its proposed successor, Town Planning Scheme No. 5, will be advertised at some stage during 2007 or early 2008.

In accordance with proposed Scheme No. 5 the land the subject of this ODP is to be designated a 'Special Control Area' and zoned 'Residential R20'. The northern and eastern extremities of the properties located within the flood fringe are proposed to be zoned 'Local Reserve'.

3.3 Relevant State & Local Government Policy

3.3.1 *Inner Peel Region Structure Plan*

The Inner Peel Region Structure Plan, finalised in December 1997, provided the basis for the preparation of the Peel Region Scheme. The Peel Region Scheme (gazetted in March 2003) provides the statutory planning mechanisms to implement the initiatives of the Structure Plan.

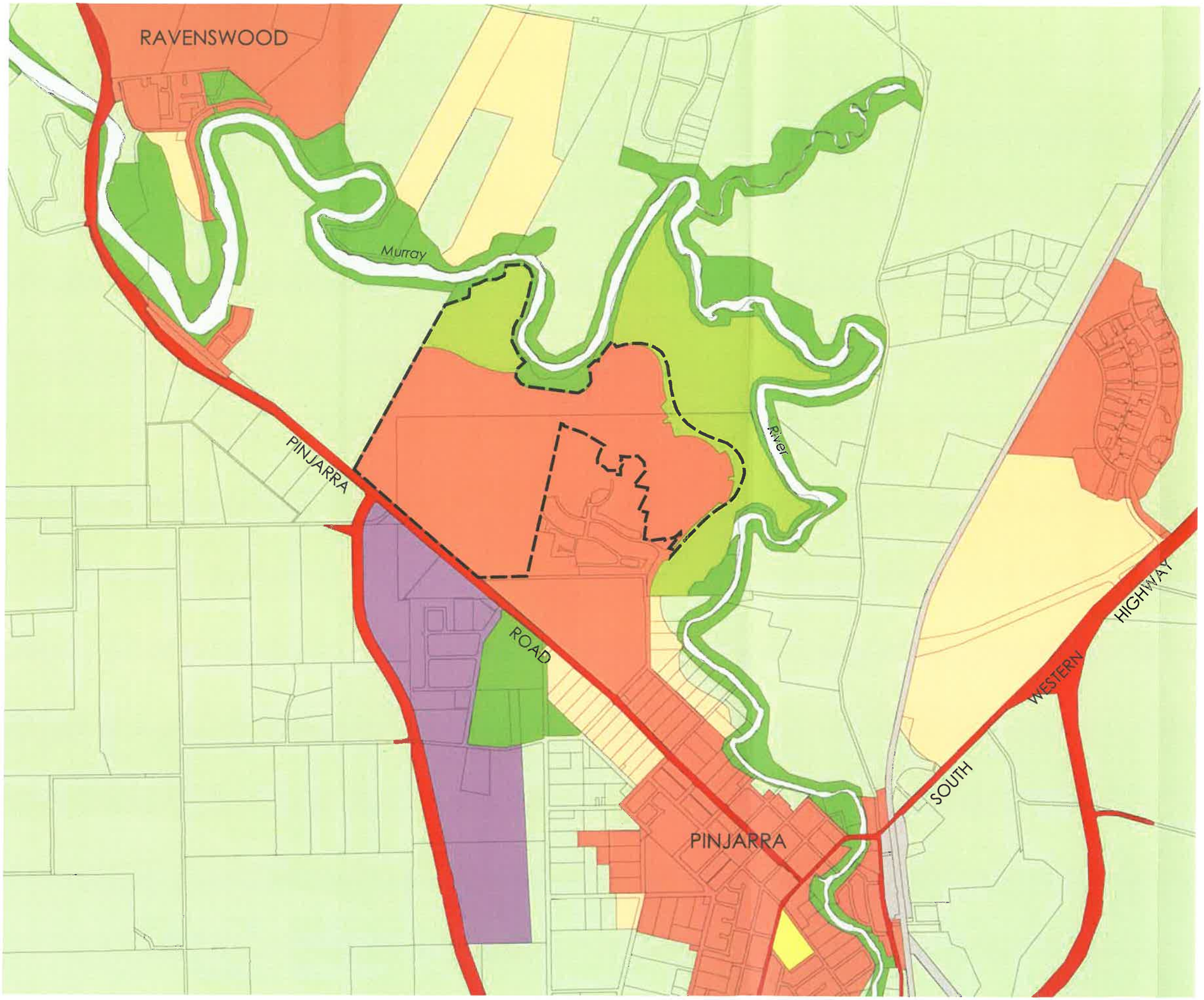
The Inner Peel Region Structure Plan identified four major areas of urban expansion for the Inner Peel one of which is the Ravenswood North Precinct, the land subject of this ODP. The Precinct was considered to have the potential to accommodate a population of 10,500.

3.3.2 *Pinjarra Urban Expansion Strategy*

The Pinjarra Urban Expansion Strategy was prepared by the Shire of Murray in 1998 to provide for the effective management and coordination of the future development of Pinjarra. The Strategy designated the ODP land as the 'Ravenswood South' Precinct, stating it provided the opportunity for *"quality urban development at the north western gateway to Pinjarra"*.

3.3.3 *Ravenswood Sanctuary Outline Development Plan*

The Shire of Murray approved the Ravenswood Sanctuary Golf Resort ODP in mid-1996. The key conditions of the ODP approval requiring statutory effect were later embodied in Schedule 7 of the Shire's Town Planning Scheme No. 4 (TPS No. 4).



LEGEND

RESERVED LANDS

- REGIONAL OPEN SPACE
- RAILWAYS
- STATE FORESTS
- WATERWAYS
- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS
- PUBLIC PURPOSES - DENOTED AS FOLLOWS
  - H HOSPITAL
  - HS HIGH SCHOOL
  - PU PUBLIC UTILITIES
  - SU SPECIAL USES
  - U UNIVERSITY

ZONES

- URBAN
- URBAN DEFERRED
- REGIONAL CENTRE
- INDUSTRIAL
- RURAL
- PRIVATE RECREATION

- SPECIAL CONTROL AREAS DENOTED AS FOLLOWS
  - SCA NO.1 WATER CATCHMENTS
- EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

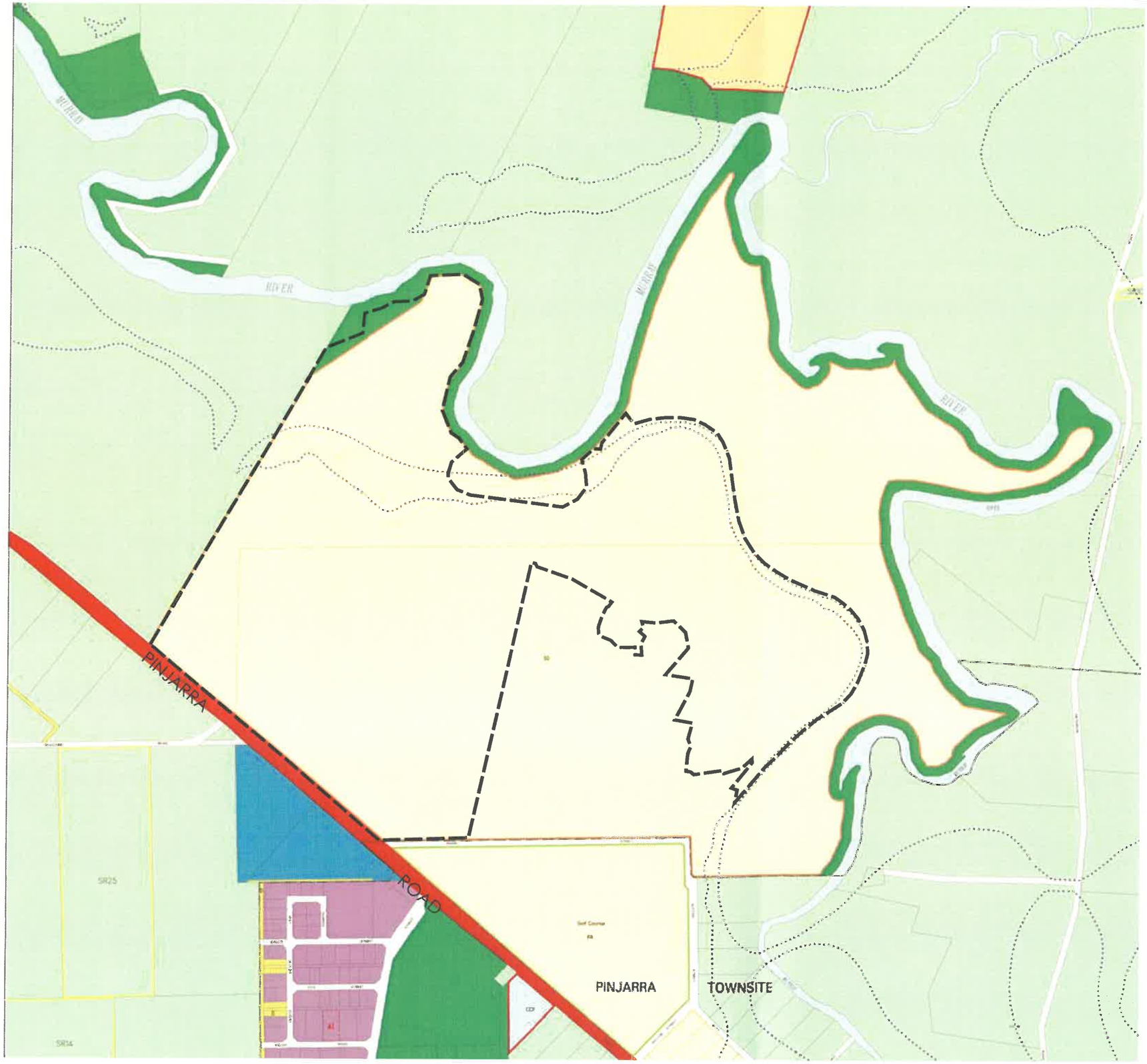
MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

EXTRACT FROM PEEL REGION SCHEME

200m 0m 200 400

22 JAN 2007 | 03/148/FIG3

FIGURE 3



LEGEND

LOCAL SCHEME RESERVES

- CIVIC / CULTURAL
- MAJOR HIGHWAY
- PRIMARY REGIONAL ROADS (PER REGIONAL SCHEME)
- PUBLIC PURPOSES
- PUBLIC PURPOSES DENOTED AS FOLLOWS
  - A AMBULANCE DEPOT
  - AC ADMINISTRATION CENTRE
  - AHS AGRICULTURAL HALL SITE
  - C CEMETERY
  - CS CAUSEWAY SITE
  - D DEPOT
  - E EDUCATION/RESEARCH
  - F FIRE STATION
  - FF FIRE FIGHTING FACILITY
  - GR GOVERNMENT REQUIREMENTS
  - H HOSPITAL
  - HA HALL SITE
  - HC HEALTH CENTRE
  - HS HIGH SCHOOL
  - OS OFFICE AND STABLES
  - P POLICE
  - PS PRIMARY SCHOOL
  - PSC PRE SCHOOL
  - PU PUBLIC UTILITY
  - PWD PUBLIC WORKS DEPARTMENT
  - RC RACE COURSE & SHOW GROUND
- PUBLIC PURPOSES DENOTED AS FOLLOWS
  - RSL RETURNED SERVICES LEAGUE
  - S SCHOOL PURPOSES SITE
  - SC SCHOOL
  - T TELECOM
  - W WATER TOWER
  - WSD WATER SUPPLY
  - WT WATER TREATMENT
- PUBLIC RECREATION / CONSERVATION
- RAILWAY
- ROAD TO BE CLOSED
- STATE FOREST

ZONES

- CANAL DEVELOPMENT
- RESIDENTIAL
- RESIDENTIAL DEVELOPMENT
- SPECIAL DEVELOPMENT DENOTED AS FOLLOWS
  - SD SPECIAL DEVELOPMENT
- SPECIAL RESIDENTIAL
- COMMERCIAL
- HOTEL / MOTEL
- SERVICE COMMERCIAL
- TOWN CENTRE
- CARAVAN / CHALET PARK DENOTED AS FOLLOWS
  - CCP CARAVAN / CHALET PARK
- SPECIAL USE
- SPECIAL USE DENOTED AS FOLLOWS
  - A ABATTOIR
  - AEV ARTISANS' VILLAGE
  - AGC PROCESSING OF AGRICULTURAL CHEMICALS
- SPECIAL USE DENOTED AS FOLLOWS
  - ETC EMPLOYMENT AND TRAINING CENTRE
  - G GARDEN CENTRE
  - K KENNEL
  - MLFC MASONIC LODGE AND FUNCTION CENTRE
  - P PORNOGRAPHY
  - RC RECREATIONAL CLUBROOMS
  - RH RECREATION HALL
  - RRH&H RESIDENTIAL RESORT, RESTAURANT & HOME HOOCH
  - RTTR RESIDENTIAL HORSE TRAINING, TROTTING AND RACING
  - S STABLE
  - SR SINGLE RESIDENTIAL
  - SS SERVICE STATION
  - SSLB SERVICE STATION & BOAT DISPLAY
  - SSS SERVICE STATION & SHOP
  - TD TOURIST DEVELOPMENT
  - V VARIOUS - SEE SCHEME TEXT
  - X PLACES OF INTEREST
- PRIVATE CLUBS AND INSTITUTIONS
- PRIVATE RECREATION DENOTED AS FOLLOWS
  - PR PRIVATE RECREATION
- INDUSTRY
- FARMLET
- HILLS LANDSCAPE PROTECTION
- RURAL
- SPECIAL RURAL

OTHER

- R CODES
- ADDITIONAL USES
- SCHEME BOUNDARY
- LOCAL GOVERNMENT BOUNDARY
- TOWNSITE - LAND ACT
- PLACES OF LANDSCAPE VALUE (SEE SCHEME TEXT)
- FLOODPRONE AREAS (100 YEAR FLOOD)
- SPECIAL RURAL AREA (SEE SCHEME TEXT)
- PEEL HARVEY COASTAL PLAIN CATCHMENT AREA (SEE SCHEME TEXT)
- HILLS LANDSCAPE PROTECTION AREA (SEE SCHEME TEXT)
- PLACES OF HERITAGE VALUE (SEE SCHEME TEXT)
- NO ZONE

EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

EXTRACT FROM SHIRE OF MURRAY TOWN PLANNING SCHEME No. 4

100m 0m 100 200 300m

22 JAN 2007| 03/148/FIG4

FIGURE 4

The ODP proposed that the then rural landholding be redeveloped for the purposes of a predominantly residential golf course estate with riverside tourism facilities. Key features of the plan included:

- Two main residential cells located east and west of the transmission lines that traverse the site along a north-south alignment.
- An golf course, interwoven through the residential planning cells.
- A predicted yield of 1,200 lots, with a lot product mix as follows:

Lot Type	Characteristics	Density
Special Residential	1,500-2,000m²	R10
Golf Course Frontage	700-800m²	R12.5-R15
Park Frontage	700-800m²	R12.5-R15
Vacation/Tourist	333-450m²	R30
Strata Lots	3,000-10,000m²	R30
Conventional	700-800m²	R12.5-R15
Aged Persons/Retirement	10,000m²	R30-R40

- A Neighbourhood Centre with a maximum retail floor area of 1,400m² Net Lettable Area.
- An open space network which predominantly comprised:
  - Golf Course 150 ha
  - Foreshore Reserve 30 ha
  - Aboriginal Sites 9 ha
  - Theme Park 9 ha
- Public Open Space, while not clearly defined, was expressed as meeting the minimum 10% contribution.

3.3.4 *Ravenswood Sanctuary Revised Outline Development Plan*

Following WAPC and Shire approval of the initial Ravenswood Sanctuary ODP, and conditional approval of the initial stage of subdivision in March 1997, a revised ODP was prepared and lodged in October 1997 proposing modifications to various elements of the overall Plan. A further revised ODP was later lodged in July 2002 (shown at **Figure 3**), which implemented significant changes to the portion of the Plan east of the Western Power easement. It is understood that the purpose of the ongoing revisions was to; respond to market forces relating to the proposed lot product, rationalise the public open space provision and layout, and improve connectivity between the various development components.

Ongoing subdivision and development of the Estate, until the most recent Stages 6 and 8, has been in accordance with the various revisions of the Ravenswood Sanctuary ODP.

3.3.5 *Past and Existing Subdivision Approvals*

As previously discussed, a number of Stages (being 1 – 5, 7, 8 & 9) of the Ravenswood Sanctuary Estate were approved for subdivision and developed under the Ravenswood Sanctuary ODP.

During the current revision of the ODP, it has been necessary to ensure that a sufficient supply of lots be maintained to fund ongoing works at the Estate. To this end, it became necessary to pre-emptively lodge applications for Stage 6 and Stage 8 of the (now named) Murray River Country Estate. Both Stages have been strategically chosen and designed to fit closely with the original Ravenswood Sanctuary ODP, whilst not compromising the future planning of the balance of the Estate. The subdivision layouts of these Stages are generally in accordance with the original ODP, but importantly also make some improvements in recognition of the improved design philosophy of the revised MRCE ODP.

Stage 6 of the Estate was issued conditional subdivision approval by the WAPC on 18 September 2006, and Stage 8 on 31 October 2006.

4.0 EXISTING ENVIRONMENT

4.1 Existing & Surrounding Land Use

The ODP area is currently vacant land. The ODP land has historically been used for wheat production associated with Coopers Mill (until approximately 1910) and stock grazing, and this, in conjunction with activity associated with development of initial stages of the Ravenswood Sanctuary Estate, has resulted in extensive clearing of the property.

The aerial photo at **Figure 5** shows the site and its surrounding context. Immediately adjacent the ODP area to the east is the Peel Zoo, an interactive wildlife sanctuary with associated bird park (these form part of the overall estate). Also located within this area, between the ODP land and the Murray River, is the Redcliffe Barn restaurant / café and Murray River Conference Centre.

To the immediate south of the initial stages of the Ravenswood Sanctuary Estate is Pinjarra Golf Course, which is 2 km north-west of Pinjarra town centre on Pinjarra Road.

4.2 Access

4.2.1 Regional Transport

Regional Road System

A number of regional road initiatives have the potential to impact on access arrangements for the Murray River Country Estate ODP, as follows:

- The Western Australian State Government has recently signed an AusLink agreement with the Commonwealth Government to secure $170 million in funding towards the construction of the Perth-Bunbury Highway/Peel Deviation (extension of Kwinana Freeway south of Safety Bay Road). The roadworks associated with this infrastructure are planned to commence in 2006. This highway will have an interchange at Pinjarra Road, approximately 5 kilometres west of the ODP area.

  However, due to a variety of issues relating to the potential for several interchanges to be constructed south of Pinjarra Road (including Beacham Road), as well as the recognition of the future urban development potential on both sides of the Peel-Bunbury Highway alignment, an access investigation study (cosponsored by the Shire of Murray and Main Roads Western Australia) has commenced which is currently addressing issues such as land requirements for these interchanges, potential increases in traffic within the immediate area (including that generated by the Murray River Country Estate) as a result of future urban development and the potential need to designate the highway as a High Wide Load corridor.

- Project traffic consultant, Transcore, has reviewed the brief for the current Main Roads Western Australia project, Pinjarra Road: Perth-Bunbury Highway (Mandurah) to South Western Highway (Pinjarra Road) – Intersection and Access Strategy, and has maintained regular contact with both MRWA staff and the appointed consultant. Discussions with both MRWA and the consultant have indicated the outcomes of the study could potentially impact the access arrangements for the Murray River Country Estate ODP area, however at the time of the preparation of the ODP, this project has not yet been completed.

- In addition, under the existing Peel Region Scheme, a Primary Regional Road (Red Road) reservation has been denoted at the western boundary of the ODP, to the south of Pinjarra Road, to function effectively as a by-pass of the Pinjarra Town Site, linking Pinjarra Road to the South-Western Highway.

  The Peel Region Scheme, however, is currently undergoing a detailed review process and preliminary discussions with DPI, the Shire of Murray and Main Roads WA have indicated that the alignment of this red road immediately south of Pinjarra Road is likely to be changed and/or reservation removed at its intersection with Pinjarra Road - as there are significant implications with respect to the proposed signalised main access to the Town Centre within the Western Subdivision on the north side of Pinjarra Road. Under existing conditions, this main access is intended to align with the existing Beacham Road, which would form the southern leg of this intersection at Pinjarra Road.

Regional Public Transport System

The New MetroRail (South-West Metropolitan Rail) project is planned for completion in mid-2007 with the southern terminus at Mandurah, some 15 km to the west of the ODP area. This public transport service will provide 30-minute rail service in the off-peak periods and 15-minute service in the peak periods between Mandurah and the Perth CBD. It is anticipated that local bus services along Pinjarra Road will be expanded to serve built-up communities east of Mandurah, and to provide a feeder service to the rail station. However, details relating to this potential upgrade are not available at this time.

4.2.2 *Local Transport*

4.2.2.1 Local Road System

The Murray River Country Estate ODP area is bounded to the south by Pinjarra Road; to the east by the existing Pinjarra Golf Course and Murray River; to the north by the Murray River; and to the west by a Western Power easement corridor and vacant land.

Pinjarra Road is a four-lane divided carriageway with a posted speed of 80 km/hr in the vicinity of the ODP area. The existing speed limit west of the ODP area is 100 km/hr. It has been classified as a Primary Regional Road in the Peel Region Scheme (PRS). The existing traffic volumes on Pinjarra Road are approximately 12,500 vpd.

In the vicinity of the eastern Western Power Easement, which bisects the ODP area, there is an existing locational difference in gradient where the eastbound (near/north side) section of Pinjarra Road is elevated above the westbound (far/south side) section. Pinjarra Road operates under the jurisdiction of Main Roads Western Australia.

Sutton Street (located within the eastern section of the ODP area) is an existing wide two-lane divided local road, which intersects with Pinjarra Road at a stop-controlled 4-way intersection, with Moores Road functioning as the southern leg of the intersection. Sutton Street is operated under the jurisdiction of the Shire of Murray. This road currently serves the existing golf course and the constructed residential dwellings within the ODP area, and functions as the only access to the existing Ravenswood Sanctuary Park area, which is located at the north-eastern corner of the ODP.

4.2.2.2 Local Public Transport

Due to the location of the ODP area outside the general Metropolitan Perth Transperth service boundaries, there is currently no significant level of public transport servicing the area. At present, conventional Transperth bus services along Pinjarra Road (Route 163) terminate approximately 7.5 km to the west of the ODP area in the suburb of Furnissdale.

In 2004, the Minister for Planning and Infrastructure approved a trial weekly (Thursday) public transport shuttle bus service between North Pinjarra and the Centro Mandurah shopping centre, providing service inbound to Mandurah in the morning and the outbound return trip to Pinjarra in the afternoon via Pinjarra Road. Following from the introduction of this trial service, an extended fortnightly service to include Yarloop and Waroona was added. Both services currently only serve the established western area of Ravenswood, in the vicinity of the Ravenswood Hotel, with a stop at Nancarrow Way/Pinjarra Road (some 2 km to the west of the ODP area). This service is currently provided by a private charter bus company, and the viability and funding associated with continuing this service will be reviewed by the Department for Planning and Infrastructure.

4.3 Landform

Much of Lots 9008 and 331 Pinjarra Road have been significantly modified from their natural state, by past land use activities, such as stock grazing, the development of the golf course development, and recent urban development. This has resulted in extensive clearing, trampling and grazing of native vegetation, changes in soil nutrient status, introduction of weed species, creation of artificial waterbodies and modifications to the natural drainage system.

The site features two broad landforms; a floodplain adjacent to the Murray River on the northern and eastern side of the landholding, and a larger area of higher elevation over the remainder of the site.

LEGEND

EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

OUTLINE DEVELOPMENT PLAN CONTEXT

200m 0m 200 400 600m

22 JAN 2007 | 03/148/FIG5

FIGURE 5

The lower floodplain area ranges from 2m to 5m AHD, with wetlands in the form of ox bow lakes (remnant river channels) and surface expressions of the groundwater occurring along the river's edge. The higher portion coincides with the Bassendean dune system and lies at an elevation of between 5m to 11m AHD, with the highest peak in the south eastern corner of the ODP area. A reasonably pronounced sloping zone ranging between 3m to 5m AHD separates the two basic landforms.

Areas of existing natural vegetation consist of single species assemblages such as Spearwood (*Kunzea ericifolia*), which indicates previous clearing and grazing history. In some areas only the mature overstorey exists, whilst much of the understorey exhibits characteristics of post clearing regeneration.

The visual amenity is varied, however the site is generally of a rural parkland appearance on a relatively flat plain, with the riverine landscape to the north and eastern boundaries where the Murray River meanders. The Murray River is a unique element of the site that provides a natural habitat for wildlife and an area for passive recreation. The river is lined by remnant vegetation of flooded gum (*Eucalyptus rudis*) that stabilise the river banks and add to the character of the riverine landscape. The raised areas of the site offer views over the alluvial plain of the river and to the Darling Range in the east and south east. This natural elevation will be an asset for the future amenity of the site.

4.4 Environment

The Environmental Report prepared by Ecoscape is provided at **Appendix 1** and summarised below.

4.4.1 Watercourses

The Murray River is an important and major natural feature that is located along the northern and eastern boundary of the ODP area, and covering a distance of over 9km, as mentioned previously. The Flooded Gum (*Eucalyptus rudis*) forms a narrow woodland fringe on the riparian margins of the river. This species contains a large number of stately mature specimens that contribute to the amenity of the area. A number of relic natural drainage channels are present around the perimeter of the site. In the south western corner of the site there is an ephemeral creekline about 570 meters in length that has been mapped by Hill et al (1996). It runs from the Murray River to the north of the site and into adjacent property to the south. This section of creekline on the site may have been modified over time which is inferred by the linear morphology and the lack of fringing vegetation.

4.4.2 Wetlands

The Murray River Country Estate includes a variety of wetland types, including damplands, sumplands, palusplain and artificial wetlands. **Damplands** are seasonally waterlogged basins of variable shape and size where, for part or all of the winter-spring period, the water table is at or close to the ground surface. **Sumplands** are seasonally inundated basins, with most groundwater fed sumplands retaining surface water between at least August and December. **Palusplains** are seasonally waterlogged flats.

The majority of the site is mapped Geomorphic Wetlands of the Swan Coastal Plan dataset as palusplain (82%) and the remainder as sumplands (12.5%) and damplands (5.5%). The majority of the palusplain has been cleared or impacted upon through cattle grazing and other agricultural land uses.

Wetlands are assigned a management category that reflects their condition and environmental values (Hill *et al.* 1996).

Environmental Consultant ATA Environmental was first commissioned in 2004 to investigate the environmental opportunities and constraints of the site to guide the development of a revised ODP for the Murray River Estate.

The outcome of a preliminary survey undertaken by ATA Environmental (2004) indicated that:

- Extensive areas of the ODP area is defined by the Geomorphic Wetlands of the Swan Coastal Plan dataset as wetland, with the majority mapped as palusplain;
- A number of the wetland areas were incorrectly classified and need to be re-evaluated; and
- There are a number of boundary issues associated with the wetlands which will impact on the ODP area.

Subsequently, Ecoscape conducted a vegetation survey of the Murray River Country Estate to identify the presence of wetland dependent vegetation to determine if the site contained any wetlands of ecological significance. An assessment of the wetland management categories assigned by Hill *et al.* (1996) was also undertaken using EPA Bulletin 686 (1993d) to confirm if these management categories were applicable.

Geomorphic classification of the wetlands of the Swan Coastal Plain and was undertaken in 1996 by Hill *et al.* and from this work the management categories were assigned. A number of wetlands with a variety of management categories have been identified on the site including five wetlands that have been assigned a Conservation management category. The Department of Environment and Conservation's position on Conservation Category wetlands is no development (WRC, 2001).

The identification of these wetlands is based on the mapping and classification of wetlands by Hill *et al.* (1996). There are a number of known limitations to the Hill *et al.* (1996) study in that it relied heavily on aerial photography, only limited ground truthing was undertaken and broad principles were used to assign management categories to the wetlands. Thus it was deemed necessary to ground truth the study area and assess the wetlands to assign updated management categories based on the Environmental Protection Authority Procedure detailed in Bulletin 686 (1993d).

Wetlands within the study area were identified using the Unique Feature Identifier (UFI) from the Department of Environment and Conservation's Online Geographic Data Atlas. Areas of Palusplain within the estate have largely been cleared and wetlands within this area have been assigned a management category of Multiple Use (M). Areas in the centre of the estate which support native vegetation have been identified as Conservation (C) or Resource Enhancement (R).

It is also recognised that the Structure Plan area has been significantly modified by past land use activities such as stock grazing which has occurred for over 100 years. As a result, extensive vegetation clearing has been undertaken to accommodate stock grazing and artificial water bodies have been constructed for stock watering purposes.

An analysis by Ecoscape (2005) demonstrated that none of the Conservation Category wetlands were considered to be this category and consideration based on the assessment should be made for reassignment of the management category to **R** but also potentially Multiple Use (**M**) for wetland 5184, based on the poor quality of the vegetation. Also, consideration needs to be given to the removal of the wetland status of wetlands 5442 and 5443 that occur in FCT 21a. This community is more typical of upland vegetation that occurs on the Bassendean dunes and is not considered a wetland vegetation community (Gibson *et al.* 1994). For those wetlands that were not formally assessed the existing allocation of Resource Enhancement (**R**) and Multiple Use (**M**) appears to be appropriate for the remainder of the wetlands within the study area.

The analysis done by Ecoscape (2005) used Bulletin 686 to assess wetland values. This document has since been superseded by the *Protocol for proposing modifications to the 'Geomorphic Wetlands Swan Coastal Plain' dataset* (DEC, 2006). Therefore further survey work is being undertaken to justify changes in wetland classification and the possible removal of wetland status entirely, using the assessment procedures outlined in this document. If such work is undertaken it is likely that the DEC will take 3-6 months to re-assess these wetland categories.

Under the approved ODP most of the wetlands including Conservation and Resource Enhancement category wetlands were given approval to be cleared or modified for drainage and development purposes.

Under current policy the deletion (clearing and filling) of a Conservation Category wetland is likely to contravene the clearing provisions of the Environmental Protection Act. CCW's are identified as an Environmentally Sensitive Area (ESA) and therefore is likely to require a Clearing Permit.

4.4.3 Vegetation & Flora

4.4.3.1 Vegetation Complexes

The Murray River Country Estate is classified as being within the Swan Vegetation Complex, with a portion of the South West corner mapped as Bassendean - Central and South Vegetation Complex (Heddle *et al.*, 1980). These complexes are described by Heddle *et al.* (1980) below;

Swan Vegetation Complex

Fringing Woodland of Flooded Gum (*Eucalyptus rudis*) – Paperbark (*Melaleuca rhaphiophylla*) with localised occurrences of Low Open Forest of Swamp Sheoak (*Casuarina obesa*) and *Melaleuca cuticularis*.

Bassendean – Central and South Vegetation Complex

Vegetation ranges from a Woodland of Jarrah (*Eucalyptus marginata*) – Sheoak (*Allocasuarina fraseriana*) – *Banksia* spp. to a Low Woodland of *Melaleuca* spp., and sedgelands on the moister sites. This area includes the transition of Jarrah to Coastal Blackbutt (*Eucalyptus todtiana*) in the vicinity of Perth.

The EPA guidance for the Assessment of Environmental Factors No. 10, which looks at the level of assessment for proposals affecting natural areas within the System 6 region, is based on a standard level of vegetation retention of at least 30% of the pre – clearing extent of ecological communities. It is the EPA's position to "preferentially locate developments in cleared areas, particularly where 30% or less of the pre-clearing extent of the ecological community remains".

Both the Swan Complex and Bassendean Central and South Complex remain at less than 30% of their pre-clearing extent at 15.6% and 27% respectively (EPA, 2003). Despite the finding that most of the Murray River Country Estate better fits the description of Bassendean Central and South complex there is still less than 30% of this ecological community remaining.

Much of the development area is on degraded rural land which conforms to the EPA's position in Guidance Statement 10 (2003). Most of the existing remnant vegetation is small and isolated although where feasible, remnants that contribute to linkages and fauna habitat and do not compromise the viability of the development, have been retained.

4.4.3.2 Vegetation Communities

In a vegetation survey of the site undertaken by Ecoscape (2005) fourteen different vegetation communities were defined for the vegetation within Murray River Estate. The descriptions of these are presented in Table 6 and the distribution of these units is presented in Figure 6.

The Swan Vegetation Complex is dominated by *Eucalyptus rudis – Melaleuca rhaphiophylla* woodland and vegetation that matched this complex on site was only found at vegetation units 8 and 11 in (Figure 6).

Bassendean Central and South is a broad vegetation complex that ranges from woodland of Jarrah/Marri-Sheoak-Banksia woodland to *Melaleuca* woodlands and sedgelands. These main structural units of this complex are evident throughout the Murray River Country Estate.

4.4.3.3 Floristic Community Types

The Floristic Community Type (FCT) of these mapping units was assessed using Gibson et al. data and three FCTs were defined for the project area. Melaleuca preissiana Damplands (FCT 4), Mixed Damplands (FCT 5) and Banksia attenuata – Eucalyptus marginata Woodlands (FCT 21a). FCT's 4 and 5 belong to communities of the seasonal wetlands and are both shrub rich damplands. FCT 21a belongs to the community types centred on the Bassendean System that are not considered wetland communities.

4.4.3.4 Threatened Ecological Communities (TEC's)

The three floristic communities identified on the site (4, 5 and 21a) are considered "well reserved", that is, they are known from at least two National Parks or Nature Reserves and with no risk to their conservation status (Gibson et al. 1994). Therefore no Threatened Ecological Communities pursuant to s182 of the EPBC Act 1999 were inferred from the vegetation units described for the project area.

4.4.3.5 Vegetation Condition

Vegetation Condition ranged from Excellent to Completely Degraded (Keighery, 1994) but the majority of the vegetation on the site was classified as very good, good or degraded. The vegetation communities have been altered due to agricultural land use.

4.4.4 Flora

As recommended in EPA Guidance Statement 51 (2004), a desktop search was undertaken of Department of Environment and Conservation's (DEC) databases for Rare and Priority Flora, along with Threatened Ecological Communities occurring in the area. The online *EPBC Act* list of TECs was also consulted.

As part of the field assessment a grid based search for declared rare and priority flora, and other flora of particular conservation significance was undertaken by Ecoscape in Spring 2005. This involved searches of areas proposed to be cleared under the revised ODP.

The Wetland Assessment Report (Ecoscape, 2005) (included at **Appendix 2** of this ODP document) presents the Declared Rare and Priority Flora that could have been potentially located within the Murray River Estate. A DEC database search identified 65 significant flora species within a 15 km radius of the Murray River Estate. Ten of these species were also found within 2 km of the project area and were found in swamps, damplands or along the Murray River. These species are listed in Appendix 1 of the Wetland Assessment Report, as they are more likely to occur in the study area were there is suitable habitat.

A total of 98 taxa from 76 genera and 34 families were recorded during the flora, vegetation and wetland assessments conducted at Murray River Estate. A total of 72 of these taxa were found within the vegetation quadrats and 44 of the total taxa were also recorded for the wetland sites. All of the 11 weed species recorded for the site at this time were located at the wetland sites. Only two of these weed species were also located in the vegetation quadrats (see appendix in Ecoscape, 2005).

A photographic record of all of the vegetation quadrats and wetland assessment sites is presented in Appendix 5 of the Wetland Assessment Report (Ecoscape, 2005).

4.4.4.1 Declared Rare Flora

Under the Wildlife Conservation Act, the Minister for the Environment may declare species of protected flora to be *Rare Flora* if they are considered to be in danger of extinction, rare or otherwise in need of special protection. Such species are referred to as Threatened Flora, and receive special management attention by DEC (DEC, 2005).

No Declared Rare Flora species, pursuant to Subsection 2 of Section 23F of the *Wildlife Conservation Act 1950* and listed by DEC were located during the survey. No Endangered or Vulnerable species, pursuant to s178 of the EPBC Act were located within the study area.

4.4.4.2 Priority Flora

Flora species that are known from only a few sites and have not been adequately surveyed are included on a supplementary conservation list called the Priority Flora List. These flora species may be rare but cannot be declared rare until a survey has been undertaken to adequately assess its conservation status.

There are three categories of priority flora covering these poorly known species. The categories are arranged to give an indication of the priority for undertaking further surveys based on the number of known sites, and the degree of threat to those populations. A fourth category of priority flora is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened (DEC, 2005).

A single Priority 3 Flora species, *Dillwynia dillwynioides* was located at Murray River Estate which was located in wetland 5043. Whilst it is not an offence to take Priority Flora, efforts should be made to maintain populations of these taxa as conservation codes are revised as situations change and further information comes to hand. In some instances species can be upgraded to a higher conservation code.

4.4.5 Fauna

4.4.5.1 Mammals

Mike Bamford Ecologists (1995) conducted a fauna survey for the Southern Brown Bandicoot / Quenda (*Isoodon obesulus fusciventer*) in four areas located near the powerline corridor in the study area. These survey sites are located within Floristic Community Type 4, a shrub rich community containing species such as *Pericalymma* and *Hypocalymma* providing dense ground cover and protection for the Quenda. At the time of this survey the Quenda was placed on Schedule 1 (endangered and liable to become extinct and therefore in need of special protection) of the *Wildlife Conservation Act*. Since then, the Quenda has been removed from this list and it is now listed as a Priority 5 species by the DEC. Priority 5 species are taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years. However the Quenda is not listed on the *EPBC Act* list of threatened species (DEH, 2006).

Twenty Quendas were caught with the majority of Quenda activity occurring in northwest area compared to the southeast that appeared not to support Quenda. Considering the level of disturbance at the site the population density is impressive and suggests that the site is particularly favourable to Quenda (Bamford, 1995). This area is proposed to be retained as part of the revised ODP and therefore no re-location of the Quenda is required compared with the previous ODP.

4.4.5.2 Avifauna

The site contains some water birds but their use of the site is not extensive as identified in the Wetland Management Plan by LeProvost, Dames and Moore (1998). The Ibis and Spoonbill species occur on a seasonal basis where there are open grassed floodplains. Furthermore, the previous land owner had undertaken a bird census and recorded some 64 species of avifauna in the past 30 years.

4.4.5.3 Reptiles

The retention of wetlands and native vegetation under the revised ODP will help to conserve the reptile species that are likely to occur on the site.

4.4.5.4 Amphibians

The retention of wetlands and native vegetation under the revised ODP will help to conserve the amphibian species that are likely to occur on the site.

4.5 Groundwater

The Groundwater Investigation prepared by JDA Consultant Hydrologists is provided at **Appendix 3** and summarised below.

4.5.1 Regional Geology and Hydrogeology

The surface geology at the site is generally comprised of two geomorphic elements which relate to the topography of the site. The low lying flood plain areas belong to the Guildford formation, while the central raised portion of land belongs to the Bassendean Dune System. In addition, alluvial deposits border the Murray River.

The Bassendean Sands form a surface cover over most of the site. This formation is comprised of sand generally 1-3m thick that forms gently sloping ridges and valleys creating natural drainage lines towards the Murray River.

The Bassendean Sand overlies the Guildford Formation, which consists mainly of reddish brown loams and clayey sand. Near the river this formation forms the surface layer as the Bassendean Sand is absent. Jandakot Beds lie below the Guildford Formation, and consist of a mixture of silty clay, sand and gravel. The Jandakot Beds overlie the Leederville Formation (URS 2003) which is unconformable.

Alluvial plains adjacent to the Murray River contain terraced drainage areas that slope down to the river.

The property is underlain in vertical succession by the following groundwater formations:

- Superficial formation (approximately 0 to 32m in depth);
- Leederville formation (approximately 32 to 150m in depth); and
- Gage Sandstone and Cockleshell Gully Formation (below approximately 150m in depth).

The superficial formations contain fresh (Bassendean Sand) to brackish (Guildford Formation) groundwater which discharges towards the Murray River. The water table is shallow, with a seasonal variation of up to 2m. For further groundwater details see the below Section 'Groundwater Levels'.

Groundwater in the Leederville formation in the Ravenswood-Pinjarra area is generally fresh (approximately 500 mg/L Total Dissolved Solids). Locally, the aquifer has a potentiometric head of about 4 to 6m AHD, so that the groundwater generally rises to within a few metres of the ground surface. The direction of groundwater flow in the Leederville formation is towards the west (URS 2003).

4.5.2 Drainage

The presence of the river terraces constrains runoff from entering the river in average rainfall years, but would be overtopped in flood events. As a result some of the site is poorly drained and remains inundated during winter and damp in places during summer. There are few natural drainage lines on the property since a majority of the rainfall soaks into the Bassendean sands and the sandy alluvial terraces on the floodplain.

A number of natural and man made soaks occur at the edge of the Bassendean Dune system which are fed by superficial groundwater flow throughout most of the year. The border between the two soil types is damp during a majority of the year. The low lying flood plain is largely impermeable and water drains into natural impermeable depressions and ox bow lakes. Much of the western part of the Bassendean sands on the site also remain inundated during winter (LeProvost Dames and Moore 1998a).

The water table within the superficial aquifer is shallow, generally less than 2 m in winter and 3 m in summer. In some locations, especially on the western side of the site, groundwater levels reach natural surface.

Land to the west of the Western Power easement may become saturated at the surface as a result of poor drainage characteristics.

4.5.3 Groundwater Monitoring and Production Bores

Two groundwater exploration programmes associated with the development have been completed. The shallow peizometers were installed in February/March 1995 in two stages and have been monitored since May and October 1995. In April/May 1997 two Leederville formation test production bores (PB1 and PB2) and multi-level peizometers (OBS1 and OBS2) were installed, test pumping occurred and aquifer parameters were derived (URS 2003).

4.5.4 Licensed Groundwater Abstraction

A groundwater licence exists for the site for groundwater abstraction for the purpose of irrigation. This groundwater licence was issued for the Lower Leederville aquifer.

The depth at which water is abstracted is significantly deeper than the superficial aquifer. It is therefore expected that the abstraction will have negligible effect on the superficial aquifer water levels. Monitoring performed agrees with this assessment (URS, 2003).

The Groundwater Licence is for 250,000 kL/yr and the period 2001 to 2003 used only approximately half this volume for the early stages of development, including the watering of a 3 hole golf course.

No subsequent aquifer review reports have been produced, but JDA is preparing a proposal to bring the licence reporting up to date.

4.5.5 Water Management to Date

The original Water Management Proposal is described in the Nutrient and Irrigation Management Plan (NIMP) for Ravenswood Sanctuary Resort (URS 1998). The NIMP describes that the groundwater would be abstracted from the Leederville Formation to supplement the water level in the lakes which form along an old river channel of the Murray River roughly at the 100 yr flood level. Lake 1 at the southeast corner was to overflow progressively through to Lake 7 and flow to the Murray River via a dethridge wheel.

There was proposed to be some recycling of this water prior to discharge to the Murray River. Bore water would therefore be lost to evaporation from the lakes and to evapo-transpiration on the irrigated areas. The Licence covers both these uses.

This water management process would tend to elevate the water table within the lake chain in summer months.

To our knowledge this proposed continuous flow of water through the chain of lakes with discharge to the Murray River has not occurred. Rather, the bore has been used to supplement Lake 1 for irrigation of the first stage of the golf course, comprising 3 holes.

4.5.6 Groundwater Levels

This section analyses the water levels measured in the superficial aquifer monitoring bores to deduce the Average Annual Maximum Groundwater Level (AAMGL) and Average Annual Lowest Groundwater Level (AALGL) contours.

To collect further information on groundwater levels, a survey was conducted of open waterbody levels in May 2006 through the lake system. Rather than performing a correction to a longer term monitoring bore located nearby, long term monitoring data collected within the landholding from March 1996 to May 2006 has been used directly to calculate AAMGL and AALGL.

From the monitoring completed during March 1996 and June 2006 the following conclusions can be made:

- Depth to groundwater is generally less on the western edge of the site than on the eastern side because the surface levels are generally higher on the eastern side (DP 2005).
- Groundwater depths on the western side were found to range from 0.1m (RS9) to 2.52m (RS2).

- Groundwater depths on the eastern side were found to range from 0.2m (RS12) to 6.53m (RS21).

As expected, the greatest variation in groundwater levels occurs near to the rivers edge with the western side experiencing a median rise between AALGL and AAMGL of 1.42m (median RS1 and RS2) and the eastern side a median increase between AALGL and AAMGL of 0.92m (median RS4, RS5, RS20 RS21). Bore RS3, located at the furthest end of the wetland/lake sequence, where water is discharged to the Murray River had the largest water table variation of 1.95m. The upper reaches on the eastern side experience a rise between AAMGL and AALGL of 1.22m and the western upper region, a rise of 0.93m.

Groundwater levels come within 1m of the natural surface in winter at bore locations RS1, RS3, RS7, RS9, RS10, RS12, RS14 and RS16s. Summer groundwater levels are less than 1m of the natural surface at bores RS9, RS16s.

When vertical transects are taken through the property, they show AAMGL approximately at natural surface in some areas, corresponding with the existence of wetlands.

4.5.7 *Controlled Groundwater Levels*

To facilitate land development it is desirable to install subsoil drainage at a level below AAMGL within the zone of seasonal groundwater variation to minimise imported fill requirements. The average difference between AAMGL and AALGL is approximately 1m and therefore we consider a controlled groundwater level 0.5m below AAMGL is appropriate.

To mitigate any possible impacts from Acid Sulphate Soils, discussions with DoE (Stephen Wong *pers. comm.)* have indicated that installation of subsoil drainage within the zone of seasonal variation is acceptable in principle. There is no policy document on this but it is consistent with the soil profile being aerated annually between the summer and winter levels so that it is already oxidised therefore having negligible risk of additional acid generation.

It is important that the CGL does not impact adversely on significant wetlands on the site which are to be retained in the revised ODP. To maintain the natural hydrology in and around the wetlands and to minimise drawdown effects from drainage on wetland water levels, a 100m drainage buffer is recommended around the perimeter of all wetlands to be retained under the revised ODP.

4.6 Indigenous Heritage

An archaeological and ethnographic survey of the subject land and surrounding area was undertaken as part of the Ravenswood Sanctuary ODP preparation. A meeting on site between the consultant team and two local Aboriginal Elders, Mr Joe Wally and Mr Frank Nannup, was held to review the results of this survey. A plan showing the existence of two aboriginal heritage sites (being S02229 and S02230) was approved by Mr Joe Wally, and the report findings incorporated into the Shire of Murray Town Planning Scheme Amendment No. 72, which rezoned the ODP site to 'Special Development'.

Site S02229, the Adam Road Camp 1, is listed on the Interim Register of Aboriginal Sites, and is located in the main outside the area for which the ODP is being prepared. The corner of the site which falls within the ODP area is reserved under the Peel Region Scheme, and is therefore protected from development. This is reflected in the ODP.

Site S02230, the Adam Road Camp 2, is listed on the Interim Register of Aboriginal Sites, and is located at that northern part of the site where the power easements meet the Murray River. This site, like S02229, is reserved under the Peel Region Scheme, and is reflected in the ODP.

5.0 CONSULTATION

The Murray River Country Estate ODP has been prepared in accordance with extensive research undertaken by a multi-disciplinary team of specialist consultants. Research methods have included site investigations, in-the-field studies, review of existing literature (both government policy and documentation associated with the former ODP), general desktop studies and various rounds of consultation.

Regular and ongoing contact has been maintained with the various relevant regulatory authorities throughout the preparation of the ODP. Agencies consulted to date have included; the Shire of Murray, the Department for Planning and Infrastructure (Peel), various branches of the Department of Environment and the Water Corporation.

In addition, the project team held a series of stakeholder workshops, the purpose of which was to establish a design brief; identify critical issues for resolution; formulate a design concept for the site and finally gain comment on the draft proposal. Key meetings included:

- Workshop with client group and members of consultant team – 2nd March 2005;
- Workshop with regulatory authorities, client group and consultant team – 20th April 2005
- Presentation of draft concept to Shire of Murray Elected Members – 20th September 2005;
- Presentation of draft concept to regulatory authorities – 3rd October 2005; &
- Final meeting with regulatory authorities prior to lodgement – 31st January 2006.

The critical issues and comments identified during these various meetings and during the investigative phase of works are summarised below.

5.1 Summary of Considerations

- MRCE located within future urban growth direction of Pinjarra. (Pinjarra townsite constrained to south, south-east and by river to north.)
- The residential estate, Riverland Ramble, to northeast of MRCE.
- Site 5 km from future bypass (15 minutes closer than Mandurah to Perth CBD once bypass in place).
- Discussions with Shire of Murray indicate support for development of MRCE continuing to northwest along Pinjarra Road, development front then to meet Riverland Ramble.
- MRCE has first right to refuse purchase of land to northwest.
- Four-way light-controlled intersection planned for land on southern side of Pinjarra Road into industrial estate. (Note to TBB: Zoning plan (TPS4) requires more context to be useful).
- Construction of bypass will be catalyst for development of regional facilities at the intersection with Pinjarra Road, i.e. regional rec and commercial (retail) hub.
- Shire of Murray will not support big-box retail development. Main street principles to prevail.
- TBB to follow up location of new rail link in proximity of MRCE, closest station. Is there to be a spur from the new Mandurah line?
- Strip development along Pinjarra Road, special residential has been knocked back as too intensive, no ribbon development between Furnissdale and Pinjarra proper.
- Cottage industry, business park earmarked for land between bypass and Pinjarra Road – south of Riverland Ramble.
- Karkula – possibilities for expansion? Landowner has expressed desire for such.
- Rezoning required under local scheme to be more reflective of actual uses at MRCE as land taxes are predicated on current blanket zoning.
- Pinjarra Thunder Hockey Club makes use of sports oval. 300-400 people per fortnight.
- Opportunity to undertake a land swap with Pinjarra golf course. MR to develop golf course and hand over. President of golf club was interested in prospect but no further action taken.
- Policy implications, key issues:
- 1:100 year flood events
- DoE wetland classifications
- Liveable Neighbourhoods
- Acid sulphate soils
- Drawing people to the river is important; therefore eastern link to river is critical.
- Perhaps consider putting village centre by the river.
- Leeuwin Estate type event – icon event.
- Need accommodation close to river nodes.
- Indigenous camp is an international drawcard.

- Need to set aside a site for major institutional employment facility in the district (north-west corner of the site is suitable). Peel Waterways Institute is one option.
- Estate needs an exposure on the Pinjarra Road focus.
- Need to look at a facility on the eastern-most peninsula.
- Boat ramp is a good idea to meet future boating needs
- Need to procure a key office development.
- Provide a range of lot sizes.
- Keep the country town character with larger lots.
- The land is considered strongly as being part of Pinjarra.
- What will golf course be replaced with?
- Ravenswood settlement on banks of River located 3 km east.

PART TWO

6.0 PROPOSED OUTLINE DEVELOPMENT PLAN

The Outline Development Plan (refer to **Figure 6**) proposes a predominantly residential land use with densities ranging from R10 through to R60. Complimentary uses are also proposed to support of the resident population and for the benefit of the wider Pinjarra community. These complimentary uses include a range of retail and commercial uses, education, a tourism precinct; and a range of public open spaces for general use and conservation.

The Outline Development Plan and Report has been modified from the original submitted to Council. In accordance with its resolution of 27 September 2007, Council required various specific modifications to the ODP prior to it being advertised. Murray Riverside Pty Ltd has made these modifications, which include a number of management plans and other requirements, for the purpose of allowing the ODP to proceed to advertising.

6.1 Integration of ODP into Existing Planning Framework

The ODP area is zoned 'Special Development' in accordance with the Shire of Murray Town Planning Scheme No. 4. The provisions of TPS No. 4 require that the preparation and adoption of an ODP is a precursor to the 'Special Development' zone.

In accordance with existing Scheme provisions, landuse permissibility within any part of the ODP area is in accordance with the generic provisions of Table 1 for the 'Special Development' zone.

In accordance with Table 1, the following uses may be contemplated within the 'Special Development' zone and therefore within the Murray River Country Estate ODP.

- Single House
- Attached House
- Aged or Dependant Persons Accommodation
- Ancillary Accommodation
- Home Occupation
- Caretakers House
- Retirement Village
- Residential Hotel
- Lodging House
- Chalet Park
- Caravan Park
- Camping Area
- Bed & Breakfast Accommodation
- Park Home Park
- Hotel
- Motel Tavern
- Wine Shop
- Liquor Store
- Licensed Restaurant
- Shop
- Restaurant/Café
- Take Away Food Outlet
- Car, Caravan hire
- Car Park
- Service Station/Petrol Filling Station
- Bank
- Office
- Consulting Rooms
- Medical Clinic
- Showrooms
- Dry Cleaning Agency
- Funeral Parlour
- Hardware Outlet
- Hire Outlet
- Landscape Supplies
- Garden Centre
- Laundromat
- Cottage Industry
- Day Care Centre
- Kindergarten
- Health Centre/Studio
- Infant Welfare Clinic
- Public Amusement
- Place of Public Worship
- Place of Public Assembly
- Civic Building
- Public Utility
- Private Club
- Family Day Care Centre
- Rural Pursuit
- Garden Centre

This generic range of uses is supplemented by the provisions of Schedule 7 which allow for the specification of a range of additional uses (as well as specific provisions and development controls) for an individual ODP area. In relation to the MRCE ODP area, the existing provisions of Schedule 7 are based on the Ravenswood Sanctuary Outline Development Plan (which is intended to be replaced by the current proposed MRCE ODP).

Schedule 7 permits the following uses specific to the ODP area:

- Car/Caravan Hire
- Educational Establishment
- Bird Sanctuary
- Health Retreat
- Equestrian Training Facility
- Convention Centre
- Golf Course/Club House
- Boat Hire
- Helipad
- Theme Park

Although the existing provisions of the Scheme allow for a relatively broad range of uses to be developed on the subject land, there is a key flaw inherent to the current standard development control mechanisms offered by the Scheme:

1. There is no guidance provided by the Scheme as to where, geographically, the various uses may be developed. Therefore any of the aforementioned uses could be considered across the ODP area without any strategic application. That is, the Scheme does not appear to specifically provide for precinct planning.

Accordingly implementation of the ODP will require an approach that allows precinct planning to be undertaken and controlled within the existing statutory framework.

6.1.1 *Land Use Precincts*

It is not practical or desirable to rezone the site to reflect each individual land uses proposed under the ODP. Doing so would restrict the ease of implementation of the ODP over time by rendering it inflexible. It would hinder the ability to easily contemplate minor departures, modification or redesign and would require a Scheme Amendment to change even the simplest landuse boundary. Essentially, it would mean locking in the ODP design and exact landuse boundaries at the 'broad brush' level, before the detailed design stage.

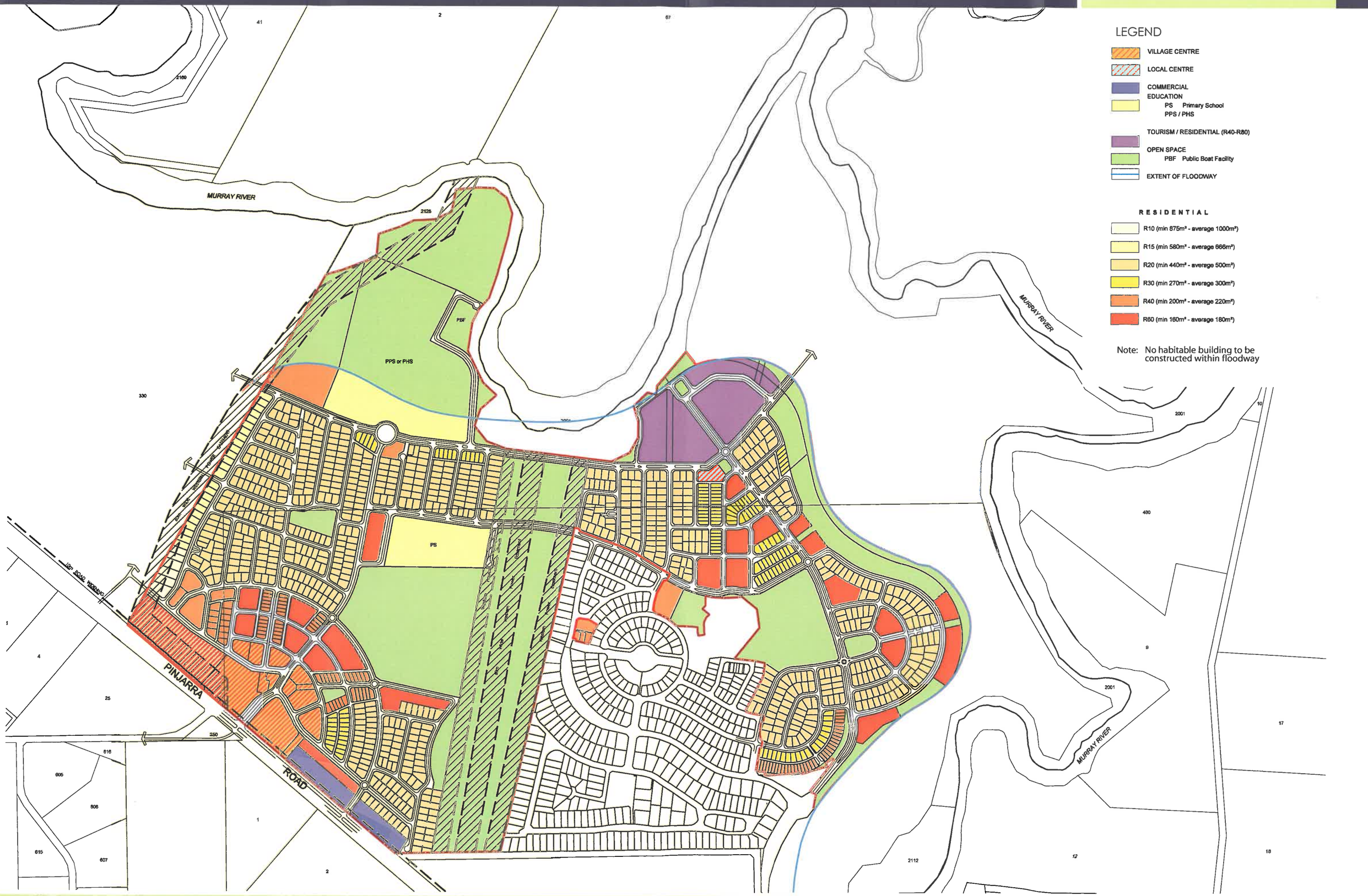
Also, it is likely that in order to rezone the site to reflect the landuses shown on the MRCE ODP the introduction of new zones to the Scheme would be required. This observation is made on the basis that the Scheme is dated and does not include contemporary landuse zones such as those included in the Model Scheme Text.

We believe the most appropriate and straightforward approach to achieve the development intended by the ODP, is to maintain the 'blanket' Special Development zone over the ODP area (so long as Scheme No. 4 remains current) and introduce a series of land use precincts to the ODP to administer landuse and development intent specific to each individual precinct. This will ensure that areas with distinct character and function are able to be developed.

The proposed land use precincts are:

- Local Centre
- Village Centre
- Commercial
- Education
- Tourism/Residential (R40-R60)
- Open Space
- Residential
  - R10
  - R15
  - R20
  - R30
  - R40
  - R60

Each of the proposed land use precincts will be described in the subsequent sections of this report. The description of development desired for each precinct along with an associated preferred landuse table will guide the Shire of Murray in considering future development within the estate.



MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

FIGURE 6

Land uses included under Table 1 have been assessed in terms of their appropriateness within each of the various land use precincts, and where additional uses should be contemplated (by virtue of the broader intent and character sought for each precinct) then these will also be specified in each landuse precinct table. Likewise, uses that are permitted in the Special Development zone of the Scheme but are not appropriate to a particular precinct may be excluded within the relevant precinct table.

6.2 Preferred Uses and Development

Notwithstanding uses and development classes identified in Table 1 – Zoning Table of the Scheme and in Schedule 7 'Special Development Zone', the uses and development classes considered appropriate for the land are as follows:

6.2.1 *Local Centre Precinct*

The 'Local Centre Land Use Precinct' is intended to accommodate small scale businesses together with a mixture of residential development in a primarily residential scale environment. The predominant uses will be convenience retail, local offices and or community uses. Residential development will be actively encouraged particularly where such development is built above, or ancillary to, a retail or office use.

Land Use Permissibility

Land Use Permissibility in the 'Local Centre Land Use Precinct' shall be in accordance with the following table:

Landuse	Landuse
Hotel	Consulting Rooms
Motel Tavern	Medical Clinic
Wine Shop	Dry Cleaning Agency
Liquor Store	Laundromat
Licensed Restaurant	Cottage Industry
Shop	Day Care Centre
Restaurant/Café	Kindergarten
Take Away Food Outlet	Health Centre/Studio
Bank	Infant Welfare Clinic
Office	Public Amusement
Mixed Use	Place of Public Worship
Civic Building	Place of Public Assembly

6.2.2 *Village Centre Precinct*

The 'Village Centre Land Use Precinct' is an activity 'hub' and is intended to accommodate a range of retail, office, community, hospitality, health services, education and residential uses. Residential development will be encouraged where such development is built above, or ancillary to, another use (mixed use development).

Land Use Permissibility

Land Use Permissibility in the 'Village Centre Land Use Precinct' shall be in accordance with the following table:

Landuse	Landuse
Residential Hotel	Educational Establishment
Lodging House	Mixed Use
Bed and Breakfast Accommodation	Consulting Rooms
Hotel	Medical Clinic
Motel Tavern	Showrooms

Landuse	Landuse
Wine Shop	Dry Cleaning Agency
Liquor Store	Funeral Parlour
Licensed Restaurant	Landscape Supplies
Shop	Garden Centre
Restaurant/Café	Laundromat
Take Away Food Outlet	Cottage Industry
Car, Caravan Hire	Day Care Centre
Car Park	Kindergarten
Service Station/Petrol Filling Station	Health Centre/Studio
Bank	Infant Welfare Clinic
Office	Public Amusement

6.2.3 *Commercial Precinct*

The 'Commercial Land Use Precinct' is primarily intended accommodate showrooms, trade and professional services and small scale complementary and incidental retail uses, as well as providing for retail and commercial businesses which require large areas such as bulky goods.

Land Use Permissibility

Land Use Permissibility in the 'Commercial Land Use Precinct' shall be in accordance with the following table.

Landuse	Landuse
Motel Tavern	Consulting Rooms
Wine Shop	Medical Clinic
Liquor Store	Showrooms
Licensed Restaurant	Dry Cleaning Agency
Shop	Funeral Parlour
Restaurant/Café	Hardware Outlet
Take Away Food Outlet	Hire Outlet
Car, Caravan Hire	Laundromat
Car Park	Day Care Centre
Service Station/Petrol Filling Station	Kindergarten
Bank	Health Centre/Studio
Office	Place of Public Worship
Civic Building	Place of Public Assembly
	Public Utility

6.2.4 *Education Precinct*

The objective of the 'Education Land Use Precinct' is to make specific provision for educational establishments within the Estate and may range from kindergarten, through primary and high school. Tertiary institutions may also be contemplated for the precinct. Education based facilities may be publicly or privately operated.

Child care, sporting facilities, cafes, public libraries, and incidental retail may occur within the 'Education Land Use Precinct' where it is ancillary to the predominant use of the site.

Land Use Permissibility

Land Use Permissibility in the 'Education Land Use Precinct' shall be in accordance with the following table:

Landuse	Landuse
Residential Building	Day Care Centre
Shop	Kindergarten

Landuse	Landuse
Restaurant/Café Educational Establishment Public Utility Private Recreation Family Day Care Centre	Infant Welfare Clinic Place of Public Worship Place of Public Assembly Civic Building

6.2.5 *Tourism/Residential (R40-R80) Precinct*

The objective of the 'Tourism /Residential (R40-R80) Precinct' is to make specific provision for a range of Short-stay accommodation, medium to high density residential, hospitality, tourism based retail, entertainment and recreation uses.

Land Use Permissibility

Land Use Permissibility in the 'Tourism/Residential (R40/80) Land Use Precinct' shall be in accordance with the following table:

Landuse	Landuse
Residential Hotel Lodging House Chalet Park Camping Area Bed and Breakfast Accommodation Hotel Motel Tavern Wine Shop Liquor Store Licensed Restaurant Shop	Consulting Rooms Medical Clinic Health Centre/Studio Infant Welfare Clinic Public Amusement Place of Public Worship Place of Public Assembly Civic Building Restaurant/Café Take Away Food Outlet Office

6.2.6 *Residential Precinct*

The 'Residential Land Use Precinct' is intended to promote a high quality residential environment by maintaining the quality and character of existing residential areas and providing for a range of residential densities and housing types throughout the Estate.

Within the Residential Precinct, a 'Residential Building' will only be considered where it is to accommodate boarding associated with an educational establishment.

Land Use Permissibility

Land Use Permissibility in the 'Residential Land Use Precinct' shall be in accordance with the following table:

Landuse	Landuse
Hotel Residential Building Bed and Breakfast Accommodation Bank Office	Consulting Rooms Cottage Industry Day Care Centre Kindergarten Public Utility Family Day Care Centre

6.2.7 *Open Space*

The 'Open Space Land Use Precinct' designates appropriate locations for district, neighbourhood and local open space reserves. The open space may be designated public open space for active or passive recreation, or a reserve for conservation or other public benefit, such as a recreational boating facility adjacent to the Murray River foreshore.

6.2.8 *Definitions*

For the purpose of this Outline Development Plan, 'Mixed Use' is defined as buildings that contain residential dwellings with commercial and non-residential land use components.

6.2.8.1 Development Standards

The development and subdivision standards that apply to the 'Residential Land Use Precinct' are as per the R Code density shown on the Outline Development Plan and the standards specified in Residential Design Codes.

6.3 Management Plans and Other Requirements

The developer shall prepare Environmental Management Plans detailed in this section to meet the following objectives:

i) to maintain and enhance the integrity, functions and values of the environment and water dependent ecosystems;

ii) maintain and enhance the quality of surface water and groundwater so that existing and potential uses, including ecosystem maintenance, are protected;

iii) to ensure environmental values of the Peel-Harvey Estuary are not adversely impacted by development and that development is consistent with the provisions of the Statement of Planning Policy No. 2.1: The Peel-Harvey Coastal Plain Catchment and the Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992.

The Environmental Management Plans shall be prepared and implemented to the satisfaction of the Shire of Murray and advice form other regulatory authorities as described below.

6.3.1 *Urban Water Management Plan*

Prior to any subdivision or development arrangements for the endorsed Urban Water Management Strategy Plan to implemented to the satisfaction of the Shire of Murray, on advice from the Environmental Protection Authority and Department of Water shall be established to protect water resources, provide street drainage and ensure that the rate, quantity and quality of water leaving the site will not adversely impact on the Peel Inlet-Harvey Estuary, or wetlands in the vicinity of the subject land.

6.3.2 *Wetland Management Plan*

Prior to any subdivision or development, arrangements for the endorsed Wetland Strategy Plan over the wetland areas and buffers to be implemented to the satisfaction of the Shire of Murray, on advice from the Department of Environment and Conservation (DEC) shall be established, to ensure that the wetland area and buffer are protected and managed in an appropriate and sustainable manner.

6.3.3 *Fire Management Plan*

Prior to any subdivision or development, a Fire Management Plan shall be prepared and implemented for the subject land to the satisfaction of the Shire of Murray, on advice form the Fire and Emergency Services Authority and DEC to reduce the threat to residents and fire fighters in the event of bush fire within or near the site.

6.3.4 *Mosquito Management Plan*

Prior to any subdivision or development, a Mosquito Management Plan shall be prepared and implemented to the satisfaction of the Shire of Murray, on advice from the DEC to identify mosquito nuisance, public health risks and management strategies. Notification of prospective purchasers by way of memorial on the title of proposed lots it to be undertaken to warn of the potential threat of viral infection from mosquitos.

6.3.5 *Fauna and Flora Management Plan*

Prior to any subdivision or development, a Flora and Fauna Survey shall be undertaken to the satisfaction of the Shire of Murray, on advice from the DEC. If any protected and/or threatened fauna or declared rare flora are identified through these surveys, a Flora and Fauna Management Plan shall be prepared to the satisfaction of the Shire of Murray on advice from the DEC to ensure the proper management, protection or relocation of specialty protected and/or threatened fauna within the development area.

6.3.6 *Pinjarra Road Traffic Management and Implementation Plan*

Prior to any subdivision or development, a Traffic Management and Implementation Plan addressing Pinjarra Road access shall be prepared and implemented by the proponent to the satisfaction of the Shire of Murray and on advice from Main Roads WA.

6.3.7 *Commercial Areas Traffic Management and Implementation Plan*

Prior to any subdivision or development, a Commercial Areas Traffic Management and Implementation Plan addressing but not limited to access arrangements for the village centre and commercial areas shall be prepared and implemented to the satisfaction of the Shire of Murray.

6.3.8 *Rehabilitation and Weed Management Plan*

Prior to final approval of the Outline Development Plan, a Rehabilitation and Weed Management Plan for the areas to be reserved shall be prepared and implemented to the satisfaction of the Shire of Murray, on advice from the Department of Water, to ensure that reserve areas are appropriately rehabilitated and weed free.

6.3.9 *Developer Contribution and Staging Plan*

Prior to any subdivision or development, the proponent is to prepare a developer contribution and staging plan to the satisfaction of the Shire to ensure the proponent's appropriate and timely contribution toward service infrastructure and community facilities on a progressive and staged basis.

6.3.10 *Acid Sulphate Soils and Dewatering Management Plan*

Prior to commencement of substantial bulk earthworks, an Acid Sulphate Soils and Dewatering Management Plan shall be prepared and implemented to the satisfaction of the Shire of Murray, on advice from the DEC for the subject land, to identify 'actual' and 'potential' Acid Sulphate Soils and to determine appropriate management strategies for these.

6.3.11 *Construction Management Plan*

Prior to commencement of substantial bulk earthworks, a Construction Management Plan shall be prepared and implemented to the satisfaction of the Shire of Murray, on advice from the DEC, to ensure the protection of remnant vegetation, fauna and their associated habitat during construction.

6.3.12 *Ethnographic and Archaeological Survey*

Prior to commencement of earthworks, an Ethnographic and Archaeological Survey will be undertaken and the findings reported to the Shire of Murray and the Department of Indigenous Affairs.

6.3.13 *Boat Access to Murray River*

Any boat access to the Murray River shall be for non-powered boats only and established in consultation with the DPI, Environmental Protection Agency and the Shire of Murray.

6.3.14 *Detailed Area Plans*

Prior to any subdivision or development, the proponent shall prepare and submit to the Shire of Murray a Detailed Area Plan for the residential, neighbourhood and village centre precincts within which subdivision or development approval is being sought, prior to subdivision and development approval.

6.3.15 *Local Area Plans*

Prior to any subdivision or development, the proponent shall prepare and submit to the Shire of Murray Local Area Plans consistent with Liveable Neighbourhoods principles, Planning Bulletin 79 Designing Out Crime Planning Guidelines and which should be referenced in the ODP report and designs and shall be adopted by the Shire of Murray and forwarded to the Western Australian Planning Commission for reference for a particular development precinct prior to approval of subdivision or development within that precinct.

6.3.16 *Local Area Plans – Requirements*

A local Area Plan is to contain such detail as, in the opinion of the Shire of Murray, is required to satisfy the planning requirements of each development precinct and should include the following details:

i) the proposed internal and external road network;
ii) the proposed bicycle and pedestrian network;
iii) the relationship between residential, commercial, residential and community uses;
iv) buffering or similar treatment at the interface of different land uses and at the interface of the Outline Development Plan area and adjoining land;
v) buffering or similar treatment at the interface of development precincts and local distributor roads or significant local roads;
vi) the indicate lot layout;
vii) the lot yield;
viii) the average lot area and density;
ix) public open space provision and arrangements between different landowners, if required;
x) the landscaping strategy;
xi) drainage areas;
xii) density codings; and
xiii) provisions for land use and development control.

6.3.17 *Local Area Plans – Landscaping Strategies/Plans*

Landscaping strategies/plans that are considered along with a Local Area Plan shall include:

i) restoration of remnant vegetation in public open space areas, including the replacement of endemic understorey plant species wherein considered necessary, and management of weeds;

ii) the retention of paddock trees where practicable; and

iii) the provision of habitat for wetland bird species and rehabilitation of wetland areas, where appropriate.

6.3.18 *Local Area Plan – Process*

Upon receiving a Local Area Plan, the Shire of Murray is to determine either that the Local Area Plan is:

i) to be advertised for a minimum period of 21 days; or

ii) to be considered without advertising; or

iii) not to be advertised or considered until further details have been provided or modifications undertaken; or

iv) not satisfactory for advertising or immediate consideration and refuse it, with the reasons for this decision to be provided to the proponent.

If, after advertising or immediate consideration, the Shire of Murray determines the Local Area Plan to be consistent with the endorsed Outline Development Plan, the Scheme and the orderly and proper planning of the locality, the Shire of Murray may adopt the plan with or without modification and forward the Plan to the Western Australian Planning Commission for its noting.

A Local Area Plan shall be deemed to form part of this Outline Development Plan and a right of appeal in relation to an Outline Development Plan pursuant to the Scheme shall apply to any decision made by the Shire of Murray or the Western Australian Planning Commission in respect to a Local Area Plan.

6.3.19 *Inconsistency with Outline Development Plan and Management Plans*

i) Any changes to the subdivision design resulting from the findings of the above management plans shall be considered in the preparation of the relevant Local Area Plans.

ii) A Consolidated Residential Densities Plan may include plans or other documents, and in any case shall not be adopted by the Shire of Murray until the above are prepared and implemented to the satisfaction of the Shire of Murray and advice from other regulatory authorities.

6.3.20 *Commercial Areas*

Although this Outline Development Plan indicates up to 5000 m^2 GLA, only 1,400 m^2 can be developed until the Scheme is accordingly amended. Council reserves the right to request the proponent to prepare a plan that depicts alternate land use and development of the commercial area (for up to 3,600 m^2 GLA) as part of the Local Area Plan process.

6.4 Design Philosophy

The planning of MRCE sets out to create a variety of land use nodes and a strong relationship to the natural features of the land. The key land use nodes are located in the four corners of the site, and are complemented by the central open space system that runs between Pinjarra Road and the Murray River.

The existing tourist development in the southeast part of the site is planning to be enhanced with new facilities and attractions. This area will be directly linked to a new additional tourist oriented development area located in the northeast corner of the ODP area at the edge of the Murray River foreshore. The focus of the northern tourist node is to provide a comprehensive short-stay accommodation and hospitality attraction, which combines with the other tourist node to establish MRCE as an important regional tourist destination as part of the Pinjarra and Ravenswood experience.

The major landuse feature of the ODP is the Village Centre located in the south west corner on Pinjarra Road. The Village Centre is designed to serve a district function whilst being a gateway experience into the western half of the MRCE. The philosophy of seeking to create a largely self-functioning settlement is embodied in the design and proposed development and management of this activity centre. The provision for employment needs sits alongside the important hospitality and local consumer opportunities for cultural and social community engagement. The Village Centre plays a leading role in facilitating and fostering the formation of the 'contemporary rural community' vision.

Linking the Village Centre ad the northern tourist node is the education precinct containing a public primary school and a site for a private school for primary and secondary students. In conjunction with the existing community oval and sports facilities, the schools will also facilitate broader recreation needs for the community.

The opportunity for community interaction with the natural environment and landuse features of the MRCE is the final layer in providing a great place to live. Significant effort will be undertaken to implement the ODP vision of a place that caters for enjoyment by the full spectrum of the community. It is the combination of activities, services, leisure and recreation opportunities that underpins the achievement of the vision for the MRCE.

View looking north over the Village Centre

Village Centre streetscape

6.4.1 *Village Centre*

A market demand study was undertaken by Hames Sharley as part of the ODP preparation, in order to determine the retail potential for a Village Centre and Mixed Use site within the Murray River Country Estate. The objective of this analysis was to establish how much retail floor space such a centre could sustain. The recommendations of this study were that a 5,000m^2 supermarket-based Village Centre with supporting fresh food specialty stores and complementary Mixed Use development be proposed for that part of the Estate fronting Pinjarra Road. The study is summarised below, and a full copy of the report is available at **Appendix 4**.

The Peel Region's economy is driven by mining, manufacturing, building and construction, retail and tourism. Agriculture also makes a significant contribution to the region's diverse economy. In 2003/04, new business registrations increased by 8 percent over the previous year.

There is an opportunity for the Village Centre at MRCE to provide a range of retail services that the Pinjarra town centre is unable to offer. In the context of strong future residential growth in the area, the Village Centre will meet the demand for goods and services from existing and future residents, and its strategic location on Pinjarra Road will extend its area of influence beyond its Neighbourhood Centre function. In fact, keen interest has already been expressed to the developer of the MRCE in the retail floor space in the proposed Village Centre.

Liveable Neighbourhoods calls for an urban structure based on walkable, mixed use towns and neighbourhoods that have a community focus and offer a compatible mix of uses. The intent is to create complete integrated communities that promote a local identity and create a sense of place. The preferred urban form is main street mixed use centres that offer street frontage retail and high density residential with good access to public transport. The model is based on the premise that mixed use centres are inherently more socially, environmentally and economically sustainable and adaptable to change over time.

The Village Centre at MRCE will have more than a residential catchment; they will be defined by their accessibility and strategic location on Pinjarra Road that will encourage patronage from further afield than the local catchment area. The Centre will act as a catalyst for the overall development of the estate. It proposes a people-friendly environment that will offer a compatible mix of uses ranging from convenience shopping needs, community facilities and a place that will become a community focal point for the estate. It will also service the west Pinjarra special rural area.

To foster the best level of convenience, the centre falls within a walkable catchment of future higher density residential areas. Easy access and egress from Pinjarra Road provides shoppers from further afield with a destination for convenience purchases that precludes the need to visit Mandurah for these purposes.

Pinjarra itself will maintain its town centre status as it is an important service centre for the surrounding rural community and offers retail and business services, civic, tourism and service functions that are not available at lower order centres such as MRCE. These higher order functions will continue to attract shoppers and visitors to Pinjarra which will serve to maintain its primacy in the Shire of Murray.

The intention for the Village Centre is to create a people-friendly supermarket based centre that reflects the heritage environment of nearby Pinjarra. It will be a main street centre offering a range of uses that complement, rather than compete with, existing retail outlets and services in Pinjarra. The primacy of Pinjarra and the need to maintain this significant centre is recognised by the proponents of MRCE.

The MRCE Village Centre will be integrated with adjacent medium density residential development which will encourage pedestrian activity within the centre. The church, child care facility, open space and built form will create the sense of place that will make the Village Centre a destination for residents of the estate and for shoppers from further afield. The social and economic sustainability of the Village Centre relies on shoppers being able to satisfy their convenience shopping needs close to home in a well designed centre that creates a unique sense of place and identity. Co-location with higher residential density will create a level of activity in the Village Centre not experienced elsewhere in the region and adds to the critical mass that creates atmosphere and energy and a place people want to be.

The Village Centre will provide the convenience of professional and commercial services close to home and street activity during the day. Mixed Use developments attract non-retail uses such as dentists, medical suites, real estate offices and personal services with residential above street level. The inclusion of cafes and restaurants, the proximity to community facilities and the walkability of the centre will create activity after hours which further contributes to the sustainability of the centre.

A concept for the Village Centre is shown on **Figure 7**.

6.4.2 *Residential*

Residential lot design has been based on the principles outlined within 'Element 3 – Lot Layout' of Liveable Neighbourhoods, which aims to guide effective provision of housing density and diversity to allow housing choice and affordability in new urban developments. Accordingly, the ODP provides a mixture of lot sizes, located appropriately to ensure compatibility of uses across the Estate. A base density coding of R20 has been applied across the Structure Plan area. The R20 coding allows for a minimum lot size of 440m^2 and an average lot area of 500m^2.

Typical streetscape

LEGEND

- R20 Residential Housing
- R40 Residential Grouped Housing
- R60 Residential Grouped Housing / Multiple Dwellings
- Retail / Office / Commercial, with R80 Residential
- Showrooms / Bulky Goods Retail / Service Commercial
- Commercial / Showrooms / Hospital / Residential
- Civic / Community / Commercial

1. Traditional Country town 'Main Street Boulevard', with angled parking, wide footpaths, and street edge shops, forming a signalised 4-way intersection with Pinjarra Road.
2. 5000m of retail, with supermarket and specialty shops along an acarde and both sides of Main Street, on-site parking and servicing provided behind buildings. Potential to integrate residential and offices above retail.
3. Village Square edged by shops, restaurants and Village Hall.
4. Village Hall including cafe, for community use and functions.
5. Church situated in landscaped gardens at landmark location.
6. Mixed-use building with retail and office / residential.
7. Landmark Commercial building with possible office / tavern uses.
8. Rear parking area surrounded by commercial / medical / bulky goods retail development.
9. Highway commercial development with built form and landscaping directed by design guidelines to present attractive edge to Pinjarra Road.
10. Formal parkland at the edge of restored wetland.
11. Linear park containing seating, playgrounds, bbqs, and overlooked by residences to provide an attractive and safe direct connection for pedestrians and cyclist to the Village Centre.
12. Child Care Centre.
13. Use and development of commercial land to be determined subsequent to investigations for relocation of powerlines.
14. Diversity of housing choices provided throughout Village Centre, including single houses, townhouses, duplexes, villas and apartments.

MURRAY RIVER COUNRTY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

VILLAGE CENTRE CONCEPT PLAN

20m 0m 20 40 60m

22 JAN 2007 | 03/148/FIG7

FIGURE 7

6.4.2.1 Residential R20

A base density coding of R20 has been applied across the Structure Plan area, to allow a predominant product of single residential regular shaped lots. This density is compatible with current market demands in Pinjarra. The R20 coding allows for a minimum lot size of 440m² and an average lot area of 500m².

6.4.2.2 Residential R10 & R15

Areas of Residential R10 and R15 have been proposed adjacent to the Western Power Transmission Lines at the western boundary of the structure plan area. The R10 density permits a minimum lot size of 875m² and an average lot area of 1,000m², typically with dimensions of approximately 25m x 40m; while the R15 density allows minimum 580m2 and average 666m2 lots.

Whilst land use buffers are not technically required in this location, it is considered beneficial to maximise the separation between the various power easements and residential buildings. The R10 density and associated lot dimensions will facilitate an optimum level of separation for future residents.

6.4.2.3 Residential R30

Densities of R30 are strategically located in proximity to open space, and close to the key non-residential uses in the Estate, being the Tourism node; the school sites; and the mixed use and Village Centres nodes.

In proposing these increased densities around community and environmental assets the ODP aims to promote a more equitable urban structure, and to ensure that sufficient critical mass exists to support the provision of infrastructure in these locations. This strategic allocation of densities will also provide for increased accessibility and the promotion of a lively and vibrant community focus.

The R30 density allows a minimum lot size of 270m2, and an average lot size of 300m².

6.4.2.4 Residential R40

The R40 density coding permits a minimum lot size of 200m² and an average lot area of 220m². This is moderately dense in the context of Pinjarra and will generally comprise grouped dwellings (many of a 4-pack configuration), although single residential lots are also permissible.

The R40 medium density sites have been strategically located, in line with the same philosophies behind the design of the R30 sites, and in accordance with Liveable Neighbourhoods' recommendations, adjacent to the high amenity areas of parkland and wetland, and in support of the Village Centre and Mixed Use Node.

Example of grouped housing

6.4.2.5 Residential R60

Development with a residential density coding of R60 is permitted with a average of 180m² lots for single and grouped dwellings, and a minimum site area of 166m² pr dwelling for multiple dwellings.

The R60 sites have been located adjacent to activity centres and key landscape areas. The particular focus for R60 development is within the Village Centre. The R60 density provides significant flexibility to support a diversity of medium density housing types. Grouped dwellings, mostly in the form of townhouses, are likely to be the predominant building type. Appropriately designed low scale multiple dwellings could also be developed or combined with grouped dwellings as part of a quality development to offer diversity. Mixed use development could also see apartments built above retail/commercial floorspace in the core of the Village Centre.

6.4.3 *Lot Yields and Product Mix*

Precise lot yields will only be known as detailed subdivision design progresses. However, for the purposes of predicting the total lot yield in order to establish the facilities and infrastructure required for the Estate, a calculation based on Gross Subdivisible Area and the proposed residential density mix is provided in **Tables 2 & 3** below:

Table 2 – Gross Subdivisible Area

Total Structure Plan Area		**227.9267 ha**
Deductions for Calculating Net Site Area		
D1	Primary School Site	4.2421 ha
D2	Private Primary or High School Site	15.9807 ha
D3	Commercial	2.2931 ha
D4	Village Centre	8.6798 ha
D5	Tourism (exclusive of mixed tourism/residential)	1.5611 ha
D6	Local Centre	0.2866 ha
D7	Wetlands	33.1614 ha
Total Deductions:		66.2048 ha
Gross Subdivisible Area (GSA)		161.7219 ha
10% POS Requirement		16.1722 ha
Actual POS provision (excluding area affected by wetlands)		36.0225 ha
Net Subdivisible Area (NSA)		125.6994 ha

Table 3 – Indicative Development Product

Lot Product	**Area (ha)**	**%**	**No.**
R10	0.8523	1%	6
R15	1.8374	2%	25
R20	46.7272	53%	781
R30	5.2268	6%	134
R40	11.4076	13%	518
R60	12.0649	14%	670
Tourism/Residential R80	5.5459	6%	443
Village Centre (mixed use components)**	4.9553	6%	275
Total	88.6174 ha		**2852**

**Estimated Village Centre lot yield based on assumption that areas suitable for mixed use development will have residential at a density of R60.

6.4.4 *Tourism Facilities*

A designated tourist node is proposed for a riverfront location in the north-east of the Estate. This location will create the potential for some very pleasant visual outlooks from the facility(s) to be developed. The tourist precinct will offer direct river access, and will be developed with landscaped gardens and recreational areas with high visual amenity.

Generally, the Pinjarra area's close proximity to the excellent recreational waterways of the Peel Inlet and Harvey Estuary attracts visitors to try fishing, crabbing and prawning pursuits. However the area is not known as a well developed tourism destination, and lacks both visitor attractions with major 'pulling power' and important visitor based infrastructure, such as large capacity accommodation facilities.

Existing accommodation operators in the Pinjarra townsite include the 3 star AAA rated Pinjarra Motel, offering a low number of 10 units, and the Pinjarra Caravan Park with a mix of 65 sites, 9 park cabins and 1 cottage. The lack of a significant local accommodation industry has constrained growth in local tourism, and has hampered the projection of potential market sizes.

Pinjarra has achieved significant residential growth in recent years, and this investment has kick started a major transformation of the general area - the Murray River Country Estate is a substantial contributor to this growth.

The Estate has the potential to be a major focal point for visitor activity to and through the region. Visitor based strengths of the Estate include riverfront access to the Murray River; a range of good quality nature walks; its location adjacent to Pinjarra Golf Course; the existing sanctuary park incorporating Peel Zoo; and the Redcliffe Barn restaurant/café and its picturesque surrounds.

