City of Wanneroo

Koondoola Regional Bushland Management Plan

July 2008

Originally prepared by Ecoscape (Australia Pty Ltd) & adapted by the City of Wanneroo

ecoscape

City of Wanneroo

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Koondoola Regional Bushland Management Plan

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Fauna and flora data has been drawn from the Koondoola Regional Bushland Management Plan (Murray 1998), data collected by the Friends of Koondoola Regional Bushland, flora survey by Pike (2004) and fauna survey by Crypto (1995).

Executive Summary

Koondoola Regional Bushland Management Plan

Koondoola Regional Bushland covers approximately 137 hectares and is the second largest conservation reserve managed by the City of Wanneroo.

There are 274 native plant species recorded for the site (Stubber, 2001), three of which are considered significant. The reserve is recognised as being regionally significant through its listing as Bush Forever Site 201 and contains a Threatened Ecological Community (TEC) (Floristic Community Type 20a) and a conservation category wetland. The TEC is a Banksia woodland community, most of which is in very good to excellent condition with an unusually diverse understorey.

A fauna survey of Koondoola Regional Bushland, using pitfall traps, was conducted by Crypto (1995), which resulted in 34 species of birds observed, 2 species of native mammals as well as 21 species of reptiles and amphibians.

The southern area of the reserve is degraded and includes two seasonal sumplands which fulfil a drainage function. There are various management problems in the southern sumpland area, including the introduction of weeds via stormwater drains, which are continuing to spread through the southern area of the reserve as a result of annual bushfires.

There are a number of complex management issues, particularly in relation to weeds, fire, stormwater management and bike riding/cubby building in the sumpland. The formation of the Friends of Koondoola Regional Bushland community group emphasises the great community value of the reserve, and regular guided walks are well attended by people throughout the region.

A total of 47 recommendations are made in this management plan, which are summarised in Table S1.

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	INTEGRATED MANAGEMENT OF RESERVE AND ADJACENT AREAS		
1	Investigate potential partnerships with other land managers e.g. with DEC to enhance the connectivity between Koondoola Regional Bushland and other bushland sites.	MEDIUM	CoW
	INFRASTRUCTURE		
2	An assessment of all informal bushland paths should be undertaken to determine if any paths could be closed and rehabilitated. Formlisation of paths that are heavily utilised by pedestrians should be investigated. Informal paths functioning as firebreaks should be retained.	MEDIUM	CoW

3	Investigate opportunities to upgrade selected limestone paths for universal access. Materials used in path construction should be appropriately sourced to ensure diseases are not introduced to the site.	MEDIUM	CoW
4	Continue to deter anti-social behaviour, repair any damage caused and investigate possible solutions to undesirable behaviour, such as BMX jump construction and arson.	MEDIUM	CoW and FKRB
5	Formal carparks are required. Appropriate localities for car parking should be investigated.	LOW	CoW and FKRB
6	Investigate additional rest areas along walk trails which utilise shaded areas or highlight places of interest.	LOW	CoW
	TRACK MANAGEMENT		
7	Continue regular monitoring of limestone tracks; report any signs of erosion and rectify any deterioration.	HIGH	CoW and FKRB
	SOILS		
8	Prior to any excavation works or dewatering in the southern portion of the site, undertake Acid Sulfate Risk Assessment.	LOW (Priority should be increased when/ if excavation/ dewatering activities are planned)	CoW
9	Monitor southern portion of the site for signs of acid sulfate soils as part of the normal maintenance routine.	HIGH	CoW
10	Undertake a trial to revegetate the bare area of the site to prevent weed encroachment into good quality bushland.	HIGH	CoW
	HYDROLOGY		
11	Preparation of a memorandum of Understanding between CoW and Water Corporation, the City of Swan and the City of Stirling regarding the Stormwater Management of Koondoola Regional Bushland.	HIGH	CoW, City of Stirling, City of Swan, Water Corporation
12	Develop a Stormwater Management Plan for Koondoola Regional Bushland in consultation with the City of Swan, the City of Stirling and Water Corporation. Development of the Stormwater Management Plan should include continuing to monitor groundwater levels, initiating water quality monitoring in the drains and investigating the installation of GPT and/or infiltration devices on drains entering the bushland.	HIGH	CoW, City of Stirling, and City of Swan
13	Continue to liaise with Water Corporation in order to remain informed about plans to upgrade the wastewater pumping station emergency storage and any changes in the emergency arrangements for the site.	HIGH	CoW and Water Corporation
	WEED CONTROL		
14	Continue to use an integrated approach to weed control including herbicides and manual removal as part of the ongoing maintenance program.	HIGH	CoW
15	As part of ongoing maintenance, monitor weed infestation on Water Corporation land and liaise with Water Corporation as necessary to prevent spread of weeds into the rest of the reserve.	HIGH	CoW
16	Continue to control weeds in southern area as a priority.	HIGH	CoW and FKRB
	DISEASE MANAGEMENT		
17	Utilise the reserve's dieback management plan to ensure standard hygiene practices are followed.	HIGH	CoW
18	Confirm presence of *Armillaria luteobubalina* and monitor if required.	HIGH	CoW and FKRB

19	Conduct soil monitoring for *Phytophthora cinnamomi* and other diseases as necessary i.e. if plants show signs of stress.	LOW	CoW and FKRB
	BUSHLAND RESTORATION		
20	Undertake bushland restoration in order of priority shown in the bushland restoration section of this plan. It should however be ensured that any actions undertaken do not conflict with other requirements such as firebreaks.	HIGH	CoW
21	Produce a rehabilitation plan for the site, which includes as a minimum; the type of works, the boundary of works, a planting list, native plants present that require protection and a 5-year action plan.	HIGH	CoW
22	As part of the Stormwater Management Plan identify drainage sumps and upgrade or develop as living streams as appropriate.	MEDIUM	CoW, City of Stirling, and City of Swan
23	Investigate suitability of plant species for the southern wetland area given change in the hydrological regime.	LOW	CoW and DEC
24	Maintain use of local provenance seedlings in revegetation activities.	HIGH	CoW
25	Continue to compile a comprehensive list of species present.	MEDIUM	CoW and FKRB
	NATIVE ANIMALS		
26	Continue to retain tree hollows where possible as refuges for fauna e.g. Carnaby's Cockatoo.	MEDIUM	CoW and FKRB
27	Maintain healthy plant communities to support fauna.	HIGH	CoW and FKRB
28	Utilise current Friends Group knowledge to better understand local invertebrate populations. Undertake further assessment as necessary.	MEDIUM	CoW and FKRB
	FERAL ANIMALS		
29	Actively seek funding and other opportunities to monitor, control and eradicate feral animals where practical.	MEDIUM	CoW
	FUNGI		
30	Continue to work with PUBF to conduct fungi surveys at the site.	MEDIUM	CoW and PUBF
	FIRE MANAGEMENT		
31	Continue to follow the current Fire Pre-Plan and review and update it as necessary.	HIGH	CoW and FKRB
32	Continue to instigate a ban of all open fires at all times within the area unless new research indicates controlled burns are required.	HIGH	CoW
33	Continue to reduce fuel loads through control of weeds.	MEDIUM	CoW
34	Continue to suppress and contain any wildfires within the study area as quickly as possible.	HIGH	CoW
35	Continue to document fire history including mapping of fires, dates and causes recorded.	LOW	CoW and FKRB
36	Continue to control access into burnt areas as soon as possible after the fire. Access to any burnt areas should be limited to management vehicles only for the first six to twelve months.	HIGH	CoW and FKRB
37	Seed germination and regeneration should be monitored for a year following fire and post fire weed control undertaken as necessary.	HIGH	CoW

	INFORMATION, INTERPRETATION & EDUCATION		
38	Upgrade the current information shelter.	MEDIUM	CoW
39	Install signage that includes a map of the reserve, and the track network at least at one point in addition to the information shelter.	LOW	CoW and FKRB
40	Develop an interpretation plan that reviews current signage and establishes interpretative signs along walk trails as appropriate.	MEDIUM	CoW and FKRB
41	Utilise current educational programs such as the "Adopt a Bushland Program" which encourages schools to become involved in bushland management.	HIGH	CoW
42	Design education programs to help raise awareness about issues threatening Koondoola Bushland such as feral animals, fire, weed invasion, dieback etc.	HIGH	CoW
	INDIGENOUS AUSTRALIAN HERITAGE		
43	Prior to any activity at the site resulting in disturbance, an Aboriginal heritage survey should be conducted for Koondoola Regional Bushland and if necessary any appropriate approvals obtained.	HIGH	DEH
	COMMUNITY RELATIONS		
44	Continue current FKRB activities to maintain interest in the group. The City should also continue to provide support and maintain relationships with this group.	HIGH	CoW
	RESEARCH AND MONITORING		
45	Continue to liaise with research organisations such as Greening Australia, the Department of Environment and Conservation, and Universities to develop research initiatives.	HIGH	CoW
46	Develop a detailed monitoring program that aims to improve the understanding of biological and ecological functions, health and values and improved management effectiveness.	HIGH	CoW and FKRB
47	Compile the results of the monitoring program and make publicly available. Undertake an annual audit on management actions undertaken in response to monitoring program and make results publicly available.	HIGH	CoW

1.0 Introduction

Koondoola Regional Bushland Management Plan

1.1 Koondoola Regional Bushland

Koondoola Regional Bushland, which covers approximately 137 hectares, is the second largest conservation reserve managed by the City of Wanneroo.

Originally titled Koondoola Open Space, the bushland's purpose was as a buffer zone between residential areas and a proposed airport that was subsequently abandoned.

Historically, Homeswest owned the 98.4ha in the north of the area and the Western Australian Planning Commission (WAPC) owned the southern area of 38.1ha. In 1994, Homeswest requested that the northern portion of the area be rezoned as urban deferred under the Metro Planning Scheme, in order to allow residential development.

Since this time the WAPC has purchased the land owned by Homeswest and initially leased this land to the City of Wanneroo. The WAPC subsequently transferred the area to the State of Western Australia to enable the creation of "A" class reserve 48449 and to facilitate the protection of the environment and community recreation. The reserve is now vested in the City of Wanneroo for the purpose of Parks and Recreation and Public Purposes.

Koondoola Regional Bushland, which comprises Lots 15502, 15503 & 15504 on Deposited Plan 43510, is a regionally significant area of remnant bushland (Bush Forever Site 201) located in the southeast corner of the City of Wanneroo where it abuts the City of Stirling to the south and the City of Swan to the east, within the residential suburb of Koondoola. Koondoola Regional Bushland, which is shown in Figure 1.0, is situated approximately 13km north of the Perth Central Business District.

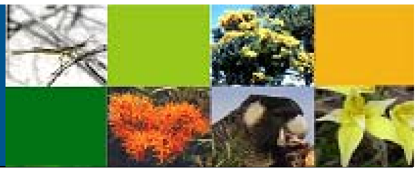


Figure 1.0 Location of Koondoola Regional Bushland

1.2 Purpose and Scope of the Management Plan

The Koondoola Regional Bushland Management Plan was originally drafted in 1995 and the final plan completed in 1998. This original management plan needed to be updated to provide specific direction, addressing current management issues and to reflect the requirements of the latest environmental policies and legislation.

The objective of the project is primarily concerned with formulating these revised directions for the future improvement and management of this reserve by:

- Providing a basis to guide the use and management of Koondoola Regional Bushland over the next 5 years;
- Maintaining the ecological integrity of the vegetation in Koondoola Regional Bushland, and restoring the degraded areas to stable self-sustaining communities resembling the original structure and floristics, where natural regeneration can occur;
- Providing recommendations for stormwater drainage management upgrades of all the outlets in accordance with the best current practices;
- Ensuring that landforms and the full suite of indigenous plants and animals are protected;
- Protecting life, property and the ecological values of the bushland from fire;

- Minimising the risk of introducing and spreading disease, weeds and feral animals;
- Minimising the degree of human disturbance;
- Identifying the natural resources and processes as well as the necessary management measures for preserving and enhancing the conservation values of the area;
- Identifying ecotourism, recreation and leisure resources and providing for public use of the area where appropriate, to meet the needs of nature based passive recreation while maintaining natural ecosystem processes; and
- Investigating the potential and opportunity for the development of passive recreational and interpretational amenities consistent with the values of the area, including bushland conservation.

Connell Wagner Pty Ltd developed a separate specific concept design for the upgrade of the stormwater drainage in conjunction with this management plan.

1.3 Term of this Management Plan

The term of this management plan is 5 years commencing in 2008 and reviewed in 2013.

2.0 Existing Environment

Koondoola Regional Bushland Management Plan

2.1 Location

The site is located between Beach Road to the south, Marangaroo Drive to the north, Koondoola Avenue to the west and Alexander Drive to the east.

2.2 Planning Context

2.2.1 Introduction

To ensure this Management Plan is consistent with other local, regional and national management initiatives, relevant documents, guidelines and policies were reviewed and brief outlines of these documents are given below.

2.2.2 Local Government

Koondoola Regional Bushland Management Plan (Murray, 1998)

The Management Plan for the Koondoola Regional Bushland contains planning concepts and recommendations for the management of the reserve with the aim of:

- Maintaining ecological integrity of Koondoola Regional Bushland, and restoring degraded areas to self sustaining communities resembling the original structure;
- Ensuring that landforms and the full suite of indigenous plants and animals are protected;
- Protecting life, property and ecological values of the bushland from fire
- Minimising the risk of introduction and spread of disease, weeds and feral animals;
- Facilitating the conservation and drainage functions of the southern bushland area;
- Providing nature based recreational opportunities for people in the region without compromising its ecological values; and
- Retaining and enhancing the natural character and aesthetic value of the reserve and preserve the natural vegetation.

The five-year management plan included 53 recommendations. Of these recommendations, 20 were implemented, 6 were partially implemented and 27 have not been implemented by 2005, as indicated in Table 2.1.

Table 2.1 Audit of 1998 Management Plan Recommendations

Focus	Implemented	Partially Implemented	Not Implemented	Unknown	Total
Access	5	0	1	0	**6**
Weeds	3	1	5	0	**9**
Fire	1	1	2	0	**4**
Dieback	4	0	4	0	**8**
Animals	2	1	2	0	**5**
Rehabilitation	1	0	3	1	**5**
Southern Sumpland Area	1	0	4	0	**5**
Education	2	1	2	0	**5**
Monitoring	0	2	2	0	**4**
Liaison	1	0	1	0	**2**
Total	**20**	**6**	**26**	**1**	**53**

Source: Ecoscape, 2005

Full details of implemented recommendations are in Appendix 4.

Management of Phytophthora Dieback at Koondoola Regional Bushland (Zuvela, 2002)

This document provided guidelines for the management of *Phytophthora* dieback at Koondoola Regional Bushland and included the following recommendations:

- Access to Koondoola Regional Bushland should be managed as to minimise the risk of *Phytophthora cinnamomi* introduction;
- No soil/gravel/mulch/plants are to be brought into the bushland area. If these materials must be introduced they must be *Phytophthora cinnamomi* free;
- No drainage water or run off should be discharged into the area;
- Communication with surrounding landholders, visitors to the reserve and other stakeholders to inform them that Koondoola Regional Bushland is free from *P. cinnamomi* and how they can assist in maintaining this position;
- Maintenance activities (eg. Fencing, track maintenance etc) to occur in dry soil conditions, when possible;
- Vegetation to be monitored regularly to identify the death of plants that are susceptible to *P. cinnamomi*; and
- The management guidelines given are to be considered in all management decisions, particularly in relation to bush restoration activities.

The Table of Recommendations and appropriate actions from this report are in Appendix 9.

Rehabilitation Plan (Syrinx, 2002)

This document briefly outlines recommendations to assist with the revegetation planning of Koondoola Regional Bushland, as well as the road verges of Beach Road and Alexander Drive in front of the Ground Water Treatment Plant.

The recommendations for rehabilitation span a period of 3 years from November 2002 to July 2005. For Alexander Drive the recommendations include:

- Weed control of the area, of both hand-pulling and spraying, to be repeated in the second year as well; and
- Monitoring of native seed germination on site, since the adjacent bush would have a high seed bank, plant recruitment is thought to be sufficient.

For Beach Road the recommendations include:

- Due to low weed coverage from recent earthworks, mulch was required to keep weed growth down;
- Planting of native species required to achieve maximum coverage in the shortest possible time; and
- Follow up maintenance is also requested.

Fire Pre-plan for the Urban Bushland area of Koondoola Regional Bushland (John Harper A/FESA, 2004)

This document briefly outlines recommendations to assist with the protection and preservation of Koondoola Regional Bushland from fire.

The recommendations for fire prevention and management include:

- A ban of all open fires at all times should be instigated within the area;
- Reduce fuel loads through control of weeds such as *Ehrharta calycina*, *Eragrostis curvula* and *Paspalum dilatatum;*
- Better documentation of fire history including mapping of fires, dates and causes recorded;
- Control access into burnt areas as soon as possible after the fire. Access to any burnt areas should be limited to management vehicles only for the first six to twelve months. Seed germination and resprouting of vegetation or regeneration should be monitored for a year following fire;
- Revise the current Fire Management plan and update it; and
- Develop public education programs informing the public about the negative effects of fire on bushland and encourage early fire detection (eg. Signs).

FESA and City of Wanneroo personnel are currently reviewing all Fire Pre-Plans within the City, including the Fire Pre-Plan for Koondoola Regional Bushland.

2.2.3 State Government

Bush Forever (Government of Western Australia, 2000)

Bush Forever replaces the System 6 recommendations as a blueprint for conservation of bushland of regional significance in the Perth Metropolitan Region. Bush Forever was prepared by the Department of Environment Protection, Ministry for Planning, CALM (now the Department of Environment and Conservation) and the Water and Rivers Commission (now the Department of Water) and was endorsed by Cabinet and supported by the Environmental Protection Authority as the principle mechanism to identify and protect regionally significant bushland in the Perth Metropolitan Region.

Koondoola Regional Bushland is listed as Bush Forever Site 201 and its recognition as regionally significant bushland is due to:

- It being part of a regionally significant potential bushland linkage forming parts of Greenways 12 & 13 as well as a regionally significant fragmented bushland/wetland linkage;
- The rich reptile assemblage for the size of reserve;
- Significant reptile species: Gould's Goanna (*Varanus gouldii*);
- Significant bird species: Carnaby's Cockatoo Category 1 (1), Western Thornbill Category 3 (2), Splendid Fairy Wren Category 4 (6); and
- Significant flora*: Jacksonia sericea (Priority 4).* As well as *Verticordia drummondii* and *Verticordia nitens*, which are poorly conserved in the Perth Metropolitan Region.

The Bush Forever Site implementation recommendation for Koondoola Regional Bushland is:

> *'The existing care, control and management intent of the reserve is endorsed. The purpose of the reserve should be amended to include conservation and appropriate mechanisms applied in consultation with the management body'.*

Draft Bushland Policy for the Perth Metropolitan Region Statement of Planning Policy 2.8 (Western Australian Planning Commission, 2004)

This policy recognises the protection and management of significant bushland areas, which have been identified for protection through an endorsed strategy, as a fundamental consideration in the planning process, while also seeking to integrate and balance wider environmental, social and economic considerations, thereby reflecting the principles of sustainability (Western Australian Planning Commission, 2004).

The key objectives of this Policy are:

- To establish a conservation system that is, comprehensible, adequate, and representative of the ecological communities of the Swan Coastal Plain portion of the Perth Metropolitan Region (PMR);
- To seek, to protect and manage bushland within the PMR through a range of mechanisms based on site opportunities and constraints and as a collective and

shared responsibility and general duty of care on the part of government, landowners and the community;

- To provide a policy and implementation framework for bushland areas of significance that are identified for protection and management in the PMR to assist planning assessment and decision-making processes, and to ensure:
    i. Consistency, transparency and certainty for landowners, decision-makers and the broader community;
    ii. Integrated and balanced environmental, social and economic outcomes;
    iii. Existing planning or environmental commitments or approvals are recognised; and
    iv. Development and land uses compatible with bushland protection and/or provide for an improved environmental outcome, are supported and incorporate best practice performance based planning, design and management outcomes.

National Trust of Australia (W.A) Act 1964

Bush Forever (Government of Western Australia, 2000) indicated that Koondoola Regional Bushland is listed on the Register of the National Trust of Western Australia. The Register includes landscapes, buildings, industrial sites etc, which the Trust determines as having heritage significance and being worthy of conservation. Listing by the National Trust W.A is an authoritative statement of the heritage significance of a particular location and is not legally binding on the landowner.

Koondoola Regional Bushland has been classified as an area of heritage significance and has been entered in the National Trust's Register of heritage places under the criteria from the Urban Bushland Policy. The dominant community type of *Banksia attenuata* woodlands over species rich dense shrublands has been acknowledged as being a highly diverse and unusual *Banksia* dominated community. The high scientific value of this community type dictates its great regional significance, and endangered status.

Aboriginal Heritage Act 1972

There are no registered Aboriginal Sites within Koondoola Regional Bushland. Aboriginal Sites, regardless of whether they are registered or not, are protected under the Aboriginal Heritage Act, 1972:

- **Section 5** defines sites as places of importance where objects connected with traditional life have been left, stored or taken from; ceremonies have been conducted; some ethnographic interest;
- **Section 15** requires that findings be reported;
- **Section 17** makes it an offence to excavate, destroy, damage, conceal or in any way alter any Aboriginal site; and
- **Section 18** establishes the conditions for certain uses of land unaffected by the Act.

Banksia attenuata over species rich dense shrublands Draft Interim Recovery Plan (V. English, 2005)

Interim recovery plans identify key actions urgently required to preserve Threatened Ecological Communities (TECs) such as the *Banksia attenuata* over species rich dense shrublands (Floristic Community Type 20a) that occurs in Koondoola Regional Bushland.

A five year Interim Recovery Plan (IRP) is being developed for the management of *Banksia attenuata* over species rich dense shrublands with the objective of maintaining or improving the overall condition of the plant community in the known locations and reduces the level of threat.

The IRP for this plant community has yet to be finalised or endorsed by the Department of Environment and Conservation but the major potential threats to the occurrence at Koondoola Bushland that need to be addressed are:

- The lack of a secure conservation purpose for the site;
- Inappropriate fire regimes;
- Rubbish;
- Weeds; and
- Grazing (by rabbits).

A Guide to Wetland Management in the Perth and near Perth Swan Coastal Plain Area (EPA Bulletin 686)

Wetlands have value for two reasons:

- They are important to wildlife as 'natural' ecosystems; and
- They are important to people for human use purposes.

Based on this it is possible to identify five different management categories in which to place wetlands (Environmental Protection Authority, 1993).

The southeast portion of Koondoola Regional Bushland includes two seasonal sumplands that are mapped and classified under the EPA Bulletin 686. Little Emu Swamp is a category C and the other unnamed sumpland is a category R

Conservation (Category C)
These wetlands possess a high degree of naturalness. This classification aims to maintain and enhance the natural attributes and functions of the wetland.

Resource enhancement (Category R)
These wetlands have been modified and do not have clearly recognized human uses in their urban or rural settings. They have a moderate degree of naturalness and human interest. Some of the wetlands in this category will be the focus for controversy if uncontrolled developments begin to impinge upon them. Management of such a wetland is to maintain and enhance the existing ecological functions.

2.2.4 Federal Government

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

*Calyptorhynchus latirostris (*Carnaby's-Cockatoo) is recorded for the site and is listed as *Vulnerable* and is protected under the *Commonwealth EPBC Act, 1999*.

Under the EPBC Act, approval is required for actions that are likely to have a significant impact on: a matter of national environmental significance. The EPBC Act contains several compliance and enforcement mechanisms. These include court injunctions, required environmental audits, strict civil and criminal penalties, remediation of environmental damage, liability of executive officers, publicising contraventions.

2.2.5 Land Tenure/Ownership and Management Orders/Vesting

Koondoola Regional Bushland is owned by the State of Western Australia and vested in the City of Wanneroo. It is reserved for Parks and Recreation under the Perth Metropolitan Region Scheme (MRS) and City of Wanneroo District Planning Scheme, while the MRS for Waddington Park is Urban and the Water Corporations land is reserved for Public Purposes (Table 2.2).

Koondoola Open Space land parcels have recently been largely redefined on Deposited Plan (DP) 43510. It is now contained in lots 15502, 15503 and 15504 on DP 43510 as A class reserve 48449 (Figure 2.0) (Ruscoe, 2006).

Table 2.2: Managing Authority and Zoning of Koondoola Regional Bushland

Lot Number	Reserve Number	Reserve Name	Managing Authority	MRS Zone	Hectares (ha)
not listed					0.04
2			Water Corporation	Public Purposes	0.808
3			Water Corporation	Public Purposes	14.984
301			Water Corporation	Public Purposes	5.959
15502	48449	Koondoola Regional Bushland	City of Wanneroo	Parks and Recreation	92.1421
15503	48449	Koondoola Regional Bushland	City of Wanneroo	Parks and Recreation	40.89
15504	48449	Koondoola Regional Bushland	City of Wanneroo	Parks and Recreation	0.571
Swan Loc 3146	18642	Trig Station	Water Corporation	Public Purposes	0.405
11724	42347	Waddington Park	City of Wanneroo	Urban	2.418
Total					**158.217**

Source: Ecoscape, 2005

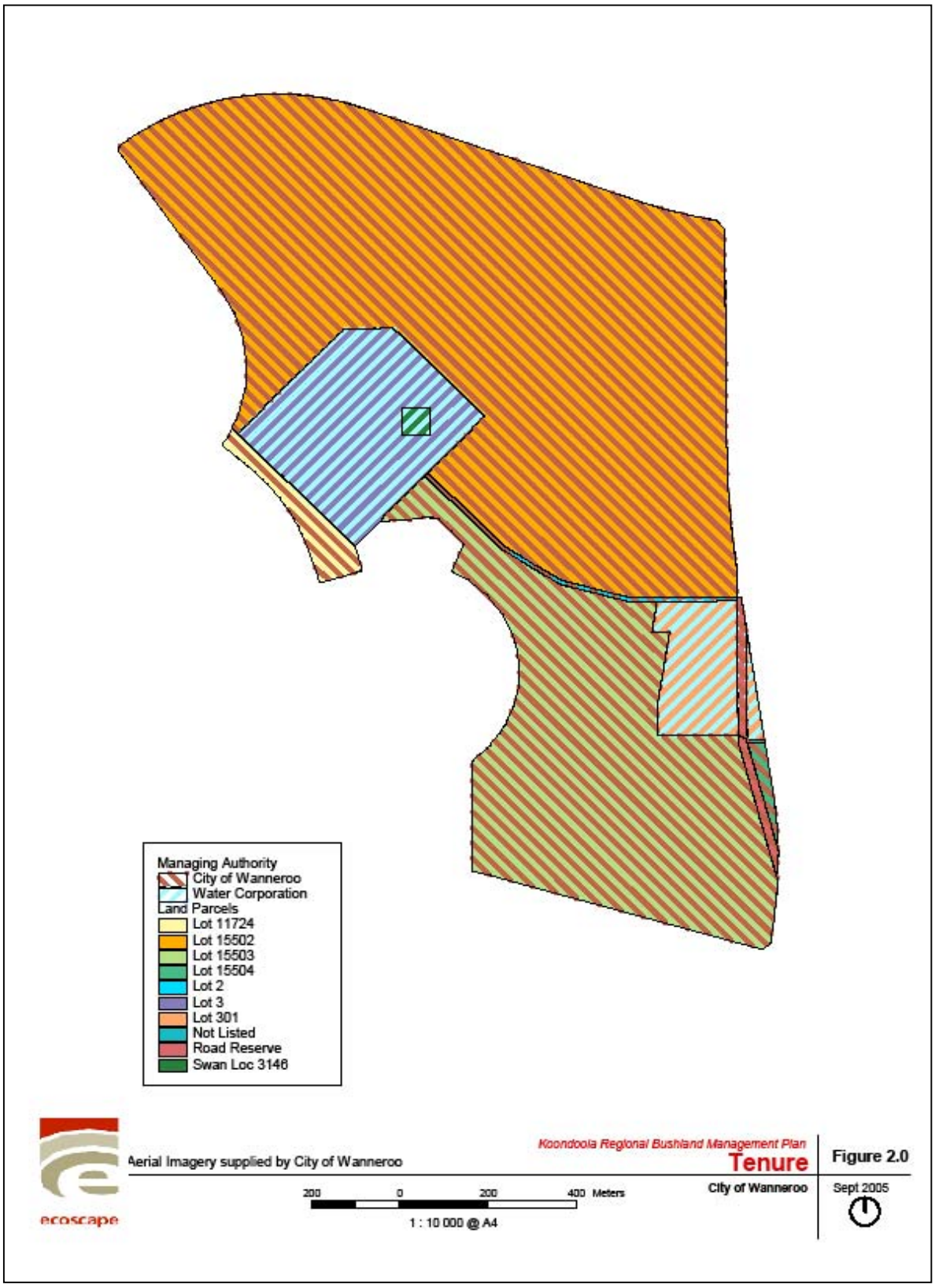


Figure 2.0 Land Tenure arrangement for Koondoola Regional Bushland

2.2.6 Surrounding Land use

The bushland is largely bounded by roads and surrounded by residential development to the north, west and south. The western boundary is formed by the Water Corporation's Mirrabooka Reservoir site and Koondoola Avenue, the southern boundary is formed by Waddington Crescent (Waddington Park is included as part of Koondoola Regional Bushland in this plan), adjoining housing and Rendell Park.

To the east there is a Water Corporation water treatment plant abutting the bushland and commercial and retail development across Alexander Drive.

2.2.7 Corridors and Linkages

Habitat loss and fragmentation have been recognised as key global issues facing conservation of biological diversity (World Conservation Strategy, IUCN 1980). Linkages are not necessarily linear or continuous, but they must enhance connectivity for species, communities and/or ecological processes.

Links and corridors have a number of benefits;

- They provide habitat for plants and animals;
- They are used as pathways by animals undertaking regular movements either daily, seasonally, are migratory or are moving between different habitats at different stages in its life cycle;
- They can allow individuals to move into isolated habitats to recolonise, introduce new genetic variation or supplement small and declining populations;
- They contribute to ecological processes such as, seed dispersal and pollination. Protect stream water quality and act as a buffer from runoff of nutrients and pollutants; and
- They provide important social benefits for people in urban areas as places for recreation, relaxation and appreciating nature, a sense of location and identity and landscape value.

Koondoola Regional Bushland is adjacent to Reid Highway Bushland (Bush Forever Site 385) to the south. These form part of the Marangaroo Road and Alexander Dr-Gnangara Lake Greenways (greenways 12 & 13) and are a regionally significant fragmented bushland/wetland linkage (Government of Western Australia, 1990).

2.3 Biophysical Environment

2.3.1 Climate

The Perth region exhibits a Mediterranean climate with wet mild winters and dry hot summers. The average rainfall is 760mm each year, this generally occurs in the winter months when little is lost through evaporation (Bureau of Meteorology, 2007). The average rainfall and temperatures for Perth are shown in Figure 2.1 below.

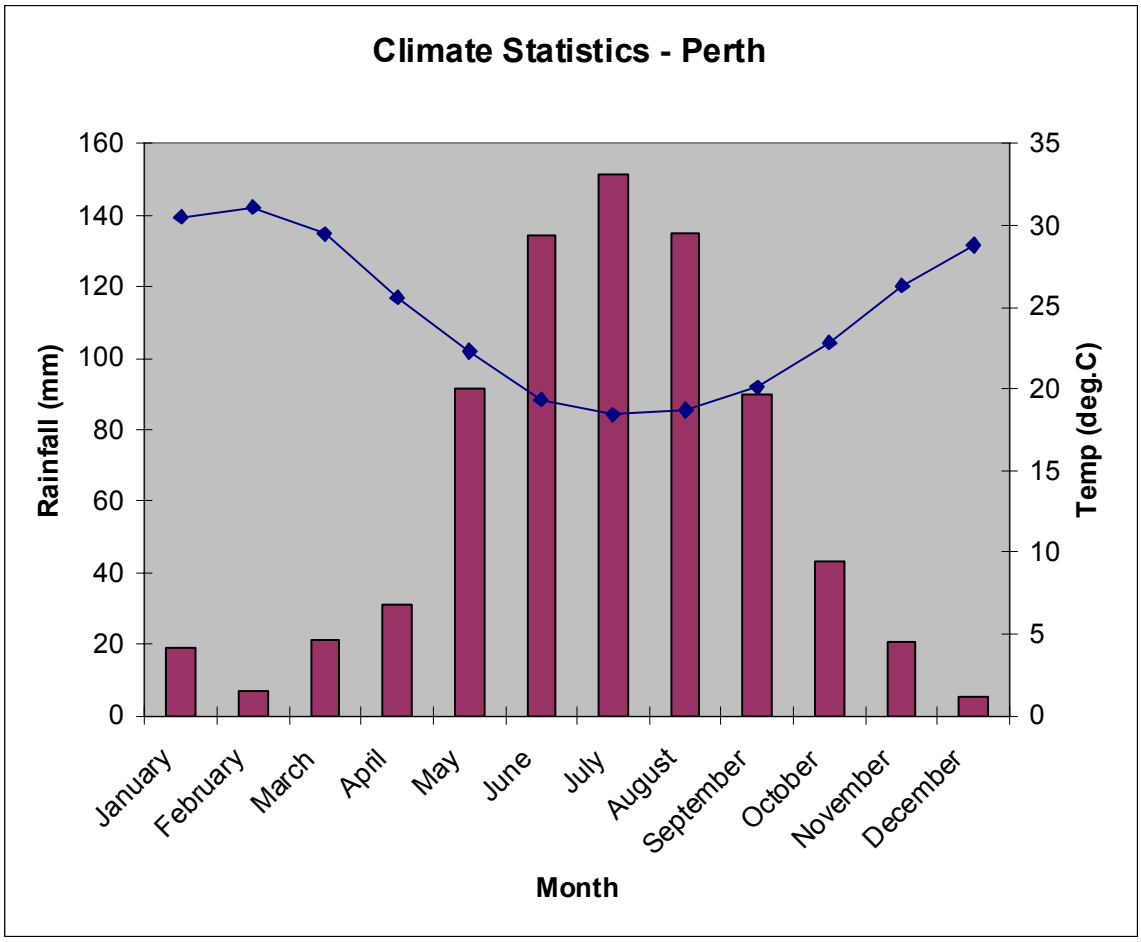


Figure 2.1 Temperatures and Rainfall for Perth (Bureau of Meteorology 2005)

Climate Change

Historical climatic data indicates that southwest Western Australia is becoming warmer and drier. Average temperatures for the South West have risen by 0.7 degrees in the last 50 years and rainfall has decreased between 10-20% in the past 30 years. An indication of the magnitude of the impact of the combined effect of decreased rainfall and increased evaporation on wetlands is the 30% decline in the volume of water being captured by dams in the South West.

Whilst difficult to make accurate predictions regarding future trends, computer climate modelling suggests that this trend will continue in the South West and will likely be significant over the next century (IOCI, 2002).

2.3.2 Geology, Soils and Landforms

Landforms

The site varies from a high point of 90m AHD to the west in the vicinity of the Water Corporation Water Reservoir to a low point of approximately 34m AHD in the south east of

the site where two seasonal wetlands or sumplands occur in depressions as surface expressions of the Gnangara mound which underlies the area.

Geology

Perth is located on the Swan Coastal Plain, comprising of a series of dunes running parallel to the coast, which become older from west to east (as one moves inland). The dune system closest to the coastline is the Quindalup Dunes, which are the youngest dunes. The Spearwood Dunes is the next system to the east and Bassendean Dunes are the oldest and most inland dune system.

Koondoola Regional Bushland is located on the Spearwood Dune System but the southeast of the Reserve forms part of the transition zone to the Bassendean Dune system that is delineated by a line of swamps and lakes.

The Spearwood Dunes are relatively young, of Aeolian origin with a degraded surface as a result of leaching, and show complex patterns of erosion and superdeposition. The dunes have relatively high hills due to being young and tend to possess variable topography (Seddon, 1972).

Soils

Koondoola Regional Bushland overlies the boundary between the Bassendean and Spearwood Dune Systems.

The Spearwood Dune System is divided into two soil associations. The Koondoola Regional Bushland coincides with the easternmost of these two soil associations. This is the Karrakatta Soil Association which consists of deep, leached yellow and brown sands overlying limestone at depth (Heddle, Longeragan et al., 1980).

The Bassendean Dune System is associated with Bassendean Soil Association. The Bassendean soil association consists of grey, and some yellow quartz sands that form low hills while the Karrakatta soils consist of Surface Quartz sands, coated with iron oxide, giving them a yellowish colour. These are slightly acidic, free draining and nutrient poor (Gozzard, 1983).

Both associations are well leached and highly erodible. They are also susceptible to *Phytophthora cinnamom*i, the fungus that causes Dieback, especially in the damper areas of the swales of the Bassendean sands, located in the southern area of Koondoola Regional Bushland (Murray, 1998). However, due to the higher levels of the dunes and the underlying Karrakatta soil associations the risk of Dieback is reduced (Keighery, 1994; Zuvela, 2002).

Acid Sulfate Soils

As shown in Figure 2.2, the southeast portion of Koondoola Regional Bushland was identified as having a high risk of actual acid sulfate soils (ASS) and potential acid sulfate soils (PASS) (WAPC, 2003).

Actual Acid Sulfate Soils (ASS) are naturally occurring soils containing iron sulfides that have reacted with oxygen to produce acids. Potential Acid Sulfate Soils (PASS) contains sulfides that have not reacted with oxygen (usually due to being permanently waterlogged). They produce acids when exposed to air by excavation, filling, creation of artificial water courses, or groundwater abstraction/dewatering (WAPC, 2003).

The impacts associated with acid sulfate soils can be associated with the increase in acidity and/or the release of heavy metals into the environment. This can result in:

- Wetlands degradation;
- Localised reduction in habitat and biodiversity;
- Deterioration of surface and groundwater quality;
- Loss of groundwater for irrigation;
- Increased health risks associated with arsenic and heavy metals contamination in surface and groundwater, and acid dust;
- Risk of long-term infrastructure damage through corrosion of sub-surface pipes and foundations by acid water; and
- Invasion by acid tolerant waterplants and dominance of acid tolerant plankton species causing loss of biodiversity.

Bare Soil

There is an area of bare soil towards the centre of the Koondoola Regional Bushland. City of Wanneroo staff observed that this area was not supporting native vegetation or weed species. Anecdotal evidence revealed that in the past this part of the site might have been used to bury rubbish. Soil testing was therefore undertaken to determine the presence of any contamination (City of Wanneroo, 2007).

No soil contamination has been found at this location and it remains a mystery as to why this area is not populated with plant species.

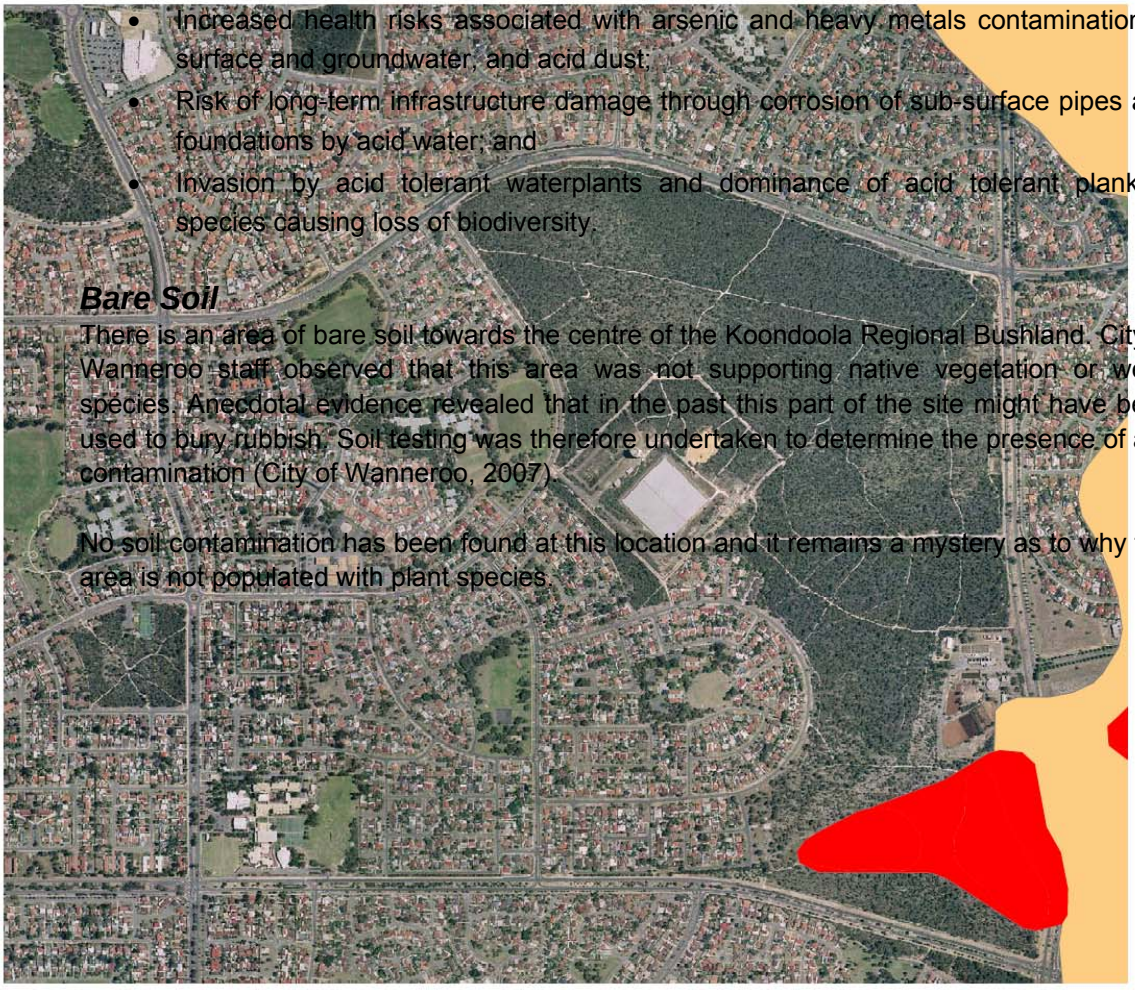


Figure 2.2 Acid Sulfate Soils Risk Map

2.3.3 Hydrology and Hydrogeology

Groundwater Levels

Estimates of the maximum groundwater levels across the site relative to AHD (Australian Height Datum) are shown in Table 2.3.

Table 2.3 Groundwater levels at monitoring sites at Koondoola Regional Bushland

Bore Number	Easting	Northing	Last measured depth (AHD)
4549	393624	6476099	30.65
4557	393705	6476381	31.05

Source: Department of Environment and Conservation, 2005

The height of the watertable varies slightly throughout the entire area. The groundwater in the north section of Koondoola Bushland has been found at 41 m below the surface in winter and 44m in summer of past years. At the highest point of the reserve the water has been found at 47-50m below the surface. The southern end of Koondoola Regional Bushland has seasonal changes in groundwater of approximately 3m and on occasion water appears in the basins. The wetlands have been dry since 1995, possibly as a result of the reduction in water flow from Big Emu Swamp after the development of "Summer Lakes" in Ballajura. The stormwater drainage into this area could partially compensate for the reduction in water input, however it is more likely to decrease water quality and enhance weed production (Murray, 1998).

The groundwater flow through Koondoola Regional Bushland is in a south westerly direction (Department of Environment and Conservation, 2004).

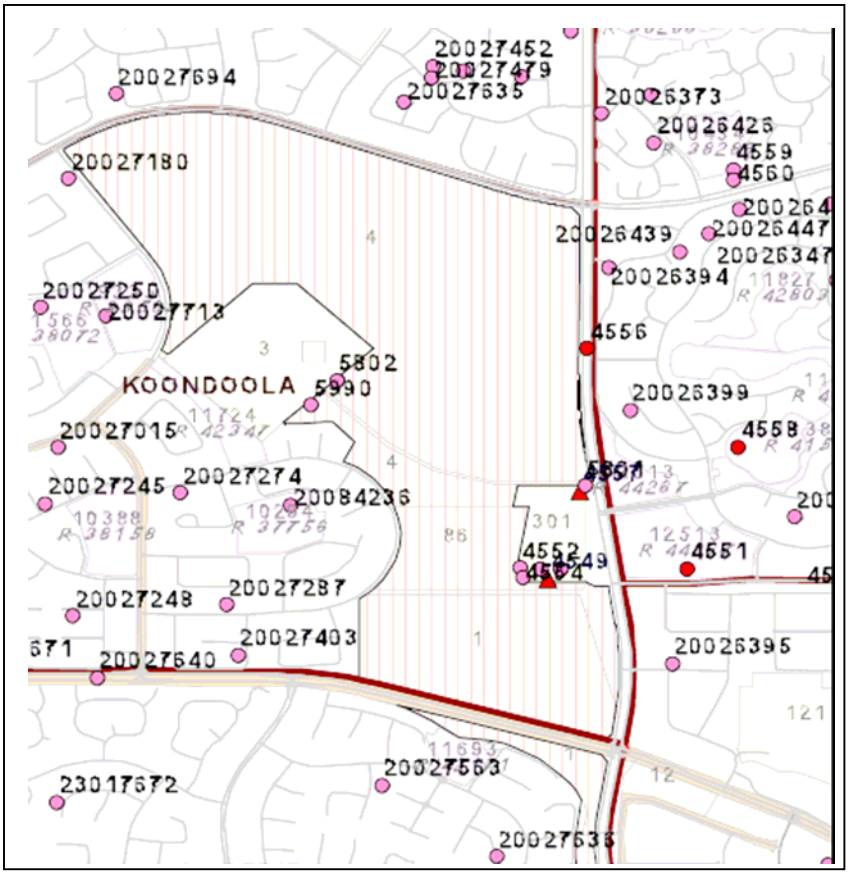


Figure 2.3 Bores in the Vicinity of Koondoola Regional Bushland

Data for monitoring bores in the vicinity is available and the two bores closest to Koondoola Regional Bushland (4557 & 4549) show a slight decline in groundwater levels over the past 30 years, but are still within the range of previous years fluctuations. These are shown in Appendix 5. The falling groundwater in the vicinity of the bushland is consistent with decreasing rainfall in the southwest of Western Australia and falling groundwater levels across the Gnangara Groundwater Mound over a similar timeframe and therefore it is **not** likely that changes in the hydrology around Koondoola Regional Bushland are purely the result of groundwater abstraction in the immediate vicinity.

In addition to the bores shown in Figure 2.3, houses surrounding the Bushland are using domestic bores (Miotti, 2005).

There are 158 groundwater observation and abstraction bores registered by the Department of Environment and Conservation within 2300 metres of Koondoola Regional Bushland. The purpose of these bores is indicated in Table 2.4.

Table 2.4 Purpose of Bores in vicinity of Koondoola Regional Bushland

Purpose	Number of Bores
Domestic	9
Observation / Monitoring	23
Production	11
Irrigation (schools, parks etc)	17
Garden Irrigation	4
Not listed	91
Total	**158**

Source: Department of Environment and Conservation, WA

The effects of changes in hydrology are determined by the rapidity, extent and permanence of groundwater draw-down (Dodd and Heddle, 1989). Watertable lowering may also have an impact on ecosystems dependant on shallow groundwater and result in a decrease in the abundance and distribution of drought sensitive tree species that fringe wetlands (Groom, Froend et al., 2001).

Vegetation complexes, like *Banksia* woodlands, found at Koondoola Regional Bushland can be particularly susceptible to changes in groundwater levels, depending on the historic proximity of groundwater to the soil surface, the availability of water in the unsaturated zone, plant root depth and morphology (Department of Environment and Conservation, 2005).

Previously the low drawdown from bores in the immediate area was thought unlikely to cause any deaths of the species typical of *Banksia* woodlands. However, current observations have shown there to be an increase in the deaths of mature *Banksia* trees across the bushland. The reduction of water in the basins could be responsible for reducing the diversity and abundance of wetland plants, such as the sedges that grew there. This has resulted in an increase of weed invasion, and the succession of non-wetland plants is most likely to occur.

2.3.4 Vegetation and Flora

Regional Scale Vegetation Units

The representation of vegetation at a regional scale was examined with reference to the two regional vegetation classification systems required to assess the conservation significance of vegetation:

- Vegetation Complexes as defined by Heddle *et al.* (1980); and
- Floristic Community Types (FCTs) defined by Gibson *et al*. (1994).

Vegetation Complexes

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).

Koondoola Regional Bushland is located within the area mapped by Heddle *et al.* (1980) as the *Karrakatta – Central and South Vegetation Complex*. This Complex is characteristic of the Karrakatta soil association and occurs as a narrow belt approximately five km wide two to three km from the coastline. This Vegetation Complex type is typically dominated by *Eucalyptus marginata* and *Banksia* species.

The site is also in close proximity to the boundary of the Karrakatta and Bassendean Complexes, the boundaries of which are not precise given that mapping was at a regional scale. In the *Bassendean Central and South Vegetation Complex* the dominant vegetation type is *Eucalyptus marginata -Allocasuarina fraseriana - Banksia* species, to woodlands of *Melaleuca* species and Sedgelands on moister sites. Table 2.5 shows the area that each complex occupies within Koondoola Regional Bushland.

Table 2.5 Remaining Complexes on the Swan Coastal Plain (SCP)

Vegetation Complex	Remaining on SCP/PMR		Remaining on SCP in Secure Tenure	
	Area (ha)	% Original Area	Area (ha)	% Original Area
Karrakatta Central and South	6275	18	1941	5.6
Bassendean Central and South	10919	24.0	2818	6.1

Source: Bush Forever (2000)

Floristic Community Types

The community grouping method of Gibson *et al.* (1994) uses Floristic Community Types (FCT). 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 (Government of Western Australia, 2000).

As vegetation communities form part of a continuum (rather than discrete groups), a definitive classification of the vegetation requires all species within a 10x10m quadrat to be recorded,

and the data statistically analysed against the records of more than 500 previously established quadrats.

