LIGHTNING SWAMP BUSHLAND MANAGEMENT PLAN

Prepared by

The City of Bayswater and the Friends of Lightning Swamp

October 2002

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Prepared by

The City of Bayswater and The Friends of Lightning Swamp

Original Management Plan prepared by Students of N319: Environmental Management, Environmental Science, Murdoch University, 1996

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Cover : Lightning Swamp Eastern Wetland (Photo - Sarah Dawson)

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MANAGEMENT PLAN RECOMMENDATIONS

It is recommended that:

GENERAL

1.9.1 **The management plan is to be in force for an initial period of five years, followed by a review, then another period of five years.**

1.9.2 **A committee is to oversee the implementation of this management plan, deal with any interim contingencies, and review the plan as per 1.9.1.**

HISTORICAL PERSPECTIVE

2.4.1 **An updated ethnographic and archaeological survey of the area is conducted in consultation with the local aboriginal community.**

2.4.2 **Relevant historical and cultural information is incorporated into strategically placed interpretation displays in LSB.**

PHYSICAL ENVIRONMENT

3.5.1 **The severely eroded north east corner of LSB is stabilised to eliminate its impact on the bushland, while other areas at risk of eroding are monitored.**

3.5.2 **The fire management plan is reviewed in accordance with the overall management plan, and in consultation with FESA.**

HYDROLOGY

4.6.1 **A baseline study of the surface water quality is prepared which measures the water quality of:**

- **the three main input drains**
- **the perched wetland**
- **the Widgee Branch drain output culvert at eastern edge of Lightning Swamp**

4.6.2 **A weir replace the eastern wetland output culvert to allow for greater control of water levels (completed May 2001).**

4.6.3 **A risk management plan is prepared to prevent or mitigate accidental chemical or other contaminant spillage within the total water catchment area draining into the Widgee Road Branch Drain.**

4.6.4 **Main Roads Western Australia is approached to ensure that a spillage plan for the Reid Highway drainage system is developed.**

4.6.5 **A long-term strategy is developed to control and eradicate *Typha orientalis* from the drain by means other than mechanical digging.**

4.6.6 **Rehabilitation of the drain with local species is conducted to assist with the process of nutrient stripping.**

FLORA

5.7.1 **A comprehensive flora survey be completed and incorporated into a detailed vegetation map of LSB.**

5.7.2 **Dieback treatment and preventative measures as recommended in the Dieback report are implemented.**

5.7.3 **As part of the overall education process, information on Dieback is made available to the general public, and operating procedures developed and distributed to authorities operating in LSB.**

5.7.4 **The preservation and protection of the declared rare flora and priority three species is a high priority.**

5.7.5 **A weed management plan including vegetation condition mapping be prepared and implemented. This should include the outer perimeter areas and allow for weed identification workshops.**

FAUNA

6.13.1 **A detailed fauna species list is prepared, as part of a baseline monitoring survey.**

6.13.2 **A Feral animal control program be developed and implemented.**

RECREATION

8.5.1 **Stabilised pathways be installed at the suggested locations (Section 8.3 & Figure 8.1) thereby reducing the impact from cycling, bushwalking and dog exercising.**

8.5.2 **Dogs are restrained on leashes while walking in LSB, both for the protection of native flora and fauna and to prevent snakebite.**

8.5.3 **Vehicle access is restricted to fire and maintenance vehicles that should follow established tracks when entering LSB.**

8.5.4 **Signage (see Figure 8.1) should indicate restrictions for access to sensitive areas, provide warnings of snakes, and other relevant information for visitors.**

CONSERVATION AND REHABILITATION

9.10.1 **Options for the long-term preservation of LSB are investigated, for example; the land be reserved for the purpose of 'Conservation & Passive Recreation' and classified as Class 'A' Reserve, vested in the City of Bayswater.**

9.10.2 **A permanent vehicle exclusion fence is erected and maintained around the perimeter of LSB.**

9.10.3 **All existing rubbish is removed and on-going rubbish removal is carried out.**

9.10.4 **Eroded and degraded areas in the bushlands are rehabilitated, including the areas earmarked for buffer zones.**

EDUCATION AND INFORMATION

10.7.1 **A "Friends of Lightning Swamp Bushland" community group be established.**

10.7.2 **Educational/Interpretation display centres be established (see Figure 8.1).**

10.7.3 **A long-term public education and awareness programme is implemented.**

RECOMMENDATIONS CONTAINED IN THE ATTACHED FIRE MANAGEMENT PLAN

1. **Establish and maintain a Fire Event Register for LSB.**

2. **Maintain the perimeter fencing and NO ENTRY signage by regular monitoring.**

3. **Conduct regular public fire awareness programs, preferably prior to the high fire season from November to April of each year.**

4. **Implement a program to maintain existing fire access tracks as prescribed by this plan.**

5. **Seek an exemption relating to the northern firebreak from the City of Swan as soon as possible.**

6. **Monitor the fuel loads in LSB regularly by FESA or another qualified agency or person.**

7. **A weed control program, as in Section 9.10, be implemented to reduce potential fire risk.**

8. **Develop policies and procedures for LSB as part of the City of Bayswater's overall disaster and emergency planning for:**

    - **Controlled burns to reduce extreme fuel loads.**

- **Immediate post-fire response.**

EXECUTIVE SUMMARY

Perth has numerous areas of remnant bushland within its metropolitan boundaries. Many of these areas are surrounded by urban development but still retain many of the values associated with natural bushland. These include aesthetic, cultural, historical and environmental values which, once lost, are gone forever. Today there is increasing public concern as to the future of these tracts of remnant bushland. Many people are concerned that if these areas are not managed in a sustainable manner, the values associated with them will decline until very few characteristics of the original bushland remain.

The ultimate aim of the management plan is to prevent further degradation of Lightning Swamp Bushland and to enhance its natural characteristics. The area concerned is Lot 101, bound by Malaga Drive, Reid Highway, Matthews Close and the former Della Road (unmade).

The land is seen to be worthy of conservation as it is a valuable representation of local flora and fauna and is in a location that is readily accessible to the local community. It is a diverse natural environment that can provide recreational, aesthetic and spiritual benefits for both residents and visitors if managed in a sustainable manner.

Lightning Swamp Bushland is bounded by roads and surrounded to the east, west and south by populated urban areas, and industrial development has recently commenced to the north. It is located approximately 17 kilometres to the north east of the Perth central business district in the suburb of Noranda. The site is at present leased from the Western Australian Planning Commission (WAPC) by the City of Bayswater. It was previously leased by the City of Swan.

In the past there has been no clear objective as to how Lightning Swamp Bushland was to be managed and therefore no maintenance or conservation work has been carried out on the site. The present concerns associated with the site are; uncontrolled access by vehicles, frequent fires, invasion by exotic plants and feral animals, and altered drainage regimes, all of which have taken their toll on the remnant bushland.

The management plan, was originally formulated by the Students of Environmental Management at Murdoch University in 1996. It has since been updated by the City of Bayswater in 2000-2001. The plan now contains clear objectives and recommendations as to the future of the site. If initiated they will ensure that the land will continue to provide a sustainable habitat for flora and fauna, and be of benefit to the conservation and passive recreation needs of the local community, now and in the future.

The overall objectives of the management plan are:

1. To protect, conserve and rehabilitate the natural habitat to promote the continued survival of local species of native flora and fauna.

2. To ensure sustainable and responsible use of the area.

3. To develop and promote an understanding of the value and importance of the natural environment within the community.

4. To protect cultural and heritage values of the area.

It is recognised that for this management plan to be initiated a number of factors will need to be considered. A coordinated approach between local residents, local authorities and a number of government agencies will need to be instituted for successful implementation. Ongoing management, maintenance and monitoring will need a coordinated approach between those key stakeholders. Without a strategic management plan the area will continue to become further degraded until it no longer retains any value for conservation purposes.

Preface

The Lightning Swamp bushland was reserved for parks and recreation in the original Metropolitan Region Scheme of 1963. The City of Bayswater has now entered into a lease agreement for the land. This agreement provides the City with the authority to manage and protect the areas unique character and environment in partnership with the local community.

An Advisory Committee (Lightning Swamp Working Party) was appointed by the City of Bayswater to provide advice on the management of Lightning Swamp and to assist in the preparation of this Management Plan. This Committee is comprised of Councillors and staff of the City of Bayswater, State Authorities and representatives from the community and special interest groups. A coordinated approach to management by the City, the local community and a number of State Authorities will need to be implemented to ensure the success of the plan.

Students from N319, Environmental Management, at Murdoch University prepared this plan in October 1996 under the direction of the unit coordinator, Associate Professor Frank Murray. The original plan has been amended by the Lightning Swamp Working Party established by the City of Bayswater in order to meet the requirements of vesting changes and to include updated data and further management recommendations.

ACKNOWLEDGMENTS

The original management plan proposal was prepared as part of the course 'N319 Environmental Management' by the students of Murdoch University. The plan was updated in 2000 – 2001 by the City of Bayswater.

The preparation of this plan was made possible with advice and assistance from the following organisations, agencies and individuals:

Aboriginal Affairs Department
Aboriginal and Torres Strait Islander Commission
Bennett Brook Catchment Group
Bayswater Integrated Catchment Management
Bureau of Meteorology
City of Bayswater
City of Swan
Department of Conservation and Land Management
Department of Environment and Water Catchment Protection
Department of Land Administration
Ecosystem Management Services
Education Department of WA
Friends of Lightning Swamp Bushland
Main Roads of Western Australia
Malaga Fauna Rehabilitation Centre
Michael Bourke
Department for Planning & Infrastructure
Murdoch University
Noranda Shopping Centre
Royal Australian Ornithological Union
WA Fire Brigade
WA Museum
WA Wildflower Society
Water and Rivers Commission
Water Corporation
Western Power
Whiteman Park

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Section 1.0 Introduction

1.1 Special Nature of Perth's Bushland and Wetlands

Perth, unlike many other cities throughout the world, is in the enviable position of still retaining a substantial amount of natural bushland, but population growth and urban expansion is placing increasing pressure on the areas that remain.

There are many reasons why it is important to retain as much as possible of the remaining bushland in its natural state. Many of these reasons have to do with its uniqueness.

The bushland of the Swan Coastal Plain, on which Perth is situated, has a number of distinct flora and fauna communities. These are mainly associated with the variation in soil type but elevation, slope and hydrology of the region play an important role in dictating which communities exist. Subtle variations in any of these factors allow the plant communities and thus fauna habitat to change dramatically over relatively short distances (Bell and Bennett 1986).

The vegetation of the Swan Coastal Plain is part of the South Western Botanical Province of Western Australia. This is an area in which species richness is considered to be very high in comparison to areas of similar size in most parts of the world (Marchant et al 1981) and was recently recognised as one of the worlds 25 'biodiversity hotspots' (Myers et al 2000).

Wetlands are an integral part of the remnant bushland and in themselves show a rich diversity of flora and fauna. Most of the flora and fauna has evolved to rely on this groundwater for survival as the Mediterranean climate of the region restricts substantial rainfall to only six months of the year. As well as having to rely on groundwater for part of the year, the upland plant communities have also adapted to the relatively infertile soils of the region.

There are also the ethical and moral considerations that should be considered. Future generations should have the right to enjoy the natural landscape. Others will argue that the animals and plants have as much right to exist as humans, and for this reason alone the bushland that remains needs to be retained.

1.2 Current Status of Perth's Bushland and Wetlands

Much of Perth's bushland has been lost through urban development. Land clearing has left little of the many plant communities that once covered the Swan Coastal Plain. Extensive areas of banksia woodlands which occur on the Bassendean dune system have also been cleared for agriculture and pine plantations (Wake and Reeves 1995).

Clearing aside, much of the bushland in the Perth Metropolitan Region has been degraded through factors such as weed invasion, modified drainage, the introduction of domestic and feral animals, changed fire regimes, rubbish dumping and through human usage. Over the past 20 years awareness has grown for the need to conserve and manage Perth's bushland and now there are numerous community groups working in natural areas (Scheltema and Harris 1995).

Perth's wetlands have also faired poorly through urban development. It is estimated that as much as 70% to 80% of Perth's wetlands have been lost to urban development and farming through filling, draining and clearing of fringing vegetation.

1.3 Location and Description of Lightning Swamp Bushland (LSB)

LSB is an area of bushland situated in Noranda, a north-eastern suburb of Perth. The bushland is bounded on two sides by Tonkin and Reid Highways (north), the former Della Road and Malaga Drive (west) and to the south by Mathews Close which provides the only entry into the area.

The total area of LSB is 70 hectares, comprising bushland and wetlands (Figure. 1.1).

An open stormwater drain traverses the length of the site, draining into an ephemeral wetland area at the eastern end of the bushland. There is also a perched wetland in the north-east corner of the bushland which contains some water all year round.

1.4 Current Status of Lightning Swamp Bushland

The majority (70 hectares) of LSB is currently owned by the WAPC. There is a small section of four hectares currently owned by Main Roads Western Australia and an unmade road reserve that traverses the bushland. The road reserve will be closed and the land component converted to a Crown Reserve pursuant to the *Land Administration Act* with a purpose allocated that reflects the status of the surrounding bushland. LSB was reserved for Parks and recreation in 1963 as part of the Metropolitan Region Scheme (Maunsell and Parnters undated) and is also a Bush Forever site.

Current uses of the bushland area at LSB include passive recreation and its inherent value as an area for bushland and wetland conservation. The Water Corporation uses the drain that flows through the bushland for discharge of storm water. Western Power also has power line corridors which run through the area. The bushland on the whole is in good condition (Keighery, 1995). However it will need to be carefully managed to maintain its continued preservation.

1.5 Significance of Lightning Swamp Bushland

LSB is an island of bushland significant in size and quality, surrounded by industrial land to the north, and urban areas on all other sides. It represents some of the plant communities that once covered the Swan Coastal Plain before urban development cleared and destroyed vast tracts of bushland. The area is situated on the transition zone between the Southern River Soil Complex and the Bassendean Soil Complex, and as such it contains the vegetation types characteristic of both soil types. Hills of the Southern River soils have vegetation similar to the banksia woodlands of the infertile Bassendean sands.

However, vegetation in drainage lines and valleys of the Southern River Complex is characterised by forests of Marri, Wandoo and Flooded Gum (Wake and Reeves, 1995). Only a small proportion of Southern River Complex vegetation type remains uncleared on the Swan Coastal Plain (J Alford, pers. Comm. 1996) the majority having been cleared for agriculture. The proportion remaining uncleared of the broad vegetation category in which this site belongs was 17% in 2000 (W.A. Government, Southern River Complex, 2000). Within this broad group it is likely that specific sub-categories of vegetation are even more scarce. Two examples of scarce lower groupings at LSB appear to be Banksia illicifolia woodland and the perched wetland.

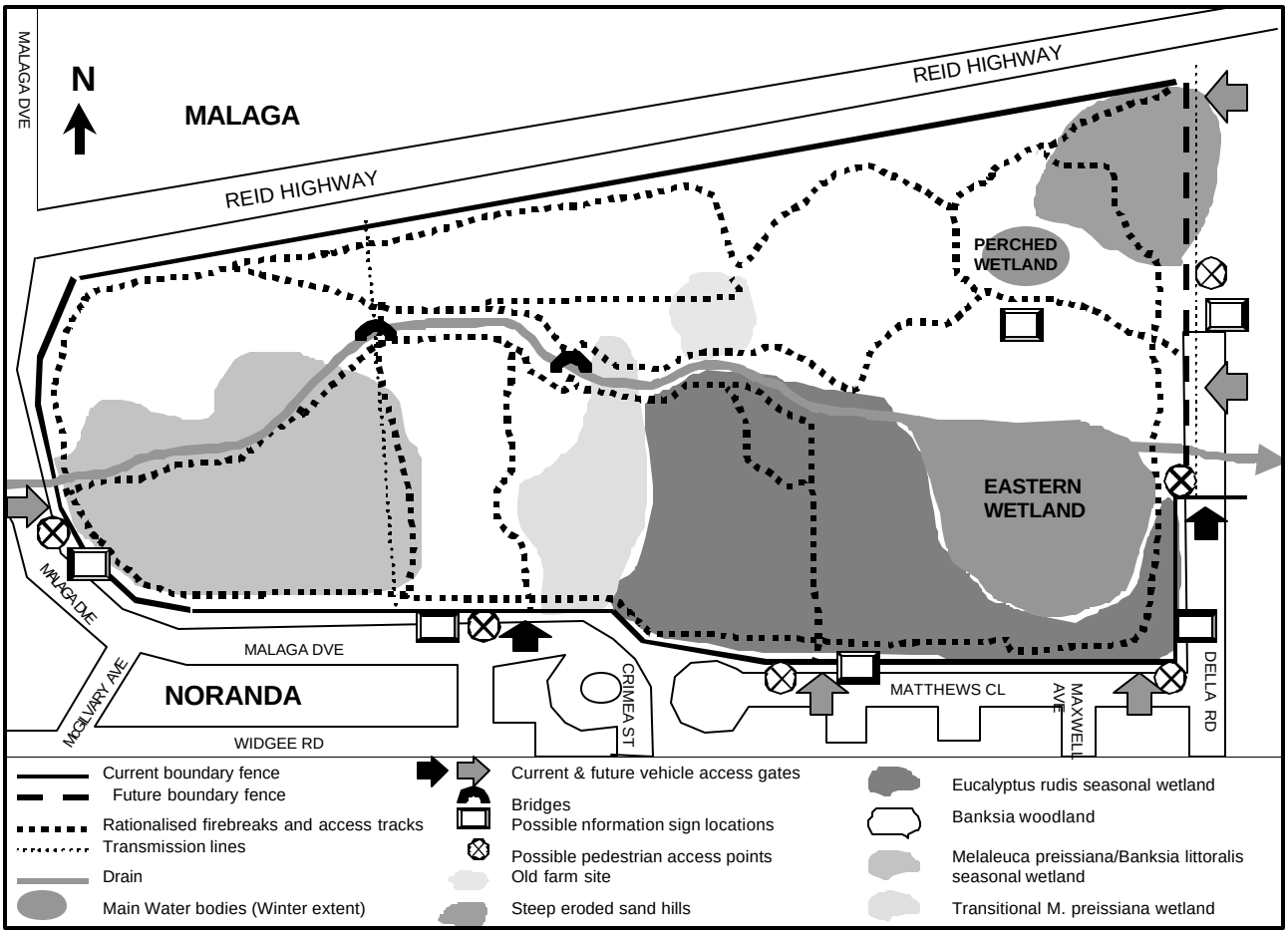


Figure 1.1: Lightning Swamp Bushland

Other areas of bushland in the vicinity include the regional reserves of Whiteman Park and Bennett Brook, which were included in the 1983 System Six report published by the Environmental Protection Authority. The report proposed the conservation of important natural areas of bushland and wetlands within the Darling System (Department of Planning and Urban Development, 1994). Lightning Swamp was included in Perth's Bush Forever (2000) as Site 307. Bush Forever is an initiative of the State Government which aims to protect and manage areas of regional natural significance to achieve a comprehensive, adequate and representative reserve and protected area system (WAPC, 2000)

LSB is also linked to important bushland areas in Dianella and Mirrabooka by the Greenways scheme and Main Road bushland corridors along the Reid Highway.

The drain that runs through the bushland eventually flows into the Bennett Brook Reserve. It is therefore essential that the bushland and wetlands be retained in healthy condition so that they can filter and improve the quality of water leaving the site, and subsequently entering Bennett Brook.

1.6 Need for a Management Plan for Lightning Swamp Bushland

This valuable area of natural bushland is currently declining in value due to the uncontrolled and illegal access by four-wheel drive vehicles and trail bikes, rubbish dumping, and frequent fires. Rabbits are creating enormous damage throughout the reserve, while foxes are a danger to native fauna species. There is an increasing use of the area by local residents for passive recreation, such as jogging or walking dogs. There is a need to address the increasing degradation of the natural flora caused by the presence of Phytophthora Dieback, and to manage the area for sustainable community use.

1.7 Administration of the Lightning Swamp Bushland Management Plan

This management plan and the recommendations contained within shall be in force for an initial period of five (5) years, commencing from its final acceptance by all concerned participants. This initial period will be followed by a review, after which the plan will be in force for another period of five years.

A committee similar to the City of Bayswater's Lightning Swamp Working Party, consisting of representatives from managing bodies and interested members of the community such as the Friends group, is required to oversee the plan and deal with any interim contingencies or catastrophies such as major chemical spills, drought deaths or severe fires. In addition, it will be necessary to establish an implementation sub-committee to facilitate and oversee the recommendations contained within the plan.

1.8 Objectives of the Lightning Swamp Bushland Management Plan

1. To protect, conserve and rehabilitate the natural habitat to ensure the continued survival of locally native flora and fauna.

2. To ensure sustainable and responsible public use of the area.

3. To develop and promote an understanding of the value and importance of the natural environment in the community.

4. To protect cultural and heritage values of the area.

1.9 Recommendations

It is recommended that:

1.9.1 The management plan is to be in force for an initial period of five years, followed by a review, then another period of five years.

1.9.2 A committee is to oversee the implementation of this management plan, deal with any interim contingencies, and review the plan as per 1.9.1.

Section 2.0 Historical Perspective

2.1 Aboriginal History and Significance

The LSB lies in an area of the Swan Coastal Plain once inhabited by the Mooro tribe, and was one of several wetland areas used for activities such as hunting. The Mooro tribe occupied the area bounded by Moore River to the north, Ellen Brook to the east, the sea to the west and the Swan River to the south (Figure 2.1). The people of the tribe were the Oordalkalla, led by Yellagonga (c. 1780-1843) (Brittain 1990).

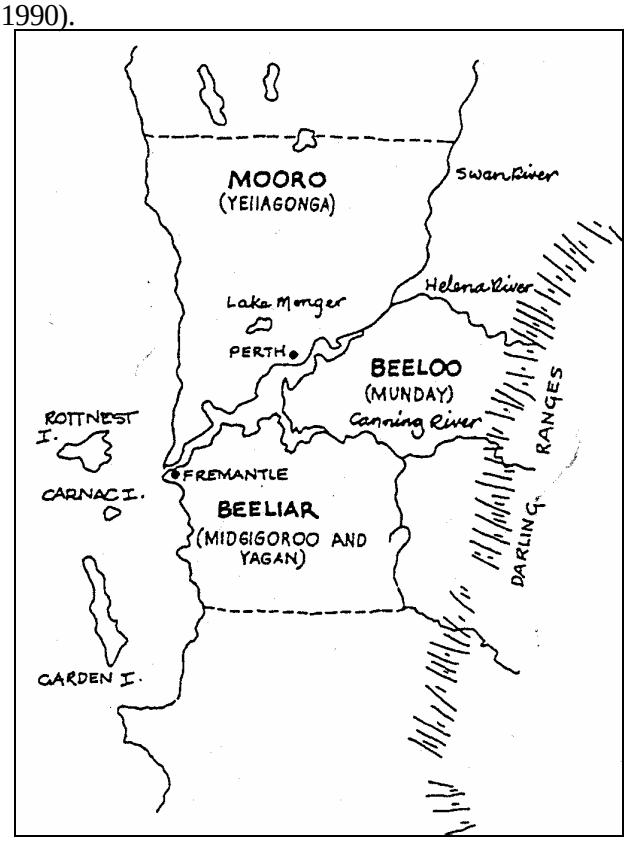


Figure 2.1: Aboriginal tribal districts around Perth

The main camp of the Mooro was at Goodinup (Mt Eliza). However, when the British arrived in 1829, the tribal leader Yellagonga yielded this camp to the 63rd Regiment and retreated with his people to Galup (Lake Monger) (Brittain 1990). The surrounding region provided refuge, and yearly burning and seasonal movements continued, but the population of the Mooro tribe soon went into decline due to encroachment by European settlers, disease and collapse of their lifestyle (Brittain 1990).

In 1988 the area was subject to an ethnographic investigation in response to a proposal regarding the construction of a link road from Crimea Street, Noranda, to Marshall Road, Malaga. The study was commissioned by the State Planning Commission and conducted by Rory O'Connor and Associates. It involved a review of past literature and consultation with a number of Aboriginal people retaining cultural links to the area. The areas of wetland were found to be significant as sources of food. The land was used for kangaroo hunting and yugoyne (long-necked tortoise) harvesting by Aboriginal people camped in Guildford and in the vicinity of Bennett Brook. This usage of the land extended into quite recent times, probably the late 1950s (O'Connor and Bodney 1988).

The importance of swamps as significant sources of food has also been documented by Brittain (1990) and Berndt and Berndt (1979). They identified crustaceans (eg. Marron, jilgies, coonac), frogs and insect larvae as other types of food, which were found in trees such as *Xanthorrhoea, Acacia, Eucalyptus* and *Banksia*.

LSB is not registered with the Department of Aboriginal Affairs. However, as a result of its importance as a hunting ground (O'Connor and Bodney 1988), it is defined as a site under Section 5 of the *Aboriginal Heritage Act* (1972). Under Section 17 of the Act, no area of a site should be damaged or altered, and it is an offence to do so unless authorised by the Trustees of the Western Australia Museum under Section 16, or consented to by the Minister for Aboriginal Affairs under Section 18 (Balla 1994).

The owner of the LSB (WAPC) should seek written permission from the Aboriginal Cultural Material Committee early in the planning process of any proposed development, or implementation of any management plans (Balla 1994).

To prevent violation of Section 17, an updated ethnographic and archaeological survey of LSB must be conducted. This would augment the original survey by O'Connor and Bodney (1988) which was commissioned for the sole purpose of development of perimeter roads, rather than for development of the actual wetland.

All development recommendations in the management plan are therefore subject to authorisation by the Trustees of the Western Australia Museum, or consent from the Minister.

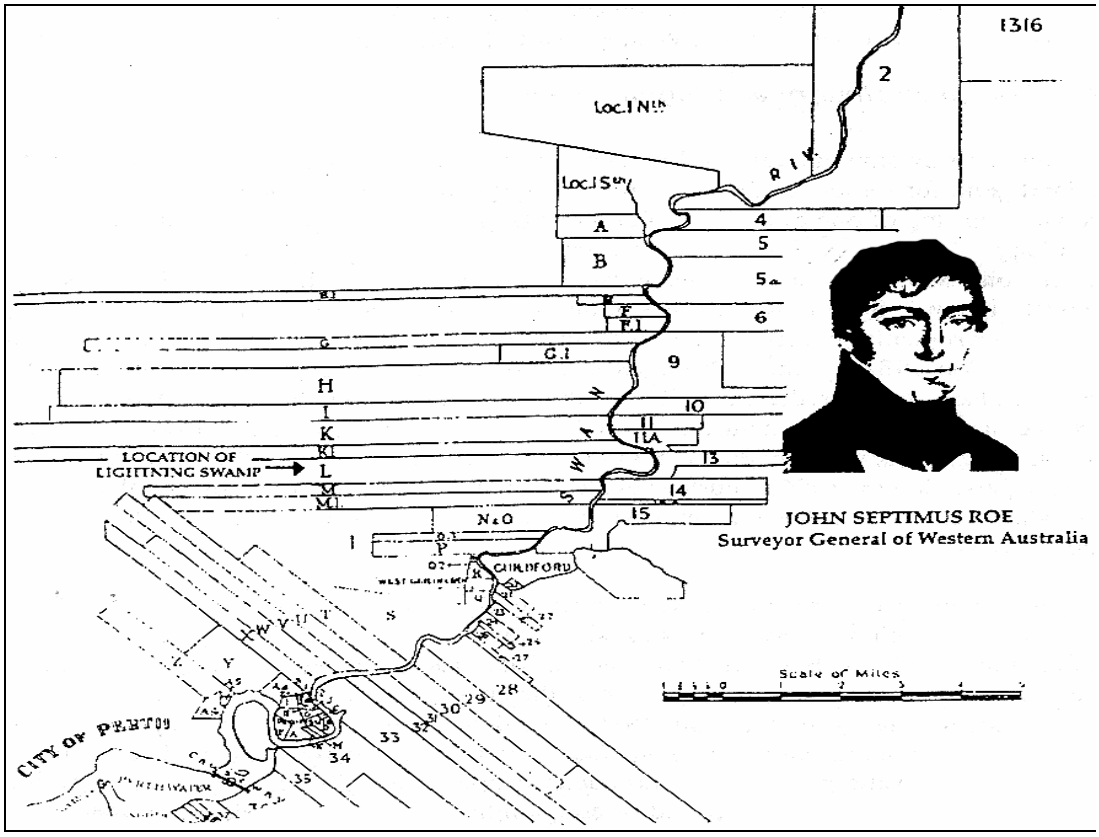


Figure 2.2: Allotment of Land Surveyed and Allocated by John Septimus Roe in 1829

2.2 European History and Significance

LSB entered the European historical records of Western Australia as part of the very first land grant for settlers of the Swan River Colony, in 1829 (Burton undated). The wetland area was a portion of one of a series of allotments given to civil, naval and military officers in the colony. The allotments were surveyed and allocated by the colony's first surveyor-general, John Septimus-Roe, and his assistant H. C Sutherland (Burton 1982; Bourke 1987). LSB formed part of the Swan River allotment called Location L (Figure 2.2). It was originally granted to J. S Roe himself, who named the land Sandalford but never used it (Burton 1982). James Broun, Roe's son, leased the property to a farmer and later Roe's grandson, John Frederick, built two dwellings on the Sandalford property. However, given the narrow elongated nature of the lot and the poorer soils further away from the river (Seddon 1972), it is unlikely the area was ever utilised for anything other than rough grazing (Bourke, pers. Comm.1996). Further evidence that the land remained essentially unused by early white settlers was the ongoing use of the area by Aboriginal people (O'Connor and Bodney 1988).

Location L remained intact in the Roe family until 1894, when records show that the area, including LSB, was subdivided and partly sold (Department of Land Administration 1996). Between that time and the 1960s, when the WAPC began purchasing it, the various lots covering the area belonged to numerous different owners (Department of Land Administration 1996). Evidence found in the area suggests that there was a brick building present at one time.

Other evidence of settlement includes a large cleared area (Fig. 1.3) and the presence of introduced Cape Lilac trees in the center of LSB. This was the location of a predominantly poultry farm owned by the Luderman family, established in 1932 and worked until the land was reclaimed in 1969 or '70. An oral account by members of the family is held by the Friends of LSB, while the farm is clearly identified in aerial photographs from 1949. The Luderman family have agreed to allow the use of their photographs when and if interpretation signs are situated in this location, to assist with retaining part of the area's early history.

2.3 Past Management and Use

The Metropolitan Regional Scheme 1963, under Section 33, designated LSB (as part of a larger area) Parks and Recreation which provided development controls and the ability to purchase the land is a decision which saved it from other uses. Under this zoning the WAPC was obliged to purchase the individual lots. Prior to this the land was in private ownership and there was no control over it's use until the rezoning in 1963.

There are no past management plans for LSB, and management has been limited to basic maintenance such as fencing (Robinson, pers. Comm. 1996). The only fire prevention policy has been the inclusion of fire breaks, and these have been maintained by the WAPC (Robinson, pers. comm. 1996).

2.4 Recommendation

It is recommended that:

2.4.1 An updated ethnographic and archaeological survey of the area is conducted in consultation with the local aboriginal community.

2.4.2 Relevant historical and cultural information is incorporated into strategically placed interpretation displays in LSB.

Section 3.0 Physical Environment

3.1 Climate

As LSB is located on the Swan Coastal Plain, the climate of the area can be described primarily as that of the Perth region. The climate is considered Mediterranean, consisting of two distinct seasons; a hot, dry summer and a cool, wet winter (Seddon, 1972).

3.2 Geology

Swan Coastal Plain

LSB is situated on the geomorphic element known as the Bassendean Dune System. The Bassendean Dune System is one of five elements that together form the Swan Coastal Plain. The Swan Coastal Plain extends west from the Darling Scarp to the Indian Ocean having a width of between 20 to 30 kilometres *(Department of Conservation and Environment* 1980), and ranging in elevation from 0 to 75 metres above sea level (Wilde & Low 1978). It is formed almost completely from either aeolian or fluvuate activity (McArthur & Bettenay 1974).

The Swan Coastal Plain displays distinct landforms that run parallel with the current coastline with the aeolian sediments originating in the west, and the alluvial sediments in the east (Seddon 1972).

The five geomorphic elements beginning at the foothills of the Darling Scarp and moving westward are - the Ridge Hill Shelf, the Pinjarra Plain, the Bassendean Dune System, the Spearwood Dune System and the Quindalup Dune System.

The Bassendean Dune System

Moving from east to west, the fertile alluvial soils of the Pinjarra Plain dissipates into the first and oldest of the dune systems known as the Bassendean Dune System. This Geomorphic element represents the accumulation of beach sand during the Pleistocene period (approximately 1.6 million years ago), when the Bassendean System existed as the most western landform of the Darling Scarp and constituted the coastline.

