

CITY OF WANNEROO

**GNANGARA LAKE RESERVE
MANAGEMENT PLAN
2002 – 2007**



VERSION 4

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REPORT NO: 2001/166

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1. OVERVIEW

1.1 Background

Preparation of this Management Plan was initiated by the City of Wanneroo to provide a comprehensive Management Plan for Gnangara Lake and adjoining areas of bushland. Specifically, a review of a previous Management Plan prepared in 1990 by the City of Wanneroo for Gnangara Lake and adjoining Local Authority reserves and preparation of an updated and expanded Management Plan was required. The earlier Management Plan covered a large portion of the present study area comprising the lake and abutting reserves to the east and west under the vesting of the City of Wanneroo.

The previous plan outlined a series of recommendations aimed at improving recreational and public use of the area while preserving the natural values of the lake and adjoining areas. These recommendations however, have largely not been acted upon or implemented. Since the preparation of the previous Management Plan, relevant policies have been revised or new policies released, and community and governmental attitudes towards conservation issues and values have changed. The information and recommendations contained in the previous Management Plan therefore required a review and update.

1.2 Gnangara Lake Reserve

For ease of reference, the area covered by this Management Plan is referred to as the Gnangara Lake Reserve (GLR). GLR is located approximately 18km north of Perth City Centre in the local government authority of the City of Wanneroo and within the locality of Gnangara ([Figure 1](#)). The name GLR is distinct from other names associated with components of the study area such as Gnangara Lake and Gnangara Lake Park, and nearby areas such as Gnangara Park.

The boundary of the area covered in this Management Plan has been delineated largely to incorporate existing reserves and Vacant Crown Land (VCL). GLR includes Gnangara Lake and several fringing reserves including the area referred to as Gnangara Lake Park immediately to the east. Areas of State Forest supporting remnant vegetation to the east and north-east of the lake and adjoining properties to the south-east of the lake reserved as Parks and Recreation under the current Metropolitan Region Scheme (MRS) are also included in the area covered by this Management Plan.

GLR consists of numerous parcels of land that are vested with several agencies as well as VCL and freehold land owned by government agencies, as shown in [Figure 2](#). The individual parcels making up GLR are therefore currently managed by the various agencies, which presents difficulties in terms of providing coordinated management of the area.

Gnangara Lake is the dominant feature of the study area. The lake occupies approximately 117.3ha (Hill *et al.* 1996). The lake forms part of a chain of wetlands

referred to as the “eastern circular wetlands” due to their distinctive round or oval shape.

Gnangara Lake is located on the western side of the Gnangara Mound and is a surface expression of the superficial aquifer. The water levels within the lake fluctuate seasonally with an area of generally permanent water restricted to a portion along the eastern margin of the lake. Water levels within the lake have altered over time and previously supported boating activities, water-skiing and swimming. The lake is now almost completely dry for most of the year.

The bushland fringing the lake and to the east is in variable condition. There is evidence of degradation in the bushland from human activities. In places the bushland has been removed and the landscape modified for the excavation of sand.

Increases in the population of the area progressively over time has led to greater use and access to the area including the provision of public amenities, which are presently in a state of disrepair. Numerous tracks used by vehicles, trail bikes, walkers, and horse riders have developed within seasonally dry portions of the lake and the bushland areas. The bushland areas are currently being used for undesirable activities such as the dumping of vehicles and rubbish.

1.3 Purpose and Status of the Management Plan

1.3.1 Purpose of the Plan

The purpose of this Management Plan is to provide a basis to guide the use and management of Gnangara Lake and the adjoining bushland areas primarily over the next 5 years but also in the longer term. This Management Plan is a strategic document and it is envisaged that more detailed specific plans may be required prior to implementation (such as weed control plans, monitoring programs and vegetation rehabilitation plans).

This Management Plan is a review of the previous Gnangara Lake Management Plan (City of Wanneroo, 1990). The objective is to produce an updated and expanded plan for the lake and adjoining bushland.

1.3.2 Status of the Plan

This Management Plan acts to guide the use and implementation of management strategies to protect the values of the area. Detailed implementation plans for specific uses, areas or management strategies will need to be consistent with the overall management strategies outlined in this document.

A Draft Management Plan was prepared following review of existing information, a workshop with invited community representatives and agencies, and discussion with the agencies that own, or are responsible for, the land parcels or reserves in GLR.

The Draft Management Plan was presented for public comment to obtain the comments and opinions of the broader community.

Submissions received following the public comment period were reviewed and modifications to the draft report incorporating comments contained in submissions were proposed.

The City of Wanneroo resolved to adopt the Management Plan in November 2002 subject to the proposed modifications being made.

This Final Management Plan for Gnangara Lake Reserve incorporates the proposed changes adopted by the City of Wanneroo.

1.4 Planning Context

Policies and publications that have relevance to GLR and its management are identified briefly below.

Environmental Protection (Swan Coastal Plain Lakes) Policy 1992

Gnangara Lake is protected under provisions of the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (Lakes EPP).

The Lakes EPP, gazetted in December 1992, was recently reviewed by the Environmental Protection Authority (EPA) to appraise the effectiveness of the Policy and the status of wetlands of the Swan Coastal Plain. The review, released for public comment in November 1999, stated that the Lakes EPP be re-drafted such that lakes protected under the existing policy continue to be protected and that provision be made to also protect seasonal wetlands (ie. sumplands and damplands) of conservation significance.

The provisions of the 1992 policy still apply and include the prohibition of filling, mining or excavation of EPP wetlands, and the draining of waters into or from the lake without permission from the relevant government authorities. As a general guide, the EPA recommends that the environmental values of an EPP wetland be protected by the provision of a dryland buffer around the periphery of the wetland. The EPA usually supports a buffer of at least 50m or 1mAHD higher than the furthest extent of the wetland dependant vegetation.

Any direct alterations to the lake and hydrology of the lake therefore would be subject to approval from the EPA.

Environmental Protection (Gnangara Mound Crown Land) Policy 1992

This aim of this EPP is to protect groundwater under the Crown and State-owned land on the Gnangara Mound for public water supply. The policy sets out specific levels for the quantity and quality of groundwater to ensure protection of the resource, and includes controls to limit clearing of native vegetation and activities that threaten groundwater in the area. The policy established a minimum water level for Gnangara Lake of 41.3mAHD, which was based on conditions imposed on the abstraction of groundwater for public drinking water supply by the Minister of Environment in March 1988. Conditions imposed on the abstraction of groundwater for public

drinking water supply have subsequently been revised with the minimum water level for Gngangara Lake now set at 42mAHD, however the EPP has not been revised to reflect this.

A revised draft *Environmental Protection (Gngangara Mound Crown Land) Policy* (1998) has been prepared but has not been adopted. The revised draft EPP will protect environmental values of the Gngangara Mound under the *Environmental Protection Act 1986*. Its objective is to declare under the Act, certain beneficial uses of groundwater, vegetation and wetlands on or under the policy area, to be beneficial uses of the Gngangara Mound Crown Land EPP and to establish a consistent regulatory framework for the protection of these uses (WAPC, 2001).

Statement of Planning Policy No. 3 (Gngangara Mound Crown Land) 1995

This policy was prepared in tandem with the Gngangara Mound Crown Land EPP and establishes the land use planning principles for use of land within the policy area. The SPP provides a guide to land use decision making for land over the Gngangara Mound to protect the quantity and quality of groundwater, promote sustainable use of groundwater, protect wetlands and vegetation and encourage recharge. The SPP outlines permitted, non-permitted and restricted land uses in the policy area.

Under this policy, proposals for land use or development that are not consistent with those stated will be subject to referral and assessment under the *Environmental Protection Act 1986* prior to approval being granted.

Draft Environmental Protection (State Groundwater) Policy 1998

This policy was prepared in recognition of the need to protect groundwater resources for human use and ecosystem maintenance including both quantity and quality. The policy sought to provide a consistent regulatory framework for protection of the State's groundwater according to the principles of ecologically sustainable development.

The purpose of the draft EPP was to protect declared environmental values and beneficial uses of critical groundwater areas. The policy outlines a program for protecting groundwater by provisions for implementing groundwater protection regulations, ensuring consistent approvals between state and local government agencies and planning policies and statutory planning schemes, and where appropriate assessing land use and development proposals.

Underground Water Pollution Control Areas (UWPCA)

Protection of public water supplies is undertaken by the Water & Rivers Commission (WRC) by declaring Underground Water Pollution Control Areas (UWPCA) under provision of the *Metropolitan Water Supply, Sewerage and Drainage Act 1909*. The strategy encompasses the Gngangara, Mirrabooka and Wanneroo UWPCA.

The study area lies within the Wanneroo and Mirrabooka UWPCA. Gngangara Lake presently lies largely within a Priority 2 zone of the Wanneroo UWPCA while the bushland areas to the east and south of the lake lie within the Mirrabooka UWPCA in

Priority 1 and Priority 2 areas. The portion of the lake and bushland in north-west corner of GLR lie within a Priority 3 Source Protection Area.

Priority 1 areas are defined to ensure there is no degradation of the water source. Priority 1 areas are declared over land where the provision of the highest quality public drinking water is the prime beneficial use.

Priority 2 protection areas are defined to ensure there is no increased risk of pollution to the water source and are declared over areas where the provision of public drinking water supply is a high priority but where low intensity development already exists.

Priority 3 areas are defined to minimise the risk of pollution to the water source. Priority 3 areas occur where water supply needs to co-exist with other land uses such as residential and commercial developments.

Activities and land use within UWPCAs are restricted according to the Priority source protection in order to protect the drinking water sources based on vulnerability to different contamination threats.

Gnangara Land Use and Water Management Strategy

The Western Australian Planning Commission (WAPC) in liaison with other agencies produced the final Gnangara Land Use and Water Management Strategy (GLUWMS) in 2001. The report was prepared to provide a strategy for the protection of important groundwater and environmental features of the Gnangara Mound while permitting development where appropriate. The strategy covers an area of about 800km².

The implementation strategy presented in the GLUWMS in relation to Gnangara Lake recommended the majority of the lake be included in a Gnangara UWPCA Priority 1 area. The proposed boundaries exclude the western edges of the lake from the UWPCA. The strategy made the following recommendation in relation to the Gnangara Lake planning precinct:

“Incorporate into the Gnangara Park Management Plan that is to be prepared recognising groundwater values.”

Gnangara Park Concept Plan

Gnangara Park is situated over the Gnangara Mound and extends between Gnangara in the south to Wilbinga in the north covering around 91000ha. The area includes expansive areas of State Forest 65 supporting both native vegetation and plantations, existing nature reserves, Crown land and private lands.

The area covered by Gnangara Park was initially promoted as an area for conservation in Conservation Reserves for Western Australia report (the System Six Study) (EPA, 1983). Government approved the concept for the park in 1996 and CALM has subsequently published the Gnangara Park Concept Plan (CALM, 1999).

The eastern portion of GLR that is vested with CALM and reserved as State Forest is included within the boundaries of Gnangara Park. Gnangara Lake however, is

identified as an 'Area of Influence' in the concept plan as management and land use within the adjoining Gnangara Park has the potential to influence and impact on processes and uses of the wetland. There is potential that these adjoining areas of conservation significance such as Gnangara Lake may be included within Gnangara Park as planning of the park proceeds and the concept evolves.

The Concept Plan has been prepared largely to establish the principles and broad strategies to guide management and planning of Gnangara Park. The Concept Plan separates the Park into zones based on land and vegetation characteristics and recreation and interpretation concepts. The eastern portion of GLR and the area immediately adjacent to the present study area are located within Zone 1 – Gnangara. The principal focus of this zone is proposed to be public interaction and resources use. The area will be a main entry point to the park with an associated and complimentary major recreation node.

Wetland Atlas

In 1996, the Water and Rivers Commission (WRC) and Department of Environmental Protection (DEP) published a series of maps identifying wetlands occurring within the Perth Metropolitan Area (Hill *et al.*, 1996). The wetland mapping, referred to as the Wetland Atlas, shows the boundaries of wetlands, wetland classification and preliminary management category.

The Wetland Atlas identified Gnangara Lake as a 'Lake', defined as a permanently inundated basin of variable size and shape, and assigned a management rating of 'Conservation'. Conservation management rated wetlands are described as wetlands which support high levels of attributes and functions. The management priorities for conservation category wetlands are to preserve wetland attributes and functions through reservation in national parks, crown reserves, state owned land and protection under environmental protection policies (Hill *et al.*, 1996).

The Wetland Atlas identifies Gnangara Lake as being part of the Gnangara Suite (B2) and describes its geomorphic setting as Bassendean Dunes with slightly higher undulating dunes on the western margin of this area. The wetlands are groundwater wetlands with drainage impeded by thin clay, diatom mud or ferricrete layers superimposed on, or within the Bassendean sand.

No other wetlands, other than Gnangara Lake, are identified within GLR in the Wetland Atlas.

Bush Forever

Bush Forever is a 10 year strategic plan to protect around 51,200ha of regionally significant bushland within 287 Bush Forever Sites, representing, where achievable, a target of at least 10 per cent of each of the original 26 vegetation complexes of the Swan Coastal Plain portion of the Perth Metropolitan Region (Government of Western Australia, 2000). Bush Forever was prepared by the Ministry for Planning (MFP) (now DPI), DEP, CALM and WRC. Bush Forever represents an update of the earlier System Six study and recommendations in the Perth Metropolitan Region and is the final version of the draft Perth's Bushplan.

The whole of the study area for this Management Plan, including Gnangara Lake, is contained within Bush Forever Site 193.

2. EXISTING ENVIRONMENT

2.1 Regional Setting

2.1.1 Location

GLR is located approximately 18km north of Perth city centre in the local government authority of the City of Wanneroo and within the locality of Gngangara (Figure 1).

The area generally extends from Sydney Road eastwards to the local authority boundary between the City of Wanneroo and City of Swan, and between Gngangara Road and existing special rural development to the north, encompassing roughly 162ha (Figure 2).

2.1.2 Land Tenure & Zoning

GLR consists of numerous parcels of land that are vested with several agencies as well as VCL and freehold land owned by government agencies, as shown in Figure 2. The property located in the south-eastern portion of the site abutting Gngangara Road has recently been purchased from ACI Operations by WAPC. No vesting or ownership details were available from the Department of Land Administration (DOLA) for a small linear section of land orientated north-south within the north-eastern section of State Forest 65. The land immediately adjacent to an approved subdivision along the south-western margin of the lake is proposed to be reserved for recreation and transferred to the City of Wanneroo.

Under the Perth Metropolitan Region Scheme the majority of GLR is reserved as 'Parks and Recreation' with the eastern most parcels of land reserved as 'State Forest' (Figure 2). A narrow section of GLR on the southern most boundary along Gngangara Road is reserved as 'Important Regional Road' for the possible future upgrade of Gngangara Road.

The various reserves, excluding state forest areas, which make up GLR are vested with the City of Wanneroo for the purpose of recreation. Table 1 indicates the responsible authority and vesting purpose for each of reserve or lot within GLR.

**TABLE 1
OWNERSHIP/VESTING**

Reserve/Lot No.	Owner/ Vesting Agency	Purpose	Area (ha)
↑8399	City of Wanneroo	Recreation	33.9936
↑27278	City of Wanneroo	Recreation	2.1859
↑27279	City of Wanneroo	Recreation	108.4558
↑42558	City of Wanneroo	Public Recreation	21.5737
↑43901	City of Wanneroo	Public Recreation	2.0783
Proposed Reserve (Pt Lot 883)	City of Wanneroo	Public Recreation	2.3123
Lot 1	WAPC	Freehold [C/T 1103/699]	.3869 [includes house]

Reserve/Lot No.	Owner/ Vesting Agency	Purpose	Area (ha)
Lot 970	WAPC	Freehold [C/T 1579/383]	6.3700 4717m ² required for road
Lot 2470	WAPC	Freehold [C/T 1779/788]	6.23322
Lot 51	WAPC	Freehold [C/T 1823/79]	1.9862 9324m ² required for road
Lot 50	WAPC	Freehold	13.8800 4378m ² required for road
Lot 65 Steel Rd	CALM	State Forest 65	11.0003
Pt Lot 65 Gnangara Rd	CALM	State Forest 65	7.7100
Lot 5199 Sydney Rd	CALM	State Forest 65	71.2316
VCL	Unallocated	VCL	4.9
VCL	Unallocated	VCL	0.5363

Current tenure of the land within GLR presents difficulties in terms of providing coordinated management of the area. There is a strong need to define management responsibilities and arrangements between agencies managing portions of GLR.