Two FCT were identified as occurring within Koondoola Regional Bushland. These are SCP 20a (which was confirmed through floristic sampling); and SCP 11 (which was inferred, i.e. assessed without floristic sampling).

The status of these FCT are listed in Table 2.6

Table 2.6 Status of Floristic Community Types Recorded Onsite

Floristic Community Types	Conservation Status	Reservation Status
20a *Banksia attenuata* woodlands over dense rich shrublands	Endangered	Unreserved
11 *Wet forests and woodlands.*	Low Risk	Well Reserved

Source: Ecoscape, 2005

Local Scale Vegetation Units

A detailed flora and vegetation survey was not required for the purpose of this management plan, as a survey was conducted in the spring of 2004 by an ecologist employed by the City of Wanneroo (Pike 2004). The results of this survey have been incorporated into the Koondoola Regional Bushland Management Plan (Figure 2.4).

An initial survey completed by Pike (2004) described and mapped three vegetation communities (Sedgelands, *Melaleuca preissiana* Woodlands and *Banksia attenuata/Banksia menziesii* Woodlands). Ecoscape adapted this to only two communities (Table 2.7). Eucalyptus marginata-Banksia woodlands with Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana with a diverse understorey dominate the majority of the bushland. Vegetation is dense and robust in this area and should be fairly resistant to weed invasion. The other communities present, occur between the Karrakatta Soil Association and the depression of the Bassendean Soil Association. The Southern section is dominated by *Melaleuca preissiana-Eucalyptus rudis* with two sumplands occurring in the swale. The Eastern sump is dominated by *Astartea fascicularis* heathland over *Baumea articulata-Juncus pallidus* sedgeland, while exotic grasses dominate the Western sumpland.

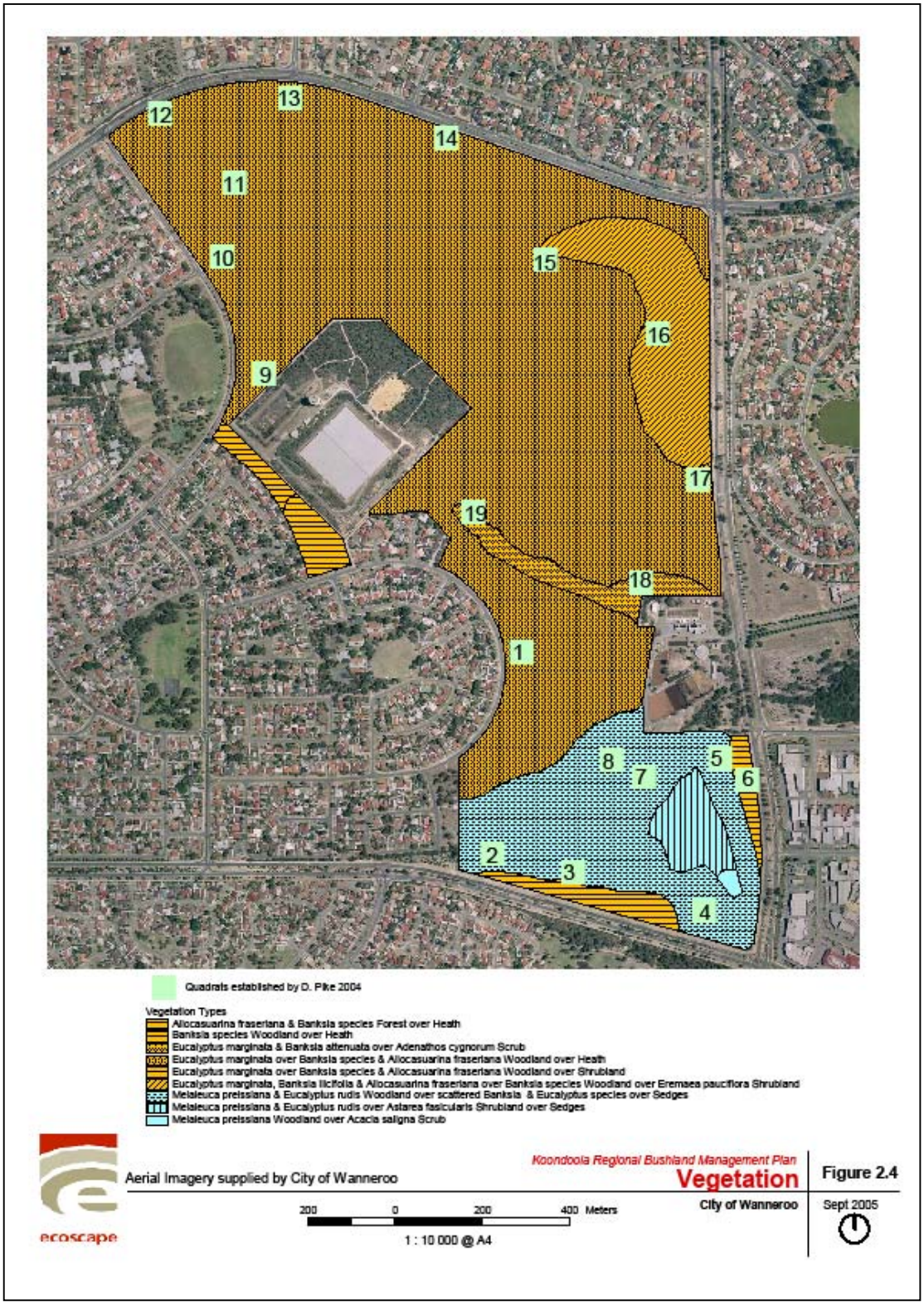


Figure 2.4 Vegetation Types

Table 2.7 Two Vegetation Associations within Koondoola Regional Bushland

Associations	Area (hectares)	Sub-associations	Area (hectares)
Melaleuca preissiana Woodlands	21.7	*Melaleuca preissiana* and/or *Eucalyptus rudis* Low Closed Forest - Low Open Woodland over scattered *Banksia attenuata /Banksia menziesii / Banksia ilicifolia / Eucalyptus todtiana* over *Baumea juncea* Sedgeland-Open Sedgeland and Veldt Grass/Love Grass Grassland	19.418
		Melaleuca preissiana Low Woodland over *Acacia saligna* Tall Open Scrub over Mixed Exotic Herbland	0.248
		Scattered Emergent *Eucalyptus rudis /Melaleuca preissiana* over *Astartea fascicularis (Verticordia densiflora /Hibbertia vaginata)* Open Shrubland - Open Low Heath over *Baumea articularis /Baumea juncea* Sedgeland - Open Sedgeland	2.96
Banksia attenuata/Banksia menziesii Woodlands	110.5	*Allocasuarina fraseriana / Banksia attenuata / Banksia menziesii* Low Open Forest over *Allocasuarina humilis /Jacksonia sternbergiana* Open Heath Mixed Open Low Heath	0.9
		Banksia attenuata / Banksia menziesii Low Woodland over Mixed Open Low Heath	2.562
		Scattered *Banksia ilicifolia /Allocasuarina fraseriana /Eucalyptus marginata* over *Banksia attenuata / Banksia menziesii* Low Woodland - Low Open Woodland over *Eremaea pauciflora* Low Shrubland over *Patersonia occidentalis /Phlebocarya ciliatum* and *Mesomelaena pseudostygia* Herbland/Sedgeland	10.361
		Scattered Emergent *Eucalyptus marginata / Banksia attenuata* over *Adenanthos cygnorum* Tall Open Scrub over *Leucopogon conostephioides /Jacksonia sericea /Scholtzia* involucrata Low Shrubland - Open Low Heath over Mixed Open Herbland	3.1
		Scattered *Emergent Eucalyptus marginata* over *Banksia attenuata / Banksia menziesii / Allocasuarina fraseriana /Banksia ilicifolia* Low Woodland - Low Open Woodland over Mixed Low Shrubland - Open Heath over *Phlebocarya ciliatum /Patersonia occidentalis /Alexgeorgea arenicola* Open Herbland / Open Sedgeland	1.941
		Scattered *Emergent Eucalyptus marginata* over *Banksia attenuata / Banksia menziesii /Allocasuarina fraseriana* Low Woodland - Low Open Woodland over scattered *Banksia ilicifolia / Banksia grandis /Nuytsia floribunda* over Mixed Open Low Heath	95.93
		Degraded Alexgeorgea nitens Sedgeland over *Veldt Grass /*Wild Oats Grassland	0.1
Total	**132.2**		**132.2**

Source: Ecoscape, 2005

The varied topography may be a contributing factor to the diversity in the communities present.

Bushland Condition

The majority of the site is in very good to excellent condition (Figure 2.5)

Table 2.8 Extent of Bushland by Condition

Condition Rating	Area (ha)
Very Good - Excellent	105
Fair - Good	4
Poor	17
Very Poor	6
Total	132

Source: Ecoscape, 2005

Flora

Indigenous Flora

There were 274 native plant species recorded by the Friends of Koondoola Regional Bushland, full listing in Appendix 3. There are three known significant species. *Jacksonia sericea* was recorded in the 1998 Management Plan and is identified by the Department of Environment and Conservation as a *Priority 4 Taxa*. This means that this species is considered to have been adequately surveyed and whilst rare in Australia is not currently threatened by identifiable factors and requires monitoring every 5-10 years.

Verticordia drummondii was recorded at Koondoola and is recognised as being poorly conserved in the Perth Metropolitan area along with *Verticordia nitens* which is also recognised as the most western appearance of this species in the Perth Metropolitan Region (Government of Western Australia, 2000).

Non –indigenous Flora

There are 74 weed species recorded for the site by the Friends of Koondoola Regional Bushland.

Non-indigenous Flora or weeds are defined as introduced plants that invade native communities and are undesirable from an ecological perspective. They have the potential to reduce the aesthetic appeal of the bush as well as reducing habitat for the native fauna. Weeds will also out compete many of the native/local species, especially if the area has been disturbed, either by clearing or fire. Such species as **Ehrharta calycina* (Perennial Veldt Grass), **Eragrostis curvula* (Love Grass) and **Paspalum dilatatum* which are found in Koondoola Regional Bushland possess lifecycles that are facilitated by annual fires.

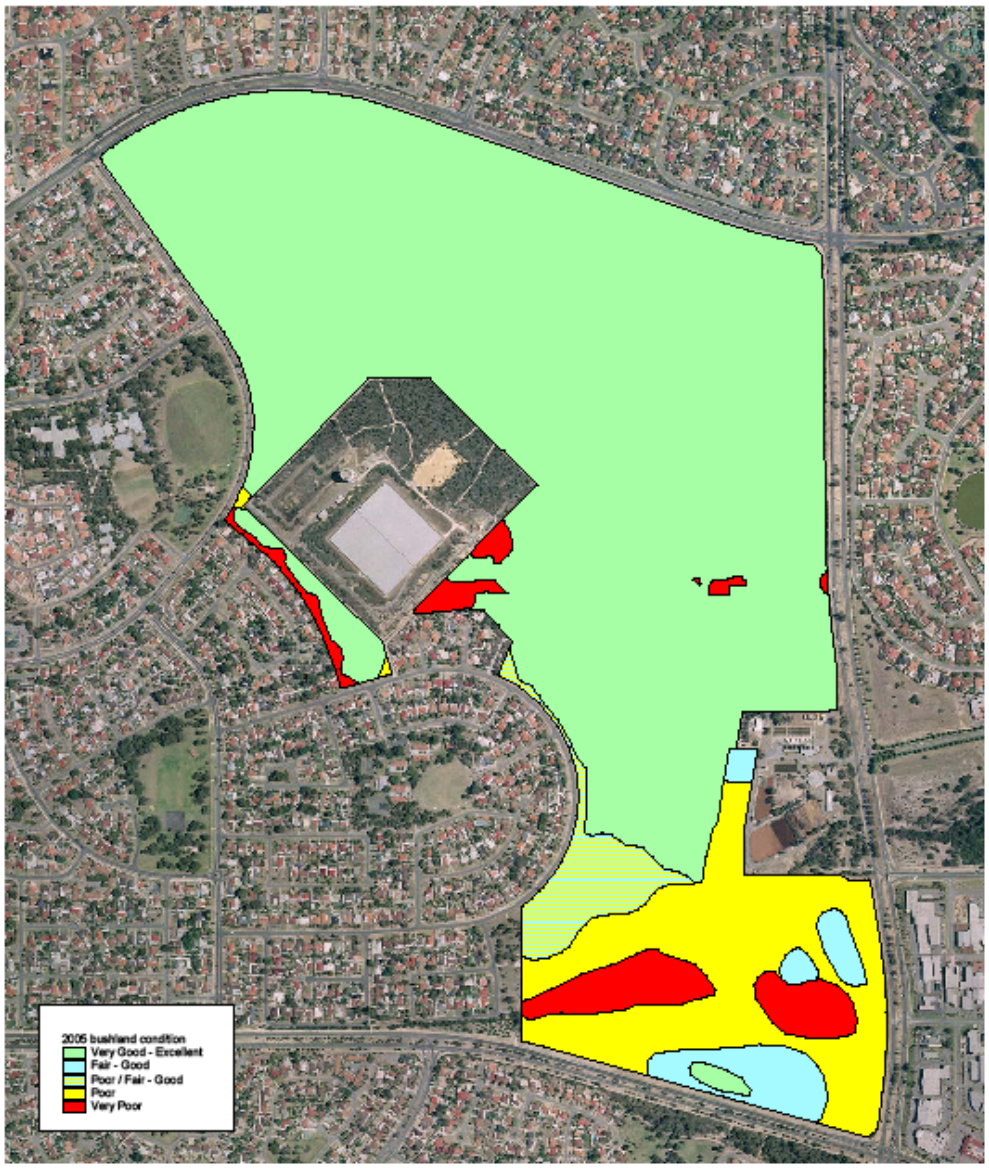


Figure 2.5 Bushland Condition

The methods utilised in the control of such weeds is varied, depending on the type of weed, its abundance, its potential invasive capability and the natural community in which it occurs (Murray, 1998). A list of the main weed species with eradication methods is provided in Appendix 2.

2.3.5 Fauna

A Fauna survey of Koondoola Regional Bushland, using pitfall traps, was conducted by Crypto (1995), which resulted in 34 species of birds observed, 2 species of native mammals as well as 21 species of reptiles and amphibians. A 2003 bird survey revealed only 32 species compared to the 1995 Crypto survey (Jones and Gole, 2003). Due to more recent development and increased urbanisation of the Wanneroo area, more species may no longer be present.

With the increase in urban development, bushland reserves like Koondoola Regional Bushland are very important. They provide a last refuge for the native species that were once widespread throughout the Swan Coastal Plan. For example, birds can use these areas as green corridors or linkages through which to move, and in some cases, shelter and breed. With the less mobile species, these reserves provide the essential elements required for survival (Murray, 1998).

Fauna that has been observed by Crypto (1995) is presented in Table 2.9 (full listing in Appendix 1).

Table 2.9 Species of Significance found at Koondoola Regional Bushland

Species	Common Name	Conservation Status#
Calyptorhynchus latirostris	Carnaby's Cockatoo	Endangered
Hypochrysops haliaetus	Western Jewel Butterfly	Threatened
Synemon gratiosa	Graceful Sun Moth	Rare
Merops ornatus	Rainbow Bee-eater	Migratory
Isoodon obesulus	Quenda (Southern Brown Bandicoot)	Schedule 1
Macropus irma	Western Brush Wallaby	Priority 4
Acanthiza inornata	Western Thornbill	Schedule 3

Source: Crypto, 1995; Wildlife Conservation Act, 1950; and Environmental Protection and Biodiversity Conservation Act, 1999

#Conservation status defined in Appendix 6

Indigenous Fauna

Four species of frogs were found during the 1995 survey. These were: *Crinia insignifera* (Sandplain Froglet), *Heleioporus eyrei* (Moaning Frog), *Limnodynastes dorsalis* (Banjo Frog) and *Myobatrachus gouldii* (Turtle Frog). All these frogs except *Myobatrachus gouldii* (Turtle Frog) need water for the development of their larval stages (How and Dell, 1993). No frogs have been recorded since 1997 when the last Moaning Frog was heard in the southwest drainage basin (Friends of Koondoola Regional Bushland, 2001). This could be due to the

wetlands of the Koondoola Regional Bushland becoming increasingly dry and the periods of inundation having decreased.

Eighteen species of reptiles were observed, with the family Pygopodidae (Legless Lizards) well represented. *Pletholax g. gracilis* (Keeled Legless Lizard) was found and is dependant on *Banksia –Eucalyptus* woodlands or heaths on sandy soils (Wilson and Knowles, 1988). This habitat type has become locally reduced leading to a decline in this species range through the Perth Metropolitan Region. Koondoola Regional Bushland is therefore an important habitat locality for this species.

Of the family Varanidae, two out of the three species occurred at Koondoola. These were *Varanus gouldii* (Common Sand Monitor) and *Varanus t. tristis* (Black Tailed Monitor). There are only a few reserves within the Perth region where these two species have been observed concurrently.

Bird species observed were representative of the Swan Coastal Plain, as Koondoola Regional Bushland can provide refuge, food and breeding sites for a variety of species. One of particular importance is *Calyptorhynchus latirostris* (Carnaby's Cockatoo), listed under the Environmental Protection Biodiversity Conservation (EPBC) Act (1999) and Schedule 2 in the Wildlife Conservation Act (1950) or Category 1(1) in Bush Forever (2000) and is recognised as needing special protection. There were also sightings of *Malurus splendens* (Splendid Fairy Wren), seldom seen in urban areas with Bush Forever (2000) classifying it as a Category 3(2) species.

Only one species of native mammal was recorded during the Crypto (1995) survey: *Macropus irma* (Western Brush Wallaby), listed on the 2000 IUCN Red List of Threatened Species as Low Risk (near threatened) and is listed as a Priority 4 (taxa in need of monitoring) species by the Department of Environment and Conservation.

The *Isoodon obesulus* (Southern Brown Bandicoot or Quenda) is listed as Priority 5 (conservation dependent), by the Department of Environment and Conservation. The presence of this species in swamps and dense understorey vegetation of *Banksia* woodlands and jarrah forests is seen via their distinct diggings. Due to evidence of these diggings found at Koondoola Regional Bushland it is thought likely to occur. This species is also listed on the 2000 IUCN Red List of Threatened Species, as Lower Risk (near threatened) and under the EPBC Act (1999) as, Endangered. Their preferred habitat is, dense shrubland vegetation with considerable cover in the 0-1 m height interval, with adjacent forest and woodland (Maxwell, Burbidge et al., 1996).

The major threats that need to be managed to ensure the viability of Quenda populations are:

- Fragmentation and loss of habitat;
- Fire in fragmented habitat; and
- Predation by foxes (particularly in more open habitat), cats and dogs.

Non-Indigenous Fauna

From the Crypto (1995) survey the introduced bird species *Streptopelia senegalensis* (Laughing Dove), *Trichoglossus haematodus* (Rainbow Lorikeet) and Mammals *Mus musculus* (House Mouse) were observed with more recent observations confirming the presence of *Oryctolagus cuniculus* (European Rabbit). Due to the close proximity of houses, the domestic dog and cat are also likely to be present.

The presence of domestic and feral cats and dogs generate the greatest threat to the native fauna of the Koondoola Regional Bushland. Cats compete with native carnivores for prey and disrupt the populations of medium sized mammals, reptiles, frogs and birds through predation. Rabbits contribute to soil erosion by burrowing, removing vegetation and disturbing soil. Their feeding habits can also damage many of the native plants and seriously reduce natural regeneration by eating the young trees and shrubs, digging and promoting weed growth.

2.3.6 Fungi

Fungi are the second largest group of organisms in the world, after the insects. Although primarily microscopic and thus usually unseen, fungi are ubiquitous organisms that mediate critical biological and ecological processes. They have significant roles as saprotrophs in the breakdown and nutrient cycling of plant and animal remains, as parasites and disease agents, as food, and in mutualistic relationships. Fungi form beneficial partnerships with many local plants, such as, *Eucalyptus, Acacia, Allocasuarina* and Orchids which cannot survive without fungi partners (Department of Environment and Heritage, 1996)

Fungi also interact with insects and other animals in a multitude of ways. Many are pathogenic, some provide a key food resource and others are toxic. A number of microfungi are specialist commensals of herbivores, living in their gut and undertaking the crucial breakdown of cellulose, while truffles are an important part of the diet of marsupials, such as woylies and potoroos (Department of Environment and Heritage, 1996)

Australia is estimated to have about 250,000 species of which only about five per cent have been described. The majority of fungi in the Perth Region are probably yet to be discovered, well defined or named (Maxwell, Burbidge et al., 1996). Urban bushland is an important refuge for many native fungi and needs to be incorporated as part of overall management plans. Highly degraded bushland has relatively fewer native fungi.

A survey of fungi was undertaken in Koondoola Regional Bushland in 2006 in conjunction with the Perth Urban Bushland Fungi Project. Fungi that was been observed as part of this survey is presented in Table 2.10.

Table 2.10 Fungi Species found at Koondoola Regional Bushland

Scientific Name	Common Name	Form	Habitat	Life Mode
Amanita sp.		mushroom	litter/ground	Mycorrhizal
Amanita umbrinella		mushroom	litter/ground	Mycorrhizal
Cortinarius sp.		mushroom	litter/ground	Mycorrhizal
Laccaria sp.		mushroom	litter/ground	Mycorrhizal
?Marasmiellus sp.		mushroom	litter/ground	-
Mycena sp.		mushroom	litter/ground	Saprotropic
Pisolithus sp.	Dog Poo Fungus	puffball	litter/ground	Mycorrhizal
Pycnoporus coccineus	Scarlet Bracket Fungus	bracket	dead wood	Saprotropic
Ramaria sp.		coral	litter/ground	Mycorrhizal
Russula sp.		mushroom	litter/ground	Mycorrhizal
Russula neerimea group		mushroom	litter/ground	Mycorrhizal

Source: Perth Urban Bushland Fungi Project (2006)

2.3.7 Fire

There has been a history of fires through the Koondoola Regional Bushland, with the worst occurring in the northern corner of the reserve in 1995 (Table 2.11). However, since then the frequency of fire has predominantly been in the southeast portion of Koondoola Regional Bushland (Stubber, 2001). This could be due to the large amount of weed grass species such as *Paspalum dilatatum* and *Eragrostis curvula*, as well as this area being in close proximity to residential property and playground facilities.

Table 2.11 Fire History 1995-2002

Year	Number of Fires	Area Burnt (ha)	% Burnt
1995	2	19.6	14.3
1996	0	0.0	0
1997	2	6.1	4.45
1998	1	3.6	2.62
1999	7	6.1	4.45
2000	7	1.1	0.80
2001	9	12.9	9.41
2002	5	6.5	4.74
Total	33	55.9	40.77

Source: City of Wanneroo, 2004

Average of 4 fires burning an average of a total of 7 hectares per year

Both the immediate and cumulative impacts of fires on biological values are of major concern. Fires can impact upon the natural vegetation in a number of ways including:

- Promotion of weed growth;
- Alteration of species composition;
- Threat to the viability of rare, endangered or geographically restricted species; and
- Threat to the viability of obligate seeder species (which are typically more sensitive to fire than lignotuberous species that can resprout following fire).

Fires at intervals more frequent than the inherent regenerative capacity of the vegetation can promote the spread of exotic weeds by creating the required conditions, which include, an increase in light penetration through burnt-out overstorey, a reduction in competition from native perennial species and an increase in the availability of nutrients (Ecoscape, 2005).

The implication for fire management within Koondoola Regional Bushland is to control the spreading of grass seeds, especially from downwind of the water treatment plant. Grasses also create a higher potential for fire along pathways and where the drains enter the bushland, as they occur at these locations in higher densities.

There are 19 Fire hydrants accessible nearby.

2.3.8 Disease

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 southwest of Western Australia. As *Phytophthora* is a parasite, it requires a living host on which to feed and extracts its food by a mass of thread-like mycelium, which forms the body of the organism. *Phytophthora* is a water mould that kills its host by girdling the base of the stem, destroying the roots and depriving the plant access to nutrients and water.

The most significant *Phytophthora* species is *Phytophthora cinnamomi*. The life cycle of this *Phytophthora* requires moist, non-alkaline conditions that favour survival, sporulation and dispersal.

Human activity is perhaps the biggest factor contributing to the spread of the disease. Infected soil can be moved around the forest on vehicles or bikes, footwear, animal movements, road construction and earth moving equipment (Ecoscape, 2005).

Species vary in susceptibility to the fungus. *Banksia* species have no resistance and die quickly once infected. *Xanthorrhoea* and *Macrozamia* species are also susceptible. Plant susceptibility also increases in situations of disturbances, such as fire or drought.

The results of a survey by Tuffnell (2001) found there was no evidence of *P. cinnamomi* in Koondoola Regional Bushland. However, the southern area near the storm water drain outlets (Figure 2.5) was identified as being suspect. The status of this site is unknown, although the wet nature of this site and the introduction of water from unknown sources make this area a potential vector for the pathogen to enter the reserve (Tuffnell, 2001).

The absence of *P. cinnamomi* in Koondoola Regional Bushland can be attributed to the soil type. The mildly alkaline Spearwood dune systems soils are not conducive to the long-term survival of *P. cinnamomi*. The reasons why alkaline soils do not support *P. cinnamomi* infestation are unknown. The soils of Bassendean dune systems are susceptible to infestation, however, the absence of any susceptible species in those areas of Koondoola Regional Bushland is probably the reason why an infestation has not occurred (Zuvela, 2002). Although, Koondoola Regional Bushland appears to be free of *P. cinnamomi* it is necessary to take precautions to ensure the pathogen is not introduced into the reserve.

Honey Fungus (Armillaria luteobubalina)

Armillaria luteobubalina (Honey Fungus), is a toadstool-producing parasitic fungus, lives off both live and dead hosts and is native to Western Australia. It commonly occurs in the southwest of the state and unlike *Phytophthora cinnamomi* is not restricted by soil or landform types. It occurs in woodlands, forests, scrublands and parks on a wide variety of eucalypts and other plants such as *Acacia, Agonis, Banksia, Bossiaea, Grevillea, Hakea, Trymalium* and *Xanthorrhoea*. In some circumstances it can act as a virulent parasite that kills hosts (Bougher and Syme, 1998).

Armillaria luteobubalina appears as a golden yellow fruiting body at the base of tree stumps around June or July. The infection is caused by the aerial dispersion of spores, or through mycelium in root systems. Infection entry points for the spores may be provided by wounds caused by fire, broken limbs and insect damage. It is impossible to contain *Armillaria luteobubalina*; however a site can recover once infested (Zuvela, 2002).

A small infestation of *Armillaria luteobubalina* was identified at Koondoola Regional Bushland, south of the Water Tower (Figure 2.6) in 2002 (Zuvela, 2002). However, this

fungus does appear to be having the effects usually associated with its presence (City of Wanneroo 2007). The presence of this fungus will therefore need to be confirmed. If present, this plant pathogen is contributing to the deaths of *Banksia attenuata* and *Allocasuarina humilis* plants in Koondoola Regional Bushland.

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 southwest with those of the Proteacae and Myrtaceae families particularly vulnerable. Occurrence of the disease is dependant on a combination of a susceptible host,

2.4 Social Environment

2.4.1 Landscape Amenity

Koondoola Regional Bushland lies within the Swan Coastal Plain landscape character type and displays two major landform characteristics, the gently inclined hills of the Spearwood Dune System and the wetlands in the interdunal swale of the eroded Bassendean Dune System.

The landscape was assessed for scenic quality using judgemental criterion based on the descriptive frames of reference applied to areas within the Swan Coastal Plain character type, established by Stuart-Street (1993). Under this system, the two seasonal wetlands in the Southern portion of the bushland, and the dunal formation in the Northern area are given a high scenic quality rating (Murray, 1998).

The formation of the Spearwood Dune System at Koondoola Regional Bushland provides a distinct contrast to the sumplands in the low dunes and depressions of the Bassendean Dune System. This contrast is what gives it such a high scenic value compared to other landforms of a more uniform configuration. The vegetation is similarly classified with the communities of Koondoola giving a colourful seasonal display, such as of *Nuytsia floribunda* and *Banksia menziesii*. These are given a high scenic value compared to other complexes that display a more regular pattern in the height, colour and texture of the vegetation (Murray, 1998).

The criteria from the Urban Bushland Policy, classifies this bushland as regionally significant. The high scenic value of the highly diverse and unusual dominant community dictates its great regional status of the reserve. The large area of bush as well as its position within an urban setting attracts people throughout the region for recreation and also provides an important social value.

2.4.2 Heritage

Koondoola means “place of the Emu”. It was speculated that the site might have been an Aboriginal campsite until European settlement intruded upon the area. This was thought likely, due to the closeness of Big Emu Swamp, a place of recognised Aboriginal significance and registered Aboriginal Heritage site. Wetlands are particularly significant to Aboriginal people as a traditional and important source of food and water, as well as being a site of cultural ceremony. Big Emu Swamp was used for hunting and camping before and even after European contact.

Koondoola Regional Bushland is classified as an area of heritage significance and has been entered in the National Trust’s Register of Heritage places (National Trust, 1995; Murray, 1998).

2.4.3 Recreation

There is already provision for active/structured recreation within the suburb of Koondoola and the surrounding suburbs of Alexander Heights, Marangaroo and Warwick. The community consensus was and continues to be that Koondoola Regional Bushland should be preserved as bushland for its ecological value (refer to Table 2.13). Therefore, nature based/passive recreation should be encouraged. Activities such as bushwalking, photography and bird watching are appropriate as long as they occur on the designated tracks and not sensitive regions (erosion prone, recently burnt). This is very important as uncontrolled access can cause substantial damage to the ecology through soil compaction, plant trampling, bush fragmentation and spread of weeds and disease (Murray, 1998).

Koondoola Regional Bushland is frequently visited by many local residents. The Friends of Koondoola Regional Bushland conduct regular guided walks and bushcare activities as well as monitoring and observing the bush for maintenance purposes. The limestone tracks appear to have been well used and have succeeded in leading pedestrian traffic away from more sensitive areas. However, there is still some evidence of undesirable activities within the bushland near the sumplands, such as BMX bike jump mounds.

2.4.4 Facilities

The facilities within the reserve are shown in Figure 2.7

Paths

There is approximately 8.6 km of formal tracks (limestone paths) and 9.2 km of informal paths (sand tracks). The lengths of formal and informal tracks throughout Koondoola Regional Bushland are in Table 2.12.

Table 2.12 Track type and lengths throughout Koondoola Regional Bushland

Track Type	Length (metres)
Open (formal)	8615
Closed (informal)	9237
Total	**17851**

Source: Ecoscape (2005)

Formal Paths

From the 1998 Management Plan, some of the tracks were formalised with compacted limestone. The perimeter fencing directs the public to these pathways to discourage any trampling of the vegetation. The implementation of the hardened pathways helps to facilitate community access, especially for the disabled and elderly. The appearance of compacted limestone coincides with the nature of the bushland character as well as directing people away from sensitive areas. The material also assists with dieback in the reserve.

The location of the paths was based on existing tracks and also maximises facilitation for fire control access.

Informal Paths

Paths identified as Sand are tracks that have been established by and maintained by pedestrian traffic rather than any maintenance.

These tracks are useful as additional firebreaks and access by authorised vehicles into the bushland. Since they are usually maintained by local traffic, expenses are minimised through the lack of maintenance requirements.

However, the problem of weeds spreading and bush fragmentation is a consequence of these paths. Minimising the usage of informal paths through fencing and a clearly outlined walk trail would reduce these problems allowing for the paths to regenerate.

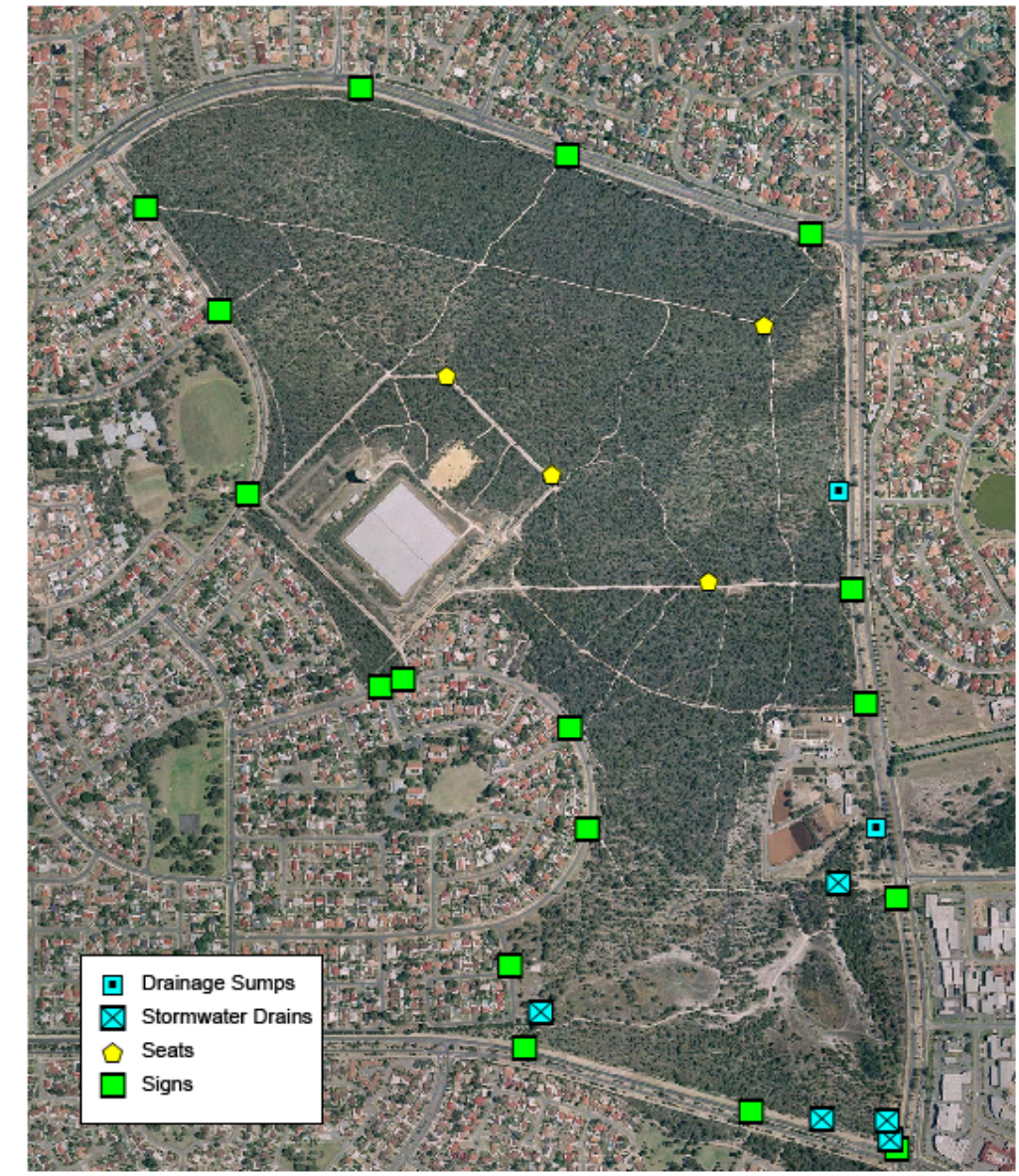


Figure 2.7 Facilities and Infrastructure

Fences

There is approximately 8.2 km of fencing around and within Koondoola Regional Bushland. Fences were recommended in the 1998 Management Plan because of the large area involved and because of the major roads forming much of the boundary of the bushland. They were required to act as a barrier to vehicles and rubbish dumping and other undesirable activities within the bushland. Conservation fencing (treated pine posts with black PVC coated mesh) now surrounds the entire reserve, with cyclone and electric fencing around the Water Corporation's property.

The perimeter fencing directs pedestrians to the appropriate access points. With members of the Friends of Koondoola Regional Bushland Group conducting regular checks of the fenceline to ensure any damage is reported to the City of Wanneroo.

The total lengths of the different types of fences are listed in Table 2.13.

Table 2.13 Fence types and lengths at Koondoola Regional Bushland

Fence Type	Length (metres)
Cyclone*	760
Electric*	1476
Conservation	5191
Residential	804
Total	8232

*Water Corporation Boundary Fences

Source: Ecoscape (2005)

Signs

There are seventeen signs onsite at Koondoola Regional Bushland, with three main types of signage:

- Reserve identification;
- Regulatory signage; and
- Informative and Educational signage.

Other

There is no formal parking bays found around Koondoola Regional Bushland, there are no toilet facilities due to the possibility of attracting activities thought undesirable within the bushland. However, there is a playground in Rendell Park adjoining the Bushland.

2.5 Stakeholder Consultation

A stakeholder workshop was held at Wanneroo Civic Centre in the Leschenaultia Room on the evening of Wednesday 29th June 2005, full details of workshop proceedings in Appendix six.

A summary of the community's perceived values of Koondoola Regional bushland is presented in table 2.14 below.

Table 2.14 Summary of Feedback from Stakeholder Workshop 29th June 2005

Number of Responses	Values	Threats/Issues
High	• Size • Condition • Biodiversity • Education/recreation • Fauna • Flora	• Weeds • Fire • Changes to hydrology • Rubbish • Paths/access • Education • Seat condition
Medium	• Viability • Threatened Ecological Community	• Disease (including dieback) • Parking/vehicles • Inappropriate activities • Tracks • Marketing • Parking
Low	• Heritage • Proximity to suburbia • Boundary of soil types	• Feral animals • Wildflower picking • Inadequate resources • Toilets • Seat condition • Monitoring

3.0 Principal Management Objectives

Koondoola Regional Bushland Management Plan

3.1 Reserve Values

Bushland reserves are extremely important, especially in the urban setting. The human use value is high and includes passive recreation, cultural and historical values. Urban bushland is also very important aesthetically, providing relief from the built environment and providing the community with a sense of identity. These areas enhance the awareness of natural surroundings and fulfil an educational role.

It has been previously discussed that Koondoola Regional Bushland is classified as an area of heritage significance because of its high scenic values. This is due to its unique community type of *Banksia attenuata* woodlands over species rich dense shrublands as well as its contrasting landforms from the Spearwood Dune System to the sumplands in the interdunal swale of the Bassendean Dune System.

3.2 Vision

The main visions for the management of Koondoola Regional Bushland are:

- To protect the landscape, natural processes and indigenous flora and fauna;
- Return degraded areas to stable bushland, through natural regeneration following weed removal, with direct planting of local species around the two sumplands; and
- Minimising disturbance caused by fire, weeds, feral animals and human activities (Murray, 1998).

3.3 Objectives

The objective of the Management Plan is primarily concerned with formulating revised directions for the future improvement and management of this reserve in the context of:

- Balancing conservation and recreation, in an ecological sustainable manner and taking into account the regional significance of the reserve;
- Compiling a sound data set relevant to the reserve;
- Incorporating catchment management principles; and
- Involving the community/stakeholders in shared ownership, responsibility and management.

3.4 Management Zones

Management zones are required to minimise conflict between stakeholders in relation to management responsibilities, objectives or practices. The objectives of management zones are:

- To facilitate effective communication between stakeholders involved in the management of Koondoola Regional Bushland;
- To provide clear delineation between the adjacent parkland and bushland and associated management practices;
- To facilitate the development of specific management practices appropriate to the different landforms (such as the bushland in the north and the sumplands in the south); and
- To facilitate resource allocation to specific sites.

3.5 Integrated Management of the Reserve with Adjacent Areas

Koondoola Regional Bushland is adjacent to Reid Highway Bushland (Bush Forever Site 385), which is situated to the south and is contiguous with the Bush Forever Site 307. Alexander Park is 500 m to the North of Koondoola Regional Bushland and there is also Shelvock Reserve just 250 m to the west.

Aligning the management of these bushland remnants across the different land managers - the Department of Environment and Conservation, the Friends of Koondoola Regional Bushland and the City of Wanneroo - could help enhance the connectivity and expand the habitat range of the species within all five areas.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	Integrated Management of Reserve and Adjacent Areas		
1	Investigate potential partnerships with other land managers e.g. DEC to enhance the connectivity between Koondoola Regional Bushland and other nearby bushland sites.	MEDIUM	CoW

4.0 Management for Conservation

Koondoola Regional Bushland Management Plan

The following section describes the requirements and management for conservation within Koondoola Regional Bushland. It contains details on:

- Access;
- Soils and Landforms;
- Groundwater;
- Surface Water;
- Flora;
- Fauna;
- Fungi;
- Fire;
- Corridors and Linkages; and
- Signage.

4.1 Access

Objectives

The objectives for maintaining, rationalising or upgrading access within the bushland is to:

- Provide access for the public's use of the bushland; and
- Provide access for Council works programs and firefighting.

These objectives need to be implemented with consideration to the environment, as well as construction and maintenance costs.

Access is presently managed through paths and fences shown in Figure 4.0. Wider access could be provided through the inclusion of car parking at the reserve.

4.1.1 Access Requirements

Access to Koondoola Regional Bushland needs to be controlled in order to conserve the bushland whilst still allowing public access and enjoyment of the site.

Paths

Designated paths allow the reserve to be enjoyed whilst minimising disturbance. The path network requires periodic review to meet changing demands of the public and to ensure the standard of paths remains adequate. As a recommendation from the previous Management Plan (1998), a limestone path was constructed (Plate 5.1). At present, the current path network is in need of upgrading.

Formal Paths

The formal paths within the reserve are in need of an upgrade.

Formal paths should be periodically inspected to ensure that they do not expose the City of Wanneroo to a risk in terms of public liability and they continue to meet the City's standards.

A walk trail that provides universal access is currently provided between gates 1 and 2. This path could be upgraded to provide interpretation or extended to provide a complete loop that is more appealing to visitors. Any material brought into the site to construct sites needs to be appropriately sourced in order to ensure diseases are not introduced into the site.

Plate 4.1 Limestone track in excellent condition

Informal Paths

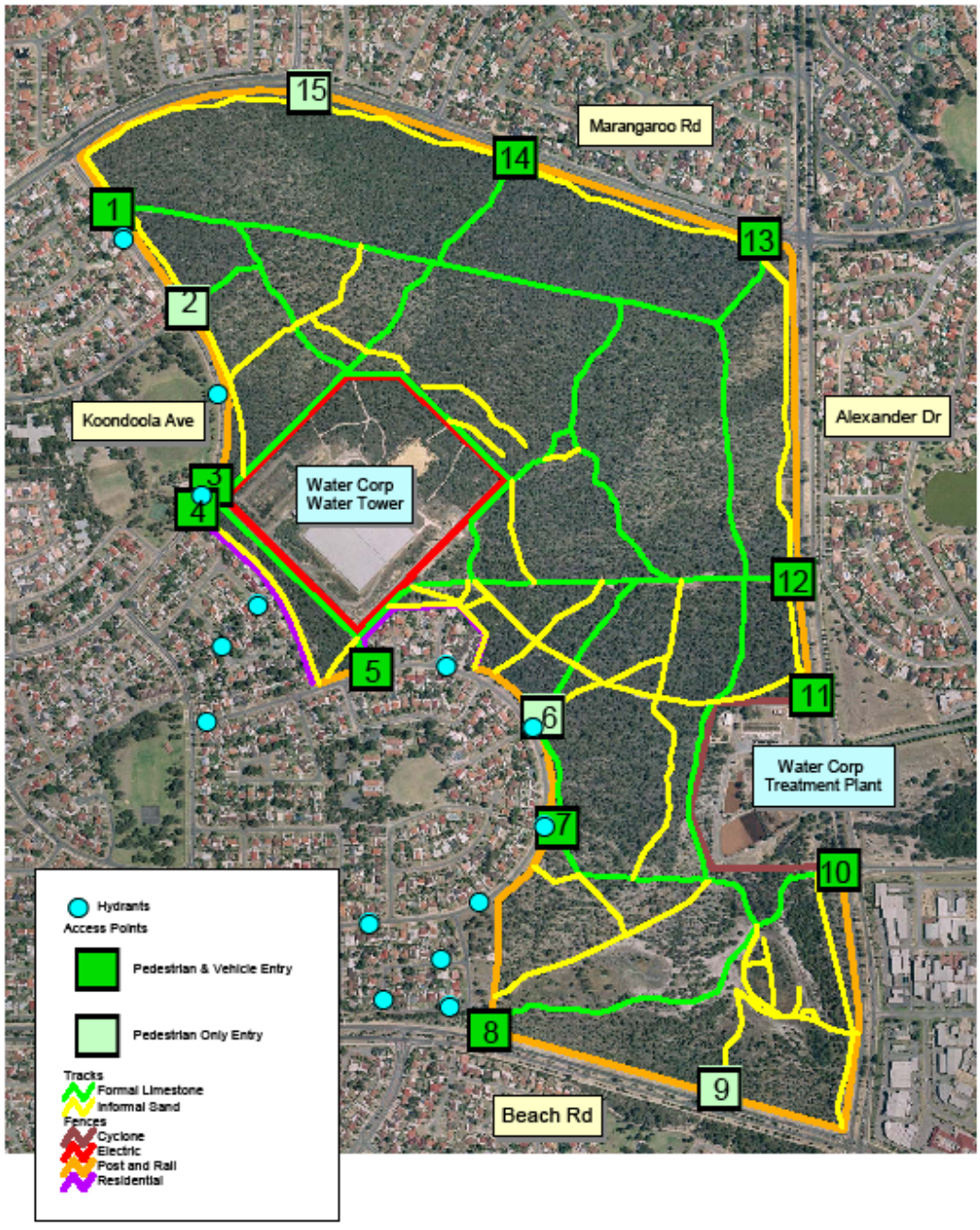
Informal paths do not need to be specifically managed unless they are also utilised as a firebreak. Informal paths may indicate preferred routes by pedestrians. An assessment of the informal paths at the reserves should be undertaken to determine those utilised as firebreaks and those used preferentially by pedestrians. This can then be taken into account when determining which informal paths to close in order to reduce weed invasion and erosion.

Following the recommendations made by the Murray (1998) Management Plan, the tracks in eroded areas were fenced off and an attempt at rehabilitation proceeded. Unacceptable species were however planted and as a result most died and subsequently weedy species were removed.

Paths that have become eroded, unstable or overgrown expose the City of Wanneroo to risks with regards to public liability. Of particular concern is the usage construction of the informal tracks by BMX riders. They are creating mounds to be used as jumps at irregular intervals across these tracks, which then have the potential to cause injury to pedestrians. Closure or upgrade of tracks that are a public liability or a detriment to the environment will need to be investigated.

Plate 4.2: Disused track revegetating

Plate 4.3: Informal track in need of revegetation



ecoscape

Aerial Imagery supplied by City of Wanneroo

Koondoola Regional Bushland Management Plan

Access, Fences & Hydrants

200 0 200 400 Meters

1 : 10 000 @ A4

City of Wanneroo

Figure 4.0

Sept 2005

Figure 4.0 Access, Fences and Hydrants

Fences

Since the construction of the conservation fencing (Plate 5.6) surrounding the reserve from the 1998 Management Plan, there has been a reduction in the anti-social behaviour that had major impacts upon the reserve (car bodies dumped, motorbikes, large rubbish dumps). This fence serves as a function in discouraging these activities by restricting mainly vehicle access through the bushland (Plate 5.7).

The Water Corporation structures (water treatment plant etc) within Koondoola Regional Bushland are surrounded by cyclone and electric fences (Plate 5.4 and 5.5). These fences detract from the aesthetic value of the area, however, are necessary as they are there for the protection of property as well as the public.

No priorities for the removal, installation, modification or upgrading of fencing are identified for the site at this point in time.

Plate 4.4 Cyclone fencing

Plate 4.6 Conservation fencing

Plate 4.5 Electric fencing

Plate 4.7: Anti-social behaviour (Bike damage)

Gates

The gates installed at Koondoola Regional Bushland were designed to prevent or deter access to those who wish to participate in undesirable activities, which result in damage to the bushland. Horses and unauthorised vehicles have been prevented but access for disabled and elderly people was accommodated through pedestrian gates (Plate 5.8).

Access points into the reserve for pedestrians should be limited, where the environment is sensitive (e.g. prone to erosion) or paths are required. Most of these entrances would be utilised by local residents and should be low key.

There are sufficient entry points for authorised personnel (Fire Department, Maintenance), with keys for vehicle access (Figure 4.0). There are 16 main access points into Koondoola Regional Bushland. Ten for both pedestrians and authorised vehicles and four of which are pedestrian only (Table 4.1). There is also one access point (gate 11) that is meant for vehicle access only, and one informal entrance just north of gate 8 that has no gate, but a post to restrict vehicle access, and to reduce the cutting of the fence.

Table 4.1 Access type and number around Koondoola Regional Bushland

Access Type	Number
Pedestrian and Vehicle	10
Pedestrian only	4
Vehicle only	1
Other	1
Total	16

Plate 4.8 Pedestrian Gate

These gates do limit access; however, unauthorised vehicles are still entering the bushland (eg. motorbikes) and causing damage to the bushland.

4.1.3 Track Maintenance required due to Erosion Control

There is 2930m of limestone tracks that are susceptible to erosion identified by their long straight paths with alignments directly down-slope (Figure 2.7)

Due to the location and frequent use of the paths some erosion is expected. To minimise the effects of erosion, the condition of the paths should be regularly monitored and upgrades should be conducted on a regular bases.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	INFRASTRUCTURE		
2	An assessment of all informal bushland paths should be undertaken to determine if any paths could be closed and rehabilitated. Formalisation of paths that are heavily utilised by pedestrians should be investigated. Informal paths that also functioning as firebreaks should be retained.	HIGH	CoW
3	Investigate opportunities to upgrade selected limestone path for universal access. Materials used in path construction should be appropriately sourced to ensure diseases are not introduced to the site.	MEDIUM	CoW
4	Continue to deter anti-social behaviour, repair any damage caused and investigate possible solutions to undesirable behaviour such as BMX jump construction and arson.	MEDIUM	CoW
	TRACK MANAGEMENT		
7	Continue to regularly monitor limestone tracks, report any signs of erosion and rectify and deterioration.	HIGH	CoW and FKRB

4.2 Soils and Landforms

4.2.1 Soils

Acid Sulfate Soils

The Southern portions of Koondoola Regional Bushland are identified as having a high risk of Acid Sulfate Soils (ASS) and Potential Acid Sulfate Soils (PASS) at less than 3m from the surface (Figure 2.2). Risk mapping for acid sulfate soils has been undertaken by the Western Australian Planning Commission (2003) at a regional scale, and therefore boundaries should not be interpreted as being precise and caution should be exercised in the vicinity of high-risk areas.