Originally the soil was calcareous in nature, similar to the type found on current coastal beaches, but through the passage of time all the carbonate has been leached out leaving insoluble quartz sand grains (Seddon 1972).

The low dune landforms evident today may not be where they originally built up due to the action of wind. They may also have been planed off at about the 30 metre contour by the last (mid Pleistocene) marine reworking of the old surface (McArthur & Bettenay 1974).

Bordering with the west side of the Bassendean Dune System is the Spearwood Dune System which is often separated by a line of swamps or lakes (McArthur & Bettenay 1974).

The Bassendean Dune System has seasonal swamps running parallel to the present coastline that become dry in summer due to factors associated with evaporation and a receding water table. The water table ranges from 0 to 30 metres below ground level and is a source of Perth's groundwater (Gnangara mound) (Wilde & Low 1978).

Types of Soils Found in LSB

The classification of different units in the Bassendean system relates mainly to their association with swamps *(Department of Conservation and Environment 1980).*

* Bassendean Sand - very light grey at surface, yellow at depth, fine to medium grained, sub rounded quartz, moderately well sorted of aeolian original (Gozzard 1986).

* Thin Bassendean Sand over Guildford formation (Gozzard 1986) - also referred to as Southern River Complex (Churchward & McArthur 1978). Initially in 1978, Churchward and McArthur produced a geological survey map with the scale 1:250000 describing an area where sand appeared to have been blown over alluvial soils (Guildford Formation) producing swamps with clay bases.

* In 1986, Gozzard produced a much more detailed geological survey operating in a scale of 1:100000. His investigation identified the geological action of the prevailing south westerly winds acting on the Bassendean Dunes producing swales and the resulting thin layer of soil over Guildford formation (Gozzard-personnel communication 1996). In retrospect the two surveys are open to individual interpretation although they both describe the same geological phenomena. Churchward and McArthur (1978) describe Southern River Complexes as sandplains with low dunes and many intervening swamps with iron and humus podozols, peats and clay.

* Swamp deposts (found in perched wetland) - described as Peaty Clay soils which are dark grey and black with variable sand content of lacustrine origin (Gozzard 1986).

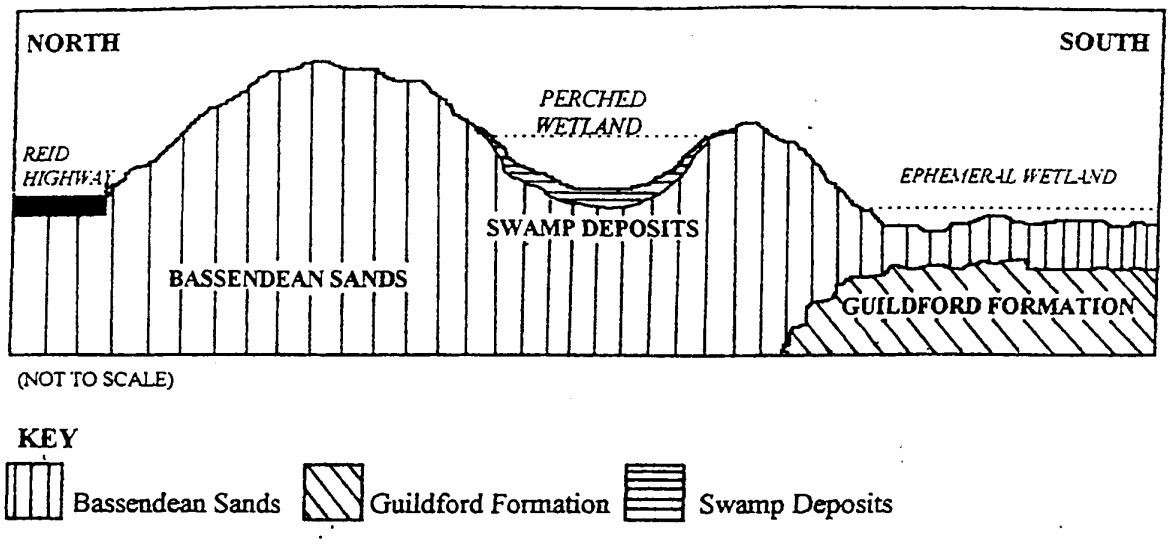


Figure 3.1: Location of Soil Unit

Bassendean Sand

In general, the ancient age of soils of the Bassendean Dunes, means that they are the most heavily leached of the three dune systems. Described as podzols (leached of iron compounds and lime) they are agriculturally poor, but at the same time species rich, being inhabited by banksia low forest with a diverse understorey of shrubs (refer to 5.3). However the associated swamps, often peaty, are used

for intensive culture using the shallow groundwater for irrigation (Department of Conservation & Environment 1980).

The dune soils are grey quartz sands, with very low levels of calcium, iron and most other minerals and are described as chemically and physically infertile (Seddon 1972).

Due to the high permeability and low water holding capacity leaching is active and any small amounts of clay or silt fraction is quickly washed out of the profile.

Being massive in structure, there is a general absence of horizon differentiation except for a darker A_1 horizon from the accumulation of organic matter (Stace *et al* 1972). The sands appear to have a dark brownish grey A_1 horizon of low to moderate organic content grading below into strongly leached pale yellow to whitish sands which may occur to depths of more than 7 metres (Stace *et al* 1972).

The yellow sands of the Bassendean dunes consist of quartz, felspar, heavy minerals and kaolin (Glassford & Semeniuj 1989). The yellow colouration is the result of goethite-stained coating of kaolin and quartz on the grains (Glassford & Semeniuk 1989).

The removal of carbonate over a 100,000 to 200,000 year period (McArthur & Bettenay 1974) and formation of an organic B horizon, through intense leaching have contributed to making the soil mildly acidic.

Guildford Formation

The Guildford Formation that underlies the Bassendean Sands of the ephemeral wetlands is alluvial. It consists of clay, loam, sand and gravel and is a mixture of piedmont, lake river and estuarine sediments. On the Swan Coastal Plain it is up to 30 metres thick, and ranges from 15 metres below the sea level to 15 metres above, deepening in the west (Seddon 1972).

The Bassendean Sand over Guildford Formation (Southern River Complex) starts at 10 metres above sea level and finishes 55 metres above sea level (Gozzard 1986).

3.3 Erosion

Description

The sandy nature of the two soil types in LSB make them highly susceptible to erosion following removal of vegetation. Erosion processes occurring in the area include primarily wind and mechanical erosion. On the whole, erosion processes in the study area are site specific in distribution, and related to quantity of vegetation cover, degree of exposure to prevailing winds, intensity of use (recreation, vehicles, etc.) and slope.

There is an extensive and very active area of wind erosion occurring in the north east corner of the study area (see Figure 1.1), coincident with high wind exposure (high position in the landscape, oriented to prevailing easterly winds and cleared area upwind) and which is resulting in the inundation of native vegetation in the area downwind. The disturbed nature of the vegetation in this area and its position in the landscape are the main contributing factors. In terms of rehabilitation, this area should

be of high priority as the size of the active erosion area has the potential to spread and inundate more of the native flora.

There are several sites throughout the study area which, due to land-use activities (including four wheel drive use, bushwalking, drain construction), are degraded and are partially or totally denuded of vegetation as a result. These areas may be susceptible to erosion by wind; however, they are generally surrounded by vegetated areas, low in the landscape, and therefore protected from the wind to some degree so that active erosion is not actually occurring.

Wind erosion in the North East corner of LSB (Photo – Sarah Dawson)

Mechanical erosion is occurring on the various vehicle tracks and walking trails in the area. Some of these are service, fire control and proposed recreation paths and should be stabilised. Sealed paths or roads are not recommended in the area due to the runoff they generate. This tends to concentrate water and nutrients to certain areas resulting in increased weed growth. Other alternatives such as crushed limestone pathways should be researched (Refer to Section 8.4 for further information).

3.4 Fire

Fire Management Plan

Because of the importance of fire prevention and management in urban bushland areas, comprehensive strategies have been developed for LSB. These are contained within Appendix 11.1, the *Lightning Swamp Bushland Fire Management Plan.*

Fire Behaviour

Fire behaviour is often unpredictable, commonly leaving a path of destruction and scorching the vegetation. However, it is known that hot, intense fires regularly occur during the summer/autumn months in Perth, when the humidity is low and temperatures are high (Underwood & Christensen, 1981). The dry winds during this period also help to transport the fire and increase its area of burn. In particular, fires move more rapidly up slopes, as the flames are closer to the fuel bed. Thus, the slopes of LSB are areas susceptible to rapid wildfires.

Frequent, high intensity wildfires are known to reduce the species diversity of flora within an area, as well as provide an avenue for the colonisation of introduced weed species, such as veldt grass.

Records from the Western Australian Fire Brigade indicate that fire at LSB is a frequent event. For example, between July 1994 and 1996 there have been 15 reports of bush, grass, scrub and rubbish fires within the boundaries of LSB (Burns, 1996).

Areas of Risk

As fires are frequent within the boundaries of LSB, it is important to consider the area and its inhabitants that would be most affected in the advent of a fire. This includes the flora and fauna of LSB, some of which are sensitive to fire. Property, houses and lives can be destroyed by fire. One objective of this plan is to minimise that risk.

3.5 Recommendations

It is recommended that:

3.5.1 The severely eroded north east corner of LSB is stabilised to eliminate its impact on the bushland, while other areas at risk of eroding are monitored.

3.5.2 The fire management plan is reviewed in accordance with the overall management plan, and in consultation with FESA.

3.6 Glossary for Section 3

Aeolian - material which have been transported or laid down on the earth's surface by the wind.

Fluviatile - deposits produced by the action of river and/or rivers.

Goethite - anhydrous iron oxide (FeO, OH) which occurs in earthy forms as various shades of yellow, red and brown.

Kaolin - is a hydrous aluminium silicate and is a common weathering product of many minerals such as feldspars. It is usually white, unless stained by impurities and occurs as earthy aggregates.

Lacustrine - refers to lakes and relates to the formation of the soil due to lake sediments.

Piedmont - a gentle slope leading from the foot of a mountain (in this case the Darling Range) to a region of flat land.

Podozol - soils whereby the upper reaches are leached of iron and aluminium compounds, lime and/or organic material. Podozols make poor agricultural soils.

Pleistocene - refers to geological time classification of a period approximately 1.6 million years ago.

Section 4.0 Hydrology

4.1 Introduction

Several waterbodies lie within LSB including the Widgee Road Branch Drain of Wonga Road Main Drain which traverses the entire length of the area. The main water bodies that are formally recognised (Hill *et al*, 1996) and illustrated in Figure 4.1 are:

* Eastern Wetland
* Western Wetland
* Perched Wetland
* Damplands
* Widgee Road Branch Drain of the Wonga Road Main Drain (open drain).

Perched wetland in LSB, August 2002 (Photo – Sarah Dawson)

Current Situation

Although in reasonably good condition, the wetlands have experienced changing conditions as the surrounding land has been developed. Subsequently, changes to the hydrology of the area have occurred. Some of these changes have been detrimental to the water bodies, therefore future management should include control of such conditions. The underlying cause of the changes is the increased influx of water into the bushland through increased runoff from surrounding land and increased recharge to the groundwater. Changes that have occurred directly or indirectly from the altered hydrology in this area include:

* Algal blooms in Eastern Wetland and Widgee Road Branch Drain
* Slow drainage through the area
* Waterlogging
* Wetlands increasing in size
* Changes in flora species diversity

These conditions and other hydrological problems should be corrected or controlled with management of the wetlands, groundwater, drainage and water quality.

4.2 Wetlands

Wetlands can be defined as an area of permanent, seasonal or intermittent inundation, whether natural or otherwise; fresh, brackish or saline; static or flowing (Environmental Protection Authority, 1993). LSB has three different wetland bodies. There is a perched wetland and two seasonal wetlands referred to here as the Western and Eastern Wetlands. All have been classified as sumplands (Hill, 1996). There is also an area of dampland along the drain where there is seasonal waterlogging (refer Figure 4.1).

Perched Wetland

The perched wetland is located in the north east of the bushland. This wetland is predominantly damp due to the underlying peaty clay, which has a poor hydraulic conductivity. Therefore water mainly leaves through evaporation and evapotranspiration.

The perched wetland appears to be in good condition. However, degredation to both flora and the physical landscape has occurred due to the use of off-road vehicles in the area.

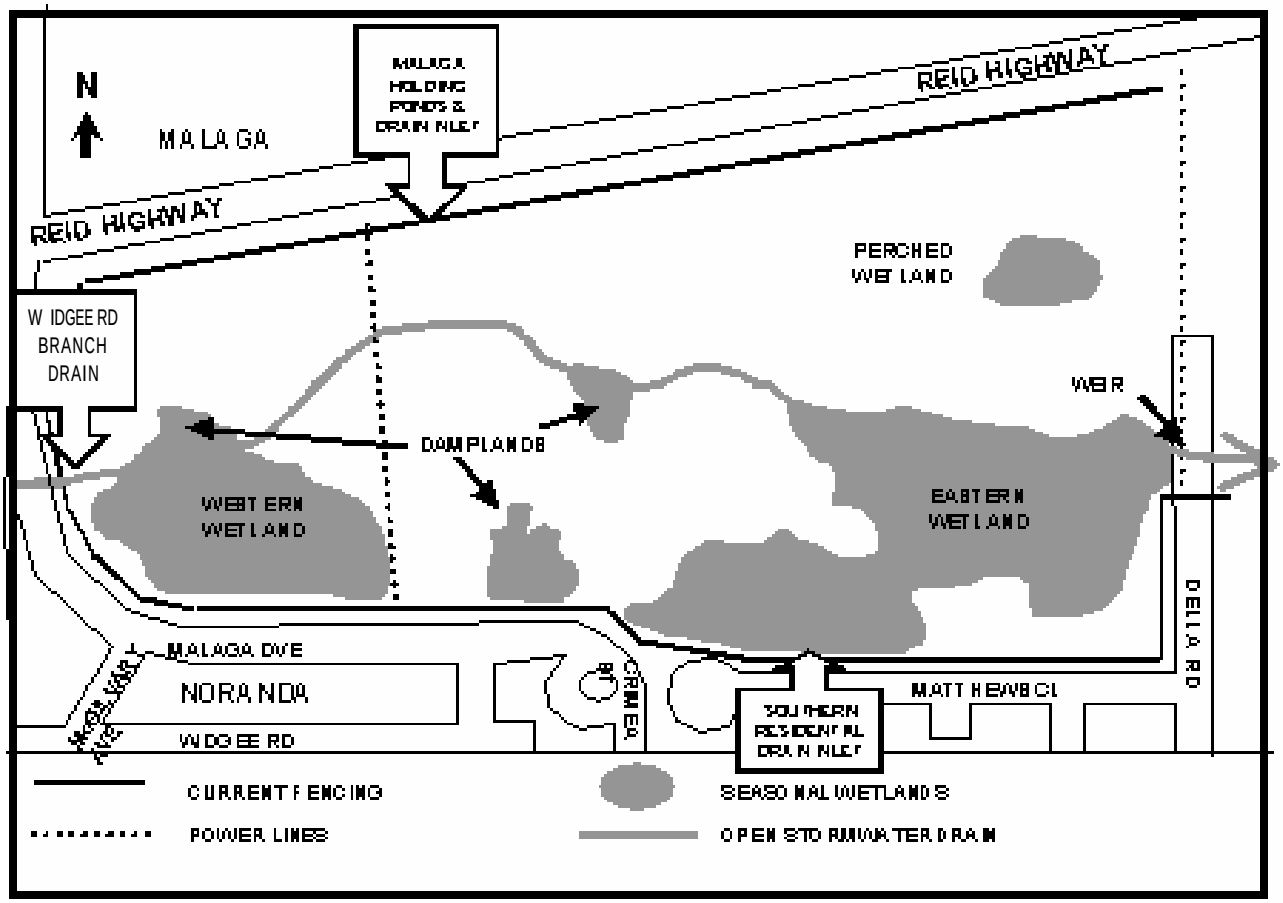


Figure 4.1: Groundwater locations in Lightning Swamp Bushland

Western Wetland

This wetland is found in the south western corner of the area. This wetland is shallow and there are no signs of algae. The wetland is found on a gradual slope, is relatively shallow (<0.5m), has no definite banks, and waterlogging is occurring at the edges. This is causing the fringing vegetation to evolve and change characteristics.

4.3 Groundwater

The groundwater influences the location and structure of the Eastern and Western wetland. Seasonal fluctuations in the water table depth (low in summer and high in winter) are partly responsible for fluctuations in the water level of wetlands. Other factors such as drainage and bore water extractions would see these fluctuations increase in magnitude (City of Melville, 1991).

Groundwater Flow

The general flow is from the north to the south-southeast with flow being strongest in the south-east region (refer Fig.4.2). This has implications for the management of the groundwater as any contamination from the Malaga industrial area to the north will flow directly through the bushland and into the wetlands. Therefore, there is a need to constantly monitor and control the quality and/or quantity of water entering from Malaga to the north.

Surface water bodies such as wetlands or sumps exist as a thin region of high permeability (low resistance) and provide a path of least resistance to groundwater flow (Management Proposal, Murdoch University, 1994). This causes a local effect where groundwater surrounding the wetlands are drawn both vertically and horizontally towards them, altering the groundwater flow in the immediate vicinity.

4.4 Drainage

Water Inlets

Water from the Wonga Road Main Drain catchment area enters the bushland via three main inlets:

1. Wonga Road Branch Drain - via McGrath Place Pumping Station.
2. Malaga Drive Branch Drain (industrial area TPS 14) situated north.
3. "Southern Residential" Branch Drain situated south.

In addition to these three main inlets which flow into the Widgee Road Branch Drain, stormwater drains positioned along Crimea Street, Matthews Close, Malaga drive, and Reid Highway also flow into the bushland.

It was observed in 1996 that the Widgee Road Branch Drain inlet was partially blocked by refuse, so having an impact on rate of water flow. It is important that both inlets and outlets are functioning effectively and not impaired in any way.

The Main Roads Department (MRD) provides drainage facilities to remove stormwater from its road systems, directing runoff to local authority drains, Water Corporation drains or to infiltration basins. Local authorities are responsible for the control of local surface drainage within council areas. It is this fragmentation of responsibility which can be a source of problems within the overall drainage system. Water quality issues relating to this are covered in Section 4.6.

Water Outlets

Water exits via a culvert channelling throughflow from the eastern wetland into the continuing Widgee Road Branch Drain, which flows on and into Bennett Brook (approximately 4km to the East).

Water Content

Waters entering via Widgee Road Branch Drain, typically include stormwater discharge and runoff from the residential area of Noranda. Likewise, waters collecting in the main Southern Residential Local Authority Drain (iii) will include similar types of discharge and runoff from Noranda and Morley.

Waters entering via Malaga Drive Branch Drain will include stormwater discharge from the Malaga industrial area (including 'grey' water from the various businesses). Much of the future business activities of the Malaga area are as yet undefined, but concerns have been raised as to potential levels of hazardous substances (eg. heavy metals) which may flow from this Branch Drain.

An infestation of *Typha orientalis* in the Widgee Rd Branch Drain, LSB (Photo – Kim Grace)

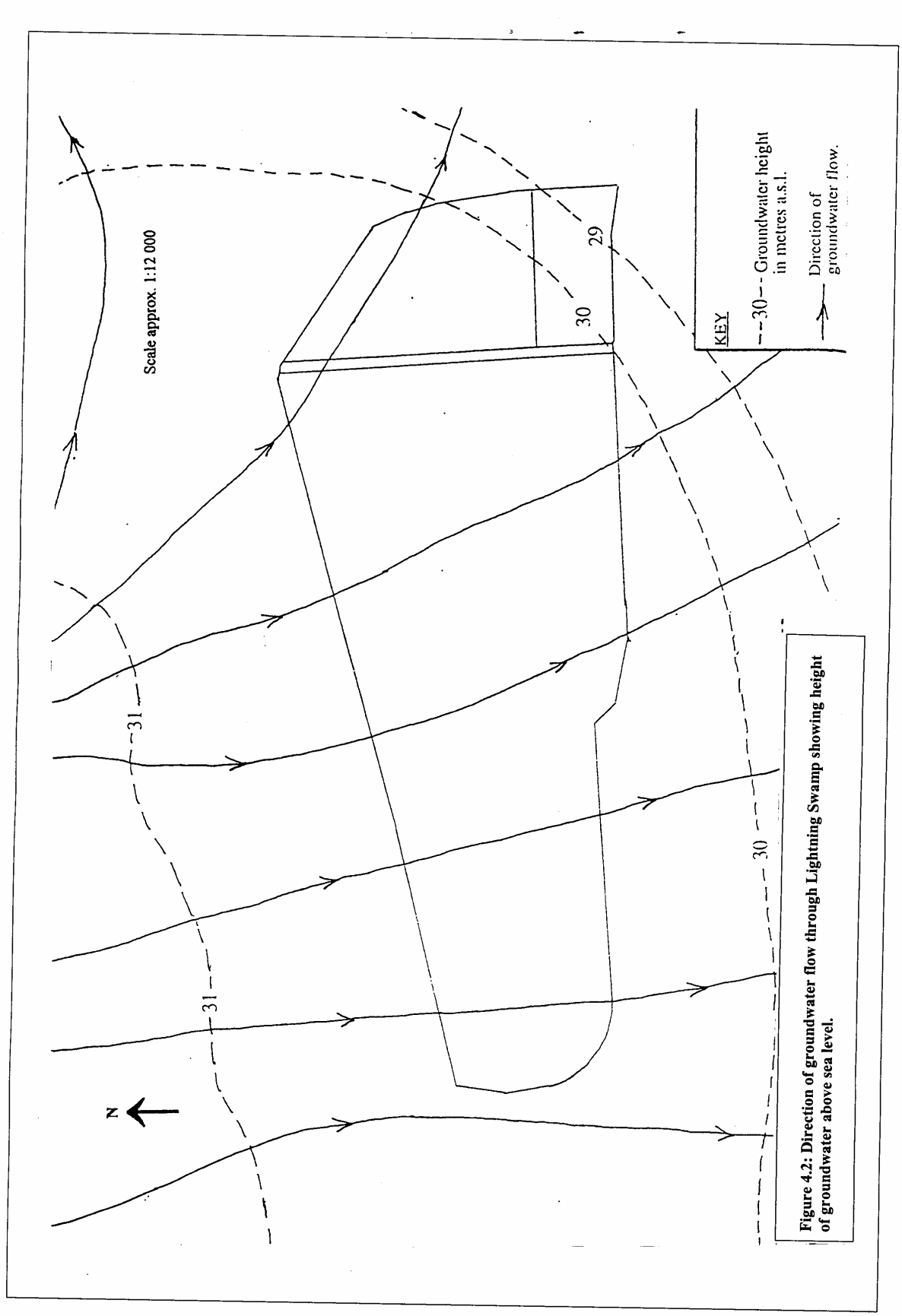


Figure 4.2: Groundwater Flow in LSB

Controlled Drainage

When drainage issues are being managed to maintain and enhance the environment, recommendations should be considered in conjunction with the water sensitive guidelines developed by the Water Sensitive Urban Design Group (DPUD, 1993). The water resource management objectives of maintenance of water balance, maintenance and where possible, enhancement of water quality, and maintenance of related environmental values (and best planning practices) are all integral to current and proposed drainage regimes.

Historically, the mainstay for these wetlands was groundwater, while now the wetlands are subject to diverse influences, including watersheds from highways and local access roads, an altered water table and free-flowing water via drains. This has resulted in changes to the vegetation and ecology of LSB, so that areas once inundated for substantial periods of time are now relatively dry, while once dry areas are now underwater during winter months.

While it would be preferable to return LSB back to something resembling the pre-development water regime, this does not appear to be realistic, either economically or environmentally, and may even result in negative effects to vegetation now adapted/adapting to the new conditions. However, the key to preventing any further degradation to the wetlands is to closely monitor the quantity and quality of water coming from outside LSB.

Neither Widgee Road Branch Drain, Malaga Drive Branch Drain nor the Southern Residential Local Authority Drain currently have any specific filtering devices in place. Of particular concern in the risk posed to the integrity of the waterbodies by pollution from the Malaga Drive Branch Drain (outlet from TPS 14). In this area, water flows through a system of five compensating basins, and various control mechanisms can be utilised at these locations.

Of concern also is the possible flow into the Widgee Road Branch Drain of fuels, chemicals and/or other hazardous substances spilled in traffic accidents on the Reid Highway (section within the Wonga Road Main Drain catchment) as occurred on July 16, 2001. Accidental spills or large-scale seepage of organic compounds could have major detrimental effects on wetland flora and fauna.

A contingency plan should be devised to alleviate or prevent such possible impacts on wetlands. The plan would need to contain a list of possible pollutants and their potential environmental risks, and outline preventative measures, which can be taken.

Widgee Road Branch Drain

This is an open drain that was constructed in the late 1970s; it peters out about 500 meters from Della Road where stormwater from surrounding urban developments discharge into the (seasonal) eastern wetland. Due to the nature of the land contours and the relative heights of drainage inlet points, during periods of intense storms there is actually reverse flow (E-W) in the section marked as AB on Fig. 4.3. Further, between points B and C, water flow slows significantly due to C being marginally higher than B (Vadja, 1996).

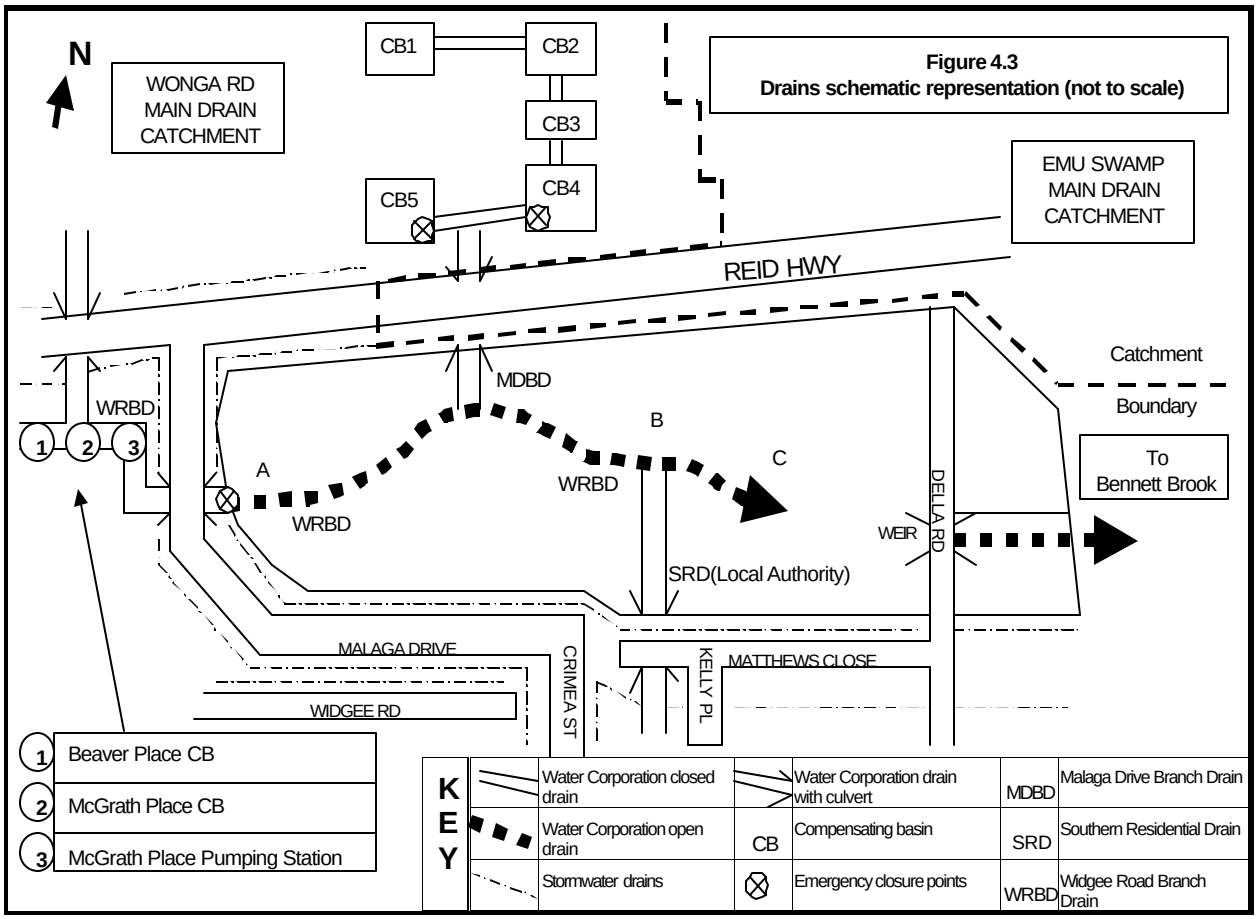


Figure 4.3 – Drain schematic representation

Increasingly, in the winter months, the levels of water in the eastern wetland and the western wetland have been rising. Flooding has actually been recorded within the residential location of Kelly Place; this is in part due to the relative heights of sections of the Widgee Road Branch Drain (see above) and also due to the inadequacy of the "Southern Residential" Branch Drain in times of intense storms (Vadja, 1996).

The effect of increased water levels has several negative impacts upon the wetland ecosystem, in addition to those related to water quality. Consideration has been given to various means by which water levels can be returned to something akin to naturally occurring levels via adjustment to the drainage system.

Peak Possible Flows from Primary Drain Inlets
(Vadja, 1996)

* Malaga Drive Branch(TPS 14) - ~ 200 Litres/sec
* Widgee Road Branch Drain (Via McGrath Place Pumping Station) - ~ 450 Litre/sec
* "Southern Residential" Local Authority Drain - > 600 Litre/sec

Based on the current drainage regime and figures for peak possible flows from main inlets, consideration can be given to the most appropriate changes to the system.

4.5 Water Quality

The water quality is currently determined by residential wastewater and road runoff which may include oil, nutrients (mainly from organophosphate fertilisers), pesticides and herbicides, heavy metals and suspended solids whether coming from point sources or non-point sources. The future will see an increase in the amount of runoff from industrial wastewater from the adjacent light industrial area. Through proper management strategies, the quality of the water should be maintained or improved and the input of pollutants reduced.

Nutrients

Nutrients are essential for the growth of plants. However, excess input of nutrients from artificial sources such as domestic and industrial wastewater can lead to algal blooms. The widespread problem of industrial and residential pollution is the input of organic wastes and nutrients which cause eutrophication of waterbodies (Davis and Chambers, 1996). The eutrophication process leads to the development of algal blooms.

Current Situation

Due to the lack of available water quality data, algae growth is the only visually apparent problem with the water quality. The algal growth is concentrated in the eastern wetland, after the entry of the Southern Residential Local Authority Drain, which suggests that the main point source of nutrients is via urban runoff.

Another indicator of the detrimental effects of excess water and nutrient levels is the presence of invasive plant growth associated with drains, in particular, *Typha orientalis* (Bullrush). This plant, which is more suited to prolonged inundation and higher nutrient levels than native species, has colonized the western half of the Widgee Road open drain. There is also a small stand of the local variant, *Typhus domingensis.* Bullrush responds aggressively to the current conditions in the drain, and previous disturbance caused by mechanical removal, and produces masses of easily transported seed. If allowed to spread, the bulrush will do so at the expense of other native wetland species such as *Baumea articulata.*

The presence of *T. orienalis* and algal blooms at the confluence of the Widgee and Southern Residential drains suggests that steady, adverse changes in soil characteristics due to sediment may also be occurring. A sediment load may alter soil pH, redox potential, texture and structure.

No water quality monitoring is currently undertaken on the wastewater, which enters this drainage system.

Future Management of Nutrient Levels

If nutrient input should increase, it could result in increased eutrophication, algae growth, odours, midges, invasive weed growth, and possibly aquatic fauna deaths. Excessive nutrients may be controlled via nutrient stripping flora, however, these natural filtration methods will eventually reach maximum capacity if the nutrient level continues to rise. Subject to the results of water quality testing for nutrient levels, a combination of the following procedures could be implemented depending upon the severity of the nutrient levels:

* development of an education program for the Malaga industrial area to minimise pollutant runoff.
* development of an education program for the community to reduce nutrient runoff.
* research into pollutant control devices which can be fitted into the drainage system.
* the use of local species only for the purposes of nutrient stripping in drains.

Heavy Metals

Heavy metals, such as lead and mercury, are extremely detrimental to ecosystems. They are generally not needed for biological processes and are toxic to living organisms even at low concentrations (Dingle, 1996). Once introduced into aquatic food chains, heavy metals have the ability to accumulate in organisms and for concentrations to amplify through biological systems. The main problem concerning heavy metal is their apparent ease of penetrating living cells and interfering with biochemical processes (Dingle 1996) and their persistence in the environment. Heavy metals are extremely difficult to remove once present in an aquatic system such as a wetland as they do not readily break down and quickly become part of the sediment of the water body.

