Shire of Serpentine Jarrahdale

Darling Downs Trail Network Reserves Management Plan

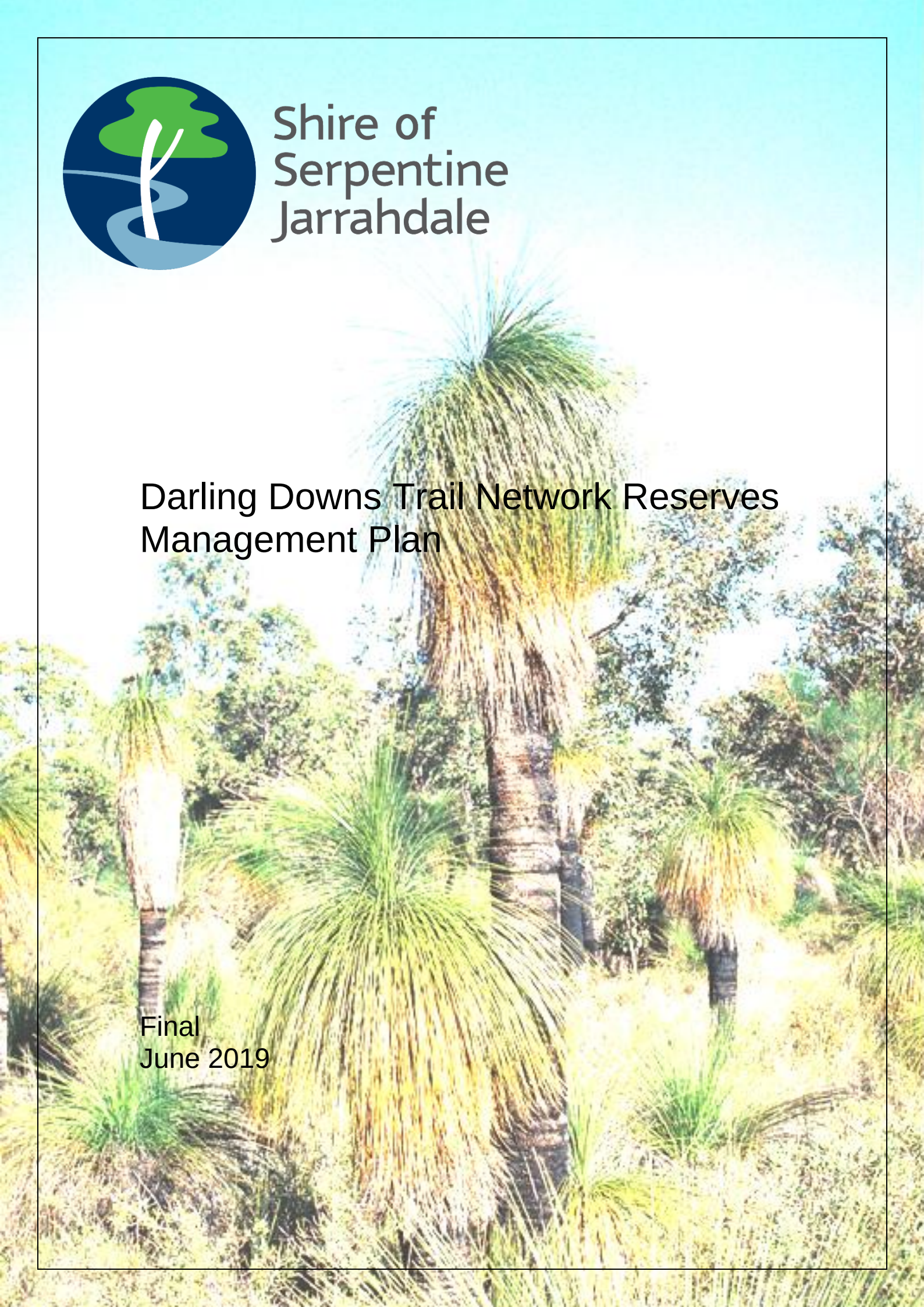

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TABLE OF CONTENTS

1. Executive Summary

1.1 Introduction

The Darling Downs Trail Network Reserves (also referred to as the 70-acre reserve, which includes associated bridle trails) is located in Darling Downs, north of Byford, linking properties within an equestrian precinct to a large recreational reserve primarily used for equestrian purposes. Both the trails and the larger reserve are highly disturbed areas with almost no natural understorey and many trees (mostly planted) of both natural and introduced types, with constructed drains and an artificial wetland forming a drainage network that often follows the trails. The majority of the reserves which comprise the Darling Downs network are vested with the Shire of Serpentine Jarrahdale for the purpose of public recreation.

