

Serpentine Sports Reserve Management Plan



Final January 2012

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TRIM REFERENCE

1. Executive Summary

1.1. Introduction

The Serpentine Sports Reserve covers a total area of 68 hectares. It is located about 60 km south of Perth on the eastern edge of the Swan Coastal Plain, near the Serpentine River, the Perth to Bunbury rail line and the townsite of Serpentine. The reserve includes recreational facilities, consisting of a golf club, pony club and polocrosse club, and regionally significant areas of remnant vegetation.

The Serpentine Sports Reserve consists of two land parcels, one on each side of Karnup Road. Unless otherwise specified, the terms *Serpentine Sports Reserve*, *SSR* or just *reserve*, all refer to the combined areas of both the northern and southern land parcels.

1.2. Vision

Vision for the Serpentine Sports Reserve

To provide a family orientated recreation and conservation area that provides casual, golf and equine organized quality sport and recreation facilities amid well managed regionally significant bushland.

1.3. Location and Description

The Serpentine Sports Reserve consists of two land parcels, one on each side of Karnup Road. On the southern side, Lot 778 Karnup Road is over 46 hectares and was ceded to the Shire as a “Crown Grant in Trust” in 1925. This transferred ownership to the Shire, but the land is still considered part of the Crown Reserves System administered by the State Government. It includes club houses for the golf club and equestrian sports clubs, the first nine holes of a golf course, the David Buttfield Equestrian Park, the John Lyster Polocrosse Ground and a small area leased for a communications tower. It also includes regionally significant areas of remnant vegetation in the Paul Robinson Reserve and nearby banksia woodland.

Lot 870 covers 21 hectares and lies to the north of Karnup Road. It is Crown Land and was vested in the Serpentine Jarrahdale Shire in 1965 for the purpose of recreation and show grounds. This reserve (R27453) contains holes 10 to 18 of the golf course.

Figure 1 shows the location of Serpentine Sports Reserve and Figure 2 shows the land uses current on the two land parcels.

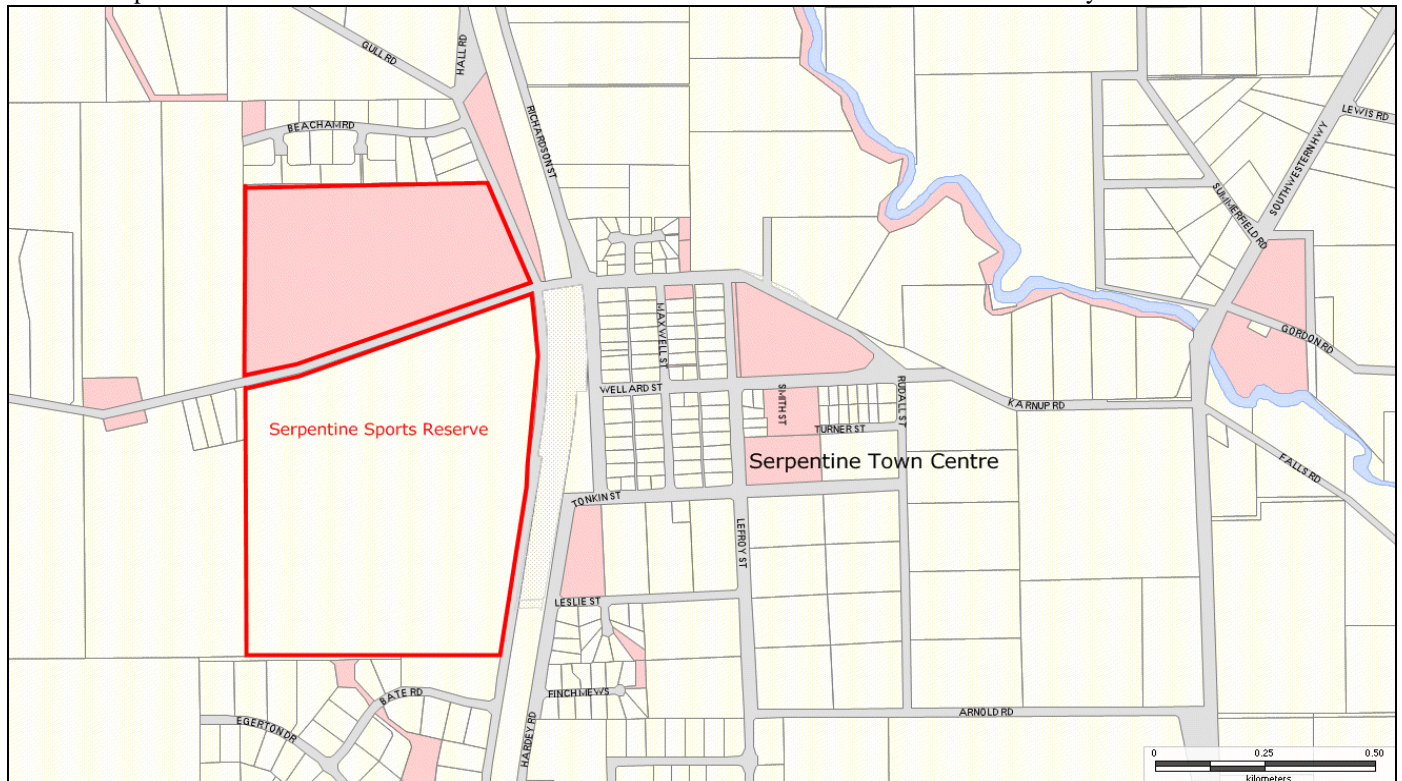


Figure 1 – Site Location of Serpentine Sports Reserve

Prior to European settlement, mixed woodlands and swamps provided abundant resources for Indigenous people. In the early 1920s, land was made available for settlers, leading to clearing of bush and draining of swamps, significantly altering the landscape. The small patches of remnant vegetation found within the reserve now provide important examples of vegetation complexes which once covered much of the eastern side of the Swan Coastal Plain.

The settlement of Serpentine was originally located one kilometre to the east but moved to its current location adjacent to the reserve when the railway line was built in 1893. The town serviced the rural community and a timber mill operated on the southern portion of the reserve. Recreational activities commenced on the reserve at this time and have continued to the present day.

In recent years, the community of Serpentine has an increasing number of members who commute to Perth. Many of the broad-acre farms have been subdivided, and today the land to the north, south and west of the reserve is small-holdings, hobby farms and lifestyle blocks, many of which house horses.

As more people move into the area, the conservation and recreation values of the reserve are being placed under increasing pressure. This plan seeks to sustainably manage the increasing pressures in view of the environmental, social and economic values of the reserve.

The Serpentine Sports Reserve Management Committee (SSRMC) is a community group with membership from local recreational and bushcare groups. This committee has provided a focus for community consultation in relation to the development of this plan. In addition, input from the broader community, including Government agencies, has been sought.

The *Shire Reserves Planning and Management Framework* stipulates the need for Council endorsement of management plans. In addition, as the SSR is a regional reserve within the Metropolitan Region Scheme, this management plan must also be endorsed by the State Government.

This management plan is expected to remain current for ten years commencing from the time the final draft is endorsed by Council, and will remain operational until such time as it is reviewed. Any review process will involve broad community consultation.

1.4. Report Structure

This management plan has been prepared in accordance with the *Shire Reserves Planning and Management Framework*. The report is structured into the following sections:

- Governance:
 - *Identifies the existing legislation and policies that apply and therefore have management implications for the reserve. The management plan has been prepared within this framework.*
- Environmental characteristics:
 - *Analyses landform, land, water and biodiversity features on the reserve. Threats to these features have also been considered.*
- Social and economic characteristics:
 - *Identifies the main human uses of the reserve, with consideration given to issues such as tenure, access, recreation and heritage.*
- Implementation:
 - *Provides guidance to Council and the community on implementation mechanisms for each management recommendation. Priorities, responsibilities and potential costs and partners are identified.*

1.5. Key Strategies

Table 1 – Key Strategies for the Management of Serpentine Sports Reserve

No.	Strategy
8.	a) Install meters and monitor water extraction from bores. b) Prepare an inventory of all water consumption on the reserve.
9.	a) Prepare a plan to reduce consumption and reuse water by for example: <ul style="list-style-type: none"> • Storing and reusing rain water; • Reducing evaporation from dams and irrigation; • Reviewing the extent and standard of turf; • Using and reusing surface water; b) Applying best management practices for water use on turf surfaces as follows: <ul style="list-style-type: none"> • Installing automatic sprinkler systems; • Adjusting the quantity of water applied in accordance with evaporation and turf conditions; • Adjusting the timing of water application to minimise evaporation and wastage; • Monitoring soil infiltration rates and applying wetting agents and other amendments as required.
10.	a) Design and implement a monitoring program for water quality: <ul style="list-style-type: none"> • Entering and leaving the reserve; • Adjacent to and downstream of potential nutrient hotspots; • Entering and leaving the existing constructed wetland. b) Maintain joint records of fertilizer and animal waste applications (as equivalent horse hours per hectare and management techniques) and maintain levels below target amounts (150kg/ha/year N and 15kg/ha/year P). c) Distribute educational material about minimal impact equine management and the impacts of nutrient pollution. d) Minimise nutrient export by implementing best management practices including: <ul style="list-style-type: none"> • Adjust fertilizer application for turf condition. • Establish vegetated buffers between all nutrient sources and surface water features. • Pick up manure and export it within 12 hours.

No.	Strategy
	<ul style="list-style-type: none"> • If horse pens are exporting significant quantities of nutrients, provide and frequently renew temporary absorbent surfaces in horse pens and/or construct covered pens with sealed floors. • Develop and implement procedures to ensure that manure is not stored on the reserve, even for short periods, unless in appropriate covered containers with impermeable bases. • Develop and implement procedures to ensure that fertilizers and other chemicals are transported, stored and used in such a manner that the risk of spillage and pollution is minimal. <p>e) Maximise nutrient stripping from flowing surface waters by reviewing, and where possible implementing, best management practices (e.g. planting native rushes, sedges and other vegetation along drains, treatment trains and artificial wetlands).</p> <p>f) If the existing constructed wetland is not effectively stripping nutrients:</p> <ul style="list-style-type: none"> • Adjust its design and management (e.g. in relation to its size, shape, planting, flow rates and vegetation and sediment removal programs); and. • Investigate constructing additional wetlands.
15.	<p>a) Map dieback distribution within the bushland areas, zone dieback free areas as high conservation, and manage any tracks through dieback free areas (where they cannot be closed) without unreasonably impacting on existing uses.</p> <p>b) Treat vegetation for dieback by spraying and injecting vulnerable plants at 3 to 5 year intervals.</p> <p>c) Raise community awareness (such as by provision of signs, club newsletters, event briefings etc.).</p> <p>d) Raise the awareness of staff, volunteers and contractors of appropriate dieback hygiene procedures and ensure they are adhered to.</p> <p>e) Minimise risks of disease spread by:</p> <ul style="list-style-type: none"> • Where practical, reconciling the alignment of tracks with dieback fronts; and • Otherwise, ensuring tracks are constructed with appropriate materials and suitable buffer zones maintained on either side by spraying with a dieback treatment and trimming vegetation at recommended intervals. <p>f) Liaise directly with Shire Officers for identification, protection and management of important flora.</p> <p>g) Construct barriers where necessary to prevent pedestrian and stock traffic from crossing dieback fronts or important areas of flora.</p> <p>h) Minimise risks of disease spread by adopting dieback hygiene processes including:</p> <ul style="list-style-type: none"> • Construction and maintenance work to be undertaken in dry conditions only; • Wash-down of vehicles and footwear prior to commencing construction or maintenance work in the bushland area; • No material (e.g. soil and pathway surfaces) to be introduced into the bushland area unless guaranteed dieback free.
17.	<p>a) Map weed distribution within the bushland, and compare with previous maps.</p> <p>b) Prepare a weed control program by identifying and prioritising weed affected areas, including sources of weed seed outside the bushland area.</p> <p>c) Remove weeds with physical and chemical treatments in accordance with the weed control program. Mulch, brush, seed, or plant treated areas with local native plants.</p> <p>d) Minimise disturbance and weed introduction and actively remove weeds from the bushland area through:</p> <ul style="list-style-type: none"> • Maintaining the number and width of tracks but disallowing the development of new tracks without prior approval; • Diverting nutrient rich surface drainage away from bushland areas; • Picking up all traces of manure by stock owners in the bushland area within 12 hours of deposition; • Picking up all traces of bedding and stock feed from the bushland area within 12 hours of use; • Raising the awareness of all users of the importance of minimising weed spread (by event briefings etc.); • Removing all <i>Eucalyptus camaldulensis</i> saplings and regrowth plants.
28.	a) Negotiation, agreement and preparation of current lease and licence use of the reserve.
29.	<p>a) Review applications from the equine clubs for normal event camping.</p> <p>b) Impose additional approvals for camping outside the conditions set for normal event camping.</p> <p>c) Review current camping practices in relation to health and other statutory requirements, and where necessary rearrange or move traditional camp sites to locations which better comply with health and other regulations.</p>
30.	a) Continue to maintain the turf area and analyse and document the needs, benefits, carrying capacity and cost sharing associated with budgeting to maintain the turf area at an acceptable standard

No.	Strategy
	<p>including estimating the costing for raising the height of the polocrosse ground.</p> <p>b) Submit this document to Shire staff for assessment and to Council to seek endorsement and allocation of funds to bring the turf area up an acceptable standard for equine purposes and for ongoing annual maintenance.</p> <p>c) Review potential solutions to flooding on the golf course.</p> <p>d) Seek expert advice regarding feasibility and impacts of solutions, and submit preferred proposals and any requests for Shire funds to Shire staff for assessment and Council for endorsement.</p>
31.	<p>a) Minimise environmental impact in bushland by raising the awareness of club members and developing a code of practice with a detailed process for its implementation.</p> <p>b) Formalise and designate tracks and jumps to limit expansion, and adjust the cross-country course if current use causes further degradation of the bushland.</p> <p>c) Constraints and approval requirements:</p> <ul style="list-style-type: none"> • No tree/vegetation in bush areas to be removed without a DEC Clearing Permit; • Any proposal for the trimming of trees/vegetation to go through the RWG's Reserve Improvement Application Form Process; • Camping to be restricted to turf areas on the edge of the bush area and not occur in any bush areas; • Ongoing vegetation monitoring in the bush area will result in recommendations for the demarcation and protection of vegetation from use of tracks by horses; • Access for horses in the bush area to be restricted to demarcated tracks; • The Pony Club to always possess a map showing the designated horse tracks in the bush areas; • Any horse manure to be removed by stock owners within 12 hours in any part of the reserve.

2. Governance

2.1. Land Tenure

The SSR consists of two land parcels which are zoned for Parks and Recreation in both the *Metropolitan Regional Scheme* and the *Serpentine Jarrahdale Town Planning Scheme No. 2*. The northern parcel (Lot 870) is crown land vested in the Shire of Serpentine Jarrahdale in 1965 for the purpose of recreation and showground. The southern parcel (Lot 778) was given to the Shire as a “Crown Grant in Trust” in 1925. While this transferred ownership of the land to the Shire, it is still considered part of the Crown Reserves System administered by the State Government and use must comply with conditions placed on the grant. Table 2 shows the locations and uses of the land parcels.

Table 2 – Serpentine Sports Reserve Locations and Uses

Location Number	Reserve Number	Area (ha)	Land transfer date	Purpose	Current Use
Cockburn Sound 870	27453	21.8	19/03/1965	Recreation and Showground	Golf course
Cockburn Sound 778	19134	46.4	04/12/1925	Recreation, Racecourse and Showground	Golf course, pony club, polocrosse club and nature conservation

Under both forms of tenure the Shire is able to lease the land or licence its use, provided the use is consistent with the reserve purpose. The Shire has responsibility for management of the equestrian ovals and the bushland on the southern section of the reserve, while the remainder of the southern and all of the northern sections are leased to the Serpentine and Districts Golf Club (SDGC), which has responsibility for the management and improvement of the recreation values of the land.

The Shire has overall responsibility for the management, use and protection of the values of all these lands. This includes ensuring that the management and use of the land complies with relevant State and Commonwealth legislation, regulations and policies, as well as local government legislation and strategic policy frameworks.

The SSR is located within the catchment of the Peel Harvey Estuary, the area presided over by the Peel Harvey Catchment Council and its parent body, the South West Catchment Council. These catchment councils administer much of the Commonwealth funding for natural resource management. Water Corporation is responsible for two rural drains through the Serpentine Sports Reserve and therefore has a vested interest in the development, use and management of the reserve in relation to both surface and ground water drainage. Any works undertaken in a Water Corporation drain requires approval before any work can be commenced.

This management plan requires the endorsement of Council, and thereafter any significant departures from the endorsed plan, or additional development proposals, also require Council endorsement. The *Shire Reserves Planning and Management Framework* details the required format for reserve management plans, and the processes for developing and reviewing them. This policy sets out requirements for community consultation, including the establishment and support of two community forums: the Reserves Advisory Group (RAG), and the Reserves Working Group (RWG).

Many of the works on Shire reserves are undertaken by community members, and must comply with legislation, Shire policies and approved plans, and be coordinated under the guidance of the Natural Reserves Coordinator. The Shire *Policy for Reserve Improvement/Development by the Community* outlines the process for undertaking works, including an application form to note recommendations and proposals for developments and improvements.

The reserve has been divided into four different management zones: High Conservation, Conservation, Vegetation Management and Recreation. Figure 3 shows the location and extent of each of the management zones. Each zone has a range of activities that can or cannot occur there.

High Conservation Zone: Areas of remnant vegetation of high biodiversity and scientific reference value which are dieback free and largely weed free. This zone has no planned burn, no dieback treatment and minimal revegetation requirements. Should revegetation or any type of access for scientific or other purposes be proposed within this zone, extreme care is to be taken to not introduce any soil particles which may bring dieback into the zone.

Conservation Zone: Areas of remnant vegetation of high biodiversity and scientific reference value which are not dieback free. This zone has no planned burn, but includes dieback treatment, seeding, weeding and planting operations. Access within this area must consider movement and reduce spread of dieback from infected to uninfected areas through clean-down procedures.

Vegetation Management Zone: Areas of remnant vegetation of biodiversity and scientific reference value which are not dieback free. This is a buffer zone and has burning prescribed for protection of people, property and conservation values, but also includes dieback treatment, seeding, weeding and planting operations. Access within this area must consider movement and reduce spread of dieback from infected to uninfected areas through clean-down procedures.

Serpentine Sports Reserve Recreation Zone (remaining uncoloured): Areas with little remnant vegetation which are largely for use for active and passive recreational activities where management relates to reticulation, horse trails, golf course or other active recreational pursuits.

2.2. Community Consultation and Participation

Community input is essential for the protection of the high conservation or recreation values of many reserves. There are three main community forums which are involved in the management of the SSR – the Reserves Working Group (RWG), the Reserves Advisory Group (RAG), and the Serpentine Sports Reserve Management Committee (SSRMC) – as well as four main stakeholder groups.

The **Reserves Working Group (RWG)** consists of staff from the Shire and the Community Landcare Centre and two community members (nominated respectively by the Land Conservation District Committee and the Roadside Care Volunteers). It coordinates and assesses the progress of on-ground works and considers management issues relating to biodiversity and recreation values within Shire vested reserves. The RWG considers recommendations from the SSRMC in accordance with the *Policy for Reserve Improvement/Development by the Community*, and records of RWG meetings are forwarded to the SSRMC and RAG. The RWG may request advice from community groups.

The **Reserves Advisory Group (RAG)** consists of up to 8 community members, supported by Shire staff and appointed by Council for renewable terms of three years. Members have a high level of knowledge, expertise or experience in biodiversity and conservation, natural resource management, sport and recreation, indigenous and other cultural values, equine activities, and/or commercial tourism, wildflower and seed picking. The combined knowledge, expertise or experience of all group members covers all of these topics. Members are expected to participate in a non-representative manner rather than protecting the interests of individual stakeholder groups.

On Thursday the 15th 2011, 5:00pm at the Shire Offices, a workshop was held with the Serpentine Sports Reserve Committee.

An overview of Shire reserves management and management plan issues was presented by the Manager of Environmental and Sustainability Services. Biodiversity implications and requirements for approvals were discussed. The workshop mostly involved brainstorming and participants prioritizing listed items which are summarized below:

PRIORITY VALUES

1. Polo Crosse Ground
2. Pony Club Ground
3. Golf Cub Ground
4. Other Equestrian Groups
5. Bush Forever Site Conservation of DRF and TECS & Education and Scientific Study for DEC
6. Area for General Community Facility Uses and other Casual Users
7. Playgroup, Cross Country Run, Bike Club and Use by Schools
8. Cultural Heritage and History
9. Recreation Use including for Spotighting Animals
10. Catchment Water Collection

PRIORITY ISSUES / THREATS / CONSTRAINTS

1. Carrying Capacity of Turf Area and its Management
2. Running Costs – Expenditure and Income and Available Resources
3. Bush Management Dieback/Weeds/Special Species
4. Competing Uses and Facility Use Clashes
5. Public Liability and Risk Management
6. Infrastructure Management and Whole of Life Cost
7. Drainage and Water/Nutrient Management
8. Camping Event Management and Crowd Parking Planning
9. Signage and Education Programs
10. Use of Paths in the Bush, Security Locks, Gates, Dogs, Horses Conflicts and Motorbikes
11. Public Perceptions, History and Planning for the Future
12. External Neighbourhood Expansion

FUTURE LONG TERM POSSIBLE OPPORTUNITIES

1. Improvements in Surfaces and Sustainability and Capacity Management
2. Improvement in Club House Facilities, Parking Expansion & Longer Term Plan 15 to 20 Years
3. Other Potential Regional Underutilised Alternative Locations ie Webb Road or Whitby Falls
4. Turf Upgrade with Underground Reticulation and Redeveloping Drainage and Irrigation
5. Higher Profile Varied Events ie Enclosed Arenas
6. Bush Education Awareness Raising - Establishing Bush Walks with Interpretive Information



LEGEND

	High Conservation
	Conservation
	Vegetation Management
	Serpentine Sport Reserve (including uncoloured areas as Recreation Zones)

Figure 3 – Management Zones of Serpentine Sports Reserve

The roles of the RAG are to:

- Provide advice to Council on reserve values, threats, management targets and strategies to protect ecological and social values and take account of community aspirations;
- Provide advice to Council and RWG about on-ground management programs and issues; and
- Undertake audits of reserve management plans and report the results to Council.

The SSRMC remains the primary focus for community discussion in relation to activities on the SSR. The RAG will maintain an interest by referring to minutes, providing advice to Council and liaising with the SSRMC and RWG, as well as periodically auditing implementation of this management plan.