The preferred option for management of the area is for all of the land within GLR to be created as reserves and placed within the care of a single agency or coordinated management body with the necessary expertise. The establishment of formal management arrangement between the relevant agencies should be considered as a means of ensuring a coordinated approach and effective implementation of management strategies. The previously promoted concept of establishing a Regional Park incorporating the linear chain of east Wanneroo wetlands would enable coordinated management by placing management responsibility with a single agency such as CALM.

2.1.3 GLR Boundary

The boundary of GLR has been determined based on the current Perth Metropolitan Region Scheme Parks and Recreation reservations for Gnangara Lake and immediate surrounds, and the boundary of reserved State Forest to the east of the lake that supports remnant vegetation (Figure 2). The boundary of the area corresponds to that identified in Bush Forever as Site 193 (Government of Western Australia, 2000).

In the future, neighbouring properties may also be included in the area of Parks and Recreation reservation and the boundary of the area to be managed in association with GLR may expand.

2.1.4 Land Use

Areas within GLR largely support native vegetation or wetland. A tenanted house is located near the south-eastern margin of the lake. Previous sand quarries are evident to the east of Gnangara Lake and to the south-east along Gnangara Road. The more centrally located sand quarry within CALM managed land is presently used by an off road vehicle club for training activities. CALM also permit commercial wildflower collecting within the bushland areas under their jurisdiction. The area is currently being used for limited recreation including horse riding, dog exercising, walking and

relaxation. The area is also used illegally as a dumping area for household refuse and abandoned vehicles.

GLR is situated within a largely rural based area, although residential development in areas to the south is expanding. The study area is bordered by special rural development to the north, south-west and west of Sydney Road. Areas immediately south of Gngangara road support residential development associated with the locality of Landsdale. Land east of the area supports extensive pine plantations. Property south east of the study area supports telecommunications infrastructure. A horse riding facility and the Swan Valley Nyoongah Aboriginal Community are on Sydney Road immediately west of GLR.

2.2 Biophysical Environment

2.2.1 Climate

The area experiences a Mediterranean climate which is characterised by mild wet winters and hot dry summers. Bureau of Meteorology data dated 28 May 2001 indicate the long-term annual average rainfall recorded in Perth is 870mm. Mean monthly rainfall is greatest during the months of May, June, July and August. Lowest monthly average rainfall occurs in January, February and December.

February is the hottest month of the year with an average maximum temperature of 30.0°C while July is the coolest month with an average maximum of 17.4°C. Mean minimum temperatures range from 9.0°C in July to 18.1°C in February.

The annual average daily evaporation for Perth is 4.8mm with the highest average evaporation of 8.1mm occurring in January and the lowest evaporation of 2.0mm in July. The annual mean daily evaporation suggests an average of about 1752mm of evaporation occurs annually.

2.2.2 Landform, Geology & Soils

GLR lies within the Bassendean Dune System near the boundary between the Bassendean Dune System and more westerly located Spearwood Dune System (Gozzard, 1986). The Spearwood Dune system occurs immediately to the west of GLR and occurs in the area abutting the south west margins of Gngangara Lake.

The Bassendean Dune System consists of low to very low relief dunes, with intervening swamps and undulating sand plain (Gozzard, 1986). The upland areas surrounding the lake are typically flat or gently sloping, however, a low ridge occurs immediately to the east of the lake. The lake itself is a large shallow circular depression located between two ridges of the Bassendean and Spearwood Dune Systems. The lake basin has deposits of diatomite, particularly in the northern and western section, with sandy foreshores and low fringing dunes, or lunettes, on the eastern and southern shores.

Available contour information indicates the eastern portion of the site lies at about 48mAHD rising to as high as about 60mAHD along the low ridgeline bordering the

eastern edge of Gngangara Lake (WRC, 1997). The lake itself lies at less than 43mAHD. The western margins of the lake along Sydney Road are elevated at between 44 to 46mAHD.

The upland portions of the site comprise light grey over yellow fine to medium grained quartz sand of aeolian origin associated with Bassendean Sand (Qpb) (Gozzard, 1986). In the eastern and north-eastern portion of the site Bassendean Sand occurs thinly over the Guildford Formation (Qpa), which consists of alluvial derived material with a greater portion of fine to medium sized silts and sands.

The margins of the lake consist of Peaty Clay (Cps) which is described as dark grey in colour with variable sand content associated with lake deposits.

2.2.3 Groundwater

GLR is located on the Gngangara Mound, a large shallow groundwater aquifer which occurs between the Swan River and Gingin Brook (WAWA, 1995). The Gngangara Mound is a major water source, supporting a number of groundwater abstraction schemes by the Water Corporation, and private abstraction for agriculture, industry, and recreational and domestic use. In general, groundwater abstraction lowers groundwater levels, with greater drawdown experienced in close proximity to wells.

Regional groundwater contour mapping of the area suggests average maximum groundwater levels lie at about 46mAHD in the north-eastern section of GLR and 44mAHD along the southern boundary near Gngangara Road and the south-western margin of the lake (WRC, 1997). Based on this information the groundwater is expected to be within 2 to 3m of the natural surface within the eastern section of GLR. The contours suggest general groundwater flow is in a south-westerly direction.

As mentioned in Section 1.4 above, GLR falls within UWPCAs with Priority 1, 2 and 3 areas located within GLR. The boundaries of the existing UWPCAs and Priority areas and the recommended protection areas within GLR are shown in [Figures 3 and 4](#) respectively. Land use and activities within these protection areas are restricted in order to protect the drinking water source. Greatest restriction and protection is placed on areas that are located with Priority 1 source areas, with generally decreasing restrictions imposed on Priority 2 and Priority 3 areas. Priority 1 areas are generally suitable only for low-intensity and low-risk land uses, such as forestry and extractive industries, with most land uses being incompatible with the management objectives.

Acceptable land use within the priority areas is outlined in the WRC's Water Quality Protection Note entitled *Land Use Compatibility in Public Drinking Water Source Areas* (October 2002). The WRC have also prepared a draft Water Quality Protection Policy - *Policy and Guidelines for Recreation and General Access on Crown Land within Public Drinking Water Source Areas and Other Water Source Catchments* (2001). The conditional and incompatible land-based and water-based recreational and transient activities within Priority 1 areas as outlined in the draft WRC policy document are presented in [Appendix 1](#). In many instances recreational activities may be acceptable subject to appropriate management and are listed as 'Conditional'.

These activities should be referred to the Water and Rivers Commission for assessment on the merits of the specific case.

In addition to the Priority classifications, wellhead protection zones are delineated around groundwater wells to protect the drinking water source from contamination in the immediate vicinity of production wells. Statutes provide for defined land uses and activities within these zones that are prohibited, restricted or subject to imposed agency conditions so that contamination of the water source is prevented. Wellhead protection zones fall within UWPCAs and usually encompass a radius of 500m within Priority 1 areas and 300m in Priority 2 and Priority 3 areas. A portion of the south-east section of GLR is affected by a wellhead protection zone (Figure 5) and therefore activities and land use within these sections need to accord with the defined acceptable uses.

2.2.4 Gngangara Lake

Gngangara Lake is a Conservation Category wetland and EPP lake that forms part of the Gngangara Suite (B2) of wetlands (Semeniuk, 1996), which includes the East Wanneroo wetlands. The Gngangara Suite of wetlands has the following characteristics:

Geomorphic Setting	Primary Wetlands	Stratigraphy	Origin of Wetlands
Bassendean Dunes with slightly higher undulating dunes on western margin of this area. Wetlands enclosed by saddles or ridges.	Lakes & sumplands & occasional damplands.	Diatom, mud, peaty sand & clay overlying quartz sand. Hardpans (ferricreted quartz sand) at level of watertable.	Groundwater wetlands. Large lakes appear as coalesced smaller basins. Drainage impeded by thin clay, diatom mud or ferricrete layers superimposed on, or within the quartzose Bassendean sand.

Source: Bush Forever (Government of Western Australia, 2000)

No other wetlands have been identified within the study area in available mapping. The vegetation survey of the site however, suggests a linear area toward the eastern boundary of the study area within State Forest is low lying and includes areas that support species typically associated with wetlands such as *Melaleuca preissiana*. The watertable is expected to be close to the surface in these areas.

Other wetlands of the East Wanneroo chain are located in close proximity of GLR. Badgerup Lake lies about 1.5km to the west of GLR and Jandabup and Mariginiup Lakes are located approximately 5km north-west. Several smaller modified or constructed wetlands occur nearby within surrounding special residential and residential developments to the south, west and north of GLR. The linear lakes within Yellagonga Regional Park such as Lake Joondalup, Lake Goollellal and intervening swamps are situated roughly 5km to the west of GLR.

Bathymetry

Gngangara Lake is a relatively shallow wetland, gently sloping on the western side, with steeper slopes on the east.

Soundings of Gngangara Lake in July 1978 indicate the lake bed slopes very gently from the western shores at over 42mAHD to two deeper sections along the eastern margin with bases at about 41mAHD (City of Wanneroo, 1990). The eastern shores

rise up to over 42mAHD much more sharply than in the western section. A slightly deeper and steeper sloping section also occurs in the south-western portion of the lake. The base of this area lies at about 41.6mAHD.

Water Levels

Water levels within Gngangara Lake have changed markedly since the 1960s. An increase in water levels occurred in 1960s when much of the surrounding area was cleared for the establishment of pine plantations and above average rainfall was recorded. Since 1965 the water levels have been steadily declining and there was a sharp decline in levels after 1976 which is believed to be associated with the commissioning of the Mirrabooka Groundwater Scheme in 1971, and continued growth of nearby pine plantations. Water levels within the lake began to rise after 1990 as a result a thinning of pine plantations, above average rainfall and reduced abstraction from nearby production wells (WAWA, 1995).

The lake previously contained water for prolonged periods over the warmer months enabling the lake to be used for boating and waterskiing. At present the lake is typically dry or almost dry over the drier summer months. The lake fills with water following winter rains and the associated rise in local watertable during the late winter and spring months.

Water level monitoring data provided by the WRC between 1953 and 2001 are shown in [Figure 6](#). The data demonstrate the changes in water levels within the lake during this period and indicate that lake water levels have receded over the past two decades with the maximum levels experienced over the past several years about the lowest recorded during the monitoring period. The water level data indicate the slight rise in water levels after 1990 mentioned above was followed by a decline in levels in the mid-1990's. A slight increasing trend in the maximum water levels is evident since about 1997.

According to the monitoring data, water levels reached a maximum of 44.6mAHD in 1965. The lake is likely to have contained water within much of the lake all year round until about 1976 when water levels declined to less than 41.5mAHD during the warmer months. Maximum water levels over the past 5 years typically range between 42.0 and 42.5mAHD, with the lake largely drying out over summer.

Water Quality

The Water Authority of Western Australia has historic water quality data records from Gngangara Lake (1970-1986) that show prior to 1978 the lake was predominantly alkaline and became predominantly acidic after 1978. The lake was reported as being slightly alkaline with pH levels ranging between 6.7 and 8.9 between 1970 and 1977. Since this time, Gngangara Lake has consistently recorded pH levels of generally less than 4, and has elevated concentrations of nitrate and nitrite (City of Wanneroo, 1990).

Reduced water levels from groundwater abstraction appear to have exacerbated the trend of increased acidity in Gngangara Lake. Although biological data prior to

acidification is not available, it is likely that this has had significant impact on fauna and vegetation (WAWA, 1995).

The lake is reported as being mildly brackish, with low total phosphorus concentrations (generally below 20µg/l) and relatively high total nitrogen (up to 40000µg/l), very high ammonia concentrations, and high sulfate. The inorganic nitrogen levels increased when the lake acidified (WAWA, 1995).

The Water & Rivers Commission has been monitoring numerous wetlands located on the Gngangara Mound and East Gngangara wetlands between 1996 and 2001. A summary of the range of the concentrations and measurements recorded over this time at Gngangara Lake is presented in Table 2. The range of levels include those taken when the lake contains substantial water and when water levels have receded and the lake is drying out. Relevant guideline levels (EPA, 1993; ANZECC, 2000) for the maintenance of aquatic systems are provided in Table 2 for comparative purposes.

TABLE 2
PHYSICOCHEMISTRY OF GNANGARA LAKE
RECORDED SUMMER 1996 TO SUMMER 2001

Parameter	Recorded Range		EPA 1993 Guidelines	ANZECC 2000 Guidelines	
	Low	High		Lake	Wetland
pH	3.00	4.52	6.5 – 9.0	6.5 - 8.0	7.0 - 8.5 ²
Conductivity (µS/cm)	513	5130	-	300 - 1500	300 - 1500
Temperature (°C)	17.9	36.4	-	-	-
Dissolved Oxygen (mg/l)	4.16	9.80	>6	90% - ND	90 – 120%
Chlorophyll- <i>a</i> (µg/l)	0.21	10	1 – 10	3 - 5	30
Turbidity (NTU)	1	53	-	10 - 100	10 - 100
Gilvin (g440)	0.2	3	-	-	-
Nitrate/Nitrite (µg/l)	5.5	1105	-	10	100
Ammonia (µg/l)	3220	19500	-	10	40
Total Kjeldahl Nitrogen (µg/l)	5803	30677	100 – 500 ¹	350 ¹	1500 ¹
Orthophosphate (µg/l)	<2	5	-	5	30
Total Phosphorus (µg/l)	6	25	5 – 50	10	60
Iron (mg/l)	1.3	4.3	1	-	-
Sulfate (mg/l)	218	845	-	-	-

Adapted from Chapman & Horwitz (2001)

Note: 1 - Total Nitrogen guideline values

2 – in highly coloured wetlands (gilvin >52g₄₄₀m⁻¹) pH typically 4.5 - 6.5

ND – no data

The monitoring data indicates that the pH levels in the lake are constantly below the recommended levels. Concentrations of nitrogen within the system are extremely high with levels of Ammonia and Total Kjeldahl Nitrogen individually well above the recommended range for Total Nitrogen, which includes all forms of nitrogen. Levels of iron are in excess of the recommended level and dissolved oxygen concentrations have been recorded below the recommended level.

Chlorophyll-*a*, which is indicative of algal growth, and concentrations of Total Phosphorus are within EPA guideline ranges and relevant ANZECC guidelines for

wetlands but levels above the ANZECC guidelines for lakes or reservoirs have been recorded. Levels of Orthophosphate comply with the ANZECC guidelines.

The large difference between the low and high records for temperature, conductivity and turbidity largely reflect water levels within the lake and the seasonal variation between when the wetland contains water and when it is largely dry. Temperature and conductivity measurements, in particular, typically rise as water levels decline.

Monitoring in spring 2000 recorded the presence of a filamentous algae forming a suspended mat over the substrate (Chapman and Horwitz, 2001). The algae appeared purple-coloured due to stress from the acidic conditions of the lake. The lake sediments were found to be anoxic (oxygen depleted) in summer 2001.

General Wetland Ecosystem Health

The poor water quality at Gngangara Lake has had significant impacts on the ecological values of the lake. Conditions within the lake are now generally unfavourable for aquatic fauna. This is reflected in records of predominantly only flying insects and limited distribution of sedges within the wetland margins, and a paucity of avifauna and frogs being present. Fauna and vegetation are believed to have been adversely affected by the low pH of the lake.