There are two levels of assessment required to determine the level of risk associated with acid sulfate soils. Firstly, a preliminary site assessment is undertaken to determine whether there is actually any risk of acid sulfate soils occurring. Such an assessment is required for any proposed change of zoning that will lead to any intensification of land use and/or where any dewatering works are proposed, for example:

- Where the surface elevation is ≤ 5m AHD, and it is proposed to excavate ≥ 100m^3 of soil (i.e. 10 standard dump truck loads); and
- Where the surface elevation is > 5m AHD, and it is proposed to excavate ≥ 100m^3 of soil (i.e. 10 standard dump truck loads), and the excavation depth is ≥ 2m.

As major earthworks, change in landuse, and dewatering are not proposed in the lower portions of the reserve, acid sulfate soils assessment is not currently required. Acid sulfate soils can however be monitored as part of maintenance operations so that in the event falling groundwater levels expose potential acid sulfate soils to air any problems are quickly addressed.

In the future, a detailed assessment will be required conducted if excavation or dewatering activities are planned in the southern portion of the site. This assessment should:

- Identify potential direct, indirect and cumulative impacts and demonstrate how these will be managed;
- Demonstrate that every reasonable step has been taken to avoid impacting on acid sulfate soils;
- Demonstrate that the development is to be carried out in a manner that ensures that the potential effects on the environment are reduced to as low as reasonably practical; and
- Demonstrate that there are likely to be no unacceptable effects on the natural and built environment (including infrastructure).

Bare Ground

There is an area of bare ground located towards the centre of this site. Due to lack of vegetation growth, including both native species and weeds, this area was tested for contamination. The results of this testing reveal that there is no contamination and therefore a trial to revegetate this area should be undertaken (City of Wanneroo, 2007).

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	ACID SULFATE SOILS		
8	Prior to any excavation works or dewatering in the southern portion of the site, undertake Acid Sulfate Risk Assessment	LOW (Priority should be increased if proposed works require ASS assessment)	CoW
9	Monitor southern portion of the site for signs of acid sulfate soils as part of the normal maintenance routine	HIGH	CoW
10	Undertake a trial to revegetate the bare area of the site to prevent weed encroachment into good quality bushland.	HIGH	CoW

4.3 Groundwater

4.3.1 Groundwater Levels

Monitoring

Groundwater level monitoring data is available for Koondoola Regional Bushland from the Department of Environment and Conservation. This shows groundwater levels are declining.

Declining water levels

Decline in water levels is resulting in the stress and death of trees in the lower portions of the reserve at present. If the current trend of falling groundwater levels continues, then this trend could

be expected to continue particularly as computer climate modelling suggests that rainfall will continue to decline in the South West (IOCI, 2005).

Changes in hydrological regimes will have a significant impact upon vegetation around the sumplands of Koondoola Regional Bushland in terms of the position where they grow around the wetland, and whether they can persist in the long term. This is particularly pertinent for fringing plants such as *Eucalyptus rudis*, which are adapted to seasonal inundation.

Generally species inhabiting low-lying winter-wet areas tend to exhibit the greatest loss of vigour in response to declining groundwater levels (Groom, Froend et al., 2001) and drought induced stress is evident in *Eucalyptus rudis* trees around the peripheries of the two sumpland areas within Koondoola Regional Bushland. There are also species present such as *Banksia sp.* that have been known to directly utilise groundwater (Dodd, Heddle et al., 1982).

The result of falling water levels would be more drought tolerant trees replacing existing trees downslope. Typical changes (from down slope to upslope) that would be expected at Koondoola Regional Bushland are the replacement of *Banksia littoralis* with *Banksia attenuata* and *Banksia attenuata* with *Banksia menziesii*. These changes can be expected to occur over decades (Groom, Froend et al., 2001). Most of these changes have already occurred within Koondoola Regional Bushland, since *Melaleuca raphiophylla* and *Banksia littoralis* have not been recorded within the bushland. In addition to plant communities moving down slope, Dodd & Heddle (1989) suggest that the plant communities will have fewer and smaller trees in the long term as a response to the decline in groundwater levels.

If it is assumed that plant communities will change over time due to permanent changes in hydrology then species used for revegetation should be chosen on the basis that:

- They can survive at that particular part of the landscape in the long term regardless of whether they occupy that part of the landscape presently; and
- They are part of the suite of plants that would have naturally occurred onsite (although they may have been eliminated from the site at some point by disturbances such as fire, grazing or timber cutting) and are capable of surviving under the changed conditions.

However, due to the presence of a Threatened Ecological Community in the reserve, any activity that would result in alteration of the species composition should be checked with the Department of Environment and Conservation.

Falling water levels would also have an effect on the animal's including mammals, frogs, birds and invertebrates but effects are difficult to quantify.

4.3.2 Groundwater Quality

No groundwater quality data has been taken since 1971 (Department of Water, 2007) it is therefore difficult to assess any trends with regards to water quality. Surface water quality is most likely to be

affected by the land use surrounding Koondoola Regional Bushland and therefore the monitoring of groundwater quality is not considered to be a priority for the City.

4.4 Surface Water

4.4.1 Surface Water Quality

There is no apparent surface water quality data for Koondoola Regional Bushland. At the time of this survey there was no water present in the sumplands. It would be beneficial however, to take water quality readings from the water that enters the Bushland via the storm drains. This could help determine if there is a potential environmental threat from another source.

4.4.2 Wastewater

The existing Water Corporation Pump Station also has the potential to contribute to the surface water at the site. In the event of a pump station failure the sewage will flow into soak wells on site and seep into the ground. When the soakwells become full, the sewage has the potential to follow the overflow path into Koondoola Regional Bushland (Connell Wagner, 2005).

The Pump Station currently has approximately 1.5 hours emergency storage between 6am and 10pm and up to 5 hours storage during the night. Further contingency arrangements involve employing the use of tankers to handle the peak and average flows into this station over an indefinite period. The agreed response time for deployment of tankers is 1 hour. The Water Corporation is confident that the soakwells are capable of managing any seepage from pump station failure for about an hour and therefore the risk of sewage flowing into the bushland is minimal.

The Water Corporation also has a program of works to upgrade pumping station emergency storage. Work is yet to be scheduled at the Koondoola site as larger more environmentally sensitive sites currently have higher priority.

The City of Wanneroo should liaise with the Water Corporation so that they are aware of any changes in the emergency overflow measures at the site and any upgrades to the pump station emergency system.

For more detailed information refer to Appendix 10.

4.4.3 Nutrient Control/ Pollution Control

The current sources of pollution and nutrients into Koondoola Regional Bushland are mainly from the stormwater drains located in the southern region of the reserve (Figure 2.7).

Options for maintaining water quality in stormwater drains can be grouped into structural and non-structural controls:

- Non-structural controls reduce pollution of stormwater by optimising practices of local council operations, construction companies and householders through regulation and education;

- Structural controls reduce pollution through engineering solutions such as Stormwater Pollutant Traps (SPTs).

For more detailed information refer Appendix 10.

Non- Structural Control Options

Education Campaigns

Education can reduce pollution through the appropriate disposal of garden waste and pet waste, appropriate car washing practices and use of detergents, minimising bird feeding in Public Open Space areas and encouraging composting, and appropriate fertilising habits.

Education campaigns may include but are not limited to: workshops for residents; forming of community action groups; newspaper articles; distribution of leaflets; posters & newsletters; production and distribution of stickers and fridge magnets; drain stencilling or plaques; installation of informative signs in public areas; and catchment model exhibits at local events, shopping centres and schools.

Modifying Horticultural Practices

Management techniques include appropriate application of fertilisers (timing and quantities), disposal of grass clippings, planting of non-deciduous verge trees, refinement of street sweeping programs and practices, minimising potential for sewer overflows and pollution control regulation.

The effectiveness of non-structural controls can be variable and difficult to assess but some observations have been made:

- Deciduous trees can deliver bulk nutrients into the drainage system over short periods of time during leaf fall. This is exacerbated by the composition of exotic foliage, which is softer than that of native species and decomposes faster than detritivores can assimilate the nutrients (Swan River Trust, 2003). Replacing deciduous verge trees with non-deciduous trees can help to reduce nutrient input; and
- Appropriately timing street sweeping maintenance of structural control services can reduce levels of gross pollutants entering drains. However this only effectively removes particles greater than 300µm, which may have a minimal effect in improving stormwater quality since many sediment-bound pollutants and nutrients are bound to finer sediments (Swan River Trust, 2003).

Structural Control Options

There are a large number of structural controls available, including:

- Stormwater Pollutant Traps;
- Connection of toilets to mains sewers rather than septic systems;
- Chemical treatment;
- Constructed Wetlands;
- Spill Control Separators
- Oil and Grit Separators;

- Litter Baskets;
- Grass Swales; and
- Detention Basions.

The selection of appropriate structural controls for individual applications will involve consideration of:

- Types of pollutants to be removed;
- Site constraints;
- Lifecycle cost (capital and maintenance costs);
- Public acceptance;
- Equity issues (polluter pays principle); and
- Ease of implementation.

Stormwater Pollutant Traps (SPTs) are effective in removing litter, oils, vegetation debris, sand and silt once they have entered the drainage network. These SPTs need to be regularly maintained to avoid the build-up of material that will impede water flow and cause flooding (Swan River Trust, 2003). There are also opportunities to improve both the nutrient and fine particle filtering and aesthetics of some of the drains feeding into the sumplands of Koondoola by establishing native species around the outlet.

Recommendations were made in a report written by Connell Wagner (2005) for the purpose of this Management Plan on the concept and design of the stormwater outfalls at Koondoola Regional Bushland. The objectives of the report were:

- To review the quality of water discharging to the wetland; and
- To recommend stormwater drainage management upgrade of all outlets in accordance with current best management practices (see Appendix 10).

Implementation

There were six stormwater catchments identified by Connell Wagner (2005). Their extent and the landuses within them are identified in Table 4.2 below.

Table 4.2 Stormwater Catchments impacting Koondoola Regional Bushland

Catchment	Extent (Ha)	Landuse	Local Government

			Authority
1	10.6	Mercy College, Mercy Primary School	CoW
2	103.1	Koondoola Park, Koondoola Primary School, Koondoola Plaza, Moorhead Park, Butterworth Park, Rendell Park	CoW
3	15.3	Malaga Markets	CoW
4	2.6	Alexander Drive	CoW
5	2.6	Alexander Drive	CoW
6	2.86	Beach Road	CoS

Connell Wagner has summarised the possible devices that could be used to reduce pollutant levels into Koondoola Regional Bushland, shown in Table 4.3 the potential pollutants have been identified as weeds and seeds, litter, total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS).

Table 4.3 Pollutant Removal Device Summary

	Weeds & Seeds	Litter	TP	TN	TSS	Site Constraints
Screen	×	√	×	×	×	**Installed catchment 3, minimal removal of most pollutants.**
SPT	√	√	√	√	√	**Need space for unit.**
Swale	×	×	√	√	√	**Lack of space for some catchments-area for weeds to grow.**
Wetland	×	×	√	√	√	**Site porous, not suitable for sandy sites with low Ground Water Level, liner required.**
Infiltration Basin	×	×	√	√	√	**Lack of space for some catchments.**
Bioretention Basin/Trench	×	×	√	√	√	**Site porous, not proposed for sandy sites.**
Wet Sedimentation Basin	×	×	√	√	√	**Dependant on ground water level, not ideal.**

Based on the above, a SPT with some form of infiltration to polish flows is proposed for this system (Connell Wagner, 2005).

Western Australia currently does not have any guidelines for the required performance of storm water treatment systems. Australian Runoff Quality (ARQ) is currently released in Draft format and is a design guideline that provides an overview of current best practice in the management of urban stormwater in Australia

As a companion document to the Australian Rainfall and Runoff design manual, ARQ provides a range of indicative pollutant loads that can be expected from an urban catchment, and provides some performance objectives utilised in other Australian states (Connell Wagner, 2005).

Table 4.4 Performance Objectives

Pollutant Removal	Target Reduction
Total suspended solids	**80%**
Total Nitrogen	**45%**
Total Phosphorus	**45%**
Gross Litter	**95%**

Recommendations

It is proposed by the Connell Wagner (2005) report that a series of stormwater treatment devices be installed in Koondoola Regional Bushland as part of the Koondoola Regional Bushland Management Plan. This aims to significantly reduce the volume of seeds, weeds and other pollutants such as phosphorus, nitrogen, and gross pollutants (litter) entering the reserve.

The stormwater devices proposed are stormwater pollutant traps (SPTs) and infiltration basins, individually or simultaneously. The SPTs provide removal of suspended solids and the infiltration devices assist in nitrogen and phosphorus removal (Connell Wagner, 2005).

Recommendations from the Connell Wagner report for each catchment are:
Catchments 1&2

- Install a diversion manhole;
- Divert flows from catchment 1 to this manhole;
- Install new 625mm diameter pipeline to divert flows;
- Install SPT;
- Install new 1200mm diameter pipeline to outfall from SPT to Infiltration Basin; and
- Excavate, level and develop Infiltration Basin and baffle trap and weir.

Catchment 3

- Install SPT on 1050mm outfall;
- Install new 1050mm outfall pipe from SPT to Infiltration Basin; and
- Excavate, level and develop Infiltration Basin and baffle trap and weir.

Catchment 4
No works for the outfall pipe to catchment 4 proposed. However, regular maintenance to the existing drainage sump should be undertaken.

Catchment 5

No works for the outfall pipe to catchment 5 proposed. However, regular maintenance to the existing drainage sump should be undertaken.

Catchment 6

- Install SPT on 525mm outfall pipe; and
- Install SPT on 300mm outfall pipe.

Before initiating any of these works an assessment needs to be made on the possible impacts on the existing vegetation, the likely occurrence of acid sulphate soils and the potential reduction of flow to the existing conservation areas (Connell Wagner, 2005).

For more information and recommendations refer to the Connell Wagner report, Provision of Investigation and Concept Design Services for the Stormwater Outfalls located within the Koondoola Regional Bushland, 2005 (Appendix 10).

4.4.4 Midge and Mosquito Management

Non-biting midge (Chironomids) and mosquitoes commonly occur in inland and coastal bodies of water. Midges and mosquitoes are some of the most common and most abundant organisms in natural and man-made aquatic habitats. Their larvae can be found in small and large natural lakes, sewage oxidation and settling ponds, residential lakes and ponds, and slow moving shallow rivers. Midges and mosquitoes emerging from these bodies of water can become a severe nuisance to residence as well as posing health problems. Control strategies should aim to preserve the wetland character, minimise adverse effects on the wetland ecosystem, whilst inhibiting mosquito and midge production (Musk and Oldham, 1999).

Long-term strategies to reduce populations include:

- Re-establishing fringing vegetation around wetlands, as this reduces the number of midges and mosquitoes flying off water, or being blown into residential areas; and
- Creating buffer zones around wetlands to help reduce the amounts of nutrients in groundwater and surface runoff reaching the wetland (Suffell, 2005).

The wetlands at Koondoola Regional Bushland are seasonal sumplands, and only retain water during peak winter rainfall. The effect of summer drawdown helps to reduce the population of midges and mosquitoes within the wetlands of Koondoola Regional Bushland naturally, without additional control strategies needing to be implemented.

Until such time when midge and mosquito populations exceed public comfort and complaints are made to the City of Wanneroo, further management recommendations do not need to be considered.

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY

	HYDROLOGY		
10	Develop a Stormwater Management Plan for Koondoola Regional Bushland in consultation with the City of Swan, the City of Stirling and Water Corporation. Development of the Stormwater Management Plan should include continuing to monitor groundwater levels, initiating water quality monitoring in the drains and investigating the installation of GPT and/or infiltration devices on drains entering the bushland.	HIGH	CoW
11	Prepare a Memorandum of Understanding between CoW and Water Corporation, the City of Swan and the City of Stirling regarding the Stormwater Management of Koondoola Regional Bushland.	HIGH	CoW, City of Stirling, City of Swan, Water Corporation
12	Continue to liaise with Water Corporation in order to remain informed about plans to upgrade the wastewater pumping station emergency storage and any changes in the emergency arrangements for the site.	HIGH	CoW and Water Corporation

4.5 Flora

4.5.1 Conservation of Indigenous Flora and Vegetation

Objectives

The objectives for the conservation of indigenous flora are to:

- Provide an adequate habitat and food source for native fauna;
- Prevent the incursion of weed species; and
- Retain representatives of a diminishing environment within urban areas.

Background

There were three known significant species found at Koondoola Regional Bushland. *Jacksonia sericea* was recorded in the 1998 Management Plan and is identified by the Department of Environment and Conservation as a *Priority 4 Taxa*. *Verticordia drummondii* and *Verticordia nitens* had also been recorded at Koondoola Regional Bushland in 1998; however since then they have become locally extinct due to fire and were not recorded by Pike in the 2004 flora survey. Both species were recognised as being poorly conserved in the Perth Metropolitan Region (Government of Western Australia, 2000).

Koondoola Regional Bushland is listed as Bush Forever Site 201 and contains a Threatened Ecological Community (TEC) (Floristic Community Type 20a) and a Conservation Category Wetland. The TEC is a *Banksia* woodland community, most of which is in very good to excellent condition with an unusually diverse understorey. It is an endangered complex within urban bushlands and is mainly unreserved throughout the Swan Coastal Plain.

Strategies

The most critical factors for the conservation of indigenous flora onsite are:

- Minimising fires which could destroy habitat;
- Improving bushland condition within the southern sumplands where conditions are very poor to poor; and
- Maintaining weed control so they do not out-compete the natives for nutrients, water and space.

These issues are also dealt with in the Fire, Hydrology, Revegetation and Rehabilitation Sections of this Plan and recommendations are not duplicated here.

4.5.2 Weed Monitoring and Management

Objectives

The objectives for weed control are to:

- Identify and control existing weeds with the highest priority for control;
- Prevent introduction of additional weed species;
- Minimise any detrimental effects of the weed control programme on the native biota; and
- Integrate the weed control programme with bushland restoration programmes.

Background

Environmental weeds are plants that establish themselves in natural ecosystems and modify natural processes, resulting in the decline of the communities they invade. Impacts on ecosystem function by environmental weeds include:

- Resource competition, as weeds often out-compete native species;
- Prevention of seedling recruitment of native species;
- Alteration to geomorphological processes, such as increased erosion;
- Changes to soil nutrient status;
- Alteration of fire regime, usually through increased fire frequency;
- Changes to the abundance of indigenous fauna due to less diverse habitat;
- Loss of genetic diversity;
- Loss of species diversity; and
- Changes to the structure of vegetation communities, often by the removal of the shrub layer or native ground covers.

The fire weed cycle that is a primary cause of the degradation of bushland and loss of understorey species is particularly prevalent at Koondoola Regional Bushland. The shrubs, herbs and sedges are gradually replaced by weed species, notably grassy weeds as fire frequency increases. Grassy weeds have characteristics which enable them to respond quickly to fires, and which support more frequent fire events, than many of the native perennial understorey shrubs. Some of the contributing factors to the fire weed cycle are summarised below:

- Weed species are often advantaged by the burst of nutrients available immediately after a fire;
- Weed species, particularly grassy weed species, accumulate biomass rapidly, increasing fuel loads to levels that will sustain fires;
- High growth rates of weed species allows them to out-compete native species;
- Grassy weeds, and many other weed species, are able to set seed within a single year;

- Grassy fuels have a different structure to shrubby fuels. The grasses have a fine, evenly spread structure compared with the more heterogeneous, discrete structure of native understorey shrubs. This affects fire behaviour and rate of spread, particularly in the initial stages of a fire;
- Native species require time between fires not only to set seed but also to replenish their seed stocks. This may take several years. Frequent fires deplete seed stocks, rapidly eliminating these species from the species assemblage; and
- Native re-sprouting species (i.e. species that have an underground lignotuber) can also succumb to frequent fires if fire recurs before the new growth has had time to harden.

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.

Strategy

Prioritisation

The prioritisation of weed control is necessitated by the large number of weeds and the generally degraded state of the bushland. Some of the priority weed species have been mapped in Figure 4.1 and 4.2. There are two forms of weed prioritisation:

1. Site-based management; and
2. Species-based management.

The weeds at Koondoola Regional Bushland require a combination of site-based and species-based management.

Site-based Management

Site-based Management is based on focal points and is developed with consideration of:

- Specific biological values requiring protection (such as Priority or Declared Rare Flora);
- Infrastructure at elevated risk from fire due to proximity of weeds with high fuel loads such as Veldt Grass;
- The extent of infestations;
- Level of degradation (the circumstances will determine whether the worst or best sites are the initial point of control);
- Site fragility (such as revegetation sites and drains);
- Reducing causes of degradation such as access tracks or weed nodes; and
- Available resources.

Site–based weed control should be focused at sites where either:

- Intensive rehabilitation efforts are being undertaken;

- Where weeds are contributing to an unacceptable fuel load near vulnerable property;
- There are areas of environmental significance (e.g. rare or priority species, very good condition bushland); or
- Areas where condition is likely to decline rapidly without active weed management (e.g. drains).

The priority sites for weed control are:

- Southern section near the Water Corporation waste water treatment plant;
- Areas in front of stormwater drains entering Koondoola Regional Bushland; and
- Water Corporation property (source of seed).

Species-based Management

The prioritisation of weeds for control is critical given that:

- There are a large number of weed species present at Koondoola Regional Bushland,
- The effectiveness of controls varies between species;
- The methods and intensity of control varies between weed species;
- The impact of weeds in terms of their ability to displace native plants varies between species; and
- The removal of easily controllable weeds can facilitate the greater proliferation of weeds that are more difficult to control.

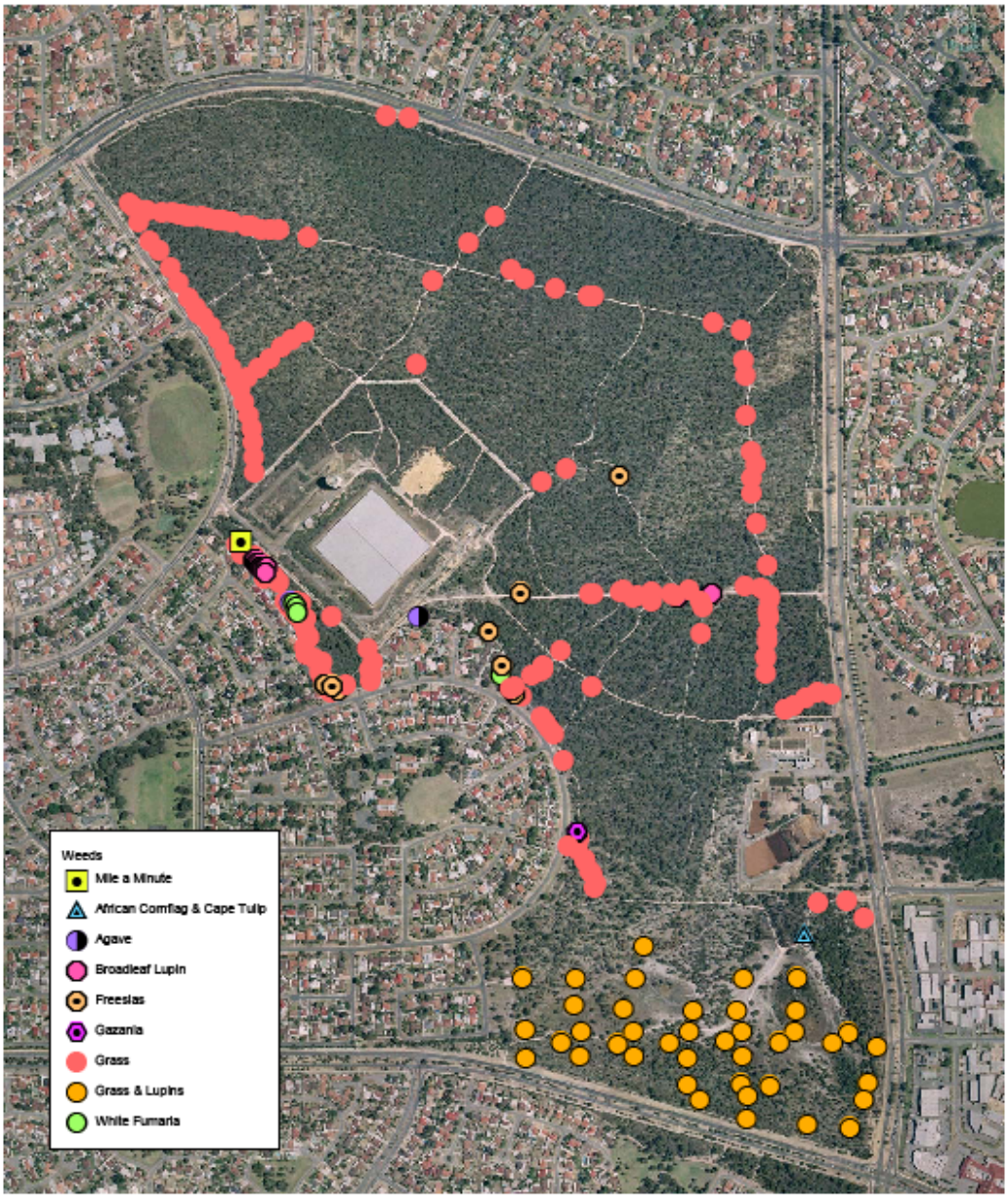
The *Environmental Weed Strategy for Western Australia* (EWSWA) rating provides a basis for determining which weeds are most critical to control. The three characteristics used for determining EWSWA rating are:

- Invasiveness – ability to invade bushland in good to excellent condition, and waterways;
- Distribution – wide current or potential distribution including consideration of known history of wide distribution elsewhere in the world; and
- Environmental impacts – ability to change the structure, composition and function of ecosystems, in particular to form a monoculture in a vegetation community.

The weed priority ratings are based on these characteristics in the following way:

- High – weeds that have all three of the characteristics;
- Moderate – weeds that have two of the characteristics;
- Mild – weeds that have one of the characteristics; and
- Low – weeds that are not deemed to have any of the characteristics.

The numbers of weed species within each of the rating classes are shown in Table 4.5.



ecoscape

Aerial Imagery supplied by City of Wanneroo

Koondoola Regional Bushland Management Plan

Herbaceous & Grass Weeds

City of Wanneroo

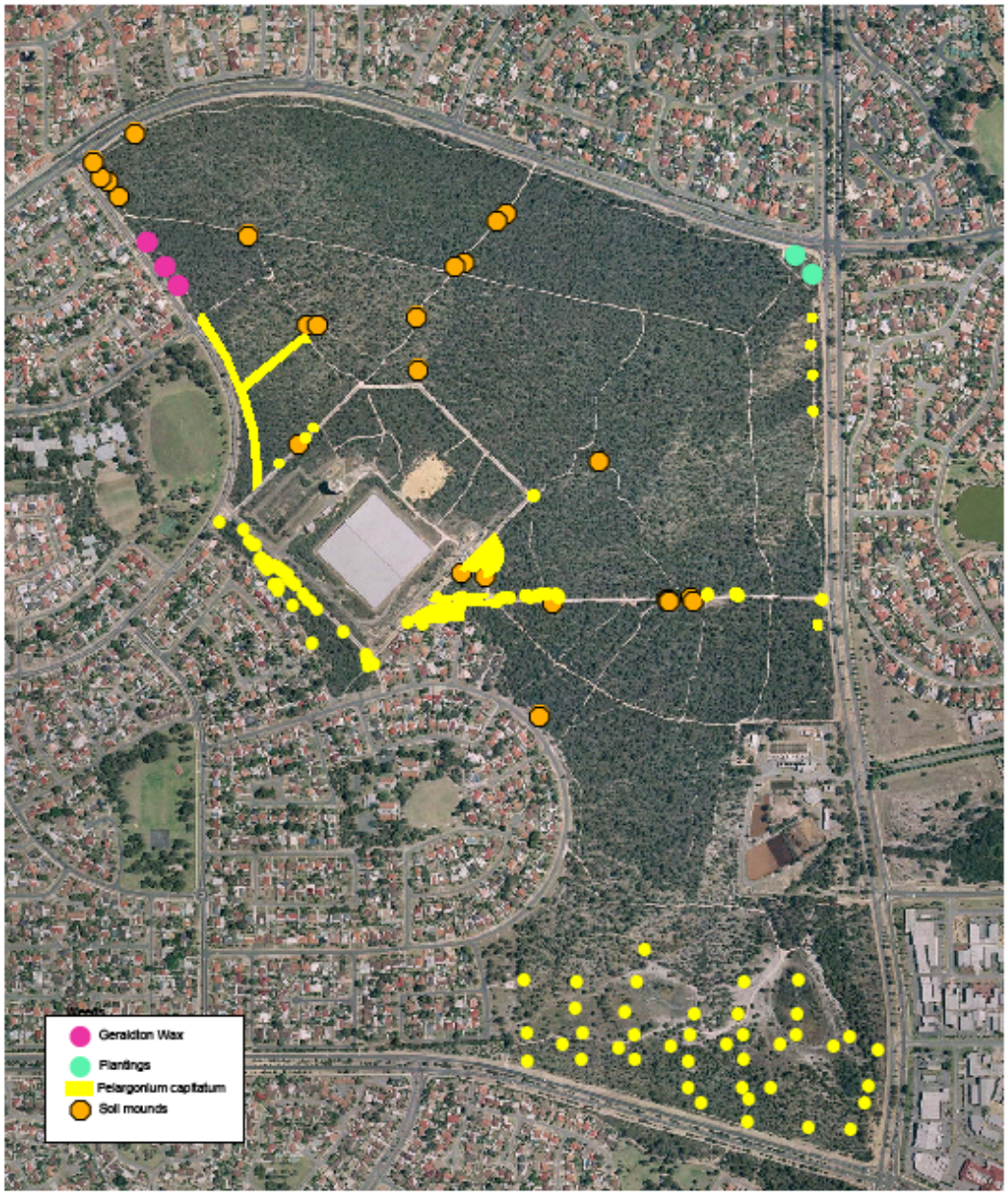
200 0 200 400 Meters

1 : 10 000 @ A4

Figure 4.1

Sept 2005

Figure 4.1 Herbaceous and Grassy Weeds



ecoscape

Aerial Imagery supplied by City of Wanneroo

Koondoola Regional Bushland Management Plan

Shrubby Weeds & Dumped Soil

City of Wanneroo

200 0 200 400 Meters

1 : 10 000 @ A4

Figure 4.2

Sept 2005

Figure 4.2 Shrubby Weeds and Dumped Soil

Table 4.5 Number of Weeds in each Weed Rating Category

Weed Rating	Number of Weeds
High	11
Moderate	17
Mild	6
Low	34
Unrated	6
Total	**74**

It should be noted that in the EWSWA some highly invasive weeds such as Black Flag were unrated at the time of publication, and that the Strategy provides ratings at a state scale and there are weeds that are generally not considered highly invasive but can be very invasive in specific situations and therefore consideration also needs to be given to the specific ecosystem being managed. These priorities are based on the ratings for the species in the EWSWA and distributions and densities of the species onsite (Table 4.6).

Table 4.6 Priority Weeds Present at Koondoola Regional Bushland

Botanical names	Common Name/s
Chasmanthe floribunda	African Cornflag
Ehrharta calycina	Veldt Grass or Perennial Veldt Grass
Eragrostis curvula	Weeping Love Grass
Ferraria crispa	Black Flag
Freesia hybrid	Freesia
Gladiolus angustus	Long Tubed Painted Lady
Gladiolus caryophyllaceus	Pink Gladiolus
Leptospermum laevigatum	Victorian Tea Tree
Lotus angustissimus	Narrow Leaf Trefoil
Lupinus cosentinii	Broad-Leaved Lupin
Paspalum dilatatum	Paspalum

Weed Control

Weed Control methods are listed in Appendix 2. Manual control has a specific role to play in weed control, however the application of herbicides is often the most cost-effective method for weed control and a wide range of herbicides are available for different weed species.

Herbicide Application

Dixon and Keighery (1995) identified three methods of applying herbicides:

1. Herbicide Wipe, Stem Injection and Cut Stump Application
2. Herbicide Spot Spraying
3. Herbicide Blanket Spraying

Herbicide Solutions

In considering which herbicides to use near waterways the Heath Department's 'Circular No.: PSC 88 Use of Herbicides in Water Catchment Areas' was consulted. Whilst the Circular does not dictate which herbicides can be used onsite, as it applies to areas where drinking water is obtained, it can provide some indication as to which herbicides are least detrimental to waterways. The Circular states that 'Other than with the expressed approval of the Executive Director, Public Health, the only herbicides that may be used in water catchment areas are: 2,4-D; amatol; glyphosate; hexazinone; Picloram; triclopyr (with 2,4 D being the least preferred). This document is presently being revised (Brown and Brooks, 2002).

Glyphosate based products such as Roundup® Biactive™ and Fusillade® were recommended by the Water and Rivers Commission (2001) for use in the vicinity of wetlands by community groups if used with care and according to instructions.

Glyphosate does not bioaccumulate and has a low toxicity (Water & Rivers Commission, 2001). Roundup® Biactive™ controls many aquatic weeds, as well as an extensive range of grasses, broadleaf weeds and woody weeds. Roundup® Biactive™ can be used for weed control in sensitive environmental areas such as channels, drains, streams and rivers that are in or near all situations including tree crops (Pest Genie, 2004)

Fusillade® is an herbicide registered for use in bushland that controls most grasses except Winter Grass *(Poa annua)*, Silver Grass *(Vulpia bromoides)*, Nutsedge *(Cyperus* species*)* and broadleaf weeds. The Swan River Trust approved the use of Fusillade® after trials to assess its impact on aquatic life (City of South Perth, 1994). Fusillade will not damage sedges and rushes, has low toxicity to bees and rats, is practically non-toxic to ducks and mammals (Water & Rivers Commission, 2001).

In addition the WRC (2001) also recommended the following herbicides for use in the vicinity of wetlands, if applied by professionals:

- Metsulfuron-methyl (Brushoff®, Ally®, Groper® and Escort®) for broadleaf weeds and some grasses;
- Chlorsulforun (Glean®, Siege®, Tackle®) for broadleaf weeds and some grasses; and
- Diquat (Aquacide®/Reglone®) for floating, submerged and emergent aquatic weeds.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	WEED CONTROL		
13	Continue to use an integrated approach to weed control including herbicides and manual removal as part of the ongoing maintenance program.	HIGH	CoW
14	As part of ongoing maintenance, monitor weed infestation on Water Corporation land and liaise with Water Corporation as necessary to prevent spread of weeds into the rest of the reserve.	HIGH	CoW
16	Continue to control weeds in southern area as a priority	HIGH	CoW and FKRB

4.5.3 Disease Monitoring and Management

There are no signs of the plant pathogen *Phytophthora cinnamomi* or Aerial Canker in the study area. However a small infestation of *Armillaria luteobubalina* was discovered south of the Water Corporations, water tower in a dieback study by Zuvela (2002). While the southern sumpland area was classified as uninterpretable due to the absence of indicator species (Zuvela, 2002).

As the *Armillaria luteobubalina* does not appear to be spreading its presence should be confirmed and continue to be monitored if necessary.

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. The method is a non-toxic way of preventing the disease attacking the plant. Even after infection, an injection of phosphite can help the plant recover. However, the treatment only lasts for 3 to 5 years. The major disadvantages of this method are that it is relatively expensive due to the intensive labour requirements, and can only be effectively used on small or isolated occurrences of dieback.

The best defence against these species is to reduce disturbances within the park that could stress plants, such as frequent fire and alterations to hydrology.

The Koondoola Regional Bushland Dieback Management Plan makes a number of recommendations to limit the spread of dieback (Zuvela 2002). The recommendations in this report should be followed to ensure dieback and other diseases are not introduced at the site.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	DISEASE MANAGEMENT		
17	Utilise the reserve's dieback management plan to ensure standard hygiene practices are followed.	HIGH	CoW
18	Confirm the presence of *Armillaria luteobubalina* and monitor if required.	HIGH	CoW and FKRB
19	Conduct soil monitoring for *Phytophthora cinnamomi* and other diseases as necessary i.e. if plants show signs of stress.	LOW	CoW and FKRB

4.5.4 Bushland Restoration

Objectives

The objectives for bushland restoration are to:

- 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 bushland; and
- Optimise the use of resources by prioritising areas for rehabilitation.

Background

Aspects of bushland management are interrelated but to increase the accessibility of this document, these have been separated with:

- The Rehabilitation section identifying priority areas in which rehabilitation should be undertaken; and
- The Revegetation section identifying techniques for rehabilitation.

Rehabilitation

Ecological restoration involves restoring the vegetation and habitats through means of reinforcing and reinstating the system's ongoing natural regenerative processes. This involves reducing or eliminating disturbance factors, removal of inhibitors to natural regeneration such as weeds, and the reconstruction of the ecosystem in highly disturbed areas where the potential for natural regeneration has been markedly reduced or lost.

The bushland condition map presented in Figure 2.5 can be used as a tool for determining restoration strategies as:

- Maintaining better condition bushland is often more cost effective and sustainable than improving poor condition bushland; and
- Weed control is generally most critical in the better condition bushland and revegetation is usually only considered in very poor condition bushland.

The main issues that need to be addressed in improving the condition of the bushland at Koondoola Regional Bushland are assisted natural regeneration in the form of weed control and reconstruction in the form of strategic revegetation. The appropriate situations for applying these two techniques are detailed in Table 4.7:

Table 4.7 Situations for applying alternate Bushland restoration techniques

Assisted natural regeneration	This method is used where a remnant of vegetation exists in *Fair – Good* or *Very Good – Excellent* condition and retains its natural regenerative capacity. It can also be used once a reconstructed community regains its natural regenerative capacity. Assisted natural regeneration involves removing weeds and disturbance factors from the environment.
Reconstruction	This technique is applicable where a bushland remnant is seriously depleted – for example where only some overstorey species are left, or when there is no remnant vegetation left. Reconstruction relies on methods to re-establish vegetation such as replanting, topsoil relocation and direct seeding.

Assisted natural regeneration following the Bradley method is currently undertaken in bushland in *Fair – Good* condition or better. Replanting and reconstruction is required in the *Poor* to *Very Poor* condition bushland as the exclusion of further disturbance will not lead to significant regeneration in these areas.

The priority areas for assisted natural regeneration (which is for weed control in good condition bushland) and reconstruction (which is for revegetation of poor condition bushland) will therefore not coincide. As a general rule maintaining good condition bushland (i.e. weed control) should be a higher priority than revegetation, but considerations such as creating linkages between bushland or improving amenity or consolidating areas of bushland may justify variances to this rule on occasion.

Social and environmental factors considered in setting priorities for revegetation are outlined in Table 4.8. It is noted that not all factors for setting a particular level are expected to coincide at any one point.

Table 4.8 Considerations in prioritising Revegetation

Priority	Social Factors	Environmental factors
High	• High Degree of Public Access • Highly visible • Focal Point of Public Area • Extensive views from site • Wide range of activities facilitated • Unique activities • Extensive interpretation opportunities • Public Liability risks • Provides protection for infrastructure (e.g. erosion) or public (e.g. industry buffer)	• Good – Excellent Bushland • Flora, fauna or vegetation uncommon in Study Area • Rare or significant species at regional scale • Significant degrading factors present (e.g. disease, changes in hydrology, noxious weeds, large perimeter to area ratio; adjacent areas in much poorer condition) • Significant degrading activities present (e.g. informal tracks being used)
Medium	• Limited Public Access; • Moderate visitation rates; • Limited interpretation Opportunities • Non-focal point in Public Area; • Moderate Visibility • Moderate views from site	• Vegetation is or may degrade slowly • Fair-Good Condition Bushland • Vegetation common in Study Area
Low	• No or limited public access; • Low visitation rates • Not visible from accessible areas • No views from site • Little or no opportunities for interpretation	• Very Poor-Poor Vegetation • Vegetation not degrading or unlikely to degrade either due to no degrading impacts or poor condition of bushland • Common vegetation in study area and region

Strategies for Bushland Rehabilitation

Priorities for Assisted Natural Regeneration

Assisted natural regeneration should be underpinned by the basic principles of the Bradley method. This method involves selective weeding around native species to decrease competition, increase the size and number of native plants and gradually improve the condition of the bushland. The underlying principles of this method are to:

1. Work from areas in good condition to areas in poor condition. Start regeneration work in areas with least disturbance to increase its resilience and then gradually work into areas with more weeds.
2. Minimise disturbance to soils and trampling of plants while working. This is important so that regeneration work does not simply create conditions suitable for weed invasion.
3. Let the rate of natural regeneration determine rate of weed removal. This can be important, as over-weeding will leave large bare areas that can be reinvaded by more or different weeds.

The area in best condition within Koondoola Regional Bushland is in the north section of the reserve (Figure 2.5), and this area is the highest priority for expansion/improvement through assisted natural regeneration. Current activity at the site includes assisted natural regeneration in the northern section of the site.

Priorities for Reconstruction

Determining priorities for reconstruction in urban bushland can be complicated as the sites that can be successfully reconstructed may be very small, the bushland may be highly fragmented, bushland condition can occur across a site in a patchy distribution, and consideration of social values such as aesthetics may be required.

The highest priority for reconstruction is the completion of any rehabilitation works already commenced. Currently there are no rehabilitation works within the Koondoola Regional Bushland.

The southern area of Koondoola Regional Bushland including the sumplands has been heavily affected by fire. As a result the Flooded Gum and Paperbarks have suffered. Flooded Gum has the capacity to rapidly establish itself under suitable conditions. At Koondoola Regional Bushland it has been able to re-establish, however, due to vandalism, fire, weed competition and unsuitable water levels this was not for long. If the latter two factors are managed through weed control and possibly watering of seedlings then relatively little effort should be required to maintain an overstorey of these species.

In addition, the drains in the southern corners of the reserve are causing erosion and encouraging the development of weeds. This degradation needs to be dealt with by revegetating this drainage line with appropriate native plants. The preferable option is to revegetate this area as a living stream so that it will manage both the erosion and nutrient input from the drain in conjunction with the SPT recommended by Connell Wagner (2005). A concept plan for the restoration of Koondoola Regional Bushland is shown in Figure 4.3. Further plans should be developed as part of the proposed stormwater management plan.

Monitoring

Bushland condition can be used to measure the success of ecological restoration, as it can be used to demonstrate increases in area of *Very Good – Excellent* or *Fair – Good* condition bushland, through improvements to the proportion of native species present, the structural integrity of the bushland and a decline in the number and/or level of disturbances present. Targets can therefore be set to determine what increase in area of *Very Good – Excellent* or *Fair – Good* condition bushland is required over the term of the management plan.

Bushland condition is useful in tracking large changes in the bushland's status and should continue to be measured each time this management plan is reviewed. However subtle improvements are not necessarily reflected in the results and these more subtle changes are better measured more frequently by monitoring the distribution and abundance of selected weed species, or quantitative data collected from fixed quadrats or transects such as those established by Pike (2004).

Revegetation

Objectives

Revegetation is a component of bushland restoration. The objectives for revegetation are to:

- Reinstate indigenous flora and vegetation communities, where they have been disturbed and/or depleted; and
- Ensure that vegetation communities are self-sustaining and are capable of natural regeneration.

Background

Revegetation includes planting seedlings directly into sites where native species have been partially or wholly lost due to disturbance and sites that have been sufficiently degraded such that natural regeneration would be insufficient without such activities.

Revegetation involves a number of steps including:

- Species selection;
- Sourcing plant material;
- Plant establishment; and
- Documentation.

Strategies for Revegetation

Species Selection

Ideally the species used in revegetation would consist of the entire suite of plants that naturally occur in that plant community. Whilst the flora inventory for Koondoola Regional Bushland appears to be relatively comprehensive there also appear to be some discrepancies between observations onsite and the previous flora inventory. Changes can occur over time and a detailed survey was not envisaged when this project began but the list should be rigorously reviewed over the life of this plan.

In developing revegetation lists consideration should be given to:

- The fact that not all species can be commercially propagated;
- Species may have been lost from the site as it has become degraded; and
- Long-term viability.

Species lost from the reserve

As species may be lost from degraded sites such as Koondoola Regional Bushland the species list with the least assumptions would be from the Friends of Koondoola Regional Bushland who have been conducting comprehensive flora surveys for the past ten years, showing which species have been lost over time within the bushland. The other location would be from species common to the *Karrakatta Central and South* and *Bassendean Central and South* Complexes as well as the Floristic Community Types found at Koondoola Regional Bushland. Lists developed on the basis of these inventories should have some expert input as: the lists are very broad, give no indication

of species that tend to co-occur, nor any indication of where within the reserve species would occur with respect to topography.

Long-term Viability

When plants are established in the lower parts of the reserve, the long-term viability of those particular species in that particular part of the landscape should be considered in terms of whether a portion of species from higher up the slope are included in the planting regime.

Impacts on Access

Prickly plants can be useful in where it is desirable to restrict access but not suitable when close to paths.

The common name of *Acacia pulchella,* Prickly Moses, is sufficiently descriptive to indicate why it can be effectively used for blocking access. It is relatively short-lived and therefore should not be the only species planted in large or highly visible areas.

Sourcing Plant Material

Ideally plant material should be sourced onsite or from nearby sites, with no more than one third of the available seed being collected from any individual plant and numerous "parent" plants used. This avoids problems of:

- In breeding where too few "parents" are used and the seedlings produced lack vigour; and
- Genetic pollution due to the introduction of dissimilar genetic material from a different area, which can result in sterile plants or a form of a species not native to the site becoming rampant.

The seed of many species may be easily obtained from within Koondoola Regional Bushland; however sourcing material for some species close by may prove difficult.

There is presently a dearth of information in the public domain with regard to the distances at which genetic variation becomes important for native species. The precautionary principal therefore needs to be adhered to by sourcing material as close to Koondoola Regional Bushland as possible, keeping good records and noting obvious morphological differences between plants occurring onsite and seedlings planted.

When this principal cannot be adhered to, obtaining seeds or cuttings from sites far removed from Koondoola Regional Bushland can sometimes be justified. As a general rule species with good dispersal capabilities (e.g. bird or wind dispersed) can be obtained from relatively large distances, while species with poor dispersal capabilities (insect dispersed, winged seeds or vegetative reproducing) should be sourced locally. However, until adequate time for species to be confirmed truly extinct, reintroductions may not be appropriate for Koondoola Regional Bushland.

Where practicable, the City of Wanneroo currently sources all revegetation material from local sources so as to maintain the genetic integrity of sites.

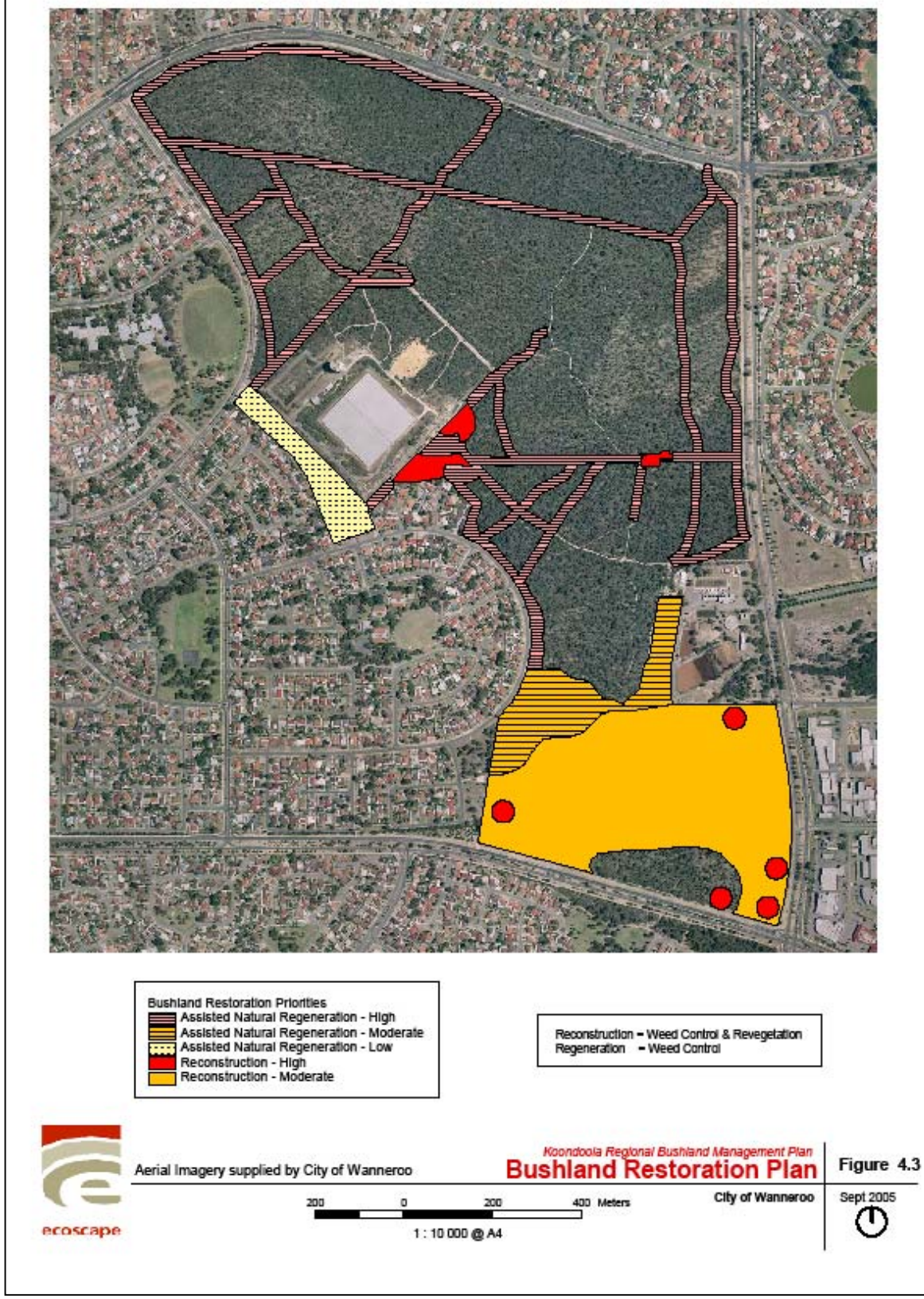


Figure 4.3 Bushland Restoration

Plant Establishment

Seedling planting

Native seedlings should be planted in late autumn and early winter to ensure good establishment from beneficial winter rains and should only be planted after initial winter rainfall has thoroughly moistened the soil and further rain is expected. Seedlings that have grown beyond post-emergent stage (around four to nine months, depending on species growth rates) in square plastic pots (e.g. 75 x 75 x 100 mm or similar) are considered most suitable for planting. Mature stock, although less suitable, do provide an obvious statement to the general public that a regeneration programme is underway and are useful in some places. Native seedlings should include a range of ground strata, middle strata and upper strata species with a view to achieving the floristic and structural composition of the original vegetation community.