Sources of Heavy Metal Contamination

Heavy metals could indirectly be introduced in several ways. They are often present in industrial discharge and wastewater, for example, mercury used in the production of plastic and other products (Chiras, 1994). This highlights the importance of monitoring the drain water coming from the proposed industrial area if light manufacturing or refining plants are built in the area. Heavy metals could also contaminate groundwater if they are present in water sitting in compensating basins which intersect the water table. Lead, a potentially harmful metal, is found along roads and is emitted from car exhausts therefore runoff from urban areas may transport lead into the bushland. Both drainage and groundwater represent a means of transport for heavy metals.

Current Situation

As no water sampling has been conducted on the wetlands in the bushland, the current levels of heavy metals are not known. As no level is necessarily "safe" for biological systems all efforts should be made to reduce the input of heavy metals. Identifying point sources and increasing the depth of compensation basins are methods of reducing heavy metal contamination.

4.6 Recommendations

It is recommended that:

4.6.1 A baseline study of the surface water quality be prepared which measures the water quality of:

* **the three main input drains**
* **the perched wetland**
* **the Widgee Branch drain output culvert at eastern edge of Lightning Swamp**

4.6.2 A weir replace the eastern wetland output culvert to allow for greater control of water levels (completed, May 2001).

4.6.3 A risk management plan is prepared to prevent or mitigate accidental chemical or other contaminant spillage within the total water catchment area draining into the Widgee Road Branch Drain.

4.6.4 Main Roads Western Australia is approached to ensure that a spillage plan for the Reid Highway drainage system is developed.

4.6.5 A long-term strategy is developed to control and eradicate Typha orientalis from the drain by means other than mechanical digging.

4.6.6 Rehabilitation of the drain with local species is conducted to assist with the process of nutrient stripping.

Section 5.0 Flora

5.1 Introduction

LSB contains a mixture of plant communities from winter-wet swamplands with *Eucalyptus rudis* communities and sumpland to upland sites containing *Banksia-Eucalypt* woodland communities. Of note are the significant stands of *Nuytsia floribunda*, the WA Christmas Tree (Dixon, 1993).

The bushland sits on the Bassendean Soil Complex and partially on the Southern River Complex. The natural vegetation on these dunes is very rich in species; the dunes are the main home of the low banksia forest, which has a very diverse understorey of shrubs (Seddon, 1972).

A survey conducted by B.J. Keighery in October 1995 identified 129 plant species from four sites on the eastern portion (Keighery, 1996). One species, *Macarthuria apetala*, found in the survey was designated a priority two species at the time (Department of Conservation and Land Management, 1995), but is now a priority three. The survey gives a good indication of the flora on the eastern side and highlights the need to conduct a comprehensive floristic survey. *Banksia ilicifolia* (Holly Leaf Banksia) woodlands, Floristic Community Type 22, are poorly reserved and their conservation status is considered susceptible (Gibson *et al*, 1994).

Since 2000, an ongoing and extensive survey of the flora in LSB has been conducted by the Bennett Brook Catchment Group Herbarium Team (see the progressive flora list at Appendix 11.3). This has resulted in the identification of over 150 species including the declared rare flora species, *Caladenia huegelii*, and the addition of another priority three species, *Jacksonia sericea.* These species are protected under the WA Wildlife Conservation Act, and as such, a penalty of up to $10,000 can be enforced if they are illegally removed or damaged (O'Donohue, 2001). Several species that occur in LSB are protected under the same legislation. Deliberate damage occurred to one of these species, a Melaleuca preissiana tree, in 2001.

5.2 Vegetation Communities in Lightning Swamp Bushland

Zone 1: *Eucalyptus rudis* Seasonal Wetlands

The eastern seasonal wetland is the dominant feature of this zone and has a distinct influence on the floral community, *Eucalyptus rudis* (Flooded Gum) and *Melaleuca preissiana* (Stout Paperbark) are the dominant tree species with *Nuytsia floribunda* also occurring in the region. *Adenanthos cygnorum* (Woollybush), *Regelia ciliata* and *Xanthorrhoea preissii* (Grass Tree) tend to dominate the shrub layer of the terrestrial plants. Weeds in the terrestrial environment are dominated by *Ehrharta calycina* (Perennial Veldt Grass) with other weed species occurring in abundance near the eastern perimeter of this zone.

Aquatic plants are dominated by the sedge species: *Lepidosperma longitundinale* (Sword Sedge), *Juncus pallidus* (Pale Rush), and *Baumea juncea*. The seasonal nature of this wetland is common for the Swan Coastal Plain (Lane and McComb, 1988).

The current nature of the eastern wetland has serious implications for the vegetation of the area. The present hydrological regime (see Section 4), influenced by the drain, is flooding areas not necessarily contained within the "original" wetland. Although rushes and sedges can adjust to flooding, prolonged flooding can lead to the degradation and even loss of fringing tree communities (Froend *et al*, 1993). Species such as *E. rudis* and *M. preissiana* rely on seedling recruitment to change their distribution and higher water levels can reduce recruitment potential (Froend *et al*, 1993). Hence the structure and seasonality of this vegetation community is likely to be altered should raised water levels persist.

While the new weir outlet constructed at the Della Road entrance will effectively take away more water from the line of the main drain, it will be necessary to study and possibly alter the levels of land to the south of the main drain, where it appears that deep water levels remain well after the rest of the eastern wetland dries up or drains away. This may be the result of a gradual build up of silt, or artificial banking caused by extensive damage from off-road vehicle access in the past.

In 2001 a survey for Dieback found the wetlands of Zone 1 to be extensively infected by the *Phytophthora cinnamomi* fungal disease. Because of the extent of the infection, there is little that can be done to treat the area, except preventing its spread into unaffected areas (see Appendix 11.2 for further information).

Zone 2: Banksia Woodland

This site is typical of many Banksia woodlands of the Bassendean sands, despite some part of this zone being of the Southern River Complex; however the presence of a declared rare flora species gives it additional conservation value. Of all the zones this is the most extensively studied, and it includes sites surveyed by Keighery (1996).

The dominant tree species include *Banksia menziesii* (Firewood Banksia), *B. attenuata* (Candlestick Banksia), *B ilicifolia (Holly leaf Banksia), Nuytsia floribunda (Christmas tree)* and *Eucalyptus todtiana* (Prickly Bark). *E. Todtiana* prefers crests of sandy rises, and thus highlights the relationship between the topography and vegetation of this zone (Seddon, 1972). Less common trees in this community include *Coryumbia calophylla* (Marri), *E. rudis* (Flooded Gum) and *M. preissiana* (Stout Paperbark). A second storey community consists of various shrub species including, *Xanthorrhoea preissii, Macrozamia riedlei* (Zamia Palm), *Allocasuarina humilis* (Dwarf She-Oak), *Jacksonia furcellata* (Grey Stinkwood), and *Adenanthos cygnorum.* The understorey contains *Hibbertia sp., Conostylis sp., Patersonia occidentalis* (Purple Flags), *Conospermum stoechadis* (Common Smokebush) and *Alexgeorgia nitens* (Keighery, 1996).

Of some conservation value are the species of *Orchidaceae* (Orchids) and *Stylidiaceae* (Triggerplants) present within this zone. Although no priority orchids were recorded by Keighery during her study, several species of the genus *Caladenia* (Spider Orchids) were observed (Keighery 1996), and as already noted the declared rare flora species, *C. heugelii*, has since (2001) been identified by Dr Andrew Brown of CALM.

Of particular significance, *Macarthuria apetala*, a then priority two species, was found in a survey of the area (Keighery, 1996). Priority two taxa are species with one or a few known populations with some not under immediate threat (Kelly *et al, 1993).* Although not currently endangered, a priority two designation notes the taxa as under consideration to be declared "rare flora", but further

study is required urgently (Kelly *et al*, 1993). Since this study, the species has been re-designated as a priority three species.

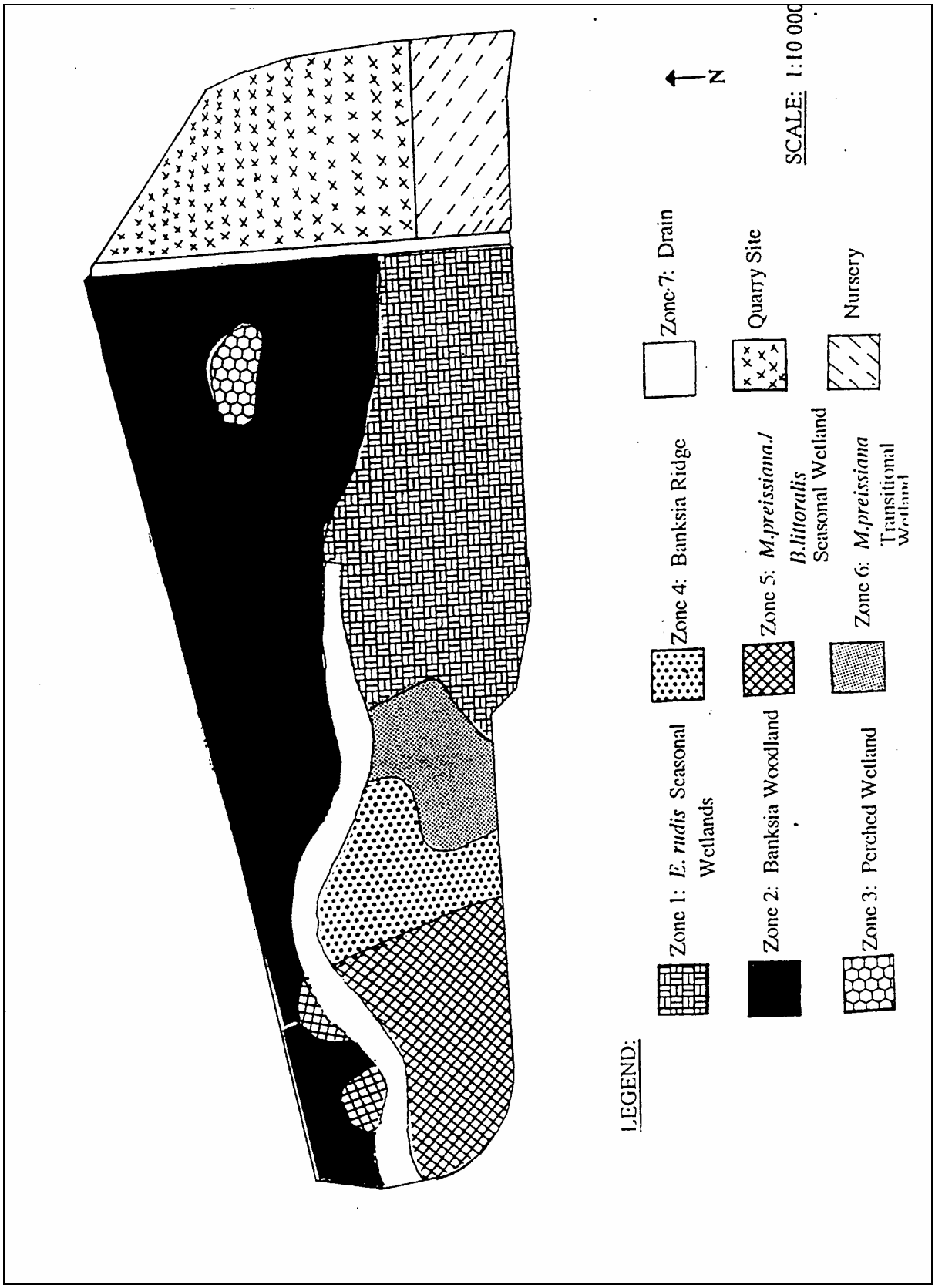


Figure 5.1: Vegetation communities in LSB

Banksia woodland in LSB, August 2002 (Photo – Sarah Dawson)

Zone 3: Perched Wetland

Perched wetlands (wetlands not connected to the ground water) are relatively rare on the Swan Coastal Plain, as most wetlands are ground water fed (Balla, 1994). The water is usually contained within the wetland by either peat, clay or a ferruginous hardpan (Balla, 1994).

The perched wetland in the north eastern corner of the site is surrounded by a large area of banksia woodland. This zone is in good condition. Weed infestation is minimal and restricted to the fringes of the wetlands resulting from disturbance such as 4WD tracks. The predominant weed is *Ehrharta calycina.* There is considerable loss of vegetation due to disturbance from off road vehicles.

Its floral assemblages are unique in that they more closely resemble those of a permanent water body. Species such as *Baumea articulata* and *Baumea arthrophylla* dominate with *Melaleuca preissiana* forming part of the littoral community. Other species associated with such areas include *Centella asiatica* and *Villarsia albiflora.* There are few problems regarding eutrophication and little evidence of aquatic weed invasion.

In 2001 a survey for Dieback found the area around the perched wetland to be extensively infected by the *Phytophthora cinnamomi* fungal disease. Because of the extent of the infection, there is little that can be done to treat the area, except prevent its spread into unaffected areas, and treating re-growth that is susceptible (see Appendix 12.2 for further information).

Zone 4: Banksia Ridge

Dominated by Banksia woodland species *B. ilicifolia* and *B. menziesii*, this zone could be considered as a transition zone. It forms a barrier between the two seasonal wetlands and shows some similarities to both Zone 2 and Zone 6. Similar to Zone 6 the tree species *Coryumbia calophylla* and *Melaleuca preissiana* are present with *Allocasuarina fraseriana* (Common She-

Oak) also a part of this community. Dominant understorey species include: *X. preissii, M. riedlei, Hibbertia* and *Beaufortia*. The weed *Gladiolus caryophyllaceous* (Wild Gladiolus) is relatively abundant.

***Hibbertia hypercoides* (Common buttercups) in LSB (Photo – Sarah Dawson)**

In 2001 a survey for Dieback found the outside edge of this low ridge to be extensively infected by *Phytophthora cinnamomi.* It has been treated by the Friends group through spraying and injection of the affected understorey and tree species with Phosphonate Acid which effectively kills the fungal disease for a certain period (see Appendix 2 for further information).

Zone 5: *Melaleuca preissiana, Banksia Littoralis* Seasonal Wetland

The wetland in this zone is in excellent condition, as a result of having had little or no impact from the drain. Terrestrial plants include *Melaleuca preissiana, Eucalyptus calophylla, Banksia littoralis,* and shrubs of *Hibbertia sp, Xanthorrhoea preissii, Patersonia occidentalis, Adenathos sp.* and *Scaevola repens* (Fan Flowers). Aquatic vegetation includes at least one species of Restionaceae, an unidentified water weed, and species of *Baumea.* Among the weed species of the area, *Carbrobrotus edulis* (Pigface) features prominently.

Dense stands of rushes such as *Baumea* inhibit the spread of *Typha orientalis* (Bulrush), thus this area appears to be at low risk of invasion (Froend *et al,* 1993).

Given this site does not receive water and nutrient input from the drain the current likelihood of algal blooms is low. Possible problems could occur if nutrients do enter this system.

In 2001 a survey for Dieback found this area to be extensively infected by *Phytophthora cinnamomi*. The most important species affected by the condition is *B. littoralis* and individual trees in Zone 5 will require protection through injection with Phosphonate Acid for a certain period (see Appendix 2 for further information).

Zone 6: *M. preissiana* Transitional Wetland

This area shows a similarity to zones one and four, with a greater representation of woodland species. It is generally dominated by the tree species of *Melaleuca preissiana, Eucalyptus calophylla, Banksia littoralis* and *Nuytsia floribunda.* The water tolerant species *(M. preissiana, B. littoralis)* are interspersed with woodland species. A shrub layer of *Hypocalymma angustifolium* (White Myrtle), *Xanthorrhoea preissii,* and *Patersonia occidentalis,* form a mixed understorey.

The transitional nature of this site makes it particularly vulnerable to changes in the hydrological regime, as the woodland species have lower tolerance to waterlogging. In 2001 a survey for Dieback found the edges of this area to be extensively infected by *Phytophthora cinnamomi*. This will require the establishment of a protection buffer zone through injection and spraying with Phosphonate Acid (see Appendix 2 for further information).

Zone 7: Drain

The drain zone is predominantly a continuous stand of *Typha orientalis*. Included in the drain is a small stand of *Typhus domingensis*, Indian water fern (an exotic weed), and mats of algae. *T. orientalis* is known to colonise waterways and disturbed areas rapidly by seed or vegetatively and can displace local rushes and sedges (Bartle *et al*, 1986). *Typha orientalis* is native to eastern Australia but not to Western Australia. Although it serves a useful purpose in removing nutrients from the water, and as bird habitat, it does cause problems for water flow. Indian water fern is of similar concern due to its ability to clog waterways.

Terrestrial and littoral species found immediately adjacent to the drain include *Hypocalymma angustifolium, Melaleuca preissiana* with *Eucalyptus calophylla* toward the western end of the drain.

In 2001 a survey for Dieback found both sides of the drain to be extensively infected by *Phytophthora cinnamomi*. Due to its extent, there is little possibility of effectively treating the problem, except to prevent its spread into unaffected areas by establishing treated buffer zones as discussed in Appendix 2.

5.3 Dominant Weed Species and their Distribution.

In the context of this management plan the term weed may be used in reference to those species of plants that invade native communities or ecosystems in the area and are undesirable from an ecological perspective (Hussey & Wallace, 1993). The invasion of weed species amongst the vegetation communities of LSB, can largely be attributed to the dumping of rubbish, frequent fires and physical disturbances such as 4WD tracks. Many of the exotic plant species are typically native to South Africa or other Mediterranean regions, and can rapidly modify the structure and composition of natural communities (Smith, 1985). Figure 5.1 presents the dominant weed species present, while the flora list at Appendix 3 offers a larger list.

Table 5.1: Dominant Weed Species Present at Lightning Swamp

Species Name	Common Name
Arctotheca calendula	Capeweed
Avena fatua	Wild Oats
Bromus hordeaceus	Soft Brome
Ehrharta calycina	Perennial Veldt Grass
Fressia afin.l Leichtlinni	Freesia
Gladiolus caryophyllaceus	Wild Gladiolus
Juncus articulatus	Jointed Rush
Lupinus consentinii	Sandplain Lupin
Solanum-nigrum	Black Berry Nightshade
Ursinia anthemoides	Ursinia

The greatest invasion risk to those native communities remaining is likely to be presented by *Bromus hordeaceus*, *Erharta calycina*, and *Avena fatua* (Wild Oats). These three species can be regarded as "disturbance opportunists", as they respond to disrupted sites with prolific germination and growth (Hussey & Wallace, 1993). They can potentially out compete and displace native vegetation within a very short time frame if disturbances are substantial and frequent. *Bromus hordeaceus* and *Ehrharta calycina* are more common along the northern extremity of the Banksia woodland (Zone 2). In some areas they have completely excluded native species from the understorey in both burnt and unburnt areas. They have also colonised smaller areas throughout LSB along the sides of 4WD and walking tracks as well as along the borders of Malaga Drive. *Avena fatua* was mainly distributed along the track that separates the recreational and conservation areas, and has not significantly infested other areas of Lightning Swamp as yet. Once infestation of any of these three species occurs they can exploit conditions of disturbance such as the intensity and frequency of fires to enhance their spread and retard the recruitment of native species.

Gladiolus caryophyllaceus is consistently spreading throughout all of the communities. However, it does not present itself as an immediate threat as it does not spread as fast as other weeds. *Lupinus consentinii* (Sandplain Lupin) has not smothered large areas, but is well established adjacent to Malaga Drive and at the main entrance in Della Rd. This emphasises the profound impact that the disturbances associated with roads and tracks have in allowing introduced species to gain a foothold in original plant communities.

Another factor which allows weed species to become established is an increase in soil nutrient levels. *Archototheca calendula* (Capeweed), is typically suppressed by the infertility of Australian soils, however rabbits often disturb the ground and their dung raises nutrient levels encouraging the growth of this weed (Hussey & Wallace, 1993). *Arctotheca calendula* has invaded certain areas and is confined to areas of high disturbance associated with 4WD tracks. Less dominant weeds include *Freesia affin. leichtlinni*, which occurs in one isolated patch towards the north-eastern corner of the Banksia woodland, and *Ursinia Anthemoides* (Ursinia) in two areas along Malaga Drive).

5.4 Weed Control

Terrestrial Weeds

Established weeds can cause significant environmental damage as they compete with native species for resources and are able to colonise disturbed or degraded areas rapidly. There are several dominant species of weeds that have been found in LSB (see Table 5.1), some of which present a very real fire danger to the area, for example, Wild Oats *(Avena fatua)* and Perennial Veldt Grass *(Ehrharta calycina)*. However, while certain areas do contain serious weed infestation, such as the drain easements, the outer perimeter, and on the northwestern end, LSB is in a relatively weed-free state.

The removal of weeds manually is environmentally desired; however, due to the extensive invasion this is not feasible, except in small patches. The most successful chemical control of Veldt Grass and Wild Oats is with the use of Fusilade, as recommended by Kings Park (McQuoid, pers. comm. 1996), but will often result in an increase of substitutes such as flatweed. It may be necessary to employ contractors, particularly after fires when weed growth out-competes native regeneration.

The outer verges surrounding LSB will require regular slashing and/or mowing by the City of Bayswater, especially prior to seeding, to reduce future weed growth and the fire risk.

A detailed and extensive weed control plan should be developed and implemented for LSB, including a weed map overlay for the vegetation map. At the same time, common weed identification workshops for members of the community as well as City of Bayswater grounds staff will prevent the accidental removal of native species while concentrating efforts on major problem weeds.

Aquatic Weeds

Bullrush *(Typha orientalis)* is prolific within the open drain and is quite difficult to remove. The recommended method is to remove the flowers which are the seed source, then during autumn cut the stems below the water level. This will cause the plant to rot, and by repeatedly cutting it during the growing season, the plant will eventually die (Scheltema *et al*, 1995). Another method is to cut and wipe the plant with bioactive Roundup which has been used with reasonable success in 2001.

The previously used method of using large machinery to remove bullrush is *not* recommended due to the re-growth created by soil disturbance, as well as the loss of life of fauna species such as the Long-necked Tortoise *(Chelodina oblonga)*, frogs and freshwater crayfish.

5.5 The Effects of Introduced Fauna on Flora

The health of native flora can suffer enormously as a consequence of feral animals and native fauna competing against each other for finite resources such as food and habitat which plants largely provide.

Rabbits, *Oryetolagus cuniculus*, pose a greater threat to the flora than any other introduced fauna. Their preference to graze on green, growing vegetation has heavily retarded the growth of seedlings and resprouts, particularly in those areas recovering from recent fires. Rabbits are selective grazers, eating many native plants, and have the potential to decimate preferred species, for example flowering shoots of orchids (Hussey & Wallace, 1993). This is significant as a declared rare orchid species has been identified in LSB. The construction of warrens can also result in severe soil disturbance, destroying vegetation by burial or damaging root systems. The soil disturbance that they cause creates suitable sites for weed invasion and their habit of depositing their dung in piles further encourages this by altering the nutrient status of the soil (Williams *et al*, 1995). There is also the strong possibility of *Phytophthora cinnamomi* being transported through both burrowing activities and dung.

The native flora of LSB can also be threatened by grazing, trampling or digging by foxes, feral cats or dogs let off a leash, but to a far lesser extent than by rabbits. Nutrient levels in the excrement and urine of these introduced species can also have a detrimental effect, particularly if large numbers of dogs are introduced into the area. The management of introduced fauna is contained in Section 6.8 of this plan.

5.6 Effects of Fire on Vegetation

The present vegetation reflects its history of frequent fires. There have been fifteen fires in the area since July 1994, one occurring in March 1996 of high intensity (Burns, 1996). Factors effecting the survival of plants after a fire include the frequency and intensity of fires, seasonality, type of fires,

topography of the area and the distribution of fire (Department of Environment, Sport and Territories, 1994).

There are two main fire responses in plants. Plants that rely on their seed storage in the ash bed to regenerate are known as 'seeders'. They are characterised by high seed production and some store their seeds in structures that open upon heating (Recher & Christensen, 1981). Although germination is induced by fire these plants cannot withstand frequent fires as they require between two and ten years to recover and produce more seed (Hobbs, 1995). Plants that resprout from their bark or rootstock are called 'resprouters' (Hobbs, 1995), these species are more fire resistant than seeders (Christensen *et al.*, 1981). See Figure 5.2 for the effects that various factors have on survival of seeders and resprouters.

Fire and Lightning Swamp Bushland Vegetation

According to Hobbs and Atkins (1990) seeders make up a small proportion of Banksia woodland. At LSB the main areas affected by fire seem to be regenerating through epicormic resprouting. These species include *Banksia menziesii, B. attenuatta, Xanthorrhoea preissii* and *Eucalyptus calophylla.* The vegetation here reflects the herbaceous cover common in young burns evidenced by the presence of *Xanthosia, Stylidium* and *Opercularia* (Bell & Koch, 1980).

There are several native species that are considered fire weeds as they are so well adapted to fire. These species include *Acacia pulchella* (Prickly Moses), *Hibbertia hypericoides* (Yellow Buttercups) and *Stirlingia latifolia* (Blueboys) (Bell & Kosh, 1980; Seddon, 1972). The native trees such as species of *Banksia* and *Eucalyptus* appeared to be regenerating quite well through resprouting but lack of saplings and young trees in large burnt out areas is a cause for concern. *Hybanthus calycinus* (Native Violet), *Anigozanthos humilis* (Cat's Paw) and native orchids were present in recently burnt areas.

Erharta calycina and *Solanum nigrum* rapidly spread after a fire choking out slower growing native species (Seddon, 1972). This changes the fuel characteristics by providing plenty of fuel, leaving the area predisposed to fire (Christensen & Burrows, 1986). However, another exotic species, *Gladiolus caryophyllaceous* was very common all over the area, but noticeably sparser in distribution in recently burnt areas.

Figure 5.2 summarises the tolerances to fire of some of the dominant species.

Table 5.2: Fire Tolerance of Common Plants at Lightning Swamp

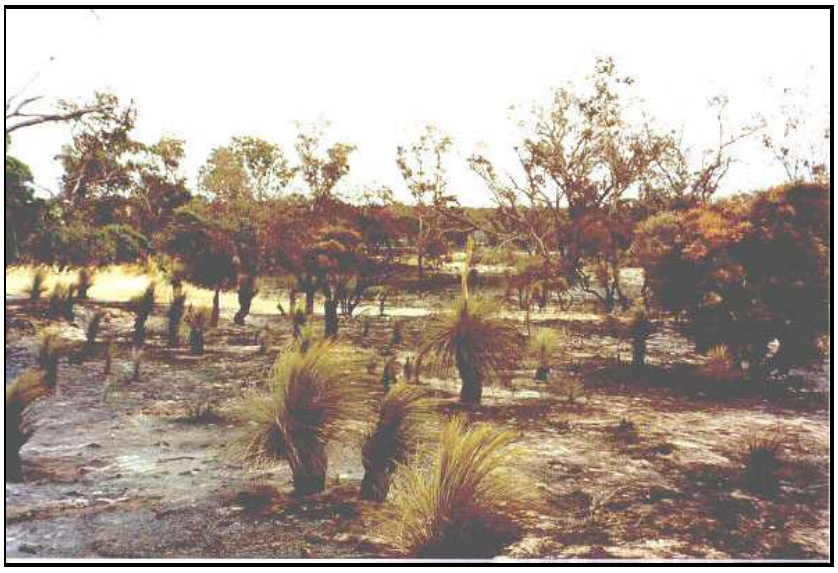
Introduced fire weeds	Native fire species	Fire tolerant natives	Native species promoted by fire/damaged by frequent fires
Ehrharta calycina *Solanum nigrum*	Acacia pulchella Stirlingia latifolia Hibbertia hypericoides	Eucalyptus calophylla E. todtiana Xanthorrhoea preissii	Caladenia flava Pterostylis species

There are three main characteristics of fire regimes that influence plant regeneration. These are outlined in Figure 5.2.

The management of fire is contained in Section 3.4 of this proposal, and in Appendix 1, *Lightning Swamp Bushland Fire Management Plan.*

Figure 5.2 - The effect of the fire regime on plant regeneration
(From: Hobbs, 1995)

FREQUENCY	SEEDERS:	must have enough time to flower and set seed
	RESPROUTERS:	must have enough time to build up a replacement food store
SEASONALITY	AUTUMN:	fires usually intense, rain soon follows
	SEEDERS:	germinate in ashbed with rain
	RESPROUTERS:	have water available for new food manufacture
	WINTER:	fires less intense, patch. Plants already growing
	SEEDERS:	germinate in ash bed with rain
	RESPROUTERS:	shoots destroyed before they have replaced their food stored food reserves
	SUMMER/SPRING:	hot dry season follows
	SEEDERS:	long wait in ashbed - insect or fungal attack may destroy seeds. Erosion may remove seeds and nutrients.
	RESPROUTERS:	delicate new growth under severe stress for long period.
INTENSITY	HIGH:	favours some plants. Consumes most of the above-ground material.
	LOW:	favours other plants. Patchy, some above-ground material not burnt.



The aftermath of a fire in LSB, December 2001 (Photo – Sarah Dawson)

5.7 Dieback

Dieback is the common name given to the disease caused by microscopic root rotting water mould belonging to the genus *Phytophthora*. Eight species of *Phytophthora* have been isolated from native vegetation in Western Australia. The most common and destructive species is *Phytophthora cinnamomi* (Hart, 1992).

These fungi are exotic and can infect and kill many native plants. The impact of *Phytophthora* disease on the environment is severe. It has the potential to damage entire ecosystems by altering the structure of the vegetation and degrading available habitat.

New infections are primarily caused by human activities that move soil and root material from infected to healthy areas, usually on the tyres of off-road vehicles and the feet of walkers.

In 2001 a Dieback survey of LSB was commissioned by the Friends of Lightning Swamp Bushland (FOLSB; see Appendix 11.2). The area was found to be extensively infected with *Phytophthora cinnamomi*, comprising approximately 45 hectares of LSB, most of this being wetland zones. Because of the extent of the infection, there is little that can be done to treat these areas, except to prevent its spread into unaffected areas by establishing treated buffer zones, closing and signposting tracks that traverse across unaffected areas from affected areas, limiting access to infected areas, and preventing further soil disturbance in LSB, for example, by plowing firebreaks.

Fortunately, the predominant soil type (Bassendean sand) and topography of LSB have retarded the spread of *Phytophthora cinnamomi* mainly to the low wetland areas, although the banksia woodlands have been affected in places, and will be devastated completely if left untreated. It is believed that Dieback may have been present in LSB for over 15 years.

Dieback control and treatment currently involves spraying and injecting techniques that minimise the spread of dieback disease and enhance fungi resistance by establishing buffer zones. However, the treatment must be repeated and on-going, for tree injection, approximately every three years and for understorey spraying, between six months and three years depending on species.

Preventative practices also involve the use of hygiene procedures where operations are likely to spread the disease, eg. washdown points for machinery, equipment and vehicles used in LSB. As such, all parties involved in maintenance and remedial works within LSB, for example, firebreak contractors, the Water Corporation and Western Power, must be made aware of the existence of Dieback, and the measures used to prevent its spread.

As part of any revegetation programs in infected areas it may also be necessary to modify understorey composition, that is, replacement of susceptible flora, such as *Banksia grandis* with more resistant legume species, such as *Acacia*, providing local provenance is maintained.

The full Dieback Report is enclosed as Appendix 2.

5.8 Recommendations

It is recommended that:

5.7.1 A comprehensive flora survey be completed and incorporated into a detailed and revised vegetation map of LSB.

5.7.2 Dieback treatment and preventative measures as recommended in the Dieback report are implemented.

5.7.3 As part of the overall education process, information on Dieback is made available to the general public, and operating procedures developed and distributed to authorities operating in LSB.

5.7.4 The preservation and protection of the declared rare flora and priority three species is a high priority.

5.7.5 A weed management plan including vegetation condition mapping be prepared and implemented. This should include the outer perimeter areas and allow for weed identification workshops.

Section 6.0 Fauna

6.1 Introduction

Many mammal species have either become locally or totally extinct in the Perth region since European settlement. The fauna in LSB has been subject to a number of disturbances in recent years, including the development of major roads, industry, and residential areas that surround the bushland habitat. These disturbances have the capacity to affect the fauna in a variety of ways including loss of habitat, pollution, introduced species, traffic casualties and noise. Due to these factors a large decline in species numbers is likely to have occurred. The native mammalian fauna of the area appears to be quite impoverished. The avian fauna, however, appears to be abundant and diverse, as is the reptilian and amphibian fauna.

Field observations during the initial Murdoch University project recorded 29 species of birds, 3 introduced mammals, 5 reptiles and 4 amphibian species. Since late 2000 there have also been monthly observations made for Bird Atlas Australia. On the basis of literature searches and known habitat preferences LSB may support approximately 86 bird species, 6 native and 6 introduced mammals, 39 reptiles and 10 amphibians (see Appendix 11.4).