The **Serpentine Sports Reserve Management Committee** (SSRMC) provides a forum for the four main stakeholder groups to discuss issues relating to the management of the reserve. SSR is one of a very small number of Shire reserves where there is intensive commitment and involvement of community groups in the use and management of the land. It is also unusual in having an established and active management committee with representation from each of the user groups.

The SSRMC includes representatives from each of the Serpentine Horse and Pony Club, the Serpentine/Foothills Polocrosse Club, the Serpentine Bushland Group and the Serpentine and Districts Golf Club; two Council delegates; representation from the Land Conservation District Committee and Landcare; and Shire staff members.

The SSRMC, rather than the RAG, provides the focus for community input into planning and the provision of advice to Council on day-to-day management for SSR. The SSRMC should continue to liaise with Shire staff and the RAG. The implementation of recommendations made by the SSRMC that are not specifically within this plan must be referred to the Natural Reserves Coordinator under the *Policy for Reserve Improvement/Development by the Community*.

Each of the four **stakeholder groups** involved in the use and management of the SSR is an incorporated body with a defined decision-making structure. Each group holds an annual general meeting, has a constitution and an active committee and holds regular meetings. The three recreation groups are all affiliated with State bodies and need to abide by their conditions for competitions and day-to-day management. The pony club is affiliated with the Pony Club Association of Western Australia, the polocrosse club with the Polocrosse Association of Western Australia, and the golf club with the Darling Range Association and the WA Golf Association.

The *Shire Reserves Planning and Management Framework* sets out processes for the preparation and review of management plans, including two rounds of public participation: during the development of the draft plan, and when the draft plan is made available for public comment during a submission period. For the development of this management plan, SSRMC undertakes the usual role of RAG.

A clear understanding of the processes of Council planning and decision-making, the roles and responsibilities of participants in the planning and management process, and the mechanisms for community input will lead to effective short- and long-term management and protect the sense of community ownership.

Consultative planning and management is time-consuming and potentially frustrating. This can be minimised by raising awareness and understanding about planning and management processes, and the development of achievable expectations. The endorsement of this management plan should provide a step forward in decision-making and articulate roles, responsibilities and decision-making processes.

All of the community groups that operate on the SSR are entirely voluntary, but must administer and manage their groups to a high standard. This significant burden often falls on the shoulders of just a few dedicated members, and while the groups may currently have access to considerable expertise and experience in governance, there is no guarantee that this will be the case in the future. To maintain good governance, it is essential that all participating groups are kept informed of available training, and where groups identify the need for additional skills amongst their office-bearing members, they should be encouraged to attend relevant training.

2.3. Governance Strategies

Issue	Target	Priority	Strategy	Responsibility
1. Many statutes and government policies relate to SSR.	Compliance with all Commonwealth, State and Local Government legislation and policy frameworks.	Medium	<ul style="list-style-type: none"> a) Develop and implement a process to inform and advise SSMC, RAG and RWG members of current legislation. b) Make reserve users aware of the <i>Policy for Reserve Improvement/Development by the Community</i>. c) All community recommendations and requests for works received under the above policy are to be referred by the Natural Reserves Coordinator to the RWG, and thence to the Council if it is of sufficient magnitude or involves the construction of new infrastructure. 	Shire in partnership with all stakeholders
2. Independent auditing provides accountability and ensures appropriate implementation as resources are made available.	Independent audits of this plan to be undertaken and reported to Council by the RAG at a minimum frequency of every 3 years from the date of endorsement of this plan.	Medium	<ul style="list-style-type: none"> a) RAG meetings to be conducted with broad membership as required in the <i>Shire Reserves Planning and Management Framework</i>. b) Provide assistance and support to RAG members to ensure that proper independent audits are undertaken and reported to Council at a minimum frequency of every 3 years from the date of endorsement of this plan. c) Facilitate a review and debate relating to audit results and the endorsed management plan. 	Shire staff with Council, community groups and the broader community
3. Community groups manage a significant administrative and management burden, often without governance expertise.	Community groups which regularly use the SSR to be made aware of appropriate governance training opportunities.	Medium	<ul style="list-style-type: none"> a) Maintain a record of relevant governance training opportunities and communicate this to SSR community groups. 	Shire

3. Environmental Characteristics

3.1. Geology, Geomorphology and Soils

3.1.1. Description

The apparent stability and eroded appearance of Australia's landforms belie an ancient geological history of spectacular turmoil. A general drift north resulted in climatic changes, and ice and snow gave way to a warm climate. The exceptional biodiversity in the SSR is due to geological instability, resulting in variations in soil types within relatively short distances.

Today, the SSR is situated on the eastern side of the Swan Coastal Plain. About 2.5 km further east is the Darling Range, underlain by some of the oldest rocks in the world. Historical erosion from the range accumulated as sediments up to 15 km thick, forming the underlying bedrock of the Swan Coastal Plain.

The surface deposits on the eastern side of the Swan Coastal Plain originate from two sources. The first source is recent erosion of the Darling Range to form the Pinjarra Plain soil complex. These are characterised by grey sandy duplex soils, clays, loams and gravels. Effective agricultural use has relied on a network of drains to remove winter water.

Agriculture WA soil maps indicate that there are two soil types from the Pinjarra complex within the SSR. *Pinjarra 8* lies beneath the pony club and polocrosse fields, and beneath the northern and eastern sectors of the golf course. This soil type is described as:

Moderately deep to deep sands over mottled clays; acidic or less commonly alkaline grey and yellow duplex soils to uniform bleached or pale brown sands over clay.

Pinjarra 1b is located beneath the south-west corner of the golf course and is described as:

Deep acidic mottled yellow duplex soils. Moderately deep pale sand to sandy loam over clay.

The second source of surface deposits on the eastern side of the Swan Coastal Plain is coastal processes. Massive sea level fluctuations formed a series of sand dunes on top of the plain, the oldest of which lies to the east. Soils from this dune system belong to the Bassendean complex and are characterised by deep, pale siliceous sands which are leached and often waterlogged.

Agriculture WA maps indicate that there are two soil types from this complex within the SSR. *Bassendean 1* soil lies beneath the remnant bushland and under much of the central and south-west portion of the northern sector of the reserve. This soil type is described as:

Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than two meters.

Bassendean 3 is located under the golf course in the south-east corner of the reserve, and is described as:

Moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil; surfaces are dark grey sand or sandy loam.

The SSR has a low relief landscape, with the *Bassendean 1* soils forming sandy rises and the *Pinjarra* soils low-lying and poorly drained flats. These natural contours have been altered by excavation in some areas and the addition of soils to others. Soil was excavated from several locations within the northern and southern sections during the 1970s to elevate some of the fairways, with the excavations helping drainage.

Excavations have revealed more details of *Bassendean 1* soil profiles. The sand pit within the bushland shows very deep uniformly-grained yellow sand with a shallow grey surface layer enriched by organic matter. Re-establish in the sand pit has been slow, and erosion has undermined adjacent bushland. Further north, adjacent to the southern boundary of the pony club grounds, the excavated sands have clay subsoil.

Bassendean 1 sand from the bushland was used to elevate and assist with drainage on the polocrosse ground. To level the grounds, the sand layer was spread thicker in the south than the north. The pony club grounds underwent major works during 1999, when the area was levelled and the top 200 mm of soil replaced with 300 mm of imported sand.

Agriculture WA has prescribed the maximum numbers of stock that various soils can support. The sand layers on both ovals form a thin cover over *Pinjarra 8* soils, which have a stocking rate equivalent to two horses permanently on one hectare of irrigated land, or 17,500 horse-hours per hectare per year. The current usage for both ovals is within this limit, and the minor soil erosion that occurs during major events recovers quickly.

The pony club also uses a cross-country track which passes through the bushland. About 300 m of this has been covered with crushed bluemetal to help prevent erosion, compaction and the formation of ruts in the underlying fragile *Bassendean 1* soil. The bluemetal is now wearing, with ruts, hollows and side banks becoming evident. The rest of the cross-country trail has a natural surface of *Bassendean 1* soil.

Little is known about the current condition of SSR soils in terms of changes to chemical and microbial composition. Surface salinity is evident along some drainage lines and in low-lying areas in the northern section, and there is the potential for changes associated with nutrient build-up and acidification. These issues are discussed under threats and pressures, and in the water section of this management plan.

The risk characteristics of the four soil types present in the SSR are shown in Table 3.

Table 3 – Risk Characteristics of Soils of Serpentine Sports Reserve

Soil type	Characteristics
Bassendean 1	Wind erosion
Bassendean 3	Water logging, phosphorus export, acidity
Pinjarra 8	Wind erosion, water logging in low-lying areas
Pinjarra 1b	Moderately susceptible to salinity, soil water storage

Source: Agriculture WA

3.1.2. Threats and Pressures

Water logging is characteristic of the soils over much of the SSR. These impacts are considered in the water and recreation sections of this management plan.

Wind erosion is preventable if soils retain vegetation cover. Wind has been the primary cause of continued erosion following the extraction of *Bassendean 1* soil from the sand pit for the polocrosse grounds. The native vegetation in this area is slowly recovering.

Phosphorus export occurs because different soil types possess differing ability to retain nutrients. The addition of fertilisers to soils which export nutrients is more likely to result in surface- and ground-water pollution than application to soils which retain nutrients. Excess fertilisers and manure pose a threat to the chemical balance and microbial communities within soil. Nutrient management is discussed further in the water section of this management plan.

Surface salinity can result from two causes, and it is likely that both are operating in the SSR. The evaporation of shallow pools causes water to become increasingly saline through concentration of salts. Salt may also be introduced by rising saline groundwater. Surface salinity can be managed by drainage to ensure that evaporation cannot concentrate salt in standing water. Rising groundwater can be controlled through the planting of deep-rooted perennial plants. Increased salinity causes changes to the chemical composition of soils. However, the impacts of salinity are most evident in ground- and surface-water resources, and this topic is therefore discussed further in the water section of this management plan.

Soil compaction refers to the crushing of soils to a point where the physical structure is altered, creating layers that are almost impenetrable, which affects fertility and the soil microbial community. Little is known about the extent of any soil compaction on the reserve. However, the protection of fragile soils by a surface material that holds its structure helps to minimise the potential for soil compaction and erosion.

The SSR is within a medium risk area for **acid sulphate soils**, which contain chemicals that, when exposed to oxygen, form sulphuric acid, which is highly toxic and corrosive. The component chemicals form in swamps, where constant inundation by stagnant, anoxic water prevents the formation of acid. However, if these soils are disturbed and exposed to air, or water is pumped from them to lower the water table, sulphuric acid forms. This not only alters the chemical nature of the soils themselves but has the potential to cause severe pollution of ground and surface water.

The Department of Environment has defined the acid sulphate soil risk within the SSR as:

Moderate to high risk of acid sulphate or potential acid sulphate soils occurring greater than three meters from the soil surface; no risk of occurrence less than three meters from the soil surface.

The acidification of soils within the SSR can be prevented by ensuring that there is no soil disturbance or dewatering below a depth of three meters from the surface. Any proposal that might cause or mobilise acid sulphate soils should be investigated in accordance with DEC guidelines and referred to that Department for assessment and advice.

3.1.3. Environmental Characteristics: Geology, Geomorphology and Soils Strategies

Issue	Target	Priority	Strategy	Responsibility
4. Soil erosion of sandpit.	Sand pit wall profiles to be stabilised and soil erosion stopped.	Medium	a) Monitor the profile of the sand pit wall and determine whether soil erosion remediation is required.	Shire
5. Potential erosion of polocrosse and pony club ovals.	Ovals to have adequate cover of pasture and/or mulch at all times.	Medium	a) Pasture and mulch cover to be monitored and managed adaptively to ensure management target.	Shire with pony club and polocrosse club
6. Acid sulphate soils.	All members of community groups who make management decisions and/or undertake construction or maintenance works to be aware of acid sulphate soil risks. No acid sulphate soils to be exposed within the SSR.	High	a) The potential risks of acid sulphate soils are to be communicated to all community groups that use the reserve, taking place frequently enough to ensure the management target when club members change. b) No excavation or dewatering is to take place without consultation with DEC.	Shire and all other stakeholders

3.2. Water

3.2.1. Description

Water resources of the SSR consist of drains, natural and artificial wetlands, plus superficial and artesian groundwater. The area has a Mediterranean climate with hot, dry summers and cool, wet winters. About 70% of annual rain falls from May to August; these winter rains recharge the ground and surface water.

Surface Water

Much of the reserve is low-lying and originally formed part of a dampland (a basin-shaped wetland which was waterlogged in winter) with no natural drainage off-site and slow surface flows. From the 1920s, a network of drains was constructed to remove excess surface water and reduce inundation, opening the region for agriculture. Later extensions passed through the SSR, removing excess water and draining surrounding areas. The drains flow west to the Serpentine River and the Peel Inlet.

The Peel Harvey Estuary is of regional, national and international significance, and is protected by Commonwealth legislation. It is listed on the Register of the National Estate, as a Ramsar site of international significance for water birds, and supports migratory birds protected under agreements with Japan and China. However, the estuary has been severely degraded by high concentrations of nutrients from the catchment via the drainage network which cause nutrient enrichment and algal blooms. The Dawesville Channel was constructed in 1994 to increase estuarine flushing. Water quality was also improved through better land management to reduce nutrient input into, and increase nutrient stripping from, surface waters.

Catchment land use is subject to policies that set nutrient export targets: the *Environmental Protection (Peel Inlet Harvey Estuary) Policy 1992 (EPP)* and the *Statement of Planning Policy No.2 (SPP)*. The EPP sets a maximum phosphorus load from the Serpentine River, while the SPP requires water management plans for recreation facilities. The DEC position statement *New Conventional Sprinkle Irrigation Agricultural Proposals in the Swan Coastal Plain Catchment of the Peel Harvey Estuary* sets maximum nutrient application rates at 150 kg of nitrogen and 15 kg of phosphorus per hectare per year.

The SSR is in a proclaimed catchment under the *Rights in Water and Irrigation Act 1914*, so a license is required to take water from waterways. Works that interfere with watercourse beds or banks also require a licence, although the differentiation between natural and artificial watercourses is unclear.

A dampland of 1.8 hectares, on the south-east edge of Paul Robinson Reserve, is a regionally significant “conservation category” wetland. The primary management objective is to preserve wetland attributes and functions; State Government policies require land uses to be compatible. It is protected under the *Water and Rivers Water Quality Protection Guideline No. 13 Environmental Guidelines for Horse Facilities and Activities*, and the *Rights in Water and Irrigation Act 1914* which prohibits taking water that affects wetland water levels. The remaining low-lying areas are “resource enhancement” wetlands.

Runoff from the SSR empties into three Water Corporation drains, which also carry runoff from upstream (see Appendix 2 for a drainage map). The drain along the southern boundary of the south sector carries runoff from south of the townsite and a subdivision south of the reserve, passing north along the western boundary to join a second drain which bisects the south section, carrying water from the townsite, the southeast portion of the golf course, the pony club arena and part of the polocrosse grounds. This flows

through an artificial nutrient stripping wetland before crossing two fairways to the western boundary where the drains unite and flow towards the Serpentine River. Runoff from the north section discharges into a third drain running along its northern boundary, which later joins this combined drain.

In 1999 a major project improved the drainage of, and reduced nutrient export from, the pony club arena. The drain carrying runoff from the townsite was diverted through an artificial nutrient stripping wetland. The arena surface was reshaped and covered with a deep layer of sand, draining half of the runoff towards a central channel and half into a subsurface channel to the north, which both discharge into the artificial wetland. During peak flow, water backs up from the wetland, covering the outlet pipes; water levels approach the surface and local flooding occurs, caused by limited discharge from the downstream drain.

The polocrosse field has also been raised slightly. The surface soils still have low infiltration rates, and the northern section is often inundated and waterlogged throughout winter. The grounds drain slowly towards channels in the north and east and the drain in the south. Polocrosse carnivals are held in autumn and spring when drainage is not an issue. Use by other activities would require improved drainage.

A dam constructed by the golf club provides water to irrigate all 18 fairways. It is filled from a bore, and receives runoff from the equine areas and fairways. It is next to the artificial wetland, but connectivity between dam, wetland and groundwater flows is uncertain. During winter the dam overflows.

The fairways are mounded to drain sideways, using soil from between the fairways and some shallow excavations. Runoff collects in the channels, along with subsurface flows through the deep duplex soils or deeper sands, accumulating south of the natural wetland and slowly discharging via a drain through the wetland and bushland to join the central Water Corporation drain. In the north section, water collects in shallow drains between the fairways. Drainage is slow, with localised flooding, particularly south of the club house where the central drain crosses the first fairway. This drain has gradually filled so that the base level is above that of the drain upstream. On the western edge of this fairway the two Water Corporation drains meet and, after heavy rain, water floods back along and across the fairway, lasting for several days and causing the high water levels in the artificial wetland, which backs up and floods the equine arenas.

Information on surface water quality is limited. The Department of Water has coordinated monitoring in the Serpentine River catchment since 2001. No differences occur in total phosphorus or nitrogen levels at the discharge point of the river, but 57% of the sites (not those closest to the reserve) exceed ANZECC trigger values for water quality in streams. The Serpentine River community group sampled nutrient levels along the Serpentine River in 2001. Total phosphorus levels along the river increased moving downstream. No difference was detected between the sampling sites up- and down-stream of the junction with the main Water Corporation drain from the SSR and surrounding areas.

Salt-affected land occurs in the north section of the reserve and on the northern edge of the polocrosse field, on clay soils with slow drainage due to low slope and infiltration. The largest area is near the western boundary of the north section, where deep-rooted perennial vegetation appears to have reduced the severity of the salt problem. On the polocrosse field it is not clear whether salt or water logging is the problem, but salt- and water-tolerant couch grass (*Cynodon dactylon*) has replaced the other turf species.

Groundwater

The SSR is in the Serpentine Groundwater Area. Extensive supplies are contained in superficial aquifers within surface sediments throughout the Swan Coastal Plain. In general, Bassendean sands, due to higher porosity and ease of infiltration, store more water than Pinjarra soils. Because the reserve lies on the boundary between these two sediment types, supplies from the superficial aquifer are likely to be erratic.

The older underlying sediments form confined (artesian) aquifers that contain substantial quantities of groundwater, known as the Leederville Aquifer. Water leaks downwards and upwards between the two aquifers. Groundwater movement is generally from east to west, but the patterns of flows close to the Serpentine River are more complex. Here the superficial aquifer discharges to the river (and the artificial surface drains) and water leaks upward from the underlying aquifer to recharge the superficial aquifer.

Groundwater extraction is controlled and licensed by the Department of Water. The Shire holds a license to extract water from the Leederville Aquifer, covering two bores, as does the golf club.

The Leederville Aquifer in this subregion is more than 50% allocated. Sustainable levels of extraction, and therefore water allocations, are limited as it is a discharge zone. The aquifer is not being replenished by rainfall but is instead losing water. Groundwater allocation is guided by the *Serpentine Groundwater Area - Leederville Aquifer Recharge and Discharge Zones Policy - 1999 (confined aquifer policy)*. A deeper artesian water resource could be accessed if the allocation was sustainable.

The SSR is within a proposed *Public Drinking Water Source Area (PDWSA) Priority Level 3 (Proposed Karnup-Dandalup Underground Water Pollution Control Area, UWPCA)*, extending from the Serpentine River south to the Dandalup-Murray System. The purpose of the PDWSA is to protect the quality of water in the superficial aquifer from overuse and pollution, and land use planning and management must reflect this. In Priority 3 areas, land use and recreation activities are permitted provided that threats to water quality can be adequately managed, as stated in the *Policy and Guidelines for Recreation within Public Drinking Water Source Areas on Crown Land*.

Water Use and Management

Regulation of surface water flow and extraction of groundwater have impacts on the environment and ecological communities. People expect almost unlimited access to water to service high demands, but resources are limited and costs high. Water use efficiency is an important environmental, social and economic issue. Providing amenities for the community is fundamental to social health, but where the needs of community and environment conflict, a balance must be reached or alternatives sought.

The State and many local governments are increasing water use efficiency. In 2003 the State Government released the *State Water Strategy* and the *State Sustainability Strategy*, which ensure sustainability of water supplies and manage environmental impacts. Thirteen local governments in the Peel Harvey catchment, including the Serpentine Jarrahdale Shire, are participating in the International Council for Local Environmental Initiatives (ICLEI) Water Campaign, to increase water use efficiency and reduce environmental impacts of Council operations and local communities.

Over three quarters of the reserve is turfed and irrigated from the Leederville Aquifer. Shire staff manage irrigation of the pony club and polocrosse fields (16.5 hectares), using two travelling irrigators applying about 15 mm of water once per week. Best management practices suggest applying around 70% of weekly evaporation (up to 38 mm per week), divided between 3 or 4 applications at times of low wind and evaporation. Currently, less water is applied, in one extended application irrespective of wind and evaporation. More efficient sprinkler systems for equine areas are now available and installation would improve water efficiency and require much less staff time to operate.

The golf course fairways are irrigated via a pump on the dam, which is filled from a bore and receives runoff from the horse grounds. The system is owned and managed by the club. Evaporation is recorded and water inputs calculated accordingly. Fairways are watered every second day at rates of up to 35 mm per week, wetting only the top 200 mm of the soil profile, in line with recommended best management practice. Only the centres of the fairways are irrigated, totalling about 30 hectares.

3.2.2. Threats and Pressures

Water Quality

The most critical water quality issue is nutrient management, which on the SSR is well within the recommended maximum rates of 150 kg/ha/year nitrogen (N) and 15 kg/ha/year phosphorus (P).

The polocrosse field receives about 40 kg/ha N once a year, and no P. The animal waste input is calculated at about 0.6 kg/ha/year P and 6.7 kg/ha/year N. Total inputs are 46.7 kg/ha/year N and 0.6 kg/ha/year P. The animal waste is not evenly distributed in space or time and there may be significant nutrient export from high concentration points such as horse pens, particularly on porous sandy soils.

Nitrogen is applied on the pony club arena twice a year, at rates of 46 kg/ha and 51 kg/ha. Calculated animal waste inputs are 1 kg/ha/year P and 11.3 kg/ha/year N. Total inputs are 108.3 kg/ha/year N and 1 kg/ha/year P. The nutrient loads are not even in space or time and may be exported from high use hot spots. Runoff drains into the artificial wetland where nutrients and sediments can be removed.