The Estate's near neighbour Mandurah boasts a strong visitor profile and attracts a relatively large proportion of visitors emanating from the Perth metropolitan area. Previously a strong day tripper and budget style caravan park accommodation destination, Mandurah is now developing into a growing higher yield overnight visitor base. As this trend continues, there will be opportunities for nearby destinations such as Pinjarra to grow visitation levels by offering a range of different yet complementary visitor experiences.

It is proposed that the tourism development at Murray River be based around provision of a good quality meeting and functions facility, with resort style accommodation facilities as supporting services, that will service guest and local resident recreational and leisure needs. Specifically, the weddings and other group meeting/function markets will be the key targets, as well as local resident use of food and beverage and resort/country club facilities (further detail on the tourism product proposed is available upon request).

Tourism facility

Visitors are likely to come to Murray River Country Estate for daytrip experiences, revolving around family based attractions including the Peel Zoo, the network of walk and bicycle trails, and the staging of regular special events. Overnight visitors will be attracted by the provision of purpose built wedding and social function settings in and around the facility on weekends, and meeting and conference markets during weekdays. The range of accommodation and relatively close proximity to the Perth metropolitan area will encourage these types of events and activities.

A relaxed country club atmosphere with a range of food and beverage and extensive recreational facilities will service the local Estate resident market.

View from river towards tourist facility

A review of other local Pinjarra commercial accommodation indicates no accommodation operations offering similar room styles and/or service standards. In terms of meeting and function room facilities, the Fairbridge and Leonda Reception Centre offer similar group seating capacities, however neither have the standard and/or overnight room capacity of that proposed for Murray River.

The Murray River Country Estate tourist product will therefore offer a unique package of visitor based products and services, to the benefit of the local and wider community.

6.4.5 *Education*

Current WA Planning Commission and Education Department Guidelines require the provision of one public primary school for every 1500-1800 residential lots. Based on the estimated lot yields described in 5.2.2 above, the Murray River Country Estate generates the need for one public primary school.

Table 4 Primary School Calculations

EDWA Guideline	1 school per 1,500-1,800 dwellings
Average Requirement	1500 + 1800/2 = 1 school per 1,650 dwellings
Required No. School Sites	2852/1,650 = 1.7 schools

The ODP therefore proposes one school site for the Estate, located according to Liveable Neighbourhoods principles and Development Control Policy 2.4 'School Sites'. The 4 ha site can be conveniently accessed from the entire Estate, via key integrator arterial and neighbourhood connector roads, and via the pedestrian and cycle network; is a regular rectangle in shape; has frontage to public roads on three sides; and is located adjacent to public open space.

6.4.5.1 Private School

In addition to the allocation of a public primary school site, the proposed ODP identifies a site for development of a private school facility catering for Kindergarten through to Year 12 education. The demand for such a facility exists as the two existing private high schools in the Mandurah area are becoming overcrowded, and the Murray River Country Estate is ideally situated to supplement these facilities and to provide an alternative education option for those families living closer to Pinjarra than to Mandurah.

Current information indicates that both the Mandurah Catholic and Frederick Erwin Anglican Schools have extended waiting lists and cannot take any more students graduating from other Primary Schools. New schools being provided as part of other significant developments south of Perth, at Lakelands and Melros, for example, are removed from the central Peel Region and will therefore not provide for those seeking a private education closer to Pinjarra.

To substantiate this perceived demand, the Estate developer has conducted initial investigations into the level of interest from private education providers towards locating at MRCE, and strong interest was expressed by at least three parties.

The proposed private school site has been strategically located within the ODP area to allow the school playing fields and other compatible land uses to make optimal use of the Murray River floodway, whilst also ensuring that the site is accessible and appropriate for its proposed use.

6.4.6 *Open Space*

6.4.6.1 Public Open Space

WAPC Liveable Neighbourhoods Policy requires the provision of a variety of different forms of public parkland across a structure plan area, ranging from local parks of up to 3000m2, to district parks of 2.5-4 ha, each performing different functions and providing a balance between conservation and active and passive recreational uses.

The Murray River Country Estate, in accordance with these guidelines and the more detailed policy provisions relating to the different parkland forms, provides open spaces that range from 250m2 to 14.5 ha, each performing different functions and each well located to allow good access to parks from all properties in the Estate. A plan of the Estate's POS locations and areas is provided at **Figure 8.**

The following summary provides an indication of the compliance of the MRCE POS strategy with policy requirements, and further detail on the landscaping philosophy and treatment of the public open space areas is provided in Section 6.5 and in **Figure 11**.

District Parks

Three district level parks (16, 17 and 26 on **Figure 8**) of in excess of 2.5 ha are provided across the Estate, and are located no more than a 1km walk from any dwelling. In addition to these parks, an open space area of 5.8 ha (POS 7) is available to residents in the form of the wetland in the central east of the Estate. While not contributing to the WAPC POS calculations, this area will provide a valuable environmental recreation opportunity for the Estate.

The district level parks will provide for both informal passive recreation, organised sport and other active recreational pursuits.

Neighbourhood Parks

The Estate design incorporates fourteen neighbourhood parks (1, 2, 3, 4, 6, 8, 9, 12, 14, 19, 22, 24, 25, 27 on **Figure 8**) of 3000 m² and larger. Each of these parks is no more than a 300m walk from each dwelling. The parks are designed to allow surveillance from both the surrounding streets and adjacent properties, and will provide parking opportunities for park visitors.

Local Parks

Nine local parks (5, 10, 11, 13, 15, 18, 20, 21, 23 on **Figure 8**) of between 255 m² and 1576 m² are provided across the Estate for local children's play and as resting places, and are designed as small intimate spaces which allow pedestrian connectivity and create a sense of place. The parks are located to promote good visual supervision from surrounding streets and properties.

6.4.6.2 Open Space Schedule

The table below indicates the proportion of total open space that is affected by the Estate's wetlands, and establishes the remaining balance of POS that is provided solely for passive and active recreation purposes. This information is also presented in **Figure 8**.

Table 5 – Public Open Space Schedule

(A) Open Space	(B) Total Area (m²)	(C) Area affected by Wetland (m²)	(D) Balance Area (m²)
1	**7586.419**	311	7275.419
2	**3215.622**	181	3034.622
3	**5241.283**	4653	588.283
4	**73146**	58832	14314
5	**1404.039**	0	1404.039
6	**5009.947**	0	5009.947
7	**57787.805**	52452	5335.805
8	**9490.524**	0	9490.524
9	**3534.896**	0	3534.896
10	**1164.317**	0	1164.317
11	**1274**	321	953
12	**5300.658**	2221	3079.658
13	**1194.136**	0	1194.136
14	**3832**	2979	853
15	**1447.161**	832	615.161
16	**45116.308**	4475	40641.308
17	**349705.772**	204357	145348.772
18	**255.937**	0	255.937
19	**2183.151**	0	2183.151
20	**854.722**	0	854.722
21	**1576.46**	0	1576.46
22	**4451.593**	0	4451.593
23	**1484.743**	0	1484.743
24	**8480.616**	0	8480.616

LEGEND

- PUBLIC OPEN SPACE
- FORESHORE RESERVE
- PROPOSED WETLAND
- EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

TABLE

Public Open Space No.	Total Area (m2).	Wetland Area (m2).	Balance Area (m2).
1	7586.419	311	7275.419
2	3215.622	181	3034.622
3	5241.283	4653	588.283
4	73146	58832	14314
5	1404.039	0	1404.039
6	5009.947	0	5009.947
7	57787.805	52452	5335.805
8	9490.524	0	9490.524
9	3534.896	0	3534.896
10	1164.317	0	1164.317
11	1274	321	953
12	5300.658	2221	3079.658
13	1194.136	0	1194.136
14	3832	2979	853
15	1447.161	832	615.161
16	45116.308	4475	40641.308
17	349705.772	204357	145348.772
18	255.937	0	255.937
19	2183.151	0	2183.151
20	854.722	0	854.722
21	1576.46	0	1576.46
22	4451.593	0	4451.593
23	1484.743	0	1484.743
24	8480.616	0	8480.616
25	5154.985	0	5154.985
26	81519.323	0	81519.323
27	10427	0	10427

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

PUBLIC OPEN SPACE PLAN

100m 0m 100 200 300m

FIGURE 8

(A) Open Space	(B) Total Area (m^2)	(C) Area affected by Wetland (m^2)	(D) Balance Area (m^2)
25	**5154.985**	0	5154.985
26	**81519.323**	0	81519.323
27	**10427**	0	10427
TOTAL	691839.417	331614	360225.417

6.4.6.3 Public Open Space Contribution

Western Australian Planning Commission (WAPC) policy requires a standard minimum of 10% of the gross subdivisible area be provided for public open space in residential developments.

As shown in the **table 6** below, the gross subdivisible area at MRCE is 161.7219 ha, generating a required POS contribution of 16.1722 ha.

Table 6 – Public Open Space Contribution

Total Structure Plan Area		**227.9267 ha**
Deductions		
D1	Primary School Site	4.2421 ha
D2	Private Primary or High School Site	15.9807 ha
D3	Commercial	2.2931 ha
D4	Village Centre	8.6798 ha
D5	Tourism (exclusive of mixed tourism/residential)	1.5611 ha
D6	Local Centre	0.2866 ha
D7	Wetlands	33.1614 ha
Total Deductions:		66.2048 ha
Gross Subdivisible Area (GSA)		161.7219 ha
10% POS Requirement		16.1722 ha
Actual POS provision (excluding area affected by wetlands)		36.0225 ha = **22.3%**

The open space provided is 36.0225 ha, which is 22.3% of the gross subdivisible area. Not only is this figure substantially in excess of that required, it does not take into account those areas of the Estate's wetlands that will be landscaped and managed for passive recreation purposes. It is considered therefore that the Murray River Country Estate performs exceptionally well in providing recreational opportunities for its future residents, and in its efforts at preserving and enhancing its natural environmental attributes.

6.4.7 *Public Boating Facility*

In order to enhance the amenity and recreational opportunities at the Estate, the potential exists to provide a boat ramp for boating access to the Murray River as part of the Estate development. MP Rogers & Associates have been commissioned by Murray Riverside to investigate the future demand for a boat ramp within the development, and to provide a concept plan for the ramp. The full report detailing the outcomes of this investigation is available upon request, the following is a summary of the findings.

There exists a high level of boat ownership in the Peel region and Shire of Murray, which is likely due to the proximity of these areas to major water bodies. The Peel Inlet, Harvey Estuary, Murray River and Indian Ocean are all within close proximity to the MRCE, and offer a wide variety of water activities. People living in this region can easily tow a boat to the various water bodies.

The local demand for a boat ramp in the MRCE development has been assessed as being approximately that presented in **Table 7** below:

Year	Number of Boats Launched on Peak Day	Number of Lanes of Ramp Required	Number of Trailer Parking Bays Required
2009	74 Launchings	2	75
2019	190 Launchings	4	190

This assessment was based on DPI statistics for boat ownership and use in the Peel Region, and the projected population of the MRCE (see report for detailed assessment). These figures are likely to be a maximum estimate, as with the high number of boats stored on trailers, many people will travel to the major water bodies and may not use the local Murray River near the development for boating. However, even if a fraction of the anticipated boat owners use the local MRCE boat ramp, there is enough demand for the construction of a 1 lane boat ramp and 40 bays of trailer parking.

It is considered that a 1 lane boat ramp, to cater for power boats up to 6.5 metres in length, with 40 bays of trailer parking would be appropriate at MRCE, and that the usage of the 1 lane boat ramp be monitored over the coming years, to see if the demand for local water usage increases. The design of the facilities is to be such to allow for expansion to multiple lanes, should the need arise in the coming decade.

It has been established that the boat ramp could be located on either the western or eastern side of the river meander (at the location of the power easement), and consequently the proposed location of the boat ramp to the west of this meander is tied to the wider land use planning requirements of the development.

6.5 Movement Network

In order to estimate the traffic that would be generated by the proposed ODP, a traffic generation and distribution exercise was undertaken by Transcore Pty Ltd. The aim of the exercise was to establish the traffic on the key internal road network and to ensure that the proposed movement network would operate satisfactorily.

6.5.1 *Traffic Generation/Distribution*

To establish the traffic generation rates for the development, the document *"Land Use Traffic Generation Guidelines, Director-General of Transport, South Australia"* and the *"Institute of Transportation Engineers, Trip Generation Manual, 7th Edition"* were sourced. From these documents, the typical daily and peak-hour weekday traffic generation rates for the proposed land uses were established.

It is estimated that the ODP area ultimately would generate approximately 30,500 daily vehicle trips (total of both ins and outs) during a typical weekday, approximately 2,000 am peak hour trips (both ins and outs) and 3,200 pm peak hour trips (both ins and outs).

Based on the surrounding road network and land uses, the following assumptions were made for the distribution of the ODP traffic:

- 70% of the non-residential traffic generated by the development would be distributed in proportion to the directional volume split on Pinjarra Road during each of the respective a.m. and p.m. peak periods and as a 50/50 split over a daily period;
- 10 % of the non-residential traffic was assumed to be generated internal to the development;

- 20 % of the non-residential traffic was assumed to be passing trade along Pinjarra Road;
- 70% of the residential traffic generated by the Eastern Subdivision (east of the bisecting existing Western Power easement) would enter and exit via Sutton Street;
- 30% of the residential traffic generated by the Eastern Subdivision would enter and exit via the Town Centre Road opposite Beacham Road;
- 80% of the residential traffic generated by the Western Subdivision (west of the bisecting existing Western Power easement) would enter and exit via the Town Centre Road opposite Beacham Road;
- 20% of the residential traffic generated by the Western Subdivision would enter and exit via Sutton Street; and
- The split for in and out movements for the residential development traffic would generally be 25% in/75% out and 65% in/35% out during the a.m. and p.m. peak hours, respectively; and generally 50% in/50% out for the office/medical land uses and 30% in/70% out for the commercial land uses.

6.5.2 *Road Hierarchy and Reserves*

Based on the estimated daily traffic volumes and the anticipated function of the roads, **Figure 9** illustrates the proposed road classifications for the ODP key road network.

The road hierarchy as defined in the *Liveable Neighbourhoods – Edition 3* (2004) document has been used in relation to the roads within the ODP area, including the existing Sutton Street.

Both Sutton Street and the Town Centre Main Access Road (opposite Beacham Road), north of Pinjarra Road, have been classified as *Integrator Arterial B* roads.

Several other key roads have been designated as *Neighbourhood Connector A* and *B* roads. The balance of the roads within the ODP area has been classified as *Access Streets*.

For an *Integrator Arterial B* (Town Centre Main Street), a typical reservation would range between 20 and 25 metres and would consist of 2 through/travelling lanes, on-street parking on both sides, a 2.0 metre median (primarily in place as a pedestrian crossing refuge), a shared path on one side of the road and a footpath on the other.

For a *Neighbourhood Connector A*, a typical road reservation would range between 20 to 24 metres. The cross-section for this road would be similar to that of an *Integrator Arterial B*. For the ODP area, the lower range of 20 metres is suggested based on anticipated pedestrian volumes, where a footpath/shared path is unlikely to be required on the both sides of the street except around the town centre area.

For a *Neighbourhood Connector B*, a typical road reservation would range between 18 and 20 metres. Generally, the lower range of 18 metres is recommended for the ODP area, as this reservation would not entail a central median or a footpath/shared path on both sides of the road.

For an *Access Street* a minimum reservation of 14.0m is recommended which entails a carriageway width of 6.0m and verges of 4.0m each.

6.5.3 *Intersection Treatments*

Figure 9 shows the proposed intersection controls for the key internal and external intersections of the ODP area. In establishing the proposed intersection controls, consideration was given to the road network layout and classifications, estimated traffic volumes and requirements and plans by relevant authorities.

Peripheral to the ODP area, there is a general understanding that a traffic signal is likely to be implemented at the intersection of Town Centre Main Access Road/Pinjarra Road/Beacham Road.

The main access points to the development will consist of a proposed signalised intersection on Pinjarra Road (as described above); a partial movements access to Pinjarra Road (east of the traffic signal) serving the proposed commercial uses flanking Pinjarra Road; a full movements unsignalised access road just west of the bisecting Western Power easement; and an existing full movements unsignalised 4-way access at Sutton Street/Pinjarra Road/Moores Road.

There are several roundabouts proposed along the Town Centre Main Access road, as well as on the Neighbourhood Connector A road.

Due to relatively short lengths of approach roads, low speeds and relatively low traffic volumes, no other roundabouts are justified at four-way intersections within the ODP area. However, in order to control excessive traffic speed and improve safety, it is proposed to provide traffic management measures in the form of 'raised junctions' at a number of locations within the ODP area. The raised areas are proposed to be either distinctively brick-paved and/or coloured with red bitumen.

With regard to auxiliary lanes (left- and right-turning pockets) on Pinjarra Road, for the proposed access points to the ODP area, it is proposed that all access points on Pinjarra Road should entail both left and right turn pockets as appropriate and in accordance with the proposed future operating speed on Pinjarra Road.

6.5.4 *Public Transport*

As outlined previously in this report, due to location of the ODP area the existing bus services are very limited at present. However, liaison with PTA/Transperth has indicated some opportunities to service the ODP area with bus services. These opportunities have been based on the present bus network in the vicinity.

The Mandurah Railway Station will be the closest transit station to the proposed ODP area. The South-Western Metropolitan Rail Line (as part of the New MetroRail project) is anticipated to be completed and opened by mid-2007. Discussions with the Public Transport Authority suggest that the existing Pinjarra Road line haul bus service (Route 163 which currently terminates at Furnissdale, some 7.5 km west of the ODP area) may be extended east to serve the Murray River Country Estate, once the railway line comes on-stream. The nature and/or detail of this service extension is not known, apart from the likelihood that if this service is to be extended, bus stops potentially may be located at the Town Centre Main Access Road/Pinjarra Road and at the Sutton Street/Pinjarra Road intersections.

Also, there is the potential to modify/extend the existing private charter bus service as described previously, between Mandurah and Pinjarra/Yarloop/Waroona to serve the proposed ODP area as an interim measure until the rail service comes on-stream and Route 163 is extended.

6.5.5 *Pedestrian and Cyclist Facilities*

The reasonably flat topography of the area creates the opportunity for provision of good pedestrian and cyclist facilities to maximise non-motorised transport modes.

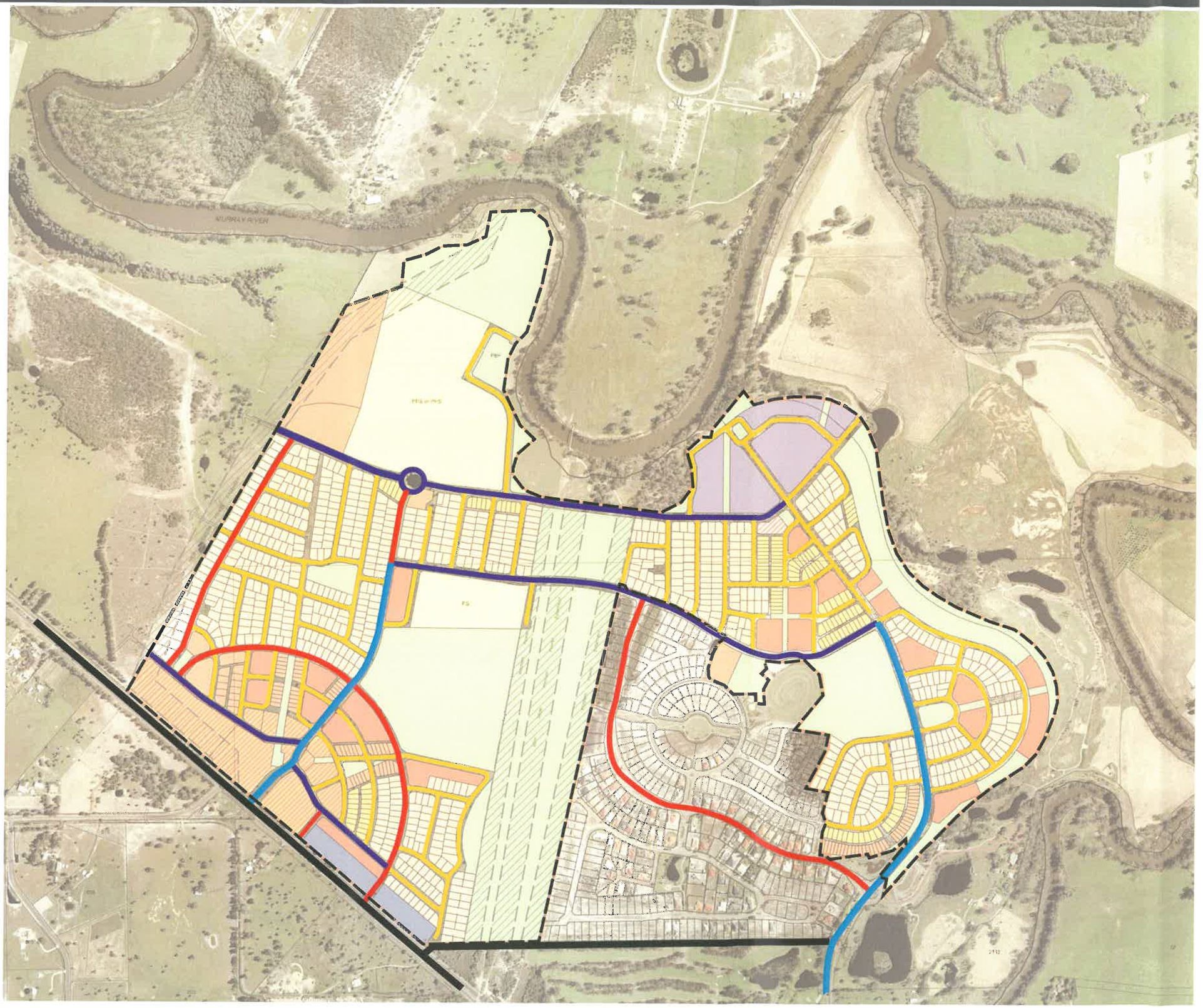
Figure 10 outlines the proposed pedestrian and cyclist network for the ODP area.

It is proposed to provide shared paths on the *Integrator Arterial B* and *Neighbourhood Connector A* and *B* roads. Also, it is proposed to provide shared paths on the *Access Streets* where a demand is anticipated such as next to a school. Accordingly, the proposed shared path network will include, but not be limited to, the following:

- Eastern side of both the Town Centre Main Access Road and Sutton Street; and
- Through the ODP area serving the proposed schools, the shopping/mixed use facilities and foreshore/recreational/public open space facilities.

Also, it is proposed that footpaths should be provided as a minimum along the following roads:

- Along the Neighbourhood Connector B roads;
- Abutting the public open space and foreshore/recreational facilities;
- In the vicinity of the schools; and
- In the vicinity of shopping/mixed use facilities.



LEGEND

- EXTENT OF OUTLINE DEVELOPMENT PLAN 2007
- INTEGRATOR ARTERIAL 'B'
- NEIGHBOURHOOD CONNECTOR 'A'
- NEIGHBOURHOOD CONNECTOR 'B'
- ACCESS STREET

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

ROAD HIERARCHY PLAN

100m 0m 100 200 300m

22 JAN 07| 03/148/FIG9

FIGURE 9

LEGEND

EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

SHARED PATHS AND CYCLE LANES

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

PEDESTRIAN NETWORK PLAN

100m 0m 100 200 300m

22 JAN 2007 | 03/148/FIG10

FIGURE 10

6.5.6 *Future Initiatives*

This section outlines a series of conclusions in relation to both the regional and local transport systems in the vicinity of the Murray River Country Estate ODP area.

The outcomes in relation to the current Main Roads Western Australia project, *Pinjarra Road: Perth-Bunbury Highway (Mandurah) to South Western Highway (Pinjarra Road) – Intersection and Access Strategy,* should take into consideration the access requirements to accommodate the transport demands generated by the ODP area and should also carefully consider the future access implications for urban development along Pinjarra Road. Transcore will maintain regular contact with both the consultant and MRWA through to the project's completion.

In addition, under the existing *Peel Region Scheme,* a *Primary Regional Road* (Red Road) reservation has been denoted at the western boundary of the ODP, to the south of Pinjarra Road, to function effectively as a by-pass of the Pinjarra Town Site, linking Pinjarra Road to the South-Western Highway. The ongoing review of the Peel Region Scheme should consider the modification or removal altogether of the proposed alignment of this Red Road at Pinjarra Road due to the significant implications for direct and convenient access to the Town Centre within the Murray River Country Estate ODP. A primary objective to structure planning in this area should be to maintain good connectivity between the land uses to the north and south of Pinjarra Road and to minimise potential land and activity severance, which may occur, should the Red Road in its current alignment be maintained within the Scheme.

Based upon the anticipated transport demand to be generated by the ODP land uses, it is recommended that four major access points on the north side of Pinjarra Road serve the development. These access points will consist of a fully signalised 4-way intersection at the Town Centre Main Access road/ Pinjarra Road/Beacham Road, a partial movements access (left-in/left-out only) to the east of the signalised access, a full movements T-intersection immediately west of the bisecting Western Power easement and a full movements unsignalised 4-way intersection at Sutton Street/Moores Road/Pinjarra Road. e

A detailed review of the required internal road reservations and pedestrian and cyclist facilities as well as internal Local Area Traffic Management measures was also undertaken for the ODP area.

In relation to public transport requirements, discussions with the Public Transport Authority have indicated that it is likely that the existing Transperth Route 163 line haul bus service along Pinjarra Road could be extended easterly to serve the ODP area, once the South-West Metropolitan Railway Line has been completed and becomes operational.

6.6 Environmental and Landscape Design

6.6.1 *Design Philosophy*

The landscape design philosophy for the Murray River Country Estate draws on the strong natural and cultural heritage of the site. The site is adjacent to the Murray River, which is to be protected and enhanced by all proposed development.

The Murray River is a significant environmental and ecological resource for the Pinjarra area, and will create an inspirational setting for the residential and public open space areas of the Estate. The landscape design theme will incorporate environmental and ecological awareness, to educate the public on the principles of sustainable development and water sensitive urban design and to ensure that the Murray River remains a Regional Riparian attraction.

The elements which have inspired the design process include:

- The environmental setting of the site adjacent to the ecologically and culturally significant Murray River.
- The distinctive rural character of Pinjarra, typified by the use of robust forms, warm colour palette and local materials.
- The past rural and agricultural uses of the site, which can be interpreted through the material palette of limestone, stone, tin, timber and rammed earth.

- The proximity to the Pinjarra and Mandurah district centres and their rural and coastal settings.
- The existing wetland ecosystem and floodplain characteristics of the site.

The landscape proposals aim to create a contemporary interpretation of the Pinjarra character, with strong reference to the environmental and rural influences. Hard landscape materials are likely to include timber, steel, rammed earth, limestone, stone and exposed aggregate concretes and gravels.

A rich and interesting public realm is to be established through the creative use of materials, colours, landscaping and detail design, with a special sense of arrival created at major entry points. Exotic plant species are to be used at key locations such as the focal gathering and feature areas to create a strong contrast to the surrounding indigenous theme.

Colourful mass planting of native vegetation and avenues of mature native tree transplants are proposed to frame and provide presence to the development, beyond which the riverine and wetland network will unfold in a series of public open space areas, walk trails, boardwalks, and semi-active and passive recreation areas.

The planning and design of the public realm is to embrace the riparian and wetland ecosystems and vegetation as a positive attribute of the site. This will be achieved by minimising the loss of vegetation and maximising the retention of clusters of trees and natural aquatic environments where possible, and promote views and connections into the broader landscape context and the riparian zones.

The overall Landscape philosophy for the Murray River Country Estate Development is based on the following Ecological Sustainable Design Principles:

- Create an exciting and vibrant contemporary rural landscape that reflects the existing wetland and riparian characteristics of the site;
- Create an ecologically sensitive landscape, based on sustainable principles;
- Utilise the Murray River and adjoining riverine / wetland landscape to form a strong visual and sustainable edge to the site;
- Retain existing Flooded Gums, Melaleucas and wetland vegetation as the main site structure wherever possible;
- Utilise a fully sustainable and holistic approach for all aspects of the landscape works, to ensure that ongoing management and maintenance of the landscape can be easily achieved;
- Utilise best practice stormwater treatment eg. fully integrate stormwater requirements into the open space and streetscape networks and treat this element as a positive feature of the site;
- Incorporate low water use endemic and native vegetation species, to ensure that water use and maintenance is minimised;
- Minimise extent of irrigated areas in order to minimise capital and ongoing costs, and consider use of a temporary irrigation system to low-key areas; and
- Create education/interpretive opportunities.

6.6.2 *Landscape Design Principles*

The open space system within the Murray River Country Estate will provide residents and visitors alike with a variety of visual and recreational opportunities and experiences, as well as linkages to the adjacent River and wetlands. Visitor and resident enjoyment will be enhanced by improved interpretation of key significant features:

- Murray River
- River Foreshore
- Floodplains
- Wetlands / Damplands

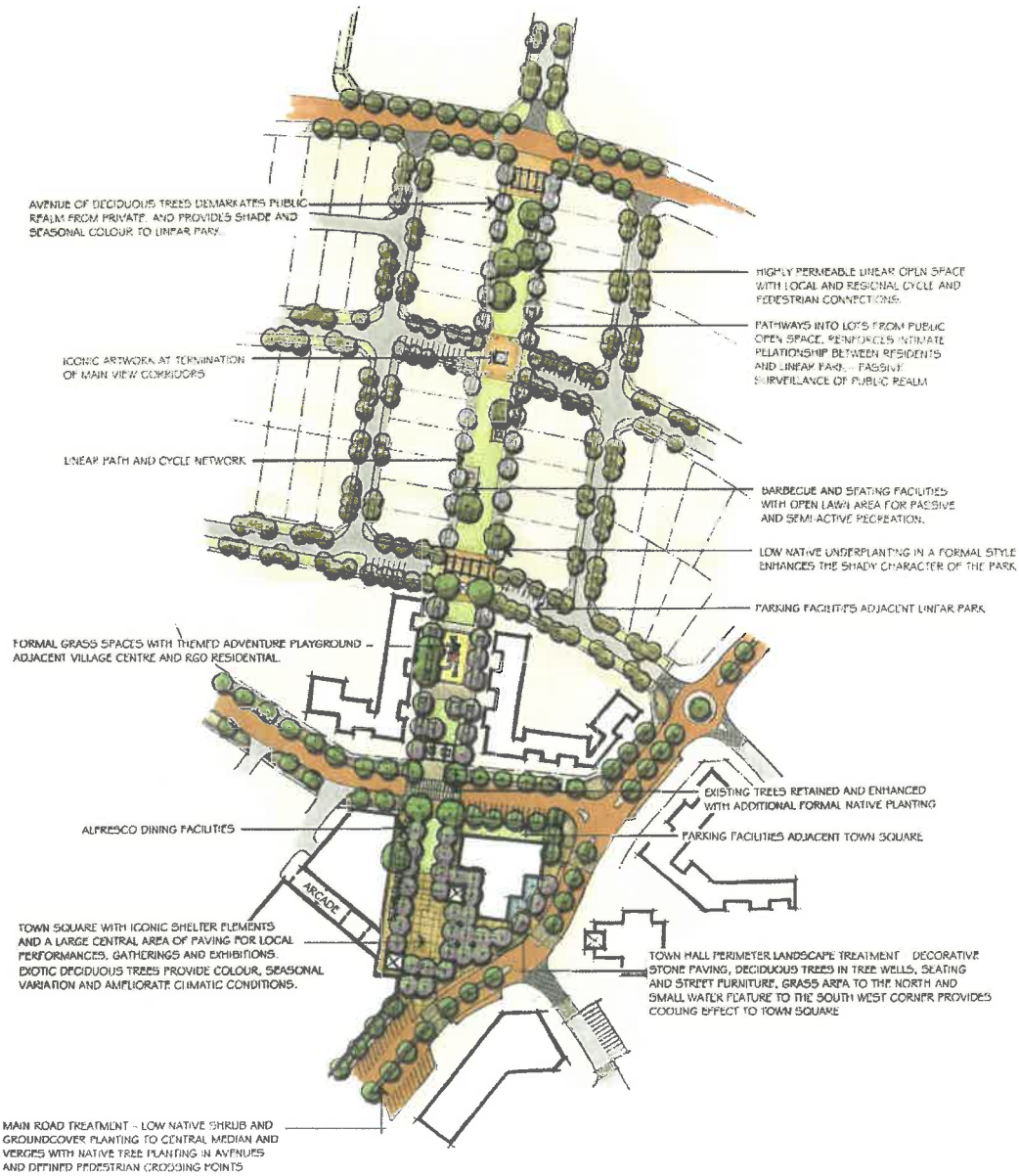
- Existing flora and fauna networks

Low-key facilities at sites of natural significance are to include boardwalks, decks, lookouts, and picnic facilities, all of which are to be designed and constructed in an environmentally-sensitive manner. Also important will be the integration of walking trails and pedestrian connections into the broader regional network.

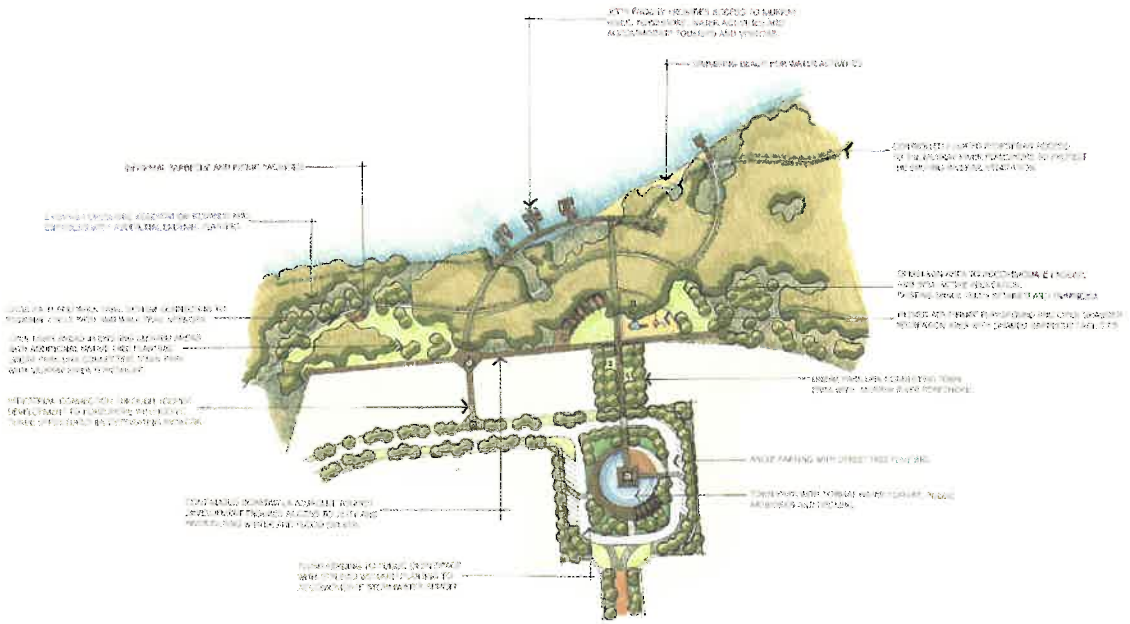
The challenge of an Ecological Sustainable Development such as the Murray River Country Estate is to provide opportunities for experiencing the Estate's unique qualities without impacting on them. The landscape design will address the following features:

- Regional and Site Landscape Context
- Ecology and Environment
- Footpaths, Paths, Walk and Cycle Trails
- Bridge, Boardwalks and Crossing Structures
- Open Space and Environmental Design
- Water Cycle and Stormwater Management
- Streetscapes
- Public Realm Materials and Character

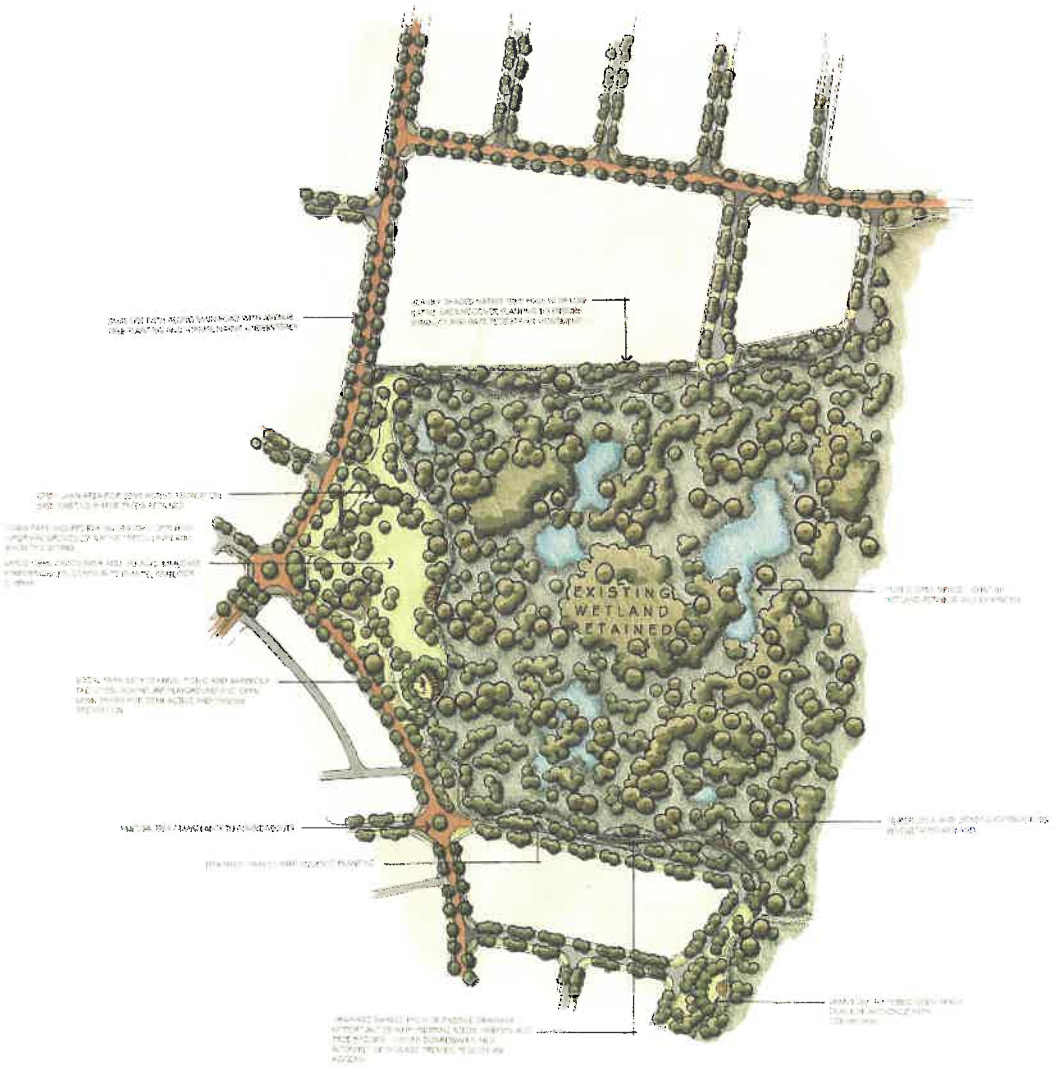
A Landscaping Concept Plan is included at **Figure 11.** A selection of preliminary landscape concepts for various landscaped areas within the ODP are illustrated below.



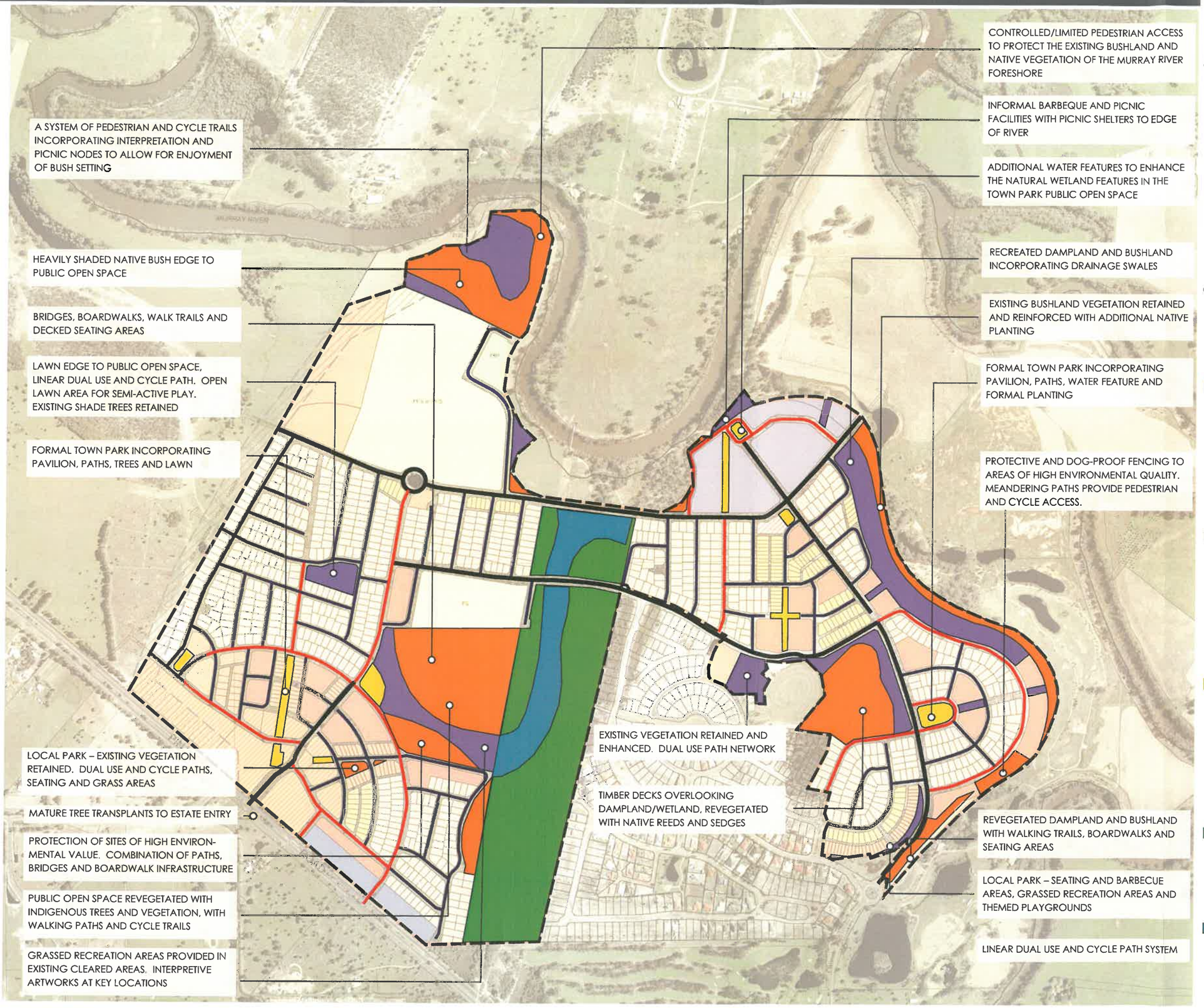
Preliminary Landscape Concept: Town Centre Linear POS



Preliminary Landscape Concept: Tourist Node and Foreshore POS



Preliminary Landscape Concept: Central Wetland POS



LEGEND

EXTENT OF OUTLINE DEVELOPMENT PLAN 2007

BOULEVARD STREET
COLOURED ASPHALT;
PLANTED CENTRAL MEDIAN WITH STREET TREES;
VERGE PLANTING WITH STREET TREES;
DEFINED PAVED PEDESTRIAN CROSSING POINTS; AND
DUAL USE PATH TO BOTH SIDES OF STREET

CONNECTOR STREET
COLOURED ASPHALT;
NO CENTRAL MEDIAN;
DUAL USE PATH TO ONE SIDE, FOOTPATH TO OTHER SIDE;
LOW NATIVE GROUNDCOVER VERGE PLANTING;
AVENUE OF STREET TREES; AND
DEFINED PEDESTRIAN CROSSING POINTS

RESIDENTIAL STREET
BLACK BITUMEN;
NO CENTRAL MEDIAN;
COMBINATION OF GRASS AND PLANTING TO VERGES;
FOOTPATH TO BOTH SIDES OF STREET; AND
INFORMAL GROUPINGS OF NATIVE STREET TREES

TYPE A – CONSERVATION/REHABILITATION
PROTECTION OF EXISTING ENVIRONMENT;
REDEVELOPMENT AND REHABILITATION OF DEGRADED AREAS;
CONTROLLED ACCESS – BOARDWALKS, DECKS, BRIDGES, WALKING PATHS AND CYCLE TRAILS TO PERIMETER;
PROTECTIVE FENCING;
UNDISTURBED AREAS;
INTERPRETIVE SIGNS AND SEATING NODES;
LIMITED PICNIC AND BARBECUE FACILITIES; AND
ENDEMIC SPECIES VEGETATION ONLY

TYPE B – SEMI-ACTIVE/PASSIVE RECREATION
PROTECTION OF SIGNIFICANT NATURAL FEATURES;
BROAD RANGE OF SEMI-ACTIVE AND PASSIVE FACILITIES INCLUDING SEATING NODES, BARBECUE FACILITIES AND THEMED PLAYGROUNDS;
INFORMAL CHARACTER;
CYCLE PATH AND WALK TRAIL SYSTEM CONNECTING TO REGIONAL CYCLE PATH AND WALK TRAIL NETWORK;
OPEN LAWN AREAS;
PARKING FACILITIES; AND
PUBLIC ARTWORKS

TYPE C – FORMAL TOWN PARK
PROTECTION AND FORMALISED TREATMENT OF EXISTING NATURAL FEATURES;
FORMAL CHARACTER;
HIGH LEVEL OF DETAIL DESIGN;
SHADE STRUCTURES AND PAVILIONS;
PUBLIC ARTWORK AND LIGHTING;
COMMUNITY FACILITIES INCLUDING BARBECUE, PICNIC FACILITIES AND GATHERING, PERFORMANCE AND EXHIBITION SPACES;
ADDITIONAL WATER FEATURES

TYPE D – POWER EASEMENTS
PROTECTION OF EXISTING ENVIRONMENT;
REDEVELOPMENT AND REHABILITATION OF DEGRADED AREAS IN ACCORDANCE WITH WESTERN POWER REGULATIONS;
INFORMATION AND DIRECTIONAL SIGNS; AND
ENDEMIC SPECIES VEGETATION ONLY

REDEVELOPMENT AND REHABILITATION OF DEGRADED AREAS IN ACCORDANCE WITH WESTERN POWER REGULATIONS;
ENDEMIC SPECIES VEGETATION ONLY;
LIMITED PATH AND CYCLE TRAILS WITH DIRECTIONAL SIGNS; AND
SMALL RANGE OF PASSIVE RECREATION FACILITIES INCLUDING SEATING NODES, DRINKING TAPS AND BINS

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN 2007

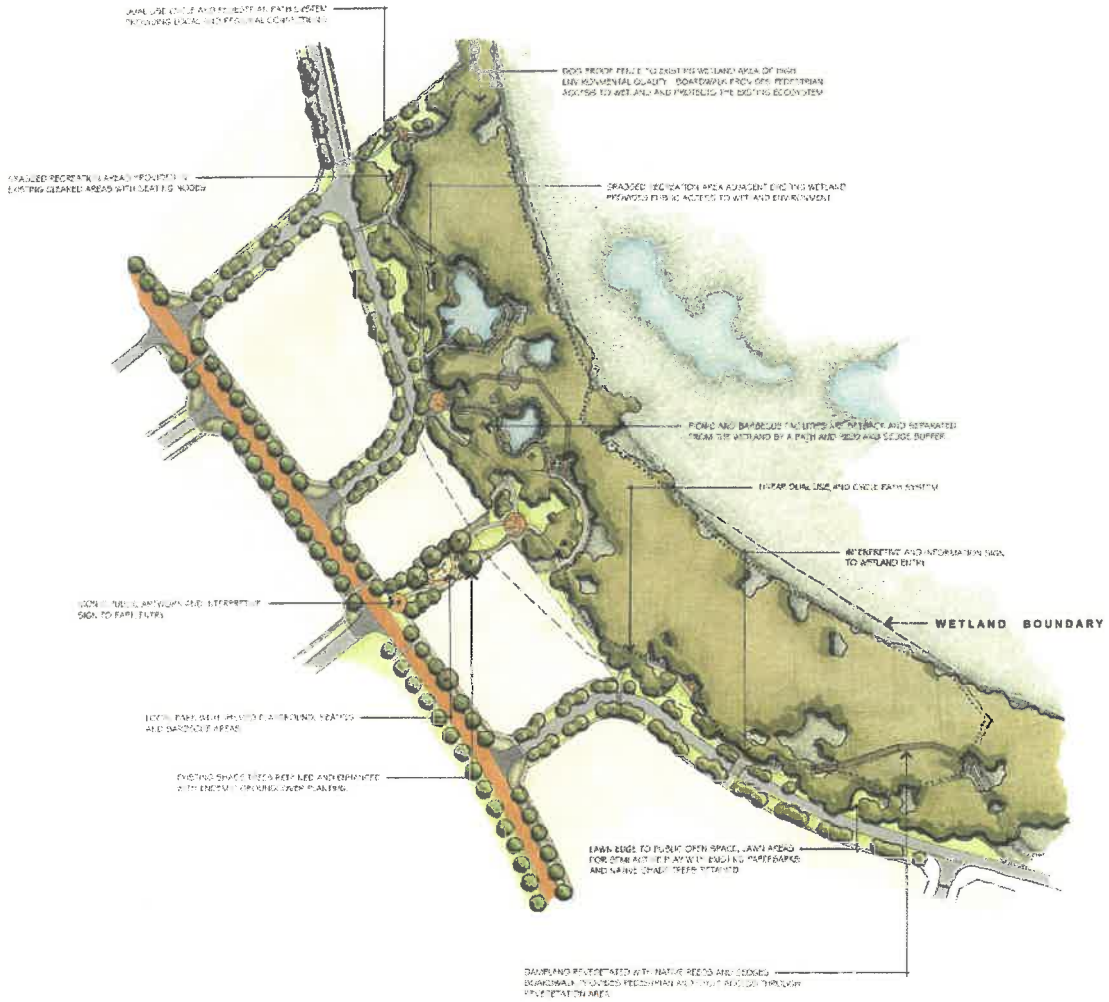
LANDSCAPING CONCEPT PLAN

N

100m 0m 100 200 300m

22 JAN 07| 03/148/FIG11

FIGURE 11



Preliminary Landscape Concept: Eastern Wetland POS

6.7 Public Art and Sign Strategy

Public art and signs for the Estate will be developed and implemented as follows:

- Informative and interpretive signs and artworks will help orientate and educate visitors, reduce management problems and contribute to a broader understanding of the natural environment and long-term management objectives.
- Provision of appropriate signs and interpretation at key sites requiring special protection.
- Assist residents and visitors to discover, enjoy and appreciate the natural and cultural features of the site through the use of integrated artworks and a cohesive sign strategy.
- Artworks to focus on interpretation, information and community education, and to address various themes that relate to the diverse environmental characteristics of the Murray River Country Estate.
- A Public Art and Sign Strategy to be developed and implemented in the context of broader regional opportunities and natural resources, focusing on the following themes:
  - Endemic remnant vegetation
  - Wetlands/Damplands
  - Riparian Environment and foreshore
  - Cultural heritage
  - Existing flora and fauna networks

6.8 Design Guidelines

The Murray River Country Estate establishes a dialogue between a traditional Australian rural setting and contemporary sustainable urban development models. The architectural expression of this dialogue will draw from the local landscape and associated rural building typologies, and simultaneously promote an architectural philosophy based on climatic sensibilities, use of local materials and (where possible) a pedestrian based-lifestyle.

Detailed design guidelines shall be prepared prior to subdivision to ensure that developers of all building typologies are thoughtful in their approach to design, and so that desired built form design objectives can be achieved across the Estate.

Design Guidelines will primarily be driven by sustainability initiatives addressing the "triple bottom line". That is, by providing buildings that are more socially, environmentally and economically sustainable. Under this banner, a wide range of issues can be addressed.

It is important to note that the adoption of sustainable principles does not intend to limit design outcomes, or create a narrow band of building typologies. The guidelines will promote high quality sustainable design, which will create a diversity of form and material selection that relate to the local environs: *"Harmony in Diversity."*

The guidelines will promote an architectural character based on:

- Innovative contemporary design engaging with the themes of landscape and traditional rural formal interpretations.
- Site-specific design.
- Passive solar design – overhangs, lightweight roofs, high quality indoor/outdoor spaces, innovative construction (eg. reverse brick veneer),
- Naturally finished materials such as earth, galvanised steel, stone and timbers.
- Local materials such as stone and earth.
- The articulation of form through the use of differing materials as opposed to the application of ornamentation/adoption of inappropriate historical European architectural styling.

The detailed building design guidelines will be prepared on a precinct basis, with a focus on predominant land uses and landmark qualities. It is anticipated that the guidelines will focus heavily on the village centre (including commercial, mixed use, civic, and highway commercial lots), residential areas (encompassing the range of densities) and tourist areas.

Guidelines for the lower density housing (R10-R20) shall be performance based, rather than a schedule of specific requirements. The built form guidelines for these dwellings will celebrate *harmony through diversity*. In addition, careful lot planning guidelines will be required to ensure high standards for penetration of northern sun, capture of natural ventilation and successful building/street relationships are maintained.

The following sections address the areas of the Estate that will require particular attention, and the anticipated scope of these guideline requirements.

6.8.1 *Village Centre/ Medium Density Residential/ Tourism Zone Guidelines*

- Highway Commercial - Pinjarra Road.
- Civic and Community Facilities - Hub of Town Centre and Estate Entry
- Commercial Mixed Use Hub focussed on the village centre and Estate Entry Point
- Residential Development Sites of R40 to R60 densities.
- Tourism Zone
- Private and Public School Buildings

6.8.1.1 Site Planning

- Site analysis
- Masterplan integration
- Public art integration
- Passive solar planning
- Building envelope (height, scale)
- Overlooking, over shadowing
- Setbacks
- Open space, parking and landscaping
- Security, surveillance and lighting
- Service access
- Fencing
- Storage
- Mature tree retention (where appropriate)

6.8.1.2 Building Design

- Architectural intent
  - Form,
  - Materials,
  - Colour
- Environmentally sustainable design
  - Passive solar design requirements
  - Water conservation
  - Energy usage
  - Construction waste reduction
  - Low emission material selection
- Socially sustainable design
  - Architectural diversity / articulation of facades (particularly for ground level commercial / retail premises)
  - Pedestrian interface / equitable access
  - Flexible and adaptable spaces
  - Street activation
  - Pedestrian amenity and weather cover
  - Bicycle parking
  - Light pollution / glare mitigation
  - Noise attenuation
- Economically sustainable design
  - Affordable housing. (These guidelines will depend upon overall planning initiatives)
- General
  - Plant and services
  - Safety
  - Signage

Particular attention will be required with the Highway Commercial guidelines. These will be heavily integrated with landscaping guidelines to provide amenable pedestrian / vehicle environments.

6.8.2 *Residential Typologies*

- Lower Density housing areas (R10 / R20)

Design Guidelines will be prepared to address the following design elements:

6.8.2.1 Site Planning

- Site analysis
- Passive solar planning
- Building envelope (height, scale)
- Overlooking, over shadowing
- Setbacks
- Open space, parking and landscaping

- Street surveillance and lighting
- Relationship of fencing and street
- Storage
- Mature tree retention (where appropriate)

6.8.2.2 Building Design

- Architectural intent
  - Form,
  - Materials,
  - Colour
- Environmentally sustainable design
  - Passive solar design requirements
  - Water conservation
  - Energy usage
  - Construction waste reduction
  - Low emission material selection
- Socially sustainable design
  - Architectural diversity / articulation of facades
  - Glare mitigation
  - Noise attenuation

6.8.3 *Architectural Storyboard*

6.8.3.1 Existing Pinjarra Examples

Original Workers Cottage

- Framed construction featuring weatherboard cladding
- Simple hipped roof form – corrugated metal
- Eave overhangs and deep verandahs

Civic Church Building

- Solid Masonry Construction
- Architectural Character
- Simple High Pitched Roofs
- Landmark Building

Civic Church Building

- Solid Masonry Construction
- Architectural Character
- Simple High Pitched Roofs
- Landmark Building

Contemporary Rural Residence

- Retained trees enhance rural experience
- Simple hipped roof forms – corrugated metal
- Deep eave overhangs and verandah
- Visually permeable post and rail fence to street

6.8.3.2 *Harmony in Diversity* : Relevant Contemporary Architectural Buildings

Single Dwelling

- Traditional housing form
- Permeable screen to street
- Timber framed/reverse brick veneer
- Naturally finished materials

Single Storey Grouped dwellings

- Traditional housing form
- Permeable screen to street
- Timber framed / reverse brick veneer

Contemporary grouped dwelling site

- Traditional roof forms
- Garages do no dominate streetscape
- Permeable screen to street
- Deep eaves and overhangs.
- Excellent Street Address.

Contemporary Residential Grouped Dwelling Site

- Passive solar design.
- Successful relationship between private and shared spaces.
- Simple traditional roof forms – corrugated metal.
- Successful combination of materials and colour.
- Deep eaves and overhangs
- Naturally landscaped shared spaces.
- Successful relationship to street.

Contemporary Residential Grouped Dwelling Site

- Passive solar design.
- Maximises outlook / views.
- Successful combination of materials and colour.
- Simple skillion roof forms – corrugated metal.
- Successful relationship to street.

Contemporary Tourism / Civic Facility

- Excellent articulation of materials.
- Naturally finished / local materials.
- Landmark building.
- Simple hipped roof forms - corrugated metal.
- High level of pedestrian amenity.

Contemporary Civic Facility

- Passive Solar Design.
- Excellent articulation of materials.
- Naturally finished materials.
- Landmark building.
- Simple roof forms - corrugated metal.
- High level of pedestrian amenity and street address

Contemporary Civic Facility

- Passive Solar Design
- Naturally finished materials
- Civic Form with Pedestrian interface

Contemporary Civic Facility

- Passive Solar Design.
- Excellent articulation of materials.
- Naturally finished / local materials.
- Simple roof forms - corrugated metal.

Contemporary Civic Facility

- Excellent articulation of materials
- Landmark building and location.
- Simple hipped roof forms - corrugated metal.
- High level of pedestrian amenity

Town Centre – Mixed Use Building

- Ground Level Retail / Upper Level Residential
- High level of pedestrian amenity and street address.
- Zero setbacks.
- Alfresco areas on street.
- Pedestrian Cover.

Town Centre – Mixed Use Building

- Ground Level Retail / Upper Level Residential
- High level of pedestrian amenity and street address.
- Zero setbacks.
- Naturally finished materials
- Traditional form, materials and colour.
- Alfresco areas on street.

Town Centre – Mixed Use Building

- Ground Level Retail / Upper Level Residential
- High level of pedestrian amenity and street address.
- Zero setbacks.
- Traditional form, materials and colour.
- Intensive Landscaping.

Town Centre

- Natural Vegetation
- High level of pedestrian amenity and street address

Town Centre

- Intensive Landscaping.
- High level of pedestrian amenity and street address.
- Zero setbacks.
- Diversity of form, materials and colour.
- Alfresco areas on street.
- Pedestrian Cover.

6.9 Community Formation and Integration

The Shire of Murray is a developing, largely rural local authority, with a population of less than 12,000 people. In recognition of the need for additional community development commensurate with current levels of population in the region, a Community Development Plan is currently being prepared by the Shire. Given the size of the proposed Murray River Country Estate and its potential population, it is considered essential that the developer participate in this planning process, in order to ensure the creation of a strong and vibrant community at the Estate. It is proposed that a Community Development Plan be prepared for the MRCE to complement the wider study being undertaken by the Shire.

In the meantime, prior to formulation and implementation of a Community Development Plan, the principles engrained in the MRCE Outline Development Plan will ensure that a strong, integrated community structure develops at the Estate. Future residents will have access to all of those services and facilities that make a community, including local shopping facilities; restaurants and tourist facilities; active and passive recreational opportunities; education opportunities, in the form of a public primary school, and private school catering for students from kindergarten to year 12; religious/worshipping facilities; social function and other recreation facilities; and areas of land conservation. In addition, and as previously discussed, detailed design guidelines are to be prepared for the Estate to enable the formation of a distinct sense of place and identity for the developing community.

The developers will retain control over the progressive development of public open space areas within the Estate over time, and over the establishment of various community buildings. Close contact will be maintained with the Shire of Murray regarding these facilities to ensure that those provided are consistent with the overall Community Development Plan for the Shire. As previously acknowledged, it is intended that development within the MRCE will occur in a manner that complements the existing Pinjarra Townsite, in terms of development, services and urban form.

6.10 Indigenous Heritage

The known Aboriginal Heritage sites discussed at **Section 4.6**, and validated by local Aboriginal Elders during the Ravenswood Sanctuary design process, are protected from any disturbance under the MRCE ODP. Should any archaeological material be uncovered during the development process, the appropriate procedures and notifications will be undertaken in accordance with the provisions of the *Aboriginal Heritage Act 1972*.

6.11 Engineering Infrastructure

The Engineering Report prepared by Dennis Price & Miller is provided at **Appendix 5** and summarised below.

6.11.1 Earthworks

Site works will include earthworks (i.e. cutting and filling as required), with earthworks areas to be stabilised during construction. Existing remnant vegetation is to be kept where possible.

6.11.2 Urban Water Management Strategy

The following provides initial concepts for the integrated urban water management of the site. The initial urban water management concepts discussed will be split into the two major areas of quality and quantity. The concepts for the stormwater management are based on the *Decision Process for Stormwater Management for WA* (Department of Environment, 2005). This document stipulates water quality management targets via statutory documents such as Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992 (EPA, 1992). To demonstrate compliance with these targets an assessment using the *MUSIC* Model can be used. At present this model requires DEC to calibrate it to WA conditions. This report also highlights quality and quantity objectives based on various stormwater events as follows:

- The 1-year storm – namely events up to a 1 in 1-year average recurrence interval (ARI);
- Minor Storm Events – namely events greater than a 1 in 1-year and less than a 1 in 10-year ARI (i.e. the 1 to 10-year storms);
- Major Storm Events – namely events less frequent than the 10-year storm and up to the 1 in 100-year ARI (i.e. the 100-year storm).

Preliminary storage model calculations have been completed to reduce the outlet surface water flows from a fully urbanised catchment back to the pre-development status. The engineering report provides some detail as to the type of storage facilities and location of these in the planning layout.

Quality of the surface water and groundwater are to be addressed by a number of studies and subsequent modelling currently initiated by the developer's project team and various authorities. The Department of Environment (DoE) has set out some basic guidelines for data collection of surface water and groundwater information. This is to be provided on a staged basis through the subdivision process. One of the criteria to be addressed is a specified reduction in nutrients from the stormwater system when compared to the traditional piped drainage system. A suite of design tools is available to incorporate at the detailed design stage but a number of initiatives can be taken at the early planning process to achieve the objectives. As the development process proceeds to when particular plans of subdivision receive conditional approval, the concept proposed is proved in more detail with various data gathered from groundwater and surface water investigations and modelling. At the ODP stage only a drainage concept is to be provided. A programme of data gathering and modelling is to be initiated that would prove the drainage concept validity or require its modification as required during the future planning milestones.

6.11.2.1 General Concept

The major considerations for the site in terms of stormwater quantity are the 100-year flood levels created by the Murray River, the relatively flat nature of the site and the high groundwater in winter. The 100-year flood requires storage within selected areas of the POS areas on site with top water levels higher than that occurring in the Murray River. The detailed drainage design will include checking of scenarios such as high flows in the Murray River combined with high site flows and low site flows combined with high River flows. In limited parts of the subject land (i.e. the river's flood fringes), fill is to be placed to provide a minimum of 0.5m freeboard above the predicted 100-year flood levels of the site.

A series of open spaces are proposed to be utilised as drainage storage and conveyance for stormwater events exceeding the 1-year storm. All of the site catchment areas generally drain to the Murray River. In combination with this is a system of shallow vegetated soakage swales on selected streets to enable soakage of the low recurrence interval storms (i.e. less than the 1-year storm) as high in the catchment as possible. Where swales are not practical, the drainage system will be designed with more gully and junction pits to operate as soakwells. The swales will also create flood routes to the POS storage areas for the less frequent storm events. This strategy maximises infiltration, where possible, at the source for the 1-year storm events. Road grading design will be such that all roads will fail safe – namely where excess runoff is conveyed along the road reserve without flooding any houses to nearby POS areas. Where roads abut the POS, the pavement will crossfall to the POS and flush kerbs along that side will ensure that runoff 'sheets' into grassed swales alongside the roads and within the POS.

6.11.2.2 Site Subsurface Soil and Groundwater

Monitoring bores are already provided across the whole site and monitored at regular intervals. These bores will be used to calibrate the information currently available from the existing DEC, Water Corporation and private bores. A suite of tests is to be undertaken on the groundwater samples from these monitoring bores to assist with a drainage nutrient model and to confirm there are no contamination issues. There is no evidence to suggest that there is now or will be an issue. Testing and monitoring to date has confirmed that the existing drainage system installed under the approved 1998 Drainage Management Plan (ref LeProvost Dames & Moore May 1998) has been operating within expected and acceptable criteria.

In their Aquifer Review Report for the period from July 2004 to June 2005 and lodged with the DoE, Hydro-Plan stated that *"Groundwater is of fresh quality and acidic to near neutral with surface waters near the Murray River tending to be brackish. Previous and current analysis indicate that nutrient levels are low within the groundwater samples."* In their report for the previous twelve months, Hydro-Plan also said *"... it can be concluded that site activities are not adversely affecting the groundwater nutrient levels."*

In their report *"Murray River Country Estate Groundwater Investigation"* (June 2006), the Hydrologist JDA Consultant Hydrologists advised that:-

"To facilitate land development it is desirable to install subsoil drainage at a level below AAMGL within the zone of seasonal groundwater variation to minimise imported fill requirements. The average difference between AAMGL and AALGL is approximately 1m and therefore a reduction in AAMGL if just 0.5m will allow for lowering of the water table whilst minimising potential problems with acid sulphate soils.

It is important that the Controlled Groundwater Level (CGL) does not adversely impact on significant wetlands on the site that are to be retained in the revised ODP. To maintain the natural hydrology in and around the wetlands and to minimise drawdown effects from drainage on wetland water levels, a 100 metre drainage buffer should be applied around the outskirts of all ODP wetlands."

There is a general minimum requirement of 1.2m minimum separation between the CGL and the lot levels for residential development. The CGL's are to be set on a broad scale and are designed to maintain water levels where necessary for the maintenance of wetland quality. The development proposes to maintain the groundwater levels around the wetlands to the pre-development state but lower them elsewhere where possible. Initial monitoring bore measurements indicate that extensive fill would be required in the western part of the subject land if CGL's are not adopted to achieve a minimum vertical separation of 1.2m. A combination of groundwater monitoring and modelling (*'modflow'*) will be undertaken during the detailed design phase to ensure that the subsoil drainage system is designed at depths to ensure that the reduced CGL's will not impact on the wetlands. In other words, during the detailed design phase, the extent of filling above the forecast groundwater levels and the desired CGL will be specifically balanced to ensure there is no negative impact on the wetlands.

The geotechnical consultant, Douglas Partners completed an investigation of the geotechnical conditions of the whole site and reported in November 2005 that the subsurface conditions beneath the overall development area are generally comprised as follows:

Western Portion

Inter-bedded layers of clayey-silt, sandy-clay, clay, sand and clayey sand (more generally described as alluvium) within the northern area adjacent to the River – the River's floodplain.

Medium dense grey, fine to medium grained sand grading to dark brown (Bassendean Sand) overlying inter-bedded layers of grey to grey-brown, clayey sand, sand and sandy clay within areas to the south of the River floodplain to Pinjarra Road.

Eastern Portion

Loose to medium dense, light grey to grey, fine to medium grained sands (Bassendean Sand) and similar Alluvium soils as noted above in the western portion within the River floodplain.

6.11.2.3 Minor Stormwater Events

Street drainage is proposed to be directed to vegetated swales within the verge at the side of connecting east west roads for soakage of the 1-year storm events and storage of up to the 3-year events. It is proposed via a planned grid pattern of streets to allow road stormwater to flow down street gutters for up to 100m in length and discharge at the end of a street grid to a vegetated swale that runs alongside the side verge of a connecting street. To avoid problems of crossovers over the swale the street and lot pattern has been arranged so that side boundary fences abut the swales. Due to the subsurface conditions it is proposed to have subsoil drainage system in each street, including underneath the swales.

Lots are planned to front the opposite side of the street to the swales. By rotating the grid pattern to suit existing roads and features the streetscape can be planned to provide traffic calming, a pleasant outlook and reduce the length of streetscape with the swales and side boundary fences on one side. The swales are to be sized to allow soakage of a 1-year event and storage capacity for a 3-year storm event from the road catchments. The swale length and capacities are designed to overflow to specifically lowered areas within the POS areas once the 3-year storm recurrence interval design has been exceeded. The catchment for the swales and the size of the swales are sized to suit the 3-year storm capacity for storage and 1-year storm event for soakage (i.e. contained locally) within the swale. A variety of storm durations are required to be tested for each swale and catchment.

Where longitudinal grades of the streets with side verge swales exceed 2% it is proposed to use a traditional piped drain that would discharge to a swale located in a street with longitudinal grades less than 2%.

The lot drainage is proposed to be discharged on each lot via soakage where possible or connected to the street pipe stormwater system. In Sand where a minimum of 1.5m minimum clearance can be achieved to the AAMGL onsite soakage from each lot is proposed. In Sand where a minimum of 1.2m of clearance is available onsite soakage from each lot with a combination of subsoil drainage within the street is proposed.

In circumstances where the subsurface conditions require lot drainage connections for roof drainage these can be piped directly to a piped stormwater system via piped lot connections. A pipe drain (with subsoil drainage) is to be located under the proposed swales with discharge to the selected areas within the proposed open space areas.

Major flood routes are to be considered in the detailed engineering design stage with safe flood paths to storage areas in the POS and subsequent overflow to the receiving water bodies (i.e. the Murray River).

6.11.2.4 Major Stormwater Events

The northern part of the site (most of which is outside the amended ODP area) is predominately within the floodway of the Murray River. A narrow flood fringe defines the area between the floodway and the southern and major part of the development area. This flood fringe forms the northern boundary of the land the land that is the subject of the amended ODP. Development is planned to occur within the flood fringe. This area will be filled to achieve a minimum of 0.5m clearance between the habitable floor levels and important infrastructure and the 100-year flood levels.

A combination of the swales and roadways are to be used to convey major stormwater events to the POS and subsequently to the River. The road, lot and POS levels are to be designed to allow a safe flood route and maintain a minimum clearance of 500 mm to the habitable floor levels and important infrastructure. For the major or less frequent storm events, the overflow of runoff towards waterways and wetlands will follow these overland flow paths across vegetated surfaces - a particular requirement noted in the *"Decision Process for Stormwater Management in WA"* (DoE, 2005).

Storage volumes have been modelled for each sub-catchment to ensure that the pre-development capacity of the downstream drainage system is not exceeded.

6.11.2.5 External Catchments

The Pinjarra Golf Course abuts the southern boundary of the eastern portion of the subject land and Pinjarra Road and rural areas abut the southern boundary of the western portion of the subject land. Neither of these abutting areas is considered to contribute any significant stormwater flows to the subject land.

6.11.3 *Roadworks*

The street layout and street hierarchy is proposed as per the current WAPC liveable neighbourhood guidelines. All streets are proposed to be kerbed with an asphalt seal. In locations where the verge is adjacent to a swale, the roads will be constructed with a one-way cross fall and flush kerbs will be provided on the swale side to ensure runoff 'sheets' off the pavement into these areas. Traditional gully pits are not required on these roads. Similarly roads alongside POS will have a one way crossfall towards the open space with a flush kerb to enable street drainage water to enter the POS via overland flow – so called sheet flow. The verges and POS are to be stabilised and/or grassed and/or vegetated to prevent erosion.

6.11.4 *Wastewater*

All lots are to be serviced by a sewer reticulation system to be installed by the Developer and subsequently taken over and operated by the Water Corporation. An existing wastewater pumping station is located near the northern edge of the development in a central location that serves both land parcels located on each side of the Western Power transmission line easements that cross the middle of the subject land.

The site has a shallow groundwater level, it is relatively flat and dewatering will be required for much of the sewer installation. Prior to construction subsurface investigations along the sewer routes would be completed to assist in the preparation of specific acid sulphate soil management plans for the excavation and dewatering for the sewer installation. This is required to obtain dewatering permits from the Department of Water (DoW) and approval of an ASS Management Plan from the DEC and to prevent the creation of acid from potential acid sulphate soils. Planning Bulletin Number 64, prepared by the WAPC show the area as a moderate to low risk of AASS (actual acid sulphate soils) and PASS (potential acid sulphate soils) occurring generally at depths > 3m. More details on the ASS issues follow later in this report.

6.11.5 *Water Supply*

All lots are to be serviced by a water reticulation system to be installed by the Developer and subsequently taken over and operated by the Water Corporation. The existing development and all future areas are to be connected to the existing infrastructure fed from the North Dandalup Water Scheme.

A ring main feeder system will distribute water along the local distributor roads within the proposed ODP area and then standard water reticulation mains are to be extended from the distribution mains to service each of the lots created.

6.11.5.1 Water Corporation Headworks

The Water Corporation will charge headworks for sewerage and water supply at the current rates per lot.

6.11.6 *Grey Water*

Recycling of grey water (the 'third pipe') for reticulation over these large areas is not seen as advanced enough a system in terms of health requirements (pathogens and *e coli*) or on an economic level (eg less flow in sewer pipes requires steeper grades and hence deeper and more expensive excavations and dewatering). There may be more opportunities on a local lot level to achieve this type of recycling. The option of using bore water via a reticulation pipe in conjunction with a water balance model over the site is seen as a more viable alternative and will be investigated in detail.

Existing bore water use for the reticulation of parks and lots is a matter that was determined in the water balance for the urban water strategy adopted for this development. Existing water licences within the groundwater district are regularly reviewed and managed closely in accordance with the DoE's requirements.

6.11.7 *Power*

Western Power has confirmed that adequate power distribution lines are available to suit the proposed development. Ring mains are now being extended into the subject land from powerlines located along Pinjarra Road.

6.11.8 *Telecommunications*

Telstra advises it have adequate network on Pinjarra Road to service the proposed development. At the moment, however, neither Broadband nor Pay TV nor Telstra's Smart Community services can be provided. No published plan is provided by Telstra to suggest the timing for these services although it is expected that as the development proceeds Telstra will submit to demand and provide these services.

MATV and Broadband Services are provided by the Developer in an arrangement with the company Broadcast Engineering Services. BES has recently taken over the ownership and operation of the existing system and will upgrade it to provide digital TV services and broadband internet services in addition to the existing free-to-air TV and satellite services.

6.11.9 *Gas*

Alinta has confirmed that gas supplies can be provided to the whole of the development.

6.12 Environmental Management

There are a number of natural areas that are to be retained as part of the MCRE ODP and require management to ensure the retention and enhancement of the ecological values. Wetlands, vegetation and fauna have a number of environmental management processes in common for example weed control, fire control, disease control and feral animal control for fauna. The following section describes the main environmental management considerations as they relate to the ODP.

A series of Environmental Management Plans needs to be prepared for the site including:

- Weed Management Plan
- Fire Management Plan
- Foreshore Management Plan
- Rehabilitation Plan
- A Wetland Management Plan.

These management plans and their timing and implementation should be prepared at subdivision stage.

6.12.1 *Weed Management*

Environmental weeds are plants that establish themselves in natural ecosystems and modify natural processes, resulting in the decline of the communities they invade. Disturbances that contribute to the spread of weeds include:

- clearing;
- trampling;
- off-road vehicles;
- increased fire frequency;
- rubbish dumping, including soil and garden waste; and
- movement of weed seed, especially by vectors along the numerous tracks in the area.

A number of weeds are present in the wetland and bushland areas within the ODP area. Some of these weeds have the potential to impact on the ecological and habitat values of the natural areas to be retained.

Strategy

Develop a Weed Management Plan for the natural areas within the ODP at subdivision stage, which addresses the following;

- Avoiding the introduction of species that pose a weed threat to the bushland areas,
- Developing a control program based on site-based management and species-based management.

Control options for environmental weeds include:

- Manual control;
- Herbicides; and
- Controlling ecosystem degradation processes.

6.12.2 *Fire Management*

Bushfires can be devastating and frightening occurrences. This is particularly true in rural and semi-rural areas of the Swan Coastal Plain of Western Australia. Bushfires in remnant bushland in urban and rural landscapes threaten not only lives and property; they also present one of the most severe threats to the ongoing retention and integrity of remnant bushland.

Although fire is a natural part of the ecology of the ODP natural environment, the current environmental conditions are very different to the natural situation, due to a number of related changes, including:

- The isolated nature of the remnant vegetation within the urban and rural context; and
- The greatly increased risk of fire ignition due to arson.

Strategy

A Fire Management Plan should be developed for the ODP area which should address the following:

- Separation area and hazard reduction;
- reducing frequency of ignitions (either accidental or deliberate);
- rapid response and fire suppression;
- public education; and
- post-fire recovery and incident analysis.

6.12.3 *Feral Animals*

There are potentially several species of feral animal within the study area, as well as domestic cats and dogs. Future urban development could increase the number of feral and domestic species in the ODP area. Cats and foxes would be the most likely invader from this source.

Control Strategy

Feral cats and foxes are predators of a wide range of small native animals, including birds, mammals, frogs and reptiles. Control of feral cats is extremely difficult, although selective trapping and removal of individuals could be implemented if cats became a significant problem in the area.

Other initiatives to protect fauna would be to minimise domestic cats and dogs exercising unleased in these particular areas. Night curfew on cats and the encouragement of responsible pet ownership to reduce the impact of domestic cats on wildlife would be beneficial for the native fauna. An approved co-ordinated program of fox baiting before development construction would ameliorate the impact of foxes (*Vulpes vulpes*). Programs for managing feral and domestic animals should be co-ordinated by the Shire of Murray and the Department of Conservation and Land Management.

6.12.4 *Disease Management*

There is the potential for various diseases to impact on the native vegetation and habitat area of the ODP area. These include:

Dieback (*Phytophthora cinnamomi*)

There are 15 *Phytophthora* species in Western Australia. These are soil-borne water moulds that kill a wide selection of plant species of the south west of Western Australia. The most significant *Phytophthora* species is *Phytophthora cinnamomi*.

Honey Fungus (*Armillaria luteobubalbina*)

Armillaria luteobubalbina (Honey Fungus), is a toadstool-producing parasitic fungus lives off both live and dead hosts and is native to Western Australia. In some circumstances it can act as a virulent parasite that kills hosts including Tuarts.

Aerial Canker

Aerial Cankers are diseases caused by a group of largely air-dispersed fungi (including *Cryptodiaporthe melanocraespida* and *Zythiostroma* and *Diplodena* species) that affect the State's flora in the south-west. Under suitable conditions the disease can cause the death of plants within 2 years.

Strategy

Standard horticultural hygiene procedures that minimise the introduction and spread of infected material (by destroying infected material, minimising vehicle access through reserves, ensuring vehicles and tools are free of soil and plant material when they come onsite, and ensuring materials brought onsite such as greenstock, soil and mulch are disease free) should provide sufficient protection.

As there is no practical large scale cure for dieback, prevention of infection is the primary means of defence. If it did become established within the study area then protection of individual plants from dieback can be achieved using phosphite, which is injected or sprayed onto individual trees.

There are no known methods for controlling Aerial Canker or *Armillaria luteobalbina*. The best defence against these species is to reduce disturbances within the ODP area that could stress plants, such as frequent fire and alterations to hydrology.

6.12.5 *Foreshore Management Plan*

A Foreshore Management Plan has been previously prepared by LeProvost Dames and Moore (1998) for the approved ODP that dealt with:

- Bank stability;
- Maintenance of riverine vegetation;
- Public access;
- Demarcation of foreshore reserve;
- Aboriginal Heritage Sites;
- Mosquito breeding;
- Wildlife corridor and habitat;
- Bushfire management;
- Management responsibilities;
- Funding;
- Implementation;
- Monitoring; and
- Review.

Strategy

The Foreshore Management Plan be reviewed and amended to meet the goals of the revised ODP at subdivision stage.

6.12.6 *Rehabilitation Plan*

The revised ODP has an increased area of vegetation that is to be retained. The goals of the MRCE should be to enhance the ecological values of these areas through ecological rehabilitation. The objectives of ecological rehabilitation for the revised ODP should include:

- To reinstate indigenous flora and vegetation communities, where they have been disturbed and/or depleted, particularly after infrastructure works;
- Minimise the impact of activities that could result in degradation to vegetation communities through the use of appropriate management strategies;
- Improve the overall condition of vegetation communities within the site; and
- Ensure that vegetation communities are self-sustaining and are capable of natural regeneration.

Strategy

Develop a Rehabilitation Plan for bushland areas within the revised ODP at subdivision stage.

6.12.7 *Wetland Management Plan*

A Wetland Management Plan has been previously prepared by LeProvost Dames and Moore (1998) for the approved ODP with the following objectives:

- Providing a strategy for the management of surface waters on site including natural wetlands and artificial lakes.
- To provide for the integrated management of the wetlands in conjunction with drainage and irrigation management to ensure that the water quality in the wetlands remains acceptable.
- That runoff from the site is managed in accordance with the provisions of the Drainage Management Plan and that its quality meets the requirements of the Peel Harvey Environmental Protection Policy as set out in the Nutrient and Irrigation Management Plan.

Strategy

The Wetland Management Plan be reviewed and amended to meet the goals of the revised ODP at subdivision stage.

6.12.8 *Acid Sulphate Soils*

Associated with the development of Stages 3, 4, 5 and 7 during the period from August 2004 to mid 2006, Douglas Partners prepared specific ASS Management Plans for the construction of sewers. These plans approved by the DoE were successfully implemented for the works now completed on each of these four stages. The geological conditions encountered during the investigations for these stages were similar. Given that ASS are typically related to particular geological formations, the types and level of soil and groundwater management specified in the ASS and dewatering management plans are also similar and likely to continue to be similar for all stages of development on the subject land.

During November and December 2005 Douglas Partners completed a preliminary ASS and geotechnical investigation over the whole of the balance of the subject land. Based on the results of the study Douglas Partners concluded that:

- ASS or PASS are not likely to occur within the alluvium material found north of the edge of the Murray River's 100-year flood fringe
- A pH_{FOX} of less than 3 is a reasonable indication that the net acidity is likely to be greater than 0.03%

- The grey sands within the Bassendean Formation are generally not likely to have net acidities greater than 0.03%
- The brown, grey-brown and dark brown samples of Bassendean Sand are most likely to have net acidities greater than 0.03%

Groundwater

- The depths to the groundwater are generally less on the western side of the site than the eastern side because the surface levels are higher on the eastern side
- The groundwater depths on the western side of the site were found to range from 0.4m to 0.9m whereas they ranged from about 0.6m to 2.4m deep on the eastern part of the site

Management

It is expected that similar levels of soil and groundwater management that have been successfully implemented for the recently completed stages of the project would also be applicable to the overall development of the ODP area. The project team has adopted ASS management strategies that are effective, comply with the DoE's requirements and meet with their approval. Based on experience with Stages 3, 4, 5 and 7 the management plans were readily implemented and managed. The knowledge and expertise gained with these earlier stages is demonstrative of the relative ease of management of ASS issues for this site.

For each subdivision stage, specific and localised ASS and groundwater investigations are to be undertaken. Such investigations can only follow sufficient design (i.e. depth and alignment of the sewers in particular) so that the ASS and groundwater management plans are focused on the specific construction works associated with an individual stage of the development. For each stage of the works, a management plan and application for a dewatering licence will be prepared for DoE approval.

7.0 IMPLEMENTATION

In order for the ODP to fulfil its function as a formal component of the planning framework, the following are the key actions required:

- Adoption of ODP.
- Initiation of an Amendment to Schedule 7 of the Shire of Murray Town Planning Scheme No. 4 to introduce the various landuse precincts discussed in Section 6.2 of this report and the recognised need for additional management plans and studies.

In addition to establishing the statutory framework necessary to implement the ODP, the following key actions will be required during the course of the development:

- Implementation of other initiatives.
- Identification and agreement of Environmental offsets.

7.1 Adoption of Outline Development Plan

The overall objective of an ODP is to establish a planning framework that will enable an area to develop in the most orderly and integrated manner, meeting sound planning principles, and promoting high quality sustainable development solutions. In terms of the Murray River Country Estate ODP, the statutory vehicle used to implement this objective is the Shire of Murray Town Planning Scheme No. 4.

The ODP should therefore be formally adopted under Clause 6.8 of the Town Planning Scheme No. 4.

Once adopted this ODP will provide the basis for guiding subdivision and development within the Murray River Country Estate

7.2 Amendment to Town Planning Scheme No. 4

The ODP will provide the basis the basis for initiation of an Amendment to the Scheme to introduce provisions and land use permissibility specific to the various landuse precincts shown on the ODP. It is envisaged that a request for Council to initiate a Scheme Amendment will be prepared shortly and lodged with Council following submission and initial assessment by Council of the ODP.

7.3 Other Initiatives

7.3.1 Formulation of Community Plan

As discussed previously, a Community Development Plan is to be prepared for the Murray River Country Estate that will complement a wider Community Planning process currently being undertaken by the Shire of Murray. Responsibility for formulation and implementation of this plan has been taken by the developers of the Estate, who have also committed to retaining control over the progressive development of public open space areas within the Estate over time, and over the establishment of various community buildings as appropriate.

7.3.2 Preparation of Design Guidelines

Detailed design guidelines will be prepared on a precinct basis at subdivision stage, to ensure that developers of all building typologies are thoughtful in their approach to design, and so that desired built form design objectives can be achieved across the Estate.

It is anticipated that the guidelines will focus heavily on the village centre (including commercial, mixed use, civic, and highway commercial lots), residential areas (encompassing the range of densities) and tourist areas.

Guidelines for the lower density housing (R10-R20) shall be performance based, rather than a schedule of specific requirements. The built form guidelines for these dwellings will celebrate *harmony through diversity*. In addition, careful lot planning guidelines will be required to ensure high standards for penetration of northern sun, capture of natural ventilation and successful building/street relationships are maintained.

Responsibility for preparation of these guidelines lies with the developer.

7.3.3 *Environmental Management Plans*

As identified in Section 6.11, a series of Environmental Management Plans need to be prepared for the site including:

- Weed Management Plan
- Fire Management Plan
- Foreshore Management Plan
- Rehabilitation Plan
- A Wetland Management Plan.

These management plans and their timing and implementation should be prepared at subdivision stage.