2.2.5 Vegetation & Flora

Regional Context

Gngangara Lake and surrounding bushland is located in the Drummond District of the South-west Botanical Province of WA as defined by Beard (1980). The District is more or less equivalent to the Swan Coastal Plain (SCP) and has a considerable variety of vegetation types found in it, as well as a rich flora (Trudgen, 1999).

Within the SCP the study area is mapped as comprising vegetation of the Bassendean Cental and South Vegetation Complex. According to Heddle *et al* (1980), this complex is highly variable, ranging from Jarrah-Banksia-Sheoak on upland areas to a Low Woodland of *Melaleuca* spp. and sedgelands on the low-lying interdunal depressions and swamps. The study area represents the northern extent of this Complex and reaches the southern limit of its range near Mandurah.

The northern region of the study area comprises the transition zone of the Bassendean Complex (Bassendean Complex – North Transition Vegetation Complex). This Complex generally consists of a Low Open Forest to Woodland of *Banksia* and Pricklybark (*Eucalyptus todtiana*) over understorey species which reflect the dominating soil type of deep pale grey/yellow sands, including *Leucopogon conostephioides*, *Conospermum stoechadis*, *Mesomelaena pseudostygia* and *Synaphea polymorpha*.

Vegetation Types

The vegetation types of GLR as mapped during the site inspections for the preparation of this Management Plan are shown in [Figure 7](#).

The vegetation can be described and delineated according to changes in soil types, topography and depth to groundwater. In general, the vegetation comprises emergent sedgelands and *Astartea fascicularis* Heaths at the wetland edge, fringing *Melaleuca preissiana* Woodlands, and mixed *Banksia* Woodlands interspersed with Marri (*Corymbia calophylla*), Pricklybark (*Eucalyptus todtiana*), Sheoak (*Allocasuarina fraseriana*) and/or Holly-leaf *Banksia* (*B. ilicifolia*) on the upland area. Stands of *M. preissiana* occur in the eastern area of the site interspersed with the *Banksia* Woodlands.

The vegetation types of GLR are summarised in [Table 3](#).

**TABLE 3
VEGETATION TYPES**

UPLAND AREA	
BaBmAh	Candle <i>Banksia</i> (<i>Banksia attenuata</i>) and Firewood <i>Banksia</i> (<i>B. menziesii</i>) Low Woodland with scattered Marri (<i>Corymbia calophylla</i>) and <i>Eucalyptus todtiana</i> over Dwarf Sheoak (<i>Allocasuarina humilis</i>)
BaBm	<i>B. attenuata</i> and <i>B. menziesii</i> Low Open Woodland to Low Woodland with occasional Sheoak (<i>Allocasuarina fraseriana</i>)
BaBmBiMp	<i>B. attenuata</i> , <i>B. menziesii</i> , <i>B. ilicifolia</i> and <i>Melaleuca preissiana</i> Low Woodland
BmBa	<i>B. menziesii</i> , <i>B. attenuata</i> Low Woodland
BmBaAf	<i>B. menziesii</i> , <i>B. attenuata</i> and Sheoak Woodland
Db	<i>Dasyogon bromeliifolius</i> Closed Sedgeland with scattered <i>M. preissiana</i> , Marri. Occasional stands of <i>Verticordia densiflora</i>
Vd	<i>Verticordia densiflora</i> Low Open Heath
CcBaBmMp	Marri, <i>B. attenuata</i> and <i>B. menziesii</i> Woodland with scattered <i>M. preissiana</i> over Woolly Bush (<i>Adenanthos cygnorum</i>), Balga (<i>Xanthorrhoea preissii</i>) and <i>D. bromeliifolius</i>
CcBaBi	Marri, <i>B. attenuata</i> and <i>B. ilicifolia</i> Woodland over <i>Verticordia densiflora</i>
CcMpBi	Marri, <i>M. preissiana</i> and <i>B. ilicifolia</i> Low Woodland
CcMpXpDb	Marri Woodland with <i>M. preissiana</i> over <i>X. preissii</i> and <i>D. bromeliifolius</i>
AcEc	Woolly Bush Open Scrub over disturbed understorey of Veldt Grass (<i>Ehrharta calycina</i>)
Ec	Veldt Grass Grassland
FRINGING WETLAND	
Mp	<i>M. preissiana</i> High Shrubland to Closed Scrub
MpAcJf	<i>M. preissiana</i> with Woolly Bush and <i>Jacksonia furcellata</i> Low Woodland with occasional Flooded Gum (<i>Eucalyptus rudis</i>) over a disturbed understorey
MpBiXpDb	<i>M. preissiana</i> , <i>B. ilicifolia</i> Low Open Woodland over <i>X. preissii</i> and <i>D. bromeliifolius</i>
MpAfDs	<i>M. preissiana</i> High Shrubland to Open Scrub over <i>Astartea fascicularis</i> Open Heath with <i>Dielsia stenostachya</i>
MpRi	<i>M. preissiana</i> Closed Heath to Closed Scrub with <i>Regelia inops</i>
Af	<i>Astartea fascicularis</i> Open to Closed Heath
AfDsAc	<i>Astartea fascicularis</i> Open to Closed Heath over <i>D. stenostachya</i> with occasional Woolly Bush, <i>M. preissiana</i> and Sheoak
ErMpPe	Flooded Gum (<i>Eucalyptus rudis</i>) Open to Closed Forest over <i>M. preissiana</i> and Bracken Fern (<i>Pteridium esculentum</i>) with annual grasses and the creeper, <i>Dipogon lignosus</i> , dominating the understorey closer to the wetland edge
ErMpVj	Flooded Gum Woodland to Open Forest over <i>M. preissiana</i> and Swishbush (<i>Viminaria juncea</i>)

WETLAND - EMERGENT	
Ds	<i>Dielsia stenostachya</i> Closed Sedgeland
AfDs	<i>Astartea fascicularis</i> Open to Closed Heath over <i>D. stenostachya</i>
VjDs	<i>Viminaria juncea</i> Open Scrub with <i>D. stenostachya</i>

Floristic Community Types

The Floristic Community Type study of vegetation on the SCP was developed by Gibson *et al.* (1994) and is based on an underlying concept that flora species occur in groups as a response to environmental factors and that defining such groups of species over the SCP would enable individual stands of vegetation to be assigned to a group of sites with similar flora composition. In general, floristic community types comprise groups of flora that consistently occur together (Trudgen, 1995).

The floristic composition of vegetation fringing Gnangara Lake and in the surrounding upland areas belongs to the seasonal wetlands and upland vegetation centred on the Bassendean Dunes, that is the Group 2 and 3 classification of Gibson *et al.* (1994), respectively.

According to Gibson *et al.* (1994), Group 2 is highly variable, having by far the largest number of community types which are more or less uniformly spread across the SCP. In general, this group has low species richness with weed frequency moderately high.

The flora group identified as Group 3 has the highest species richness and lowest weed frequency of major vegetation types on the SCP.

Within the study area, Group 2 may be further classified into two Floristic Community Types:

- S3 Wet sedgelands on sandy clays.
- S17 Flooded Gum (*Eucalyptus rudis*)/*Agonis linearifolia* wetlands in Bassendean Dunes.

These Community Types are restricted to the wetland and the wetland periphery.

Under the Group 3 classification, the study area comprises:

- 23a Central *Banksia attenuata* – *B. menziesii* Woodlands.

Floristic Community Type 23a is generally restricted to the Bassendean system ranging from Bullsbrook south to Woodman Point.

Threatened Ecological Communities

Ecological Communities are defined as ‘naturally occurring biological assemblages that occur in a particular type of habitat’ (English and Blyth, 1997). Threatened Ecological Communities (TEC) are those that have been assessed and assigned to one of four categories related to the status of the threat to the community, ie Presumed Totally Destroyed, Critically Endangered (CR), Endangered (EN) and Vulnerable

(VU). TEC identified in these four categories are protected under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*.

No Threatened Ecological Communities occur in the study area.

Flora

A total of 182 species of flora, including 152 native and 30 introduced species, have been identified at Gngangara Lake and surrounding bushland ([Appendix 2](#)).

146 vascular plant species, including 116 native species, were recorded from the study area during the September 2001 survey. 85 species of flora (80 native, and 5 introduced flora) were recorded from the study area during plot sampling undertaken by the DEP in 1996 (DEP, 1996).

All species recorded are flowering plants, except one cycad (*Macrozamia fraseri*), a fern (*Pteridium esculentum*), and a pine (*Pinus pinaster*). Of the plants recorded during the survey, 30 taxa are introduced including Arum Lily (*Zantedeschia aethiopica*) which is listed as a Declared Plant under the *Agriculture and Related Resources Protection Act*, and one species of Pest Plant, Pampas Grass (*Cortaderia selloana*). In accordance within the Act, population of Declared Plants are required to be adequately managed to prevent further invasion of the plant in WA.

Significant Flora

A review of the Department of Conservation and Land Management's Declared Rare and Priority Flora database (August, 2001) revealed one Declared Rare and eight Priority Flora species have been recorded at or in the vicinity of the study area, as listed in [Table 4](#).

Of the significant flora likely to occur in the study area, only *Cyathochaeta teretifolia* was recorded at the site during the September 2001 survey.

TABLE 4
SIGNIFICANT FLORA RECORDED IN THE VICINITY OF
GNANGARA LAKE RESERVE

<i>Species</i>	<i>Conservation Code</i>	<i>Comments</i>
<i>Acacia benthamii</i>	2	
<i>Caladenia huegelii</i>	R	Recorded to the northwest of Gngangara Lake in 1945
<i>Conostephium minus</i>	4	
<i>Cyathochaeta teretifolia</i>	3	Recorded at the N edge of Gngangara Lake in 1994
<i>Jacksonia sericea</i>	3	
<i>Nemcia axillaris</i>	3	
<i>Pityrodia axillaris</i>	1	
<i>Sarcozona bicarinata</i>	3	
<i>Stachystemon axillaris</i>	4	

Conservation Value

A significant portion of the Bassendean Central and South Vegetation Complex has been cleared for the establishment of pine plantations and urban development. As a result, approximately 24% of the original distribution of this complex remains uncleared on the SCP. While most of the Complex occurs south of the Swan River, a significant portion of the original extent of the Complex to the north of Perth is protected, or proposed for protection as part of Bush Forever (Government of WA, 2000) in the conservation estate. In particular, good examples of this Complex to the north of Perth are found in Whiteman Park (Bush Forever Site 304), the Beechboro Road Bushland encompassing approximately 431ha (Bush Forever Site 198) and Gnangara Road Bushland including approximately 236ha of bushland (Bush Forever Site 196). The implementation of Bush Forever will increase the reservation of this Complex on the SCP from approximately 6% to 13%.

In terms of Floristic Community Types, the supplementary categories of S3 and S17 have not been classified yet according to reservation status. Gibson *et al.* (1994) identified that Type 23a are 'well reserved' and 'low risk'. That is, a significant area of this Floristic Community Type is in secure reserves but sufficient remains uncleared to suggest that the floristic community type will in time be adequately protected through Government action. None of the Community Types present at the site are identified as Threatened Ecological Communities under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*.

The northern margin of the wetland supports a population of the uncommon sedge, *Cyathochaeta teretiflora*, a Priority 3 flora species. No other significant flora species were recorded during the September 2001 survey, and the identification of other populations of Declared Rare and Priority Flora is likely to be constrained due to clearing and other disturbances resulting from the development of the surrounding land. In particular, the identification of the Grand Spider Orchid (*Caladenia huegelii*), a Declared Rare species, in the north-western region of the study area in 1945 is unlikely today due to disturbance and fragmentation of the bushland.

Vegetation Condition

The condition of the vegetation in the study area is mapped in [Figure 8](#) according to the rating scale applied in the Bush Forever study. Most of the study area is in Good to Very Good condition with degraded areas concentrated near areas of high activity or where the boundary to area ratio of a particular vegetation parcel has been reduced due to road alignments and adjacent developments. It is in these areas that the concentration of weed invasion is greatest, with species such as Perennial Veldt Grass (*Ehrharta calycina*), Flat Weed (*Hypochaeris glabra*), Lupins (*Lupinus* sp.), Wild Oats (*Avena fatua*) and Pelargonium (*Pelargonium capitatum*) dominant in the understorey.

Numerous tracks and paths dissect the study area and with limited provisions to restrict vehicle access, particularly to 4WD and motorbikes, these tracks are well utilised by the local and surrounding community. An abandoned sand extraction area in the south-eastern region of the study area is now a popular location for off-road

vehicle use and dumping of rubbish. The network of tracks from this area into the surrounding bushland is expansive.

The proximity of the surrounding pine plantations at the eastern and northern boundary have resulted in the establishment of scattered pine trees (*Pinus pinaster*) in the bushland.

The dominance of Perennial Veldt Grass was noted at the southern boundary of GLR forming dense stands to the detriment of native understorey species and the colonisation of the site by native shrubs and trees. At the northern boundary of the wetland, the understorey of the fringing *Melaleuca preissiana/Eucalyptus rudis* Woodland is dominated by annual grasses and ephemeral species such as Arum Lily (*Zantedeschia aethiopica*) and Watsonia (*Watsonia bulbifera*). The introduced creeper, *Dipogon lignosus* is rampant throughout this area. Invasive species such as the Century Plant (*Agave americana*), Pampas Grass (*Cortaderia selloana*) and Victorian Tea-tree (*Leptospermum laevigatum*) were found scattered in the degraded areas at the western and northern boundary, probably as garden escapes from nearby residences.

2.2.6 Fauna

Avian Fauna

Surveys as part of broader study revealed only 11 species of birds and low numbers of birds inhabit Gngangara Lake (Storey *et al.*, 1993). The previous Management Plan indicated that small to moderate numbers of wading birds feed around the margins as the water recedes during summer.

This low diversity and abundance is most likely related to the acidic nature of the wetland and corresponding paucity of invertebrate food source. Historically, it is believed that greater numbers of birds occurred on the lake (WAWA, 1995). It is probable that if the acidity of the lake was reduced it would offer enhanced wading and waterbird habitat.

According to Storey *et al.* (1993) and the previous Management Plan, the species known to have occurred at Gngangara Lake include:

- Black Swan (*Cygnus atratus*)
- Australian Shelduck (*Tadorna tadornoides*)
- Pacific Black Duck (*Anas superciliosa*)
- Grey Teal (*Anas gracilis*)
- Australian Pelican (*Pelecanus conspicillatus*)
- Red-necked Advocet (*Recurvirostra novaehollandiae*)
- Black-winged Stilt (*Himantopus himantopus*)
- Banded Stilt (*Cladorhynchus leucocephalus*)
- Black-fronted Dotterel (*Elsyornis melanops*)
- Red-capped Plover (*Charadrius ruficapillus*)
- White-faced Heron (*Egretta novaehollandiae*)
- White-necked (Pacific) Heron (*Ardea pacifica*)
- Australian White Ibis (*Threskiornis molucca*)

- Straw-necked Ibis (*Threskiornis spinicollis*)

The site visit in July 2001 revealed very few waterbirds using the lake or lake margins. Species observed included Australian Shelduck, Australian White Ibis and an unidentified plover.

Terrestrial Fauna

Faunal surveys of the northern SCP by the Western Australian Museum in 1977/1978 indicate a range of native species could be expected to occur within GLR (Western Australian Museum, 1978). The vegetation within much of the GLR is relatively intact and it is expected that a diverse range of fauna still persist at the site. Banksia woodlands typically support a relatively highly diverse fauna, particularly avifauna. Many of the birds utilising the area will be seasonal or opportunistic visitors to the area depending on conditions.