Nutrient input levels on the golf fairways are about 25 kg/ha/year N in two applications. This is much lower than professional advice (100 kg/ha N per year, in 6 or 7 applications) for semi-active turf. Fairway shaping and tree planting between fairways creates the basis for a “treatment train” consistent with water sensitive urban design practices. Water travels slowly along shallow channels and collects in artificial sumps, allowing in-stream processes to occur, removing nutrients and sediment.

Water is also used to operate toilets and catering facilities. The toilets at the Eric Senior Pavilion use a Biomax system, while the golf club toilets have a septic system on a deep sandy profile with high infiltration. The household equivalents, based on estimated use, are 1.6 for the Pavilion and 0.3 for the golf club, well within the guidelines for environmentally sensitive areas.

Climate Change

Local impacts of global climate change include significant changes to rainfall patterns. Recent dry conditions are predicted to continue, and may become more distinct and associated with warming and more frequent extreme events. Less rainfall provides fewer water resources and increased pressure for conservation and reuse. SSR managers will have little direct impact on global weather patterns, but pressure is growing to reduce energy use and greenhouse gas emissions. Low energy- and water-consumption initiatives at a public facility provide the additional benefit of community education.

Water Pollution

Nutrient export is a significant threat to water flowing into, through and from the reserve. The main sources are fertilisers and animal wastes, but water from upstream may already be poor quality. Fertiliser use is well within recommended rates, but small amounts can cause pollution if large proportions are exported. Effective application relies on nutrient penetration to root depth at a rate plants can assimilate.

Best management practices to minimise nutrient export from turfed surfaces include:

- Repeated application of small amounts of fertiliser rather than infrequent applications of large amounts, with amount and time managed by monitoring nutrient levels in soil;
- Applying soil conditioners and wetting agents to ensure absorption rather than runoff;

- Repeated application of small amounts of water to maintain dampness in surface layers, with amount and time managed by monitoring soil water content and evaporation rates;
- Avoidance of applying fertiliser before very heavy rain or just prior to inundation; and
- Maintenance of healthy vegetation over fertilised areas to maximise nutrient uptake.

Horse manure and urine are nutrient sources that require careful management. Total input for the grounds from horse excreta are currently well within allowable limits, but only assuming that it is spread evenly. In practice, the horses spend far more time in some parts of the grounds, particularly the horse pens, than in others. Any nutrients not assimilated by plant roots are exported to surface or ground water. Healthy plant material in the horse yards varies, often being dense during spring but limited for much of the year.

Removal of manure from horse pens could reduce levels at these “hot spots”, but large proportions of nutrients are in urine, so 84% N and 36% P remains even when manure is picked up. Sand or other absorptive material in the pens would absorb some of the urine, and subsequent removal would reduce the likelihood of nutrient export as long as rain does not wash nutrients through prior to collection. Covered pens with sealed floors would guarantee the confinement of nutrients.

Best management practice prevents export of nutrients from the source, but nutrients in water can be removed if the water passes slowly enough for assimilation through areas where plant roots can absorb the nutrients. Effective nutrient stripping requires establishment of vegetation with roots at appropriate depths and the slowing down of nutrient-rich water through these areas.

Constructing an artificial wetland to strip nutrients and sediments from surface flows improved nutrient management, but it was only designed to process runoff from the pony club grounds. The addition of the much larger flows from the Serpentine townsite puts the system under pressure, and the residence times may be inadequate. The redesign of this wetland and construction of others may be appropriate.

Chemicals such as pesticides, herbicides, cleaning agents and petrochemicals also present the threat of water pollution. A precautionary approach should be taken when transporting, storing and using chemicals, and manufacturers’ instructions must be adhered to at all times.

Water Quality in the Conservation Category Wetland

Inflows to the wetland could significantly alter its ecological balance. The drain from the golf course may import nutrients, weeds and disease, and affect water levels. Ideally, there should be no hydraulic connection between a dampland and surrounding land uses. Water quality deterioration could be minimised by redirecting and perhaps reusing water from the golf course, or by installing a nutrient stripping wetland to remove pollutants prior to entering the wetland. The wetland is an expression of the water table, and any activities that affect the water table impact on it, including alteration of water levels and leaching of nutrients and other pollutants into the groundwater.

Unsustainable Use of Water Resources

Groundwater is a limited resource under increasing demand. Knowledge of aquifers is incomplete, but license allocation helps to keep usage of ground water resources within sustainable limits. There is significant pressure to increase water use efficiency and maintain natural water flow regimes. Originally, very little water would have left the SSR, evaporating, transpiring or infiltrating to the groundwater. Water sensitive urban design aims to keep most if not all of the water on site and maximise infiltration.

A wide range of best management practices can be adopted to:

- Minimise water demand by efficient irrigation, application as required, and improved infiltration;
- Collect, store and reuse water via collection dams or tanks and reused waste water;
- Reduce evaporation and wastage via lined dams, sealed tanks, and irrigation during cooler hours;
- Slow the passage of water by meandering or infiltration; and
- Increase transpiration by establishing vegetation that absorbs water.

Salinity

Salinity alters soil structure and limits plant growth. Secondary impacts include bare sealed surfaces with low infiltration and increased runoff, increasing erosion and nutrient and sediment transport. Saline waters impact the health of freshwater ecosystems. On the Swan Coastal Plain the primary cause of salinity is salt accumulation from evaporation of standing water on clay soils with low infiltration. This is known as secondary salinity and differs from the salinity caused by rising groundwater. Management includes reducing flood time through drainage, increasing surface water use on site and upstream and reducing evaporation by shading.

Acid Sulphate Soils

Acid sulphate soils occur in the region, and when exposed to oxygen, release sulphuric acid that directly impacts terrestrial and aquatic ecosystems and has serious indirect impacts by liberation of heavy metals and acid compounds to surface and ground water. Hydrological systems for detaining and treating storm water must identify and avoid creating an acid sulphate soils problem.

3.2.3. Environmental Characteristics: Water Strategies

Issue	Target	Priority	Strategy	Responsibility
7. Climate change is reducing rainfall in the Peel Harvey catchment.	Zero net contribution to greenhouse gases.	Medium	a) Prepare an energy consumption and emissions audit of all operations and activities on SSR, including methane production, carbon sinks and carbon trading contingencies. b) Establish vegetation as required to offset emissions.	Coordinated by Shire with involvement of all stakeholders & partners
8. Current water use is uncertain and needs to reflect license conditions.	Compliance with all groundwater license allocation and other conditions.	Key	a) Install meters and monitor water extraction from bores. b) Prepare an inventory of all water consumption on the reserve.	Coordinated by Shire with involvement of all stakeholders & partners
9. Large quantities of water are being used within a catchment subject to water consumption reduction policies and targets.	Decrease water consumption by 15% of 1999/2000 levels within one year from the date of endorsement of this plan.	Key	a) Prepare a plan to reduce consumption and reuse water by for example: <ul style="list-style-type: none"> • Storing and reusing rain water; • Reducing evaporation from dams and irrigation; • Reviewing the extent and standard of turf; • Using and reusing surface water; b) Applying best management practices for water use on turf surfaces as follows: <ul style="list-style-type: none"> • Installing automatic sprinkler systems; • Adjusting the quantity of water applied in accordance with evaporation and turf conditions; • Adjusting the timing of water application to minimise evaporation and wastage; • Monitoring soil infiltration rates and applying wetting agents and other amendments as required. 	Coordinated by Shire with involvement of all stakeholders & partners
10. Excess nutrients in the catchment are causing down-stream algal blooms and ecological collapse in the Peel Harvey estuary.	Surface waters leaving the reserve to be of equal or improved water quality compared with surface waters entering reserve. Total nutrients from fertilizers and animal wastes to be applied to turfed areas at rates no greater than 150kg/ha/year N and 15kg/ha/year P.	Key	a) Design and implement a monitoring program for water quality: <ul style="list-style-type: none"> • Entering and leaving the reserve; • Adjacent to and downstream of potential nutrient hotspots; • Entering and leaving the existing constructed wetland. b) Maintain joint records of fertilizer and animal waste applications (as equivalent horse hours per hectare and management techniques) and maintain levels below target amounts (150kg/ha/year N and 15kg/ha/year P). c) Distribute educational material about minimal impact equine management and the impacts of nutrient pollution. d) Minimise nutrient export by implementing best management practices including: <ul style="list-style-type: none"> • Adjust fertilizer application for turf condition. • Establish vegetated buffers between all nutrient sources and surface water features. 	Coordinated by Shire with involvement of all stakeholders

Issue	Target	Priority	Strategy	Responsibility
			<ul style="list-style-type: none"> • Pick up manure and export it within 12 hours. • If horse pens are exporting significant quantities of nutrients, provide and frequently renew temporary absorbent surfaces in horse pens and/or construct covered pens with sealed floors. • Develop and implement procedures to ensure that manure is not stored on the reserve, even for short periods, unless in appropriate covered containers with impermeable bases. • Develop and implement procedures to ensure that fertilizers and other chemicals are transported, stored and used in such a manner that the risk of spillage and pollution is minimal. <p>e) Maximise nutrient stripping from flowing surface waters by reviewing, and where possible implementing, best management practices (e.g. planting native rushes, sedges and other vegetation along drains, treatment trains and artificial wetlands).</p> <p>f) If the existing constructed wetland is not effectively stripping nutrients:</p> <ul style="list-style-type: none"> • Adjust its design and management (e.g. in relation to its size, shape, planting, flow rates and vegetation and sediment removal programs); and • Investigate constructing additional wetlands. 	
11. Groundwater reserves under the reserve are currently used for domestic and agricultural purposes and are proposed as a major drinking water source.	Comply with legislative and policy requirements associated with groundwater protection.	High	<p>a) Establish a mixture of deep and shallow rooted vegetation to absorb nutrients as they seep down to groundwater resources.</p> <p>b) Seek advice from the Department of Water on meeting the total target of 150kg/ha/year N and 15kg/ha/year P within the reserve.</p>	Coordinated by Shire with involvement of all stakeholders
12. Saline water is causing salt scalds in turf.	Salt scalds to be eliminated.	High	<p>a) Lower the water table and reduce evaporation by establishing a mixture of deep and shallow rooted vegetation in areas where surface water occurs.</p>	Coordinated by Shire with involvement of all stakeholders
13. Surface water draining the golf course flows through the conservation category wetland, and is likely to add nutrients and degrade the wetland ecosystem.	Water draining into or through the conservation category wetland to be free of pollution, with levels no higher than 0.1 mg/L of total P and 0.75 mg/L of total N.	High	<p>a) Monitor water quality entering the conservation category wetland.</p> <p>b) Reduce runoff and filter water from the golf course by, for example:</p> <ul style="list-style-type: none"> • Establishing a mixture of deep and shallow rooted vegetation throughout the golf course area; • Constructing a nutrient stripping wetland within the drain prior to water entering the wetland. <p>c) If water quality entering the wetland is above target levels (0.1 mg/L total P and 0.75 mg/L total N), review and implement options to isolate golf course runoff from the wetland (e.g. by diverting the drain to a storage dam which drains to the south).</p>	Shire in partnership with the golf club

3.3. Biodiversity

3.3.1. Description

The SSR has about nine hectares of remnant vegetation of three community types, generally in good condition, not well represented elsewhere on the Swan Coastal Plain, and of enhanced value by being well connected with each other and with significant vegetation remnants on adjacent rail and nature reserves. Small vegetation areas, isolated plants and revegetation contribute to the biodiversity values.

Biodiversity is the variety of life, including species, their genetic material and ecosystems. The Commonwealth *Environmental Protection and Biodiversity Conservation Act (EPBC) 1999* defines it as:

“...the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.”

Australia has signed a global agreement to protect biological diversity, ensure its sustainable use and the fair and equitable sharing of its benefits (*Convention on Biological Diversity, 1996*). Commonwealth legislation (EPBC 1999) provides a framework for protecting of biodiversity, particularly threatened or endangered species and ecosystems. The south-west of Western Australia is a world biodiversity hotspot.

At a State level the *Wildlife Conservation Act 1950* protects species of plants and animals that are listed as “threatened”. The responsible agency, DEC, maintains a list of priority species, which are not listed as threatened but have uncertain status and require further research, and depend on active conservation strategies to ensure long-term survival. There are four declared rare flora (DRF) species in the SSR and another seven priority species. There is currently no State legislation that protects ecological communities or unique assemblages of plants and animals. At present, threatened ecosystems are listed by the State Government and some are afforded protection under Commonwealth legislation (EPBC 1999).

The State Government has a strategic plan to conserve bushland on the Swan Coastal Plain, *Bush Forever*, which establishes a representative system of protected areas under the 1996 *National Strategy for the Conservation of Australia’s Biodiversity*. It identifies areas of regionally significant bushland and strategies for their protection. The SSR bushland is mapped, with adjacent bushland, as *Bush Forever Site 375*, grouped with two other sites as the *Byford to Serpentine Rail/Road Reserves and Adjacent Bushland*, forming a corridor to other significant areas, including the Serpentine River and Mundijong Road. It is part of a network of small sites whose connectivity increases their opportunity for long term survival.

The *Bush Forever* implementation guidelines for local government or Crown Reserves include:

- (having) *reserve purpose amended to include conservation*
- (preparing) *management plans for local reserves to protect bushland and ensure that any proposed development (in accordance with the reserve’s existing purpose) is compatible with Bush Forever conservation objectives and achieves a reasonable outcome.*

3.3.2. Flora

Australia has been divided into 85 “Biogeographic Regions” for the purpose of conservation planning and natural resource management. The SSR is in the Swan Coastal Plain Interim Biogeographic Region of Australia (IBRA), which lies west of the Darling Fault line and extends from Jurien Bay to Dunsborough. The Swan Coastal Plain biogeographic region is described as:

Low lying coastal plain, mainly covered with woodlands. It is dominated by Banksia or Tuart on sandy soils, Allocasuarina obesa on outwash plains, and paperbark in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland. Three phases of marine sand dune development provide relief. The outwash plains, once dominated by A. obesa-marri woodlands and Melaleuca shrublands, are extensive only in the south.

A variety of plant communities occur within this IBRA region and were defined and described by Heddle *et al.* in 1980 (Government of Western Australia 2000). The Heddle classification is based on soil types and landforms with some survey data. A vegetation complex contains an array of different plant communities that are associated with a single geomorphic element or soil landscape system.

The SSR is on the boundary of two elements, the Pinjarra Plain and Bassendean Dunes, an interzone of greater diversity with elements from both systems. Heddle lists the vegetation as Guildford Complex, associated with Pinjarra Plain soils: open to tall open forest of *Corymbia calophylla* (marri), *Eucalyptus wandoo* (wandoo), *E. marginata* (jarrah) and woodland of *E. wandoo* (with rare *E. lane-poolei*). Minor components include *E. rudis* (flooded gum) and *Melaleuca raphiophylla* (freshwater paperbark).

The bushland in the center of the reserve, on the low sandy dune, is more typical of the Southern River Complex which is transitional between Pinjarra Plain and Bassendean Dune elements and is described as:

Open woodland of Corymbia calophylla – Eucalyptus marginata – Banksia species with fringing woodland of Eucalyptus rudis – Melaleuca raphiophylla along creek beds.

The Gibson analysis of communities on the Swan Coastal Plain (Gibson *et al.* 1994) used the presence or absence of particular species in standard sample areas to define floristic groupings. The Gibson study also investigated the total areas of each community and defined some as vulnerable, endangered or critically endangered. Three Gibson floristic communities are represented in the remnant vegetation in SSR. They are Banksia Woodland (community type 20b), Marri Woodland (community type 3b) and Wetland Heath.

Banksia Woodland (community type 20b)

“*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain” covers an area of about 4.5 hectares. The community is listed as *Endangered* by the Threatened Species and Communities Unit of DEC, but is not listed under Commonwealth legislation.

This community is found on the western side of the bushland on a low dune of grey Bassendean sand. The central section was excavated more than 50 years ago, leaving a pit scar. West and south is about two hectares of woodland with small areas of degraded open woodland, dominated by firewood banksia (*Banksia menziesii*) and candlestick banksia (*B. attenuata*) with scattered jarrah (*Eucalyptus marginata*) and bull banksia (*B. grandis*). The understorey is diverse, dominated by balga (*Xanthorrhoea preissii*).

About half of the woodland is in very good condition with little structural alteration apart from numerous tracks fragmenting the habitat. A substantial cross-country horse track bisects the woodland, about 1.5 m wide and surfaced with granite fines. It enters from the north-west corner and travels south and east to the sand pit, traversing bushland in very good condition with few weeds and a healthy understorey. Most was assessed as dieback free in 2000, but the track also traverses dieback infected bushland.

The banksia-jarrah woodland south of the sand pit and towards the southwest corner is more disturbed. There is evidence of clearing, grazing and/or trampling, and near the golf course are infestations of weeds, particularly African lovegrass (*Eragrostis curvula*), veldtgrass (*Ehrharta calycina*) and wild oats (*Avena barbata*). The condition varies, with healthy diverse understorey mixed with areas where the understorey is highly disturbed or absent. Many small tracks fragment and disturb the area.

The dune sands north of the pit and along the northwest boundary have a structurally distinct community. The lower slopes are open woodland of firewood banksia (*Banksia menziesii*) and swamp banksia (*B. littoralis*) with scattered jarrah (*Eucalyptus marginata*) and Christmas trees (*Nuytsia floribunda*). Further upslope the community grades into dense low shrubs with *B. menziesii* and *E. marginata* emergents. It may be a distinct community, or the result of past disturbance or the ongoing disruption of dieback. This community is very diverse and resembles a sandplain heath. There are very few weeds and the vegetation appears healthy, although highly fragmented by tracks. Dieback is evident, particularly upslope north of the pit. A small area in the open woodland was assessed as free of dieback. The horse track continues through this community from the eastern edge of the pit, and more incised as the soils are lighter and more fragile. This section is dieback infected and a few grass weeds are evident.

Marri Woodland (community type 3b)

“*Corymbia calophylla* - *Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain” is recorded on the east and north-east section of the bushland. The community is listed as *Vulnerable* by DEC, but is not listed under Commonwealth legislation.

The community is marri (*Corymbia calophylla*) woodland with an understorey of sedges and balga (*Xanthorrhoea preissii*). It occurs on the lower slopes in the soil transition, covering about 2 hectares (including several clearings) in the north-east and a little less than one hectare in the southeast near Hall Road. There are other small patches of marri on the western edge of the bushland near the golf club dam. All of the marri woodland is infected with dieback.

The condition of the northeast section is “good” on the Keighery condition scale. It has been significantly disturbed, with localised aggressive weeds and highly fragmenting tracks, but retains much of the original structure and the potential to regenerate with good management. Extensive cleared areas for old, unused horse pens have heavy infestations of African lovegrass (*Eragrostis curvula*), which is beginning to invade the small wetland heath. The track from the pens to the polocrosse field has some localised dense infestations of lovegrass. A healthy, if fragmented, understorey on the eastern side has weeds confined largely to the tracks and clearings. A severe infestation of watsonia (*Watsonia* sp.) lies along the eastern boundary in and adjacent to the road reserve. The western part, including the horse pens, is completely degraded in places, but retains patches with fairly healthy understorey. There are many tracks, including two horse tracks passing through the cleared western edge and through the woodland on the eastern side, up to 10 m wide. The condition of this community has degraded rapidly over the last ten years.

The smaller marri woodland to the south is in very good to good condition, linked by revegetation in the Paul Robinson Reserve. An area within and near the Paul Robinson Reserve is degraded to completely degraded, with heavy weed infestations and few native plants in the understorey. Immediately south is an area of woodland in very good condition with diverse, healthy understorey, lying on each side of the fence and extending west towards the wetland. It is particularly important as the only intact area of this understorey within the bushland and as a healthy transitional community between two distinct ecosystems. The woodland remnant narrows along the Hall Road boundary towards the golf course. The condition of this area has declined with higher levels of weed infestation, but generally there is a healthy understorey. There are patches of watsonia along the tracks and the fairway edges.

Wetland Heath

Wetland heath occurs in the southeast of the reserve and belongs to the Bennett Brook Suite, found in the Serpentine River area, originating in depressions intersecting the water table within the Bassendean Dune system. The wetland covers just over 1 hectare and supports a low closed heath dominated by swamp

teatree, *Pericalymma ellipticum*. The community is listed as *Vulnerable* by DEC and has been submitted for listing under Commonwealth legislation. It is a *conservation category wetland*, which has implications for management and activities which affect its health and function. The *Rights in Water and Irrigation Act* prohibits the drawing of water or construction of dams that affect its hydrology.

The condition of the wetland vegetation is very good to excellent. There is some weed invasion along the western boundary and vigorous weeds along the artificial drain, probably due to increased nutrients. This is a low nutrient environment and any increase affects the vigour of the native plants and delivers a competitive advantage to introduced plants.

Other Vegetation

Outside the remnant bushland the natural vegetation is limited to one linear vegetation unit along the southern boundary plus scattered trees and clumps of vegetation elsewhere in the southern section. The bushland along the southern boundary is marri woodland on duplex soils, covering about 1.4 hectares. The woodland condition is good, being significantly altered by high density aggressive weeds and partial clearing but retaining its basic structure, and could be regenerated with good management. The understorey retains a range of plant species including balga (*Xanthorrhoea preissii*), scattered grass trees (*Kingia australis*) and a number of sedges.

Small clumps or narrow lines of native vegetation have been retained between the southern fairways, mostly overstorey species such as marri and banksias with some balga and other understorey. This includes some very large trees with significant aesthetic and habitat values. In the shallow basins, native sedges and other wetland plants have regenerated. Some trees have been planted, including large pine trees near the bushland and non-local species on the lower slopes. A small area of sedges occurs between the polocrosse field and Hall Road. It is currently weed free but significant infestations of watsonia nearby pose a threat to its long-term survival.

Some local vegetation fringes the equestrian fields and club houses, and there are stands of marri and flooded gums on the eastern edge of the polocrosse field, including some large flooded gums with significant aesthetic and habitat value. At the corner of Hall and Karnup Roads the remnant marris have a scattered understorey of *Acacia pulchella*, with watsonia and African love grass. Small groups of marri occur around the equestrian and the golf club rooms, providing shade and habitat.

The northern section was almost completely cleared when the golf course was established. Only five or six native trees were retained as the course was revegetated with mostly non-local trees.

Revegetation has occurred at two sites within and near the remnant bushland. The Paul Robinson Reserve, between the northern and southern marri woodland, was revegetated with a variety of Western Australian plants over 20 years ago. The decommissioned go-kart track has been revegetated with a range of non-local species. A high level of weed infestation occurs in both revegetation areas, particularly African lovegrass (*Eragrostis curvula*), veldtgrass (*Ehrharta calycina*) and wild oats (*Avena barbata*). All of these weeds thrive in disturbed and open environments and require regular and intensive management.