7.4 Environmental Offsets

The opportunity for environmental offsets to support the Outline Development Plan for the Murray River Country Estate has been reviewed by ENV Australia Pty Ltd (ENV).

The identification of environmental offsets has been undertaken in order to enhance the environmental performance of the Murray River Country Estate. Independent of the offsets recommended in this section, the revised ODP represents a better environmental outcome for the site when compared to the 1996 approved development.

The previous approval for development on the site has naturally generated economic and environmental expectations for the site, however, within the context of these expectations, the development of a revised ODP represents an opportunity to advance the site's environmental performance. It is considered that the implementation of the recommended offsets will represent a fulfilment of that opportunity.

The following offsets have been informed by Position Statement No. 9 -Environmental Offsets (EPA, 2006). In particular the guiding principles were used as a basis for the individual and collective offsets. The principles are presented here in summary form:

- Offsets considered only after all attempts to mitigate impacts are exhausted;
- Offsets package should address both direct and contributing offsets;
- Offsets should ideally be 'like for like or better';
- Positive offset ratios should apply where risk of failure is apparent;
- Offsets must entail a robust and consistent assessment process;
- Offsets must meet all statutory requirements;
- Offsets must be clearly defined, transparent and enforceable; and
- Offsets must ensure long lasting benefit.

7.4.1 *Defining the Scope of Environmental Assets Requiring Offsets*

As per the previous approval for the site, areas identified as wetlands of significance and their associated vegetation are proposed to be lost to development. The largest of these wetland areas are located in the north east of the site. The wetlands affected in this area are identified as wetland 5442 and 5443. Both of these palusplain wetlands are identified as Conservation Category Wetlands (CCW) by the Geomorphic Wetlands of the Swan Coastal Plain dataset.

An assessment of the vegetation associated with both of these wetlands has identified the vegetation complex as floristic community type (FCT) 21a. FCT 21a is an upland community therefore the wetland status of these areas will be challenged via application for an adjustment of the Geomorphic Wetlands of the Swan Coastal Plain dataset.

FCT 21a is a community which is adequately represented. The vegetation of these areas also do not contain flora of significance. On the basis of this information and in anticipation of the removal of their wetland status, the areas identified as wetland 5442 and 5443 are not considered further in the context of offsets as they are not considered to be significant environmental assets.

Two smaller areas of wetland immediately south west of wetland 5442 are also proposed to be mostly cleared for development. These wetland areas are identified as wetland 5184 and the northern extremity of wetland 5043. Wetland 5184 is a palusplain wetland and is identified as a CCW. This wetland has been assessed as supporting vegetation of good condition. The northern portion of this wetland, representing approximately 30% of its total area, is proposed to be conserved as part of the foreshore reserve. The remainder of this wetland will be lost and as such is considered in the context of offsets.

The northern tip of wetland 5043 is also conserved in the foreshore. The majority of this wetland will be conserved and enhanced in the central POS/Western Power easement. This sumpland is mapped as a Resource Enhancement wetland and in the area in question is assessed as supporting vegetation of good condition. The portion of wetland 5043 that is proposed to be lost to development is considered in the context of offsets.

Wetlands 5044 and 5046 are mapped in the west of the site. These are both palusplain wetlands. Wetland 5044 is mapped as a CCW. It has been assessed as supporting vegetation of good quality. Following the assessment of this wetland, it is considered that it is more representative of a Resource Enhancement or Multiple Use category wetland. As such a downgrade of this wetland's management category will be pursued. The ODP proposes to clear this wetland and therefore it is considered in the context of offsets.

Wetland 5046 is mapped as a Resource Enhancement wetland and has been assessed as supporting degraded vegetation. This wetland is partially conserved through the large area of POS that also conserves wetland 5045. Whilst approximately 20% of wetland 5046 is conserved, the remainder is proposed for development and therefore it is considered in the context of offsets.

In summary, the environmental features that are to be offset include:

- Part wetlands 5043, 5184 and 5046;
- Wetland 5044.

7.4.2 *Current Environmental Protection*

This environmental offsets package is provided to enhance those conservation features of the revised ODP that demonstrate a commitment to normal environmental management responsibilities. The current conservation features of the revised ODP include:

- Conservation of the Resource Enhancement wetland 5445;
- Conservation of the Resource Enhancement wetland 5449;
- Conservation of the Resource Enhancement wetland 5045;
- Conservation of the majority of the Resource Enhancement wetland 5043 and part of Multiple Use Wetland 14043 via POS/Western Power easement;
- Partial conservation of CCW wetland 5184;
- Partial conservation of Resource Enhancement wetland 5046; and
- Conservation of 13.71 ha of foreshore area.

With the exception of the conservation of part of the Multiple Use wetland 14043, the environmental offsets described in this section are in addition to those usual management responsibilities associated with these wetland and foreshore areas. This approach is consistent with the objectives of Position Statement No. 9.

7.4.3 Environmental Offsets Package

The following offsets package has been designed to provided 'like for like'. The package provides direct and contributing offsets. Importantly, it is considered that a net environmental benefit will be provided.

7.4.3.1 Wetland Offsets

The majority of the wetlands impacted upon are palusplain wetlands with an identified or inferred management category of Resource Enhancement. It is proposed that the loss of these wetlands can be offset through the conservation and improvement of the palusplain wetlands identified as part of wetland 14043 and mapped as Multiple Use category. This area is located in the 21.4ha POS/Western Power easement corridor. This corridor also supports the majority of the sumpland identified as 5043 and mapped as a Resource Enhancement wetland. This corridor runs north south and provides a habitat corridor between the Murray River and associated foreshore reserve and the bushland areas to the south of the site, including the golf course.

The majority of the vegetation in this corridor has been assessed as very good condition and represents the largest area of vegetation of such condition on the site. Being mapped as a Multiple Use wetland, the majority of this corridor POS area is available for development. The presence of the Western Power transmission line does not preclude development in this area and commercial opportunities have been considered.

In recognition of the potential linkage benefits of this corridor and in-situ conservation value, a commitment is provided to conserve this area and rehabilitate the vegetation and wetland functions with an objective of achieving a wetland that would attract a classification of Conservation Category. A portion of this wetland area is currently altered hydraulically for farming and drainage purposes. This altered area will be remediated as much as is practicable given the identified need to utilise a portion of this area for ongoing drainage and nutrient management purposes. Notwithstanding the use of a portion of this wetland to achieve broader environmental objectives, the majority of this corridor consisting of sumpland and palusplain wetland areas will be managed for improvement and conservation objectives. Specifically this will include but is not limited to:

- Fencing for restricted pedestrian and vehicle access, whilst permitting faunal movements;
- Provision of formalised access paths for Wester Power service vehicles, with alignment designed to limit disturbance;
- Provision of formalised but limited pedestrian access paths;
- Erection of interpretive signage;
- Remediation of drainage to provide for natural state in a large portion of the wetland;
- Weed removal and ongoing management;
- Revegetation, including translocation of any suitable significant flora from areas of palusplain/sumpland proposed for removal; and
- Traffic calming devices at the junction of roads with the corridor boundaries.

Further wetland offsets can be achieved through the remediation of the vegetated wetland that is situated centrally on the north western peninsula of the site. The area is currently proposed for POS. The wetland in question does not have its own identification number and is identified as forming part of 14043. Aerial photography indicates that the Geomorphic Wetland dataset has incorrectly identified this wetland. A more appropriate assessment of its type would appear to be sumpland. In consideration of the extent of vegetation, a more appropriate classification would appear to be either Resource Enhancement or CCW.

In consideration of this, the rehabilitation of this wetland can be considered as an offset for the proposed impact on wetland 5184 and the northern portion of 5043.

The rehabilitation of this wetland can also take advantage of the position of the wetland and bridge the peninsula on which it is situated, linking the east and west bounding foreshore reserve areas. Revegetated strips of approximately 40m in width can link the rehabilitated wetland to these areas.

As indicated previously, the remediation and management of the wetlands of Resource Enhancement and CCW classification that are already identified for conservation in POS and foreshore reserve areas are not documented here as this is already a required management responsibility.

7.4.3.2 Biodiversity Corridors

In addition to the north south corridor identified under the wetlands section, further corridors can be provided via the golf course areas. The north south corridor can be linked in an easterly direction toward the Murray River by enhancing the vegetation that currently abuts the southern border of the development. Plantings will increase the width of this corridor to an average width of 20m. Crossing the road, this corridor can be extended in 2 directions in a linear fashion through the new golf course to eventually link:

1. east to the Murray River foreshore area (outside the ODP area but within the control of the Murray Riverside); and

2. north to the conserved wetland 5449, which in turn connects with the foreshore reserve.

7.4.3.3 Murray River Action Plan

The Foreshore Management Plan (FMP) has been implemented as part of the existing requirements for the development of the site. The foreshore area has now been vested with the Shire of Murray. Rehabilitation works within the foreshore have been undertaken with the support of the Peel Harvey Catchment Council, Greening Australia and the Department of Environment and Conservation (DEC). The area of foreshore reserve associated with the site is viewed by these bodies as an important conservation asset.

The Murray River Action Plan is the strategic document guiding the restorative and management works for the Murray River, known as the Murray River Project. Discussions with the Peel Harvey Catchment Council and the DEC have indicated that further commitments of work by the Murray Riverside within the foreshore and for the broader Murray River Project would be of great benefit.

The following commitments are made with regard to the foreshore and greater Murray River:

- conduct another round of weed eradication in accordance with the management program; and

- provision of $10,000 to the Peel Harvey Catchment Council to fund research into the impact of the Pinjarra Weir on fish species breeding and migration. This research will identify the impact of the Pinjarra Weir and recommend management actions.

- improvement of existing access points.

7.4.4 Implementation of Commitments

Position Statement No. 9 states a preference for the ability to enforce commitments. In this instance, unless incorporated as WAPC approval conditions, the opportunity for enforcement may be limited. As demonstrated through the work conducted in implementing the Murray River Action Plan via the Foreshore Management Plan implementation, Murray Riverside has a history of commitment to work with relevant agencies and to implement environmental actions. This same commitment will be applied to implementing the described offsets.

7.4.5 Further Work

As is evident in the documentation of the proposed offset package, details of some of the commitments will require additional investigation and documentation. It is considered appropriate that these are undertaken at subdivision stage.

APPENDIX 1
MRCE ODP Report – Environmental Section Ecoscape

MURRAY RIVER COUNTRY ESTATE ODP REPORT ENVIRONMENTAL SECTION

MURRAY RIVER COUNTRY ESTATE

Prepared by:

Ecoscape (Australia) Pty Ltd

Limitations Statement

This report has been exclusively drafted for the needs of Murray Country Estate. No express or implied warranties are made by Ecoscape (Australia) Pty Ltd regarding the research findings and data contained in this report. All of the information details included in this report are based upon the existent land area conditions, research provided and obtained, and so forth at the time Ecoscape (Australia) Pty Ltd conducted its analysis into the area. Ecoscape (Australia) Pty Ltd will not be responsible for the application of its recommended strategies by Murray River Country Estate.

Please note that the strategies devised in this report may not be directly applicable towards another Land Developer's needs or any other specific land area requiring management strategies. We would also warn against the environmental dangers of adapting this report's strategies to another land area which has not been researched and analysed by Ecoscape (Australia) Pty Ltd. Instead, please contact Ecoscape (Australia) Pty Ltd to provide a tailored report for your area's needs. Otherwise, Ecoscape (Australia) Pty Ltd accepts no liability whatsoever for a third party's use of, or reliance upon, this specific report.

Direct all inquiries to:

Ecoscape (Australia) Pty Ltd
9 Stirling Highway • PO Box 50 North Fremantle WA 6159
Ph: (08) 9430 8955 Fax: (08) 9430 8977
mail@ecoscape.com.au

Document Status

Rev. No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	VY,SB,DK	DK,		DK		17/2/06
1	VY SB DK BT	DK, BT				
2	VY SB DK BT	DK				
3	VY SB DK BT	DK				
4	VY SB DK BT	DK				
Final	SB BT DK	DK		DK		12/12/06

ecoscape

COPYRIGHT STATEMENT FOR:
Murray River Country Estate ODP Report - Environmental

Table of Contents

MRCE ODP Environmental Section

LIST OF TABLES

1.0 Introduction

MRCE ODP Environmental Section

Murray Riverside Pty Ltd has undertaken a revision of the approved Outline Development Plan (ODP) prepared for Lots 13 and 331 Pinjarra Road previously known as Ravenswood Sanctuary. New Urbanism, Liveable Neighbourhoods and Sustainability are all part of new approaches to the design for more appropriate community and economic development. Taylor Burrell Barnett has developed a revised ODP which integrates the existing development with these new planning approaches. The revised ODP incorporates improved environmental outcomes, such as;

- An increase in retention of wetlands in their natural state of 28 hectares. This is a desired outcome of the EPA as set out in Guidance Statement number 33, (EPA, 2005) "*Wetlands are an intrinsic part of the hydrology of a region. They are widely recognised as significant for their ecological, hydrological, social and economic values. Wetlands typically support a high level of biological productivity and diversity. Wetlands can act as biological filters by retaining sediment and absorbing nutrients and pollutants (Hill et al. 1996). They also provide flood control by storing and detaining storm water*";
- Increased protection of the Murray River ecosystem due to the significant down-sizing of the Golf Course and therefore a potential reduction in uncontrolled nutrient input;
- Improved ecological connectivity between the Murray River and the last remnants of native vegetation in the Pinjarra township; and
- An increase in the habitat conservation for the Southern Brown Bandicoot (*Isoodon obesulus* subsp. *fusciventer*) and other native fauna species naturally occurring in the area.

As part of the preparation of the revised ODP Ecoscape undertook the following assessment:

- A review of current environmental approvals for the Ravenswood Sanctuary Project, Golf Resort and Residential subdivision;
- A desktop review and field assessment of the vegetation conducted in summer 2004 and spring 2005;
- A desktop review and field assessment of wetlands and re-assessment of their management classification using EPA Bulletin 686 (see **Appendix 2**); and
- A fauna desktop review.

The following report presents the findings of these investigations. The results of the field investigations undertaken by Ecoscape are provided in **Appendix 2**.

2.0 Legislative and Policy Framework

MRCE ODP Environmental Section

2.1 Previous Environmental Approval

In 1995 the Environmental Protection Authority set the level of assessment for the project entitled Ravenswood Sanctuary Project, Golf Resort and Residential subdivision, Lot 331 and Part Lot 13 Pinjarra Road, Pinjarra as an Informal Review with Advice Given.

The Ravenswood Sanctuary was designed as an international standard tourist centre integrated with a world standard golf course and recreational facilities provided in conjunction with a range of residential lots. It comprised five distinct but interrelated elements, these were:

- Recreational and tourist facility (including golf course);
- Residential areas;
- Resort facilities;
- Foreshore reserves; and
- Public open space

Although portions of this plan have been implemented, the new owners do not wish to proceed with major aspects of the previously approved design particularly down-sizing the 44 hole golf course to a 9 hole course. There is therefore a need to prepare a revised ODP.

A number of proponent commitments were made as part of the environmental approvals granted for the development. These related to:

- Construction;
- Floodway/floodplain;
- Residential/resort development;
- Foreshore reserve;
- Southern Brown Bandicoot (requiring significant relocation of animals);
- Nutrient and irrigation management
- Land management and conservation;
- Waste removal; and
- Nuisance insects

A number of management plans relating to the above commitments were prepared by the proponent and approved by the then Department of Environmental Protection. These management plans were used as a basis for the construction of development cells.

The Ravenswood Sanctuary development received approval in 1996 for modifications to the environment that included:

- Clearing of remnant vegetation situated on un-cleared agricultural land;
- Clearing or modification of all existing wetlands including additional drainage functions and the creation of new lakes for amenity and drainage purposes;

- Reduction in fauna habitats resulting in potential translocation of bandicoot populations; and
- Modifying surface drainage to manage water volumes and quality.

2.2 Planning Context

There are a number of policies and regulations that relate to the Murray River Country Estate including the Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992, the Wetlands Conservation Policy for WA (Government of WA, 1997), the Environmental Protection of Wetlands Position Statement No. 4 (EPA, 2004b) and the Guidelines for Determining Wetland Buffers (WAPC, 2005).

2.2.1 Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992 (EPA, 1992)

This policy is relevant to the Murray River Country Estate as it is situated within the Peel-Harvey Catchment area.

This policy relates to the health of the estuary, specifically nutrient enrichment. This is a result of the clearing of native vegetation and land uses that leach nutrients, especially phosphorus, into the waterways that flow into the Estuary. The nutrient enrichment of the Estuary has stimulated the excessive growth of algae, causing the degradation of the Estuary and creating serious public nuisance.

The purpose of the policy is:

- To set out environmental quality objectives for the Estuary which if achieved will rehabilitate the Estuary and protect the Estuary from further degradation; and
- To outline the means by which the environmental quality objectives for the Estuary are to be achieved and maintained.

These principles should be considered by those submitting proposals for EIA. They are also valuable for guiding the on-going management of wetlands and adjacent activities.

2.2.2 The Wetlands Conservation Policy for Western Australia (State Government, 1997)

This policy states the West Australian government's commitment to prevent the further loss or degradation of wetlands and have proposals likely to have a significant environmental impact on wetlands referred to the EPA for environmental impact assessment.

2.2.3 Waters & Rivers Commission Position Statement on Wetlands (WRC, 2001)

This position statement is relevant to the Murray River Country Estate because of the wetlands that occur on the site. This document focuses on the management and protection of wetlands in relation to development in the Swan Coastal Plain region and outlines buffer requirements for wetlands. It also states that Conservation Category wetlands should be afforded the highest priority for conservation and protection. Buffers are designed to protect

wetlands from potential impacts on the ecological processes and functions within the wetland. Buffers also act to protect the community from potential impacts such as nuisance midge problems. Buffer distances are measured from the outside extent of wetland dependant vegetation to the outside edge of any proposed development or activity. The required buffer distances for wetlands depend on the land use, 50 metres being the minimum buffer distance applied (WRC, 2001)

2.2.4 The Environment and Natural Resources Policy (WAPC, 2003)

This policy establishes and defines the principles and considerations that represent responsible planning in relation to environmental and natural resources issues within the framework of the State Planning Strategies.

The objectives of the policy are:

- to integrate the environment and natural resource management with broader land use planning and decision making ;
- to protect, conserve and enhance the natural environment; and
- to promote and assist in the wise and sustainable use and management of natural resources

The particular policy measures which are relevant to the subject site include:

- **General measures**; such as to seek opportunities for improved environmental outcomes, for example, development that provides for environmental restoration and enhancement.
- **Water resources**; this includes enhancing the wetlands to be retained and ensure that there are adequate buffers between development and the wetland foreshore to protect wildlife habitat and facilitate filtration of sediment and waste associated with surface run-off from adjacent land uses.
- **Biodiversity**; protecting areas where there are significant flora and fauna and seek to establish adequate and representative conservation reserve systems such as ecological linkages for flora and fauna. Also support the use of management plans to protect the biodiversity of areas to be retained under the revised ODP.
- **Landscape**; identify landscape types requiring special attention.

2.2.5 Guidance for the Assessment of Environmental Factors No. 10 (EPA 2003)

EPA Guidance Statement 10- *Level of assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region* identifies that the following characteristics should be considered in determining the regional significance of bushland:

- Size and Shape;
- Vegetation Condition;
- Uplands and Wetlands;
- Ecological Communities below 10 percent pre-clearing extent and threatened ecological communities;
- Relationship to other areas;
- Ownership or reservation status.

2.2.6 The Environmental Protection of Wetlands Position Statement No. 4 (EPA, 2004)

This EPA position statement aims to define the environmental values and function of wetlands that the EPA considers important and to explain why they are worthy of protection. It also provides a set of principles for the protection of wetlands which is applicable to the Murray River Country Estate to assist in the management of the wetlands to be retained as part of the revised ODP. These principles are:

1. Ecologically Sustainable Development
2. "Wise Use" Concept
3. Ecosystem Management Approach which is focused on the sustainability of wetland ecosystem functions, integrity and the processes required to maintain these essential environmental services.
4. Inter-generational Equity.

2.2.7 Draft Environmental Guidance for Planning and Development (EPA 2005)

This Draft Guidance Statement updates the EPA's 1997 Guidelines for Environment and Planning. It provides advice on protecting the environment during planning, and information on environmental impact assessment processes.

The purpose of the Guidance Statement is to:

- provide an overview of environmental protection processes and information, to assist land use planning and development in Western Australia;
- describe referral and environmental impact assessment processes under Part IV of the *Environmental Protection Act 1986* and, in particular, the procedures applied to schemes; and
- provide the EPA's advice on a range of environmental factors in order to assist participants in land use planning and development to protect, conserve and enhance the environment.

Guidance Statement No 33 states that:

- A proposal that has previously been referred to the EPA cannot be referred again unless its assessment was terminated under s40A *EP Act*. Thus a decision-making authority does not need to refer a significant proposal if it has already been referred. Ravenswood Sanctuary Project, Golf Resort and Residential subdivision (now Murray River Country Estate) has previously been referred to the EPA and therefore cannot be referred again.

2.2.8 Draft Guideline for the Determination of Wetland Buffer Requirements (WAPC, 2005)

The Draft Guideline for the Determination of Wetland Buffer Requirements (2005) has been developed to assist landowners, developers, planners and architects in identifying appropriate buffers between wetlands and land uses that will enhance or maintain the significant attributes and values of the wetland.

The wetland management category system established by the EPA in Bulletin 686 (1993) is currently endorsed by the EPA; however, current practices tend to use the system outlined in this document. Bulletin 686 is under review.

The system outlined in the Guideline includes three wetland management categories:

- C category (conservation): wetlands with high conservation value for both natural or human use (incorporates Bulletin 686 categories H and C);
- R category (resource enhancement): wetlands with moderate natural and human use attributes that can be restored or enhanced (incorporates Bulletin 686 categories O and R); and
- M category (multiple use): wetlands that score poorly on both natural and human use attributes.

The review of Bulletin 686 is not expected to result in any change to the current management categories as it is purported to result in the amalgamation into one document of the range of methodologies already used (Western Australian Planning Commission 2005).

This guideline states that the Western Australian Planning Commission's stance is that proposals with footprints impinging upon the buffers of:

- C Category Wetlands are to be referred to the EPA; and
- R and M Category Wetlands are to be referred to the EPA if their management objectives can not be met.

Where the objectives for Resource Enhancement (R category) Wetlands is to restore wetlands through maintenance and enhancement of wetland functions and attributes, and the objective for Multiple Use (M category) wetlands is to use, develop and manage wetlands in the context of water, town and environmental planning.

The buffer requirements stated in the draft WAPC (2005) document have been based on management objectives. Achievement of these management objectives may require more than the proposed distance, or may be able to be achieved with less. Variation from the suggested distances needs to be considered on the merits of each case.

The recommended separation and management to mitigate potential impacts (threatening processes) for category C, R and M wetlands is shown in Table 1.

Table 1: Recommended Wetland Buffers and Management (WAPC, 2005).

Key threatening Process	Conservation	Resource Enhancement	Multiple Use	Separation area Management
Alteration to the water regime	Regulation of groundwater abstraction as catchment management measure			• Area to be vegetated with deep-rooted perennial vegetation • Preferably native plant communities • 6m firebreak minimum, inside of fence • Fence to limit vehicle, stock, exotic fauna access • Clear perimeter outside of fence (path, firebreak, road). • Fire control to maintain habitat and species diversity • Minimise track access/clearing, maximise native vegetation • Management for water quality outcomes as required
Habitat modification	• 100 m weed infestation • Up to 100 m for bird habitat dependent on extent of use • 6-50 m firebreak • Fence for controlling exotic fauna access • >100 m to minimise edge effects	• 50 m weed infestation • 50 m avifauna habitat • 6 m firebreak	• 50 m weed infestation • 50 m avifauna habitat • 6 m firebreak	
Inappropriate recreational use	• >50 m to improve aesthetics • >50 m for barrier • Fence, paths for controlling access	• 10 m - 50 m for improving aesthetics • 10 m - 50 m for barrier • Fence, paths for controlling access	• 10 m - 50 m for improving aesthetics • 10 m - 50 m for barrier	
Diminished water quality	• Drainage inflows eliminated or managed • Where a proposal may affect wetland water quality, particularly through un-channelised flow, detailed site specific work should be undertaken to determine the specific separation measures required, including management measures			

Buffer provisions have been made for wetlands retained in the revised ODP. In some wetlands the buffer widths vary from the recommended requirement and therefore a relaxation in the buffer requirements will need to be negotiated with the relevant authorities. Measures have been provided through water sensitive urban design to ensure the purpose of buffers is met through appropriate ecological engineering mechanisms.

2.2.9 Environmental Offsets Position Statement No. 9 (EPA, 2006)

The EPA (2006) describes offsets as an environmental management tool for a net environmental benefit outcome. One of the principles of the Offsets policy is to conserve biological diversity and ecological integrity. In the case of the Murray River Country Estate, fragmented areas of vegetation that are proposed to be cleared could be offset by the preservation and management of other areas of bushland in better condition. In particular, the vegetation along Murray River and foreshore reserve, that is part of the boundary of the Outline Development Plan and forms a valuable ecological corridor.

2.2.10 Clearing of Native Vegetation in Western Australia

The Environmental Protection Act 1986 (WA) specifies that clearing native vegetation is prohibited, unless a clearing permit is granted by the Department of Environment and Conservation, or the clearing is for an exempt purpose. Exemptions include industry licences and approved sub-divisions. The clearing provisions of this Act are described in the

Environmental Protection Amendment Act 2003 (WA) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)*.

The Department of Environment and Conservation has responsibility for the administration, assessment and approval of clearing permit applications relating to all activities except mining. As of 1 July 2005, the Department of Industry and Resources is responsible for clearing permits related to mineral and petroleum activities in Western Australia.

Environmentally Sensitive Areas (ESA)

Environmentally sensitive areas are locations where the vegetation has high conservation value and cannot be cleared without a permit (DEC, 2005). Examples of ESA are:

- Declared World Heritage property as defined in section 13 of the *Environmental Protection and Biodiversity Conservation Act 1999*;
- A Threatened Ecological Community;
- A Bush Forever Site;
- A defined wetland, for example Conservation Category, and the area within 50m of the wetland; and
- Areas covered by policy such as the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*.

At the Murray River Country Estate, the only areas that would be considered to be ESA are the conservation category wetlands 5044, 5184, 5442, 5443 and 5450.

Clearing Permit

There are two types of clearing permits, an Area Permit (C1 form) and a Purpose Permit (C2 form). If a Clearing Permit is required by the Murray River Country Estate, an Area Permit would be applicable. An Area Permit is for those who:

- intend to clear a defined area of land in a specified time frame; and
- are the owner of the land to be cleared; or
- are acting on the owner's behalf and have written authority from the owner stating this.

There are 10 principles related to native vegetation that need to be investigated and documented in the application for a Clearing Permit. Native vegetation cannot be cleared if:

1. it comprises a high level of diversity of plant species;
2. it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia;
3. it includes, or is necessary for the continued existence of, flora declared to be rare under the *Wildlife Conservation Act 1950*;
4. it comprises the whole or part of, or is necessary for the maintenance of, an ecological community declared under the *Environmental Protection and Biodiversity Conservation Act 1999* as threatened, endangered or vulnerable;
5. it is significant as a remnant of native vegetation in an area that has been extensively cleared;
6. it is growing in, or in association with, an environment associated with a watercourse or wetland;

7. the clearing of the vegetation is likely to cause appreciable land degradation;
8. the clearing of the vegetation is likely to have an impact on the environmental values of any conservation park, national park, nature reserve, marine nature reserve, marine park or marine management area;
9. the clearing of the vegetation is likely to cause deterioration in the quality of surface or ground water; or
10. the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.

3.0 Existing Environment

MRCE ODP Environmental Section

3.1 Background

Lots 13 and 331 Pinjarra Road have been significantly modified over the previous 100 years by past land use activities such as stock grazing, urban development and golf course development. This has resulted in extensive clearing, trampling and grazing of native vegetation, changes in soil nutrient status, introduction of weed species, creation of artificial waterbodies and modifications to the natural drainage system.

Significant areas of the existing natural vegetation consist of single species assemblages such as Spearwood (*Kunzea ericifolia)* which indicates previous clearing and grazing history. In some areas only the mature overstorey exists whilst much of the understorey exhibits characteristics of post clearing regeneration.

3.2 Landform

The topography at the Murray River site was described by LeProvost Dames & Moore (1998b) as generally undulating ranging from 3m AHD to 11m AHD in the south eastern corner. The land on the northern and western boundaries is undulating with small wetlands and surface expressions of groundwater. The predominant soil type of the site is Bassendean Dune sands that are characterised by a low relief dune and plain system comprised of grey siliceous sands. The predominant topographic features of the site are:

- The river bounded by a raised terrace of loamy sands;
- A low-lying floodplain adjacent to the river containing a number of minor depressions and rises. Also wetlands in the form remnant river channels for example wetland 5527 (Figure 2);
- The majority of the site is raised above the 100 year floodplain and is generally flat to undulating.

The visual amenity is varied, however, the site is generally of a rural parkland appearance on a relatively flat plain with the riverine landscape to the north and eastern boundaries where the Murray River meanders. The Murray River is a unique element of the site that provides a natural habitat for wildlife and an area for passive recreation. The river is lined by remnant vegetation of flooded gum (*Eucalyptus rudis*) that stabilise the river banks and add to the character of the riverine landscape. The raised areas of the site offer views over the alluvial plain of the river and to the Darling Range in the east and south east. This natural elevation will be an asset for the future amenity of the site.

3.3 Wetlands

The Murray River Country Estate includes a variety of wetland types, including damplands, sumplands, palusplain and artificial wetlands. **Damplands** are seasonally waterlogged basins of variable shape and size where, for part or all of the winter-spring period, the water table is at or close to the ground surface. **Sumplands** are seasonally inundated basins, with most groundwater fed sumplands retaining surface water between at least August and December. **Palusplains** are seasonally waterlogged flats.

The majority of the site is mapped as palusplain (82%) and the remainder as sumplands (12.5%) and damplands (5.5%) (**Figure 1**). The majority of the palusplain has been cleared or impacted upon through cattle grazing and other agricultural land uses.

Wetlands are assigned a management category that reflects their condition and environmental values (Hill *et al.* 1996) see **Table 2**.

Table 2: Wetland Management Categories (Hill et al, 1996)

Management category	General Description of Wetlands	Management Objectives
C Conservation wetlands	Wetlands that support high levels of attributes and functions.	To preserve wetland attributes and functions through reservation in national parks, crown reserves, state owned land and protection under environmental protection policies.
R Resource Enhancement wetlands	Wetlands that have been partly modified but still support substantial functions and attributes.	To restore wetlands through maintenance and enhancement of wetland functions and attributes by protection in crown reserves, state or local government owned land and by environmental protection policies, or in private property by sustainable management.
M Multiple Use wetlands	Wetlands with few attributes that still provide important wetland functions.	Use, development and management should be considered in the context of water (catchment/strategic drainage planning), town (land use) and environmental planning through landcare.

ATA Environmental was first commissioned in 2004 to investigate the environmental opportunities and constraints of the site to guide the development of a revised Structure Plan for the Murray River Estate.

The outcome of a preliminary survey undertaken by ATA Environmental (2004) indicated that:

- All of the structure plan area is defined as wetland, with the majority mapped as palusplain;
- A number of the wetland areas were incorrectly classified and need to be re-evaluated; and
- There are a number of boundary issues associated with the wetlands which will impact on the structure plan area.

Subsequently, Ecoscape conducted a vegetation survey of the Murray River Country Estate to identify the presence of wetland dependent vegetation to determine if the site contained any wetlands of ecological significance. An assessment of the wetland management categories assigned by Hill *et al.* (1996) was also undertaken using EPA Bulletin 686 (1993d) to confirm if these management categories were applicable.

Geomorphic classification of the wetlands of the Swan Coastal Plain and was undertaken in 1996 by Hill *et al.* and from this work the management categories were assigned. A number of wetlands with a variety of management categories have been identified on the site including five wetlands that have been assigned a Conservation management category **(Table 3)**. Although not legally protected the Department of Environment and Conservation's position on Conservation Category wetlands is no development (WRC, 2001).

The identification of these wetlands is based on the mapping and classification of wetlands by Hill *et al.* (1996). There are a number of known limitations to the Hill *et al.* (1996) study in that it relied heavily on aerial photography, only limited ground truthing was undertaken and broad principles were used to assign management categories to the wetlands. Thus it was deemed necessary to ground truth the study area and assess the wetlands to assign updated management categories based on the Environmental Protection Authority Procedure detailed in Bulletin 686 (1993d).

Wetlands within the study area were identified using the Unique Feature Identifier (UFI) from the Department of Environment and Conservation's Online Geographic Data Atlas (http://apostle.environment.wa.gov.au). **Figure 1** shows the wetland locations and wetland numbers (UFI's). The management classification that was assigned to each of these wetlands by Hill et al. (1996) is presented in **Figure 2**. Areas of Palusplain within the estate have largely been cleared and wetlands within this area have been assigned a management category of Multiple Use (M). Areas in the centre of the estate which support native vegetation have been identified as Conservation (C) or Resource Enhancement (R).

It is also recognised that the Structure Plan area has been significantly modified by past land use activities such as stock grazing which has occurred for over 100 years. As a result, extensive vegetation clearing has been undertaken to accommodate stock grazing and artificial water bodies have been constructed for stock watering purposes.

Table 3: Wetlands within the study area

UFI	Type	Current Category	Size (ha)
5044	Palusplain	C	2.78
5184	Palusplain	C	1.17
5442	Palusplain	C	5.89
5443	Palusplain	C	3.82
5450	Sumpland	C	0.63
5043	Sumpland	R	14.32
5045	Palusplain	R	13.56
5046	Palusplain	R	6.61
5445	Sumpland	R	5.78
5449	Dampland	R	13.76
5042	Sumpland	M	1.03
5047	Sumpland	M	2.25
5050	Sumpland	M	0.74
14043	Palusplain	M	173.34
		Total Area (ha)	**245.68**

(DoE, 2006, adapted from Hill *et al.* 1996)

The Department of Environment's wetland mapping for the approved and revised ODP's along with the reference wetland numbers and their management category are shown in **Figure 2** and **Table 3**.

An analysis by Ecoscape (2005) demonstrated that none of the Conservation Category wetlands were considered to be this category and consideration based on the assessment should be made for reassignment of the management category to **R** but also potentially Multiple Use (**M**) for wetland 5184, based on the poor quality of the vegetation. Also, consideration needs to be given to the removal of the wetland status of wetlands 5442 and 5443 that occur in FCT 21a. This community is more typical of upland vegetation that occurs on the Bassendean dunes and is not considered a wetland vegetation community (Gibson *et al.* 1994). For those wetlands that were not formally assessed the existing allocation of Resource Enhancement (**R**) and Multiple Use (**M**) appears to be appropriate for the remainder of the wetlands within the study area. The Ecoscape (2005) wetland management category proposed changes are shown in **Figure 3**.

The analysis done by Ecoscape (2005) used Bulletin 686 to assess wetland values. This document has since been superseded by the *Protocol for proposing modifications to the 'Geomorphic Wetlands Swan Coastal Plain' dataset* (DEC, 2006). Therefore it is recommended that further survey work be undertaken to justify changes in wetland classification and the possible removal of wetland status entirely, using the assessment procedures outlined in this document. If such work is undertaken it is likely that the DEC will take 3-6 months to re-assess these wetland categories.

Under the approved ODP most of the wetlands including Conservation and Resource Enhancement category wetlands were given approval to be cleared or modified for drainage and development purposes (**Table 4**).

Under current policy the deletion (clearing and filling) of a wetland is likely to contravene the clearing provisions of the Environmental Protection Act as the area of CCW is identified as an Environmentally Sensitive Area (ESA) and therefore is likely to require a Clearing Permit.

Table 4: ODP Wetland Classification and Development Impacts

Unique Feature Identifier (UFI)	Wetland Type	Hectares	% of ODP boundary	Current Classification	Ecoscape Revised Classification	Approved ODP Outcome	Revised ODP Comments
5042	SUMPLAND	1.03	0.42	M	M	Cleared and filled	Same as Approved ODP
5043	SUMPLAND	14.32	5.8	R	R	Substantial area retained - within power line buffer	Same as Approved ODP
5044	PALUSPLAIN	2.78	1.13	C	R	Cleared and filled	Same as Approved ODP
5045	PALUSPLAIN	13.56	5.52	R	R	Cleared and Filled	Significant area retained
5046	PALUSPLAIN	6.61	2.7	R	R	Cleared and Filled	Same as Approved ODP
5047	SUMPLAND	2.25	0.92	M	M	Cleared and filled	Same as Approved ODP
5050	SUMPLAND	0.74	0.3	M	M	Cleared and Filled	Same as Approved ODP
5184	PALUSPLAIN	1.17	0.48	C	R or MU	Cleared and filled	Same as Approved ODP
5442 *	PALUSPLAIN	5.89	2.4	C	None	Cleared	Same as Approved ODP
5443 *	PALUSPLAIN	3.82	1.55	C	None	Cleared	Same as Approved ODP
5445	SUMPLAND	5.78	2.35	R	R	Mostly retained with some modification for drainage	Same as Approved ODP
5449	DAMPLAND	13.76	5.6	R	R	Modified for drainage	Retaining significant areas
5450	PALUSPLAIN	0.63	0.26	C	R	Modified	Possible modifications
14043	PALUSPLAIN	173.34	70.56	M	M	Cleared or modified for drainage purpose, some components retained under power lines	Same as Approved ODP
	Total Area (ha)	**245.68**					

* These wetlands occur in Floristic Community Type 21a (Gibson *et al.* 1996) which is not a wetland community, therefore their wetland status is questionable.

3.4 Watercourses

The Murray River is an important and major natural feature that is located along the northern and eastern boundary of the ODP area. The Flooded Gum (*Eucalyptus rudis*) forms a narrow woodland fringe on the riparian margins of the river. This species contains a large number of stately mature specimens that contribute to the amenity of the area. A number of relic natural drainage channels are present around the perimeter of the site. In the south western corner of the site there is an ephemeral creekline about 570 meters in length that has been mapped by Hill et al (1996). It runs from the Murray River to the north of the site and into adjacent property to the south. This section of creekline on the site may have been modified over time which is inferred by the linear morphology and the lack of fringing vegetation.

3.5 Vegetation and Flora

3.5.1 Vegetation Complexes

The Murray River Country Estate is classified as being within the Swan Vegetation Complex, with a portion of the South West corner mapped as Bassendean - Central and South Vegetation Complex (Heddle *et al.*, 1980). These complexes are described by Heddle *et al.* (1980) below;

Swan Vegetation Complex

Fringing Woodland of Flooded Gum (*Eucalyptus rudis*) – Paperbark (*Melaleuca rhaphiophylla*) with localised occurrences of Low Open Forest of Swamp Sheoak (*Casuarina obesa*) and *Melaleuca cuticularis*.

Bassendean – Central and South Vegetation Complex

Vegetation ranges from a Woodland of Jarrah (*Eucalyptus marginata*) – Sheoak (*Allocasuarina fraseriana*) – *Banksia* spp. to a Low Woodland of *Melaleuca* spp., and sedgelands on the moister sites. This area includes the transition of Jarrah to Coastal Blackbutt (*Eucalyptus todtiana*) in the vicinity of Perth.

The EPA guidance for the Assessment of Environmental Factors No. 10, which looks at the level of assessment for proposals affecting natural areas within the System 6 region, is based on a standard level of vegetation retention of at least 30% of the pre – clearing extent of ecological communities. It is the EPA's position to "preferentially locate developments in cleared areas, particularly where 30% or less of the pre-clearing extent of the ecological community remains".

Both the Swan Complex and Bassendean Central and South Complex remain at less than 30% of their pre-clearing extent at 15.6% and 27% respectively (EPA, 2003). Despite the finding that most of the Murray River Country Estate better fits the description of

Bassendean Central and South complex there is still less than 30% of this ecological community remaining (**Table 5**).

Table 5: Vegetation Remaining on the Swan Coastal Plain System 6 & part System 1

Vegetation Complex	Total pre1750 extent (ha)	Present Extent (ha)	Percentage Remaining	Area in secure tenure (ha)	Percentage in secure tenure
Bassendean Central & South	87477	23624	27	572	0.70
Swan Vegetation Complex	15783	2454	15.6	0.00	0.00

(EPA, 2003)

Much of the development area is on degraded rural land which conforms to the EPA's position in Guidance Statement 10 (2003). Most of the existing remnant vegetation is small and isolated although where feasible, remnants that contribute to linkages and fauna habitat and do not compromise the viability of the development, have been retained.

3.5.2 Vegetation Communities

In a vegetation survey of the site undertaken by Ecoscape (2005) fourteen different vegetation communities were defined for the vegetation within Murray River Estate. The descriptions of these are presented in Table 6 and the distribution of these units is presented in Figure 6.

The Swan Vegetation Complex is dominated by *Eucalyptus rudis – Melaleuca rhaphiophylla* woodland and vegetation that matched this complex on site was only found at vegetation units 8 and 11 in (Figure 6).

Bassendean Central and South is a broad vegetation complex that ranges from woodland of Jarrah/Marri-Sheoak-Banksia woodland to *Melaleuca* woodlands and sedgelands. These main structural units of this complex are evident throughout the Murray River Country Estate.

Table 6: Description of Vegetation Mapping Units (Refer to Figure 6 for distribution)

Mapping Unit	Site	Condition	Description
1	A	Very Good	Open Woodland of *Allocasuarina fraseriana* over Tall Shrubland of *Kunzea ericifolia* with *Banksia attenuata, Banksia ilicifolia* over Herbland of *Dasypogon bromelifolius.*
2	B / W1	Excellent	Closed Heath of *Pericalymma ellipyicum, Hypocalymma angustifolium and Euchilopsis linearis* over an open sedgeland of *Baumea juncea, Lepidosperma and Hypolaena exscula.*
3	C / W4	Very Good	Low Open Woodland of *Eucalyptus marginata, Melaleuca preissiana* and *Kunzea ericifolia* over Closed Heath of *Pericalymma ellipticum, Hypocalymma angustifolium* and *Astartea fascicularis.*
4	D / W6	Degraded	Low Open Woodland of *Kunzea ericifolia* over Low Open Shrubland of *Gompholobium tomentosum Brachyloma preissii* over a Herbland of *Ursinia anthemoides.*
5	E	Good	Low Woodland of *Kunzea ericifolia, Banksia ilicifolia* and *Banksia attenuata* over Tall Open Shrubland over *Jacksonia furcellata* over as Open Low Heath of *Pteridium esculentum, Dasypogon bromelifolius* over an open grassland of *Briza maxima.*
6	F	Good	Low Open Forest of *Kunzea ericifolia* with *Eucalyptus marginata* over Low Shrubland of *Dasypogon bromelifolius, Phlebolcarya ciliata* and *Gompholobium tomentosum* over a very open sedgeland of *Hypolaena exsulca.*
7	G	Degraded	Open Woodland of *Melaleuca preissiana, Eucalyptus marginata,Corymbia calophylla* and *Nuytsia floribunda* over Low Open Woodland of *Kunzea ericifolia* over a closed heath of *Hypocalymma angustifolium, Pericalymma ellipticum* and *Astartea fasicularis*
8	W2	Degraded	Woodland of *Eucalyptus rudis* and *Kunzea ericifolia* over a completely degraded understorey of grasses and *Pteridium esculentum.* Wetland species included *Baumea articulata, Typha domengensis* and *Juncus* sp.
9	W3	Very Good	Woodland of *Melaleuca rhaphiophylla* and *Eucalyptus rudis* over shrubland of *Astartea fascicularis, Hypolaena exsulca* and *Phlebocarya ciliatum.*
10	W5		Woodland of *Kunzea ericifolia* over completely degraded understorey of *Ursinia anthemoides* and occasional *Jacksonia furcellata*
11	W7	Very Good	Woodland of *Eucalyptus rudis, Melaleuca rhaphiophylla* and *Melaleuca preissiana* over *Astartea fascicularis* and *Acacia pulchella.*
12	W8	Degraded	Woodland of *Melalueca preissiana* and *Kunzea ericifolia* over grazed understorey of pasture grasses.
13	W9	Degraded	Woodland of *Melalealeuca preissiana* and *Melaleuca rhaphiophylla*
14	G	Degraded	Open Woodland of *Melaleuca preissiana* over low open woodland of *Kunzea ericifolia*

Floristic Community Types

The Floristic Community Type (FCT) of these mapping units was assessed using Gibson *et al.* data and three FCTs were defined for the project area (**Table 7**). *Melaleuca preissiana* Damplands (FCT 4), Mixed Damplands (FCT 5) and *Banksia attenuata – Eucalyptus marginata Woodlands* (FCT 21a) (Figure 7). FCT's 4 and 5 belong to communities of the seasonal wetlands and are both shrub rich damplands. FCT 21a belongs to the community types centred on the Bassendean System that are not considered wetland communities.

Table 7: Floristic Community Types of the site

FCT	Description	TEC (CALM and DEH, 2006)
4 *Melaleuca preissiana* Damplands	Shrub-rich community with scattered *M. preissiana* overstorey. Where tree species are absent, heaths or scrubs are present. The most consistent species of this community type are; *Pericalymma ellipticum, Hypolaena exsulca, Hypocalymma angustifolium* and *Dasypogon bromeliifolius*. This FCT is distributed on the Swan Coastal Plain on the Bassendean and Southern River Vegetation Complexes.	No
5 Mixed Damplands	Similar to FCT 4. No consistent overstorey, higher frequencies of *Banksia ilicifolia, Kunzea ericifolia* and *Jacksonia furcellata*. It can also contain *Melaleuca rhaphiophylla and Eucalyptus rudis*. This FCT generally has more open ground and a less dense shrub layer.	No
21a *Banksia attenuata – Eucalyptus marginata* Woodlands	Floristic Community Type 21a is primarily dominated by combinations of *Eucalyptus marginata, Corymbia calophylla* and *Banksia attenuata. Allocasuarina* and *Eucalyptus gomphocephala* are sometimes present as dominant or codominant overstorey. This community type commonly occurs on the central part of the coastal plain from Perth to Capel.	No

(Gibson *et al.* 1994)

Threatened Ecological Communities (TEC's)

These three communities (4, 5 and 21a) are considered "well reserved", that is, they are known from at least two National Parks or Nature Reserves and with no risk to their conservation status (Gibson et al. 1994). Therefore no Threatened Ecological Communities pursuant to s182 of the EPBC Act 1999 were inferred from the vegetation units described for the project area.

Vegetation Condition

Vegetation Condition ranged from Excellent to Completely Degraded (Keighery, 1994) but the majority of the vegetation on the site was classified as very good, good or degraded (Figure 8). The vegetation communities have been altered due to agricultural land use.

3.5.3 Flora

As recommended in EPA Guidance Statement 51 (2004), a desktop search was undertaken of Department of Environment and Conservation's (DEC) databases for Rare and Priority Flora, along with Threatened Ecological Communities occurring in the area. The online *EPBC Act* list of TEC's was also consulted.

As part of the field assessment a grid based search for declared rare and priority flora, and other flora of particular conservation significance was undertaken by Ecoscape in Spring 2005. This involved searches of areas proposed to be cleared under the revised ODP.

The Wetland Assessment Report (Ecoscape, 2005) presents the Declared Rare and Priority Flora that could have been potentially located within the Murray River Estate. A DEC database search identified 65 significant flora species within a 15km radius of the Murray River Estate. Ten of these species were also found within 2km of the project area and were found in swamps, damplands or along the Murray River. These species are listed in Appendix 1 of the Wetland Assessment Report, as they are more likely to occur in the study area were there is suitable habitat.

A total of 98 taxa from 76 genera and 34 families were recorded during the flora, vegetation and wetland assessments conducted at Murray River Estate. A total of 72 of these taxa were found within the vegetation quadrats and 44 of the total taxa were also recorded for the wetland sites. All of the 11 weed species recorded for the site at this time were located at the wetland sites. Only two of these weed species were also located in the vegetation quadrats (see appendix in Ecoscape, 2005).

A photographic record of all of the vegetation quadrats and wetland assessment sites is presented in Appendix 5 of the Wetland Assessment Report (Ecoscape, 2005).

3.5.4 Declared Rare Flora

Under the Wildlife Conservation Act, the Minister for the Environment may declare species of protected flora to be *Rare Flora* if they are considered to be in danger of extinction, rare or otherwise in need of special protection. Such species are referred to as Threatened Flora, and receive special management attention by DEC (DEC, 2005).

No Declared Rare Flora species, pursuant to Subsection 2 of Section 23F of the *Wildlife Conservation Act 1950* and listed by DEC were located during the survey. No Endangered or Vulnerable species, pursuant to s178 of the EPBC Act were located within the study area.

3.5.5 Priority Flora

Flora species that are known from only a few sites and have not been adequately surveyed are included on a supplementary conservation list called the Priority Flora List. These flora

species may be rare but cannot be declared rare until a survey has been undertaken to adequately assess its conservation status.

There are three categories of priority flora covering these poorly known species. The categories are arranged to give an indication of the priority for undertaking further surveys based on the number of known sites, and the degree of threat to those populations. A fourth category of priority flora is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened (DEC, 2005).

A single Priority 3 Flora species, *Dillwynia dillwynioides* was located at Murray River Estate which was located in wetland 5043. Whilst it is not an offence to take Priority Flora, efforts should be made to maintain populations of these taxa as conservation codes are revised as situations change and further information comes to hand. In some instances species can be upgraded to a higher conservation code.

3.6 Fauna

3.6.1 Mammals

Mike Bamford Ecologists (1995) conducted a fauna survey for the Southern Brown Bandicoot / Quenda (*Isoodon obesulus fusciventer*) in four areas located near the powerline corridor in the study area. These survey sites are located within Floristic Community Type 4, a shrub rich community containing species such as *Pericalymma* and *Hypocalymma* providing dense ground cover and protection for the Quenda. At the time of this survey the Quenda was placed on Schedule 1 (endangered and liable to become extinct and therefore in need of special protection) of the *Wildlife Conservation Act*. Since then, the Quenda has been removed from this list and it is now listed as a Priority 5 species by the DEC. Priority 5 species are taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years. However the Quenda is not listed on the *EPBC Act* list of threatened species (DEH, 2006).

Twenty Quendas were caught with the majority of Quenda activity occurring in northwest area compared to the southeast that appeared not to support Quenda. Considering the level of disturbance at the site the population density is impressive and suggests that the site is particularly favourable to Quenda (Bamford, 1995). This area is proposed to be retained as part of the revised ODP and therefore no re-location of the Quenda is required compared with the previous ODP.

A database search of mammals that are likely to occur on the site are indicated in **Table 8**.

Table 8: Mammal species likely to occur in the Pinjarra area.

Family	Common Name	Scientific Name
BURRAMYIDAE	Western Pygmy Possum	*Cercartetus concinnus*
DASYURIDAE	Brush-Tailed Phascogale	*Phascogale tapoatafa tapoatafa*
MACROPODIDAE	Western Brush Wallaby	*Macropus irma*
MURIDAE	Water Rat Black Rat (feral)	*Hydromys chrysogaster* *Rattus rattus*
MUSTELIDAE	Ferret (feral)	*Mustela putorius*
PERAMELIDAE	Southern Brown Bandicoot (Quenda)	*Isoodon obesulus fusciventer*
PHALANGERIDAE	Common Brush-Tailed Possum	*Trichosurus vulpecula vulpecula*
VESPERTILIONIDAE	Gould's Wattled Bat Southern Forest Bat	*Chalinolobus gouldii* *Vespadelus regulus*

3.6.2 Avifauna

The site contains some water birds (**Table 9**) but their use of the site is not extensive as identified in the Wetland Management Plan by LeProvost, Dames and Moore (1998). The Ibis and Spoonbill species occur on a seasonal basis where there are open grassed floodplains. Furthermore, the previous land owner had undertaken a bird census and recorded some 64 species of avifauna in the past 30 years.

Table 9: Waterbirds identified on the Murray River site (LeProvost Dames & Moore 1998).

Family	Common Name	Scientific Name
ANHINGIDAE (darters)	Darter	*Anhinga melanogaster*
ARDEIDAE (herons & egrets)	White-faced Heron Nankeen Night Heron	*Ardea novaehollandiae* *Nycitcorax caledonicus*
PLATALEIDAE (Ibis & spoonbills)	Australian White Ibis Yellow-billed Spoonbill	*Threskiornis molucca* *Platalea flavipes*
ANATIDAE (ducks, geese & swans)	Australian Shelduck Pacific Black Duck	*Tadorna tadornoides* *Anas superciliosus*
PANDIONIDAE (osprey)	Osprey	*Pandion haliaetus*
RALLIDAE (crakes & rails)	Dusky Moorhen Purple Swamphen Eurasian Coot	*Gallinula tenebrosa* *Porphyrio porphyrio* *Fulica atra*

3.6.3 Reptiles

The retention of wetlands and native vegetation under the revised ODP will help to conserve the reptile species that are likely to occur on the site.

A database search indicated the following reptiles (**Table 10**) likely to occur in the area.

Table 10: Reptile species likely to occur in the Pinjarra area.

Family	Common Name	Scientific Name
AGAMIDAE	Western Bearded Dragon	*Pogona minor minor*
CHELUIDAE	Oblong Turtle	*Chelodina oblonga*
ELAPIDAE	Crowned Snake	*Elapognathus coronatus*
	Tiger Snake	*Notechis scutatus*
	Gould's Snake	*Parasuta gouldii*
	Dugite	*Pseudonaja affinis affinis*
	Jan's Banded Snake	*Simoselaps bertholdi*
GEKKONIDAE	Marbled Gecko	*Christinus marmoratus*
PYGOPODIDAE	Burton's Legless Lizard	*Lialis burtonis*
SCINCIDAE	Odd Striped Skink	*Ctenotus impar*
	Southwestern crevice Skink	*Morethia lineoocellata*
	Bobtail Skink	*Tiliqua rugosa rugosa*
		Ctenotus australis

3.6.4 Amphibians

The retention of wetlands and native vegetation under the revised ODP will help to conserve the amphibian species that are likely to occur on the site.

Table 12 indicates the amphibian species likely to occur on the site.

Table 11: Amphibian species likely to occur in the Pinjarra area.

Family	Common Name	Scientific Name
HYLIDAE	Slender Tree Frog	*Litoria adelaidensis*
MYOBATRACHIDAE	Bullfrog	*Limnodynastes dorsalis*

4.0 Environmental Benefits

MRCE ODP Environmental Section

The revised ODP provides a number of environmental benefits that contribute to a more sustainable outcome for the project area. There are significantly more environmental benefits compared with the previously approved ODP.

4.1 Wetlands and Lakes

The significant difference from the approved ODP is the greater area of wetlands to be retained thereby enhancing the environmental values of the site (Table 12).

The Ecoscape (2005) assessment of wetland status and management categories recommends the reassignment of Conservation Category Wetlands to Resource Enhancement Wetlands.

The changes proposed by Ecoscape (2005) to the wetland management categories are re-assigning Wetlands 5044 and 5450 to Resources Enhancement Category, 5184 to Resource Enhancement or potentially Multiple use and the removal of wetland status of wetlands 5442 and 5443 **(Figure 3)**. **Table 4** lists the wetlands in the ODP area including, wetland type and management category under existing approvals and proposed changes under the revised ODP.

Wetlands currently classified as CCW's in the ODP area are classed as Environmentally Sensitive Areas (ESA) under the Environmental Protection (Clearing of Native Vegetation) Regulations (2004) and therefore require a Clearing Permit. Should an evaluation using current wetland assessment protocols enable a change from the conservation management category to Resource Enhancement or Multiple Use it will, through due process, enable a lifting of the ESA status.

Consideration needs to be given to the removal of the wetland status of wetlands 5442 and 5443 that occur in vegetation type FCT 21a. This community is more typical of upland vegetation that occurs on the Bassendean dunes and is not considered a wetland vegetation community (Gibson *et al.* 1994).

Under existing approvals most of the wetlands have been proposed to be cleared and filled or modified through excavation for drainage management purposes (**Figure 4**). The revised ODP has proposed to increase the area of wetland for conservation purposes (**Table 12**) and the provision of buffers ensuring that both important habitat and ecological linkages are retained (**Figure 5**). Buffers will generally be comprised of wetland and bushland vegetation, public open space, roadways, footpaths and nutrient stripping drainage swales.

Artificial lakes on the western edge of wetland 5445 (**Figure 5**) were created as part of the Approved ODP. These lakes provide additional habitat for wildlife particularly waterbirds and enhance the ecological connectivity to wetland 5445.

Table 12: Additional wetlands to be retained under revised ODP (Figure 5)

UFI	Size (ha)	Approved ODP Outcome	Revised ODP comments	Change in area (ha)
5043	14.321	Area retained within powerline easement	Same as approved ODP	No change
5045	13.56	Cleared and Filled	Significant area retained	13.56
5445	5.78	Mostly retained with some modification for drainage	Same as approved ODP	No change
5449	13.763	Modified for drainage	Retaining significant areas	13.763
5450	0.634	Modified	Possible modifications	0.634
			Additional area retained	**27.97 ha**

4.2 Watercourses

Watercourses such as the Murray River can be adversely impacted upon as a result of conflicting land uses. Protection of watercourses has been achieved through the establishment of the foreshore reserve, which was established in accordance with the Peel Regional Scheme (WAPC, 2003b). The foreshore reserve is vested with the Crown and under the care and control of the Department of Environment and Conservation.

The EPA (1997) provides guidelines for wetland buffers for watercourses and rivers on private land. The following buffer widths, measured from the edge of the riparian vegetation or the edge of the 1 in 100 year floodway, are recommended by the EPA:

- Water courses with permanent water: 50m
- Seasonally flowing watercourses: 30m
- Watercourses which flow in response to specific rain events: 10m

Under both ODP's the ephemeral creekline in the south western corner of the site is proposed to be filled by development. This creekline may have already been modified over time as it does not have a natural meandering morphology and the creekline is un-vegetated.

One of the main benefits of the revised ODP is the reduced area of irrigated and fertilised lawn that abuts the Murray River thus reducing impacts to the river environment, namely reduced nutrient runoff. Subsequently this will contribute to improving the ecological linkage of the Murray River resulting in an improved environmental outcome.

4.3 Vegetation

A significant environmental benefit of the revised ODP is the increase of approximately 20 hectares of native vegetation to be retained. These areas are located within and around wetlands 5045 and 5449. This is an important improvement as native vegetation is an intrinsic part of maintaining ecological processes and preventing land and water degradation (EPA, 2005).

The vegetation assessment undertaken by Ecoscape (2005) determined that the Floristic Community Types of the site are well reserved (see section 3.5.2) and there are no Threatened Ecological Communities present. Subsequently this allows for more flexibility in development.

4.4 Fauna Habitat

The retention of more habitat, under the revised ODP, and the provision of ecological linkages, in particular between wetlands 5043 and 5045 and the foreshore, and wetland 5449, are highly beneficial to the preservation of the Quenda. The linkages are to be in the form of tunnels/culverts under the roads that cross the powerline reserve and under the road linking 5445 and 5449.

4.4.1 Ecological Linkages

A major benefit of the revised ODP is to provide ecological linkages to the Murray River foreshore as well as south around the western edge of the Pinjarra Townsite (Figure 9). Ecological linkages are important for fauna movement and dispersal. Through ecological linkages the retention and protection of flora and fauna can be achieved. These linkages have been defined as two-dimensional landscape elements that connect two or more patches of wildlife (animal) habitat that have been connected in historical time (Soule, M.E. and Gilpin, M.E. 1991). Linkages/corridors have been identified as key integrative components of landscape ecology (Forman, R.T.T. 1991) and the application of the principles of the patch-corridor-matrix paradigm offer significant benefits to numerous public policy issues. The values of linkages have been shown to provide landscapes with conservation value; habitat value; shelterbelts and educational value (Saunders, D.A. and Hobbs, R.J. 1991). It is the conservation and habitat values that are focussed on for the retention and promotion of wildlife, and their movement through the landscape, which will affect ecosystem services and their function.

5.0 Environmental Management

MRCE ODP Environmental Section

There are a number of natural areas that are to be retained as part of the revised ODP and require management to ensure the retention and enhancement of the ecological values. Wetlands, vegetation and fauna have a number of environmental management processes in common for example weed control, fire control, disease control and feral animal control for fauna. The following section describes the main environmental management considerations as they relate to the ODP.

A series of Environmental Management Plans need to be prepared for the site at subdivision stage, such as a;

- Weed Management Plan;
- Fire Management Plan;
- Foreshore Management Plan;
- Rehabilitation Plan;
- A Wetland Management Plan; and
- Drainage and Nutrient Management Plan.

These management plans and their timing and implementation should be prepared at subdivision stage.

5.1.1 Weed Management

Environmental weeds are plants that establish themselves in natural ecosystems and modify natural processes, resulting in the decline of the communities they invade. Disturbances that contribute to the spread of weeds include:

- clearing;
- trampling;
- off-road vehicles;
- increased fire frequency;
- rubbish dumping, including soil and garden waste; and
- movement of weed seed, especially by vectors along the numerous tracks in the area.

A number of weeds are present in the wetland and bushland areas within the ODP area. Some of these weeds have the potential to impact on the ecological and habitat values of the natural areas to be retained.

Strategy

Develop a Weed Management Plan for the natural areas within the ODP at subdivision stage, which addresses the following;

- Avoiding the introduction of species that pose a weed threat to the bushland areas,
- Developing a control program based on site-based management and species-based management. Control options for environmental weeds include:

- Manual control;
- Herbicides; and
- Controlling ecosystem degradation processes.

5.1.2 Fire Management

Bushfires can be devastating and frightening occurrences. This is particularly true in rural and semi-rural areas of the Swan Coastal Plain of Western Australia. Bushfires in remnant bushland in urban and rural landscapes threaten not only lives and property; they also present one of the most severe threats to the ongoing retention and integrity of remnant bushland.

Although fire is a natural part of the ecology of the ODP natural environment, the current environmental conditions are very different to the natural situation, due to a number of related changes, including:

- The isolated nature of the remnant vegetation within the urban and rural context; and
- The greatly increased risk of fire ignition due to arson.

Strategy

A Fire Management Plan should be developed for the ODP area which should address the following:

- Separation area and hazard reduction;
- reducing frequency of ignitions (either accidental or deliberate);
- rapid response and fire suppression;
- public education; and
- post-fire recovery and incident analysis.

5.1.3 Feral Animals

There are potentially several species of feral animal within the study area, as well as domestic cats and dogs. Future urban development could increase the number of feral and domestic species in the ODP area. Cats and foxes would be the most likely invader from this source.

Control Strategy

Feral cats and foxes are predators of a wide range of small native animals, including birds, mammals, frogs and reptiles. Control of feral cats is extremely difficult, although selective trapping and removal of individuals could be implemented if cats became a significant problem in the area.

Other initiatives to protect fauna would be to minimise domestic cats and dogs exercising unleased in these particular areas. Night curfew on cats and the encouragement of responsible pet ownership to reduce the impact of domestic cats on wildlife would be beneficial for the native fauna. An approved co-ordinated program of fox baiting before

development construction would ameliorate the impact of foxes (*Vulpes vulpes*). Programs for managing feral and domestic animals should be co-ordinated by the Shire of Murray and the Department of Environment and Conservation.

5.1.4 Disease Management

There is the potential for various diseases to impact on the native vegetation and habitat area of the ODP area. These include:

Dieback (Phytophthora cinnamomi)
There are 15 *Phytophthora* species in Western Australia. These are soil-borne water moulds that kill a wide selection of plant species of the south west of Western Australia. The most significant *Phytophthora* species is *Phytophthora cinnamomi*. .

Honey Fungus (Armillaria luteobubalbina)
Armillaria luteobubalbina (Honey Fungus), is a toadstool-producing parasitic fungus lives off both live and dead hosts and is native to Western Australia. In some circumstances it can act as a virulent parasite that kills hosts including Tuarts.

Aerial Canker
Aerial Cankers are diseases caused by a group of largely air-dispersed fungi (including *Cryptodiaporthe melanocraespida* and *Zythiostroma* and *Diplodena* species) that affect the State's flora in the south-west. Under suitable conditions the disease can cause the death of plants within 2 years.

Strategy
Standard horticultural hygiene procedures that minimise the introduction and spread of infected material (by destroying infected material, minimising vehicle access through reserves, ensuring vehicles and tools are free of soil and plant material when they come onsite, and ensuring materials brought onsite such as greenstock, soil and mulch are disease free) should provide sufficient protection.

As there is no practical large scale cure for dieback, prevention of infection is the primary means of defence. If it did become established within the study area then protection of individual plants from dieback can be achieved using phosphite, which is injected or sprayed onto individual trees.

There are no known methods for controlling Aerial Canker or *Armillaria luteobalbina*. The best defence against these species is to reduce disturbances within the ODP area that could stress plants, such as frequent fire and alterations to hydrology.

5.1.5 Foreshore Management Plan

A Foreshore Management Plan has been previously prepared by LeProvost Dames and Moore (1998) for the approved ODP that dealt with:

- Bank stability;
- Maintenance of riverine vegetation;

- Public access;
- Demarcation of foreshore reserve;
- Aboriginal Heritage Sites;
- Mosquito breeding;
- Wildlife corridor and habitat;
- Bushfire management;
- Management responsibilities;
- Funding;
- Implementation;
- Monitoring; and
- Review.

Strategy
This Foreshore Management Plan will need to be reviewed and amended to meet the goals of the revised ODP at subdivision stage.

5.1.6 Rehabilitation Plan

The revised ODP has an increased area of vegetation that is to be retained. The goals of the MRCE should be to enhance the ecological values of these areas through ecological rehabilitation. The objectives of ecological rehabilitation for the revised ODP should include:

- To reinstate indigenous flora and vegetation communities, where they have been disturbed and/or depleted, particularly after infrastructure works;
- Minimise the impact of activities that could result in degradation to vegetation communities through the use of appropriate management strategies;
- Improve the overall condition of vegetation communities within the site; and
- Ensure that vegetation communities are self-sustaining and are capable of natural regeneration.

Strategy
Develop a Rehabilitation Plan for bushland areas within the revised ODP at subdivision stage.

5.1.7 Wetland Management Plan

A Wetland Management Plan has been previously prepared by LeProvost Dames and Moore (1998) for the approved ODP with the following objectives:

1. Providing a strategy for the management of surface waters on site including natural wetlands and artificial lakes.
2. To provide for the integrated management of the wetlands in conjunction with drainage and irrigation management to ensure that the water quality in the wetlands remains acceptable.
3. That runoff from the site is managed in accordance with the provisions of the Drainage Management Plan and that its quality meets the requirements of the Peel Harvey Environmental Protection Policy as set out in the Nutrient and Irrigation Management Plan.

Strategy

This Wetland Management Plan be reviewed and amended to meet the goals of the revised ODP at subdivision stage.

5.1.8 Drainage and Nutrient Management Plan

A series of plans which dealt with drainage and nutrient management were prepared for the approved ODP which considered both water quantity and quality issues. The plans previously prepared included a Drainage Management Plan, a Wetland Management Plan and a Nutrient and Irrigation Management Plan. All three management plans integrated the management of water quantity and quality and mitigation strategies for impacts on wetlands. A revision of these plans will need to be undertaken and a new plan(s) prepared which addresses the following:

- Drainage regime;
- Controlled groundwater levels;
- Groundwater dependant ecosystems (wetlands);
- Nutrient management; and
- Water sensitive urban design measures.

Strategy

A new Drainage and Nutrient Management Plan be prepared as a Strategic Water Management Plan for the entire ODP area and as individual Water Management Plans for future subdivision stages.

6.0 References

MRCE ODP Environmental Section

ATA Environmental (2004) Ravenswood Sanctuary, Murray River Estate Structure Plan. Environmental Opportunities and Constraints Analysis. Unpublished report for Taylor Burrell Barnett, Perth.

Bamford, AR and Bamford, MJ (1995) Survey of the Quenda or Southern Brown Bandicoot Isoodon Obesulus at Ravenswood June 1995. Unpublished report for LeProvost Dames & Moore, Perth.

Bradley J (1988) Bringing Back the Bush: the Bradley method of bush regeneration. Landsdowne Press. Sydney.

Bradley J (1971) Bush Regeneration. Mosman Parklands and Ashton Park Association, Sydney.

Davies, PM and Lane, JAK (1995) Guidelines for design of effective buffers for the wetlands on the Swan Coastal Plain. Report for the Australian Nature Conservation Agency, Canberra.

Department of Environment and Conservation (2006) Protocol for proposing modifications to the 'Geomorphic Wetlands Swan Coastal Plain' dataset. DEC, Perth.

Department of Environment and Conservation (2006) Geographic Data Atlas [Online]. Available: http://www.apostle.environment.wa.gov.au [2006, September 15].

Department of Environment and Conservation (DEC) (2006) List of CALM's Threatened Ecological Communities Database [online]. Available: http://www.naturebase.net/plants_animals/watscu/pdf/tec/tec_database.pdf [2006, September 13].

Department of Environment and Conservation (DEC) (2005) Protection Out Plants [online]. Available: http://www.naturebase.net/plants_animals/licensing/protecting_flora.html [2006, September 13].

Department of Environment and Conservation (2005) A Guide to Clearing Permits under the Environmental Protection Act 1986. DEC, Perth.

Ecoscape Pty Ltd (2005) Murray River Estate (Ravenswood Sanctuary) Wetland Assessment. Unpublished report for Murray Riverside Pty Ltd, Western Australia.

Environmental Protection Authority (2006) Environmental Offsets Position Statement No. 9. EPA, Perth.

Environmental Protection Authority (2005) Environmental Guidance for Planning and Development Draft Guidance Statement no. 33. EPA, Perth.

Environmental Protection Authority (2004a) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia Guidance Statement No. 51 EPA, Perth.

Environmental Protection Authority (2004b) The Environmental Protection of Wetlands Position Statement No. 4. EPA, Perth.

Environmental Protection Authority (2003) Guidance Statement 10 - Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986) Level of assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of System 1 Region. W.A. EPA Perth.

Environmental Protection Authority (1997) Environmental Guidance for Planning and Development Guidance Statement no. 33. EPA, Perth.

Environmental Protection Authority (1993a) Strategy for the Protection of Lakes and Wetlands of the Swan Coastal Plain (EPA Bulletin 685). EPA, Perth.

Environmental Protection Authority (1993c) A Guide to Wetland Management in the Perth and near Perth Swan Coastal Plain area. EPA, Perth.

Environmental Protection Authority (1993d) A guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area (EPA Bulletin 686). Environmental Protection Agency Perth, Western Australia.

Environmental Protection Authority (1986) Environmental Protection Act 1986. Western Australian Government, Perth.

Forman, R.T.T. (1991). Landscape corridors: from theoretical foundations to public policy. In 'Nature Conservation. 2, The role of corridors.' (Surrey Beaty & Sons: Chipping Norton, N.S.W.

Gibson, N, Keighery, B, Keighery, G, Burbidge, A and Lyons, M (1994) A Floristic Survey of the Southern Swan Coastal Plain. Department of Conservation and Land Management, Perth.

Government of Western Australia (1997) Wetlands Conservation Policy for Western Australia. Government of Western Australia, Perth.

Heddle, EM, Lonergan, OW, Havel, JJ (1980) Vegetation - Perth Sheet. In Atlas of Natural Resources - Darling System Western Australia. Forests Department, Perth, Western Australia.

Hill, AL, Semeniuk, CA, Semeniuk, V and Del Marco, A (1996) Wetlands of the Swan Coastal Plain Volume 2b. Waters and Rivers Commission and Department of Environmental Protection, Perth Western Australia.

Keighery, BJ (1994) Bushland Plant Survey – A Guide to Plant Community Survey for the Community. Wildflower Society of WA (Inc.), Nedlands, Western Australia.

LeProvost Dames & Moore (1998) Ravenswood Sanctuary Foreshore Management Program. Unpublished report for RRCM Pty Ltd, Western Australia.

Saunders, D.A. and Hobbs, R.J. (1991). What do we know and where do we go? In 'Nature Conservation. 2, The role of corridors.' (Surrey Beaty & Sons: Chipping Norton, N.S.W.)

Soule, M.E. and Gilpin, M.E (1991). The theory of wildlife corridor capability. In 'Nature Conservation. 2, The role of corridors.' (Surrey Beaty & Sons: Chipping Norton, N.S.W.)

Waters and Rivers Commission (2001) Position Statement on Wetlands. WRC, Perth.

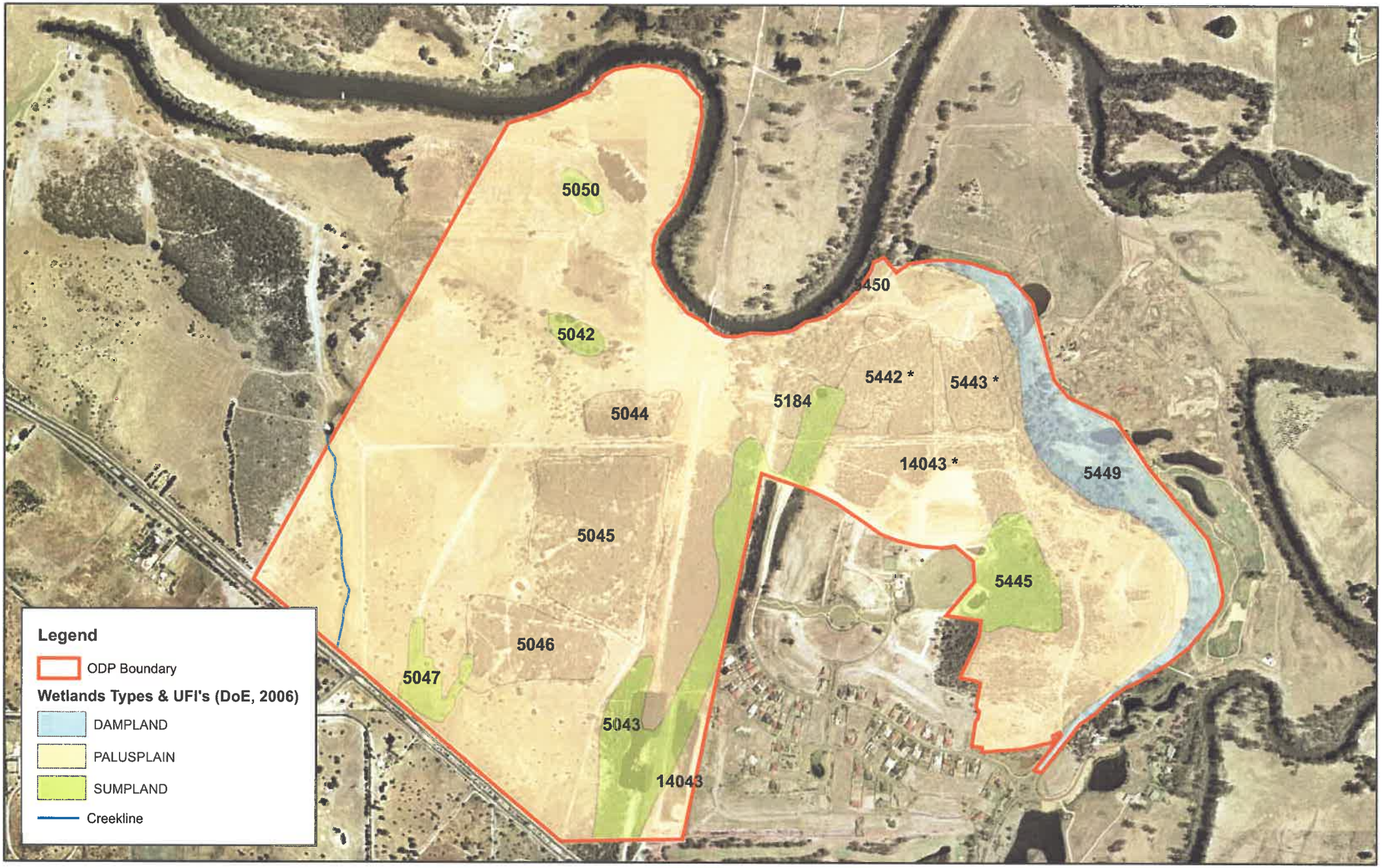
Western Australian Planning Commission (2005). Guideline for the determination of wetland buffer requirements draft 2005. WAPC, Perth.

Western Australian Planning Commission (2003a) Statement of Planning Policy No. 2: Environment and Natural Resources Policy. WAPC, Perth.

Western Australian Planning Commission (2003b) Peel Regional Scheme. WAPC, Perth.

Appendix One: Figures

MRCE ODP Environmental Section



ecoscape

300 150 0 300 Meters

1:12,500

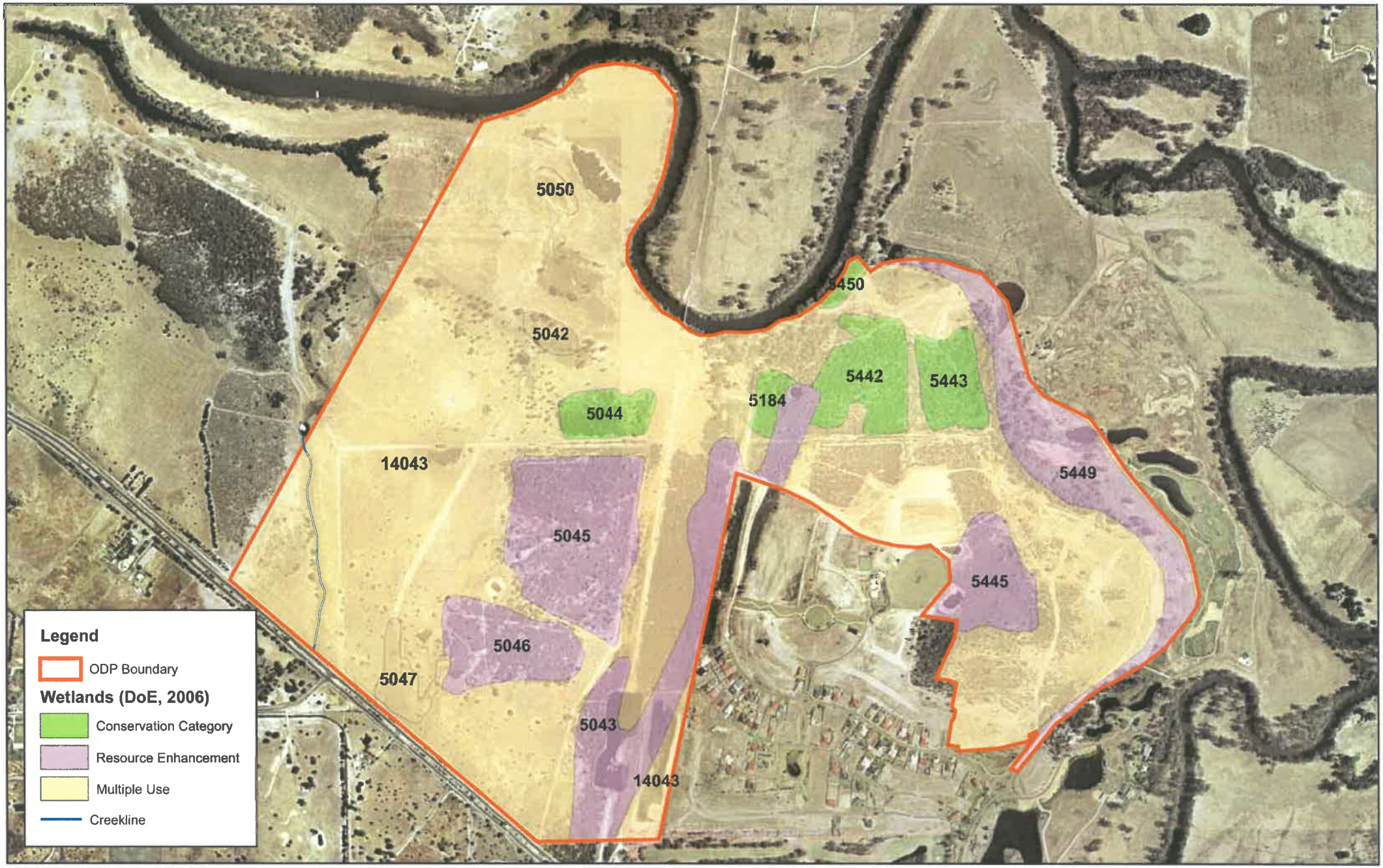
Murray River Country Estate ODP

Study Area and Wetland Types

MURRAY RIVERSIDE PTY LTD

Figure 1

Sept 2006



ecoscape

Murray River Country Estate ODP

Current Wetland Management Categories (adapted from Hill et al. 1996)

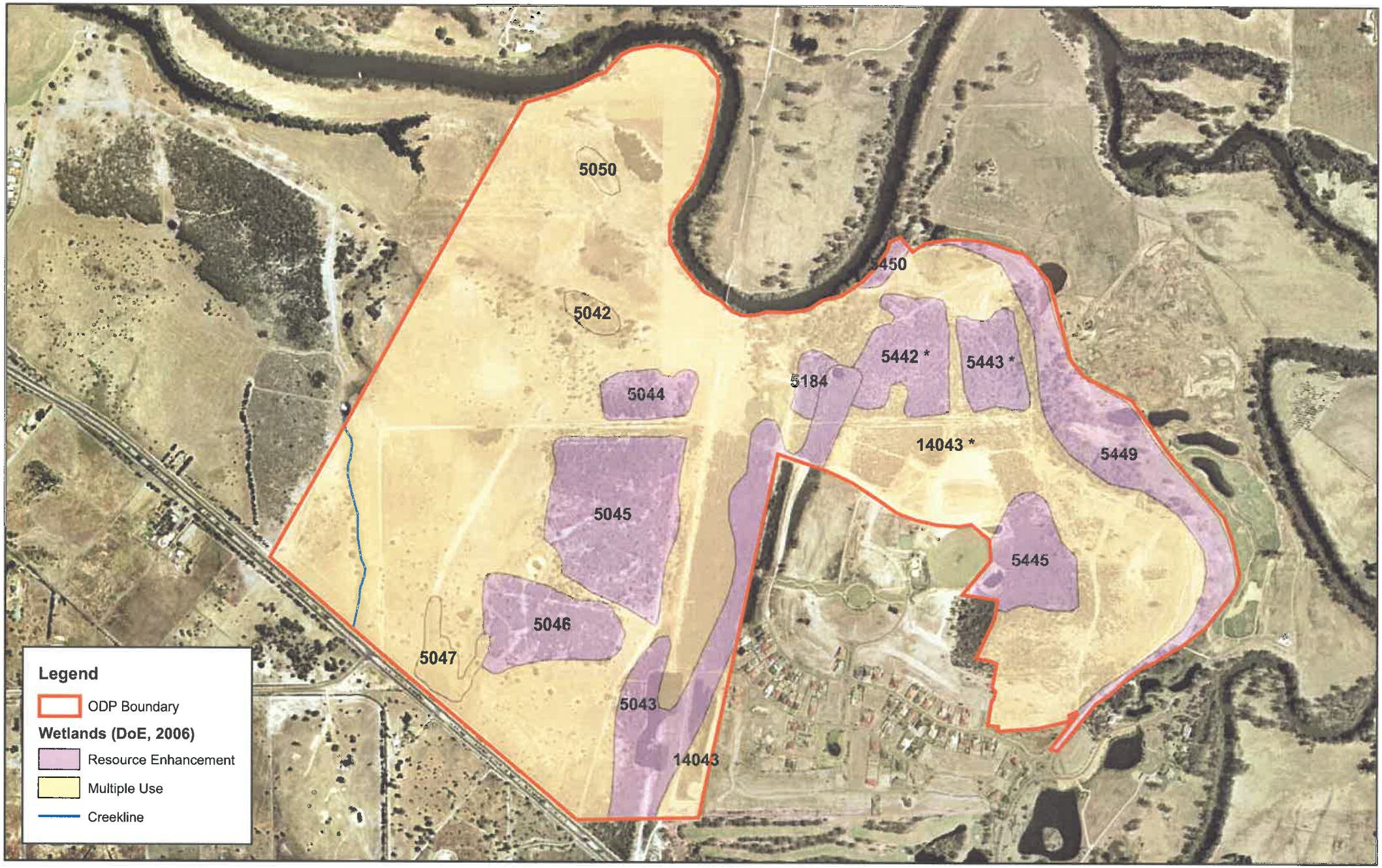
Figure 2

300 150 0 300 Meters

1:12,500

MURRAY RIVERSIDE PTY LTD

Sept 2006



* Wetland status questioned.
The vegetation community of these areas is FCT 21a, which is not a wetland vegetation community.