Large areas of bushland are located to the south of Gnangara Road within the telecommunications site which adjoins Whiteman Park to the east, and scattered areas are located to the north, allowing some connectivity and fauna movement within the area.

Continual disturbance and degradation of the bushland and lake through uncontrolled access and inappropriate activities such as rubbish dumping impacts on the habitat and associated fauna it supports. Expansion of residential and special rural properties in proximity of the lake is likely to have increased disturbance and introduced additional predators such as cats that may have significant impact on local faunal populations over time. An increase in the frequency and extent of fire within the area also has significant impact on fauna. In some instances, disturbance factors may result in local extinction of susceptible species, such as the Southern Brown Bandicoot and Honey Possum, although these species may still occur within GLR.

Species observed or noted during the site inspection in July 2001 are listed below:

Reptiles

Long necked Tortoise (carapace) (*Chelodina oblonga*)

Birds

Short-billed Black-Cockatoo (*Calyptorhynchus latirostris*)

Western Gerygone (*Gerygone fusca*)

Red Wattlebird (*Anthochaera carunculata*)

Singing Honeyeater (*Lichenostomus virescens*)

Brown Honeyeater (*Lichmera indistincta*)

White-cheeked Honeyeater (*Phylidonyris nigra*)

Western Spinebill (*Acanthorhynchus superciliosus*)

Rufous Whistler (*Pachycephala rufiventris*)

Australian Magpie-lark (*Grallina cyanoleuca*)

Australian Magpie (*Gymnorhina tibicen*)

Australian Raven (*Corvus coronoides*)

Grey Fantail (*Rhipidura fuliginosa*)

Welcome Swallow (*Hirundo neoxena*)

Tree Martin (*Hirundo nigricans*)
Silvereye (*Zosterops lateralis*)

Mammals

Western Grey Kangaroo (scats) (*Macropus fuliginosus*)
European Fox (scats) (*Vulpes vulpes*)

Low numbers of frogs were also heard calling from the margins of the lake and drainage areas to the north of the lake. A tadpole was observed within the lake during invertebrate monitoring of the lake in spring 2000 (Chapman and Horwitz, 2001). This coincided with a higher than usual pH of 4.52 at this time of year.

Aquatic Invertebrate Fauna

Gnangara Lake is considered to have a paucity of aquatic fauna (Davis *et al.*, 1993). The recorded low species diversity and abundance is considered to be a consequence of the acidic nature of the lake.

Monitoring of aquatic invertebrates at Gnangara Lake has shown the lake to typically have the lowest species richness of the lakes on the Gnangara Mound and East Gnangara wetlands (Chapman and Horwitz, 2001). Gnangara Lake has been found to have the lowest cumulative number of invertebrates of all the lakes on the Gnangara Mound due to the low pH. The only taxa found consistently in the Gnangara Lake are flying insects (larvae and/or adults) which can leave the wetland when the pH of the water drops to low levels.

The invertebrate fauna of Gnangara Lake is dominated by Ceratopogonidae (Diptera), Hydrophilidae and Dytiscidae (Coleoptera), Corixidae and Notonectidae (Hemiptera) (Chapman and Horwitz, 2001). Species from Chironominae (Diptera), Daphnidae and Macrothricidae (Cladocera) and Oribatida (Acarina) have also be recorded within the lake.

2.2.7 Dieback

Dieback is a disease that affects many of our native plants and is caused by an introduced microscopic soil-borne fungus belonging to the genus *Phytophthora*. The *P.cinnamomi* fungus is the most widespread and destructive being highly invasive and infecting the roots of a wide range of plants.

A survey to assess the distribution of dieback within GLR was undertaken in July 2001 (Reynolds, 2001). The survey involved systematic examination of susceptible species for secondary symptoms, such as crown decline and/or death of infested plants, combined with soil and root sampling.

The survey revealed that most of the low-lying relatively flat eastern section of the area and the lower slopes of the western side of the low ridge along the lake were infested with dieback. The lake area and fringing areas of vegetation were uninterpretable due to a general lack of susceptible species. The distribution of dieback in GLR is shown in [Figure 9](#).

The survey suggested that infestation in the area had resulted from high risk activities such as road building and mining in the past rather than from vehicle activity. There is potential for the spread of dieback within GLR due to the extensive use of the area by off road vehicles. The survey however, recorded no evidence of small or new infestations within susceptible vegetation.

It was revealed that *P.cinnamomi* is presently spreading within *Banksia* woodland at a rate of about 1m per year. Areas of woodland to the east of the lake that do not show evidence of dieback will become infested from areas to the west and east over time. The application of phosphorus acid could reduce the spread of dieback and the impact on susceptible species.

Despite the extensive area of dieback infestation with GLR, the vegetation and flora survey undertaken in 2001 identified most of the vegetation as being in Good to Very Good condition. At present therefore, dieback does not appear to be significantly affecting the overall health of the system but poses significant risk.

2.3 Social Environment

2.3.1 Cultural Heritage

A search of the Register of Aboriginal sites was conducted on 29 June 2001 and advice regarding listed sites was provided by the Department of Indigenous Affairs in August 2002. The results revealed four sites cover portions of GLR, three of which are archaeological and are located on the southern shores of Gngangara Lake and one of which is mythological/historical and is associated with the entire lake (Figure 10). No sites were identified within the eastern upland areas of GLR.

Gngangara Lake was referred to as “Winnaitch” by the aboriginal people, the significance of the name was that it was an area to be avoided as it was thought that the Waugel lived there (City of Wanneroo, 1990; O’Conner et al. 1989). The wetland is registered on the Aboriginal Sites Register with the Department of Aboriginal Affairs. The Nyoongah Community no longer regards Gngangara Lake as sacred because of the low water levels, the lack of water in the wetland means that it has lost its strength and now falls into the realms of mythology and archaeology (City of Wanneroo, 1990; Wanneroo Times, 19 June 1990). There is evidence that Aboriginals once hunted at Gngangara Lake (City of Wanneroo, 1990).

According to K. Colbung Gngangara Lake was an aboriginal camping and meeting place for two tribal groups, from which tortoises and birds were taken for food (WAWA, 1995).

2.3.2 Recreation Usage

Most of GLR including the lake, and western, northern and eastern margins is reserved for recreation. Utilisation of the GLR is not high and largely consists of off-road vehicle and motorbike activity.

GLR is currently used for limited recreation including horse riding, dog exercising, and walking. People also have been observed using the area for short periods such as during lunch breaks, for relaxation or appreciation of the landscape. Most of these activities occur near the existing access road and facilities along the south-eastern margin of the lake although access is also gained from the north-western portion where vehicular access is available. Pedestrian or horse access can presently be gained at various locations around the perimeter of GLR.

The bushland areas and exposed parts of the lake bed are currently regularly accessed by off road vehicles and motorbikes. Rubbish and garden refuse dumping is evident within the upland areas and abandoned vehicles are often present within the bushland and car parking areas.

2.3.3 Existing Facilities & Infrastructure

Recreation Reserve 27278, of the western side of Gngangara Lake, has largely been parkland cleared. The reserve has not been reticulated and the extent of grass cover is seasonal. During the summer months the sandy soil can become exposed where the groundcover is disturbed by vehicles. No parking is provided, and many visitors park on the reserve.

The wetland basin of Gngangara Lake falls within Reserve 27279, vested in the City of Wanneroo for the purpose of recreation. A boat ramp was previously provided to enable access to the lake however this has subsequently been removed.

The existing facilities in GLR are contained in Reserve 8399, vested in the City of Wanneroo. These facilities include an informal carpark, toilets, picnic tables and remains of play ground equipment. The facilities are generally in need of repair or upgrade to improve function and appearance. A partly sealed road provides vehicle access from Gngangara Road to the carparking area.

A property owned by WAPC in the south-east corner of GLR supports a residential house. The State Forest areas vested in CALM contain no facilities and predominantly support remnant vegetation.

2.3.4 Landscape Amenity

Tracts of bushland in populated areas are valuable in terms of landscape amenity. The lake viewed from its shores is the area of highest scenic quality in GLR although the bushland areas particularly during spring offer some scenic opportunities. The visual amenity of GLR would be of higher quality if the water levels within the lake were higher than the current levels and more similar to the levels previously experienced in the lake.

2.4 Leases & Commercial Operations

There have been several previous leases and mining operations including sand quarries in the upland areas and diatomaceous earth mining within the lake. There is one pending mining lease (M70/351) for diatomaceous earth over most of Gngangara

Lake. The lease area occupies 74.5ha and encompasses the majority of Gnangara Lake excluding the eastern and south-eastern margins. The approximate area affected is shown in [Figure 11](#).

Tenement records of the Department of Mineral and Petroleum Resources (DMPR) indicate the lease application was lodged in 1987 but has not been granted. No further lease applications will be considered by DMPR for this area until the pending lease application is resolved. Issues such as groundwater protection and conservation values of the lake are likely to ensure referral of applications to the DEP for consideration prior to the DMPR granting a mining lease over the area.

CALM has authorised wildflower picking within the State Forest area of GLR and permitted 4WD training in the old quarry located within CALM managed land.

The existing house near the south-west edge of lake is leased to a residential tenant by DPI.

There are currently no commercial recreational activities occurring in GLR.

2.5 Consultation

The consultation that was conducted during the preparation of this report included:

- meetings and consultation with City of Wanneroo, CALM and DPI; and
- workshop with City of Wanneroo's Conservation Advisory Committee, local environmental based groups and relevant agencies. A list of stakeholders invited to the workshop is included in [Appendix 3](#).

Participants at the workshop discussed what the principal management objectives for GLR should be and, identified the issues that needed to be addressed to meet the objectives.

The principal objectives raised during the workshop included:

- Management to protect and enhance the conservation values of GLR.
- Provision of passive recreation opportunities in GLR.
- Integration of GLR with the surrounding land uses, particularly Gnangara Park.
- Recognition of cultural heritage.
- Improvement of water quality & water levels in Gnangara Lake.
- Coordinated management of GLR with community participation.

The draft Management Plan was also publicly advertised for 6 weeks to allow community and agency input and comments.

3. PRINCIPAL MANAGEMENT DIRECTIONS

3.1 GLR Values

Natural Environment Value

GLR contains a variety of ecosystems from upland woodlands, upland heath, fringing wetland and open water.

The upland portions of GLR largely support remnant vegetation that show varying degrees of disturbance. There are several distinct vegetation communities occurring within the area. Along the western margin and in some areas to the north the bushland is highly disturbed. To the east, the vegetation and habitats show fewer signs of disturbance and are better quality.

Gnangara Lake generally has low ecological value due to the water levels being low, the acidic water conditions and the paucity of fauna. Prior to acidification Gnangara Lake would have supported a wide range of fauna. If the pH of the lake were to rise to a more neutral level, it is highly likely that the lake would be able to support similar fauna again.

The principal value of GLR at present is that it is a large area of diverse bushland that incorporates a large seasonal waterbody.

Cultural Heritage Value

Generally, open water has a cultural significance to Aboriginal people. Gnangara Lake has been significant to the Aboriginal people in the past, particularly during periods when water levels were high and prior to the acidification of the lake when it supported a variety of fauna. There are four listed Aboriginal sites in GLR on the Register of Aboriginal sites as at 29 June 2001. Three of the sites are archaeological and are located on the southern shores of Gnangara Lake and one of the sites is mythological/historical and is associated with the entire lake.

Landscape Value

GLR provides significant landscape and amenity opportunities to the region. The vegetation cover of the reserves adjacent to the lake is good, and it provides an area of bushland and a large seasonal wetland in an expanding urban setting.

Recreational Value

The recreational value of GLR, based on current usage and visitation, is not high. There are many opportunities to provide improved recreational facilities in GLR that could dramatically increase its use by the community. Recreational demand and use of the area is likely to increase with the residential development of surrounding areas.

Commercial Value

There has been mining in GLR in the past, however, mining is not considered compatible with the conservation and recreational values of GLR, and should not be permitted in the future.

There may be opportunities for the development of commercial recreational operations in GLR in the future.

Research Value

Gnangara Lake has research value for investigation of lake acidification, the causes and potential remediation measures. There are also opportunities to investigate the re-colonisation of fauna species to the lake if and when the acidity of the lake decreases.

3.2 Vision

3.2.1 Vision

GLR will be an area of high conservation and recreational value to the surrounding community. Gnangara Lake will be a healthy wetland system, supporting diverse fauna, with sustainable community use.

3.2.2 Goals

Conservation

Protect and conserve GLR's natural, cultural and scenic values, and enhance these values through rehabilitation. Promote or sustain linkages with other nearby reserves, bushland and wetlands.

Recreation

Provide opportunities and facilities for recreational uses compatible with the protection of GLR's existing values and ensure sound management to minimise conflict between users and other management objectives.

Information, Interpretation & Education

Facilitate informed appreciation of GLR's natural environment, cultural associations and recreational opportunities amongst the community through the provision of services and facilities. Promote community ownership of the area and enable access to information and liaison regarding management.

Research & Monitoring

Seek a broader understanding of the values of GLR and natural processes. Monitor impacts associated with use of the area, changes in the natural environment and effectiveness of management techniques.

Integration of Management

Develop and maintain coordinated management of GLR between vested agencies and planning authorities and promote integration with nearby reserves and future regional parks.

Management Strategies

P1 Establish conservation as the primary goal of GLR and allow and promote managed recreational, educational and research activities consistent with the conservation objectives.

3.3 Management Policies

The agencies with which various portions of GLR are vested will need to ensure policies applicable to the management of the area are consistent and compatible. Each agency should adopt the principles outlined in this Management Plan for the direction for the future management of the area.

Management Strategies

P2 Adopt the management principles for GLR outlined in this Management Plan.

3.4 Management Zones

The designation of Management Zones in GLR provides a framework for achieving the vision and goals. It enables acceptable uses and facilities to be identified in each zone.

The Management Zones within GLR are as follows:

- Conservation and Protection
- Recreation
- Rehabilitation Demonstration

The Management Zones are shown in [Figure 12](#) and are described briefly in [Table 5](#).

**TABLE 5
MANAGEMENT ZONES**

Management Zone	Acceptable uses and Facilities
Conservation and Protection	Restricted public access primarily by dual use (walking/ cycle) paths, walking trails and bridle trails. Access by unauthorised vehicles would be prohibited. Recreation would be passive and based on enjoying the natural values of GLR. Habitat protection, rehabilitation of degraded areas and weed management to improve condition.
Recreation	Public use may be high in these areas. Facilities for the public would be concentrated in these areas. Development may include park and picnic facilities, play equipment, interpretive facilities and car parking.

Management Zone	Acceptable uses and Facilities
Rehabilitation Demonstration	Controlled public access focussed on allowing public education and interpretation. Facilities would be limited to walk trails, interpretive signage, demonstration areas and those to enable possible “hands-on” activities.

Management Strategies

P3 Implement management of GLR according to the zones and their acceptable uses and facilities identified in this Management Plan.

3.5 Integrated Management of GLR & Adjacent Areas

GLR consists of numerous parcels of land that are vested with or owned by several agencies as well as VCL and freehold land owned by government agencies, as shown in [Figure 2](#). This presents difficulties in terms of providing coordinated management of the area. There is need to define management responsibilities and arrangements between agencies managing GLR.

The preferred option for management of the area is for all of the land within GLR to be created as reserves and placed within the care of a single agency or coordinated management body with the necessary expertise. This is expected to involve a high level of negotiation between the various owners and responsible agencies. Until such time as this occurs therefore, formal management arrangements between the relevant agencies should be established as a means of ensuring a coordinated approach and effective implementation of management strategies.

The potential of a Regional Park being formed that would include the Wanneroo eastern chain of wetlands and Gngangara Lake has been promoted for many years. The formation of a Regional Park in the future that incorporates GLR and transfer of management responsibility for the area to CALM would facilitate consistent and coordinated approach and should be encouraged. Inclusion with a Regional Park would raise the status of GLR and is likely to generate additional public interest in the area.