The Darling Downs Residents' Association (DDRA) manages the area for recreation through facility maintenance, weed control, slashing, and other vegetation management activities. The DDRA is funded by the Shire to the value of $10,000 per year from 2018 to 2020 for its maintenance of the reserves. Landcare SJ Inc. received a grant to construct the wetland in 2006, conducted an extensive program of planting and weed control in and around the constructed wetland from 2007 to 2013, and maintains an interest in developing the conservation value of the reserves.

1.2 Objectives

The objectives of this management plan are to:

- Provide the necessary background information and site descriptions for informed management of the reserves;
- Define specific management objectives for maintaining and improving the conservation values of the reserves:
    1. Define areas that may require different management methods (e.g. conservation versus active recreation);
    2. Assess the vegetation quality and potential for rehabilitation;
    3. Assess the major problems affecting safety, aesthetics and public enjoyment, such as fire management and weed control;
    4. Assess the types and degree of environmental degradation and possible ways to address these issues; and
    5. Provide a plan for the residents' group to follow when managing and regenerating the area;
- Document the actions required to successfully manage the reserves;
- Identify any management constraints and possible ways to overcome them;
- Ensure consistent management into the future, so that the goal or focus is clearly defined and easy to follow despite change of position holders; and
- Provide the community with the opportunity to become involved in the decision-making process for management of the reserves.

1.3 Location and Description

The Darling Downs Trail Network Reserves is situated in the locality of Darling Downs, immediately north of Byford in the Shire of Serpentine Jarrahdale and south of the boundary with the City of Armadale. This is a designated equestrian precinct, with a network of trails leading into a large focal reserve which concentrates multiple equestrian activities. The trail network consists of 12 reserves (38 lots) and 4 freehold lots in the area bounded by Thomas Road in the south, Hopkinson Road to the west, Rowley Road to the north, and newer subdivisions in the east (see Figures 1 - 3, and Appendix 1). The total area of the network is approximately 56 hectares.

Constructed drains (including the northern end of the Birrega Drain) and an artificial wetland form part of a drainage network that often follows the trails, ultimately discharging via the Oakford Main Drain into the Serpentine River, which empties into the Peel Harvey Inlet. The Birrega Drain formerly originated from the Wungong Brook in the north, but the connection was filled in 2014 to prevent the spread of the pearl cichlids (an invasive feral fish), which had been found in the Wungong Brook, into the Birrega Drain and from there the Serpentine River and other waterways of the Peel catchment area. Regional Ecological Linkages run along the Birrega Drain and Wungong Brook, while some sections are classified as Bush Forever, Conservation Category Wetlands, and/or Environmentally Sensitive Areas (see Figure 3).

1.4 Report Structure

This management plan is structured into the following sections:

- Legislative and policy framework:
    - *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.*
- Physical and biological characteristics:
    - *Analyses landform, land, water and biodiversity features on the Study Area. Threats to these features have also been considered.*
- Cultural and social characteristics:
    - *Identifies the main human uses of the Study Area, 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 Priority Actions