Until recently local provenance plants (grown from local seed) were not available. The Serpentine Bushland Group planted native species that were not found in the reserve in order to avoid polluting the gene pool. Now that local provenance plants are available, there is a greater opportunity to rehabilitate and expand the local ecosystems. The ongoing fauna studies conducted by the SBG since 2001 provide evidence of the value of this revegetation as habitat linking and expanding the natural bushland.

A line of swamp mahogany (*Eucalyptus robusta*) separates the equestrian grounds and continues along the southern boundary of the polocrosse field. Trees have been planted along the eastern boundary, including *E. maculata* and *E. robusta*, and some local trees retained. Along the northern edge a line of trees was planted on either side of the cross-country track. These are river red gum (*E. camaldulensis*), now considered an environmental weed because it seeds prolifically and invades bushland, and can cross-breed with the local flooded gum (*E. rudis*). The trees are well established and have significant amenity value, particularly during summer. However, many saplings occur along the fenceline and the road reserve which could be removed. There are also stands of Victorian teatree (*Leptospermum laevigatum*) and isolated plants near horse jumps should be removed and can spread into new areas if not controlled.

A range of non-local trees were planted by the golf club between the fairways in the northern section of the reserve, including *Eucalyptus grandis*, *E. robusta*, *E. camaldulensis* and *Pinus radiata*, recommended and supplied by Alcoa Australia. The local species *Casuarina obesa* was used in the original plantings and more recent revegetation along the northern edge of the course. All of the trees are now very large and well established. Where shallow drains were created between the fairways, some rushes and sedges have become established, including local species as well as the introduced bulrush (*Typha orientalis*) which is a targeted wetland weed for removal in many areas.

Conservation Listed Flora

Flora within the remnant bushland is diverse because the area encompasses three community types and a range of habitats. Four plant species are listed under the State *Wildlife Conservation Act 1950* as Declared Rare Flora and are also protected by Commonwealth legislation in the *EPBC Act 1999*. The disturbance of DRF requires the permission of the Minister. Seven species on the reserve are listed as priority species by DEC. The conservation listed plant species are shown in Table 4.

Table 4 – Conservation Listed Plant Species of Serpentine Sports Reserve

Conservation Category	Species Name
Declared Rare Flora	<i>Synaphea stenoloba</i> <i>Tetraria australiensis</i> <i>Verticordia plumosa</i> ssp. <i>pleiobotrya</i> <i>Verticordia plumosa</i> ssp. <i>ananeotes</i>
Priority 1	<i>Synaphea odocoileops</i>
Priority 2	<i>Johnsonia pubescens</i> ssp. <i>cygnorum</i>
Priority 3	<i>Acacia oncinophylla</i> ssp. <i>oncinophylla</i> <i>Isopogon drummondii</i> <i>Lambertia multiflora</i> ssp. <i>australiensis</i>
Priority 4	<i>Anthotium junciforme</i> <i>Drosera occidentalis</i> ssp. <i>occidentalis</i>

3.3.3. Fauna

Fauna have been surveyed by the Serpentine Bushland Group and Birds Australia. The Serpentine Bushland group conducted fauna surveys in the Paul Robinson Reserve, to investigate the effectiveness of replanting, twice a year in early summer and autumn between 2001 and 2004. Species recorded during these surveys are listed in Table 5. Had surveys been conducted throughout the remnant bushland in the more intact ecosystems, it is likely that the fauna list would be more extensive.

Table 5 – Amphibian, Reptile and Mammal Species Recorded in Paul Robinson Reserve (May 2001 – May 2004)

Fauna Group	Common Name	Species Name
Frogs	<i>Crinia glauerti</i>	Glauerts Froglet
	<i>Crinia insignifera</i>	Sandplain Froglet
	<i>Heleioporus eyrei</i>	Moaning Frog
	<i>Lymnodynastes dorsalis</i>	Pobblebonk
Reptiles	<i>Tiliqua rugosa</i>	Bobtail
	<i>Bassiana trilineata</i>	SW Cool Skink
	<i>Hemiergis quadrilineata</i>	Two Toed Earless Skink
	<i>Menetia greyii</i>	Common Dwarf Skink
	<i>Notechis scutatus</i>	Tiger Snake
	<i>Lialis burtonis</i>	Burton's Legless Lizard
	<i>Varanis gouldii</i>	Goanna
	<i>Cryptoblepharus plageocephalus</i>	Fence Skink
	<i>Ramphotyphlops australis</i>	Southern Blind Snake
	Mammals	<i>Isoodon obesulus</i>
<i>Mus musculus</i> *		House Mouse*
<i>Rattus sp.</i> *		Rat*

*Introduced species

In 1998, a bird survey conducted by Ninox Wildlife Services recorded 18 species of birds within the remnant bushland, shown in Table 6. Three are listed as significant under the *Bush Forever* classification system, which includes four categories of significance for bird species: Category 1 species are listed under the *Wildlife Conservation Act 1950*; Category 2 species are listed under international treaties with Japan and China for the protection of migratory birds; Category 3 species are habitat specialists with a reduced distribution on the Swan Coastal Plain; and Category 4 species are wide-ranging species with reduced populations on the Swan Coastal Plain.

Table 6 – Bird Species Recorded at the Serpentine Sports Reserve (December 1998)

Species	Category of Significance
Common Bronzewing	3
Galah	
Red-capped Parrot	
Port Lincoln Ringneck	
Laughing Kookaburra	
Rainbow Bee-eater	
Shining Bronze-Cuckoo	
Grey Fantail	
Rufous Whistler	
Black-faced Cuckoo-shrike	
Western Gerygone	
Yellow-rumped Thornbill	3
Splendid Fairy Wren	3
Silvereye	
Brown Honeyeater	
Singing Honeyeater	
Australian Magpie	
Australian Raven	

All fauna (all native animal species) are protected throughout the State under the *Wildlife Conservation Act 1950*. However, some species have been identified as rare or likely to become extinct, including the Baudin's and Carnaby's Black Cockatoos which occur in SSR. These birds are also listed under the *EPBC Act 1999* and are therefore protected under Commonwealth legislation as well. A second category of species in need of special protection includes the carpet python, which is likely to occur in the SSR. The disturbance, or taking, of these scheduled species attracts higher penalties.

The Southern Bandicoot is listed as a Priority 4 species by DEC, meaning that it is in need of monitoring. Until 2004, fauna surveys in the SSR regularly trapped bandicoots, including young animals, suggesting a viable population, but the 2004 data indicated a population crash. The reason is unclear, although a harsh summer may have contributed. The surveys indicate that the area is rich in reptile species.

Black Cockatoos have been recorded in the Serpentine area and are known to feed on local species such as marri and banksia. Cockatoo breeding has been recorded on the Swan Coastal Plain, especially of Carnaby's Black Cockatoo in marri woodland. Whilst breeding of black-cockatoo species may not have been recorded in the bushland on SSR, it is a possibility that cannot be discounted.

Rabbits are a major problem in the bushland and need to be controlled periodically. Feral cats and foxes have also been observed in the area.

3.3.4. Threats and Pressures

The biodiversity values of the SSR vegetation have been degrading for some years, indicated by anecdotal data and a recent review of satellite images by the Peel Harvey Catchment Council. The continuation of current usage plus inadequate management is unsustainable and will lead to irreversible degradation.

Dieback (*Phytophthora* spp.)

The spread of dieback is a critical threat to much of Western Australia's bushland. Dieback is a disease that affects the roots of many species, usually leading to their death. It is caused by several fungi of the genus *Phytophthora*, most commonly *P. cinnamomi*. Susceptible plants include jarrah (*Eucalyptus marginata*), the banksia family (Proteaceae), heath family (Epacridaceae), pea family (Fabaceae), hibbertia family (Dilleniaceae), balga (*Xanthorrhoea* spp.) and zamia (*Macrozamia* spp.), while marri (*Corymbia calophylla*), kangaroo paws (*Anigozanthos* spp.), sedges (Cyperaceae) and rushes (Juncaceae and Restionaceae) are not affected.

The fungus is spread by the movement of water or soil from infected sites, or directly between plant roots. The most common means for moving the fungus to new areas are human activities, particularly vehicles. Tyres, shoes and horse hooves (which can pick up divots of soil) are recognised as vectors.

There is no known way to eliminate dieback once it has been introduced. Dieback control therefore involves minimising its spread by controlling the movement of vehicles, people and stock from affected areas into dieback free areas. It is standard management practice to:

- Route pathways to avoid crossing boundaries between dieback infected and non-infected areas;
- Provide wash-down or other hygiene facilities for vehicles and footwear prior to entering dieback free areas;
- Provide education for visitors; and
- Avoid transporting soil and plant material into dieback free areas unless guaranteed disease free.

There are chemical treatments available to mitigate the intensity of dieback. The application of phosphite (phosphoric acid) by spraying vegetation and injecting trees is an intensive management technique which only mitigates the intensity of disease, not eradicate it. The SSR bushland is ideal for treatment, usually at three to five year intervals. The highest priority areas for treatment are mapped dieback fronts.

Fire

Fire is important for stimulating regrowth and regeneration in native ecosystems, but if uncontrolled can damage property and vegetation and cause high fauna mortality. Small remnants are vulnerable to local extinctions from single catastrophic fires which burn the whole area. Although the SSR bushland is linked to other bushland nearby, community 20b, banksia woodland, is not connected to other areas of the same community. Regeneration at this site is therefore likely to lack components of the original community.

Reducing the risk of catastrophic wildfire involves maintaining fire breaks and/or controlled burning to reduce fuel loads. Direction on time of year and intensity of burns for vegetation management will be guided by advice from DEC.

Weeds

Introduced weeds comprise up to 11% of the plants in Western Australia and pose a significant threat to native plants through competition for limited resources, particularly space, light and water. Weeds flourish in disturbed sites and often out-compete the native understorey. The displacement of native plant species leads to loss of habitat for dependent fauna, but in some cases fauna use weeds for habitat.

The primary means of controlling weeds in remnant vegetation is to avoid disturbance, either direct disturbance by trampling or grazing or indirectly by increased nutrient levels, particularly in wetlands. Fire is also a disturbance that causes vulnerability to weed invasion. The second essential strategy is to reduce the vectors or carriers of weed seed, including horse manure and other introduced materials such as soil. It also includes excluding vectors such as storm-water runoff that can introduce nutrients and other pollutants, which is especially important in wetlands.

Many of the SSR weeds are grasses with wind-distributed seeds. Each plant is the potential source of many others, so it is important to control the seed source. The most effective strategy is to remove weeds from areas of light infestation first (called the Bradley method), then heavily infested areas that are adjacent to healthy areas. Other priorities include heavy infestations upwind of less infested sites.

Techniques to control the spread of seed and weed plants range from selective seed head removal to physical or chemical plant removal. Large-scale weed removal must be integrated with revegetation, otherwise the bare areas will be recolonised by weeds. The removal of weeds that provide significant habitat values also needs to be carefully planned and integrated with revegetation, including the removal of watsonia, which is commonly used by the Southern Brown Bandicoot.

Fragmentation

Fragmentation is the process of creating smaller disconnected populations of plants and/or animals. Smaller, more disconnected and poorer condition habitats will contain smaller populations with less genetic diversity and less ability to adapt to environmental pressures such as climate change. Areas of bushland can be separated by major roads, paddocks or cleared land, while tracks, fences and other barriers within bushland can interfere with fauna movement. Fragmentation also creates more edges, which are vulnerable to disturbances such as erosion, nutrient and pathogen incursions and weed invasion. Overall it decreases resilience and sustainability, reducing the chance of long term survival.

Management to minimise fragmentation requires the maintenance and/or establishment of buffers and corridors around and among remnant patches of vegetation.

Loss of Rare and Threatened Species

The SSR bushland is regionally significant in preserving several species of threatened flora, whose small and vulnerable populations are threatened by individuals who may trample plants or pick flowers. The locations and health of individual plants needs to be regularly monitored. In line with DEC management practice, this information cannot become common knowledge as this introduces further threats from plant collectors or those who might see the occurrence of threatened species as an obstacle to development. Any plans to create pathways or other activities that impact on the bushland should be referred to the Threatened Species Unit at DEC for assessment and/or advice. In particular, tracks should be located away from threatened plants. Operators of equipment need to be aware that they are required to remain on the track and not use the bush as a turning circle.

Trampling

Foot, stock and vehicle movement on plant communities causes breakage, root damage and habitat disruption. Prolonged, frequent and/or intense trampling causes degradation; such activities could widen tracks and open out dense thicket communities. Management of trampling involves keeping walkers, stock and vehicles on designated tracks, and not creating new tracks.

Erosion

Wind erosion and colluvial movement of soil on the walls and floor of the sand pit could erode the surrounding communities and prevent or suffocate natural regeneration. The sand pit area requires mulch or brush cover to reduce erosion and provide better conditions for regeneration or revegetation.

Acid Sulphate Soils

The exposure of acid sulphate soils by excavation or lowering the water table results in plumes of sulphuric acid moving through the groundwater. If this occurred in the SSR it would affect the vegetation, particularly wetlands connected to the groundwater table, and impact on aquatic communities. The acid reacts with clay soils to release heavy metals that can impact directly on surrounding ecosystems and can be transported through ground and surface waters to impact on ecosystems further afield. Management of potential acid sulphate soils focuses on avoiding their exposure to air as a result of excavation or lowering the water table.

Drainage and Drawdown

Lowering of the water table as a result of bore usage in and adjacent to the SSR could affect all plant communities, particularly the wetland community, which is dependent on hydrological balance. Groundwater extraction and water course modification requires State Government assessment and approval to ensure regulation and minimal impact.

Feral Animals

Feral animals are an ongoing threat to the flora and fauna of bushland remnants. Rabbit colonies can seriously disturb vegetation and limit regeneration, and impact on local fauna through competition for food and habitat removal. Foxes and cats (feral and domestic) pose a direct threat to small birds and

mammals such as the Bandicoot. Feral rodents thrive in adjacent agricultural and equine properties, and most likely also occur in the SSR bushland where they would compete with native fauna. Feral honey bees compete with native bees, in some cases preventing the pollination of specialized plants, and take over the nesting hollows of native birds and other animals.

Feral animal control relies on a variety of techniques, including trapping and poisoning. Current reserve usage and proximity to populated areas limits management options. Feral animals pose a threat to the biodiversity values of the SSR, and monitoring and quick response is the best way to deal with outbreaks.

Appreciation, Awareness and Understanding

A lack of appreciation of the importance of protecting biodiversity, and a lack of understanding of threatening processes, is a significant threat to good management. Awareness-raising programs for user group members, through (for example) newsletters, guided walks and presentations, should be extended to all users of the reserve, using techniques such as sporting event briefings and interpretive signage.

Climate Change

To cope with the stresses of climate change, vegetation must remain healthy and support a large and diverse population. This requires careful management of threatening processes, and positive action to increase ecosystem resilience. Climate change is likely to cause a general southerly shift in species distribution, and significant southerly extensions to the distributions of some species have already been recorded. The availability of ecological linkages will play a vital role in facilitating this shift.

Fire Management

Fire is important in conjunction with herbicide usage to control weeds. Controlled burns within the Vegetation Management Zone will be planned to affect small areas at a time (200 – 300 m²) in a mosaic pattern. Specific biodiversity values (i.e. DRF or TECs) will be taken into consideration, utilising advice from DEC. DEC supports a 12 to 13 year minimum inter-fire interval. DEC and the Shire have flora lists which will also be considered. The Shire's Emergency Services Manager is responsible for coordinating controlled burns in conjunction with Environmental Services in significant local natural areas.

In many cases the management areas will be delineated by existing tracks to avoid further disturbance. In order to achieve mosaic burning, minor existing tracks will be utilised wherever possible. Alternatively, least impact tracks such as 'kangaroo tracks' will be chosen, with rake hoe tracks (hand trails) being reinforced with wet lines, as currently used by local government and DEC as best management practice.

Fire intervals will be determined by fuel load and interval between burns, with the aim being intervals of at least 12 years and/or fuel levels between 8 and 12 tonnes per hectare. Only small areas will be burned at any one time, and burning will be done in a variety of seasons within safe limits, using spring and autumn burns. Factors such as weather conditions, wind and soil moisture availability will ultimately determine the timing of prescribed burns.

3.3.5. Environmental Characteristics: Biodiversity Strategies

Issue	Target	Priority	Strategy	Responsibility
14. Conservation values are very high within the Bush Forever area of the reserve.	Investigate and implement the inclusion of “conservation” as a purpose for the bushland area of southern section of reserve.	Medium	a) Investigate potential options and seek Council advice toward recognising “conservation” as a purpose for the southern section of the reserve.	Shire to coordinate with input from SSRMC and RAG
15. Dieback disease is already present within the bushland area, and has the potential to cause local extinctions and significantly alter community structures.	No increase in the area of bushland infected by dieback.	Key	a) Map dieback distribution within the bushland areas, zone dieback free areas as high conservation, and manage any tracks through dieback free areas (where they cannot be closed) without unreasonably impacting on existing uses. b) Treat vegetation for dieback by spraying and injecting vulnerable plants at 3 to 5 year intervals. c) Raise community awareness (such as by provision of signs, club newsletters, event briefings etc.). d) Raise the awareness of staff, volunteers and contractors of appropriate dieback hygiene procedures and ensure they are adhered to. e) Minimise risks of disease spread by: <ul style="list-style-type: none"> • Where practical, reconciling the alignment of tracks with dieback fronts; and • Otherwise, ensuring tracks are constructed with appropriate materials and suitable buffer zones maintained on either side by spraying with a dieback treatment and trimming vegetation at recommended intervals. f) Liaise directly with Shire Officers for identification, protection and management of important flora. g) Construct barriers where necessary to prevent pedestrian and stock traffic from crossing dieback fronts or important areas of flora. h) Minimise risks of disease spread by adopting dieback hygiene processes including: <ul style="list-style-type: none"> • Construction and maintenance work to be undertaken in dry conditions only; • Wash-down of vehicles and footwear prior to commencing construction or maintenance work in the bushland area; • No material (e.g. soil and pathway surfaces) to be introduced into the bushland area unless guaranteed dieback free. 	Shire to coordinate with involvement of all stakeholders
16. The level of knowledge in relation to the biodiversity values is	Databases of biodiversity values to be established.	Medium	a) Review fauna surveys and gather additional information. b) Liaise with Birds Australia in relation to continuing bird surveys.	Shire in partnership with DEC, WA Museum, bushland and bird groups

Issue	Target	Priority	Strategy	Responsibility
low.			c) Maintain a limited access inventory of declared and priority plant species, with annual inspections of plants. d) Monitor Black Cockatoos' usage of the reserve.	
17. Many weeds out-compete indigenous plants, causing significant changes to species compositions and habitat structure.	All bushland currently free of weeds to remain so. No weeds to occur within the northern and western sections of the banksia woodland. At least 50% of bushland infected with weeds to be weed free within two years from the date of endorsement of this plan, rising to 75% within four years and 80% within six years.	Key	a) Map weed distribution within the bushland, and compare with previous maps. b) Prepare a weed control program by identifying and prioritising weed affected areas, including sources of weed seed outside the bushland area. c) Remove weeds with physical and chemical treatments in accordance with the weed control program. Mulch, brush, seed, or plant treated areas with local native plants. d) Minimise disturbance and weed introduction and actively remove weeds from the bushland area through: <ul style="list-style-type: none"> • Maintaining the number and width of tracks but disallowing the development of new tracks without prior approval; • Diverting nutrient rich surface drainage away from bushland areas; • Picking up all traces of manure by stock owners in the bushland area within 12 hours of deposition; • Picking up all traces of bedding and stock feed from the bushland area within 12 hours of use; • Raising the awareness of all users of the importance of minimising weed spread (by event briefings etc.); • Removing all <i>Eucalyptus camaldulensis</i> saplings and regrowth plants. 	Shire to coordinate with involvement of all stakeholders
18. Feral animals predate native species, compete with them and destroy their habitat.	All nests of feral bees and rabbit warrens to be eradicated from the southern section of reserve and thereafter excluded.	High	a) Maintain records of feral animal sightings and monitor southern section of reserve annually for rabbit warrens. b) Destroy rabbit warrens and feral bees' nests where required. c) Raise awareness among surrounding landowners about the damage done by feral cats and other animals and encourage owners to restrain pets and control pests on their land. d) Disallow the placement of bee hives anywhere on the reserve.	Shire to coordinate with the participation of all stakeholders
19. Disturbance to and fragmentation of bushland areas results in loss of biodiversity and vulnerability to local extinction.	Compliance with State and Commonwealth legislation, policies and recommended procedures for biodiversity protection. No loss of remnant vegetation. No tracks through the bushland	High	a) Prepare and implement a bushland rehabilitation plan, including weed management and rehabilitation criteria. b) Map locations of listed flora and maintain records of health of individual plants or clumps. c) Raise stakeholder awareness of the requirements for approvals under State and Commonwealth legislation and policies. d) Map bushland condition periodically and compare with previous maps. e) Monitor track width within banksia woodland and adjust	Shire to coordinate with DEC and all stakeholders

Issue	Target	Priority	Strategy	Responsibility
	<p>area to increase in width.</p> <p>Prepare and implement a bushland rehabilitation plan, including weed management and rehabilitation criteria.</p> <p>All areas previously or to be rehabilitated to be managed adaptively to approximate the community structures of natural reference communities.</p>		<p>access to achieve target of no vegetation loss in bush areas through demarcation and barrier installation.</p> <p>f) Review tracks through marri woodland and narrow to a minimum safe width for cross-country riding events.</p> <p>g) Rehabilitate all but essential designated tracks through the bushland, the sand pit, previously weed infested areas, Paul Robinson Reserve, old go-kart track, vacant areas where remnant vegetation abuts cleared or weed infested land, and the banks of water courses and artificial wetlands, including some of the golf course swales.</p> <p>h) Recreate the dominant species, growth forms and community structure of identified natural reference communities.</p> <p>i) Limit collection of indigenous seeds and cuttings to propagation of plant material for local rehabilitation only.</p> <p>j) Disallow use of marri woodland community for stock yards, camping and parking and establish alternative overflow stockyards, camping and parking facilities for polocrosse club.</p> <p>k) Work with neighbouring land managers to encourage responsible management of ecological linkages.</p> <p>l) Review all fencing and replace if necessary with a design that will not form a barrier to wildlife.</p>	
<p>20. Fire management, including suppression and controlled burning, are planned in the context of a reserve fire management plan for protecting people, property and conservation values as well as managing to conserve biodiversity.</p>	<p>Fire to be used as a management tool to enhance the reserve's biodiversity values and to reduce fuel loads to reduce risk and damage associated with unplanned fires.</p>	<p>High</p>	<p>a) Update and seek approval for a Reserve Fire Management Plan in conjunction with relevant State agencies (including TEC experts from DEC) and Commonwealth Departments.</p> <p>b) Ensure all burning in the reserve conforms to this plan.</p>	<p>Shire to coordinate with the participation of all stakeholders</p>

4. Social and Economic Characteristics

4.1. Indigenous Heritage

4.1.1. Description

Local Aboriginal people are part of the Noongar community, whose territory covers the area southwest of a line from Geraldton to Esperance. Prior to European settlement, family groups in the Serpentine region were part of the Whadjug tribe. During the post-European settlement period, forced migration to Aboriginal settlement camps or into areas where labour was required resulted in a shift of tribal groups.