Management of GLR should be integrated with the management of neighbouring Gngangara Park.

Management Strategies

P4 Seek to amend the vesting orders and create reserves as necessary to ensure the entire GLR is managed as a Conservation and Recreation “A” Class reserve as part of a broader Regional Park with CALM as the managing authority.

P5 Establish a coordinating group to oversee implementation of this Management Plan.

P6 Ensure adequate liaison with relevant agencies to promote integrated management of GLR with adjoining areas such as Gngangara Park and any future Regional Park incorporating nearby wetlands.

4. CONSERVATION

4.1 Principal Conservation Directions

4.1.1 Conservation Goal

To protect, preserve and enhance the vegetation, fauna and natural functions of GLR.

4.1.2 Conservation Strategy

To conserve the natural areas, minimise the conflict between recreational use and conservation values, rehabilitate degraded areas and promote community involvement and use of the area through the implementation of this Management Plan.

4.2 Gngangara Lake

Gngangara Lake is classified as a Conservation Category wetland however, the values of the lake have been significantly degraded through the direct and indirect affect of human activities within and in close proximity of the lake as well as long-term climatic trends. The water levels are presently very low and the water quality is poor due to acidification. Indiscriminate access to the wetland margins and lake bed are also contributing to the degradation of the wetland. Consequently, the lake is unable to support the ecological processes and diversity as it did in the past. It is considered that the fauna species and ecological values of the lake could be returned if appropriate measures were undertaken to improve the water quality.

Historically, the water levels in the lake have been much higher, and the indirect impacts of human activities in the proximity of the lake coupled with lower than average annual rainfall in recent years have significantly affected the water levels in the lake. The lake water levels are believed to be linked with the acidification processes and low ecological and recreational values.

Possible methods for the increasing water levels in Gngangara Lake are outlined below:

- Artificially top up water levels with groundwater. This currently occurs in several lakes in the City of Wanneroo such as Jandabup Lake.
- Continue to liaise with Forests Products Commission, CALM and WRC regarding the removal of pine trees in the area east of the lake.
- Excavate the lake so that there would be a larger basin below the current watertable.
- Liaise with WRC regarding the lowering of groundwater abstraction from public and private bores in close proximity of the lake and provide greater environmental water allocation for Gngangara Lake.

Excavation of the lake is not considered appropriate as it is considered to be a drastic, short-term solution that will permanently alter the natural features of the lake when a less drastic long-term solution may be available. All other options are intrinsically linked with groundwater abstraction in the area and groundwater resource allocation. Measures to increase water levels within the lake will require negotiation with the Water & Rivers Commission regarding the availability of groundwater resources.

The 1992 Gngangara Mound Crown Land EPP establishes a minimum water level for Gngangara Lake of 41.3mAHD, which was based on the ministerial conditions imposed on the abstraction of public drinking water supply at the time. Subsequent to adoption of the EPP, conditions on the abstraction of public drinking water supply have been revised and a preferred minimum water level for the wetland was set at 42mAHD in 1996. The EPP has not been updated to reflect this. Conditions are presently under review again under Section 46 of the *Environmental Protection Act 1986* and the minimum water levels may be further revised.

Water quality within the lake is a major concern. Acidification of the wetland is a primary issue in terms of the ecological value and function of the lake. Remediation is required in order to enhance or restore the ecological values of Gngangara Lake. The pH of the lake needs to be raised to near neutral for the water quality of the lake to improve. If the acidity is decreased, it is likely that the fauna populations the lake supports would increase.

The decline in water levels and associated prolonged periods of drying of acid producing sediments (acid sulfate soils) is likely to be a major causative factor for the acidification. Acidification may have resulted from previous mining of diatomaceous earth from the lakebed and possible exposure of pyritic soils. Raising of the water levels to those typical of the lake decades ago however, even if this was feasible, may not be sufficient in itself to restore water quality in the short to medium term.

The causes of the acidification require further investigation to be clearly identified so that appropriate methods for remediation can be developed. The extent of areas within the wetland that produce acidic conditions and depth of the sediments that are conducive to forming acid need to be assessed prior to methods for remediation being implemented.

It is not certain whether increasing the water levels within Gngangara Lake will improve the water quality and reduce the present acidity in the lake, although there has been some success in alleviating acidification issues within nearby lakes, such as Jandabup Lake, by artificially maintaining water levels (O'Neill *et al.*, 2001). From an aesthetic point of view however, the values of Gngangara Lake would increase if higher water levels were maintained in the lake throughout a greater part of the year.

Management Strategies

- C1 Investigate the causes of acidification within the lake and develop a remediation program.
- C2 Regularly review results of water level, water quality and biological monitoring within the lake, and identify significant changes or issues and implement strategies as necessary.

4.3 Vegetation and Flora

The remnant vegetation on the site is generally in relatively good condition. Some areas in GLR have been severely degraded by mining or other activities such as uncontrolled access.

Site surveys of GLR in September 2001 indicate a Priority Flora species, *Cyathochaeta teretifolia*, occurs along the northern margins of the lake.

The best quality vegetation within GLR and populations of significant flora should be preserved and protected from disturbance factors. Access and provision of facilities should be restricted to that proposed in [Section 5](#) and shown in [Figure 12](#). Controlled access should restrict indiscriminate disturbance and opportunities for dumping of rubbish and garden waste and spread of weeds and diseases.

Management Strategies

C3 Progressively rehabilitate disturbed and degraded areas initially focussing efforts in areas that have greatest potential to impact on better quality vegetation areas and using local native species where practicable.

4.4 Fauna

General numbers and diversity of fauna are low at Gngangara Lake most likely due to the high acidity (low pH) of the lake. It is considered that if the acidity of the lake was reduced that aquatic, amphibious, macro-invertebrate and avian fauna populations would increase.

Management of fauna typically relates to the protection of habitats and vegetation. Management strategies implemented to protect the vegetation within the site from disturbance and degradation will assist in the preservation of faunal habitat. Access and provision of facilities should be restricted to that proposed in [Section 5](#) and shown in [Figure 12](#).

Habitat features such as logs, fallen trees and/or rocks should be kept in the woodland areas of the reserve. Hollows within logs, loose bark and dead trees can provide habitat and refuge for a range of fauna such as reptiles and should be introduced to rehabilitation areas from suitable areas as part of implemented rehabilitation programs.

Management Strategies

C3 Progressively rehabilitate disturbed and degraded areas initially focussing efforts in areas that have greatest potential to impact on better quality vegetation areas and using local native species where practicable.

4.5 Invasive Weeds

Most of the study area is in good to very condition with degraded areas concentrated near areas of high activity. In these areas there is a high concentration of weed invasion.

The introduction and spread of weeds in bushland areas presents a major threat to biodiversity including the loss of native floristic diversity, vegetation structure and native fauna habitat. In addition, the prevalence of weeds in bushland areas can increase the threat of fire. The most effective method of keeping weeds out of GLR will be to maintain the vegetation in good condition so that it is resistant to weed invasion and control and prevent the source of invasion, such as by preventing the dumping of garden refuse, and minimising disturbance by reducing vehicular access.

The most common and potentially serious weeds recorded within GLR comprise:

- *Ehrharta calycina* Perennial Veldt Grass
- *Zantedeschia aethiopica* Arum Lily
- *Watsonia bulbifera* Watsonia
- *Dipogon lignosus*
- *Cortaderia selloana* Pampas Grass
- *Leptospermum laevigatum* Victorian Tea-tree
- *Pinus pinaster* Pine Trees
- *Agave americana* Century Plant
- *Hypochaeris glabra* Flat Weed
- *Lupinus* sp Lupins
- *Pelargonium capitatum* Rose Pelargonium
- *Avena fatua* Wild Oats

The occurrence of these weed species within GLR recorded during the site investigations in spring 2001 is noted on [Figure 13](#). Flat Weed, Lupins, Pelargonium and Bearded Oats are widespread within the area and therefore localised populations have not been mapped.

Appropriate methods of control for each of the species listed above and the relative priority for removal of the weed species are presented in [Appendix 4](#). The basic principles of bush regeneration irrespective of the method employed to remove a particular species of weed are outlined below.

In most instances it is not possible, nor desirable, to remove all weeds during one site visit as the factors contributing to weed invasion will be continually operating. Therefore, for a successful weed control program it will be important to re-weed the site on a regular basis. Any weed control program implemented should focus on the following principles:

- work from areas in good condition towards weed infested areas;
- ensure minimal disturbance to soil and vegetation;

- let the rate of regeneration of native plants determine the rate of weed removal (as appropriate); and
- implement a long term maintenance program to monitor weed control methods and native flora regeneration. This will be especially important along the eastern perimeter fence adjacent to the pine plantation.

The control of invasive weeds should be a major priority in the management of the native bushland in the GLR. Any weed control programs should not be undertaken in isolation but as a component of a vegetation rehabilitation program. This will both increase the success of any rehabilitation programs and prevent soil loss during clearing areas of weed species. Fire can increase the rate of establishment and distribution of weeds and the need for weed control measures in affected areas should be evaluated following a fire event.

Weed control should be addressed in detailed control programs for specific areas and as part of the programs for rehabilitation. Control measures may be necessary within Recreation Zones as well as conservation and rehabilitation areas to reduce the potential of weed species spreading into the adjoining areas. The extent of weed distribution and identification of areas that require weed control should be assessed and updated as control measures are implemented.

Weed control can greatly benefit from the involvement of the local community. Coordinated involvement by the community in weed control programs should be encouraged.

Management Strategies

- C4 Implement a weed control program that prioritises control of weeds based on invasiveness, distribution and impacts, focuses on areas adjacent to those that are largely weed free, and is integrated with rehabilitation works.
- C5 Ensure recreation areas are appropriately designed to minimise potential for grass and other species to invade bushland areas.

4.6 Dieback

Dieback is present in GLR, however it is not yet significantly affecting the health of the vegetation based on the numbers of deaths occurring within infested areas. Management of dieback should aim to minimise the risk of increasing the occurrence of the disease through spreading and impacts on existing infestations.

The survey report suggested that infestation of areas was more likely to be attributable to track creation and mining in the past rather than general vehicle activity in the area. Use of the area by off road vehicles including training within the old quarry site in the area of State Forest and access to harvest wildflowers has the potential to spread dieback within GLR and therefore conflict with the primary conservation goal. The areas used for wildflower harvesting and off road vehicle training are located within State Forest sections of GLR. The majority of the State Forest area is infested with dieback. The removal of wildflowers itself is unlikely to spread dieback because no soil or root material should be collected in the process.

Soil and vegetative material that are from infested areas or areas that may be infested should not be used within areas where infestation has not been recorded. Plants considered suitable for revegetation within areas where dieback is known to, or may, exist and those that area susceptible to infestation and should not be used in rehabilitation program in infested areas are provided in [Appendix 5](#).

The following hygiene practices should be adopted within GLR to minimise the spread of the disease:

- Identification and demarcation of areas within GLR as Dieback free, uninterpretable and infested; with appropriate control of machinery, topsoil and mulch from the areas classified as Dieback infested or uninterpretable.
- Implementation of activities such as constructing trails and pathways, clearing firebreaks and slashing of woody weeds should occur in dry soil conditions typically in the summer months.
- All machinery, vehicles and tools (ie shovels, spades, etc) should be cleaned down to remove potentially infected mud and soil prior to, or on arrival at site, and prior to leaving the site. Any equipment operated in Dieback affected areas should be cleaned down by either washing down or using compressed air before being moved into non-affected areas.
- Weeds that are manually removed should be immediately placed into a container to reduce the potential for vegetative material or soil to be inadvertently transferred to other areas.
- Revegetation works should use direct seeding rather than planting as much as possible to reduce the possibility of introducing infected material with seedlings and saplings. If plants are used these should be sourced from dieback free nurseries. Use mulch that has been sourced from dieback free areas in dieback free and uninterpretable areas.
- Control over the movement of soils into and out of GLR to minimise the possibility of spreading Dieback infection. Any fill to be used on site, or brought onto the site should be obtained from pits certified to be Dieback-free.
- Ensure vehicle, motorcycle, horse and pedestrian access to the bushland areas is restricted and managed to minimise the risk of introducing dieback or spreading the disease from areas that are infested via tyres, hooves and footwear, and by eliminating the dumping of garden refuse and soil.
- Erect signage to advise visitors of the issues and encourage them to stay on formalised paths.
- All dieback free remnants should be protected from infection where practicable, even if they are small and isolated.

- All machinery operators, contractors and volunteers should be aware of the issues and advised of locations that are or may be infested, and provided strict procedures for the works to be carried out.

Additional information and guidance is provided in guidelines produced by the Dieback Working Group (2000) for local authorities entitled “Managing *Phytophthora* Dieback- Guidelines for Local Government”. More detailed guidelines for managing dieback within bushland areas extracted from the Dieback Working Group document are provided in [Appendix 6](#).

Management Strategies

- C6 Follow suitable *Phytophthora* dieback hygiene practices during implementation of works.
- C7 Use species that are resistant to dieback to revegetate areas that have been mapped as infested or uninterpretable.

4.7 Pets & Introduced Fauna

GLR is currently used by nearby residents as an exercise area for horses and dogs. Surrounding residential and special rural development also suggests that cats are likely to occur in the area and within GLR.

A horse riding school is located to the west of GLR. There are also several rural residential lots to the north and west that exercise their horses in GLR. Horse riding presently occurs within GLR. Horse riders from the surrounding area currently use trails within GLR to access the Gngangara pine plantation area. The Gngangara Park Concept Plan includes the provision for an equestrian trail within the adjoining areas (CALM, 1999). Horses should be encouraged to use designated bridle tracks within GLR through fencing and signage.

According to Landsberg *et al.* (2001) horse riding activities cause little degradation to sandy tracks. There is the potential for the introduction or spread of weeds through manure and material attached to hooves. Compacting or adding material such as limestone to the sandy tracks, and avoiding steeply sloping trails and wet areas, can reduce the potential for weed establishment and proliferation.

It is acknowledged that domestic pets such as cats and dogs are often important companions to people however, these pets can have quite significant impacts on native fauna and therefore measures should be considered to limit impacts on native fauna populations within GLR wherever practical.

The City of Wanneroo’s local laws on dogs apply to the reserves vested in them. Areas should be nominated where dogs are and are not permitted in GLR and appropriate signage erected. Dogs are currently exercised within the upland areas and along the margins of the lake. There is no signage to warn dog owners that the lake water is acidic and may not be suitable for dogs to swim in.

Dog exercising is considered to conflict with the primary conservation objective of GLR. Dog exercising should be permitted only within the nominated recreational

areas in the south-eastern corner of the lake and along the western margin of the lake and dogs must be kept on a leash at all times. These areas should be clearly defined and appropriately signposted. Owner management of dog waste should be encouraged by providing the appropriate plastic bags and bins to enable owners to collect and dispose of dog wastes. Rangers should patrol the area to ensure GLR is being used appropriately by dog owners.

Domestic cats can impact on native fauna. Nearby residents should be encouraged to keep cats at home, especially at night and have them de-sexed to help control the feral cat populations. Residents should be discouraged from dumping unwanted litters within local parks and bushland areas. The implementation of cat curfews and banning cat ownership within the nearby areas should also be considered.

Other introduced animals such as foxes and rabbits are likely to occur in GLR. These animals are detrimental to the environment and natural values of GLR and should be controlled and removed where possible. Limiting access and rubbish dumping, implementing weed control programs and rehabilitating degraded areas will assist in minimising populations of introduced species.

Rabbits have the potential to hamper regeneration efforts and create conditions more suitable for weed species to proliferate. The total removal of rabbits from the reserve is probably not feasible, however their potential impact on the vegetation and habitats should be controlled through the use of tree guards and/or brush to protect regenerating vegetation and weed control measures.