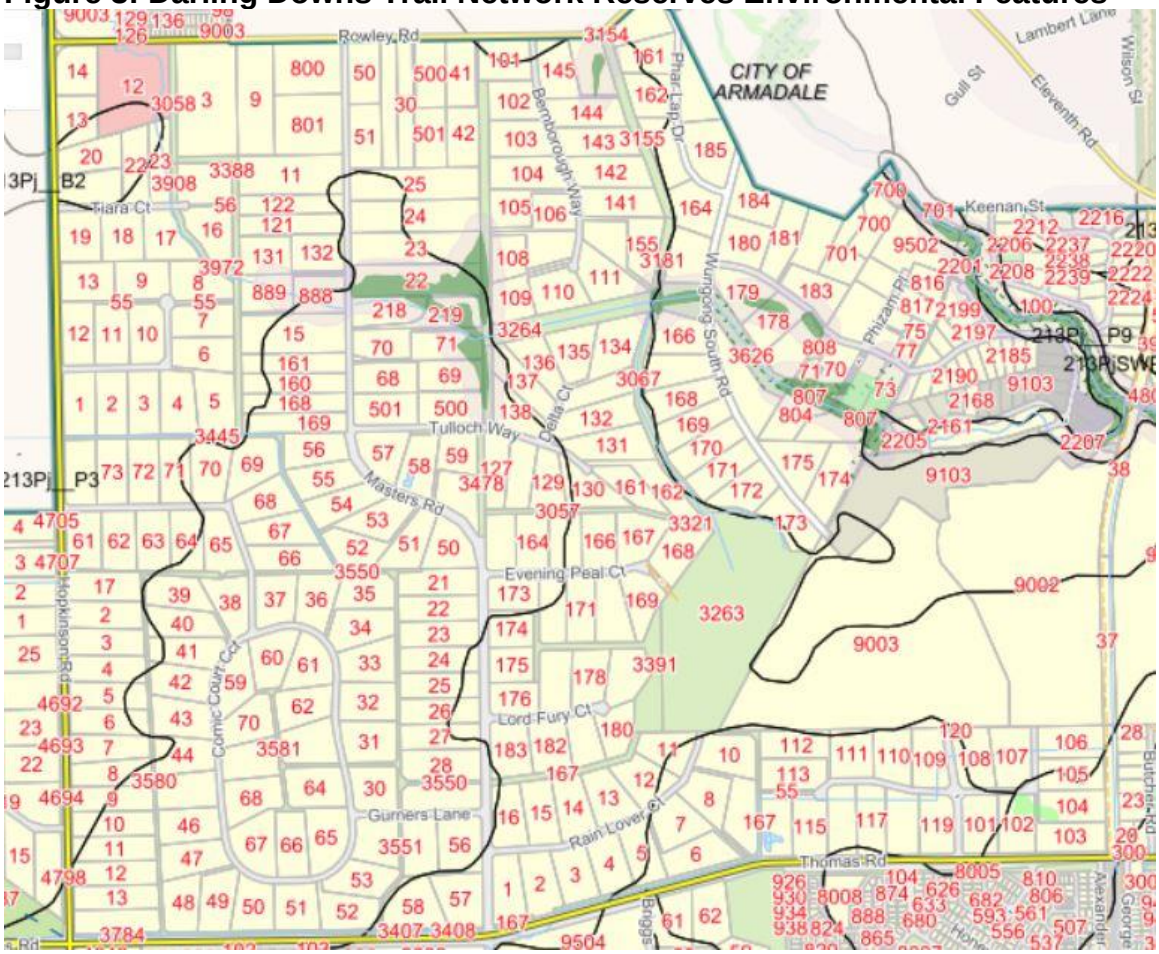
Table 1: Key Priority Recommendations

No.	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
Governance						
1	An appropriate application form is to be submitted and assessed prior to improvement or development.	Key	Ongoing	Natural Reserves Coordinator Natural Assets Community Services DDRA	Staff Time	Actions are carried out with Shire Officer support and to a mutually acceptable standard.
2	Periodically monitor and review the Agreement between the Shire and the DDRA regarding Shire contributions and DDRA responsibilities in management of the reserves.	Key	Ongoing	Natural Assets Community Services DDRA	Staff Time	
Environmental Characteristics						
9	Liaise with Emergency Services to create/update and implement a Fire Management Plan.	Key	Implemented in part	Emergency Services Natural Assets	Staff Time	
12	Follow up any burning with weed control measures.	Key	Ongoing	Emergency Services Natural Assets DDRA	Staff Time	
14	Strategically remove weeds and invasive non-local species such as Eastern States eucalypts.	Key	Ongoing	Natural Assets DDRA	Contract spraying - charged by hour and chemical type	
15	Control weeds and invasive non-local species using organised community working bees, local species planting, and other events including with Landcare SJ.	Key	Ongoing	Natural Assets Landcare SJ DDRA	Staff Time	
19	Develop and implement a rehabilitation plan in identified areas.	Key	Ongoing	Natural Assets Emergency Services Landcare SJ DDRA	Staff Time Implementation costs for site preparation and plants	Order plants each October for planting the following winter, every year.
Social and Economical Characteristics						
27	Encourage ongoing community management, maintenance and upgrade of the reserves.	Key	Ongoing	Natural Assets DDRA	Staff Time	DDRA currently undertakes management and maintenance, with assistance from the Shire.
28	Monitor and maintain the reserves and their infrastructure in a safe, maintained condition, with adequate insurance coverage, in the context of an asset management plan and annual works programs.	Key	Ongoing	Operations DDRA	Maintenance costs currently $10,000 per year from 2018 to 2020 under Agreement with DDRA	Infrastructure includes external fences, bridle and walk trails, car parks, equestrian facilities, storage sheds, signage, picnic tables and shelters, and park benches.