Noongar family groups did not have permanent places of habitation and generally moved along major river systems, such as the Serpentine and Murray River systems, or chains of freshwater bodies. The family groups would camp at favoured points along these trails, where food and water resources were reliable, for short periods of time. The use of food from these systems still occurs today.

The water systems are spiritual places for Aboriginal people. Local tradition records that Waugal, the dreaming ancestor, created the Murray and Serpentine river systems. The Waugal is a spiritual force with a physical serpentine manifestation that is widespread throughout the southwest region. Most of the major rivers that drain the Darling Range, and many creeks, springs, pools, swamps and lakes within the Swan Coastal Plain, are associated with the Waugal belief.

The SSR lies on a level to undulating plain, much of which used to be inundated swamp land during the winter months. The wetland areas within the reserve would have been used as a source of food and may have held spiritual meaning for the local Aboriginal people. Aboriginal people maintain a responsibility to care for their country, but information relating to the nature of any specific spiritual connection with the SSR area was not available for this management plan.

The Swan Coastal Plain has a high density of Aboriginal archaeological sites, associated with the richness of food resources. The Department of Indigenous Affairs, under the *Aboriginal Heritage Act 1972*, currently has 46 sites listed within the Shire's boundaries. Under this Act, all places and objects of Aboriginal importance are protected.

The Serpentine River is listed on the register of mythological and ceremonial sites, but the exact locations of areas of particular value along and near the river remain unpublished to assist with their protection. Instead, registered sites include a wide enough buffer to encompass all the Aboriginal values that occur in the vicinity. It is through this process that the SSR is encompassed within the buffer and therefore formally listed as a Heritage site under the *Aboriginal Heritage Act 1972*.

A Native Title Claim currently exists over land extending from Garden Island south to a point due west of Capel, east to Kojonup, north to Corrigin and west back to Garden Island, encompassing an area of 30,424.531 square kilometres. The Shire of Serpentine Jarrahdale is included in this Claim area. Native Title enables local Aboriginal people to have their rights and interests in land and waters under traditional laws and customs recognised under Australian law.

The Gnaala Karla Booja claim which resides over the Shire was submitted to the National Native Title Tribunal for registration on 17 September 1998, and passed the registration test the following year. With the Gnaala Karla Booja Claim having passed registration into mediation, this gives the claimants the right to negotiate in relation to land management issues on lands subject to the claim. However, in 2002 a determination was made that Native Title is extinguished on Crown Lands that were vested prior to December 1996, and this is the case with the northern section of the reserve. It is also likely that Native Title has been extinguished over the freehold land which constitutes the southern section of the reserve. Administration of the Gnaala Karla Booja Land Claim is being co-ordinated by the South West Aboriginal Land and Sea Council, and although Native Title has been extinguished over the reserve, the Shire is required to notify this body of any intended public works and to give claimants the opportunity to document their concerns.

To date no formal consultation has occurred with either the South West Aboriginal Land and Sea Council or local Noongar people regarding management of the SSR, nor is there any Indigenous representation on the current Serpentine Sports Reserve Management Committee.

A lack of effective consultation with Noongar people and their representatives may result in management practices not guided by traditional laws and customs. This could lead to poor management decisions, conflict of use on the reserve and the degradation of Aboriginal values.

4.1.2. Social and Economic Characteristics: Indigenous Heritage Strategies

Issue	Target	Priority	Strategy	Responsibility
21. Aboriginal people have a right to be informed of public works on the reserve, but there are no Indigenous representatives currently involved in reserve management.	Establish and implement an effective process for ongoing Aboriginal liaison.	High	a) Administrate the RAG with membership of at least one person who can speak for local Indigenous people as required. b) Ensure that minutes from SSRMC and RAG meetings are exchanged. c) Consult the South West Land and Sea Council and South West Catchment Council for advice on other appropriate liaison processes and implement as appropriate.	Shire to coordinate with involvement of SSRMC and RAG members
22. Aboriginal names have not been used for places or events on the reserve.	When naming a place, structure or event give consideration to Aboriginal names.	Medium	a) When naming a place, structure or event give consideration to Aboriginal names, seek advice from Aboriginal representatives and obtain approval for the use of appropriate names from the South West Land and Sea Council and the Shire Council.	Shire and stakeholders
23. Reserve visitors generally do not know about Indigenous perspectives on areas in and around the SSR.	Provide interpretive material for visitors to the reserve about Indigenous perspectives.	High	a) Develop an interpretation plan for the reserve that takes account of Aboriginal heritage values.	Coordinated by Shire with involvement of all stakeholders

4.2. European Heritage

4.2.1. Description

In March 1827, Captain James Stirling arrived in the Swan River and pronounced that the land possessed great natural attractions. This led to the foundation of the Swan River Settlement in June 1829. Soon after, in 1830, Mandurah was established and settlers started to move up the Murray River in search of agricultural land. Remnant bushland on the reserve provides a glimpse of what the settlers encountered.

Around this time explorers ventured up the Serpentine River, but due to navigational difficulties, settlement was delayed. The area was initially part of a massive 250,000 acre land grant to Thomas Peel, stretching from Wungong (near Armadale) to Pinjarra and out to the coast. However, the nature of the land and vegetation, and the availability of good agricultural land elsewhere, ensured that much of the Peel Estate remained in its natural state for many years.

Some farms were established along the Serpentine River between the scarp and the present town in 1865. These were smallholdings, the largest only a few hundred hectares. At this time the Serpentine settlement was established on the river at the foot of the scarp, about 1 km east of its present location, but in 1893, with the Perth to Bunbury railway almost complete, the present Serpentine townsite was gazetted.

Major agricultural development of the area occurred with the implementation of the group settlement scheme in the early 1920s. Land from the Peel Estate was bought by the Government and made available to settlers from England. They were organised into groups and paid a small allowance while they developed their land for agriculture. The sandy soil and persistent winter inundation of much of the area made the transition from native bushland to farmland particularly difficult.

A program to drain the group settlement areas of the Peel Estate began in 1922. Large drains were cut with the aid of horse-drawn carts and finished by hand, a challenging task as they were dug during the middle of summer to avoid inundation. By 1925, 540 km of drains had been completed. The drainage network was later expanded, and the administration and management of most of the drains was taken over during the 1950s by the Public Works Department, later to become the Water Corporation.

During the early 1920s, horse racing was held on the southern section of the reserve. The race track was located on the eastern edge of the reserve, with the track extending over what is now the John Lyster Polocrosse Ground and part of the David Buttfeld Equestrian Park. The grandstand and finishing post was located near the current railway station. Horse racing lasted for 3 to 4 years.

In 1925, Lot 778 Karnup Road, which is the southern section of the SSR, was vested as a reserve for the purposes of Recreation, Racecourse and Showgrounds (R19134). It is likely that it had been used for recreation prior to vesting, but no records exist. In 1925 Reserve 19134 was transferred to the Serpentine Jarrahdale Road Board by the State Government, and is still owned by the Council. The northern section was vested in the Shire as a reserve for the purposes of Recreation and Showground in 1965.

In 1934 the Serpentine Agricultural Show began when interest in the race meetings waned. This was organised by the local agricultural community and well patronised. The show was originally split between the SSR and the grounds at the RSL club house in the town of Serpentine. However, all show activities were located on the SSR from 1950, and this arrangement continued until 1960 when the Serpentine Agricultural Society disbanded and the Show was replaced by a rodeo which used the grounds until 1969.

A scout and guide camp site was located at the western end of the bushland adjacent to the dam. Some years ago, leaders were requested to move to a more degraded section of the bush further south, but the area has not been used by the scouts and guides since.

The Whittaker's Brothers Timber Company built a steam-driven mill in the southern section of the reserve, where the remains of the go-cart track are located today, opening in 1944. It had an average intake of 2200 cubic feet of raw wood a day, producing about 800 cubic feet of sawn timber, primarily for the housing industry and railway sleepers. Logs were delivered to the mill by trucks from the extensive Whittaker's Bros. timber leases in the jarrah forest. After milling, the timber was transported to Subiaco and Midland by rail. The railway spur line entered the reserve where the Hall Road entrance is today, and relicts of this old line can occasionally be found.

The mill was a major part of the post-war rejuvenation of Serpentine and a major employer, providing jobs for 40 local men. However, in 1964, sawmill technology changed dramatically and the Serpentine mill became inefficient and unproductive by comparison. Whittaker's Bros. built a new mill in Kewdale in 1964/5, employing only 6 local men. As a result the local mill was closed and dismantled. Whittaker's Bros. had built 10 houses and the State Housing Commission 8 duplexes along Lefroy Street, to provide accommodation for mill employees. Many of these houses are still lived in today, representing an important part of the built heritage of the Serpentine townsite.

The SSR was initially managed by the Greater Sports Ground Committee from 1949. In 1953 the committee became the Serpentine Sportsman's Council, which was the key organising body for events at the reserve. This group coordinated the development of football, cricket and the equestrian clubs at the reserve until its lease expired in 1976. Even then the Sportsman's Council remained the only organised body to coordinate activities at the reserve.

Organised sporting activities began at the reserve in 1947 when the Serpentine Football Club cleared an area for a football field, covering parts of what is now the John Lyster Polocrosse Grounds and David Butfield Equestrian Park. The football club continued to use the grounds until the mid-1980s. In 1963 the local cricket club was granted permission by the Serpentine Sportsman's Council to construct a pitch on the reserve, which was used until the mid-1980s.

Both polo and polocrosse used to be played on the SSR. However, the reserve has not been used for polo for over 10 years. Polocrosse has been played in the district since the late 1930s when local farmers Jim Henderson and Ivan Elliott introduced the sport. The sport was initially played on suitable paddocks in the locality, but players began to use the SSR in the 1970s. In the 1980s the club became the Serpentine/Foothills Polocrosse Club. The club uses the Ivan Elliott Pavilion, named in honour of Ivan Elliott who volunteered his time and money to the promotion of the sport. The club also uses the John Lyster Ground, which was named in the 1990s in memory of a longstanding and active member.

The Serpentine Horse and Pony Club was initiated and affiliated with the Western Australian Pony Club Association in 1964 and a request was made to the Serpentine Sportsman's Council to use the reserve for events and training. They held their first event in 1967 and remain a thriving club at the reserve today. In 2003 the Horse and Pony Club grounds were named the David Butfield Equestrian Park in memory of Councillor David Butfield who supported the club and the upgrading of their facilities.

In 1964, the Serpentine and Districts Golf Club (SDGC) was formed as an incorporated organisation with the aim of developing an 18-hole golf course at the SSR. The first nine holes were constructed by members between 1964 and 1970 in the southern section of the reserve. Competition started in 1971. At

this stage, the course was not irrigated and it was quite dry in the summer months. In 1976 holes 10 to 18 were developed on the northern section of the reserve with the assistance of the mining company Alcoa.

During 1971 the Serpentine Go-Kart Club developed a high-quality bitumen track on the old mill site in the southern section of the reserve. This track was used regularly for practice and competition. However, by the end of 1986 the track had closed down after numerous requests by residents and a public meeting about noise and relocating the facility. Council has no further records regarding this activity.

In 1971, the Netball Association also began searching for a suitable site to hold seasonal competitions. The SSR hard courts were used for regular competition by the club, with lights being installed for night games and a playground for children. Netball was played at the SSR until the mid 1990s, but the club is now part of the Serpentine Jarrahdale Netball Association which uses alternative grounds in the district.

The Paul Robinson Reserve, located in the southern section, was named after a local Serpentine volunteer fire-fighter who was just 22 when he lost his life whilst fighting a bushfire in the area. Paul Robinson had helped to revegetate this section of the reserve as part of the Landcare and Environmental Action Program. The Serpentine Bushland Group Inc. is still actively involved in the Paul Robinson Reserve and other bushland areas, both on the SSR and in other areas around Serpentine. They undertake weed control and revegetation works, and promote biodiversity through educational sessions. The group has been operating in the reserve for over ten years.

Whilst compiling this section of the management plan it became evident that records had been lost and this has inevitably reduced accuracy. To ensure that this does not occur in the future, comprehensive and accurate records of activities and developments need to be maintained from now on.

There are no obvious historical remains on the reserve. However, if visitor experience is to be enriched by knowledge and understanding of cultural heritage, it could be interpreted through signage on site, displays at the local museum, school programs and other publications. The names of buildings and grounds, plus the sawmill site, would provide interesting focal points for interpretive signage. A historic trail through the town site and reserve could also be given consideration.

4.2.2. Social and Economic Characteristics: European Heritage Strategies

Issue	Target	Priority	Strategy	Responsibility
24. Historical records relating to the SSR are scarce and scattered.	All developments and activities to be documented and archived from the date of endorsement of this plan.	Medium	a) All stakeholders to provide a summary of their developments and activities for SSRMC meetings. b) Stakeholder summaries of developments and activities to be incorporated in formal minutes of meetings, and files maintained and archived.	Coordinated by Shire with involvement of all stakeholders
25. Reserve visitors generally do not know of the European history of the SSR and surrounding areas.	Raise visitor awareness of local European history.	Medium	a) Develop an interpretation plan for the reserve that takes account of European heritage values.	Coordinated by Shire with involvement of all stakeholders

4.3. Recreation

4.3.1. Description

Sport, recreation and active lifestyles are vital for individual and community health and well-being. The social, emotional, psychological and physical benefits of sport and recreation are well known.

The State Government document *Strategic Directions for Western Australian Sport and Recreation 2003 - 2005* provides a vision for the sport and recreation industry:

Lifelong physical activity and sport and recreation participation is valued as a cultural trademark of Western Australian society.

It also provides a state-wide perspective on sport and recreation outcomes, shown in Table 7.

Table 7 – Sport and Recreation Key Areas and Outcomes

Key Focus Areas	Outcomes
Industry development	A cohesive industry that provides a framework to optimise the social, economic and health benefits of sport and recreation
Organisational development	Organisations that provide sport and recreation services that are effective viable and responsive to their stakeholders
Participation	A more physically active society in which sport and recreation maintains and increases its contribution to community well being
High performance	Excellence is achieved in sporting performance
People development	All providers of sport and recreation in Western Australia are well informed, skilled and resourced
Infrastructure	All Western Australians, regardless of the level at which they participate, their means or geographical location, have access to quality sport and recreation facilities.

Source: *Strategic Directions for Western Australian Sport and Recreation*

The document also recognises the following issues as some of the key challenges for the next few years:

- Implementing legislative reforms to address the public liability crisis and risk management while balancing the interests of both service providers and consumers;
- Increasing the activity levels of target groups with low participation rates (e.g. seniors, people with disabilities, adults with young children, Indigenous people and adolescent girls);
- Applying contemporary principles of human resource management to volunteer personnel to provide improved volunteer management practices; and
- Embracing sustainability principles in design and management of sport and recreation infrastructure planning and development.

A report entitled *Recreation Planning for the Shire of Serpentine Jarrahdale* was published in 2002. The Shire is considered in two regional recreation planning documents, which discuss the equine industry and mention golf facilities at SSR, but passive recreation is not addressed.

The State equestrian centre is located at Brigadoon in the northern suburbs of Perth. The *South East Regional Sport and Recreation Facilities Strategy Plan (1998)* recognises the need to develop a regional level equestrian facility in the southeast corridor to accommodate a wide range of equine sports, stating:

It is recommended that a regional, multipurpose equestrian centre be established in the Serpentine Jarrahdale area, in a location which is likely to be zoned "Rural" in the long term, suitable for activities such as polocrosse, pony club, show jumping, rodeo, camp drafting and riding for the disabled.

The proposed multipurpose equestrian centre could be a principal attraction to the region, and specifically to the Shire. The *Report on Recreation Planning for the Shire of Serpentine Jarrahdale 2002* takes up the concept. Additional grassed areas could be provided for sport, festivals and other community events, integrating with the golf course and allowing for the possible development of an indoor recreation centre.

The *Peel Regional Recreation Facilities Plan* identifies the need for a quality equine facility in the Peel region. The plan identifies SSR as a potential location, though it predicts the need for additional land to complement it, and recognises the potential for competing interest between venues throughout the region.

The SSR golf course is recognised in regional and Shire recreation planning documents as the only course within the Shire, and it is therefore important in servicing the whole district. The golfing facilities at SSR are well developed, so the documents do not identify the need for any additional development other than a current small lease area for a communications facility.

There are five organised user groups whose members regularly use the SSR:

- Serpentine and Districts Golf Club Inc. (SDGC);
- Serpentine Horse and Pony Club Inc. (SH&PC);
- Serpentine/Foothills Polocrosse Club Inc. (SFPC);
- Serpentine Bushland Group Inc. (SBG); and
- Serpentine Primary School (SPS).

The first four groups interface formally with each other and the Shire through the SSRMC.

Apart from providing physical health benefits to participants, the clubs provide opportunities for local people to interact with each other and meet people from other areas with similar interests, building a sense of community, belonging and local ownership. Through participation and achievement, members build confidence and self-esteem and have the opportunity to develop team and leadership skills. The reserve also has a broader social function in providing and maintaining bushland areas for education and scientific purposes and as a place where people can experience nature.

4.3.2. User Groups

Serpentine and Districts Golf Club Inc. (SDGC)

The SDGC has been developed and is managed by volunteers from the local community. The club's constitution lists its objectives as follows:

- *To promote the game of golf and to encourage social activities between members of the club and others.*
- *To establish, maintain and conduct the golf club for the accommodation of the members of the club and their guests and generally afford them all the usual privileges, advantages, conveniences and accommodation of a club.*
- *To acquire by purchase, lease or otherwise golf course and grounds at Serpentine and to lay out, prepare and maintain the same for golf and to build or otherwise provide clubhouse and other convenience in connection therewith and to furnish, alter, enlarge, prepare and maintain the same and permit the same to be used by members and others.*

- *To provide and hold, either alone or jointly with another association, club or persons, meetings, competitions and matches for the playing of golf and to offer or contribute towards prizes, medals and awards thereof and to promote, give or support dinners, balls and other entertainment.*
- *To apply for and obtain a licence issued under the Liquor Licensing Act 1988.*

The golf course has 18 holes with irrigated grass fairways, turf tees and oil-sand greens. The first 9 holes are in the southern section of the SSR and holes 10 to 18 in the northern section. The Club leases the land from the Shire, and is responsible for its management and improvement.

The SDGC has operated on the SSR since 1964 and all of the work to create the course has been undertaken by members of the club. Holes one to nine were developed between 1964 and 1971 and competitions began in 1972. Holes 10 to 18 were developed in conjunction with Alcoa in 1976. An irrigation system was installed on the fairways in 1999/2000. Members carry out all ongoing maintenance work, including mowing and servicing of the irrigation system. This effort and investment by the SDGC has resulted in the development of the best sand-green golf course on publicly owned land in the region.

The SDGC has a private membership of over 200 people, drawn mostly from the local community and adjoining shires. The number of members has doubled during the last ten years but is currently stable. Public players are welcomed, and with low green fees, the course is popular with non-members, particularly pensioners and shift workers. The SDGC is affiliated with the Darling Range Golf Association, and thereby linked to State, national and international golf associations.

The SSR golf course is used all year, but members are more active during the cooler months. Informal competitions are held through the week over the whole year. A major competition is held during the long weekend in June, which attracts around 140 players. There are open days for men and women once a year, which attract 100 to 140 players from over 15 different clubs. Once every four years the SDGC hosts the Darling Range Golf Championships, and held the State Sand Green Championships in 2008.

Social clubs from around the metropolitan area use the golf club facilities for the occasional day in a rural setting. The visitors play golf and follow with a barbeque picnic. The clubhouse is occasionally used by the local community.

The club facilities are adequate for the current use. The club holds a Restricted Liquor Licence that puts constraints on the number of people that can use the club, and would need to upgrade the conveniences and other facilities to cater for more than 200 people. Ongoing improvements to the facilities are carried out as materials and funds become available.

The club fairways are generally in good condition, but with winter drainage problems in several areas. There is regular flooding of the fairway south of the club house where the central Water Corporation drain crosses over. While this causes few problems, flooding in the southeast corner adjacent to the wetland and in the far northern section of the course is more disruptive. Proposals to raise the height of, or increase drainage from, flooded areas would be assessed by the Shire, but additional feasibility and environmental impact studies may be necessary. Water use, reuse and drainage are considered further in the water section of this management plan.

Serpentine Horse & Pony Club Inc. (SH&PC)

The SH&PC states in its constitution that its objectives are:

- *To encourage young people to ride and to learn to enjoy all kinds of sports connected with horses and riding.*

- *To provide instruction in riding and horsemanship and to instil in members the proper care of their animals and gear.*
- *To promote the highest ideals of sportsmanship and loyalty thereby cultivating strength of character and self discipline.*
- *To hold horse and pony sports for young people under the age of 25 years.*

The SH&PC seeks to be a leading and innovative pony club. It has been conducting activities at the SSR since 1956 and the Club has been affiliated with the Pony Club Association of Western Australia since 1964, which sets rules and guidelines that clubs must obey.

Membership of the SH&PC is over 100 riding members. All junior members under the age of 18 must be accompanied by a parent or guardian whenever the club conducts events as a condition of insurance. Members come from all over the Peel region, encompassing Byford, Mandurah and Baldivis. The club does not plan to increase the number of members, as a larger membership would strain the administration and management of club activities and impact on the social values inherent in a small club.

The pony club season runs from February to November and includes a variety of events. The grounds are known as the David Butfield Equestrian Park, an irrigated turf surface that was substantially remodelled to improve drainage. The club also uses a national standard 3000 m one day event track, which traverses sections of the bushland and is used three times a year for events and once for training. The dimensions and features of this cross-country course are defined by the State body, the Pony Club Association.

There is one rally for members every month during pony club season (10 per year), for training, practice and coaching. There are three one day events, three gymkhanas, two dressage testing sessions and up to four closed training sessions for members. These events are very popular, with all open events attracting participants from as far as Geraldton and Esperance. The One Day Events generate a principal income stream for the SH&PC.