Foxes and cats predate on native fauna and can deplete populations sufficiently to result in local extinctions. Fencing to prevent foxes and cats entering the area is probably not feasible, particularly if community access is desired. Baiting for these species can have some impact particularly in controlling fox populations, however the baits are not target-specific and the death of pets can result. Implementation of a baiting program would require approval from the relevant agencies and notification of nearby residents and may not be acceptable for GLR. Baiting could occur in association with any efforts undertaken in the adjoining pine plantations however, CALM does not generally undertake baiting in urbanised areas due to the associated risks, except where vermin proof fencing is in place.

Management should focus on improving habitat and refuge for fauna and enhancing local populations to ensure these are more resilient to the effect of predation from introduced predators. Community involvement and awareness promoting control of pets such as cats and dogs, and preventing dumping of unwanted litters is an important aspect of managing predation by introduced species.

Management Strategies

- C8 Consider developing measures to reduce the impact of feral animals on native fauna.
- C9 Consider imposing controls on domestic cats within surrounding development areas.

4.8 Fire

Fire management should aim to protect people, nearby property and the natural values of GLR in the case of an unplanned fire. Uncontrolled and frequent fires can significantly impact on the ecology of bushland areas and can encourage the spread of weed species, which can further increase the risk of fire. Wild fires within GLR can also threaten lives and properties particularly those located in close proximity to the area along the south-western and northern boundaries. The areas of upland vegetation and the pine plantations present considerable risk of fire and the spread of fire.

Dual Use Paths (DUP) recommended for the periphery of the wetland and within the bushland will provide the dual function of vehicle access in the event of fire (Figure 12). Firebreaks should be maintained along the boundary of GLR particularly at the interface with private properties and homes and the pine plantations (Figure 12). Sydney and Gngangara Roads provide sufficient separation without additional firebreaks along these sections of the boundary. Firebreaks along the boundary of the pine plantations should be restricted to those located within pine plantations and adjoining cleared tracks. The lake itself presents a natural barrier to fire movement. Additional dedicated fire access routes should utilise existing tracks to avoid further disturbance of the vegetation.

Access within GLR for fire fighting purposes will be provided at strategic locations through lockable gates or collapsible bollards (Figure 12).

Material such as limestone should be added to firebreaks to ensure these areas are readily trafficable for fire fighting vehicles and minimise the risk of erosion and weed establishment.

Firebreaks should be installed or maintained to be 3m wide and utilise the existing tracks where possible. Overhanging branches should be pruned to allow an overhead clearance of 4m, except at corners where a clearance of 5m should be provided. Adjoining special rural lots are required to maintain 3m wide firebreaks within property boundaries, thereby a total separation of 6m is provided along interfaces with private properties.

Firebreaks along the pine plantations should be wider than 3m to prevent fire from spreading from the pine plantations. Sufficient width firebreaks should be provided along the boundary of the plantations and not within GLR. Any widening that is required should involve clearing of pine trees rather than additional clearing of bushland within GLR.

In order to reduce the likelihood of intense summer fires, the fuel loading within GLR should be kept at a reasonable level. The recommended methods of reducing fuel loads within GLR are:

- weed control; and
- mowing or slashing.

Weeds have the potential to increase the fire risk and are often proliferate and spread after fire. Weed control by means such as manually removing by hand and use of

herbicides such as glyphosate is important in reducing the risk of fire and the need for other fuel reduction methods.

Large areas of weed infestation within GLR such as along the south-west boundary of the lake should be rehabilitated however, until weeds are controlled and the area is rehabilitated the material may need to be slashed. Care must be taken however, to avoid damage to native species and along edges of weed infestation areas to ensure further encroachment of weeds into bushland areas does not occur.

A detailed Fire Management and Response Plan should be prepared in accordance with Fire Management Planning for Urban Bushland (FESA, 2000). During the ongoing management of GLR, fire prevention measures should be implemented wherever possible. In the event of a fire, the Fire Management and Response Plan aimed at minimising the area affected by fire through rapid response should be implemented. The management plan should take due account of the presence of dieback, limit the movement of soil between uninfested and infested areas and should restrict the creation of additional fire access routes during fire fighting.

Management Strategies

- C10 Develop and implement a Fire Management and Response Plan for GLR.
- C4 Implement a weed control program that prioritises control of weeds based on invasiveness, distribution and impacts, focuses on areas adjacent to those that are largely weed free, and is integrated with rehabilitation works.

4.9 Midge & Mosquito Control

Mosquitoes and midges can significantly reduce the amenity of areas and can, in the case of mosquitoes, pose serious health risks. Poor water quality with high nutrient loads usually contributes to high midge and mosquito populations. The acidic conditions within the lake however, causes numbers of invertebrate species to be low. The potential for large populations of mosquitoes and midges at the lake therefore is considered to be at present relatively low.

Management Strategies

- C2 Regularly review results of water level, water quality and biological monitoring within the lake, and identify significant changes or issues and implement strategies as necessary.

4.10 Ecological Restoration & Rehabilitation

GLR is severely degraded in certain areas due to past land uses, such as mining, or from disturbance from vehicles in high areas of activity, such as the boundaries of GLR. The enhancement and ecological restoration of the wetland and surrounding bushland involves restoring the natural regeneration capacity of the native vegetation. This generally involves reducing, or where possible eliminating, the range of disturbances which can inhibit natural regeneration.

At GLR the greatest inhibiting factor for rehabilitation is physical disturbance caused by uncontrolled access and weed invasion. Generally the areas of intact vegetation, specifically where the overstorey vegetation as well as the understorey vegetation are undamaged, are very resistant to weed invasion. The areas most prone to weed invasion are those which have been physically disturbed through clearing or rubbish dumping.

In order to realise the Conservation Goal, degraded areas should be rehabilitated with local native species to promote the growth of a healthy ecosystem. A detailed Rehabilitation Plan should be prepared for GLR in order to facilitate the ecological restoration. The vegetation condition ratings are shown on [Figure 8](#), and the major areas that should be revegetated and rehabilitated are marked on [Figure 13](#). The presence and possible spread of dieback within GLR through uncontrolled access and rehabilitation works needs to be considered during planning of restoration and rehabilitation programs. Information on suitable rehabilitation techniques is presented in [Appendix 7](#). Species for rehabilitation should be selected from the list of flora recorded within GLR as presented in [Appendix 2](#). Rehabilitation of dieback infested areas should involve those species that are resistant to the disease ([Appendix 5](#)).

Restoration of large degraded areas such as the old quarries east of the lake can be costly and to some extent unfeasible. Extraction of sand has resulted in the landscape at these locations being significantly altered from their natural state. Substantial works would be required to rehabilitate these areas to resemble their pre-disturbance state. These areas however, provide a variety of opportunities to be rehabilitated to enhance the ecological, education and recreational values of GLR. These areas, particularly the quarry located close to Gngangara Road, should be considered for the creation of habitats that may be poorly represented within the area or that could be complemented.

For example, portions of both quarries may be suitable for the creation of small seasonal wetlands that could be provided to maximise frog populations and some waterbirds. These areas have a lower elevation than the natural state due to excavation, and may now experience moister conditions conducive to the creation of wetlands with some additional excavation. Alternatively, the use of a lining material such as clay may ensure surface water is contained for several months of the year.

These areas may also be suitable for the creation of woodland habitats by planting dense stands of appropriate eucalypts. This would provide additional habitat for native fauna and/or provide opportunities for recreational amenity such as walk trails and rest areas.

Nest boxes for birds and possums could be placed within newly created woodland habitats to encourage local populations. Rehabilitated and/or orphaned individuals of appropriate species could be released into the area to increase local populations, subject to approvals from CALM.

The old quarries and particularly the southernmost quarry, are located within easy access of the existing road into GLR and facilities in the main recreation area, thereby providing opportunities for walk trails and educational pursuits in relation to the natural environment, and integration with recreational nodes.

Management Strategies

- C11 Remove all waste such as car bodies, sheet metal and household refuse from GLR on a continuous basis.
- C3 Progressively rehabilitate disturbed and degraded areas initially focussing efforts in areas that have greatest potential to impact on better quality vegetation areas and using local native species where practicable.
- C4 Implement a weed control program that prioritises control of weeds based on invasiveness, distribution and impacts, focuses on areas adjacent to those that are largely weed free, and is integrated with rehabilitation works.

4.11 Cultural Heritage

Gnangara Lake is an important site for the Aboriginal people. All aspects of the management of GLR should give consideration to the significance of the area and the presence of registered sites. The preparation of this Management Plan should result in better management of GLR and the conservation of the lake and surrounding areas for the future. The four registered Aboriginal heritage sites located within GLR (as shown in [Figure 10](#)) are protected under provisions of the Aboriginal Heritage Act 1972 and clearance is required from the Department of Indigenous Affairs prior to any disturbance of these sites.

The local Aboriginal people should be consulted prior to and during implementation of the measures outlined in this Management Plan, and prior to any disturbance of Aboriginal heritage sites. The community located immediately west of GLR in particular should be consulted about the significance of the area and impacts of proposed works such as the possible manipulation of water levels within Gnangara Lake. Interpretive signage should recognise the significance of the area to the Aboriginal people. Opportunities to involve the local Aboriginal community in management activities within GLR should be explored as part of the discussions.

Management Strategies

- C12 Ensure the implementation of management measures is in accordance with the requirements of the *Aboriginal Heritage Act 1972*.
- C13 Incorporate information on the cultural values into interpretative material and facilities where feasible.
- C14 Liaise with Aboriginal groups to discuss proposed works and determine possible involvement in the management of GLR.

4.12 Landscape Amenity

GLR has landscape amenity value from areas outside its boundaries as an area of bushland in a residential/rural residential area.

From within the boundaries of GLR, the main landscape feature is Gnangara Lake. The current landscape amenity of the lake is not high, particularly when the lake is almost dry. If the water levels in Gnangara Lake increased the landscape amenity from the adjoining areas would improve and it is likely that more people would use the area as a picnic/recreation site.

Viewscapes over the lake from the recreational nodes, particularly from the eastern area should be protected. The recreational areas are intended to have the highest level of usage and views from these areas are important to maintain in order to encourage greater visitation.

Management Strategies

C15 Protect important viewscapes from nominated recreational areas.

4.13 Corridors and Linkages

GLR is located immediately west of the Gnangara pine plantations, which are included within Gnangara Park and connect with other nature reserves and bushland areas. GLR is located to the north of the large telecommunications south of Gnangara Road that supports extensive areas of native vegetation and connects with Whiteman Park, which also supports areas of bushland. Wetlands occur to the north of GLR but connection to these is interrupted to some extent by special rural and rural based properties.

Perth's Greenways (Alan Tingay & Associates, 1998), includes GLR in the south-west corner of a large secure tenure area (ie. areas in the CALM conservation Estate, Parks and Recreation reserves under the MRS and Regional Parks). GLR is associated with the Greenway 22 that is aligned along Gnangara Road and Greenway 13 which runs down Alexander Drive. GLR is important as part of a larger secure tenure area of vegetation. Rehabilitation of degraded areas within GLR will improve the value as a corridor or linkage.

Management Strategies

C3 Progressively rehabilitate disturbed and degraded areas initially focussing efforts in areas that have greatest potential to impact on better quality vegetation areas and using local native species where practicable.

5. RECREATION

5.1 Principal Recreation Directions

5.1.1 Recreation Goal

Manage GLR for recreation by providing appropriate recreation opportunities without compromising the conservation values of GLR.

5.1.2 Recreation Strategy

As the urban areas of Perth continue to expand into the City of Wanneroo, open areas and large areas of bushland in the city are increasingly valuable recreational resources. The improvement of GLR for recreation purposes will provide better recreational opportunities for residents in the surrounding regions.

Recreational use of GLR should not compromise the conservation objectives of this Plan.

5.2 Recreation Areas

The major opportunities for recreational activities, which are described in the following sections, are shown in [Figure 12](#). The plan has been developed based on the management zones identified for GLR and identifies two main areas which should be utilised for recreation.

Areas identified as Conservation and Protection will be used predominantly for the enjoyment of the natural environment. Access will be limited to dual use paths, walk trails, bridle trails, and possibly boardwalks in the future.

The main areas identified for recreation and the provision of facilities include the existing area on the south-east margin of the lake and the area located along the western boundary of GLR. These areas would have picnic areas in parkland cleared areas (non-irrigated) and associated parking.

Visitor facilities are to be concentrated in the recreation area on the south-eastern shores of Gnangara Lake. This location offers higher visual amenity than many other areas of GLR due to the fact that surface water is present along the eastern shores of the lake for longer duration than other parts. This recreational node would include toilet facilities, play equipment and possibly other recreational or educational facilities.

As discussed in Section 4.10, the old quarries located east of the lake present a variety of opportunities for rehabilitation and integration of recreational and educational facilities. The quarry located close to Gnangara Road, in particular, is identified as a Rehabilitation Demonstration Zone and could be rehabilitated to include creation of specific habitats, such as seasonal swamps suitable for frog breeding, and vegetation that offer additional opportunities, such as dense eucalypt woodlands that provide a focal point for walk trails and shady picnic locations ([Figure 12](#)). The quarry is

located within easy access of the main recreation area and therefore limited disturbance is required to provide access to facilities created within this area. The proximity of the quarry to the existing residence owned by the WAPC could offer opportunities to integrate an educational centre into the rehabilitation area.

The western margin of GLR has been developed to enable some recreational use, however this area is not well utilised and there are limited facilities and access. This area may be suitable for low key facilities such as picnic tables and limited off-street parking. It may be a suitable area to be developed as a nominated dog exercising area however, animals should be kept on a leash to prevent animals entering the bushland and straying onto roads.

Recreational facilities and activities should be consistent with the compatible uses outlined by the WRC for Priority source protection areas, and be promoted within GLR in close liaison with WRC and/or Water Corporation (refer to [Appendix 1](#)).

Management Strategies

R1 Develop recreational areas with appropriate facilities within the areas of GLR nominated as suitable for recreational use in accordance with this Management Plan.

5.3 Recreation Sites & Facilities

The picnic area, play equipment, toilets and car parking in the existing recreation area on the south-eastern shore of the lake should be removed and replaced with more modern facilities. The general location of proposed facilities is shown in [Figure 12](#). The establishment of a recreation node in this area comprising parkland with tables/seating and play equipment will ensure that passive recreation activities are promoted outside of the conservation areas of GLR. Interpretive material providing educational and directional information should be focussed in this area.

Consideration should be given to the possible relocation of the ablution facilities to the Rehabilitation Demonstration Zone ([Figure 12](#)) to provide greater separation from the lake. The toilets should be connected to deep sewerage or use alternative treatment units (ATU) or a composting system rather than septic tanks.

There is an opportunity for the existing house located on the WAPC owned land immediately south of the lake to be developed as an Interpretation/Environment/Cultural Centre in the future for use by a variety of community groups. The area containing the house has been included in the Recreation Zone. The condition of the house and its suitability for this purpose however, requires closer examination.

The proposed Rehabilitation Demonstration area in the southern quarry near Gnangara Road could be developed as a major location for groups, schools and the broader community in the region for a range of activities. This may include undertaking walks to identify plants and fauna such as frogs, birds and butterflies, and for broader environmental awareness regarding weeds and fires. Rehabilitation of the southern quarry area should be undertaken to promote these types of activities. The activities could be linked with the interpretation centre that may be provided in the

existing house. Picnic areas and walk trails should be identified in this area as part of a detailed rehabilitation and restoration program. Interpretive signage would be appropriate if nature based educational activities are to be promoted.

Irrigation of the recreation areas is not considered appropriate. Picnic areas should be seeded with a suitable grass species that does not require irrigation. The use of Kikuyu should be avoided within GLR. Common couch should be utilised (as opposed to more shade tolerant cultivars) to maximise the effect of the native canopy cover in limiting its spread. Grass should be used only within the main recreational nodes. Gravel or limestone could be used as an alternative in other areas such as within the rehabilitated quarry sites and at strategic points along pathways where necessary to provide open areas while limiting the potential for weed growth.