Figure 1: Darling Downs Trail Network Reserves Location - Lots and Cadastre

Figure 2: Darling Downs Trail Network Reserves Outline

Figure 3: Darling Downs Trail Network Reserves Environmental Features



Key: Green hatching – Bush Forever
Dark green – Conservation Category wetland
Pale bright green – Resource Enhancement wetland (remainder of area is Multiple Use wetland)
Purple – Environmentally Sensitive Area
Black lines – soil type boundaries (see section 3.1.1 for names and descriptions)

2. Governance

2.1 Vesting

The Darling Downs Trail Network Reserves consists of 12 reserves, totalling 38 lots, plus four non-reserved (freehold) lots. Of the reserves, 11 (36 lots) are vested with the Shire of Serpentine Jarrahdale for the various purposes of Public Recreation, Drainage and Right of Way. The remaining reserve (2 lots) is vested with the Water Corporation for the purpose of drainage.

The first reserves were created for the purpose of 'Public Recreation' on 8 December 1978, and vested to the Shire on 9 October 1981. New vesting orders were issued on 13 May 1983 and 27 June 1995, on which occasions additional areas (mostly bridle trails) were added to the Public Recreation reserve.

2.2 Land Tenure

The land tenure and vesting purpose of the several sections of Darling Downs Trail Network Reserves (see Figures 1 - 3) are shown in Table 2. An expanded version can be found in Appendix 1. Only some of the reserves listed are included in the DDRA Memorandum of Understanding with the Shire, and some areas (such as R42696) do not contain trails but contribute to the connectivity of the network.

Table 2: Darling Downs Trail Network Reserves Locations and Uses

Reserve number	Lot no.	Plan number	Area (ha)	Gazettal	Purpose	Responsible agency	Vesting	DDRA MOU
R35701	7x lots		33.3842	8/12/1978	Public recreation	Department of Lands	SoSJ	Included
R35702	L3068	P012440	0.7224	8/12/1978	Public recreation	Department of Lands	SoSJ	Included
R35706	7x lots		7.3544	8/12/1978	Public recreation and drainage	Department of Lands	SoSJ	Included
R35601	2x lots		1.0701	24/11/1978	Public recreation	Department of Lands	SoSJ	Included
R35603	11x lots		9.9377	24/11/1978	Public recreation	Department of Lands	SoSJ	Included
R42696	2x lots		0.6226	1/6/1993	Drainage	Water Corporation	Water Authority of WA	
R38471	2x lots		0.3036	14/10/1983	Public recreation	Department of Lands	SoSJ	
R39190	L3478	P091556	0.6744	6/9/1985	Recreation	Department of Lands	SoSJ	Included
R38830	L3444	P014489	0.2066	17/8/1984	Public recreation	Department of Lands	SoSJ	Included
R50480	L808	P062599	0.2837		Drainage	Department of Lands	SoSJ	
R51274	L702	P066606	0.3851		Public recreation	Department of Lands		
R52763	2x lots		0.6435		Right of way	Department of Lands	SoSJ	
Non-reserved trails	L56	D083119	0.0675	Freehold				
	L55	D075039	0.2039	Freehold				
	L66	P013944	0.1624	Freehold				
	L55	P019948	0.1014	Freehold				

2.3 History (1978-2018)

The Darling Downs Equestrian Estate was created in 1978 by subdividing a dairy farm into 260 lots. The estate includes a 35 hectare reserve (primarily used for equestrian and other recreation) and over 25 km of bridle paths (public multiple use trails). Prior to reservation, Darling Downs Trail Network Reserves were heavily grazed. None of the reserves are currently grazed, but parts are regularly slashed by the Residents Association and the Shire. By the late 1970s, almost none of the original indigenous understorey flora remained, and weed infestation was heavy, including African Lovegrass (*Eragrostis curvula*), Cotton Bush (*Gomphocarpus fruticosus*) and Paterson's Curse (*Echium plantaginium*).