The numbers of horses and people at pony club events is shown in Table 8, with 15-30 horses for officials also present.

Table 8 – Number of Horses at Pony Club Events at Serpentine Sports Reserve

Event	No. of Horses	Frequency	No. of People
Club Rallies	Average of 80 horses	10 per year	200
One Day Events	Approximately 130 horses	3 per year	400
Gymkhanas	Approximately 60 horses	3 per year	180
Dressage	Approximately 80 horses	2 per year	180
Closed training sessions	20 to 50 horses	4 per year	50 to 150

Camping occurs three to five times a year, associated with major events, when up to 50 people use the club house and shed facilities. Overnight camping on site is cheap, making the excursion more affordable. Camping provides additional opportunities for social contact, and has taken place for several years.

Serpentine/Foothills Polocrosse Club Inc. (SFPC)

The SFPC constitution lists the following objectives:

- *The organisation advancement in carrying out the sport of polocrosse, the training of umpires and other equestrian activities.*

- *The encouragement of the breeding of horses for the purpose of polocrosse and other equestrian activities.*
- *To participate in regular matches throughout the state and/or elsewhere.*

These were developed many years ago and the club now operates with the following working objective:

To develop and support individuals participating in the sport of Polocrosse through a locally based, community minded club. The emphasis is on a family focus without discriminating against race, religion, age or ability.

The club has been operating at the reserve since 1986. It seeks to be recognised as the leading polocrosse club in the Central Zone and constantly sets new benchmarks when developing its resources and facilities.

The John Lyster Polocrosse Ground is in the northeast corner of the southern section of the reserve. The polocrosse season runs from February to November, although the SSR is not used during the wettest months when the ground is inundated. Members assert that this is the best polocrosse ground in the State because of the quality of the irrigated turf. The ground accommodates four polocrosse fields, allowing eight teams to play at any one time.

The SFPC has 40 playing members, about one third of whom are juniors under sixteen, the highest proportion in the State. Juniors pay no club fees to encourage club development and ensure the continued growth and development of the sport. Membership has been steadily increasing, and several SFPC members have progressed to State and national teams.

The SFPC hosts three major carnivals during the season, which attract people from as far as Geraldton and Albany. These carnivals run across a weekend and twenty teams, each with six players, participate in the competition. Each team plays at least two games per day. Members practice at least once per week during the season and this includes coaching of individual members.

The polocrosse grounds are of sufficient standard to be used for State and national competitions, and it is the goal of the club to host these competitions in the future.

The pavilion provides ample facilities for the club's activities and enhances their operations significantly. In particular it provides teaching facilities for the training of umpires. Over the longer term, members hope that the drainage problems can be solved so that the grounds can be used all year round. Prior to the allocation of Shire resources towards raising the height or increasing drainage, the Shire would seek additional information from a detailed analysis of needs, benefits, impacts and costs. Water use, reuse and drainage are considered in the water section of this management plan.

Overnight camping on-site makes the excursion more affordable and provides additional opportunities for social contact. However, many campers have used the Bush Forever site (which is no longer permitted), leading to problems, particularly with toilet waste and dogs.

Serpentine Bushland Group Inc.

The stated mission of the Serpentine Bushland Group is to improve and maintain the bushland and ecosystem linkages within a five-kilometre radius of the Serpentine townsite, and to raise awareness within the local community about the value of the SSR bushland.

The SBG formed over 10 years ago in response to concern over the degradation of bushland in the SSR, and in recognition of the unique ecosystem of the banksia woodland near the sandpit. The SBG has a core membership who regularly conduct activities focused on the protection and restoration of ecological

values of Serpentine's bushland and is closely aligned with other landcare and bushcare groups in the district through the Landcare Centre and Land Conservation District Committee.

The SBG has been active in areas from Mardella to Serpentine, but their main activities have centred on the SSR, the Lambkin Nature Reserve adjacent to the SSR, the Bradby Nature Reserve and the railway reserve. Most of these areas are recognised as regionally significant bushland under *Bush Forever*, and contain State listed threatened ecological communities and declared rare flora.

The SBG's activities include revegetation, fauna surveys, remnant fencing, weed management, and working with school groups. Trapping surveys have been conducted in the SSR for over ten years, significantly increasing understanding of how native fauna use the reserve. They have a regular biannual trapping program in the Paul Robinson Reserve to investigate the value of the revegetation for fauna.

The SBG has focused on three revegetation projects in and around the bushland on the SSR:

- The Paul Robinson Reserve, which links the north and south sections of marri woodland;
- The disused go-cart track area, which provides a linking and buffering function for the native communities and reduces the weed burden; and
- The sandpit area, which has been seeded with local species.

The SBG is also active in weed control.

The SBG has a close relationship with the Serpentine Primary School. Students and some parents have been involved in the fauna surveys, seeding and revegetation projects in the SSR.

The group aims to expand their membership, to involve more of the community and provide a greater labour pool to manage and carry out activities. SBG would like to continue and expand the current educational function of the bushland and revegetated areas through involvement with schools and the development of walk trails to provide better access. Overall, SBG would like to continue to educate children and adults, so that they will understand and appreciate the unique natural values of the area.

Serpentine Primary School

The Serpentine Primary School uses the SSR as a focus for the values of social and civic responsibility and environmental responsibility. The students have taken measurements of environmental variables between 1996 and 2001 in and around the SSR. The bushland area is an important resource for the school. The accessibility and variety of environmental values is a great asset to teaching and education.

Potential Uses

Other uses include a small area lease for a communications facility. Organised group recreation has occurred, including netball, football, cricket and go-kart racing. Although the reserve accommodated more activities in the past, the potential to increase the number of groups once again is limited:

- The golf course has a lease and therefore has exclusive use of this portion of the reserve;
- Go-kart racing ceased in 1986 due to noise complaints and the track has since been demolished;
- The cricket and football clubs are still active but now use other purpose built ovals;
- Horse riding impacts on turf, making shared use impractical due to manure; and
- Serpentine netball players now play at the Mundijong courts.

There is some potential to involve other community groups in activities on the reserve and to expand its use to include a greater range of organised group recreation activities. Future uses could include athletics, seniors' indoor bowls, and gardening in proposed raised garden beds near the pavilion.

Informal Recreation

SSR offers opportunities for recreation by individuals and small informal groups. Active uses, such as walking, jogging and companion animal exercise, and passive uses, including picnicking, reading, contemplation, sketching, painting and nature study, are carried out. However, no formal records of the types and frequencies of these pursuits exist. The pavilion provides a facility for birthday and wedding celebrations and community group fund-raising events.

Informal recreation facilities promote the pursuit of a healthy lifestyle through physical activity, personal development, opportunities for social interaction and spiritual growth and renewal. The use of public open space by the Serpentine community plays an important role in generating a sense of place and ownership.

It is proposed that the reserve be linked to other areas of public open space and bushland through a system of multiple-use trails. Local Planning Policy 9 *Multiple Use Trails within the Shire of Serpentine Jarrahdale* provides for linking all suburbs and communities within the Shire by a network of trails, designed to cater for walkers, cyclists, horse riders and other non-motorized outdoor activities. An existing trail connects with the southern boundary of the reserve in the golf course.

4.3.3. Threats and Pressures

Risk Management

Increasing insurance premiums and stricter attitudes to liability have made risk management plans mandatory for recreational facilities and clubs. Even the SBG needs to consider risks like the use of chemicals and snake bites which can be associated with bushland management tasks. Formal risk management plans must be developed by each user group in cooperation with the Shire to avoid exposing participants to unacceptable levels of risk.

Membership and Member Involvement

The club committees have a general problem with attracting and maintaining motivated volunteers to fill positions and undertake other tasks. A few people tend to do most of the work and this can lead to burnout of members who repeatedly take on key roles. The SBG finds inadequate club membership a problem as low numbers limit activities and threaten their long-term involvement in the SSR.

Individual groups may benefit from reviewing activities to identify the pressures and obstacles for volunteers in joining groups or participating more fully in club management. Strategies to overcome these barriers can then be considered.

Conflict Among User Groups

Conflict among user groups can lead to withdrawal from cooperative management of the reserve, either formally or informally, leading to further difficulties in resolving conflict. Conflicts over the use of resources can lead to ineffective use and possibly degradation, and can arise for many reasons, including:

- Long term lack of resolution to issues and uncertainty relating to future management;
- Misunderstandings of roles and responsibilities; and
- Perceptions of inequity.

The committed volunteers in all user groups have endured unresolved conflicts for many years, and find themselves having to continually defend their interests. The lack of resolution is partly due to the informal forum in which potential solutions have been developed and adjudicated. The *Shire Reserves Planning and Management Framework* now provides a formal framework for the development and adjudication of draft management plans.

The drafting of this plan has been thorough to provide all available information to:

- Facilitate broad community input into the planning process;
- Provide an acceptable level of certainty for all stakeholders; and
- Ensure that Council, during its formal endorsement of the plan, is fully informed of the facts, community opinions, and consequences of management decisions.

The *Shire Reserves Planning and Management Framework* provides for the establishment of the Reserves Advisory Group, which provides a focus for local community input to the development of management plans for Shire reserves. In the case of the SSR, this role is taken by the SSRMC.

Flooding

Flooding during winter affects the golf course. The areas worst affected are the first fairway, the southeast corner of the southern section near the wetland, and the most northerly section of the golf course.

The first fairway is crossed by a low profile drain which backs up, and has gradually filled in over the last ten years. Players tolerate the flooding, and treat it as a water feature. It may be appropriate to investigate the impacts of re-excavating the drain to improve flow, which would require Water Corporation approval and careful consideration of water quality and excavation design to ensure no increase in nutrient export.

Flooding in the southeast corner of the course near the wetland is a problem for several weeks a year. An increase in capacity of the drain would pose an additional threat to the wetland. Any water flowing from the golf course through the wetland must be previously stripped of nutrients. Preferably, all water from the golf course should be diverted away from the wetland, perhaps into a lined dam, or further south to the drain along the southern boundary of the reserve. Infilling to raise this fairway may offer another solution. Acid sulphate soils may impose limitations on the depth and location of dam excavation.

Flooding also disrupts play along the northern section of the reserve, where water covers fairways 13 and 16 for up to five weeks of the year. This land and its surrounds are all low-lying, so accelerated drainage off-site will always be difficult. Proposals to alleviate flooding at all three sites require further assessment of environmental impacts, and if relying on Shire funds, a detailed analysis of needs, benefits and costs.

The John Lyster Polocrosse Ground is generally of a high standard, but poor drainage causes the grounds to flood during the winter months, particularly in the north. There is no obvious natural fall that would allow for drainage off-site, though excavation into a northern ditch which flows west would alleviate the problem. The most effective, but expensive, method of ensuring good drainage from the northern section of the polocrosse ground would be the levelling and resurfacing of the grounds with high quality sand. This would allow water to seep down below the surface and then flow over the impermeable soils below, towards the central Water Corporation drain at the southern end of the grounds.

Pressure to Exclude Horses from the Bushland

The SH&PC have used the bushland track for many years and has built and maintains jumps along the required 3000 m length. Historical use infers a right to continue using the area, and suggestions for moving the course would leave the club feeling that they have wasted previous investments.

The following parameters have been identified by the SH&PC as essential for the cross-country course:

- Mixture of lengths, jumps and obstacles as specified by the Pony Club Association;
- Ambulance access, preferably to all jumps; and
- Buffering from other activities which could “spook” or endanger horses, riders and spectators.

When the cross-country course was first constructed, there was significantly more bushland on the Swan Coastal Plain than there is today. As more remnant bush is cleared, the pressure to preserve what is left has increased. The sustainability of cross-country riding within the bushland area has been debated, but the SH&PC has the opportunity to demonstrate that this activity can be carried out without further degradation by monitoring use, impacts and management. Indeed, the SH&PC is well placed to improve environmental management on small properties throughout the Shire by raising awareness about environmental issues and management strategies amongst club members.

Compliance with Health and Camping Legislation

Both the pony club and the polocrosse club are required under the *Camps and Caravan Parks Act 1995* to obtain permission from the Shire for camping on the SSR. The acquisition of a license allows the Shire to assess compliance with the *Health Act 1911*, the *Camps and Caravan Parks Act* regulations and the *Building Code of Australia*. It also ensures that the locations used, management of pets, numbers of people per ablution facility, litter and other waste management issues are considered. Participants wishing to stay more than three nights will be required to move to the local licensed caravan park.

Inadequate Parking Facilities

The lack of organised parking areas is a problem for orderly management of events. Currently, large numbers of vehicles and floats park in a haphazard manner which results in inefficient use of space and increases the risk of injury. A new design and construction of car and horse float parking would reduce risks, which is considered in the infrastructure section of this management plan.

Security of Tenure for the Golf Club

No reasons have been identified as to why the golf club should not retain use of the area currently leased. It is therefore appropriate to negotiate further ongoing lease agreements. The golf club has been developed and is maintained entirely by volunteers, whose work and the low lease payments enable the course to offer a valuable service to the local community by providing affordable access.

4.3.4. Social and Economic Characteristics: Recreation Strategies

Issue	Target	Priority	Strategy	Responsibility
26. Some of the clubs that use the SSR do not have a comprehensive risk management plan.	All clubs that use the SSR on a regular basis to develop and implement risk management plans within two years from the date of endorsement of this plan.	Medium	<ul style="list-style-type: none"> a) All clubs that use the SSR on a regular basis to develop and implement risk management plans. b) Shire to notify clubs of risk management training opportunities, and club members to attend as required. 	All clubs that use the SSR with advice from Shire
27. Conflict among clubs can result from a lack of resolution to issues, misunderstandings of roles and responsibilities, and perceptions of inequity.	<p>Any conflict among stakeholders to be raised, and a process for resolution agreed to, at the first SSRMC meeting after the issue is identified, and be resolved within a reasonable time.</p> <p>Full record of decisions at SSRMC, RAG and RWG meetings to be minuted, with reciprocal arrangements for viewing minutes operational within two years from the date of endorsement of this plan.</p>	Medium	<ul style="list-style-type: none"> a) Accurate and complete minutes of SSRMC, RAG and RWG meetings be kept and archived. b) Encourage members of SSRMC, RAG and RWG to attend each others' meetings as observers. c) Information about SSR management to be maintained on the Shire website, and the local newspaper to be advised of major decisions regarding SSR management. 	Shire in partnership with all committee members
28. Leases or licences are appropriate for users in particular areas, and existing leases/licences may need to be renewed should they expire during the term of this plan.	A new lease for the golf club (which allows continued affordable access by the current cross-section of users) to be drafted, negotiated and agreed to, and any new leases or licences to be developed for other users.	Key	<ul style="list-style-type: none"> a) Negotiation, agreement and preparation of current lease and licence use of the reserve. 	Shire staff, Council and Serpentine Districts Golf Club, Pony Club and Polocrosse Club
29. Equine clubs have a long history of camping on the reserve.	<p>All camping associated with equine events to have prior approval from the Shire, and to comply with the Shire's conditions of approval.</p> <p>All camping to comply with health and other regulations.</p>	Key	<ul style="list-style-type: none"> a) Review applications from the equine clubs for normal event camping. b) Impose additional approvals for camping outside the conditions set for normal event camping. c) Review current camping practices in relation to health and other statutory requirements, and where necessary rearrange or move traditional camp sites to locations which better comply with health and other regulations. 	Shire in consultation with equine clubs
30. The polocrosse ground and golf course are partially flooded during winter months.	Review potential solutions to flooding on the polocrosse ground and golf course.	Medium	<ul style="list-style-type: none"> a) Continue to maintain the turf area and analyse and document the needs, benefits, carrying capacity and cost sharing associated with budgeting to maintain the turf area at an acceptable standard including estimating the costing for raising the height of the polocrosse ground. 	Polocrosse club and golf club in consultation with Shire

Issue	Target	Priority	Strategy	Responsibility
			b) Submit this document to Shire staff for assessment and to Council to seek endorsement and allocation of funds to bring the turf area up to an acceptable equine standard for ongoing maintenance. c) Review potential solutions to flooding on the golf course. d) Seek expert advice regarding feasibility and impacts of solutions, and submit preferred proposals and any requests for Shire funds to Shire staff for assessment and Council for endorsement.	
31. The pony club cross-country course goes through a Bush Forever site of high conservation value, and pressure has been placed on the pony club in relation to this issue.	A high quality cross-country riding track, compliant with Pony Club of Western Australia specifications, to be provided on the SSR. An endorsed code of conduct for minimal impact cross-country riding to be implemented.	Key	a) Minimise environmental impact in bushland by raising the awareness of club members and developing a code of practice with a detailed process for its implementation. b) Formalise and designate tracks and jumps to limit expansion, and adjust the cross-country course if current use causes further degradation of the bushland. c) Constraints and approval requirements: <ul style="list-style-type: none"> • No tree/vegetation in bush areas to be removed without a DEC Clearing Permit; • Any proposal for the trimming of trees/vegetation to go through the RWG's Reserve Improvement Application Form Process; • Camping to be restricted to turf areas on the edge of the bush area and not occur in any bush areas; • Ongoing vegetation monitoring in the bush area will result in recommendations for the demarcation and protection of vegetation from use of tracks by horses; • Access for horses in the bush area to be restricted to demarcated tracks; • The Pony Club to always possess a map showing the designated horse tracks in the bush areas; • Any horse manure to be removed by stock owners within 12 hours in any part of the reserve. 	Pony club in partnership with Shire
32. There is potential to increase the use of current facilities and to broaden use to additional organised groups and informal users.	SSR facilities and recreational opportunities to be promoted to broader community and other recreation providers.	Medium	a) Community forums and groups to be kept informed of recreational opportunities. b) Contractor of District Recreation Centre in Byford to liaise with SSRMC. c) Include SSR facilities in Peel Physical Activity brochure for Serpentine Jarrahdale Shire. d) Develop plans to encourage additional and broader use of the reserve.	SSRMC in partnership with Shire, SSRMC, Contractors, recreation clubs and the Peel Physical Activity Group
33. Reserve gates are kept locked which excludes	Develop and implement a reserve access policy.	High	a) Consider and document access issues. b) Develop and seek Council endorsement for an access policy	Shire in partnership with all stakeholders

Issue	Target	Priority	Strategy	Responsibility
potential users.			document.	

4.4. Business and Tourism

4.4.1. Infrastructure

The SSR includes open space used for active recreation, and an area of bushland managed with the assistance of community groups. The grounds include about 39 hectares of irrigated turf, of which 9.5 hectares is used by the Serpentine/Foothills Polocrosse Club (SFPC), another 9.5 hectares by the Serpentine Horse and Pony Club (SH&PC), and 20 hectares by the Serpentine and Districts Golf Club (SDGC). The main buildings on the reserve consist of three club-houses used by the active recreation groups, an ablution block, various sheds and a wooden toilet with historical value. Associated infrastructure includes kilometres of fencing, several gates, drains, two dams, an artificial wetland, horse pens, loading ramps and a cross-country trail with jumps.

Turf Surfaces

The central infrastructure for the three active recreation clubs is the turf surfaces. These range from high quality active turf used by the SH&PC to lower quality turf on the golf fairways.

The SH&PC uses the David Buttfield Equestrian Park. These 9.5 hectares of turf were substantially remodeled to improve drainage and turf quality in 1999. The SH&PC now has a high quality active turf surface that is well drained and can be used throughout the year. Future maintenance will be managed by the Shire within water license allocations.

The SFPC uses the John Lyster Polocrosse Ground, about 9.5 hectares of turf used only during summer. The grounds have been modified in attempts to decrease winter water logging, but the surface is still very poorly drained because there is clay under its base. During summer, the turf is of a reasonable quality for active use and is adequate for polocrosse. Improving the drainage would make the grounds useable all year. An additional water allocation would be needed for the maintenance of higher quality turf. The Council might consider such a project if an overwhelming case could be made from thorough analysis of needs and overall benefits. Maintenance is managed by the Shire.

The golf course fairways are a lower quality turf suitable for passive use, while the tees are higher quality. The fairway turf is adequate, but the club would like to upgrade in future, particularly where cover is incomplete or subject to water logging. The irrigation system only waters the centre of each fairway, and the edges become degraded during summer, especially on the light sandy soils.

There are several sections of fairways that become waterlogged and sometimes flooded during winter. Flooding occurs between fairway three and the wetland, and near the outlet of the drain across fairway one. In the northern section several fairways are severely waterlogged for extended periods, particularly numbers 13 and 16. The club has enlarged the depression between fairways 12 and 13 to create a new dam with the dual objectives of reducing water logging and providing a backup to the current irrigation dam.

The SDGC maintains its grounds and facilities by volunteer labour plus membership and other fees. Maintenance and improvement of the grounds is a condition of their lease. The club funded the construction and improvement of its fairways and facilities with the assistance of Alcoa, its members and occasional use of Shire loans.

Irrigation water is supplied by two bores, used by the golf club to fill their dam and by Shire staff to water the equestrian grounds.

All 18 fairways of the golf course are irrigated by pop-up sprinklers down the middle of the fairways. The course uses sand greens that do not require watering. Water is pumped from a bore to the dam. The irrigation system draws water from the dam using an electric pump housed in a small shed. A control box in the buggy shed allows detailed programming of water delivery. Irrigation is scheduled according to frequent measurements of evaporation and other weather factors at a nearby turf farm.

The equestrian grounds are watered by two travelling irrigators which connect directly to the bore pump. The two irrigators are able to water each section of the fields once a week, and are manually set up for each run, making the system labour intensive. The Shire plans to replace one of the travelling irrigators with a below-ground sprinkler system for the SH&PC arena. This would require a separate pump fixture and possibly another bore, with requirements for this system being different from that of the travelling irrigators.

Buildings

Eric Senior Pavilion

This is a recently built multi-purpose building of rammed earth with an inside floor area of 320 m² and a covered verandah of 150 m². The building has a general purpose hall, a meeting room, a kitchen with kiosk and servery plus an office and commentators' room.

Ivan Elliott Pavilion

Used by the SFPC, this is a brick building in the southern section of the reserve. Most is used for storage, except for a kitchen area and toilets. Waste water and sewage discharge into the Biomax system for the ablution block. The pavilion has been painted and is in reasonable condition.

Serpentine & Districts Golf Club Buildings

The SDGC club-house provides toilet and change facilities, a kitchen and bar, and a covered patio with barbecue facilities. The club-house has seating for around 100 people, and a restricted liquor licence that allows it to cater for up to 200 people. The building is in good condition and is adequate for the club's needs. The Shire owns the building and funds insurance and some repairs as necessary.