6.2 Birds

The avifauna is characterised by the diverse and rich assemblage of birds. The avian fauna can be separated into bush birds and waterbirds. The presence of two ephemeral wetlands has significance for a large number of waterbirds, whilst the banksia woodland, heathland and riparian fringe of the wetlands, provides an ideal habitat for a large complement of bush birds.

During winter, the ephemeral swamps have the potential to act as important roosting and nesting sites for waterbirds such as the Eurasian Coot, Purple Swamphen and Maned Wood Duck, the former two species have been sighted on numerous occasions in the area. The presence of inundated thickets towards the western end of the larger southern wetland provides a secluded location for waterbirds, and a number of Eurasian Coots, Hardheads and Pacific Black Ducks have been recorded in this area. Observations of juvenile Eurasian Coots suggest that breeding may occur here. Other waterbirds such as the Sacred Ibis, Straw-necked Ibis, Yellow-billed Spoonbill, White-faced Heron, Pacific Heron, Little Pied Cormorant and Great Cormorant are almost certainly expected to occur in the wetlands where they forage for food such as invertebrates and fish (Lindsey, 1992).

During summer, when the wetlands dry out, they have the potential to attract a number of migratory waders which take advantage of exposed mudflats in order to forage for invertebrates. Such waders may include the Black-winged Stilt which has been recorded on numerous occasions at nearby Whiteman Park and many other urban wetlands. A number of other waders such as the Black-fronted Dotterel, Red-necked Avocet and various Plovers may also occur. Many of these birds are protected under international conventions and treaties such as the Japan Australia Migratory Birds Agreement and the China Australia Migratory Birds Agreement each of which cover migratory waders in the East Asian-Australasian Flyway.

Aside from the direct use of the wetlands by waders and waterbirds, species such as the Swamp Harrier occur in the area, and rely on the wetlands as an important source of food. The Sacred Kingfisher is a regular migrant to LSB, and at least four different individuals are known to occur in the area, including one juvenile. This may suggest that breeding of this species is occurring in the vicinity of the wetland.

Away from the wetlands, the extensive *Banksia* woodland and heathland provide an important habitat for a diverse range of bush birds. The most numerous bird group is that of the Meliphagidae (Honeyeaters), including Singing Honeyeaters, Brown Honeyeaters, White-cheeked Honeyeaters and Western Spinebills. Red Wattlebirds and Little Wattlebirds were not recorded during this survey but are almost certainly expected to occur, as are other honeyeaters such as the Tawny-crowned and New Holland Honeyeaters. The abundance of flowers such as *Banksia, Anigozanthos* (Kangaroo Paw) and *Nuytsia*, provide an important food source in spring and summer and would attract large numbers of honeyeaters. Other nectivorous birds such as the Silvereye are common in the area.

During spring and summer, the associated insect fauna will also attract large numbers of insectivorous birds such as the Rainbow Bee-eater, which were present in high densities throughout LSB. Other birds such as the Striated Pardalote, Weebill, Splendid Fairy Wren, Western Gerygone, Inland Thornbill and Yellow-rumped Thornbill also occur in the area and are attracted by the rich insect fauna. Rufous Whistlers make extensive use of the *Banksia* woodland and are good indicators that the habitat is in relatively fair condition. Birds such as the Thornbills and Wrens can be found in the thick heathland and riparian vegetation, which provides shelter for these species.

The Marri trees of the area are extensively used by parrots such as the Port Lincoln Ringneck, Red-capped Parrot, Western Rosella and a number of other parrots, which feed off the fruits and flowers. Of significance, is the White-tailed Black Cockatoo, which would almost certainly use the Eucalypts to feed upon. It may also drink from the wetlands in extensive flocks. This species is a Schedule One species and is thus of conservation significance. The varied Sitella may also inhabit the large Eucalyptus. The Black-faced Woodswallows make extensive use of large Eucalypts to roost and take-off from, whilst species such as the Tawny Frogmouth and Barn Owl may nest in such trees.

Many raptors may also use these trees as perches. A number of raptors are thought to occur in the study site, and the Swamp Harrier and Little Eagle were recorded during the study. The Brown Falcon, Australian Hobby, Australian Kestrel, Black-shouldered Kite and Wedge-tailed Eagle have all been recorded from nearby Whiteman Park and thus have the potential to occur in the study site.

Avian Corridors

LSB is in essence a habitat island, with the nearest major bushland area being Whiteman Park, some 5 kilometers northeast. Currently large tracts of bushland exist on the northern edge of Reid Highway. It is suggested that retention of areas of this bush will be beneficial in acting as a buffer for the industrial area and also as an avian corridor to facilitate exchange. It is noteworthy that some areas of this possible avian corridor are seasonally inundated and hence may also be important corridors for waterbirds.

The remnant vegetation to the north of Reid Highway is generally of sufficient magnitude to encourage dispersal of birds between habitats, although some replanting may be required. The retention of this habitat and its use as an avian corridor is essential to ensure the biodiversity of the local avifauna and to avoid a habitat island occurring.

6.3 Amphibians

The amphibian fauna was dominated by an abundance of up to ten frog species, of which four were positively identified during the survey (Appendix 11.4). The most prolific species is the Sandplain Froglet *(Crinea insignifera)*. Also found were the Quacking frog (*C. georgania)*, Western green tree frog *(Litoria moorei)* and the Slender tree frog *(L. adelaidensis*). The habitats generally utilised by frog species include the littoral fringe of the wetlands, the riparian strip of the drain, and the low-lying damp reed beds. However specimens were noted in the drier areas of the *Banksia* woodland.

6.4 Reptiles

There is a diverse range of reptile species expected to inhabit the bushland. Unfortunately an exhaustive list of reptiles has not been previously compiled, and indeed, a long-term survey of the reptile and amphibian species of LSB was begun in May, 2001, the results of which are not yet known. Based on known habitat preferences and ranges, up to 39 reptile species may occur, including tortoises, snakes, and lizards (Appendix 11.4). Five species were identified in the field, including the Bobtail *(Tiliqua rugosa)*, Western Worm Lerista *(Lerista praepedita)*, West Coast Ctenotus *(Ctenotus fallens)*, South Western Sandplain Worm Lizard *(Aprasia repens)*, and Western Tiger Snake *(Notechis scutatus)*.

The Long-necked Tortoise *(Chelodina oblonga*) is common in many wetlands on the Swan Coastal Plain, and was confirmed during bulrush clearing operations in May, 2001. During its breeding season females move away from the wetland to dry ground in order to lay their eggs. In recent years, the decline in remnant vegetation has forced the tortoises to cross the roads and has subsequently led to the death of many through injuries inflicted by traffic (Balla, 1994). Thus, a sufficient vegetation buffer zone would be required between the wetlands and the roads to prevent this.

Whilst reptiles may be found in all areas of the reserve, pieces of dumped rubbish such as cars and sheets of iron roofing are a preferred habitat. The noted abundance of the Western Tiger Snake and probable existence of other venomous snakes may be of some danger to the public, and should be signposted.

6.5 Mammals

As there has been no previous fauna study, the native mammal fauna remains largely unknown. Data obtained from nearby Whiteman Park indicates that there may have been a range of small and medium sized mammals present such as the Southern Brown Bandicoot *(Isoodon obesulus)*, Brush-Tailed Possum *(Trichosurus vulpecula)*, Echidna *(Tachyglossus aculeatus)*, and a number of bat species. The Southern Brown Bandicoot or Quenda has previously been found in high rainfall regions in the south west of Western Australia. This native species may tolerate human activity in

close residential areas, however, as it is small in size it is vulnerable to predation by dogs, cats and foxes.

Southern Brown Bandicoot (Isoodon obesulus) (Photo – Sarah Dawson)

On the Swan Coastal Plain the Bandicoot prefers to inhabit dense riparian heath that surrounds wetlands (Balla, 1994), providing them with food resources and refuge from predators. The open *Banksia* woodland is a habitat more suited to the Brush-Tailed Possum and Echidna, however, these animals do not survive well in small bushland habitats (How and Dell, 1993).

6.6 Fish

The presence of native freshwater fish has not, as yet, been determined and thus a more detailed study of the wetlands would be required. Such species that may be present include the Western Pygmy-perch *(Edelia vittata)*, the Nightfish (*Bostockia porosa)*, and possible other species which have been identified at nearby Whiteman Park (Appendix 11.4).

6.7 Invertebrates

The invertebrate composition of a wetland can indicate the condition of a habitat and its water quality. At present an invertebrate list does not exist, although a number of species were noted. Firstly, a high dragonfly and damselfly (Order Odonata) population exists within the wetland areas of the reserve. The characteristic shift of a wetland from a pristine to a degraded state can be recognised through the abundance or the diversity of specific invertebrate fauna, such as the dragonfly. Dragonflies are predatory organisms and present the highest invertebrate trophic level of the wetland foodweb. If they are absent from a habitat often the integrity of the foodchain has been altered (Samways, 1994).

A survey of the residents surrounding the bushland indicated that high concentrations of the non-biting midges (Chironomidae) at this stage are not present. Non-biting midges can be indicators of eutrophication. They respond to an increase in nutrient levels indirectly, i.e. they utilise food sources of decomposing algae during the larvae stage of their life cycle enhancing the later breeding cycle. As a result very large numbers of the nuisance midge become a noticeable problem to nearby residents (Pinder *et al*, 1992). As no definite data exists on the abundance of midges it is unclear

whether they are present in extreme numbers. Nevertheless, the invertebrate fauna appears to be structurally sound as the indicators of a degraded habitat are absent. This does not indicate that the wetlands are pristine, and further research is required to prevent potential problems arising.

Small freshwater crayfish were also observed. There are two species, the Gilgie *(Cherax quinquecarinatus*) and the Koonac *(C. pressii),* which are endemic to the Swan Coastal Plain.

6.8 Impacts of Introduced Fauna

Rabbits

Rabbits *(Oryctolagus cuniculus)* can grow extremely quickly, becoming sexually mature at four months if conditions are favourable. Since rabbits mature fast they can have several litters over a year (usually up to six) and therefore reach high numbers in an area over a short period of time. (Hussey and Wallace, 1993).

The LSB area has numerous rabbit warrens, and populations need to be controlled if the native fauna is to prosper. This is because the rabbits compete with the native fauna food resources and shelter in the area. This will undoubtedly have implications for the native fauna.

Cats

Both feral and domestic cats cause major problems for the fauna located within the reserve. The major food source of cats is small mammals (including rabbits), birds, reptiles and insects. For this reason, the removal of feral cats through means of trapping is desirable. However, the significance of predation on rabbit communities is unclear. Therefore an integrated program of rabbit and cat control is needed to avoid any unforeseen ecological impacts. Cats also have the potential to carry infectious diseases such as toxoplasmosis and sarcosporidiousis, which has the capacity to debilitate the native fauna within the reserve (ANCA, 1996).

Foxes

It is inferred that the area is a habitat for the European Red Fox *(Vulpes vulpes)* as tracks, scats and possible dens were found. The European Red Fox is a known predator of many small to medium (33g to 5.5 kg) sized mammals including rabbits, birds, tortoises and other small invertebrates (Hussey and Wallace, 1993). The presence of foxes is beneficial in the respect that it may control rabbit numbers, although this benefit is outweighed by the deleterious effects, primarily predation on native fauna.

Other

Dogs that are not restrained by leads may stress the native fauna within the area. They may pursue native animals resulting in increased stress and possibly mortality of these creatures. It is also possible that stresses imposed upon the fauna by dogs may lead to reduced breeding success.

Mosquito fish *(Gambusia affinis* and/or *G. holbrooki*) exist throughout the drains and wetlands of LSB. In 1943 the mosquito fish was introduced into Western Australia from central America as a mosquito control method (Balla, 1994). There is evidence to suggest that the Mosquito fish has a

deleterious effect on wetland communities by selectively preying on macroinvertebrates and via their highly aggressive nature, inflict injury upon endemic fish species which may be present and compete for habitat and food resources (Williams, 1983; Chambers & Davis, 1988; Gill, pers. comm. 1996).

With receding water levels and increasing temperatures in the wetlands during late spring or early summer, water may become deoxygenated leading to outbreaks of avian botulism caused by the bacterium *Clostridium botulinum* (National Wildlife Heath Centre, 1996). A neurotoxin released by this organism causes blurred vision, respiratory failure, and muscular seizure culminating in the death of the animal (Prescott *et al*, 1993). The nearby Malaga Fauna rehabilitation centre has reported numbers of waterfowl affected from this disease, although it is not known whether any of these birds are from *C. botulinum* outbreaks in LSB.

Control of domestic and feral animals is a problem in the reserve that requires a number of different management approaches. These are addressed in the Conservation and Rehabilitation recommendations 9.11.2 and 9.11.5.

6.9 Control of Introduced Fauna

Rabbits

Rabbits *(Oryctolagus cuniculus*) are a major problem in any bushland area as they compete with native fauna and destroy native flora (refer to Section 5.4 and 6.8). There are many methods available for their control, most of which are very time consuming. These include warren destruction by explosives or implosives, fumigation and baiting (Hussey and Wallace, 1993). The urban location of LSB makes the use of some methods, for example shooting, illegal and/or dangerous.

Feral and Domestic Cats and Foxes

Both feral and domestic cats and foxes are a problem in this urban bushland area (refer to Section 5.4 and 6.8). Baiting using 1080 is an option to eradicate feral animals as this toxin is a low risk to native animals and specific for introduced animals. However, the use of 1080 is not allowed in urban areas.

Dogs

Dogs can also destroy native animals in the bushland, therefore it is important to control the actions of these animals. The recommended exclusion fence will help control the entrance of most stray dogs. It is suggested that dogs be allowed entrance into LSB, on the condition that owners keep dogs restrained for the benefit of the environment and the animal (refer to Section 8.3). Signage and public education should refer to this.

Midges and Mosquitoes

According to EMS and local residents, midges or mosquitoes are not a major problem in the area (refer to Appendix 11.5). However, given the future increase in clearing within close proximity of the bushland and an increase in industry, a rise in nutrient input into the wetlands may occur. This rise in nutrient levels can promote the growth of algal blooms, which become suitable and abundant food source for midges and mosquitoes. It is therefore necessary to initiate preventative measures to avoid increases in these nutrients. The wetlands should have a high density of fringing vegetation such as

rushes, sedges, flooded gums and paperbark woodlands. This will absorb much of the nutrients coming into the wetlands from the channel, and create wider habitat diversity and an increased diversity of invertebrate and vertebrate fauna (Pinder *et al*, 1992). *Melaleuca raphiophylla* at edges of the wetlands will also shade the littoral zone, decreasing the water temperature and making it less ideal for algal growth, and hence, less suitable for midges and mosquitoes.

6.10 Reintroduction of Native Fauna

The reintroduction of native animals could be a long-term consideration, but would require total exclusion fencing. The relatively small size of LSB may also prevent such plans, as well as the other problems outlined in Section 9.2, Exclusion Fencing.

6.11 Effects of Fire on Fauna

Fire

Fire affects fauna by destroying individuals and habitat. Fauna which is at particular risk to fire includes smaller birds which nest <4m from the ground and ground dwelling vertebrates, especially those which utilise hollow logs (Smith, 1995). However, Friend (1996) has found that invertebrates and small vertebrates are quite resilient to fire, provided that not all of the bushland has been destroyed. The response of individual species to fire is dependent upon their life strategies.

The time required for the fauna community structure to return to pre-fire conditions is approximately 20 years (Friend, 1996). In response to fire, the composition of invertebrate orders do not change, however, species within orders alter markedly (Friend, 1996). As with most disturbances to an area, successional communities will alter with time after the event of a fire (Bamford, 1986).

6.12 Effects of Roads and Vehicles on Fauna

LSB is bounded by the Tonkin and Reid Highways to the east and north respectively, and a number of lesser roads to the south and west. The impact of roads on native fauna is significant, causing segregation of habitat, deaths and noise disturbance.

Due to the construction of roads around the reserve, the vegetation has become isolated. This therefore restricts the available area of habitat and movement between bushland areas, leaving it extremely vulnerable to a local catastrophic event (i.e. fire). Additionally, off-road vehicle tracks throughout the reserve have exacerbated fragmentation. Vehicles, both on the adjacent highways and within the reserve, inflict injury or death upon fauna.

Of less certainty is the impact of noise from the surrounding highways and from off-road vehicles. Whilst it is known that some species, particularly birds, require areas of habitat free from any source of disturbance to breed (Stansfield, 1991), biological surveys carried out at Boddington Bauxite Mine found that 59 bird species (87% of total), 3 native mammal taxa, 4 amphibian species and 16 reptile species occurred, and in many cases inhabited areas either directly under or immediately adjacent to the mine's overland conveyor. It was found that a number of these species were breeding (Ninox Wildlife Consulting, 1990). Hence it can be concluded that noise from the

highways may not be a significant impact upon the fauna present, with those species present being adapted to noise. However, highly localised sporadic noise disturbances such as from off-road vehicles may be of greater impact (Ninox Wildlife Consulting, pers. comm. 1996).

6.13 Recommendations

It is recommended that:

6.13.1 A detailed fauna species list is prepared, as part of a baseline monitoring survey.

6.13.2 A Feral animal control program be developed and implemented.

Section 7.0 Land Use and Community

7.1 Current Situation

Land Tenure

The land parcel for LSB is comprised of one large lot with an area of approximately 70 hectares. All existing titles have been amalgamated and now appear as Lot 100 on Certificate of Title Volume 2134 Folio 13 in the name of the Western Australian Planning Commission.

Planning

Metropolitan Region Scheme

The study area is reserved for "Parks and Recreation" under the Perth Metropolitan Region Scheme (WAPC 1994). Under this reservation, any development requires planning approval from the WAPC in accordance with Clause 13 and 16 of the Metropolitan Region Scheme Text 1963 (as amended).

Town Planning Scheme

The Shire of Swan Town Planning Scheme No. 2 reserves the study area as "Regional Parks and Recreation" (Shire of Swan 1985).

Wetland Management

Wetlands in Western Australia have been assessed by the State Government to determine their significance. Management categories are assigned to the wetland based on the evaluation which guides the management and protection of the wetland (Hill et al 1996). Management categories assigned to wetlands in LSB are described below:

1. Conservation : These wetlands support a high level of ecological attributes and functions. Are the highest priority wetlands and the government's objective is to preserve wetland functions and attributes.

2. Resource Enhancement : These wetlands have been partially modified but retain substantial ecological attributes and functions. They are priority wetlands and the government's objective is for the management, restaoration and protection towards improving their conservation value, they have the potential to be restored to Conservation category.

Most of the reserve is classified as Resource Enhancement and multiple use whilst a small area of Conservation is situated in the north-east portion of the site. Significantly, a 50 metre zone of critical influence surrounds these areas and an artificial drainage channel which passes through the site.

The purpose of this zone is to "maximise the beneficial uses of uncleared wetlands by providing a minimum 50 metre buffer of upland vegetation so as to protect the ecologically important transition

from wetland to upland vegetation" (WAWA, 1993:35). This buffer area should be retained or rehabilitated where appropriate (refer Section 9).

Bush Forever

The LSB was not included within the recommendations of System 6 Conservation Reserves for Western Australia (Department of Conservation and Environment, 1983). However, LSB is now included in Bush Forever (site 307), which is the Western Australian Government's strategic plan to conserve and maintain a representative system of bushland and wetlands on the Swan Coastal Plain.

Existing Land Uses

A total of four (4) land uses have been identified within LSB. These are discussed in detail below.

State Government Infrastructure

The reserve is affected by the following State Government infrastructures:

* an intermittent drainage channel (Water Corporation); and
* aerial power lines (Western Power)

The intermittent drainage channel traverses the reserve from the western to the eastern property boundaries. Maintenance of the channel is undertaken by the Water Corporation who have an easement along its duration. The design has enabled it to integrate relatively successfully with the reserve, although in some sections excavation earth (from the construction of the channel), has been placed on its shoulders creating relatively steep inclines to the watercourse. If public access to these areas is to be encouraged, the associated danger of these slopes needs to be assessed and rectified if necessary.

Some of this earth has also been placed on top of native bushland next to the easement, creating disturbance problems. This practice has since ceased due to hand, rather than machine, control of bullrush, and a commitment from the Water Corporation to remove any future silt from the LSB site. Two pipe bridges currently cross the drain, as well as one earthen ford.

One aerial power line crosses directly through the reserve in a north/south direction. Two other aerial power lines traverse in a north/south direction on the eastern boundary of LSB, while one passes in a west/east direction across the old quarry site, which is outside the true boundaries of LSB. The power lines consist of three standard transmission lines and one high power voltage line. Western Power has easements over these. These powerlines create a significant adverse visual impact that undermines the integrity of the reserve and one has caused a small brush fire on the eastern boundary.

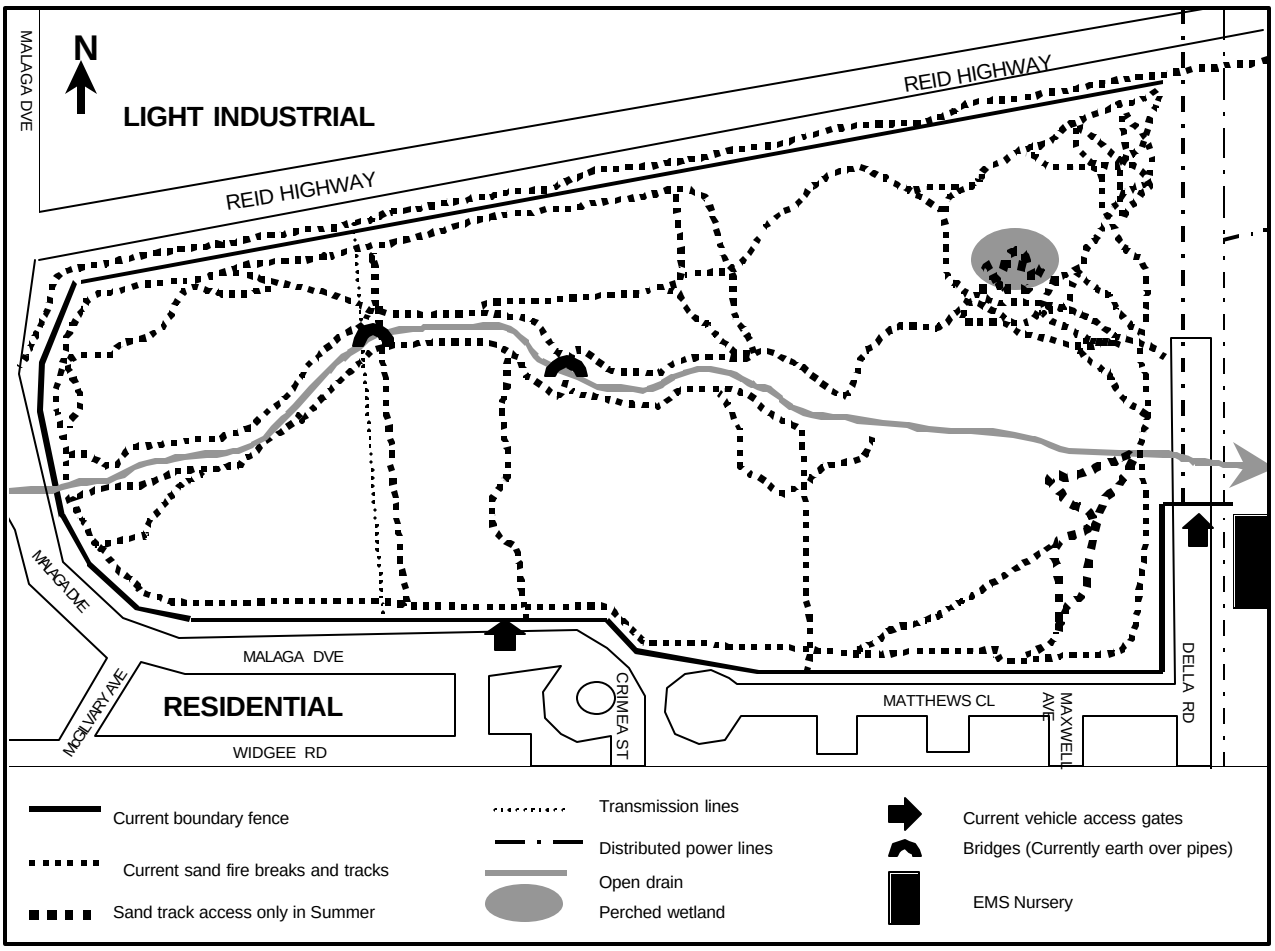


Figure 7.1: Current Land Uses in Lightning Swamp Bushland

Community Use

The reserve is currently used by the local community for passive recreational activities such as bush walking and walking pets (refer to Section 7.0 for further information).

Illegal Activities

Field inspections of the reserve as well as eye witness accounts have revealed evidence of illegal activities including use by off-road vehicles and for waste disposal and removal of flora. These activities have had a detrimental effect upon the reserve's natural values including:

- the impact of off road vehicles upon the distribution of native vegetation, increasing disturbance allowing weed encroachment and the spread of dieback; and
- the visual and potential polluting effects of discarded materials from illegal waste disposal.

Tracks

A large number of tracks and firebreaks are present throughout the reserve, possibly as a consequence of off-road vehicle activities, as well as previous traffic from the old quarry site to the east. Whilst these tracks have encouraged off-road vehicles, they have also provided the opportunity for bush walkers to explore and discover the intrinsic value of the reserve. If bush walking is to be promoted, and the spread of Dieback restricted, all existing tracks need to be reviewed. Required tracks will need to be rationalised in order to prevent illegal vehicle access, and

to riestrict pedestrian movement within the area to minimise detrimental impacts to the bushland (see Section 8 for further information). Those that aren't required should be closed and natural regeneration encouraged in these areas.

The major firebreak that surrounds LSB also acts as a pathway, and should be maintained. However, the existence of Dieback in the reserve, and the promotion of weed growth by soil disturbance means that clearance by mechanical methods such as plowing should be replaced by other methods such as selective use of herbicides (see Appendix 11.1 for further information).

Closure of a number of minor tracks with log barriers, windfall timber and signage will also allow natural regeneration and prevent entry into and out of Dieback-infected areas. The Friends of LSB have already begun the process of closing off a number of minor tracks in and around the severely eroded northeastern corner.

Local Roads

Entry to the site is currently accessed by Della Road via Benara Road. Currently, there are few directional signs to guide the public to the reserve. Increased use of the reserve is also likely to result in a subsequent increase in local traffic. Therefore consideration should be given to the impact of local traffic movements with regard to:

* future traffic projections
* street calming devices such as a roundabout may be necessary at the intersection of Della Road, Matthews Close and the entry point into the reserve
* the need for a footpath along Della Road between Benara Road and Matthews Close;
* the provision of a right turning bay off Benara Road
* potential parking on street verges;
* the consideration of incorporating the local road reserves within rehabilitation plans, such as complimentary street planting; and
* the absence of any signage to indicate direction to the reserve.

The preparation of a local traffic management plan would enable the above issues to be addressed.

Reserve Access and Car Parking

An unmade portion of Della Road extends for 500 metres on the eastern boundary of LSB. However, the former road reserve is still used as the main access to the site, and in particular, a wetland rehabilitation nursery. Should this remain as the main access, it will require resurfacing to cater for additional traffic, and possible realignment to remove the current straight configuration.

At present approximately 16 sealed car parking bays are available at the reserve; however, these are directly associated with the wetland rehabilitation nursery. To ascertain the car parking requirements of the reserve, it will be necessary to formulate visitor projections to determine whether more car parking is required. Issues to be addressed include:

* the need for convenient and centralised parking which does not compromise the intrinsic value of LSB.
* the appropriateness of extending the existing parking areas.
* the provision of bus parking and turning circle.

With the proposed development of sporting facilities at the old quarry site, future access and parking facilities may also be possible on the eastern border of LSB, and as such, pedestrian and fire vehicle access ways have already been planned.

Pedestrian Paths/Cycleways

The reserve does not have high accessibility from pedestrian and cycleways, nor does it have bike racks. To encourage equitable community accessibility, the provision of these facilities may be required. In particular, BikeWest should be contacted to investigate the possibility of including the reserve within regional cycle networks once a multi-purpose stabilised pathway has been constructed.

It may be more practical and desirable for retaining the conservation values of LSB, to establish this pathway either along the southern side of the LSB perimeter fencing, or along the current firebreak. The proposed sporting/recreational project at the old sand quarry site will also facilitate these activities without compromising the integrity of LSB (see Section 8 and Figure 8.1 for further information).

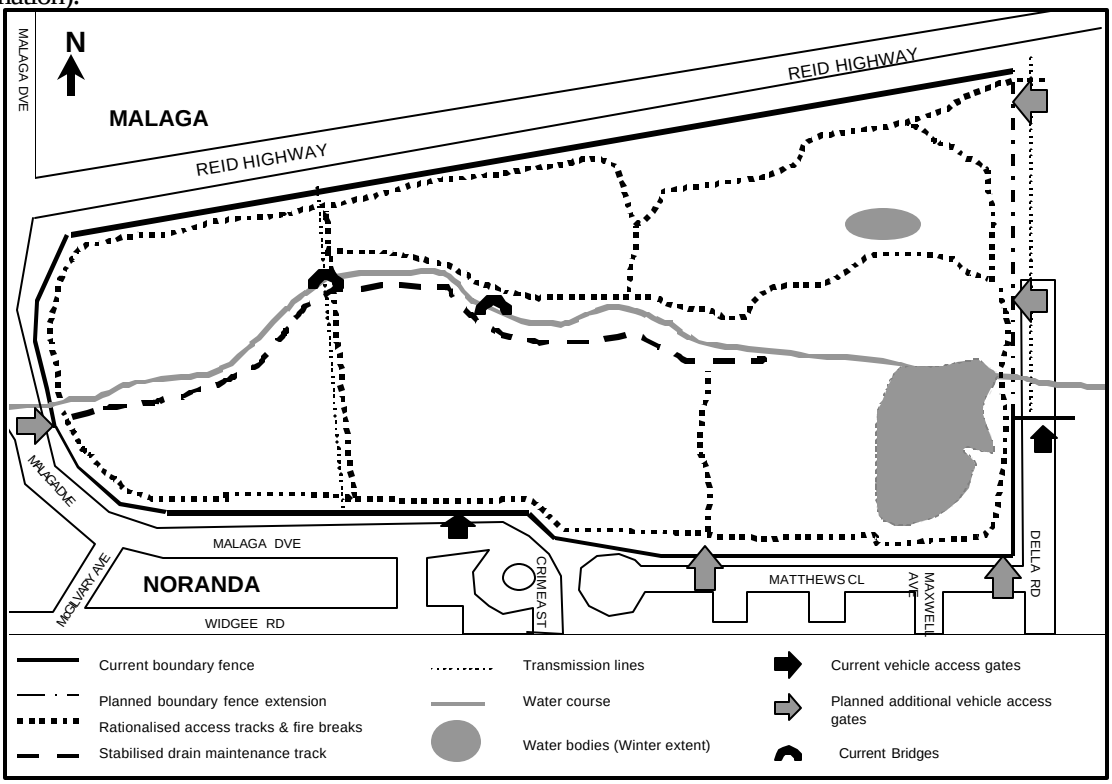


Figure 7.2: Rationalised Major Track and Firebreak Plan

Fencing

Cyclone fencing to a height of 1.2 metres has been provided by Main Roads on the reserve's boundaries to the north (Reid Highway) and east of the old sand quarry site (Tonkin Highway). Low fencing is provided on parts of the southern (Malaga Drive/Matthews Close/Sewell Court) and western (Malaga Drive) boundaries.

Areas where no fencing is provided, particularly at the eastern end of LSB, are likely to allow illegal activities such as off-road vehicle access to continue. A proposal has been funded to install such a fence, as well as replace the current star picket and wire fences along the southern and western boundaries with more substantial post-and-rail fencing in the financial year 2001-2002. Regular patrols to ensure the integrity of the fences will be required.

Surrounding Land Uses

A variety of land uses are in the general vicinity of the reserve. These are outlined in detail below:

Industry

Malaga Industrial Area is located directly to the north. At present the area is only partially developed. The City of Swan has zoned this area "Industrial Development" to cater for general industry uses where potential environmental impacts will be minimal and can be dealt with on site (City of Swan 1985). Noxious industries, where the process involved constitutes an offensive trade under the Health Act 1911 (as amended), will not be permitted by the Shire (Theile, 1996). Potential impacts of the drainage from this industrial development are discussed in Section 4.

Residential

Residential land uses immediately surround the reserve to the south (City of Bayswater), west and east (City of Swan). The reserve acts as both a visual and noise buffer to Reid and Tonkin Highways and the Malaga Industrial Area. Aesthetically, it provides residents with a contrast to the typical urban streetscape. This buffer value needs to be maintained.