The areas were rezoned during the Darling Downs subdivision in 1978 from grazing land to public recreation reserves. As Darling Downs was envisaged as an equestrian precinct, it was designed with rear access from private lots to bridle trails, leading to a large recreational reserve. The estate was intended to be much larger, extending to the east of the current area, with the recreational reserve more than twice the size and surrounded by private lots and bridle trails. However, the landowner on the east of the current estate withdrew from the subdivision, leaving the estate and its equestrian reserve much smaller than originally envisaged. The remaining developer could not complete the work, but paid a proportion of the block sales (amounting to approximately $109,000) into a trust fund held by the Shire. Partway through the subdivision process, in 1977, responsibility for the area passed from the City of Armadale to the Shire of Serpentine Jarrahdale.

The Darling Downs Residents' Association began in 1986 as an advisory committee of residents (known in its original form as the Darling Downs Development Committee) formed by the Shire to guide the completion of the Darling Downs Estate trails, park and facilities. Responsibility for management and construction gradually passed to the DDRA, including installation of arenas, trotting tracks, storage sheds and other facilities, paid for by the trust fund. In 2008, prompted by a lack of adequate insurance and no clear licence to operate, the committee was incorporated as a not-for-profit Association. After incorporation, an operating licence over the trails, park and reserves was agreed with the Shire, insurance cover for the committee and volunteers was obtained, and additional funding from grants and sponsorship was secured to supplement the Association's trust fund. The Darling Downs Residents Association has historically undertaken almost all the necessary maintenance of the trails and larger reserves, relying on volunteer labour by its members.

In 2017, following exhaustion of the trust fund, the Shire and DDRA signed a Memorandum of Understanding under which the Shire contributes $10,000 per year from 2018 to 2020 towards the Association's management of the area. In 2018, the Darling Downs Residents' Association distributed its newsletter to over 180 members, of whom approximately 60 live in the area. Up to 10 members regularly participate in busy bees and other management activities.

Landcare SJ Inc. has long had an association with the main reserve. In 2006, Landcare SJ received funding from the Federal Government's Community Water Grants program to create and revegetate a wetland within the recreational reserve. This grant also paid for a water tank near the DDRA's storage shed. The funding was insufficient to complete the earthworks for the wetland, so a further sum of $4,400 (in matched funding) was granted

to the DDRA in 2008 as Devolved Funding from the SJ LCDC Rivers, Wetlands and Habitats Grants. Between 2007 and 2013, over 10,000 local native seedlings were planted around the wetland, funded from a variety of sources (including the original Community Water Grant, the Bendigo Bank, State Government grants, and the Caring for our Country program). Little other planting has occurred in the reserves, with the exception of historical planting of exotic trees.

In 2015, the wetland was reshaped and cleaned out, incidentally removing much of the vegetation from the banks. This reshaping changed the way the reserve drains, interrupting the natural flow across the reserve which the wetland retained. The wetland was always seasonal, but now holds water for a shorter period as more of the water flows out rather than being retained. The original slope of the wetland banks was designed to accommodate wildlife, but the reshaping has made the banks very steep and unsuitable for wildlife, and susceptible to erosion.

The Birrega Drain formerly originated from the Wungong Brook in the north, but the connection was filled in 2014 to prevent the spread of the pearl cichlids (an invasive feral fish), which had been found in the Wungong Brook, into the Birrega Drain and from there the Serpentine River and other waterways of the Peel catchment area.

Due to the areas of dense and diverse tree canopy cover on the trails and parts of the large reserve, the locality is frequented by many types of birds, including black cockatoos. Informal observations from local residents indicate that quenda may utilize the less managed areas for habitat, and use the trails as corridors linking to larger areas of habitat such as the Wungong Brook.