Adequate ground preparation is important for good plant establishment. A small area approximately 50 cm in diameter should be cleared of weeds either by using a weedmat, manual hoeing or herbicides, as thick layers of mulch can deny weed seeds access to light and thereby restrict their growth. Following the application of manual and herbicide control, weed-free mulch can be spread around revegetated seedlings to help reduce weed growth. Care must be taken in sourcing mulch to ensure that it is not contaminated with weed seeds or disease. It is not necessary to water plants on planting provided they are well watered before planting and the planting precedes further rains.

There are a number of techniques that could be used in association with the planting of seedlings such as the use of tree guards and mulch but these should be considered on a site-by-site basis.

Plants should preferably be grown from seeds or cuttings collected within the study area or surrounding areas of similar vegetation type. All of the propagated plants should be grown by accredited *Phytophthora*-free (dieback-free) nurseries, preferably those specialising in contract growing of revegetation species. Generally no fertilisers should be used at the time of planting. Seedlings should not be staked for support as freestanding plants become more durable and strong. Care should also be taken to ensure that plants are not evenly spaced or planted in rows. Seedlings should be randomly clumped or spaced to achieve a natural effect and tree guards should be used to protect seedlings.

Direct Seeding

Direct seeding can be a useful technique in the reconstruction of areas where the level of weeds is low. The areas requiring reconstruction within Koondoola Regional Bushland have significant levels of weeds and therefore this method would not appropriate.

Documentation

Rehabilitation Plans

Rehabilitation plans should be prepared for all sites to be intensively managed. A rehabilitation plan should therefore be produced for Koondoola Regional Bushland. This should include as a minimum, the boundary of works, a planting list, and assets (including relatively rare plants) requiring special consideration. This plan could include a 5-year action plan for the site.

Monitoring

There is still much to learn in terms of rehabilitation techniques and all rehabilitation works offer an opportunity to build upon the knowledge base of the Municipality and the wider community of bushland regenerators. The critical component of this process is the collection and storage of data such as what, how and when actions were taken.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	BUSHLAND RESTORATION		
20	Undertake bushland restoration in order of priority shown in the bushland restoration section of this plan. It should however be ensured that any actions undertaken do not conflict with other requirements such as firebreaks.	HIGH	CoW
21	Produce a rehabilitation plan for the site, which includes as a minimum; the type of works, the boundary of works, a planting list, native plants present that require protection and a 5-year action plan.	HIGH	CoW
22	As part of the Stormwater Management Plan identify drainage sumps and upgrade or develop as living streams as appropriate	MEDIUM	CoW
23	Investigate suitability of plant species for southern wetland area given change in the hydrological regime.	LOW	CoW and DEC
24	Maintain use of local provenance seedlings in revegetation activities.	HIGH	CoW
25	Continue to compile a comprehensive list of species present.	MEDIUM	FKRB & CoW

4.6 Fauna

4.6.1 Preservation of Existing Resources for Native Fauna

The most critical factor for all the native fauna onsite is to maximise habitat and protection by:

- Minimising fires which could destroy habitat;
- Improving bushland condition; and
- Managing feral animals that may compete with or predate upon them.

These issues are also dealt with in the Fire, Hydrology, Revegetation and Feral Animal Sections of this Plan and recommendations are not duplicated here.

4.6.2 Provision of Resources for Native Fauna

Urban bushland reserves like Koondoola are very important. They provide refuge for native species once widespread throughout the Swan Coastal Plan. For example, birds can use these areas of bushland as green corridors or linkages through which to move, and in some cases, shelter and breed. With the less mobile species, these reserves provide the essential elements required for survival (Murray, 1998).

The majority of the bushland within Koondoola Regional Bushland is in Very Good to Excellent condition. However, the area surrounding and including the sumps in the southern section is in

Poor condition. This area when water is present is additional habitat for fauna such as frogs, water birds or migratory birds.

Koondoola Regional Bushland has been surveyed by Crypto (1995) who found 54 native animal species that are either, occurring or likely to occur within the reserve (32 birds, 2 mammals, and 21 reptile and amphibian species). These species (listed in Appendix 1) include significant species such as, *Calyptorhynchus latirostris* (Carnaby's Cockatoo) which is protected under the *EPBC Act 1999*, *Hypochrysops haliaetus* (Western Jewel Butterfly) which is threatened, *Isoodon obesulus* (Quenda or Southern Brown Bandicoot) which is classified as Schedule 1, *Acanthiza inornata* (Western Thornbill) which is classified as Schedule 3 and *Macropus irma* (Western Brush Wallaby) which is a Priority 4 species according to the Wildlife Conservation Act 1950. At present all these species are managed indirectly through improving bushland condition, and control of feral animals which have the potential to predate, compete with or displace native animals. These issues have been dealt with in other sections of this plan and recommendations are not repeated here.

The Friends of Koondoola Regional Bushland regularly conduct surveys of the invertebrate species at the site. The Department of Environment and Conservation (DEC) has also obtained funding to do some work on *Synemon gratiosa* (Graceful Sun Moth), which commenced in 2005 with follow-up surveys in 2006. The results of the DEC surveys are yet to be released however, the results of other surveys, suggest that weediness, frequent or extensive fires, and other disturbances (such as excessive grazing) are just as detrimental to butterflies as to other conservation values.

Because so little is known of the biology of many invertebrate species it is impossible to suggest management options. However it is proposed to utilise local knowledge of the site in order to better understand invertebrate popultations.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	NATIVE ANIMALS		
26	Retain tree hollows where possible as refuges for fauna e.g. Carnaby's Cockatoo.	MEDIUM	FKRB and CoW
27	Maintain healthy plant communities to support fauna	HIGH	FKRB and CoW
28	Utilise Friends Group knowledge in order to better understand local invertebrate populations. Undertake further assessments as necessary.	MEDIUM	FKRB and CoW

4.6.3 Management of Introduced Species

Objectives

The objective is to suppress feral animal numbers to:

- Minimise predation pressure on native animals by foxes and cats; and
- Minimise grazing pressure on native plants and seedlings by rabbits.

Cats

The issue of controlling cats in urban bushland is complicated by the different categories of cats. The Biodiversity Group of Environment Australia (1999) define the following three categories of cats:

- *Feral cats* are those that live and reproduce in the wild, eg. forests, woodlands, grasslands and wetlands, and survive by hunting or scavenging. None of their needs are satisfied intentionally by people. (Feral cats differ little in appearance from their domestic counterparts except in being generally more robust when in good condition (Department of Natural Resources Mines and Energy, 2003));
- *Stray cats* are those found in and around cities, towns and rural properties. They may depend on some resources provided by humans, but are not owned;
- *Domestic cats* are those owned by an individual, a household, a business or corporation. Most of their needs are supplied by their owners.

The *Threat Abatement Plan for Predation by Feral Cats* by Environment Australia (1999a) states that:

> *The responsibility for managing domestic cats ultimately rests with their owners. State, territory and local governments are supporting initiatives aimed at encouraging responsible pet ownership, including developing appropriate legislation, education and awareness programs, and management plans to address local problems with domestic and stray cats. Victoria has enacted the* Domestic (Feral and Nuisance) Animals Act 1994 *which requires cat owners to register their animals and gives councils the power to set fees and take remedial action when landowners experience problems with wandering cats. New South Wales has initiated the development of legislation to promote responsible ownership and improved welfare of companion animals.*

Feral cats which maintain stable home ranges, depending upon the availability of suitable den sites and food availability, can range from 4 to 8 square kilometres (Department of Natural Resources Mines and Energy, 2003). On this basis it could be assumed that stray and domestic cats will be in greater numbers and have a greater impact on the native animals in an urban bushland such as Koondoola Regional Bushland.

Around Perth, some areas have been declared cat prohibited areas meaning cats are prohibited from entering the area at all times. Extending 200 m outwards from cat prohibited areas are declared fauna protected buffer zones. In these buffers, a cat permit is required if more than one cat is kept in a household. While, trapping and baiting of cats is limited in its effectiveness (and would be politically undesirable) leaving fencing as the only feasible method of control when special areas need protection from cats (NRME, 2003). However, the fencing required to exclude cats may not be deemed appropriate for areas of small urban bushland such as Koondoola Regional Bushland due the visual impact and/or the financial burden.

Dogs

Dogs are not feral at Koondoola Regional Bushland but they can disturb native animals if they are not kept under control whilst being taken for a walk within the reserve. They can:

- Harass wildlife;
- Chase native mammals;
- Attack and kill native reptiles;
- Faeces add nutrients and supports weeds;
- Scent trails can impact on native animals; and
- Threaten walkers and other reserve users if not under control.

Local Government bylaws state that dogs must be on a lead or under effective control when in a reserve, and a $40 fine is issued to owners caught offending. However, lack of patrol officers makes this difficult to enforce. The perception of the degree to which this is a problem is variable amongst people. Signs requesting that people keep their dogs under control and informing them of on the spot fines when this is not adhered to should be situated around Koondoola Regional Bushland. The City of Wanneroo should monitor this situation.

Introduced Birds

Some of the introduced or feral birds recorded within the bushland are:

- Feral Pigeon;
- Laughing Kookaburra;
- Little Corella;
- Long-billed Corella; and
- Rainbow Lorikeet.

Little can be done to effectively control introduced birds within Koondoola Regional Bushland, as they are highly mobile species and unless control was undertaken at least across the Metropolitan area site specific control would have limited impact.

Foxes

Since they were introduced for recreational hunting in the mid-1800s, foxes have spread across most of Australia. They have played a major role in the decline of a number of species of native animals. Foxes are not uncommon in urban bushland. They occupy distinct areas, called home ranges. Fox numbers are relatively stable, except when animals are removed and there is an influx of new individuals. The size of a home range is determined by food and resources but can typically range from 280 to 1600 ha (Western Australian Department of Agriculture, 2004).

Fencing and broadscale fox control with poison baits has been used successfully in Western Australia, allowing populations of some native mammals to begin to recover and return to former habitats. Such control can ease the pressure on populations of native animals, but it is expensive and must be maintained indefinitely (Department of Environment and Heritage, 2004).

The use of poison baits for fox control must take into account possible effects on non-target species. Burying baits reduces the likelihood of the baits being taken by native animals, and foxes can still find them (Lund, 2001).

The idea of construction of exclusion fences may not be deemed appropriate for areas of small urban bushland due to the visual impact and/or the financial burden. The construction and maintenance of fencing that is capable of excluding foxes is expensive and costs in the order of $18 000 to $50 000 per kilometre have been reported (Biodiversity Group Environment Australia, 1999).

Den fumigation can be effective in reducing fox numbers. Cubs are born during August and September and fumigation must be carried out during the first 10 weeks or so that the cubs are confined to the den. The vixen is likely to be killed in the den only during the first three weeks after the birth of the cubs. While cage traps are also used to control foxes. A permit from the Department of Agriculture is required to use any type of trap or snare in the metropolitan and outer metropolitan areas. Captured foxes must be disposed of humanely (Lund, 2001).

The removal of shelter for foxes is difficult as a fox may have numerous resting sites within its home range and therefore the destruction of any one shelter is less critical (Thompson, 2000). Foxes rest during the day in dens, often enlarged rabbit burrows, or in sheltered sites such as rock piles, hollow logs, or thickets (Thompson, 2000). The possibility of shooting feral animals is greatly constrained in urban areas due to public safety concerns and therefore it will not be discussed as an option.

Scientists are investigating ways to improve conventional fox control methods to make them more effective and humane, and less likely to harm non-target animals. New biological control techniques are also being investigated. These include a vaccine to prevent pregnancy.

Predation by the European red fox is listed as a key threatening process under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the EPBC Act, the Australian Government in consultation with the states and territories has developed the *Threat Abatement Plan for Predation by the European Red Fox* (Department of Environment and Heritage, 2004).

More information about the *Threat Abatement Plan for Predation by the European Red Fox* can be found at http://www.deh.gov.au/biodiversity/threatened/publications/tap/foxes/index.html

Rabbits

Baiting

Both water-soluble and water insoluble Pindone® products are registered for controlling rabbits in Australia but they should be used according to the label and, where appropriate, mechanisms be put in place to reduce the risk to non-target species. The use of Pindone® is carefully controlled and the Western Australian Department of Agriculture (2004) recommend that Pindone® only be

used in WA where the use of 1080 is not practicable (such as urban areas). The risk to non-target species needs to be considered in its use because it can be toxic to kangaroos, bandicoots, wedge-tailed eagles, possibly some parrots, some of which do occur in Koondoola Regional Bushland (Western Australian Department of Agriculture, 2004).

Pindone® is the only poison that could be considered for use as 1080 poison can not be used in urban areas. The advantages of using Pindone® are:

- Highly effective for rabbit and fox control;
- Convenient and safe to use;
- Degradable and non-cumulative;
- Vitamin K1 is an effective antidote;
- Reduced risk of secondary poisoning to dogs (compared with 1080 poison);
- Dyed green to reduce risk to birds which prefer red or yellow food;
- Husk-coated to increase safety to many bird species that de-husk the grain and eat only the non-poisoned kernel;
- Low-dose strategy reduces risks to wildlife;
- Highly palatable to rabbits; and

Uses sterilised, seed-tested and screened grain to eliminate the risk of oat or weed seed germination (Department of Primary Industries, 2004; Western Australian Department of Agriculture, 2004; Animal Control Technologies, 2005)

The disadvantages of this product however, include:

- Several feeds over several days is required;
- It can take anywhere from six to 14 days after the first baiting to work; and
- Additional signage would be required stating the use of Pindone® within Koondoola Regional Bushland (Twigg and Lowe, 2003; Department of Primary Industries, 2004).

Bait stations (small enclosures/coverings for bait) provide one means to reduce potential risks to non-target species, although trail baiting is more effective in reducing rabbit numbers. Twigg and Lowe (2003) note that Pindone® in bait stations usually reduces rabbit numbers by about 50 per cent but the result can be highly variable, ranging from little effect to kills of up to 80 per cent; and that results can also take 30-60 days to manifest as the poison does not cause acute death and it takes time for rabbits to become accustomed to taking the bait. Baiting is most effective during summer when natural feed is scarcer. This method may not be appropriate as the non-target species have been known to occur within Koondoola Regional Bushland.

Warren Fumigation and Destruction

If undertaken correctly, ripping and use of explosives can be an effective means of rabbit control through the destruction of their warrens. However, it is generally a fairly expensive option and warren destruction may not be suitable for all areas (e.g. public access areas, areas that have been replanted, areas prone to erosion or where rabbits are harbouring in native vegetation rather than in warrens).

Warrens can also be fumigated (gassed) with Phosphine (e.g. Phostoxin®, aluminium phosphide) and carbon monoxide may be an option where warrens and burrows are located (Department of Agriculture, 2004). Appropriately trained personnel should only undertake such activities.

The success of both warren destruction and fumigation requires that the entire warren system is treated.

Fencing

Rabbit-proof fencing can provide a viable option for excluding rabbits from areas of high conservation value once they have been eliminated from the site. It is suggested that fencing can provide a better long-term and cost-effective solution to many rabbit problems in urban areas than baiting, despite the initial cost outlay for rabbit-proofing boundary fences with wire-netting being in the order of $1,600 per km (Bougher and Syme, 1998).

Where such fencing is erected then consideration also needs to be given to the possible effects on native animal species. The larger native animals, such as the Quenda could be affected and reptiles such as Bobtails would be impeded by tightly knit fencing wire. However holes large enough for Bobtails to move through would not be large enough for rabbits.

Tree guards

In the absence of fencing even simple tree guards have been found to be effective in protecting seedlings in revegetation projects around Perth (personal observation).

Biological Control

A number of biological controls have been introduced into Australia to control rabbits. These include:

- Rabbit Calicivirus Disease (RCD);
- The myxoma virus (myxomatosis); and
- Rabbit Haemorrhagic Disease Virus (RHD).

Whilst useful in controlling overall rabbit numbers, their impact varies across Australia (for example RHD has little effect in high rainfall areas) and none of these diseases will result in the elimination of rabbits. Therefore it is crucial that biological controls are not relied upon alone for the sustained long-term effectiveness of rabbit control programs in Australia

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	FERAL ANIMALS		
29	Actively seek funding and other opportunities to monitor, control and eradicate feral animals where practical.	MEDIUM	CoW

4.7 Fungi

Fungi as a broad group are key components in development and sustainability of ecosystems because of their role in nutrient cycling and interaction with other organisms. But little is known about their physiological variation or how each species operates and contributes in its unique way (http://www.deh.gov.au/biodiversity/abrs/publications/fungi-of-australia/vol1b.html).

For conservation and management, unfortunately there is too little known about what species are present in Australia, what functions they each perform, which have more important roles than others and what population size and extent of distribution is required to maintain viability to determine strategies specifically for fungi when considering the conservation of an area (Bougher and Syme, 1998).

Remnant patches of vegetation in urban and agricultural areas are significant refuges for fungi, as they are for other organisms. Therefore the need to conserve these areas is urgent as their loss would have deleterious effects on fungi as it would plants and animals. There is also the need to consider management practices that could affect fungi, such as fire. Conservation and management strategies that impact negatively on fungi may potentially affect ecosystem stability (Stubber, 2005).

A recent fungi survey conducted at the site by the Perth Urban Bushland Fungi (PUBF) Project recorded 16 species of fungi. It was however thought that unusually low rainfall in the period prior to the survey restricted the abundance and diversity of fungi observed. Far more fungi are likely to occur in Koondoola Regional Bushland and due to the unpredictable nature of fungi fruiting, surveys will need to be conducted over many years in order to capture the biodiversity of fungi present in any given area (Bougher et.al. 2006).

Due to the nature of fungi which fruit irregularly and intermittently it will be necessary to conduct numerous surveys over different days in the fungi season (May-July) as well as in successive years to produce an accurate inventory of fungi present.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	FUNGI		
30	Continue to work with PUBF to conduct fungi surveys at the site.	MEDIUM	CoW and PUBF

4.8 Fire

Objectives

A Fire Response Plan was prepared by the Friends of Koondoola Regional Bushland in December 2002, while a Fire Pre-Plan was documented in April 2004 by FESA (Murray, 1998).

A Fire Management Strategy was developed for Koondoola Regional Bushland prior to the 1998 Management Plan. This was in conjunction with Fire and Rescue, Shire of Wanneroo and the Friends of Koondoola Regional Bushland. The objectives were:

- To identify the stakeholders concerned with the "environmentally sensitive" area;
- To minimise the potential for, and the impact of incidents in urban bushland arising from fire and other hazards; and
- To ensure the preservation of any environmentally sensitive features (Davies, 2000).

The objectives for fire management are also to ensure:

- Protection of human life;
- Protection of property; and
- Protection of ecological integrity and biological values.

There is no single optimal fire regime for balancing all these requirements and fire management must always consider local conditions.

Background

General Impacts of Fires on the Biological Environment

Both the immediate and cumulative impacts of fires on biological values are of major concern. Fires can impact upon the natural environment in a number of ways including:

- Promotion of weed growth;
- Alteration of species composition;
- Threat to the viability of rare, endangered or geographically restricted species;
- Threat to the viability of obligate seeder species (which are typically more sensitive to fire than lignotuberous species that can resprout following fire);
- Exposure of animals to predation, dehydration and death due to lack of cover;
- Increase of scavengers, such as ravens; and
- Local extinctions of flora and fauna

Fires at intervals more frequent than the inherent regenerative capacity of the vegetation can promote the spread of exotic weeds by creating the required conditions, including:

- Increased light penetration through burnt-out overstorey;
- Reduced competition from native perennial species; and
- Increased availability of nutrients.

Increased weed growth, particularly annual grassy weeds, greatly increases the fire risk in a number of interrelated ways, including:

- Forming a fine-textured fuel which is highly flammable;
- Producing a high fuel load annually depending on climate and growth rate. Native plants take much longer to reach the same fuel levels;
- Forming a continuous fuel bed, permitting a fire to spread quickly (native plants usually have gaps between them which act to slow down the spread of fire); and
- Creating a very hot fire at ground level.

This situation leads to a cycle of increased weed growth leading to increased fire risk and thus increased fire intensity and frequency, which in turn lead to increased weed growth. The effect this situation has on natural communities is profound and can quickly lead to a greatly reduced diversity of flora and fauna.

There has been a history of fires through the Koondoola Regional Bushland, with the worst occurring in the Northern corner of the reserve in 1995 (Table 2.9). However, since then the frequency of fire has predominantly been in the southeast portion of Koondoola Regional Bushland. This could be due to the large amount of weed grass species such as *Paspalum dilatatum* and *Eragrostis curvula*, which are easily burnt when lit by arsons, as well as this area being in close proximity to residential property and playground facilities.

Between 1995 and 2002 there was an average of 4 fires, burning at an average of 7 hectares, per year. The extent of these fires is shown in Figure 4.5.

Although fire is a natural part of the ecology of the study area, the current environmental conditions are very different to the natural situation, due to a number of interrelated changes, including:

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

Strategy

4.8.1 Fire Prevention

The fire pre-plan for Koondoola Regional Bushland had suggested 3m wide firebreaks to be installed inside the perimeter fence. The Friends of Koondoola Regional Bushland thought that this would encourage weed growth in areas that are in excellent condition and greatly increase the risk from dry flammable material. Therefore it was suggested that firebreaks should only be installed to the areas that back onto residential property, with the road verge adjoining the reserve acting as the firebreak on all other sides.

Under the Bush Fire Act council does not have to comply with its own firebreak notice. *Fire Management Planning for Urban Bushland* published by FESA states that “Fire break notices are issued by Local Government”. They are legally enforceable under the Bush Fire Act. Each local government can set and enforce specifications for fire breaks for private land, determine the width and location of such firebreaks. If traditional fire breaks are not considered appropriate for a bushland area, a proposal will need to be submitted to the Local Government outlining the proposed alternative. In some cases, where bushland is located adjacent existing roads, a boundary firebreak may not be required, subject to Local Government approval.

The road verges of Marrangaroo Drive, Koondoola Ave, Waddington Cr, Rendell Way, Beach Rd and Alexander Dr are slashed/mown to maintain a low fuel state. This area of the road verge forms an important part of fire protection for the bushland, by stopping potential fires starting on the road reserve impacting on the bushland. They are at least 3m wide and are well maintained and can

provide the fire break requirement to the external boundary (Dixon and Keighery, 1995). The 1998 Koondoola Regional Bushland Management Plan also only called for 3m breaks where the bushland adjoins residential properties.

Assets Requiring Protection

Natural Assets

The best condition bushland onsite is the northwest to northeast portion of the reserve. It is a classified Bush Forever site with Floristic Community Type 20a described as, *Banksia attenuata* woodlands over species rich dense shrublands. Conservation status indicates that this diverse community is unusually species rich and endangered. Fire in this area would facilitate the invasion of weeds and degradation of the bushland.

Hazard Reduction

Hazard reduction involves fuel and ignition reduction.

Fuel reduction

In the bushland areas the most effective manner in fuel reduction is achieved by weed control and selective hand clearing if necessary. Grasses such as *Ehrharta calycina, Eragrostis curvula* and *Paspalum dilatatum* are recognised as flash fuel sources and can result in rapid fire spread, facilitating annual, intense fires. Therefore reducing these weed grasses, as well as other weeds, will reduce the flammable nature of the bushland.

The bushland areas are dissected by a number of tracks that serve a dual role as low fuel buffer areas, preventing the spread of low and moderate intensity fires, and also provide access trails for fire suppression vehicles. These tracks also allow the area to be divided into a number of cells that can be protected in the event of a major fire. However, the weed survey shows that the tracks are where the majority of the weeds occur increasing the risk of fire in these areas. Weed control and rehabilitation of the track edges, especially from Gate 13 heading south and the paths coming out from the Water Corporations Water Tower should be considered.

Ignition Reduction

A significant proportion of fires in urban bushland are intentionally lit. As arson is difficult to police, education is a worthwhile option for reducing fires.

Interpretive signage within the study area could be installed which make reference to the dangers of wildfires to human life and property, and the destructive cumulative effects of frequent fire on flora and fauna. The message should focus on the risk of accidental fire lighting and the need for the public to be vigilant against arsonists. Education programmes should also include the importance and vulnerability of the flora and fauna of the reserve, methods of preventing wildfire, controlling their spread and ensuring human safety in the event of a major fire within the reserve.

Other preventative methods suggested in the Fire Pre-Plan included;

- Hand clearing of dead weed matter, to be done by the Friends of Koondoola Regional Bushland group; and

- Weed control, with allocated responsibility to the City of Wanneroo.

Slashing of weeds in the southern area 1m along the fence-line was carried out last year and spraying of weeds around the boundaries was carried out this year.

4.8.2 Fire Response Plan

Fire Suppression

Fire suppression involves fire-fighting application once a fire has started and taken hold.

The Fire and Emergency Services Authority is the peak fire fighting body in Western Australia. The Authority administers the: *Fire and Emergency Services Authority of Western Australia Act 1998*; *Fire Brigades Act 1942*; *Bush Fires Act 1954*; and *Emergency Services Levy Act 2002* (FESA, 2003). The structure of FESA is shown in Figure 4.4.

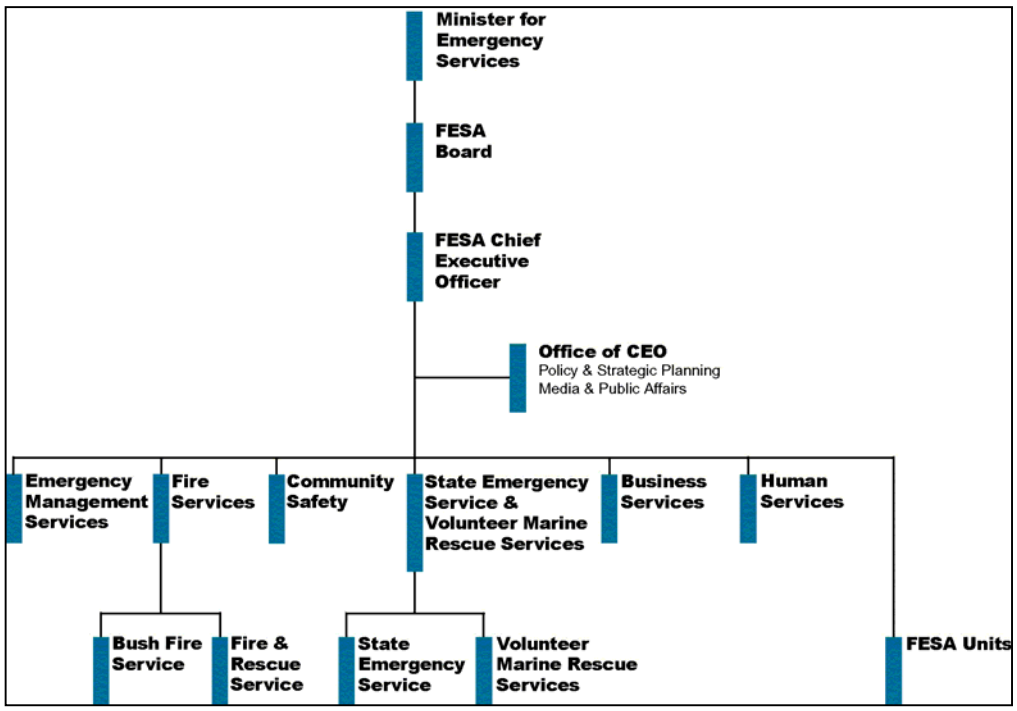


Figure 4.4 Structure of Fire and Emergency Services (FESA, 2003)

Fire suppression can only be effective if fires are detected quickly and fire fighters can respond and access the fire and contain it before it becomes uncontrollable.

From the Fire Pre-Plan for Koondoola Regional Bushland the suggested response to fire were the;
a) Fire Suppression Strategy:

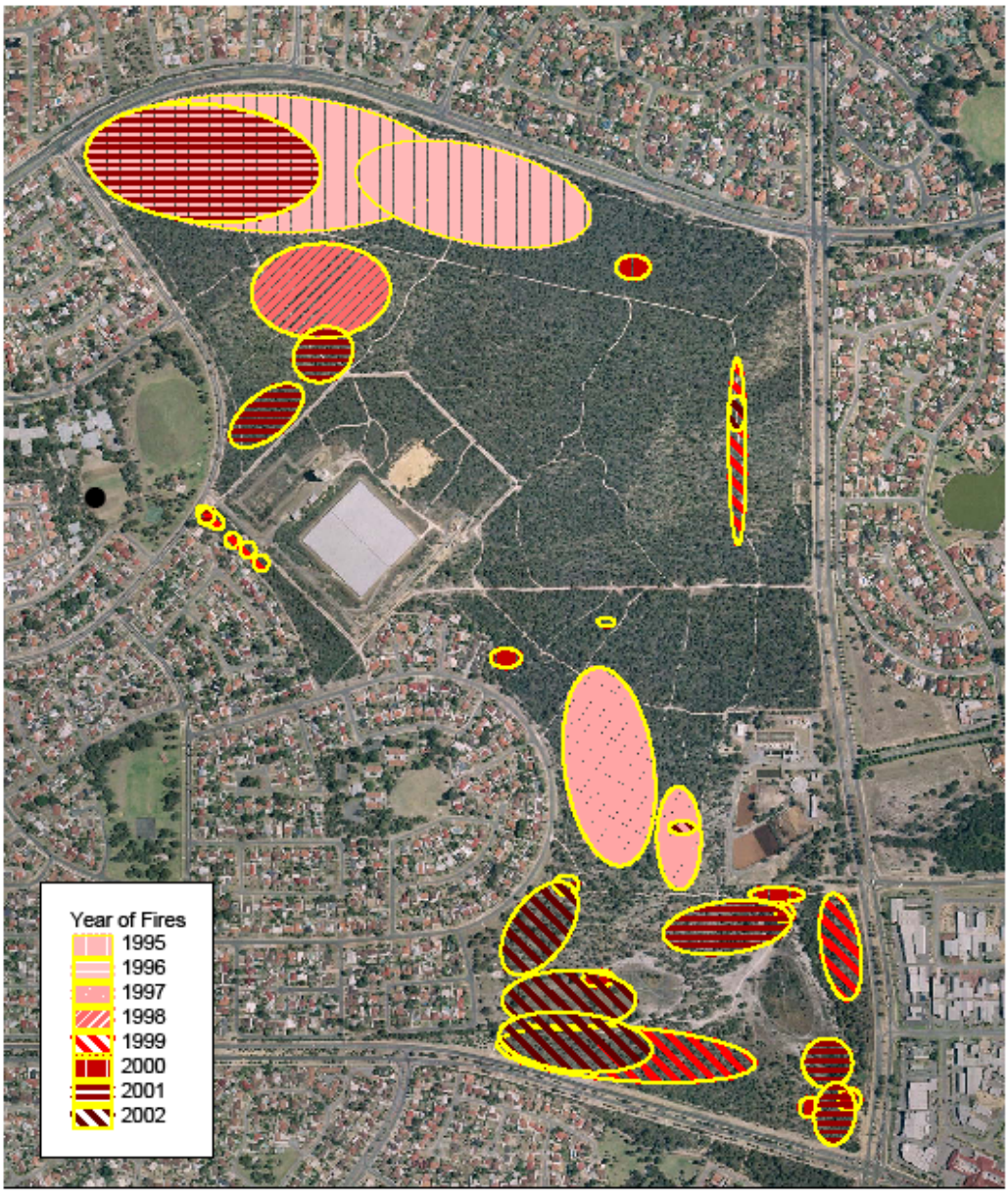
- Evaluate factors affecting fire spread;
- Consider resources required for exposure protection;
- Instigate appropriate fire suppression techniques.

and;

b) Fire Suppression Tactics:

- Direct attack-dependant on size of the fire front;
- Initial attack on flanks or head to slow rate of spread.

The responding fire appliances for Koondoola would be the Malaga pump and a light tanker with Balcatta and Wangara as backup. There are approximate 14 fire hydrants in close proximity to Koondoola Regional Bushland shown in Figure 4.1.



ecoscape

Aerial Imagery supplied by City of Wanneroo

200 0 200 400 Meters

1 : 10 000 @ A4

Koondoola Regional Bushland Management Plan

Fire History

City of Wanneroo

Figure 4.5

Sept 2005

Figure 4.5 Fire History

Fire Management

The aim of fire management is the protection of life, property and the ecological values of Koondoola Regional Bushland.

4.8.3 Post-fire Actions

Post-fire Recovery and Incident Analysis

Bushland is in a highly sensitive condition following fire. The soil is left bare and sensitive to erosive processes, such as vehicle and foot movements, heavy summer rain and wind.

Following a bushfire within the study area, an initial assessment should be undertaken of the potential for pedestrian tracks to become established in burnt areas. Access control measures should be implemented as soon as possible after the fire. Access to any burnt areas should be limited to management purposes in the first six to twelve months.

Seed germination and re-sprouting in vegetation should be monitored for a year following fire. Although recovery should be adequate if grazing and weed control measures are implemented, additional direct seeding and tubestock replanting may need to be considered if germination success is low.

Following fire, weed species have an opportunity to increase in density and abundance. Weed control measures will need to be implemented if a fire occurs. The post-fire environment is susceptible to further damage, and weed control works should be undertaken at a time that will give the bushland the greatest chance of successful regeneration. Weed control should therefore be revised after each fire.

Fire fighting operations have the potential to cause mechanical damage through trampling of vegetation, water erosion, small scale clearing and disease introduction. This cannot be entirely avoided, though should be minimised where possible through appropriate training within the fire-fighting authorities. Trained bush regenerators should carry out reparation of mechanical damage.

Post-fire incident analysis is an important facet of fire management, which enables fire fighters and fire control authorities to review procedures, strategies and tactics and revise them in light of experience. All fires that occur within the park should be recorded. Information that should be compiled includes the date, season, time, cause of ignition, intensity and extent of the fire, fire control methods used and damage caused by the fire. This information can be used for long-term fire management planning.

The Fire Pre-Plan states that a Post incident analysis is to be conducted within three weeks of a significant incident, liaising with vested authorities, such as the Friends of Koondoola Regional Bushland.

4.8.4 Planned Burning

Strategic Burns

Strategic or controlled burns in urban bushland such as Koondoola Regional Bushland are **not** currently recommended. Controlled burns have been discontinued in Kings Park, which contains approximately 270 ha of bushland in the centre of Perth, because it was considered counterproductive. A comparison of the prescribed block burning program in Kings Park (1954 – 1962) with later fire suppression regimes revealed that the area burnt by wildfire did not vary significantly but that the total area burnt decreased dramatically when prescribed burns were not conducted.

It was also found that Kings Park would have to be burnt every 3 to 4 years to ensure fuel levels are kept below 8 tonnes per hectare, and burning at this frequency has been shown to exacerbate the fire hazard by facilitating the replacement of native understorey with grass weeds such as Veldt Grass (George, 1996).

As a general rule occasional fires at close intervals will not necessarily lead to the demise of species but regular and frequent burning will lead to the increase of short-lived herbs and some grasses at the expense of obligate-seeding species (i.e. species which do not resprout).

To ensure that all native species have adequate time to build up a seed bank between fires Burrows and Wardell-Johnson (2002) recommend that fire regimes have a fire frequency twice the period required for the slowest maturing species at a site to set seed. Without comprehensive information to determine what the minimum fire interval would be required on this basis, it is worth noting that, specific to Koondoola Regional Bushland:

- Firewood Banksia (*Banksia menziesii*) take six-ten years to flower after germination (George, 1996) and;
- Slender Banksia *(Banksia attenuata)* is a slow-growing species that takes ten years to flower after geminating from seed (Standards Australia International, 2001).

The response of vegetation can involve a successional process in which the fast growing colonising plants replace the dominant slower growing species for a period of time after fire.

Sampling of fuel levels in December 2000 found that the litter depths were quite low on the woodland floor ranging from bare soil to 7mm depth and showing a fuel level of under 8 tonnes per hectare. Vegetation condition was recorded as very good, with low level of weed invasion, particularly in the northern parts of the bushland.

The recommendation was that at 8 tonnes per hectare, in this type of vegetation wildfire suppression would be successful in over 95% of weather conditions. Therefore with fuel levels below this level in Koondoola Regional Bushland, planned burning should not be undertaken.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	FIRE MANAGEMENT		
31	Review the current Fire Management plan and update it.	HIGH	CoW and FKRB
32	Continue to instigate a ban of all open fires at all times unless new research indicates controlled burns are required.	HIGH	CoW
33	Reduce fuel loads through control of weeds.	MEDIUM	CoW
34	Suppress and contain any wildfires within the study area as quickly as possible.	HIGH	CoW and FKRB
35	Continue to document fire history including mapping of fires, dates and causes recorded.	LOW	CoW and FKRB
36	Control access into burnt areas as soon as possible after the fire. Access to any burnt areas should be limited to management vehicles only for the first six to twelve months.	HIGH	CoW and FKRB
37	Seed germination and resprouting of vegetation or regeneration should be monitored for a year following fire and post fire weed control undertaken as necessary.	HIGH	CoW

4.9 Corridors and Linkages

A Local Biodiversity Strategy is currently being prepared by the City of Wanneroo. With Planning Services to provide more information on how the Local Biodiversity Strategy deals with linkages.

Koondoola Regional Bushland is adjacent to Reid Highway Bushland (Bush Forever Site 385) to the south, which is contiguous with the Bush Forever Site 307. These form part of the Marangaroo Road and Alexander Dr-Gnangara Lake Greenways (greenways 12 & 13) and are a regionally significant fragmented bushland/wetland linkage (Government of Western Australia, 1990).

Alexander Park is 500 m to the North of Koondoola Regional Bushland with plantings along Alexander Drive being the most effective method for consolidating the greenway. By maintaining roadside vegetation the existing links between these bushland remnants will remain.

4.10 Information, Interpretation and Education

It is important to provide experiences that are interesting and meaningful to visitors by enabling visitors to make connections between their own experiences and that which is presented, providing an understanding about the meaning and significance within a place. In Koondoola Regional Bushland the subjects for interpretation may include:

- Aboriginal heritage;
- European activities;

- Flora and Vegetation (e.g. distributions of plant species from low-lying areas to upland areas);
- Fauna;
- The activities of local volunteer bushcare groups;
- The dynamics of the wetlands (e.g. how water levels have been altered over time by changing landuse and climate); and
- Threats and causes.

4.10.1 Signage

At present information, interpretation and education of the site is in the form of seventeen signs relating mainly to indicating the name of the reserve and permitted activities. There are also guided tours conducted by the Friends of Koondoola Regional Bushland.

Signage Standards

Koondoola Regional Bushland contains a number of different variations to the standard information sign, which according to the Standards Australia document *Walking Tracks-classification and signage* (2001), is a sign which provides information related to the track and its use, including advisory signs, descriptive signs, interpretive signs, regulatory signs and warning signs.

According to the Standards Australian document, information signs should also be placed so that they cause minimal adverse visual impact on natural areas or culturally significant sites. Ideally they should be integrated into the design of facilities (Standards Australia International, 2001).

The signs around Koondoola Regional Bushland adhere to these guidelines, however a review of the information on the current signs or the addition of new signs should be considered.

Reserve Identification Signage

Large signs around the perimeter of the bushland have been used to increase the perceived status of the reserve and denote ownership, example seen in Plate 5.9. At present the only points at which the public can view a map of the reserve, and the track network is at the point of access into the bushland. Given the convoluted shape of the bushland it would be preferable to install signage that includes a map of the reserve, and the track network at least at one other point in addition to the information shelter. Such a sign would not have to be large and would be useful for the public to orientate themselves.

In positioning signs along paths careful consideration should be given to their location. Such locations include; places near to what they describe, near significant views, places of historical interest or places of educational significance such as information bays. The text could be accompanied with images and diagrams' showing what it is that is being interpreted.

Having signs throughout the bushland along the paths would also encourage pedestrians to remain on the tracks as well as reaffirm them of the appropriate uses and behaviours deemed acceptable within the bushland.

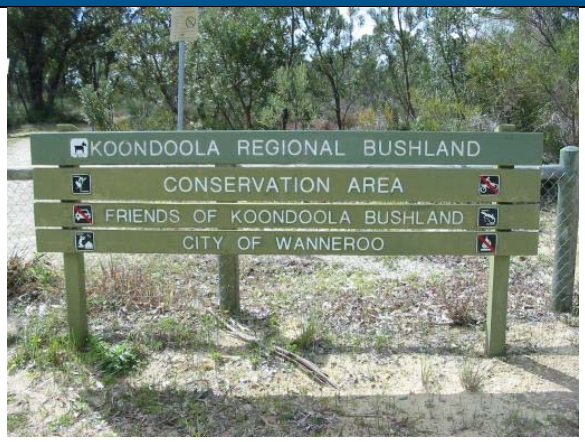


Plate 4.9 Name of Bushland Sign

Regulatory Signage

Regulatory signs are signs which specify legal requirements and regulation associated with the use of a track (Standards Australia International, 2001).

All signage, where possible, should display messages in a positive manner to capture the interest of potential users. Since Koondoola Regional Bushland is used quite regularly, it would be beneficial to have more informative descriptions of the things that are and are not deemed appropriate within the bushland. This would help educate the public and create more understanding and hopefully increase compliance through knowing more on how those undesirable activities do damage to the bush. The totem signs (Plate 5.10) are suitable for this purpose, however the introduction of more informative descriptions of uses/activities deemed appropriate within Koondoola Regional Bushland, especially at pedestrian entrance points is recommended

Plate 4.10 Totem sign found at entrance

Plate 4.11 Dieback warning sign

Informative and Educational Signage

The opportunities to inform and inspire the public are not fully realised in the current information shelter. This would be improved by the replacement of part of the permanent panel that holds information that's not needed to be changed frequently (such as a map and the values of the Bushland) with a panel that can be periodically updated with information (such as the activities of the Friends of Koondoola Regional Bushland).

Replacing the panels in the information shelters would provide an opportunity to upgrade the entire structure. The Perspex that covers the information is regularly vandalised and is unable to be fixed at the site. Considerations should be made to change the design making it easier to replace the covering onsite, rather than have the entire shelter removed and replaced. This would be a more cost effective method of maintenance.

Interpretation helps to meet the demand for educational visitor experiences and encourages people to care about the places they visit. It should build on the experiences, and interests of the area, in order to enhance an understanding and enjoyment of the place.

The style and content of interpretive signs is the prerogative of the managing authority (National Trust, 1995; Murray, 1998).

The information shelter and panel with map and interpretive information found at Koondoola Regional Bushland are shown in Plates 4.12 and 4.13.

Plate 4.12 Information Shelter

Plate 4.13 Information Panel

4.10.2 Information

Information about the Friends of Koondoola Regional Bushland and the bushland itself can be found at the website http://www.stumacsu.com/friendsofkoondoola/seasons.html, informing the community about dates, times and meeting places of the regular activities held at Koondoola Regional Bushland. There is also a newsletter intermittently published as a stand alone document, sent to current members of the Friends of Koondoola Regional Bushland and a calendar of events published in the Wanneroo Times Community paper, and information sheets on site in the information shelter. Wider advertisement of Koondoola activities is still required to attract continued interest from the local community.

On site information is essential in creating understanding of the bushland and its unique features as well as educating the public on the importance of its conservation. By creating signs that are attractive and informative it can help raise this awareness and enhance the values wanting to be instilled by the public on the bushland.

The information shelter found on site contains a number of documents describing parts of the bushland and some of the priority species found in it. This information should not stand alone, in terms of informative/descriptive signage.

Other Forms for Presenting Information

The creation of a Friends of Koondoola Regional Bushland website where maps of walk trails, background information, etc could be made available as could an aerial photo of the reserve. Other information on the reserve such as extracts of the management plan could provide a useful addition.

Interpretation

Interpretation helps to meet the demand for educational visitor experiences and encourages people to care about the places they visit. It should build on the experiences, and interests of the area, in order to enhance an understanding and enjoyment of the place.

The development of an interpretation plan should preferably be based around a theme as this provides continuity in the stories, which reinforces people's memories of the facts and stories presented. Interpretation should provide easily understood concepts built around a theme such as:

- The bushland as a home for endangered species, with examples being provided such as Carnaby's cockatoo and the Western Jewel butterfly;
- Changes in the bushland over time, with reference being made to fire, the use of the bushland once as an aboriginal camping ground;
- Changes to the wetlands; or
- The importance of urban bushland reserves.

The inclusion of additional signage throughout the bushland along certain paths can act as a method of connecting people with the bushland and help in creating a sense of ownership. This would not be necessary along all paths. There is a proposal for a specialised track to be constructed to accommodate electric wheelchairs. This will most likely be between gates 1 and 2 as a loop (refer Figure 4.0) and would be suitable for additional signage, as it would receive an increase in pedestrian traffic.

Education

Educating the public and especially the local community surrounding Koondoola Regional Bushland about the reserve and its conservation value could help encourage participation in its management, increase awareness of its sensitivity, increase awareness of threats and reduce anti-social behaviour within the bushland.

Some methods to achieve this are:

- Educational programs for local schools;
- Planting days;
- Guided tours and talks; and
- Brochures/pamphlets about the bushland.

It has also been identified that maintenance vehicles, such as vehicles used to maintain firebreaks are not following sufficient hygiene practices. Education programs should be developed to raise awareness about the introduction of diseases and weeds via unclean vehicles. The need for maintenance vehicles to maintain hygienic practices is waived when there is risk to life or property however once this risk is removed, hygiene protocols should be practiced, for example, when maintaining a firebreak.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	INFORMATION, INTERPRETATION & EDUCATION		
38	Upgrade the current information shelter.	MEDIUM	CoW
39	Install signage that includes a map of the reserve, and the track network at least at one point in addition to the information shelter.	LOW	CoW and FKRB
40	Develop an interpretation plan that reviews current signage and establishes interpretative signs along walk trails as appropriate.	MEDIUM	CoW and FKRB
41	Utilise current educational programs such as the “Adopt a Bushland Program” which encourages schools to become involved in bushland management.	HIGH	CoW
42	Design education programs to help raise awareness about issues threatening Koondoola Bushland such as feral animals, fire, weed invasion etc.	HIGH	CoW

5.0 Management for Leisure/Recreation

Koondoola Regional Bushland Management Plan

5.1 Access

The objectives for maintaining, rationalising or upgrading infrastructure within the reserves is to:

- Provide access for the public's use of the reserves; and
- Provide access for Council works programs and fire fighting.

These objectives need to be implemented with consideration to construction and maintenance costs.

5.1.1 Access Restrictions

Restricted access to such a high conservation bushland is important as uncontrolled access can cause substantial damage to the ecology through soil compaction or erosion, plant trampling, bush fragmentation and spread of weeds and disease.

The gates installed were specifically chosen to prevent or deter access for those participating in undesirable activities. For example, horses and unauthorised vehicles will be prevented, but access for the disabled and the elderly has still been accommodated, through the use of easy to use pedestrian gates.

Recommendations for restricting access discussed in section 4.1.2

5.1.2 Vehicle Access and Parking

There are 16 entry points to Koondoola Regional Bushland, of which 10 are accessible by both pedestrian and authorised vehicles and one only (Gate 11) is accessible to authorised vehicles only. The locations of the tracks within the bushland were based on existing tracks and were located to facilitate access to maintenance vehicles and fire control vehicles.

There is currently no formalised parking bays around Koondoola Regional Bushland, however, a need for car parking has been identified and possible sites should be investigated. For example, there is sufficient land between the fence line and the road along Koondoola Avenue that may be suitable for verge parking and would provide an alternative to developing a formalised car park. In addition, off street parking is provided on Burbridge Avenue.

Pedestrian and authorised vehicle access points shown in Figure 4.0.

5.1.3 Pedestrian Access

All gate entries into the bushland are accessible by pedestrians, with 5 being restricted to pedestrians only. These access points are guided to by the fence line and lead onto the formalised pathways to avoid trampling of the vegetation. One however, is an informal gate north of Gate eight to reduce the amount of fence cutting that occurs

The current formal tracks made of limestone are in need of an upgrade. Due to vandalism by children cyclists and abuse by fire vehicles some areas are beginning to show signs of erosion (refer Plate 5.1) Paths that have become eroded or unstable expose the City of Wanneroo to risks with regards to public liability.

There also needs to be allocated paths that are wheelchair accessible. The Australian Standard for Walking Tracks (AS2156.1-2001) establishes that tracks should have a minimum width of 90 cm for minor paths and a minimum of 120 cm for major paths or paths with wheelchair access.

Plate 5.1 Minor erosion of limestone path

5.1.4 Other

Rest Areas

There are 4 rest areas within the reserve. Whilst the number of rest areas may be adequate many are not positioned where there is shade. This limits their attractiveness in the heat of summer and the planting of shade trees should be contemplated. Consideration should also be given as to whether any additional rest areas can be provided to utilise shaded areas or highlight areas of interest.