The close proximity of residential land uses may contribute to the encroachment of exotic vegetation into the reserve and predation of fauna by domestic pets. These incursions need to be carefully controlled or managed.

Parks and Recreation Reserves

Parks and Recreation Reserves exist to the northwest and northeast of LSB.

To the northwest, a series of Parks and Recreation Reserves are adjacent to each other from the corner of Reid Highway and Malaga Drive, Malaga to the corner of Alexander Drive and Marangaroo Drive, Koondoola. An opportunity exists to consolidate links between these and LSB to promote wildlife and pedestrian/cycling movement systems.

Whiteman Park is situated approximately 5 km to the north east, as shown in Figure 7.3. However, there is no official link between it and LSB. Due to the regional significance of Whiteman Park, it would be desirable to connect it with LSB. As land between them is yet to be developed for industrial and urban purposes, a corridor could be established and reserved for Parks and Recreation purposes. For example, the 10 percent public open space policy requirement for residential subdivisions could be used to form a corridor through the future residential area earmarked for Beechboro at the intersection of Reid Highway and Beechboro Road North. Alternatively the viability of utilising the Main Roads road reserves along Reid Highway (existing and proposed) for corridors should be investigated.

An existing avenue for this is the WAPC's Greenways scheme, already identified, with LSB as a hub, connecting to No. 38 to the west and east (Reid Hwy: Star Swamp to Whiteman Park>City of Stirling, City of bayswater, City of Swan), and No. 26 to the south (Tonkin Hwy: Noranda – Swan River – Perth Airport> City of Bayswater and City of Belmont) (Alan Tingay & Associates, 1998).

It may be possible for the City of Bayswater, particularly through the established ELAG committee structure, to advocate and facilitate this initiative through:

- preparation of its own specific Greenways plan.
- liaison with other relevant Councils via Environmental Officers in order to galvanise and coordinate planning and implementation.
- consultation with the WAPC and Main Roads departments, particularly in the use of local native flora species along road verges to conserve and promote biodiversity.

Educational Institutions/Shopping Centres

There are five shopping centres, four secondary schools and eleven primary schools within a 4 km radius of the reserve. This indicates that there is a potentially significant community resource that can be tapped into to assist in the development, understanding and promotion of the reserve. An example of this is the use of organisations such as BICM and Bennett Brook Catchment Group to coordinate and encourage schools to facilitate the "Ribbons of Blue" project in testing metropolitan water quality standards, or to assist in rehabilitation measures (refer Section 10).

7.2 Conclusion:

Land use and key community issues relating to perimeter fencing, carpark facilities, removal of visual waste and investigating the opportunities for wildlife corridors are addressed in Sections 9.0, 8.0, 9.0, 6.0 respectively.

Section 8.0 Recreation

8.1 Introduction

LSB provides local residents with a natural area for pursuing passive recreational activities. However, its paramount importance is as a piece of remnant urban bushland for conservation purposes (Sections 7.5 & 9).

8.2 Impacts of Recreational Use

Vehicle based activities

The existing vehicle-based activities include illegal four-wheel driving and trail bike riding. These activities are known to have significantly impacts on bushland areas, including;

- landform disturbance
- disturbance of drainage patterns
- soil erosion
- siltation
- vegetation clearance
- fragmentation of habitat
- spread of disease such as Dieback *(Phytophthora)*
- entry of exotic flora and fauna
- increased visitation and therefore greater risk of fire and littering
- disturbance of wildlife by noise (Robertson *et al*, 1992)

Off-road vehicles have illegally entered the bushland by cutting and damaging the perimeter fence surrounding LSB, requiring costly repairs.

Cycling

Although no hard surfaces suitable for cycling are currently provided within LSB, access by bicycles is currently undertaken. According to CALM (1991), impacts of cycling are minimal on the environment providing this activity is confined to designated paths. However, there is evidence of cyclists leaving the existing tracks, for example, with mountain bikes, resulting in similar impacts to vehicle-based activities.

Dog Exercising

Currently the sand tracks and some areas of the remnant bushland are utilised by local residents to exercise their dogs. It has been noted by Brooker *et al* (1994) and Moore (1984) that the scent from dogs may deter native animals, and urination can lead to the death of native vegetation. Increased nutrient loads from dog excrement and urine also have an adverse effect on native flora while assisting weed growth. Previous studies have noted that the absence of native species in bushland may be attributed to the presence of dogs (Brooker *et al*, 1994). In addition to problems

with scent, dogs that are allowed to roam free also have the potential to chase and frighten native fauna.

Bushwalking

Bushwalking is a low impact physical activity that can enable people of various degrees of fitness to explore the natural environment. The impact of bushwalking on the environment is generally low; however, problems can arise, such as loss of vegetation through trampling, soil compaction, soil erosion and the introduction of weeds and plant diseases (CALM 1991).

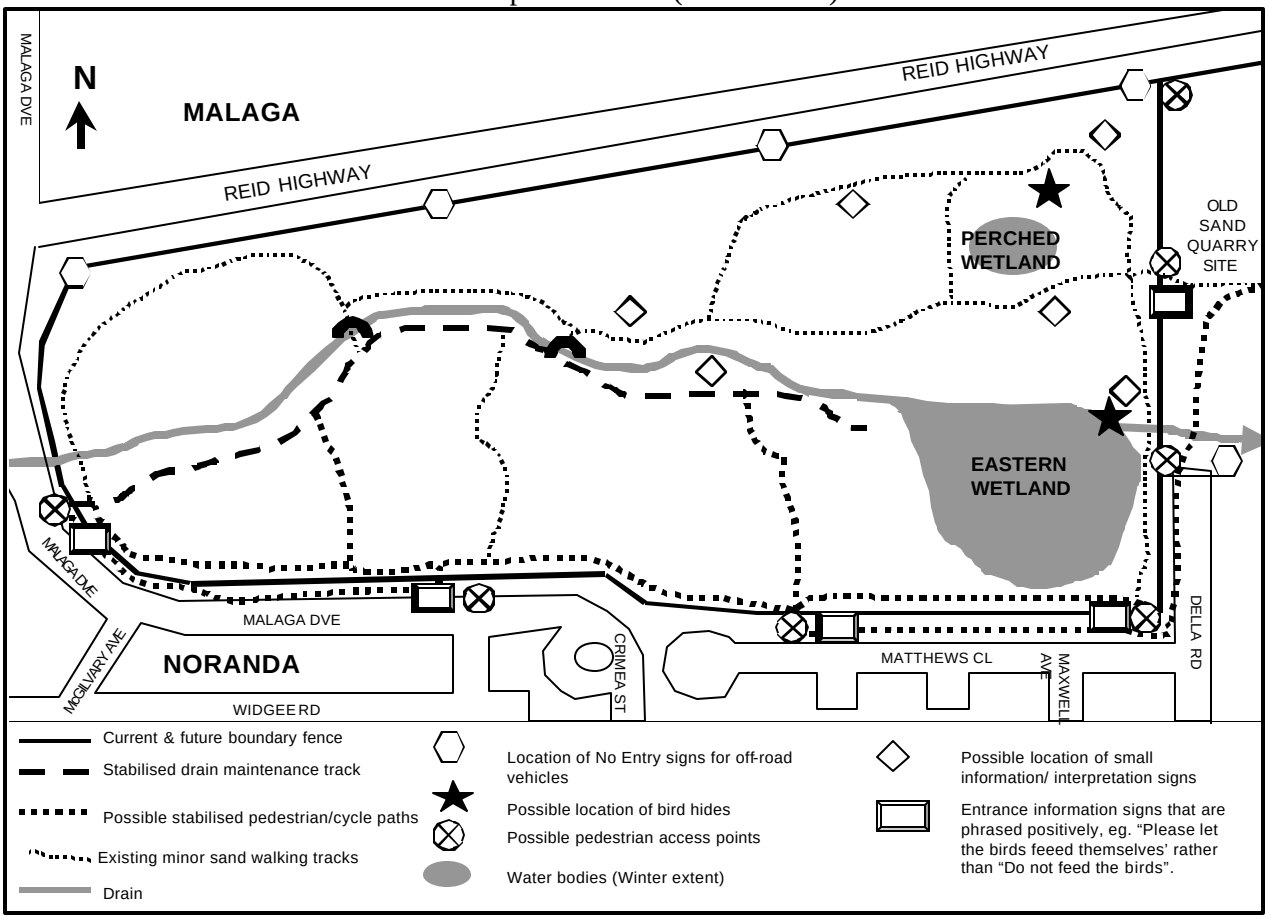


Figure 8.1: Recreational and Information Map

Nature Studies

Nature studies in the area include bird watching, observing flora and fauna, and photography. As passive activities, these can be compatible with conservation of the site. However, adverse impacts result when these activities interfere with the habitats of native species. For example, the noise from birdwatchers and the general public may disturb birds, especially during nesting periods.

The feeding of birds attracts unwanted seagulls, contributes to the spread of disease, and results in artificially high numbers of waterfowl (Street, 1992). Wildlife observers venturing into bush areas may trample vegetation. Picking of wildflowers, which is illegal, can impact on the bio-diversity of the area. Signs and education will prevent a great deal of possible damage.

8.3 Proposed Future Recreational Uses

LSB consists of remnant bushland and wetlands, which are considered extremely important in terms of its conservation value. Currently in this area there is evidence of degradation, and it is therefore proposed to limit public access to rationalised paths and restrict conflicting activities that may occur (see also 7.5 and Section 9).

Pedestrian/Bushwalking/Cycling Access

Of the local population consulted in October 1996, 90% of the 80 residents surveyed, indicated that bushwalking is an activity that should be encouraged in the area, and 69% supported the construction of cycle paths (appendix 11.5). There is a need for some multi-purpose paths to be constructed to cater for these requirements, and to minimise the associated impacts, eg., walking off pathways through bushland.

One multi-purpose pathway of a 3m width should be established on the existing sand track adjacent to the main drain, and used for maintaining the drain by the Water Corporation (see Figure 8.1). This would allow fire and maintenance vehicles into the area with less impact to the physical landscape, reduce the problem with weed growth on sand tracks, and allow cycle/pedestrian traffic. Minor dual use trails (suggested width 2m) along a current Western Power maintenance track and the southern firebreak will act as connecting access paths or lead to areas of interest, while removing the damaging practice of plowing firebreaks.

It may also be practical to establish a pathway along the 4m wide verge along Matthews Close and Malaga Drive, thus allowing cycling, dog exercising and walking to take place outside LSB, while also providing a circuit track of over 4 kms in length, but with little impact on conservation values (Figure 8.1). This pathway could then connect into cycling/walking routes along Widgee Rd/Camboon Rd/Alexander Dve to the west, and to paths established within the future sporting/recreation facility at the eastern end, across the Tonkin Hwy via the current footbridge, and on to Beechboro.

Other existing trails, as set out in Figure 8.1, can also be used for bushwalking into areas further away from housing. These sand tracks, often in sloped areas, should predominantly be left as firebreaks so as to prevent significant impact on the bushland through pathway runoff, nutrient buildup from dog excreta, transmission of Dieback-infected material, and disturbance through over-use. Many of these tracks also traverse through, or close to, areas of high conservation values such as the perched wetland. Having the stabilised tracks on the outer perimeter and leaving these other tracks as they are will direct traffic away from the more environmentally sensitive areas. However, it may also be possible to establish some stabilised sections to allow access for less mobile people, including boardwalk sections.

Benches should be provided at suitable locations along the trails to act as rest and observation points, including the possible double use of bird hides at the perched and eastern wetlands (see Figure 8.1). Access points should be made available at various locations on the perimeter of the conservation area and adjacent to residential areas (see Figure 8.1) to accommodate pedestrians, cyclists and disabled persons. Appropriate signs should be provided to minimise conflict between pedestrians and cyclists (Section 10.4) and to provide information on flora, fauna, history and heritage.

Paths should be constructed using a porous, flexible surface such as crushed limestone, which would accommodate the requirements of pedestrians and cyclists. Limestone paths are cheaper and less intrusive than bitumen surfaces and considered more appropriate for the area, but they are generally not suitable for use by disabled persons (CALM, pers. comm.). An option to consider is to add a cement mixture to the limestone which stabilises and consolidates the path (CALM), pers. comm.). Limestone surfaces can prevent detrimental effects on the area such as runoff and erosion (Balla, 1994). These trails should be positioned appropriately so as not to interfere with natural drainage lines.

Vehicle Access

Maintenance vehicles, for example, Western Power and fire control vehicles, could access the conservation area via the main multi-purpose path as described above. The multi-purpose path along the drain and connecting with the Western Power track should be 3 metres in width to accommodate these vehicles (see Appendix 11.1 for further information).

The use of unauthorised vehicles such as 4-wheel drives and trail bikes must be prohibited in LSB, as these activities will cause site degradation and transmission of Dieback even if restricted to designated areas. Signs stating this should be located around the perimeter fence, particularly at places where the fences have been cut in the past (see Figure 8.1)

Bird Watching

The survey of 80 local residents conducted October 1996, indicated that 92% of participants supported the use of LSB for bird watching (Appendix 11.5). Hides could be provided for this activity at the perched and eastern wetland, at an appropriate distance so as not to interfere with the wildlife (see Figure 8.1).

Self-Guided Nature Walks

Signs should be provided along the paths indicating places of interest, and fauna and flora species that may be present in the area, allowing for an informative self-guided tour. Large covered information boards, similar to those in CALM reserves, should also be provided at the main Della Road entrance. These would contain maps, photographs and other information relating to the area, including how to help with the conservation of LSB.

Dog Exercising

As previously outlined (Sections 5.4, 6.8, 8.2), the impact on conservation areas from dogs can be substantial, particularly if numbers of visitors to LSB increase as a result of improved access and public education. However, their impact can be reduced by:

- Owners restraining dogs on leashes while inside LSB. This would also protect dogs from snake bite.
- Provision of bags for dog excrement at entrances, although it has been found that many owners will not use these, and when they do, they are often thrown into bushland.
- Public education and signage on the negative effects of dogs in conservation areas.

A combination of the above should be successful. With the pathway configuration described in the previous sections, as well as the development of parklands in the old sand quarry, the majority of dog exercising can take place outside wetland and bushland areas, thereby reducing this impact.

Rubbish Bins

Sulo bins (240L) are recommended for the entrances to the area, with devices to restrict bin use to recreational users by allowing the bin to open to 30cm. Bins should be secured to the fencing or a separate post and located at the western and main entrance of LSB, to discourage people taking rubbish into the bushland.

Car Park

The existing access road (Della Road) should be resurfaced with limestone (300m north of Widgee Road). The realignment of this road into a series of curves will make the entranceway more aesthetically pleasing, and reduce the vision of predatory animals. A car park accommodating six vehicles (1 disabled bay) should be provided (Figure 8.1). As previously stated, the use of limestone is cheaper and a more aesthetically pleasing option than bitumen. See Section 7.1 for further information on parking.

Toilets

The WAPC suggests that toilets are required at regional facilities, but are not deemed essential for areas designed for local use, for example, LSB. It is presumed that there will be toilet facilities within the sporting/recreation facilities proposed for the old sand quarry site, and these should be located so that they do not impact on the conservation area.

8.4 Ongoing Maintenance and Monitoring

Once LSB is provided with facilities such as pathways, benches, signs and rubbish bins the area will require continuous monitoring and maintenance. Monitoring will involve periodic investigations of the site to identify increased pressures from recreational users. Excessive demand on the site may be indicated by factors such as site degradation and bin overflow. In this event, management will be required to repair any damage. Any budgeting for LSB should make allowance for such ongoing maintenance.

8.5 Recommendations:

It is recommended that:

8.5.1 Stabilised pathways be installed at the suggested locations (Section 8.3 & Figure 81) thereby reducing the impact from cycling, bushwalking and dog exercising.

8.5.2 Dogs are restrained on leashes while walking in LSB, both for the protection of native flora and fauna and to prevent snakebite.

8.5.3 **Vehicle access is restricted to fire and maintenance vehicles that should follow established tracks when entering LSB.**

8.5.4 **Signage (see Figure 8.1) should indicate restrictions, provide warnings of snakes, and other information for visitors.**

SECTION 9.0 Conservation and Rehabilitation

9.1 Introduction

LSB has suffered degradation in the past, but the area has retained many qualities worth conserving and rehabilitating. This bushland vegetation is rated in the top 6-10% of vegetation classified in 'very good condition', in the Perth metropolitan area (MFP, 1996). The only other area in this condition is an area of bushland north of Reid Highway, which is zoned for industrial use, and will therefore gradually disappear as development occurs. The bushland should not only be retained to conserve the natural attributes, but also preserve values such as recreation, community involvement and education.

It is also important to note the importance of LSB to the overall ecosystem function of the Swan coastal plain. It appears that the retention of at least 30% of an ecosystem as remnant vegetation is critical for the continued survival of species in that system. When it is considered that the vegetated part of the area within the Swan coastal plain portion of the metropolitan area is less than 30%, and only about 18% is within Bush Forever sites (ABC, 2001) such as LSB, its conservation is critical for retaining original biodiversity.

Conservation Considerations

LSB has been included in Perth's Bush Forever as Site 307, which demonstrates the uniqueness and high conservation value of the area (DEP, 1994-95). The conservation area has three wetlands and a dampland, which contribute to the diversity of the ecosystem and enhance its conservation value. One of the wetlands is perched, and is in the top 13% of 'conservation' wetlands in the Perth metropolitan region (Hill *et al*, 1996). Approximately one third of the conservation area contains Southern River Complex, a soil type which is important in the Perth metropolitan area because of its geological significance and floristic diversity in native bushland (Section 3.2) MFP, 1996). For this reason it is important that the integrity of the wetland be maintained, and limited access to the area be established.

The long-term protection of LSB would have greater security if it were classified as Class 'A' under the 1933 *Land Administration Act*, ensuring its purpose as a conservation area, and enabling change only with consent of both Houses of Parliament.

9.2 Exclusion Fencing

The main disturbances within the area are by off-road vehicles and introduced animals such as foxes and cats. Uncontrolled access has previously damaged a large proportion of the area including the wetlands, while possibly spreading Dieback into unaffected areas and other reserves An exclusion fence around the entire perimeter of LSB would be the most appropriate and effective method of limiting access of vehicles and introduced animals.

However, it is expensive, can prevent native fauna from escaping bushfires, restrict legitimate community access to LSB, may appear unattractive to local residents, and can still be illegally cut, as shown by the fencing on the northern side of Reid Highway.

9.3 Regeneration and Rehabilitation Practices

Erosion

The objective is to control and rehabilitate eroded areas. Erosion and deposition occur naturally in any system and have a role in soil formation and degradation over long periods of time. Erosion causes the reduction of topsoil, leaching and removal of nutrients, and has the potential to do considerable soil and vegetation damage. However it is a physical process which can be controlled (CALM 1992).

A natural soil profile will help assist any rehabilitation or regeneration process (Hussy and Wallace, 1993), especially if using provenance seed stocks (Seabrook, 1990). Methods for regeneration of eroded areas include sand stabilisation, followed by rehabilitation or regeneration.

Sand Stabilisation

Three methods of sand stabilisation are suggested:

* Spray-on mulches to physically stop sand motion.

* Frogmesh or similar physical net barriers are types of geotextiles which stabilise sand. These are very expensive products that are relatively unsightly when compared to aesthetically pleasing natural bush. The FOLSB have been using this method in combination with mulching, brushing and planting on the eroded sand hills to the northeast.

* Mulching, using straw or cut-brush methods. Cut-brushing involves laying seed-bearing portions of native plants directly on or above the ground, this disperses the seed and protects the seedling that may grow, as well as adding humus (Hussey and Wallace, 1993). This has the advantages of adding nutrients, protecting seedlings and stabilising the sand from wind. The disadvantages are availability of local seed-carrying cut brush, weed invasion from outside sources, prevention of natural seed regeneration if the mulch is too deep, and fire risks.

Bushland Regeneration/Re-vegetation

In those areas of LSB not severely degraded, natural regeneration will almost certainly occur over time, and has been the case where tracks have already been closed or off-road vehicles have been kept out, such as in the perched wetland. Viable seed banks have and will continue to establish themselves (Seabrook 1990). Restricting access to regenerating areas, and possibly some weed control measures will assist this process.

Severely degraded areas such as the old farm site, the sand hills in the northeast, and possibly some tracks will require assistance through re-vegetation. Any re-vegetation in LSB will requires careful thought and planning in order to avoid costly and damaging mistakes. This will involve completing an extensive flora survey and vegetation map for areas considered for work so that the appropriate species are used.

There are two main methods of re-vegetation suggested by APACE Western Australia, CALM and Ecosystem Management Services, planting seedlings and using direct seeding. The most important aspect of re-vegetation, whatever the method, is to maintain local provenance by collecting seed from the same type of vegetation at or near the site. Allowance should also be made for more than one round of sowing and planting in the severely degraded areas as it may take several efforts for the native species to predominate. Weed control will complement this. Hence, any re-vegetation work should be of a size that can be realistically monitored and maintained by those carrying out the work rather than plantings on a mass scale.

Seedlings

Seedling planting is considered a high priority in very degraded and eroded areas such as the old farm site and the northeastern sand hills. Although a more expensive option, it has the advantages of a high success rate with immediate or short-term rewards such as wind reduction. It is a less viable option for the less degraded areas. If the local community were involved, watering and care would become part of their project until trees are established. The FOLSB are currently in the process of planning medium sized plantings in the autumn of 2002, but only in severely degraded or eroded areas.

The major problem with planting in LSB is rabbits eating new seedlings, and plant guards may need to be used. However, in hot weather plants can become over-heated and guards will need to be removed.

Seeds

Seeding is another option for assisted re-vegetation. Both CALM and APACE recommend using direct or broadcast seeding methods, using provenance seed on the basis that it will conserve the local genotype and have a better chance of survival on that soil type (Seabrook, 1990). Provenance seed is defined as native seed "that was collected within a 15 km radius of the site to be re-vegetated" (Hussey and Wallace, 1993). Seed collection is well described by Hussey and Wallace (1993), Seabrook, (1990). The cut-brush method is also a viable seed source. Bought seed is another option, but is a less economic alternative, and is unlikely to be of provenance seed stock, although Bennett Brook Catchment Group collect from the area.

It is advised that the seed be applied at the rate of 1 kg/ha for general re-vegetation, and up to 3 kg/ha applied in very degraded areas. Approximately 3 ha of eroded/degraded land along Reid Highway and the 4WD tracks will require re-vegetation by Main Roads.

There are a number of problems with seeding, including insects, wind and water carrying away the seed, as well as applying the right mix of seed in the most appropriate places. A light covering of mulch may protect seed and promote a greater survival rate.

Bushland Buffer Zone, Eastern Boundary

As part of the sporting/recreation facilities proposed at the eastern end, the establishment of a buffer zone between LSB and ovals will be necessary to both protect conservation values and to make the area look more attractive. Most of this area lies under Western Power transmission lines, is very degraded sand dunes, and constitutes the eastern slopes of the main ridge line running through LSB

in an east/west direction. At present the areas not vegetated are being eroded by wind, while the remaining patches of native vegetation are being inundated and isolated.

Because of the power lines, any re-vegetation will require careful planning (maintain access, no tall trees), in consultation with Western Power and the City of Bayswater Parks & Gardens branch. The most important aspect concerns maintaining local provenance by planting local species and removing any potential problem plants such as Victorian Teatree, Geraldton Wax and *Acacia longifolia*. The area may also require extensive mulching and brushing to stop further erosion.

Wetlands

Buffer Zones

A buffer of vegetation surrounding a wetland is vital to minimise human impact and to protect the integrity of the wetland. The width of the buffer zone is dependent upon its purpose (see below), however; it should be constructed or maintained as wide as possible (Balla, 1994). It was recommended by the Water Authority (1993) that a minimum of 50 metre buffer zones be implemented surrounding the wetlands.

A buffer zone has many attributes for protecting and maintaining wetland quality (Balla, 1994, Davies and Lane, 1995). These benefits include;

* Protecting water quality and quantity through groundwater catchment management.

* Reducing run-off from surrounding land to minimise additional sediments, contaminants and nutrients, and hence reducing the chance of algal blooms.

* Providing wildlife habitat and wildlife corridors to maintain species diversity and abundance.

* Mitigating erosion by assisting bank stabilisation.

* Buffering physical disturbance and noise to enhance the ecological and recreational value of the wetland.

* Minimising the invasion of weeds and exotic plants.

* Providing a barrier between midge and mosquito populations and residential areas.

Vegetation in the Buffer Zone

Attention should be given to the zoning of existing vegetation that acts as a guide for the re-establishment and regeneration of local native species. An extensive floristic study of the area would generate a comprehensive species list and vegetation map to assist in planting the appropriate local natives as wetland vegetation and as a buffer zone (see Appendix 11.3).

Special attention needs to be given to the eastern ephemeral wetland. At present, winter rainfall has inundated and denuded the fringing vegetation. A number of 4WD tracks through the wetland have disturbed the native vegetation. In order to restore the area it is advised that the area be rehabilitated by replanting dominant aquatic plant communities. In the winter of 2001, the FOLSB began rhizome

transplanting the dominant species, *Baumea juncea* with a high success rate, and this practice will continue.

Drainage

Waterways

Storm water, urban and industrial drainage runs into the Water Corporation main drain, and may be contaminated with nutrients and other pollutants (refer to Section 4). This channel prevents flooding problems, alleviates street runoff, and the vegetation acts as a nutrient filter. The Bullrush *(Typha orientalis)* is abundant along the drainage channel, while *Juncus microcephalus* is also increasing. Control measures to restrict spread must be undertaken to ensure the survival of native species (refer to Section 9.4) and to prevent its spread into the major eastern wetland.

Banks

Stabilising the drain banks is essential to reduce erosion and prevent further weed infestation. The native fringing vegetation Lake Club Rush *(Schoenoplectus validus)* grows quickly and reaches heights of 2-3 metres. They are very important for stabilising banks and reducing erosion. Sedges, *Baumea juncea* and *Juncus pallidus* grow 1-2 metres in height, are effective for stabilising banks, and grow extremely well in sand substrates. The native ground cover *Centella asiatica* is already present.

9.4 Fire Management

Stakeholders and interested parties should refer to Appendix 11.1, the *Lightning Swamp Bushland Fire Management Plan* for fire reduction, prevention, and response strategies.

9.5 Rubbish Removal and Management

Initial Removal

Initial removal of rubbish from LSB, including two car bodies was conducted during a clean-up undertaken by the local community, in conjunction with the City of Bayswater. Local community groups such as the FOLSB and annual events such as "Clean Up Australia Day" should be utilised to remove future rubbish. To date, the amount of rubbish in LSB has been reduced significantly.

9.6 Monitoring

The follow-up to any rehabilitation and regeneration plan is very important for the continued viability and integrity of LSB, and there are a number of different techniques that can be used.

It is important that a record be kept of changes to the area so that the effectiveness of weed control, re-vegetation projects, rubbish collection, fire control, and other measures can be determined, not only as an historical and environmental record but for future funding and management strategies.

It is important the area be surveyed for any signs of plant diseases, exotic plants and introduced animal species, and if these exist, eradication methods are undertaken.

The monitoring plan should involve local environmental organisations, the Friends group and schools, as well as interested community members possibly as part of the Neighbourhood Watch scheme. Local residents and those involved in the programme should be informed of who to contact in case of fire or vandalism, and of by-laws that are relevant to the area.

Methods of Monitoring

A photographic record of LSB should be maintained. This is important so that there is a visual example of any change in the health of the ecosystem and for ease of communication. This should be carried out on a regular basis and used as a tool for community education (refer to Section 10).
Records should be kept of sightings of rare species, endangered species, and introduced species and their frequency. This may involve the Friends and other community groups, schools and interested community members (refer to Section 10).

Rubbish dumping and use of bins provided should also be monitored on a regular basis to ensure that the frequency of removal is adequate, and the need for additional bins.

Local community and school groups could play a very important role in the ongoing monitoring of the area.

For a full list of organisations and groups that can help with monitoring and education to promote conservation in the area refer to Appendix 11.6.

9.7 Recommendations

It is recommended that:

9.7.1 **Investigate options for the long term security of LSB, for example; the land be reserved for the purpose of 'Conservation & Passive Recreation' and classified as Class 'A' Reserve, vested in the City of Bayswater.**

9.7.2 **A vehicle exclusion fence be erected and maintained around the perimeter of LSB.**

9.7.3 **All existing rubbish is removed and on-going rubbish removal is carried out.**

9.7.4 **Eroded and degraded areas in the bushlands are rehabilitated, including the areas earmarked for buffer zones.**

Section 10 Education and Information

10.1 Introduction

Urban bushland in Australia is an extremely important educational resource in the understanding and appreciation of values that the bush has to offer. As approximately two thirds of Australia's population live in large urban areas (Collins, 1993) pockets of bushland such as LSB that are within walking distance of suburban houses provide the opportunity for city dwellers to experience a unique natural environment (Harris & Scheltema, 1995).

Perth's urban bushland has outstanding ecological value, containing diverse communities of flora and fauna, many of which are endemic to the region. (Harris & Scheltema, 1995). However, since European settlement much of the original bushland on the Swan Coastal Plain has been cleared (Beard, 1990). As Perth's population increases there will be growing pressure to clear the few remnants of natural bushland still existing in the metropolitan area. Therefore, there is urgent need to educate and inform the general public of the value of these remaining areas before it is consumed by developments, or degraded through inappropriate use.

The LSB is a remnant of the native flora and fauna of the Perth region highly worthy of preservation (Dixon, 1993). However, lack of management in the past has resulted in the area becoming severely degraded through inappropriate uses. The role of education in the management of LSB is very important as it involves making information available to the community that encourages an awareness and understanding of the area. It also facilitates the establishment of community groups that may wish to be involved. Involvement of the community is an effective means of achieving conservation goals, as commitment is high due to the increased personal responsibility felt towards the management of the area. Indeed the W.A.Government, through the Urban Bushland Strategy (WA Govn. 1995), has recommended that local government bodies and the community be jointly involved in management of bushland areas.

Educating residents of Noranda and the surrounding areas on the most appropriate methods of reversing degradation trends will enable them to actively participate in its maintenance and rehabilitation. Schools, in particular, have been keen to use bushland for educational and recreational purposes (State Ministry for Education pers. comm.).

10.2 Strategies

1. To educate and inform visitors to the area about the historical, cultural and conservation values.

2. To generate interest and enthusiasm within the broader community, and to encourage people to use the area in a responsible and caring way.

3. To develop an awareness among young people, in particular, of the importance of urban bushland.

10.3 On-site Educational Facilities and Public Information

It is important to create an appreciation so that the community will not only enjoy using the area for recreation, but will take away with them an understanding of the values that this and many urban bushland areas have to offer. The existence of on-site educational facilities that inform the community are a valuable means of achieving this goal.

On-site educational facilities are required to be both low maintenance and easily accessible by the public. Such facilities could include an interpretative visitor's centre with display panels outlining the following:

(i) Significant animal and plant species found in the area;
(ii) The role of wetlands;
(iii) The importance of remnant bush in the urban environment;
(iv) Aboriginal and European history of the area;
(v) The conservation and rehabilitation strategies of the area;
(vi) Contact details of managing bodies and community groups involved in LSB.

Other information/interpretation signs may be erected along the walk trails and at areas of significance such as the wetland fringes, Aboriginal sites (see Section 2) and regeneration areas (see Figure 8.1 for proposed locations). It should be noted that signage has proven to be more effective where it reflects positive behaviour. Therefore, where it is possible it is suggested not to use instructions of a negative or prescriptive nature. An example of a positive sign is 'Please appreciate the wildflowers in their natural environment' as opposed to 'Picking wildflowers is prohibited' (Matheny, 1978). It would also be advisable to have signs in surrounding streets to direct the public to the access gates.

Signage and pedestrian gates at LSB, August 2002 (Photo – Sarah Dawson)

10.4 Friends Groups

The Council is often the first point of contact for residents with enquiries or complaints. Therefore, it would be beneficial for the City of Bayswater to be involved in assisting the establishment of a community-based interest group. 'Friends' groups have been successfully established by other Shires in the Perth metropolitan area to assist in the management or urban bushland. The involvement of the community in the management of bushlands invokes a 'sense of pride' in the area and increases the likelihood of successful conservation and rehabilitation. Such groups also help in the dissemination of information between different sectors within the community.

In October 2000, the Friends of Lightning Swamp Bushland was officially formed, and as of November 2001 had 50 members.

10.5 Progress Reports and Displays

Progress reports on LSB are vital in raising awareness of the area, and informing the community of what is being done to the bushland area. One method in which the dispersion of information can be achieved is through displays and provision of pamphlets in local libraries and shopping centres. Such displays could include information regarding the progress of any rehabilitation programs, new findings of particular species of flora and fauna and any special events such as wildflower season.