Grassed areas should be delineated from wetland and bushland areas by a path/DUP to prevent the spread of weeds including rhizomatous grasses. Bins should be provided where picnic facilities are developed, and bins for dog excrement should be provided within relevant recreation areas where dog exercising is permitted.

Due to the low water levels and poor water quality, there is limited opportunity to observe fauna within the lake and therefore bird hides and platforms have not been proposed at this time. Should the water levels and quality improve these types of facilities could be considered.

The boundary between conservation areas and the recreational nodes should be delineated by fencing or bollards.

Management Strategies

- R2 Remove existing facilities on the south-east of the lake and develop new facilities including toilets, picnic areas, parkland, play equipment and car parking.
- R3 Consider development of a Rehabilitation Demonstration area within the disused quarry near Gngangara Road to include recreational opportunities associated with environmental education as part of the rehabilitation strategy.

5.4 Access

Vehicle Access

The use of off road vehicles and motorbikes is incompatible anywhere in GLR. The area however, is currently regularly accessed by off road vehicles. Measures are necessary in order to control access within GLR and reduce the negative impact current access is having on the bushland and lake.

Public vehicle access to GLR is provided to the main recreation from Gngangara Road along the existing access road. Limited vehicle access is also appropriate within the recreation area along the western boundary to enable off street parking.

The installation of recreational facilities will provide suitable opportunities for picnics and passive recreational pursuits. As such, parking areas are required to allow visitors

from outside the local area to visit GLR. Car parks are proposed in the main recreation areas on the south-east boundary of the lake and the western margin of GLR. The installation of periphery fencing or bollards around recreation nodes and the car parks will prevent access beyond those points.

An off road vehicle club currently has permission to use the old quarry site located east of the lake within CALM managed land. Use of areas within GLR is not compatible with the primary conservation objective for the area. The quarry site within CALM land in GLR should be rehabilitated. Rehabilitation of the quarry site should be undertaken shortly after vehicular access to the site has been denied to minimise opportunity for weeds to establish and potentially invade the surrounding bushland areas.

Access within GLR for the wildflower industry should be restricted to only the State Forest area where CALM currently permits the collection of wildflowers.

Access to GLR by off road vehicles needs to be more restrictive than it presently is. Tracks that are not identified to enable access for recreational pursuits within GLR or are not necessary for fire management and maintenance should be closed and rehabilitated. Access points to these paths should be blocked by the use of logs, vegetative material, rocks or sand to deny vehicular access.

Fencing should be installed along Gngangara Road and Sydney Road, along boundaries of GLR that border private properties and pine plantations, and around recreation nodes (Figure 12). CALM has indicated that off road vehicle access into the Gngangara pine plantations is controlled and therefore fencing should not be necessary along boundaries of GLR with the pine plantations. To provide added certainty and further prevent vehicle access into the natural bushland areas of GLR it is recommended that fencing be installed along the eastern boundary of the area. Fencing along the eastern boundary will also act to prevent the incursion of horse riders into GLR from the pine plantations. Design and specifications of the fence should be to the relevant authorities' satisfaction.

Cycle & Pedestrian Access

Tracks within GLR should be rationalised, and their uses identified as one of, or a combination of the following uses;

- walking/cycling;
- equestrian use; or
- firebreak/ fire access.

Those tracks that do not have identified uses should be closed and revegetated. The function of paths should be maximised by careful planning to ensure tracks can serve dual or multiple purposes.

It is recommended a Dual Use Path (DUP) be constructed of crushed limestone and located on elevated land within the woodland around the periphery of the wetland for pedestrian and cyclist use (Figure 12). The path could also be used for fire fighting if necessary, but vehicle access to the DUP should be controlled by installing collapsible

or removable bollards at entry points to deny access to unauthorised vehicles. Installation of the path network may be undertaken on a staged basis depending on a variety of factors such as the availability of resources and priorities for works.

Several walk trails should be provided within GLR to provide further recreational enjoyment of the area. Walk trails are proposed along the very edge of the lake linking with the DUP located along the lake margins, and within the bushland areas east of the lake.

Access to walk trails and the DUP will be provided from the recreation nodes and at strategic locations to enable residents from surrounding areas to gain access. At some locations it will be necessary to provide specific pedestrian access through the fencing. This could be achieved by installing bollards however, “kissing gates” should be used for walk trails in preference to bollards to restrict entry for trailbikes.

Maintenance & Fire Control Vehicles

Vehicle access within the GLR will be restricted except for fire-fighting and maintenance purposes. The Dual Use Path or walk trails will be constructed of crushed limestone and will provide suitable access for fire and maintenance vehicles with demountable bollards at ingress/egress points.

A detailed Fire Management and Response Plan for GLR should be prepared in accordance with Fire Management Planning for Urban Bushland (FESA, 2000) and consultation with FESA. Access and control measures should be in accordance with those prescribed in the [Section 4.8](#) of this report and as shown in [Figure 12](#).

Animals

The City of Wanneroo’s local laws on dogs apply to the reserves vested in them. Dogs will be permitted on a leash within the recreational nodes but will be prohibited from the remaining area of GLR. Appropriate signage should be erected to advise users where dogs are permitted.

Horses should be permitted access to GLR using only dedicated bridle trails. Access within GLR for horses should be primarily to enable access from neighbouring rural - residential areas and the nearby horse riding school to the Gnangara pine plantation, where an equestrian trail is proposed in the future. The provision of facilities and access for horse riding activities should be in accordance with the WRC’s Water Quality Protection Note - Stabling, Agistment and Riding of Horses (2001) and with the permission of the Water and Rivers Commission/Water Corporation within Public Drinking Water Source Areas (PDWSAs).

Bridle trails area proposed adjacent to the DUP that runs around the lake with access points from Gnangara Road, Sydney Road, Vintage Lane and Lorian Road. Bridle trails will also be provided along the firebreak extending roughly between the end of Vintage Lane and Lorian Road, and the access path from Lorian Road to the pine plantations.

The usage of tracks for horse riding is not considered detrimental to the environment provided possible introduction and establishment of weeds can be suitably managed. Fencing along the boundary of GLR should be located internal of the firebreaks/bridle paths to enable access by horse riders but restrict divergence into other parts of GLR. The bridle paths should be compacted and/or consolidated through the addition of material such as limestone on steep slopes or low areas that may become boggy to reduce the potential for erosion and establishment of weeds. Signage should be provided to identify paths and encourage users to stay on the paths and ensure hooves are clean of material before entering GLR. The impacts of horse riding should be continually reviewed on an annual basis and this use within GLR evaluated in relation to the primary conservation goal.

Watercraft Use on Gngangara Lake

The use of watercraft is not considered acceptable on Gngangara Lake. The water levels are typically not suitable for watercraft use of the lake as the lake is virtually dry over the warmer months and opportunities for activities on the lake are limited.

The water quality of the lake may not be conducive to safe recreational use. The current adopted EPA guidelines for recreational use, particularly for primary contact activities, suggest pH of the water should remain within 5.0 and 9.0, assuming the buffering capacity of the water is low at the extremes of the pH units (EPA, 1993). The pH and other water characteristics such as microbiological and nuisance organisms would require routine investigation and monitoring if primary or secondary contact activities are permitted within Gngangara Lake.

Disabled Access

Redevelopment of the recreation area on the south-east of the lake should ensure facilities that allow disabled access are implemented.

Management Strategies

- R4 Install fencing or bollards around recreation nodes and GLR perimeter to limit off road vehicle access.
- R5 Prohibit access for off-road vehicles and restrict the wildflower industry to the areas reserved for State Forest.
- R6 Install dual use paths and walk trails around the periphery of the wetland and within the bushland areas.
- R7 Ensure access for fire fighting and maintenance vehicles.
- R8 Permit dogs within Recreation Zones only on a leash.
- R9 Install bridle trails adjacent to the dual use path around the lake and along firebreaks in the northern section of GLR.
- R10 Annually review the impacts of horse riding and dog exercise activities as part of routine monitoring.
- R11 Rationalise tracks by closing and rehabilitating tracks with no identified use.

5.5 Signage

Signage is an important factor in managing recreation in GLR, and minimising the conflicts between recreation and conservation.

Following the upgrade of the recreation facilities in GLR an entry statement should be constructed opposite Alexander Drive on Gngangara Road. The entry statement should include appropriate signage of the facilities located in GLR to enable traffic to recognise which facilities are available and to increase the visitor use of the area. Signage showing the location of facilities and allowable activities within GLR should also be placed within the recreation node along the western boundary of GLR. Bridle trails and dog exercise areas should be clearly identified through signage.

Signage should be placed along walk trails, asking people to stay to the paths, advising them when they enter specific areas such as a dieback area, identify hazards and outline how they should conduct themselves.

Management Strategies

R12 Erect signage at strategic locations that informs visitors of access and facilities, and provides interpretive material about the values of GLR and possible impacts of inappropriate use of the area.

5.6 Visitor Safety

Gngangara Lake should be appropriately signed, prohibiting swimming due to the acidic nature of the water, until such time as the monitoring of the lake identifies that the pH is within accepted guidelines for recreational use, which is currently 5.0 – 9.0 (DEP, 1993).

As with all bushland areas there are certain dangers or safety risks such as snakes. Visitors to the area will need to be advised to take due caution.

Management Strategies

R13 Promote visitor safety through educative material and signage.

6. LEASES & COMMERCIAL OPERATIONS

6.1 Principal Commercial Directions

Commercial Goal

Allow for appropriate commercial uses within GLR provided these are compatible with the conservation goal.

Commercial Strategy

Recreation and tourism ventures may increase the number of visitors to the GLR. If the ventures do not compromise the conservation value of the GLR, they should be encouraged. Commercial ventures could provide the opportunity to raise revenue to assist in the management and provision of facilities in GLR.

Commercial Guiding Principles

Any commercial operations in the GLR should be consistent with the following Commercial Guiding Principles or should not be permitted in the GLR;

1. A commercial operation should be consistent with the Management Zone.
2. A commercial operation should not compromise the natural and cultural values of the GLR.
3. A commercial operation should not impair other forms of acceptable use, should not jeopardise safety of visitors, and should only be directed to areas that are appropriate.
4. A commercial operation should be managed through either lease or licence arrangement with the managing agency for which it is proposed.
5. A commercial operation should be financially viable, with proceeds contributing to the management of the GLR and appropriately managed.
6. Mining and quarrying operations are not considered to be consistent with the objectives for GLR.

6.2 Commercial Operations & Leases

Mining Operations

No future mining applications for diatomaceous earth in the Gngangara Lake wetland bed should be considered. Mining within the lake is not compatible with the management objectives for GLR.

There have previously been mining leases over the wetland area and mining was undertaken within the lake in the past. A mining lease (M70/351) is pending over

most of Gnangara Lake at present (Figure 11). The lease has not been granted and therefore no mining activities or exploratory works can presently be undertaken within the lake. Issues such as Native Title and location of the lease area within a Priority 1 groundwater protection area will be considered in the process of granting a mining licence. The lake is also covered by the Swan Coastal Plain Lakes EPP and is identified as a conservation category wetland and part of a Bush Forever site, and therefore it is expected any proposed mining or exploration operations will be referred to the DEP/EPA for assessment prior to approval being granted.

The previous Management Plan for Gnangara Lake did not prohibit mining in the lake (City of Wanneroo, 1990). In the last 10 years, since that plan was prepared, research has been undertaken that suggests a possible cause of the acidification of the lake may be that acid - generating soils which occur naturally beneath the lake have been disturbed and exposed. Disturbance of the soils through mining in the past may have been causative of the current problem, and further mining may compound the problem and make remediation even more difficult.

In addition, the lake is protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy (EPA, 1992) that prohibits unauthorised filling, mining or draining of protected wetlands. This policy was released after the previous Management Plan was prepared.

Opportunities for Commercial Visitor Services

There are no existing or presently proposed commercial visitor services in GLR. Given the relatively low numbers of visitors at the present stage, commercial ventures are not likely to be viable. However, when the aesthetic qualities and passive recreation opportunities in the reserve increase, and visitor numbers increase, there may be an opportunity for commercial visitor services in GLR. At that time, expressions of interest will require a comprehensive environmental impact study, feasibility study and business plan to ensure the suitability and viability of the proposal. Commercial ventures will provide services to the public that may draw more visitors to the reserve and raise revenue to assist in the management of the reserve.

Management Strategies

- L1 Mining and quarrying activities within GLR should not be permitted.
- L2 Any permitted commercial activities are to be consistent with or complementary to the conservation objectives.

7. COMMUNITY RELATIONS

7.1 Principal Community Relations Directions

Community Relations Goal

Promote informed appreciation of GLR's natural environment, cultural values and recreation opportunities within the community. Encourage community involvement in the management of GLR.

Community Relations Strategy

Foster increased awareness and appreciation of GLR and its natural and cultural values by providing relevant information for the community and visitors to the area. Promoting community involvement in the management of GLR by liaising with groups and individuals and to provide support wherever feasible and consider any comments and recommendations made.

7.2 Information, Interpretation & Education

An effective and coordinated public communication program is an important aspect for achieving the Community Relations Goal for GLR. A program should be implemented to inform the public of attractions, facilities and recreation opportunities in GLR. Methods could include interpretive and educational signs, displays, publications and guided activities.

There is an opportunity to create, at some time in the future, a visitor education or cultural and environment centre in the existing house owned and currently leased by DPI on the south-eastern side of the lake. There are several options for the focus of the centre. It could be based on the natural values of the existing environment, the science and research values of the site or a constructed area of interest in GLR. The feasibility and viability for converting the existing house at the site to a centre for community use and appreciation of GLR should be investigated. The house could be used as a headquarters for various local environment-based community groups.

If a visitor or environment centre were created there would be an opportunity for staff or volunteers to create an effective and coordinated public communication program to inform the public of attractions, facilities and recreation opportunities in GLR. There could also be an opportunity for school groups to use the area for educational purposes.

Greater awareness and appreciation of GLR should be promoted through education. Interpretive signage should be erected at strategic locations within GLR, and leaflets could be distributed to nearby residents identifying values, recreational opportunities and how to become involved. Articles about GLR and the management being undertaken could appear in local and community newspapers. Walk trails within GLR could be assigned a theme and include interpretive information and key features.

Management Strategies

CR1 Investigate the potential use of the existing house within GLR for interpretive and educative purposes and/or as a base for community groups assisting within environmental management in the area.

CR2 Signage, leaflets, articles and interpretive walk trails should be used to encourage greater appreciation of the values of GLR and its management.

7.3 Interaction with the Community & Other Organisations

The development of community involvement (eg. local residents, schools, interest groups) is desirable to ensure that the local community has a sense of ownership in GLR as this will afford a level of protection against the threat of damage by fire, vandals, etc. In addition, promoting an understanding of the sensitivity of the wetland ecosystem amongst local residents and the community will assist in reducing the inappropriate use of the Reserve (eg. uncontrolled access, rubbish dumping).

The development of a sense of ownership can be achieved by involving the local community in both the implementation of works and in future planning for GLR. Many areas of bushland in urban areas have “friends groups” that are instrumental in the implementation of management measures. The existing Lake Gngangara Community Conservation Group should be encouraged to maintain their involvement in the management of GLR.

It is important to ensure that the efforts of the local community towards the future management of GLR are recognised. This can be achieved by installing signage which identifies existing and future management work undertaken by a local community group and provides a point of contact at the City of Wanneroo if community members are interested in becoming involved. Annual or occasional events could also be organised within GLR to thank community members and volunteers and encourage further involvement and input.

Other organisations such as the Weeds Action Network and Wildflower Society may be able to assist with aspects of the management of GLR particular in relation to technical aspects, baseline mapping, monitoring and development of detailed site specific plans.