300 150 0 300 Meters

1:12,500

ecoscape

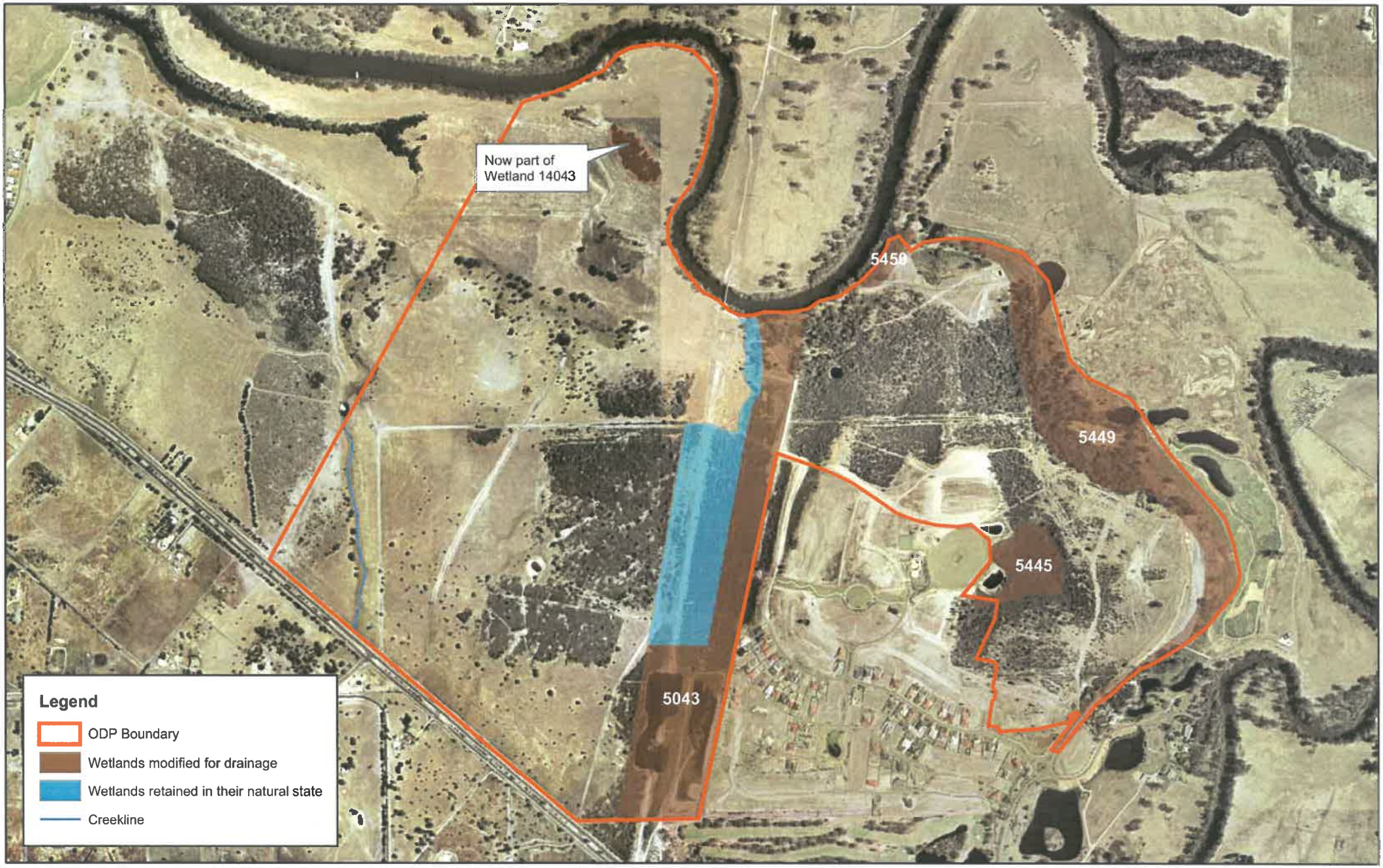
Murray River Country Estate ODP

Proposed Wetland Management Categories (Ecoscape, 2005)

MURRAY RIVERSIDE PTY LTD

Figure 3

Sept 2006



ecoscape

Murray River Country Estate ODP

Wetlands to be retained and modified under the Approved ODP (within the revised ODP boundary)

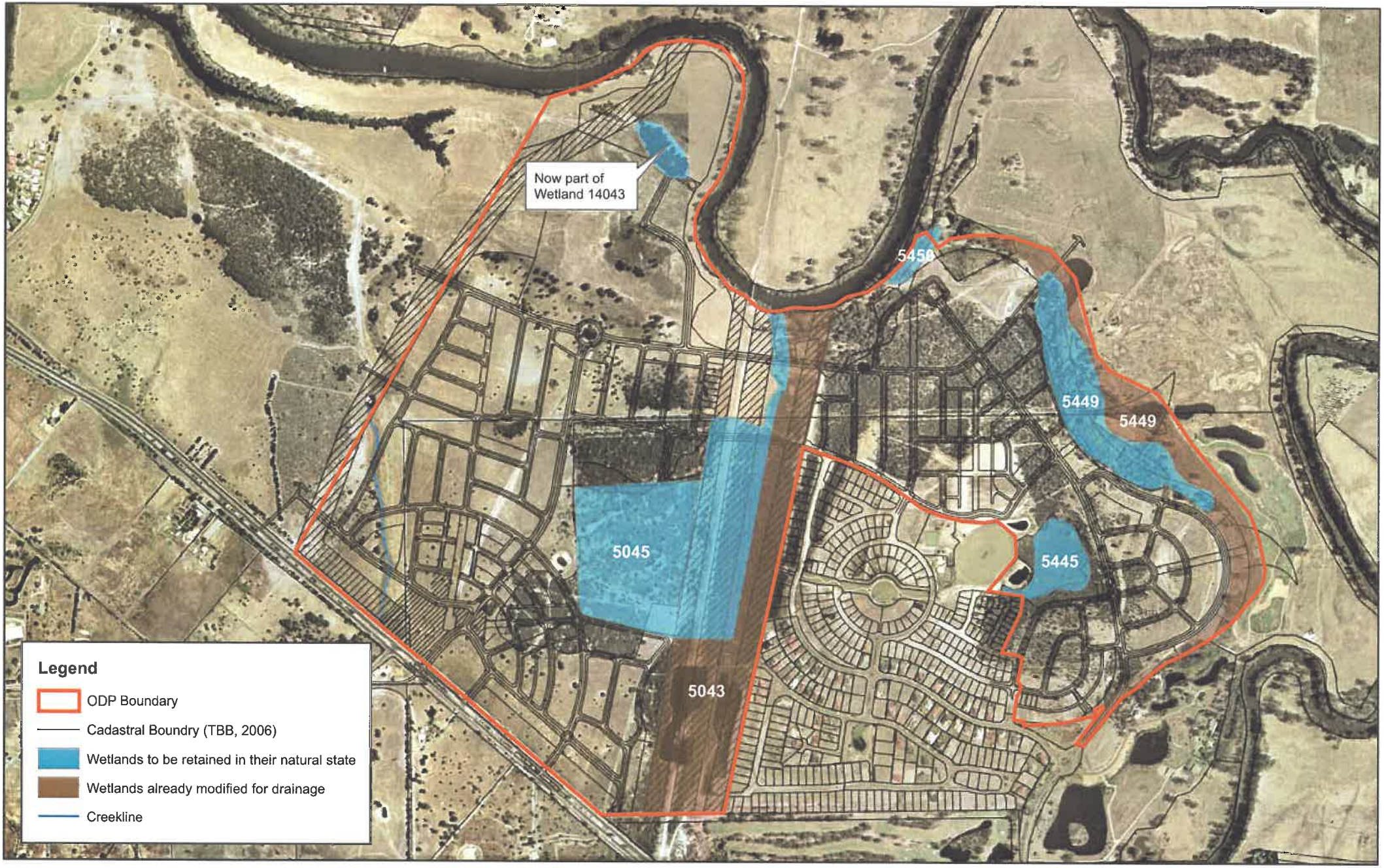
300 150 0 300 Meters

1:12,500

MURRAY RIVERSIDE PTY LTD

Figure 4

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Country Estate ODP

Wetlands Retained and Modified under the Revised ODP

MURRAY RIVERSIDE PTY LTD

Figure 5

Sept 2006

ecoscape

300 150 0 300 Meters

1:12,500

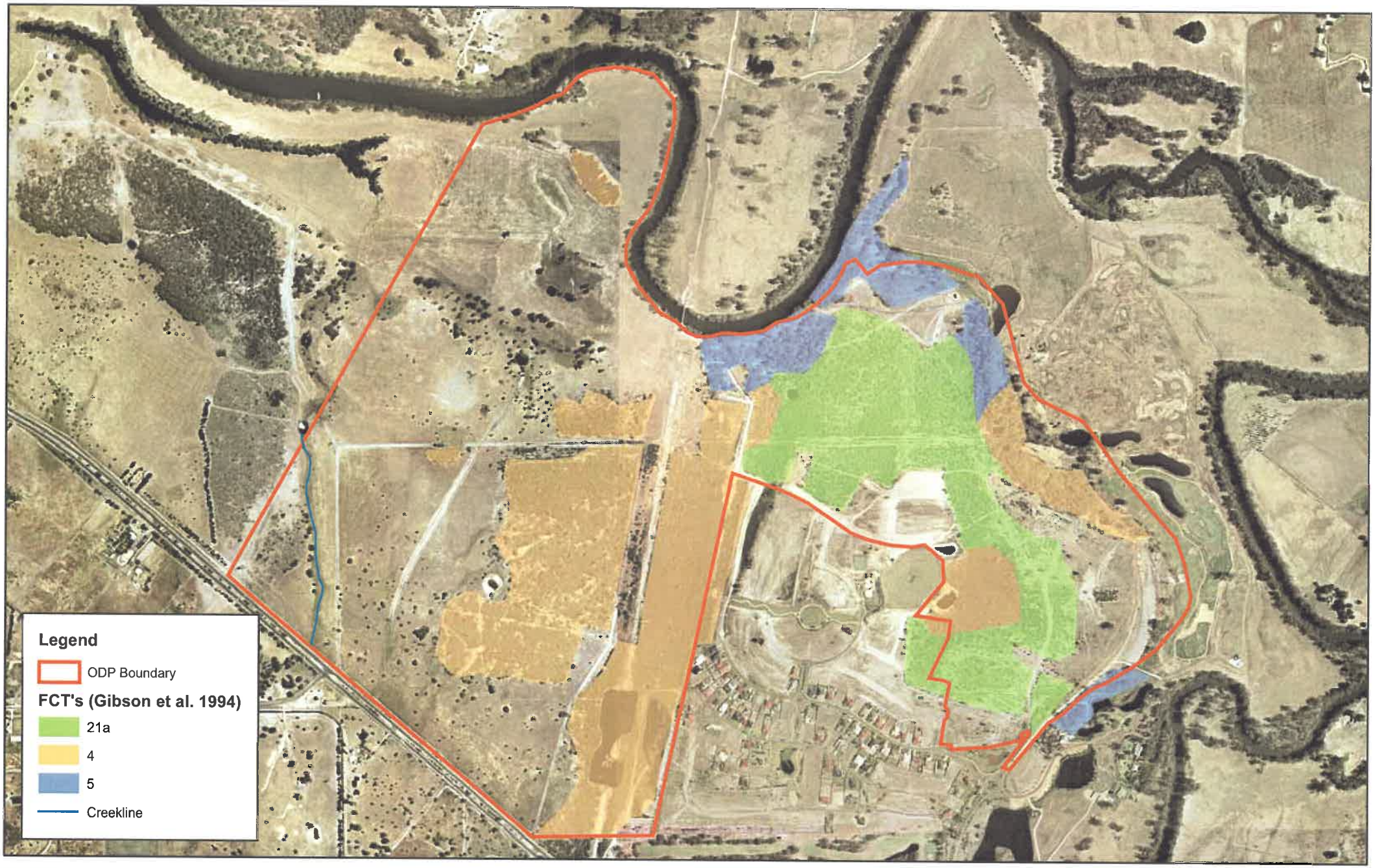
Murray River Country Estate ODP

Vegetation Mapping Units

MURRAY RIVERSIDE PTY LTD

Figure 6

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

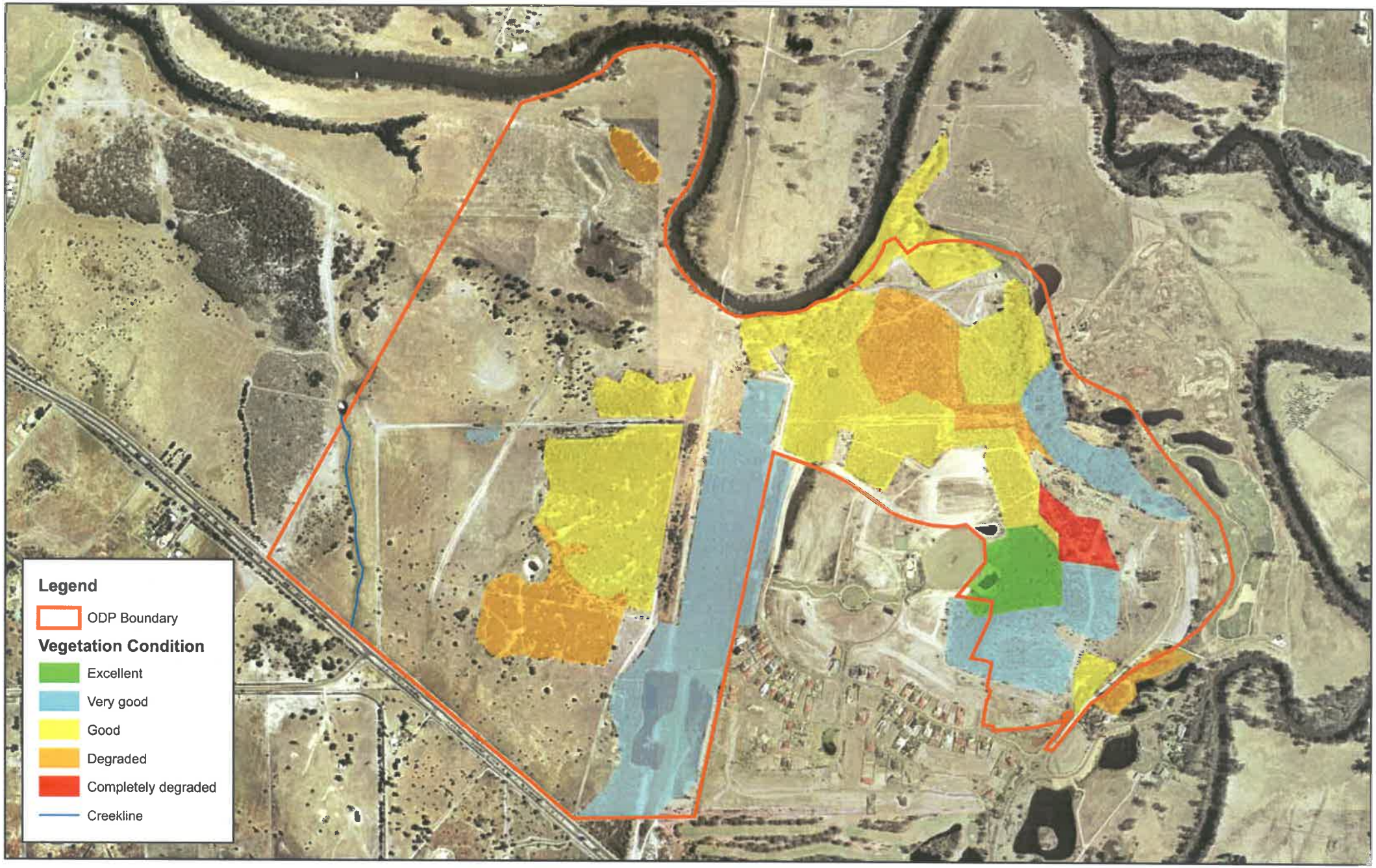
Murray River Country Estate ODP

Floristic Community Types

MURRAY RIVERSIDE PTY LTD

Figure 7

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

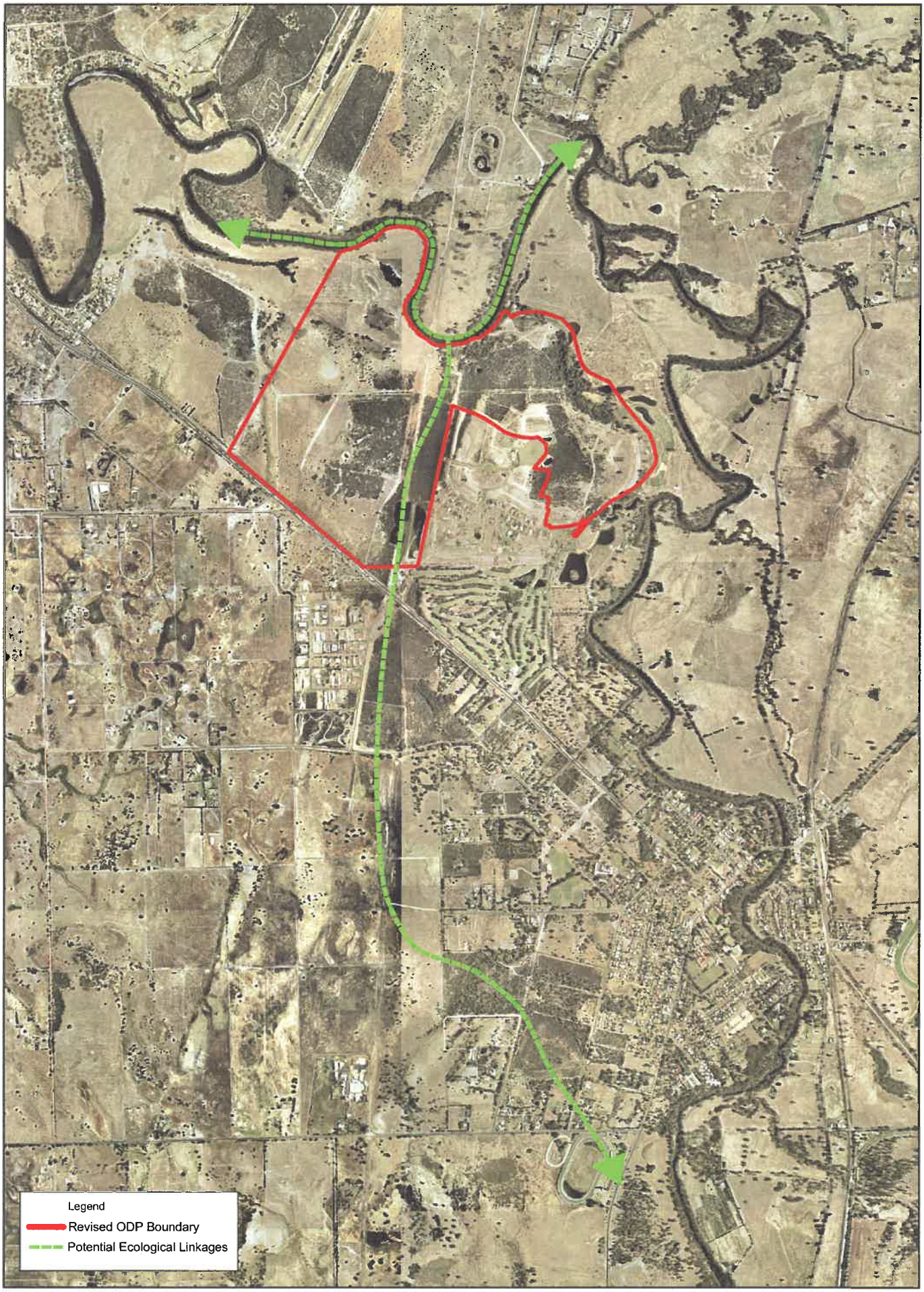
Murray River Estate Wetland Assessment

Vegetation Condition (Keighery et al. 1994)

MURRAY RIVERSIDE PTY LTD

Figure 8

Sept 2006



ecoscape

Murray River Country Estate ODP

Potential Ecological Linkages

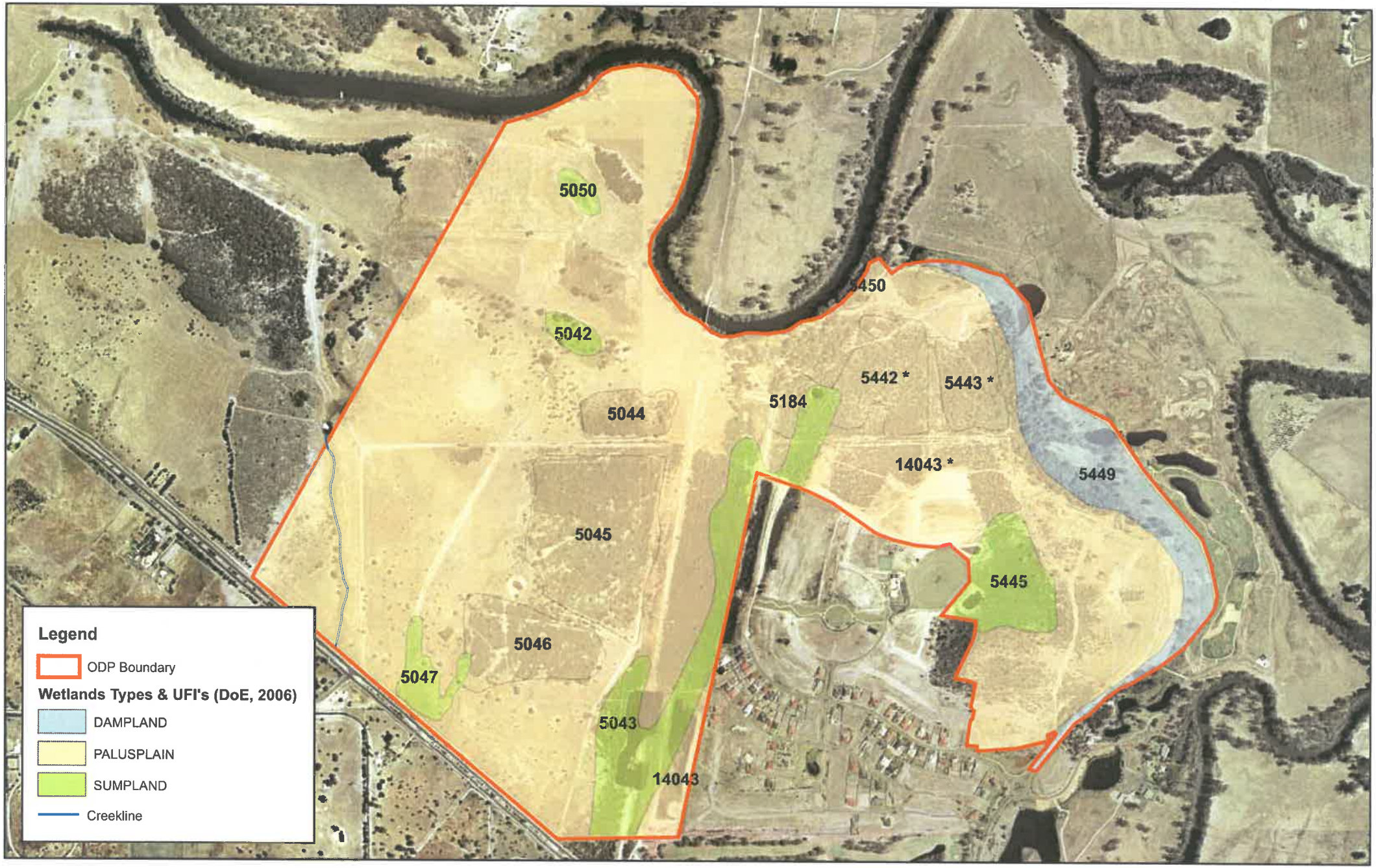
620 310 0 620 Meters

1 : 30,000

MURRAY RIVERSIDE PTY LTD

Figure 9

May 2006



ecoscape

300 150 0 300 Meters

1:12,500

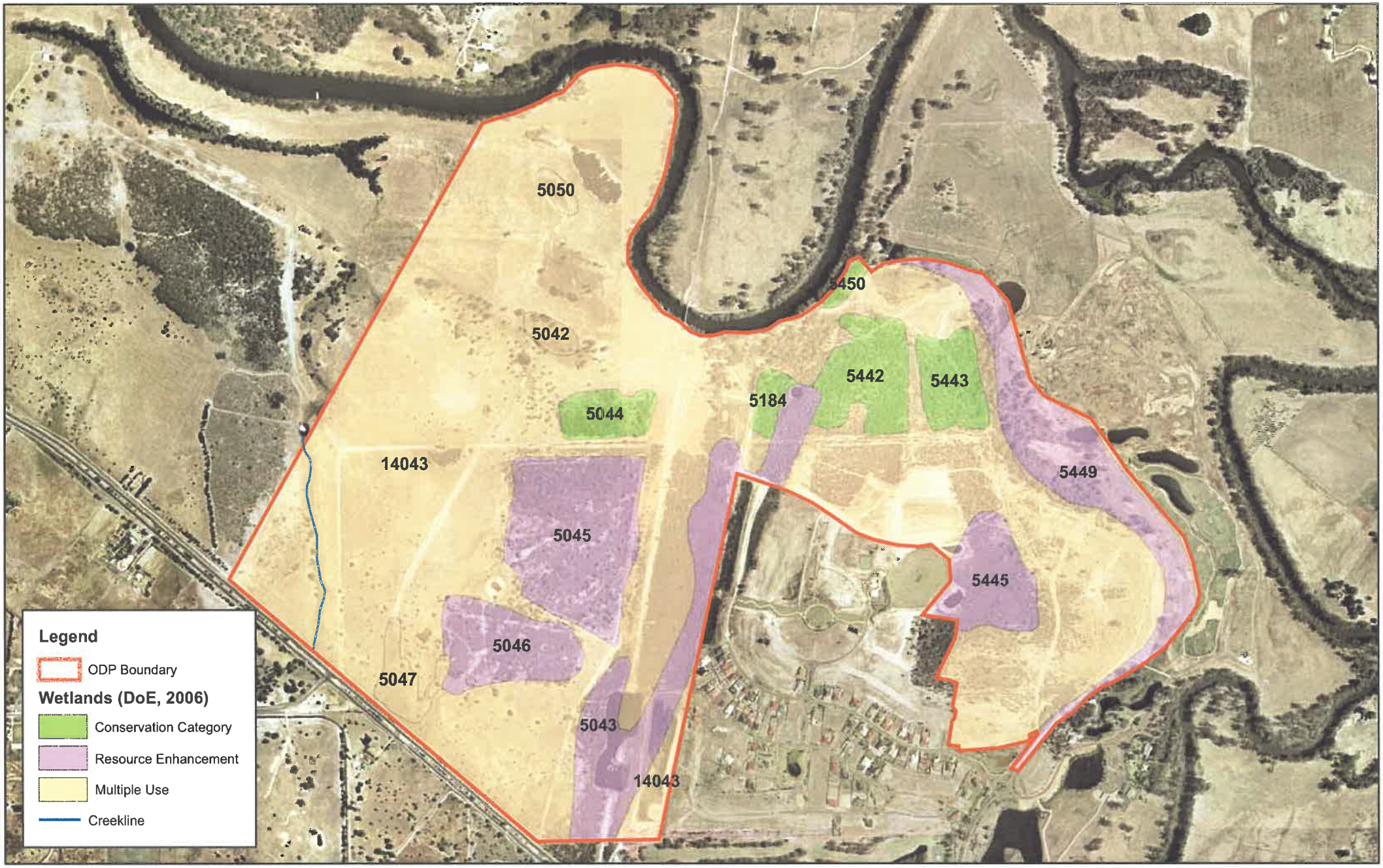
Murray River Country Estate ODP

Study Area and Wetland Types

MURRAY RIVERSIDE PTY LTD

Figure 1

Sept 2006



ecoscape

Murray River Country Estate ODP

Current Wetland Management Categories (adapted from Hill et al. 1996)

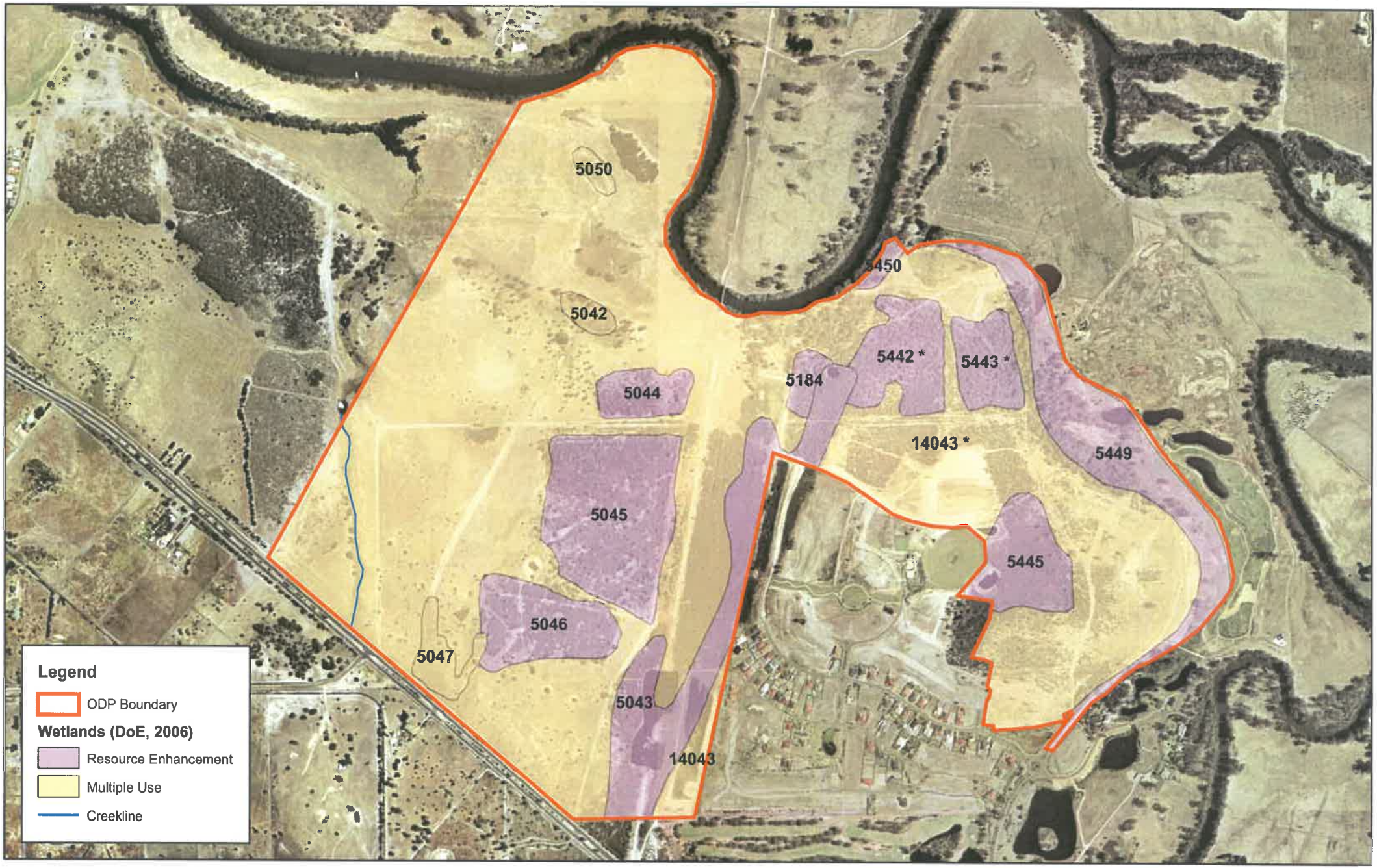
Figure 2

300 150 0 300 Meters

1:12,500

MURRAY RIVERSIDE PTY LTD

Sept 2006



* Wetland status questioned.
The vegetation community of these areas is FCT 21a, which is not a wetland vegetation community.

300 150 0 300 Meters

1:12,500

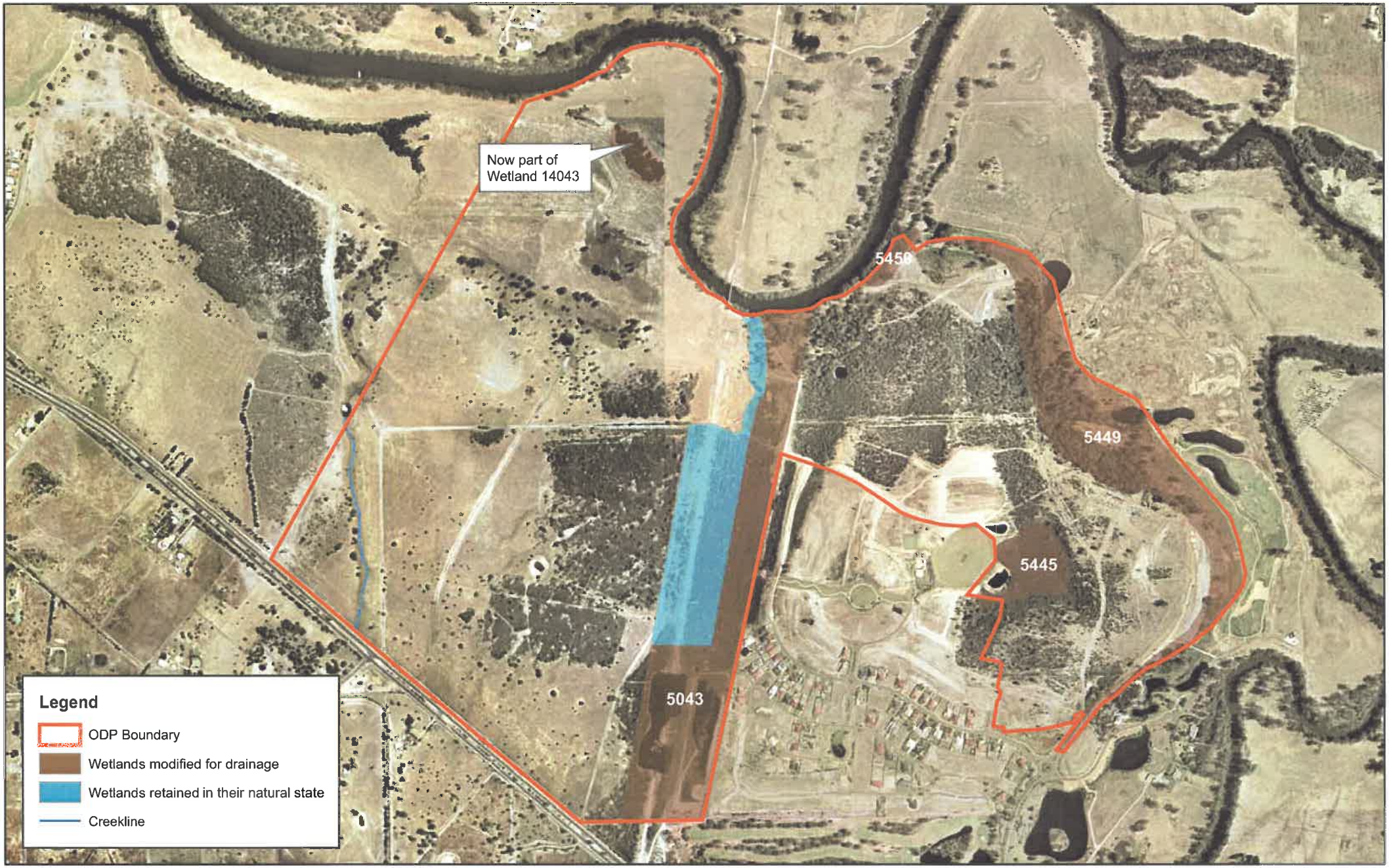
Murray River Country Estate ODP

Proposed Wetland Management Categories (Ecoscape, 2005)

MURRAY RIVERSIDE PTY LTD

Figure 3

Sept 2006



ecoscape

Murray River Country Estate ODP

Wetlands to be retained and modified under the Approved ODP (within the revised ODP boundary)

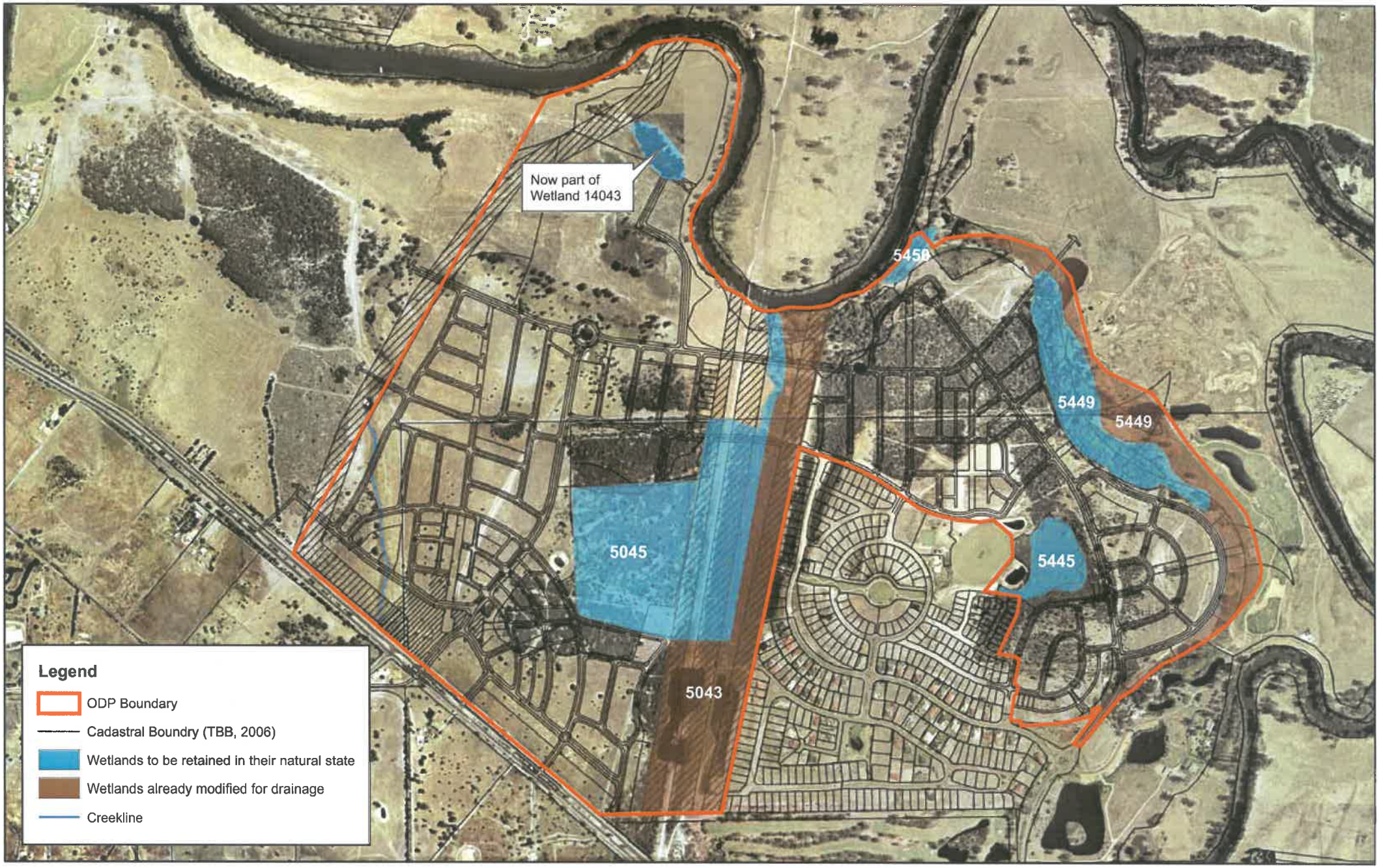
Figure 4

300 150 0 300 Meters

1:12,500

MURRAY RIVERSIDE PTY LTD

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Country Estate ODP

Wetlands Retained and Modified under the Revised ODP

MURRAY RIVERSIDE PTY LTD

Figure 5

Sept 2006

ecoscape

300 150 0 300 Meters

1:12,500

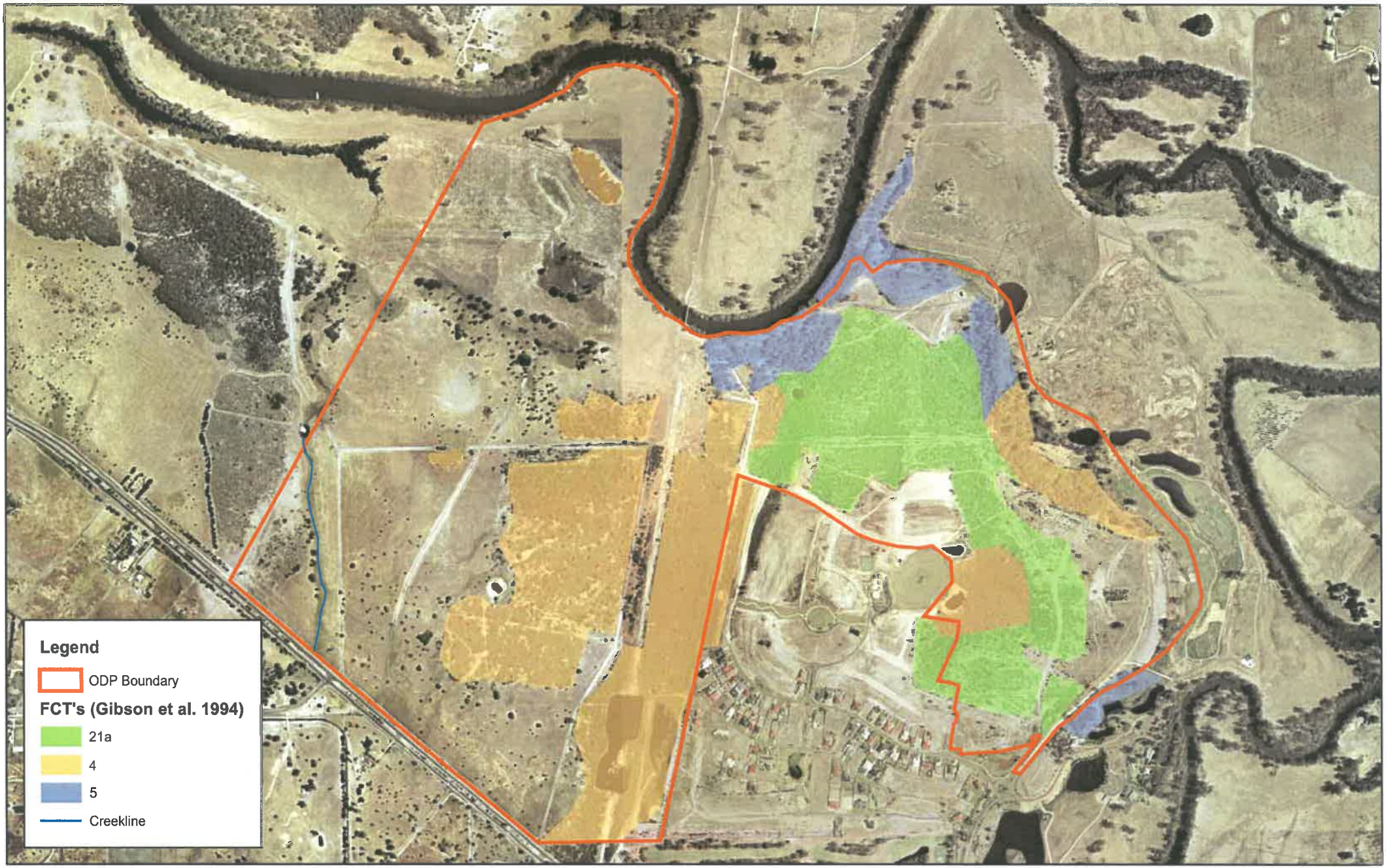
Murray River Country Estate ODP

Vegetation Mapping Units

MURRAY RIVERSIDE PTY LTD

Figure 6

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

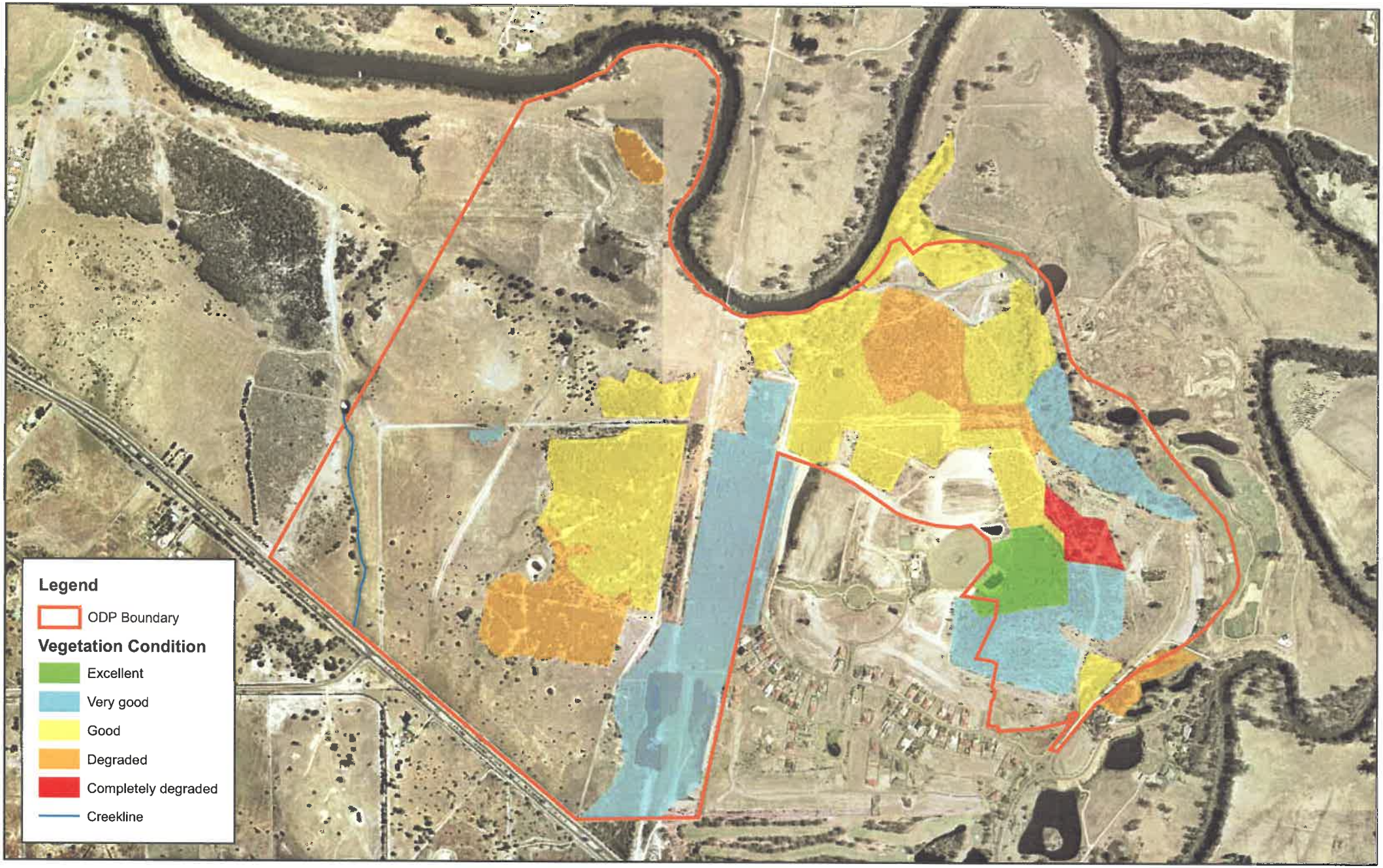
Murray River Country Estate ODP

Floristic Community Types

MURRAY RIVERSIDE PTY LTD

Figure 7

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

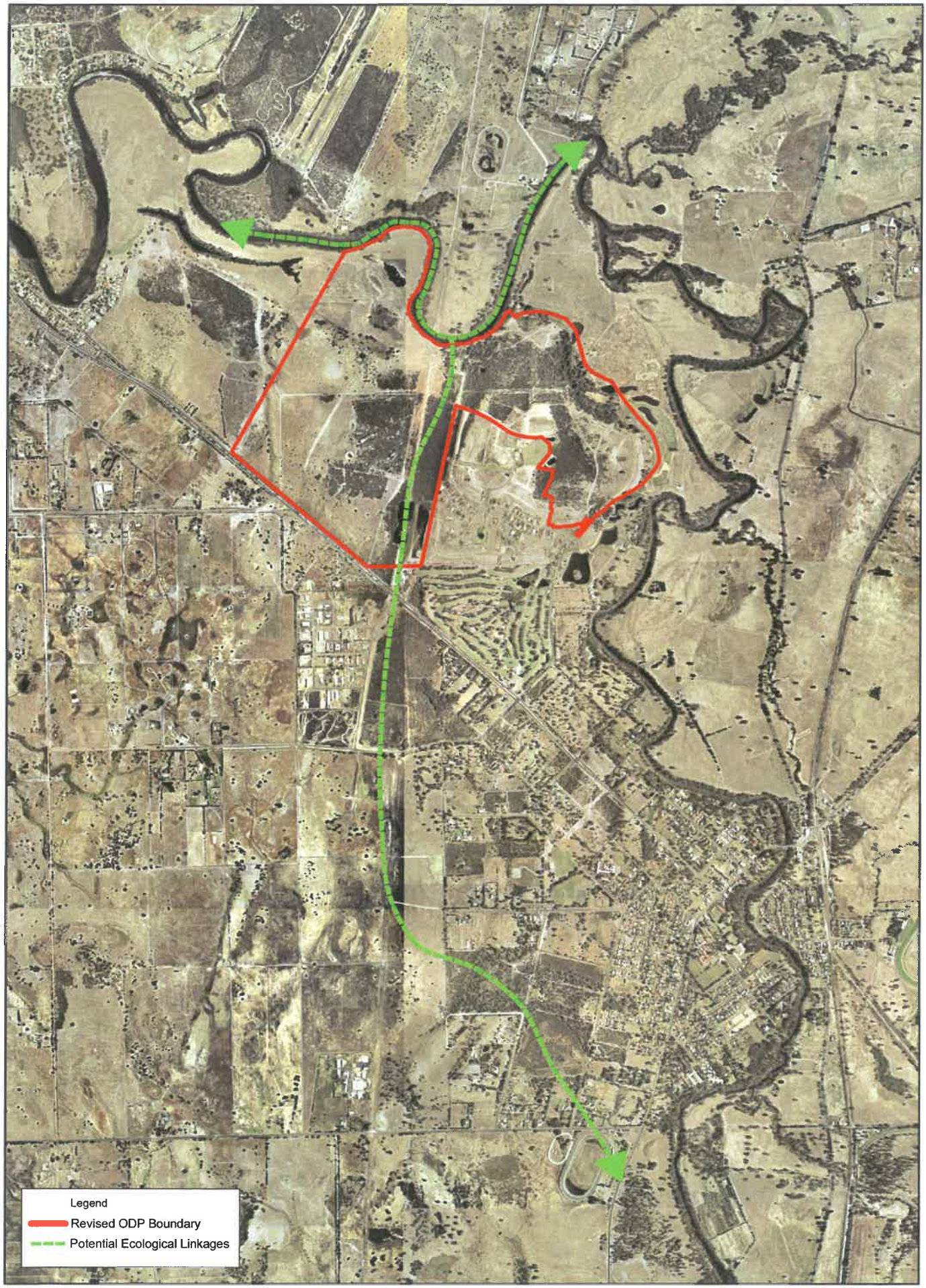
Murray River Estate Wetland Assessment

Vegetation Condition (Keighery et al. 1994)

MURRAY RIVERSIDE PTY LTD

Figure 8

Sept 2006



ecoscape

Murray River Country Estate ODP

Potential Ecological Linkages

Figure 9

620 310 0 620 Meters

1 : 30,000

MURRAY RIVERSIDE PTY LTD

May 2006

APPENDIX 2
MRCE Wetland Assessment
Ecoscape

MURRAY RIVER ESTATE (RAVENSWOOD SANCTUARY) WETLAND ASSESSMENT

MURRAY RIVERSIDE PTY LTD

Prepared by:

Ecoscape (Australia) Pty Ltd

Limitations Statement

This report has been exclusively drafted for the needs of **MURRAY RIVERSIDE ESTATE**. No express or implied warranties are made by Ecoscape (Australia) Pty Ltd regarding the research findings and data contained in this report. All of the information details included in this report are based upon the existent land area conditions, research provided and obtained, and so forth at the time Ecoscape (Australia) Pty Ltd conducted its analysis into the area. Ecoscape (Australia) Pty Ltd will not be responsible for the application of its recommended strategies by **MURRAY RIVERSIDE ESTATE**.

Please note that the strategies devised in this report may not be directly applicable towards another company's needs or any other specific land area requiring management strategies. We would also warn against the environmental dangers of adapting this report's strategies to another land area which has not been researched and analysed by Ecoscape (Australia) Pty Ltd. Instead, please contact Ecoscape (Australia) Pty Ltd to provide a tailored report for your area's needs. Otherwise, Ecoscape (Australia) Pty Ltd accepts no liability whatsoever for a third party's use of, or reliance upon, this specific report.

Direct all inquiries to:

Ecoscape (Australia) Pty Ltd
9 Stirling Highway • PO Box 50 North Fremantle WA 6159
Ph: (08) 9430 8955 Fax: (08) 9430 8977
mail@ecoscape.com.au

Document Status

Rev. No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	V.Yeomans	SB				
2	VY, SB	DK, SB		DK		Dec 2006

COPYRIGHT STATEMENT FOR:
MURRAY RIVER ESTATE WETLAND ASSESSMENT

Table of Contents

Murray River Estate Wetland Assessment

LIST OF TABLES

LIST OF FIGURES

Acknowledgments

Murray River Estate Wetland Assessment

Thank you to Ray Ayres of Murray Riverside Pty Ltd and his office staff for assistance on site during the field assessment.

1.0 Introduction

Murray River Estate Wetland Assessment

The Murray River Estate (Ravenswood Sanctuary) is located 75km south of Perth, 3km east of Pinjarra on the north side of Pinjarra Road in the Shire of Murray. It is situated on the Pinjarra Plain (Hill *et al.* 1996) in a low lying region between one of the convoluted bends of the Murray River. Here the alluvial soils were originally cleared to support agriculture however the pressure of urbanization from the surrounding districts of Mandurah have resulted in the need to plan for future land uses in this area.

The Murray River Estate Project has been an ongoing residential estate development which is aimed at attracting people to the area through the lifestyle options it provides. The product offered by the Estate was initially based on a structure planning process that reflected specific recreation and amenity values, e.g. golfing. This original approach was based on lifestyle values of the 1990's which have since changed due to a number of contemporary factors. This has provided an opportunity to review the existing structure plan and amend it to reflect a more contemporary subdivision design based on new planning principals.

The Structure Plan area comprises Lots 13, 330 and 331 Pinjarra Road, Ravenswood and encompasses a total area of approximately 353ha. The northern and eastern boundaries are the Murray River, the southern boundary is the Ravenswood Golf Course and Pinjarra Road and the western boundary adjoins cleared agricultural land. Ravenswood Sanctuary comprises of, a housing subdivision, recreation facilities including playing fields and golf course and cleared agricultural land with patches of remnant vegetation.

The study site is located on an area that has been classified as a wetland (Hill *et al.* 1996). A Wetland is defined in Schedule 5 of the *Environmental Protection Act 1986* as:

> *"an area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, marsh, spring dampland, tidal flat or estuary."*

Wetland areas can also be identified and delineated on the presence of wetland dependent vegetation. This is particularly useful for an area where there is an absence of groundwater data, surface expressions of the water table and low variations in local topography.

Ecoscape conducted a vegetation survey of the Murray River Country Estate to identify the presence of wetland dependent vegetation to assist in the assessment of the current wetland categories assigned by Hill *et al.* (1996). This assessment was conducted using EPA Bulletin 686 (1993b) to determine if these management categories were applicable.

1.1 Study Area

The study site is located on the Pinjarra Plain (Hill *et al.* 1996) which has been described as one large wetland area with large sections that have been severely degraded by agricultural activities. These wetlands have few if any wetland ecological functions, although they may have some hydrological functions for part of the year (EPA, 1993a). Hill et al. (1996) and the Department of Environment's wetland mapping for the study area indicates that much of the area is defined as various wetland types with different management categories.

The Murray River Country Estate includes a variety of wetland types, including damplands, sumplands, palusplain and artificial wetlands. **Damplands** are seasonally waterlogged basins of variable shape and size where, for part or all of the winter-spring period, the water table is at or close to the ground surface. **Sumplands** are seasonally inundated basins, with most groundwater fed sumplands retaining surface water between at least August and December. **Palusplains** are seasonally waterlogged flats.

The majority of the site is mapped as palusplain (82%) and the remainder as sumplands (12.5%) and damplands (5.5%) (**Figure 1**). The majority of the palusplain has been cleared or impacted upon through cattle grazing and other agricultural land uses.

Wetlands are assigned a management category that reflects their condition and environmental values (Hill *et al.* 1996) see **Table1**.

Table 1: Wetland Management Categories (Hill et al, 1996)

Management category	General Description of Wetlands	Management Objectives
C Conservation wetlands	Wetlands that support high levels of attributes and functions.	To preserve wetland attributes and functions through reservation in national parks, crown reserves, state owned land and protection under environmental protection policies.
R Resource Enhancement wetlands	Wetlands that have been partly modified but still support substantial functions and attributes.	To restore wetlands through maintenance and enhancement of wetland functions and attributes by protection in crown reserves, state or local government owned land and by environmental protection policies, or in private property by sustainable management.
M Multiple Use wetlands	Wetlands with few attributes that still provide important wetland functions.	Use, development and management should be considered in the context of water (catchment/strategic drainage planning), town (land use) and environmental planning through landcare.

1.2 Objectives

The primary objective of this study was to ground truth the wetland boundaries as defined by Hill *et al.* (1996) and determine their correct management categories. The limitations to the Hill *et al.* (1996) and the Department of Environment's wetland mapping is the heavy reliance on aerial photography, limited ground truthing and the use of broad principles to assign management categories to the wetlands. Thus it was deemed necessary to ground truth the

study area and assess the **attributes** and **functions** of the wetlands to assign updated management categories based on the Environmental Protection Authority Procedure detailed in Bulletin 686 (EPA, 1993b). Wetland attributes are defined as characteristics that are valued by a group in society but not necessarily provide a function or support a use. A wetland function is defined as some aspect of a wetland that potentially or actually supports or protects a human activity or human property without being used directly (Hill *et al.* 1996b).

Attributes may include:

- Richness or diversity of flora or fauna;
- Landscape / aesthetic qualities;
- Presence of rare and or uncommon flora or fauna;
- Presence of threatened ecological communities;
- Significant historic site;
- Maintenance of a natural system at a local, regional or national level; and
- Part of a distinct way or life, custom or land use that is in danger of being lost (Hill *et al.* 1996b).

Functions may include:

- Groundwater recharge;
- Nutrient / pollution absorption;
- Storm protection / windbreak;
- Habitat for fish and wildlife;
- Drought refuge for birds; and
- Wildlife corridor (Hill *et al.* 1996b).

From this assessment an opportunities and constraints analysis was done to assist decision making for further development of the site.

The focus of this study was on the wetlands, vegetation and flora because the issues associated with both site contamination and acid sulphate soils have relatively low risk and are less likely to impact on the structure planning process.

Specific objectives included:

- Undertake a Declared Rare Flora and Priority Flora search;
- Assess plant community type, condition and significance;
- Assess wetland management categories: and
- Use these findings in an Opportunities and Constraints analysis.

2.0 Method

Murray River Estate Wetland Assessment

2.1 Literature Review

2.1.1 Wetlands

Ecoscape conducted a vegetation survey of the Murray River Country Estate to identify the presence of wetland dependent vegetation to determine if the site contained any wetlands of ecological significance. An assessment of the wetland management categories assigned by Hill *et al.* (1996) was also undertaken using EPA Bulletin 686 (EPA, 1993b) to confirm if these management categories were applicable.

All information relevant to the study area was collated and reviewed at the initialisation of the project. Base maps including cadastral, topographic, Rare and Priority Flora, aerial photography, previous wetland mapping, vegetation mapping and water resource mapping were prepared from existing data.

ATA Environmental was commissioned in 2004 to investigate the environmental opportunities and constraints of the site to guide the development of a revised Structure Plan for the Murray River Estate.

The outcome of a preliminary survey undertaken by ATA Environmental (2004) indicated that:

- All of the structure plan area is defined as wetland, with the majority mapped as palusplain;
- A number of the wetland areas were incorrectly classified and need to be re-evaluated; and
- There are a number of boundary issues associated with the wetlands which will impact on the structure plan area.

Geomorphic classification of the wetlands of the Swan Coastal Plain was undertaken in 1996 by Hill *et al.* and from this work management categories were assigned. A number of wetlands with a variety of management categories have been identified on the site including five wetlands that have been assigned a Conservation management category **(Table 3)**.

There is a presumption against approving any activity likely to impact on any priority wetlands such as filling, clearing, mining into or out of, effluent discharge into, pollution of, and degradation to the wetland. Although not legally protected the Department of Environment and Conservation position on Conservation Category wetlands is no development (WRC, 2001).

The identification of these wetlands is based on the mapping and classification of wetlands by Hill *et al.* (1996). There are a number of known limitations to the Hill *et al.* (1996) study in

that it relied heavily on aerial photography, only limited ground truthing was undertaken and broad principles were used to assign management categories to the wetlands. Thus it was deemed necessary to ground truth the study area and assess the wetlands to assign updated management categories based on the Environmental Protection Authority Procedure detailed in Bulletin 686 (1993b).

Table 3: Wetlands within the study area

UFI	Type	Current Category	Size (ha)
5044	Palusplain	C	2.78
5184	Palusplain	C	1.17
5442	Palusplain	C	5.89
5443	Palusplain	C	3.82
5450	Sumpland	C	0.63
5043	Sumpland	R	14.32
5045	Palusplain	R	13.56
5046	Palusplain	R	6.61
5445	Sumpland	R	5.78
5449	Dampland	R	13.76
5042	Sumpland	M	1.03
5047	Sumpland	M	2.25
5050	Sumpland	M	0.74
14043	Palusplain	M	173.34
		TOTAL AREA	**245.68**

(DEC, 2006, adapted from Hill *et al.* 1996)

Wetlands within the study area were identified using the Unique Feature Identifier (UFI) from the Department of Environment and Conservation's Online Geographic Data Atlas (http://apostle.environment.wa.gov.au). **Figure 1** shows the wetland locations and wetland numbers (UFI's). The management classification that was assigned to each of these wetlands by Hill et al. (1996) is presented in **Figure 2**. Areas of Palusplain within the estate have largely been cleared and wetlands within this area have been assigned a management category of Multiple Use (M). Areas in the centre of the estate which support native vegetation have been identified as Conservation (C) or Resource Enhancement (R).

It is also recognised that the Structure Plan area has been significantly modified by past land use activities such as stock grazing which has occurred for over 100 years. As a result, extensive vegetation clearing has been undertaken to accommodate stock grazing and artificial water bodies have been constructed for stock watering purposes.

2.1.2 Vegetation

Most of the Murray River Estate is classified as the Swan Vegetation Complex with the South West corner of the site mapped as Bassendean - Central and South Vegetation Complex (Heddle *et al.,* 1980). As part of this study it is also important to consider whether the vegetation on site corresponds to the defined Heddle complexes so that regional significance can be determined. These complexes are described by Heddle *et al.* (1980):

Swan Vegetation Complex

Fringing Woodland of Flooded Gum (*Eucalyptus rudis*) – Paperbark (*Melaleuca rhaphiophylla*) with localised occurrences of Low Open Forest of Swamp Sheoak (*Casuarina obesa*) and *Melaleuca cuticularis.*

Bassendean – Central and South Vegetation Complex

Vegetation ranges from a Woodland of Jarrah (*Eucalyptus marginata*) – Sheoak (*Allocasuarina fraseriana*) – *Banksia* spp. to a Low Woodland of *Melaleuca* spp., and sedgelands on the moister sites. This area includes the transition of Jarrah to *Eucalyptus todtiana* in the vicinity of Perth.

Table 4: Vegetation Remaining on the Swan Coastal Plain System 6 & part System 1

Vegetation Complex	Total pre1750 extent (ha)	Present Extent (ha)	Percentage Remaining	Area in secure tenure (ha)	Percentage in secure tenure
Bassendean Central & South	87477	23624	27	572	0.70
Swan Vegetation Complex	15783	2454	15.6	0.00	0.00

(EPA, 2003)

The EPA guidance for the Assessment of Environmental Factors No. 10, which looks at the level of assessment for proposals affecting natural areas within the System 6 region, is based on a standard level of vegetation retention of at least 30% of the pre – clearing extent of ecological communities. It is the EPA's position to "preferentially locate developments in cleared areas, particularly where 30% or less of the pre-clearing extent of the ecological community remains" (EPA, 2003).

Both the Swan Complex and Bassendean Central and South Complex remain at less than 30% of their pre-clearing extent at 15.6 and 27% respectively (EPA, 2003). Despite the fact that most of the Murray River Estate better fits the description of Bassendean Central and South complex there is still less than 30% of this ecological community remaining **(Table 4)**. However any proposed development will need to consider the condition of this remaining vegetation.

2.2 Database Searches

A search was undertaken of the DEC databases, as recommended in Guidance Statement 51 (EPA, 2004a), for Rare and Priority Flora, along with Threatened Ecological Communities occurring within a 15 km radius of the study area. The radius searched is a standard procedure as it encompasses a greater number of search efforts for rare flora. Therefore a comprehensive species list is available resulting in a more rigorous search for rare flora of the site.

2.3 Field Work

ATA Environmental (2004) undertook preliminary investigations of the site and from this assessment further fieldwork was recommended particularly in relation to the wetland boundaries on the site. Subsequently two botanists from Ecoscape undertook a site visit on the 15th and the 17th of December 2004.

Field Maps were prepared from a desktop assessment of the local features of the site. These field maps were used to assist interpretation and demarcation of wetlands and vegetation prior to, and during field surveys.

A site reconnaissance of the distribution and condition of vegetation was undertaken to verify the previous mapping by ATA environmental (2004) and Hill *et al.* (1996). From this initial site visit, the assessment of plant communities and wetlands was coordinated.

2.3.1 EPA Bulletin 686

The wetlands of the study site were assessed using the questionnaire from Bulletin 686 (EPA, 1993b). The aim of Bulletin 686 is to assist a wide range of user groups, such a community groups and land developers to determine the management category of a wetland using a questionnaire. This questionnaire consists of four parts:

1. presence of gazetted rare species
2. natural attributes
    a. permanent and seasonal wetlands with well defined boundaries; or
    b. seasonal and episodic wetlands with poorly defined boundaries (this section was referred to for the study site).
3. human-use attributes
4. supplementary questions (for wetlands on the boundary of management categories and those on private land with private-use functions).

For wetlands with poorly defined boundaries such as those at the study site, it is recommended to use aerial photography to determine the vegetation cover and condition to assist in wetland delineation. If there is more than one vegetation unit, determine the functions for each unit separately. Thus the flora and vegetation survey was a necessary component of the wetland assessment.

2.3.2 Flora and Vegetation

Flora Assessment

The survey for declared rare and priority flora, and other flora of particular conservation significance was opportunistic. There was however targeted searches of areas with previously known occurrences or areas that were deemed to contain suitable habitat for known Priority Flora and/or Declared Rare Flora of the area, as highlighted in the database search.

Vegetation Assessment

The plant communities present throughout the study area were assessed using 10 x 10 metre quadrats and from such the structural vegetation units, condition rating and floristic groupings were assessed.

The location of these quadrats was recorded using a GPS and a peg in the NW corner (**Appendix 5**). A photo of the quadrat was also taken in the Northwest corner. The species present in the quadrat were recorded and the species list was compared to the Gibson *et al.* (1994) data for the determination of Floristic Community Type. The vegetation condition was also recorded using the bushland condition scale of Kieghery (1994), refer to **Table 6**.

The vegetation at each quadrat was also given a Muir description to assist with the mapping of vegetation communities, see **Table 5**. In this process the height and percentage cover of the dominant species was recorded. Thus the vegetation was described and analysed in accordance with EPA Guidance Statement 51 (2004).

The location of these vegetation quadrats is presented in **Figure 3**.

Table 5: Muir Description of Vegetation Structural Classes

Life Form/ Height Class	Canopy Cover			
	100-70%	70-30%	30-10%	10-2%
Trees over 30m Trees 10-30m Trees under 10m	Tall Closed Forest Closed Forest Low Closed Forest	Tall Open Forest Open Forest Low Open Forest	Tall Woodland Woodland Low Woodland	Tall Open Woodland Open Woodland Low Open Woodland
Tree Mallee	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs over 2m Shrubs 1-2m Shrubs under 1m	Closed Tall Scrub Closed Heath Closed Low Heath	Tall Open Scrub Open Heath Open Low Heath	Tall Shrubland Shrubland Low Shrubland	Tall Open Shrubland Open Shrubland Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Low Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

Keighery, BJ, 1994 (adapted from: Muir (1977) and Aplin (1979)

Table 6: Keighery (1994) Condition Scale

Condition	Description
Pristine	No obvious signs of disturbance
Excellent	Vegetation structure intact, disturbance only affecting individual species and weeds are non-aggressive species
Very Good	Vegetation structure altered, obvious signs of disturbance e.g. repeated fires, aggressive weeds, dieback, logging and grazing
Good	Vegetation structure altered and obvious signs of disturbance. Retains basic vegetation structure or ability to regenerate it. The presence of very aggressive weeds at high density, partial clearing, dieback, logging and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Requires intensive management. The presence of very aggressive weeds at high density, partial clearing, dieback, logging and grazing.
Completely Degraded	Vegetation structure is no longer intact and the area is completely or almost completely without native flora.

2.3.3 Wetlands

Each Conservation Category and Resource Enhancement wetland was visited and scored using the field sheets in the EPA Bulletin 686. Other wetlands on the site were visited but not formally assessed using the Bulletin 686 though either detailed 10m x 10m quadrats or general observation made during the assessment of floristics and bushland condition.

The following information was recorded for each wetland:

- Location using handheld GPS;
- Dominant flora species;
- The presence of free standing water;
- Vegetation condition;
- Digital photo of the wetland;
- Human Influences;
- Fencing;
- Stock presence/grazing;
- Drainage into or out of the wetland; and
- Wetland size and location was determined from aerial photography and previous wetland mapping by Hill *et al.* (1996).

2.4 Data Assessment

2.4.1 Vegetation Assessment

An assessment of the Threatened Ecological Communities (TEC's) was undertaken to ensure the presence or absence of TEC's in the area. This was achieved by first compiling the results of the Floristic Community Analysis along with vegetation descriptions and condition then consulting the Heddle *et al.* (1980) vegetation complexes and Gibson *et al.* (1994) data on the Floristics of the Swan Coastal Plain, to determine the conservation significance of any vegetation on site. The *Environmental Protection and Biodiversity Conservation (EPBC) Act* list of Threatened Ecological Communities was also consulted (DEH, 2006).

2.4.2 Wetland Categorisation

The management categories were determined using Graph 1, in Appendix 1(EPA Bulletin 686). Using the outcomes of the assessment procedure the management categories for the wetlands were reassigned where necessary. The results were then mapped using ArcView 3.2.

The results of the field assessment were compiled and reviewed to assess potential for submission to the Department of Environment and Conservation to consider adjusting the management categories for some wetlands. Should such a report be required, Ecoscape will have all the necessary field data compiled for Murray Riverside to prepare an application to the DPI for consideration.

2.5 Opportunities and Constraints Analysis

An examination, in conjunction with Taylor Burrell Barnett, will be undertaken to determine the opportunities and constraints of the site in terms of the proposed structure planning scenarios. Consideration will be given to impacts on the receiving environment and methods by which these impacts may be mitigated or offset.

3.0 Results

Murray River Estate Wetland Assessment

3.1 Flora and Vegetation

3.1.1 Flora

Appendix 1 presents the Declared Rare and Priority Flora that could have been potentially located within the Murray River Estate. A Department of Environment and Conservation (DEC) database search identified 65 significant flora species within a 15km radius of the Murray River Estate. Ten of these species were also found within 2km of the project area and were found in swamps, damplands or along the Murray River. These species are highlighted in **Appendix 1** as suitable habitat for these species was to be found in the project area and their presence was more likely.

A total of 98 taxa from 76 genera and 34 families were recorded during the flora, vegetation and wetland assessments conducted at Murray River Estate. A total of 72 of these taxa were found within the vegetation quadrats and 44 of the total taxa were also recorded for the wetland sites. All of the 11 weed species recorded for the site at this time were located at the wetland sites. Only two of these weed species were also located in the vegetation quadrats (**Appendix 2 – 4**).

A photographic record of all of the vegetation quadrats and wetland assessment sites is presented in **Appendix 5**.

3.1.2 Declared Rare Flora

Under the Wildlife Conservation Act, the Minister for the Environment may declare species of protected flora to be *Rare Flora* if they are considered to be in danger of extinction, rare or otherwise in need of special protection. Such species are referred to as Threatened Flora, and receive special management attention by DEC (DEC, 2005).

No Declared Rare Flora species, pursuant to Subsection 2 of Section 23F of the *Wildlife Conservation Act 1950* and listed by DEC were located during the survey. No Endangered or Vulnerable species, pursuant to s178 of the EPBC Act were located within the study area.

3.1.3 Priority Flora

Flora species that are known from only a few sites and have not been adequately surveyed are included on a supplementary conservation list called the Priority Flora List. These flora

species may be rare but cannot be declared rare until a survey has been undertaken to adequately assess its conservation status.

There are three categories of priority flora covering these poorly known species. The categories are arranged to give an indication of the priority for undertaking further surveys based on the number of known sites, and the degree of threat to those populations. A fourth category of priority flora is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened (DEC, 2005).

A single Priority 3 Flora species, *Dillwynia dillwynioides* was located at Murray River Estate which was located in wetland 5043. Whilst it is not an offence to take Priority Flora, efforts should be made to maintain populations of these taxa as conservation codes are revised as situations change and further information comes to hand. In some instances species can be upgraded to a higher conservation code.

3.1.4 Vegetation

Two alternate regional vegetation classification systems are used for describing vegetation on the Swan Coastal Plain. These two classifications, which are based on different parameters, are:

- Vegetation **Complexes**, defined by Heddle *et al.* (1980), which divide the Swan Coastal Plain into medium to large areas based on **soils and landforms**; and
- **Floristic Community Types** (FCTs), defined by Gibson *et al.* (1994), which divide the Swan Coastal Plain into comparatively small to medium areas on the basis of **groups of plant species that tend to co-occur**.

Whilst FCTs are distributed in more of a mosaic than complexes, the classifications are equivalent in that they are both regional classifications that divide the region into a roughly equal number of classes. As would be expected there are some associations between FCTs and complexes (i.e. some FCTs tend to occur in particular complexes), but there is no hierarchical structure in which complexes are either FCTs or complexes would be considered finer or broader classifications.

Both classifications are referred to because vegetation complexes are useful in determining the degree to which vegetation types have been cleared and Threatened Ecological Communities are often defined in terms of FCTs.

Vegetation Complexes (Heddle)

Heddle *et al.* (1980) mapped broad vegetation boundaries which were based on major geomorphological units of the Swan Coastal Plan. These vegetation complexes are comprised of groups of vegetation units (including plant communities and vegetation associations) that generally occur in repeatable patterns throughout the extent of the complex. These units are based on where they occur rather than by having particular characteristics such as the same dominant species in common or a majority of species in common (Trudgen 1996).

The vegetation complexes of Heddle *et al.* (1980) are mapped, dividing the landscape into medium to large areas and are appropriate for assessing the value of vegetation at a regional scale (i.e. at a scale of 1:250 000).

Table 7: Vegetation Complexes (Heddle et al, 1980) of the Site

Vegetation Complex	Typical Vegetation
Bassendean Central & South	Vegetation ranges from Woodland of Jarrah (*Eucalyptus marginata*) – Sheoak (*Allocasuarina fraseriana*) – *Banksia* spp. to a Low Woodland of *Melaleuca* spp. and sedgelands on the moister sites.
Swan Vegetation Complex	Fringing Woodland of Flooded Gum (*Eucalyptus rudis*) – Paperbark (*Melaleuca raphiophylla*) with localised occurrences of Low Open Forest of Swamp Sheoak (*Casuarina obesa*) and *Melaleuca cuticularis*.

The vegetation of the site is classified as the Swan Vegetation Complex and the south west corner of the site is mapped as Bassendean Central and South Complex (Heddle *et al.* 1980). These vegetation complexes are described in **Table 7**.

The Swan Vegetation Complex is dominated by *Eucalyptus rudis – Melaleuca rhaphiophylla* woodland and vegetation that matched this complex on site was only to be found at Wetland 2 and 7, corresponding to vegetation units 8 and 11 in **Figure 4**.

Bassendean Central and South is a broad vegetation complex which ranges from woodland of Jarrah/Marri-Sheoak-Banksia woodland to *Melaleuca* woodlands and sedgelands. These main structural units of this complex are evident throughout the Murray River Estate.

Floristic Community Types (FCTs)

The community grouping method of Gibson *et al.* (1994) uses Floristic Community Types. This is an alternate form of vegetation classification to that of Heddle *et al.* (1980) vegetation complexes. It creates abstract groups based on similar flora composition, which divide the landscape into a similar number of classes to that of vegetation complexes with the individual units, however, covering comparatively small to medium areas. It is considered to be the most recent and detailed analysis of the patterning of plant communities on the Swan Coastal Plain.

As vegetation communities form part of a continuum (rather than discrete groups), a definitive classification of the vegetation requires all species within a 10 x 10 metre quadrat to be recorded, and the data statistically analysed against the records of more than 500 previously established quadrats.

Fourteen different vegetation communities were defined by Ecoscape for the vegetation within Murray River Estate. The descriptions of these are presented in **Table 9** and the distribution of these units is presented in **Figure 4.**

The Floristic Community Types of these mapping units was assessed using Gibson *et al.* data and three FCTs were defined for the project area **(Table 8)**. *Melaleuca preissiana*

Damplands (FCT 4), *Mixed Damplands* (FCT 5) and *Banksia attenuata – Eucalyptus marginata Woodlands* (FCT 21a). **Figure 5**

Table 8: Floristic Community Types of the site

FCT	Description	TEC (CALM and DEH, 2006)
4 *Melaleuca preissiana* Damplands	Shrub-rich community with scattered *M. preissiana* overstorey. Where tree species are absent, heaths or scrubs are present. The most consistent species of this community type are; *Pericalymma ellipticum, Hypolaena exsulca, Hypocalymma angustifolium* and *Dasypogon bromeliifolius*. This FCT is distributed on the Swan Coastal Plain on the Bassendean and Southern River Vegetation Complexes.	No
5 Mixed Damplands	Similar to FCT 4. No consistent overstorey, higher frequencies of *Banksia ilicifolia, Kunzea ericifolia* and *Jacksonia furcellata*. It can also contain *Melaleuca rhaphiophylla and Eucalyptus rudis*. This FCT generally has more open ground and a less dense shrub layer.	No
21a *Banksia attenuata – Eucalyptus marginata* Woodlands	Floristic Community Type 21a is primarily dominated by combinations of *Eucalyptus marginata, Corymbia calophylla* and *Banksia attenuata. Allocasuarina* and *Eucalyptus gomphocephala* are sometimes present as dominant or codominant overstorey. This community type commonly occurs on the central part of the coastal plain from Perth to Capel.	No

(Gibson *et al.* 1994)

FCT's 4 and 5 belong to communities of the seasonal wetlands and are both shrub rich damplands. FCT 21a belongs to the community types centred on the Bassendean System that are not considered wetland communities.

Threatened Ecological Communities (TEC's)

The three Floristic Community Types are considered well reserved and with no risk to their conservation status (Gibson et al. 1994). Therefore no Threatened Ecological Communities pursuant to s182 of the EPBC Act 1999 were inferred from the vegetation units described for the project area.

Consideration needs to be given to the removal of the wetland status of wetlands 5442 and 5443 that occur in vegetation type 21a. This community is more typical of upland vegetation that occurs on the Bassendean dunes and is not considered a wetland vegetation community (Gibson *et al.* 1994).

3.1.5 Vegetation Condition

Vegetation Condition ranged from Excellent to Completely Degraded but most of the vegetation was classified as either good or degraded. This is due to the long history of agriculture on site that these communities can be considered to have been largely altered in most instances from their original structure and condition **(Figure 6)**.

Table 9: Description of Vegetation Mapping Units (refer to Figure 3 for site locations)

Mapping Unit	Site	Condition	Description
1	A	Very Good	Open Woodland of *Allocasuarina fraseriana* over Tall Shrubland of *Kunzea ericifolia* with *Banksia attenuata, Banksia ilicifolia* over Herbland of *Dasypogon bromelifolius.*
2	B / W1	Excellent	Closed Heath of *Pericalymma ellipyicum, Hypocalymma angustifolium and Euchilopsis linearis* over an open sedgeland of *Baumea juncea, Lepidosperma and Hypolaena exscula.*
3	C / W4	Very Good	Low Open Woodland of *Eucalyptus marginata, Melaleuca preissiana* and *Kunzea ericifolia* over Closed Heath of *Pericalymma ellipticum, Hypocalymma angustifolium* and *Astartea fascicularis.*
4	D / W6	Degraded	Low Open Woodland of *Kunzea ericifolia* over Low Open Shrubland of *Gompholobium tomentosum Brachyloma preissii* over a Herbland of *Ursinia anthemoides.*
5	E	Good	Low Woodland of *Kunzea ericifolia, Banksia ilicifolia* and *Banksia attenuata* over Tall Open Shrubland over *Jacksonia furcellata* over as Open Low Heath of *Pteridium esculentum, Dasypogon bromelifolius* over an open grassland of *Briza maxima.*
6	F	Good	Low Open Forest of *Kunzea ericifolia* with *Eucalyptus marginata* over Low Shrubland of *Dasypogon bromelifolius, Phlebolcarya ciliata* and *Gompholobium tomentosum* over a very open sedgeland of *Hypolaena exsulca*.
7	G	Degraded	Open Woodland of *Melaleuca preissiana, Eucalyptus marginata,Corymbia calophylla* and *Nuytsia floribunda* over Low Open Woodland of *Kunzea ericifolia* over a closed heath of *Hypocalymma angustifolium, Pericalymma ellipticum* and *Astartea fasicularis*
8	W2	Degraded	Woodland of *Eucalyptus rudis* and *Kunzea ericifolia* over a completely degraded understorey of grasses and *Pteridium esculentum*. Wetland species included *Baumea articulata, Typha domengensis* and *Juncus* sp.
9	W3	Very Good	Woodland of *Melaleuca rhaphiophylla* and *Eucalyptus rudis* over shrubland of *Astartea fascicularis, Hypolaena exsulca* and *Phlebocarya ciliatum.*
10	W5		Woodland of *Kunzea ericifolia* over completely degraded understorey of *Ursinia anthemoides* and occasional *Jacksonia furcellata*
11	W7	Very Good	Woodland of *Eucalyptus rudis, Melaleuca rhaphiophylla* and *Melaleuca preissiana* over *Astartea fascicularis* and *Acacia pulchella*.
12	W8	Degraded	Woodland of *Melalueca preissiana* and *Kunzea ericifolia* over grazed understorey of pasture grasses.
13	W9	Degraded	Woodland of *Melalealeuca preissiana* and *Melaleuca rhaphiophylla*
14	G	Degraded	Open Woodland of *Melaleuca preissiana* over low open woodland of *Kunzea ericifolia*

3.2 Wetlands

Ground truthing of the wetlands that were mapped by Hill *et al.* (1996) determined that much of these wetlands or parts of are severely degraded and either contained no water or wetland vegetation.

Two of the Conservation Category (5442 and 5443) wetlands were not considered to be distinctive wetland communities at all when an assessment of the floristics from the quadrats was undertaken. The vegetation of these wetlands is most similar to Community Type 21a which is not a wetland community but is instead documented to surround wetland sites on the Bassendean Dunes (Gibson *et al.*, 1994). The other significant factor for reassignment of the management category of these wetlands was uncontrolled stock access (5044) resulting in severe trampling of the understorey and compaction of the soil which has downgraded the ecological values of the site. The vegetation of wetland 5184 is most similar to Community Type 4, and is likely to be considered an Environmentally Sensitive Area (ESA). Therefore clearing and filling this wetland is likely to require a Clearing Permit.

From the wetland assessment none of the Conservation Category wetlands were considered to be C category and consideration, based on Ecoscape's assessment, should be made for reassignment of the management category to either Resource Enhancement (R) or Multiple Use for Wetland 5184 and the removal of wetland status entirely for wetlands 5442 and 5443. The existing and proposed changes to the wetland management categories are shown in **Table 11** and **Figure 7**.

The suggested removal of the wetland status of wetlands 5442 and 5443 is due to the vegetation community (FCT 21a) being more typical of upland vegetation that occurs on the Bassendean dunes which is not considered a wetland vegetation community (Gibson *et al.* 1994).

For those wetlands that were not formally assessed the existing allocation of Resource Enhancement (R) and Multiple Use (M) appears to be appropriate for the remainder of the wetlands within the study area. An additional wetland that was not mapped by Hill et al. (1996) was located in the western portion of the Study area and has been assigned a R management category as it has the same structure and composition as the nearby *Wetland 5045.*

Scores for the natural attributes of the wetlands ranged from 26 to 34 (**Table 10**). The wetlands had very low human use scores (between 3 and 8). With very low human use scores the management categories were largely determined by the natural attributes score.

Wetlands that were not assessed include:

- Wetland 2 (part of 5449), that is not in the revised ODP boundary area;
- Wetland 5, that was formerly a Conservation Category wetland directly south of wetland 5442, but is now part of wetland 14043, a large Palusplain area that is categorised as Multiple Use; and

- Wetland 9 (that was north of wetland 5050) no longer has a separate Multiple Use boundary, it is now part of Multiple Use wetland 14043.

Table 10: Wetland Scores for assigning management categories

Wetland Identification & UFI	W1 5445	W3 5449	W4 5043	W6 5442	W7 5443	W8 5044
Natural Attributes	27	26	31	34	28	32
Human Use	7	3	5	3	8	3

Table 11: Wetland current categories and proposed categories.

UFI	Type	Size (ha)	FCT	Vegetation Condition	Current Category	Proposed Category (Ecoscape)
5044	Palusplain	2.78	4	Degraded	C	R or MU
5184	Palusplain	1.17	4	Good	C	R or MU
5442 *	Palusplain	5.89	21a	Degraded	C	None
5443 *	Palusplain	3.82	21a	Good	C	None
5450	Sumpland	0.63	5	Good	C	R
5043	Sumpland	14.32	4	Very Good	R	retain
5045	Palusplain	13.56	4	Degraded / Good	R	retain
5046	Palusplain	6.61	4	Degraded	R	retain
5445	Sumpland	5.78	4	Excellent	R	retain
5449	Dampland	13.76	4 5	Very Good Good	R	retain
5042	Sumpland	1.03	(cleared)	-	M	retain
5047	Sumpland	2.25	(cleared)	-	M	retain
5050	Sumpland	0.74	(cleared)	-	M	retain
14043	Palusplain	173.34	21a	Very Good to Completely Degraded	M	retain
	Total Area	**245.68**				

* These wetlands occur within Floristic Community Type 21a (Gibson *et al.* 1996) which is not a wetland community. Therefore their wetland status is questionable.

The boundaries of these wetlands were not resolved as it would require additional field days to accurately map the borders of these wetlands. In any case this task would prove difficult for the wetlands that consist of FCT 21a as there was no distinction of the wetlands within this vegetation. Thus the wetland mapping in this report is based on the boundaries defined by Hill *et al.* (1996).

4.1 Key Issues

4.1.1 Flora and Vegetation

No Declared Rare Flora species, pursuant to Subsection 2 of Section 23F of the *Wildlife Conservation Act 1950* and listed by DEC were located during the survey. No Endangered or Vulnerable species, pursuant to s178 of the EPBC Act were located within the study area.

A single Priority species *Dillwynia dillwynioides* (P3) has been located in wetland 5043, an area that will be retained in any case due to the power line reserve that runs through it. An effort should be made to appropriately manage this area of bushland to reduce weed invasion and fire threats to ensure the preservation this priority species.

No Threatened Ecological Communities were identified from the FCT analysis, and the three FCTs (4, 5 and 21a) that were located within the study site are well reserved with no risk to their conservation status.

The vegetation complexes that are represented by remnant vegetation within the project area are present within the System 6 portion of The Swan Coastal Plain at less than 30% of their original extent, thus the EPA is likely to favour development of the already cleared areas.

There is a significant extent of cleared land within the project area that has very little conservation value, this area is part of Wetland 14043, a Multiple Use category Palusplain. Prior to the Ravenswood Sanctuary subdivision the site was farmland with considerable clearing of the native vegetation. Thus due to the status of the representative vegetation complexes in the conservation estate of the Swan Coastal Plain it is recommended that as much remaining native vegetation as possible be incorporated into Public Open Space. However vegetation that has been severely downgraded due to past agricultural practices could be considered for development if adequate offsets and commitments to improve the ecological values of the remaining vegetation are made.