5.2 Recreation Sites and Facilities

Mentioned previously, the suburb of Koondoola and the surrounding suburbs provide an adequate provision for active recreation, therefore it makes it possible to maintain Koondoola

Regional Bushland for its ecological value with passive recreation activities only. This can include such things as, bushwalking, photography and bird watching, as long as they occur on the designated paths.

Active recreation such as horse riding or irresponsible bicycle riding can cause damage to the pathways as well as increase the risk of erosion and trampling of vegetation. Therefore this type of activity should be prohibited within the bushland.

Formal picnic areas, barbeques and play equipment were not considered appropriate for this bushland from the previous Management Plan (1998). These types of facilities are more suited to Rendell Park; a dry park adjacent to Koondoola Regional Bushland, as rubbish dumping and vandalism associated with such facilities would be less in a more open area. There is also Butterworth Park and Koondoola Reserve, however, for the reasons stated above would benefit by not having barbeque facilities.

5.3 Public Safety

The main issue with regards to public safety within Koondoola Regional Bushland is the condition of the limestone paths. Since the tracks are used by many people including the elderly, track condition is important as any unstable or overgrown path can expose the City of Wanneroo to risks with regards to public liability. With the paths being susceptible to erosion and damage through excessive use an annual audit of the tracks to determine areas in need of repairs would be beneficial.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	INFRASTRUCTURE		
5	Formal carparks are required. Appropriate localities for car parking should be investigated.	LOW	CoW and FKRB
6	Investigate additional rest areas along walk trails which utilise shaded areas or highlight places of interest	LOW	CoW

6.0 Management for Cultural Heritage

Koondoola Regional Bushland Management Plan

The objectives for cultural heritage are to:

- Identify, encourage respect for, and preserve Aboriginal and European cultural heritage;
- Engender a spirit of care for the park, and sense of ownership of the reserve amongst the community;
- Develop opportunities for recreation with minimal impact on the environment;
- Increase the level and quality of information available to the community on the flora, vegetation and fauna of the reserve;
- Increase public knowledge of the environmental, local and regional significance of the study area; and
- Inform the local community of the current and proposed management objectives and structures proposed for the park and encourage public participation in the management and maintenance of the reserve.

6.1 Indigenous Australian Heritage

There are no Aboriginal Heritage listings within Koondoola Regional Bushland, however, it has been classified as an area of heritage significance and is listed for its Natural Heritage value in the National Trust's Register of Heritage places (Friends of Koondoola Regional Bushland, 2001).

Koondoola is very close to Big Emu Swamp, a place of recognised Aboriginal significance. Waterbodies hold particular significance to Aboriginal People.

Recommendations

	RECOMMENDATIONS		
	INDIGENOUS AUSTRALIAN HERITAGE		
43	Prior to any activity at the site resulting in disturbance, an Aboriginal heritage survey should be conducted for Koondoola Regional Bushland and if necessary any appropriate approvals obtained.	HIGH	DEH

7.0 Community Relations

Koondoola Regional Bushland Management Plan

7.1 Community Relations Directions

7.1.1 Stakeholder Community Groups

Friends of Koondoola Bushland

The Friends of Koondoola Regional Bushland are a community group interested in the conservation and care of Koondoola Regional Bushland. Their primary aims are to care for the local bushland and encourage the rest of the community to participate in its preservation and enjoy learning about it.

Friends of Koondoola Regional Bushland officially formed in 1995 and undertake a wide range of activities times and days of which vary, they:

- Conduct guided nature walks;
- Weed out problem plants;
- Remove rubbish;
- Collect and press plant specimens for a herbarium;
- Make observations of plant occurrence and flowering times;
- Take photographic records;
- Collect seed for regeneration work;
- Discourage and report damage to the bushland and anti-social behaviour;
- Educate about the bushland through talks and displays; and
- Publish a quarterly newsletter.

The Friends of Koondoola Regional Bushland activities provide an excellent way for community groups/members to gain great satisfaction in knowing they are making a difference to the conservation of Perth's unique bushland for future generations (English, 2005).

7.1.2 Future Community Consultation

As part of the development of this management plan and subsequent implementation of recommendations discussions between the City of Wanneroo and the Friends of Koondoola Regional Bushland should be ongoing to ensure the reserve is maintained.

Generally community-based groups should be encouraged to provide assistance with focused projects, such as specific sites or weeds within a reserve, while the Municipality bears the burden of broader responsibilities (such as control of extensive weeds through spraying programs).

The community projects need to be sufficiently focused such that visible results are obtainable. A sense of on-going ownership is also important and the development of specific rehabilitation sites can facilitate this, with the community group participating in follow-up weeding after planting the same site. This would be beneficial with the rehabilitation of the sumplands and around the drainage areas.

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	COMMUNITY RELATIONS		
44	Continue current FKRB activities to maintain interest in the group. The City should also continue to provide support and maintain relationships with this group.	HIGH	CoW

8.0 Research and Monitoring

Koondoola Regional Bushland Management Plan

8.1 Research

8.1.1 Research Priorities

Koondoola Regional Bushland is a large and important bushland that has ecological and scientific significance. This is reflected in the fact that a draft Interim Recovery Plan is being prepared by Department of Environment and Conservation for the Threatened Ecological Community onsite. The site has also recently been used to conduct research trials regarding the effectiveness of weed control following fire and the effect of fire and weed control on native grasses.

Some of the research priorities for the bushland include:

- Threatened Ecological Community (FCT 20a);
- The effects of fire;
- Groundwater levels and impacts on groundwater dependant ecosystems;
- Endangered fauna such as the Graceful Sun Moth and Carnaby's Cockatoo;
- Bushland fungi; and
- Appropriate methods of bushland restoration where changes in hydrology occur.

8.1.2 Research Projects

The Draft Interim Recovery Plan by Department of Environment and Conservation for *Banksia attenuata* over species rich dense shrublands (English, 2005) identifies research designed to increase the understanding of characteristics of the community to assist future management decisions as a priority. The Draft Interim Recovery Plan states that such research will ideally include:

1. The impact of weeds on the community;
2. The role of disturbance in regeneration of the community;
3. The recovery of the community following recent fires and burns;
4. The development of an appropriate monitoring system. Protocols will be developed as part of a future policy on threatened ecological communities based on recommendations in English and Blyth (1997a); and
5. Important biological processes in the community, eg pollination biology, germination requirements, longevity and time taken for significant plant taxa in the community to reach maturity.

A series of research trials, as a partnership between the City of Wanneroo and Greening Australia, have also been conducted investigating:

- How effective weed control is after fire; and
- The effect of fire and resultant weed control on native grasses.

This research project was initiated in 2006 following a fire and involved setting up a number of quadrats, subjecting them to different weed control levels and monitoring new plant growth in spring. This project is due for completion in 2008 and the results will be available in the near future.

Other potential research projects include:

- Determination of the impacts of groundwater decline on the vegetation, particularly groundwater dependent vegetation. This project could be undertaken with the Water Corporation, Department of Environment and Conservation or universities;
- Determination of the site's value and significance as habitat for endangered species such as the Graceful Sun Moth and Carnaby's Cockatoo. This potential project could be undertaken with Department of Environment and Conservation and other research institutions;
- Fungi form an important component of the bushland ecosystem and the types, distribution and ecological role of different species is poorly understood. Research opportunities which could involve the Friends Group, City of Wanneroo, Wildflower Society, Department of Environment and Conservation, the Perth Urban Bushland Fungi Project and research institutions exist for fungi related projects; and
- Changes in hydrology may necessitate the establishment of plant communities that respond to new hydrological regimes. Research needs to be undertaken to establish the appropriateness of specific species to be used and the best methods of establishing these through periods of changes in hydrological regimes.

8.2 Monitoring

There is a need to continue the collection of information on the study area. The main role of monitoring is to enable the revision of the management strategies proposed in this Management Plan.

The major aspects requiring monitoring include:

- Flora (which encompasses bushland condition);
- Weeds;
- Extent and Boundaries of Plant Communities;
- Fire;
- Public perceptions and impacts; and
- Hydrology.

Other aspects that require monitoring include:

- Feral animal population levels; and
- Erosion levels along tracks and erosion mitigation techniques.

8.2.1 Monitoring Priorities

The Draft Interim Recovery Plan for *Banksia attenuata* over species rich dense shrublands (English, 2005) identifies the need for monitoring floristics, weeds and community

boundaries as a priority. Onsite monitoring should be consistent with the monitoring program that will be established by Department of Environment and Conservation.

Flora

The Draft Interim Recovery Plan (English, 2005) states that:

> *[a] monitoring program will be established for a representative subset of Banksia community 20a community and management practices (eg Shire reserves, and private land). A quantitative method such as the line intercept method will be used. This will consist of installing a transect or number of transects, and/or utilising the permanent plots already in place from the Gibson et al. (1994) survey wherever possible. It is likely that the method used will be to record species present at set intervals along the transect so that cover values can be determined for all taxa.*
>
> *A subset of occurrences will be monitored every five years, or following a disturbance event, such as fire, to provide information on condition and response to environmental variables. Data collected will then be entered on to a database and then analysed. The results of data analysis will be added to the threatened ecological communities' database as recommended in English and Blyth (1997a). This information is essential for determining changes in the community over time and the effects of specific events (eg too frequent fire).*

Weeds

The Draft Interim Recovery Plan (English, 2005) states that:

> *Floristic data from Gibson et al. (1994) and consultants reports regarding specific sites may help determine weeds that pose the greatest threat to some occurrences as weed species that occur in plots have been recorded. Some significant weeds in occurrences may not occur in plots, however. Populations of major weeds will be accurately mapped in occurrences of the community where weeds are a significant threat, and appropriate herbicides or other methods of weed control determined.*

Monitoring should provide a basis for assessing the effectiveness of weed control and bushland restoration efforts particularly in the southern area of the site.

Extent and boundaries of Plant Communities

The Draft Interim Recovery Plan (English 2005) states that:

> *Occurrences will be monitored every five years. Boundaries can be determined from current aerial photographs and minimal on-site checking.*
>
> *Accurate GPS mapping of community boundaries has commenced and a Geographic Information System database for TECs has been developed. Extent and boundary information will be added to the threatened ecological*

communities' database as recommended in English and Blyth (1997b), as well as to the District's Geographic Information System database.

Fire

The Draft Interim Recovery Plan (English 2005) states that:

> *There is an urgent need for research into the fire-response of the community … and to determine the implications of findings for management. This would also include developing a fire history map of the occurrences, which is updated annually.*

This need is already being fulfilled by the City via demonstrated fire record keeping and by participating in research trials.

Public perceptions and Impacts

The public can incidentally or intentionally degrade the bushland by starting fires, dumping rubbish, and trampling and track creation. Apart from being visually unappealing, rubbish (and in particular garden waste), introduces weed seeds and increases the fire hazard.

To prevent accidental destruction or damage to the community, and gain public support for its conservation, management decisions need to be made in the context of the community's perceptions and demands. There is therefore a need to collect information about these perceptions and values changes, and monitor changes in attitudes as they change. Part of this monitoring should include the effectiveness of interpretation programme, and evidence and extent of vandalism).

Hydrology

Priorities relating to hydrology include:

- Monitoring water quality parameters associated with stormwater entering the site, this should include monitoring prior and post construction of stormwater devices advocated in the Connell Wagner report (2005);
- Monitoring changes in the hydrology of the area particularly around wetlands, changes have already been detected and therefore future changes need to be determined so that these can be correlated with changes in vegetation; and
- Monitoring the health and vigour of groundwater dependant vegetation and developing a monitoring program which conforms to established protocols for this type of work;
- Undertake negotiations with the Water Authority to provide monitoring data on the superficial aquifer levels and water quality for their land holdings adjoining Koondoola Regional Bushland.

8.2.2 Monitoring Program

A proposed monitoring program is shown below:

Monitoring Item	Method	Timeframe	Organisation

TEC 20a	Protocol established by Department of Environment and Conservation	Every five years	Department of Environment and Conservation (WATSCU)
Stormwater quality	Sampling stormwater at first flush and subsequent flows prior to being treated. Sampling after treatment	Onset of first rains and during winter	CoW, Consultants
Surface water hydrology	Piezometer network near wetland	Monthly	CoW, Friends Group
Groundwater dependant vegetation	Determine protocol for site based on that used by Edith Cowan University and Water Corporation	Annual	CoW, Friends Group, University
Weed Control Effectiveness	Establish quadrats and monitor cover/abundance, photographs from fixed points	Annual	CoW, Friends Group
Effectiveness of Weed control following fire	Continue existing research	Annual	CoW, Greening Australia
Bushland Restoration	Establish quadrats, measure survival and vigour and bushland condition	Annual	CoW, Friends Group
Fire control	Fire risk assessment through measurement of fuel levels	Annual	FESA
Vandalism, user impacts	Visual assessment, regular surveys	Monthly	CoW
User Requirements	User survey	Annually	CoW, Friends Group, Independent Survey Professionals
Feral animals	General observation, reporting to CoW	Ongoing	CoW, general public, Friends group
Erosion control	Visual assessment of tracks	Annual	CoW, Friends Group

Recommendations

	RECOMMENDATIONS	PRIORITY	RESPONSIBLE PARTY
	RESEARCH AND MONITORING		
45	Continue to liaise with research organisations such as Greening Australia, the Department of Environment and Conservation, and Universities to develop research initiatives	HIGH	CoW

46	Develop a detailed monitoring program which aims to improve the understanding of biological and ecological functions, health and values and improved management effectiveness.	HIGH	CoW, FKRB
47	Compile the results of the monitoring program and make publicly available. Undertake an annual audit on management action undertaken in response to monitoring program and make results publicly available.	HIGH	CoW

9.0 Implementation

Koondoola Regional Bushland Management Plan

9.1 Prioritisation and Allocation of Responsibility

9.1.1 Prioritisation of Management Strategies and Capital Works Projects

A five-year works programme has been developed and is outlined in the following section. This programme aims to achieve the implementation of major capital works, including bushland restoration, weed control and stormwater management. The environmental strategies that should be implemented during this period include weed control, ecological restoration, TEC, stormwater management, environmental monitoring including hydrology.

Various management strategies have been prioritised with consideration given to the factors listed in Table 4.9.

9.1.2 Allocation of Responsibility

The implementation of the management plan rests primarily with the City of Wanneroo. However management support may be derived from the Friends Group, other community groups, the Department of Environment and Conservation, Water Corporation and others as available.

9.2 Community Involvement

Community involvement in the management of Koondoola is already high and should further be encouraged in the implementation of this management plan. An appropriate division of tasks between various community groups and the Council will enable the most efficient use of available resources and volunteer efforts. Tasks that volunteers could contribute to include weed control, ecological restoration, monitoring and educational activities.

The community groups should not be seen as a free labour source and should be recognised for their skills and valuable contributions to the area. Part of this recognition could be through provision of funds for training of volunteers in bush regeneration techniques. Liaison between volunteers and the Councils is important to ensure co-operation at all times. This is best achieved on a day-to-day level through an appointed Council liaison officer.

9.3 Program of Works

While no specific program of works has been developed as part of the management plan because of unknown financial commitments by the City of Wanneroo, it is anticipated that this program will be developed by the City upon adoption of the plan by Council. Nevertheless those management strategies that are allocated a high priority should be done first and started within the first year of the new management plan.

9.4 Cost Estimation and Projected Cash Flow Requirements

The cost of implementing management strategies was based on industry rates which are contained within Ecoscape's construction rates database. Bushland restoration rates were determined from the following cost standard.

The estimates provided in this plan give a broad indication of the commercial costs of maintaining or restoring bushland in an urban setting to *Very Good – Excellent* condition. It is assumed that seedlings will be bought at a cost of approximately $1.75 each and that 2-3 seedlings will be planted per square metre in poor to very poor sites.

It can be argued that the costings are under-estimates as infill planting maybe required if seedlings fail to establish to due a number of factors such as a prolonged dry summer. This will increase costs as new seedlings are purchased and planted but also in terms of the greater cost of controlling weeds for a longer period until the native plants start to exclude them.

The costs of maintaining *Very Good – Excellent* condition bushland can also vary significantly between sites, larger remnants being less expensive per square metre than maintaining small or fragmented remnants (Table 9.1).

Table 9.1 Cost of professional rehabilitation per square metre

Condition	Very Good to Excellent	Fair to Good	Poor	Very Poor
Establishment	NA	NA	$5.00	$6.00
After 1st Year	$0.02	$0.25	$2.00	$3.00
After 2nd Year	$0.02	$0.05	$1.00	$1.20
After 3rd Year	$0.02	$0.02	$0.50	$0.50
Years thereafter	$0.02	$0.02	$0.02	$0.02

These estimates reflect the cost of maintaining or restoring bushland to very good condition. The cost of maintenance is lower than restoration because costs of propagative materials such as seedlings do not have to be borne. It should be noted that even though the cost of maintaining *Very Good – Excellent* condition bushland is approximately $0.02/m^2, the maintenance costs will be greater in poorer quality bushland as the weeds are in higher abundance and increase their extent more rapidly. This should be taken into account when considering if the overall goal of a site should be maintenance rather than restoration.

The cost estimates in the above Table are based on a five-year plan to restore those areas identified in the Bushland Restoration Plan (Figure 4.3) to *Very Good to Excellent* condition.

Table 9.2 Cost of Rehabilitating Bushland vested with City of Wanneroo

Restoration Priorities	Regeneration High 10.9 ha	Regeneration Moderate 5.1 ha	Regeneration Low 2.6 ha	Reconstruction High 2.2 ha	Reconstruction Moderate 21.0 ha
Establishment	N/A	N/A	N/A	$132,000	$1,050,000
1st Year	$27,250	$12,750	$6,500	$66,000	$420,000
2nd Year	$5,450	$2,550	$1,300	$22,000	$210,000
3rd Year	$2,180	$1020	$520	$11,000	$105,000
4th Year	$2,180	$1020	$520	$440	$42,000
5th Year	$2,180	$1020	$520	$440	$42,000
Total of above	$39,240	$18360	$15,860	$231,880	$1,869,000

Annual costs can also be reduced by extending works beyond the five-year life of this Management Plan, for example by staggering the restoration over a greater period of time. It is not proposed that the restoration of the entire Bushland area is practical within a five-year period.

9.5 Table of Actions for Implementation of Management Strategies

Recommendations	Action	Priority	Timeframe/ Frequency	Costing	Responsibility
INTEGRATED MANAGEMENT OF RESERVE AND ADJACENT AREAS					
Investigate potential partnerships with other land managers	Contact agencies such as DEC to enhance the connectivity between Koondoola Regional Bushland and other bushland sites.	MEDIUM	Ongoing	Utilise existing budgets/ staff time	CoW
INFRASTRUCTURE					
Maintain all bushland paths and fences to satisfactory standard.	An assessment of all informal bushland paths should be undertaken to determine if any paths can be closed and rehabilitated. Formalisation of paths that are heavily utilised by pedestrians should be investigated. Informal paths also functioning as firebreaks should be retained	MEDIUM	Ongoing	TBA	CoW
Upgrade limestone path for universal access	Review pathway requirements for universal access, ensure impacts on bushland are minimised	HIGH	2008/9	TBA	CoW

Continue to deter anti-social behaviour and maintain results of damage and investigate possible solutions to undesirable behaviour such as BMX jump construction.	Develop bushland watch program, involve youth and general community in bushland activities. Investigate the development of alternative facilities or the formalisation of the informal BMX circuit.	MEDIUM	2009/10	$5,000	CoW and FKRB
Provide carparking.	Investigate appropriate localities for car parking	LOW	2010/11	$3,000	CoW
Provide carparking.	Provision of carparks	LOW	2011/12	TBA	CoW
Provide additional rest areas.	Investigate additional rest areas along walk trails which utilise shaded areas or highlight places of interest	LOW	2010/11	$2,000	CoW
TRACK MANAGEMENT					
Monitor limestone tracks	Continue regular monitoring of limestone tracks; report any signs of erosion and rectify any deterioration.	HIGH	Ongoing	$5,000	COW and FKRB
SOILS					
Monitor acid sulfate soils risk	Prior to any excavation works or dewatering in the southern portion of the site, undertake Acid Sulfate Risk Assessment;	LOW	As required	$12,000	CoW
Monitor acid sulfate soils risk	Monitor southern portion of the site for signs of acid sulfate soils as part of the normal maintenance routine.	HIGH	Ongoing	Utilise existing budgets/ staff time	CoW
Remediate bare soil area towards the centre of the site.	Undertake a trial to revegetate the bare area of the site to prevent weed encroachment into good quality bushland.	HIGH	2008	$3000	CoW
HYDROLOGY					
Preparation of a memorandum of Understanding between CoW and Water Corporation, the City of Swan and the City of Stirling regarding the Stormwater Management of Koondoola Regional Bushland.		HIGH	2008/9	TBA	CoW, the Water Corporation, the City of Swan and the City of Stirling
Develop a Stormwater Management Plan for Koondoola Regional Bushland in consultation with the City of Swan, the City of Stirling and Water	Develop brief, engage consultants, develop design and implement	HIGH	2008/9	$30,000	CoW

Corporation					
Continue to liaise with Water Corporation in order to remain informed about plans to upgrade the wastewater pumping station emergency storage and any changes in the emergency arrangements for the site.		HIGH	Ongoing	N/A	CoW and Water Corporation
WEED CONTROL					
Use an integrated approach to weed control including herbicides and manual removal.	Develop weed control program that matches the bushland restoration priorities detailed in this report	HIGH	Ongoing	$10,000 p.a.	CoW
As part of ongoing maintenance, monitor weed infestation on Water Corporation land.	Liaise with Water Corporation as necessary to prevent spread of weeds into the rest of the reserve	HIGH	Ongoing	Utilise existing budgets/ staff time	CoW
Control weeds in southern area as a priority	Include this in the rehabilitation plan recommended in the Bushland Restoration section of this plan.	HIGH	Ongoing	Included in the $10,000 above	CoW and FKRB
DISEASE MANAGEMENT					
Utilise the reserve's dieback management plan to ensure standard hygiene practices are followed.		HIGH	Ongoing	Utilise existing budgets/ staff time	CoW
Confirm presence of *Armillaria luteobubalina* and monitor if required.		HIGH	Ongoing	$1000	CoW and FKRB
Conduct soil monitoring for *Phytophthora cinnamomi* and other diseases as necessary i.e. if plants show signs of stress.	Liaise with dieback experts to test for pathogen occurrence	LOW	As required	$1,000	CoW
BUSHLAND RESTORATION					
Undertake bushland restoration in order of priority shown in the Bushland Restoration section of this plan.	Develop a detailed rehabilitation plan in conjunction with the Friends of Koondoola Regional Bushland which includes priority bushland restoration.	HIGH	Ongoing	$1,900,000 (refer to Table 9.2)	CoW and FKRB
Produce a rehabilitation plan for the site		HIGH	2008/9	$20,000	CoW and FKRB
Identify drainage sumps and develop as part of living stream upgrades.	Develop as part of the proposed stormwater management plan. Seek joint funding for the project with the Cites of Stirling and Swan.	MEDIUM	2009/10	$200,000	CoW, City of Stirling and City of Swan
Investigate suitability of plants species for southern wetland areas given change in the hydrological regime.	Undertake research into suitability of plant species given predicted changes in hydrological regimes.	LOW	20010/11	$5,000	CoW and DEC
Maintain use of local provenance seedlings in revegetation activities.		HIGH	Ongoing	Utilise existing budgets/ staff time	CoW

Continue to compile a comprehensive list of species present.	Maintain database of existing plant species	HIGH	Ongoing	Utilise existing budgets/ staff time	CoW
NATIVE ANIMALS					
Retain tree hollows where possible as refuges for fauna eg. Carnaby's Cockatoo.	Remove feral bees from tree hollows	MEDIUM	Ongoing	$2,000	CoW
Maintain healthy plant communities to support fauna	Ensure restoration programs include species that will support fauna	HIGH	Ongoing	$500	CoW and FKRB
FERAL ANIMALS					
Continue to monitor and control program for feral animals where practical.	Develop monitoring program for feral animals	MEDIUM	Ongoing	$1500	CoW
FUNGI					
Continue to work with PUBF to conduct fungi surveys at the site.		MEDIUM	Ongoing	$500	CoW
FIRE MANAGEMENT					
Continue to follow the current Fire Pre-Plan and revise and update it as necessary.	Update plan as necessary	HIGH	2008/9	Utilise existing budgets/ staff time	CoW and FESA
Continue to instigate a ban of all open fires at all times within the area unless new research indicates controlled burns are required.	Develop appropriate signage on fire ban	HIGH	2008/9	$1,000	CoW
Reduce fuel loads through control of weeds.	Undertake weed control in conjunction with bushland restoration priorities	MEDIUM	Ongoing	see weed control	CoW
Suppress and contain any wildfires within the study area as quickly as possible.	Develop fire watch program and response system	HIGH	2008/9		CoW or FKRB
Continue to document fire history including mapping of fires, dates and causes recorded.		LOW	Ongoing	Utilise existing budgets/ staff time	CoW
Control access into burnt areas as soon as possible after the fire. Access to any burnt areas should be limited to management vehicles only for the first six to twelve months. Seed germination and resprouting of vegetation or regeneration should be monitored for a year following fire.	Develop protocol for fire affected areas and develop monitoring program for post fire regeneration	HIGH	2008/9	$2,000	CoW
Seed germination and regeneration should be monitored for a year following fire and post fire weed control undertaken as necessary.	Undertake weed control as required	HIGH	As required	$5,000	CoW
INFORMATION, INTERPRETATION & EDUCATION					

Upgrade the current information shelter.	Develop new signage for the information shelter, liaise with Friends group.	MEDIUM	2009/10	$10,000	CoW and FKRB
Install signage that includes a map of the reserve, and the track network at least at one point in addition to the information shelter;	Develop signage panels that include track network information.	LOW	20010/11	$6,000	CoW and FKRB
Develop an interpretation plan that reviews current signage and establishes interpretative signs along walk trails as appropriate.	Develop plan and implement	MEDIUM	2009/10	$15,000	CoW and FKRB
Utilise current educational programs such as the "Adopt a Bushland Program" which encourages schools to become involved in bushland management	Advertise existing programs for wider uptake.	MEDIUM	2009/10	$5,000	CoW
Design education programs to help raise awareness about issues threatening Koondoola Bushland such as feral animals, fire, weed invasion etc.	Develop signage and other material on the negative effects of impacts such as arson and weed invasion.	LOW	20010/11	$5,000	CoW and FKRB
INDIGENOUS AUSTRALIAN HERITAGE					
Prior to any activity at the site resulting in disturbance, an Aboriginal heritage survey should be conducted for Koondoola Regional Bushland and if necessary any appropriate approvals obtained.	Obtain relevant approvals as required	LOW	As required	TBA	CoW and DEH
COMMUNITY RELATIONS					
Continue current FKRB activities to maintain interest in the group.	Continue to provide support and maintain relationships with the Friends group.	HIGH	Ongoing	TBA	CoW
RESEARCH AND MONITORING					
Continue to liaise with research organisations such as Greening Australia, the Department of Environment and Conservation, and Universities to develop research initiatives.	Establish contacts database with key personnel in various government agencies and Universities	HIGH	2008/9	$3,500p.a.	CoW
Develop a detailed monitoring program, which aims to improve the understanding of biological and ecological functions, health and values and improved management effectiveness.	Develop monitoring plan and seek input from other organisation eg the Department of Environment and Conservation and the Wildflower Society.	HIGH	2008/9 Ongoing	$5,000	CoW and FKRB

Compile the results of the monitoring program and make publicly available. Undertake an annual audit on management action undertaken in response to monitoring program and make results publicly available	Expand role of environmental officers to include compilation of results from monitoring program	HIGH	Ongoing	$2,000p.a.	CoW

9.6 Evaluation and Review

The management plan should be reviewed and modified as necessary by the City of Wanneroo after five years, at the end of 2013. The works programme will need to be reviewed every year and appropriate financial allocations made to ensure ongoing management is undertaken. Review and Key performance indicators (KPI's) should be related to the outcomes of the monitoring program and developed in conjunction with relevant stakeholders including the Friends group.

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Appendix One: Fauna Inventory

Koondoola Regional Bushland Management Plan

Scientific Name	Common Name
MYOBATRACHIDAE	**Frogs**
Crinia insignifera	Sandplain froglet
Heleioporus eyrei	Moaning frog
Limnodynastes dorsalis	Banjo frog
Myobatrachus gouldii	Turtle frog
GEKKONIDAE	**Geckos**
Phyllodactylus m. marmoratus	Marbled Gecko
PYGOPODIDAE	**Legless Lizards**
Aprasia repens	Sandplain Worm Lizard
Delma grayii	Yellow Bellied Delma
Lialis burtonis	Burtons Legless Lizard
Pletholax g. gracilis	Keeled Legless Lizard
AGAMIDAE	**Dragons**
Pogona m. minor	Bearded Dragon
VARANIDAE	**Monitor Lizards**
Varanus gouldii	Common Sand Monitor
Varanus tristis	Black Tailed Monitor
SCINCIDAE	**Skinks**
Cryptoblepharus plagiocephalus	Snake eyed or Fence Skink
Ctenotus fallens	West coast Ctenotus
Hemiergis quadrilineata	Two toed earless skink
Lerista elegans	West Coast Four Toed Lerista
Lerista praepedita	Western Worm Lerista
Menetia greyii	Common Dwarf Skink
Morethia obscura	Southern Pale-Flecked Morethia
Tiliqua r. rugosa	Bobtail
ELAPIDAE	**Front Fanged Land Snakes**
Pseudonaja affinis	Dugite
Rhinoplocephalus gouldii	Gould's Hooded Snake
Birds	
Accipiter fasciatus	Brown Goshawk
Aquila morphnoides	Little Eagle
Larus novaehollandiae	Silver gull
Streptopelia senegalensis	Laughing Dove
Streptopelia chinensis	Spotted Turtle Dove
Cacatua sanguinea	Little Corella
Trichoglossus haematodus	Rainbow Lorikeet
Platycercus zonarius	Twenty-eight Parrot
Platycercus spurius	Red Capped Parrot
Calyptorhynchus latirostris	White Tailed Black Cockatoo
Cacatua roseicapilla	Galah
Tadorna tadornoides	Australian Shelduck
Podargus strigoides	Tawny Frogmouth

Halcyon sancta	Sacred Kingfisher
Dacelo novaeguineae	Kookaburra
Hirundo neoxena	Welcome Swallow
Merops ornatus	Rainbow Bee-eater
Hirundo nigricans	Tree Martin
Rhipidura leucophrys	Willie Wagtail
Smicrornis brevirostris	Weebil
Malurus splendens	Splendid Fairy Wren
Zosterops lateralis	Grey Breasted White eye
Meliphaga virescens	Singing Honeyeater
Lichmera indistincta	Brown Honeyeater
Phylidonyris novaehollandiae	New Holland Honeyeater
Phylidonyris nigra	White Cheeked Honeyeater
Acanthorhynchus superciliosus	Western Spinebill
Acanthiza inornata	Western Thornbill
Gerygone fusca	Western Gerygone
Anthochaera carunculata	Red Wattlebird
Grallina cyanoleuca	Magpie Lark
Cracticus torquatus	Grey Butcherbird
Cracticus tibicen	Australian Magpie
Corvus coronoides	Australian Raven
Berardius zonarius	Australian Ringneck
Petroica goodenovii	Red-capped Robin
Rhipidura fuliginosa	Grey Fantail
Mammals	
Macropus irma	Western Brush Wallaby
Oryctolagus cuniculus	European Rabbit
Mus musculus	House Mouse
Resident butterflies	
Trapezites sciron	Sciron ochre
Motasingha trimaculata	Large brown skipper
Motasingha dirphia	Western brown skipper
Croitana croites	Yellow sand-skipper
Mesodina cyanophracta	Blue iris-skipper
Taractrocera papyria	Western grass-dart
Geitoneura klugei	Marbled xenica
Heteronympha merope	Western brown
Hypochrysops haliaetus	Western jewel
Ogyris idmo	Large bronze azure
Nacaduba biocellata	Two-spotted line-blue
Theclinesthes serpentata	Saltbush blue*
Neolucia agricola	Fringed heath-blue
Zizina labrudus	Common grass-blue
Synemon sp. aff. sophia	Spring sun moth
Synemon gratiosa	Graceful sun moth
Pollanisus cupreus	Forester moth
Non-resident butterflies (*=introduced species)	

Cephrenes augiades	Orange palm-dart*
Catopsilia pomona	Lemon migrant*
Belenois java	Caper white
Delias aganippe	Spotted jezebel
Pieris rapae	Cabbage white*
Vanessa kershawi	Australian painted lady
Vanessa itea	Yellow admiral
Danaus chrysippus	Lesser wanderer
Danaus plexippus	Monarch*
Lampides boeticus	Long-tailed pea-blue

* introduced spp

Appendix Two:
Weed Control Methods

Koondoola Regional Bushland Management Plan

Botanical names	Common Name/s	Growth Form	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method	Method Control Description	Comments
Chasmanthe floribunda	African Cornflag						C	C							3	Spot spray Glyphosate 1%+Pulse (1.)	
Ehrharta calycina	Veldt Grass or Perennial Veldt Grass	P						C	C						3&4	Cut out - ensure crown removal: spray with fusillade 8mL/L (4L/ha) + wetting agent$_1$. (1.)	Requires follow up in subsequent years; utilise unplanned fires.
Eragrostis curvula	Weeping Love Grass	P	C	C	C								C	C	1,2&3	Burn off tussocks in January and spray new growth with Roundup at 3-5L per hectare when actively growing (Nov-March)(1.)	Serious fire hazard.
Ferraria crispa	Black Flag									C	C	C			1,2&3	Hand remove small populations, sift soil to find corms. Some control spraying metasulfuron methyl 0.2g/15L+glyphosate 1%+Pulse (1.)	
Freesia hybrid	Freesia								C	C					1,2&3	Spot spray metasulfuron methyl 0.2g/15L+Pulse (2.5-5g/ha) (1.)	
Gladiolus angustus	Long Tubed Painted Lady									C	C	C			3&4	Spot spraying degraded sites 0.2g/15L+glyphosate 1%+Pulse. Physical removal can result in spread or cormels (2.)	
Gladiolus caryophyllaceus	Pink Gladiolus									C	C				2&3	Wipe individual leaves glyphosate 10%. Spray dense infestations in degraded areas 1% glyphosate (1.)	
Leptospermum laevigatum	Victorian Tea Tree	P	C	C	C	C	C	C	C	C	C	C	C	C	1,2&3	Hand pull seedlings; fell mature plants; Resprouting has been recorded, if in doubt basal bark spray with triclopyr+picloram (2.)	

Lotus angustissimus	Narrow leaf trefoil	A/P								C	C	C	C		1,2&3	Improve drainage to reduce water logging during winter. Use 100mL Tordon 75-D plus 25mL wetting agent in 10L water in grass dominant situations. For selective control hand spray 25mL wetting agent plus 1g Logan or 10mL Lontrel in 10L water (3.)	Don't burn infested areas
Lupinus cosentinii	Broad-Leaved Lupin	A						C	C						1,2,3&4	Pull out seedlings. Where natives are absent, spot spray large colonies with Glyph. Plant natives to quickly revegetate bare areas. Lontrel 1 in 100 may also be used (do not use over sensitive plants). Ally at 2 to 3 g ha can give good results[1(2.)]	
Paspalum dilatatum	Paspalum	P										C	C		1,2,3&4	Cut out small populations, ensure rhizome removal. Spray with herbicide or cut near ground level and immediately wipe with 10% glyphosate or spray adult plants 10ml/L Fusillade and Wetting agent. (1.)	Use Herbicide on the young leaves

Growth Forms: a: annual; b biennial; p perennial Control Methods: 1. Hand weeding, pulling, digging 2. Herbicide wipe, stem injection, cut stump 3. Spot spraying 4. Blanket spraying

Shading indicates Flowering Time, C indicates Control time

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Appendix Three A: Flora Inventory

Koondoola Regional Bushland Management Plan

Species list from surveys conducted by the Friends of Koondoola Regional Bushland.

Native Flora of Koondoola Regional Bushland

Genus/Species	Common Name/s
Acacia huegelii	
*Acacia lasiocarpa**	
Acacia pulchella	Prickly Moses
Acacia saligna	Orange Wattle
Acacia sessilis	
Acacia stenoptera	Winged Wattle
Acacia willdenowiana	Grass Wattle
Adenanthos cygnorum	Common Woolybush
*Aira caryophyllea**	Silvery Hairgrass
Alexgeorgea nitens	
Allocasuarina fraseriana	Sheoak
Allocasuarina humilis	Dwarf Sheoak
Amphipogon turbinatus	
Angianthus cunninghamii	Coastal Amianthus
Anigozanthos humilis	Cat's Paw
Anigozanthos manglesii	Kangaroo Paw
Anigozanthos manglesii hybrid	
Aotus procumbens	
Arnocrinum preissii	
Astartea aff. Fascicularis	
Asteridea pulverulenta	Common Bristle Daisy
Astroloma pallidum	Kick Bush
Austrodanthonia occidentalis	Wallaby Grass
Austrostipa compressa	
Austrostipa flavescens	
Austrostipa semibarbata	Bearded Speargrass
Baeckea camphorosmae	
Banksia attenuata	Yellow Candle Banksia
Banksia grandis	Bull Banksia
Banksia ilicifolia	Holly leaf Banksia
Banksia menziesii	Firewood Banksia
Baumea articulata	Jointed Twig-rush
Baumea juncea	Bare Twig-rush
Boronia ramosa subsp. anethifolia	
Bossiaea eriocarpa	Common Brown Pea

Brachyscome bellidioides	
Burchardia congesta	Milkmaids
Caladenia arenicola	Carousel Spider Orchid
Caladenia discoidea	Dancing Spider, Bee Orchid
Caladenia flava	Cowslip Orchid
Caladenia longicauda subsp. longicauda	White Spider Orchid
Caladenia vulgata	Common Spider Orchid
Calectasia cyanea	Blue Tinsel Lily
Callistachys lanceolata	Native Willow Wonnich
*Callitris preissii**	
Calothamnus sanguineus	Silky Leaved Blood Flower
Calytrix angulata	Yellow Starflower
Calytrix flavescens	Summer Starflower
Calytrix fraseri	
*Cardamine sp. A**	Common Bitter Cress
Cartonema philydroides	
Cassytha glabella	Tangled Dodder Laurel
*Centaurea melitensis**	Maltese Cockspur
*Centaurium erythraea**	Common Centaury
Centella asiatica	
Chamaescilla corymbosa	Blue Squill
Chamelaucium uncinatum	Geraldton Wax
Chasmanthe floribunda	African Corn flag
Chordifex sinuosus ms	
Comesperma calymega	Blue-spike Milkwort
Conospermum acerosum	Needle Leaved Smoke bush
Conospermum stoechadis	Common Smoke bush
Conostephium pendulum	Pearl Flower
Conostephium preissii	
Conostylis aculeata	
Conostylis aculeata subsp. cygnorum	
Conostylis aurea	
Conostylis juncea	
Conostylis setigera	Bristly Cotton head
Corynotheca micrantha	Sand Lily
Crassula colorata	Dense Stonecrop
Cyanicula deformis	Blue Fairy Orchid
Cyanicula deformis	White form
Cyanicula gemmata	Blue China Orchid
Dampiera linearis	Dampiera linearis
Dasypogon bromeliifolius	Pineapple bush
Daviesia divaricata	Marno
Daviesia nudiflora	

Daviesia physodes	
Daviesia triflora	
Desmocladus fasciculata	
Desmocladus flexuosa	
Dianella revoluta	Dianella, Native Flax
Diuris corymbosa	Common Donkey Orchid
Diuris longifolia	Purple Pansy Orchid
Drosera erythrorhiza subsp. erythrorhiza	Red Ink Sundew
Drosera menziesii	Pink Rainbow
Drosera pallida	Pale Rainbow
Dryandra lindleyana subsp. lindleyana	Honey-pots Dryandra
Elythranthera brunonis	Purple Enamel Orchid
Eremaea asterocarpa	
Eremaea pauciflora subsp. pauciflora	
Eriochilus dilatatus subsp. dilatatus	
Eriochilus dilatatus subsp. multiflorus	Common Bunny Orchid
Eucalyptus marginata	Jarrah
Eucalyptus rudis	Flooded Gum
Eucalyptus todtiana	Prickly Bark
Euchilopsis linearis	Swamp Pea
Exocarpos sparteus	Broom Ballart, Djuk
*Gaura lindheimeri**	
Gompholobium aristatum	
Gompholobium confertum	
Gompholobium tomentosum	Hairy Yellow Pea
Gonocarpus pithyoides	
Goodenia micrantha	
*Grevillea leucopteris**	Smelly Socks
Haemodorum laxum	Mardja, Blood Root
Haemodorum paniculatum	
Haemodorum spicatum	Mardja
Hakea prostrata	Harsh Hakea
Hakea ruscifolia	Candle Spike Hakea
Hardenbergia comptoniana	Native Wisteria
Hemiandra linearis	Speckled Snake bush
*Hemiandra pungens**	Snake Bush
Hibbertia aurea	
Hibbertia huegelii	
Hibbertia hypericoides	Yellow Buttercups
Hibbertia racemosa	Stalked Guinea Flower
Hibbertia subvaginata	sessile flowers
Hovea pungens	Devils Pins
Hovea trisperma var. trisperma	Common Hovea

Hybanthus calycinus	Native Violet
Hypocalymma angustifolium	White Myrtle
Hypocalymma robustum	Swan River Myrtle
Hypolaena exsulca	
Isotropis cuneifolia	Granny's Bonnets, Common Lamb Poison
Jacksonia densiflora	Holly Leaf
Jacksonia furcellata	Grey Stinkwood
Jacksonia sericea	
Jacksonia sternbergiana	Green Stinkwood
Juncus pallidus	Pale Rush
Kennedia prostrata	Scarlet Runner
Kunzea ericifolia	
Lagenifera huegelii	Coarse Lagenifera
Laxmannia sessiliflora subsp. australis	
Laxmannia ramosa	Branching Lily
Laxmannia squarrosa	
Lechenaultia floribunda	Free Flowering Lechenaultia.
Lepidosperma angustatum	
Lepidosperma striatum	
Lepidosperma tenue? Leptostachyum	Coastal terete
Leporella fimbriata	Hare Orchid
Leptomeria spinescens	
*Leptospermum laevigatum**	Coastal Teatree
Leptospermum spinescens	
Leucopogon conostephioides	
Leucopogon parviflorus	Coast Beard-heath
Leucopogon polymorphus	
Leucopogon propinquus	
Levenhookia pusilla	
Lobelia alata	Angled Lobelia
Lobelia gibbosa	Tall Lobelia
Lobelia tenuior	Slender Lobelia
Lomandra caespitosa	Close Tuffed Matt Rush
Lomandra hermaphrodita	
Lomandra nigricans	
Lomandra preissii	
Lomandra suaveolens	
Lyginia barbata	
Lysinema ciliatum	Curry Plant
Macarthuria australis	
Macrozamia riedlei	Zamia, Djiridji
Melaleuca preissiana	Stout Paperbark Moonah
Melaleuca scabra	Rough Honey myrtle

Melaleuca seriata	
Mesomelaena pseudostygia	
Microtis media subsp. media	Mignonette Orchid
Millotia myosotidifolia	
Millotia tenuifolia var. laevis	Soft Millotia
Monotaxis grandiflora	Diamond of the Desert
Nemcia capitata	Eggs & Bacon
Nemcia reticulata	
Neurachne alopecuroidea	Foxtail Mulga Grass
Nuytsia floribunda	WA Christmas Tree
Olearia elaeophila	
Oligochaetochilus aff. vittatus	Crowded Banded Greenhood
Oligochaetochilus sanguineus	Dark Banded Greenhood
Oligochaetochilus vittatus	Banded Greenhood
Opercularia vaginata	Dog Weed
Ozothamnus cordatus	Tangle Daisy
Paraserianthes lophantha subsp. lophantha	
Patersonia occidentalis	Purple Flag
Patersonia pygmaea	
Pericalymma elliptica	Swamp Teatree
Persoonia saccata	Snottygobble
Petrophile linearis	Pixie-mops
Petrophile macrostachya	
*Petrorhagia velutina**	Velvet Pink
Philotheca spicatus	Pepper & Salt
Phlebocarya ciliata	
Phyllangium paradoxum	
Phyllanthus calycinus	False Boronia
Pimelea leucantha	
Pimelea sulphurea	Yellow Banjine
Pithocarpa pulchella	Beautiful Pithocarpa
Platysace compressa	Tapeworm Plant
Platytheca galioides	
Podotheca angustifolia	Sticky Longheads
Podotheca chrysantha	Yellow Podotheca
Polygonum salicifolium	Slender Knotweed
Poranthera ericoides	Heath Poranthera
Poranthera microphylla	
Prasophyllum aff parvifolium	
Prasophyllum parvifolium	Autumn Leek Orchid
Prasophyllum plumiforme	Dainty Leek Orchid
Pronaya fraseri	Elegant Pronaya
Pterostylis barbata	Bird Orchid

Pterostylis brevisepala ms	Short Eared snail orchid
Pterostylis recurva	Jug Orchid
Ptilotus manglesii	Pom-poms, Rose tipped Mullah Mullah
Ptilotus polystachyus	Prince of Wales Feather Green
Ptilotus polystachyus	Prince of Wales Feather Pink
Pultenaea reticulata	
Pyrorchis nigricans	Red Beak Orchid
Regelia ciliata	
Ricinocarpos glaucus	Wedding Bush
Samolus repens	
*Scabiosa atro purpurea**	Purple Pincushion
Scaevola canescens	
Scaevola repens var. repens	Shining Fan flower
Schoenus brevisetis	Bog Rush
Schoenus clandestinus	
Schoenus curvifolius	
Schoenus grandiflorus	Large Flowered Bogrush
Schoenus subfascicularis	
Scholtzia involucrata	Spiked Scholtzia
Senecio pinnatifolius	
*Silene gallica var. gallica**	French Catchfly
Sowerbaea laxiflora	Purple Tassels
Stackhousia monogyna	
Stirlingia latifolia	Blue Boy
Stylidium adpressum	
Stylidium brunonianum	Pink Fountain Triggerplant
Stylidium bulbiferum	Circus Triggerplant
Stylidium calcaratum	Book Triggerplant
Stylidium carnosum	Giant Triggerplant
Stylidium piliferum	Common Butterfly T/plant
Stylidium repens	
Stylidium schoenoides	Cow Kicks
Symphyobasis alsinoides	
Synaphea spinulosa	
Tetraria octandra	
Tetratheca hirsuta	Black Eyed Susan
Thelymitra macrophylla	Scented Sun Orchid
Thysanotus multiflorus	Many Flowered Fringe Lily
Thysanotus patersonii	Twining Fringe Lily
Thysanotus sparteus	Fringe Lily
Thysanotus triandrus	
Trachymene pilosa	Native Carrot
*Tribulus terrestris**	Caltrop

Tricoryne elatior	Yellow Autumn Lily
Verticordia densiflora var. densiflora	Compacted Feather flower
Verticordia drummondii	Drummond's Feather flower
Verticordia nitens	Morrison-flower, Kodjeningara
Wahlenbergia preissii	Austral Bluebell
Waitzia paniculata	
Waitzia suaveolens	Fragrant Waitzia
Xanthorrhoea brunonis	
Xanthorrhoea preissii	Blackboy, Palga, Balga
Xanthosia huegelii	

* Weed/Introduced Species

Weed Species of Koondoola Regional Bushland with EWSWA ranking

Species	Common Name	EWSWA Rating
Acacia iteaphylla	Flinders Range Wattle	Low
Acacia longifolia		Moderate
Aira caryophyllea	Silvery Hair Grass	Moderate
Arctotheca calendula	Cape Weed	Moderate
Asphodelus fistulosus	Wild Onion	Mild
Avena barbata	Bearded Oat	Moderate
Avena fatua	Wild Oat	Moderate
Babiana stricta		Low
Brassica rapa		Unrated
Briza maxima	Blowfly Grass	Moderate
Carpobrotus edulis	Hottentot Fig	Moderate
Centaurea melitensis	Maltese Cockspur	Moderate
Centaurium erythraea	Common Centaury	Moderate
Chamelaucium uncinatum	Geraldton Wax	Moderate
Chasmanthe floribunda	African Corn-flag	Moderate
Conyza albida	Tall Fleabane	Low
Conyza bonariensis	Flaxleaf Fleabane	Low
Conyza parva	Fleabane	Low
Cortaderia selloana	Pampas Grass	High
Cotula turbinata	Funnel Weed	Low
Cynodon dactylon	Couch	Moderate
Cyperus rotundus		Moderate
Cyperus tenuiflorus		Low
Dimorphotheca ecklonis		Low
Dischisma capitatum		Unrated
Ehrharta calycina	Veldt Grass or Perennial Veldt Grass	High
Eragrostis curvula	Weeping Love Grass	High
Erodium cicutarium	Storksbill	Moderate
Euphorbia peplus	Petty Spurge	Moderate
Euphorbia terracina	Geraldton Carnation Weed	High
Ferraria crispa	Black Flag	Unrated
Foeniculum vulgare	Fennel	Unrated
Freesia hybrid	Freesia	High