Local shopping centres and libraries responded enthusiastically when approached with regard to providing suitable areas for public displays. Other appropriate venues for these displays and distribution of pamphlets could include community fairs, council offices and school fetes.

Newspaper reports are another method that could be employed in distributing information to a wider audience. A number of articles and photographs have already been published in local papers and magazines.

10.6 Education and Information for School Groups

Education of children of all ages is a key to building appreciation amongst the younger generation of the importance of urban bushland. This is a valuable direction to take and may prevent children partaking in activities that are not compatible with the conservation and rehabilitation of the area such as the lighting of fires and taking trail bikes into LSB as they get older. The education of school children is a useful tool for disseminating information throughout the community as children expose their parents to the ideas and perspectives of a generation which appears to be more committed to environmental issues (Campbell, 1994).

LSB is within a 4km radius of 11 primary and 4 secondary schools (see Appendix 11.6) and is therefore well positioned to provide both an educative and recreational role. The present school curriculum allows for educational activities involving urban bushland to be incorporated into the primary and secondary school syllabus in a variety of ways. Schools contacted indicated they regularly made use of urban bushland areas for purposes such as:

* orienteering;
* native flora and fauna studies;
* WA week activities; and
* learning Aboriginal history and culture.

However, activities such as orienteering, particularly off designated tracks, can be very damaging for the long-term conservation of such small and isolated reserves as LSB and should be discouraged.

Some schools also participated in voluntary rehabilitation programs. Infant Jesus Primay School in Morley has its own greenhouse where native trees are grown from seed and used for Landcare programs in the wheatbelt (Grabski, 1996), while Noranda Primary School won the 1999 Earth Schools Competition for its work with native bushland reserves. The school also has a Junior Bushwardens program, partly sponsored by the City of Bayswater, with over 70 members as of November 2001.

Any rehabilitation work with schools needs to be guided by the principle of local provenance (obtaining seed from the site of within a small radius of LSB that contains the same vegetation). Small-scale vegetation maps and plant identification sheets would be required as a guide.

The State Government will be developing a Schools Bushland Program in consultation with the State Ministry of Education which will see schools adopting a local bushland area for the purpose of environmental studies (Govt. of WA, 1995). This program, and organisations such as those listed in Appendix 11.6 will prove to be useful resources for information on urban bushland.

LSB straddles two active environmental organisations, both with schools environmental coordinators. BICM and Bennett Brook Catchment Group actively go out to schools with environmental programs, and have already used LSB for a number of projects such as macro-invertabrate sampling, tree identification and catchment education (see Appendix 11.6 for contact details). BICM, in association with Noranda Primary School, has also produced a guide to cross-curriculum bushland studies aimed specifically at local conditions found in LSB. This guide, called Our Bushland Classroom contains notes for teachers as well as activity sheets and information (Ireland, 2001).

10.7 Recommendations:

It is recommended that:

10.7.1 A "Friends of Lightning Swamp Bushland" community group be established.

10.7.2 Educational/Interpretation display centres be established (see Figure 8.1).

10.7.3 A long-term public education and awareness programme is implemented.

Section 11 References

Andrew, Ruth. 1996, Swan Shire Historian, *personal communication*, 4 October 1996.

Australian Broadcasting Commission, 2001, *How much native bush is enough*? Earthbeat, 20/01/01.

Australian Nature Conservation Agency (ANCA). 1996, Feral Cats Page (On line), Available world Wide Web; URL; http://www.anca.gov.au/plants/manageme/cats,htm (Accessed 5 October 1996).

Balla S. (1994) *Wetlands of the Sswan Coastal Plain - Volume 1 - Their Nature and Management*, (WAWA and DEP, Perth).

Bamford, M.J. 1986, *The Dynamics Of Small Vertebrtes In Relation To Fire In Banksia Woodland Near Perth*, Western Australia, Unpublished PhD thesis, Murdoch University, Perth.

Barlte, J., Graham G., Lane, J., Moore, S. 1986 *Forrestdale Lake Nature Reserve Draft Management Plan*, Department of Conservation and Land Management.

Bayly, I.A.E. and Williams, W.D. 1973, *Inland Waters and their Ecology*, Longman, Australia pp. 17-19.

Beard, J.S. (1990), *Plant Life of Western Asutralia* Kangaroo Press, Kenthurst NSW.

Bell, D.T. and Koch, J.M. 1980, *Post-fire succession in the Northern Jarrah forest of Western Australia*, Australian Journal of Ecology, 5, 9-14.

Berndt, C.H. and Berndt, R.M. (eds) 1979, *Aborigines of the West*, University of WA Press, Perth.

Bourke, M.J. 1987, *On the Swan: a history of the Swan District*, WA, University of WA Press, Perth.

Bourke, Michael. 1996, Swan Shire Historian, personal communication, 3 October 1996.

Brittain, R.K. 1990, *Yellagonga Regional Park, City of Bayswater of Wanneroo Ethnography Position Paper*, Department of Planning and Urban Development.

Brooker J., Carr A. and Knox I. (1994) *Waterford Foreshore Reserve - Management Plan*, (City of South Perth - Community Representatives).

Brooks, R & Jeffries, M. (1990) *Regeneration of Coastal Dune Environment* Sowing the Seeds Conference Proceedings of Regeneration Conference - Greening Australia, Deakin A.C.T.

Brown, C. (pers. comm. 1996) Simsmetal, Perth, Personal telephone interview, 11 Oct. 1996.

Bureau of Meteorology (1993) *Wind, Waves and Weather (Perth Waters)*, Commonwealth of Australia, Canberra, Australia.

Bureau of Meteorology (1996) *Climatological Summary for Perth Airport & Surface Wind Analysis*, Commonwealth of Australia, Canberra, Australia.

Burns, D (1996) Verbal Conformation, W.A. Fire Brigade, Perth, Western Australia.

Burns, D. 1996, Verbal Conformation, W.A. Fire Brigade, Perth, Western Australia.

Burton, J.L. 1982, *Not an Idle Man: a biography of John Septimus Roe*, Fremantle Arts Centre Press, Fremantle.

Burton, Rev. Canon A. undated, *The Store of the Swan 1843-1938*, no publisher.

Bush, B., Maryan, B., Browne-Cooper, R. and Robinson, D. 1995, *Reptiles and Frogs Of The Perth Region*, UWA Press, Perth.

CALM (1991) *Recreation, Tourism and Visitor Services*, (CALM Policy Statement No. 18., Perth).

CALM (pers. comm. 1996) Department of Conservation and Land Management, Perth, Personal telephone interview, 8 Oct. 1996.

CALM, National Parks and Surveys and City of Canning (1995) *Canning River Regional Park Draft Management Plan 1995 - 2005*, Como, W.A.

Cambell, A. (1994) *Landcare: Communities Shaping the Land of the Future* Alan and Unwin PTY Ltd., NSW. Pg: 136.

Chambers, J.M. & davis, J.A. 1988, *How Wetlands Work* in Proceeding of the Swan Coastal Plains Groundwater Management Conference. WA Water Resources Council, Perth. Pp. 97-103.

Chiras, D.D., *Environmental Science: Action for a Sustainable Future 4th Ed.* Benjamin/Cummings, Sydney, pp. 415.

Christensen, P., Recher, H. and Hoare, J. 1981, *Responses of Open Forest Fire Regimes*. In Fire and the Ausralian Biota Eds, Gill, A.M., Groves, R.H. and Noble, I.R. (Griffin Press:Adelaide).

Christensen, P.E.S.and Burrows, N.D. 1986, Fire. *An old Tool with a new use. In: Ecology of Biological Invasion: An Australian Perspective*. Eds. Groves, R.H. and Burdon, J.J. (Australian Academy of Science: Canberra).

Churchward, H.M. & McArthur W.A. (1978) Perth Sheet - Landforms and Soils - *Western Australia, Darling System, Landforms and Soils.* Division of Land Resources Management, CSIRO, Perth, Western Australia.

City of Melville, 1991, *Blue Gum Reserve (no A25562) A Draft Management Plan*,

Clare, B. (pers. comm. 1996) Agricultural Protection Board, Personal telephone interview, 6 November 1996.

Collins, T. (1993) *Living for the City; Urban Australia: Crisis or Challenge*? ABC Books, Sydney.

CSIRO (1990) *The Greenhouse Effect: Regional Implications for Western Australia*, Commonwealth of Australia, Canberra, Australia.

Davies, P.M. & Lane, J.A.K. (1995), *Guidelines for design of effective buffers for wetlands on the Swan Coastal Plain*, Department of Conservation and Land Management Science Supplement (in press).

Davis, J. and Chambers, J. 1996, *Management of Aquatic Systems Reader, vol 1*, School of Environmental and Biological Sciences, Murdoch University, Murdoch W.A.

Department of Conservation and Environment (1980) *Atlas of Natural Resources Darling System Western Australia* pp. 30, 78-85.

Department of Conservation and Environment Western Australia 1983, *Conservation reserves for Western Australia as recommended by the Environmental Protection Authority - 1983, The Darling System - System 6, Part 2: Recommendations for Specific Localities*, Perth.

Department of Conservation and Land Management 1995, *Declared rare and priority flora list, Swan Region, 14 September 1995*, CALM

Department of Environment, Sport and Territories 1994, *Fire and Biodiversity: The Effects and Effectiveness of Fire Management: Proceedings of the Conference held 8-9 October 1994, Footscray, Melbourne: Biodiversity Series Paper No. 8 (Biodiversity Unit)*, Department of Environment, Sport and Territories: Canberra.

Department of Environmental Protection (1994-95) (Unpublished) *System Six update program*, Department of Environmental Protection, Perth WA.

Dew, R. (pers comm. 1996) The Eastern Suburbs 4WD Club, Personal telephone interview, 20 Oct. 1996.

Dieback Working Group, 2000, Managing Phytophthora Dieback in Bushland (2nd ed.). DWG.

Dingle, Peter. 1996 *Pollutants and Toxicology Study Guide* Murdoch University, Murdoch W.A.

Dixon, Dr.K (1993) Assistant Director, *Science and Education Division Kings Park and Botanic Garden*, Letter to Mr T Foteriou, Ecosystem Management. 19/8/93.

Dixon, K. 1993 *Biological Status of Land in Noranda, South of Tonkin Highway.* Letter to Mr T Foteriou, of Ecosystem Management, from Dr Kingsley Dixon, Kings Park and Botanic Garden.

DPI 1995, *Urban Bushland Strategy for the Metropolitan Region*, DPI, Perth.

DPUD (1993) *Water Sensitive Urban (Residential) Design Guidelines for the Perth Metropolitan Region - Discussion Paper*, Perth Western Australia.

Eastern Suburbs Reporter Community, (1996), *New Sports Site Plan*, (Eastern Suburbs Reporter Community 1/10/96, Perth).

Ecosystem Management Services pers.comm. October 1996.

Environmental Protection Authority & Western Australian Water Authority. 1993, *Wetland Management and the Conservation Estate*, Water Resources Planning Branch, Western Australian Water Authority, Perth.

Environmental Protection Authority 1990, *A Guide to Wetland Management in Perth, Western Australia*, Bulletin 374, Perth.

Environmental Science 1994, Murdoch *University Draft Management Proposal For Wetlands in the City of Melville*, 1994.

Ferguson R.J. and Stephenson, G. 1975, *Survey of Historic Buildings in the Shire of Swan*, Western Australia, Shire of Swan, Perth.

Freeman, A & Reid, G. (1995) *APACE Revegetation Catalogue - Species Lists and Locality Guide for the Swan Coastal Plain and Darling West*, Perth.

Freeman, T. (pers. comm. 1996) APACE Western Australia, Personal interview, 4 Oct. 1996.

Friend, g. 1995, *Impact of fire on fauna in remnant vegetation - a summary of key research findings*, in Burning Our Bushland, Urban Bushland Council (WA), Perth, pp. 49-51.

Froend, R.H., Farrell, R.C.C., Wklkins, C.F., Wilson, C.C., McComb, A.J. 1993, *Wetlands of the Swan Coastal Plain Volume 4: The effect of altered water regimes on wetland plants*, Environmental Protection Authority of Western Australia and Water Authority of Western Australia.

Garnett, S. 1992, *Threatened and Extinct Birds of Australia*. RAUO, Victoria.

Gentilli, J. (1972) *Australian Climate Patterns*, Thomas Nelson (Aust.), Melbourne, Australia.

Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H. and Lyons, M.N., 1994, *A Floristic Survey of the Southern Swan Coastal Plain*. Unpublished Report for the Australian Heritage Commission, prepared by Department of Conservation and Land Management and the Conservation Council of Western Australia. Appendix 1, Community type: 22.

Glassford, D.K. & Semeniuk, V. 1990, *Stratification and disconformities in yellow sands of the Bassendean and Spearwood Dunes, Swan Coastal Plain, South-western Australia*, Journal of the Royal Society of Western Australia, vol.72, no.3, pp. 75-92.

Government of Western Australia (1995) *Urban Bushland Strategy* June 1995.

GOW, G. 1986, *Snakes of Australia*, Angus and Robertson, Sydney.

Gozzard J.R. 1986, *Perth, sheet 2034 11 and part 2034 111 and 2134 111*. Perth Metropolitan Region Environmental Geology series, Geological Survey of Western Australia.

Grabiski. S., Deputy Principal, Infant Jesus Primary School, Morley. Pers. comm. 18 October 1996.

Gray (1996) Urban Bushland Council of W.A. pers. comm.

Harris, J. & Scheltema, M. (1995) Introduction in Harris, J. & Scheltema, M (Eds.) *Managing Perth's Bushland* Greening Western Australia, Perth.

Hart, R., 1992, *Phytophthora - the fungi and their impact*, In: Proceedings of the Northern Sandplains Dieback Working Party Seminar, Perth, 23 September 1992.

Hill, A.L., Semeniuk, C.A., Semeniuk, V & Del Marco, A. (1996) *Wetlands of the Swan Coastal Plain - Wetland Mapping, Classification and Evaluation*, Vol 2B.

Hinks, P. 1996, DPI, Personal telephone interview.

Hobbs R. and Atkins L, 1990, *Effects of Fire in a Banksia Woodland*, Australian Journal of Botany, 38, 97-110.

Hobbs, R. 1995, Fire. In: *Managing Perth's Bushlands: Perth's Bushlands and how to Manage Them*. Eds, Shetema, M. and Harris, J., Greening Western Australia: Perth.

Hollingsworth, P. 1996, Western Power, Personal interview.

Hopper, S., van Leewen, S., Brow, A., Patrick, S. 1990, *Western Australia's Endangered Flora and other plants under consideration for declaration*, Department of Conservation and Land Management.

How, R., Dell, J. 1993, *Vertebrate fauna of the Perth Metropolitan Region: consequences of a modified environment* in Urban Bushland, Western Australian Museum, Perth, pp. 28-37.

Hunt, H.A., Taylor, G., Quayle, E.T. (1913) *The Climate and Weather of Australia*. Commonwealth Bureau of Meteorology. Melbourne.

Hussey, B & Wallace, K. (1993) *Managing Your Bushland*, CALM, Como, W.A.

Ireland, Karen. (2001). *Our Bushland Classroom*, Bayswater Integrated Catchment Management (BICM) and Noranda Primary School.

Keighery, B.J. 1996, *Floral Survey of Lightning Swamp*, October 1995, Unpublished.

Kelly, A.E., Taylor, A., Langley, M.A., Spooner, A., Coates, D.J. 1993, *Declared rare flora and other plants in need of special protection in the Metropolitan Area*, Department of Conservation and Land Management and Australian National Parks and Wildlife Service.

Kimseeds (pers. comm. 1996)

Kings Park Personal telephone interview, 6 Nov. 1996.

Lane, J.A.K., McComb, A.J. 1988, *Western Australian Wetlands* In: The Conservation of Australian Wetlands, ed A.J. McComb and P.S. Lake, Surrey-Beatty & Sons, Chipping-Horton, Australia. pp 127-146.

Linacre, E. & Jobbs J. (1977) *The Australian climatic Environment*, John Wiley & Sons, Queensland, Australia.

Malcolm, R. (pers. comm. 1996) ARC Smorgon Fencing, Personal telephone interview, 11 Oct. 1996.

McArthur, W.M. & Bettenay, E. 1974, *The Development and Distribution of the Soils of the swan Coastal Plain*, Western Australia, Commonwealth Scientific and Industrial Research Organisation, Australia, Melbourne, pp. 4-34.

McComb, A.J. and Lake, P.S. 1990 *Australian Wetlands*. Collins/Angus and Robertson, NSW, Australia pp 90-92.

McQuoid, N. (pers. comm. 1996) Kings Park Personal telephone interview, 6 Nov. 1996.

Moore S.A. (ed.), (1984*) The Management of Small Bush Areas in the Perth Metropolitan Region*, (W.A. Wildlife Research Centre, Wanneroo, Perth).

Murdoch University (1995) N310 *Land Management Course* Reader, Vol. 2, Murdoch University, Perth.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fanseca, G.A.B. and Kent, J. Biodiversity hotspots for conservation priorities, *Nature* 403, 853 (2000)

National Wildlife Health Centre. 1996 Botulism (On line), Available World Wide Web; URL: http://www.emtc.nbs.gov/http_data/nwhc/factshts/botulism.html (Accessed 5 October 1996).

Ninox Wildlife Consulting. 1990, *Stage 3 Vertebrate Fauna Studies 1983 & 1987*, Ninox Wildlife Consulting, Keysbrook, Australia.

O'Connor, R. and Bodney, C. 1988, *Report on the Ethnographic Investigation of the Proposed Link Road from Crimea Street Noranda to Marshall Road Malaga*, State Planning Commission, Perth.

O'Donohue, Mike (Wildlife Protection Unit, CALM). 2001, Telephone conversation, 13/11/01.

O'Loughlin, P. 1996, Main Roads Department of Western Australia, Personal interview.

Pinder, A., Davis, J & Lane J (1992) *Managing the Midge*, Landscope, Department of Conservation and Land Management, Perth.

Pizzey, G. 1983, *A Field Guide to the Birds of Australia*. Collins, Sydney.

Prescott, L.M., Harley, J.P., Klein, D.A. 1993, *Microbiology*, Wm. C. Brown, Melbourne, 2nd ed, p. 765.

Recher, H. and Christensen, E. 1981, *Fire and the Evolution of the Australian Biota. In Ecological Biogeography of Australia* Ed Keast, A., Dr W. Junk Publishers: The Hague.
Robertson M., Vang K. and brown A.J. (1992) 'Wilderness in Australia: Issues and Options, A Discussion Paper', (Australian Heritage Commission, Canberra, Australia).

Robinson, Neil. 1996, DPI, personal communication, 7 October 1996.

Samwaym M.J. 1994, *Insect Conservation Biology*, Chapman & Hall, London.

Seabrook J (1990) *Seed Production for Local Revegetation*, Sowing the Seeds - Conference Proceedings of Regeneration Conference for Greening Australia, Deakin A.C.T.

Seddon, G. 1972 *Sense of Place*, University of Western Australia Press, Perth pp.7-19, 27-59.

Serventy, V. and Seventy, C. 1981, *Australian Birds*, Rigby, Sydney.

Shire of Swan 1985, *East Malaga Industrial Estate - revised Outline Development Plan*, Shire of Swan, Perth.

Shire of Swan. 1985, *Shire of Swan - Town Planning Scheme, No. 2*, Shire of Swan, Perth.

Simms, T. 1996, Department of Environmental Protection, Personal telephone interview.

Simpson, K. and Day, N. 1993, *Field Guide to the Birds of Austrlaia*, Viking, Sydney.

Smith, K. 1995, *Fire and Fana* in Burning Our Bushland, Urban Bushland Council (WA), Perth, pp. 46-48.

Smith, V. 1985, *Wireless Hill Park - Management Plan*, City of Melville.

Smith, V. 1986, *Booragoon Lake Management Plan*, City of Melville, Perth, p. 38.

Stace, H.C. Hubble, G.D., Brewer, R., Northcote K.H., Sleeman, J.R., Mulcahy, MH., & Hallsworth, E.G. 1972, *A Handbok of Australian*, Commercial Printing House, South Australia, pp 40-43.

Stansfield, J. 1991, *Focus on Australian Birds*, Peter Antill-Rose Associates, Castlehill, Australia, p.43.

Stranham, R. 1995, *The Mammals of Australia*. Reed Books, NSW.

Street M. (1992) *Blue Gum Lake Reserve Management Plan* (Parks Services for the City of Melville, Perth).

Street, M. (pers.comm. 1996) Melville City Council, Melville, Personal telephone interview, 5 Nov. 1996.

Taman, L. 1996, Ecosystem Management Services, Personal interview.
Taylor, R.D. and Partners undated, Shire of Swan Town Planning Scheme no. 1 report no. 2, West Perth, WA. Water Corporation, minutes of meeting held 2 August 1996.

Tebbut, T.H.Y. 1983, *Principals of Water Quality Control*, Pergana Press, London.
Thiele, S. 1996, Shire of Swan, Personal interview.

Tingay, Alan & Associates. 1998, *A Strategic Plan for Perth's Greenways*, Final Report.

Tuffnell, Glenn. *LightningSwamp: Assessment for the Presence of Phytophthora* sp. April, 2001. Glevan Dieback Consultancy Services.

Tyler, M.J., Smith, L.A. and Johnstone, R.E. 1984, *Frogs of Western Australia* University of Western Australia Press, Perth.

Underwood, R.J. & Christensen, P.E.S. (1981) *Forest Fire Management in Western Australia*, Forests department of Western Australia, Perth, Western Australia.

Vadja, A. Personal Interview. Water Corporation. 11 October 1996.

W.A. Environmental Protection Authority Draft *W.A. Water Quality Guidelines for Fresh and Marine Water - Adapted from the Australian Water Quality Guidelines for Fresh and Marine Water* (ANZ ECC 1992) Perth Environmental Protection Authority 1993.

Water Corporation, 1996, *Map of Emu Swamp Main Drainage Features*, Perth W.A.

Water Corporation, *Wonga Road Main Drain Scheme Review* - Minutes of Meeting, Friday 2 August 1996.

Western Australian Planning Commission, 1994, *Perth Metropolitan Regional Scheme*, Western Australian Planning Commission, Perth.

Western Australian Planning Commission, 2000, *Bush Forever*, WAPC, Perth.

Western Australian Water Authority, 1993, *Wetlands in the Shire of Swan*, Western Australian Water Authority, Leederville, Perth.

Wilde, S.A. & Low, G.H. 1978, Perth, Western Australia, *Sheet SH50-14 International Index; 1:250 000 Geological Series - Explanation Notes*, Geological Survey of Western Australia, pp. 1-32.

Williams K., Parer I., Coman B., Burley J., and Braysher M. 1995, *Managing Vertebrate Pests: Rabbits*, CSIRO Division of Wildlife and Ecology, Australian Government Publishing Service, Canberra.

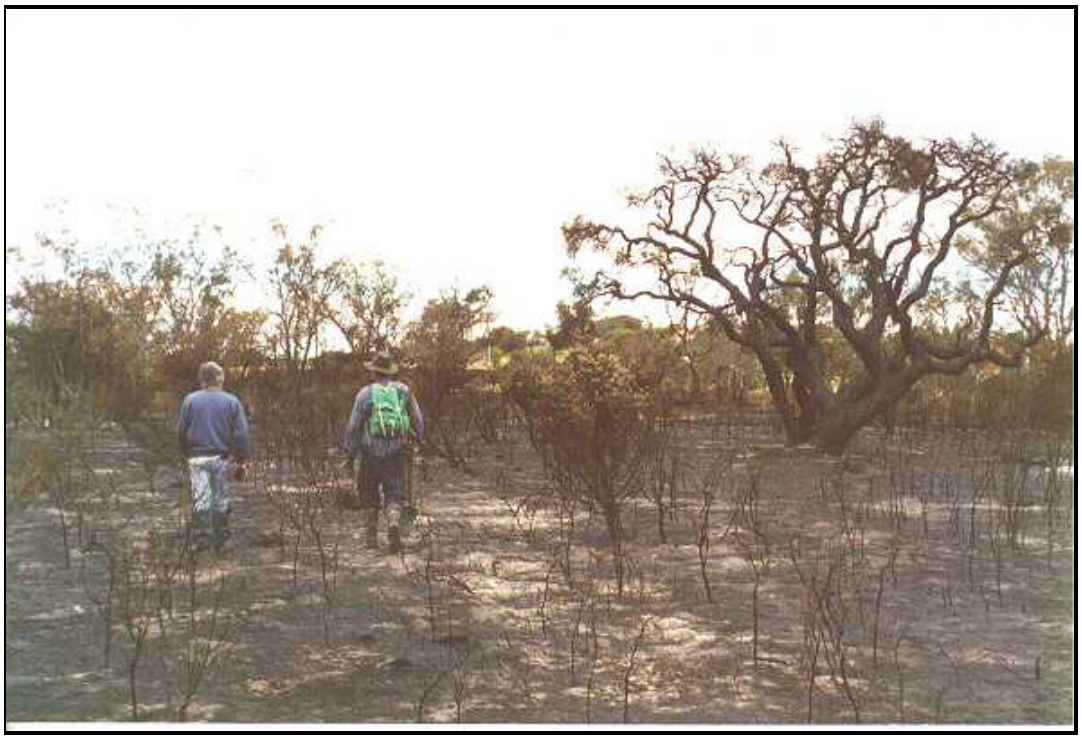
Williams W. D. (1983) *Life in Inland Waters*, Blackwell Scientific Publications, Victoria.s

APPENDIX 1
LIGHTNING SWAMP BUSHLAND FIRE MANAGEMENT PLAN

Introduction

The Lightning Swamp Bushland (LSB) is a significant area of urban bushland, providing opportunities for many passive recreational and environmental-based activities in metropolitan Perth. Its size, location and geography make it quite unique, particularly in the City of Bayswater. For a full description and history of the area, refer to the main management plan.

Fire is one of the greatest threats to urban bushland. Accessibility, a large surrounding residential area, and often-neglected bushland make these areas prime candidates for arson and accidental fire. This not only kills and damages native flora and fauna, but threatens human life and property as well. This fire management plan aims to identify and significantly reduce the risks associated with fire in the LSB.



The aftermath of a fire in LSB, December 2001 (Photo – Sarah Dawson)

Purpose of this Document

This document is an addition to the main LSB Management Plan. Its primary purpose is to formulate strategies designed to reduce the number and impact of fires in LSB, and to ensure the safety of those involved in fire suppression activities, as well as residents surrounding the area.

The major concepts covered in this document are:

- The identification of parties involved with fire management in Lightning Swamp, and their responsibilities.
- Fire *prevention* strategies for LSB by looking at ways to stop fires from starting in the area.
- Fire *preparedness* strategies that aim to reduce the size and impact of fire on LSB.

- Fire *response* strategies to coordinate the response to and management of a fire when it occurs.
- Fire *recovery* strategies to assist the recovery of LSB from the effects of fire.
- Make recommendations pertaining to the fire management of LSB.
- The establishment of a review mechanism for the fire management plan.

In addressing these issues, a number of strategies and initiatives will be recommended, and illustrated by maps and diagrams.

Responsibilities

The occupier and leaseholder (City of Bayswater) is responsible for the prevention, preparedness and recovery initiatives of this fire management plan pursuant to the Bush Fires Act and the lease agreement with the Western Australian Planning Commission.

FESA is responsible for response activities, and will provide advice and support on all aspects of fire management. The responsible local station is the fire station in Malaga, just north of LSB.

Stakeholder	**Responsibility**
City of Bayswater	Overall fire management planning. Implementation of prevention, preparedness and recovery strategies. Maintaining the integrity of perimeter fencing. Compliance with the *Bush Fires Act 1954*, including firebreak inspections and exemptions. Overall fire management planning and implementation of prevention, preparedness and recovery strategies for vested lands. Provision and maintenance of perimeter signs. Support of Friends (FOLSB) group.
FESA	Planning and implementation of response strategies. Response activities. Provision of advice on all aspects of fire management planning, including prevention, preparedness, response and recovery.

PREVENTION STRATEGIES

This part covers:

- *Fire prevention strategies suitable for LSB including:*
  - *preventing or reducing arson;*
  - *controlling access to the area;*
  - *separating the sources of fire risk; and*
  - *community involvement.*

Preventing or Reducing Arson

Fire prevention is all about stopping fires from starting in bushland, and minimising the impact of any fires that start. The total prevention of fires in LSB may not be possible, but steps can be taken to reduce the number of unplanned fires through consultation with community members, and the implementation of the strategies below.

Maintaining a register of fires in the area will aid in the arson prevention strategy by pinpointing previous ignition points and trouble spots. It has been found that many small fires in the area are started on the northern side, where there is less public scrutiny and easier illegal access. By recording information about fires in the area, such as location, day and time of fires, these spots can be patrolled during periods of high fire danger and when fires are seen to be most frequent.

Controlling arson in bushland is very difficult. Reducing the incidence and opportunity for arson is the practical option. There are two Fire Services initiatives that are aimed specifically at reducing the incidence of arson.

- The Wildfire Investigation Action Team (WIAT) investigates the cause of unknown or suspicious wildfire. The WIAT works in close association with the Police Service Arson Task Force to identify fires that have been started by arson and assist in the apprehension of arsonists.
- The Juvenile and Family Fire Awareness (JAFFA) program is aimed at juveniles from 4-16 years of age who have been involved in the lighting of unsanctioned fires. The program aims to help juveniles understand the dangers of fire play, educate them in various aspects of fire behaviour, and alert them to the consequences of fire.

  Strategies to prevent arsonists starting fires in LSB include the following:

  - controlling the access of unauthorised vehicles and persons
  - separating sources of risk from the bushland
  - encouraging community involvement

Each of these points is discussed in more detail below.

Controlling access

Controlling access to an area with vehicle-exclusion fencing and well designed pedestrian access ways reduces the chances of the area being used for illegal activities, such as the burning of stolen cars or drug- and alcohol-related activities, and may help reduce the incidence of arson. Official NO ENTRY TO OFF-ROAD VEHICLES signage will also reduce illegal access, and allow offenders to be prosecuted. It is vital that perimeter fencing, signs and gates are maintained, and breaks or damage fixed as soon as possible.

In some cases, this initiative may need to be supplemented by frequent patrols of the area to monitor the security of the fence and discourage illegal activities. Members of the Friends group and City of Bayswater rangers are suitable for this task, particularly during times of high fire risk.

Separate the sources of fire risk

Areas where high human interaction is anticipated, such as entrance points, visitor interpretation centres and other recreational facilities need to be maintained and presented in a manner which will prevent accidental fires from starting and not attract undesirable behavior. Human interaction facilities should be kept away from areas of high fire risk, such as the perched wetlands.

Community involvement

By keeping the local community informed about the value of LSB, its beneficial aspects, and encouraging their involvement in the management of the area their interest and awareness of both bushland and the dangers of fire will increase. Such information can be conveyed using letterbox drops in the surrounding areas, shopping centre displays, and newspaper articles prior to the main fire season annually. This should be coordinated between the City of Bayswater, Catchment groups, and the Friends group.

It is especially important that the community understand that LSB is being actively managed, and that they can contribute to fire prevention initiatives. Simple precautions, like encouraging neighbours to keep a watch on the area for suspicious activity, can help reduce the incidence of arson. Even the presence of other people in the bushland area may discourage arsonists and illegal activity. Signs are also another effective method of advising visitors of the danger of fires in the area, and what to do should a fire start in the reserve.

It is also important to stress to the community that initiatives to prevent arson in bushland will also help to protect properties surrounding LSB. For more information on community involvement refer to Sections 7 and 10 of the main plan.

PREPAREDNESS STRATEGIES

This part covers:

- *Fire preparedness strategies that aim to reduce the size and impact of fire on LSB*
- *Fire Watch by the community*
- *Firebreaks and fire access tracks*
- *Fuel load monitoring and reduction*

Introduction to Preparedness Strategies

It is too late to begin planning for fires during the event. Preparedness strategies aim to keep fires small, help firefighters effectively fight the fire, and to ensure the safety of emergency personnel. Preparedness strategies can also help to minimise environmental disturbance during fire, and generally reduce the impact of wildfire.

It is vital that the community is made aware of just how quickly and easily a small fire can become a large fire, with devastating and long-term consequences.

Fire Watch by Neighbours

An early response helps to keep the fire small. Neighbours should be encouraged to report fires in the LSB area with the same urgency accorded to house fires by dialing '**000**'. This information should be included in the public education and awareness program mentioned above.

Fire Access Tracks

The provision of fire access tracks through LSB is a key measure that will assist firefighters to contain fires that occur in the reserve. LSB has a well-established fire access track network already in place, preventing the need for any further tracks to be installed.