Also used by the SDGC is a machinery shed in good condition, used as a workshop and to store maintenance equipment, made of steel-framed galvanised iron and measuring about 15 by 10 m. A small fibro-cement shed houses the irrigation controls and members' buggies. The original toilet from the Whittaker's sawmill has been relocated nearby, in fair condition and made of jarrah boards. A shed has been built to house equipment, of similar size and construction to the machinery shed. The SDGC has organised and financed the construction of all of their facilities over an extended period.

Ablution Facility

In 2002 an ablution facility was built of rammed earth and provides toilets and change and shower facilities at the health requirement ratios for club members and visitors. The clubs are responsible for cleaning, but maintenance and insurance are the responsibility of the Shire.

Waste water is processed by a Biomax alternative treatment unit (ATU) which has a capacity of up to 700 people per day and includes 400 m² of sub-strata irrigation where treated water is discharged. The discharge area is a fenced row of trees along the Karnup Road boundary. The expected peak output from the system is 4000 L per day (10 L per person) and the maximum output that the system can assimilate is 7,200 L per day.

The club-houses, ablution blocks and associated facilities are connected to the mains water supply.

Storage Shed

The SH&PC has a steel shed near the arena, which has recently been extended to approximately 6 by 10 m. It is used to store equipment and is in good condition.

Equine Facilities

Wash Bays

Two wash bays, used to wash and cool down horses after activities, are connected to the surface drainage system. One set of bays is located west of the pavilion near the equipment shed and the other on the eastern side near the old netball courts.

Horse Yards

Horse yards have been constructed by both equine clubs near the northeast and southern edges of the polocrosse grounds. There are around 20 yards on the south consisting of two sets of eleven parallel sections of fence with large diameter poly pipe uprights and steel crossbars. Another set of poly pipe and steel yards, providing 10 bays, is on the northern edge. Near the northern bays are twelve wooden posts which can be roped off to form six yards, and there is a set of six older wooden yards near the northeast corner of the grounds. The polocrosse club has indicated the need for additional yards.

There are a number of degraded yards in the marri woodland which are no longer used due to impacts on the bush.

The SH&PC yards horses in the northwest corner of their grounds, consisting of wooden posts and rails in average condition, but the area is subject to water logging in winter. There are also some short sections of steel post and rail west of the club-house which can be used as hitching rails. Most are in reasonable condition, but some are poor.

Stock Ramp

There is a ramp for loading stock west of the SH&PC club-house which is in reasonable condition. It is a double ramp with higher and lower sections made from laterite rock and cement with a gravel surface. The ramp is currently used to unload horses from trucks. It has historic value as part of the facilities dating from the Serpentine Show.

Cross-Country Track

A cross-country track for the SH&PC extends for 3000 m around the edges of the equestrian ovals, through the two revegetation areas (the Paul Robinson reserve and the old go-cart track), the remnant vegetation and the central sandpit. Sections have been surfaced with ground granite where the track traverses the bushland and in several other places in an effort to prevent erosion, but some continued erosion shows as channelling along the centre and mounding on the edges. There are about 25 sets of jumps along the cross-country track, each of which has two or three different heights, totalling about 80 jumps. There is a water jump in the southwest corner of the pony club grounds, which is about 200mm deep. The water jump basin is full through winter and dry in summer, and is filled twice a year for one day events. The specifications for the course are set by the State Pony Club Association, which must be met in order to retain the event and the substantial income it provides to the club.

Bin Facility

The rubbish bins used by the equestrian clubs are stored in a cyclone fencing cage behind the Ivan Elliot Pavilion, adjoining Karnup Road. The cage is approximately 3 by 3 m and 2.5 m high, with a locked gate on either side, storing twelve standard and recycling bins between events. Waste management services and the clubs have keys to the cage. This facility is in good condition.

Gates and Fences

About 20 km of fencing is on the reserve. Fences adjoining the golf course along Karnup and Hall Roads and on the southern boundary were replaced in 2002, with funds and labour provided by the golf club. These fences consist of wooden strainers and steel posts with ringlock and a single strand of barbed wire along the top, and are in good condition.

An older fence runs along the western boundary of the golf course and part of the southern boundary, consisting of wooden posts with ringlock, plain and barbed wire. It is in poor to reasonable condition but adequately contains the cattle in the adjoining property. The drain along the southern boundary of the golf course provides an additional barrier.

A small section of low cyclone fencing in front of the golf club-house is in good condition. Gates on either side of Karnup Road near the club-house provide access to the northern and southern sections of the golf course. These are in good condition.

The fence between the equestrian and bushland areas consists of wooden posts with three strands of plain wire for most of its length, and is in reasonable condition. There is a small section of barbed wire fencing between the golf course and the first access gate, which is in reasonable condition but may pose a safety hazard. There are two sets of gates into the equestrian areas on Karnup Road, and another gate on Hall Road provides access to the Paul Robinson Reserve and bushland. Gates to the reserve are padlocked, with allocation of keys limited to the user groups, and are in good condition. There are two pedestrian access points; one on the corner of Hall and Karnup Roads and one adjacent to the gate to the Paul Robinson Reserve, consisting of wooden posts and in good condition.

The banksia bushland around the sandpit is encircled by a fence with two gates, in the northwest and southeast corners, all in reasonable condition. Another fence along the southern edge of the go-kart track and Paul Robinson Reserve to Hall Road separates the golf course from the revegetation areas. This fence is in poor condition in parts but reasonable overall.

Other Facilities

Netball Courts

There are two degraded, unused netball courts west of the equestrian facilities near Karnup Road. The courts have working floodlights, goal posts at both ends in reasonable condition, and a small iron shelter. The bitumen surface is cracked and uneven.

Signs

There are signs at each entry gate that detail the types of activities that occur on the reserve. In 2004, a new “welcome” sign was erected on the corner of Karnup and Hall Roads, and “condition of entry” signs at each of the three entrances along Karnup Road. All are aluminium with non-reflective backgrounds and the Shire logo, and complement the pre-existing signs. Signs throughout the reserve are aluminium or wood, and they range in style, age and condition.

Parking Facilities

There are no formal parking areas, with space limited to an informal area near the pony club and golf club entrances with little shade and bare soil surfaces. The equestrian clubs have indicated that the informal parking areas are inadequate and need to be organised more effectively.

Walking Tracks

A number of tracks have been created through the bushland and revegetation areas. Many of the tracks through the banksia bushland have been closed and are beginning to revegetate. The SBG is keen to continue the process of rehabilitation and establish a clearly marked walking track through the revegetation areas and the bushland to allow for education and enjoyment.

Drainage Network

There is an extensive system of artificial drains traversing and surrounding the reserve, as well as an artificial wetland designed to improve water quality. The network is described in detail in the water section of this management plan.

4.4.2. Threats and Pressures

Building Maintenance

Inadequate or infrequent building maintenance would lead to accelerated deterioration of building value and the increased risk of safety hazards. The general appearance of poorly maintained facilities also tends to attract vandalism. The Shire has an established inspection and maintenance program.

Vandalism and Theft

Vandalism and theft is a constant but low-level threat to the reserve, which is likely to increase with the population and use of the area. Where possible, the design of all buildings and other structures should incorporate vandalism-resistant features. Use of tough materials, protection of vulnerable surfaces with barriers resistant to breakage and graffiti, visibly high maintenance, removal of objects likely to be used by vandals, high security and provision of appropriate lighting all decrease the likelihood of theft and damage.

Surveillance is an effective deterrent, but while the levels of vandalism are a nuisance they do not currently warrant the expense of regular patrols or the installation of surveillance equipment. A security alarm would be appropriate on the pavilion. The local community is well placed to keep an eye on facilities and report unlawful activities. Best practice management strategies facilitate community ownership by encouraging broad use and participation. Community use of appropriate areas within the reserve for a range of activities is therefore likely to improve security.

Vehicles, including two or four wheel motorbikes, can cause a great deal of damage to irrigation infrastructure, turf and bushland. Stock can cause minor damage to turf surfaces and may also cause a nuisance. Strong fencing and locked gates will exclude most vehicles and stock, while pedestrian access can be maintained through openings with narrowly spaced posts to exclude motorbikes.

Fire Damage

Fire can threaten people, property and conservation values. Prevention and resistance needs to be incorporated into the design and management of buildings, other structures and their surrounds. Fires can start inside or adjacent to buildings and structures and are often the result of vandalism, kitchen accidents or electrical faults. Bush or grass fires threaten buildings and structures through embers, radiant heat and direct contact. Buildings and structures in the open are unlikely to be threatened by radiant heat, but embers can travel several kilometres under the right conditions and remain a threat.

Cleared areas around buildings limit the opportunity for bush and grass fires to reach them. No flammable material should be stored close to buildings, and gutters kept clear. Strategies to limit the frequency and severity of vandalism will reduce the likelihood of arson. Irrigated turf is unlikely to carry a fire, but a hot fire close to turf areas could produce enough radiant heat to severely damage it. Fire in nearby bushland has the potential to damage turf, buildings, fencing and other infrastructure.

It is standard practice to develop a fire management strategy for reserves and associated infrastructure that integrates all aspects of building design, equipment and procedures.

Limited Access to Water

The water allocation is insufficient to maintain 39 hectares of turf in a lush condition. High quality turf is not required for most purposes in the reserve, so an assessment of water use requirements plus minimising evaporation and reusing water will facilitate the maintenance of turf to minimum standards. Water availability and use is discussed in the water section of this management plan.

Inadequate Car Parking Facilities

During major sporting events, informal car parking arrangements lead to the damage of soil, vegetation, infrastructure and personal property. A clearly marked and structured parking area with a modified surface to prevent erosion would significantly improve reserve facilities. For large competitions, areas for overflow parking need to be designated and clearly marked or directed. To design and develop an organised parking area or areas, information on vehicle numbers and types would need to be provided by the equine clubs.

Lack of Designated Camping Areas

During equestrian events that are held over two or more days, participants regularly camp on the reserve. In the absence of designated camping areas, camping is haphazard which poses risks to property and to the campers themselves. Designated camping areas are limited to turf bordering the bushland, for event use only, with low fire risk, and (ideally) close to ablution facilities. This minimises impacts on the bush and facilities, and improves safety for participants but degrades turf areas which costs the Shire annually for maintenance and upgrades. Alternative camping areas are being explored as horse floats and recreational camping vehicles are getting larger and heavier each year causing greater and greater degradation to the turf areas.

Winter Drainage

Water logging and flooding affect several areas of the golf course and most of the polocrosse ground. Poor drainage of turf surfaces can reduce their utility and value, by restricting use during certain periods of the year and affecting the overall health of the turf. On clay soils, poor infiltration combined with long periods of inundation can lead to secondary salinity, which has negative impacts on the turf and the environment. The impacts of water logging on turf health can be managed to a great extent by selecting appropriate turf species. This has occurred on the polocrosse field.

A recommendation to further investigate options to improve drainage was first put forward in the *Serpentine Sports Reserve Drainage Plan*. Water use, reuse and drainage are considered further in the water section of this management plan. More detailed design feasibility studies and options to raise the levels of recreation surfaces or construct alternative drainage and irrigation systems would be dependent on the results of a detailed analysis of needs, benefits and costs.

Community Use of Reserve Areas and Lease/License Arrangements

Fostering community ownership of the reserve has a number of benefits, including heightened surveillance and greater community support for reserve improvements. An increase in community ownership would be achieved by increasing usage, such as by encouraging the use of existing facilities by other clubs and individuals, and by providing additional facilities that encourage passive and active recreational use of the area, such as interpretive signage. License arrangements with the SH&PC and the SFPC for use of the reserve will be facilitated, linked to the management plan and a Memorandum of Understanding for some ongoing contribution toward reserve management requirements. The issue of community use of the reserve is discussed in the recreation section of this management plan.

4.4.3. Social and Economic Characteristics: Business and Tourism Strategies

Issue	Target	Priority	Strategy	Responsibility
34. The full business potential of SSR events could be further developed.	<p>All major SSR events to be coordinated and promoted by the Peel Development Commission.</p> <p>SSR event organizers to offer promotions, sponsorships and advertising to local businesses prior to accepting or searching for promotions, sponsorship and advertising from outside the Shire.</p>	High	<p>a) Event organizers to liaise closely with the Peel Development Commission in relation to event promotion and coordination with events elsewhere.</p> <p>b) Raise broad community awareness of planned events and sponsorship opportunities well in advance of events through newspaper articles, stakeholder and other club newsletters, Shire website and other local communication avenues.</p> <p>c) Raise the awareness of event participants and visitors about opportunities in the local area, and promote a register of local businesses appropriate to this audience through the Shire and club websites and printed materials.</p> <p>d) Undertake an analysis of goods and services provision needs for regular and special events, and use this study to encourage the development and expansion of local businesses.</p>	Stakeholders organizing events with Shire support
35. There is currently no ongoing close liaison between the tourism industry, local business community and the SSRMC.	Develop effective ongoing liaison between the tourism industry, local business community and the SSRMC.	Medium	<p>a) Administrate the RAG with a membership that includes someone who is both knowledgeable and well-connected in relation to business and tourism.</p> <p>b) Implement a system to exchange minutes between SSRMC and RAG.</p> <p>c) Undertake an annual review of the effectiveness of liaison between SSRMC and RAG in ensuring that business and tourism interests are taken account of in day-to-day management of the reserve.</p> <p>d) Work with the local business and tourism communities to seek other effective ways to establish effective ongoing liaison.</p>	Shire in partnership with the local business, tourism industries, SSRMC and RAG

5. Implementation

5.1. Introduction

An implementation plan is provided in this section. Various divisions within the Shire will be responsible for implementation and it is anticipated that the recommendations will be acted on over several years. All recommendations in this plan are reproduced in a single table below, along with priorities, responsibilities and cost estimates.

5.2. Priorities

Priorities for implementation of the recommendations have been classified as follows:

- Key – within the first financial year from the date of endorsement of this plan;
- High – within the next five years;
- Medium – within the next ten years; and
- Ongoing – as required.

5.3. Responsibilities, Monitoring and Review

The Shire of Serpentine Jarrahdale is responsible for recommendations within this plan. In some instances, the Shire may be assisted in implementing a recommendation by a partner who has an interest or responsibility, and there may be opportunities for grants to implement strategies. The management plan strategies will be monitored and reviewed, and the management plan will be revised if necessary.

Divisions within the Shire with responsibilities for implementation, sometimes in collaboration with the Landcare Centre, Fire Brigade, User Groups or Community, are as follows:

- Environmental and Sustainability Services;
- Natural Reserves Coordinator;
- Operations and Parks;
- WSUD Project Manager;
- Fire and Emergency Services;
- Corporate Services;
- Community Development;
- Development Services; and
- Environmental Health.

Cost estimates are either approximate one-off costs or ongoing per year. It is estimated that the first year of implementation of the management plan (the Key strategies) will cost \$37,000. For the following 10 years, average cost per year is estimated at \$20,000 per year for those strategies listed as High and Medium Priority.

5.4. Implementation Strategies

Issue	Target	Priority	Strategy	Responsibility
36. The efficiency and effectiveness of the management plan and its implementation will need to be assessed in consultation with all stakeholders.	Number of strategies to be implemented annually and the effectiveness of the objectives of management being met.	Medium	a) Periodically monitor and review the efficiency and effectiveness of management plan strategy implementation and revise if necessary.	Shire in partnership with SSRMC, RAG and the local business and tourism industries

5.5. Implementation Plan

Table 9 – Strategies for Management of Serpentine Sports Reserve

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
Governance Strategies					
1.	<ul style="list-style-type: none"> a) Develop and implement a process to inform and advise SSMC, RAG and RWG members of current legislation. b) Make reserve users aware of the <i>Policy for Reserve Improvement/Development by the Community</i>. c) All community recommendations and requests for works received under the above policy are to be referred by the Natural Reserves Coordinator to the RWG, and thence to the Council if it is of sufficient magnitude or involves the construction of new infrastructure. 	Medium	Ongoing	Natural Reserves Coordinator, Environmental & Sustainability Services	\$1,000
2.	<ul style="list-style-type: none"> a) RAG meetings to be conducted with broad membership as required in the <i>Shire Reserves Planning and Management Framework</i>. b) Provide assistance and support to RAG members to ensure that proper independent audits are undertaken and reported to Council at a minimum frequency of every 3 years from the date of endorsement of this plan. c) Facilitate a review and debate relating to audit results and the endorsed management plan. 	Medium	Ongoing	Natural Reserves Coordinator, Environmental & Sustainability Services	\$1,000
3.	<ul style="list-style-type: none"> a) Maintain a record of relevant governance training opportunities and communicate this to SSR community groups. 	Medium	Ongoing	Natural Reserves Coordinator	\$1,000
Environmental Characteristics: Geology, Geomorphology and Soils Strategies					
4.	<ul style="list-style-type: none"> a) Monitor the profile of the sand pit wall and determine whether soil erosion remediation is required. 	Medium	Implemented in Part	Environmental & Sustainability Services	\$1,000
5.	<ul style="list-style-type: none"> a) Pasture and mulch cover to be monitored and managed adaptively to ensure management target. 	Medium	Implemented in Part	Operations & Parks	\$1,000
6.	<ul style="list-style-type: none"> a) The potential risks of acid sulphate soils are to be communicated to all community groups that use the reserve, taking place frequently enough to ensure the management target when club members change. b) No excavation or dewatering is to take place without consultation with DEC. 	High	Implemented in Part	Natural Reserves Coordinator	\$2,000
Environmental Characteristics: Water Strategies					
7.	<ul style="list-style-type: none"> a) Prepare an energy consumption and emissions audit of all operations and activities on SSR, including methane production, carbon sinks and carbon trading contingencies. b) Establish vegetation as required to offset emissions. 	Medium	Not Yet Implemented	Environmental & Sustainability Services	\$1,000
8.	<ul style="list-style-type: none"> a) Install meters and monitor water extraction from bores. b) Prepare an inventory of all water consumption on the reserve. 	Key	Implemented in Part	Environmental & Sustainability Services, Operations & Parks, Natural Reserves	\$3,000

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
9.	a) Prepare a plan to reduce consumption and reuse water by for example: <ul style="list-style-type: none"> • Storing and reusing rain water; • Reducing evaporation from dams and irrigation; • Reviewing the extent and standard of turf; • Using and reusing surface water; b) Applying best management practices for water use on turf surfaces as follows: <ul style="list-style-type: none"> • Installing automatic sprinkler systems; • Adjusting the quantity of water applied in accordance with evaporation and turf conditions; • Adjusting the timing of water application to minimise evaporation and wastage; • Monitoring soil infiltration rates and applying wetting agents and other amendments as required. 	Key	Implemented in Part	Coordinator Environmental & Sustainability Services, Operations & Parks, Natural Reserves Coordinator	\$5,000
10.	a) Design and implement a monitoring program for water quality: <ul style="list-style-type: none"> • Entering and leaving the reserve; • Adjacent to and downstream of potential nutrient hotspots; • Entering and leaving the existing constructed wetland. b) Maintain joint records of fertilizer and animal waste applications (as equivalent horse hours per hectare and management techniques) and maintain levels below target amounts (150kg/ha/year N and 15kg/ha/year P). c) Distribute educational material about minimal impact equine management and the impacts of nutrient pollution. d) Minimise nutrient export by implementing best management practices including: <ul style="list-style-type: none"> • Adjust fertilizer application for turf condition. • Establish vegetated buffers between all nutrient sources and surface water features. • Pick up manure and export it within 12 hours. • If horse pens are exporting significant quantities of nutrients, provide and frequently renew temporary absorbent surfaces in horse pens and/or construct covered pens with sealed floors. • Develop and implement procedures to ensure that manure is not stored on the reserve, even for short periods, unless in appropriate covered containers with impermeable bases. • Develop and implement procedures to ensure that fertilizers and other chemicals are transported, stored and used in such a manner that the risk of spillage and pollution is minimal. e) Maximise nutrient stripping from flowing surface waters by reviewing, and where possible implementing, best management practices (e.g. planting native rushes, sedges and other vegetation along drains, treatment trains and artificial wetlands). f) If the existing constructed wetland is not effectively stripping nutrients:	Key	Implemented in Part	Natural Reserves Coordinator, User Groups, WSUD Project Manager	\$10,000

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
	<ul style="list-style-type: none"> Adjust its design and management (e.g. in relation to its size, shape, planting, flow rates and vegetation and sediment removal programs); and Investigate constructing additional wetlands. 				
11.	a) Establish a mixture of deep and shallow rooted vegetation to absorb nutrients as they seep down to groundwater resources. b) Seek advice from the Department of Water on meeting the total target of 150kg/ha/year N and 15kg/ha/year P within the reserve.	High	Implemented in Part	WSUD Project Manager	\$2,000 Per Year
12.	a) Lower the water table and reduce evaporation by establishing a mixture of deep and shallow rooted vegetation in areas where surface water occurs.	High	Implemented in Part	Environmental & Sustainability Services	\$2,000 Per Year
13.	a) Monitor water quality entering the conservation category wetland. b) Reduce runoff and filter water from the golf course by, for example: <ul style="list-style-type: none"> Establishing a mixture of deep and shallow rooted vegetation throughout the golf course area; Constructing a nutrient stripping wetland within the drain prior to water entering the wetland. c) If water quality entering the wetland is above target levels (0.1 mg/L total P and 0.75 mg/L total N), review and implement options to isolate golf course runoff from the wetland (e.g. by diverting the drain to a storage dam which drains to the south).	High	Implemented in Part	Environmental & Sustainability Services	\$2,000 Per Year
Environmental Characteristics: Biodiversity Strategies					
14.	a) Investigate potential options and seek Council advice toward recognising "conservation" as a purpose for the southern section of the reserve.	Medium	Not Yet Implemented	Environmental & Sustainability Services	\$1,000
15.	a) Map dieback distribution within the bushland areas, zone dieback free areas as high conservation, and manage any tracks through dieback free areas (where they cannot be closed) without unreasonably impacting on existing uses. b) Treat vegetation for dieback by spraying and injecting vulnerable plants at 3 to 5 year intervals. c) Raise community awareness (such as by provision of signs, club newsletters, event briefings etc.). d) Raise the awareness of staff, volunteers and contractors of appropriate dieback hygiene procedures and ensure they are adhered to. e) Minimise risks of disease spread by: <ul style="list-style-type: none"> Where practical, reconciling the alignment of tracks with dieback fronts; and Otherwise, ensuring tracks are constructed with appropriate materials and suitable buffer zones maintained on either side by spraying with a dieback treatment and trimming vegetation at recommended intervals. f) Liaise directly with Shire Officers for identification, protection and management of important flora. g) Construct barriers where necessary to prevent pedestrian and stock traffic from crossing dieback fronts or important areas of flora. h) Minimise risks of disease spread by adopting dieback	Key	Implemented in Part	Natural Reserves Coordinator, Environmental & Sustainability Services	\$2,000 Per Year