Fumaria capreolata	Whiteflower Fumitory	Unrated
Gazania linearis	Gazania	Low
Gladiolus angustus	Long Tubed Painted Lady	Mild
Gladiolus caryophyllaceus	Wild Gladiolus	Moderate
Gomphocarpus fruticosus	Swan Plant or Narrow Cottonbush	Moderate
Heliophila pusilla		Moderate
Hesperantha falcata		Moderate
Hypochaeris glabra	Smooth Cat's Ear	Moderate
Isolepis marginata		Moderate
Juncus bufonius	Toad Rush	Moderate
Juncus microcephalus		Mild
Leptospermum laevigatum	Coast Teatree	High
Lotus angustissimus	Narrowleaf Trefoil	Low
Lupinus cosentinii	Sandplain Lupin	High
Narcissus tazetta		Low
Oenothera drummondii		Moderate
Ornithopus pinnatus		Low
Orobanche minor	Lesser Broomrape	Moderate
Osteospermum clandestinum	Stinking Roger	Mild
Oxalis pes-caprae	Soursob	Mild
Oxalis purpurea	Wood Sorrel	Low
Paspalum dilatatum	Paspalum	Moderate
Pelargonium capitatum	Rose Pelargonium	High
Pentaschistis airoides		Moderate
Petrorhagia velutina	Velvet Pink	Mild
Polypogon monspeliensis	Annual Beardgrass	Moderate
Romulea flava	Guildford Grass	Unrated
Sonchus oleraceus	Common Sowthistle	Moderate
Sparaxis bulbifera	Harlequin Flower	High
Tribulus terrestris		Low
Trifolium campestre	Hop Clover	Moderate
Trifolium hirtum		Low
Typha orientalis	Bulrush	High
Urospermum picroides	False Hawkbit	Moderate
Ursinia anthemoides	Ursinia	Moderate
Vellereophyton dealbatum	White Cudweed	Moderate
Vicia sativa	Vetch	Moderate
Wahlenbergia capensis	Cape Bluebell	Moderate
Zantedeschia aethiopica	Arum Lily	High

Appendix Three B: Vegetation Survey David Pike (2004)

Koondoola Regional Bushland Management Plan

Species	Common Name	Quadrat																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Acacia applanata																	✓			
Acacia huegelii			✓								✓		✓							
Acacia pulchella var pulchella	Prickly Moses	✓			✓	✓				✓			✓			✓				
Acacia saligna	Orange Wattle		✓																	
Acacia sessilis													✓							
Adenanthos cygnorum	Common Woolybush					✓													✓	✓
Alexgeorgia arenicola			✓	✓	✓					✓	✓		✓							
Allocasuarina fraseriana	Sheoak	✓								✓								✓		
Allocasuarina humilis	Dwarf Sheoak			✓						✓	✓						✓			
Amphipogon turbinatus		✓									✓		✓	✓	✓	✓	✓	✓		
Anigozanthos humilis	Cat's Paw	✓								✓		✓				✓		✓		✓
Anigozanthos manglesii	Kangaroo Paw						✓			✓	✓	✓	✓	✓						✓
Arnocrinum preissii													✓							
Arthropodium capillipes	Chocolate Lily		✓																	
Astroloma pallidum	Kick Bush										✓			✓	✓		✓			
Banksia attenuata	Yellow Candle Banksia	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Banksia grandis	Bull Banksia											✓								
Banksia ilicifolia	Holly-leaf Banksia									✓	✓						✓			
Banksia menziesii	Firewood Banksia	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		
Beaumea juncea								✓												
Boronia ramosa	Blue Boronia			✓																
Bossiaea eriocarpa	Common Brown Pea	✓		✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓			
Brachyloma preissii																				
Burchardia umbellata	Milkmaids	✓	✓	✓	✓	✓				✓	✓	✓		✓	✓	✓	✓			
Caladenia sp				✓																

Calandrinea corrigioloides	Strap Purslane						✓												
Calectasia cyanea	Blue Tinsel Lily	✓								✓			✓		✓	✓			
Calothamnus sanguinus	Silky Leaved Blood Flower									✓			✓	✓					
Calytrix angulata							✓			✓		✓				✓			
Calytrix flavescens	Summer Star Flower	✓								✓	✓		✓	✓		✓	✓		
Calytrix fraseri						✓		✓	✓							✓			✓
Cartonema philydroides			✓																
Chamaescilla corymbosa	Blue Squill										✓			✓			✓		
Comesperma calymega	Blue-spike Milkwort												✓	✓					
Conospermum stoechadis		✓								✓	✓		✓	✓		✓			✓
Conostephium pendulum	Pearl Flower	✓		✓						✓		✓	✓		✓		✓	✓	
Conostylis aculeata			✓	✓	✓	✓	✓			✓			✓		✓	✓		✓	✓	✓
Conostylis aurea		✓								✓	✓	✓	✓	✓		✓	✓	✓		
Conostylis juncea		✓																		
Conostylis setigera	Bristly Cottonhead	✓		✓						✓	✓	✓	✓	✓	✓		✓			
Corynotheca micrantha	Sand Lily		✓	✓			✓				✓	✓								
Dampiera linearis	Common Dampiera	✓	✓		✓		✓	✓	✓	✓	✓		✓	✓	✓			✓		✓
Danthonia occidentalis	Wallaby Grass	✓									✓	✓								
Dasypogon bromeliifolius	Pineapple Bush			✓			✓		✓		✓						✓	✓		
Daviesia divaricata	Marno	✓								✓	✓	✓		✓	✓	✓				✓
Daviesia nudiflora		✓									✓		✓	✓	✓					
Daviesia physodes													✓		✓	✓				✓
Daviesia triflora		✓					✓			✓	✓	✓	✓	✓	✓	✓	✓			✓
Desmocladus fasciculais		·								✓	✓			✓	✓	✓	✓	✓		·
Desmocladus flexuosus		✓				✓	✓			✓	✓				✓	✓	✓			✓
Dianella revoluta	Dianella, Native Flax			✓	✓															
Diuris longifolia	Donkey Orchid																✓			
Drosera erythrorhiza	Red Ink Sundew					✓														
Drosera menziesii ssp. penicillaris	Pink Rainbow	✓								✓	✓		✓	✓		✓	✓			
Dryandra lindleyana	Honey-pots Dryandra									✓	✓		✓	✓						
Eremaea asterocarpa		✓															✓			
Eremaea pauciflora		✓								✓	✓		✓	✓	✓	✓	✓	✓		

Eriochilus dilatatus	Bunny Orchid															✓			
Eucalyptus marginata	Jarrah										✓					✓	✓	✓	
Eucalyptus rudis	Flooded Gum		✓		✓														
Eucalyptus todtiana	Prickly Bark							✓											
Gompholobium confertum														✓		✓			
Gompholobium tomentosum		✓							✓	✓	✓		✓		✓	✓	✓	✓	✓
Gonocarpus pithyoides											✓								
Haemodorum spicatum	Mardja		✓		✓		✓	✓											✓
Hakea prostrata	Harsh Hakea													✓					
Hakea ruscifolia	Candle Spike Hakea									✓	✓	✓							
Hardenbergia comptoniana	Native Wisteria		✓																
Hemiandra pungens/linearis	Snake Bush	✓							✓	✓		✓	✓		✓	✓	✓		
Hibbertia crassifolia														✓		✓			
Hibbertia huegelii		✓		✓					✓		✓		✓		✓	✓	✓		
Hibbertia hypericoides	Yellow Buttercups	✓		✓			✓		✓		✓	✓	✓			✓	✓		✓
Hibbertia racemosa	Stalked Guinea Flower	✓							✓	✓	✓				✓	✓			✓
Hibbertia subvaginata								✓											
Homalosciadium homalocarpum	Native Carrot													✓				✓	
Hovea pungens	Devils Pins							✓											
Hovea trisperma var trisperma	Common Hovea					✓									✓	✓			
Hybanthus calycinus	Native Violet		✓							✓	✓		✓	✓	✓				
Hypocalymma angustifolium	White Myrtle							✓											
Hypocalymma robustum	Swan River Myrtle	✓					✓			✓	✓	✓	✓				✓		✓	✓
Hypolaena exsulca		✓								✓	✓		✓		✓				
Isotropis cuneifolia	Granny's Bonnets																✓		
Jacksonia floribunda		✓								✓	✓		✓	✓	✓		✓		✓
Jacksonia furcellata	Grey Stinkwood		✓	✓	✓		✓												
Jacksonia sericea							✓									✓		✓	✓
Jacksonia sternbergiana	Green Stinkwood									✓	✓		✓				✓	✓	✓	✓
Johnsonia acaulis		·																		✓
Kennedia prostrata	Scarlet Runner		✓																	
Lagenifera huegelii	Coarse Lagenifera			✓							✓									

Laxmannia squarrosa	Paper Lily			✓			✓					✓				✓				✓	
Lechenaultia floribunda		✓	✓			✓		✓										✓			✓
Lepidobolus preissianus	Veined Peppercress						✓				✓										
Leucopogon conostephioides		✓																		✓	✓
Leucopogon polymorphus									✓			✓									
Leucopogon propinquus			✓										✓								
Levenhookia stipitata	Common Stylewort										✓				✓	✓				✓	✓
Lomandra hermaphrodita					✓					✓			✓					✓			
Lomandra preissii												✓		✓							
Lyginia barbata		✓	✓		✓	✓		✓	✓			✓		✓		✓		✓			✓
Lysinema ciliatum	Curry Plant	✓								✓		✓						✓		✓	
Macarthuria australis			✓			✓								✓	✓						
Macrozamia riedlei	Zamia		✓		✓		✓														
Melaleuca preissiana			✓		✓	✓		✓	✓												
Mesomelaena pseudostygia	Semaphore Sedge									✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Millotia myosotidifolia				✓	✓																
Mitrasacme paradoxa	Mitrewort						✓									✓					
Monotaxis grandiflora	Diamond of the Desert												✓	✓							
Nemcia capitata	Eggs & Bacon			✓		✓				✓	✓		✓	✓	✓		✓		✓		
Nuytsia floribunda	Christmas Tree	✓			✓					✓	✓	✓	✓			✓					✓
Opercularia vaginata	Dog Weed						✓														
Patersonia occidentalis	Purple Flag	✓		✓	✓		✓			✓	✓		✓	✓	✓	✓	✓	✓			✓
Persoonia comata															✓						
Persoonia saccata	Snottygobble												✓								
Petrophile linearis	Pixie-mops	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Petrophile macrostachya														✓	✓						
Philotheca spicata		✓											✓				✓				
Phlebocarya ciliata		✓	✓	✓	✓	✓		✓	✓	✓					✓	✓	✓	✓			
Platytheca galioides								✓													
Pimelia leucantha										✓				✓		✓					
Pimelia sulphurea	Yellow Banjine	✓									✓			✓	✓						
Podotheca angustifolia	Sticky Longheads												✓								

Podotheca chrysantha	Yellow Podotheca	✓															✓		
Pronaya fraseri	Elegant Pronaya												✓						
Ptilotus manglesii	Pom-poms			✓										✓					
Pultenaea reticulata								✓											
Pyrorchis nigricans	Red Beak Orchid															✓			
Regelia ciliata							✓	✓											
Scaevola repens var. repens		✓		✓			✓			✓	✓	✓	✓	✓	✓	✓			✓
Schoenus curvifolius															✓				
Schoenus grandiflorus	Large Flowered Bogrush						✓												
Scholtzia involucrata	Spiked Scholtzia	✓															✓	✓	
Siloxerus humifusus	Procumbent Siloxerus							✓					✓				✓		
Sowerbaea laxiflora	Purple Tassels		✓	✓															
Stipa compressa							✓	✓	✓										
Stirlingia latifolia	Blue Boy	✓					✓			✓	✓	✓	✓		✓	✓	✓	✓	
Stylidium adpressum		✓					✓			✓		✓	✓	✓		✓			✓
Stylidium brunonianum	Pink Fountain Triggerplant						✓					✓	✓	✓		✓			✓
Stylidium calcaratum	Book Triggerplant	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Stylidium carnosum		·										✓			✓		✓	·	·	·
Stylidium piliferum	Common Butterfly T/plant	✓								✓	✓				✓					
Stylidium schoenoides	Cow Kicks	✓		✓										✓						
Synaphea spinulosa		✓					✓			✓		✓				✓				
Tetraria octandra											✓		✓	✓	✓			✓		
Tetratheca hirsuta		✓															✓			
Thysanotus manglesianus/patersonii	Twining Fringed Lily											✓					✓			
Thysanotus thyrsoideus		✓								✓	✓				✓	✓				
Thysanotus triandrusus														✓						
Trachymene pilosa	Native Carrot	✓								✓		✓	✓		✓				✓	✓
Tricoryne elatior	Yellow Sand Lily			✓						✓							✓			
Waitzia suaveolens	Fragrant Waitzia						✓			✓	✓	✓	✓	✓		✓	✓	✓		
Xanthorrhoea brunonis		·		✓								✓						✓		
Xanthorrhoea preissii	Balga			✓		✓	✓			✓		✓	✓	✓			✓	✓	✓	✓
Xanthosia huegelii														✓	✓					✓

Appendix Four: Audit of previous Management Plan recommendations

Koondoola Regional Bushland Management Plan

Category	Recommendation	Implemented
Access	Provide seats along walk trails to facilitate access for the elderly	No
Access	Rationalise existing tracks	Yes
Access	Retain strategically placed tracks for fire control	Yes
Access	Pathways should be graded with compacted limestone	Yes
Access	Tracks in eroded areas should be fenced off and rehabilitated	Yes
Access	Maintain gelding fencing, pathways and gates, with keys for vehicle access for authorised personnel	Yes
Animals	Investigate the potential for cat curfews and registration	Partial
Animals	The removal of dog excreta by the owner should also be enforced.	No
Animals	Lobby for use of 1080 baiting within Koondoola Regional Bushland	No
Animals	Prohibit dogs from the bushland unless they are on leads and keep to the pathways.	Yes
Animals	Horses should be prohibited from Koondoola Regional Bushland	Yes
Dieback	Visual evidence of plant death should be investigated	No
Dieback	Vehicles and machinery to be used on the reserve should be subject to standard hygiene procedures	No
Dieback	Discourage cool prescribed burning during spring	No
Dieback	Ensure that stormwater drainage into the reserve is directed into the basins of the two wetlands and that creation of damp conditions suitable for fungal spread is avoided in other areas	No
Dieback	Implement a monitoring program for the early detection of plant dieback and the fungi Phytophthora cinnamomi, *Armillaria luteobubalina* and that producing aerial cankers.	Yes
Dieback	If it is suspected that dieback is being caused by Phytophthora; cambium and soil samples can be taken and chemically tested for this pathogen.	Yes
Dieback	Only authorised vehicles should be allowed in the reserve.	Yes
Dieback	Any soil and plant stock brought to the area should be obtained from dieback free areas.	Yes

Education	Initiate a community education program about the importance of urban bushland and appropriate activities within; utilising the local newspaper, community displays and school based education programs	Partial
Education	Provide educational packages, displays and articles in the local newspaper about the control of domestic animals, pests and weeds.	No
Education	Develop public education programs informing the public about the negative effect of fire on bushland and encourage early fire detection	No
Education	Maintain perimeter signage and remove any vandalism promptly	Yes
Education	Update noticeboard seasonally, in conjunction with the Friends of Koondoola Regional Bushland and other community members.	Yes
Fire	Firefighting should act to minimise the area burnt by wildfire and be undertaken in an environmentally sensitive manner.	No
Fire	Maintain a 3m firebreak adjoining residential properties	Partial
Fire	Investigate fuel loads and weed abundance on an annual basis	No
Fire	Weed grasses should be sprayed annually to reduce potential and frequency of fire	Yes
Liaison	Liaise with Agriculture WA to investigate pest numbers and examine control measures	No
Liaison	Liaise with the Department of Conservation and Land Management about possible cures, prevention strategies and detection measures of plant disease	Yes
Monitoring	Undertake detailed mapping and monitoring of plant communities to be carried out over a regular basis.	Partial
Monitoring	Construct a photographic record from fixed points throughout the bushland to provide a visual record of any changes	Partial
Monitoring	Commission a more detailed fauna survey of the area and investigate which habitats and food sources are required for the continued survival of the native fauna	No
Monitoring	Monitor natural regeneration in burnt areas and evaluate the effectiveness of rehabilitation techniques by annual bushland condition mapping	No
Rehabilitation	Use of wetting agent would aid rehabilitation in elevated water repellent soils	Unknown
Rehabilitation	Incorporate rehabilitation of large degraded areas of the bushland into Green Plan Bush Care Programs	No
Rehabilitation	Control access into rehabilitation/regeneration areas	No
Rehabilitation	In good condition bushland undertake hand removal of weeds with the community and allow natural regeneration to occur.	Yes
Rehabilitation	Fertiliser, in slow release granular form should be used sparingly in direct planting.	Partial
Southern Sumpland Area	Initiate study into the management of stormwater drainage with the aim of facilitating both the conservation and drainage functions of the southern area	No

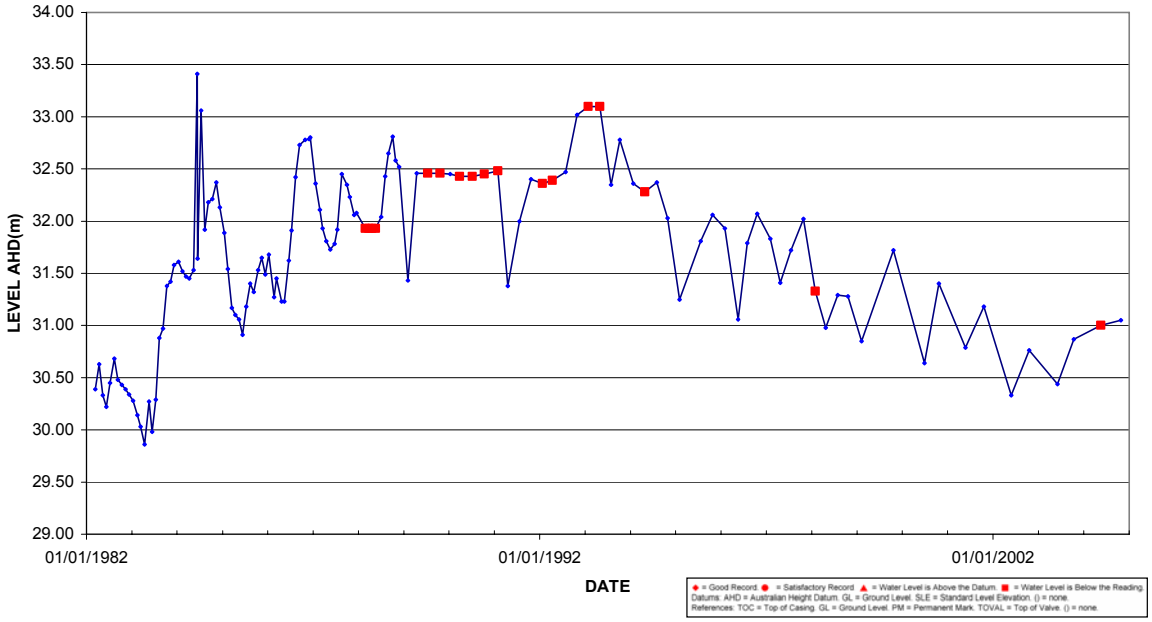
Southern Sumpland Area	Undertake erosion minimisation methods such as, gabions, mattressing and drainage pip rationalisation.	No
Southern Sumpland Area	Monitor quality, velocity and amount of water entering the bushland through the drains	No
Southern Sumpland Area	Implement a restoration program for the two sumpland basins and drainage facilities, stabilising erosion prone areas and direct planting with locally sourced plants.	No
Southern Sumpland Area	Construct a bicycle track, similar to that at Shepard's Bush, in a nearby park to deter damaging bicycle use within the sumplands.	Yes
Weeds	Prevent the dumping of garden rubbish and soil within bushland through education and fines	No
Weeds	Rubbish should be removed from the bushland regularly	No
Weeds	Spot spray Eragrostis curvula with 'Roundup Bioactive'	No
Weeds	Involve local schools in the removal of weeds as part of the Adopt a Park program	No
Weeds	Map the distribution and abundance of weed species annually to evaluate control strategies	No
Weeds	Herbicide applications should occur during winter, after germination and before flowering on an annual basis	Yes
Weeds	The dominant three grass species should be given priority in the weed control program	Yes
Weeds	Apply Fusillade to areas where Ehrharta calycina and Paspalum *dilatatum* occur	Yes
Weeds	Hand removal of other weed species to be undertaken by Corrective Services and Friends group with assistance from Council.	Partial

Appendix Five: Groundwater Measurements

Koondoola Regional Bushland Management Plan

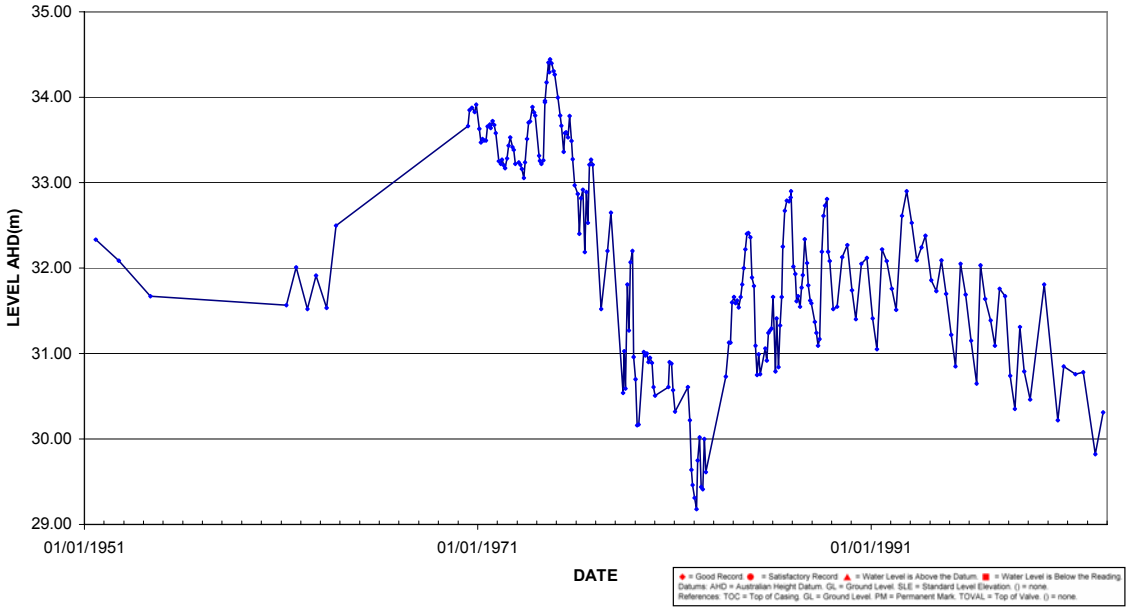
61610216 MIRRABOOKA MONITORING MM68

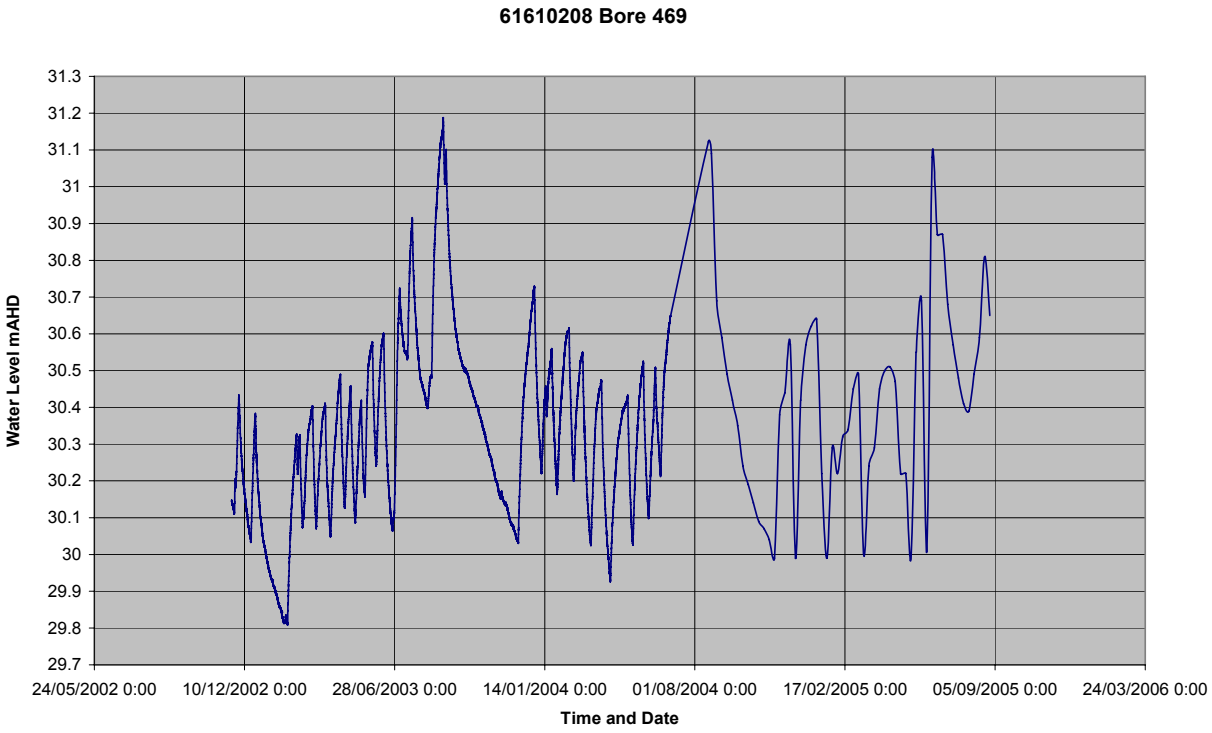
Easting = 393705.00 Northing = 6476381.00 Zone = 50 TOC = 43.28mAHD WIN SITE ID = 4557



61610208 LAKES AND WETLANDS - BORE 469

Easting = 393624.00 Northing = 6476099.00 Zone = 50 TOC = 35.79mAHD WIN SITE ID = 4549




61610208 Bore 469
Water Level mAHD
31.3
31.2
31.1
31
30.9
30.8
30.7
30.6
30.5
30.4
30.3
30.2
30.1
30
29.9
29.8
29.7
24/05/2002 0:00
10/12/2002 0:00
28/06/2003 0:00
14/01/2004 0:00
01/08/2004 0:00
17/02/2005 0:00
05/09/2005 0:00
24/03/2006 0:00
Time and Date

Appendix Six: Community Consultation

Koondoola Regional Bushland Management Plan

A stakeholder workshop was held at Wanneroo Civic Centre in the Leschenaultia Room on the evening of Wednesday 29th June 2005. The attendance was as follows:

Jacqui Maguire - CALM (now DEC)
Jill Pride – CALM (now DEC)
Robbie Rhoades
Alan Ratcliffe
Sue Ratcliffe
Cr Alan Blencowe
Karen Clarke
Steve Maylam
Erika Maylam
Sue Halnan
Bushland
Ken McKimmie
Geoff Curtis
Kevin Giles
Alice Stubber - Friends of Koondoola Regional
Elizabeth George - Friends of Koondoola Regional Bushland
Ian Denny - City of Swan
Danielle O'Neill – City of Wanneroo
Kelly Smith – City of Wanneroo
Lorraine Johnston – Burbridge School
Cade Dawkins – Water Corporation
Graham Cargeeg – Water Corporation
Mark Cavaney – Connell Wagner
Carol Walsh – Connell Wagner
David Pike – Friends of Koondoola Bushland

A summary of the community's perceived values of Koondoola Regional bushland is presented below

Values

Table 1-Values

- Threatened ecological community (20A) – Largest area known
- Threatened fauna
- Threatened flora – Poorly represented vegetation complex
- Size of conservation
- Good condition of vegetation
- Wetland area
- High biodiversity
- Forms part of a reserve network
- Recreation facility for community
  - Educational/Social
  - Community involvement/sense of place
  - Historical/Cultural values
  - Remnant Bushland (limited areas within metro area)
  - Currently protected under Bushforever. (BFS201)

Table 2-Values

- Very good to excellent condition vegetation
- Large bushland reserve
- Conservation category wetland
- Endangered flora & fauna
- Threatened ecological communities
- Natural landforms – up/down bushland, wetlands
- Protection of local flora & fauna
- School children are given opportunity to learn, appreciate & value nature
- Bushwalking trails
- Asset for the whole community
- Guided nature walks – friends of Koondoola Regional Bushland
- Meeting place for the community
- Bushcare activities by the Friends group
- "Playground" for local children
- Historical connections – wetlands
- Indigenous sites – recorded? Not recorded?
- Stories from local Aboriginal people (spiritual beliefs)
- Pre-colonisation land map
- Cultural heritage
- Eco-tourism potential
- Bushland acts as a "carbon sink"
- Bushland provides various ecosystem services (cleans air/water, suppresses dust etc.)

Table 3-Values

- Maintaining ground water levels
- Establishing transitional species from further up the hill that can cope with lower levels
- Water Conservation City Wide
- Water condition – collection basins – access for fauna
- Big picture items such as urban heat island
- Weed control – prioritised. Sufficient

Table 4-Values

- Education – program for system
- Dirt bikes/horses? Through Park?
- Cats/dogs attacking fauna – policy of cats needed by Council!!
- Tagging and control of cats!!
- Cat traps and trapping programs
- Community Communication and Information Nights
- Litter – Lot of rubbish coming from main roads

Table 5-Values

- Significant flora species
- Rare insects habitation
- Kangaroos
- Good size
- Variety of species
- High diversity
- Different vegetation communities present – Banksia Woodland, semi-wetlands

- Fun
- Educational spot – Primary, High School, organisations
- Safe
- No real car access
- Dumping minimal
- Scientific research
- Well managed

Table 6-Values

- Large size – viable in the long-term
- Intact floristic communities
- Range of habitats which supports rich fauna communities
- Boundary of Karrakatta and Bassendean soils
- Under 10% of Karrakatta complex will be preserved by Bush Forever (this site is a large area of this vegetation complex)
- Escape from suburbia
- Community education and recreation
- Contains specially protected fauna (Graceful Sunmoth)
- Has a high number of species of Jewel Beetle
- Significant habitat for Western Jewel Butterfly
- Contains significant populations of the Spoon-winged Lace Wing
- Contains a TEC
- Contains Western Brush Wallabies and Quendas
- Heritage value

Threats

Table 1-Threats

- Weeds – perennial grasses etc
- Mapping
- Plan for control
- Fire – Altered Regimes
- Implementation
- Feral animals – City wide approach to prevention
- Prevention – runoff
- PC./Other plant diseases
- Dumping of garden waste
- Fire
- Dieback survey
- Hydrology – altered drainage/groundwater
- Monitoring H^2O
- Pollutant trap
- Illegal vehicle access
- Continued Monitoring
- Educate community
- Inappropriate activity by public
- Education
- Signage
- Rubbish dumping
- Picking of flora
- Surplus of walk trails
- Closure of excess trails
- Contamination from runoff from urban environ
- Buffers around wetland

- Waste water discharge possible into wetland area
- Potential contamination from industrial area & accident event i.e. Hazardous material transport along roads
- Emergency response contingency plan

Table 2-Threats

Fire

- "Fire bugs" – arson
- Fine-weed cycle has led to deterioration of southern swampland area
- Fire management plan

Weeds

- Garden escapees – introduced plants
- Generally along edges/tracks and southern swampland area
- Weed control
- Weeds affects aesthetics – nicer to bushwalk in pristine areas

Stormwater

- Catchment management plan, nutrients
- Monitoring stormwater outfalls – potential pollutant treatments
- Water quantity & water quality – impacts on southern swampland area
- Introduction/spread of weeds, diseases, etc

Erosion

Feral Animals

- Foxes
- Rabbits

Pets

- Dogs – bushwalking
- Cats

Money/resources

- Regional partnerships
- Priority on Council's capital works budget – commitment
- Annual maintenance budget for high-priority conservation reserve

Vehicles

- Trail bikes

People

- Bush walking
- Facility provision – car parking & eco-toilets

Groundwater

- Gnangara Mound – lowering water table
- Monitoring groundwater bores
- Water level & water quality – impacts on Banksia woodland & wetlands

Awareness

- Knowledge of indigenous stories associated with the area
- Aboriginal heritage management plan
- Signage on walk trails
- Promotion of regional asset
- Local community education

Flora/Fauna

- Threatened Ecological community – Karrakatta soils
- Conservation category wetland – Bassendean soils
- Threatened mammals and insects

Rubbish

- Dumped rubbish & green waste
- Damage/Vandalism

- BMX jumps – provide nearby facilities
- Cubby building

Rehabilitation

- Nutrient stripping/filtering system for storm water
- Natural wetland species
- Use endemic plants only – material sourced from area

Access

- Disabled access – suitable walk trail apposite school
- Rehabilitation/close informal access tracks

Table 3-Threats

- Viable for biodiversity preservation
- Conservation not playing fields
- Leaf litter stows/hectare – wildfire
- Review fire response planning (Avoid cutting trees “stags”)
- Ask people to indicate tracks they use to remove others
- Dieback management techniques
- Watertable – pumping & trees dying

Table 4-Threats

- Divert flows to upstream parks
- Pollutant/Nutrient control – reduce nutrients etc
- Dumping from Industrial areas
- Chemical overflow protection from tankers
- Truck spill on main road
- Access to Water Corp Pipes – Dieback
- Protection facilities of Water Corp sites – vehicles
- Fire protection and management
- Walking areas a big plus and cycling
- Upgrade barbeque area/Parking facilities to access the site?
- Lack of peak flow storage
- Pump station – risk of overflow
- Limit weeds – limit horses/digs
- Input of kids from area eg. Cubby houses
- Industrial area – large area of pollutant – Educate local people
- GPT to go in
- Send information

Table 5-Threats

- Pollution – Industrial, road usage threats
- Surrounded by roads
- Rehabilitate the area, wet lands
- Educational letter drops about stormwater
- Information sessions
- Suburban run-off
- Erosion
- Fire
- Dumping
- Vandalism – natural, infrastructure
- Motor bikes
- Weeds
- Downsizing – Development, clearing
- Potential watertable dropping
- Drying climate
- Budget/funding

Storm-water

- Pollution traps
- Slow the water

Table 6-Threats

- Gates to be left open at night for access.
- Fire – far too frequent, also outdated FESA fire response plan.
- Weeds, especially in southern area (mainly grasses).
- Dogs off leads – issue for native fauna and personal security – failure to clean up after dogs.
- Vandalism – destruction of flora for cubbies – BMX tracks.
- Dieback – possibility of its introduction (lack of hygiene / indiscriminate vehicle use).
- Non-provenance / inappropriate planting.
- Dumping of garden rubbish.
- Storm-water:
- Bringing in rubbish
- Eroding bushland
- Bringing in weeds / advantaging weed growth
- Totally untreated and uncontrolled.
- Uncontrolled access.
- 4WD vehicles and trail bikes.
- Easements owned by other people (their management of them cause's issues).
- Range of unauthorised scientific research.
- Zoning is incompatible with its conservation values (needs conservation zoning).
- Removal of power lines running through reserve.
- Weed invasion from the Water Corporation Reservoir site (i.e. Tambookie Grass).
- Water draw down.
- Adequate funding and ongoing maintenance.
- Parking at the reserve (to be provided totally on the road verge).

Issues

Table 1-Issues

- Consolidation of pathways network.
- Provide facilities to reduce unrestricted access/use.
- Provide parking & shelter.
- Possibility for Environ Centre??
- Service provisions
    - Encourage more recreation (passive)
    - Restrict recreation (passive)
- Monitoring of visitation to access current & future use

Table 2-Issues

Pathways & Other Facilities

- Car Parking
- Eco Toilets
- Disabled access (hard paths)
- Seating areas

Interpretation

- Signs that raise awareness – values
- Electric signage – story telling
- Aboriginal Culture Centre – Guided cultured walks

Ecotourism

- Wildflowers

- Raise awareness/market the Reserve – Why would tourists go there?
- Night walks – stargazing

Future Visions

- Chairlift

Table 3-Issues

- Bins on entry/exit points (not wheelie bins) - Signed & vermin controlled. Doggie disposal points
- Bushland Education Groups and reference sites because of its great value
- Determine significance of Aboriginal Heritage Sites
- Lookout sites and park seating at various points
- Walk trail with sites marked on trail maps of highlight points at entry points (key points)
- Invoke local schools in the need to preserve the area and become actively involved in its management

Table 4-Issues

- Educational of Industrial Estate/Schools and catchment
- Community
- Funding to monitoring of drainage system
- Seats
- Bird life study
- Limit access to limit damage
- Information board, time lining board, species boards, walking tracks boards
- Education
- Timber Boardwalks access wetlands
- Education Signage
- Community information and progress nights – what has happened
- Feedback
- Cats
- Management of vandalism
- Health & safety – toxic chemicals from Industry to area
- Fauna & Flora studies completed
- Dieback studies
- Study into stormwater drainage

Table 5-Issues

- More rest areas – sit and relax areas
- Walking area brochures
- 20 or 30 min loops
- Correct signage for walks
- Trail head signage
- Interpretive signing
- Cultural information
- More information signage
- UR here signs
- Group seating
- Workshop areas
- Better access
- Pathway improvements
- Wheelchair access – elderly friendly
- Pathway updates – sealing?
- Goat tracks
- Better nearby facilities – BMX, Skate Parks etc
- General brochures

- Walk trails
- Vegetation information
- Values
- How to get involved – FKRB, COW
- Threats
- Wildflower walks, public pay

Table 6-Issues

- Funded education program – packages offered to schools covering education opportunities in Koondoola that are tied to the curriculum.
- Wider advertisement of Koondoola activities.
- City of Wanneroo produce interpretative brochures for Koondoola, covering flora and fauna found in the reserve, etc.
- Recreation needs to be restricted to passive recreation.
- Ecotourism should form part of a city-wide program: this could include a community education program and information on city-wide series of walk trails connecting and going through the City's natural areas.
- Vision: A vibrant, viable area of bushland with its full compliment of flora and fauna species, and valued by the community for its environmental, social, heritage and recreation usage.

Appendix Seven: Flora Conservation Categories

Koondoola Regional Bushland Management Plan

Definition of Conservation Categories under State and Federal Legislation

Category	Applicable Legislation	Definition
Critically Endangered (CE)	Commonwealth EPBC Act	There are very low numbers of mature plants in the wild due to a severe reduction in numbers and/or a very restricted distribution. There is a 50% probability of extinction in the immediate future.
Endangered (En)	Commonwealth EPBC Act	There are a low number of mature individuals in the wild due to a severe reduction in numbers and/or restricted distribution. There is a 20% probability of extinction in the near future.
Vulnerable (Vu)	Commonwealth EPBC Act	There are a limited number of mature individuals in the wild due to a substantial reduction in numbers and/or limited distribution. There is a 10% probability of extinction in the medium-term future.
Declared Rare (R)	WA Wildlife Conservation Act	Taxa that are extant and considered likely to become extinct or rare and therefore in need of special protection (Schedule 1) or taxa that are presumed to be extinct in the wild and therefore in need of special protection (Schedule 2).
Priority 1 (P1)	Not protected by legislation	Taxa which are known from one or a few (<5) populations which are under threat.
Priority 2 (P2)	Not protected by legislation	Taxa which are known from one or a few (<5) populations, at least some of which are not believed to be under immediate threat.
Priority 3 (P3)	Not protected by legislation	Taxa which are known from several populations, at least some of which are not believed to be under threat.
Priority 4 (P4)	Not protected by legislation	Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

Appendix Eight: Fauna Conservation Categories

Koondoola Regional Bushland Management Plan

Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act

[categories from IUCN, based on review by Mace and Stuart (1994)]

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the wild	Taxa known to survive only in captivity.
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable	Taxa facing a very high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern	Taxa that are not Threatened.

WA Department of Conservation and Land Management Priority species (species not listed under the WA Wildlife Conservation Act, but for which there is some concern)

Priority 1.	Taxa with few, poorly known populations on threatened lands.
Priority 2.	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3.	Taxa with several, poorly known populations, some on conservation lands.
Priority 4.	Taxa in need of monitoring.
Priority 5.	Taxa in need of monitoring. The subject of a conservation program the cessation of which could cause them to be threatened in 5 years.

Appendix Nine: Summary of Recommendations for the management of Phytophthora dieback at Koondoola regional Bushland (Zuvela, 2002)

Koondoola Regional Bushland Management Plan

	Management Recommendations	Actions	Responsibility
1	Access to KRB should be managed to minimise the risk of *Phytophthora cinnamomi* introduction	Continue to maintain tracks on a regular basis and ensure they are well drained and free of water and mud	City of Wanneroo
		Vehicle access to be minimised and restricted to dry soil conditions	City of Wanneroo
		Requirements for vehicles, equipment and footwear to be clean on entry	All users
		Water used for fire control to be from scheme or bore water when possible	Fire Officers and City of Wanneroo
2	No soil/gravel/mulch/plants to be brought into the bushland areas of KRB. If these materials must be introduced, they must be certified as *Phytophthora cinnamomi* free	Identify activities occurring at KRB that involves the movement or introduction of soil/gravel/mulch/plant eg track maintenance, revegetation	City of Wanneroo
		Identify alternative techniques that could be used to avoid the movement of soil/grave/mulch/plants eg direct seeding	City of Wanneroo
		If soil/gravel/mulch/plants must be introduced, they should be tested to determine if they are free of *P. cinnamomi*, or should be purchased from a supplier accredited by the Nursery Industry Association	City of Wanneroo
		Investigate Drainage disposal at KRB	City of Wanneroo

3	No drainage water or run off to be discharged into bushland areas of KRB	Identify, develop and implement alternative drainage options other than discharging to KRB if feasible	City of Wanneroo
4	Communication with surrounding landholders, visitors to the reserve and other stakeholders to inform them that KRB is free from *P. cinnamomi* and how they can assist in maintaining this position.	Determine the most frequently used entry points to KRB. Develop signage that is of an appropriate size, contains appropriate information and is designed to compliment other signs that may be erected in the future, or that are erected at reserves in the City of Wanneroo. Erect signs at reserve entrances	City of Wanneroo
		Distribute a brochure to neighbouring landholders outlining the *P. cinnamomi* status of the reserve and how visitors to the bushland can reduce the risk of introducing *P. cinnamomi*	City of Wanneroo
		Identify stakeholders and provide them with a copy of this management plan	City of Wanneroo
5	Maintenance activities (eg. Fencing, track maintenance etc) to occur in dry soil conditions, when possible.	Identify Maintenance activities that may be completed at KRB by the 'Friends' group or the City of Wanneroo	City of Wanneroo
		Program these activities to occur during dry soil conditions where possible	City of Wanneroo
6	Vegetation to be monitored regularly to identify the death of plants that are susceptible to *P. cinnamomi*	Conduct regular checks in KRB using casual observations during field walks, noting plant deaths in susceptible species	City of Wanneroo/ Community Group
		Conduct annual check of the uninterpretable area to identify plant deaths in susceptible species by walking around the perimeter of the area	City of Wanneroo/ Community Group
		Establish photo points in suspect area to record vegetation changes at the *Armillaria luteobubalina* site. Investigate further plant decline if observed	City of Wanneroo/ Community Group
		Recheck burnt area in two years to determine *Phytophthora* dieback status	City of Wanneroo/ Community Group
		Re-map bushland for *Phytophthora* infestations every 3 to 4 years	City of Wanneroo/ Community Group
		Phosphonate treatment to be implemented if assessment confirms the presence of *P. cinnamomi*	City of Wanneroo/ Community Group
7	The management guidelines given, are to be considered in all management decisions, particularly in relation to bush restoration activities.		City of Wanneroo/ Community Group

Appendix Ten: Provision of Investigation and Concept Design for the Stormwater Outfalls Located within Koondoola Regional Bushland

Koondoola Regional Bushland Management Plan

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Provision of Investigation and Concept Design Services for the Stormwater Outfalls located within the Koondoola Regional Bushland

City of Wanneroo

January 2006
Reference C472.00
Revision 1

Connell Wagner

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Appendix A
Existing Catchment, Concept Design Sketches

Appendix B
Groundwater Monitoring Results

Appendix C
MUSIC Modelling Results

Appendix D
MUSIC Model Diagrams

Appendix E
Water Corporation Correspondence

1. Introduction

The existing Koondoola Regional Bushland Management Plan is a comprehensive report written to conserve the Koondoola Bushland, an ecological and historical asset of the area. The management plan was finalised in 1998 and following changes to Government policy, requires updating. The Koondoola Bushland reserve is a Bush Forever site and contains a conservation category wetland.

Ecoscape were commissioned by City of Wanneroo to undertake a review of the existing Koondoola Regional Bushland Management Plan. Connell Wagner are acting as sub-consultants to Ecoscape and are responsible for reviewing the current stormwater discharge arrangements into the reserve. Being a bush forever site with a conservation wetland, it is desirable to improve the stormwater quality discharging into the site. Stormwater runoff from the catchment will contain a range of pollutants including, but not limited to, gross litter, hydrocarbons, heavy metals, nutrients and suspended solids. The bushland area also encounters problems from the introduction of weeds via the stormwater drains, which are continuing to spread through the southern area of the reserve as a result of annual bushfires.

As part of this study, Connell Wagner were engaged to review the water quantity and quality discharging to the wetland and recommend a stormwater drainage management upgrade of all outlets in accordance with current best management practice. The ideal objective of these works is to provide a more natural state of water flow to the reserve.

The study also included an investigation into the status of current sewer overflow management measures for the sewer pump station located in the South West corner of the site.

Based on the above, the objectives of this report were to review the current stormwater arrangements and pollutant loads and based on current best management practices recommend a stormwater upgrade strategy to improve the water quality discharging into the reserve.

An overall layout plan and aerial photography of Koondoola Regional Bushland is presented as SK01, in Appendix A.

2. Existing Catchments

The overall stormwater catchment contributing to Koondoola Regional Bushland is approximately 140 hectares and is presented as SK01. The stormwater outfalls into the Park are located on the southern and eastern sides of the reserve. On the northern portion of the park the current stormwater discharges into drainage sumps, and not into the reserve (Catchments 4 and 5). Outfalls to catchments 2 and 3 are of greatest concern due to their size and nature. Each individual catchment is described in detail below.

The catchments discharge into a low-lying area within the Park. Advice from locals is that this area acts more as a seep, with major events soaking away after a short period of time. This is consistent with groundwater monitoring records have been obtained from the Department of the Environment (refer Appendix B). The current ground level is approximately RL 33 to RL 34. The existing groundwater level has been getting lower since the early 1990's and is now currently several meters below the surface as the wetland has dried out. This long term groundwater lowering is consistent with other sites around the Perth Metropolitan area.

This long term lowering of the groundwater table implies that the type of wetland and vegetation it is supporting will potentially be changing over time.

Currently the stormwater catchments are typical piped catchments which discharge at the edge of the reserve. They will contain a range of pollutants that are generated from an urban rural catchment, including gross litter, nutrients, weeds, hydrocarbons, suspended solids and oxidation demand (BOD/COD) on receiving water bodies. There is also no spill control measures to cater for a large tanker spill for catchments 1, 2, 3, and 6 which have major roads and discharge direct into the reserve.

2.1 Catchment 1

2.1.1 General

Catchment 1 lies to the south of Koondoola Regional Bushland and is approximately 11 hectares. It extends along Beach Rd from west of Butterworth Avenue to east of Honeywell Boulevard, also collecting some storm water drainage from Honeywell Boulevard as presented as SK01. The predominant land use for the catchment is residential with a major arterial road.

2.1.2 Existing Stormwater Drainage Network

The existing stormwater drainage network is a conventional piped network with single and double grated pits located at the sides and centre of the roads, and also a series of side entry pits along Beach Road.

Catchment 1 discharges through a 675mm diameter reinforced concrete pipe, with a trash screen in the vicinity of Rendell Way Pump Station. The location of the stormwater discharge pipe is presented as SK01 and the outlet is presented in a photograph below (the outlet to the left is catchment 1). There is a lot of erosion visible in the vicinity of this outfall and evidence of an overland flow path from Beach Road to the outlet from recent heavy rain.

From site inspections it appears there are a series of relieving drains along Beach Road into Koondoola Reserve not shown on current drainage drawings. Due to the lack of As Constructed information it is recommended an As Constructed survey for this line be completed.

Photo 1 Catchment 1 675mm Outfall and Catchment 2 1050mm Outfall

2.1.3 Peak flows

The estimated peak flows for Catchment 1 based on the rational method are presented in Table 2.1 for various storm events. The capacity of a flat graded DN 625 is approximately 1.3 m3/s which equates to a 1:10 year flow which you would expect from a major road (Beach Road).

Table 2.1 Catchment 1 Flows

Event	1:3 Mth	1:1 Year	1:5 Year	1:10 Year
Time Concentration T_c (min)	9	9	9	9
Rainfall Coefficient C	0.2	0.2	0.2	0.2
Rainfall Intensity I (mm/hr)	34.65	46.2	79	92
Area (ha)	10.56	10.56	10.56	10.56
Flow Rate Q (m^3/s)	0.20	0.27	0.46	0.54

2.2 Catchment 2

2.2.1 General

Catchment 2 is the largest of the catchments contributing to Koondoola Regional Bushland. It is approximately 103 hectares as presented as SK01. Catchment 2 lies to the west of Koondoola Regional Bushland and collects stormwater from the residential area of Koondoola Avenue and Butterworth Avenue. The predominant land use for the catchment is residential, however the area comprises of two primary schools and the open space of Butterworth Reserve and Koondoola Park.

2.2.2 Existing Stormwater Drainage Network

The existing stormwater drainage network is a conventional piped network with single and double grated pits located at the sides of the roads.

Catchment 2 discharges through a 1050mm diameter reinforced concrete pipe, with a trash screen in the vicinity of Rendell Way Pump Station. The location of the stormwater discharge pipe is presented as SK01 and the outlet is presented in Photo1 above. As described in 2..1.2

there is evidence of erosion caused by an overland flow path from Rendell Way to the outlet of the pipe. For details on the Rendell Way Pump Station refer to Section *3.1*.

2.2.3 Peak flows

The peak flows for Catchment 2 are presented in Table 2.2. As a comparison the approximate capacity of a flat graded 1050mm pipe is approximately 7m³/s.