Liaison between community volunteers and organisations and a point of contact at the City of Wanneroo and other managing agencies or assigned managing body is essential to ensure a coordinated approach.

Management Strategies

CR3 Support and encourage involvement of the community and community based organisations in seed collection, tree planting, weed removal and monitoring by informing the community of planned activities and canvassing support.

CR4 Develop programs in association with local schools for involvement with activities such as seed collecting, planting and monitoring, and for visits to GLR to increase awareness and appreciation of the area.

CR5 Seek the input of local residents as part of the process of implementation and review of this Management Plan.

CR6 Use signage or organised events to identify community groups, schools, and other parties that are involved in or sponsor activities associated with management of GLR.

8. RESEARCH & MONITORING

8.1 Principal Research & Monitoring Directions

Research & Monitoring Goal

To further develop and maintain an understanding of the natural, cultural and social environments, and the impacts of visitor use and management.

Research & Monitoring Strategy

Implement a coordinated and effective approach to research and monitoring within GLR.

8.2 Research & Monitoring

Research

GLR offers opportunities for research into rehabilitation, bushland management and wetland ecology. In particular there is opportunity for research to be conducted into the causes and management of acidity at Gngangara Lake.

Monitoring

The priorities for monitoring have been defined by the following key performance indicators:

- wetland health;
- water quality;
- vegetation quality; and
- visitor numbers and satisfaction.

Monitoring should include water quality, water levels and aquatic invertebrates within the lake, vegetation condition and weed and dieback mapping, and visitor use and comments.

The WRC presently coordinates monitoring of water levels, water quality and aquatic invertebrates within Gngangara Lake as part of a broader program associated with the Gngangara Mound groundwater resource. Continuation of this program should be encouraged and results reviewed to assess any significant changes in the status of the lake. The monitoring should be incorporated as part of the monitoring program developed for GLR.

The local community should be encouraged to participate in monitoring within GLR. All levels of educational institutions can perform monitoring as well as community based groups such as the Wildflower Society, Birds Australia and local “friends of” groups. Tertiary institutions could have an instrumental role in investigating management issues such as acidification and bushland regeneration. It is important however, that a coordinated and consistent approach to the monitoring is adopted.

Implementation of management strategies identified in this Management Plan will be an on-going process that should be flexible in responding to changes in the natural environment, the recreational use of the environmental and community values. As such, a program of monitoring the success of the strategies proposed in this Management Plan will be essential for the purposes of reviewing and updating the plan in 5 years. This will ensure that the aims and objective of the Plan have been achieved and that any new developments in management techniques can be utilised.

Management Strategies

RM1 Promote research activities within GLR particularly to investigate water quality issues within Gngangara Lake through liaison with relevant agencies and educational institutions.

RM2 Support the continuation of current monitoring programs undertaken by the WRC.

RM3 Routinely monitor changes in bushland condition and weed distribution, fire events, visitor usage and impacts of activities.

9. IMPLEMENTATION

9.1 Priorities & Resources

Implementation Plans & Programs

The majority of the recommendations from the draft Management Plan for Gngangara Lake by the City of Wanneroo (1990) have not been implemented. Many of the recommendations of the draft Management Plan (City of Wanneroo, 1990) have been incorporated, updated or expanded in this Management Plan.

Implementation of some of the recommendations require detailed plans or programs to be developed prior to work being undertaken. An overall implementation plan that schedules the various works to be undertaken should be prepared following adoption of this plan in order for detailed works to be undertaken and funding resources to be allocated. The implementation plan should be based on the priorities that have assigned to the management strategies in this management plan provided in Section 10.

Funding

The City of Wanneroo, CALM, DPI/WAPC will finance and manage their respective land areas unless arrangements are made for a coordinated management approach between the various responsible agencies or owners, and contributions of funds are used as agreed between these parties. The main works proposed in this Management Plan to meet the conservation and recreation objectives of the plan occur in areas that are currently managed by the City of Wanneroo.

Indicative costs for some of the major works proposed within GLR are provided in [Table 6](#). Costings are provided for different materials for some of the works to offer cost alternatives.

TABLE 6
INDICATIVE COSTS OF IMPLEMENTATION OF WORKS

Management Proposal	Estimated Requirements	Cost per unit *	Estimated Total Cost
Car Parking	750m ² (25 bays)	Concrete / Asphalt: \$25/m ²	\$18,750
		Limestone: \$7/m ²	\$5,250
Road Access	~200m	Concrete / Asphalt: \$150/m	\$30,000
		Limestone: \$50/m	\$10,000
DUP	5800m	Limestone: \$10/m	\$58,000
Walk Paths	2400m	Limestone: \$10/m	\$24,000
Fencing	9400m	Ringlock (1.2m): \$10/m	\$94,000
Bollards	650m	1.5m, 600mm in: \$15/m	\$9,750
Vehicle Access Point	13 access points	Collapsible Bollard: \$900ea	\$11,700
		Removable Bollard: \$150ea	\$1,950
		Steel Mesh Gate: \$500ea	\$6,500
Bridle Trails/Fire Breaks (ripping of soil, minor clearing)	5900m	\$0.15/m	\$885

Management Proposal	Estimated Requirements	Cost per unit *	Estimated Total Cost
BBQ (standard two plate electric in brick surround)	2 units	\$7,000 per unit	\$14,000
Tables/Seating (on concrete slab)	6 units	\$1,000 per unit	\$6,000
Play Equipment (pit and equipment)	1 unit	\$25,000-\$35,000 per unit	\$25,000-\$35,000
Signage (Sign and posts)	2 large (80x60cm)	\$400ea	\$800
	10 small (40x30cm)	\$150ea	\$1,500
Rehabilitation (development of detailed Rehabilitation Plan and implementation of revegetation / weed control)	~400,000m ²	\$2.50/m ²	\$1,000,000

Note: * Estimates identified above do not include costs of on-going maintenance and monitoring

Assistance with funding or in implementing the measures outlined in this Management Plan may be available from sources such as various State and Federal grants and through the involvement of groups that specialise in coordinating conservation volunteers and participation of community volunteers.

Staffing

A priority for the management of GLR is funding for human resources. The City of Wanneroo will use council staff and contractors for the implementation of this plan. CALM and DPI/WAPC will service their management obligations with staff or contractors from the relevant organisation. Negotiations should however, be undertaken between relevant landowners and responsible agencies in regard to staffing and access to appropriate expertise.

Management Strategies

- I1 Develop a detailed 5 year program for the implementation of the measures outlined in this Management Plan.
- I2 Liaise with the various responsible agencies or owners of land in GLR to ensure a coordinated management approach for implementation, funding and staffing is developed.

9.2 Community Involvement

There are numerous ways in which the community could be involved within the implementation of this plan such as rehabilitation, weed control and monitoring. It is important however, that these works are carried out in a coordinated and planned manner and in accordance with proposed implementation schedules. Community involvement within GLR should be coordinated by a relevant nominated agency such as the City of Wanneroo to ensure effective communication and coordination of the works being undertaken.

Management Strategies

- I3 Coordinate activities of community groups and volunteers within GLR.

9.3 Term of the Plan

The term of this plan will be for a period of 5 years after which time it should be reviewed and updated. A review of the progress of implementation and preparation of a detailed works program should be undertaken after the initial two years. Progress should be assessed by reviewing implementation of each of the management strategies outlined in this management plan and, where appropriate, the amount of money and resources spent in implementing each strategy identified. The need for further review prior to the end of the term should be determined at that stage. The review should consider the successive monitoring results of features such as bushland condition, weed distribution, dieback and visitor use proposed in Section 8.2. It should be acknowledged that environmental restoration of GLR is a long-term project that will involve the landholders/responsible agencies and the community working together over many years, and extending beyond the life span of this Management Plan.

Amendments to the plan can be made during this term as is necessary or desired to ensure the management strategies reflect those considered most appropriate to achieve the objectives and goals for the area.

The City of Wanneroo will have overall responsibility, subject to the outcome of negotiations and identification of an appropriate management structure, for coordinating implementation of the recommendations made in this Management Plan and undertaking detailed review of the plan within 5 years.

Management Strategies

- I4 Review management strategies and implementation progress on an annual basis in conjunction with preparation of a detailed works program. The review should identify what has been achieved and consider the implications of any new information.
- I5 Revise the plan within 5 years from the date the final plan is produced.

10. SUMMARY OF MANAGEMENT STRATEGIES

All of the management strategies included in this Management Plan are listed in [Table 7](#). Each of the management strategies has been assigned a rating for implementation that identifies those strategies that should be focussed on initially and those that can be implemented at a later time.

The rating system applicable as part of this Management Plan is as follows:

- High [H] primary importance/implement immediately (within 2 years)
- Medium [M] secondary importance/implement within 2 – 5 years
- Low [L] longer term consideration/implement within 5 - 10 years

The agency that should have primary responsibility for implementing or overseeing implementation of the management strategy is nominated in [Table 7](#). In several instances all of the landowners or vesting authorities of land within GLR are considered responsible for implementation of the strategies, while for others the primary role for implementation is assigned to a single agency.

The nominated responsible agency may change subject to the negotiations and outcome of strategies to establish a Regional Park (P4) and establishment of the coordinating group (P5).

**TABLE 7
MANAGEMENT STRATEGIES**

Management Strategy		Rating	Responsible Agency
PRINCIPAL MANAGEMENT DIRECTIONS			
P1	Establish conservation as the primary goal of GLR and allow and promote managed recreation, educational and research activities consistent with the conservation objectives.	H	ALL
P2	Adopt the management principles for GLR outlined in this Management Plan.	H	ALL
P3	Implement management of GLR according to the zones and their acceptable uses and facilities identified in this Management Plan.	H	ALL
P4	Seek to amend the vesting orders and create reserves as necessary to ensure the entire GLR is managed as a Conservation and Recreation "A" Class reserve as part of a broader Regional Park with CALM as the managing authority.	H	ALL
P5	Establish a coordinating group to oversee implementation of this Management Plan.	H	ALL
P6	Ensure adequate liaison with relevant agencies to promote integrated management of GLR with adjoining areas such as Gngangara Park and any future Regional Park incorporating nearby wetlands.	M	ALL

Management Strategy		Rating	Responsible Agency
CONSERVATION			
C1	Investigate the causes of acidification within the lake and develop a remediation program.	L	CALM
C2	Regularly review results of water level, water quality and biological monitoring within the lake, and identify significant changes or issues and implement strategies as necessary.	H	CALM
C3	Progressively rehabilitate disturbed and degraded areas initially focussing efforts in areas that have greatest potential to impact on better quality vegetation areas and using local native species where practicable.	H-M	ALL
C4	Implement a weed control program that prioritises control of weeds based on invasiveness, distribution and impacts, focuses on areas adjacent to those that are largely weed free, and is integrated with rehabilitation works.	H	ALL
C5	Ensure recreation areas are appropriately designed to minimise potential for grass and other species to invade bushland areas.	H	CoW
C6	Follow suitable <i>Phytophthora</i> dieback hygiene practices during implementation of works.	H	ALL
C7	Use species that are resistant to dieback to revegetate areas that have been mapped as infested or uninterpretable.	H	ALL
C8	Consider developing measures to reduce the impact of feral animals on native fauna.	L	ALL
C9	Consider imposing controls on domestic cats within surrounding development areas.	M-L	CoW
C10	Develop and implement a Fire Management and Response Plan for GLR.	H	ALL
C11	Remove all waste such as car bodies, sheet metal and household refuse from GLR on a continuous basis.	H	ALL
C12	Ensure the implementation of management measures is in accordance with the requirements of the <i>Aboriginal Heritage Act 1972</i> .	H	ALL
C13	Incorporate information on the cultural values into interpretative material and facilities where feasible.	M	ALL
C14	Liaise with Aboriginal groups to discuss proposed works and determine possible involvement in the management of GLR.	H	ALL
C15	Protect important views from nominated recreational areas.	H	CoW
RECREATION			
R1	Develop recreational areas with appropriate facilities within the areas of GLR nominated as suitable for recreational use in accordance with this Management Plan.	H	CoW
R2	Remove existing facilities on the south-east of the lake and develop new facilities including toilets, picnic areas, parkland, play equipment and car parking.	H	CoW
R3	Consider development of a Rehabilitation Demonstration area within the disused quarry near Gngangara Road to include recreational opportunities associated with environmental education as part of the rehabilitation strategy.	M	ALL
R4	Install fencing or bollards around recreation nodes and GLR perimeter to limit off road vehicle access.	H	CoW
R5	Prohibit access for off-road-vehicles and restrict the wildflower industry to the areas reserved for State Forest.	H-M	CALM

Management Strategy		Rating	Responsible Agency
R6	Install dual use paths and walk trails around the periphery of the wetland and within the bushland areas.	H-M	ALL
R7	Ensure access for fire fighting and maintenance vehicles.	H	ALL
R8	Permit dogs within Recreation Zones only on a leash.	H	CoW
R9	Install bridle trails adjacent to the dual use path around the lake and along firebreaks in the northern section of GLR.	H	ALL
R10	Annually review the impacts of horse riding and dog exercise activities as part of routine monitoring.	M	ALL
R11	Rationalise tracks by closing and rehabilitating tracks with no identified use.	H	ALL
R12	Erect signage at strategic locations that informs visitors of access and facilities, and provides interpretive material about the values of GLR and possible impacts of inappropriate use of the area.	M	ALL
R13	Promote visitor safety through educative material and signage.	H-M	ALL
LEASES & COMMERCIAL OPERATIONS			
L1	Mining and quarrying activities within GLR should not be permitted.	H	ALL
L2	Any permitted commercial activities are to be consistent with or complementary to the conservation objectives	H	ALL
COMMUNITY RELATIONS			
CR1	Investigate the potential use of the existing house within GLR for interpretive and educative purposes and/or as a base for community groups assisting within environmental management in the area.	M	ALL
CR2	Signage, leaflets, articles and interpretive walk trails should be used to encourage greater appreciation of the values of GLR and its management.	M	ALL
CR3	Support and encourage involvement of the community and community based organisations in seed collection, tree planting, weed removal and monitoring by informing the community of planned activities and canvassing support.	H	ALL
CR4	Develop programs in association with local schools for involvement with activities such as seed collecting, planting and monitoring, and for visits to GLR to increase awareness and appreciation of the area.	M	ALL
CR5	Seek the input of local residents as part of the process of implementation and review of this Management Plan.	H	ALL
CR6	Use signage or organised events to identify community groups, schools, and other parties that are involved in or sponsor activities associated with management of GLR.	M	ALL
RESEARCH & MONITORING			
RM1	Promote research activities within GLR particularly to investigate water quality issues within Gngangara Lake through liaison with relevant agencies and educational institutions.	M	ALL
RM2	Support the continuation of current monitoring programs undertaken by the WRC.	H	ALL
RM3	Routinely monitor changes in bushland condition and weed distribution, fire events, visitor usage and impacts of activities.	H	ALL
IMPLEMENTATION			
I1	Develop a detailed 5 year program for the implementation of the measures outlined in this Management Plan.	H	ALL
I2	Liaise with the various responsible agencies or owners of land in GLR to ensure a coordinated management approach for implementation, funding and staffing is developed.	H	ALL
I3	Coordinate activities of community groups and volunteers within GLR.	H-M	CoW
I4	Review management strategies and implementation progress on	H	ALL

	Management Strategy	Rating	Responsible Agency
	an annual basis in conjunction with preparation of a detailed works program. The review should identify what has been achieved and consider the implications of any new information.		
I5	Revise the plan within 5 years from the date the final plan is produced	M	ALL

Note:

CoW: City of Wanneroo
CALM: Department of Conservation & Land Management
DPI: Department of Planning & Infrastructure
ALL: CoW, CALM and DPI
WRC: Water & Rivers Commission

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