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
	hygiene processes including: <ul style="list-style-type: none"> • Construction and maintenance work to be undertaken in dry conditions only; • Wash-down of vehicles and footwear prior to commencing construction or maintenance work in the bushland area; • No material (e.g. soil and pathway surfaces) to be introduced into the bushland area unless guaranteed dieback free. 				
16.	a) Review fauna surveys and gather additional information. b) Liaise with Birds Australia in relation to continuing bird surveys. c) Maintain a limited access inventory of declared and priority plant species, with annual inspections of plants. d) Monitor Black Cockatoos' usage of the reserve.	Medium	Implemented in Part	Environmental & Sustainability Services, Natural Reserves Coordinator	\$3,000
17.	a) Map weed distribution within the bushland, and compare with previous maps. b) Prepare a weed control program by identifying and prioritising weed affected areas, including sources of weed seed outside the bushland area. c) Remove weeds with physical and chemical treatments in accordance with the weed control program. Mulch, brush, seed, or plant treated areas with local native plants. d) Minimise disturbance and weed introduction and actively remove weeds from the bushland area through: <ul style="list-style-type: none"> • Maintaining the number and width of tracks but disallowing the development of new tracks without prior approval; • Diverting nutrient rich surface drainage away from bushland areas; • Picking up all traces of manure by stock owners in the bushland area within 12 hours of deposition; • Picking up all traces of bedding and stock feed from the bushland area within 12 hours of use; • Raising the awareness of all users of the importance of minimising weed spread (by event briefings etc.); • Removing all <i>Eucalyptus camaldulensis</i> saplings and regrowth plants. 	Key	Implemented in Part	Natural Reserves Coordinator, User Groups, Environmental & Sustainability Services	\$5,000 Per Year
18.	a) Maintain records of feral animal sightings and monitor southern section of reserve annually for rabbit warrens. b) Destroy rabbit warrens and feral bees' nests where required. c) Raise awareness among surrounding landowners about the damage done by feral cats and other animals and encourage owners to restrain pets and control pests on their land. d) Disallow the placement of bee hives anywhere on the reserve.	High	Implemented in Part	Environmental & Sustainability Services	\$2,000 Per Year

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
19.	<ul style="list-style-type: none"> a) Prepare and implement a bushland rehabilitation plan, including weed management and rehabilitation criteria. b) Map locations of listed flora and maintain records of health of individual plants or clumps. c) Raise stakeholder awareness of the requirements for approvals under State and Commonwealth legislation and policies. d) Map bushland condition periodically and compare with previous maps. e) Monitor track width within banksia woodland and adjust access to achieve target of no vegetation loss in bush areas through demarcation and barrier installation. f) Review tracks through marri woodland and narrow to a minimum safe width for cross-country riding events. g) Rehabilitate all but essential tracks through the bushland, the sand pit, previously weed infested areas, Paul Robinson Reserve, old go-kart track, vacant areas where remnant vegetation abuts cleared or weed infested land, and the banks of water courses and artificial wetlands, including some of the golf course swales. h) Recreate the dominant species, growth forms and community structure of identified natural reference communities. i) Limit collection of indigenous seeds and cuttings to propagation of plant material for local rehabilitation only. j) Disallow use of marri woodland community for stock yards, camping and parking and establish alternative overflow stockyards, camping and parking facilities for polocrosse club. k) Work with neighbouring land managers to encourage responsible management of ecological linkages. l) Review all fencing and replace if necessary with a design that will not form a barrier to wildlife. 	High	Implemented in Part	Environmental & Sustainability Services	\$5,000 Per Year
20.	<ul style="list-style-type: none"> a) Update and seek approval for a Reserve Fire Management Plan in conjunction with relevant State agencies (including TEC experts from DEC) and Commonwealth Departments. b) Ensure all burning in the reserve conforms to this plan. 	High	Not Yet Implemented	Fire & Emergency Services	\$3,000
Social and Economic Characteristics: Indigenous Heritage Strategies					
21.	<ul style="list-style-type: none"> a) Administrate the RAG with membership of at least one person who can speak for local Indigenous people as required. b) Ensure that minutes from SSRMC and RAG meetings are exchanged. c) Consult the South West Land and Sea Council and South West Catchment Council for advice on other appropriate liaison processes and implement as appropriate. 	High	Not Yet Implemented	Environmental & Sustainability Services, Natural Reserves Coordinator	\$1,000
22.	<ul style="list-style-type: none"> a) When naming a place, structure or event give consideration to Aboriginal names, seek advice from Aboriginal representatives and obtain approval for the use of appropriate names from the South West Land 	Medium	Not Yet Implemented	Environmental & Sustainability Services, Natural	\$1,000

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
	and Sea Council and the Shire Council.			Reserves Coordinator	
23.	a) Develop an interpretation plan for the reserve that takes account of Aboriginal heritage values.	High	Not Yet Implemented	Environmental & Sustainability Services, Natural Reserves Coordinator	\$3,500
Social and Economic Characteristics: European Heritage Strategies					
24.	a) All stakeholders to provide a summary of their developments and activities for SSRMC meetings. b) Stakeholder summaries of developments and activities to be incorporated in formal minutes of meetings, and files maintained and archived.	Medium	Ongoing	Natural Reserves Coordinator	\$1,000
25.	a) Develop an interpretation plan for the reserve that takes account of European heritage values.	Medium	Not Yet Implemented	Community Development, Environmental & Sustainability Services	\$3,500
Social and Economic Characteristics: Recreation Strategies					
26.	a) All clubs that use the SSR on a regular basis to develop and implement risk management plans. b) Shire to notify clubs of risk management training opportunities, and club members to attend as required.	Medium	Implemented in Part	Community Development, Environmental & Sustainability Services	\$4,000
27.	a) Accurate and complete minutes of SSRMC, RAG and RWG meetings be kept and archived. b) Encourage members of SSRMC, RAG and RWG to attend each others' meetings as observers. c) Information about SSR management to be maintained on the Shire website, and the local newspaper to be advised of major decisions regarding SSR management.	Medium	Implemented in Part	Natural Reserves Coordinator	\$1,000
28.	a) Negotiation, agreement and preparation of current lease and licence use of the reserve.	Key	Not Yet Implemented	Corporate Services, Environmental & Sustainability Services	\$3,000
29.	a) Review applications from the equine clubs for normal event camping. b) Impose additional approvals for camping outside the conditions set for normal event camping. c) Review current camping practices in relation to <u>turf impacts</u> , health and other statutory requirements, and where necessary rearrange or move traditional camp sites to locations which better comply with health and other regulations.	Key	Implemented in Part	Environmental Health, Development Services	\$7,000
30.	e) Continue to maintain the turf area and analyse and document the needs, benefits, carrying capacity and cost sharing associated with budgeting to maintain the turf area at an acceptable standard including estimating the costing for raising the height of the polocrosse ground. f) Submit this document to Shire staff for assessment and to Council to seek endorsement and allocation of funds to bring the turf area up an acceptable standard for equine purposes and for ongoing annual	Key	Ongoing	Environmental and Sustainability Services, Natural Reserves Coordinator and Community Development	\$100,000 per annum

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
	<p>maintenance.</p> <p>g) Review potential solutions to flooding on the golf course.</p> <p>h) Seek expert advice regarding feasibility and impacts of solutions, and submit preferred proposals and any requests for Shire funds to Shire staff for assessment and Council for endorsement.</p>				
31.	<p>a) Minimise environmental impact in bushland by raising the awareness of club members and developing a code of practice with a detailed process for its implementation.</p> <p>b) Formalise and designate tracks and jumps to limit expansion, and adjust the cross-country course if current use causes further degradation of the bushland.</p> <p>c) Constraints and approval requirements:</p> <ul style="list-style-type: none"> • No tree/vegetation in bush areas to be removed without a DEC Clearing Permit; • Any proposal for the trimming of trees/vegetation to go through the RWG's Reserve Improvement Application Form Process; • Camping to be restricted to turf areas on the edge of the bush area and not occur in any bush areas; • Ongoing vegetation monitoring in the bush area will result in recommendations for the demarcation and protection of vegetation from use of tracks by horses; • Access for horses in the bush area to be restricted to demarcated tracks; • The Pony Club to always possess a map showing the designated horse tracks in the bush areas; • Any horse manure to be removed by stock owners within 12 hours in any part of the reserve. 	Key	Implemented in Part	Environmental & Sustainability Services, Natural Reserves Coordinator	\$2,000
32.	<p>a) Community forums and groups to be kept informed of recreational opportunities.</p> <p>b) Contractor of District Recreation Centre in Byford to liaise with SSRMC.</p> <p>c) Include SSR facilities in Peel Physical Activity brochure for Serpentine Jarrahdale Shire.</p> <p>d) Develop plans to encourage additional and broader use of the reserve.</p>	Medium	Implemented in Part	Community Development	\$3,000
33.	<p>a) Consider and document access issues.</p> <p>b) Develop and seek Council endorsement for an access policy document.</p>	High	Implemented in Part	Environmental & Sustainability Services, Natural Reserves Coordinator	\$4,000
Social and Economic Characteristics: Business and Tourism Strategies					
34.	<p>a) Event organizers to liaise closely with the Peel Development Commission in relation to event promotion and coordination with events elsewhere.</p> <p>b) Raise broad community awareness of planned events and sponsorship opportunities well in advance of events through newspaper articles, stakeholder and other club newsletters, Shire website and other local communication avenues.</p> <p>c) Raise the awareness of event participants and visitors</p>	High	Implemented in Part	Community Development	\$10,000

No.	Strategy	Priority	Implementation	Responsibility	Cost Estimate
	<p>about opportunities in the local area, and promote a register of local businesses appropriate to this audience through the Shire and club websites and printed materials.</p> <p>d) Undertake an analysis of goods and services provision needs for regular and special events, and use this study to encourage the development and expansion of local businesses.</p>				
35.	<p>a) Administrate the RAG with a membership that includes someone who is both knowledgeable and well-connected in relation to business and tourism.</p> <p>b) Implement a system to exchange minutes between SSRMC and RAG.</p> <p>c) Undertake an annual review of the effectiveness of liaison between SSRMC and RAG in ensuring that business and tourism interests are taken account of in day-to-day management of the reserve.</p> <p>d) Work with the local business and tourism communities to seek other effective ways to establish effective ongoing liaison.</p>	Medium	Implemented in Part	Natural Reserves Coordinator, Environmental & Sustainability Services	\$1,000
Implementation Strategies					
36.	<p>a) Periodically monitor and review the efficiency and effectiveness of management plan strategy implementation and revise if necessary</p>	Medium	Implemented in Part	Environmental & Sustainability Services	\$2,000 Per Year

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Appendix 1 – Flora of Serpentine Sports Reserve

Three permanent flora monitoring quadrats were set up in 2008, one within each of the three floristic communities present in Serpentine Sports Reserve, which have been resurveyed annually since. The species recorded (including introduced weeds) are shown in Table 10.

Table 10 – Plant Species Recorded in Serpentine Sports Reserve

Plant species	Banksia woodland (20b)	Wetland heath	Marri woodland (3b)
<i>Acacia alata</i>			X
<i>Acacia lasiocarpa</i>			X
<i>Acacia sessilis</i>	X		X
<i>Acacia willdenowiana</i>	X		X
<i>Adenanthos meisneri</i>	X		X
<i>Agrostocrinum hirsutum</i>	X		X
* <i>Aira cupaniana</i>	X	X	
<i>Allocasuarina humilis</i>	X		X
<i>Amphipogon turbinatus</i>	X		
<i>Anigozanthos manglesii</i>	X		
* <i>Arctotheca calendula</i>	X	X	
<i>Austrostipa compressa</i>	X		
* <i>Avena barbata</i>		X	
<i>Baeckea camphorosmae</i>	X		
<i>Banksia attenuata</i>	X		
<i>Banksia grandis</i>	X		
<i>Banksia menziesii</i>	X		
<i>Banksia nivea</i>	X		X
<i>Billardiera</i> sp.	X		
<i>Bossiaea eriocarpa</i>	X		X
* <i>Briza maxima</i>	X	X	X
* <i>Briza minor</i>			X
<i>Burchardia congesta</i>	X		X
<i>Caesia micrantha</i>	X		X
<i>Caladenia discoidea</i>	X		
<i>Caladenia flava</i>	X	X	X
<i>Calectasia grandiflora</i>	X		
<i>Calytrix flavescens</i>	X		
<i>Calytrix fraseri</i>	X		
<i>Centrolepis aristata</i>		X	
<i>Chaetanthus aristatus</i>		X	
<i>Chamaescilla corymbosa</i>	X		X

Plant species	Banksia woodland (20b)	Wetland heath	Marri woodland (3b)
<i>*Cicendia filiformis</i>	X	X	
<i>Comesperma calymega</i>	X		
<i>Conospermum stoechadis</i>	X		
<i>Conostephium preissii</i>	X		
<i>Conostylis aculeata</i>			X
<i>Conostylis juncea</i>	X		X
<i>Conostylis setigera</i>	X		X
<i>Corymbia calophylla</i>			X
<i>*Cotula turbinata</i>	X	X	
<i>Cristonia biloba</i>			X
<i>Cyathochaeta avenacea</i>	X		X
<i>Cyathochaeta clandestina</i>	X		
<i>Dampiera alata</i>			X
<i>Dampiera linearis</i>			X
<i>Dasyogon bromeliifolius</i>	X		X
<i>Daviesia nudiflora</i>	X		
<i>Daviesia physodes</i>	X		X
<i>Desmocladius fasciculatus</i>	X		X
<i>Dianella revoluta</i>	X		X
<i>*Disa bracteata</i>		X	
<i>Drosera erythrorhiza</i>	X		X
<i>Drosera gigantea</i>		X	X
<i>Drosera glanduligera</i>		X	
<i>Drosera menziesii</i>	X	X	
<i>Drosera pallida</i>		X	X
<i>Drosera sp.</i>			X
<i>*Ehrharta calycina</i>	X		X
<i>*Eragrostis curvula</i>		X	
<i>Eremaea pauciflora</i>	X		
<i>Eucalyptus marginata</i>	X		X
<i>Eutaxia virgata</i>		X	
<i>Gastrolobium capitatum</i>			X
<i>*Gladiolus caryophyllaceus</i>			X
<i>Gnephosis angianthoides</i>	X	X	
<i>Gompholobium polymorphum</i>	X		
<i>Gompholobium tomentosum</i>	X		X
<i>Haemodorum laxum</i>	X		X
<i>Haemodorum simulans</i>			X
<i>Hakea prostrata</i>			X
<i>Hakea ruscifolia</i>	X		X
<i>Hakea sulcata</i>		X	
<i>Hakea varia</i>		X	
<i>Hemiandra pungens</i>			X
<i>Hibbertia diamesogenos</i>	X		
<i>Hibbertia huegelii</i>	X		
<i>Hibbertia vaginata</i>	X		
<i>Hovea trisperma</i>	X		
<i>Hyalosperma cotula</i>	X	X	

Plant species	Banksia woodland (20b)	Wetland heath	Marri woodland (3b)
<i>*Hypochaeris glabra</i>	X	X	X
<i>*Hypochaeris radicata</i>	X	X	X
<i>Hypolaena exsulca</i>	X	X	X
<i>Isolepis cernua</i>		X	
<i>Juncus kraussii</i>		X	
<i>Kennedia prostrata</i>	X		X
<i>Kunzea micrantha</i>	X	X	X
<i>Labichea punctata</i>	X		
<i>Lachnagrostis filiformis</i>	X		
<i>Lepidosperma leptostachyum</i>	X		
<i>Lepidosperma pubisquameum</i>	X		
<i>Lepidosperma scabrum</i>	X		X
<i>Lepidosperma squamatum</i>	X		X
<i>Leucopogon</i> sp.	X		
<i>Lomandra caespitosa</i>	X		X
<i>*Lotus angustissimus</i>		X	
<i>Loxocarya cinerea</i>		X	
<i>Lyginia barbata</i>	X		
<i>Lyginia imberbis</i>	X		
<i>Melaleuca preissiana</i>		X	
<i>Melaleuca viminea</i>		X	
<i>Mesomelaena pseudostygia</i>	X		X
<i>Mesomelaena tetragona</i>	X		X
<i>*Monopsis debilis</i>		X	
<i>Neurachne alopecuroidea</i>	X		
<i>Patersonia occidentalis</i>	X		X
<i>*Pennisetum villosum</i>		X	
<i>Pericalymma ellipticum</i>	X		X
<i>Petrophile linearis</i>	X		
<i>Petrophile macrostachya</i>	X		
<i>Phlebocarya ciliata</i>	X		X
<i>Pimelea sulphurea</i>	X		
<i>*Poa annua</i>		X	
<i>Pterostylis vittata</i>	X		X
<i>Pyrorchis nigricans</i>	X		
<i>Scaevola calliptera</i>			X
<i>Scholtzia involucrata</i>			X
<i>Siloxerus humifusus</i>	X	X	
<i>Sphaerolobium</i> aff. <i>macranthum</i>			X
<i>Stirlingia latifolia</i>	X		X
<i>Stylidium brunonianum</i>	X		
<i>Stylidium calcaratum</i>		X	
<i>Stylidium</i> spp.	X	X	
<i>Tetraria australiensis</i>	X		X
<i>Tetraria octandra</i>	X		X
<i>Tetratheca hirsuta</i>	X		
<i>Thelymitra crinita</i>	X		
<i>Thelymitra macrophylla</i>	X		X

Plant species	Banksia woodland (20b)	Wetland heath	Marri woodland (3b)
<i>Thelymitra vulgaris</i>		X	
<i>Thysanotus triandrus</i>			X
<i>Trachymene pilosa</i>	X		
<i>Tribonanthes australis</i>		X	
<i>Tricoryne elatior</i>	X		X
<i>Triglochin incurva</i>		X	
<i>Tripterococcus brunonis</i>	X		
* <i>Ursinia anthemoides</i>	X		
* <i>Watsonia meriana</i>	X	X	X
<i>Xanthorrhoea gracilis</i>	X		X
<i>Xanthorrhoea preissii</i>	X		X
<i>Xanthosia huegelii</i>	X		
<i>Xylomelum occidentale</i>	X		

*Introduced species (weed)

Appendix 2 – Drainage of Serpentine Sports Reserve

In 1999, a report was prepared for the Shire of Serpentine Jarrahdale by Therese Wade and Jim Elliot entitled *Nutrient, Water and Drainage Management in the Serpentine Recreation Area*. Included in the report are three maps, one of which shows the patterns of drainage and the locations of the Water Corporation drains in the SSR. This map is reproduced on the following page.

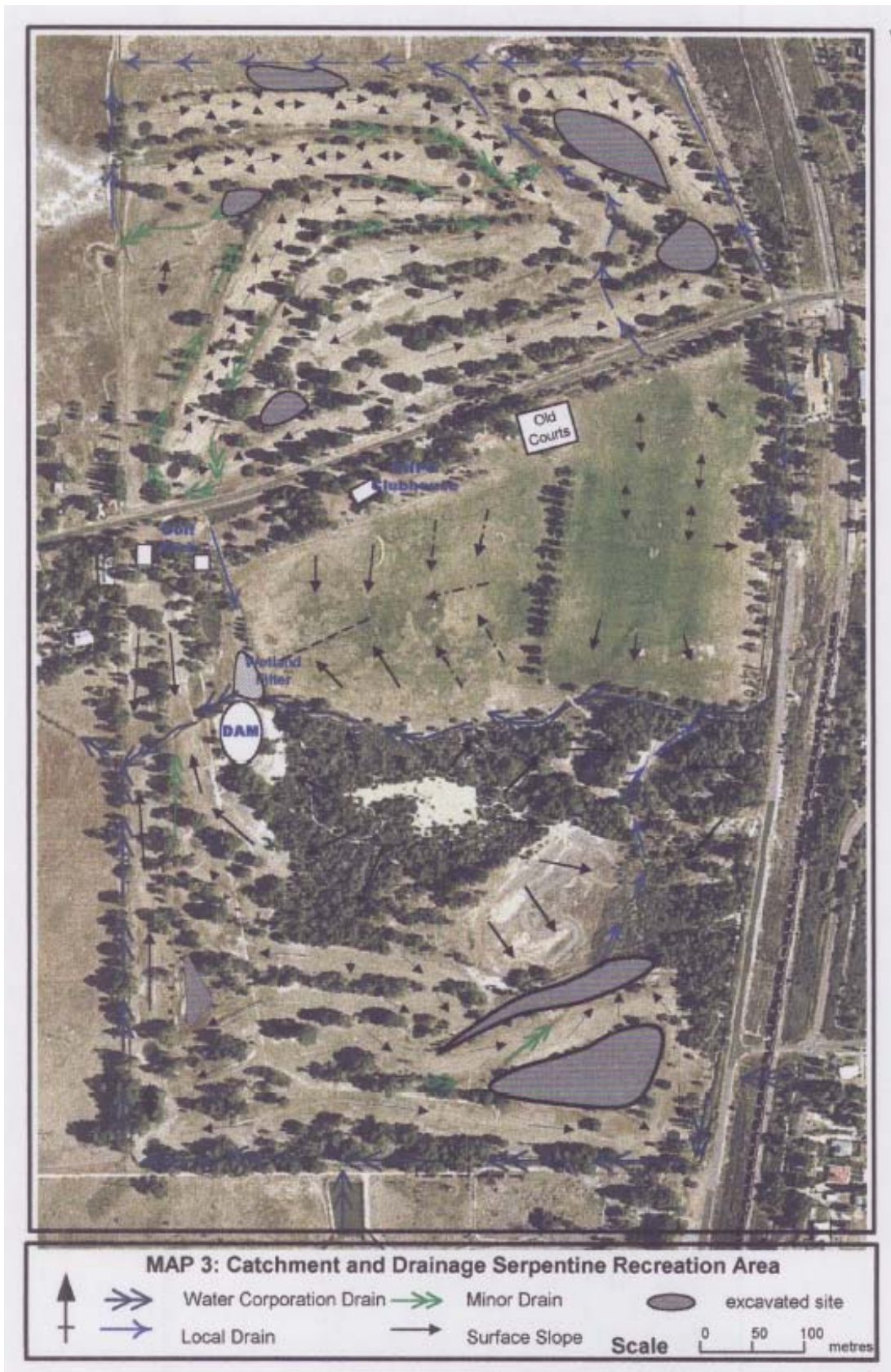


Figure 4: Drainage of Serpentine Sports Reserve (from Wade & Elliot, 1999)