Table 2.2 Catchment 2 Peak Flows

Event	1:3 Mth	1:1 Year	1:5 Year	1:10 Year
Time Concentration T_c (min)	12	12	12	12
Rainfall Coefficient C	0.2	0.2	0.2	0.2
Rainfall Intensity I (mm/hr)	30.23	40.3	68	79
Area (ha)	103.09	103.09	103.09	103.09
Flow Rate Q (m³/s)	1.73	2.31	3.89	4.52

2.3 Catchment 3

2.3.1 General

Catchment 3 lies to the east of Koondoola Regional Bushland and is approximately 15 hectares. It collects drainage from Malaga Industrial Area to the east of Alexander Drive, including Alexander Drive as presented as SK01. The predominant land use for the catchment is industrial. As such the pollutants can potentially be more toxic to the environment due to the higher risks of chemical spills and illegal dumping that can occur.

2.3.2 Existing Stormwater Drainage Network

The existing stormwater drainage network is a conventional piped network with single and double side entry pits located at the sides of the roads.

Catchment 3 discharges through a 1050mm diameter reinforced concrete pipe, with a large trash screen extending beyond the outfall. The catchment is significantly paved and noted by council officers and local residents as operating with significant discharges (full pipe flow) during rainfall events, both major and minor.

It was also noted that a significant amount of litter in the drainage swales exists, potentially indicating a high litter and pollutant load from this catchment. Due to the characteristics of this catchment it is probable that the industrial pollutant is high and the volume of seeds and weeds is low.

Photo 2 presents the litter within the reserve around catchment 3.

Photo 2 Gross Litter around Catchment 3 Outlet Pipe

2.3.3 Peak flows

The peak flows for Catchment 3 are presented in Table 2.3. The maximum capacity of the 1050mm pipe is approximately 1.8m³/s.

Table 2.3 Catchment 3 Peak Flows

Event	1:3 Mth	1:1 Year	1:5 Year	1:10 Year
Time Concentration T_c (min)	8	8	8	8
Rainfall Coefficient C *	0.3	0.3	0.3	0.3
Rainfall Intensity I (mm/hr)	36.53	48.7	84	97
Area (ha)	15.29	15.29	15.29	15.29
Flow Rate Q (m³/s)	0.47	0.62	1.07	1.24

Note: * Due to the impervious nature of the catchment the runoff from this catchment can potentially be much higher.

2.4 Catchment 4

2.4.1 General

Catchment 4 lies to the east of Koondoola Regional Bushland and is approximately 3 hectares. It collects only the stormwater drainage from Alexander Drive and is presented as SK01.

2.4.2 Existing Stormwater Drainage Network

The existing stormwater drainage network is a conventional piped network with single and double grated pits and side entry pits located along Alexander Drive.

Catchment 4 discharges through a 450mm diameter within the Water Corporation site into a contained sump. As a result there is minimal flow into the reserve a reduced amount of seed and weed pollutant.

2.4.3 Peak Flows

The peak flows for Catchment 4 are presented in Table 2.4 below.

Table 2.4 Catchment 4 Peak Flows

Event	1:3 Mth	1:1 Year	1:5 Year	1:10 Year
Time Concentration T_c (min)	7	7	7	7
Rainfall Coefficient C	0.7	0.7	0.7	0.7
Rainfall Intensity I (mm/hr)	39	52	89	104
Area (ha)	2.64	2.64	2.64	2.64
Flow Rate Q (m^3/s)	0.20	0.27	0.46	0.53

2.5 Catchment 5

2.5.1 General

Catchment 5 lies to the east of Koondoola Regional Bushland and is approximately 3 hectares. It collects only the stormwater drainage from Alexander Drive and is presented as SK01.

2.5.2 Existing Stormwater Drainage Network

The existing stormwater drainage network is a conventional piped network with single and double grated pits and side entry pits located along Alexander Drive.

Catchment 5 discharges through a 450mm diameter reinforced concrete pipe, into a drainage sump. As a result the flow from this outlet to the reserve is minimal. Pollutant removal for this outfall is not addressed as part of this study. The drainage sump for catchment 5 presented in Photo 3 below.

Photo 3 Catchment 5 Drainage Sump

2.5.3 Peak Flows

The peak flows for Catchment 5 are presented in Table 2.5 below.

Table 2.5 Catchment 5 Peak Flows

Event	1:3 Mth	1:1 Year	1:5 Year	1:10 Year
Time Concentration T_c (min)	10	10	10	10
Rainfall Coefficient C	0.7	0.7	0.7	0.7
Rainfall Intensity I (mm/hr)	33	44	75	87
Area (ha)	2.57	2.57	2.57	2.57
Flow Rate Q (m^3/s)	0.16	0.22	0.37	0.43

2.6 Catchment 6

Catchment 6 lies to the south of Koondoola Regional Bushland and is approximately 3 hectares. It collects the stormwater drainage from Beach Rd and the intersection of Alexander drive and Beach Rd and is presented as SK01.

2.6.1 Existing Stormwater Drainage Network

The existing stormwater drainage network is a conventional piped network of side entry pits located along Beach Road.

Catchment 6 discharges through a 525mm diameter outlet pipe inside the Koondoola Regional Bushland boundary. We have no information on this outlet as we could not locate it on our site inspection. We are unaware of any pollutant control measures in place on this outlet pipe and hence are assuming there is none. There is also a 300mm diameter outlet pipe discharging at the intersection of Beach Rd and Alexander Drive. It was noted during the site inspection that the litter load was high in the area.

Due to the lack of As Constructed information the extent of the catchment in relation to Catchment 1 is unknown. It is recommended an As Constructed survey be completed for this catchment to confirm pipe work and extent of catchment.

2.6.2 *Peak Flows*

The peak flows for Catchment 6 are presented in the table below. The maximum capacity of the 525mm pipe (a) and the 300mm pipe (b) is approximately 0.4m³/s and 0.1m³/s respectively.

Table 2.6 Catchment 6 Peak Flows

Event	1:3 Mth	1:1 Year	1:5 Year	1:10 Year
Time Concentration T_c (min)	9	9	9	9
Rainfall Coefficient C	0.2	0.2	0.2	0.2
Rainfall Intensity I (mm/hr)	34.65	46.2	79	92
Area (a) (ha)	2	2	2	2
Area (b) (ha)	0.86	0.86	0.86	0.86
Flow Rate Q (a) (m³/s)	0.04	0.05	0.09	0.10
Flow Rate Q (b) (m³/s)	0.02	0.02	0.04	0.04

2.7 Breakdown of the catchment areas for councils

The catchment areas are spread over several council boundaries. A breakdown of the catchment area for each council is demonstrated in Table 2.7.

Table 2.7 Breakdown of the catchment area for each council

	City of Wanneroo	Cit of Stirling	City of Swan	Total Area
Area Catchment 1 (ha)	4.60	5.96	0	10.56
Area Catchment 2 (ha)	103.1	0	0	103.10
Area Catchment 3 (ha)	0	0	15.3	15.30
Area Catchment 6 (ha)	1.46	1.40	0	2.86
Total Area (ha)	109.16	7.36	15.3	131.82
Percentage	82.81%	5.58%	11.61%	100%

3. Wastewater Pump Station Overflow

3.1 Existing System

As part of the brief, Connell Wagner were required to confirm current overflow discharge arrangements from the Water Corporation sewer pump station located in Rendell Way (refer Sketch 01). Copies of correspondence from the Water Corporation and details of the pump station are contained in Appendix E. It had been noted by local residents that the pump station had previously overflowed and discharged into the park.

The existing wastewater pump station currently has approximately 1.5 hours emergency storage between 6am and 10 pm and up to 5 hours storage during the night. In the event of a pump station failure the sewage will flow into soak wells on the site and seep into the ground. When the soakwells become full the sewage will follow the overflow path into Koondoola Regional Bushland. It is recommended this be reviewed with the Water Corporation to provide extra storage, to better reflect the conservation value of the reserve that the spills are discharging into.

Most of the runoff from other Water Corporation sites discharge into local sumps.

3.2 Pump Station Overflow Recommendations

The existing scenario (when overflow occurs) greatly reduces the quality of water in the Koondoola Regional Bushland. The overflow storage allowance (1.5 hours) at the pump station site does not appear to reflect the risks of an overflow occurring next to an environmentally sensitive area. Therefore, the following is recommended:

- Council request the Water Corporation upgrade the level of emergency storage and other contingency arrangements at the site to better reflect the impacts of the sewage overflowing into such an environmentally sensitive area;
- An emergency management plan be developed by the Water Corporation for the pump station and provided to council. A key component of the plan will need to be notification and rectification requirements for when a spill does occur;
- Council be notified when an emergency or overflow occur at the station so contingency and emergency operations can be monitored;
- The pump station overflow, instead of going overland into the park, be connected to the existing drainage system. Hence, any resultant overflow discharge will flow through the proposed gross pollutant trap and treatment measures prior to being discharged. It needs to be recognised this will provide some form of treatment when the drainage flow rates are low, however, in major storm when the Stormwater Pollutant Trap (SPT) would be bypassed the major benefit will be diluting the pollutant load prior to discharge into the park.

4. Proposed Stormwater Drainage Improvements

4.1 General

The objective of the stormwater drainage improvements is to minimise and remove pollutants and improve the quality of runoff into the reserve. In particular seed and weed contaminants reduction is requested to be addressed in this study. The pollutants are most likely to be oils/greases, heavy metals, litter/gross pollutants, seeds and weeds and suspended solids generated from streets, carparks and other impervious areas. The treatments considered shall be those best suited for removal of the general pollutants listed.

There is a large range of approaches that can be utilised when assessing treatment devices and the level of treatment implemented or required. For this study the philosophy in selection of a treatment train has been to be cost effective, have minimal impact on the existing vegetation, while removing pollutants from the stormwater to assist in rehabilitation of downstream areas. To have minimal impacts on the existing vegetation minimal works are proposed in the reserve. Infiltration and treatment works are located near the boundary to mitigate earth moving machinery moving all through the park, and are sized to have minimal impact on vegetation – not their treatment capabilities (which potentially would be larger).

Further, to the above, several of the catchments are located on major roads, with one catchment servicing an industrial area. These catchments have a higher risk of a chemical spill occurring from a tanker which has been requested to be assessed in this study.

For oil and grease removal, mechanical devices (or stormwater pollutant traps) such as oil and grit separators provide a medium to high rate of removal of the pollutant. Mechanical devices are also suitable for removing litter and gross pollutants, as well as some of the suspended solids, nitrogen and phosphorus loads. To maximise seed removal, it is important that a screen be included. Other treatments that are suitable for removing these pollutant loads include chemical treatments, mechanical devices, sediment traps, wet basins, infiltration basins, swales, and wetlands.

It is appreciated that "infiltration of runoff at source" is a preferred treatment to reduce runoff volumes, but in an existing fully developed urban area, retrofitting of this type of treatment structure is difficult due to the availability of land. Different means of achieving additional infiltration have been considered including infiltration structures in upstream public open space and converting existing side-entry pits into soakwells. The conversion of side-entry pits has been rejected because of the unknown affect on the structural integrity of the pit if the floor is broken out and intensive labour versus little return (there is only 0.8m^2 surface area on the bottom of a 1050mm diameter pit).

Constructed wetlands are rated as a high to medium level of removal for most types of pollutants. Constructed wetlands require land, and need to have reasonable level of impervious base. This is because the land area available for development of a treatment basin of any kind, which is located at the outfall, is underlain by highly permeable sands. Construction of wetlands would require the importation of lining material that would increase the cost over that of an infiltration basin and would change the nature of the site being developed. Further, a reasonable amount of earthworking will be required which will require heavy earthworking machinery and impacts on existing vegetation. It is therefore considered that smaller infiltration basins away from the existing low lying wetlands will better serve the project. The infiltration basins proposed have been sized to provide minimal impact on the existing vegetation.

A further consideration for works in the low-lying areas of the reserve is that potentially these areas will have acid sulphate soils. Therefore, for this initial assessment, to minimise impacts it is proposed to limit excavations for infiltration basins to no more than one meter. An acid sulphate soil assessment

will need to be completed during design to ensure acid runoff is controlled and not flushed into the conservation area.

It is not possible eliminate all seeds from the stormwater due to there size without eliminating all stormwater flows into the reserve. Therefore, seed management is proposed to be mitigated using SPTs with fine screens as primary treatment and infiltration basin as secondary treatment (via settling). However, this is a minimisation strategy as the SPTs are not able to capture all of seeds flowing through them. What seeds do go through the SPT are transported to the infiltration basin. The City of Wanneroo will therefore still need to develop and implement a seed control plan based on this approach.

It is proposed that the treatment systems are designed to cater for the 1:3 month first flush pollutant flows as per current best practise, with capacity to handle, and where required, bypass flows up to 1:5 to 1:10 year events from the pipe network. Where possible basins have been sized to be a minimum of 25 m^3 to cater for a tanker spill.

4.2 Overall Catchment Options

4.2.1 General

Table 4.1 below describes a series of pollutant removal devices and their feasibility of pollutant removal, in Koondoola Regional Bushland.

Table 4.1 Pollutant Removal Device Summary

	Weeds & Seeds	Hydro-carbons	Litter	TP	TN	TSS	Site Constraints
Screen	✗	✗	✓	✗	✗	✗	Minimal – installed catchment 3, however, minimal removal of most pollutants
SPT	✓	✓	✓	✓	✓	✓	Minimal – need space for unit. Requires screen for seeds
Swale	✗	✗	✗	✓	✓	✓	Lack of space for some catchments – area for weeds to grow.
Wetland	✗	Some	✗	✓	✓	✓	Site Porous, not suitable for sandy sites with low Ground Water Level, liner required. Impacts on existing vegetation.
Infiltration Basin	✗	✓*	✗	✓	✓	✓	Lack of Space for some catchments.
Bioretention Basin/Trench	✗	✓*	✗	✓	✓	✓	Site Porous, not proposed for sandy sites
Wet Sedimentation Basin	✗	✓*	✗	✓	✓	✓	Dependant on Ground water level, site porous, and not ideal.

Note: * Requires trapped overflow for hydrocarbons.

Applying the treatment train approach, a stormwater pollutant trap (SPT) followed by an infiltration structure would achieve a medium to high level of pollutant removal and reduce the volume of stormwater. An SPT is capable of removing oil and heavy metals, sediments, seeds and gross litter. However, the trade off with infiltration areas is that there is a decrease in the volume of water reaching the low-lying wetlands within the reserve, particularly during the drier parts of the year when only small storm events occur. It is also proposed the outlet to the infiltration areas be installed with a baffle to trap oils and floatable debris, the basins would also assist in sediment and heavy metal removal.

A description of the approach for each catchment follows.

4.2.2 Catchment 1

The 675mm diameter outfall at catchment 1 is located within Koondoola Regional Bushland and there is some clear space available for installing treatment devices. The options investigated and those deemed suitable for this outfall were the installation of SPT's and infiltration basins. Infiltration basin has been sized to have minimal impact on existing vegetation.

The outfall for catchment 1 is located within metres of catchment 2, hence the stormwater improvement options are looked at in conjunction with one another as well as individually. The combination of outfalls shall be discussed in Section *4.2.3 Catchment 2*.

4.2.3 Catchment 2

The 1050mm diameter outfall at catchment 2 is located in the vicinity of Rendell Way pump station and beside the outfall for catchment 1. The options investigated at outfall 2 were SPT installation, retaining the use of swales, installing infiltration basins and catchment diversion to a bubble up pit.

As catchment 1 and 2 discharged at the same point these two catchments were looked at collectively as a more logical approach for this site. The flows from the catchments were connected using a diversion manhole to divert the flows from catchment 1 to the outlet pipe of catchment 2. A series of options were then investigated for the new pipe, including SPT installation, retaining the use of swales and infiltration basins.

The catchment diversion option consisted of placing a small drainage pipe sized to take small flows that would diverted to a bubble up pit located in an adjoining park. The only site considered suitable for diversion of flows to a bubble up pit into Butterworth Park, however potentially only 30% of the flows can be diverted. Rendell Park was deemed unsuitable due to the levels in the park.

4.2.4 Catchment 3

The 1050mm diameter outfall at catchment 3 is located inside the bushland boundary near Alexander Drive as presented in Figure 1. There is sufficient open space for a range of pollutant removal options at this site. The options, which were deemed feasible and investigated at this outlet were the installation of SPT's and infiltration basins.

4.2.5 Catchment 4

The 450mm diameter outfall at catchment 4 is located within the Water Corporation site. The outlet discharges to a large drainage infiltration sump and this has minimal impact on the reserve. As a result it is not a priority to improve the water quality of this catchment. The installation of a SPT was modelled on this outfall pipe prior to the stormwater drainage entering the sump.

4.2.6 Catchment 5

The 450mm diameter outfall at catchment 5 is located inside the bushland boundary near Alexander Drive as presented in Figure 1. The outfall, which collects the road drainage drains into a drainage sump which does not impact directly on the reserve. Similar to catchment 4, it is not a priority to improve the water quality of this catchment. The option assessed was installing a SPT prior to the stormwater drainage entering the sump.

4.2.7 Catchment 6

Following a site inspection Connell Wagner were unable to locate this 525mm diameter outfall. It is assumed that no pollutant control devices are currently in place as none are shown on the

relevant drawings. The options investigated for this site were SPT installation and the use of infiltration basins.

Catchment 6 also has a 300mm pipe entering at the intersection of Alexander Drive and Beach Road. SPT installation was modelled as an option for this outlet pipe – there is limited space without impacting on existing vegetation for other works.

5. Pollutant Modelling

5.1 General

The water quality modelling was undertaken using the MUSIC modelling package Version 3.1 developed by CRC for Catchment Hydrology, Australia. MUSIC is a water quality modelling tool for comparing storm water upgrade options and is used to simulate the performance of stormwater treatment processes.

It is based on taking an atypical rainfall year (in this case Perth 1990 at 6 minute intervals) and applying an atypical pollutant generation algorithm to develop pollutant loads from a catchment. The loads are placed through empirical algorithms for various stormwater treatment train solutions to provide a theoretical end pollutant load based on the performance of the treatment devices.

It should be noted that pollutant loads from catchments may vary by orders of magnitude depending on the characteristics of the catchment. No attempt has been made to adjust the pollutant generation algorithms as the model is used as a comparative basis only, to compare options. MUSIC currently only assesses pollutant loads for Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP) and Gross Litter pollutants. These are used as indicator pollutants for other pollutants which runoff from a catchment.

5.2 Performance Targets

5.2.1 Australian Runoff Quality

Western Australia currently does not have any guidelines for the required performance of stormwater treatment systems. The Australian Runoff Quality (ARQ) is currently released in Draft format by the Institution of Engineers as a companion document to Australian Rainfall and Runoff. ARQ provides a range of indicative pollutant loads that can be expected from an urban catchment, and provide some performance objectives utilised in other states. As a comparative basis for the performance of the system Australian Runoff Quality guidelines have been used which are summarised as follows in Table 5.1.

Table 5.1 Performance Objectives

Pollutant Removal	Target Reduction
Total Suspended Solids	80%
Total Nitrogen	45%
Total Phosphorus	45%
Gross Litter	95%

5.3 MUSIC Model Parameters

For completion of the MUSIC models, default parameters where used to provide a comparative basis between options. Specific deviations and parameters are noted as follows:

5.3.1 Input Rainfall File

The default Perth 1990 rainfall year at 6 minute intervals was used.

5.3.2 Source Nodes

Urban source nodes were used for the model. Impervious areas were assessed at being between 20% – 30% for residential areas, 50% – 60% for industrial areas and 60% - 70% for main roads.

The following rainfall runoff parameters were adjusted as shown in Table 5.2 to be more compatible for the Perth Sands as per MUSIC model guidelines – all others remained at the default values.

Table 5.2 Adjusted Music Runoff Parameters

Parameter	Value
Soil Storage Capacity (mm)	250
Field Capacity (mm)	230
Infiltration Capacity coefficient a	200
Daily Groundwater Seepage Rate	0%

5.3.3 Stormwater Pollutant Traps

The performance parameters for SPT's were taken from Walker et al (1999) and published details from manufacturers. The bypass flow for SPT's is taken as the 1 in 3 month flow or first flush pollutants. The performance parameters of SPT's modelled is summarised in Table 5.3.

Table 5.3 Music Runoff Parameters SPT's

Parameter	Upstream Value	Downstream Value	Reduction
TSS (mg/L)	700	200	71.5%
TP (mg/L)	4.25	3.0	29.5%
TN (mg/L)	6.0	4.5	25%
Gross Pollutants (kg/L)	20	2	90%

5.3.4 Infiltration Basins

Infiltration/Seepage basins were modelled based on their estimated dimension and site limitation. Due to the sand located within the catchment, the seepage rate from the basins was assumed to be 200 mm/hr and the Evaporation Loss as 100% of Potential EvapoTranspiration (PET). The 1 in 5 year flow was used as the high flow by pass, where the pipe network is exceeded. MUSIC calculates the pollutant reduction ability of the infiltration/sedimentation basin based on these parameters.

Table 5.4 Properties of Infiltration System

Catchment	High Flow By-pass (m^3/sec)	Infiltration Basin Surface Area (m^2)	Depth (m)
1 & 2	5.9	60	1
3	1.12	124	1

The above basins can contain a minimum volume of 23 m^3 for a tanker spill.

5.4 Model Results

The output components, which were analysed from MUSIC were the mean annual loads. These results for each catchment are presented in Appendix C and discussed below. The target water quality pollutant removal based on Australian Runoff Quality Guidelines, are presented in Section 5.2.1:

5.4.1 Catchment 1 & Catchment 2

It is proposed for this catchment to divert the flows from catchment 1 through a diversion manhole, to a new outlet pipe, which collects catchment 1 and 2. The pollutant control options considered are presented below. The results for each option are presented in Appendix C.

Option 1: Install a SPT downstream of the diversion manhole, which can cater for the 1 in 3 month flow of the entire area of catchment 1 and 2. Then allow flows to pass from the SPT through a new outlet pipe into the existing swales in Koondoola Regional Reserve. Results for this option are presented in Appendix C. This option improves water quality, but a higher level of water quality could be achieved with additional pollutant control measures.

Option 2: Similar to option 1, but in addition install an infiltration basin (approximately 60m^2 in area), and pass flows from the SPT through a new 1200mm diameter outlet pipe, which will provide further pollutant removal and pollutant removal of any flows above the 1 in 3 month flows. There is sufficient land available in the reserve to accommodate a small sized infiltration basin. A proposed concept design sketch is presented in Drawing 2, Appendix A and results are presented in Appendix C. This is the recommended option for these catchments.

Option 3: This involved diverting the upper part of catchment 2 to a bubble up pit in Koondoola Park and installing a SPT and infiltration basin on the existing outlets of catchment 1 and 2 as presented in Option 2. The results for Option 3 are presented in Appendix C. This option was not recommended as the same improved water quality can be achieved with Option 2 at a lower cost.

The recommended concept design provides an improved water quality that almost meets the target water quality improvements as presented in Section 5.2.1. An indicative 76% removal of TSS is achieved, 39% of TP, 35% of TN and 100% removal of Gross Litter. Further works on infiltration systems can be installed, however they would impact on existing vegetation, and further reduce flows into the park.

5.4.2 Catchment 3

The treatment options considered for catchment 3 are presented below.

Option 1: Break into the existing 1050mm diameter outfall pipe to install a SPT, which will cater for the 1 in 3 month flow for catchment 3. Reconnect SPT to the existing pipe. The results for this option are presented in Appendix C.

Option 2: Break into existing pipe and install SPT as proposed in Option 1. Install a new outfall pipe and provide an infiltration basin for further pollutant removal, as there is sufficient land available in the reserve to accommodate further pollutant removal devices. A proposed concept design sketch is presented in Drawing 3, Appendix A and results are presented in Appendix C. This is the recommended option for this catchment.

The recommended concept design provides an improved water quality, which exceeds the target removal of all pollutants as presented in Table 5.1 in Section 5.2.1. The design achieves an indicative removal of 86% for TSS, 65% for TP, 62% for TN and a 100% removal of Gross Pollutants.

5.4.3 Catchment 4

The treatment options considered for catchment 4 are presented below:

Option 1: Break into existing 450mm diameter pipe and install a SPT, which will cater for the 1 in 3 month flow for catchment 4. Reconnect the SPT to the existing pipe. The results for this option are presented in Appendix C.

Option 2: Do nothing. Given this outfall passes through a very large drainage sump the pollutant control mechanisms in place provide a high level of pollutant removal, which exceeds the target removal of all pollutants as presented in Table 5.1 in Section 5.2.1. The results for this option are presented in Appendix C. This is the recommended option for this catchment.

5.4.4 Catchment 5

The treatment options considered for catchment 5 are presented below:

Option 1: Break into existing 450mm diameter pipe and install a SPT, which will cater for the 1 in 3 month flow for catchment 5. Reconnect SPT to the existing pipe. The results for this option are presented in Appendix C.

Option 2: Do nothing. Similar to catchment 4, this outfall passes through a very large drainage sump the pollutant control mechanisms in place provide a high level of pollutant removal, which exceeds the target removal of all pollutants as presented in Table 5.1 in Section 5.2.1. The results for this option are presented in Appendix C. This is the recommended option for this catchment.

5.4.5 Catchment 6

The treatment options considered for catchment 6 are presented below.

Option 1:Break into existing 525mm diameter pipe and install a SPT on the existing outfall, which will cater for the 1 in 3 month flow. Reconnect SPT to the existing pipe. It is also proposed to install a SPT on the existing 300mm diameter outfall, which collects the drainage from the intersection of Alexander Drive and Beach Road. The results for this option are presented in Appendix C. Note that the analysis indicates that this option does not meet the requirements presented in Table 5.1. This is the recommended option for this catchment.

Option 2: Similar to option 1, but install a new outfall pipe from the SPT to connect to an infiltration basin. The results for this option are presented in Appendix C. This option was disregarded, as there are a significant number of trees in this area, which limits the space available for an infiltration basin.

The recommended concept design provides an indicative water quality, which indicates removal rates of 71% for TSS, 29% for TP, 25% for TN and a 90% removal of Gross Pollutants. This option did not achieve target objectives. An optional trench could be used to cater for Oil Spill Control for catchment 6 with a total volume of 23 m^3. But if an optional trench (basin) with overflow baffle is to be constructed for catchment 6, the construction may have impacts to the existing vegetation (see SK07). It is recommended that impacts to the existing vegetation due to the construction processes be assessed further prior to further considerations.

5.4.6 Summary Water Quality Objectives

Referring to the water quality objectives it is noted that several of the above do not meet the water quality objectives prior to discharging to the wetland. A summary of the proposed options is shown below in Table 5.5.

Table 5.5 Summary of Model Outcomes for Proposed Options

	Flow Reduction (%)	TSS Reduction (%)	TN Reduction (%)	TP Reduction (%)	Gross Litter Reduction (%)
Catchment 1 & 2	10	76	35	39	100
Catchment 3	44	86	62	65	100
Catchment 4	98	98	98	98	100
Catchment 5	99	99	99	99	100
Catchment 6 a	0	71	25	29	90
Catchment 6 b	0	71	25	29	90

Further treatment and polishing can be achieved, however, this would involve either of the following:

- Increasing the infiltration area, by installing more infiltration areas downstream, which in turn will increase the seepage into the groundwater table. The trade off is there will be less flow to the wetland and it will remain "drier" for longer periods of the year, particularly for small storm events. Further there will be more impacts on existing vegetation in the conservation area.
- Installing a wetland, or impervious lined wet basin. The trade off will be increasing the amount of earthworks, which will increase costs and impact on existing vegetation in a conservation area;

Therefore, based on a minimal impact approach it is proposed to leave the proposed concept design as is. If further polishing treatment is required it is proposed they be investigated after this initial phase of work.

Prior to installing larger treatment ponds / basins the following would need to be addressed:

- Determining if and how much flow into the wetland conservation area can be reduced;
- Assessing if it is acceptable to impact on the existing vegetation in the conservation area;
- Providing further capital budget to achieve the marginal gain in stormwater quality;
- Assessing if and what impacts there may be from acid sulphate soils.

6. Budget

6.1 Capital Costs

The estimated capital works budget of the proposed works is presented in the following table. A proposed split between the three councils based on catchment area served is also included.

Table 6.1 Capital Costs

Pollutant Control Measure	Cost	City of Wanneroo	City of Stirling	City of Swan
Catchment 1 & 2:				
Diversion Pipe and Manhole	$25,000			
SPT	$55,000			
Outfall pipe to Infiltration Basin	$15,000			
Infiltration Basin	$15,000			
Basin Outlet works	$10,000			
Subtotal Catchment 1 & 2	$120,000	$114,000	$6,000	$0
Catchment 3:				
SPT	$55,000			
Outfall pipe to Infiltration Basin	$15,000			
Infiltration Basin	$15,000			
Basin Outlet works	$10,000			
Subtotal Catchment 3	$95,000	$0	$0	$95,000
Catchment 6				
SPT (x2)	$60,000			
Subtotal Catchment 6	$60,000	$31,000	$29,000	$0
Total Capital Cost	$275000	$145000	$35000	$95000
Design Costs	$25,000	$21,000	$1,000	$3,000
Project Management Costs	$25,000	$21,000	$1,000	$3,000
Planning Approvals	$15,000	$12,000	$1,000	$2,000
Acid Sulphate Soils	$15,000	$12,000	$1,000	$2,000
Sub Total	$355000	$211000	$39000	$105000
Contingency 20%	$67,000	$55,000	$4,000	$8,000
Total	$422000	$266000	$43000	$113000

The above does not include fencing, additional earthworks, signage, rehabilitation, etc, which will need to be considered during detail design

"Any opinion or estimate of costs by Connell Wagner will be made on the basis of Connell Wagner's experience and qualifications and will represent Connell Wagner's judgment as an experienced and qualified professional engineer, familiar with the construction industry. However, Connell Wagner has no control over the cost of labour, materials, equipment or services furnished by others or over Contractors' methods of determining prices or over competitive bidding or market conditions. Therefore, Connell Wagner cannot and does not guarantee that proposals, bids or actual construction costs will not vary from Connell Wagner's estimates".

6.2 Maintenance Costs

The pollutant control devices recommended by Connell Wagner are located within the Koondoola Regional Bushland. This property is owned by City of Wanneroo and any required maintenance shall be their responsibility. SPT's and swales shall require regular maintenance to keep pollutant weed and seed removal at its optimum.

SPT maintenance shall consist of:

- Removal of pollutants using a sump vacuum every 3 months; and
- Disposal of the collected pollutants to a toxic waste landfill site.

Infiltration basin maintenance shall consist of:

- Mowing/ and or spraying for weeds on an annual basis with litter removal.

The annual maintenance costs for the proposed concept designs are presented in Table 6.2.

Table 6.2 Annual Maintenance Costs

Maintenance Component	Cost
Catchment 1 & 3: SPTs Infiltration Basin Mowing and Weed Control	 $5,000 $1000
Catchment 2: SPT Infiltration Basin Mowing and Weed Control	 $5,000 $1000
Catchment 6: SPT (x2)	 $10,000
Total Maintenance Costs	$21,000

Note: The above costs do not include general weed control that will still be required for the reserve.

7. Summary and Recommendations

It is proposed to install a series of stormwater treatment devices in Koondoola Regional Bushland as part of the Koondoola Regional Bushland Management Plan. For this study the philosophy in selection of a treatment train has been to be cost effective, have minimal impact on the existing vegetation, while removing pollutants from the stormwater to assist in rehabilitation of downstream areas. To have minimal impacts on the existing vegetation minimal works are proposed in the reserve. This shall significantly reduce the volume of seeds, weeds and other pollutants such as phosphorous, nitrogen and gross pollutants entering the reserve. The stormwater devices proposed are generally stormwater pollutant traps and infiltration basins, individually or simultaneously. The SPTs provide removal of suspended solids, oils and heavy metals, seeds and the infiltration areas assist in further polishing of the stormwater.

MUSIC modelling was completed on the outfalls entering the bushland to provide a comparative basis between the existing case scenario and the proposed concept design. In all cases the treatment measures reduce the theoretical pollutant loads to achieve the proposed pollutant reduction targets in accordance with Australian Runoff Quality Guidelines. The success of this in practice will be subject to the performance of the SPT's. Further polishing is possible however, prior to initiating these works an assessment needs to be made on:

- Impacts on existing vegetation
- Occurrence of acid sulphate soils
- Potential reduction in flows to existing conservation areas.

The proposed works for each catchment are as follows:

Catchment 1 & 2

- Install a diversion manhole;
- Divert flows from catchment 1 to this manhole;
- Install new 625mm diameter pipeline to divert flows through;
- Install SPT;
- Install new 1200mm diameter pipeline to outfall from SPT to Infiltration Basin; and
- Excavate, level and develop Infiltration Basin with baffle trap and weir.

Catchment 2

- Install SPT on 1050mm outfall;
- Install new 1050mm outfall pipe from SPT to Infiltration Basin;
- Excavate, level and develop Infiltration Basin with baffle trap and weir.

Catchment 4

We have not proposed any works for the outfall pipe to catchment 4. However regular maintenance to the existing drainage sump should be undertaken.

Catchment 5

Similarly to catchment 4 we have not proposed any works for the outfall pipe to catchment 5. Again, regular maintenance to the existing drainage sump should be undertaken.

Catchment 6

- Install SPT on 525mm outfall pipe; and
- Install SPT on 300mm outfall pipe.

In regards to the Water Corporation Wastewater Pump Station it is recommended that the sensitivities of the site be highlighted to the Water Corporation and then be recommended to improve overflow and contingency arrangements for the pumps station.

8. References

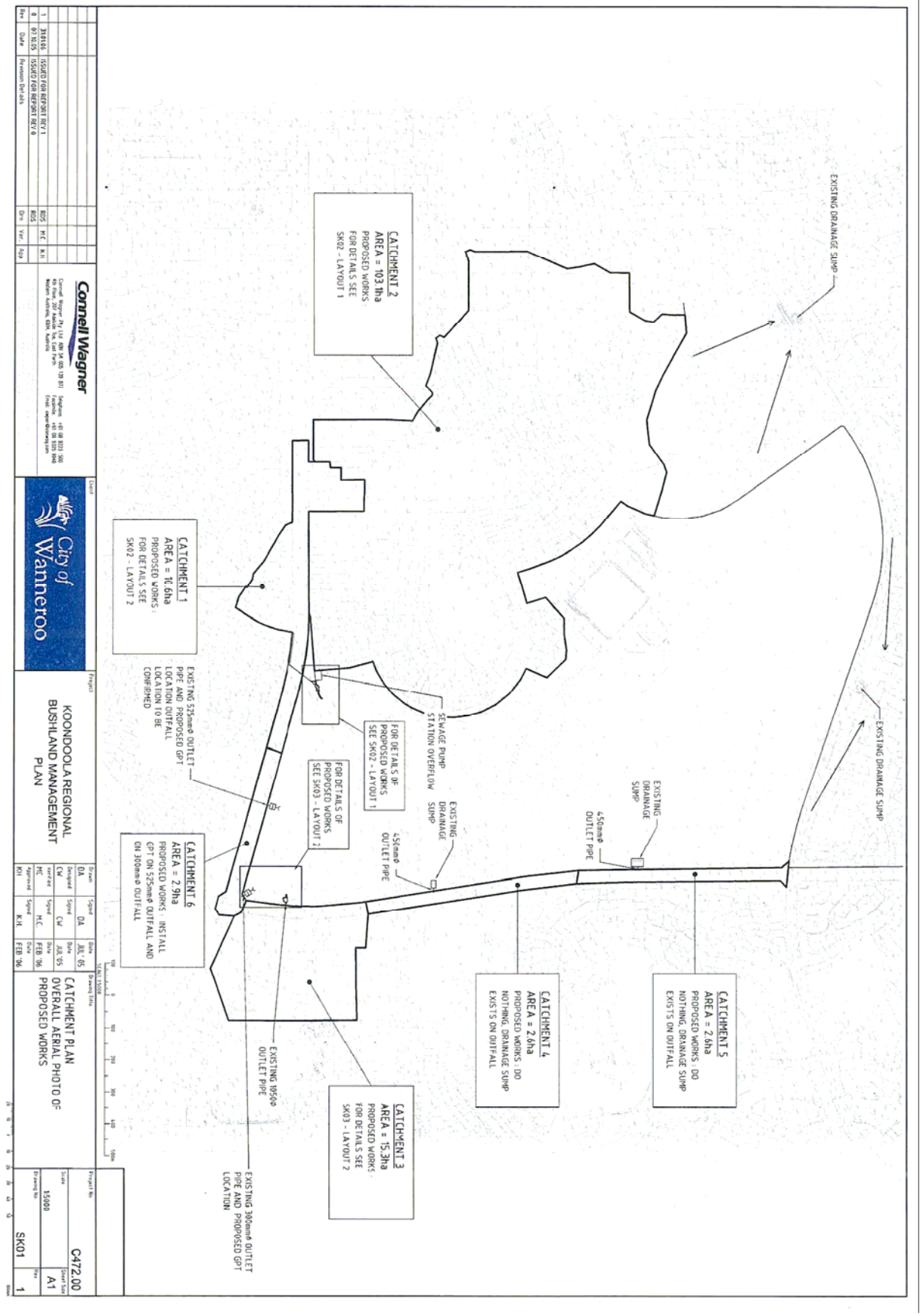
The Institute of Engineers Australia — *"Australian Rainfall and Runoff"* 2001

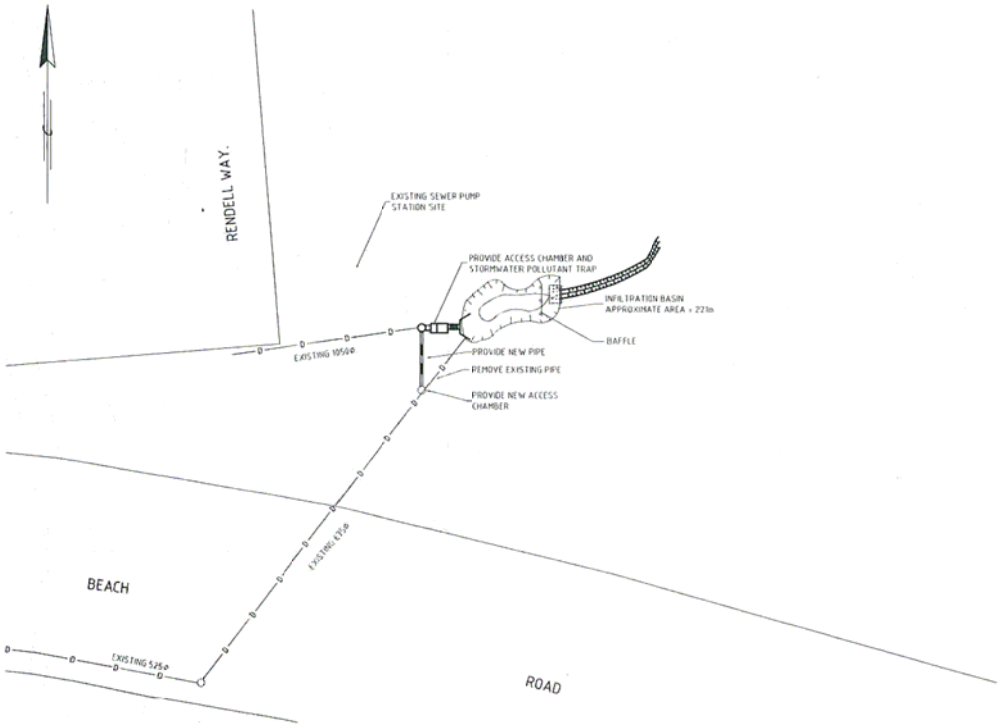
The Institute of Engineers Australia — *"Australian Runoff Quality Guidelines"*

Parks Landscaping Services — *"Koondoola Regional Bushland Management Plan'*

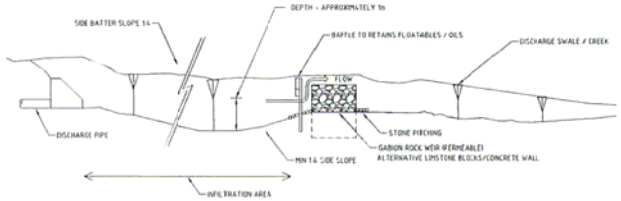
Appendix A

Existing Catchment, Concept Design Sketches


EXISTING DRAINAGE SUMP
EXISTING DRAINAGE SUMP
CATCHMENT 2
AREA = 103 ha
PROPOSED WORKS
FOR DETAILS SEE
SK02 - LAYOUT 1
EXISTING DRAINAGE SUMP
450mmø OUTLET PIPE
CATCHMENT 5
AREA = 2.4ha
PROPOSED WORKS : DO
NOTHING. DRAINAGE SUMP
EXISTS ON OUTFALL
SEWAGE PUMP STATION OVERFLOW
FOR DETAILS OF PROPOSED WORKS SEE SK02 - LAYOUT 1
EXISTING DRAINAGE SUMP
450mmø OUTLET PIPE
CATCHMENT 4
AREA = 2.0ha
PROPOSED WORKS : DO
NOTHING. DRAINAGE SUMP
EXISTS ON OUTFALL
CATCHMENT 1
AREA = 16.6ha
PROPOSED WORKS :
FOR DETAILS SEE
SK02 - LAYOUT 2
EXISTING 525mmø OUTLET PIPE AND PROPOSED GPT LOCATION OUTFALL LOCATION TO BE CONFIRMED
FOR DETAILS OF PROPOSED WORKS SEE SK03 - LAYOUT 2
CATCHMENT 6
AREA = 2.9ha
PROPOSED WORKS : INSTALL GPT ON 525mmø OUTFALL AND ON 300mmø OUTFALL
EXISTING 1050ø OUTLET PIPE
CATCHMENT 3
AREA = 15.3ha
PROPOSED WORKS
FOR DETAILS SEE
SK03 - LAYOUT 2
EXISTING 300mmø OUTLET PIPE AND PROPOSED GPT LOCATION
Connell Wagner
City of Wanneroo
KOONDOOLA REGIONAL BUSHLAND MANAGEMENT PLAN
CATCHMENT PLAN
OVERALL AERIAL PHOTO OF PROPOSED WORKS
C472.00
A1
15000
SK01
1



LAYOUT 1 - CATCHMENT 1 & 2 RECOMMENDED OPTION



PROFILE OF PROPOSED INFILLTRATION BASIN OUTLET
NTS

NOTES:
1) BASIN SIZED TO MINIMISE IMPACT ON EXISTING VEGETATION

2) BASIN TO BE REVEGETATED AS PART OF THE REVEGETATION PROGRAM

Rev.	Date	Revision Details	Drn	Ver.	App.
1	31.01.06	ISSUED FOR REPORT REV 1	RDS	M.C.	K.H.
0	07.10.05	ISSUED FOR REPORT REV 0	RDS		

Connell Wagner
Connell Wagner Pty Ltd ABN 54 005 139 873
4th Floor, 207 Adelaide Tce, East Perth
Western Australia, 6004, Australia
Telephone: +61 08 9223 1500
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Email: ewper@conwag.com

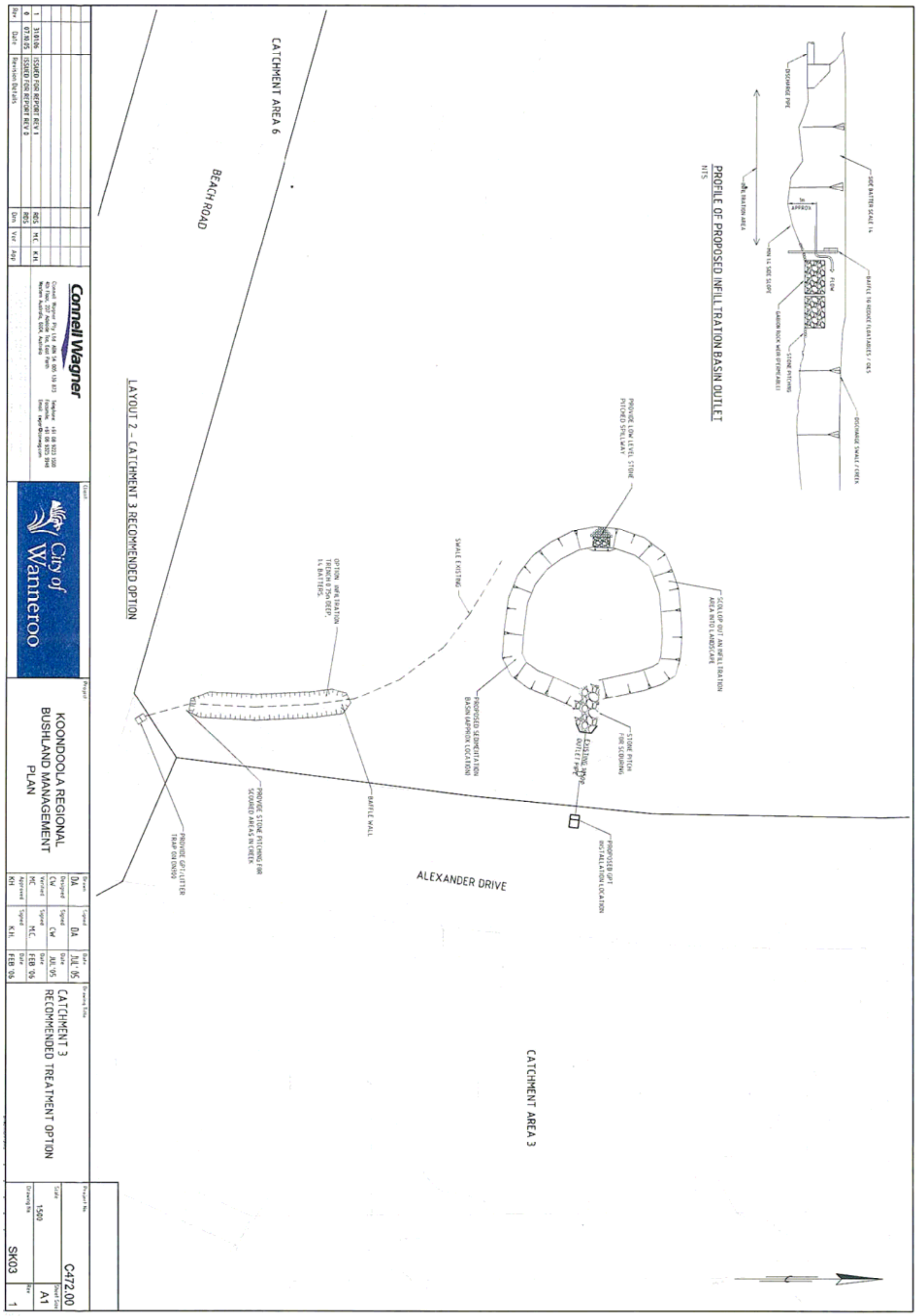
Client: City of Wanneroo

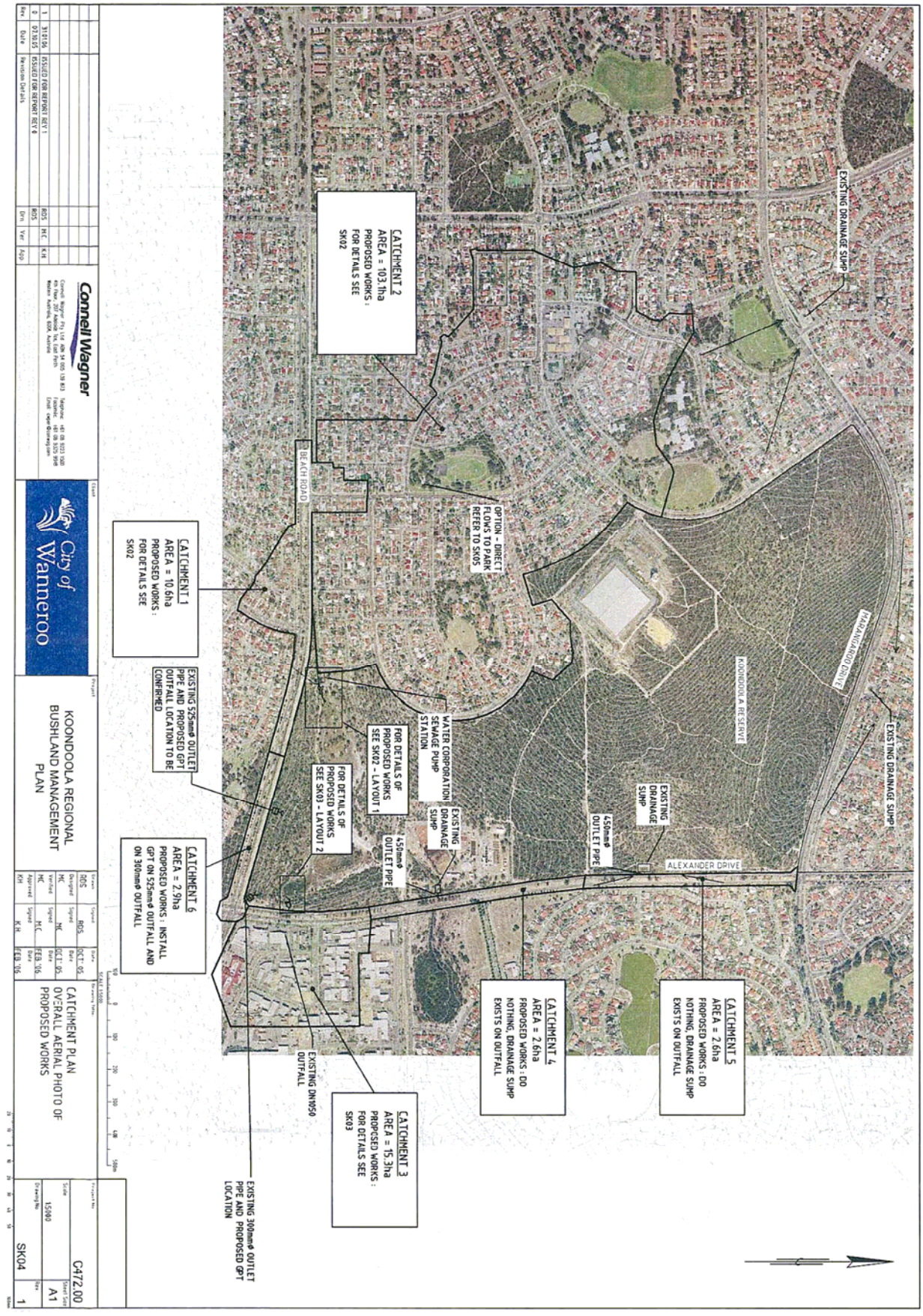
Project: KOONDOOLA REGIONAL BUSHLAND MANAGEMENT PLAN