The EPA (2006) describes offsets as an environmental management tool for a net environmental benefit outcome. One of the principles of the Offsets policy is to conserve biological diversity and ecological integrity. In the case of the Murray River Country Estate, fragmented areas of vegetation that are proposed to be cleared could be offset by the preservation and management of other areas of bushland in better condition. In particular, the vegetation along Murray River and foreshore reserve, that is part of the boundary of the Outline Development Plan and forms a valuable ecological corridor.

4.1.2 Wetlands

The Ecoscape assessment of wetland status and management category recommends the reassignment of Conservation Category Wetlands to Resource Enhancement Wetlands. Furthermore, consideration needs to be given to the removal of the wetland status of wetlands 5442 and 5443 that occur in vegetation type FCT 21a. This community is more typical of upland vegetation that occurs on the Bassendean dunes and is not considered a wetland vegetation community (Gibson *et al.* 1994).

Both of these management categories have the objective of maintaining and enhancing the existing wetland ecological functions.

As part of the future development of the land, a Wetland Management Plan will need to be prepared and implemented to ensure the long term sustainability of the retained wetlands.

4.1.3 Limitations

Since this survey the Department of Environment and Conservation has prepared and adopted the *Protocol for proposing modifications to the 'Geomorphic Wetlands Swan Coastal Plain' dataset* (DEC, 2006) that has superseded Bulletin 686. It is recognised that Bulletin 686 is more applicable to open waterbodies and is not well equipped to recognise wetland condition, floristic complexities, less conspicuous fauna and functions and values present in systems such as damplands and palusplains. The assessment procedures of the new document include:

- Visual justification;
- Wetland identification and delineation which includes information on hydrology, soils and vegetation. The vegetation survey must be in accordance with EPA Guidance Statement No. 51 (2004a);
- Desktop Study of Wetland Values; and
- Wetland vegetation condition assessment.

It is recommended that further survey work be undertaken to justify changes in wetland classification and the possible removal of wetland status entirely, using the assessment procedures outlined in the *Protocol for proposing modifications to the 'Geomorphic Wetlands Swan Coastal Plain' dataset* (DEC, 2006). If such work is undertaken it is likely that the DEC will take 3-6 months to re-assess these wetland categories.

4.2 Recommendations

1. Water levels in existing Conservation Category (C) or Resource Enhancement (R) wetlands to be maintained (i.e. wetlands not to be used as compensation basins for road or building runoff).
2. Natural runoff into C or R category wetlands be retained (i.e. no damming of natural water courses through dam, road or building construction).

3. Ground water levels are not raised or lowered (i.e. through pumping, damming or vegetation clearing).
4. C and R category wetland biodiversity values are enhanced (by stock exclusion, improved water quality, improved buffers and fringing vegetation).
5. Individual management plans should be developed for each wetland to be retained, that is, wetland 5045, 5043 (part of poweline reserve), 5445, 5449, 5450 (adjacent to Murray River Foreshore reserve) and 5050 (part of proposed public open space in north west foreshore area).
6. Further survey work to re-assess wetland values using the updated DEC (2006) procedures.

References

Murray River Estate Wetland Assessment

ATA Environmental (2004). *Ravenswood Sanctuary, Murray River Estate Structure Plan. Environmental Opportunities and Constraints Analysis*. Unpublished report for Taylor Burrell Barnett.

Department of Environment and Conservation (DEC) (2006) *List of CALM's Threatened Ecological Communities Database* [online]. Available: http://www.naturebase.net/plants_animals/watscu/pdf/tec/tec_database.pdf [2006, September 13].

Department of Environment and Conservation (DEC) (2005) *Protection Out Plants* [online]. Available: http://www.naturebase.net/plants_animals/licensing/protecting_flora.html [2006, September 13].

Department of Environment and Conservation (2006) *Protocol for proposing modifications to the 'Geomorphic Wetlands Swan Coastal Plain' dataset*. DEC, Perth.

Department of Environment and Conservation (2006) *Geographic Data Atlas* [Online]. Available: http://www.apostle.environment.wa.gov.au [2006, September 15].

Department of the Environment and Heritage (DEH) (2006) *EPBC Act List of Threatened Ecological Communities* [Online]. Available: http://www.deh.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl [2006, September 15].

Environmental Protection Authority (2006) *Environmental Offsets Position Statement No. 9*. EPA, Perth.

Environmental Protection Authority (EPA) (2004a) *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*. EPA, Perth.

Environmental Protection Authority (2004b) *Environmental Protection of Wetlands Position Statement No. 4*. EPA, Perth.

Environmental Protection Authority (2003). *Guidance for the Assessment of Environmental Factors. Level of Assessment for Proposals Affecting Natural Areas within the System 6 region and Swan Coastal Plain Portion of the System 1 Region. No.10.* Environmental Protection Agency Perth, Western Australia.

Environmental Protection Authority (1993a) *Strategy for the Protection of Lakes and Wetlands of the Swan Coastal Plain (EPA Bulletin 685).* EPA, Perth.

Environmental Protection Authority (1993b) *A guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area (EPA Bulletin 686).* Environmental Protection Agency Perth, Western Australia.

Environmental Protection Authority (1992) *Environmental Protection (Peel Inlet – Harvey Estuary) Policy.* EPA, Perth.

Gibson N, Keighery B, Keighery G, Burbidge A and Lyons M (1994) *A Floristic Survey of the Southern Swan Coastal Plain*, Unpublished report by CALM and WA Conservation Council for the Australian Heritage Commission, Perth.

Government of Western Australia (1997) *Wetlands Conservation Policy for Western Australia.* Government of Western Australia, Perth.

Heddle, EM, Lonergan, OW, Havel, JJ (1980). Vegetation – Perth Sheet in *Atlas of Natural Resources – Darling System Western Australia*, Forests Department, Perth, Western Australia.

Hill, A.L., Semeniuk, C.A., Semeniuk, V. and Del Marco, A. (1996) Wetlands of the Swan Coastal Plain, Volume 2b Wetland Mapping, Classification and Evaluation, Wetland Atlas. Department of Environmental Protection, Perth Western Australia.

Hill, A.L., Semeniuk, C.A., Semeniuk, V. and Del Marco, A. (1996b) Wetlands of the Swan Coastal Plain, Volume 2a Wetland Mapping, Classification and Evaluation, Main Report. Department of Environmental Protection, Perth Western Australia.

Keighery, B. (1994). *Bushland Plant Survey. A Guide to Plant Community Survey for the Community.* Wildflower Society of WA (Inc.). Nedlands Western Australia.

Trudgen, ME (1996) *An Assessment of the Conservation Values of the Remnant Vegetation in the City of Wanneroo with recommendations for appropriate reserves for the City*, unpublished report for the City of Wanneroo, Perth.

Waters and Rivers Commission (2001) *Position Statement on Wetlands*. WRC, Perth.

Western Australian Planning Commission (WAPC) (2005) *Guideline for the determination of Wetland Buffer Requirements.* WAPC, Perth.

Appendix One: Significant Flora of the Area

Murray River Estate Wetland Assessment

Species				Conservation Code	Within 2km radius
Acacia	*benthamii*			P2	
Acacia	*horridula*			P3	
Acacia	*lasiocarpa*	var.	*bracteolata long peduncle variant* (G.J.Keighery 5026)	P1	
Acacia	*oncinophylla*	subsp.	*patulifolia*	P2	
Acacia	*oncinophylla*	subsp.	*oncinophylla*	P3	
Anthocercis	*gracilis*			R	
Anthotium	*junciforme*			P4	
Aotus	*cordifolia*			P3	
Aponogeton	*hexatepalus*			P4	
Blennospora	*doliiformis*			P3	
Boronia	*tenuis*			P4	
Caladenia	*arrecta*			P4	
Caladenia	*huegelii*			R	
Caladenia	*longicauda*	subsp.	*clivicola*	P4	
Caladenia	*speciosa*			P4	
Calothamnus	*graniticus*	subsp.	*leptophyllus*	P4	
Cardamine	*paucijuga*			P2	
Centrolepis	*caespitosa*			R	#
Chamaescilla	*gibsonii*			P3	
Chorizema	*ulotropis*			P4	
Craspedia	*argillicola*			P2	
Cyathochaeta	*teretifolia*			P3	#
Dillwynia	*dillwynioides*			P3	
Diuris	*drummondii*			R	#
Diuris	*micrantha*			R	
Diuris	*purdiei*			R	#
Dodonaea	*hackettiana*			P4	
Drakaea	*elastica*			R	
Drakaea	*micrantha*			R	
Drosera	*occidentalis*	subsp.	*occidentalis*	P4	#
Eryngium	*ferox*			P3	
Eryngium	*subdecumbens*			P3	
Eucalyptus	*rudis*	subsp.	*cratyantha*	P4	
Grevillea	*manglesii*	subsp.	*ornithopoda*	P2	
Grevillea	*manglesii*	subsp.	*dissectifolia*	P3	
Haloragis	*tenuifolia*			P3	
Hemigenia	*microphylla*			P3	
Hydatella	*dioica*			R	
Jacksonia	*sericea*			P4	

Species				Conservation Code	Within 2km radius
Johnsonia	*pubescens*	subsp.	*cygnorum*	P2	
Lasiopetalum	*bracteatum*			P4	
Lasiopetalum	*membranaceum*			P3	
Microtis	*media*	subsp.	*quadrata*	P4	#
Myriophyllum	*echinatum*			P3	
Parsonsia	*diaphanophleba*			P4	#
Phyllangium	*palustre*			P2	
Rhodanthe	*pyrethrum*			P3	
Rumex	*drummondii*			P4	
Schoenus	*benthamii*			P3	
Schoenus	*capillifolius*			P2	
Schoenus	*natans*			P4	
Schoenus	sp.Waroona (G.J.Keighery 12235)			P3	
Senecio	*leucoglossus*			P4	
Stenanthemum	*coronatum*			P3	
Stylidium	*ireneae*			P4	
Stylidium	*longitubum*			P3	
Synaphea	sp.Fairbridge Farm (D.Papenfus 696)			P1	
Synaphea	sp.Pinjarra (R.Davis 6578)			R	#
Synaphea	*stenoloba*			R	#
Tetraria	*australiensis*			R	
Tetratheca	*pilifera*			P3	
Thelymitra	*stellata*			R	
Trichocline	sp.Treeton (B.J.Keighery & N.Gibson (564))			P2	
Tripterococcus	*paniculatus*			P1	#
Villarsia	*submersa*			P4	

Appendix Two:
Species List Murray River Estate

Murray River Estate Wetland Assessment

FAMILY		*Species*
DENNSTAEDTIACEAE		*Pteridium esculentum*
TYPHACEAE		*Typha domingensis*
POACEAE		*Amphipogon laguroides* subsp. *laguroides*
	*	*Avena barbarta*
	*	*Briza maxima*
	*	*Bromus diandrus*
	*	*Cynodon dactylon*
	*	*Ehrharta calycina*
	*	*Eragrostis curvula*
	*	*Paspalum* sp.
CYPERACEAE		*Baumea articulata*
		Eleochaeris sp.
		Lepidosperma brunonianum
		Lepidosperma longtitudinale
		Lepidosperma sp.
		Schoenus sp.
		Shoenoplectus validus
RESTIONACEAE		*Desmocladus asper*
		Desmocladus flexuosus
		Hypolaena exsulca
		Loxocarya fasciculata
		Lyginia barbata
		Lyginia imberbis
JUNCACEAE		*Juncus microcephalus*
		Juncus pallidus
DASYPOGONACEAE		*Dasypogon bromeliifolius*
		Lomandra hermaphrodita
		Lomandra maritimum
		Lomandra sp.
		Lomandra suaveolens
XANTHORRHOEACEAE		*Xanthorrhoea preissii*
ANTHERICACEAE		*Chamaescilla corymbosa*
		Thysanotus multiflorus
		Tricoryne elatior
COLCHICACEAE		*Buchardia umbellata*

FAMILY	***Species***
DASYPOGONACEAE	*Conostylis aculeata* *Conostylis juncea* *Haemodorum* sp. *Phlebocarya ciliata*
IRIDACEAE	*Patersonia occidentalis*
ORCHIDACEAE	*Orchidaceae* sp 1. *Orchidaceae* sp 2. *Orchidaceae* sp 3.
CASUARINACEAE	*Allocasuarina fraseriana*
PROTEACEAE	*Banksia attenuata* *Banksia ilicifolia*
LORANTHACEAE	*Nuytsia floribunda*
POLYGONACEAE	*Rumex* sp.
CHENOPODIACEAE	*Chenopodium* sp.
LAURACEAE	*Cassytha* sp.
DROSERACEAE	*Drosera* sp.
MIMOSACEAE	*Acacia barbinervis* subsp. *barbinervis* *Acacia pulchella* *Acacia stenoptera*
PAPILIONACEAE	*Aotus gracillima* *Bossiaea eriocarpa* *Daviesia nudiflora* subsp. *nudiflora* *Dillwynia dillwynioides* (P3) *Euchilopsis linearis* *Gompholobium tomentosum* *Hardenbergia comptoniana* *Hovea trisperma* *Jacksonia furcellata* *Latrobea tenella* var. *tenella*
DILLENIACEAE	*?Hibbertia sp.* *Hibbertia huegelii*
MYRTACEAE	*Astartea fascicularis* *Calothamnus lateralis* *Calytrix fraseri* *Corymbia calophylla* *Eucalyptus gomphocephala* *Eucalyptus marginata* *Eucalyptus rudis* *Hypocalymma angustifolium* *Kunzea ericifolia* *Melaleuca preissiana* *Melaleuca rhaphiophylla*

FAMILY		*Species*
MYRTACEAE (Cont.)		*Melaleuca thymoides*
		Pericalymma ellipticum var. *ellipticum*
HALORAGACEAE		*Gonocarpus cordiger*
APIACEAE		*Xanthosia huegellii*
EPACRIDACEAE		*Brachyloma preissii*
PRIMULACEAE		*Samolus junceus*
CHENOPODIACEAE		*Gomphocarpus fruiticosus*
SOLONACEAE	*	*Solanum nigrum*
RUBIACEAE		*Opercularia vaginata*
GOODENIACEAE		*Dampiera linearis*
STYLIDIACEAE		*Levenhookia* sp.
		Stylidium brunonianum subsp. *brunonianum*
		Stylidium diuroides subsp. *diuroides*
		Stylidium guttatum
		Stylidium piliferum
		Stylidium repens
ASTERACEAE		*Gnephosis angianthoides*
	*	*Hypochaeris glabra*
		Siloxerus humifusus
	*	*Sonchus* sp.
	*	*Ursinia anthemoides*

Appendix Three:
Species List Per Vegetation Quadrat

Murray River Estate Wetland Assessment

FAMILY	Weed	Species	Vegetation Community A	B	C	D	E	F	G
DENNSTAEDTIACEAE		*Pteridium esculentum*					x		
POACEAE	*	*Briza maxima*	x	x	x	x	x		x
		Amphipogon laguroides subsp. *laguroides*							x
CYPERACEAE		*Lepidosperma brunonianum*			x				
		Lepidosperma longtitudinale							x
		Lepidosperma sp.	x						
		Schoenus sp.		x					
RESTIONACEAE		*Desmocladus asper*	x						
		Desmocladus flexuosus	x				x		
		Hypolaena exsulca	x	x	x			x	x
		Lyginia barbata					x	x	
		Lyginia imberbis		x					
DASYPOGONACEAE		*Dasypogon bromeliifolius*	x		x		x		
		Lomandra hermaphrodita					x	x	
		Lomandra maritimum	x						
		Lomandra sp.		x					
		Lomandra suaveolens					x		x
XANTHORRHOEACEAE		*Xanthorrhoea preissii*			x				x

FAMILY	Weed	Species	Vegetation Community A	B	C	D	E	F	G
ANTHERICACEAE		*Chamaescilla corymbosa*							x
		Thysanotus multiflorus			x			x	x
		Tricoryne elatior						x	x
COLCHICACEAE		*Burchardia umbellata*	x		x	x			
HAEMODORACEAE		*Conostylis aculeata*	x						
		Conostylis juncea	x				x	x	
		Phlebocarya cilliata						x	
IRIDACEAE		*Patersonia occidentalis*	x						x
ORCHIDACEAE		Orchidaceae sp 1.		x					
		Orchidaceae sp 2.	x	x					
		Orchidaceae sp 3.		x					
CASUARINACEAE		*Allocasuarina fraseriana*	x					x	
PROTEACEAE		*Banksia attenuata*	x				x		
		Banksia ilicifolia	x				x		
LORANTHACEAE		*Nuytsia floribunda*	x			x			x
LAURACEAE		*Cassytha* sp.		x					
MIMOSACEAE		*Acacia barbinervis* subsp. *barbinervis*	x				x	x	
		Acacia pulchella	x		x				
		Acacia stenoptera			x			x	
PAPLIONACEAE		*Aotus gracillima*			x				
		Daviesia nudiflora subsp. *nudiflora*			x				
		Dillwynia dillwynioides			x				

FAMILY	Weed	Species	Vegetation Community A	B	C	D	E	F	G
PAPLIONACEAE (Cont.)		*Euchilopsis linearis*		x	x				
		Gompholobium tomentosum	x		x	x		x	
		Hardenbergia comptoniana					x		
		Hovea trisperma							x
		Jacksonia furcellata	x				x	x	
		Latrobea tenella var. *tenella*		x					
DILLENIACEAE		?*Hibbertia* sp.	x						
		Hibbertia huegelii	x						
MYRTACEAE		*Astartea fascicularis*			x				x
		Calothamnus lateralis			x				
		Calytrix fraseri	x						
		Corymbia calophylla							x
		Eucalyptus gomphocephala			x				
		Eucalyptus marginata			x			x	
		Hypocalymma angustifolium			x				x
		Kunzea ericifolia	x		x	x	x	x	x
		Melaleuca preissiana			x				x
		Melaleuca thymoides	x	x					
		Pericalymma ellipticum var. *ellipticum*	x	x	x				x
HALORAGACEAE		*Gonocarpus cordiger*						x	
APIACEAE		*Xanthosia huegellii*						x	
EPACRIDACEAE		*Brachyloma preissii*				x	x	x	
PRIMULACEAE		*Samolus junceus*	x						

FAMILY	Weed	Species	Vegetation Community A	B	C	D	E	F	G
GOODENIACEAE		*Dampiera linearis*			x				x
STYLIDIACEAE		*Stylidium brunonianum* subsp. *brunonianum*			x				
		Stylidium diuroides subsp. *diuroides*	x						
		Stylidium guttatum		x	x			x	x
		Stylidium piliferum						x	
		Stylidium repens			x				
ASTERACEAE		*Gnephosis angianthoides*	x						
		Siloxerus humifusus			x				x
	*	*Ursinia anthemoides*	x			x			

Appendix Four:
Species List Per Wetland Site

Murray River Estate Wetland Assessment

FAMILY	Weed	*Species*	Wetland 1	2	3	4	5	6	7	8	9
DENNSTAEDTIACEAE		*Pteridium esculentum*		x							
TYPHACEAE		*Typha domingensis*		x							
POACEAE	*	*Avena barbarta*		x							
	*	*Briza maxima*		x	x						x
	*	*Bromus diandrus*		x							
	*	*Cynodon dactylon*		x					x		
	*	*Ehrharta calycina*		x							
	*	*Eragrostis curvula*		x							
	*	*Paspalum* sp.		x							
CYPERACEAE		*Baumea articulata*									
		Eleochaeris sp.									
		Shoenoplectus validus		x							
RESTIONACEAE		*Hypolaena exsulca*			x		x				x
		Loxocarya fasciculata									x
		Lyginia barbata					x				
JUNCACEAE		*Juncus microcephalus*		x					x		
		Juncus pallidus			x						
COLCHICACEAE		*Buchardia umbellata*			x						

FAMILY	Weed	Species	Wetland 1	2	3	4	5	6	7	8	9
DASYPOGONACEAE		*Haemodorum* sp.									x
		Phlebocarya ciliata			x						
POLYGONACEAE		*Rumex* sp.									
CHENOPODIACEAE		*Chenopodium* sp.		x	x						
DROSERACEAE		*Drosera* sp.			x						
MIMOSACEAE		*Acacia pulchella*			x						x
PAPILIONACEAE		*Aotus gracillima*			x						
		Bossiaea eriocarpa					x				
		Euchilopsis linearis					x		x		
		Gompholobium tomentosum			x		x				x
		Hardenbergia comptoniana		x							
		Jacksonia furcellata					x				
MYRTACEAE		*Astartea fascicularis*		x	x				x		
		Eucalypyus rudis		x	x				x		
		Kunzea ericifolia		x			x				x
		Melaleuca preissiana							x		x
		Melaleuca rhaphiophylla			x				x		x
EPACRIDACEAE		*Brachyloma preissii*					x				
CHENOPODIACEAE		*Gomphocarpus fruiticosus*							x		
SOLONACEAE	*	*Solanum nigrum*		x							
RUBIACEAE		*Opercularia vaginata*			x						
STYLIDIACEAE		*Levenhookia* sp.			x						

FAMILY	Weed	*Species*	Wetland 1	2	3	4	5	6	7	8	9
ASTERACEAE	*	*Hypochaeris glabra*			x				x		x
	*	*Sonchus* sp.		x							
	*	*Ursinia anthemoides*					x				

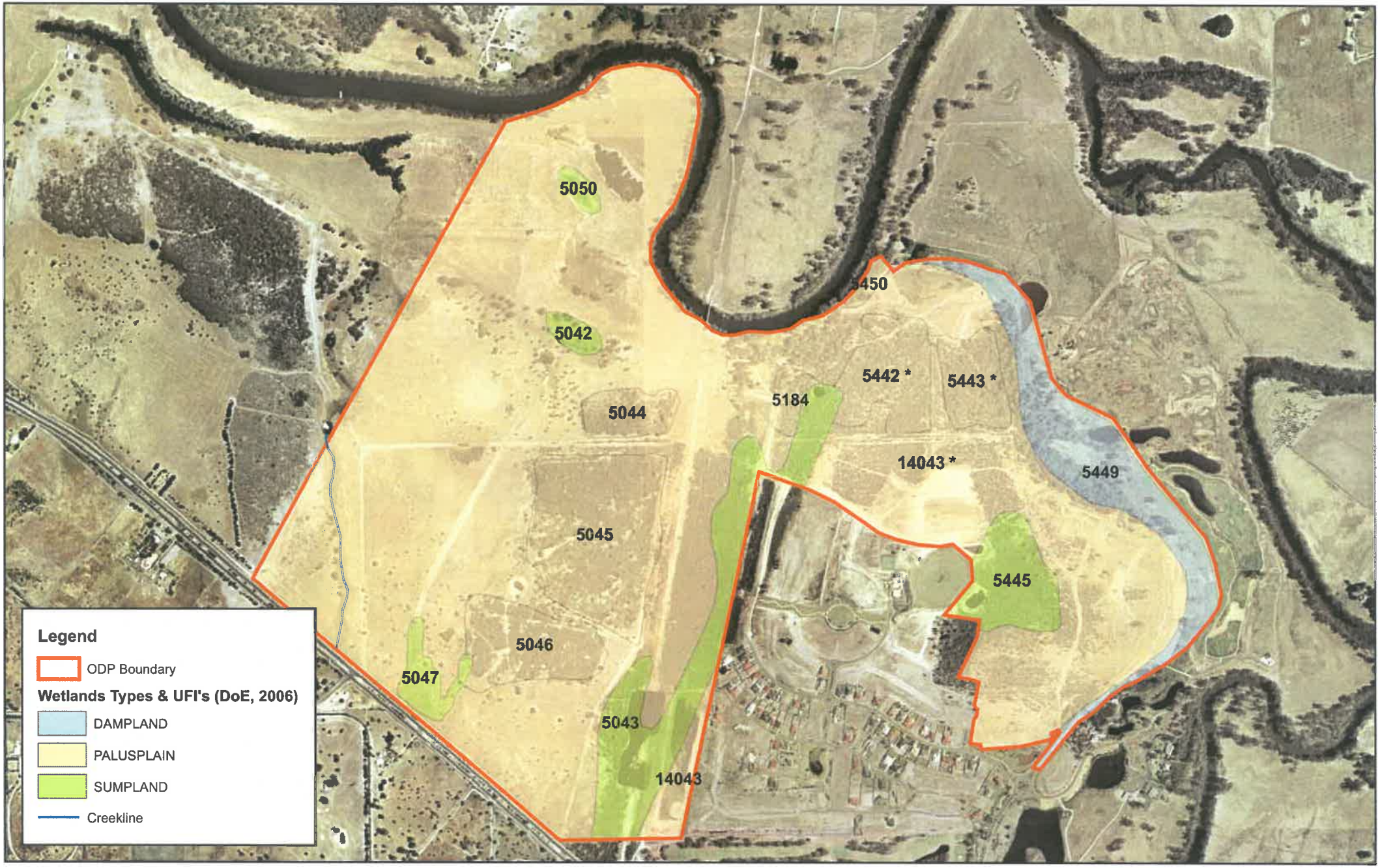
Appendix Five:
Survey Site Co-ordinates

Murray River Estate Wetland Assessment

EASTINGS	NORTHINGS	NAME	WETLAND UFI	Comments
392636	6391699	C	5043	
392634	6391695	C2		
392644	6391693	C3		
392648	6391704	C4		
393163	6392255	D	5442	
393167	6392245	D2		
393175	6392243	D3		
393176	6392257	D4		
393363	6392387	E	5449	
393372	6392386	E2		
393368	6392379	E3		
393359	6392386	E4		
392845	6392248	F	5184	
392853	6392248	F2		
392853	6392240	F3		
392841	6392241	F4		
392131	6391638	G	5046	
392128	6391632	G2		
392135	6391628	G3		
392140	6391636	G4		
393329	6391707	W1	5445	
393718	6391508	W2	5449	Outside revised ODP boundary
393675	6392024	W3	5449	
392639	6391703	W4	5043	
393110	6392118	W5	14043	Formerly a CC wetland, now MU
393170	6392254	W6	5442	
393448	6392380	W7	5443	
392495	6392173	W8	5044	
392396	6392882	W9	14043	

Appendix Six: Photographic Record

Murray River Estate Wetland Assessment



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Country Estate ODP

Study Area and Wetland Types

MURRAY RIVERSIDE PTY LTD

Figure 1

Sept 2006

ecoscape

Murray River Estate Wetland Assessment

Current Wetland Management Categories (adapted from Hill et al. 1996)

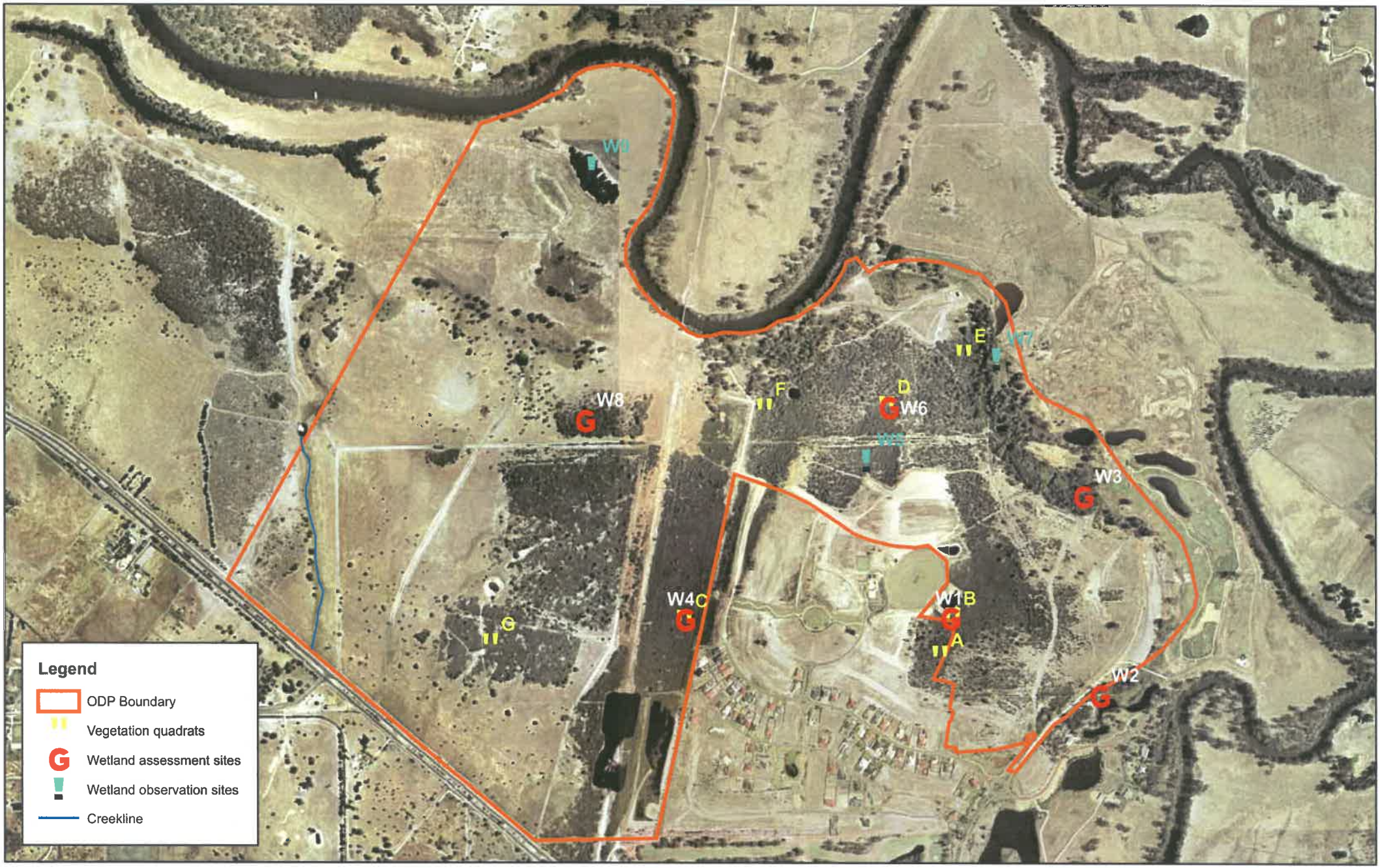
300 150 0 300 Meters

1:12,500

MURRAY RIVERSIDE PTY LTD

Figure 2

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Estate Wetland Assessment

Vegetation Quadrats and Wetland Assessment Sites

MURRAY RIVERSIDE PTY LTD

Figure 3

Sept 2006

ecoscape

300 150 0 300 Meters

1:12,500

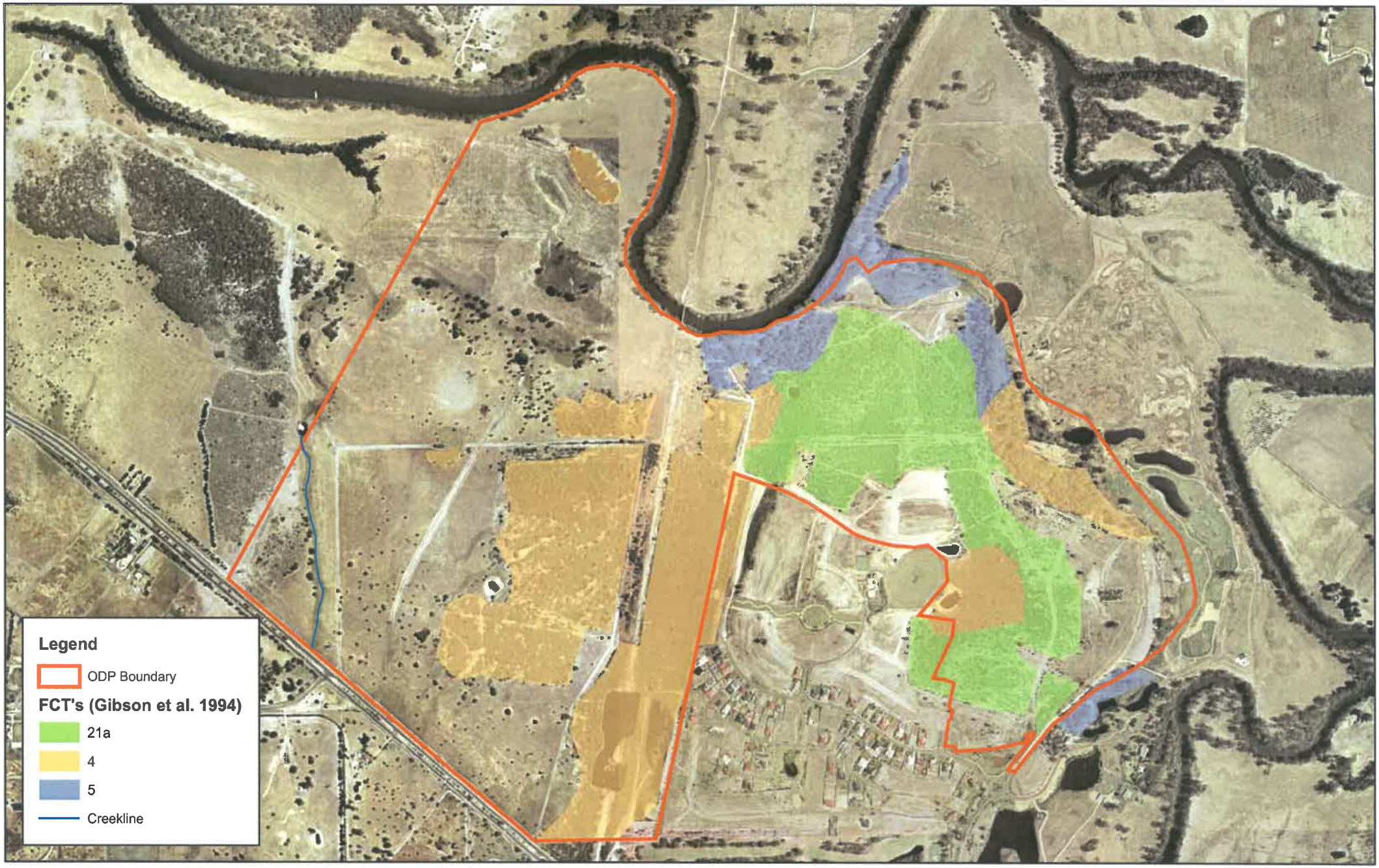
Murray River Estate Wetland Assessment

Vegetation Mapping Units

MURRAY RIVERSIDE PTY LTD

Figure 4

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

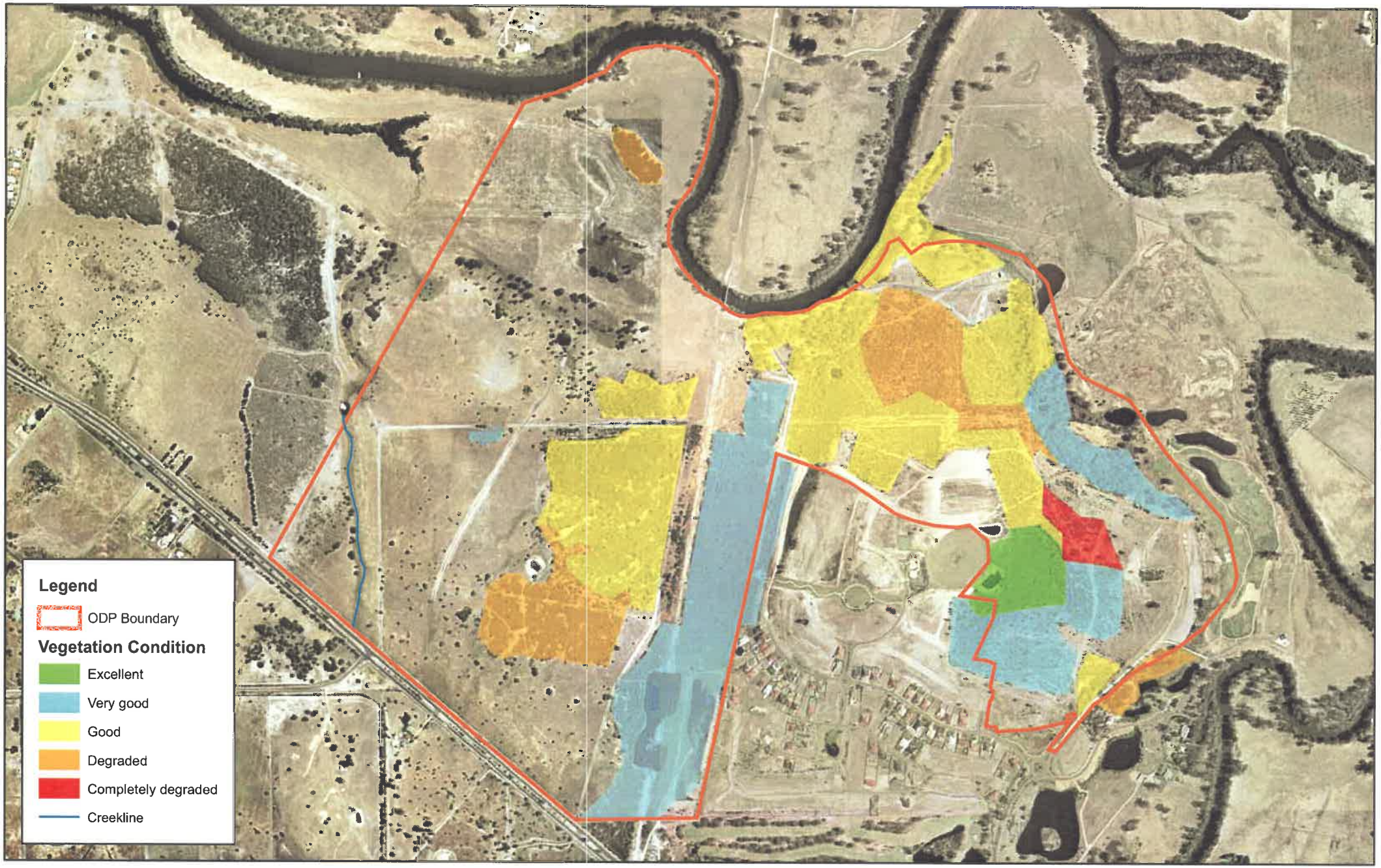
Murray River Estate Wetland Assessment

Floristic Community Types

MURRAY RIVERSIDE PTY LTD

Figure 5

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

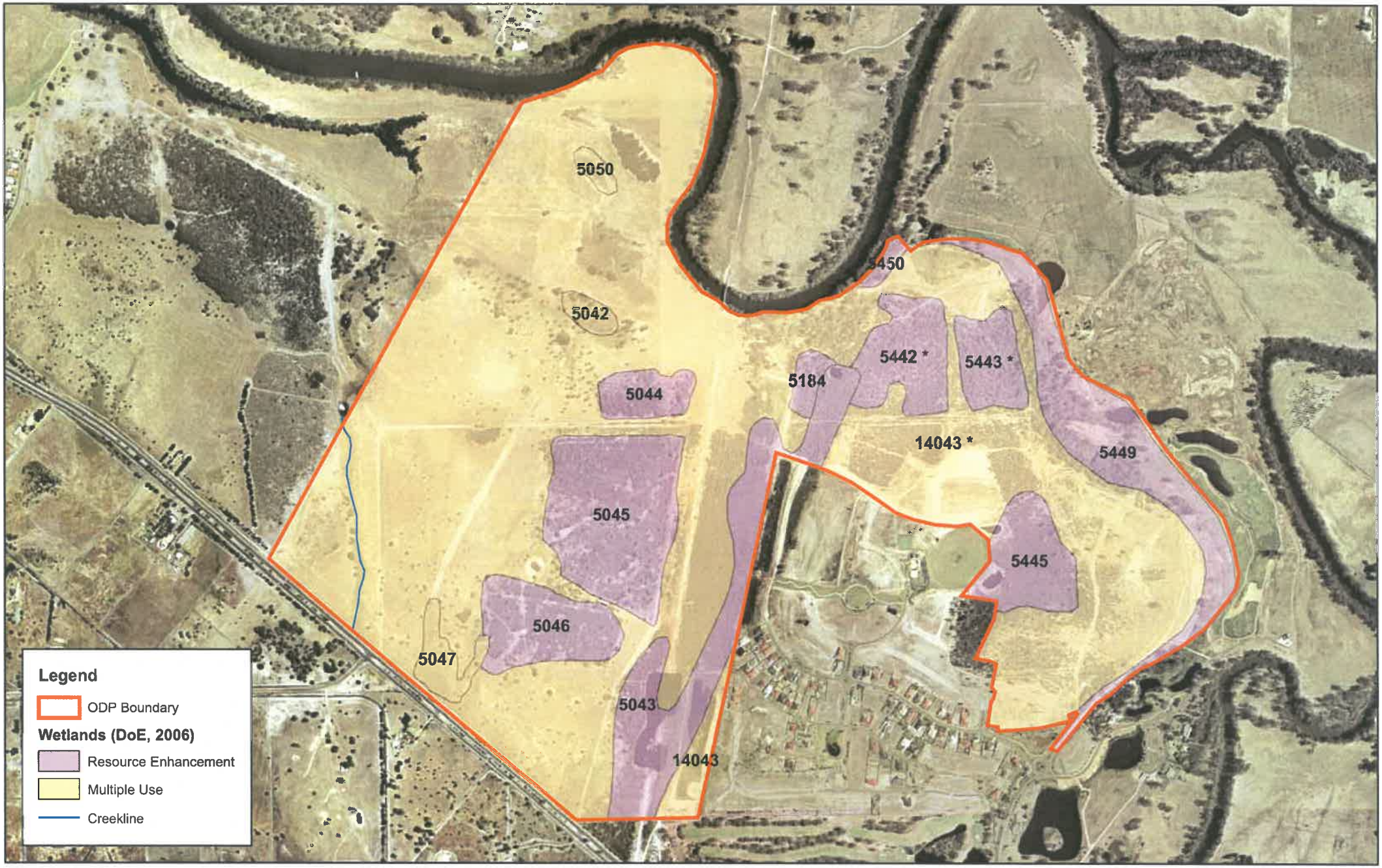
Murray River Estate Wetland Assessment

Vegetation Condition (Keighery et al. 1994)

MURRAY RIVERSIDE PTY LTD

Figure 6

Sept 2006



* Wetland status questioned.
The vegetation community of these areas is FCT 21a, which is not a wetland vegetation community.

300 150 0 300 Meters

1:12,500

ecoscape

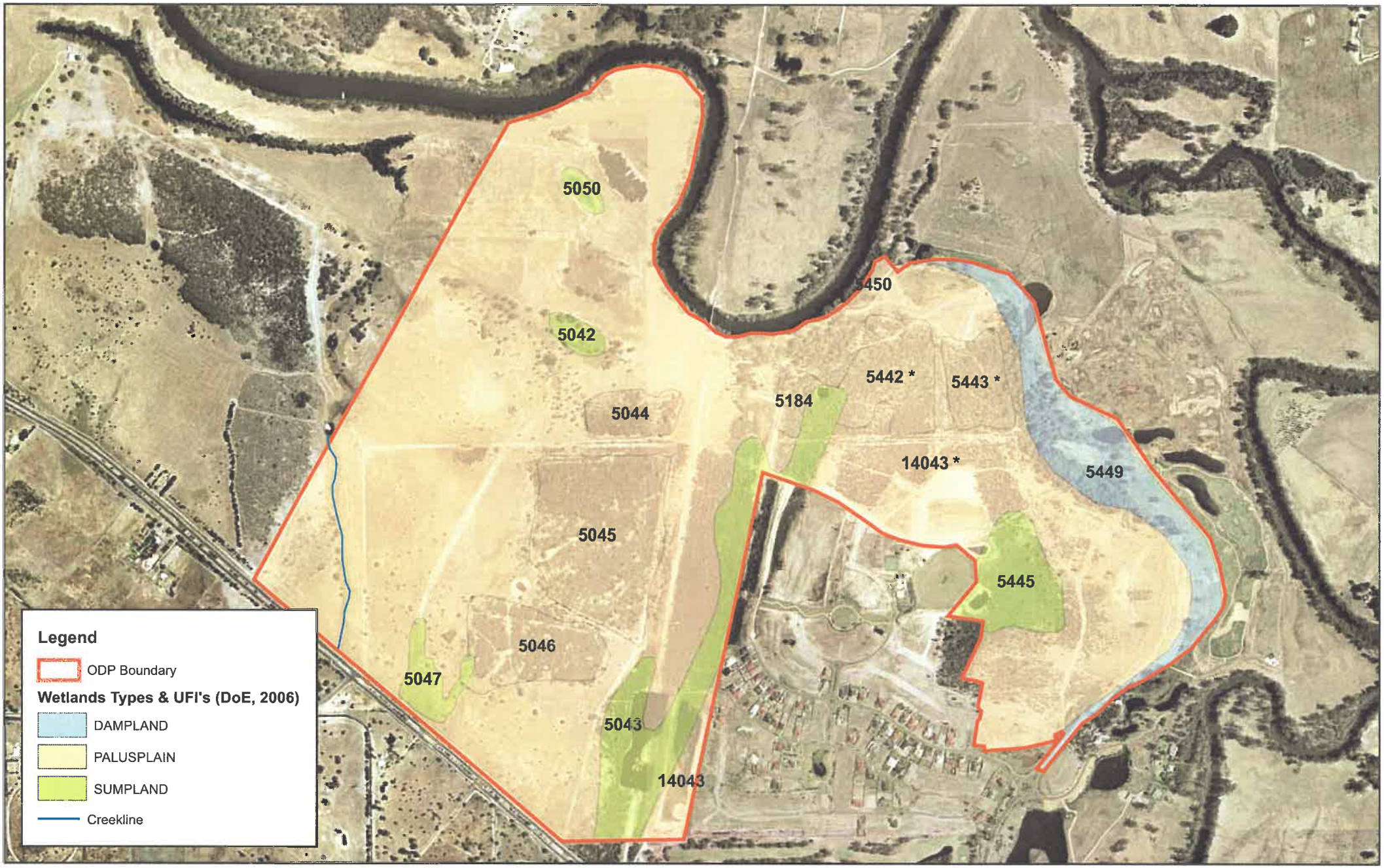
Murray River Estate Wetland Assessment

Proposed Wetland Management Categories (Ecoscape, 2005)

MURRAY RIVERSIDE PTY LTD

Figure 7

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Country Estate ODP

Study Area and Wetland Types

MURRAY RIVERSIDE PTY LTD

Figure 1

Sept 2006

ecoscape

Murray River Estate Wetland Assessment

Current Wetland Management Categories (adapted from Hill et al. 1996)

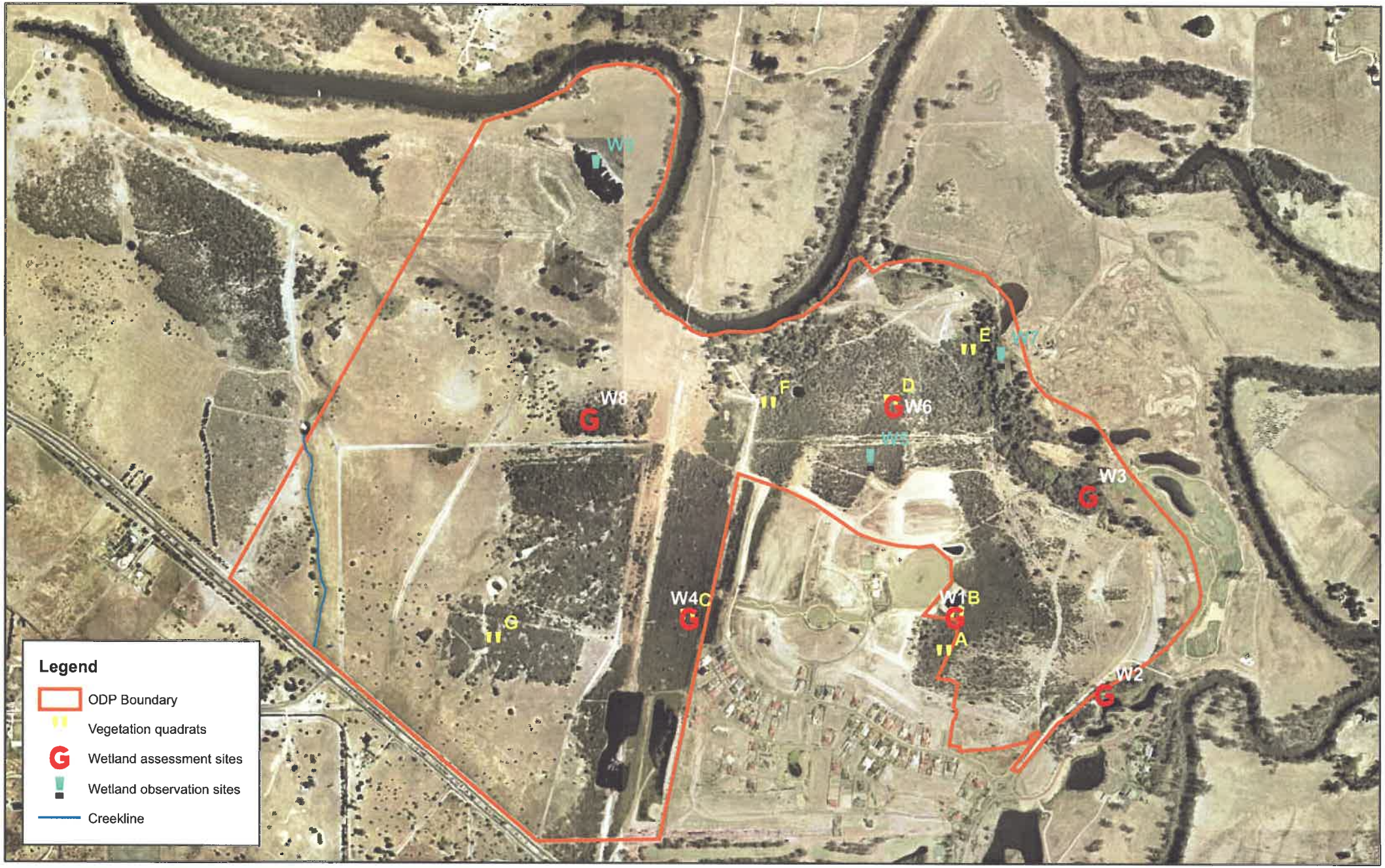
300 150 0 300 Meters

1:12,500

MURRAY RIVERSIDE PTY LTD

Figure 2

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Estate Wetland Assessment

Vegetation Quadrats and Wetland Assessment Sites

MURRAY RIVERSIDE PTY LTD

Figure 3

Sept 2006

ecoscape

300 150 0 300 Meters

1:12,500

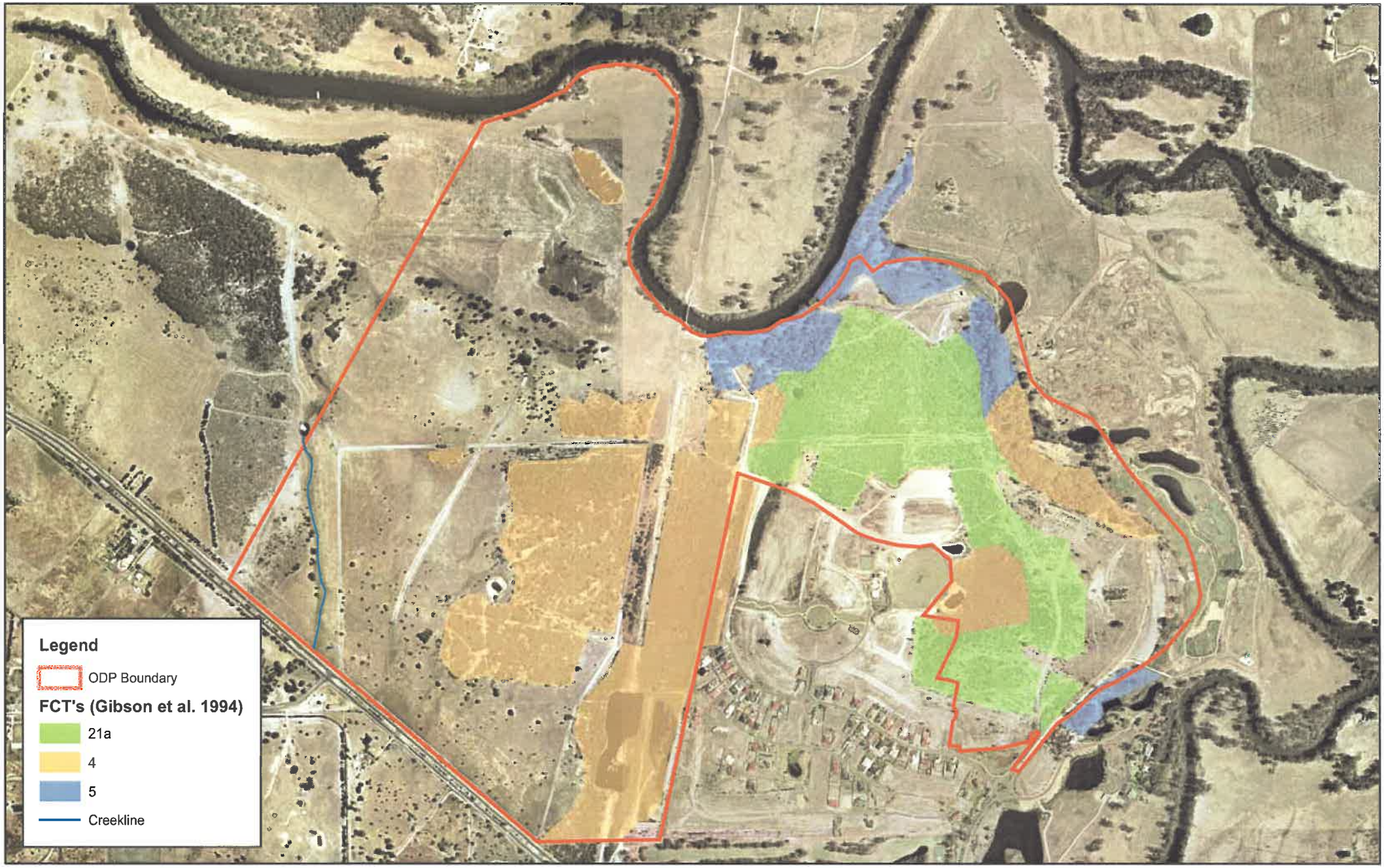
Murray River Estate Wetland Assessment

Vegetation Mapping Units

MURRAY RIVERSIDE PTY LTD

Figure 4

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

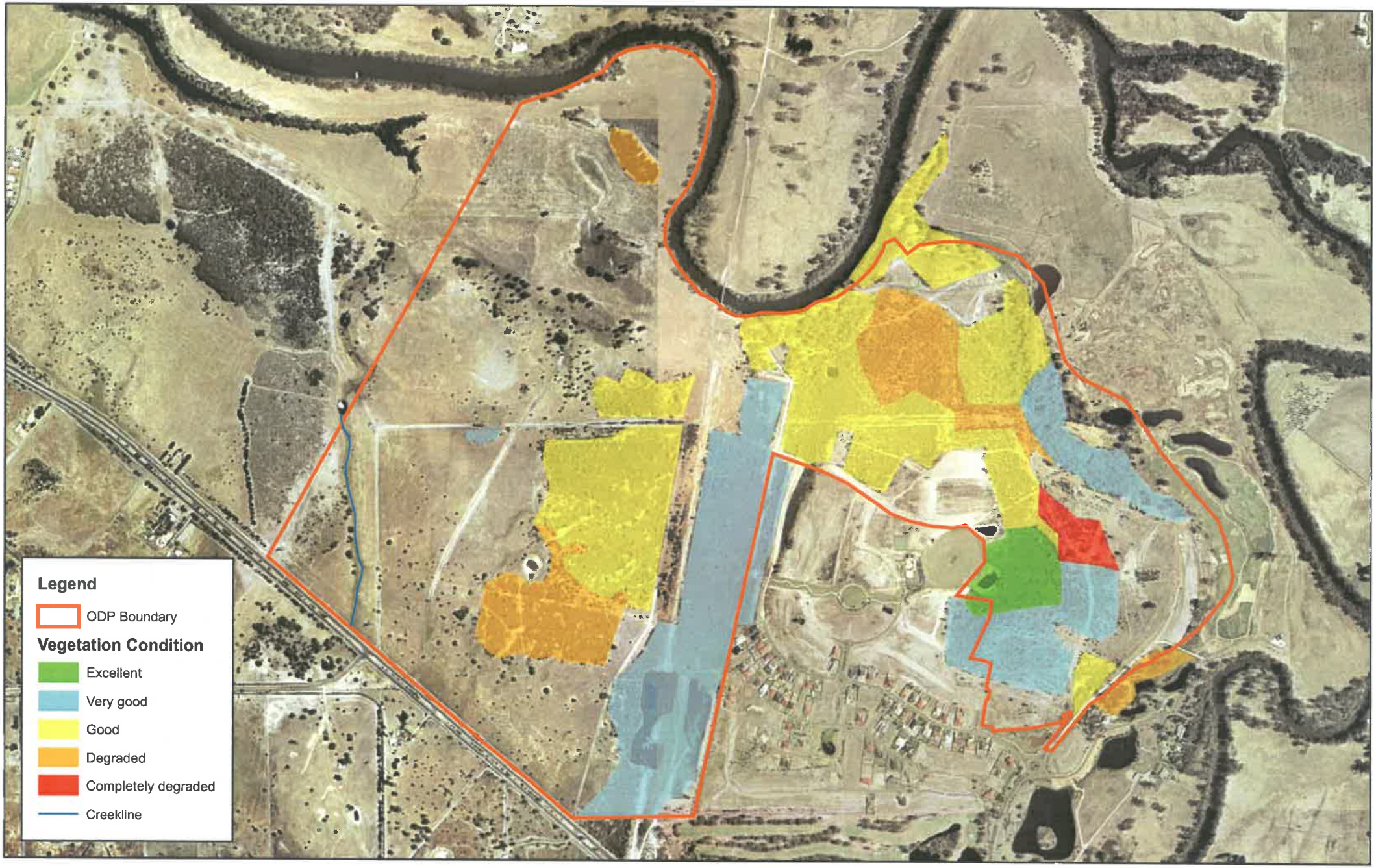
Murray River Estate Wetland Assessment

Floristic Community Types

MURRAY RIVERSIDE PTY LTD

Figure 5

Sept 2006



ecoscape

300 150 0 300 Meters

1:12,500

Murray River Estate Wetland Assessment

Vegetation Condition (Keighery et al. 1994)

MURRAY RIVERSIDE PTY LTD

Figure 6

Sept 2006

* Wetland status questioned.
The vegetation community of these areas is FCT 21a, which is not a wetland vegetation community.

300 150 0 300 Meters

1:12,500

Murray River Estate Wetland Assessment

Proposed Wetland Management Categories (Ecoscape, 2005)

MURRAY RIVERSIDE PTY LTD

Figure 7

Sept 2006

APPENDIX 3
MRCE Groundwater Assessment
JDA Consulting Hydrologists

Murray Riverside Pty Ltd

Murray River Country Estate

Groundwater Investigation

September 2006

DISCLAIMER

This document is published in accordance with and subject to an agreement between JDA Consultant Hydrologists ("JDA") and the client for whom it has been prepared ("Client"), and is restricted to those issues that have been raised by the Client in its engagement of JDA. It has been prepared using the skill and care ordinarily exercised by Consultant Hydrologists in the preparation of such documents.

Any person or organisation that relies on or uses the document for purposes or reasons other than those agreed by JDA and the Client without first obtaining a prior written consent of JDA, does so entirely at their own risk and JDA denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this document for any purpose other than that agreed with the Client.

CONTENTS

APPENDICES

1.0 INTRODUCTION

Murray River Country Estate is a residential development bordering the Murray River approximately 3 km to the west of the rural town of Pinjarra and 14 km east of Mandurah. It occupies part Murray location 13 and Lot 331 and part Murray location 14, encompassing an area of approximately 433 ha. The development has occurred in a series of stages, of which, stages located on the southern portion of the eastern half of the project site have been completed. Development of the western portion of the property and areas south of the Murray River are to follow.

This report presents the results of a groundwater investigation completed at the Murray River Country Estate (Figure 1). This investigation was requested by Brian Robinson of Murray Riverside Pty Ltd and was undertaken in accordance with JDA Consultant Hydrologists proposal dated 09/09/05.

JDA Consultant Hydrologists' scope of work was to provide a description and understanding of the groundwater levels across the property by completing a,

- Review of water table data and peizometric head data
- Review of previous reports on groundwater by URS 2003 and Douglas and Partners 2005
- Review of lithology of monitor bores
- Plotting of water table contours on specific dates and AAMGL, AALGL (average annual maximum and lowest groundwater levels).
- Assessment of adequacy of spatial coverage of groundwater data; supervision of drilling new monitor bores.
- Calculate the effect of proposed lakes, drains and Murray River flood diversion channels on water table levels and significant wetlands.

2.0 BACKGROUND INFORMATION

2.1 Climate

Figure 2 shows rainfall data at Pinjarra since 1907 indicating a long term average of 935 mm/yr. Since 1975 there has been lower rainfall generally in the southwest of WA, and a corresponding annual rainfall at Pinjarra has been 90 mm less at 845 mm/yr.

Monitoring of ground water levels at Murray River Country Estate commenced in 1996 as annotated in Figure 2, and all annual rainfalls since then have been less than the long term average. It follows that groundwater levels are also generally lower than in previous decades. This drier climate is predicted to continue into the future according to latest research by CSIRO.

2.2 Topography

The topography of the site is relatively low lying and flat. It features two broad landforms; a low lying floodplain adjacent to the Murray River on the northern and eastern side of the landholding and a larger area of higher elevation over the remainder of the site.

The lower floodplain area ranges from 2m to 5m AHD with wetlands in the form of ox bow lakes (remnant river channels) and surface expressions of the groundwater occurring along the Rivers edge. The higher portion coincides with the Bassendean dune system and lies at an elevation of between 5m to 11m AHD with the highest peak in the south eastern corner of the landholding.

A reasonably pronounced sloping zone ranging between 3m to 5m AHD, separates the two basic landforms. Figure 3 details the topography of the site at 1m contours and Figure 4 in 0.25m contours.

2.3 Regional Geology & Hydrogeology

A majority of the surface geology at the site is comprised of two geomorphic elements which relate to the topography of the site. The low lying flood plain areas belong to the Guildford formation while the central raised portion of land belongs to the Bassendean Dune System. In addition, bordering the Murray River are alluvial deposits (Figure 1).

The Bassendean Sands form a surface cover over most of the site. This formation is comprised of sand generally1-3m thick that forms gently sloping ridges and valleys creating natural drainage lines towards the Murray River.

The Bassendean Sand overlies the Guildford Formation, which consists mainly of reddish brown loams and clayey sand. Near the river this formation forms the surface layer as the Bassendean Sand is absent. Jandakot Beds lie below the Guildford Formation, and consist of a mixture of silty clay, sand and gravel. The Jandakot Beds unconformably overlie the Leederville Formation (URS 2003).

Alluvial plains adjacent to the Murray River, contain terraced drainage areas that slope down to the river.

The property is underlain in vertical succession by the following groundwater formations:

- Superficial formation (approximately 0 to 32m depth)
- Leederville formation (approximately 32 to 150m depth) and
- Gage Sandstone and Cockleshell Gully Formation (below approximately 150m depth)

The superficial formations contain fresh (Bassendean Sand) to brackish (Guildford Formation) groundwater which discharges towards the Murray River. The water table is shallow, with a seasonal variation of up to 2m. For further groundwater details see section 4 Groundwater Levels.

Groundwater in the Leederville formation in the Ravenswood-Pinjarra area is generally fresh (approximately 500mg/L Total Dissolved Solids). Locally, the aquifer has a potentiometric head of about 4 to 6m AHD, so that the groundwater generally rises to within a few metres of the ground surface. The direction of groundwater flow in the Leederville formation is towards the west (URS 2003)

2.4 Drainage

The presence of the river terraces constrains runoff from entering the river in average rainfall years, but would be overtopped in flood events. As a result some of the site is poorly drained and remains inundated during winter and damp in places during summer. There are few natural drainage lines on the property since a majority of the rainfall soaks into the Bassendean sands and the sandy alluvial terraces on the floodplain.

A number of natural and man made soaks occur at the edge of the Bassendean Dune system which are fed by superficial groundwater flow throughout most of the year. The border between the two soil types is damp during a majority of the year. The low lying flood plain is largely impermeable and water drains into natural impermeable depressions and ox bow lakes. The western part of the Bassendean sands on the site also remain inundated during winter (LeProvost Dames and Moore 1998[a]).

The water table within the superficial aquifer is shallow, generally less than 2 m in winter and 3 m in summer. In some locations, especially on the western side of the site, groundwater levels reach natural surface.

Land to the west of the Western Power easement may become saturated at the surface as a result of poor drainage characteristics.

2.5 Wetlands

Owing to the drainage characteristics of the site, a number of wetland features are located within the landholding with extensive areas of sumpland on the higher areas of the site and an extensive area of dampland found between the Bassendean sands and the lower floodplain (LeProvost Dames and Moore 1998[b])

A large proportion of the total wetland areas are classified into resource enhancement and multiple use categories. Some areas of conservation value wetlands have been identified, and one EPP wetland is located in the northern centre of the landholding. Figure 11 provides information on the wetlands that are to be retained in the revised Outline Development Plan (Ecoscape 2006)

2.6 Groundwater Monitoring and Production Bores

Two groundwater exploration programmes associated with the development have been completed. The shallow peizometers were installed in February/March 1995 in two stages and have been monitored since May and October 1995. In April/May 1997 two Leederville formation test production bores (PB1 and PB2) and multi-level peizometers (OBS1 and OBS2) were installed, test pumping occurred and aquifer parameters were derived (URS 2003). Bore locations are indicated on Figure 5.

The monitoring programme included the following

- Monthly monitoring of four on site Leederville Formation bores, 2 shallow and 2 deep (OBS1, OBS2)
- Monitoring of 21 on site superficial formation bores, including 6 in the Bassendean Sand and 15 in the Guildford Formation. RS1 to RS15 and RS19 to RS21)

Table 1 presents summary information on the Leederville formation production and observation bores, together with the shallow superficial formation monitoring bores RS1 to RS22.

Table 1: Bore Information

Bore	Coordinates (AMG)		Elevation (mAHD)		Cased Depth (m)	Screen Interval	Formation
	Northing	Easting	Ground	Collar			
Production Bores							
PB1	6392045	393297	6.2	6.5	147.4	93.1 – 147.1	Deep Leederville
PB2	6391239	393457	6.96	7.7	144.0	87.0 – 143.7	Deep Leederville
Monitoring Bores							
OBS1 shallow	6392152	393288	5.19	5.79	147	53.0 – 65.0	Shallow Leederville
OBS1 deep			5.19	6.34		93.0 – 147.0	Deep Leederville
OBS2 shallow	6391311	393502	7.08	8.01	146	48.0 – 60.0	Shallow Leederville
OBS2 deep						86.0 – 146.0	Deep Leederville
RS1	6392382	392192	3.74	4.57	5.7	2.7 – 5.7	Guildford
RS2	6392288	392367	4.12	4.99	6.1	3.1 – 6.1	Guildford
RS3	6392555	392976	1.94	2.82	6.0	3.5 – 6.0	Guildford
RS4	6392459	393564	5.65	6.52	9.5	6.5 – 9.5	Guildford
RS5	6392353	393979	6.08	6.88	6.0	4.5 – 6.0	Guildford
RS6	6392031	393091	8.81	9.63	7.0	3.0 – 7.0	Bassendean Sand
RS7	6391955	391877	7.03	7.84	5.5	1.5 – 5.5	Guildford
RS8	6391807	392153	7.53	8.32	5.5	1.5 – 5.5	Guildford
RS9	6391344	391682	7.22	7.99	6.1	2.1 – 6.1	Guildford
RS10	6391393	392444	7.58	8.43	6.0	2.0 – 6.0	Guildford
RS11	6391357	392819	8.54	9.35	6.0	2.0 – 6.0	Guildford
RS12	6391555	393185	8.21	9.05	6.0	1.0 – 6.0	Guildford
RS13	6391620	393524	9.71	10.58	6.1	3.1 – 6.1	Guildford
RS14	6391609	393798	5.53	6.43	6.3	0.3 – 6.3	Guildford
RS15	6391000	393131	8.75	9.61	6.0	2.0 – 6.0	Bassendean Sand
RS16S	6392177	392027	5.43	6.09	6.1	3.1 – 6.1	Bassendean Sand
RS16D	6392178	392025	5.38	6.12	12.8	7.65 – 10.65	Guildford
RS17S	6392324	393084	7.14	7.82	8.0	5.0 – 8.0	Bassendean Sand
RS17D	6392323	393082	7.11	7.76	11.5	8.5 – 11.5	Guildford
RS18S	6392039	393210	8.88	9.63	6.5	3.5 – 6.5	Bassendean Sand
RS18D	6392039	393208	8.97	9.66	11.5	8.5 – 11.5	Guildford
RS19	6392129	393529	5.45	6.13	8.5	5.5 – 8.5	Guildford
RS20	6392629	393958	6.23	6.98	8.5	5.5 – 8.5	Guildford
RS21	6391041	393592	6.7	7.41	8.5	5.5 – 7.1	Guildford
RS22	6391087	392432	8.98	9.68	6.0	3.0 – 6.0	Bassendean Sand

Note: 1 Bores RS 11, RS 15 and RS 22 have been destroyed

Note:2 Ground & Collar elevations 9 m AHD) for Bores RS1-RS22 were interchanged erroneously in URS (2003). They have been switched in Table 1

2.7 Licensed Groundwater Abstraction

A groundwater licence exists for the site for groundwater abstraction for the purpose of irrigation. This groundwater licence was issued for the Lower Leederville aquifer.

The depth at which water is abstracted is significantly deeper than the superficial aquifer. It is therefore expected that the abstraction will have negligible effect on the superficial aquifer water levels. Monitoring performed agrees with this assessment (URS, 2003).

The Groundwater Licence is for 250,000kL/yr and the period 2001 to 2003 used only approximately half this volume for the early stages of development, including the watering of a 3 hole golf course.

No subsequent aquifer review reports have been produced, but JDA is preparing a proposal to bring the licence reporting up to date.

2.8 Water Management to Date

The original Water Management Proposal is described in the Nutrient and Irrigation Management Plan (NIMP) for Ravenswood Sanctuary Resort (URS 1998). The NIMP describes that the groundwater would be abstracted from the Leederville Formation to supplement the water level in the lakes which form along an old river channel of the Murray River roughly at the 100 yr flood level. Lake 1 at the southeast corner was to overflow progressively through to Lake 7 and flow to the Murray River via a dethridge wheel. There was proposed to be some recycling of this water prior to discharge to the Murray River. Bore water would therefore be lost to evaporation from the lakes and to evapo-transpiration on the irrigated areas. The Licence covers both these uses.

This water management process would tend to elevate the water table within the lake chain in summer months.

To our knowledge this proposed continuous flow of water through the chain of lakes with discharge to the Murray River has not occurred. Rather, the bore has been used to supplement Lake 1 for irrigation of the first stage of the golf course, comprising 3 holes.

3.0 PROPOSED DRAINAGE REGIME

The proposed drainage strategy for the revised Outline Development Plan is currently being modified to accommodate the changes in the development plan including the exclusion of the 44 hole golf course.

As the new ODP plans to retain areas of existing remnant vegetation and significant wetlands (Ecoscape 2006), a modified drainage strategy is needed to maintain wetland water levels as well as provide adequate drainage for urban development. A range of swales, constructed wetlands and sub surface drains will be used to manage groundwater and surface water at the site.

Final drainage designs for the following stages of development will be made after all environmental and hydrological investigations have been completed.

4.0 GROUNDWATER LEVELS

This chapter analyses the water levels measured in the superficial aquifer monitoring bores to deduce the Average Annual Maximum Groundwater Level (AAMGL) and Average Annual Lowest Groundwater Level (AALGL) contours (Figures 7 and 8)

The time series data of shallow water table bores, RS1 to RS22 are presented in Appendix A as time series plots.

To collect further information on groundwater levels, a survey was conducted of open waterbody levels in May 2006 through the lake system. This is used together with bore level data at that time to produce a contoured map of water table levels in May 2006 (Figure 9). Survey data is presented as Appendix B. Note that river level was at approximately 0 m AHD (+/-0.02m).

Figure 2 shows that rainfall in Pinjarra during 2005 was close to the 1975 onwards average of 845 mm/yr, therefore, assumptions and plotting of groundwater contours from 2005 will provide indicative pre development groundwater trends during winter. Groundwater levels and contours for Sept (winter) 2005 are shown in Figure 10.

Rather than performing a correction to a longer term monitoring bore located nearby, long term monitoring data collected within the landholding from March 1996 to May 2006 has been used directly to calculate AAMGL and AALGL. This information was then used to assess the feasibility of adopting a Controlled Groundwater Level (CGL). The CGL level is a level chosen between AAMGL and AALGL, and has been adopted to minimise impacts to the wetland systems that are to be retained in the revised ODP and to facilitate land development whilst minimising the importation of fill.

AAMGL at each bore has been calculated as the average of the highest recorded water level in each year of data 1996 – 2006 as indicated on the hydrographs in Appendix A. These values have been transferred onto Figure 7 and contoured. Similarly, the lowest recorded annual groundwater level in each of the bores has been averaged to provide AALGL and these values transferred to Figure 8. Table 2 below summarises the AAMGL and AALGL information.

Table 2: AAMGL and AALGL values.

Bore No.	Ground level (mAHD)	AAMGL (mAHD)	Depth to AAMGL from natural surface (m)	AALGL (mAHD)	Depth to AALGL from natural surface (m)
RS 1	3.74	3.11	0.63	1.40	2.34
RS 2	4.12	2.73	1.39	1.60	2.52
RS 3	1.94	1.08	0.86	-0.87	2.81
RS 4	5.65	1.51	4.14	0.53	5.12
RS 5	6.08	2.57	3.51	1.70	4.38
RS 6	8.81	6.83	1.98	5.93	2.88
RS 7	7.03	6.79	0.24	5.86	1.17
RS 8	7.53	7.07	0.46	5.92	1.61
RS 9	7.23	7.13	0.10	6.24	0.99
RS 10	7.58	7.46	0.12	6.34	1.12
RS 11	8.54	obsolete	obsolete	obsolete	obsolete
RS 12	8.21	8.01	0.2	7.02	1.19
RS 13	9.71	7.49	2.22	6.14	3.57
RS 14	5.53	5.37	0.16	4.05	1.48
RS 15	8.75	obsolete	obsolete	obsolete	obsolete
RS 16s	5.43	5.30	0.13	4.67	0.76
RS 16d	5.38	3.23	2.15	2.61	2.77
RS 17s	7.14	4.73	2.41	3.97	3.17
RS 17d	7.11	4.26	2.85	2.82	4.29
RS 18s	8.88	6.37	2.51	5.61	3.27
RS 18d	8.97	6.20	2.77	5.47	3.5
RS 19	5.45	1.89	3.56	0.67	4.78
RS 20	6.23	0.64	5.59	0.10	6.13
RS 21	6.7	1.21	5.49	0.17	6.53
RS 22	8.98	obsolete	obsolete	obsolete	obsolete

Note:

Red indicates bores located on the western side or within the Western Power easement

Black indicates bores located on the eastern side of the Western Power easement

From the monitoring completed during March 1996 and June 2006 the following conclusions can be made:

- Depth to groundwater is generally less on the western edge of the site than on the eastern side because the surface levels are generally higher on the eastern side (DP 2005).
- Groundwater depths on the western side were found to range from 0.1m (RS9) to 2.52m (RS2).
- Groundwater depths on the eastern side were found to range from 0.2m (RS12) to 6.53m (RS21).

As expected, the greatest variation in groundwater levels occurs near to the rivers edge with the western side experiencing a median rise between AALGL and AAMGL of 1.42m (median RS1 and RS2) and the eastern side a median increase between AALGL and AAMGL of 0.92m (median RS4, RS5, RS20 RS21). Bore RS3, located at the furthest end of the wetland/lake sequence, where water is discharged to the Murray River had the largest water table variation of 1.95m. The upper reaches on the eastern side experience a rise between AAMGL and AALGL of 1.22m and the western upper region, a rise of 0.93m.

Groundwater levels come within 1m of the natural surface in winter at bore locations RS1, RS3, RS7, RS9, RS10, RS12, RS14 and RS16s. Summer groundwater levels are less than 1m of the natural surface at bores RS9, RS16s.

Figure 8 shows 5 vertical transects through the property along the locations indicated in Figure 5. The natural surface elevation shown on these transects was taken from digital 0.25m topographical contour information (Dennis, Price and Miller 2006)

These transects show AAMGL approximately at natural surface in some areas, for example along transect B to E, corresponding with the existence of wetlands.

5.0 CONTROLLED GROUNDWATER LEVELS

To facilitate land development it is desirable to install subsoil drainage at a level below AAMGL within the zone of seasonal groundwater variation to minimise imported fill requirements. The average difference between AAMGL and AALGL is approximately 1m and therefore we consider a controlled groundwater level 0.5m below AAMGL is appropriate.

To mitigate any possible impacts from Acid Sulphate Soils, discussions with DoE (Stephen Wong *pers. comm.)* have indicated that installation of subsoil drainage within the zone of seasonal variation is acceptable in principle. There is no policy document on this but it is consistent with the soil profile being aerated annually between the summer and winter levels so that it is already oxidised therefore having negligible risk of additional acid generation.

It is important that the CGL does not impact adversely on significant wetlands on the site which are to be retained in the revised ODP. To maintain the natural hydrology in and around the wetlands and to minimise drawdown effects from drainage on wetland water levels, a 800m drainage buffer is recommended around the perimeter of all wetlands to be retained under the revised ODP (Figure 12).

6.0 REVISED ODP

Significant changes in the revised Murray River Country Estate ODP have been made which will minimise environmental effects. Improvements include;

- Golf courses rely heavily on applied fertilisers to maintain turf and landscaped gardens. The exclusion of the 40 hole golf course which was proposed to border the Murray River will result in a significant reduction in uncontrolled nutrients, particularly Nitrogen from entering the Murray River.

- The Nutrient Input Decision Support System (NiDSS) developed by JDA Consultant Hydrologists is a model which can be used to predict the amount of nutrients (nitrogen and phosphorus) entering an urban development and how various landuses and the use of urban water sensitive design systems can be used to reduce nutrient loss to the environment. Using NiDSS to predict the nutrient input of the existing and revised ODP, a 73% reduction in total nitrogen will be entering the revised ODP compared to the existing ODP. Table 3 below summarises the NiDSS results.

ODP	Nitrogen Input kg/yr	Phosphorus Input kg/yr
Existing ODP	12,245	2,333
Revised ODP	8,930	2110
Nutrient benefit of revised ODP	**3315**	**223**

Table 3: NiDSS modelling results.

This is mainly due to the fact that the golf course has been removed in the revised ODP and larger areas of native vegetation and wetlands are to be retained.

- The preservation of larger areas of remnant vegetation and the linking with surrounding remnant vegetation on nearby properties to create wildlife corridors. An additional 20 ha of native vegetation is to be retained around the wetlands located on the site (Ecoscape 2006).

- The preservation and enhancement of a greater number of significant wetlands with a recommended 100m buffer from urban stormwater drains which will minimise groundwater drawdown effects. Wetland water levels are not to be altered. An additional 29.4 ha of wetlands is to be retained under the revised ODP making the total area of wetlands on the site approximately 49.5 ha (Ecoscape 2006).

- The exclusion of a large number of created wetlands scattered throughout the urban precinct will result in less hydrological disruption and less landscaping requiring fertiliser and watering. Infiltration of rainfall will occur through large areas of POS and management of stormwater through sub soil drainage.

- Use of a constructed wetland treatment train on the eastern side which will filter nutrients and remove a majority of sediment before the overflow water enters the Murray River.

Overall the revised ODP offers a much improved option for development than the original ODP approved by the EPA in 1996. The environmental significance and sensitivity of the site has been recognised in the revised ODP and planning has occurred with these factors in mind.

7.0 REFERENCES

Douglas Partners (2005) Report on Strategic Acid Sulfate Soil Investigation. Outline Development Plan Murray River Country Estate, Pinjarra. WA. Prepared for Murray Riverside Pty Ltd.

Ecoscape Pty Ltd (2006). Murray River Country Estate ODP Report- Environmental. Ecoscape Western Australia.

JDA Consultant Hydrologists (2001) Nutrient input decision support system (NiDSS). JDA, Western Australia.

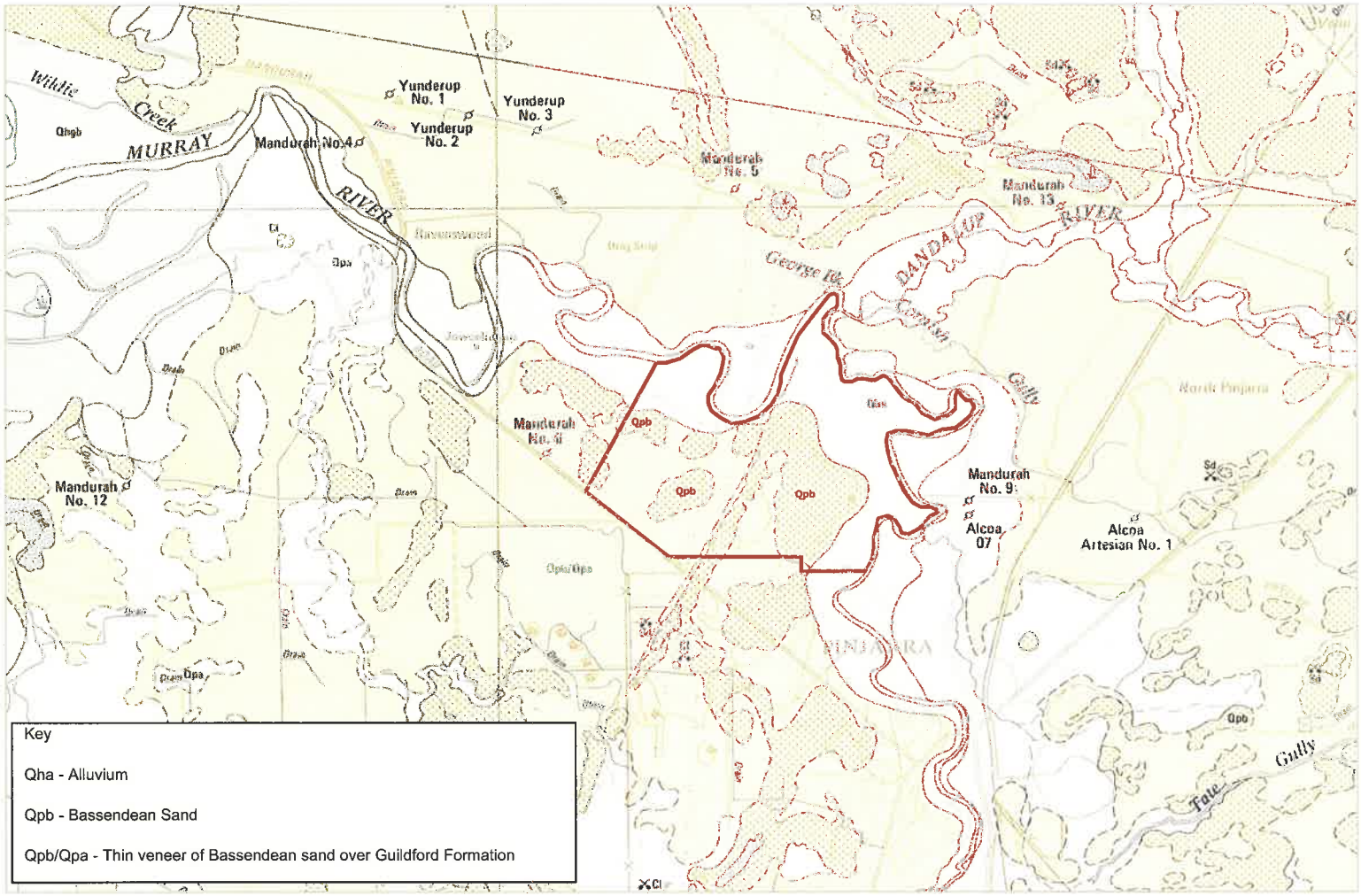
LeProvost Dames and Moore (1998[a]). Ravenswood Sanctuary Drainage Management Plan. Prepared for RRCM Pty Ltd.

LeProvost dames and Moore (1998[b]). Ravenswood sanctuary Wetland Management Plan. Prepared for RRCM Pty Ltd.