There are currently several access tracks that are unstable and pose a potential risk to the user. These tracks will be closed and revegetated in a bid to reduce unrequired access tracks in the area, particularly in the Dieback-infected areas.

The purpose of fire access tracks

Fire access tracks serve several purposes. They can help to:

- protect nearby property from fire in the bushland
- protect fencing from being damaged by low intensity fires
- protect the bushland from fires starting on private property
- give firefighters access to the bushland, to allow them to distinguish fires directly
- provide a fire break when indirect firefighting methods are necessary
- conserve high priority areas, including threatened ecological communities and rare or endangered species of flora and fauna.

Fire access tracks, particularly stabilised ones, can also perform a dual service as access for maintenance purposes, nature walk trails, pedestrian, wheelchair or cycle-paths. It is planned to stabilise a number of tracks for these reasons, as indicated in *Appendix A* and Section 8.

Location of fire access tracks

The maps included in *Appendices A* and *B* gives an indication of firebreaks and fire access tracks within LSB.

These fire access tracks break up large areas of bushland into smaller sections so that fire may be more easily contained during fire suppression operations, and damage is hopefully limited. This also allows fauna to effect an escape from one bordered area to another, and firefighting efforts to be more effective.

Fire Access Tracks – Maintenance

To fully serve their purpose, the fire access tracks in LSB require regular maintenance to ensure their serviceability. This maintenance is to be conducted before the 2 November of each year to comply with firebreak notices issued under section 33 of the *Bush Fires Act 1954*.

To prevent unnecessary disturbance to the tracks and reduce the spread of Dieback-infected soils, grading or rotary hoeing the track must be replaced by chemical weed control, and limited to where vegetation has re-grown on tracks. Rotary hoeing and grading the firebreak destabilises the soil, making it more prone to bogging and erosion. It also promotes weed growth and spreads Dieback from one area to another.

Fire access tracks need to be kept clear of overhanging tree branches and vegetation to a minimum width of 3 meters. This needs to be widened to 5 meters around corners, to allow vehicles to negotiate them safely. Vertical clearance will need to be not less than 4 meters, to allow medium tankers to access the area. As a rule, only overhanging branches will be pruned away, unless the tree is unsafe or some other reason necessitates the removal of the whole tree.

There are currently six vehicle access gates into LSB, one on the western perimeter, two on the southern perimeter and three on the Eastern perimeter. These are indicated in *Appendix A*. All gates are fitted with City of Bayswater Master Key A locks and numbered for easy identification. Chain length on gates will also allow emergency entry/exit to the reserve by cutting.

Before entry into LSB, contractors and/or Council plant may be inspected by the City's Bush Fire Control Officers to ensure that it is not likely to spread weeds or diseases such as dieback into or out of the reserve. The Fire Control Officer maintains the right to refuse entry into the reserve until he/she is satisfied that the plant will have no adverse effect on the reserve. In addition, and apart from

emergency crews, no vehicles are to enter LSB whenever the Fire Danger Index (FDI) has been posted as "VERY HIGH" or "EXTREME".

Subject to Section 33 of the Bush Fires Act 1954, the City of Bayswater is required to maintain the firebreaks from the 2 November to the 31 March of the following year. The firebreak system through LSB currently **does not** comply with the City of Swan's requirements, as the northern firebreak does not follow the cadastral boundary of the reserve.

The City of Bayswater will need to make application to the City of Swan for an exemption from this requirement, citing that a firebreak exists on the immediate external boundary of the northern side of the reserve and that there are internal firebreaks that can support the suppression efforts. If an exemption is not granted, the City would be required to realign the northern firebreak. However, this would involve the destruction of important bushland and is not recommended.

Fuel Load Monitoring and Reduction

Monitoring the fuel load

Fire management in urban bush areas must always be a compromise between the environmental needs and the safety issues involved. Only with adequate liaison, planning and local management can the needs of both fire protection and conservation be met. The responsibility for monitoring fuel loads within LSB must rest with the landowner or leaseholder, with the support and advice of FESA, the FOLSB and catchment groups.

Methodologies for monitoring fuel loadings relevant to forest fuels, grasslands and heathlands are contained in the learning manual *Prescribed Burning 1* (FESA, 2000). However, fuel loadings are expressed in tonnes/ha, and are calculated by measuring the quantity of leaf litter and scrub fuel sources that are available to burn. It is strongly recommended that regular fuel risk assessments be carried out within LSB.

Methods of reducing fuel loading

Methods available to reduce fuel loading in native bushland are:

- weed control, using hand-clearing or selective herbicides
- selective hand-clearing of dead material
- mowing or slashing
- controlled burning

Weed control and hand clearing

One of the most effective ways to reduce the fuel in urban bushland is to control the weeds. Because of the fire-weed cycle, controlled burning for removal of weedy fuel is not recommended as it usually makes the weed problem worse, and has been ruled out as an option for fuel reduction. The adoption of hand weeding is preferred to protect the area from the effects of fire.

The use of selective herbicides such as Fusilade will kill off all non indigenous and native grasses, but will leave all other native species intact. However, **the use of Fusilade requires safety handling and breathing equipment**, and will require follow-up treatments. Once grasses such as veldt grass have died off, the remaining clump can be removed by cutting the stem just under ground level with a sharp weeding knife. This should be done gradually, and in small stages, as flat weeds will claim the open areas and be harder to control. As Fusilade takes some weeks to work, the grass should be sprayed in its early stages, and well before the flower/seed forms. In areas away from sensitive native

flora chemicals such as Glysophate (eg. Roundup) may be used to provide a total kill of weed-infested spots. An example of this are the verges surrounding LSB.

Digging or pulling weed clumps up is **not** recommended, as this disturbs the soil, and actually promotes weed growth. The method described above is recommended.

NOTE: Areas selected for weeding must be monitored for regrowth by native species. The main danger after an area has had the grasses removed is the strong regrowth of flat weeds. These weeds restrict native regeneration because of their leaf configuration and ability to extract water, but do not create as large a fire hazard. If possible, weeded areas should be planted with natives to help the regeneration process.

Mowing and slashing

Where areas of weeds or cultivated grass border LSB, for example along Matthews Close and Malaga Drive, regular mowing or slashing of the adjacent areas may be sufficient to prevent the fire from reaching the natural vegetation. The eastern end of the bushland, on either side of old Della Road will also require slashing regularly. It is particularly important to slash prior to the ripening of grass and weed seed, usually in late August. Slashing can also be followed up by chemical control.

The City of Bayswater is responsible for this maintenance, while the Friends group can support with some internal slashing and advising the City when slashing is required. An alternative plan is for the City to implement a works schedule for the area using staff and contractors.

Fuel load reduction by controlled burning

Even with the reduction methods prescribed above fuel loads may still be extremely high in LSB. Ironically, the greatest build up of fuel loads can usually be found in regularly burnt areas because of the decimation of organisms that effectively break down leaf litter. However, the reliance on accidental or unplanned fires to reduce fuel loads in LSB may be seen as irresponsible by some in the community. Indeed, the reduction of the fuel load either by the methods described above or through controlled burning is one of the few aspects of fire management the landowner can control.

Controlled burning may be an effective method of reducing fuel loads in an area such as LSB that is surrounded by residential and industrial development if carried out under certain conditions and with strict supervision. However, there are a number of contentious issues raised by such a strategy. These include the fact that the City of Bayswater has imposed a total ban on burning within its district, while smoke and ash from controlled burns are seen to be undesirable by surrounding residents. Because of the close proximity of two major highways large amounts of smoke may also create dangerous driving conditions. There is also the damage fire does to native flora and fauna communities, and the possibility – notwithstanding the information in Section 5.5 – that existing species may be completely destroyed in LSB. Fire also allows aggressive weed species into previously weed-free areas thereby increasing the fire risk.

However, the controlled use of fire to reduce fuel loads should not be completely ruled out by such issues, and it would be anticipated that public opinion towards such a strategy would change to one of acceptance if and when a large fire did occur in LSB. While environmental and aesthetic concerns are important, the vast majority of the community would consider the safety of human life and

property paramount. Therefore, if and when fuel load monitoring indicates extremely high levels of fuel in LSB, the decision to use controlled burning to reduce the risk may be considered a necessity. This decision should be made in consultation with FESA, the City of Bayswater Fire Officer, other government authorities, and the relevant community/environmental groups, particularly the LSB Implementation Committee. It is also vital that the possibility of using a controlled burn in LSB is recognised and anticipated through the development of policies and procedures by the City of Bayswater, perhaps as part of the City's disaster and emergency planning.

RESPONSE STRATEGIES

This part covers:

- ***Suppression strategies in LSB.***
- ***Immediate post-fire response strategies.***

Introduction to response strategies

The response to fire within urban bushland is the responsibility of FESA. FESA has implemented a condensed fire response plan for the area based on this document.

Any stakeholder who wishes to communicate with the FESA during an incident, or enter the fireground, should attend the Incident Control Point and liaise with the Incident Controller or an appointed representative. The Incident Controller has the right to refuse entry into the fireground and this decision needs to be respected by the stakeholders. Such decisions are made with the safety of the public, stakeholders and firefighters in mind.

Suppression Strategies in LSB

Due to the number of existing fire access tracks and the importance of conserving urban bushland **the cutting of any new fire trails to control a fire in LSB should be viewed as a last resort and is not recommended.** All suppression and/or back burning should be carried out from existing tracks and firebreaks. However, if a fire is out of control it is accepted that a section of bushland may need to be burnt to bring the fire front to an existing path.

While not always feasible, fire and emergency vehicles should remain on existing tracks as much as possible during the suppression of a fire in LSB in order to reduce collateral damage to unburnt areas of bushland.

Immediate Post-Fire Response Strategies

While FESA will suppress the running fire, they will not normally remain onsite to mop up or patrol the area once the fire is extinguished. Therefore, re-ignition is a high possibility and must be planned for. It is recommended that policy and procedures be developed as part of the City of Bayswater's disaster and emergency planning. These procedures should outline the roles and responsibilities of certain personnel and groups such as the FOLSB, while allowing for the deployment of resources and equipment to a post-fire event in LSB.

The normal procedure after a large bushfire in LSB could theoretically involve extensive man-hours and the use of Council equipment in order to patrol the fire site, mop up any danger spots and prevent further fires from re-igniting. Therefore, the use of trained volunteers such as the Friends group should be encouraged and planned for in these strategies, both to reduce costs and to further encourage community ownership in the area. It will also be necessary to resource such personnel and Council off-road vehicles with the equipment required to respond to a post-fire event.

RECOVERY STRATEGIES

This section covers:

- *Fire recovery strategies to assist LSB to recover from the effects of fire. These include:*
    - *Debriefing the stakeholders*
    - *Recording and, if necessary, investigating the cause of the fire.*
    - *Assessing the safety of public facilities.*
    - *Rescuing native fauna.*
    - *Controlling access, erosion and weed invasion.*
    - *Selecting regeneration initiatives.*

Recovery is the process of returning an area to 'normal' after the impact of a fire. It includes both short and long-term activities. The responsibility for post-fire recovery initiatives rests with the landowner/leaseholder, with assistance and advice from the Friends group and other environmental agencies such as the Urban Bushland Council, Bennett Brook Catchment Group and BICM.

Debriefing

All stakeholders, including Friends Groups and the agencies mentioned above should be involved in a debriefing after any major fire incident. The debrief should occur as soon as possible after the fire, and a representative from FESA should also be in attendance.

Record the fire

The landowner/leaseholder of the area should prepare an adequate record of the fire occurrence and complete the fire register. Accurate records will provide a valuable information resource necessary for future management of the area. The records should include the extent of the fire, success or otherwise of preparedness initiatives, the fire response activity undertaken and the rehabilitation required. A map of the area should be prepared and photographs taken to provide a visual record of the fire and recovery. This will also assist in fuel load age mapping.

The Fire Services Environment Adviser can provide details of when a fire was reported and which fire appliances attended the incident.

Investigate the cause of the fire

If deemed necessary by the responding fire crews, an investigation into the cause of the fire should be undertaken, in order to assist the apprehension of offenders and the prevention of further fires. The Wildfire Investigation Action Team (WIAT) and the WA Police Service Arson Squad may need to be consulted.

Activation of the Fire Investigation Team is the responsibility of the Incident Controller. When arson is suspected, the Incident Controller should initiate an immediate investigation.

Safety of public facilities

Public facilities should be assessed for safety as soon as possible. If necessary, restrict public access to the area. For example, where walking tracks have overhanging burnt branches that are in danger of falling on the track, the track should be closed. The land owner/leaseholder should monitor any areas of possible re-ignition, with assistance from the Friends group.

Rescue of animals affected by the fire

The urgency of animal rescue must not compromise the safety of people involved. It is preferable to wait until the fireground has been declared safe.

In some circumstances, where safety will not be compromised, a group of people may be allowed to start this task early, under the direction of the Incident Controller. Injured fauna should be taken to the Fauna Rehabilitation Centre in Malaga, with clear instructions on their eventual return to LSB. Alternatively, an animal 'first aid post' can be set up near the control point, with the consent of the Incident Controller, with firefighters bringing out injured fauna for treatment if in a position to do so.

Preventing weed invasion

Prevention of weed invasion is probably the most urgent requirement after the fire. Increased nutrients (from the ash-bed) and decreased competition from native vegetation contribute to the growth of weeds. The fire regrowth period should be utilised to help eradicate weeds using a spraying or hand-clearing program and carried out by the Friends group with support from Council. In the case of a large fire, contractors will be necessary, particularly in the period July to September.

Controlling access

Burnt areas devoid of vegetation are easily trampled, hindering the regrowth process. Damaged fencing should be repaired/replaced as soon as possible after the fire. Temporary fencing may be needed around the burnt area. Signs requesting the public to stay off burnt areas may be appropriate.

Controlling erosion

Burnt areas devoid of vegetation on sloping ground are potential erosion problems, particularly during the winter following the fire. Relevant prevention initiatives should be implemented as soon as possible. This may include planting, direct seeding, channelling of water run-off, or covering the ground with brush. The steep ground in the northeast would be particularly susceptible to erosion following a fire, and this would adversely affect the perched wetland.

Regeneration initiatives

In areas where the vegetation community is disturbed, the occurrence of a fire may determine the need for regeneration initiatives, such as planting or direct seeding of local native species. These efforts may be coordinated by the Friends group with assistance from the Council and other environmental agencies in the area, particularly Bennett Brook Catchment Group.

Involve the community

Fire in LSB can have consequences for nearby residents and members of the Friends group. Involving the community in the recovery of the bushland can have positive and far-reaching effects for future preparation strategies.

Summary

- Recovery is the process of returning an area to 'normal' after the impact of a fire.
- The responsibility for post-fire recovery initiatives usually rests with the landowner.
- This fire management plan has detailed specific tasks and responsibilities. These include:
- Debriefing the stakeholders.
- Keeping adequate records of fires.
- Investigation of the fire's cause.

- Considering the safety of public facilities.
- Rescuing fire-affected native fauna.
- Planning and implementing measures to control access, erosion and weed invasion.
- Regeneration initiatives.
- Involving the community in the recovery process.

RECOMMENDATIONS

9. **Establish and maintain a Fire Event Register for LSB.**

10. **Maintain the perimeter fencing and NO ENTRY signage by regular monitoring.**

11. **Conduct regular public fire awareness programs, preferably prior to the high fire season from November to April of each year.**

12. **Implement a program to maintain existing fire access tracks as prescribed by this plan.**

13. **Seek an exemption relating to the northern firebreak from the City of Swan as soon as possible.**

14. **Monitor the fuel loads in LSB regularly by FESA or another qualified agency or person.**

15. **A weed control program, as in Section 9.10, be implemented to reduce potential fire risk.**

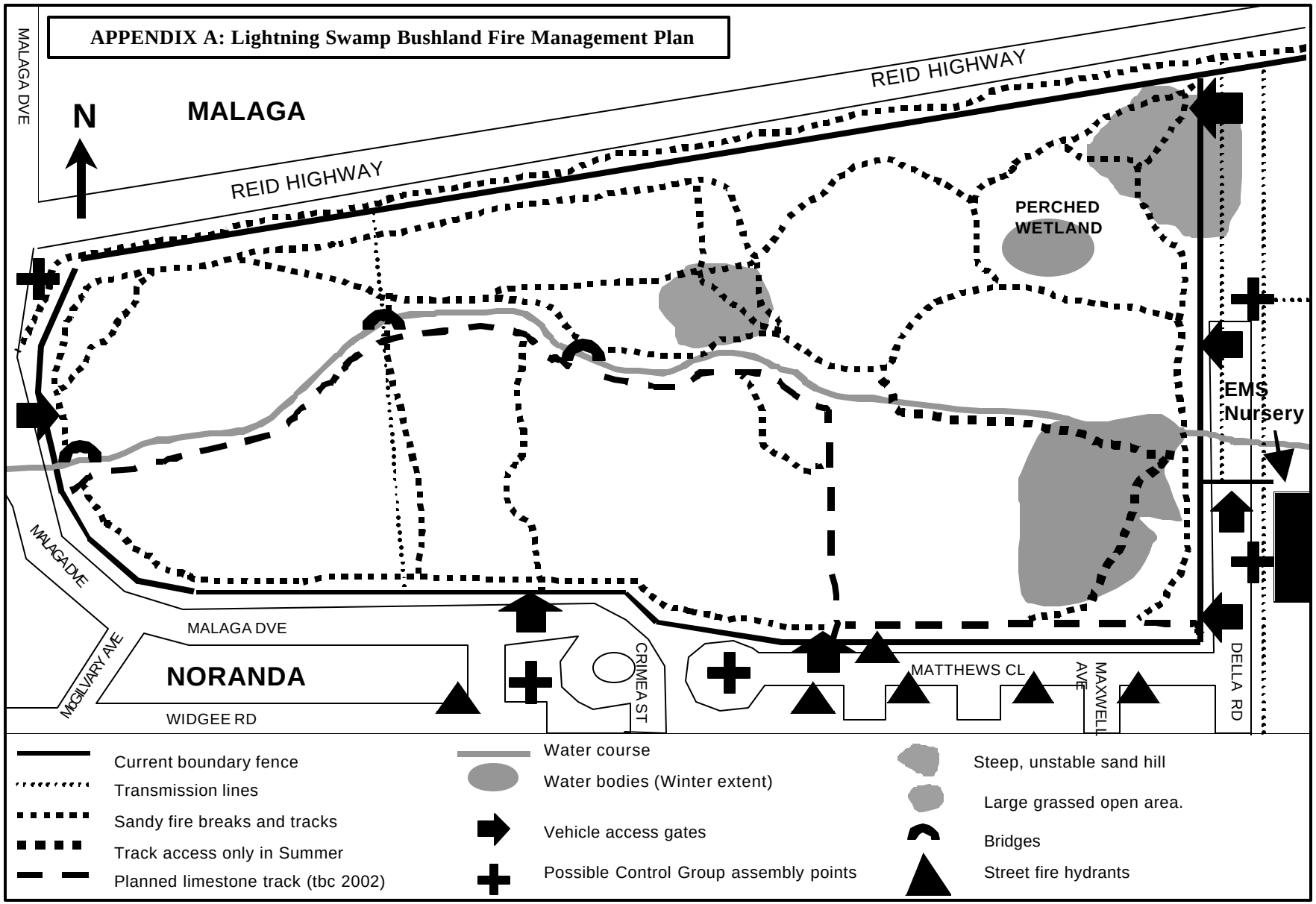
16. **Develop policies and procedures for LSB as part of the City of Bayswater's overall disaster and emergency planning for:**

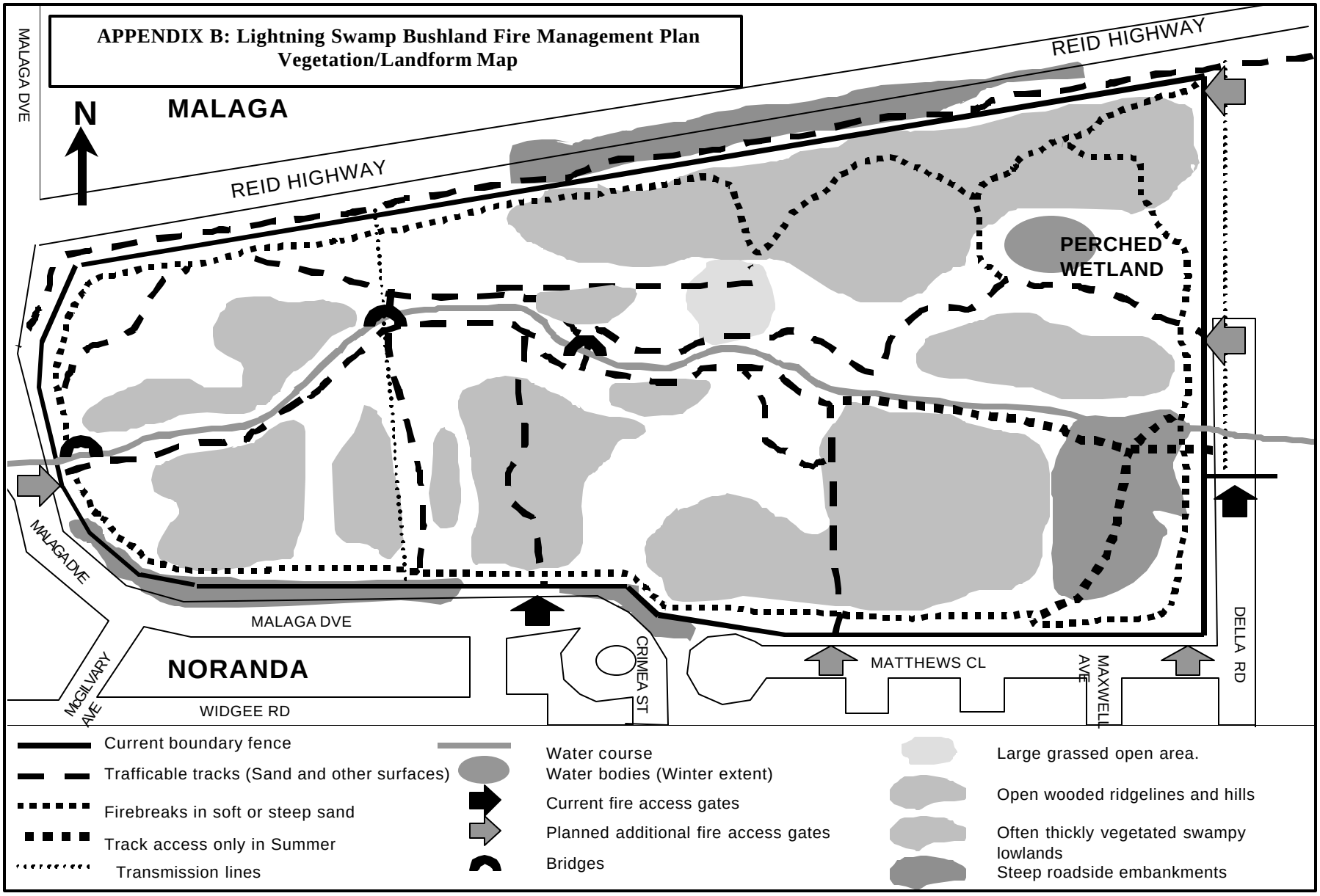
    - **Controlled burns to reduce extreme fuel loads.**

    - **Immediate post-fire response.**

REVIEW OF THE URBAN BUSHLAND FIRE PLAN

This fire management plan should be reviewed as part of the debriefing process after a major incident. A major review, including an upgrade of maps and reference works, should be carried out at the same time as the Lightning Swamp Bushland Management Plan is reviewed by the committee set up to implement that plan.


APPENDIX A: Lightning Swamp Bushland Fire Management Plan
MALAGA DVE
N
MALAGA
REID HIGHWAY
REID HIGHWAY
PERCHED WETLAND
EMS Nursery
MALAGA DVE
MALAGA DVE
McGILVARY AVE
NORANDA
WIDGEE RD
CRIMEA ST
MATTHEWS CL
MAXWELL AVE
DELLA RD
Current boundary fence
Transmission lines
Sandy fire breaks and tracks
Track access only in Summer
Planned limestone track (tbc 2002)
Water course
Water bodies (Winter extent)
Vehicle access gates
Possible Control Group assembly points
Steep, unstable sand hill
Large grassed open area.
Bridges
Street fire hydrants


APPENDIX B: Lightning Swamp Bushland Fire Management Plan
Vegetation/Landform Map
N
MALAGA
REID HIGHWAY
REID HIGHWAY
MALAGA DVE
PERCHED WETLAND
MALAGA DVE
MALAGA DVE
NORANDA
MCGILVARY AVE
WIDGEE RD
CRIMEA ST
MATTHEWS CL
MAXWELL AVE
DELLA RD
Current boundary fence
Trafficable tracks (Sand and other surfaces)
Firebreaks in soft or steep sand
Track access only in Summer
Transmission lines
Water course
Water bodies (Winter extent)
Current fire access gates
Planned additional fire access gates
Bridges
Large grassed open area.
Open wooded ridgelines and hills
Often thickly vegetated swampy lowlands
Steep roadside embankments

USEFUL CONTACTS

FESA HEADQUARTERS
Ph: 93239300

MALAGA FIRE STATION (Not to be rung for fire emergencies – dial 000)
Ph: 92496444

FESA ENVIRONMENTAL OFFICER
Ph: 93239573

CITY OF BAYSWATER
61 Broun Ave
Morley, WA, 6062
Ph: 92720622

MINISTRY FOR PLANNING
Ph: 92647777

FRIENDS OF LIGHTNING SWAMP BUSHLAND
Via City of Bayswater, or
Ph: 92765454
92757338
92768359

BENNETT BROOK CATCHMENT GROUP
266 Lord St
Caversham
Ph: 93770444

BICM (Bayswater Integrated Catchment Management Group)
212 Drake St
Morley WA 6062
Ph: 92717922

URBAN BUSHLAND COUNCIL
Ph: 94207207

BIBLIOGRAPHY

Boura, Jon (1994) *Reconciling Fire Protection and Conservation Methods at the Urban-Forest Interface* in Fire and Biodiversity: the effects and effectiveness of fire management (pp 247–252) Biodiversity Series, Paper No 8, Department of Environment, Sport and Territories

Dixon, Bob., and Keighery, Greg. (1995) *Suggested methods to control weeds*. in Managing Perth's Bushlands (pp. 43–143), M Scheltema & J Harris (Eds), Greening Western Australia

Hobbs, Richard (1995) *Fire* in Managing Perth's Bushlands (pp. 145–148), M Scheltema & J Harris (Eds), Greening Western Australia

McLean, Kevin (1999) *What are the Management Issues? Community Perspectives* in Managing Our Bushland (pp 117–121) Urban Bushland Council WA, Inc.

Perth's Bushplan. Keeping the Bush in the City (Draft, November 1998) Western Australian Planning Commission

Prescribed Burning 1—Learning Manual (AFAC Module 3.17) (1999) Fire and Emergency Services Authority [unpublished manuscript]

Safe Havens from Bush Fires. Planning a response to external fire threats for school, hospitals and other public buildings and the community (1998) Bush Fire Service of WA

Safstrom, Rod (1999) *Integrated Environmental Weed Management* in Managing Our Bushland (pp 102–106) Urban Bushland Council WA Inc

Thomas, Lesley (1999) *Bushfire Risk Management Planning* in Managing Our Bushland (pp 157–160) Urban Bushland Council WA, Inc.

*The work of Sue **Davies**, Environment Advisor: Community Safety, Fire and Emergency Services Authority of Western Australia is acknowledged and greatly appreciated. Her guide,*

FIRE MANAGEMENT PLAN NING FOR URBAN BUSHLAND - A Guide For Landowners, Fire Officers And Bushland 'Friends' Groups (2000)

was used extensively, and verbatim, for much of this fire management plan.

Kim Grace (Friends of Lightning Swamp Bushland)

Chris Souza (City of Bayswater Ranger Services)

Perth, Western Australia, March 2001

FIRE EVENT REGISTER

LIGHTNING SWAMP BUSHLAND

DATE & TIME	LOCATION OF START POINT (Grid ref. or description)	SIZE OF BURNT AREA (Attach map if necessary)	CAUSE IF KNOWN	DETAILS OF EVENT & RESPONSE (Attach report if necessary)	DEBRIEF Y/N

APPENDIX 2
DIEBACK REPORT
April 2001

Introduction

Glenn Tuffnell of Glevan Dieback Consultancy Services assessed lightning Swamp for the presence of *Phytophthora sp*. (dieback) on the 16th of April 2001.

The boundaries of interpretation for this reserve are Malaga Drive and Mathews Close in the south, Della Road in the east and the fence line that parallels Reid Highway in the North. The reserve is approximately 70 hectares in area.

The entire reserve was surveyed by noting plant deaths that could indicate the presence of dieback. The interpretation also involved the close inspection of walk trails, firebreaks and changes in vegetation complexes.

All identified infestations have been demarcated in the field with an indivisible green tapeline tied to trees with the knot facing the infestation. One soil and tissue sample has been taken in this reserve as part of the overall *Phytophthora* interpretation.

Disease expression

Lightning Swamp has four separate taped areas of dieback free vegetation surrounded by either dieback infested vegetation or road works. All four areas are subject to upslope movement of very active disease fronts and are either surrounded by, or have one side exposed to, wetlands that are infested with the Phytophthora pathogen. All areas of dieback free vegetation are made up of Banksia woodland on deep well drained sands.

The impact by *Phytophthora* on all indicator species present was consistently high and obvious. For this reason only one soil and tissue sample was taken.

A few small sections of vegetation have been subject to recent fire activity and where these areas are adjacent to active dieback edges they have been taped into the infestation. This is because there is no way of differentiating between fire deaths and burnt *Phytophthora* related deaths without allowing regrowth over a two to three year timespan.

The plants that would express symptoms associated with the *Phytophthora* pathogen in this reserve are as follows;

Adenanthos cygnorum
Allocasuarina humilis
Banksia grandis, attenuata, menziesii, littoralis and illicifolia
Bossiaea ornate
Daviesia decurrans
Dryandra nivea
Eucalyptus marginata
Macrozamia reidlei
Patersonia occidentalis
Petrophile sp..
Synaphae petiolaris
Xanthorrhoeas preissii and *gracilis*

Samples

Sample 1: Grid reference J1
An isolated *Banksia attenuata* on the down slope side of the perimeter firebreak. Significant due to its position upslope of the western area of dieback free. Evidence of scattered *Banksia* deaths on the Reid highway side of the perimeter fence

This sample returned a negative result for *Phytophthora cinnamomi*.

Management

Lightning Swamp has three significant areas of dieback free vegetation. All three of these dieback free areas are located higher in the profile than the infested portion of this reserve. The importance of this is that if left to its own devices the *Phytophthora* can only spread upslope which it does at a much slower rate than down slope spread. Unfortunately there is evidence of uncontrolled access, which has the potential to transport soil from the infested sections of the reserve to the uninfested via the numerous open tracks throughout the reserve.

To avoid this situation it is recommended that either the perimeter fence be upgraded to prevent unauthorised access or all tracks that have the potential to allow vehicles to cross from dieback to dieback free are blocked and rehabilitated. If this is the preferred method of minimising the risk to the surviving vegetation new tracks could be established in the infested sections of the reserve to enable access in and around the reserve without jeopardising the health of the existing dieback free vegetation. The tracks that pose the greatest threat to the dieback free portions of this reserve are highlighted on the Lightning Swamp Grid Reference map in Pink.

All potential soil-moving activities need to be programmed to occur during dry soil conditions and a policy of clean down on entry to the dieback free areas of the reserve needs to be implemented. Additionally it would be wise to ensure any machines that operate within the reserve clean down before exit to ensure dieback-infested material isn't being transported to other dieback free areas.

This reserve would benefit from a strategic application of phosphonic acid especially the areas that are highlighted in Yellow on the Grid Reference map. It is recommended that a 20-meter buffer each side of the green tapeline is treated as this is the zone of greatest disease activity.
It would be of great benefit to raise the awareness in all adjacent property owners of the dieback status of the park and how they can prevent the introduction and spread of the disease.