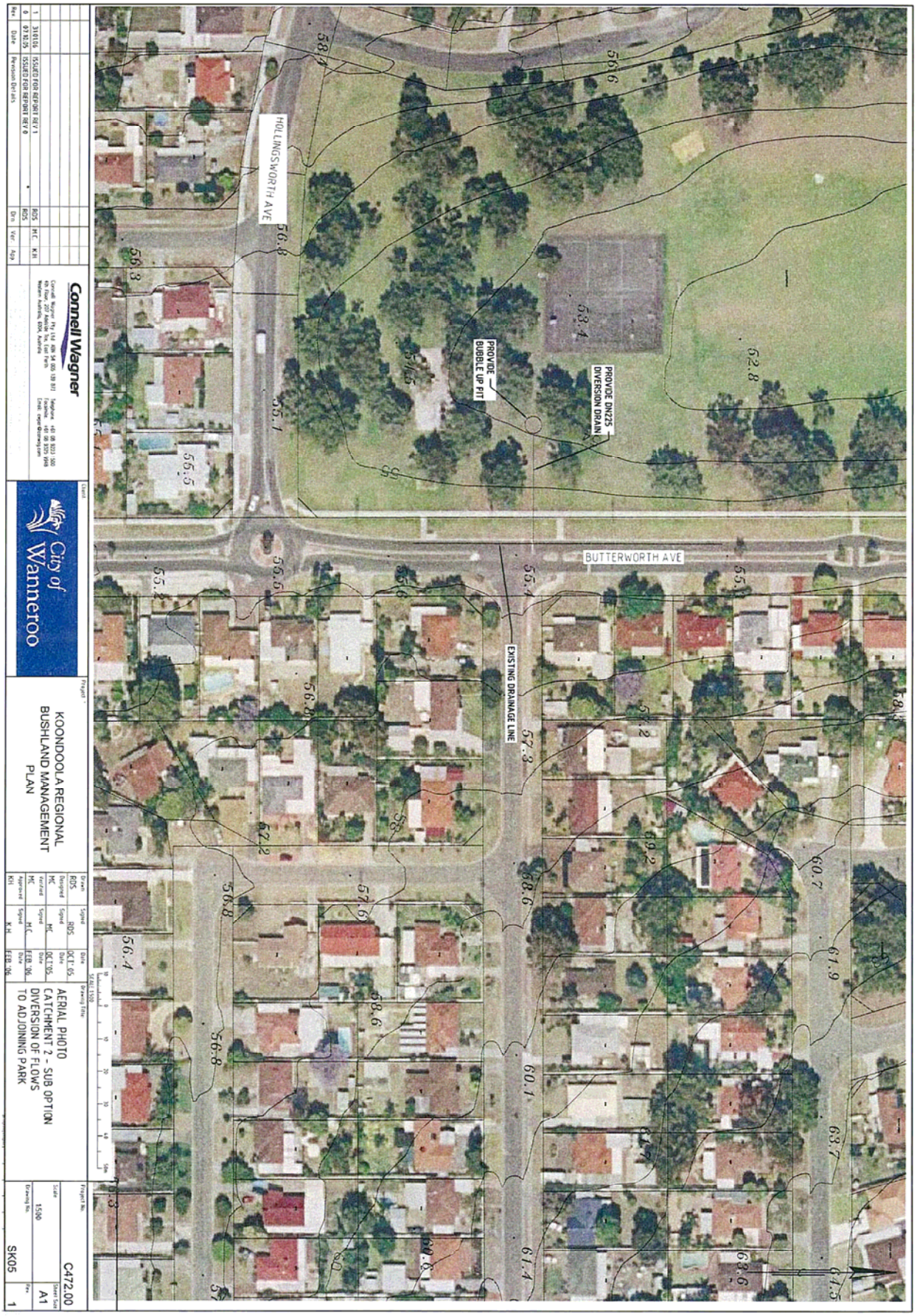
Drawn	DA	Signed DA	Date JUL '05
Designed	CW	Signed CW	Date JUL '05
Verified	MC	Signed M.C.	Date FEB '06
Approved	KH	Signed K.H.	Date FEB '06

Drawing Title: CATCHMENT 1 & 2 RECOMMENDED TREATMENT OPTIONS

Project No: C472.00
Scale: 1:500
Sheet Size: A1
Drawing No: SK02
Rev: 1


PROFILE OF PROPOSED INFILTRATION BASIN OUTLET
NTS
CATCHMENT AREA 6
BEACH ROAD
LAYOUT 2 – CATCHMENT 3 RECOMMENDED OPTION
ALEXANDER DRIVE
CATCHMENT AREA 3
Connell Wagner
City of Wanneroo
KOONDOOLA REGIONAL BUSHLAND MANAGEMENT PLAN
CATCHMENT 3 RECOMMENDED TREATMENT OPTION
C472.00
A1
1500
SK03


EXISTING DRAINAGE SUMP
CATCHMENT 2
AREA = 103.1ha
PROPOSED WORKS :
FOR DETAILS SEE
SK02
MARANGAROO DRIVE
KOONDOOLA RESERVE
EXISTING DRAINAGE SUMP
OPTION - DIRECT
FLOWS TO PARK
REFER TO SK05
CATCHMENT 1
AREA = 10.6ha
PROPOSED WORKS :
FOR DETAILS SEE
SK02
BEACH ROAD
EXISTING 525mmØ OUTLET
PIPE AND PROPOSED GPT
OUTFALL LOCATION TO BE
CONFIRMED
WATER CORPORATION
SEWAGE PUMP
STATION
EXISTING
DRAINAGE
SUMP
450mmØ
OUTLET PIPE
EXISTING
DRAINAGE
SUMP
450mmØ
OUTLET PIPE
ALEXANDER DRIVE
FOR DETAILS OF
PROPOSED WORKS
SEE SK02 - LAYOUT 1
FOR DETAILS OF
PROPOSED WORKS
SEE SK03 - LAYOUT 2
CATCHMENT 6
AREA = 2.9ha
PROPOSED WORKS : INSTALL
GPT ON 525mmØ OUTFALL AND
ON 300mmØ OUTFALL
CATCHMENT 4
AREA = 2.6ha
PROPOSED WORKS : DO
NOTHING, DRAINAGE SUMP
EXISTS ON OUTFALL
CATCHMENT 5
AREA = 2.6ha
PROPOSED WORKS : DO
NOTHING, DRAINAGE SUMP
EXISTS ON OUTFALL
CATCHMENT 3
AREA = 15.3ha
PROPOSED WORKS :
FOR DETAILS SEE
SK03
EXISTING DN950
OUTFALL
EXISTING 300mmØ OUTLET
PIPE AND PROPOSED GPT
LOCATION
Connell Wagner
City of Wanneroo
KOONDOOLA REGIONAL
BUSHLAND MANAGEMENT
PLAN
CATCHMENT PLAN
OVERALL AERIAL PHOTO OF
PROPOSED WORKS
C472.00
A1
1:5000
SK04
1


HOLLINGSWORTH AVE
BUTTERWORTH AVE
PROVIDE DN225 DIVERSION DRAIN
PROVIDE BUBBLE UP PIT
EXISTING DRAINAGE LINE
Connell Wagner
City of Wanneroo
KOONDOOLA REGIONAL BUSHLAND MANAGEMENT PLAN
AERIAL PHOTO CATCHMENT 2 - SUB OPTION DIVERSION OF FLOWS TO ADJOINING PARK
C472.00
SK05
A1
1:500
1

STORMWATER POLLUTANT TRAP
INFILTRATION BASIN
DIVERT FLOWS TO ACCESS CHAMBER
BEACH ROAD
Connell Wagner
City of Wanneroo
KOONDOOLA REGIONAL BUSHLAND MANAGEMENT PLAN
AERIAL PHOTO PROPOSED WORKS CATCHMENT 1 & 2
C472.00
SK06
1


BEACH ROAD
ALEXANDER DRIVE
INSTALL POLLUTANT TRAP (LOCATION UNKNOWN)
PROVIDE POLLUTANT TRAP
GULLEY
INFILTRATION BASIN
POLLUTANT TRAP
Connell Wagner
City of Wanneroo
KOONDOOLA REGIONAL BUSHLAND MANAGEMENT PLAN
AERIAL PHOTO PROPOSED WORKS CATCHMENT 3 AND 6
C472.00
SK07
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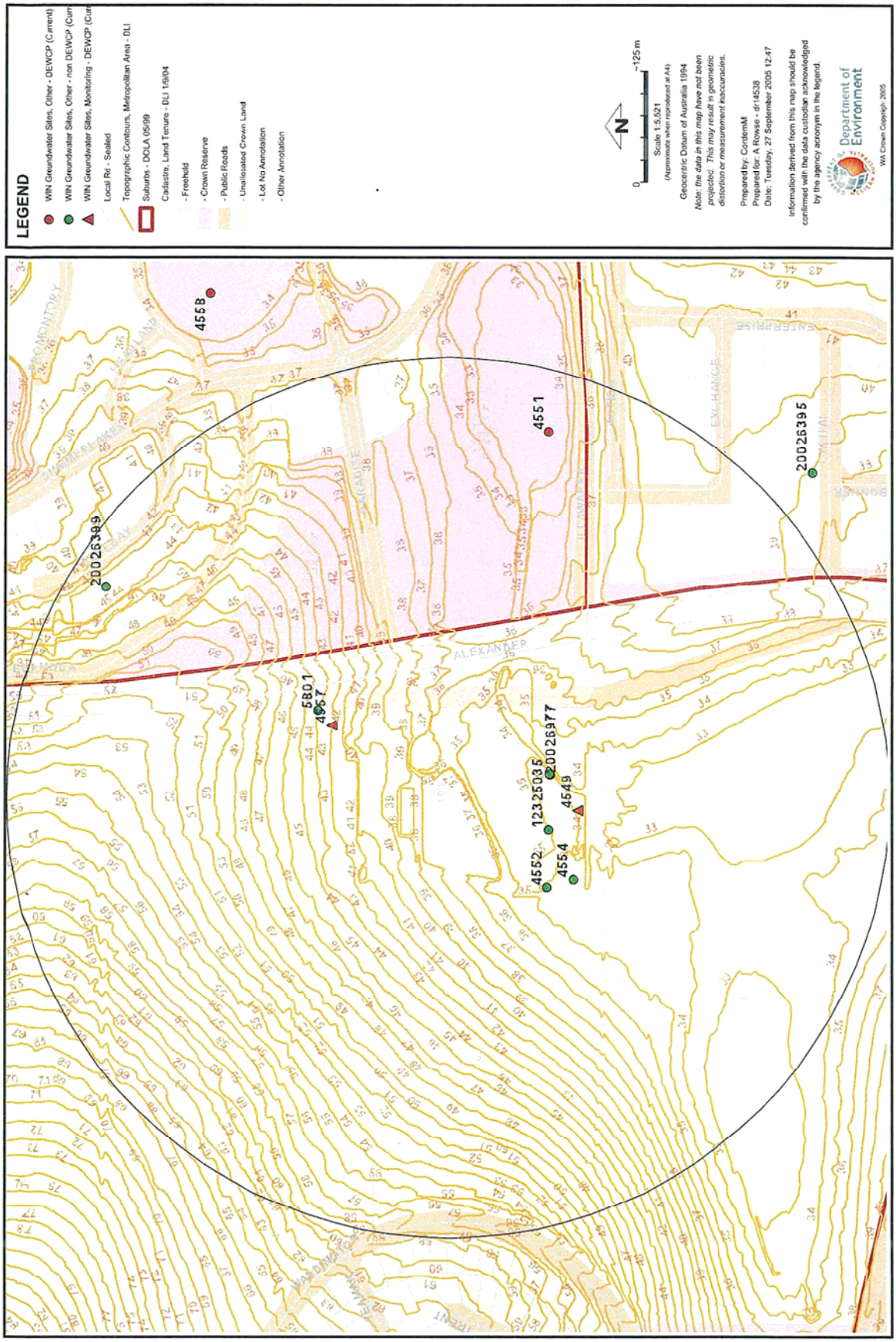
1:500

Appendix B

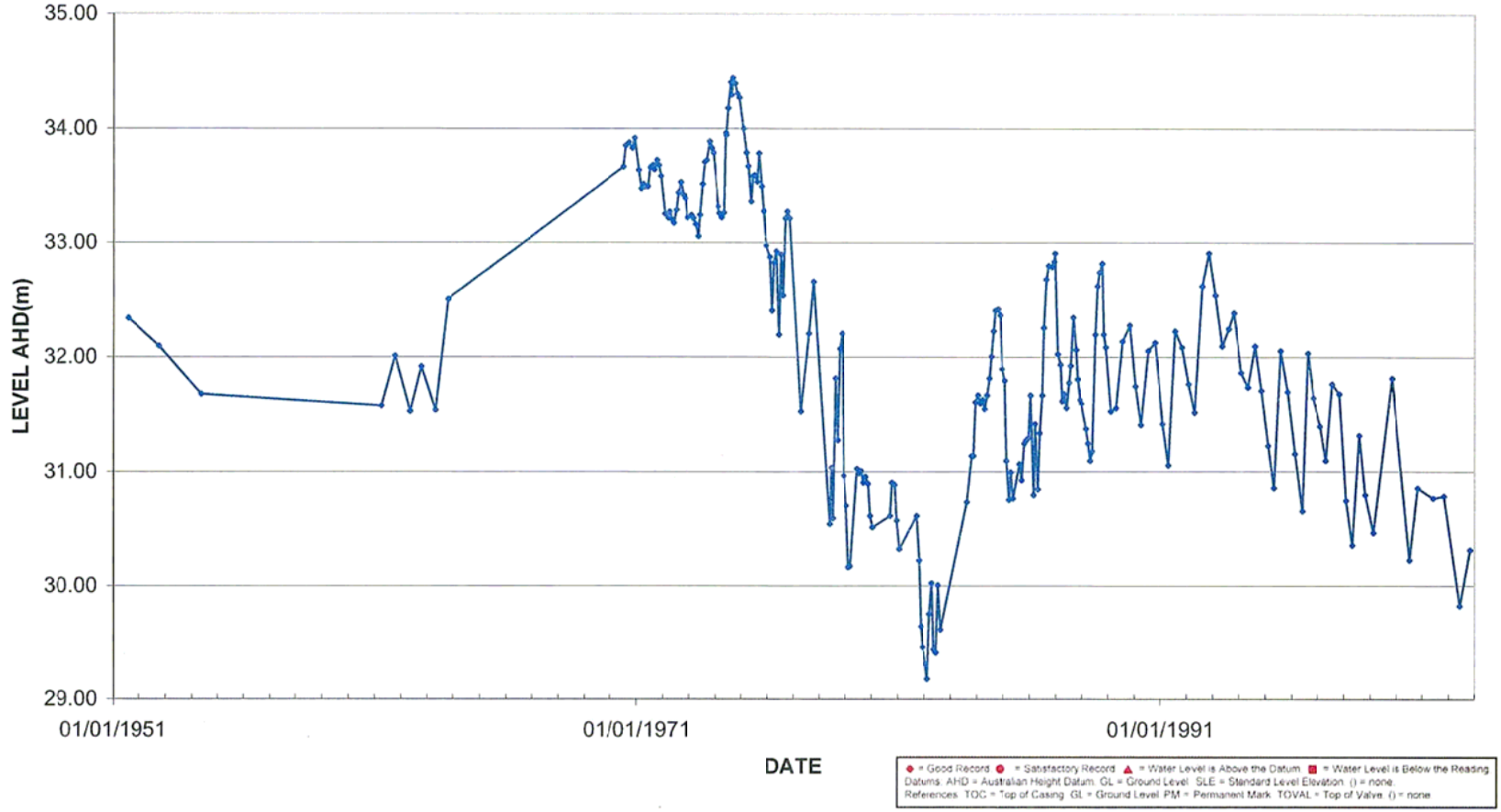
Groundwater Monitoring Results

500M radius bore search from L301 Alexander dr - Koondoola



61610208 LAKES AND WETLANDS - BORE 469

Easting = 393624.00 Northing = 6476099.00 Zone = 50 TOC = 35.79mAHD WIN SITE ID = 4549

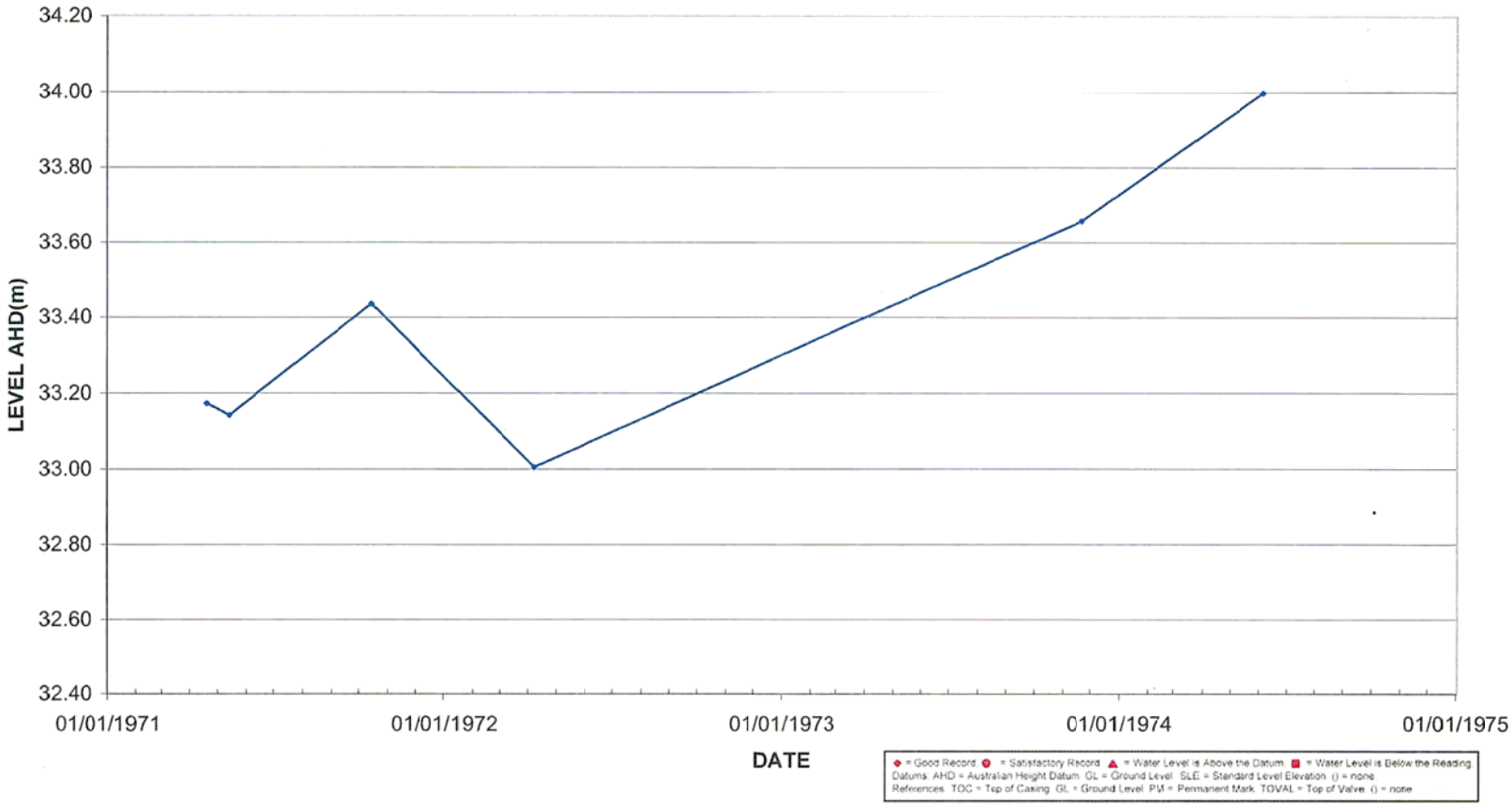


Printed 4:11 PM 7/10/2005

Prepared by: cordemm

61610210 LAKES AND WETLANDS - BORE 6003

Easting = 393995.00 Northing = 6476136.00 Zone = 50 TOC = 35.076mAHD WIN SITE ID = 4551

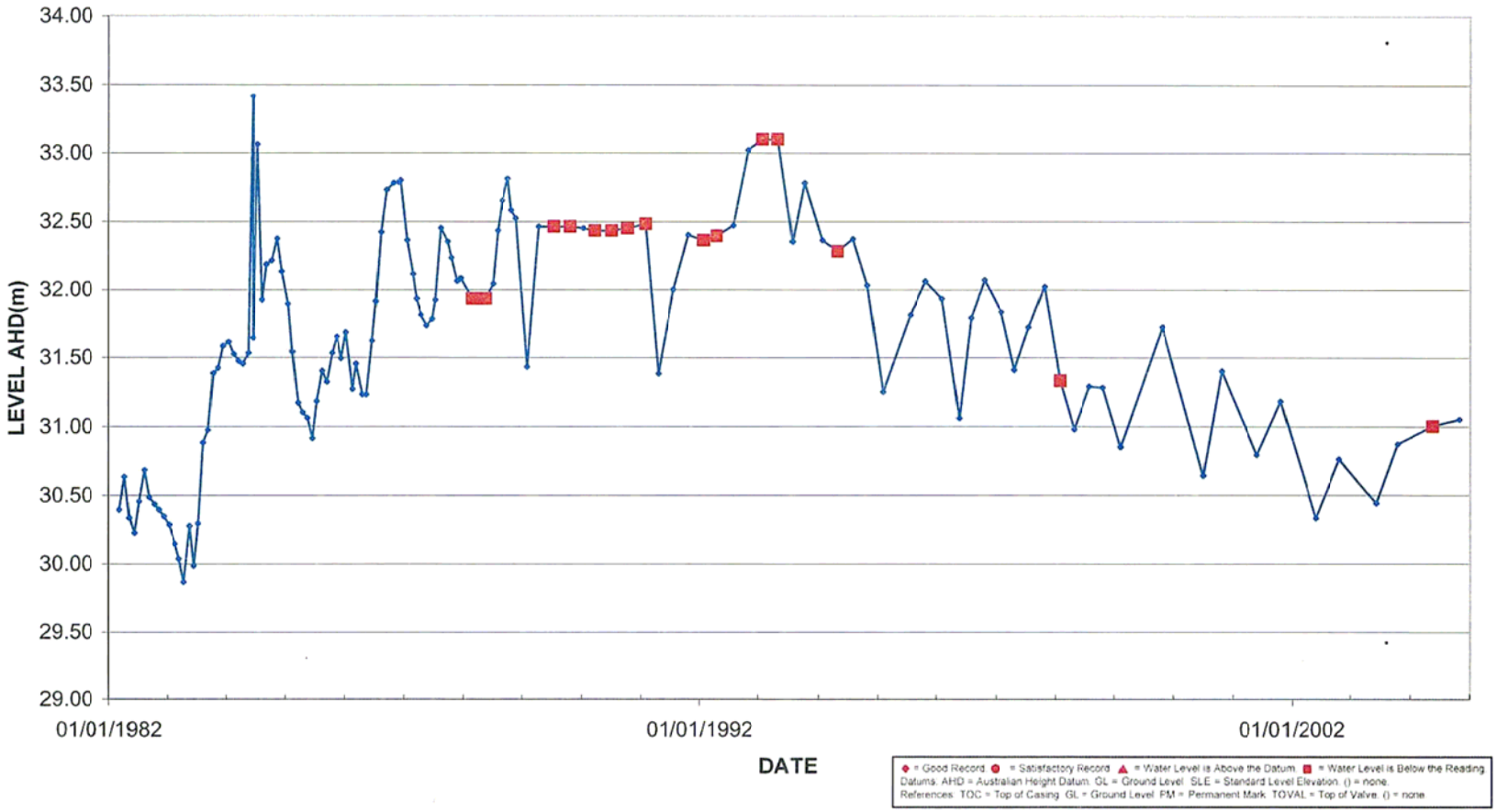


Printed 4:12 PM 7/10/2005

Prepared by: cordemm

61610216 MIRRABOOKA MONITORING MM68

Easting = 393705.00 Northing = 6476381.00 Zone = 50 TOC = 43.28mAHD WIN SITE ID = 4557



Printed 4:12 PM 7/10/2005

Prepared by: cordemm

Appendix C

MUSIC Modelling Results

Appendix C

CATCHMENT 1 & 2

Existing 1 & 2	Input
Flow (ML/yr)	124
Total Suspended Solids (kg/yr)	2.69E+04
Total Phosphorus (kg/yr)	52.1
Total Nitrogen (kg/yr)	360
Gross Pollutants (kg/yr)	6.96E+03

Option 1 GPT	Input	GPT	% Reduction
Flow (ML/yr)	124	124	0
Total Suspended Solids (kg/yr)	2.66E+04	7.60E+03	71
Total Phosphorus (kg/yr)	53.8	38	29
Total Nitrogen (kg/yr)	354	266	25
Gross Pollutants (kg/yr)	6.96E+03	696	90

Option 2 GPT & Infiltration Basin	Input	GPT	Inf Basin	% Reduction
Flow (ML/yr)	**124**	**124**	**112**	**10**
Total Suspended Solids (kg/yr)	**2.63E+04**	**7.51E+03**	**6.41E+03**	**76**
Total Phosphorus (kg/yr)	**53**	**37.4**	**32.2**	**39**
Total Nitrogen (kg/yr)	**354**	**265**	**230**	**35**
Gross Pollutants (kg/yr)	**6.96E+03**	**696**	**0**	**100**

Option 3 GPT, Infiltration Basin & BUP	Input (After BUP)	GPT	Inf Basin	% Reduction
Flow (ML/yr)	118	118	106	10
Total Suspended Solids (kg/yr)	2.36E+04	6.75E+03	5.75E+03	76
Total Phosphorus (kg/yr)	47.6	33.6	28.8	39
Total Nitrogen (kg/yr)	335	251	218	35
Gross Pollutants (kg/yr)	5.49E+03	549	0	100

CATCHMENT 3

Existing Catchment 3	Input
Flow (ML/yr)	46.9
Total Suspended Solids (kg/yr)	9.67E+03
Total Phosphorus (kg/yr)	19.3
Total Nitrogen (kg/yr)	136
Gross Pollutants (kg/yr)	2.18E+03

Option 1 GPT	Input	GPT	% Reduction
Flow (ML/yr)	46.9	46.9	0
Total Suspended Solids (kg/yr)	1.03E+04	2.96E+03	71
Total Phosphorus (kg/yr)	19.7	13.9	29
Total Nitrogen (kg/yr)	136	102	25
Gross Pollutants (kg/yr)	2.18E+03	220	90

Option 2 GPT & Infiltration Basin	Input	GPT	Inf Basin	% Reduction
Flow (ML/yr)	**46.9**	**46.9**	**26.1**	**44**
Total Suspended Solids (kg/yr)	**9.90E+03**	**2.83E+03**	**1.37E+03**	**86**
Total Phosphorus (kg/yr)	**19.9**	**14**	**7.02**	**65**
Total Nitrogen (kg/yr)	**131**	**98.4**	**50.2**	**62**
Gross Pollutants (kg/yr)	**2.18E+03**	**220**	**0.309**	**100**

CATCHMENT 4

Existing Catchment 4 - With Drainage Sump (Option 2 - Do nothing)

	Input	Drainage Sump	% Reduction
Flow (ML/yr)	**9.55**	**0.187**	**98**
Total Suspended Solids (kg/yr)	**1.92E+03**	**36.3**	**98**
Total Phosphorus (kg/yr)	**3.87**	**7.59E-02**	**98**
Total Nitrogen (kg/yr)	**27.2**	**0.579**	**98**
Gross Pollutants (kg/yr)	**417**	**0**	**100**

Option 1 GPT	Input	GPT	Drainage Sump	% Reduction
Flow (ML/yr)	9.55	9.55	0.187	98
Total Suspended Solids (kg/yr)	1.93E+03	551	9.54	100
Total Phosphorus (kg/yr)	3.91	2.76	4.90E-02	99
Total Nitrogen (kg/yr)	27.7	20.8	0.451	98
Gross Pollutants (kg/yr)	417	41.7	0	100

CATCHMENT 5

Existing Catchment 5 - With Drainage Sump (Option 2 - Do nothing)

	Input	Drainage Sump	% Reduction
Flow (ML/yr)	**8.63**	**0.114**	**99**
Total Suspended Solids (kg/yr)	**1.82E+03**	**22.4**	**99**
Total Phosphorus (kg/yr)	**3.69**	**4.40E-02**	**99**
Total Nitrogen (kg/yr)	**24.9**	**0.347**	**99**
Gross Pollutants (kg/yr)	**377**	**0**	**100**

Option 1 GPT	Input	GPT	Drainage Sump	% Reduction
Flow (ML/yr)	8.63	8.63	0.499	94
Total Suspended Solids (kg/yr)	1.76E+03	502	29.4	98
Total Phosphorus (kg/yr)	3.62	2.55	1.45E-01	96
Total Nitrogen (kg/yr)	25.1	18.8	0.986	96
Gross Pollutants (kg/yr)	377	37.7	0	100

CATCHMENT 6

Existing Catchment 6a (525mm outfall)	Input
Flow (ML/yr)	8.42
Total Suspended Solids (kg/yr)	1.76E+03
Total Phosphorus (kg/yr)	3.57
Total Nitrogen (kg/yr)	25.4
Gross Pollutants (kg/yr)	368

Option 1 GPT	Input	GPT	% Reduction
Flow (ML/yr)	**8.42**	**8.42**	**0**
Total Suspended Solids (kg/yr)	**1.67E+03**	**480**	**71**
Total Phosphorus (kg/yr)	**3.44**	**2.43**	**29**
Total Nitrogen (kg/yr)	**24.2**	**18.2**	**25**
Gross Pollutants (kg/yr)	**368**	**37.3**	**90**

Option 2 GPT & Infiltration Basin	Input	GPT	Inf Basin	% Reduction
Flow (ML/yr)	8.42	8.42	1.51	82
Total Suspended Solids (kg/yr)	1.73E+03	495	72.6	96
Total Phosphorus (kg/yr)	3.48	2.46	0.377	89
Total Nitrogen (kg/yr)	25	18.8	3.2	87
Gross Pollutants (kg/yr)	368	37.3	0.145	100

CATCHMENT 6b

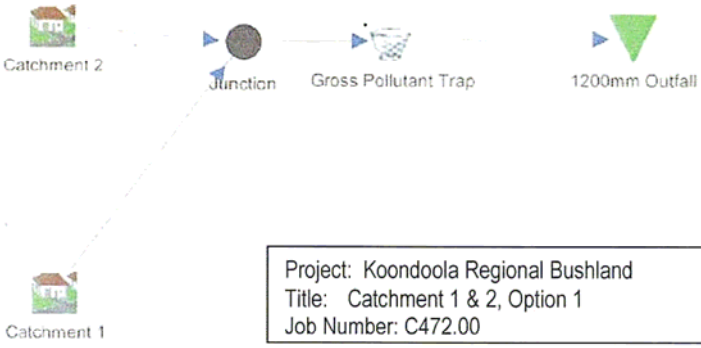
Existing Catchment 6b (300mm outfall)	Input
Flow (ML/yr)	3.79
Total Suspended Solids (kg/yr)	7.99
Total Phosphorus (kg/yr)	1.6
Total Nitrogen (kg/yr)	10.7
Gross Pollutants (kg/yr)	165

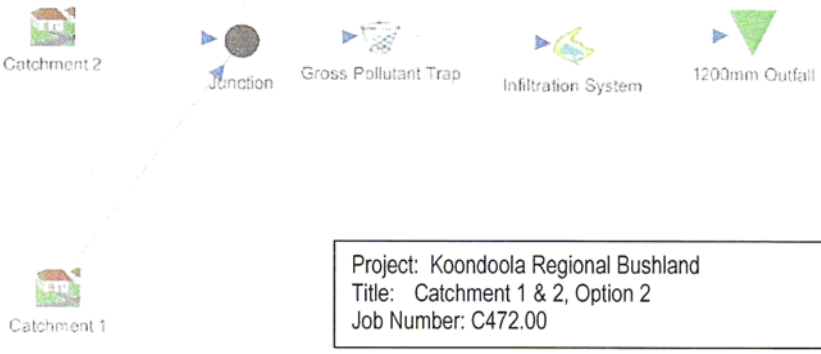
Option 1 GPT	Input	GPT	% Reduction
Flow (ML/yr)	**3.79**	**3.79**	**0**
Total Suspended Solids (kg/yr)	**833**	**238**	**71**
Total Phosphorus (kg/yr)	**1.68**	**1.19**	**29**
Total Nitrogen (kg/yr)	**10.7**	**8.03**	**25**
Gross Pollutants (kg/yr)	**165**	**16.5**	**90**

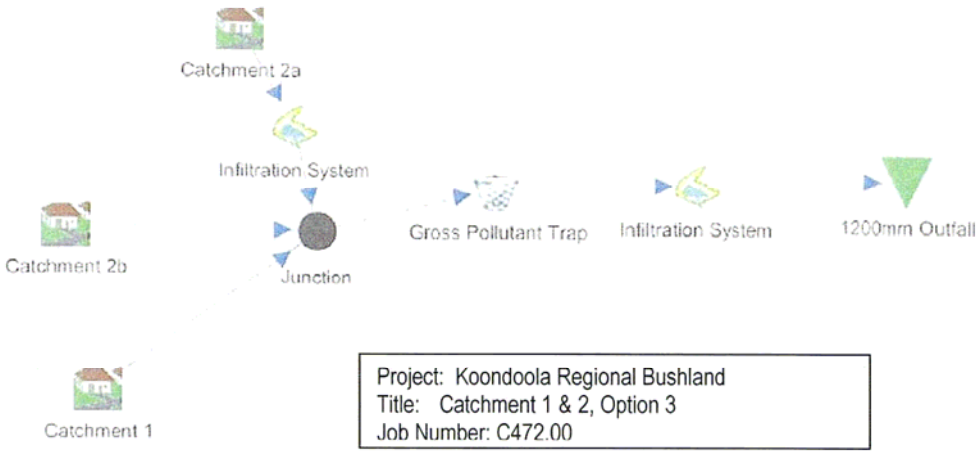
Appendix D

MUSIC Model Diagrams

Appendix D







Connell

Project: Koondoola Regional Bushland
Title: Catchment 3, Option 1
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 3, Option 2
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 4, Option 1
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 4, Option 2 (Do nothing)
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 5, Option 1
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 5, Option 2 (Do nothing)
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 6, Option 1
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 6, Option 2
Job Number: C472.00

Project: Koondoola Regional Bushland
Title: Catchment 6b, Option 1
Job Number: C472.00

Appendix E

Water Corporation Correspondence

WATER CORPORATION
ABN 28 003 434 917

Your Ref Koondoola Regional Bushland Reserve
Our Ref P:\C472 00\3.0 Correspondence\150605_WaterCorp_REV 2.doc
Enquiries Glenn Meinema
Direct Tel (08) 9424 8176

Quality System
Quality Endorsed Company
ISO 9002 LIC 12335 Standards Australia

Perth Region
273 Bannister Road
Canning Vale 6155
Western Australia
PO Box 1525
Canning Vale
Delivery Centre
WA 6970
Tel (08) 9424 8422
Fax (08) 9424 8409

15 July 2005

Ms Carol Walsh
Water Engineer
Connell Wagner
Level 4 Sheraton Court
207 AdelaideTerrace
EAST PERTH WA 6004

Dear Carol

Thank you for your letter requesting information on Water Corporation assets that are located within the boundaries of the proposed Koondoola Bushland Management Plan.

We offer the following information to address the three identified sites.

Site 1 – Wastewater Pump Station

This site is the Rendell Way SPS. In the event of a pump station failure, the sewage will flow into soak wells on the site and begin to soak into the ground. Should these soakwells become full then the sewage will overflow onto the ground at the pump station site and follow the lowest contours. The attached plan shows the likely route this overflow would take. The peak inflow into this station is only about 10 l/s with an average inflow of approximately 6 l/s. It is expected that the soakwells would be capable of managing this flow for about 1 hour before any excess began soaking into the ground on the site.

The Rendall Way pump station currently has approximately 1.5 to 2 hours of emergency storage between 6am and 10pm with up to 5 hours storage during the night. The Water Corporation has a programme of works to upgrade pumping station emergency storage; however, this site has yet to be scheduled due to other larger and more environmentally sensitive sites having a higher priority.

The contingency arrangements for this site, in the event of a total pumping failure or loss of power, is to employ the use of tankers that can easily handle the peak and average flows into this station over an indefinite period. This arrangement would continue until either mobile pumping equipment or a mobile generator set was installed at the site. The Water Corporation has a contract for the supply of tankering services with an agreed response time of 1 hour during normal working hours and has a range of mobile pumping and generator set equipment at its operations depots at Balcatta and Canning Vale.

../2

MMR 17024

Site 2 – Water Supply Reservoir

There should be no runoff leaving the Mirrabooka Reservoir site. All roof drainage from the reservoir is conveyed (by pipe) to the drainage sump. The sump lies between the reservoir, elevated tank and pump house and chlorine building, and the NW boundary. It intercepts any untrapped runoff from these structures. The ground is very sandy allowing rainfall to seep through almost immediately. There is sufficient sandy ground buffer between the roads and the boundary to intercept any water leaving the roads. Any runoff from the entrance road would flow down the front drive into Koondoola Avenue and not the surrounding bushland.

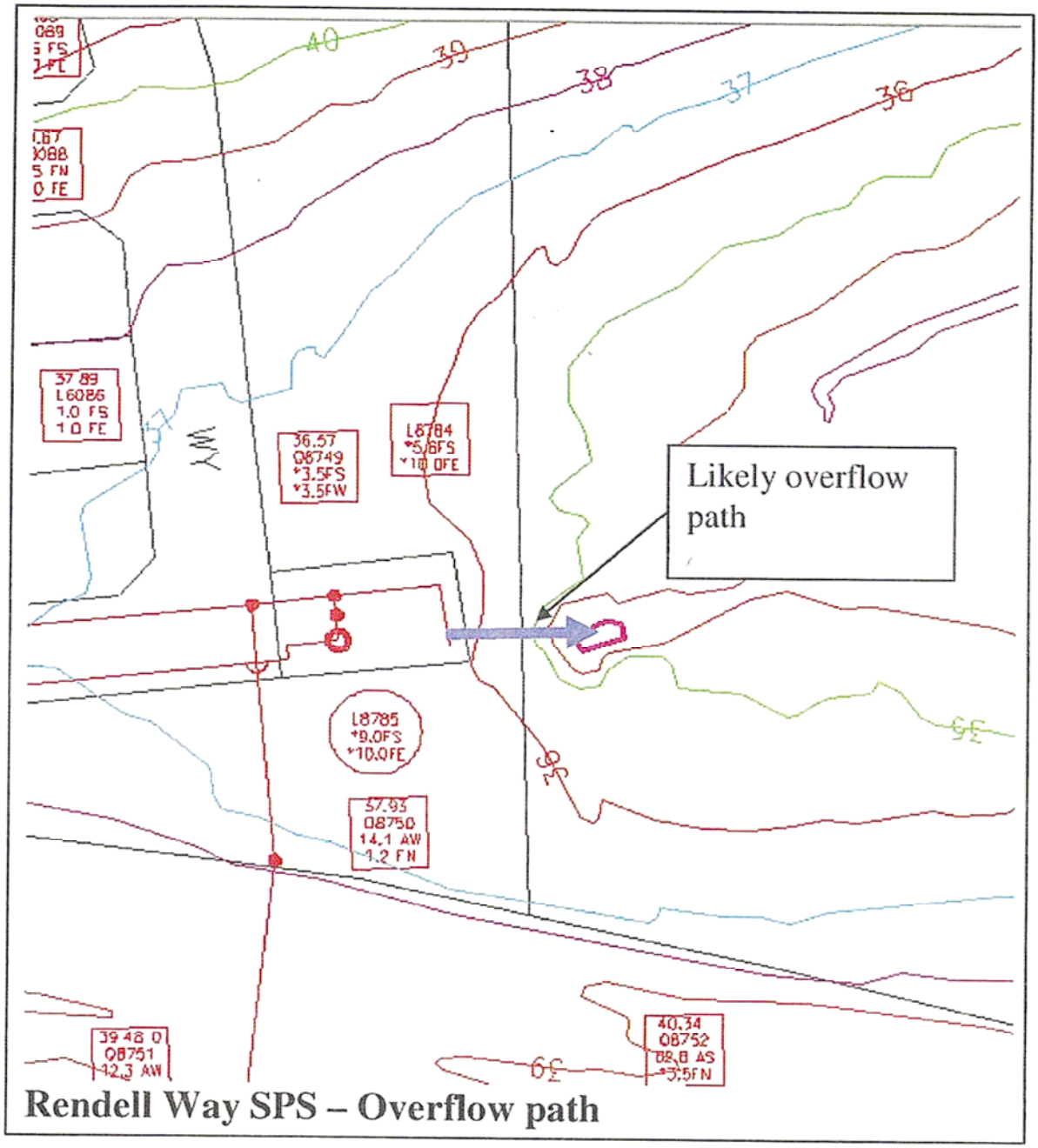
Site 3 – Koondoola water Treatment Plant

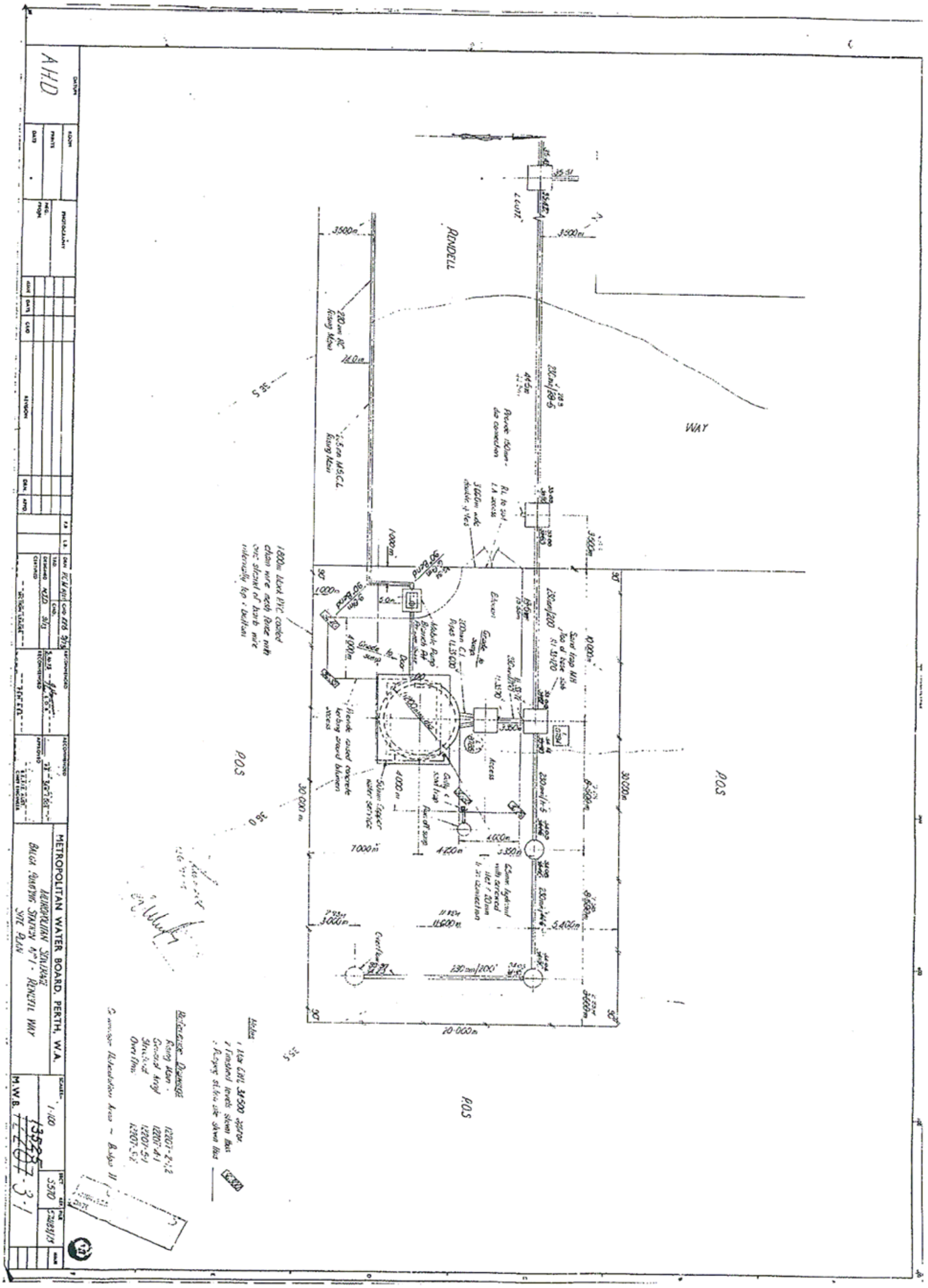
Most of the runoff is directed into the drainage system within the plant. However, some drainage on the lower portion of the plant runs into the same drain as the Shire road that runs through the south eastern side of our plant. All other overflow water is contained as much as possible within the process. Overflow, in most instances treated potable water, from the Backwash recovery system and the Clearwater tank also feeds into the same drain.

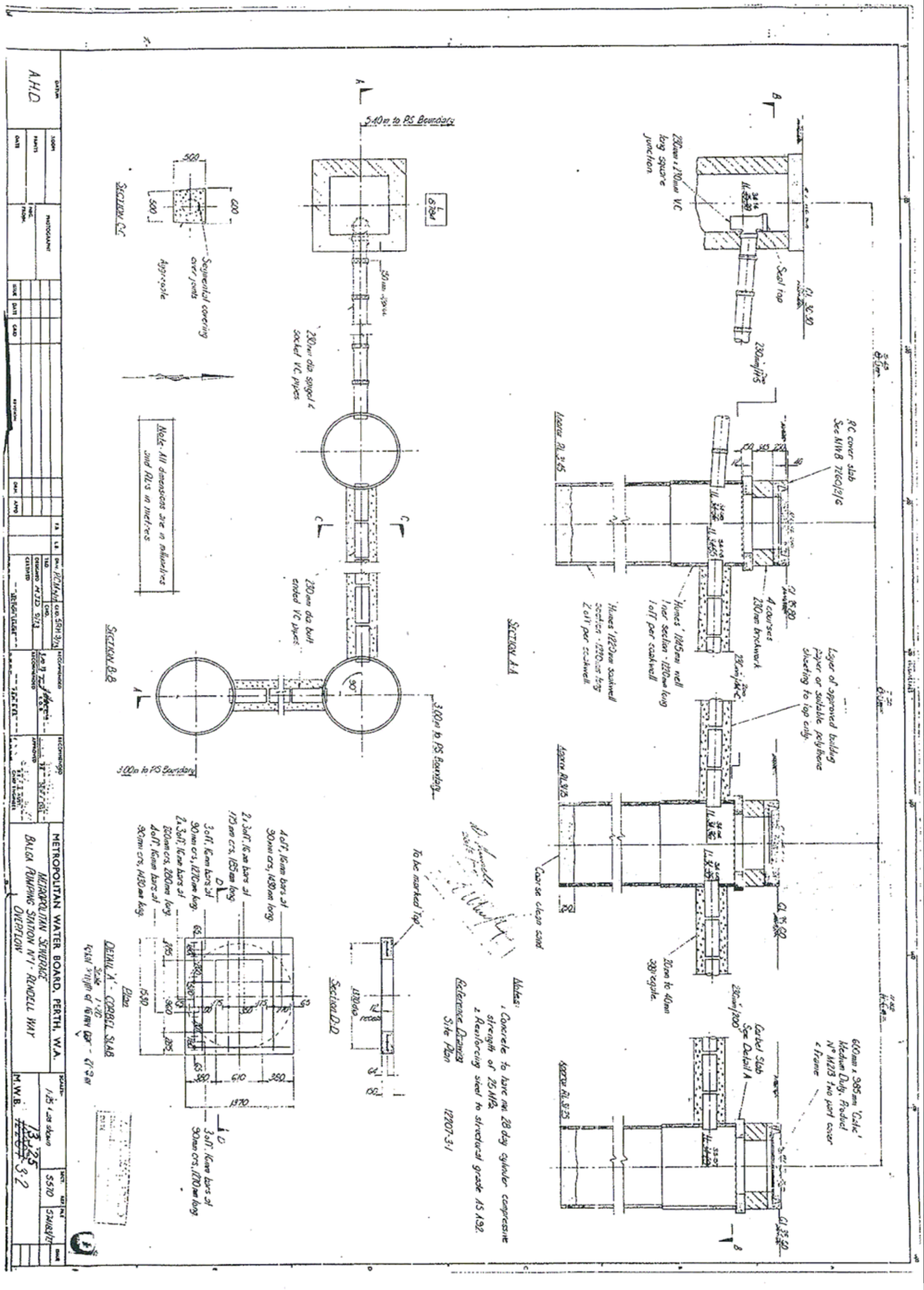
Yours sincerely

Ted Evans
MANAGER ASSETS PERTH REGION

Rendell Way SPS – Aerial Photograph


Likely overflow path
Rendell Way SPS – Overflow path


METROPOLITAN WATER BOARD, PERTH, W.A.
A.H.D.
RONDELL
WAY
P.O.S
P.O.S
P.O.S
M.W.B.


METROPOLITAN WATER BOARD, PERTH, W.A.
METROPOLITAN SEWERAGE
BALGA PUMPING STATION No 1 · RENDELL WAY
OVERFLOW
SECTION A-A
SECTION B-B
SECTION C-C
Section D-D
DETAIL 'A' - CORBEL SLAB
Note: All dimensions are in millimetres and RL's in metres