URS (1998) Ravenswood Sanctuary Estate Nutrient and Irrigation Management Plan, 15 May 1998 Report to RRCM Pty Ltd

URS (2003) Aquifer Review July 2001 to June 2003 Ravenswood Sanctuary. Report to RRCM Pty Ltd

Figures



Data Source: Geological Survey of Western Australia (1978)

JDA Consultant Hydrologists

Job No. J3723

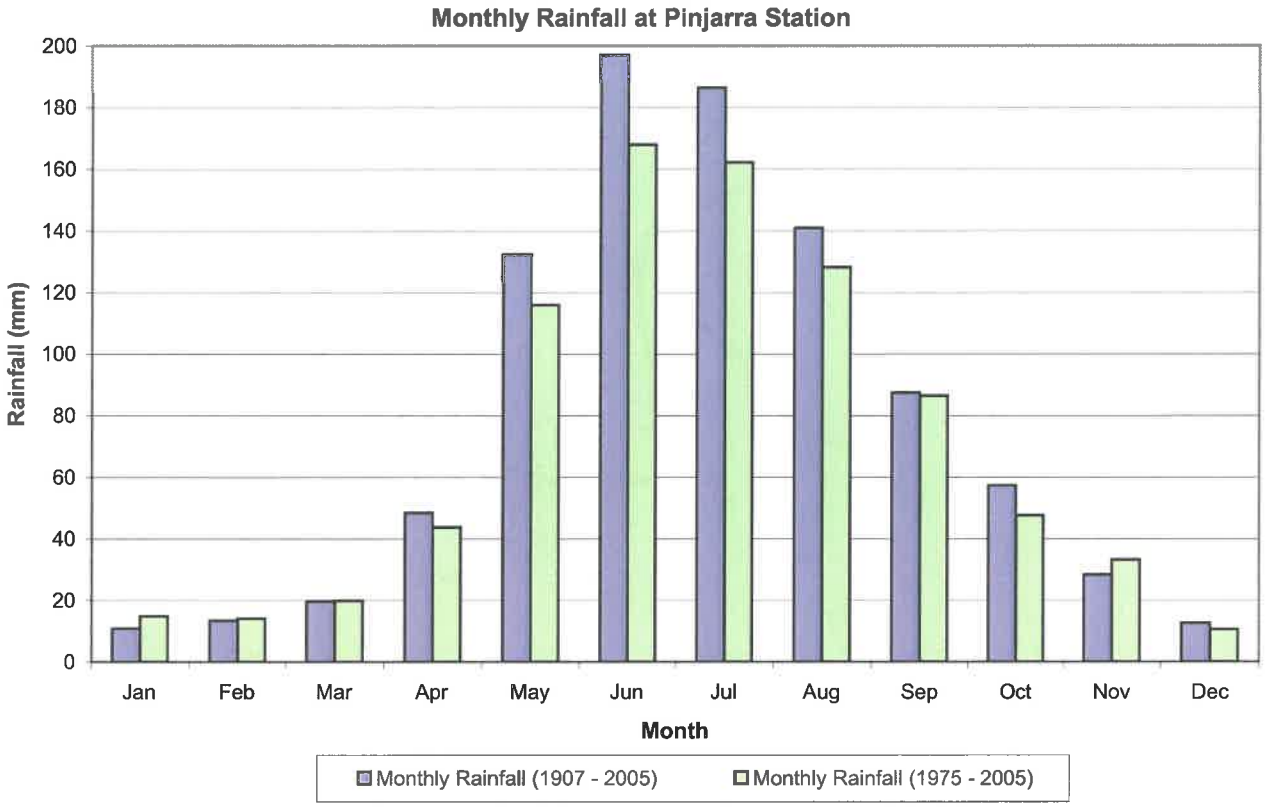
Scale 1:50,000

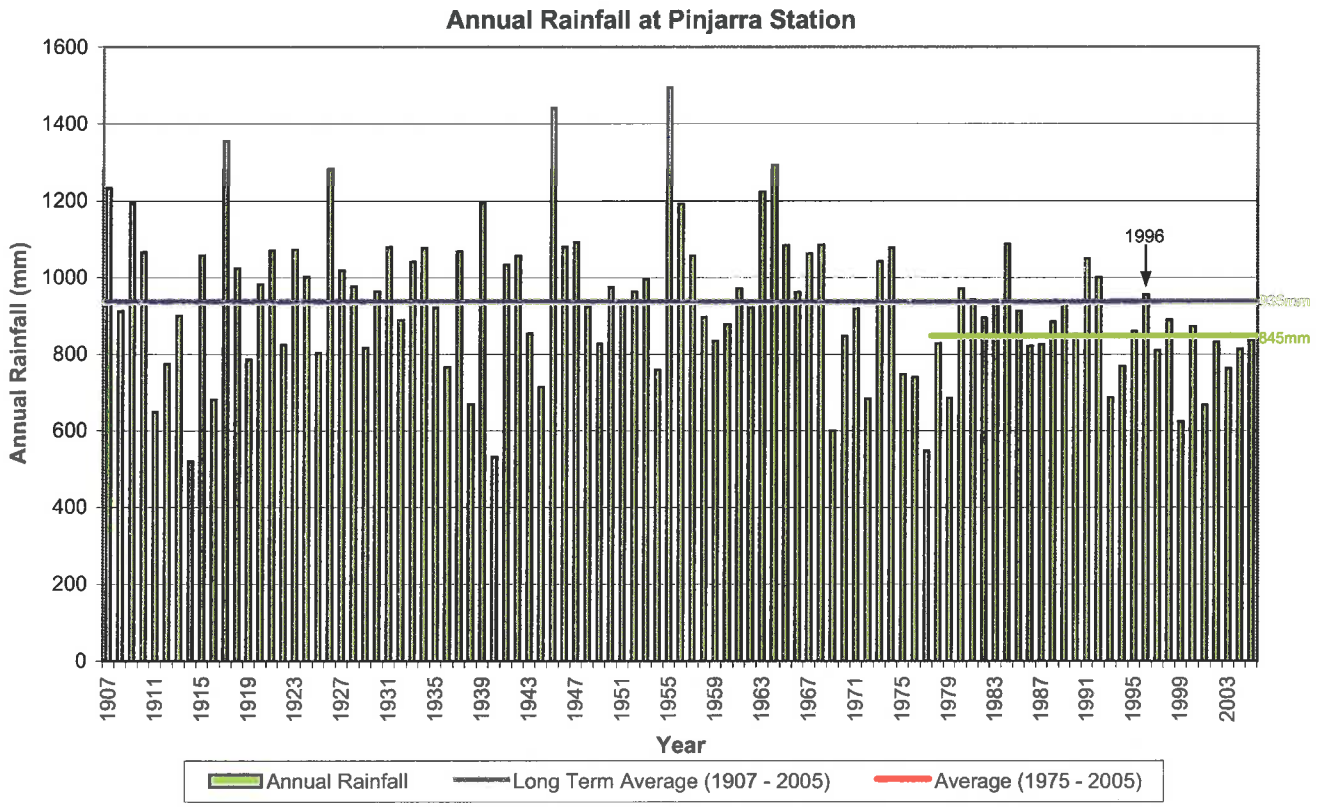
N

Murray Riverside Pty Ltd

Murray River Country Estate - Groundwater Investigation

Figure 1: Location and Surface Geology





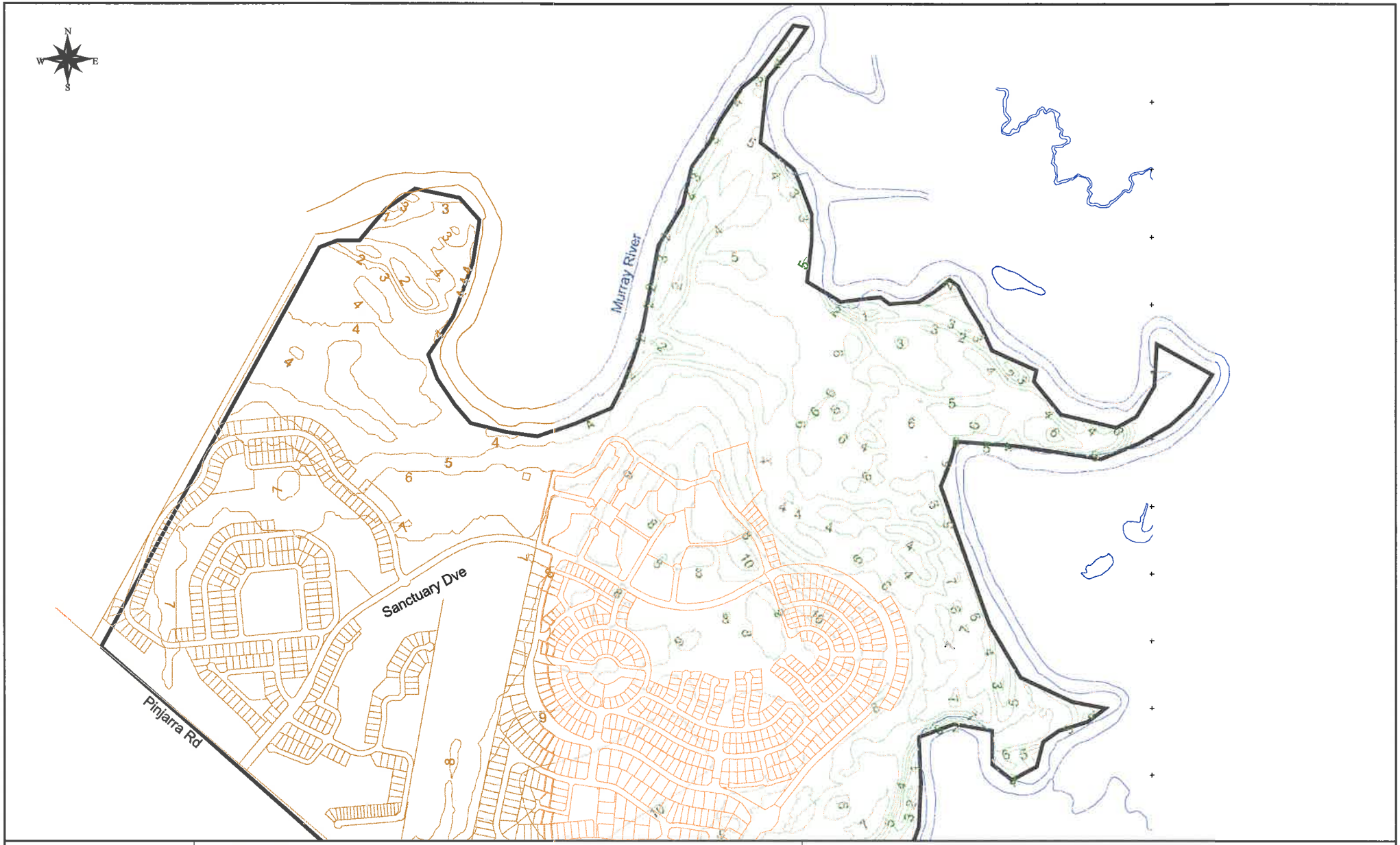
JDA Consultant Hydrologists

Job No. J3723

Murray Riverside Pty Ltd

Murray River Country Estate - Groundwater Investigation

Figure 2: Pinjarra Annual and Monthly Rainfall



JDA Consultant Hydrologists

Job No. J3723

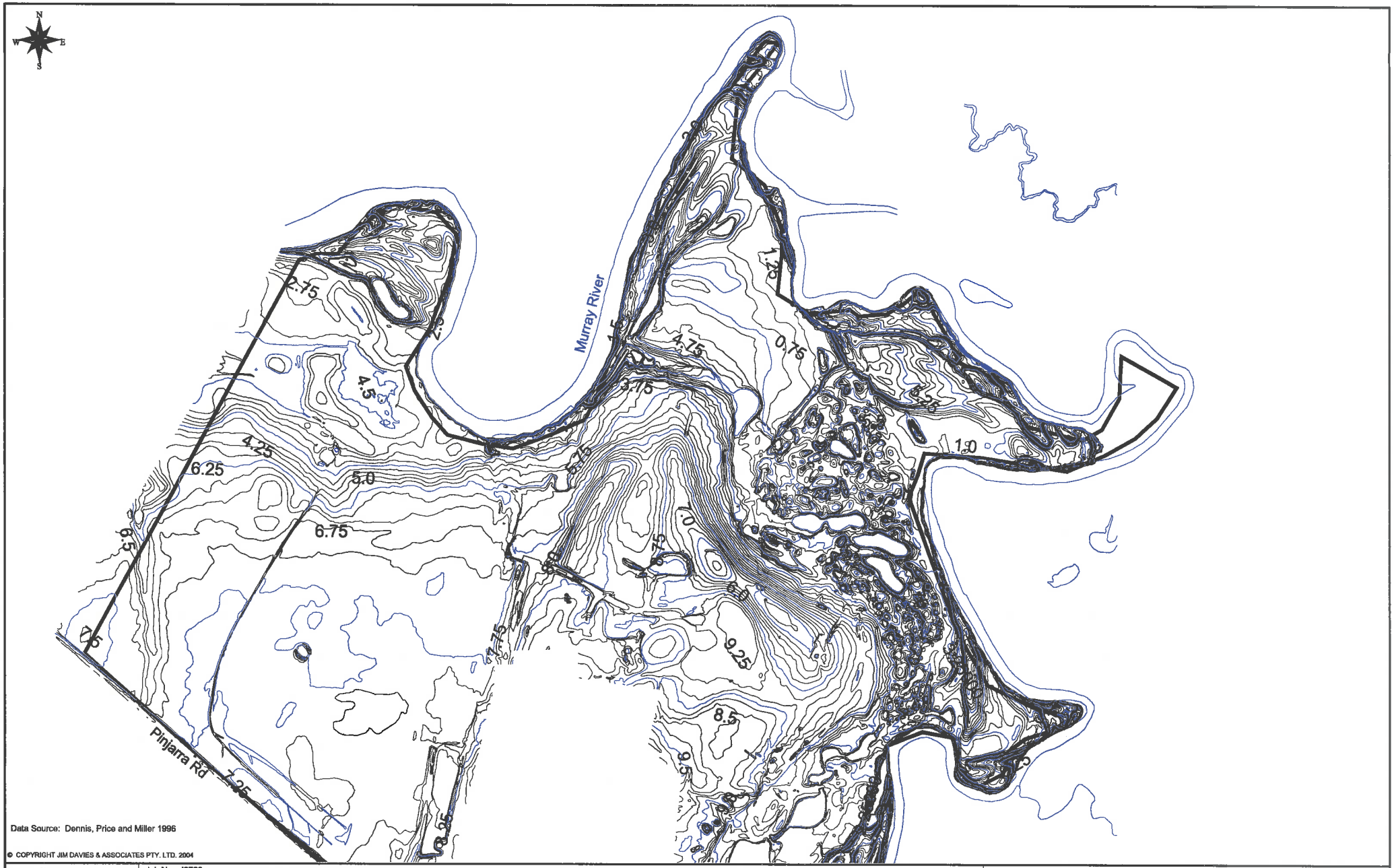
Scale 1:15000

0 200 400 600 800 Meters

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigations

Figure 3: Topography



Data Source: Dennis, Price and Miller 1996

JDA Consultant Hydrologists

Job No. J3723

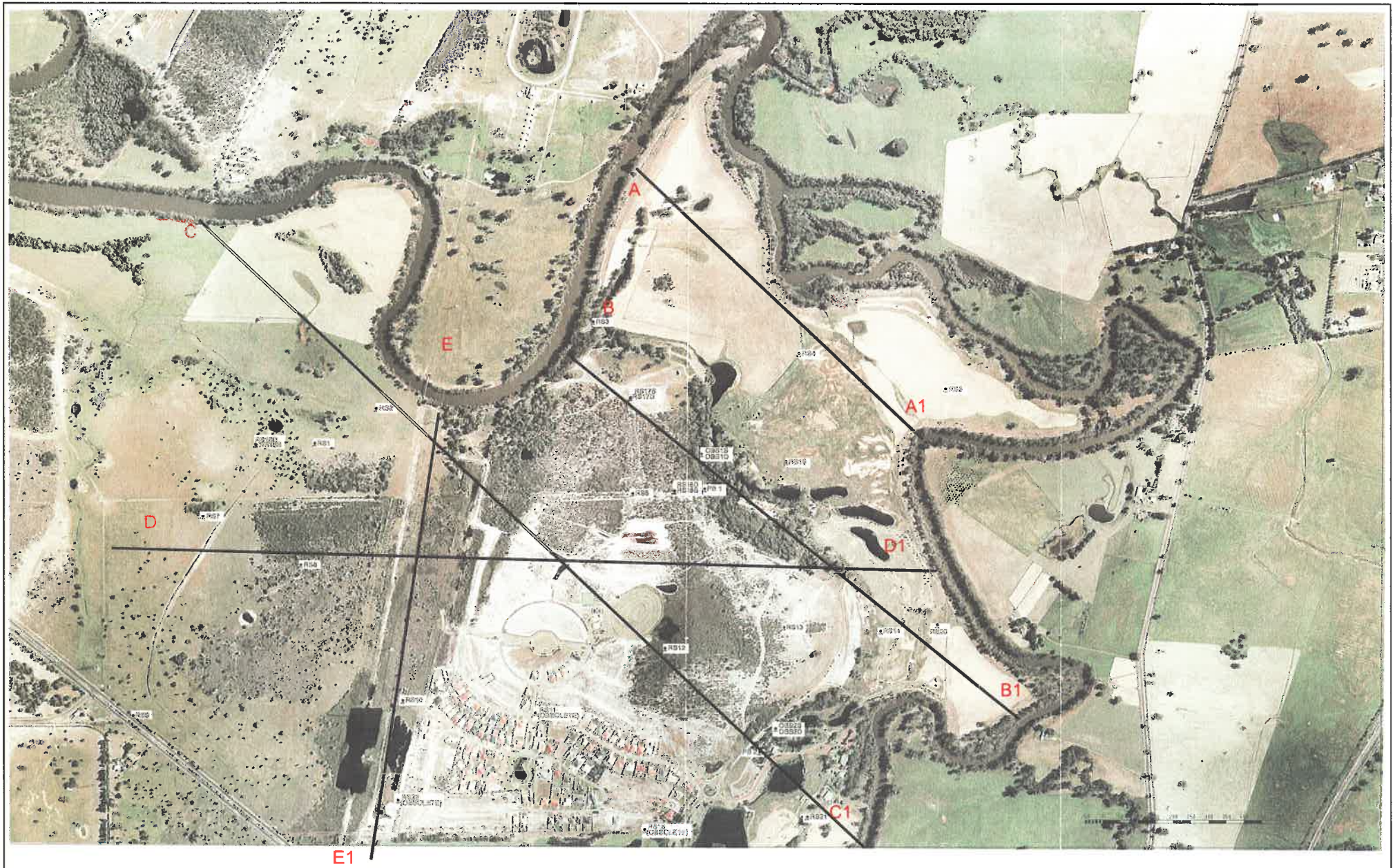
Scale 1:15,000

0 200 400 600 Meters

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigation

Figure 4: 0.25m Topgraphy



JDA Consultant Hydrologists

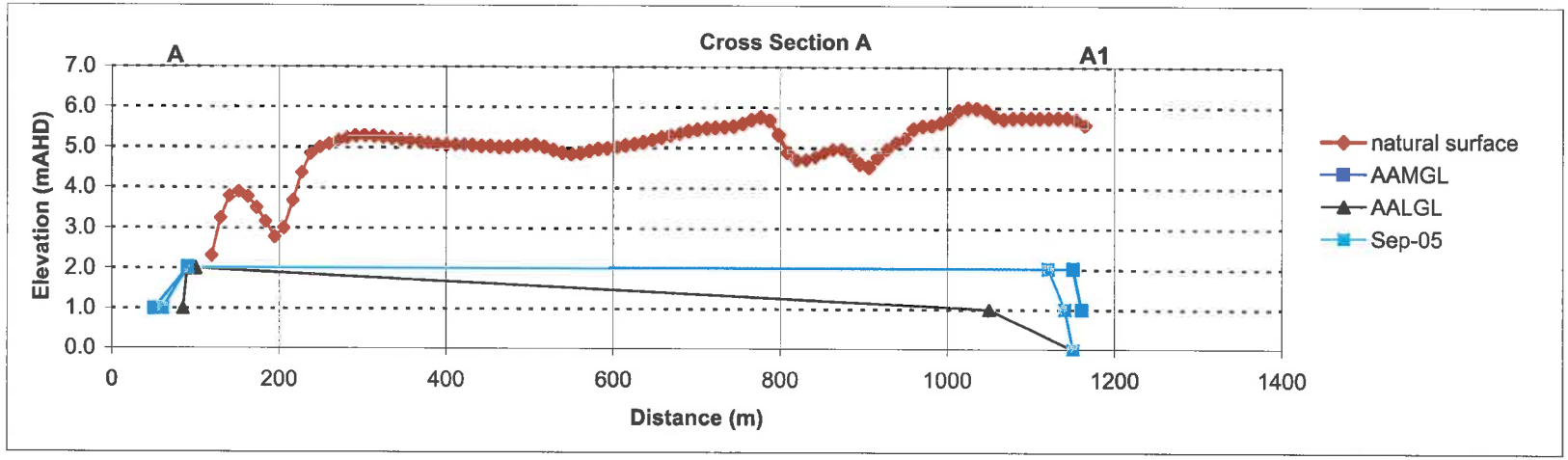
Job No. J3723

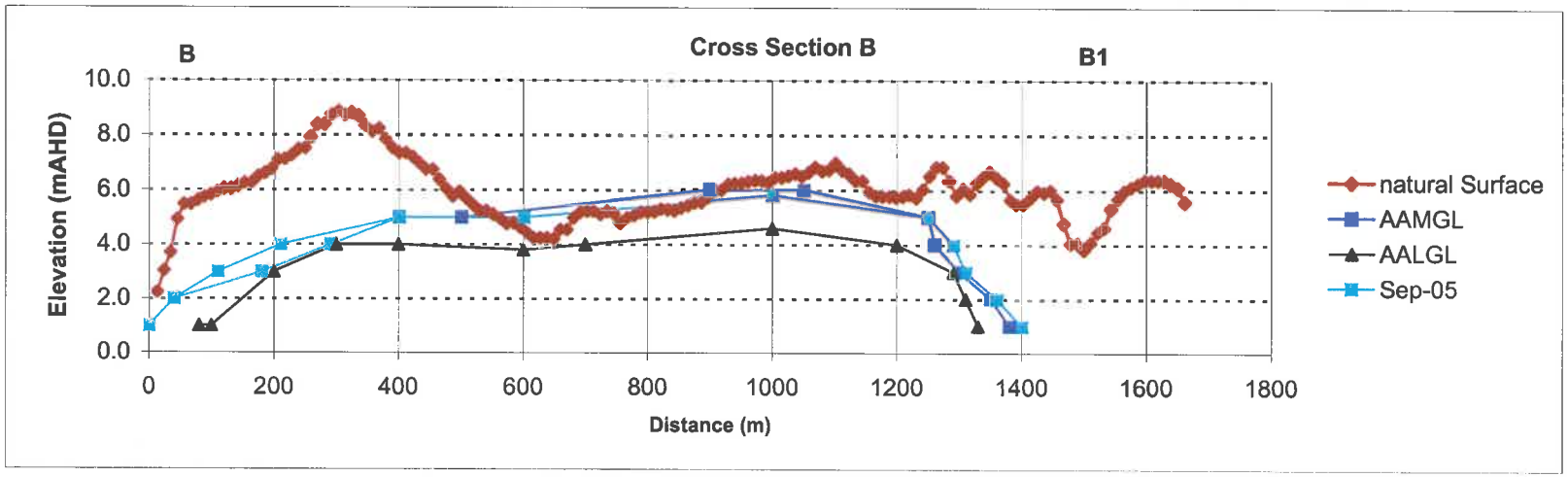
Scale 1 : 10,000

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Issues

Figure 5: Bore and Transect Locations





Data Source: Groundwater Monitoring March 1996 to May 2006

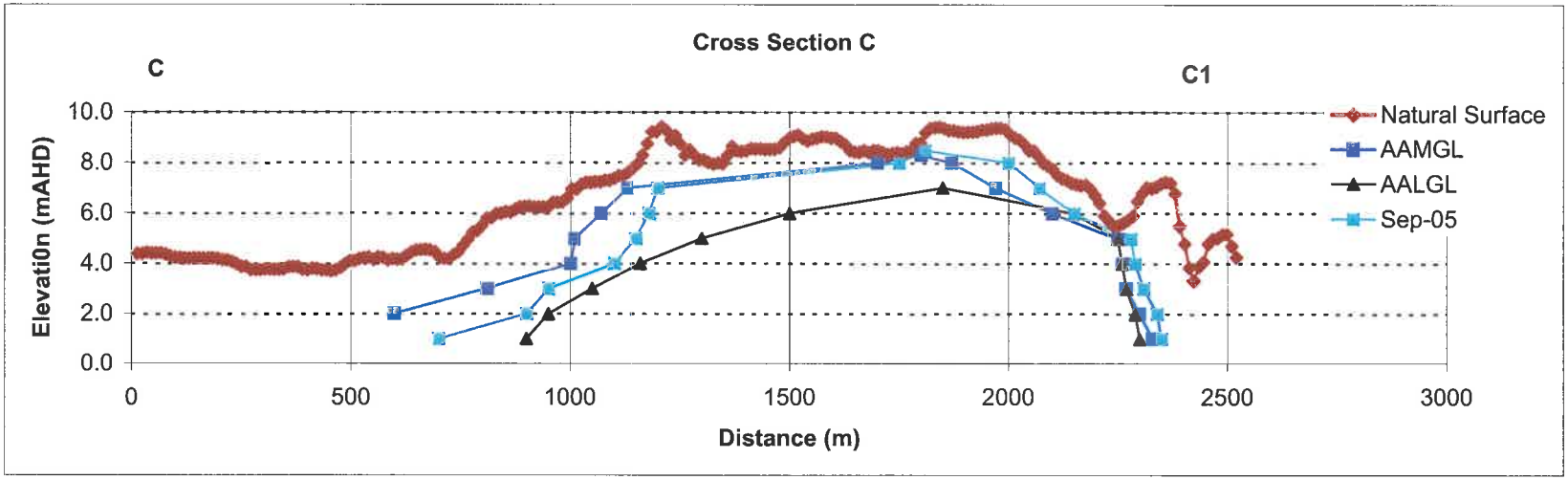
JDA Consultant Hydrologists

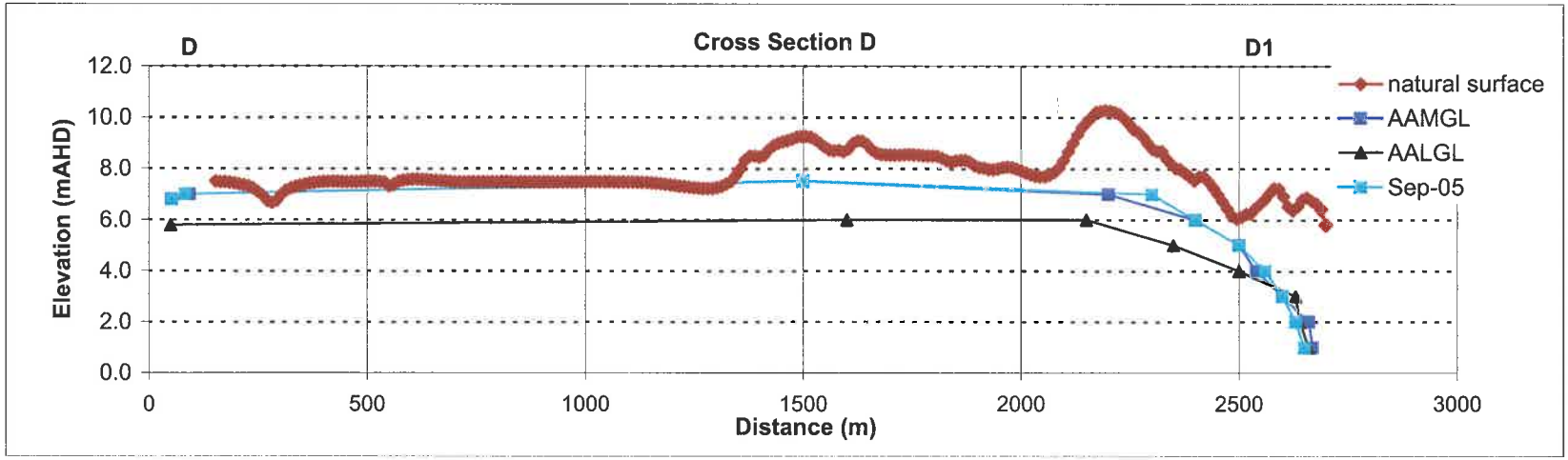
Job No. J3723

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigation

Figure 6 (a): Cross Sections A and B





Data Source: Groundwater Monitoring March 1996 to May 2006

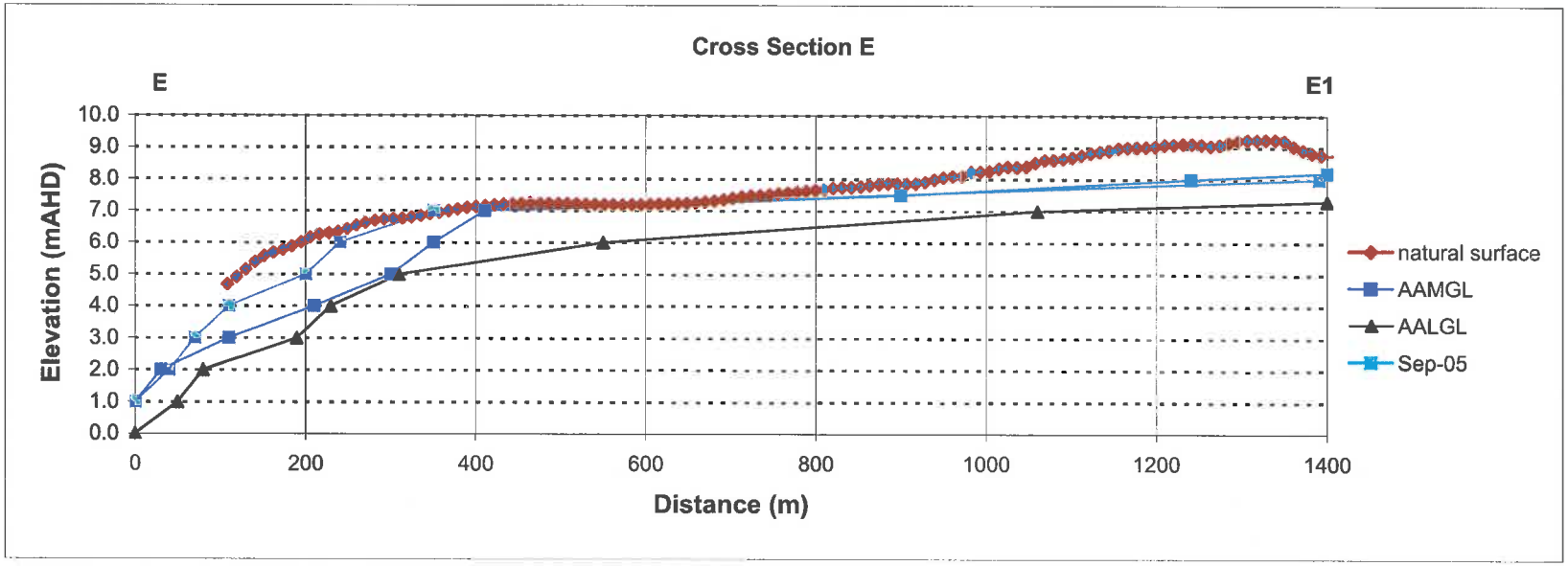
JDA Consultant Hydrologists

Job No. J3723

Murray Riverside Pty Ltd

. Murray River Country Estate Groundwater Investigation

Figure 6 (b): Cross Sections C and D



Data Source: Groundwater Monitoring March 1996 to May 2006

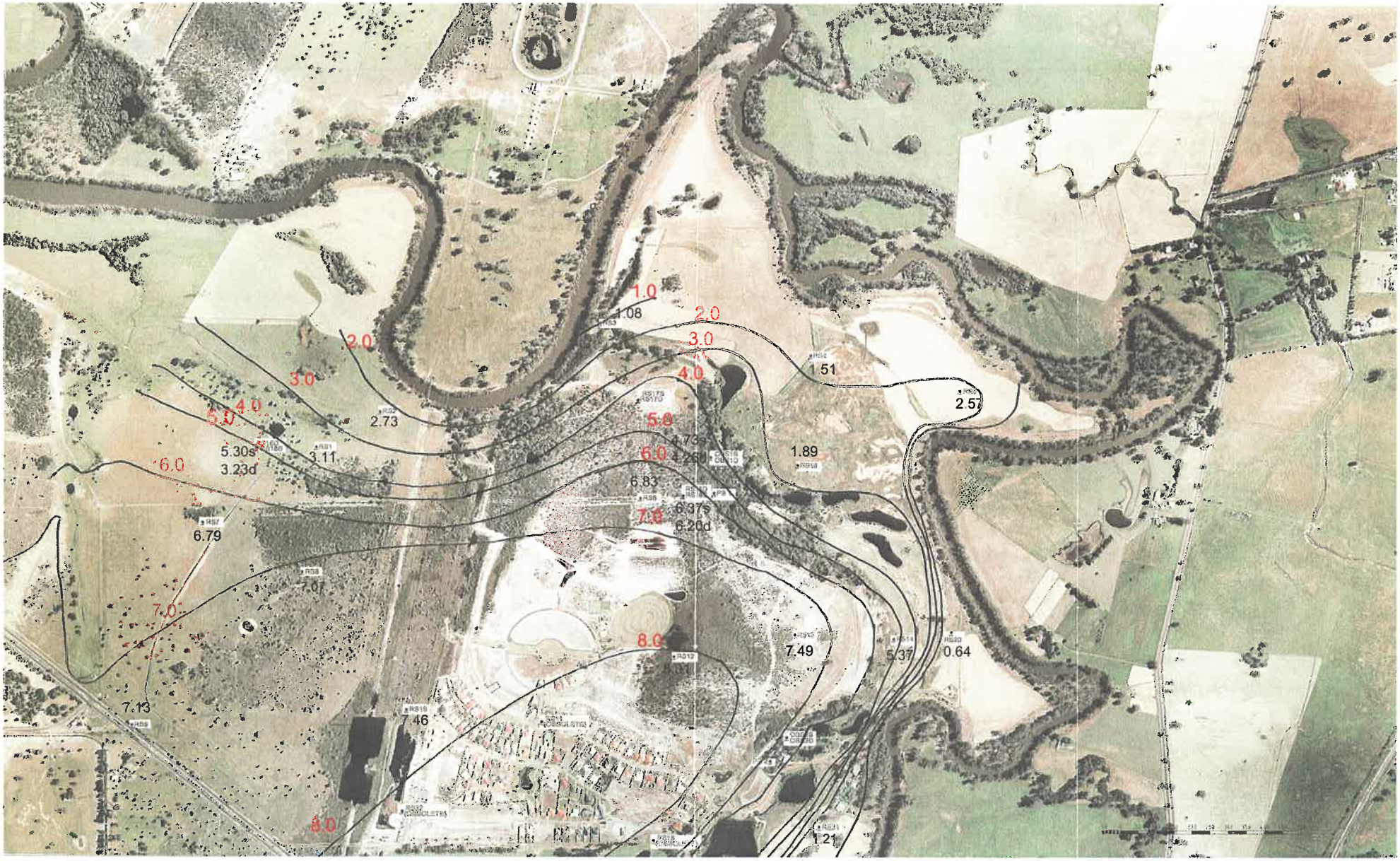
JDA Consultant Hydrologists

Job No. J3723

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigation

Figure 6 (c): Cross Sections E



Data Source: On Site Bore Monitoring March 1996 to June 2006

JDA Consultant Hydrologists

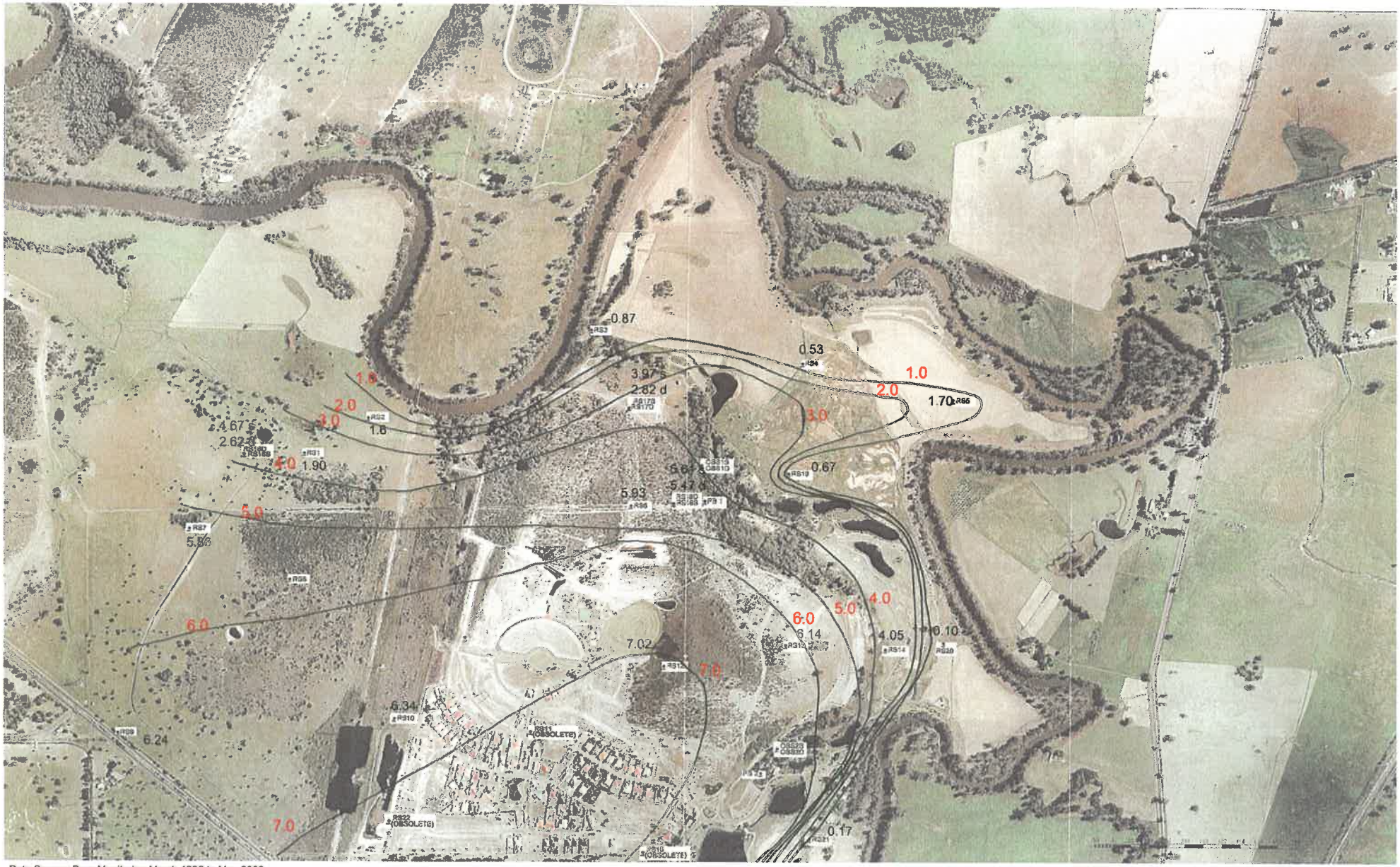
Job No. J3723

Scale 1 : 10,000

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigations

Figure 7:Average Annual Mamimum Groundwater Level AAMGL (mAHD)



Data Source: Bore Monitoring March 1996 to May 2006

JDA Consultant Hydrologists

Job No. J3723

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigations

Figure 8: Average Annual Lowest Groundwater Level (AALGL) mAHD

Data Source:On Site Bore Monitoring Data March 1996 to May 2006

JDA Consultant Hydrologists

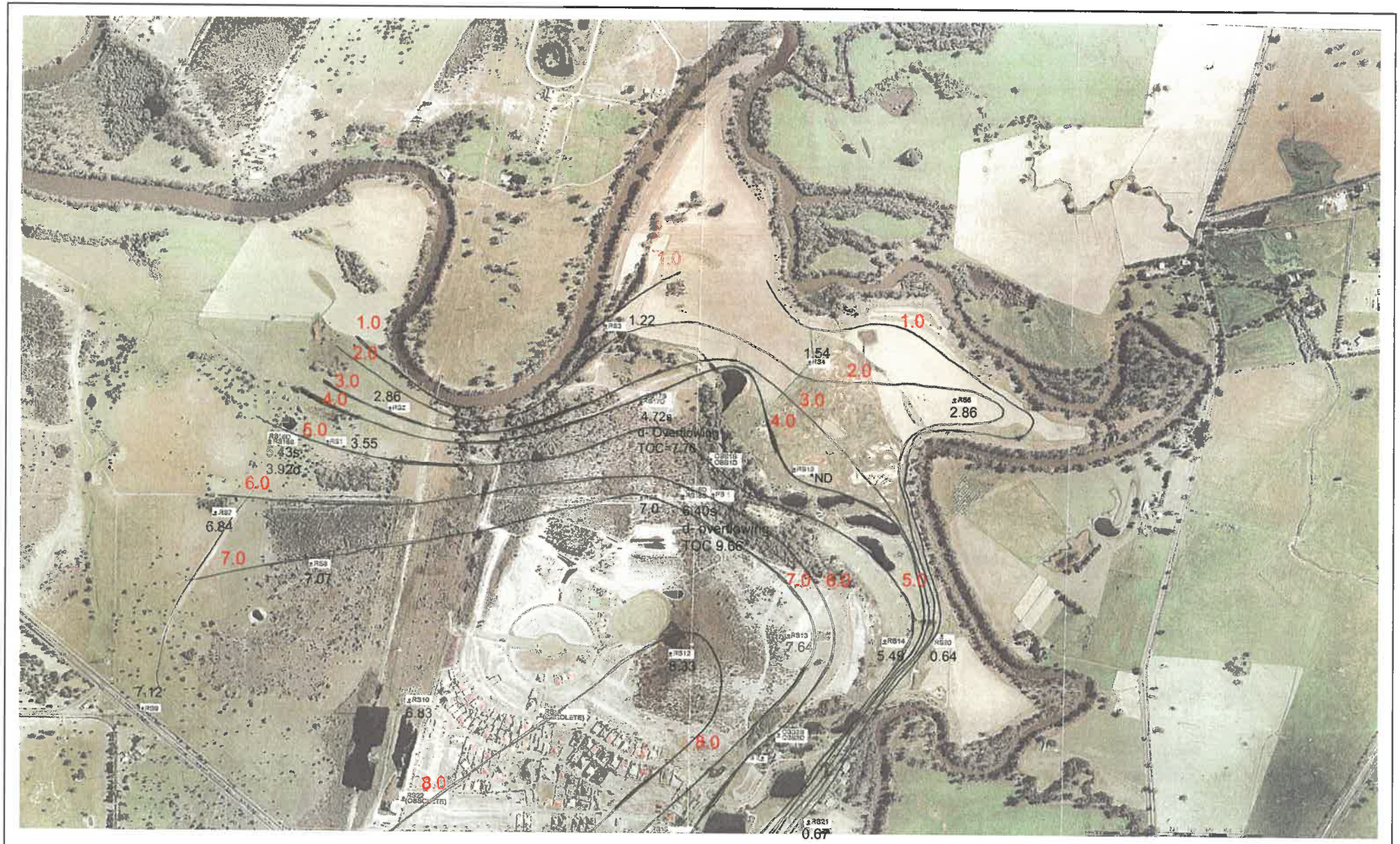
Job No. J3723

Scale 1 : 10,000

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigations

Figure 9: May 2006 Groundwater Contours and Lake Levels (mAHD)



Data Source:Bore Monitoring March 1996 to May 2006

JDA Consultant Hydrologists

Job No. J3723

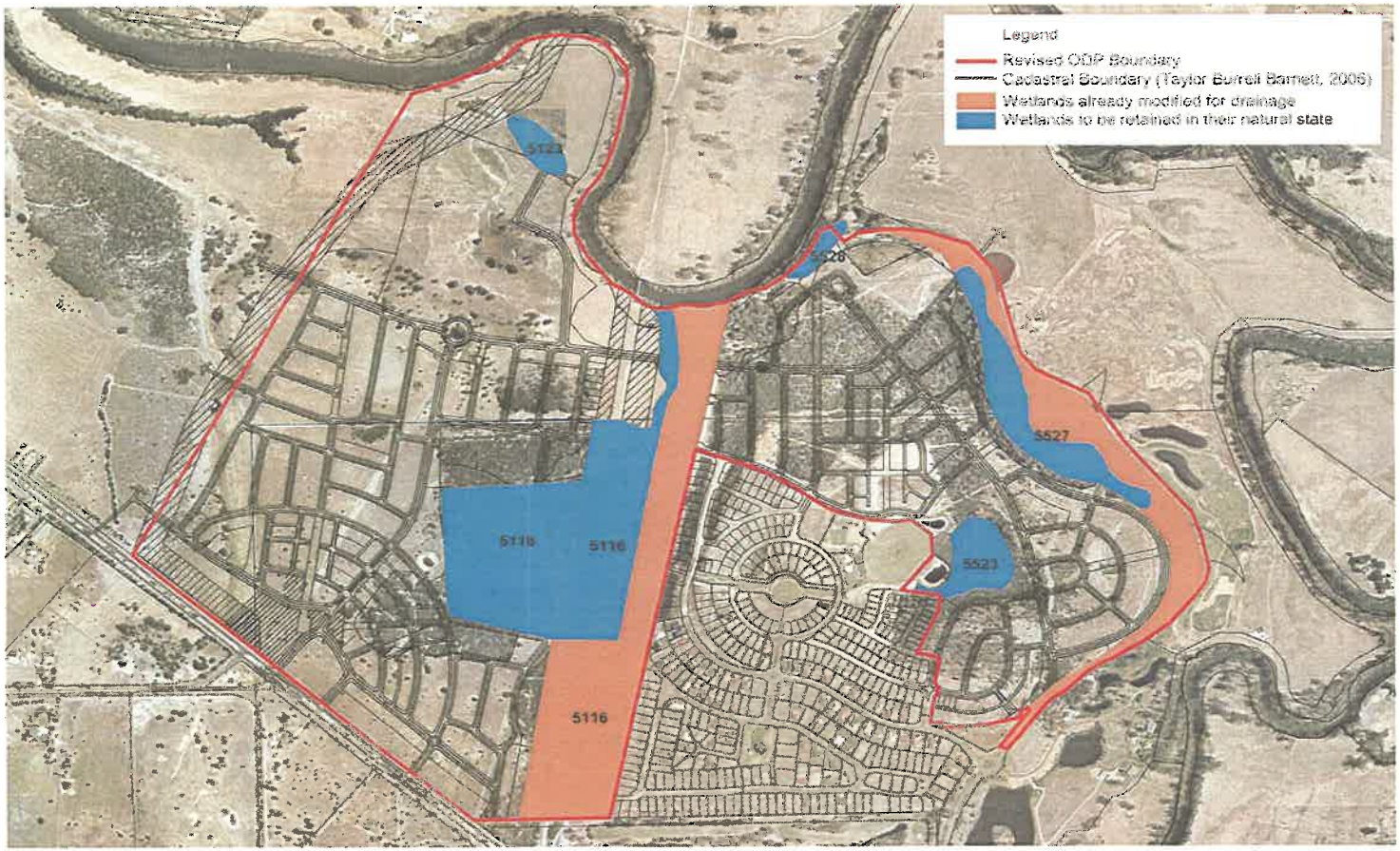
Scale 1 : 10,000

Note *ND= No Data

Murray Riverside Pty Ltd

Murray River Country Estate Groundwater Investigations

Figure 10: September 2005 Groundwater Levels (mAHD)



Ecoscape (Australia) Pty Ltd 1996

JDA Consultant Hydrologists

Job No. J3723
Scale: 1:12500

N

Murray Riverside Pty Ltd
Murray River Country Estate Groundwater Investigations

Figure 11: Wetlands to be Retained and Modified Under the Revised ODP

Data Source: Bore Monitoring Data 1996-2006 and Ecoscape 2006 Wetlands.

JDA Consultant Hydrologists

Job No. J3723

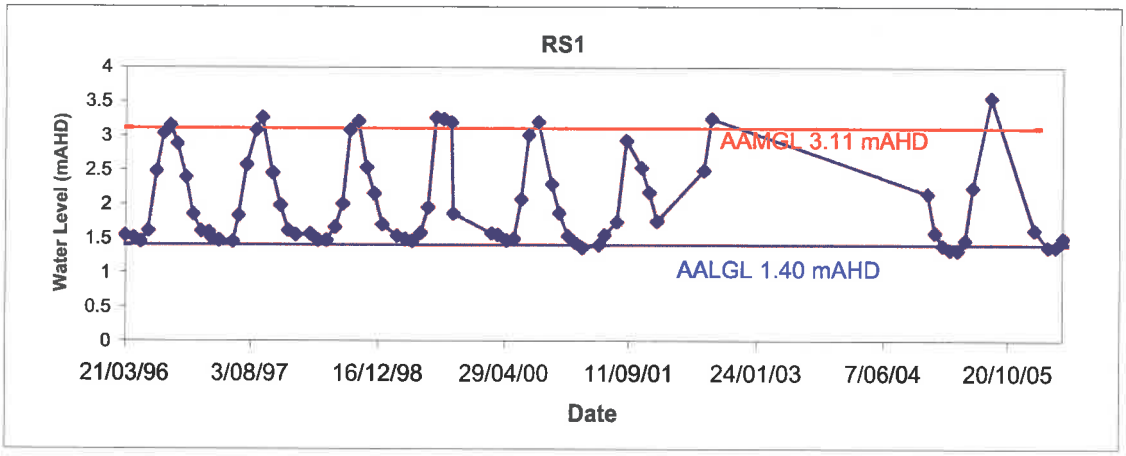
Scale 1 : 10,000

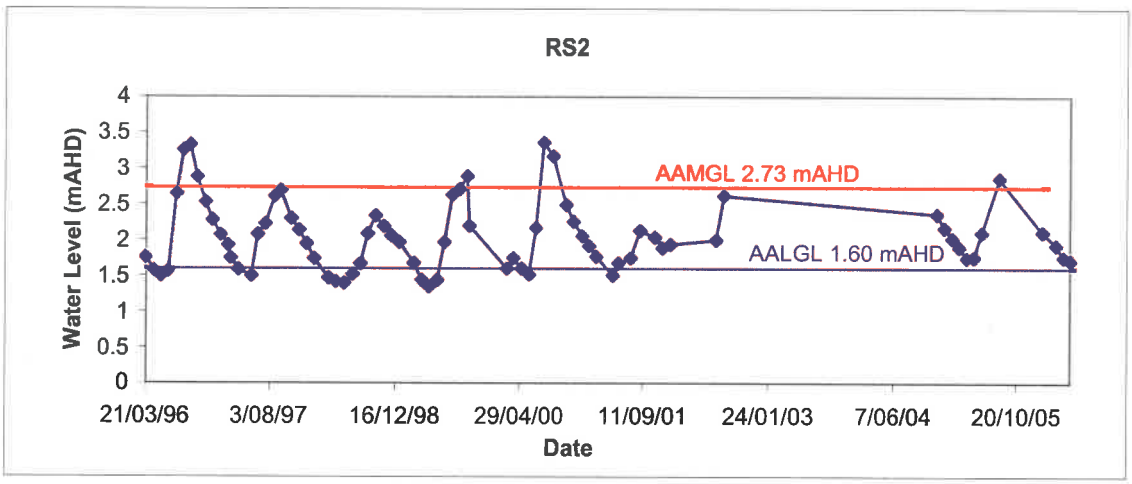
Murray Riverside Pty Ltd

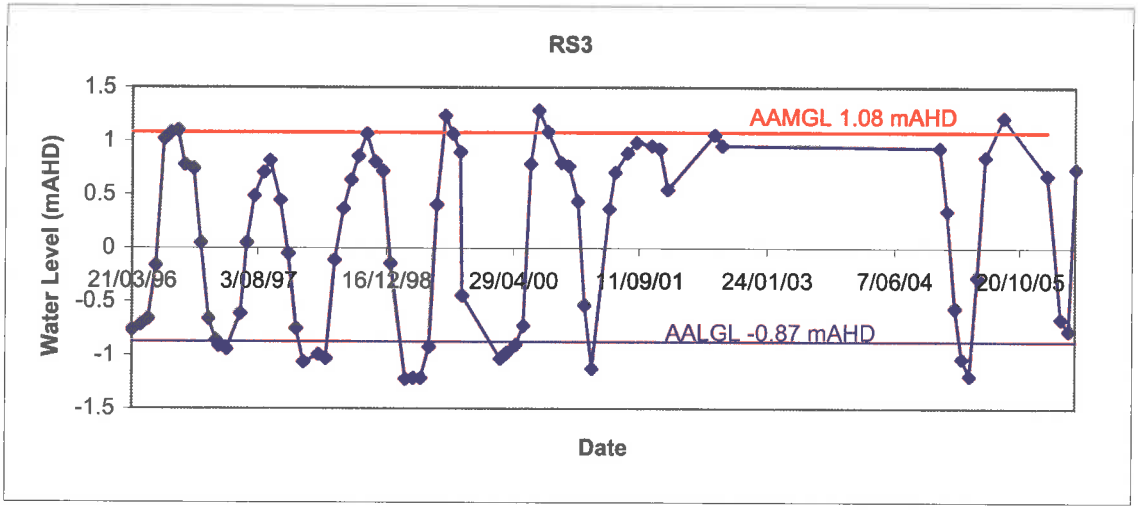
Murray River Country Estate Groundwater Investigation

Figure 12: Controlled Groundwater Level (CGL) with Wetlands Considered (mAHD)

APPENDIX A





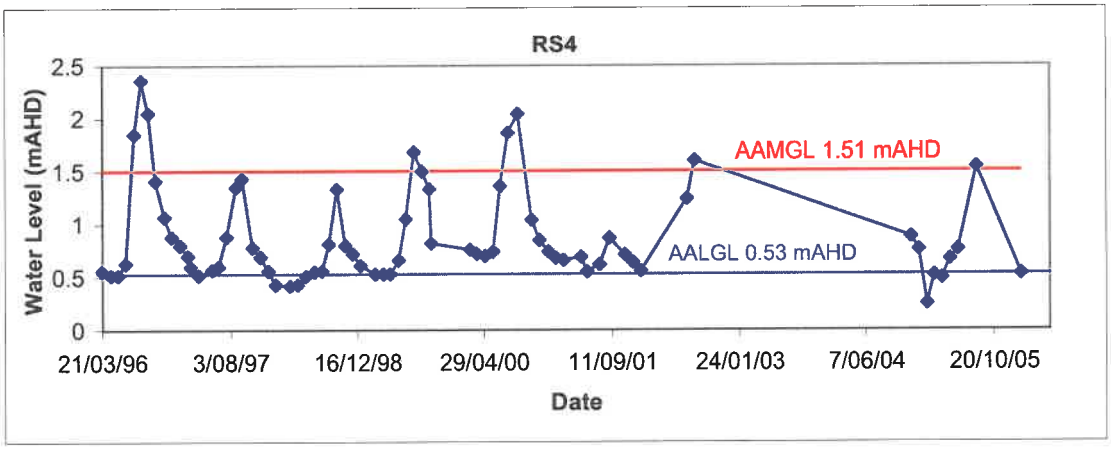


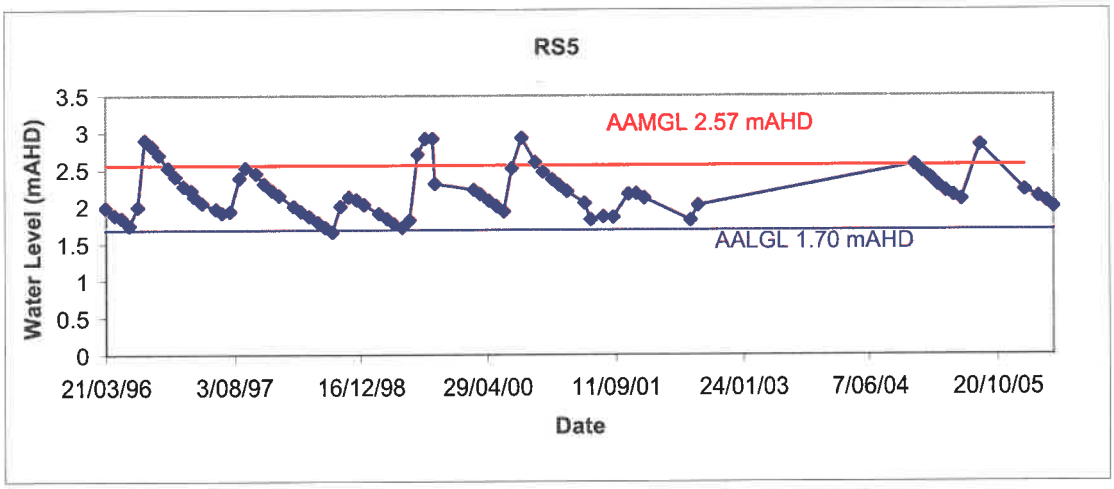
JDA Consultant Hydrologists

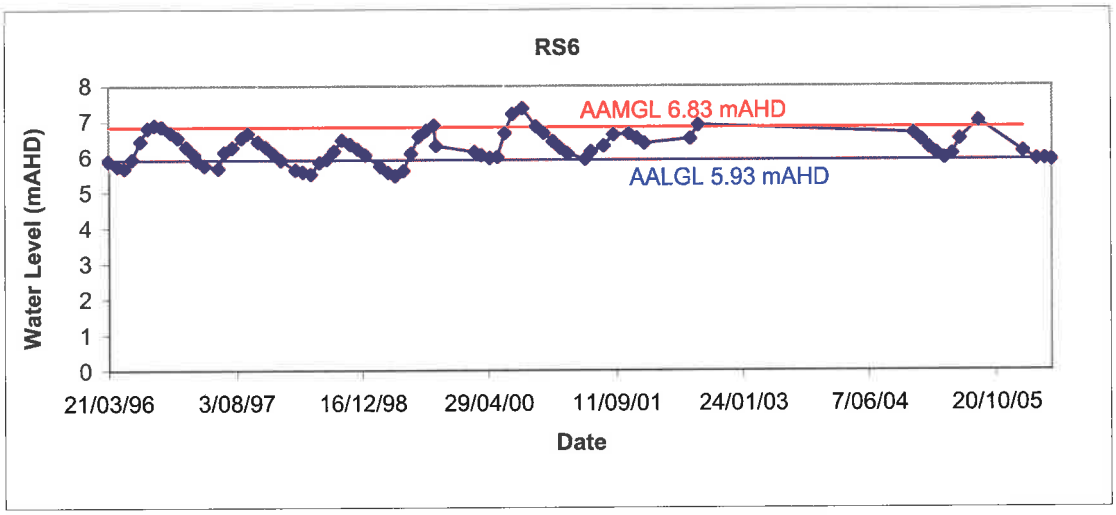
Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations





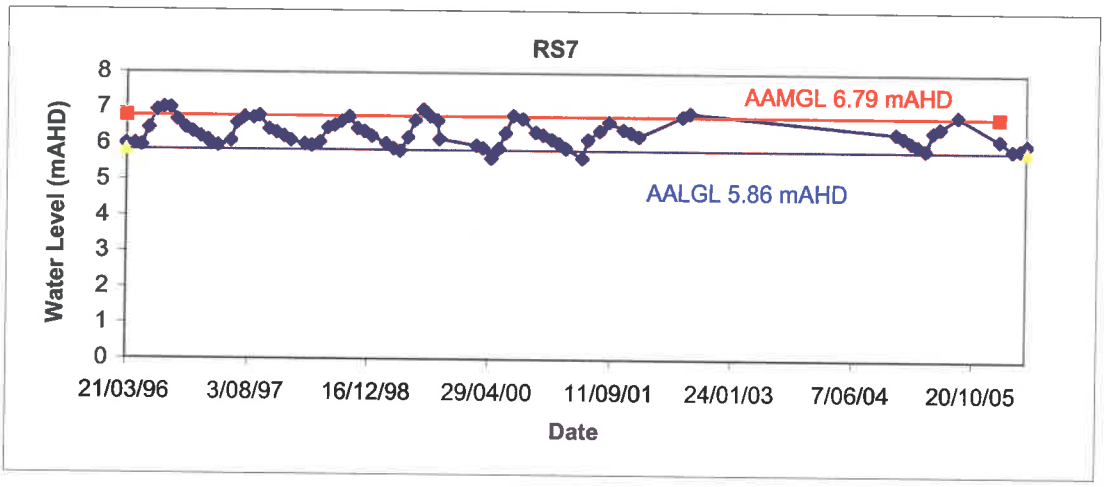


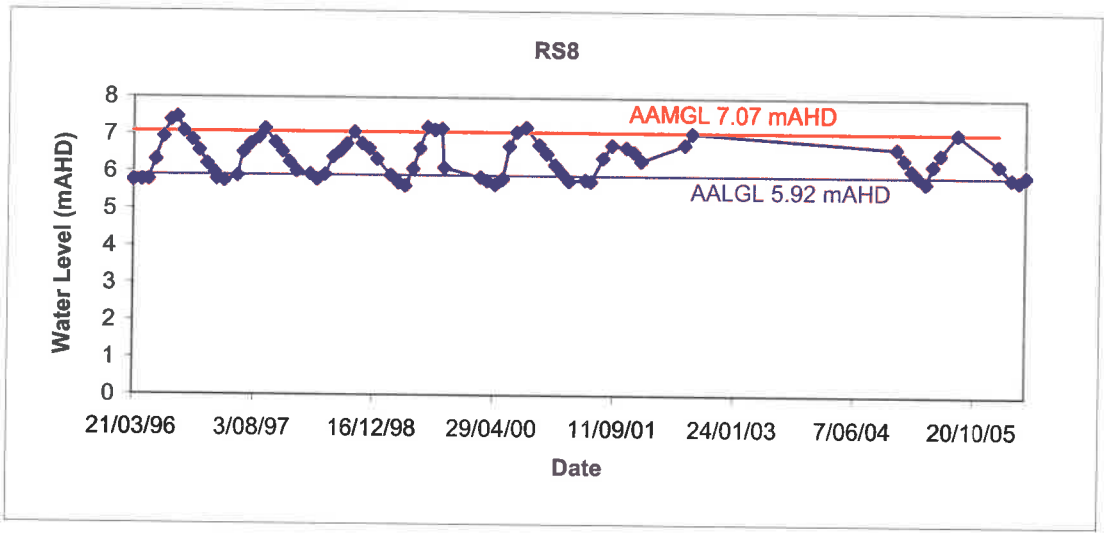
JDA Consultant Hydrologists

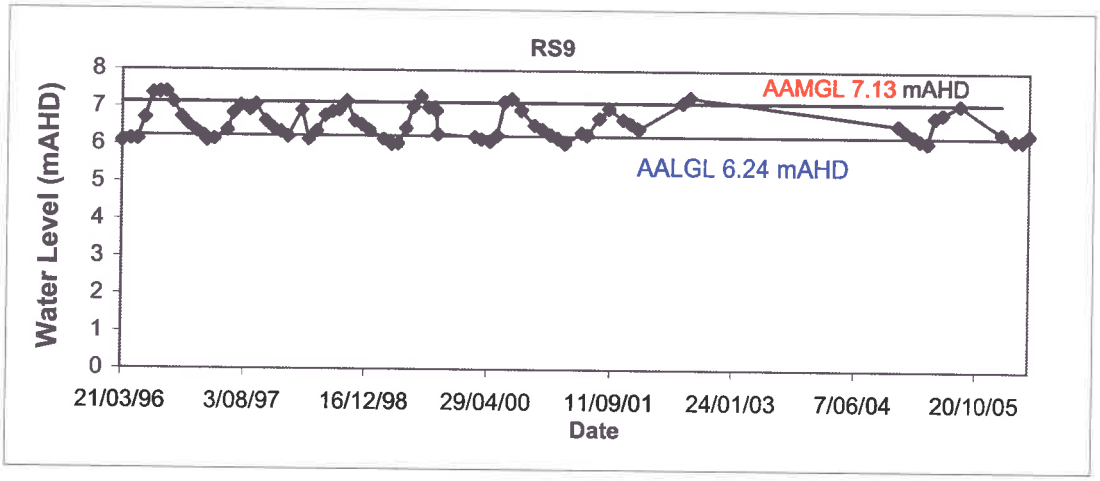
Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations





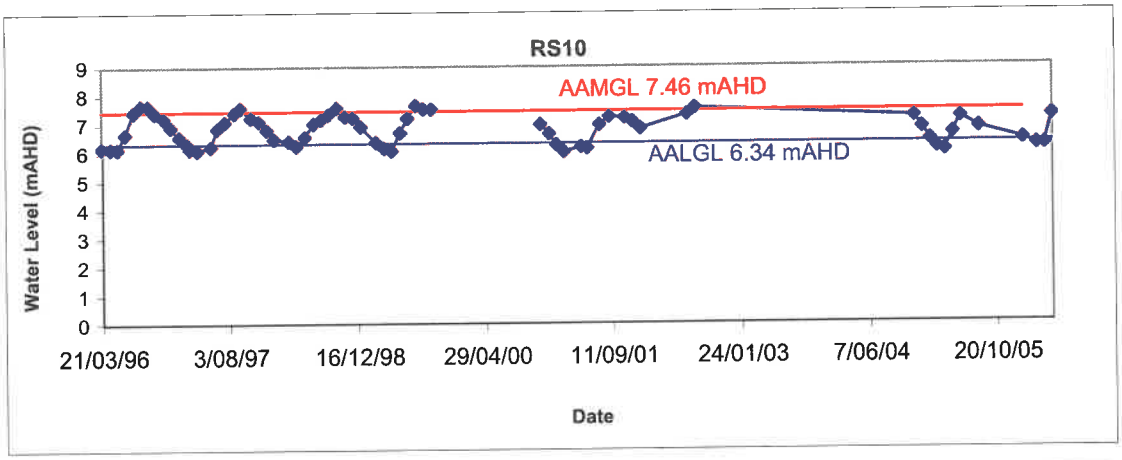


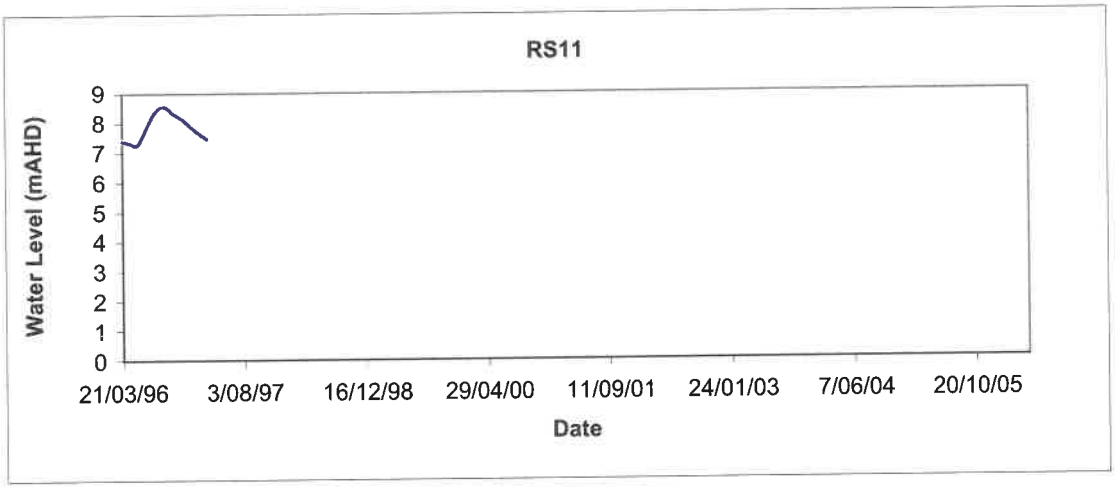
JDA Consultant Hydrologists

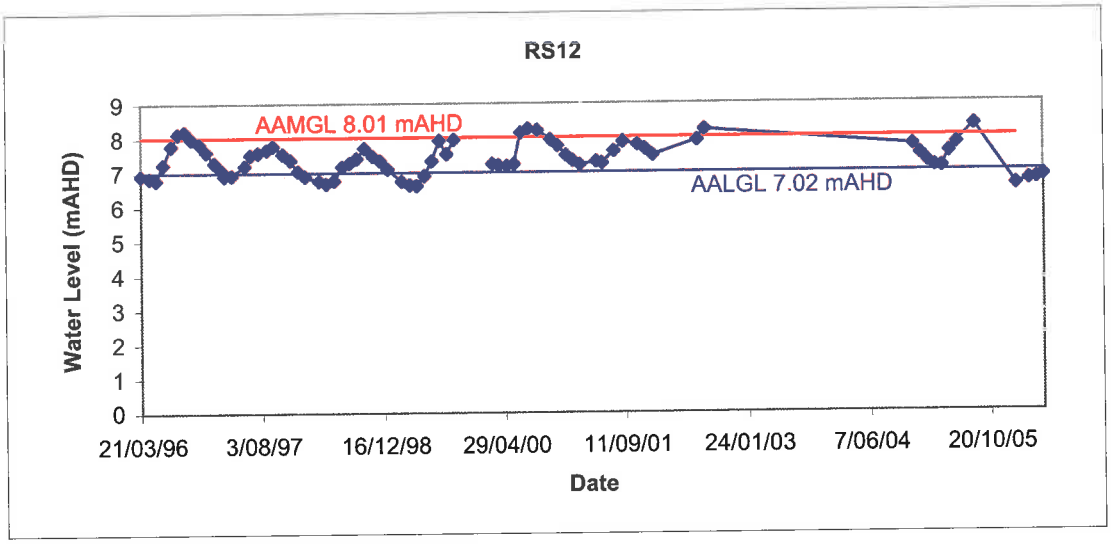
Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations





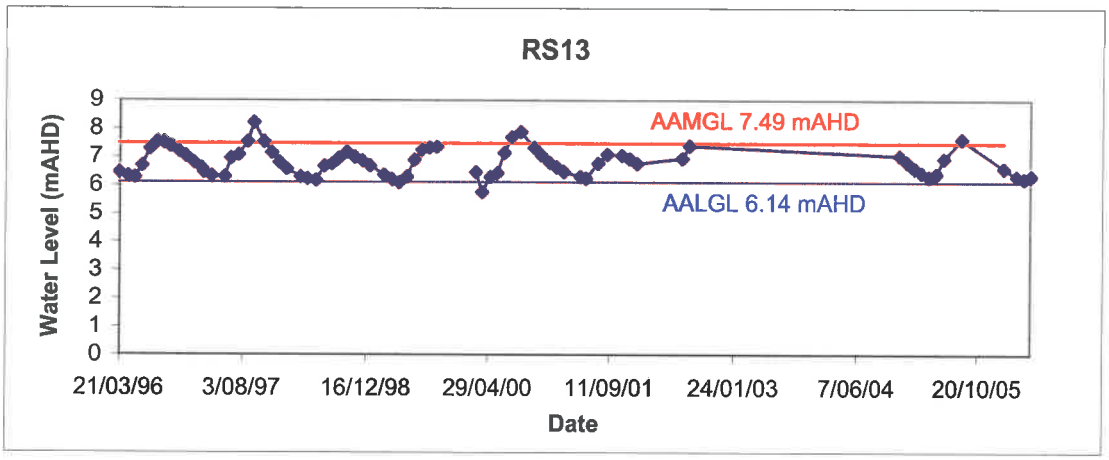


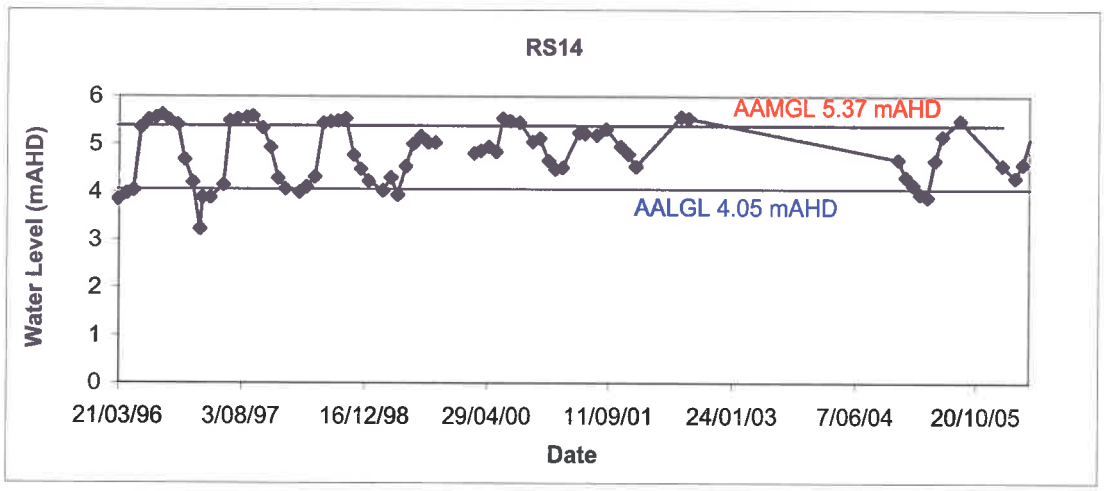
JDA Consultant Hydrologists

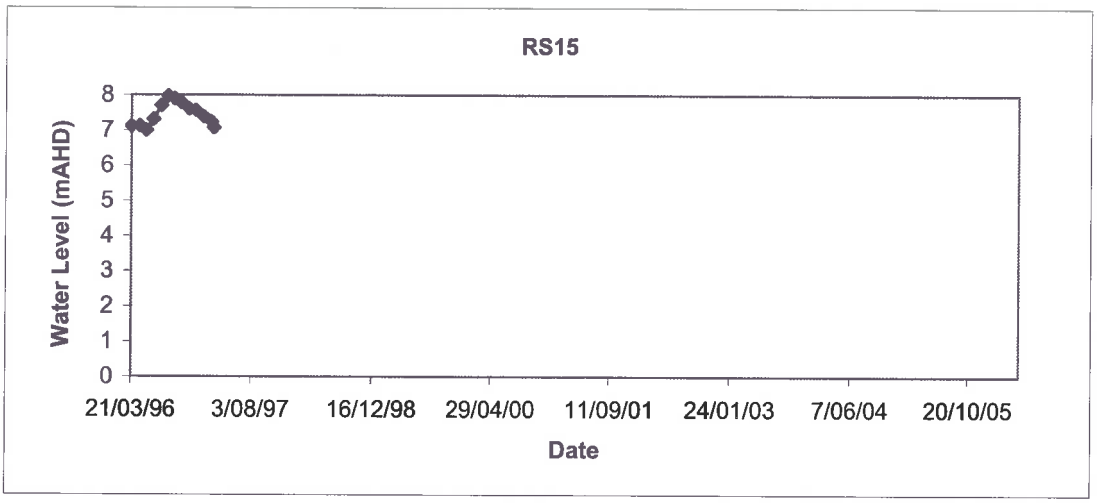
Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations





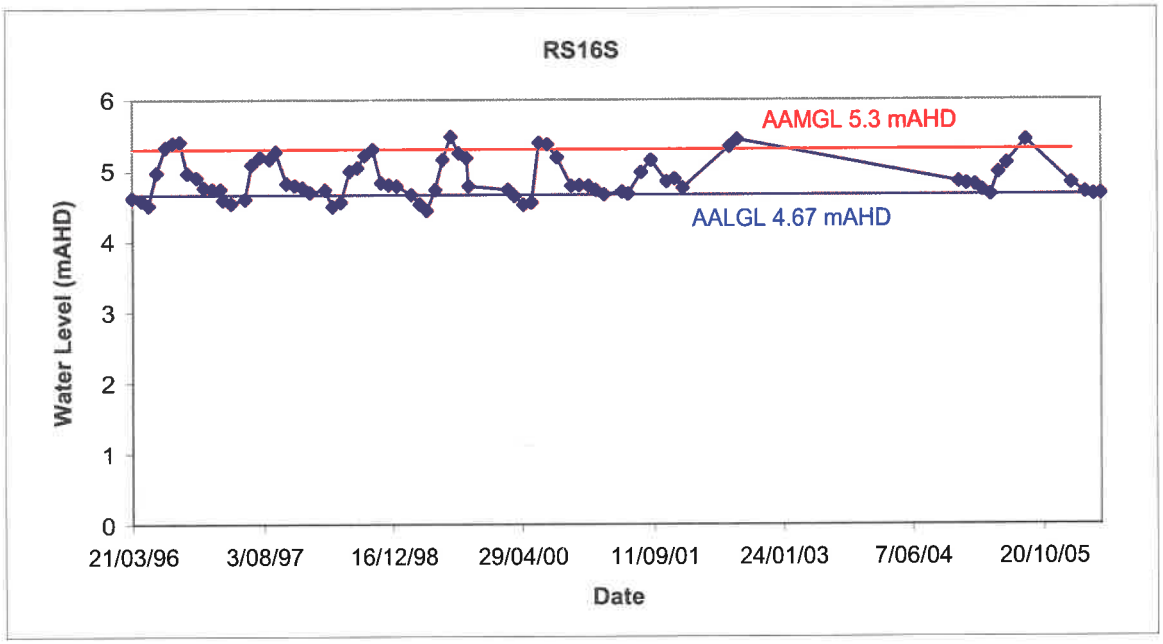


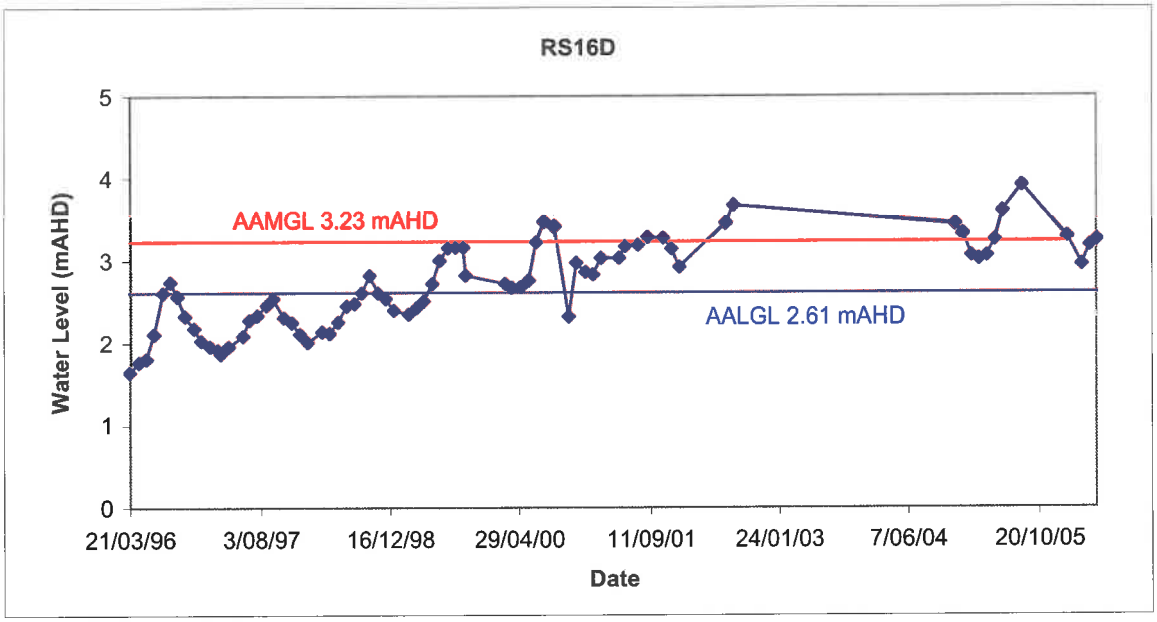
JDA Consultant Hydrologists

Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Pty Ltd



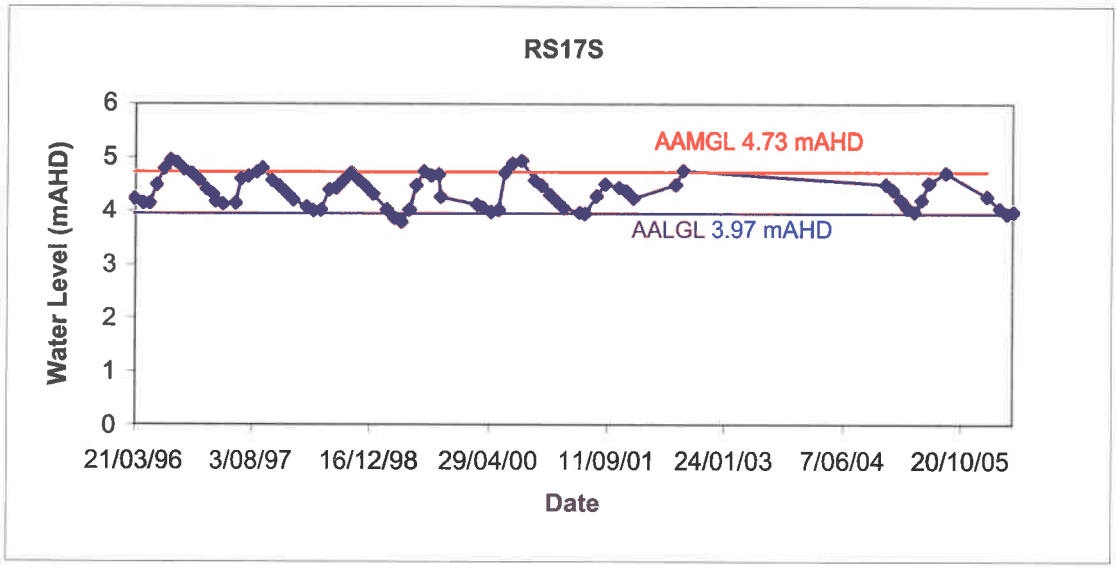


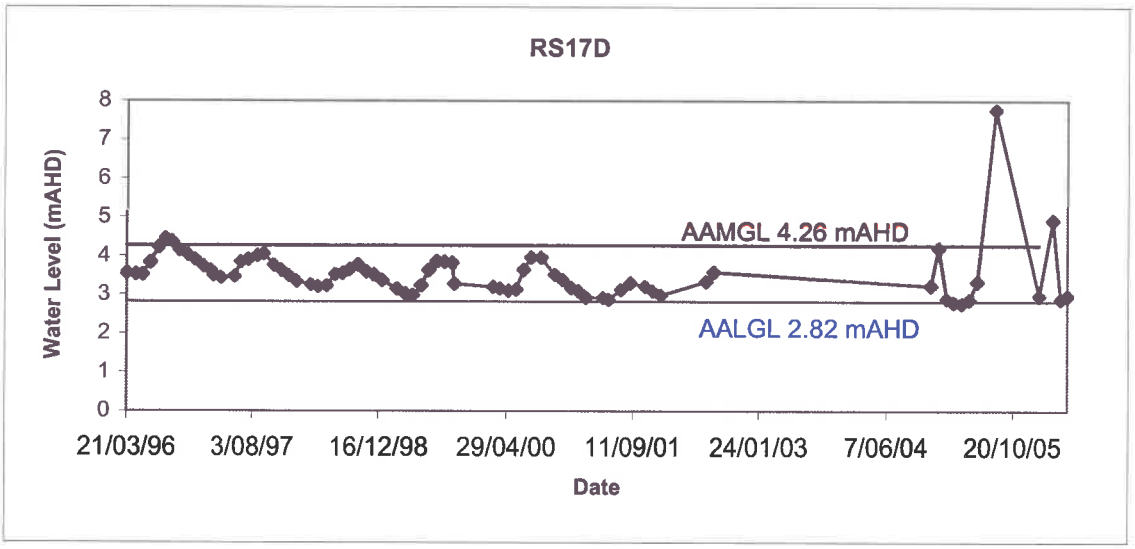
JDA Consultant Hydrologists

Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations



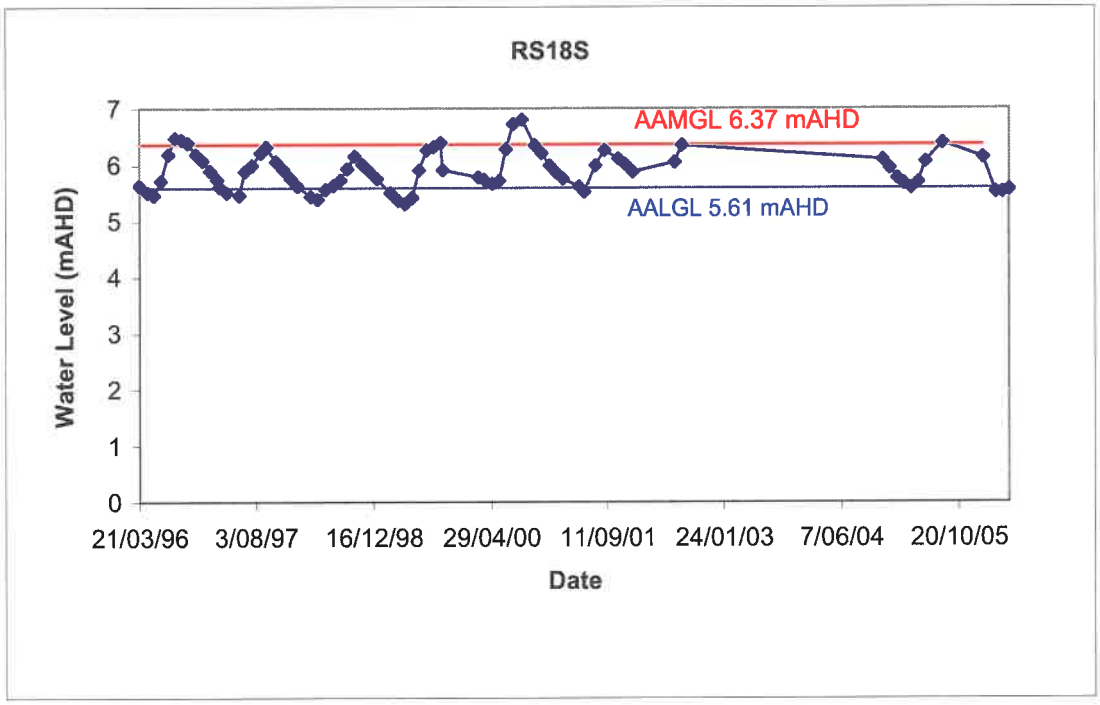


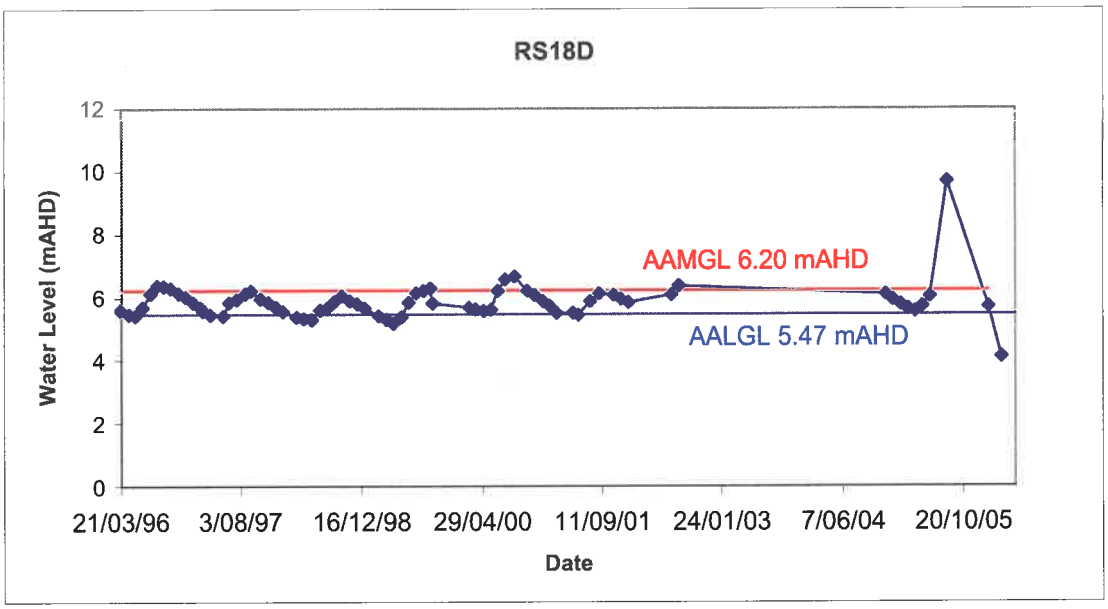
JDA Consultant Hydrologists

Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations



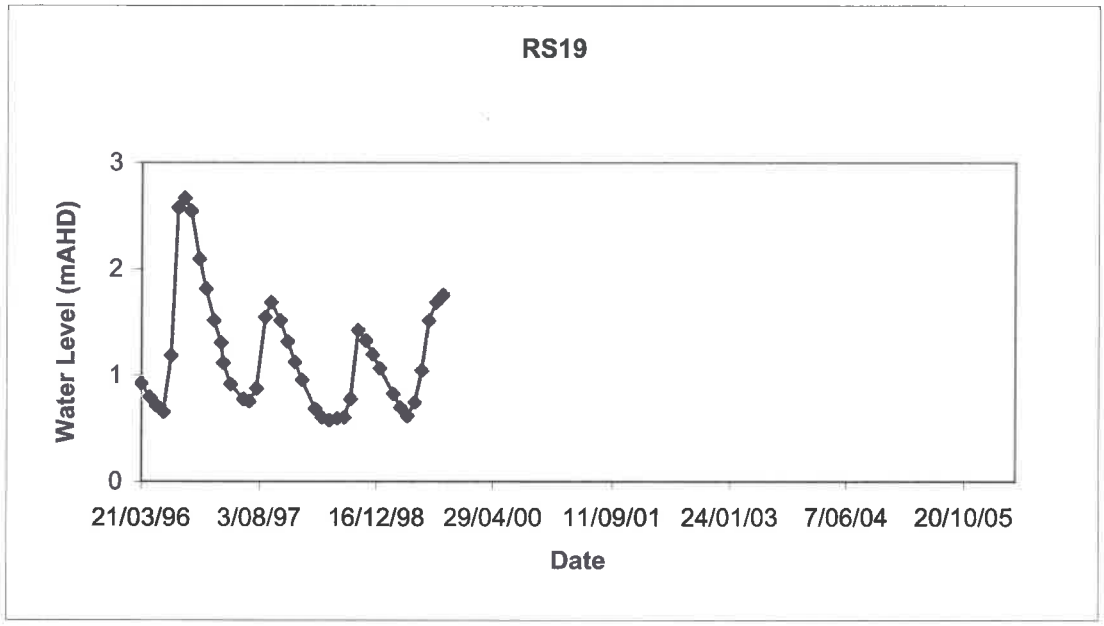


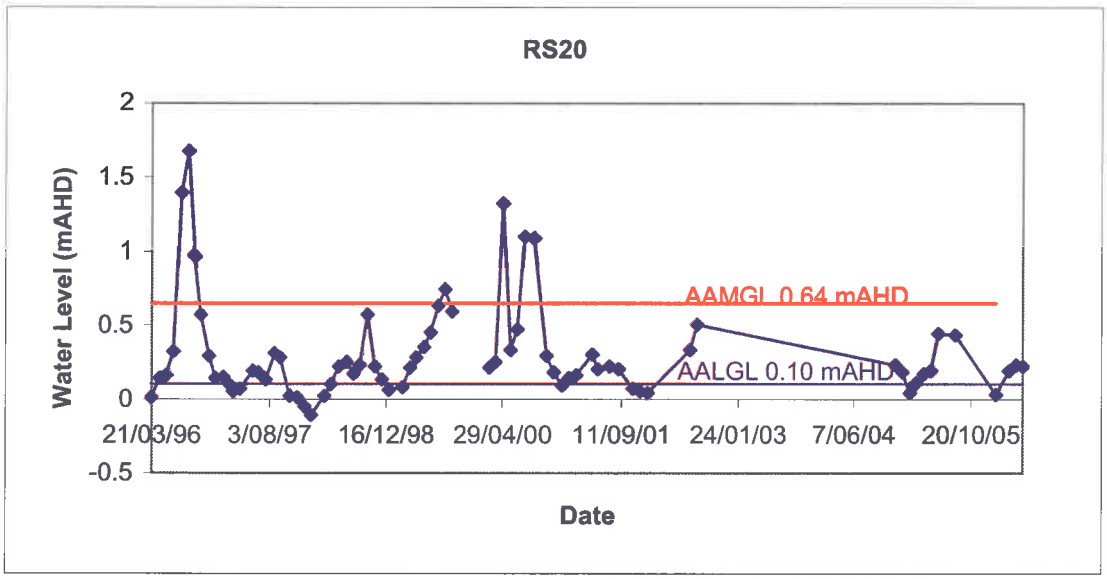
JDA Consultant Hydrologists

Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country Estate Groundwater Investigations