Conclusion

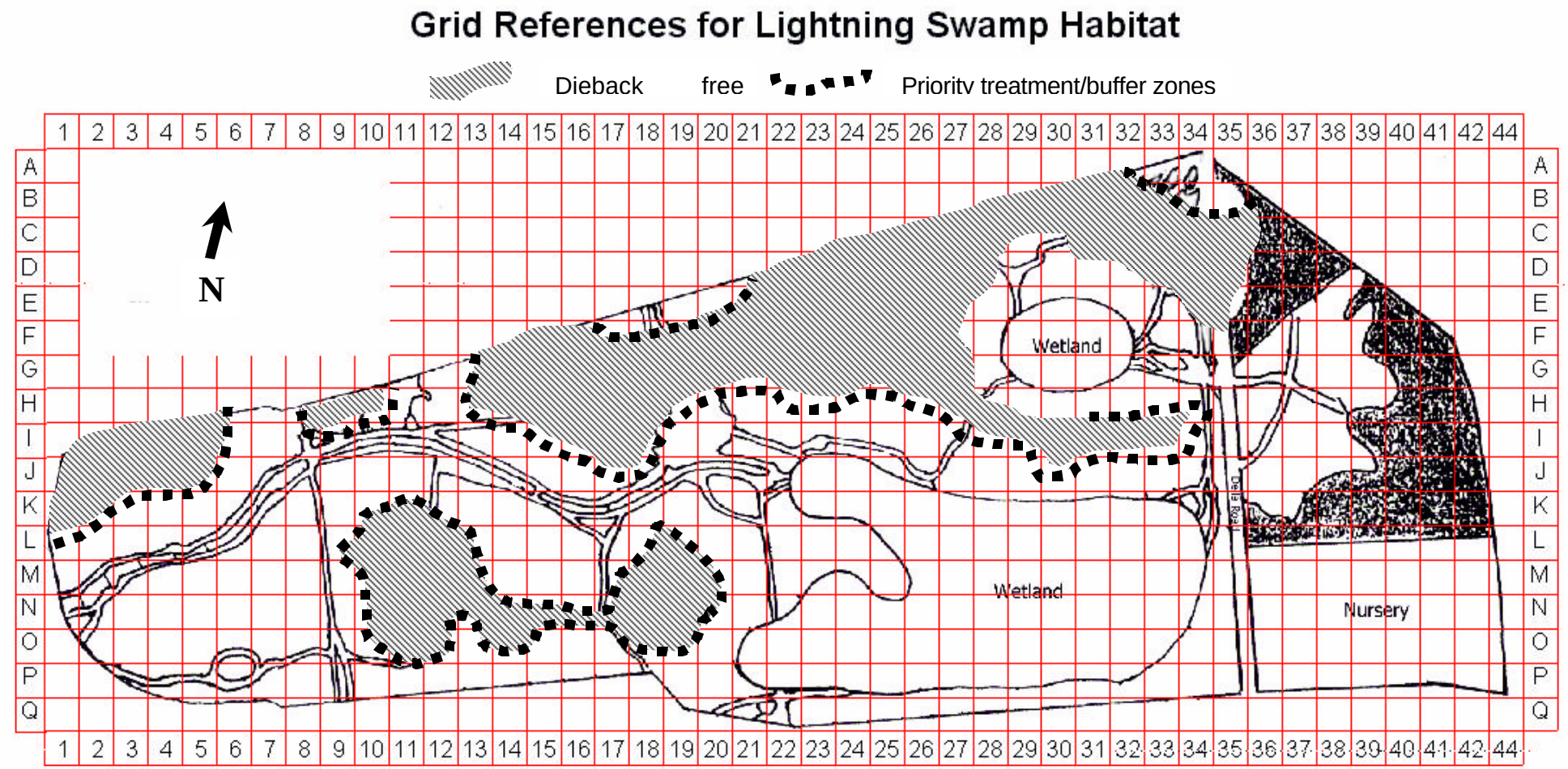
Fortunately Lightning Swamp is not completely comprised of soil with impeded layers like the wetland component; otherwise the situation would be total infestation rather than two-thirds infestation. The deep well drained sandy soils and the ridge system is the reserves strength against the *Phytophthora* pathogen. However the uncontrolled, unhygienic access into the reserve under all weather conditions is its greatest threat next to its large component of susceptible indicator species.

With the implementation of our recommendations and community and local government support this reserve should be preserved in a state of reasonable health for future generations to enjoy.

Glenn Tuffnell
Glevan dieback interpreter.
April 2001

NOTE: For the purposes of reproduction the report map has been modified and is on the following page.

Grid References for Lightning Swamp Habitat



APPENDIX 3
FLORA LIST
(as of November 2001)

Acacia applanata
Acacia pulchella var glaberrima
Acacia saligna
Acacia sessilis
Acacia stenoptera
Actinotus glomeratus
Alexgeorgea nitens
Allocasuarina fraseriana
Allocasuarina humilis (Female)
Allocasuarina humilis (Male)
Amphipogon turbinatus
Anigozanthos humilis ssp humilis
Anigozanthos manglesii ssp manglesii
Astartea fascicularis
Astartea sp
Astroloma xerophyllum
Banksia attenuata
Banksia grandis
Banksia ilicifolia
Banksia littoralis
Banksia menziesii
Baumea articulata
Baumea juncea
Bossiaea eriocarpa
Brachyscome bellioides
Burchardia congesta
Burchardia umbellata
Caladenia flava
Caladenia huegelii
Caladenia latifolia
Caladenia longicauda
Caladenia pectinata
Caladenia reptans
Calandrinia liniflora
Calectasia cyanea
Calytrix angulata
Calytrix flavescens
Calytrix fraseri
Cassytha m icrantha
Cassytha racemosa
Centrolepis dummondiana
Conospermum stoechadis
Conospermum stoechadis ssp stoechadis
Conostephium pendulum
Conostephium preissii
Conostylis aculeata
Conostylis aurea
Conostylis juncea
Conostylis setigera
Conostylis setigera ssp setigera
Corynotheca micrantha
Crassula colorata
Cyperus polystachyos
Dampiera linearis
Danthonia sp.
Dasypogogon bromeliifolius
Daviesia divaricata
Daviesia physodes
Daviesia triflora
Diuris longifolia
Drosera erythrorhiza
Drosera menziesii
Eragrostis elongata
Eremaea pauciflora
Eriostemon spicatus
Eucalyptus todtiana
Euchilopsis linearis
Eutaxia virgata
Gompholobium tomentosum
Gonocarpus pithyoides
Hakea varia
Hemiandra pungens
Hemiandra glabra ssp glabra
Hibbertia aurea
Hibbertia huegelii
Hibbertia hypercoides
Hibbertia racemosa
Hibbertia subvaginata
Homalosciadium homalocarpum
Hovea pungens
Hovea trisperma
Hybanthus calycinus
Hypocalymma augustifolium
Hypocalymma robustum

Hypolaena exsulca (Female)
Hypolaena exsulca (Male)
Isolepis marginata
Jacksonia densiflora
Jacksonia floribunda
Jacksonia furcellata
Jacksonia sericea
Johnsonia acaulis
Juncus pallidus
Kennedia prostrata
Lagenifera huegelii
Laxmannia ramosa
Laxmannia ramosa ssp ramosa
Laxmannia sessiliflora
Lechenaultia expansa
Lechenaultia floribunda
Lepidosperma tetraquetrum
Leptocarpus empetriformis
Lepyrodia muirii (Male)
Leucopogon aff oldfieldii
Leucopogon conostephiodes
Levenhookia pusilla
Lomandra hermaphrodita
Lomandra nigricans
Lomandra preissii
Loxocarya flexuosa
Lyginia barbata (Male)
Lyginia imberbis (Male)
Lyperanthus nigricans
Lysinema ciliatum
Macrozamia reidlei
Macarthuia apelata
Meeboldina roycei (Male)
Melaleuca lateritia
Melaleuca preissiana
Melaleuca seriata
Mesomelaena psuedostygia
Millotia fenas
Mitrasacme paradoxa
Nemcia capitata
Nemcia reticulata
Nuytsia floribunda
Opercularia vaginata
Patersonia occidedentalis
Pericalymma ellipticum
Pericalymma ellipticum var floridum
Petrophile linearis
Philotheca spicata
Phlebocarya ciliata
Pimelea suaveolens
Pimelea sulphurea
Platysace filiformis
Platytheca galioides
Podotheca augustifolia
Podotheca chrysantha
Poranthera microphylla
Pterostylis vittata
Quinetia urvillei
Regelia ciliata
Scaevola repens
Schoenus caespititius
Schoenus clandestinus
Schoenus curvifolius
Schoenus rodwayanus
Schoenus subfascicularis
Siloxerus humifusus
Stipa compressa
Stirlingia latifolia
Stylidium adpressum
Stylidium brunonianum
Stylidium brunonianum ssp brunonianum
Stylidium calcaratum
Stylidium cygnorum
Stylidium piliferum
Stylidium repens
Thysanotus multiflorus
Trachyymene pilosa
Tricoryne tenella
Typha domingensis
Verticordia densiflora var
Verticordia drummondii
Wahlenbergia preissii
Waitzia suaveolens
Waitzia suaveolens var suaveolens
Xanthorrhoea preissii
Xanthosia huegelii

Weeds/INTRODUCED SPECIES

Aira caryophyllea
Briza maxima
Briza minor
Chamelaucium uncinatum
Ehrharta calycina
Erodium botrys
Gladiolus caryophyllaceous
Hypochaeris glabra
Juncus microcephalus
Oxalis glabra
Pelargonium capitatum

Romulea rosea
Scholtzia involucrate
Solanumnigrum
Sonchus oleraceus
Typha orientalis
Ursina anthemoides
Vulpia myuros
Wahlenbergia carpensis
(Also see Table 5.1)

APPENDIX 4
FAUNA LIST

*Note : the following list of species was obtained from studies conducted in similar bushland sites in close proximity to Lightning Swamp, however a comprehensive fauna survey has not yet been carried out.

AMPHIBIA (After Bush *et al.,* 1995)

Myobatrachidae

Crinia georgiana	Quacking Frog
Crinia insignifera	Sandplain Froglet
Crinia glauerti	Glauert's Froglet
Heleioporus eyrei	Moaning Frog
Heleioporus psammophilus	Martbled Borrowing Frog
Limnodynastes dorsalis	Western Banjo Frog
Myobatrachus gouldii	Turtle Frog
Pseudophryre guentheri	Guenther's Toadlet

Hylidae

Litoria moorei	Western Green Tree Frog
Litoria adelaidensis	Slender Tree Frog

REPTILIA (After Bush *et al.,* 1995)

Chelidae

Chelodina oblonga	Long-necked Tortoise

Gekkonidae

Strophurus spinigerus	South-western Spiny-tailed Gecko
Phyllodactylus marmoratus	Marbled Gecko
Diplodactylus alboguttatus	White-spotted Ground Gecko

Pygopodidae

Pygopus lepidopodus	Common Scaly Foot
Pletholax gracilis	Keeled Legless Lizard
Lialis burtonis	Burton's Legless Lizard
Delma grayii	Gray's Legless Lizard
Delma fraseri	Fraser's Legless Lizard
Aprasia repens	South-western Sandplain Worm Lizard

Agamidae

Pogona minor	Western Bearded Dragon
Tympanocryptis adelaidensis	Western Heath Dragon

Varanidae

Varanus gouldii	Gould's Monitor

Scincidae

Tiliqua rugosa	Bobtail or Shingleback
Tiliqua occipitalis	Western Bluetongue
Morethia obscura	Southern Pale-flecked Morethia
Morethia lineocellata	Western Place-flecked Morethia
Menetia greyii	Common Dwarf Skink
Lerista praepedita	Western Worm Lerista
Lerista lineopunctualata	West Coast Line-spotted Lerista
Lerista elegans	West Coast Four-toed Lerista
Hemiergis quadrilineata	Two-toed Earless Skink
Ctenotus lesuerii	Western Limestone Ctenotus
Ctenotus fallens	West Coast Ctenotus
Ctenotus impar	South-western Odd-striped Ctenotus
Cryptoblepharus plagiocephalus	Fence Skink
Bassiana trilineata	South-western Cool Skink
Egernia kingii	King Skink
Egernia napoleonis	South-western Crevice Egernia

Elapidae

Notechis scutatus	Western Tiger Snake
Pseudonaja affinis	Dugite
Rhinoplocephalus gouldii	Gould's Hooded Snake
Rhinoplocephalus nigriceps	Black-backed Snake
Simoselaps bertholdi	Banded Sand Snake or Jan's Snake Banded
Simoselaps semifascilatus	Southern Half-girdled Snake
Neelaps bimaculatus	Black-naped Snake
Echiopsis curta	Bardick
Demansia psammophis	Retirulated Whip Snake

Typhlopidae

Ramphotyphlops australis	Southern Blink Snake

MAMMALIA (After Strahan, 1995)

Tachyglossidae

Tachyglossus aculeatus	Echidna

Peramelidae

Isodon obesulus	Quenda or Southern Brown Bandicoot

Peramelidae	
Isodon obesulus	Quenda or Southern Brown Bandicoot
Tarsipedidiae	
Tarsipes rostratus	Honey Possum
Macropodidae	
Macropus fuliginosus	Western Grey Kangaroo
Macropus irma	Brush Wallaby
Vespertilionidae	
Chalinolobus goldii	Gould's Wattled Bat
Chalinobolus Morio	Chocolat Bat
Eptusicus pumilis	Little Bat
Eptesicus regulus	King River Eptesicus
Nyctophilus geoffroyi	Lesser Long-eared Bat
Tadarida australis	White-striped Mastiff Bat
Muridae	
Mus musculus	House Mouse
Pseudomys albocinereus	Ash-grey Mouse
Rattus rattus	Black Rat
Leporidae	
Oryctolagus cunciculus	Rabbit
Canidae	
Vulpes vulpes	European Red Fox
Felidae	
Felis cattus	Domestic Cat

AVES (After Simpson and Day, 1993)

Podiocepididae	
Podiocephalus poliocephalus	Hoary-headed Grebe
Tachybaptus novaehollandidae	Australasian Grebe
Phalacrocoracidae	
Phalacrocorax carbo	Great Cormorant
Phalacrocorax melaneleucos	Little Pied Cormorant
Ardeidae	
Ardea pacifica	Pacific Heron
Ardea novaehollandiae	Wite-faced Heron
Egretta alba	Great Egret

Plataleidae

Threskiornis molucca	Sacred Ibis
Threskiornis spinicollus	Straw-necked Ibis
Platalea flavipes	Yellow-billed Spoonbill

Anatidae

Cygnus atratus	Black Swan
Tadorna tadornoides	Australian Shelduck
Anas supercilliosa	Pacific Black Duck
Anas gibberifrons	Grey Teal
Anas rhynchotis	Australasian Shoveller
Aythya australis	Hardhead
Chenonetta jubata	Maned Duck

Accipitridae

Elanus notatus	Black-shouldered Kite
Haliastur sphenurus	Whistling Kite
Accipiter fasciatus	Brown Goshawk
Accipiter cirrhocephalus	Collared Sparrowhawk
Aquila audax	Wedge-tailed Eagle
Hieraaetus morphnoides	Little Eagle
Circus approximans	Marsh Harrier

Falconidae

Falco peregrinus	Peregrine falcon
Falco longipennis	Australian Hobby
Falco berigora	Brown Falcon
Falco cenchroides	Australian Kestrel

Rallidae

Fulica atra	Eurasian Coot
Gallinula tenebrosa	Dusky Moorhen
Porphyrio porphyrio	Purple Swamphen

Recurvirostridae

Himantopus himantopus	Black-winged Stilt

Columbidae

Stretopelia senegalensis	Laughing Turtle-Dove
Streptopelia chinensis	Spotted Turtle-Dove
Ocyphaps lophotes	Crested Pigeon

Cacatuidae

Calyptorhynchus latirostris	Carnaby's Black-Cocatoo
Cacatua roseicapilla	Galah

Platycercidae	
Barnardius zonarius	Port Lincoln Ringneck
Purpureicephalus spurius	Red-capped Parrot
Platycercus icterotis	Western Rosella
Cuculidae	
Cuculus pallidus	Pallid Cuckoo
Cuculus pyrrhophanus	Fan-tailed Cuckoo
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo
Chrysococcyx lucidus	Shining Bronze-Cuckoo
Strigidae	
Ninox novaeseelandiae	Southern Boobook Owl
Tytonidae	
Tyto alba	Barn Owl
Podargidae	
Podargus strigoides	Tawny Frogmouth
Alcedinidae	
Dacelo novaeguineae	Laughing Kookaburra
Halycon sancta	Sacred Kingfisher
Meropidae	
Merops Ornatus	Rainbow Bee-eater
Hirundinidae	
Hirundo neoxena	Welcome Swallow
Cecropis nigricans	Tree martin
Motacillidae	
Anthus novaeseelandiae	Richard's Pipit
Campephagidae	
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Lalage suerii	White-winged Triller
Pachycephalidae	
Petroica multicolor	Scarlet Robin
Petroica goodenovi	Red-capped Robin
Pachycephala rufiventris	Rufous Whistler
Pachycephala pectoralis	Golden Whistler

Monarchidae

Rhipidura fuliginosa	Grey Fantail
Rhipidura leucophrys	Willie Wagtail

Maluridae

Malurus splendens	Splendid Fairy-Wren

Acanthizidae

Smirconis brevirostris	Weebill
Gerygone fusca	Western Gerygone
Acanthiza apicalis	Inland Thornbill
Acanthiza inornata	Western Thornbill
Acanthiza chrysorrhoa	Yellow-rumped Thornbill

Neosittidae

Daphoenositta chrysoptera	Varied Sitella

Maliphagidae

Anthochaera carunculata	Red Wattlebird
Anthochaera chrysoptera	Little Wattlebird
Lichenostomus virescens	Singing Honeyeater
Lichmera indistincta	Brown Honeyeater
Phylidonyris novaehollandiae	New Holland Honeyeater
Phylidonyris nigra	White-cheeked Honeyeater
Phylidonyris melanops	Tawny-crowned Honeyeater
Acanthorhynchus superviliosus	Western Spinebill

Pardalotidae

Pardalotus punctatus	Spoted Pardalote
Pardalotus striatus	Striated Pardalote

Zosteropidae

Zosterops lateralis	Silvereye

Grallinidae

Grallina cyanoleuca	Australian Magpie-lark

Artamidae

Artamus personatus	Masked Woodswallow
Artamus cinereus	Black-faced Woodswallow
Artamus cyanopterus	Dusky Woodswallow

Cracticidae

Cracticus torquatus	Grey Butcherbird

Gymnorhina tibicen	Australian Magpie

Corvidae

Corvus coronoides	Australian Raven

APPENDIX 5
ORIGINAL MANAGEMENT IMPLICATIONS

History and Method

In order to provide some indication of community views on the reserve, a sample survey was conducted during the original Murdoch University study which involved a total of 80 residents. The survey results are attached as Appendix 6.

Future Management Implications

The key issues that were suggested to be considered in the preparation of a management plan for LSB as devised by Murdoch University students who wrote the original plan, included the following:

- The need for rationalisation of internal cadastral boundaries and resolution of leasing arrangements for the entire reserve;

- Increased use of the reserve will require the establishment of a management committee to coordinate its protection, as well as the development and implementation of a management plan;

- Any development of the reserve will require planning approval from the Western Australian Planning Commission;

- The reservation of the reserve for Parks and Recreation under the Metropolitan Region Scheme indicates that is may have regional significance, however its conservation value is yet to be determined by the System 6 Update (DEP) and the Urban Bushland Strategy (MFP);

- The dominant land use at the site is uncleared bushland that includes four wetlands;

- The Wetland Management and Conservation Estate have a small area of the north-eastern portion of the site, corresponding to the perched wetland, classified as conservation;

- The perched wetland, because of its conservation classification, should be given priority protection and rehabilitation;

- The Wetland Management and Conservation Estate states that there should be a minimum 50 metre buffer surrounding the wetlands, this buffer area for the wetlands should also be given priority in rehabilitation measures for the reserve;

- Approximately 20% of the reserve has been cleared and this in conjunction with aerial power lines have had a detrimental impact on its appearance;

- Whilst the nursery is considered a compatible land use, existing improvement and future expansion plans will require appropriate design guidelines to ensure its successful integration with the reserve;

- Any proposal which affects the drainage channel and the aerial power lines will require approval from the Water Corporation and Western Power respectively;

- To address the issues of off-road vehicles and waste disposal, the perimeter fencing requires upgrading to prevent illegal access, and visual waste needs to be removed;

- The reserve has been divided by a number of tracks which need to be reviewed with respect to pedestrian and vehicle access, whilst also protecting conservation values;

- The reserve has high regional accessibility as it abuts major traffic routes. However, the disadvantages associated with this are the significant visual and noise impacts;

- Rehabilitation of the road reserves, in consultation with Main Roads, to complement the reserve may assist in reducing the visual and noise impacts of the major roads;

- As the main access to the reserve is currently through a residential area, a local traffic management plan may need to be prepared to address concerns such as vehicle and pedestrian safety, a right turning bay off Benara Road, and directional signage;

- The existing access requires upgrading, with a need for the provision of car parking, bus parking and turning circles;

- The development of pedestrian and cycling networks to the reserve;

- The value of the reserve as a buffer for the residential area from industrial and traffic land uses should be maintained;

- The investigation of the possibility of creating movement systems and wildlife corridor linkages with nearby parks and recreation reserves;

- A number of educational institutions and shopping centres are in the general vicinity of the reserve forming a potentially significant community resource;

- The community use of the reserve predominantly for passive recreation activities, mainly bush walking.

- The public consultation indicates that the community would like to see the reserve be retained primarily for conservation and aesthetic purposes and secondly, for the development of passive recreation; and

- A further public consultation is required to ensure community views are accurately reflected and addressed in the development of a final management plan.

Strategies

To resolve the key issues associated with land use and community it is suggested that the following eight strategies be adopted:

1. To develop the principle of community ownership by seeking suitable management and leasing arrangements;

2. To establish the regional and local significance of LSB.

3. To ensure that the conservation value is the priority land use to be protected and enhanced;

4. To promote and coordinate the protection, integration, rehabilitation and development of those land uses which are compatible with Lightning Swamp and the adjoining residential area snd remove those which have a detrimental impact;

5. To ensure that surrounding land uses do not have an adverse impact on the conservation and recreation value of Lightning Swamp;

6. To provide equitable access to LSB by developing regional movement systems for fauna, cyclists and pedestrians;

7. To liaise and develop ongoing partnerships with those State Government Departments and Local Governments who have an interest in LSB;

8. To provide ample opportunity for individual members and groups in the community to comment on the management plan and participate in its implementation.

The Key Aim and Objective of Conservation

It must be remembered that the conservation of LSB needs to be the main aim and guiding objective of this management plan, and everything else should be subservient to that context. Because most of the Perth metropolitan area has been cleared, areas such as LSB are critical in maintaining the ecology and ecosystem function that once existed throughout the Swan coastal plain. While the remaining amount of bushland is below the critical level at which accelerated loss of ecosystem function and species will occur (ABC, 2001), this does not mean LSB does not contain significant values, because it does.

However, it means that remaining areas such as LSB are far more susceptible to further losses, and therefore it requires absolute efficiencies to be maintained and achieved in order to conserve the natural heritage of such isolated pockets of bushland, which can be likened to a virtual island. Any human activities in the reserve will increase pressure on LSB, leading to a steady erosion of the natural heritage.

Main reasons for decline of the natural heritage are:

- isolation, leading to inbreeding and a greater risk of random local extinction.
- the relatively ‘small’ size of LSB for the territory and resources of some species.
- the relatively large boundary as compared to area, which maximizes the chances of weed invasion and other problems.
- the cumulative load of disturbances on LSB.

Hence, it is extremely important from an environmental point of view that the impact on LSB are minimised, while links to other bushland areas are enhanced and maintained. For example, infrastructure inside LSB needs to be minimal, while public access and activities within the reserve need to be carefully planned in order to:

- use very little space so as to prevent further loss or fragmentation of habitat. An example of this is to incorporate current firebreaks with future cycleways or pedestrian paths, while carparks and maintenance areas should be located off-site.
- eliminate any other additional pressures on LSB, for example, by increasing nutrient loads from dog/horse urination and defecation, or plowing firebreaks.

The retention of existing vegetation outside the strict boundaries and its incorporation into a bushland buffer zone between LSB and the proposed sporting/recreation facilities at the eastern end will also assist in maintaining the conservation values, while reducing the costs associated with the tendency to green the outer verges of such areas. It will also add to the attractiveness of the overall concept while reducing problems with weed infestation.

APPENDIX 6
COMMUNITY SURVEY RESULTS

Results from the sample survey of 80 people in the suburb of Noranda:

Question One: In which surburb do you live?

Suburb	Percentage (%)
Noranda	84
Morley	10
Other	6

Question Two: Are you aware of the area of bushland (Lightning Swamp) at the end of Crimea Street and cornered by Reid Highway?

Response	Percentage (%)
Yes	91
No	9

Question Three: Have you used the area for any of the following activities?

Response	Percentage (%)
Bushwalking	39
Trail bike riding	2
Four wheel driving	4
Walking the dog	31
Bird watching	18
Photography	4
Tadpole collecting	1
Cycling	1
Playing	2

Question Four: How often do you visit the area?

Response	Percentage (%)
Daily	14
Once a week	20
Once a month	10
Irregularly	15
Never	41

Question Five: Would you visit the area more frequently if any of the following facilities were provided?

Response	Percentage (%)
Walking paths	74
Playground	54
Picnic/BBQ areas	64
Cycle paths	56
Information boards and signs	52
Car parks	31
Toilets	56
Board walk	50
Oval	26
Golf Course	1

Question Six: Do you visit other bushland / wetland areas?

Response	Percentage (%)
Yes	55
No	45

Question Seven: For what purpose do you visit these areas?

Response	Percentage (%)
Bushwalking	34
Trail bike riding	4
Four wheel driving	2
Walking the dog	9
Bird watching	6
Photography	9
Cycling	5
Relaxing	4
Picnics	9
Playgrounds	1

Question Eight: What activities do you think should be encouraged, discouraged or not bothered at Lightning Swamp?

Activity	Enourage (%)	Discourage (%)	Not bother (%)
Bushwalking	90	0	10
Bird watching	93	5	2
Community Education	75	10	15
Cycling	69	19	12
Picnics/BBQs	71	17	11
Trail bike riding	10	78	6
Four wheel driving	16	81	9
Conservation of flora and fauna	72	8	7

Sporting/ovals	72	61	10
Horse riding	22	56	21

Question Nine: What information do you think should be provided at the site?

Response	Percentage (%)
Details of flora and fauna	96
Endangered species	80
Historical significance	74
Aboriginal significance	69
Wetland significance	70
Role of created wetlands	55

Question Ten: Do Would you like to become actively involved in helping to conserve this area?

Response	Percentage (%)
Yes	54
No	46

Question Eleven: Do you think that bushland affects the value of your property?

Response	Percentage (%)
Yes, it increases it	25
Yes, it decreases it	3
No	42

Question Twelve: What is your current impression of Lightning Swamp bushland?

Response	Percentage (%)
Very attractive	10
Attractive	7
Neutral	30
Unattractive	17
Very unattractive	6

Question Thirteen: What do you consider to be the most attractive aspect of the area?

Response	Percentage (%)
Aesthetics, like to look at it	25
Buffer Zone (noise from main roads)	13
A place for recreation	22
A place for conservation	32
None, I think the bush in unattractive	6

Question Fourteen: What do you consider to be the most unattractive aspect of the bush?

Response	Percentage (%)
Vegetation	6
Fire	35
Reptiles	7
Mosquitoes	29
Midges	12
Rubbish	9
Muggers	1
Lack of undergrowth	1
Fence	2
Sandpath	1
Noise from bikes	1

APPENDIX 7
ENVIRONMENTAL CONTACTS & RESOURCES LIST

Management & Conservation

BIRDS AUSTRALIA - advice, bird atlasing
Ph: 9383 7749 - guided tours

BICM (Bayswater Integrated Catchment Management)

212 Drake Street - hydrology
Morley WA 6062 - catchment issues
Ph: 9271 7922

BENNET BROOK CATCHMENT GROUP
266 Lord Street - hydrology
Caversham WA 6055 - catchment issues
Ph: 9377 0444 - frog watch and bird atlasing

CITY OF BAYSWATER (Environmental Officer)
61 Broun Ave
Morley, WA, 6062
Ph: 92720692

CALM (Conservation & Land Management)
50 Hayman Road - management techniques
Como WA 6152
Ph: 9334 0333

CONSERVATION COUNCIL OF WESTERN AUSTRALIA
Lotteries House - contacts with bushland groups
79 Stirling street
Perth WA 6000
Ph: 9220 0652

DEPARTMENT OF ENVIRONMENTAL PROTECTION
8th Floor - Westralia Square - information on setting up "friends" groups
141 St George's Terrace - information on management techniques
Perth WA 6000
Ph: 9222 7000

GREENING WESTERN AUSTRALIA

1118 Hay Street
West Perth WA 6005
Ph: 9481 2144

- networks with other groups
- information on weed control

KINGS PARK BOARD

Kings Park and Botanic Gardens
West Perth WA 6005
Ph: 9480 3600

- advice on management techniques
- information on weed control

NATURALISTS CLUB OF WESTERN AUSTRALIA

63 Merriwa Street
Nedlands WA 6009
Ph: 9427 2788

- flora and fauna surveys
- lecture programmes
- excursions

ROYAL AUSTRALASIAN ORNITHOLOGISTS UNION (RAOU)

P O Box 19
Jolimont WA 6111
Ph: 9337 5673

- bird surveys
- lecture programmes
- excursions

URBAN BUSHLAND COUNCIL (WA)

P O Box 326
West Perth WA 6872
Ph: 9271 5707

- directory of community groups
- advice on protection & management of bushland

WETLAND CONSERVATION SOCIETY

14 Stone Court
Kardinya WA 6163
Ph: 9337 7113

- management of wetlands
- lecture programmes

WILDFLOWER SOCIETY OF WA

P O Box 64
Nedlands WA 6009
Ph: 9383 7979

- management techniques
- lecture programmes
- excursions

Community & Environmental Groups

FRIENDS OF LIGHTNING SWAMP BUSHLAND

Via City of Bayswater, or
Ph: 92765454
92757338

92768359

BENNETT BROOK CATCHMENT GROUP

266 Lord St - hydrology
Caversham WA 6055 - catchment issues
Ph: 93770444 - frog watch and bird atlasing

BICM (Bayswater Integrated Catchment Management Group)

212 Drake St. - hydrology
Morley WA 6062 - catchment issues
Ph: 92717922

URBAN BUSHLAND COUNCIL (WA)

P O Box 326 - directory of community groups
West Perth WA 6872 - advice on protection & management of bushland
Ph: 9271 5707

Fire & Emergency

FESA HEADQUARTERS
Ph: 93239300

BEDFORD FIRE STATION (Not to be rung for fire emergencies – dial 000)
Ph: 92761022

FESA ENVIRONMENTAL OFFICER
Ph: 93239573

Useful Contacts

Altone Park Library
Benara Road
Beechboro WA 6063
Ph: 9377 7760

Morley Library
Dewar Road
Morley WA 6062
Ph: 9375 1766

Noranda Square Shopping Centre

Shire of Swan
Great Northern Highway
Middle Swan WA 6056
Ph: 9276 3731

Department of Conservation & Land Mgmt.
50 Hayman Road
Como WA 7152
Ph: 9334 0333

State Ministry for Education

Benara Road
Noranda WA 6062
Ph: 9276 9498

151 Royal Street
East Perth WA 6004
Ph: 9264 4111

Birds Australia
P O Box 19
Jolimont WA 6111
Ph: 9383 7749

Local Schools

Primary

Beechboro Primary School
King Road
Beechboro WA 6063
Ph: 9377 5500

Boyare Primary School
Threadleaf Way
Mirrabooka WA 6061
Ph: 9249 3440

Hampton Park Primary School
Hamersley Avenue
Morley WA 6062
Ph: 9276 5891

Infant Jesus Primary School
1 Russel Street
Morley WA 6062
Ph: 9276 1769

North Morley Primary School
75 Gordon Street
Morley WA 6062
Ph: 9375 1051

John Septimus Roe Community College
Blackboy Way
Beechboro WA 6063
Ph: 9247 2242

Noranda Primary School
Walmsley drive
Noranda WA 6062
Phone: 9275 1833

Camboon Primary School
Forder Road
Noranda WA 6062
Phone: 9276 5832

Weld Square Primary School
Dorking Place
Morley WA 6062
Ph: 9276 5891

West Beechboro Primary School
Avigrion Way
Beechboro WA 6063
Ph: 9377 6091

West Morley Primary Schhol
Fitzroy Street
Dianella WA 6062
Ph: 9375 2055

High Schools

Hampton Senior High School
Morley Drive
Morley WA 6062
Ph: 9279 5900

Lockridge Senior High School
Benara Road
Kiara WA
Ph: 9279 4055

Morley Senior High School
Bramwell Road
Noranda WA 6062
Ph: 9276 5766

John Forrest Senior High School
Drake Street
MORLEY WA 6062
Phone: 9272 1255

Other Schools

John Septimus Roe Anglican Community School
Mirrabooka Avenue
MIRRABOOKA WA 6061
Phone: 9247 2242

Chisholm College
Junior Campus
1104 Beaufort Street
BEDFORD WA 6052
Phone: 9271 9000

Chisholm College
Senior Campus
103 Wood Street
BEDFORD WA 6052
Phone: 9272 7922