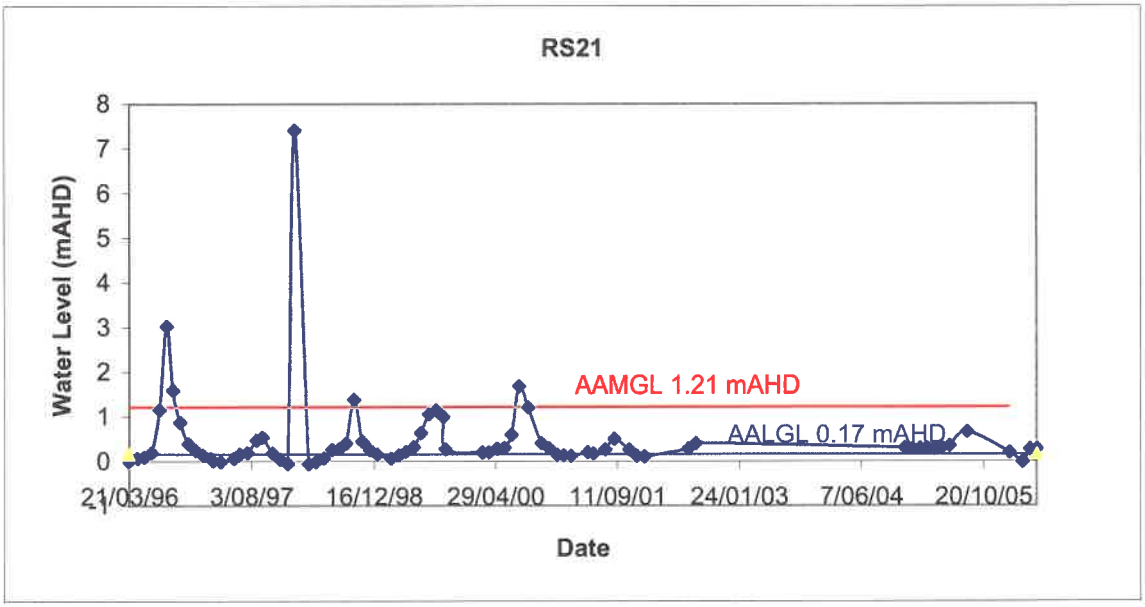


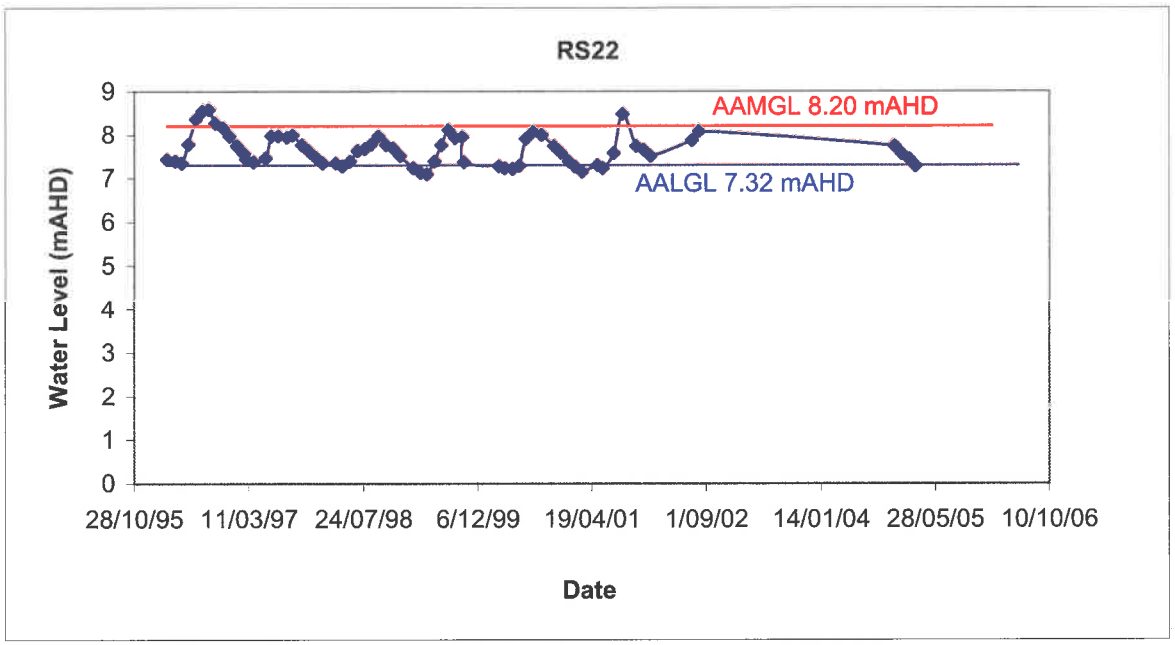
JDA Consultant Hydrologists

Job No. J3723

Client: Murray Riverside Pty Ltd

Project Title: Murray River Country estate Groundwater Investigations





APPENDIX B

JOB 91603
MURRAY RIVER
MGA 50

McMULLENNOLAN
And Partners Surveyors Pty Ltd

WATER BODIES MONITORING

DATE MONITORED 04/05/2006

Point #	Easting	Northing	R.L	Survey Code	Point #	WATER R.L
1000	393384.907	6391061.610	7.025	3700	100000	6.03
1001	393619.874	6391310.145	6.643	3700	100100	5.87
1002	393833.045	6391479.849	5.536	3700	100200	5.30
1003	393932.868	6392079.513	4.677	3700	100300	3.45
1004	393920.010	6392047.002	3.997	3700	100400	3.46
1005	393808.355	6392168.262	4.021	3700	100500	3.48
1006	393659.156	6392211.858	4.520	3700	100600	3.49
1007	393597.222	6392199.178	4.331	3700	100700	DRY
1008	393492.481	6392360.589	4.202	3700	100800	DRY
1009	393521.574	6392524.795	4.208	3700	100900	3.47
1010	393175.099	6392697.113	2.693	3700	101000	1.05
1011	393314.989	6391727.350	8.096	3700	101100	7.08
1012	393318.900	6391871.107	8.224	3700	101200	6.77
1013	392459.830	6391520.314	7.620	3700	101300	DRY
1014	392570.412	6391518.907	7.830	3700	101400	DRY
1015	392917.580	6391369.133	8.363	3700	101500	7.79
1016	392225.327	6392398.760	4.628	3700	101600	3.49
1017	392157.423	6391778.887	7.472	3700	101700	5.93

MURRAY RIVER MONITORING POINT'S

POINT #	Easting	Northing	R.L	Survey Code		WATER R.L
10000	394316.341	6391519.840	5.618	3700	High Bank Datum	0.00
100000A	394335.362	6391513.675	0.980	3700	Low Bank Datum	0.00
10001	394189.501	6392400.072	6.058	3700	High Bank Datum	-0.02
100001A	394209.217	6392403.400	2.370	3700	Low Bank Datum	-0.02
10002	393396.246	6393415.055	4.620	3700	High Bank Datum	0.00
100002A	393368.670	6393444.015	1.905	3700	Low Bank Datum	0.00
10003	392979.283	6392524.808	4.369	3700	High Bank Datum	0.03
100003A	392994.843	6392537.366	1.770	3700	Low Bank Datum	0.03

APPENDIX C

NiDSS

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date: 4-Jul-06

Murray River Country Estate exisiting (old) ODP
Urban development

Total Nutrient Input - No WSUD (kg/yr)	12,245
Reduction due to WSUD (kg/yr)	5,995
Percentage Overall Reduction	49.0%
Pecentage Development Reduction	67.1%
Cost of Selected Program ($/kg/yr)	$10.6

○ Total Phosphorus
◉ Total Nitrogen
285 m2 lots (R35)

Catchment Name	Murray River Country Estate exisiting (old) ODP
Option Description	Rural
Catchment Area	241.07 ha

Development Area	Lots	65.0%
	Minor Road Res	1.0%
	Major Road Res	0.5%
	POS (active)	8.5%
Conservation	POS (passive)	14.0%
Other	Rural Land Use	0.0%
	Golf Course	11.0%
	Total	100.0%

Nutrient Input Without WSUD

Lots	Garden	17.70	kg/net ha/yr	11.51	kg/gross ha/yr	2,774	kg/yr	22.6%
	Lawn	23.10		15.02		3,620		29.6%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.04		0.02		6		0.0%
	Sub Total	40.84		26.54		6,399		52.3%
POS	Garden/Lawn	73.40	kg/ha POS/yr	6.24	kg/gross ha/yr	1,504	kg/yr	12.3%
	Pet Waste	32.89		2.80		674		5.5%
	Sub Total	106.29		9.03		2,178		17.8%
Road	Major Roads	29.36	kg/ha RR/yr	0.15	kg/gross ha/yr	35	kg/yr	0.3%
Reserve	Minor Roads	132.00		1.32		318		2.6%
	Sub Total	161.36		1.47		354		2.9%
Rural	Rural/Semi Rural	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	125.00		13.75		3,315		27.1%
	Sub Total	185.00		13.75		3,315		27.1%
	Total			**50.79**	kg/gross ha/yr	**12,245**	kg/yr	**100.0%**

Development Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	5.75	1,387	11.3%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	90%	13.51	3,258	26.6%	$0	$0	$0.0
Native Gardens (POS)	85%	5.30	1,278	10.4%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	100%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	100%	0.00	0	0.0%	$0	$0	$0.0
Totals		**24.57**	**5,923**	**48.4%**	**$0**	**$0**	**$0.0**

Development Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	100%	0.30	72	0.6%	$859,621	$11,939	$883.5
Total		**0.30**	**72**	**0.6%**	**$859,621**	**$11,939**	**$883.5**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input Development without WSUD	37.04	8,930	72.9%			
Nutrient Input Rural Area	13.75	3,315	27.1%			
Removal via Source Control	24.57	5,923	48.4%	$0	$0	$0.0
Removal via In-Transit Control	0.30	72	0.6%	$859,621	$11,939	$883.5
Total Removal	24.87	5,995	49.0%	$859,621	$11,939	$10.6
Net Nutrient Input	**25.93**	**6,250**	**51.0%**			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type (1,2)	2	TN
Lots/net Ha Type (1,2)	2	35
Discount Rate	6%	

1	670 m^2 lots (R15)	Total Phosphorus
2	285 m^2 lots (R35)	Total Nitrogen

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse et al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

	TN (kg/yr)	TP (kg/yr)	TN or TP specified	Survey Results Pets Per Lot R15	R35	R zoning specified
Cats	0.90	0.20	0.90	0.24	**0.16**	0.16
Sml Dogs	2.75	0.70	2.75	**0.12**	**0.16**	0.16
Med Dogs	5.50	1.40	5.50	**0.16**	**0.08**	0.08
Lge Dogs	8.25	2.10	8.25	**0.19**	**0.00**	0

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	6%	12%	12%
Bins	59%	88%	88%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Area to Apply	-	ha
Number of Lots	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent TN kg/wash	TP kg/wash	TN or TP specified	Washing Frequency (one car every x weeks) R15	R35	R zoning specified
0.00009	0.00033	0.00009	?	**4.5**	4.5

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified
Garden	**0.059**	**0.027**	0.05900
Lawn	**0.033**	**0.005**	0.03300

	Fertiliser min application kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified
Garden	**0.010**	0.003	0.01000
Lawn	0.009	0.001	0.00900

	Education Campaign Fertiliser Reduction kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified	% redn
Garden	0.049	0.024	0.04900	83%
Lawn	0.024	0.004	0.02400	73%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.03
% lawn	0.28	0.07	0.07

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application kg TN/ha POS/yr	kg TP/ha POS/yr	TN or TP specified
POS	73.4	2.6	73.40

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Rural Land Use Fertiliser

Data Source: Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application kg TN/ha Rural/yr	Fertiliser mean application kg TP/ha Rural/yr	TN or TP specified
Rural	60	20	60.00

Golf Course

Data Source: Kinhill Pty Ltd (1999) Impact of golf courses on water quality.

Application Rates

	Fertiliser mean application kgN/ha/yr	Fertiliser mean application kg TP/ha/yr	TN or TP specified
Golf Course	125	8.4	125.00

Street Sweeping

Data Source: Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr) TN	Potential Reduction (kg/gross ha/yr) TP	TN or TP specified	reduction due to upstream WSUD
Sweeping	0.75	0.35	0.75	66%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$7	$/gross ha/yr
Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source: Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

			TN or TP specified
Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr	
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr	2.53

Gross Pollutant Trap

Data Source: Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humesceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal TN	Percentage Removal TP	TN or TP specified
GPT	35%	50%	35%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source: TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal TN	Percentage Removal TP	TN or TP specified
WPCP	35%	50%	35%

Cost Data

Capital Cost	$1,600,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$884	per kg
Removal	71.9	kg/year
Capital Cost	$859,621	
Operating	$11,938	
Total PV Cost	$1,058,607	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

NiDSS Nutrient Removal Calculator

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type	Total Nitrogen
R Zoning	R35

Catchment Summary of Nutrient Removal due to Source Controls

Without WSUD

37.04	kg/gross ha/yr	via developed area
12245	kg/yr	

Component	Checkbox Result	% Area to Apply Removal to	Level before Removal	Potential Removal	Adopted Removal (kg/gross ha/yr)
Native Gardens (Lots-Garden)	TRUE	50%	37.04	11.51	5.75
Native Gardens (Lots-Lawn)	TRUE	90%	31.29	15.02	13.51
Native Gardens (POS)	TRUE	85%	17.78	6.24	5.30
Education Campaign - Fertiliser	FALSE	100%	12.48	1.37	0.00
Education Campaign - Pet Waste	FALSE	100%	12.48	0.56	0.00
Education Campaign - Car Wash	FALSE	100%	12.48	0.00	0.00
Street Sweeping	FALSE	100%	12.48	0.25	0.00
Gross Pollutant Traps	FALSE	100%	12.48	0.30	0.00
Water Pollution Control Pond	TRUE	100%	12.48	0.30	0.30

Education Campaign Fertiliser Reduction

	Fertiliser Applied No WSUD kg/gross ha/yr	Removed due to Native Gardens kg/gross ha/yr	Available for further reduction	% applied reduction to min level	education campaign effectiveness	reduction kg/gross ha/yr
Garden	11.51	5.75	5.75	83%	20%	0.96
Lawn	15.02	13.51	1.50	73%	20%	0.22
Road Reserve Minor	1.32	0.00	1.32	73%	20%	0.19
					Total	1.37

Nutrient Removal via In-Transit Controls

Stormwater Load Available for Removal (ie no WSUD): 2.530 kg/gross ha/yr

	reduction due to WSUD upstream	adjusted rate to use
Gross Pollutant Traps	66.32%	0.852
Water Pollution Control Pond	66.32%	0.852

NiDSS : WSUD Option Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Catchment Name Murray River Country Estate exisiting (old) ODP
Catchment Area 241.07 ha

Total Phosphorus Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	104,290	104,290	-	104,290	16.3	-	-	-
2	Structure Plan Land Use	112,346	25,472	137,818	-	137,818	21.5	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	112,346	25,472	137,818	19,056	118,762	18.5	13.8%	17.0%	$2.6
4	Structure Plan Land Use, Street Sweeping	112,346	25,472	137,818	2,243	135,575	21.2	1.6%	2.0%	$153.2
5	Structure Plan Land Use, GPT's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$753.1
6	Structure Plan Land Use, WPCP's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$3,911.8
7	Structure Plan Land Use, Sweeping, GPT, WPCP	112,346	25,472	137,818	4,741	133,078	20.8	3.4%	4.2%	$1,300.7
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	112,346	25,472	137,818	29,130	108,688	17.0	21.1%	25.9%	$1.7
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	112,346	25,472	137,818	31,723	106,096	16.6	23.0%	28.2%	$42.8
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	112,346	25,472	137,818	85,831	51,987	8.1	62.3%	76.4%	$0.0
11	Structure Plan Land Use with zoning changed to R35	41,730	25,472	67,202	-	67,202	10.5	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	76,779	25,472	102,250	-	102,250	16.0	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	108,985	25,472	134,457	-	134,457	21.0	-	-	-

Total Nitrogen Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	304,861	304,861	-	304,861	47.6	-	-	-
2	Structure Plan Land Use	502,365	74,813	577,178	-	577,178	90.1	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	502,365	74,813	577,178	68,919	508,259	79.3	11.9%	13.7%	$0.7
4	Structure Plan Land Use, Street Sweeping	502,365	74,813	577,178	4,806	572,372	89.3	0.8%	1.0%	$71.5
5	Structure Plan Land Use, GPT's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$170.1
6	Structure Plan Land Use, WPCP's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$883.5
7	Structure Plan Land Use, Sweeping, GPT, WPCP	502,365	74,813	577,178	15,983	561,196	87.6	2.8%	3.2%	$389.1
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	502,365	74,813	577,178	101,733	475,445	74.2	17.6%	20.3%	$0.5
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	502,365	74,813	577,178	110,048	467,130	72.9	19.1%	21.9%	$12.3
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	502,365	74,813	577,178	308,070	269,108	42.0	53.4%	61.3%	$0.0
11	Structure Plan Land Use with zoning changed to R35	243,752	74,813	318,565	-	318,565	49.7	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	423,010	74,813	497,823	-	497,823	77.7	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	440,118	74,813	514,931	-	514,931	80.4	-	-	-

NiDSS : Precinct Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Catchment Name Murray River Country Estate existing (old) ODP

Total Phosphorus Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %	Poultry %	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	1,610	0	1,610	1,610	31.6
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	6,092	1,442	7,534	7,534	29.8
3	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	29,067	2,090	31,157	31,157	26.5
4	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	24,003	1,882	25,884	25,884	26.4
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	23,834	7,393	31,227	31,227	25.7
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	22,158	2,182	24,340	24,340	20.3
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	5,457	0	5,457	5,457	18.1
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	77	727	804	804	8.9
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	9,761	9,761	9,761	8.5
10											

Total Nitrogen Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %		Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	6,603	0	6,603	6,603	129.5
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	25,730	4,326	30,056	30,056	118.8
3	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	108,668	5,645	114,313	114,313	116.6
4	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	130,247	6,269	136,516	136,516	116.3
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	105,915	20,783	126,698	126,698	104.3
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	99,057	6,547	105,604	105,604	88.1
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	25,501	0	25,501	25,501	84.4
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	780	1,906	2,686	2,686	29.8
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	29,284	29,284	29,284	25.6
10											

NiDSS

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date: 4-Jul-06

Murray River Country Estate exisiting (old) ODP
Urban development

Total Nutrient Input - No WSUD (kg/yr)	2,333
Reduction due to WSUD (kg/yr)	1,195
Percentage Overall Reduction	51.2%
Pecentage Development Reduction	56.6%
Cost of Selected Program ($/kg/yr)	$70.0

(●) Total Phosphorus
( ) Total Nitrogen
285 m2 lots (R35)

Catchment Name	Murray River Country Estate exisiting (old) ODP
Option Description	Rural
Catchment Area	241.07 ha

Development Area	Lots	65.0%
	Minor Road Res	1.0%
	Major Road Res	0.5%
	POS (active)	8.5%
Conservation	POS (passive)	14.0%
Other	Rural Land Use	0.0%
	Golf Course	11.0%
	Total	100.0%

Nutrient Input Without WSUD

Lots	Garden	8.10	kg/net ha/yr	5.27	kg/gross ha/yr	1,269	kg/yr	54.4%
	Lawn	3.50		2.28		548		23.5%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.13		0.09		21		0.9%
	Sub Total	11.73		7.63		1,839		78.8%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.22	kg/gross ha/yr	53	kg/yr	2.3%
	Pet Waste	8.22		0.70		168		7.2%
	Sub Total	10.82		0.92		222		9.5%
Road	Major Roads	1.04	kg/ha RR/yr	0.01	kg/gross ha/yr	1	kg/yr	0.1%
Reserve	Minor Roads	20.00		0.20		48		2.1%
	Sub Total	21.04		0.21		49		2.1%
Rural	Rural/Semi Rural	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	8.40		0.92		223		9.5%
	Sub Total	28.40		0.92		223		9.5%
	Total			**9.68**	kg/gross ha/yr	**2,333**	kg/yr	**100.0%**

Development Nutrient Removal via Source Control

- [x] Native Gardens (Lots - Garden)
- [x] Native Gardens (Lots - Lawn)
- [x] Native Gardens (POS)
- [ ] Street Sweeping
- [ ] Community Education : Fertiliser
- [ ] Community Education : Pet Waste
- [ ] Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	2.63	635	27.2%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	90%	2.05	494	21.2%	$0	$0	$0.0
Native Gardens (POS)	85%	0.19	45	1.9%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	100%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	100%	0.00	0	0.0%	$0	$0	$0.0
Totals		**4.87**	**1,173**	**50.3%**	**$0**	**$0**	**$0.0**

Development Nutrient Removal via In-Transit Control

- [ ] Gross Pollutant Trap
- [x] Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	100%	0.09	21	0.9%	$1,132,779	$15,733	$3,911.8
Total		**0.09**	**21**	**0.9%**	**$1,132,779**	**$15,733**	**$3,911.8**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input Development without WSUD	8.75	2,110	90.5%			
Nutrient Input Rural Area	0.92	223	9.5%			
Removal via Source Control	4.87	1,173	50.3%	$0	$0	$0.0
Removal via In-Transit Control	0.09	21	0.9%	$1,132,779	$15,733	$3,911.8
Total Removal	4.96	1,195	51.2%	$1,132,779	$15,733	$70.0
Net Nutrient Input	**4.72**	**1,138**	**48.8%**			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type (1,2)	1	TP
Lots/net Ha Type (1,2)	2	35

1	670 m^2 lots (R15)	Total Phosphorus
2	285 m^2 lots (R35)	Total Nitrogen

Discount Rate 6%

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse et al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

	TN (kg/yr)	TP (kg/yr)	TN or TP specified	Survey Results Pets Per Lot R15	Survey Results Pets Per Lot R35	R zoning specified
Cats	0.90	0.20	0.20	0.24	**0.16**	0.16
Sml Dogs	2.75	0.70	0.70	**0.12**	**0.16**	0.16
Med Dogs	5.50	1.40	1.40	**0.16**	**0.08**	0.08
Lge Dogs	8.25	2.10	2.10	**0.19**	0.00	0

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	**6%**	**12%**	12%
Bins	59%	88%	88%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Area to Apply	-	ha
Number of Lots	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent TN kg/wash	Car wash detergent TP kg/wash	TN or TP specified	Washing Frequency (one car every x weeks) R15	Washing Frequency (one car every x weeks) R35	R zoning specified
0.00009	0.00033	0.00033	2	**4.5**	4.5

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA Survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application kg TN/sqm/yr	Fertiliser mean application kg TP/sqm/yr	TN or TP specified
Garden	**0.059**	**0.027**	0.02700
Lawn	**0.033**	**0.005**	0.00500

	Fertiliser min application kg TN/sqm/yr	Fertiliser min application kg TP/sqm/yr	TN or TP specified
Garden	0.010	0.003	0.00300
Lawn	0.009	0.001	0.00100

	Education Campaign Fertiliser Reduction kg TN/sqm/yr	Education Campaign Fertiliser Reduction kg TP/sqm/yr	TN or TP specified	% redn
Garden	0.049	0.024	0.02400	89%
Lawn	0.024	0.004	0.00400	80%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.03
% lawn	0.28	0.07	0.07

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application kg TN/ha POS/yr	Fertiliser mean application kg TP/ha POS/yr	TN or TP specified
POS	73.4	2.6	2.60

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

JDA

Rural Land Use Fertiliser

Data Source

Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha Rural/yr	kg TP/ha Rural/yr	specified
Rural	60	20	20.00

Golf Course

Data Source

Kinhill Pty Ltd (1999) Impact of golf courses on water quality.

Application Rates

	Fertiliser mean application		TN or TP
	kgN/ha/yr	kg TP/ha/yr	specified
Golf Course	125	8.4	8.40

Street Sweeping

Data Source

Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr)		TN or TP	reduction due to upstream WSUD
	TN	TP	specified	
Sweeping	0.75	0.35	0.35	56%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$7	$/gross ha/yr
Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source

Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

			TN or TP specified
Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr	
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr	0.40

Gross Pollutant Trap

Data Source

Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humesceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
GPT	35%	50%	50%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source

TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
WPCP	35%	50%	50%

Cost Data

Capital Cost	$1,800,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$3,912	per kg
Removal	21.4	kg/year
Capital Cost	$1,132,779	
Operating	$15,733	
Total PV Cost	$1,394,996	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

NiDSS Nutrient Removal Calculator

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type	Total Phosphorus
R Zoning	R35

Catchment Summary of Nutrient Removal due to Source Controls

Without WSUD 8.75 kg/gross ha/yr via developed area
2333 kg/yr

Component	Checkbox Result	% Area to Apply Removal to	Level before Removal	Potential Removal	Adopted Removal (kg/gross ha/yr)
Native Gardens (Lots-Garden)	TRUE	50%	8.75	5.27	2.63
Native Gardens (Lots-Lawn)	TRUE	90%	6.12	2.28	2.05
Native Gardens (POS)	TRUE	85%	4.07	0.22	0.19
Education Campaign - Fertiliser	FALSE	100%	3.88	0.54	0.00
Education Campaign - Pet Waste	FALSE	100%	3.88	0.14	0.00
Education Campaign - Car Wash	FALSE	100%	3.88	0.02	0.00
Street Sweeping	FALSE	100%	3.88	0.16	0.00
Gross Pollutant Traps	FALSE	100%	3.88	0.09	0.00
Water Pollution Control Pond	TRUE	100%	3.88	0.09	0.09

Education Campaign Fertiliser Reduction

	Fertiliser Applied No WSUD kg/gross ha/yr	Removed due to Native Gardens kg/gross ha/yr	Available for further reduction	% applied reduction to min level	education campaign effectiveness	reduction kg/gross ha/yr
Garden	5.27	2.63	2.63	89%	20%	0.47
Lawn	2.28	2.05	0.23	80%	20%	0.04
Road Reserve Minor	0.20	0.00	0.20	80%	20%	0.03
					Total	0.54

Nutrient Removal via In-Transit Controls

Stormwater Load Available for Removal 0.400 kg/gross ha/yr
(ie no WSUD)

	reduction due to WSUD upstream	adjusted rate to use
Gross Pollutant Traps	55.62%	0.178
Water Pollution Control Pond	55.62%	0.178

NiDSS : WSUD Option Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Catchment Name Murray River Country Estate exisiting (old) ODP
Catchment Area 241.07 ha

Total Phosphorus Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	104,290	104,290	-	104,290	16.3	-	-	-
2	Structure Plan Land Use	112,346	25,472	137,818	-	137,818	21.5	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	112,346	25,472	137,818	19,056	118,762	18.5	13.8%	17.0%	$2.6
4	Structure Plan Land Use, Street Sweeping	112,346	25,472	137,818	2,243	135,575	21.2	1.6%	2.0%	$153.2
5	Structure Plan Land Use, GPT's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$753.1
6	Structure Plan Land Use, WPCP's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$3,911.8
7	Structure Plan Land Use, Sweeping, GPT, WPCP	112,346	25,472	137,818	4,741	133,078	20.8	3.4%	4.2%	$1,300.7
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	112,346	25,472	137,818	29,130	108,688	17.0	21.1%	25.9%	$1.7
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	112,346	25,472	137,818	31,723	106,096	16.6	23.0%	28.2%	$42.8
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	112,346	25,472	137,818	85,831	51,987	8.1	62.3%	76.4%	$0.0
11	Structure Plan Land Use with zoning changed to R35	41,730	25,472	67,202	-	67,202	10.5	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	76,779	25,472	102,250	-	102,250	16.0	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	108,985	25,472	134,457	-	134,457	21.0	-	-	-

Total Nitrogen Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	304,861	304,861	-	304,861	47.6	-	-	-
2	Structure Plan Land Use	502,365	74,813	577,178	-	577,178	90.1	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	502,365	74,813	577,178	68,919	508,259	79.3	11.9%	13.7%	$0.7
4	Structure Plan Land Use, Street Sweeping	502,365	74,813	577,178	4,806	572,372	89.3	0.8%	1.0%	$71.5
5	Structure Plan Land Use, GPT's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$170.1
6	Structure Plan Land Use, WPCP's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$883.5
7	Structure Plan Land Use, Sweeping, GPT, WPCP	502,365	74,813	577,178	15,983	561,196	87.6	2.8%	3.2%	$389.1
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	502,365	74,813	577,178	101,733	475,445	74.2	17.6%	20.3%	$0.5
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	502,365	74,813	577,178	110,048	467,130	72.9	19.1%	21.9%	$12.3
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	502,365	74,813	577,178	308,070	269,108	42.0	53.4%	61.3%	$0.0
11	Structure Plan Land Use with zoning changed to R35	243,752	74,813	318,565	-	318,565	49.7	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	423,010	74,813	497,823	-	497,823	77.7	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	440,113	74,813	514,931	-	514,931	80.4	-	-	-

NiDSS : Precinct Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Catchment Name Murray River Country Estate exisiting (old) ODP

Total Phosphorus Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %	Poultry %	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	1,610	0	1,610	1,610	31.6
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	6,092	1,442	7,534	7,534	29.8
3	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	29,067	2,090	31,157	31,157	26.5
4	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	24,003	1,882	25,884	25,884	26.4
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	23,834	7,393	31,227	31,227	25.7
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	22,158	2,182	24,340	24,340	20.3
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	5,457	0	5,457	5,457	18.1
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	77	727	804	804	8.9
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	9,761	9,761	9,761	8.5
10											

Total Nitrogen Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %		Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	6,603	0	6,603	6,603	129.5
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	25,730	4,326	30,056	30,056	118.8
3	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	108,668	5,645	114,313	114,313	116.6
4	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	130,247	6,269	136,516	136,516	116.3
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	105,915	20,783	126,698	126,698	104.3
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	99,057	6,547	105,604	105,604	88.1
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	25,501	0	25,501	25,501	84.4
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	780	1,906	2,686	2,686	29.8
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	29,284	29,284	29,284	25.6
10											

NiDSS

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Murray River Country Estate Revised ODP
urban development

Total Nutrient Input - No WSUD (kg/yr)	8,930
Reduction due to WSUD (kg/yr)	5,995
Percentage Overall Reduction	67.1%
Percentage Development Reduction	67.1%
Cost of Selected Program ($/kg/yr)	$10.6

(○) Total Phosphorus
(●) Total Nitrogen
285 m2 lots (R35)

Catchment Name	Murray River Country Estate Revised ODP
Option Description	urban development
Catchment Area	241.07 ha

Development Area	Lots	65.0%
	Minor Road Res	1.0%
	Major Road Res	0.5%
	POS (active)	8.5%
Conservation	POS (passive)	25.0%
Rural Area	Rural Land Use	0.0%
	Poultry Farms	0.0%
	Total	100.0%

Nutrient Input Without WSUD

Lots	Garden	17.70	kg/net ha/yr	11.51	kg/gross ha/yr	2,774	kg/yr	31.1%
	Lawn	23.10		15.02		3,620		40.5%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.04		0.02		6		0.1%
	Sub Total	40.84		26.54		6,399		71.7%
POS	Garden/Lawn	73.40	kg/ha POS/yr	6.24	kg/gross ha/yr	1,504	kg/yr	16.8%
	Pet Waste	32.89		2.80		674		7.5%
	Sub Total	106.29		9.03		2,178		24.4%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.15	kg/gross ha/yr	35	kg/yr	0.4%
	Minor Roads	132.00		1.32		318		3.6%
	Sub Total	161.36		1.47		354		4.0%
Rural	Rural/Semi Rural	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	0.00		0.00		0		0.0%
	Sub Total	60.00		0.00		0		0.0%
	Total			**37.04**	kg/gross ha/yr	**8,930**	kg/yr	**100.0%**

Development Nutrient Removal via Source Control

- [x] Native Gardens (Lots - Garden)
- [x] Native Gardens (Lots - Lawn)
- [x] Native Gardens (POS)
- [ ] Street Sweeping
- [ ] Community Education : Fertiliser
- [ ] Community Education : Pet Waste
- [ ] Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	5.75	1,387	15.5%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	90%	13.51	3,258	36.5%	$0	$0	$0.0
Native Gardens (POS)	85%	5.30	1,278	14.3%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	100%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	100%	0.00	0	0.0%	$0	$0	$0.0
Totals		**24.57**	**5,923**	**66.3%**	**$0**	**$0**	**$0.0**

Development Nutrient Removal via In-Transit Control

- [ ] Gross Pollutant Trap
- [x] Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	100%	0.30	72	0.8%	$859,621	$11,939	$883.5
Total		**0.30**	**72**	**0.8%**	**$859,621**	**$11,939**	**$883.5**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input Development without WSUD	37.04	8,930	100.0%			
Nutrient Input Rural Area	0.00	0	0.0%			
Removal via Source Control	24.57	5,923	66.3%	$0	$0	$0.0
Removal via In-Transit Control	0.30	72	0.8%	$859,621	$11,939	$883.5
Total Removal	24.87	5,995	67.1%	$859,621	$11,939	$10.6
Net Nutrient Input	**12.18**	**2,936**	**32.9%**			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type (1,2)	2	TN	1	670 m^2 lots (R15)	Total Phosphorus
Lots/net Ha Type (1,2)	2	35	2	285 m^2 lots (R35)	Total Nitrogen
Discount Rate	6%				

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse et al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

	TN (kg/yr)	TP (kg/yr)	TN or TP specified	Survey Results Pets Per Lot R15	Survey Results Pets Per Lot R35	R zoning specified
Cats	0.90	0.20	0.90	0.24	**0.16**	0.16
Sml Dogs	2.75	0.70	2.75	**0.12**	**0.16**	0.16
Med Dogs	5.50	1.40	5.50	**0.16**	**0.08**	0.08
Lge Dogs	8.25	2.10	8.25	**0.19**	0.00	0

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	6%	12%	12%
Bins	59%	88%	88%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Area to Apply	-	ha
Number of Lots	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent TN kg/wash	Car wash detergent TP kg/wash	TN or TP specified	Washing Frequency (one car every x weeks) R15	Washing Frequency (one car every x weeks) R35	R zoning specified
0.00009	0.00033	0.00009	2	**4.5**	4.5

Cost Data

Distribution	51.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application kg TN/sqm/yr	Fertiliser mean application kg TP/sqm/yr	TN or TP specified
Garden	**0.059**	**0.027**	0.05900
Lawn	**0.033**	**0.005**	0.03300

	Fertiliser min application kg TN/sqm/yr	Fertiliser min application kg TP/sqm/yr	TN or TP specified
Garden	**0.010**	0.003	0.01000
Lawn	**0.009**	0.001	0.00900

	Education Campaign Fertiliser Reduction kg TN/sqm/yr	Education Campaign Fertiliser Reduction kg TP/sqm/yr	TN or TP specified	% redn
Garden	0.049	0.024	0.04900	83%
Lawn	0.024	0.004	0.02400	73%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.03
% lawn	0.28	0.07	0.07

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application kg TN/ha POS/yr	Fertiliser mean application kg TP/ha POS/yr	TN or TP specified
POS	73.4	2.6	73.40

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Rural Land Use Fertiliser

Data Source

Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha Rural/yr	kg TP/ha Rural/yr	specified
Rural	60	20	60.00

Golf Course

Data Source

NA removed in revised ODP

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha farm/yr	kg TP/ha farm/yr	specified
Poultry			0.00

Street Sweeping

Data Source

Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment
from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr)		TN or TP	reduction due to upstream WSUD
	TN	TP	specified	
Sweeping	0.75	0.35	0.75	66%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$6	$/gross ha/yr
Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source

Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

			TN or TP specified
Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr	
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr	2.53

Gross Pollutant Trap

Data Source

Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humesceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
GPT	35%	50%	35%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source

TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
WPCP	35%	50%	35%

Cost Data

Capital Cost	$1,800,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$884	per kg
Removal	71.9	kg/year
Capital Cost	$859,621	
Operating	$11,939	
Total PV Cost	$1,058,607	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

NiDSS Nutrient Removal Calculator

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type	Total Nitrogen
R Zoning	R35

Catchment Summary of Nutrient Removal due to Source Controls

Without WSUD

37.04	kg/gross ha/yr	via developed area
8930	kg/yr	

Component	Checkbox Result	% Area to Apply Removal to	Level before Removal	Potential Removal	Adopted Removal (kg/gross ha/yr)
Native Gardens (Lots-Garden)	TRUE	50%	37.04	11.51	5.75
Native Gardens (Lots-Lawn)	TRUE	90%	31.29	15.02	13.51
Native Gardens (POS)	TRUE	85%	17.78	6.24	5.30
Education Campaign - Fertiliser	FALSE	100%	12.48	1.37	0.00
Education Campaign - Pet Waste	FALSE	100%	12.48	0.56	0.00
Education Campaign - Car Wash	FALSE	100%	12.48	0.00	0.00
Street Sweeping	FALSE	100%	12.48	0.25	0.00
Gross Pollutant Traps	FALSE	100%	12.48	0.30	0.00
Water Pollution Control Pond	TRUE	100%	12.48	0.30	0.30

Education Campaign Fertiliser Reduction

	Fertiliser Applied No WSUD kg/gross ha/yr	Removed due to Native Gardens kg/gross ha/yr	Available for further reduction	% applied reduction to min level	education campaign effectiveness	reduction kg/gross ha/yr
Garden	11.51	5.75	5.75	83%	20%	0.96
Lawn	15.02	13.51	1.50	73%	20%	0.22
Road Reserve Minor	1.32	0.00	1.32	73%	20%	0.19
					Total	1.37

Nutrient Removal via In-Transit Controls

Stormwater Load Available for Removal (ie no WSUD): 2.530 kg/gross ha/yr

	reduction due to WSUD upstream	adjusted rate to use
Gross Pollutant Traps	66.32%	0.852
Water Pollution Control Pond	66.32%	0.852

NiDSS : WSUD Option Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-05

Catchment Name	Murray River Country Estate Revised ODP
Catchment Area	241.07 ha

Total Phosphorus Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	104,290	104,290	-	104,290	16.3	-	-	-
2	Structure Plan Land Use	112,346	25,472	137,818	-	137,818	21.5	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	112,346	25,472	137,818	19,056	118,762	18.5	13.8%	17.0%	$2.6
4	Structure Plan Land Use, Street Sweeping	112,346	25,472	137,818	2,243	135,575	21.2	1.6%	2.0%	$153.2
5	Structure Plan Land Use, GPT's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$753.1
6	Structure Plan Land Use, WPCP's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$3,911.8
7	Structure Plan Land Use, Sweeping, GPT, WPCP	112,346	25,472	137,818	4,741	133,078	20.8	3.4%	4.2%	$1,300.7
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	112,346	25,472	137,818	29,130	108,688	17.0	21.1%	25.9%	$1.7
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	112,346	25,472	137,818	31,723	106,096	16.6	23.0%	28.2%	$42.8
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	112,346	25,472	137,818	85,831	51,987	8.1	62.3%	76.4%	$0.0
11	Structure Plan Land Use with zoning changed to R35	41,730	25,472	67,202	-	67,202	10.5	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	76,779	25,472	102,250	-	102,250	16.0	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	108,985	25,472	134,457	-	134,457	21.0	-	-	-

Total Nitrogen Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	304,861	304,861	-	304,861	47.6	-	-	-
2	Structure Plan Land Use	502,365	74,813	577,178	-	577,178	90.1	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	502,365	74,813	577,178	68,919	508,259	79.3	11.9%	13.7%	$0.7
4	Structure Plan Land Use, Street Sweeping	502,365	74,813	577,178	4,806	572,372	89.3	0.8%	1.0%	$71.5
5	Structure Plan Land Use, GPT's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$170.1
6	Structure Plan Land Use, WPCP's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$883.5
7	Structure Plan Land Use, Sweeping, GPT, WPCP	502,365	74,813	577,178	15,983	561,196	87.6	2.8%	3.2%	$389.1
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	502,365	74,813	577,178	101,733	475,445	74.2	17.6%	20.3%	$0.5
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	502,365	74,813	577,178	110,048	467,130	72.9	19.1%	21.9%	$12.3
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	502,365	74,813	577,178	308,070	269,108	42.0	53.4%	61.3%	$0.0
11	Structure Plan Land Use with zoning changed to R35	243,752	74,813	318,565	-	318,565	49.7	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	423,010	74,813	497,823	-	497,823	77.7	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	440,118	74,813	514,931	-	514,931	80.4	-	-	-

NiDSS : Precinct Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Catchment Name Murray River Country Estate Revised ODP

Total Phosphorus Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %	Poultry %	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	1,610	0	1,610	1,610	31.6
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	6,092	1,442	7,534	7,534	29.8
3	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	29,067	2,090	31,157	31,157	26.5
4	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	24,003	1,882	25,884	25,884	26.4
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	23,834	7,393	31,227	31,227	25.7
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	22,158	2,182	24,340	24,340	20.3
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	5,457	0	5,457	5,457	18.1
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	77	727	804	804	8.9
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	9,761	9,761	9,761	8.5
10											

Total Nitrogen Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %		Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	6,603	0	6,603	6,603	129.5
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	25,730	4,326	30,056	30,056	118.8
3	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	108,668	5,645	114,313	114,313	116.6
4	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	130,247	6,269	136,516	136,516	116.3
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	105,915	20,783	126,698	126,698	104.3
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	99,057	6,547	105,604	105,604	88.1
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	25,501	0	25,501	25,501	84.4
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	780	1,906	2,686	2,686	29.8
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	29,284	29,284	29,284	25.6
10											

NiDSS

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date: 4-Jul-06

Murray River Country Estate Revised ODP
urban development

Total Nutrient Input - No WSUD (kg/yr)	2,110
Reduction due to WSUD (kg/yr)	1,195
Percentage Overall Reduction	56.6%
Percentage Development Reduction	56.6%
Cost of Selected Program ($/kg/yr)	$70.0

(•) Total Phosphorus
( ) Total Nitrogen
285 m2 lots (R35)

Catchment Name	Murray River Country Estate Revised ODP
Option Description	urban development
Catchment Area	241.07 ha

Development Area	Lots	65.0%
	Minor Road Res	1.0%
	Major Road Res	0.5%
	POS (active)	8.5%
Conservation	POS (passive)	25.0%
Rural Area	Rural Land Use	0.0%
	Poultry Farms	0.0%
	Total	100.0%

Nutrient Input Without WSUD

Lots	Garden	8.10	kg/net ha/yr	5.27	kg/gross ha/yr	1,269	kg/yr	60.2%
	Lawn	3.50		2.28		548		26.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.13		0.09		21		1.0%
	Sub Total	11.73		7.63		1,839		87.1%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.22	kg/gross ha/yr	53	kg/yr	2.5%
	Pet Waste	8.22		0.70		168		8.0%
	Sub Total	10.82		0.92		222		10.5%
Road	Major Roads	1.04	kg/ha RR/yr	0.01	kg/gross ha/yr	1	kg/yr	0.1%
Reserve	Minor Roads	20.00		0.20		48		2.3%
	Sub Total	21.04		0.21		49		2.3%
Rural	Rural/Semi Rural	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	0.00		0.00		0		0.0%
	Sub Total	20.00		0.00		0		0.0%
	Total			**8.75**	kg/gross ha/yr	**2,110**	kg/yr	**100.0%**

Development Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	2.63	635	30.1%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	90%	2.05	494	23.4%	$0	$0	$0.0
Native Gardens (POS)	85%	0.19	45	2.1%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	100%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	100%	0.00	0	0.0%	$0	$0	$0.0
Totals		**4.87**	**1,173**	**55.6%**	**$0**	**$0**	**$0.0**

Development Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	100%	0.09	21	1.0%	$1,132,779	$15,733	$3,911.8
Total		**0.09**	**21**	**1.0%**	**$1,132,779**	**$15,733**	**$3,911.8**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input Development without WSUD	8.75	2,110	100.0%			
Nutrient Input Rural Area	0.00	0	0.0%			
Removal via Source Control	4.87	1,173	55.6%	$0	$0	$0.0
Removal via In-Transit Control	0.09	21	1.0%	$1,132,779	$15,733	$3,911.8
Total Removal	4.96	1,195	56.6%	$1,132,779	$15,733	$70.0
Net Nutrient Input	**3.80**	**915**	**43.4%**			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type (1,2)	1	TP
Lots/net Ha Type (1,2)	2	35

1	670 m^2 lots (R15)	Total Phosphorus
2	285 m^2 lots (R35)	Total Nitrogen

Discount Rate 6%

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse et al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

	TN (kg/yr)	TP (kg/yr)	TN or TP specified	Survey Results Pets Per Lot R15	Survey Results Pets Per Lot R35	R zoning specified
Cats	0.90	0.20	0.20	0.24	**0.16**	0.16
Sml Dogs	2.75	0.70	0.70	**0.12**	**0.16**	0.16
Med Dogs	5.50	1.40	1.40	**0.16**	**0.08**	0.08
Lge Dogs	8.25	2.10	2.10	**0.19**	0.00	0

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	6%	12%	12%
Bins	59%	88%	88%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Area to Apply	-	ha
Number of Lots	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent TN kg/wash	Car wash detergent TP kg/wash	TN or TP specified	Washing Frequency (one car every x weeks) R15	Washing Frequency (one car every x weeks) R35	R zoning specified
0.00009	0.00033	0.00033	2	4.5	4.5

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application kg TN/sqm/yr	Fertiliser mean application kg TP/sqm/yr	TN or TP specified
Garden	**0.059**	**0.027**	0.02700
Lawn	**0.033**	**0.005**	0.00500

	Fertiliser min application kg TN/sqm/yr	Fertiliser min application kg TP/sqm/yr	TN or TP specified
Garden	0.010	0.003	0.00300
Lawn	0.009	0.001	0.00100

	Education Campaign Fertiliser Reduction kg TN/sqm/yr	Education Campaign Fertiliser Reduction kg TP/sqm/yr	TN or TP specified	% redn
Garden	0.049	0.024	0.02400	89%
Lawn	0.024	0.004	0.00400	80%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.03
% lawn	0.28	0.07	0.07

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application kg TN/ha POS/yr	Fertiliser mean application kg TP/ha POS/yr	TN or TP specified
POS	73.4	2.6	2.60

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 1.1 January 2002

Rural Land Use Fertiliser

Data Source

Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha Rural/yr	kg TP/ha Rural/yr	specified
Rural	60	20	20.00

Golf Course

Data Source

NA removed in revised ODP

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha farm/yr	kg TP/ha farm/yr	specified
Poultry			0.00

Street Sweeping

Data Source

Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment
from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr)		TN or TP	reduction due to upstream
	TN	TP	specified	WSUD
Sweeping	0.75	0.35	0.35	56%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$6	$/gross ha/yr
Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source

Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

			TN or TP
			specified
Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr	
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr	0.40

Gross Pollutant Trap

Data Source

Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humeceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
GPT	35%	50%	50%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source

TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
WPCP	35%	50%	50%

Cost Data

Capital Cost	$1,800,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$3,912	per kg
Removal	21.4	kg/year
Capital Cost	$1,132,779	
Operating	$15,733	
Total PV Cost	$1,394,996	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

NiDSS Nutrient Removal Calculator

Nutrient Input Decision Support System
Version 1.1 January 2002

Analysis Type	Total Phosphorus
R Zoning	R35

Catchment Summary of Nutrient Removal due to Source Controls

Without WSUD

8.75	kg/gross ha/yr via developed area
2110	kg/yr

Component	Checkbox Result	% Area to Apply Removal to	Level before Removal	Potential Removal	Adopted Removal (kg/gross ha/yr)
Native Gardens (Lots-Garden)	TRUE	50%	8.75	5.27	2.63
Native Gardens (Lots-Lawn)	TRUE	90%	6.12	2.28	2.05
Native Gardens (POS)	TRUE	85%	4.07	0.22	0.19
Education Campaign - Fertiliser	FALSE	100%	3.88	0.54	0.00
Education Campaign - Pet Waste	FALSE	100%	3.88	0.14	0.00
Education Campaign - Car Wash	FALSE	100%	3.88	0.02	0.00
Street Sweeping	FALSE	100%	3.88	0.16	0.00
Gross Pollutant Traps	FALSE	100%	3.88	0.09	0.00
Water Pollution Control Pond	TRUE	100%	3.88	0.09	0.09

Education Campaign Fertiliser Reduction

	Fertiliser Applied No WSUD kg/gross ha/yr	Removed due to Native Gardens kg/gross ha/yr	Available for further reduction	% applied reduction to min level	education campaign effectiveness	reduction kg/gross ha/yr
Garden	5.27	2.63	2.63	89%	20%	0.47
Lawn	2.28	2.05	0.23	80%	20%	0.04
Road Reserve Minor	0.20	0.00	0.20	80%	20%	0.03
					Total	0.54

Nutrient Removal via In-Transit Controls

Stormwater Load Available for Removal: 0.400 kg/gross ha/yr
(ie no WSUD)

	reduction due to WSUD upstream	adjusted rate to use
Gross Pollutant Traps	55.62%	0.178
Water Pollution Control Pond	55.62%	0.178

NiDSS : WSUD Option Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date : 4-Jul-06

Catchment Name	Murray River Country Estate Revised ODP
Catchment Area	241.07 ha

Total Phosphorus Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	104,290	104,290	-	104,290	16.3	-	-	-
2	Structure Plan Land Use	112,346	25,472	137,818	-	137,818	21.5	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	112,346	25,472	137,818	19,056	118,762	18.5	13.8%	17.0%	$2.6
4	Structure Plan Land Use, Street Sweeping	112,346	25,472	137,818	2,243	135,575	21.2	1.6%	2.0%	$153.2
5	Structure Plan Land Use, GPT's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$753.1
6	Structure Plan Land Use, WPCP's	112,346	25,472	137,818	1,282	136,536	21.3	0.9%	1.1%	$3,911.8
7	Structure Plan Land Use, Sweeping, GPT, WPCP	112,346	25,472	137,818	4,741	133,078	20.8	3.4%	4.2%	$1,300.7
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	112,346	25,472	137,818	29,130	108,688	17.0	21.1%	25.9%	$1.7
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	112,346	25,472	137,818	31,723	106,096	16.6	23.0%	28.2%	$42.8
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	112,346	25,472	137,818	85,831	51,987	8.1	62.3%	76.4%	$0.0
11	Structure Plan Land Use with zoning changed to R35	41,730	25,472	67,202	-	67,202	10.5	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	76,779	25,472	102,250	-	102,250	16.0	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	108,985	25,472	134,457	-	134,457	21.0	-	-	-

Total Nitrogen Input : Summary of Options

	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Reduction due to WSUD: Overall Reduction %	Reduction due to WSUD: Development Reduction %	Cost of Reduction $/kg/yr
1	Existing Land Use	0	304,861	304,861	-	304,861	47.6	-	-	-
2	Structure Plan Land Use	502,365	74,813	577,178	-	577,178	90.1	-	-	-
3	Structure Plan Land Use, Community Education 20% Effectiveness	502,365	74,813	577,178	68,919	508,259	79.3	11.9%	13.7%	$0.7
4	Structure Plan Land Use, Street Sweeping	502,365	74,813	577,178	4,806	572,372	89.3	0.8%	1.0%	$71.5
5	Structure Plan Land Use, GPT's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$170.1
6	Structure Plan Land Use, WPCP's	502,365	74,813	577,178	5,674	571,504	89.2	1.0%	1.1%	$883.5
7	Structure Plan Land Use, Sweeping, GPT, WPCP	502,365	74,813	577,178	15,983	561,196	87.6	2.8%	3.2%	$389.1
8	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%)	502,365	74,813	577,178	101,733	475,445	74.2	17.6%	20.3%	$0.5
9	Structure Plan Land Use, Native Plantings Gardens & POS (20%), & Education (20%), Street Sweeping, GPT	502,365	74,813	577,178	110,048	467,130	72.9	19.1%	21.9%	$12.3
10	Structure Plan Land Use, Minimum Recommended Fertiliser Application Rates	502,365	74,813	577,178	308,070	269,108	42.0	53.4%	61.3%	$0.0
11	Structure Plan Land Use with zoning changed to R35	243,752	74,813	318,565	-	318,565	49.7	-	-	-
12	Structure Plan Land Use with POS Doubled in Area	423,010	74,813	497,823	-	497,823	77.7	-	-	-
13	Structure Plan Land Use with Non Irrigated POS Areas	440,118	74,813	514,931	-	514,931	80.4	-	-	-

NiDSS : Precinct Summary

Nutrient Input Decision Support System
Version 1.1 January 2002
JDA Consultant Hydrologists
Report Date: 4-Jul-06

Catchment Name Murray River Country Estate Revised ODP

Total Phosphorus Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %	Poultry %	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	1,610	0	1,610	1,610	31.6
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	6,092	1,442	7,534	7,534	29.8
3	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	29,067	2,090	31,157	31,157	26.5
4	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	24,003	1,882	25,884	25,884	26.4
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	23,834	7,393	31,227	31,227	25.7
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	22,158	2,182	24,340	24,340	20.3
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	5,457	0	5,457	5,457	18.1
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	77	727	804	804	8.9
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	9,761	9,761	9,761	8.5
10											

Total Nitrogen Input : Summary of Precincts

	Precinct	Area ha	Development %	Conservation %	Rural %		Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	Net Input kg/yr	Input Rate kg/ha/yr
1	Canning Vale Proposed Land Use	51	83.9%	16.1%	0.0%	0.0%	6,603	0	6,603	6,603	129.5
2	Peel Proposed Land Use	253	68.0%	3.5%	28.5%	0.0%	25,730	4,326	30,056	30,056	118.8
3	Southern River Proposed Land Use	980	80.4%	10.0%	9.6%	0.0%	108,668	5,645	114,313	114,313	116.6
4	Wungong Proposed Land Use	1174	79.4%	11.7%	8.9%	0.0%	130,247	6,269	136,516	136,516	116.3
5	Balannup Proposed Land Use	1215	61.7%	14.2%	21.8%	2.3%	105,915	20,783	126,698	126,698	104.3
6	Forrestdale Proposed Land Use	1199	59.2%	31.7%	9.1%	0.0%	99,057	6,547	105,604	105,604	88.1
7	Sutherlands Park Proposed Land Use	302	63.2%	36.8%	0.0%	0.0%	25,501	0	25,501	25,501	84.4
8	Balannup Lake Proposed Land Use	90	9.3%	67.1%	17.5%	6.1%	780	1,906	2,686	2,686	29.8
9	Forrestdale Lake Proposed Land Use	1143	0.0%	57.3%	42.7%	0.0%	0	29,284	29,284	29,284	25.6
10											

Suite 1, 27 York St, Subiaco WA 6008
PO Box 117, Subiaco WA 6904
Ph: +61 8 9388 2436
Fx: +61 8 9381 9279

www.jda-hydrologists.net.au

jdahydro@iinet.net.au

APPENDIX 4
MRCE Retail Potential
Hames Sharley

Murray River Country Estate
Retail Potential

For

Taylor Burrell Barnett

HAMES SHARLEY

May 2006

REVISION SCHEDULE

No.	Date	Details	CM
1	April 2006	Draft	JMH
2	May 2006	Final	JMH

DISCLAIMERS

The information contained in this report has been prepared with care by our company, or it has been supplied to us by apparently reliable sources. In either case, we have no reason to doubt its completeness or accuracy. However, neither this company nor its employees guarantee the information, nor does it or is it intended to form part of any contract. Accordingly, all interested parties should make their own inquiries to verify the information, as well as any additional or supporting information supplied, and it is the responsibility of interested parties to satisfy themselves in all respects.

This report is for the use only of the party to whom it is addressed and Hames Sharley disclaims responsibility to any third party acting upon or using the whole or part of its contents.

Contents

1. Introduction

This report is prepared in response to a request from Taylor Burrell Barnett Town Planning and Design for a market demand study to determine the retail potential of a proposed Village Centre and Mixed Use site located in the Murray River Country Estate, Pinjarra.

The Outline Development Plan of the estate indicates the Village Centre and Mixed Use area fronting Pinjarra Road and the objective of this analysis is to establish how much retail floor space the centre can sustain.

1.1 Location

Murray River Country Estate is located in the Shire of Murray, approximately 87 kilometres south west of Perth in the Peel region. The Shire has a population of approximately 12,400 (WAPC, November 2005) which is expected to increase rapidly in coming years as development opportunities in Mandurah begin to wane.

The Peel Region incorporates the local municipalities of the City of Mandurah together with the Shires of Boddington, Murray, Serpentine-Jarrahdale and Waroona. Peel has a population of almost 92,000 persons and continues to be the fastest growing region in Western Australia and Australia recording a population growth rate of 4.8 percent between 2004 and 2005 (Peel Development Commission, March 2006).

New infrastructure proposed for the region includes an extension of the Kwinana Freeway from Perth through to Bunbury, an extension of the Tonkin Highway to join the South West Highway, and the Southern Suburbs Railway that will make Mandurah a 48 minute trip from the centre of Perth.

The region's economy is driven by mining, manufacturing, building and construction, retail and tourism. Agriculture also makes a significant contribution to the Peel's diverse economy. In 2003/04, new business registrations increased by 8 percent over the previous year.

1.1.1 Murray River Country Estate

The Murray River Country Estate (MRCE) is located 3 kilometres west of the township of Pinjarra and covers an area of 330 ha. The estate lies between the Pinjarra Golf Course and the Murray River and future development will serve to strengthen the relationship between the river and the estate. When fully developed, the estate will provide about 2,700 dwelling units.

The draft ODP indicates a number of land use precincts including: residential, at a range of densities from R10 to R60; a tourism precinct overlooking the river; a commercial precinct fronting Pinjarra Road adjacent to the Mixed Use and Village Centre precincts; a public boating facility and public open space, foreshore reserve areas. Two schools are also planned for the estate, a private school offering K-12 and a state primary school.

The estate is endowed with natural amenity. An Aboriginal heritage site on the river foreshore close to the proposed tourism facility enhances the potential of

eco-tourism activities in and around the estate. These are strongly supported by the Sanctuary Bird Park, golf course, boat launching facility, direct river access and proposed walking trails which will further attract day trippers and weekend visitors to the area.

There is a strong latent demand for commercial and retail floor space in the Shire of Murray which the Pinjarra Town Centre is unable to satisfy. The proponent of the Murray River Country Estate reports a keen interest in these uses and retail floor space in the proposed Village Centre and Mixed Use centre at the estate.

Figure 1.1: Location of Murray River Country Estate

1.1.2 Methodology

This report presents an independent review of the market potential of the proposed Village Centre at the Murray River Country Estate. The following tasks have been undertaken and are reported as follows:

- Policy context
- Population growth

- Definition of the catchment area
- Competition analysis
- Demographic profiling
- Assessment of household expenditure
- Conclusions and recommendations

Sources utilised include:

- *Peel Region Scheme*, Western Australian Planning Commission, March 2003.
- *Inner Peel Region Structure Plan,* Western Australian Planning Commission, December 1997.
- *Liveable Neighbourhoods* (Edition 3), Western Australian Planning Commission, October 2004.
- *Population Report No. 6, Western Australia Tomorrow,* Western Australian Planning Commission, November 2005
- 2001 Census of Population and Housing, Australian Bureau of Statistics
- *Household Expenditure Survey 1998-99, Australian* Bureau of Statistics

2. Policy Context

2.1 Peel Region Scheme

The Scheme establishes zoning and reservations to guide land uses and development at a regional level. The aims of the Scheme are to promote the sustainable development of land taking into account relevant environmental, social and economic factors. It also aims to provide for regional transportation, community services and infrastructure in a way that is efficient, equitable and timely. Environmental concerns extend to coastal and riverine foreshores and regional conservation and recreational facilities.

The Scheme classifies the region into zones which are: Urban; Urban Deferred; Regional Centre (Mandurah CBD); Industrial; Rural and Private Recreation.

2.2 Inner Peel Region Structure Plan

This plan forms the basis of the Peel Region Scheme and interprets and applies strategic goals and objectives to the actual physical arrangement of land uses on the ground. The Inner Peel Region comprises primarily the local government areas of Mandurah and the portion of the Shire of Murray which is on the Swan Coastal Plain. A small part of the north western corner of the Shire of Waroona, which is affected by the Peel Deviation Highway and Peel Regional Park, is also included.

In terms of urban form, the essential objective of development is to contain urbanisation into discrete urban villages within the coastal corridor. The villages will be compact, well-defined communities featuring a wide range of housing types and densities, pedestrian environments, have a community focus, a mix of land uses, generous public open spaces and high quality urban design.

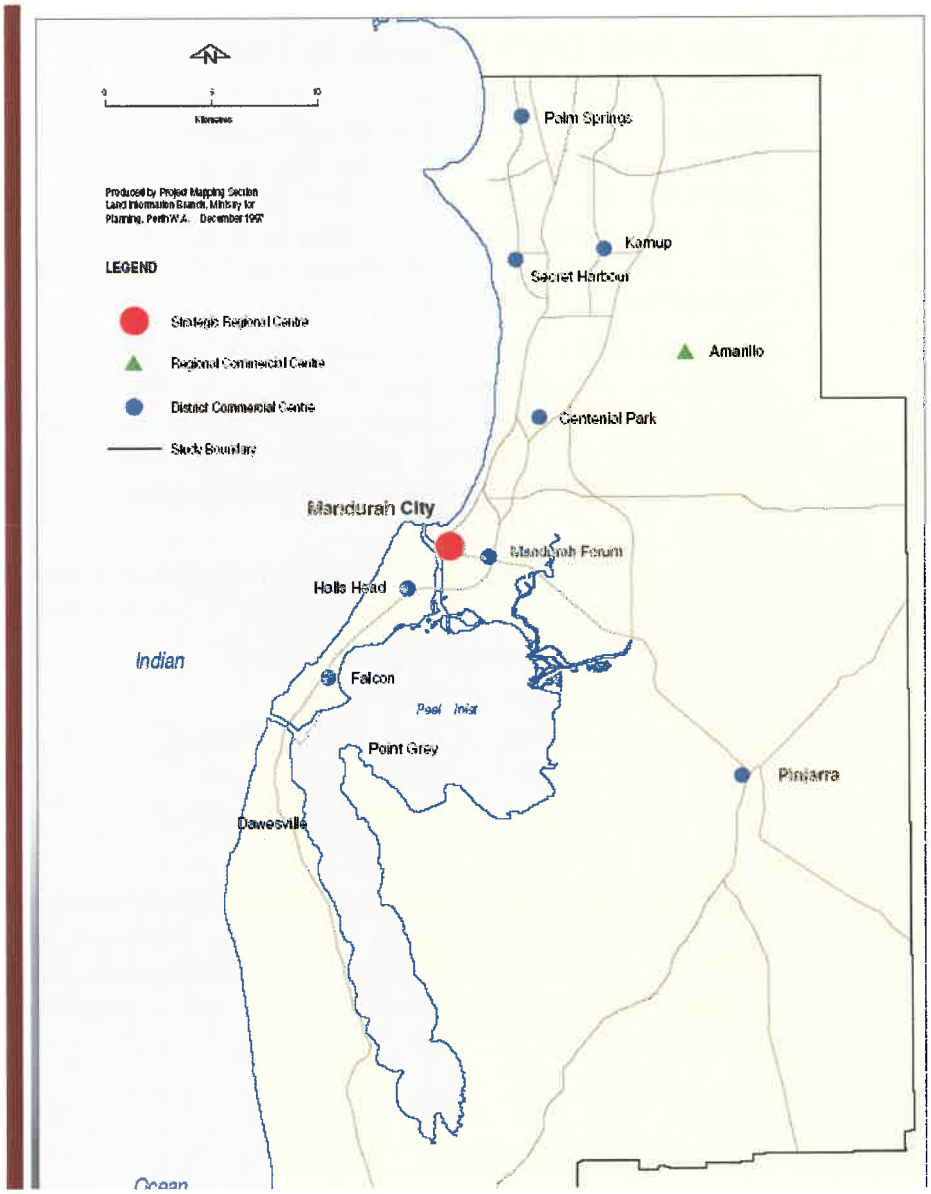
The Structure Plan determines the location of retail and commercial activities and establishes a hierarchy of centres (Figure 2.1) as described below:

- Mandurah Strategic Regional Centre
- Amarillo Regional Centre (future)
- District Centres at Centennial Park (future), Mandurah Forum, Halls Head, Falcon and Pinjarra Town Centre
- Neighbourhood and local shopping centres

The Structure Plan acknowledges that should Pinjarra Town Centre not have a town centre development plan, there is a likelihood that major retail developers will seek out of town locations to establish new shopping centres on greenfield sites where land assembly is not such a problem as in the town centre.

There is an opportunity for the Village Centre at Murray River Country Estate to provide a range of retail services that the Pinjarra town centre is unable to offer. In the context of strong future residential growth in the area, the Village Centre will meet the demand for goods and services from existing and future residents and its strategic location on Pinjarra Road will extend its area of influence beyond its Neighbourhood Centre function.

Figure 2.1: Future Commercial Centres



Source: Inner Peel Region Structure Plan, WAPC December 1997

2.3 Liveable Neighbourhoods

The primary objective of urban planning is to design a framework for a community that is sustainable, safe, vibrant and efficient. In relation to the development of centres, the Liveable Neighbourhoods approach calls for an urban structure based on walkable, mixed use towns and neighbourhoods that have a community focus and offer a compatible mix of uses. The intent is to create complete integrated communities that promote a local identity and create a sense of place.

Liveable Neighbourhoods outlines a range of mixed use centres, with varying provision of retail, civic, commercial and service functions. The preferred urban form is main street mixed use centres that offer street frontage retail and high density residential with good access to public transport. The model is based on the premise that mixed use centres are inherently more socially, environmentally and economically sustainable and adaptable to change over time.

According to Liveable Neighbourhoods, larger Neighbourhood Centres may be developed up to 4,500 sqm and those with more than a local residential catchment, should support several shops and restaurants.

The Mixed Use site and Village Centre at Murray River Country Estate will have more than a residential catchment; they will be defined by their accessibility and strategic location on Pinjarra Road that will encourage patronage from further afield than the local catchment area.

The Village Centre and Mixed Use site will act as a catalyst for the overall development of the estate. It proposes a people-friendly environment that will offer a compatible mix of uses ranging from convenience shopping needs, community facilities and a place that will become a community focal point for the estate.

To foster the best level of convenience, the centre falls within a walkable catchment of future higher density residential areas. Easy access and egress from Pinjarra Road provides shoppers from further afield with a destination for convenience purchases that precludes the need to visit Mandurah for these purposes.

Liveable Neighbourhoods supports the development of Neighbourhood Centres with exposure to main roads and accessibility to public transport as these factors are key contributors to a successful centre. The range of residential densities and variety of housing types catering to different household types creates a more sustainable outcome for the community.

3. Population Projections

3.1 The Peel Region

The Peel Region continues to be the fastest growing in Western Australia with the population increasing by 4.8% between 2004 and 2005 to total nearly 92,000 residents. This rate of growth can be contrasted to that for the whole of Western Australia which grew at 1.6% during the same period (Peel Development Commission).

Growth has been strongest in the over 50 years groups, however another notable characteristic of the Peel Region's recent population is growth in the number of children, youth and young adults. Between 1996 and 2004, the number of persons aged between 5 and 24 years of age grew by 12.7 per cent in the Peel Region compared with a 0.6 per cent increase in this cohort for Western Australia over the same period.

The growth of younger age groups is important to the future of the region as young adults seeking lifestyle changes and job opportunities move into the family formation stage of their lives and remain in the region.

Table 3.1 indicates that the City of Mandurah has enjoyed the strongest growth in the Peel region. While this is projected to continue for the coming decade, the high rates of growth in Mandurah will decline as opportunities for development begin to wane.

Table 3.1: Estimated Residential Population by Local Government Areas within Peel

LGA	Est Pop 2005	Ann Avg Growth 2004 - 05	Ann Avg Growth 2000 - 05	Ann Avg Growth 1995 - 2005
Boddington	1,408	2.60%	-0.70%	-0.50%
Mandurah	61,889	5.90%	5.60%	4.90%
Murray	12,121	2.70%	2.70%	2.60%
Serpentine Jarrahdale	12,887	3.80%	2.40%	2.80%
Waroona	3,548	0.00%	0.30%	1.50%
Peel Total	**91,853**	**4.80%**	**4.40%**	**4.00%**

Source: Peel Development Commission

3.2 The Shire of Murray

The following table indicates that the Shire of Murray is on the threshold of extremely high population growth. There is already evidence that the Shire of Murray will be part of the next development front after Mandurah as the market seeks new opportunities for land development. Riverland Ramble to the west of MRCE and extensive residential development at Yunderup are currently being developed in response to the demand for new housing opportunities in the area offering approximately 3,500 lots.

Table 3.2 below shows growth in the Shire will accelerate after 2010 and peak in 2025 after which time it slows but remains extremely high. This has positive implications for retail outlets in the area as it assumes an increased demand for goods and services and increased household expenditure.

Table 3.2: Population Projections for the Shire of Murray 2005 - 2030

	2005	2010	2015	2020	2025	2030
Population	12,163	13,270	16,032	20,687	28,783	36,068
% change	-	9%	21%	29%	39%	25%

Source: *Western Australia Tomorrow, Population Report No.6,* Western Australian Planning Commission, November 2005

3.3 Murray River Country Estate

The estate is being developed in stages with Stage 7A comprising 48 lots currently under construction. It is understood that the estate will be fully developed to 2,700 dwelling units within 10 – 15 years.

Table 3.3 shows a possible staging plan based on a 10 year horizon with the current average household size applied to determine the potential population of the estate. It is likely that the population will be less than the estimated 7,020 shown in the table as the planned medium density development will attract singles and couples and thereby reduce the overall average household size.

Table 3.3: Potential Dwelling Unit Development on Murray River Country Estate

	2006	2008	2010	2012	2014	2016
Dwelling Units	301	780	1,260	1,740	2,220	2,700
Population	783	2,028	3,276	4,524	5,772	7,020

Source: Murray River Country Estate, CData 2001

3.3.1 Potential Additional Residential Development Areas

The proponents of MRCE have indicated potential future development areas to the north east and to the west of the estate that could accommodate an additional 1,800 – 2,000 lots. These areas are currently flood prone however advances in technology may allow future occupation. Future growth in these areas is not addressed in this report; however it is worth noting that further residential development would enhance the future viability of retail and commercial outlets in the Village Centre and Mixed Use areas.

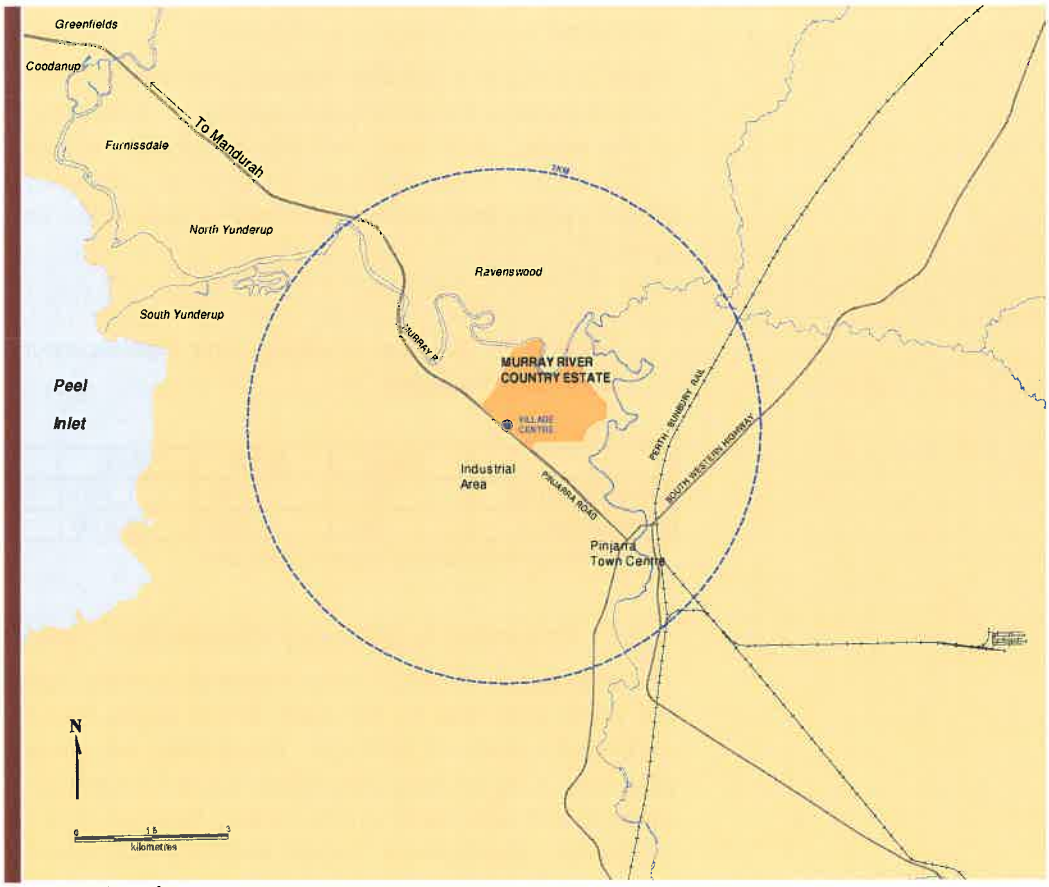
4. Trade Area Analysis

The trade area of a centre is determined by a number of factors including:

- The strength, range and appeal of services offered by the centre
- The proximity and retail offer at competing centres
- The level of accessibility and road transport network in the region surrounding the centre
- Physical barriers such as rivers, freeways or rail lines

The Primary Trade Area is the area from which the highest proportion of a centre's sales is derived with 65% - 75% of sales coming from the PTA. The centre will have a more limited impact on the Secondary Trade Area, generally due to the location of other retail complexes. The extent of trade areas varies according to the centre's function and position in the retail hierarchy.

Figure 4.1: Trade Area



Source: MapInfo

A Neighbourhood Centre is likely to draw customers from within a 1 – 1.5 km radius, however in non-urban areas the draw is greater due to the lack of competing centres and more limited opportunities for shoppers. This report

adopts a 5 km catchment (refer Figure 4.1) which is realistic in the context of the semi-rural nature of the MRCE and its strategic location between Pinjarra Town Centre and Mandurah. The Village Centre's location on Pinjarra Road will provide high exposure which inevitably means that the centre will draw from beyond a normal Neighbourhood Centre catchment and service a much wider geographic area. This has positive implications for the viability of the centre and the strong sense of identity and market presence that develops as a result of this wider exposure.

4.1 Competing Centres

The proximity of competing centres impacts on the geographic extent of a centre's trade areas. The Village Centre will be subject to competition from nearby shopping centres in Mandurah and the existing supermarket and other retail outlets in Pinjarra Town Centre. Higher order retail functions are provided at Mandurah and Rockingham Strategic Regional Centres, Bunbury and Perth. Shoppers will travel further to access these services and it can be assumed that MRCE residents will spend a high proportion of their discretionary (Non-Food) income at these centres.

4.1.1 Strategic Regional Centres

Strategic Regional Centres are multi-purpose centres and the location of major offices and retailing as well as a mix of entertainment, recreation and community facilities. Mandurah Forum and Rockingham City are the closest Strategic Regional Centres to MRCE and will attract a large proportion of local discretionary (Non-Food) spending, and a lower proportion of Food spending.

4.1.1.a Mandurah Forum

Mandurah Forum and the adjacent Mandurah Trade Centre is the main shopping centre in Mandurah. The Centre comprises 38,865 square metres anchored by Kmart, Big W, Coles and Woolworths supermarkets and Archie Martin Vox accompanied by 137 specialty shops including many national traders. There is a 300 seat food court, a fresh food market and 2,317 car parking spaces of which 600 are under cover.

Mandurah Forum is located about 14 km to the west of MRCE with direct access along Pinjarra Road. The 2 supermarket offer attracts many shoppers to Mandurah Forum however shopping industry research indicates that shoppers prefer to do their food shopping close to home at smaller Neighbourhood Centres which offer greater convenience, particularly in terms of being able to park close to entries and exits. The traffic congestion around Mandurah Forum can also deter shoppers from doing their convenience spending at the centre.

4.1.2 Regional Centres

Regional centres are also multi-purpose and provide predominantly a retail function, offices, community and entertainment facilities. Regional Centres generally have a discount department store as well as supermarkets and a full range of specialty stores and retail services (banks, post office, medical suites).

4.1.2.a Amarillo

Amarillo is the future Regional Centre in the area and is anticipated to support a population of up to 80,000 - 90,000 (Inner Peel Region Structure Plan, p.37). Because of its relatively isolated location, Amarillo will require a major Regional shopping centre and a number of Neighbourhood centres to serve its retail requirements. Given its distance from MRCE, it is unlikely that Amarillo will compete with the Village Centre for convenience spending, however it is likely to attract some discretionary spending.

4.1.3 District Centres

There are a number of District Centres available to the residents of MRCE. Meadow Springs, Halls Head and Pinjarra Town Centre are the most likely destinations for Food and Non-Food spending, by virtue of their proximity to MRCE. Anecdotal evidence suggests traffic congestion along Fremantle Road discourages shoppers from travelling to these centres, which augurs well for a local supermarket at the Village Centre. Similarly, the relatively small Supa Valu in Pinjarra offers only a limited range of supermarket and fresh food products which is also likely to discourage shoppers from utilising it for their weekly shopping needs.

4.1.3.a Halls Head Shopping Centre

The centre has 6,200 sqm floor space including an Action supermarket of 3,750 sqm and 2,250 sqm of specialty shop floor space. The centre has approval for a total of 11,600 sqm possibly including a discount department store. Staged expansion up to 20,000 sqm is planned to service a future population of up to 70,000 between Halls Head and Dawesville.

Halls Head is a popular destination for shoppers; however the issue of traffic congestion suggests that an alternative closer to home will reduce the number of MRCE shoppers visiting this centre to do their food and grocery shopping.

4.1.3.b Meadow Springs

The centre opened in 2000 and is anchored by a Coles supermarket (3,016 sqm) and Target discount department store. There are 16 specialty stores including Liquorland, Pharmacy Plus and take away food outlets. Meadow Springs is located approximately 15km to the north west of MRCE. Traffic congestion on Fremantle Road results in lengthy delays at the intersection with Pinjarra Road which acts as a disincentive to shopping there.

4.1.3.c Falcon Shopping Centre

Falcon is the newest shopping centre in the Mandurah region. Shops include Woolworths, pharmacy, award-winning bakery, video store, newsagent, post office, butcher, fruit & vegies, café, hairdresser, a medical centre and a liquor store/tavern. This is a popular centre with residents and visitors and is planned to expand to 17,500 sqm. Again, the relative distance from MRCE provides

an opportunity for the supermarket at the Village Centre to capture the spending of shoppers who currently patronise the Falcon centre.

4.1.3.d Pinjarra Town Centre

There is limited opportunity for shopping in the Pinjarra Town Centre and limited potential for expansion of retail facilities due to difficulties of land assembly to meet the needs of major supermarkets and discount department stores. For this reason, a new and larger supermarket in the Village Centre coupled with fresh food outlets at MRCE can potentially capture Food expenditure from Pinjarra.

Pinjarra will maintain its town centre status as it is an important service centre for the surrounding rural community and offers retail and business services, civic, tourism and service functions that are not available at lower order centres such as MRCE. These higher order functions will continue to attract shoppers and visitors to Pinjarra which will serve to maintain its primacy in the Shire of Murray.

4.1.4 Neighbourhood Centres

Neighbourhood Centres are designed to cater for daily convenience shopping and local services. In the context of Liveable Neighbourhoods, the role of a Neighbourhood Centre is strengthened by extending complementary uses to adjacent Mixed Use areas. These create the critical mass that supports the functioning of the retail and service tenancies and helps to establish the centre as a hub of community focus and activity.

4.1.4.a The Proposed Village Centre

The intention for the Village Centre is to create a people-friendly supermarket based centre that reflects the heritage environment of nearby Pinjarra. It will be a main street centre offering a range of uses that complement, rather than compete with, existing retail outlets and services in Pinjarra.

The centre will be integrated with adjacent medium density residential development which will encourage pedestrian activity within the centre. The church, child care facility, open space and built form will create the sense of place that will make the Village Centre a destination for residents of the estate and for shoppers from further afield. The social and economic sustainability of the Village Centre relies on shoppers being able to satisfy their convenience shopping needs close to home in a well designed centre that creates a unique sense of place and identity. Co-location with higher residential density will create a level of activity in the Village Centre and Mixed Use areas not experienced elsewhere in the region and adds to the critical mass that creates atmosphere and energy and a place people want to be.

The Mixed Use development provides the convenience of professional and commercial services close to home and street activity during the day. Mixed Use developments attract non-retail uses such as dentists, medical suites, real estate offices and personal services with residential above street level. The inclusion of cafes and restaurants, the proximity to community facilities and the walkability of the centre will create activity after hours which further contributes to the sustainability of the centre.

5. Demographic Analysis

5.1 Population

Figure 4.1 in the previous section illustrates the strategic location of the proposed Village Centre on Pinjarra Road between Pinjarra Town Centre and the growth areas of Furnissdale and Yunderup. The majority of the centre's customers will originate from this catchment and a smaller proportion will originate from beyond this area. At the time of the 2001 Census, the 5 km catchment was home to 5,560 persons accommodated in 2,055 households.

5.2 Demographic Analysis

The size and demographic characteristics of a population are a reliable indicator of the spending patterns of that group and the demands for goods and services they will generate. Demographic analysis is a useful tool to understand the structure of a population so that targeted services and facilities can be provided to suit the needs of that population.

A full demographic analysis is found in Appendix 1; following is a brief snapshot of the Village Centre's trade area.

5.2.1 Demographic Snapshot

The following snapshot highlights the key characteristics of the Village Centre trade area.

Table 5.1: Household Medians in the Village Centre's Trade Area

	Trade Area	Peel Region
Median age	42 years	38 years
Mean household size	2.7	2.7
Median household income	$600 - $699 per week	$700 - $799 per week

Source: CData 2001

Key features are:

- A relatively old catchment – a median age of 42 years compared to Peel median of 38 years
- Below average proportion of young children and teenagers
- Few young adults (20 – 29 years)
- A higher than average proportion of persons aged over 50 years
- An average distribution of Family and Lone Person households
- Higher than average proportion of Couple households (41% of all households are comprised of 2 people)
- The mean household size of 2.7 persons is average for the Peel region
- No significant groups of overseas born persons

- A lower than average household income of $600 - $699 per week, reflecting the older age groups on fixed incomes
- Relatively high levels of unemployment (14% at the time of the Census) – the unemployment rate in the Peel Region was 11% and this was one of the highest in the State at the time
- Average proportions of home ownership (39% owned outright, 30% dwellings have a mortgage)
- Relatively low commitment to mortgage, which is related to the older age profile
- Below average rental costs – 37% of households pay less than $100 per week rent. This is also related to low incomes and the types of property available to rent
- A relatively low skilled workforce with below average number of workers with a university or technical qualification
- Average levels of car ownership which is important to shoppers having convenient access to the centre

5.3 Implications for the Village Centre

The amount of expenditure available to a centre is a critical factor in determining the amount of floor space the centre can sustain. An analysis of the spending available to a centre can also confirm or contest the provision of retail floor space for various types of centres in the retail hierarchy recommended in the Metropolitan Centres Policy. While the Metropolitan Centres Policy does not apply to retail floor space allocation in the Peel Region, it is a useful guide to compare equity of access to retail services.

The objective of the following analysis is to ascertain how much floor space can be viably sustained at the Village Centre. The analysis applies the population growth rates of the Shire of Murray (refer Table 3.2) to the population within the 5 km catchment to estimate future expenditure. This approach is supported by The Peel Region Structure Plan which indicates that most of the growth projected for the Shire of Murray will occur within or close to the 5 km catchment. This has positive implications for the future economic sustainability of the Village Centre which should be developed with a view to future expansion as demand in the surrounding area increases.

5.3.1 Available Expenditure

Based on the ABS Household Expenditure Survey and the income group of the MRCE 5 km catchment, there is currently a gross amount of:

- $16.7 million available for Food spending
- $26.0 million available for Non-Food spending

within the catchment.

By 2015 this increases to:

- $21.6 million for Food spending and $33.4 for Non-Food spending

By 2025 the catchment could potentially have:

- $38.7 million available for Food spending and $60 million available for Non-Food spending

Table 5.1: Estimated Gross Household Spending in MRCE 5km Catchment

	2005	2010	2015	2020	2025
			$M		
Food spending	$ 16.7	$ 17.9	$ 21.6	$ 27.9	$ 38.7
Non-Food spending	$ 25.9	$ 27.7	$ 33.4	$ 43.1	$ 60.0
TOTAL	$ 42.6	$ 45.5	$ 55.0	$ 71.0	$ 98.7

Source: ABS Household Expenditure Survey 1998-99, CPI Dec 2005, Cdata 2001, WAPC Western Australia Tomorrow, Population Report No.6, Updated Tables

5.3.2 Food Spending

The ABS Household Expenditure Survey indicates that 70% of Food expenditure is spent at supermarkets and the remaining 30% is spent on Food specialties and take-away food etc. When this distribution is accounted for, Table 5.2 shows:

- There is currently $11.7 million available for supermarket spending in the catchment
- Approximately $5.0 million available for spending on specialty food products

Most of this spending is currently leaking out of the catchment with a small proportion being spent at the Supa Valu store in Pinjarra. It can be assumed that supermarkets and specialty food stores at Mandurah Forum, Meadow Springs, Halls Head and Falcon are capturing most of this spending.

Table 5.2: Distribution of Food Spending

	2005	2010	2015	2020	2025
Supermarket ($M)	$ 11.7	$ 12.5	$ 15.1	$ 19.5	$ 27.1
Food Specialties ($M)	$ 5.0	$ 5.4	$ 6.5	$ 8.4	$ 11.6

Source: ABS Household Expenditure Survey 1998-99, CData 2001

The supermarket at the Village Centre has the opportunity to retain a large proportion of the available supermarket spending due to the lack of competition within the catchment. The Centre's strategic location on Pinjarra Road will result in its area of influence extending beyond the normal Neighbourhood catchment, and attract customers from a wide area which contributes to its viability and strengthens its identity. The opportunity for spending at the local level will reduce leakage of expenditure out of the area and alleviate the inconvenience of travelling to Mandurah for food and grocery shopping. A supermarket can be supported by fresh food specialty stores offering a range of fruit and vegetables, delicatessen products, cheese, breads etc. Cafes and restaurants will also encourage residents to linger at the centre, to socialise close to home and thereby add to the vibrancy of the Village Centre.

5.3.3 Non-Food Spending

The ABS Household Expenditure Survey indicates that Discount Department Stores capture 17.9% of all Non-Food expenditure with the remainder being spent on fashion and footwear, pharmaceuticals, petrol, garden products etc. Table 5.3 shows that $4.7 million is available in the catchment for DDS spending and $21.2 million for Non-Food specialties spending. Most of this expenditure is being spent at shopping centres in Mandurah, Rockingham or Perth as there is little or no opportunity to make these types of purchases within the catchment area.

Table 5.3: Distribution of Non-Food Spending

	2005	2010	2015	2020	2025
Discount Department Stores ($M)	$ 4.7	$ 5.0	$ 6.0	$ 7.8	$ 10.8
Non-Food Specialties	$ 21.2	$ 22.7	$ 27.4	$ 35.4	$ 49.2

Source: ABS Household Expenditure Survey 1998-99, CPI Dec 2005, Cdata 2001,
WAPC Western Australia Tomorrow, Population Report No.6, Updated Tables

The Village Centre will capture a relatively small proportion of the available Non-Food spending as Neighbourhood Centres traditionally provide only a limited range of specialty stores. However, based on the prolonged strong growth in the catchment and the lack of competition from other Neighbourhood Centres there is clearly an opportunity to establish specialty tenancies that will provide residents and visitors with the opportunity to make discretionary purchases close to home.

The tourism facility on Murray River Country Estate will attract visitors looking to spend on food and drink, cafes, gifts, books, clothing and mementoes to remember their Murray River experience.

5.3.4 Sustainable Floor Space

Based on the available expenditure detailed in this chapter and Australian average productivities for Neighbourhood Centres, the analysis indicates that the Village Centre could support:

- 3,000 sqm – 3,300 sqm of retail floor space currently
- 3,900 sqm – 4,300 sqm by 2015
- 5,000 sqm – 5,500 sqm by 2020

Table 5.4: Estimated Sustainable Floor Space at the Village Centre

Village Centre 5 km catchment	2005	2010	2015	2020	2025
Estimated population	5,671	6,066	7,329	9,457	13,157
Estimated floor space based on MCP* (sqm)	3,006	3,215	3,884	5,012	6,973
Estimated floor space based on available expenditure (sqm)	3,340	3,573	4,317	5,570	7,750

Source: ABS, Metropolitan Centres Policy, WAPC

* Metropolitan Centres Policy average of 0.53 sqm/capita for Neighbourhood Centres

5.3.5 Additional Sources of Expenditure

The estimates detailed above do not take into account expenditure from passing trade along Pinjarra Road or from the industrial estate on the southern side of Pinjarra Road opposite the Village Centre. This expenditure is difficult to quantify but it can be assumed that these sources will provide a regular stream of spending for convenience tenancies at the centre.

It is understood that the industrial estate is to undergo significant expansion in the near future. Workers are likely to purchase food and drink and utilise services such as bank, post office, dry cleaning, newsagency and commercial services. Similarly, the capture of passing trade along Pinjarra Road will rely on good exposure and easy access and egress from the centre.

6. Conclusions and Recommendations

This report has established that the proposed Village Centre at Murray River Country Estate is well located to benefit from projected high and sustained population growth in the centre's area of influence over the coming decades. There is an obvious gap in the provision of convenience centres outside Mandurah and the Village Centre's strategic location on Pinjarra Road will provide shoppers from a wide geographic area with the opportunity to do their food and grocery shopping and make other convenience retail purchases close to home without having to navigate the traffic congestion in Mandurah.

The report has also established that the strategic location of the proposed centre on Pinjarra Road will result in its area of influence extending beyond the normal Neighbourhood catchment, attracting customers from a wide area which contributes to its viability and strengthens its identity. Opportunities for spending at the local level are to be fully encouraged to avoid leakage of expenditure out of the area.

The provision of retail services at MRCE complements those available in Pinjarra town centre, which in its capacity as the principal service centre for the Shire of Murray, will continue to provide higher order functions than will be available at the Village Centre. The primacy of Pinjarra is to be maintained and is recognised by the proponents of MRCE.

The report has also established that the floor space guide recommended in the Metropolitan Centres Policy slightly underestimates the floor space the market will support. It is prudent to be aware that the income profile of the catchment could change over the next decade as more affluent households move into the area. The reported high increases in property values ultimately mean that higher income families will be attracted to the area which has positive implications for the viability of the Village Centre.

The viability of the centre will be further enhanced by passing trade and its proximity to the soon to be expanded Pinjarra industrial area located opposite the centre on the southern side of Pinjarra Road. Proximity to the industrial area also allows future tenancies at the Village Centre and in the Mixed Use centre to provide complementary services such as hardware, stationery, office supplies, printing, catering and deliveries.

The proposed Village and Mixed Use Centre at Murray River Country Estate not only offers a viable and exciting retail component, it also creates a community focus in a people friendly environment that will make the centre unique in the Peel Region.

6.1 Recommendations

This report recommends that:

- A 5,000 sqm supermarket based centre with supporting fresh food specialty stores be developed.

- The supermarket occupy 2,000 sqm – 2,500 sqm to provide a suitably large offer that will meet the demand for the weekly food and grocery needs of the catchment and allow for increased demand in the future.
- The centre be allowed to develop to its full potential now in order to permit development of a fully integrated centre, to contain development costs and to avoid an under provision of floor space in the future.
- The centre be allowed to consolidate over the next 15 – 20 years and should there be unmet demand for further retail floor space at this time, consideration then be given to rezoning commercial floor space for retail uses.
- Should a Mixed Use centre be developed opposite the tourism facility, tenancies should be related to tourism activities.
- The centre operates extended hours to attract after hours and weekend shoppers.
- Connectivity and complementarities within the centre be developed to strengthen its viability.
- The centre reflect Liveable Neighbourhood and Main Street principles.
- The centre takes account of the catchment's market capacity to support additional floor space and that sufficient floor space be allocated to reflect this capacity.
- The centre be allowed to become a destination for convenience food outlets to support the community facilities and lifestyle tenancies planned for the centre.

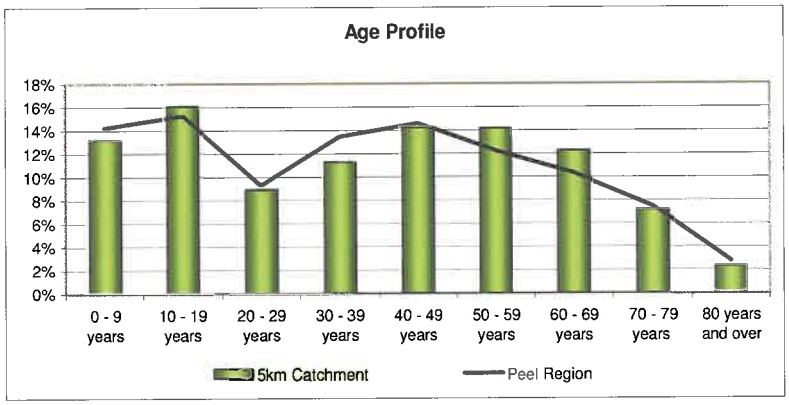
Appendix 1

Demographic Analysis

POPULATION & DWELLING PROFILE

Project Name	**Murray River Country Estate**		
Client	**Taylor Burrell Barnett Town Planning and Design**		
Study Area 1	**Murray River Country Estate 5km Catchment**	Project No	**41917**
		Date	**Mar-06**
Comparison area	**Peel Region**		

	5km Catchment	Peel Region
Population	5,560	71,000
Households	2,055	26,500
Dwellings	2,491	33,824
Median Age	42 years	38 years



Age Decile	5km Catchment	Peel Region
0 - 9 years	**13%**	**14%**
10 - 19 years	16%	15%
20 - 29 years	9%	9%
30 - 39 years	11%	13%
40 - 49 years	14%	15%
50 - 59 years	14%	12%
60 - 69 years	12%	10%
70 - 79 years	7%	7%
80 years and over	2%	3%

Trends & Implications

- There are relatively few young children (0 - 9 years) in the catchment which is reflected in fewer than average 30 - 39 year olds, the parents of the young children.
- Teenagers are more common in the catchment than in Peel overall which accords with reports that purchasers in Murray River Country Estate are 2nd and 3rd home buyers. These tend to be more mature families with teenage children.
- There is a dearth of young adults (20 - 29 year olds) both in the catchment and the Peel Region generally. This relates to employment and educational opportunities in the region as well as appropriate and affordable housing.
- 30 - 39 year olds are less common in the catchment than in Peel overall and contributes to the relatively high median age of 42 years. By comaprison, the Peel median is 38 years which is also higher than the WA median of 34 years.
- There are more persons aged 50 - 69 years in the catchment than is common in the Peel Region, which suggests the appeal of the area for retirees and the young elderly.
- By the time people have reached their 70s, they appear to be moving away from the area as the over 70s have average representation in the area, though thery are significantly more common in Peel and the catchment than in the Perth metropolitan area.

HOUSEHOLD TYPE PROFILE

Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

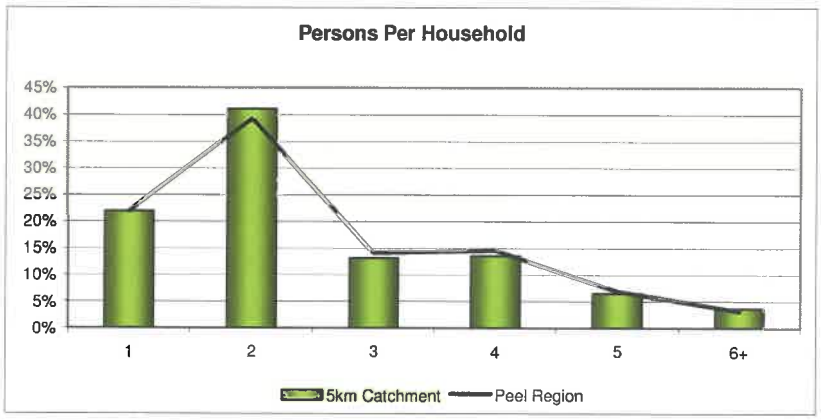
Study Area 1 **Murray River Country Estate 5km Catchment**

Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

Household Type	5km Catchment	Peel Region
Family	76%	76%
Lone person	22%	22%
Group	2%	2%

Household Type	5km Catchment	Peel Region
1	22%	22%
2	41%	39%
3	13%	14%
4	14%	15%
5	7%	7%
6+	4%	3%
Average No. of persons	*2.7*	*2.7*



Trends & Implications

- The distribution of household types resident in the catchment is very similar to those found in the Peel Region.
- The majority of households are Family households (76%) comprised of Couples and Couple Families with children.
- Lone Person households (22%) are less common in the area than they are in the Perth metropolitan area where 25% of households have only one person. This is the fastest growing household type and it is feasible that the proportions have increased since the last Census.
- Group households have only average representation which indicates there are no retirement villages or nursing homes in the catchment.
- Household type has implications for the amount of spending available to the Village Centre. Family households are likely to have more working adults than Lone person households which rely on a single income or pension in the case of older persons, which effectively limits spending available to the cetnre.

FAMILY TYPE PROFILE

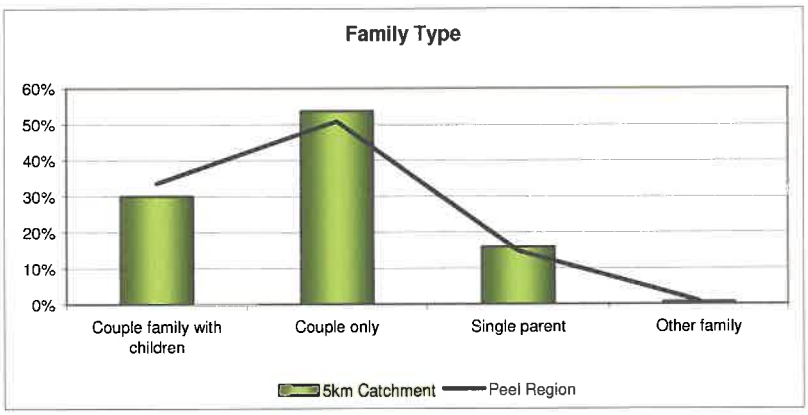
Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

Study Area 1 **Murray River Country Estate 5km Catchment**

Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

Family Type	5km Catchment	Peel Region
Couple family with children	30%	34%
Couple only	54%	51%
Single parent	16%	15%
Other family	1%	1%



Trends & Implications

- Of all Family households, there are significantly more Couple only households than Families with children.
- These are likely to be older couples which is reflected in the high median age of 42 years in the catchment and the low numbers of young adults.
- More than every one in two households is comprised of an older Couple which also has implcations for the types of tenancies and services that his group will require from the Village Centre.
- There are average proportions of Single Parent families who generally seek affordable accommodation and access to public transport and support services.This group generally has limited income which also has implications for the amount of spending available to the Village Centre from this group.

INCOME PROFILE

Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

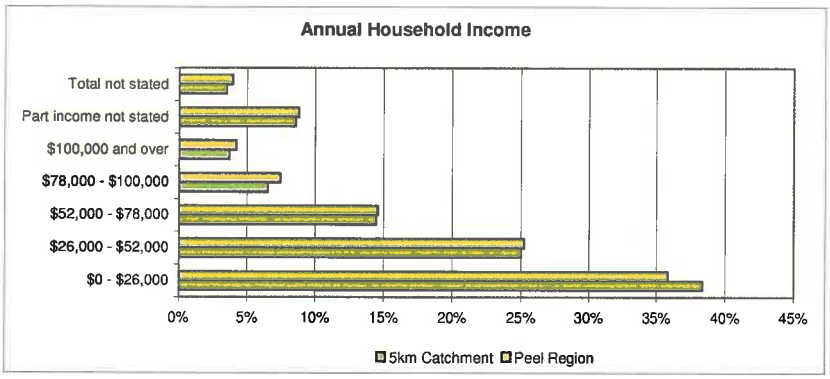
Study Area 1 **Murray River Country Estate 5km Catchment**

Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

	5km Catchment	Peel Region
$0 - $26,000	38%	36%
$26,000 - $52,000	25%	25%
$52,000 - $78,000	14%	15%
$78,000 - $100,000	7%	7%
$100,000 and over	4%	4%
Part income not stated	9%	9%
Total not stated	3%	4%

Median Household Income	$600 - $699 pw	$700 - $799 pw
WA Median	$700 - $799 pw	



Trends & Implications

- Incomes are generally lower in the catchment than in the Peel Region overall with a higher porportion of low-income households (38%) than elsewhere in Peel (36%).
- The median household income is also lower than both the Peel and WA state average of $700 - $799 per week.
- Given the age structure of the catchment, it can be assumed that the older Couple households are likely to be low-income households while the Families with children will belong to the higher income groups.
- This is important as Families with children generally demand a wider range of goods and services than smaller households and will have more expendable income than the fixed income households of retirees.

HOUSING PROFILE

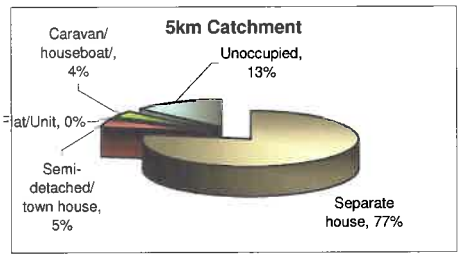
Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

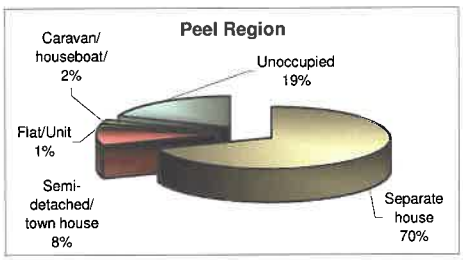
Study Area 1 **Murray River Country Estate 5km Catchment**

Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

	5km Catchment	Peel Region
Separate house	77%	69%
Semi-detached/town house	5%	8%
Flat/Unit	0%	1%
Caravan/houseboat/	4%	2%
Unoccupied	13%	19%
Nature of Occupancy		
Fully owned	39%	40%
Purchasing	30%	32%
Owner occupied	*70%*	*71%*
Rented	19%	20%
Other	10%	9%





Trends & Implications

- The majority of dwellings within the catchment are detached houses (77%) with few semi-detached dwellings (5% only).
- The ODP for the Murray River Country Estate indicates development of more medium and high density dwellings with the market targeted at both younger and older singles and couples households. These higher densities will serve to create a level of activity around the Village Centre and Mixed Use area that contributes to the sense of vibrancy at the centre. The range of resdiential densities and variety of housing types catering to different household structures creates a more sustainable outcome for the centre and the community.
- There is a relatively higher rate of Unoccupied dwellings (13%) in both the catchment and the region (19%) which is clearly related to the high number of holiday homes in the area which have only occasional occupation. It can be assumed that this figure will decrease over time as more full time residents move into the area. The occupation rate has implications for the amount of regular expenditure available to the retail outlets at the centre.
- The proportion of fully owned dwellings is higher than in Perth which is related to the older age groups resident in the area who are more likely to own their dwelling outright.
- The high proportion of owner occupiers and relatively low rentals suggest a stable population with habitual shopping habits which has positive implcations for the centre.

EDUCATION & OCCUPATION PROFILE

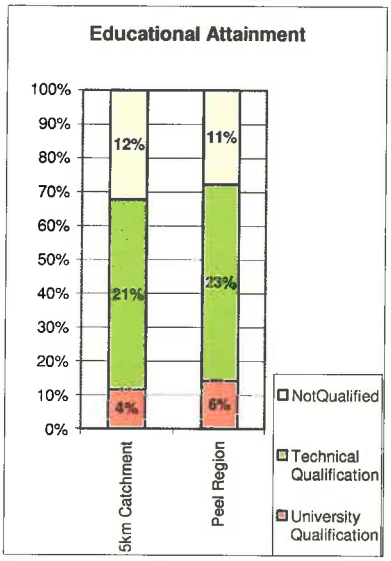
Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

Study Area 1 **Murray River Country Estate 5km Catchment**

Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

Education Level attained	5km Catchment	Peel Region
University Qualification	*4.3%*	*5.7%*
Postgraduate Degree	0%	0%
Graduate Diploma and Graduate Certificate	1%	1%
Bachelor Degree	4%	5%
Technical Qualification	*21%*	*23%*
Advanced Diploma and Diploma	4%	5%
Certificate	17%	18%
Not stated	3%	3%
Not applicable	63%	60%
TOTAL Qualified	***25%***	***29%***
NotQualified	***12%***	***11%***



Trends & Implications

- The low proportion of Professionals/Managers living in the catchment is reflected in few persons having a university qualification (4.3% only). By way of comaprison, in the metropolitan area 14% of workers are university educated.
- It is more common to have a technical qualification and 21% of workers have this level of qualification, which is marginally lower than elsewhere in Peel (23%). These averages are similar to the metropolitan average which indicates regional areas are more attractive to non-university educated workers.
- The educational attainment relates to the types of industries people work in and the high proportion of technical workers is reflected in their participation in primary industry and manufacturing, transport industries.

MOBILITY PROFILE

Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

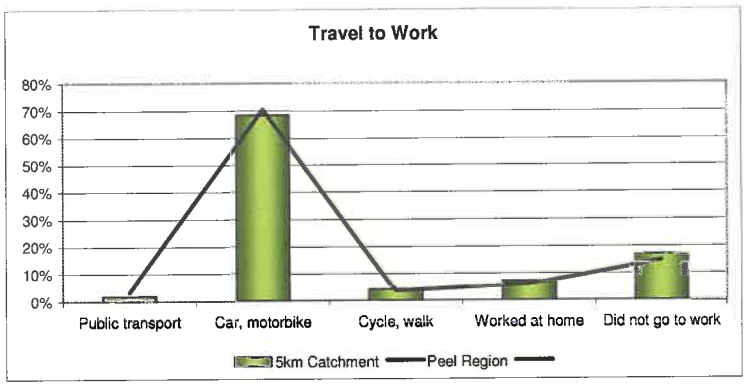
Study Area 1 **Murray River Country Estate 5km Catchment**

Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

	5km Catchment	Peel Region
Public transport	2%	3%
Car, motorbike	68%	70%
Cycle, walk	4%	4%
Worked at home	7%	6%
Did not go to work	17%	15%

% households with:	5km Catchment	Peel Region
No cars	4%	5%
1 car	33%	31%
2 cars	29%	29%
3 cars or more	13%	13%
Not stated	5%	4%



Trends & Implications

- The very lowr ates of using public transport to travel to work indicates poor public transport infrastructure in the region. The majority of workers (68%) use private transport to travel to work.
- It l interesting to note that slightly more persons worked from home in the catchment (7%) than in Peel generally (6%) and both these rates are significantly higher than their counterparts in the Perth metropolitan area where only 4% of persons worked from home at the time of the census in 2001. This suggests the catchment is keeping abreast of technology and people are moving to the region as technology allows them remote access to workplaces.
- Car ownershop is common with very few households (4% only) not having access to a vehicle. Almost two out three households has access to one or two vehicles.
- This is important to the Village Centre as easy access and convenience is a key driver of people's shopping behaviour. While the higher densities around the centre means these residents will be able to walk to the retail outlets located there, most shoppers will require easy access and convenient parking to expedite the shopping trip.
- It is unlikely that the centre will be able to rely on public transport to deliver shoppers to the centre, however this will become increasingly important as households age and are comprised of older shoppers who no longer have access to a private vehicle.

ORIGIN & RELIGION

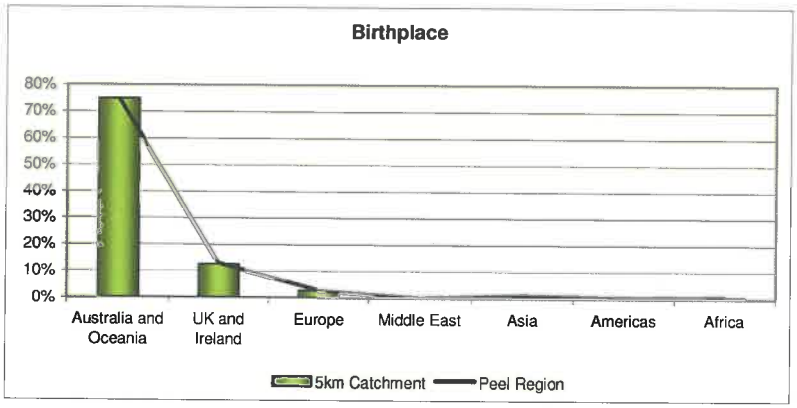
Project Name **Murray River Country Estate**
Client **Taylor Burrell Barnett Town Planning and Design**

Study Area 1 **Murray River Country Estate 5km Catchment** Project No **41917**
Date **Mar-06**

Comparison area **Peel Region**

Origin	5km Catchment	Peel Region
Australia and Oceania	75%	75%
UK and Ireland	13%	13%
Europe	3%	3%
Middle East	0%	0%
Asia	1%	1%
Americas	0%	0%
Africa	1%	1%

Religion	5km Catchment	Peel Region
Christian	62%	64%
Non-Christian	0%	1%
Other	0%	0%
No religion	21%	21%
Not stated	14%	13%



Trends & Implications

- The majority of residents are Australian born (75%) or of British or Irish origin (13%). There are few overseas born persons in the catchment or in the Peel Region.
- This pattern suggests that migrants are less inclined to reside in regional areas and prefer the metropolitan cities however, as job opportunities increase in the region this will attract newcomers to the area.
- In terms of religion, the area is predominantly Christian however one in five persons does not have a religion.
- There are significantly fewer non-Christians in the area than is found in Perth, which is related to the few overseas born persons in the area.
- This profile suggests there may not be a strong demand for exotic food or beverage products.

APPENDIX 5
MRCE ODP Servicing, Urban Water Management & Engineering Aspects
Dennis Price & Miller

7090 - ODP

18 November 2006

Taylor Burrell Barnett
PO Box 8186
Subiaco East WA 6008

Attention: **Isla Finlay**

Dear Sir

MURRAY RIVER COUNTRY ESTATE - OUTLINE DEVELOPMENT PLAN SERVICING, URBAN WATER MANAGEMENT & ENGINEERING ASPECTS

In the report that follows Dennis, Price & Miller has examined the servicing and preliminary drainage requirements on the above site as a part of the process to prepare an amended Outline Development Plan (ODP). The new ODP is being prepared by the Town Planner, Taylor Burrell Barnett for Murray Riverside Pty Ltd.

Dennis, Price & Miller is the lead consultant in conjunction with Taylor Burrell Barnett and these firms are supported by the following specialised project team members:-

Ecoscape – environmental consultant
Douglas Partners – geotechnical and acid sulphate soil (ASS) strategies and management
Jenkins Clifford – electrical engineering and communications
JDA Consulting Hydrologists – stormwater drainage hydrology and groundwater modelling
Hydro-Plan – irrigation and water resources
McMullen Nolan – survey and mapping
Plan E – landscape architect
Transcore – traffic engineering

Specific comments on servicing and developing the land follow:-

1. Water supply

All lots are to be serviced by a water reticulation system to be installed by the Developer and subsequently taken over and operated by the Water Corporation. The existing development and all future areas are to be connected to the existing infrastructure fed from the North Dandalup Water Scheme.

A ring main feeder system will distribute water along the local distributor roads within the proposed ODP area and then standard water reticulation mains are to be extended from the distribution mains to service each of the lots created.

2. *Sewerage*

All lots are to be serviced by a sewer reticulation system to be installed by the Developer and subsequently taken over and operated by the Water Corporation. An existing wastewater pumping station is located near the northern edge of the development in a central location that serves both land parcels located on each side of the Western Power transmission line easements that cross the middle of the subject land.

The site has a shallow groundwater level, it is relatively flat and dewatering will be required for much of the sewer installation. Prior to construction subsurface investigations along the sewer routes would be completed to assist in the preparation of specific acid sulphate soil management plans for the excavation and dewatering for the sewer installation. This is required to obtain dewatering permits from the Department of Environment (DoE) and to prevent the creation of acid from potential acid sulphate soils. Planning Bulletin Number 64, prepared by the WAPC show the area as a moderate to low risk of AASS (actual acid sulphate soils) and PASS (potential acid sulphate soils) occurring generally at depths > 3m. More details on the ASS issues follow later in this report.

3. *Urban Water Management - Stormwater Drainage*

This report presents the initial concepts for the integrated urban water management of the site. The initial urban water management concepts discussed will be split into the two major areas of quality and quantity. The concepts for the stormwater management are based on the *Decision Process for Stormwater Management for WA* (Department of Environment, 2005), the *Peel-Harvey Coastal Catchment WSUD Technical Guidelines* (Peel Development Commission October 2006) and the *Peel-Harvey WSUD Local Planning Model Policy* (October 2006). These documents stipulate water quality management targets via statutory documents such as Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992 (EPA, 1992). To demonstrate compliance with these targets an assessment using the *MUSIC* Model can be used. At present this model requires the DEC to calibrate it to WA conditions. This report also highlights quality and quantity objectives based on various stormwater events as follows:

> The 1-year storm – namely events up to a 1 in 1-year average recurrence interval (ARI);
> Minor Storm Events – namely events greater than a 1 in 1-year and less than a 1 in 10-year ARI (i.e. the 1 to 10-year storms);
> Major Storm Events – namely events less frequent than the 10-year storm and up to the 1 in 100-year ARI (i.e. the 100-year storm).

Preliminary storage model calculations have been completed to reduce the outlet surface water flows from a fully urbanised catchment back to the pre-development status. This report provides some detail as to the type of storage facilities and location of these in the planning layout.

Quality of the surface water and groundwater are to be addressed by a number of studies and subsequent modelling currently initiated by the developer's project team and various authorities. The Department of Conservation and Environment (DEC) has set out some basic guidelines for data collection of surface water and groundwater information. This is to be provided on a staged basis through the subdivision process. One of the criteria to be addressed is a specified reduction in nutrients from the stormwater system when compared to the traditional piped drainage system. A suite of design tools is available to incorporate at the detailed design stage but a number of initiatives can be taken at the early planning process to achieve the objectives. As the development process proceeds to when particular plans of subdivision receive conditional approval, the concept proposed is proved in more detail with various data gathered from groundwater and surface water investigations and modelling. At the ODP stage only a drainage concept is to be provided. A programme of data gathering and modelling is to be initiated that would prove the drainage concept validity or require it's modification as required during the future planning milestones.

3.1 General Concept

The major considerations for the site in terms of stormwater quantity are the 100-year flood levels created by the Murray River, the relatively flat nature of the site and the high groundwater in winter. The 100-year flood requires storage within selected areas of the POS areas on site with top water levels higher than that occurring in the Murray River. The detailed drainage design will include checking of scenarios such as high flows in the Murray River combined with high site flows and low site flows combined with high River flows. In limited parts of the subject land (i.e. the river's flood fringes), fill is to be placed to provide a minimum of 0.5m freeboard above the predicted 100-year flood levels of the site.

A series of open spaces are proposed to be utilised as drainage storage and conveyance for stormwater events exceeding the 1-year storm. All of the site catchment areas generally drain to the Murray River. In combination with this is a system of shallow vegetated soakage swales on selected streets to enable soakage of the low recurrence interval storms (i.e. less than the 1-year storm) as high in the catchment as possible. Where swales are not practical, the drainage system will be designed with more gully and junction pits to operate as soakwells. The swales will also create flood routes to the POS storage areas for the less frequent storm events. This strategy maximises infiltration, where possible, at the source for the 1-year storm events. Road grading design will be such that all roads will fail safe – namely where excess runoff is conveyed along the road reserve without flooding any houses to nearby POS areas. Where roads abut the POS, the pavement will crossfall to the POS and flush kerbs along that side will ensure that runoff "sheets" into grassed swales alongside the roads and within the POS.

3.2 Site Subsurface Soil and Groundwater

Monitoring bores are already provided across the whole site and monitored at regular intervals. These bores will be used to calibrate the information currently available from the existing DoE, Water Corporation and private bores. A suite of tests is to be undertaken on the groundwater samples from these monitoring bores to assist with a drainage nutrient model and to confirm there are no contamination issues. There is no evidence to suggest that there is now or will be

an issue. Testing and monitoring to date has confirmed that the existing drainage system installed under the approved 1998 Drainage Management Plan (ref LeProvost Dames & Moore May 1998) has been operating within expected and acceptable criteria.

In their "Aquifer Review Report" for the period from July 2004 to June 2005 and lodged with the DoE, Hydro-Plan stated that "*Groundwater is of fresh quality and acidic to near neutral with surface waters near the Murray River tending to be brackish. Previous and current analysis indicate that nutrient levels are low within the groundwater samples.*" In their report for the previous twelve months, Hydro-Plan also said "*... it can be concluded that site activities are not adversely affecting the groundwater nutrient levels.*"

In their report "Murray River Country Estate Groundwater Investigation (June 2006), the Hydrologist JDA Consultant Hydrologists advised that:-

"*To facilitate land development it is desirable to install subsoil drainage at a level below AAMGL within the zone of seasonal groundwater variation to minimise imported fill requirements. The average difference between AAMGL and AALGL is approximately 1m and therefore a reduction in AAMGL if just 0.5m will allow for lowering of the water table whilst minimising potential problems with acid sulphate soils.*

It is important that the Controlled Groundwater Level (CGL) does not adversely impact on significant wetlands on the site that are to be retained in the revised ODP. To maintain the natural hydrology in and around the wetlands and to minimise drawdown effects from drainage on wetland water levels, a 100 metre drainage buffer should be applied around the outskirts of all ODP wetlands."

There is a general minimum requirement of 1.2m minimum separation between the CGL and the lot levels for residential development. The CGL's are to be set on a broad scale and are designed to maintain water levels where necessary for the maintenance of wetland quality. The development proposes to maintain the groundwater levels around the wetlands to the pre-development state but lower them elsewhere where possible. Initial monitoring bore measurements indicate that extensive fill would be required in the western part of the subject land if CGL's are not adopted to achieve a minimum vertical separation of 1.2m. A combination of groundwater monitoring and modelling ("*modflow*") will be undertaken during the detailed design phase to ensure that the subsoil drainage system is designed at depths to ensure that the reduced CGL's will not impact on the wetlands. In other words, during the detailed design phase, the extent of filling above the forecast groundwater levels and the desired CGL will be specifically balanced to ensure there is no negative impact on the wetlands.

The geotechnical consultant, Douglas Partners completed an investigation of the geotechnical conditions of the whole site and reported in November 2005 that the subsurface conditions beneath the overall development area are generally comprised as follows:-

Western Portion

Inter-bedded layers of clayey-silt, sandy-clay, clay, sand and clayey sand (more generally

described as alluvium) within the northern area adjacent to the River – the River's floodplain.

Medium dense grey, fine to medium grained sand grading to dark brown (Bassendean Sand) overlying inter-bedded layers of grey to grey-brown, clayey sand, sand and sandy clay within areas to the south of the River floodplain to Pinjarra Road.

Eastern Portion

Loose to medium dense, light grey to grey, fine to medium grained sands (Bassendean Sand) and similar Alluvium soils as noted above in the western portion within the River floodplain.

3.3 Minor Stormwater Events

Street drainage is proposed to be directed to vegetated swales within the verge at the side of connecting east west roads for soakage of the 1-year storm events and storage of up to the 3-year events. It is proposed via a planned grid pattern of streets to allow road stormwater to flow down street gutters for up to 100m in length and discharge at the end of a street grid to a vegetated swale that runs alongside the side verge of a connecting street. To avoid problems of crossovers over the swale the street and lot pattern has been arranged so that side boundary fences abut the swales. Due to the subsurface conditions it is proposed to have subsoil drainage system in each street, including underneath the swales.

Lots are planned to front the opposite side of the street to the swales. By rotating the grid pattern to suit existing roads and features the streetscape can be planned to provide traffic calming, a pleasant outlook and reduce the length of streetscape with the swales and side boundary fences on one side. The swales are to be sized to allow soakage of a 1-year event and storage capacity for a 3-year storm event from the road catchments. The swale length and capacities are designed to overflow to specifically lowered areas within the POS areas once the 3-year storm recurrence interval design has been exceeded. The catchment for the swales and the size of the swales are sized to suit the 3-year storm capacity for storage and 1-year storm event for soakage (i.e. contained locally) within the swale. A variety of storm durations are required to be tested for each swale and catchment.

A preliminary catchment plan showing the street grids, POS, swales, outlets from each catchment is included in Appendix A. Typical cross sections of the streets with side swales are enclosed in Appendix B.

Where longitudinal grades of the streets with side verge swales exceed 2% it is proposed to use a traditional piped drain that would discharge to a swale located in a street with longitudinal grades less than 2%.

The lot drainage is proposed to be discharged on each lot via soakage where possible or connected to the street pipe stormwater system. In Sand where a minimum of 1.5m minimum clearance can be achieved to the AAMGL onsite soakage from each lot is proposed. In Sand where a minimum of 1.2m of clearance is available onsite soakage from each lot with a

combination of subsoil drainage within the street is proposed.

In circumstances where the subsurface conditions require lot drainage connections for roof drainage these can be piped directly to a piped stormwater system via piped lot connections. A pipe drain (with subsoil drainage) is to be located under the proposed swales with discharge to the selected areas within the proposed open space areas.

Major flood routes are to be considered in the detailed engineering design stage with safe flood paths to storage areas in the POS and subsequent overflow to the receiving water bodies (i.e. the Murray River).

3.4 Major Stormwater Events

The northern part of the site (outside most of the area the subject of the amended ODP) is predominately within the floodway of the Murray River. A narrow flood fringe defines the area between the floodway and the southern and major part of the development area. This flood fringe forms the northern boundary of the land the land that is the subject of the amended ODP. Development is planned to occur within the flood fringe. This area will be filled to achieve a minimum of 0.5m clearance between the habitable floor levels and important infrastructure and the 100-year flood levels.

A combination of the swales and roadways are to be used to convey major stormwater events to the POS and subsequently to the River. The road, lot and POS levels are to be designed to allow a safe flood route and maintain a minimum clearance of 500mm to the habitable floor levels and important infrastructure. For the major or less frequent storm events, the overflow of runoff towards waterways and wetlands will follow these overland flow paths across vegetated surfaces - a particular requirement noted in the "Decision Process for Stormwater Management in WA" (DoE, 2005).

Storage volumes have been modelled for each sub-catchment to ensure that the pre-development capacity of the downstream drainage system is not exceeded. The Preliminary Modelled Design Storage Volumes for each catchment are detailed in Appendices C and D.

3.5 External Catchments

The Pinjarra Golf Course abuts the southern boundary of the eastern portion of the subject land and Pinjarra Road and rural areas abut the southern boundary of the western portion of the subject land. Neither of these abutting areas is considered to contribute any significant stormwater flows to the subject land.

4. Roadworks

The street layout and street hierarchy is proposed as per the current WAPC liveable neighbourhood guidelines. All streets are proposed to be kerbed with an asphalt seal. In locations where the verge is adjacent to a swale, the roads will be constructed with a one-way cross fall and flush kerbs will be provided on the swale side to ensure runoff "sheets" off the

pavement into these areas. Traditional gully pits are not required on these roads. A cross section depicting this type of treatment is included in Appendix B. Similarly roads alongside POS will have a one way crossfall towards the open space with a flush kerb to enable street drainage water to enter the POS via overland flow – so called sheet flow. The verges and POS are to be stabilised and/or grassed and/or vegetated to prevent erosion.

Footpaths and Dual Use Paths are proposed to be provided as shown on plans prepared by Taylor Burrell Barnet.

Traffic volumes and access to and from the site are presented in detail within the Transcore report.

5. Western Power, Telstra and Alinta services

Western Power has confirmed that adequate power distribution lines are available to suit the proposed development. Ring mains are now being extended into the subject land from powerlines located along Pinjarra Road.

Alinta has confirmed that gas supplies can be provided to the whole of the development.

Telstra advise they have adequate network on Pinjarra Road to service the proposed development. At the moment, however, neither Broadband nor PayTV nor Telstra's Smart Community services can be provided. No published plan is provided by Telstra to suggest the timing for these services although it is expected that as the development proceeds Telstra will submit to demand and provide these services.

MATV and Broadband Services are provided by the Developer in an arrangement with the company Broadcast Engineering Services. BES has recently taken over the ownership and operation of the existing system and will upgrade it to provide digital TV services and broadband internet services in addition to the existing free-to-air TV and satellite services.

6. Water Corporation Headworks

The Water Corporation will charge headworks for sewerage and water supply at the current rates per lot.

7. Acid Sulphate Soils – Management Strategies

Associated with the development of Stages 3, 4, 5 and 7 during the period from August 2004 to mid 2006, Douglas Partners prepared specific ASS Management Plans for the construction of sewers. These plans approved by the DoE were successfully implemented for the works now completed on each of these four stages. The geological conditions encountered during the investigations for these stages were similar. Given that ASS are typically related to particular geological formations, the types and level of soil and groundwater management specified in the ASS and dewatering management plans are also similar and likely to continue to be similar for all stages of development on the subject land.

During November and December 2005 Douglas Partners completed a preliminary ASS and geotechnical investigation over the whole of the balance of the subject land. Based on the results of the study Douglas Partners concluded that:-

Acid Sulphate Soils

- ASS or PASS are not likely to occur within the alluvium material found north of the edge of the Murray River's 100-year flood fringe
- A pH_{FOX} of less than 3 is a reasonable indication that the net acidity is likely to be greater than 0.03%
- The grey sands within the Bassendean Formation are generally not likely to have net acidities greater than 0.03%
- The brown, grey-brown and dark brown samples of Bassendean Sand are most likely to have net acidities greater than 0.03%

Groundwater

- The depths to the groundwater are generally less on the western side of the site than the eastern side because the surface levels are higher on the eastern side
- The groundwater depths on the western side of the site were found to range from 0.4m to 0.9m whereas they ranged from about 0.6m to 2.4m deep on the eastern part of the site

Management

It is expected that similar levels of soil and groundwater management that have been successfully implemented for the recently completed stages of the project would also be applicable to the overall development of the ODP area. The project team has adopted ASS management strategies that are effective, comply with the DEC's requirements and meet with their approval. Based on experience with Stages 3, 4, 5 and 7 the management plans were readily implemented and managed. The knowledge and expertise gained with these earlier stages is demonstrative of the relative ease of management of ASS issues for this site.

For each subdivision stage, specific and localised ASS and groundwater investigations are to be undertaken. Such investigations can only follow sufficient design (i.e. depth and alignment of the sewers in particular) so that the ASS and groundwater management plans are focused on the specific construction works associated with an individual stage of the development. For each stage of the works, a management plan and application for a dewatering licence will be prepared for DEC and Department of Water approval.

8. Site works

Site works will include earthworks (i.e. cutting and filling as required), with earthworks areas to be stabilised during construction. Existing remnant vegetation is to be kept where possible.

Existing bore water use for the reticulation of parks and lots is a matter that was determined in the water balance for the urban water strategy adopted for this development. Existing water licences within the groundwater district are regularly reviewed and managed closely in accordance with the DoE's requirements.

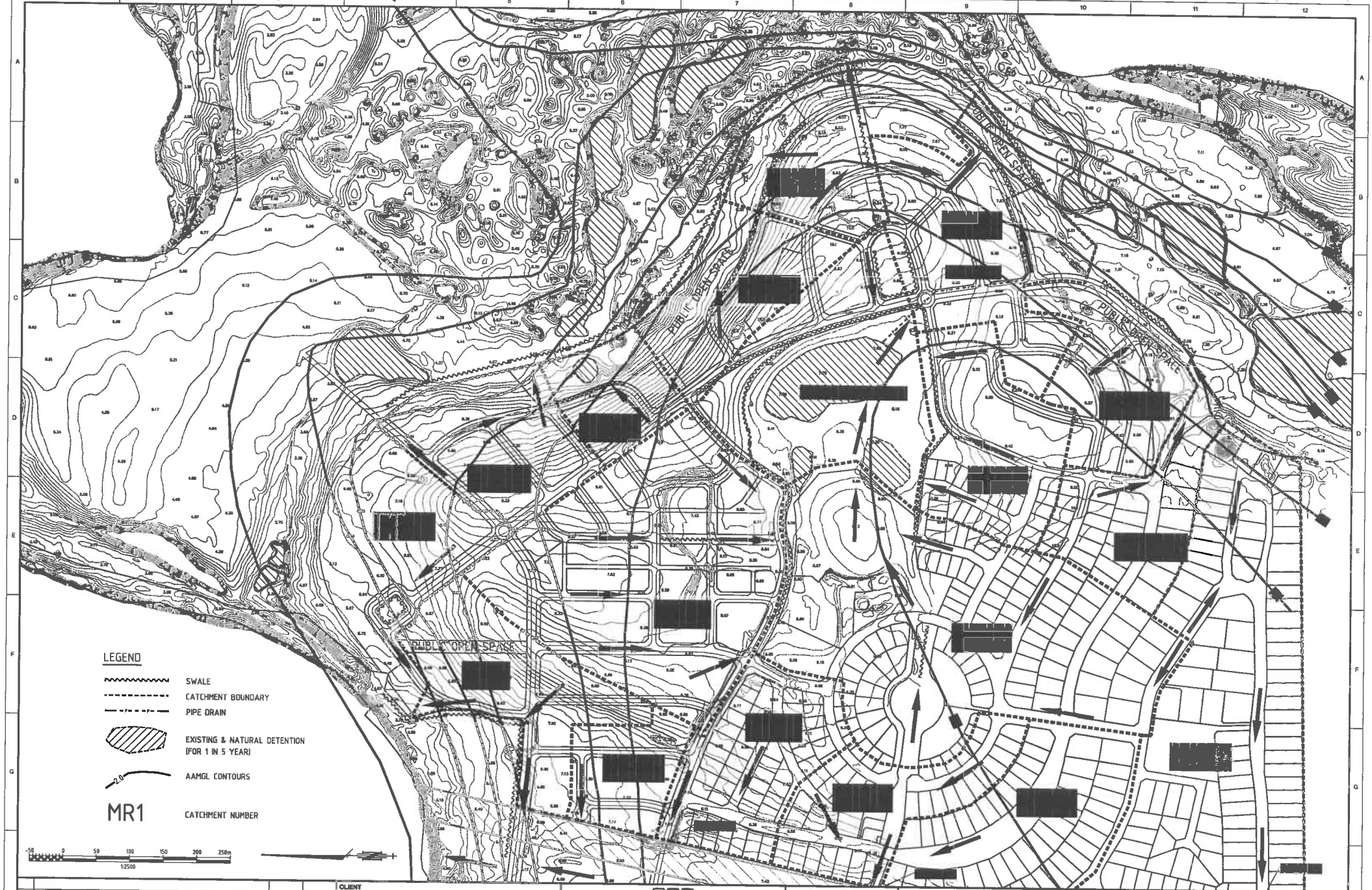
Yours faithfully
Dennis, Price & Miller (WA) Pty Ltd

Peter Bowyer
Director

encl

APPENDIX A

Catchment Plans



REV	REVISION	DATE	APPROVED
A	ISSUED FOR INFORMATION	06/07/06	P.B.

CLIENT

MURRAY RIVERSIDE PTY LTD

DPM
DENNIS, PRICE & MILLER (WA) PTY LTD
CONSULTING CIVIL ENGINEERS
38 Richardson Street West Perth WA 6005
Telephone: (08) 9481 4255 Facsimile: (08) 9481 3900
Email: dpmwa@dpmwa.com.au
ACN 006 843 705

DRAWN	B.Griffiths
DESIGNED	
CHECKED	
APPROVED	
DATE	

TITLE

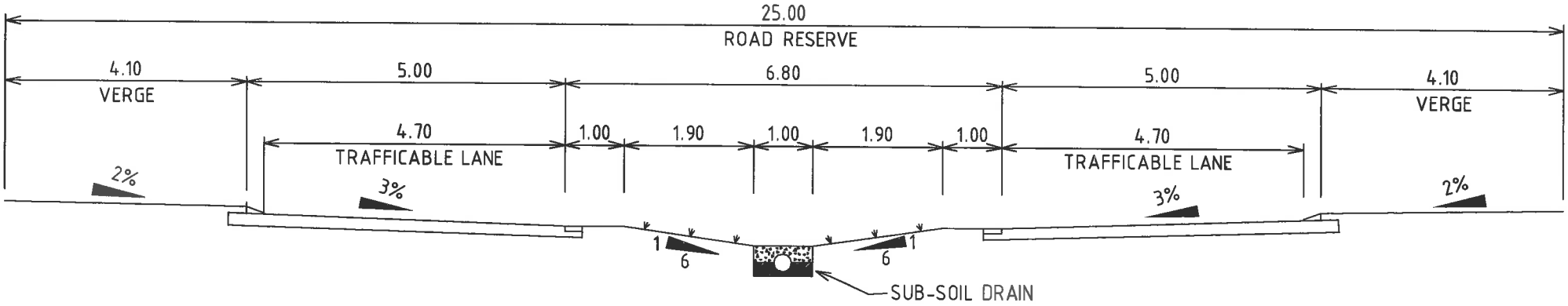
MURRAY RIVER COUNTRY ESTATE

URBAN WATER MANAGEMENT STRATEGY - EAST

ORIGINAL SHEET SIZE	A1
DO NOT SCALE	
SCALE	1:2500
LEVEL DATUM :	AHD
SHEET	1 OF 1
DRAWING No	7090-21
REV	A

APPENDIX B

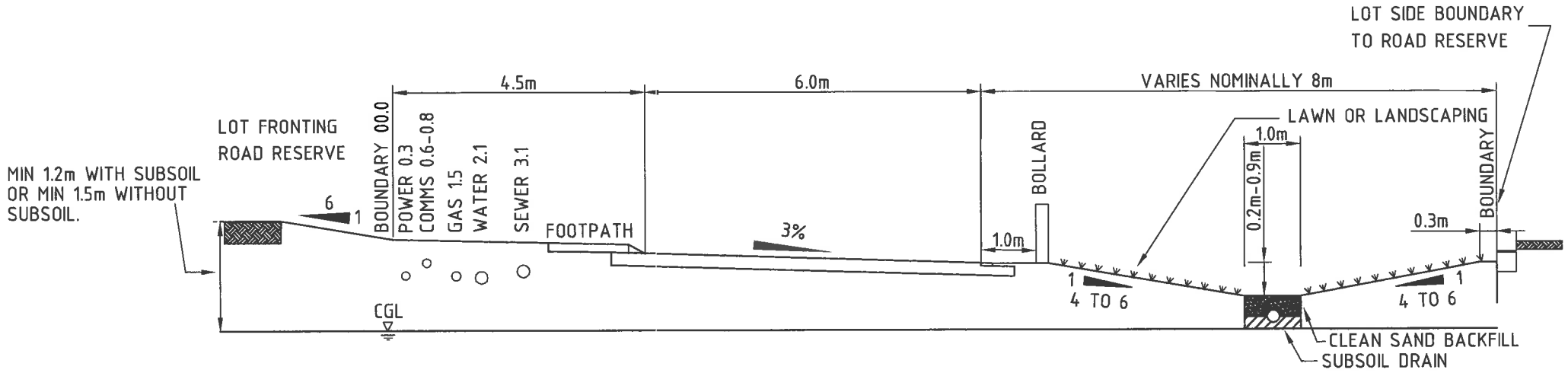
Typical cross sections of Roads with Swales



CROSS SECTION OF BOULEVARD WITH SWALE

SCALE: 1:100

D P M
DENNIS, PRICE & MILLER (WA) PTY LTD
CONSULTING CIVIL ENGINEERS
38 Richardson Street West Perth WA 6005
Telephone: (08) 9481 4255 Facsimile: (08) 9481 3900
Email: dpmwa@dpmwa.com.au
ACN 006 843 705



CROSS SECTION OF STREET WITH SWALE

OPTION 1

1:100

D P M
DENNIS, PRICE & MILLER (WA) PTY LTD
A.C.N. 086 843 705
CONSULTING CIVIL ENGINEERS
38 Richardson Street, West Perth, W.A. 6005
Telephone: (08) 9481 4255, Facsimile: (08) 9481 3900
Email: dpmwa@upnaway.com

APPENDIX C

Preliminary Modelled Design Storage Volumes

Catchment No.	POS Area Schools	Lot Area	Road Reserve Total Area	Road Reserve EIA	1 in 1 ARI critical volume required	1in 5 ARI critical volume required	Length of Swale required	Length of Swale provided
	Ha	Ha	Ha	Ha	m^3	m^3	m	m
CENTRAL WESTERN CATCHMENT								
MR1	0.00	6.76	2.00	1.60	1,088	1,687	391	500
MR2	0.00	2.66	1.30	1.04	695	1,081	247	100
MR3	0.34	6.49	1.02	0.82	542	845	192	40
MR4	0.00	1.49	1.55	1.24	837	1,301	300	130
MR5	12.53	0.00	0.00	0.00				
Sub total	12.87	17.39	5.87	4.70	3,162	4,914	1,130	770
WESTERN CATCHMENT								
MR6	0.00	1.60	1.97	1.57	1,068	1,657	385	450
MR7	0.15	8.94	2.63	2.10	1,438	2,228	520	300
MR8	0.85	3.28	1.84	1.47	995	1,544	357	530
MR9	0.00	4.86	1.94	1.55	1,054	1,635	377	410
MR10	3.66	6.53	3.41	2.73	1,876	2,902	675	300
MR11	0.00	7.86	3.31	2.65	1,825	2,823	656	1,240
MR12	19.73	0.00	1.35	1.08	722	1,123	260	500
Sub total	24.39	33.07	16.44	13.15	8,978	13,912	3,230	3,730
CENTRAL EASTERN CATCHMENT								
MRC1	0.00	3.49	1.69	1.35	884	1,378	320	0
MRC2	0.32	3.10	1.06	0.85	536	840	190	0
MRC3	0.00	5.10	1.66	1.33	868	1,353	310	0
MRC4	0.00	15.03	3.02	2.42	1,571	2,465	556	0
Sub total	0.32	26.72	4.42	3.53	3,859	6,036	1,376	0
EASTERN CATCHMENT								
MR E1	0.00	9.08	3.99	3.19	2,171	3,363	780	70
MR E2	7.12	9.91	2.30	1.84	1,218	1,894	440	130
MR E3	0.96	0.96	1.38	1.11	713	1,114	255	110
MR E4	1.46	3.27	0.87	0.70	434	683	155	280
MR E5	1.45	4.19	2.09	1.67	1,090	1,696	395	180
Sub total	10.99	27.40	10.63	8.51	5,626	8,750	2,025	770
SOUTH EASTERN CATCHMENT								
MR SE1	1.15	2.34	1.00	0.80	391	615	140	70
MR SE2	0.00	2.99	2.61	2.09	1,444	2,224	527	0
Sub total	1.15	5.33	3.61	2.88	1,835	2,839	667	70

NORTHERN CATCHMENT

MR N1	2.50	2.30	1.03	0.82	578	905	205	210
MR N2	1.55	1.96	0.82	0.66	406	639	145	180
MR N3	0.96	0.96	0.58	0.46	274	434	96	110
MR N4	1.46	2.20	1.40	1.12	1,004	1,563	360	90
MR N5	4.68	0.12	0.88	0.71	551	863	200	50
MR N6	0.34	3.90	1.07	0.86	817	1,274	290	110
MR N7	0.00	1.89	0.59	0.47	281	444	98	0
Sub total	11.50	13.31	6.37	5.10	3,911	6,122	1,394	750

TOTAL	***61.23***	***123.23***	***47.33***	***37.87***	***27,371***	***42,573***	***9,822***	***6,090***

APPENDIX D

Preliminary Modelled Design Storage Volumes - Detailed Calculations

7090

Murray River Country Estate
Urban Water Management Strategy

Drainage Catchment Area Data

Catchment	POS Area Schools	Lot Area	Road Reserve Total Area	Road Reserve EIA	1 in 1 ARI critical vol	1in 5 ARI critical vol	Length of Swale required	Length of Swale provided
	Ha	Ha	Ha	Ha	m3 required	m3 required	Lm	Lm
CENTRAL WESTERN CATCHMENT								
MR1	0.0000	6.7592	2.0008	1.6006	1,088	1,687	391	500
MR2	0.0000	2.6562	1.2970	1.0376	695	1,081	247	100
MR3	0.3423	6.4912	1.0225	0.8180	542	845	192	40
MR4	0.0000	1.4866	1.5527	1.2422	837	1,301	300	130
MR5	12.5269	0.0000	0.0000	0.0000				
Total	12.8692	17.3932	5.8730	4.6984	3,162	4,914	1,130	770
WESTERN CATCHMENT								
MR6	0.0000	1.5981	1.9654	1.5723	1,068	1,657	385	450
MR7	0.1494	8.9426	2.6269	2.1015	1,438	2,228	520	300
MR8	0.8480	3.2755	1.8352	1.4682	995	1,544	357	530
MR9	0.0000	4.8592	1.9406	1.5525	1,054	1,636	377	410
MR10	3.6590	6.5328	3.4064	2.7251	1,876	2,902	675	300
MR11	0.0000	7.8641	3.3146	2.6517	1,825	2,823	656	1,240
MR12	19.7348	0.0000	1.3459	1.0767	722	1,123	260	500
Total	24.3912	33.0723	16.4350	13.1480	8,978	13,912	3,230	3,730
CENTRAL EASTERN CATCHMENT								
MRC1	0.0000	3.4889	1.6927	1.3542	884	1,378	320	0
MRC2	0.3220	3.1038	1.0596	0.8477	536	840	190	0
MRC3	0.0000	5.1016	1.6636	1.3309	868	1,353	310	0
MRC4	0.0000	15.0297	3.0209	2.4167	1,571	2,465	556	0
Total	0.3220	26.7240	4.4159	3.5327	3,859	6,036	1,376	0
EASTERN CATCHMENT								
MR E1	0.0000	9.0796	3.9929	3.1943	2,171	3,363	780	70
MR E2	7.1198	9.9144	2.2959	1.8367	1,218	1,894	440	130
MR E3	0.9636	0.9552	1.3828	1.1062	713	1,114	255	110
MR E4	1.4587	3.2681	0.8733	0.6986	434	683	155	280
MR E5	1.4513	4.1869	2.0870	1.6696	1,090	1,696	395	180
Total	10.9934	27.4042	10.6319	8.5055	5,626	8,750	2,025	770
SOUTH EASTERN CATCHMENT								
MR SE1	1.1469	2.3384	0.9955	0.7964	391	615	140	70
MR SE2	0.0000	2.9904	2.6103	2.0882	1,444	2,224	527	0
Total	1.1469	5.3288	3.6058	2.8846	1,835	2,839	667	70
NORTHERN CATCHMENT								
MR N1	2.5033	2.2963	1.0255	0.8204	578	905	205	210
MR N2	1.5487	1.9589	0.8214	0.6571	406	639	145	180
MR N3	0.9639	0.9552	0.5779	0.4623	274	434	96	110
MR N4	1.4587	2.1954	1.4038	1.1230	1,004	1,563	360	90
MR N5	4.6837	0.1152	0.8848	0.7078	551	863	200	50
MR N6	0.3442	3.9048	1.0692	0.8554	817	1,274	290	110
MR N7	0.0000	1.8854	0.5900	0.4720	281	444	98	0
Total	11.5025	13.3112	6.3726	5.0981	3,911	6,122	1,394	750
TOTALS	***61.2252***	***123.2337***	***47.3342***	***37.8674***	***27,371***	***42,573***	***9,822***	***6,090***

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-E1
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	40076	0.8	32061	
Verge	0	0.15	0	
	0	0.7	0	
Total	40076		32061	

Sump Details		
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	780	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.350	m AHD
Downstream IL	8.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	2171	0.601	8.500	8.101	0.399	Shallow water table log model
1	24.000	1440	24	1440	1577	0.502	8.500	8.002	0.498	Shallow water table log model
1	24.000	1440	2	120	317	0.190	8.500	7.690	0.810	Clogged base model
1	24.000	1440	2	120	169	0.124	8.500	7.624	0.876	Green and Ampt model
1	24.000	1440	2	120	35	0.037	8.500	7.537	0.963	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	3363	0.764	8.500	8.264	0.236	Shallow water table log model
5	24.000	1440	24	1440	2400	0.634	8.500	8.134	0.366	Shallow water table log model
5	24.000	1440	2	120	523	0.261	8.500	7.761	0.739	Clogged base model
5	24.000	1440	2	120	347	0.201	8.500	7.701	0.799	Green and Ampt model
5	24.000	1440	2	120	188	0.134	8.500	7.634	0.866	Deep water table model
5	72.000	4320	4	240	73	0.067	8.500	7.567	0.933	Clogged base model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-E2
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	22959	0.8	18367	
Verge	0	0.15	0	
	0	0.7	0	
Total	22959		18367	

Sump Details		
GWL	7.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	9.000	m AHD
Sump Base Level	8.000	m AHD
Sump Width at base	1	m
Sump Length at base	440	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.850	m AHD
Downstream IL	8.750	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	9.000	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	1218	0.597	9.000	8.597	0.403	Shallow water table log model
1	24.000	1440	24	1440	896	0.503	9.000	8.503	0.497	Shallow water table log model
1	24.000	1440	2	120	182	0.192	9.000	8.192	0.808	Clogged base model
1	24.000	1440	2	120	98	0.126	9.000	8.126	0.874	Green and Ampt model
1	24.000	1440	2	120	22	0.041	9.000	8.041	0.959	Deep water table model
1	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Green and Ampt model
5	72.000	4320	72	4320	1894	0.761	9.000	8.761	0.239	Shallow water table log model
5	24.000	1440	24	1440	1366	0.635	9.000	8.635	0.365	Shallow water table log model
5	24.000	1440	2	120	300	0.263	9.000	8.263	0.737	Clogged base model
5	24.000	1440	2	120	200	0.203	9.000	8.203	0.797	Green and Ampt model
5	24.000	1440	2	120	110	0.137	9.000	8.137	0.863	Deep water table model
5	72.000	4320	4	240	45	0.071	9.000	8.071	0.929	Clogged base model
5	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-E3
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	13828	0.8	11062	
Verge	0	0.15	0	
	0	0.7	0	
Total	13828		11062	

Sump Details		
GWL	7.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	9.000	m AHD
Sump Base Level	8.000	m AHD
Sump Width at base	1	m
Sump Length at base	255	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.850	m AHD
Downstream IL	8.750	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	9.000	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	713	0.598	9.000	8.598	0.402	Shallow water table log model
1	24.000	1440	24	1440	534	0.508	9.000	8.508	0.492	Shallow water table log model
1	24.000	1440	2	120	111	0.197	9.000	8.197	0.803	Clogged base model
1	24.000	1440	2	120	61	0.132	9.000	8.132	0.868	Green and Ampt model
1	24.000	1440	2	120	16	0.050	9.000	8.050	0.950	Deep water table model
1	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Green and Ampt model
5	72.000	4320	72	4320	1114	0.763	9.000	8.763	0.237	Shallow water table log model
5	24.000	1440	24	1440	815	0.643	9.000	8.643	0.357	Shallow water table log model
5	24.000	1440	2	120	182	0.270	9.000	8.270	0.730	Clogged base model
5	24.000	1440	2	120	123	0.211	9.000	8.211	0.789	Green and Ampt model
5	24.000	1440	2	120	70	0.145	9.000	8.145	0.855	Deep water table model
5	72.000	4320	4	240	31	0.082	9.000	8.082	0.918	Clogged base model
5	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	9.000	8.000	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-E4
Designer	pjg

Location	Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	8733	0.8	6986	
Verge	0	0.15	0	
	0	0.7	0	
Total	8733		6986	

Sump Details		
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	155	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.350	m AHD
Downstream IL	8.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	434	0.595	8.500	8.095	0.405	Shallow water table log model
1	24.000	1440	24	1440	333	0.512	8.500	8.012	0.488	Shallow water table log model
1	24.000	1440	2	120	70	0.202	8.500	7.702	0.798	Clogged base model
1	24.000	1440	2	120	39	0.138	8.500	7.638	0.862	Green and Ampt model
1	24.000	1440	2	120	12	0.058	8.500	7.558	0.942	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	683	0.760	8.500	8.260	0.240	Shallow water table log model
5	24.000	1440	24	1440	509	0.650	8.500	8.150	0.350	Shallow water table log model
5	24.000	1440	2	120	116	0.277	8.500	7.777	0.723	Clogged base model
5	24.000	1440	2	120	79	0.218	8.500	7.718	0.782	Green and Ampt model
5	24.000	1440	2	120	46	0.153	8.500	7.653	0.847	Deep water table model
5	72.000	4320	4	240	23	0.093	8.500	7.593	0.907	Clogged base model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-E5
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	20643	0.8	16514	
Verge	0	0.15	0	
	0	0.7	0	
Total	20643		16514	

Sump Details		
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	395	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.350	m AHD
Downstream IL	8.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	1090	0.598	8.500	8.096	0.404	Shallow water table log model
1	24.000	1440	24	1440	804	0.502	8.500	8.002	0.498	Shallow water table log model
1	24.000	1440	2	120	164	0.192	8.500	7.692	0.808	Clogged base model
1	24.000	1440	2	120	88	0.126	8.500	7.626	0.874	Green and Ampt model
1	24.000	1440	2	120	20	0.041	8.500	7.541	0.959	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	1696	0.759	8.500	8.259	0.241	Shallow water table log model
5	24.000	1440	24	1440	1226	0.635	8.500	8.135	0.365	Shallow water table log model
5	24.000	1440	2	120	270	0.263	8.500	7.763	0.737	Clogged base model
5	24.000	1440	2	120	180	0.204	8.500	7.704	0.796	Green and Ampt model
5	24.000	1440	2	120	99	0.137	8.500	7.637	0.863	Deep water table model
5	72.000	4320	4	240	41	0.072	8.500	7.572	0.928	Clogged base model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-SE1
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Almp (m2)	Comments
Road pavement	7929	0.8	6343	
Verge	0	0.15	0	
	0	0.7	0	
Total	7929		6343	

Sump Details		
GWL	6.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.000	m AHD
Sump Base Level	7.000	m AHD
Sump Width at base	1	m
Sump Length at base	140	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	7.850	m AHD
Downstream IL	7.750	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.000	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	391	0.593	8.000	7.593	0.407	Shallow water table log model
1	24.000	1440	24	1440	301	0.512	8.000	7.512	0.488	Shallow water table log model
1	24.000	1440	2	120	64	0.203	8.000	7.203	0.797	Clogged base model
1	24.000	1440	2	120	36	0.139	8.000	7.139	0.861	Green and Ampt model
1	24.000	1440	2	120	11	0.059	8.000	7.059	0.941	Deep water table model
1	72.000	4320	8	480	0	0.000	8.000	7.000	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.000	7.000	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.000	7.000	1.000	Green and Ampt model
5	72.000	4320	72	4320	615	0.758	8.000	7.758	0.242	Shallow water table log model
5	24.000	1440	24	1440	461	0.649	8.000	7.649	0.351	Shallow water table log model
5	24.000	1440	2	120	105	0.277	8.000	7.277	0.723	Clogged base model
5	24.000	1440	2	120	72	0.219	8.000	7.219	0.781	Green and Ampt model
5	24.000	1440	2	120	42	0.153	8.000	7.153	0.847	Deep water table model
5	72.000	4320	4	240	21	0.095	8.000	7.095	0.905	Clogged base model
5	72.000	4320	8	480	0	0.000	8.000	7.000	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.000	7.000	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N1
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	11363	0.8	9090	
Verge	0	0.15	0	
	0	0.7	0	
Total	11363		9090	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	205	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	578	0.600	6.500	6.100	0.400	Shallow water table log model
1	24.000	1440	24	1440	436	0.512	6.500	6.012	0.488	Shallow water table log model
1	24.000	1440	2	120	91	0.201	6.500	5.701	0.799	Clogged base model
1	24.000	1440	2	120	51	0.136	6.500	5.636	0.864	Green and Ampt model
1	24.000	1440	2	120	15	0.054	6.500	5.554	0.946	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	905	0.765	6.500	6.265	0.235	Shallow water table log model
5	24.000	1440	24	1440	667	0.647	6.500	6.147	0.353	Shallow water table log model
5	24.000	1440	2	120	150	0.274	6.500	5.774	0.726	Clogged base model
5	24.000	1440	2	120	102	0.216	6.500	5.716	0.784	Green and Ampt model
5	24.000	1440	2	120	59	0.150	6.500	5.650	0.850	Deep water table model
5	72.000	4320	4	240	28	0.088	6.500	5.588	0.912	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N2
Designer	pjg

Location	Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	8214	0.8	6571	
Verge	0	0.15	0	
	0	0.7	0	
Total	8214		6571	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	145	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	406	0.594	6.500	6.094	0.406	Shallow water table log model
1	24.000	1440	24	1440	312	0.513	6.500	6.013	0.487	Shallow water table log model
1	24.000	1440	2	120	66	0.203	6.500	5.703	0.797	Clogged base model
1	24.000	1440	2	120	37	0.139	6.500	5.639	0.861	Green and Ampt model
1	24.000	1440	2	120	12	0.059	6.500	5.559	0.941	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	639	0.760	6.500	6.260	0.240	Shallow water table log model
5	24.000	1440	24	1440	478	0.650	6.500	6.150	0.350	Shallow water table log model
5	24.000	1440	2	120	109	0.278	6.500	5.778	0.722	Clogged base model
5	24.000	1440	2	120	75	0.219	6.500	5.719	0.781	Green and Ampt model
5	24.000	1440	2	120	43	0.153	6.500	5.653	0.847	Deep water table model
5	72.000	4320	4	240	22	0.095	6.500	5.595	0.905	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N3
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	5779	0.8	4623	
Verge	0	0.15	0	
	0	0.7	0	
Total	5779		4623	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	96	m
Side Slope	6.0	1 In --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	68	4080	274	0.596	6.500	6.096	0.404	Shallow water table log model
1	24.000	1440	24	1440	216	0.523	6.500	6.023	0.477	Shallow water table log model
1	24.000	1440	2	120	47	0.212	6.500	5.712	0.788	Clogged base model
1	24.000	1440	2	120	27	0.149	6.500	5.649	0.851	Green and Ampt model
1	24.000	1440	2	120	10	0.072	6.500	5.572	0.928	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	434	0.762	6.500	6.262	0.238	Shallow water table log model
5	24.000	1440	24	1440	332	0.660	6.500	6.160	0.340	Shallow water table log model
5	24.000	1440	2	120	77	0.288	6.500	5.788	0.712	Clogged base model
5	24.000	1440	2	120	54	0.231	6.500	5.731	0.769	Green and Ampt model
5	24.000	1440	2	120	32	0.164	6.500	5.664	0.836	Deep water table model
5	72.000	4320	4	240	18	0.112	6.500	5.612	0.888	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N4
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	19098	0.8	15278	
Verge	0	0.15	0	
	0	0.7	0	
Total	19098		15278	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	360	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	1004	0.599	6.500	6.099	0.401	Shallow water table log model
1	24.000	1440	24	1440	743	0.505	6.500	6.005	0.495	Shallow water table log model
1	24.000	1440	2	120	152	0.194	6.500	5.694	0.806	Clogged base model
1	24.000	1440	2	120	83	0.129	6.500	5.629	0.871	Green and Ampt model
1	24.000	1440	2	120	20	0.045	6.500	5.545	0.955	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	1563	0.763	6.500	6.263	0.237	Shallow water table log model
5	24.000	1440	24	1440	1133	0.639	6.500	6.139	0.361	Shallow water table log model
5	24.000	1440	2	120	251	0.266	6.500	5.766	0.734	Clogged base model
5	24.000	1440	2	120	168	0.207	6.500	5.707	0.793	Green and Ampt model
5	24.000	1440	2	120	93	0.140	6.500	5.640	0.860	Deep water table model
5	72.000	4320	4	240	40	0.076	6.500	5.576	0.924	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N5
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	10867	0.8	8694	
Verge	0	0.15	0	
	0	0.7	0	
Total	10867		8694	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	200	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	551	0.591	6.500	6.091	0.409	Shallow water table log model
1	24.000	1440	24	1440	417	0.506	6.500	6.006	0.494	Shallow water table log model
1	24.000	1440	2	120	87	0.197	6.500	5.697	0.803	Clogged base model
1	24.000	1440	2	120	48	0.132	6.500	5.632	0.868	Green and Ampt model
1	24.000	1440	2	120	13	0.050	6.500	5.550	0.950	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	863	0.755	6.500	6.255	0.245	Shallow water table log model
5	24.000	1440	24	1440	637	0.640	6.500	6.140	0.360	Shallow water table log model
5	24.000	1440	2	120	143	0.270	6.500	5.770	0.730	Clogged base model
5	24.000	1440	2	120	97	0.211	6.500	5.711	0.789	Green and Ampt model
5	24.000	1440	2	120	55	0.145	6.500	5.645	0.855	Deep water table model
5	72.000	4320	4	240	25	0.083	6.500	5.583	0.917	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N6
Designer	pjg

Location	Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	15710	0.8	12568	
Verge	0	0.15	0	
	0	0.7	0	
Total	15710		12568	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	290	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	817	0.601	6.500	6.101	0.399	Shallow water table log model
1	24.000	1440	24	1440	608	0.509	6.500	6.009	0.491	Shallow water table log model
1	24.000	1440	2	120	126	0.197	6.500	5.697	0.803	Clogged base model
1	24.000	1440	2	120	69	0.132	6.500	5.632	0.868	Green and Ampt model
1	24.000	1440	2	120	19	0.049	6.500	5.549	0.951	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	1274	0.767	6.500	6.267	0.233	Shallow water table log model
5	24.000	1440	24	1440	929	0.644	6.500	6.144	0.356	Shallow water table log model
5	24.000	1440	2	120	207	0.270	6.500	5.770	0.730	Clogged base model
5	24.000	1440	2	120	140	0.211	6.500	5.711	0.789	Green and Ampt model
5	24.000	1440	2	120	79	0.145	6.500	5.645	0.855	Deep water table model
5	72.000	4320	4	240	35	0.082	6.500	5.582	0.918	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-N7
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	5900	0.8	4720	
Verge	0	0.15	0	
	0	0.7	0	
Total	5900		4720	

Sump Details		
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	98	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	6.350	m AHD
Downstream IL	6.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	6.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	68	4080	281	0.597	6.500	6.097	0.403	Shallow water table log model
1	24.000	1440	24	1440	221	0.523	6.500	6.023	0.477	Shallow water table log model
1	24.000	1440	2	120	48	0.213	6.500	5.713	0.787	Clogged base model
1	24.000	1440	2	120	28	0.149	6.500	5.649	0.851	Green and Ampt model
1	24.000	1440	2	120	10	0.072	6.500	5.572	0.928	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	444	0.764	6.500	6.264	0.236	Shallow water table log model
5	24.000	1440	24	1440	339	0.660	6.500	6.160	0.340	Shallow water table log model
5	24.000	1440	2	120	79	0.288	6.500	5.788	0.712	Clogged base model
5	24.000	1440	2	120	55	0.231	6.500	5.731	0.769	Green and Ampt model
5	24.000	1440	2	120	32	0.164	6.500	5.664	0.836	Deep water table model
5	72.000	4320	4	240	18	0.112	6.500	5.612	0.888	Clogged base model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	6.500	5.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-C1
Designer	pjg

Location	Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	16927	0.8	13542	
Verge	0	0.15	0	
	0	0.7	0	
Total	16927		13542	

Sump Details		
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	320	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.350	m AHD
Downstream IL	8.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	884	0.595	8.500	8.095	0.405	Shallow water table log model
1	24.000	1440	24	1440	657	0.504	8.500	8.004	0.496	Shallow water table log model
1	24.000	1440	2	120	135	0.194	8.500	7.694	0.806	Clogged base model
1	24.000	1440	2	120	73	0.128	8.500	7.628	0.872	Green and Ampt model
1	24.000	1440	2	120	18	0.044	8.500	7.544	0.956	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	1378	0.759	8.500	8.259	0.241	Shallow water table log model
5	24.000	1440	24	1440	1002	0.637	8.500	8.137	0.363	Shallow water table log model
5	24.000	1440	2	120	222	0.266	8.500	7.766	0.734	Clogged base model
5	24.000	1440	2	120	149	0.206	8.500	7.706	0.794	Green and Ampt model
5	24.000	1440	2	120	82	0.139	8.500	7.639	0.861	Deep water table model
5	72.000	4320	4	240	35	0.075	8.500	7.575	0.925	Clogged base model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-C2
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	10596	0.8	8477	
Verge	0	0.15	0	
	0	0.7	0	
Total	10596		8477	

Sump Details		
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	190	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.350	m AHD
Downstream IL	8.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	536	0.599	8.500	8.099	0.401	Shallow water table log model
1	24.000	1440	24	1440	406	0.512	8.500	8.012	0.488	Shallow water table log model
1	24.000	1440	2	120	85	0.201	8.500	7.701	0.799	Clogged base model
1	24.000	1440	2	120	47	0.137	8.500	7.637	0.863	Green and Ampt model
1	24.000	1440	2	120	14	0.056	8.500	7.556	0.944	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	840	0.765	8.500	8.265	0.235	Shallow water table log model
5	24.000	1440	24	1440	621	0.648	8.500	8.148	0.352	Shallow water table log model
5	24.000	1440	2	120	140	0.275	8.500	7.775	0.725	Clogged base model
5	24.000	1440	2	120	96	0.217	8.500	7.717	0.783	Green and Ampt model
5	24.000	1440	2	120	55	0.151	8.500	7.651	0.849	Deep water table model
5	72.000	4320	4	240	26	0.090	8.500	7.590	0.910	Clogged base model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	swale design - catchment MR-C3
Designer	pjg

Location		Mandurah

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	16636	0.8	13309	
Verge	0	0.15	0	
	0	0.7	0	
Total	16636		13309	

Sump Details		
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	310	m
Side Slope	6.0	1 in --

Permeability			
Permeability	5.0	m/d	
Permeability Clogged Layer	1	m/d	0.15
Thickness of Clogged Layer	100	mm	75
Porosity	0.25		0.25
Initial Degree of Saturation	10.0%		10.0%
Effective Porosity, n	22.5%		
Reduction Factor - Shallow	1.000		1.000
Reduction Factor - Deep	0.330		0.330
Reduction Factor - GreenAmp	0.600		1.000
Reduction Factor - Clogged	1.000		1.000

Outlet Pipe Details (free outfall)		
Entrance Type	1	
Diameter	300	mm
Length	20.0	m
Upstream IL	8.350	m AHD
Downstream IL	8.250	m AHD
Ds	0.850	m
Pipe Slope	0.00500	m/m

Weir Details			
Weir Coefficient, Cd	1.700		1.7
Weir Length	15.000	m	
Weir Level	8.500	m AHD	

SUMMARY OUTPUT										
ARI	Storm Duration		Critical Time		Storage Required	Water Depth, H	Allowable TWL	TWL	Freeboard	Critical Model
(years)	(hours)	(min)	(hours)	(min)	(m3)	(m)	(m AHD)	(m AHD)	(m)	
1	72.000	4320	72	4320	868	0.600	8.500	8.100	0.400	Shallow water table log model
1	24.000	1440	24	1440	645	0.507	8.500	8.007	0.493	Shallow water table log model
1	24.000	1440	2	120	133	0.196	8.500	7.696	0.804	Clogged base model
1	24.000	1440	2	120	73	0.131	8.500	7.631	0.869	Green and Ampt model
1	24.000	1440	2	120	19	0.047	8.500	7.547	0.953	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Clogged base model
1	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model
5	72.000	4320	72	4320	1353	0.764	8.500	8.264	0.236	Shallow water table log model
5	24.000	1440	24	1440	984	0.642	8.500	8.142	0.358	Shallow water table log model
5	24.000	1440	2	120	219	0.268	8.500	7.768	0.732	Clogged base model
5	24.000	1440	2	120	147	0.209	8.500	7.709	0.791	Green and Ampt model
5	24.000	1440	2	120	83	0.143	8.500	7.643	0.857	Deep water table model
5	72.000	4320	4	240	36	0.079	8.500	7.579	0.921	Clogged base model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Deep water table model
5	72.000	4320	8	480	0	0.000	8.500	7.500	1.000	Green and Ampt model

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	Swale Design - Central Catchment - MR1
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	20008	0.8	16006	
Verge	0	0.15	0	
POS & School Sites	0	0.15	0	
TOTAL	20008		16006	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	1.6006	ha
GWL	7.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	9.000	m AHD
Sump Base Level	8.000	m AHD
Sump Width at base	1	m
Sump Length at base	391	m
Side Slope	6.0	1 in --
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	1141	17.76	53	1088	0.599	8.599	0.401	Shallow water table log model	
5	72	1.52	1752	21.56	65	1687	0.761	8.761	0.239	Shallow water table log model	

Project Details	
Project	Murray River Cuntry Estate
Job Number	7090
Task	Swale and Basin Design - Central Catchment - MR2
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	12970	0.8	10376	
Lots	0	0.15	0	does not contribute until after 1 in 10 year
POS & School Sites		0.15	0	does not contribute until after 1 in 10 year
TOTAL	12970		10376	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	1.0376	ha
GWL	7.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	9.000	m AHD
Sump Base Level	8.000	m AHD
Sump Width at base	1	m
Sump Length at base	247	m
Side Slope	6.0	1 in --
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	740	15.02	45	695	0.600	8.600	0.400	Shallow water table log model	
5	72	1.52	1136	18.26	55	1081	0.763	8.763	0.237	Shallow water table log model	

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	Swale Design - Central Catchment - MR3
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	10225	0.8	8180	
Verge	0	0.15	0	
POS & School Sites	0	0.15	0	
TOTAL	10225		8180	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	0.8180	ha
GWL	7.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	9.000	m AHD
Sump Base Level	8.000	m AHD
Sump Width at base	1	m
Sump Length at base	192	m
Side Slope	6.0	1 in –
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	583	13.73	41	542	0.600	8.600	0.400	Shallow water table log model	
5	72	1.52	895	16.71	50	845	0.763	8.763	0.237	Shallow water table log model	

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	Swale Design - Central Catchment - MR4
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	15527	0.8	12422	
Verge	0	0.15	0	
POS & School Sites	0	0.15	0	
TOTAL	15527		12422	

INPUT DATA

Location	Mandurah	
$A_{Impervious}$	1.2422	ha
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	300	m
Side Slope	6.0	1 in –
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	885	16.09	48	837	0.599	8.099	0.401	Shallow water table log model	
5	72	1.52	1359	19.54	59	1301	0.761	8.261	0.239	Shallow water table log model	

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	Swale Design - Western Catchment - MR6
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	19654	0.8	15723	
Verge	0	0.15	0	
POS & School Sites	0	0.15	0	
TOTAL	19654		15723	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	1.5723	ha
GWL	7.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.500	m AHD
Sump Base Level	7.500	m AHD
Sump Width at base	1	m
Sump Length at base	385	m
Side Slope	6.0	1 in --
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	1121	17.63	53	1068	0.598	8.098	0.402	Shallow water table log model	
5	72	1.52	1721	21.41	64	1657	0.760	8.260	0.240	Shallow water table log model	

Project Details	
Project	Murray River Cuntry Estate
Job Number	7090
Task	Swale and Basin Design - Western Catchment - MR7
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	26266	0.8	21013	
Lots	0	0.15	0	
POS & School Sites		0.15	0	
TOTAL	26266		21013	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	2.1013	ha
GWL	6.500	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	8.000	m AHD
Sump Base Level	7.000	m AHD
Sump Width at base	1	m
Sump Length at base	520	m
Side Slope	6.0	1 in --
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	1498	19.79	59	1438	0.598	7.598	0.402	Shallow water table log model	
5	72	1.52	2300	24.01	72	2228	0.760	7.760	0.240	Shallow water table log model	

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	Swale Design - Western Catchment - MR10
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	34064	0.8	27251	
Verge	0	0.15	0	
POS & School Sites	0	0.15	0	
TOTAL	34064		27251	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	2.7251	ha
GWL	4.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	5.500	m AHD
Sump Base Level	4.500	m AHD
Sump Width at base	1	m
Sump Length at base	675	m
Side Slope	6.0	1 in –
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	1942	22.01	66	1876	0.600	5.100	0.400	Shallow water table log model	
5	72	1.52	2982	26.69	80	2902	0.762	5.262	0.238	Shallow water table log model	

Project Details	
Project	Murray River Country Estate
Job Number	7090
Task	Swale Design - Western Catchment - MR11
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	33146	0.8	26517	
Verge	0	0.15	0	
POS & School Sites	0	0.15	0	
TOTAL	33146		26517	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	2.6517	ha
GWL	5.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	6.500	m AHD
Sump Base Level	5.500	m AHD
Sump Width at base	1	m
Sump Length at base	656	m
Side Slope	6.0	1 in –
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	1890	21.76	65	1825	0.600	6.100	0.400	Shallow water table log model	
5	72	1.52	2902	26.42	79	2823	0.763	6.263	0.237	Shallow water table log model	

Project Details	
Project	Murray River Cuntry Estate
Job Number	7090
Task	Swale and Basin Design - Western Catchment - MR12
Designer	PJG

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road pavement	13459	0.8	10767	
Lots	0	0.15	0	
POS & School Sites		0.15	0	
TOTAL	13459		10767	

INPUT DATA

Location	Mandurah	
$A_{impervious}$	1.0767	ha
GWL	3.000	m AHD
Depth to GWL from base	0.500	m
Max Allowable TWL	4.500	m AHD
Sump Base Level	3.500	m AHD
Sump Width at base	1	m
Sump Length at base	260	m
Side Slope	6.0	1 in –
Permeability	5	m/d
Permeability Clogged Layer	1	m/d
Thickness of Clogged Layer	100	mm
Reduction Factor - Shallow	1.000	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
1	72	0.99	767	15.22	46	722	0.596	4.096	0.404	Shallow water table log model	
5	72	1.52	1178	18.49	55	1123	0.758	4.258	0.242	Shallow water table log model	