2.4 Bush Forever and Other Environmental Classifications

Some sections of the reserve network, along the Birrega Drain and Wungong Brook, are classified as regionally significant through Bush Forever (site number 266). The reserves are not known to contain priority flora, but there are records of quenda inhabiting and moving through the reserve (priority 5 fauna). Environmentally Significant Areas exist around the Bush Forever area, and around several Conservation Category wetlands on other sections of the Birrega Drain and Wungong Brook (see Figure 3). Regional Ecological Linkages have been identified along the Birrega Drain and Wungong Brook (numbers 61 and 56 respectively).

2.5 Governance Recommendations

Table 3: Governance Recommendations

No.	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
Governance						
1	An appropriate application form is to be submitted and assessed prior to improvement or development.	Key	Ongoing	Natural Reserves Coordinator Natural Assets Community Services DDRA	Staff Time	Actions are carried out with Shire Officer support and to a mutually acceptable standard.
2	Periodically monitor and review the Agreement between the Shire and the DDRA regarding Shire contributions and DDRA responsibilities in management of the reserves.	Key	Ongoing	Natural Assets Community Services DDRA	Staff Time	

3. Environmental Characteristics

3.1 Physical Features

3.1.1 Land

Description

The soils of Darling Downs Trails Network Reserves are part of the Pinjarra Plain system, consisting of low-lying, poorly drained alluvial plains and duplexes (Table 4). To the east, the land rises through the foothills and Darling Scarp to the Darling Plateau.

Table 4: Landform and Soil Classifications

Soil Type	Location	Description	Land Quality Considerations
Pinjarra B2 phase	Small patch in north-west of study area	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2m.	Soil water storage
Pinjarra P3 phase	Arc running from south-west through north to north-east of study area; includes main reserve	Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.	Waterlogging risk
Pinjarra P1d phase	Large patch running from south-west to centre north of study area	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity.	Salinity risk
Pinjarra P6c phase	Small patch in north-east of study area	Very gently undulating alluvial terraces and fans. Moderate to moderately well drained uniform friable brown loams, or well structured gradational brown earths.	-
Pinjarra P9 phase	Located along the Birrega Drain and Wungong Brook, in the north-east of study area	Shallowly incised stream channels of minor creeks and rivers with deep acidic mottled yellow duplex soils.	Waterlogging risk
Pinjarra P11a phase	Small patch in south-east of study area	Shallow sand to sandy loam over lateritic material; imperfect to moderately well drained.	Wind erosion; waterlogging risk

The Darling Plateau is ancient. The basement rocks are around three billion years old and are deeply weathered in the upland areas and eroded along the western edge. The part of the Plateau lying within the Shire boundaries has an elevation of 250-350 m above sea level. The western edge drops away steeply to meet the coastal plain at about 60 m above sea level. 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.

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.

Condition and Status

The condition of the land through most of the plateau is good, as a vegetation cover of forest and woodland has been retained. Most of this area is managed as State Forest, water catchment or conservation reserves.

The soils of the Swan Coastal Plain are generally in poor condition, as wide-scale clearing for agriculture and urban development has removed most of the vegetation cover. Historical and current agriculture has exposed the land surface to wind and water erosion, and led in some areas to loss of sediments, nutrients, organic matter, and soil water retention capabilities. Impacts to soil have resulted from overly intensive grazing, inappropriate excavation, landfill and machinery use. Urban development compounds these issues, with the added pressure of impermeable surfaces over much of the area.

Major Threats and Pressures

Poorly managed human activities, from broad acre agriculture to urban development, can lead to degradation of the soils. In recent years, soil degradation on rural residential holdings and “hobby farms” (including equestrian properties) has highlighted the need for training in land management. The range of degrading processes include phosphorus (and other nutrient) export, water and wind erosion, secondary salinity, soil structure decline, subsurface acidification, waterlogging and flood. Land degradation is a result of a complex interplay between land and soil properties and their management. Good land management requires a range of highly developed knowledge and practical skills.

Erosion

Erosion is the removal of topsoil, and in extreme cases (often including along fire breaks), deeper layers of the soil profile by the action of water or wind. This means a permanent loss of part of the land asset. The risk of erosion depends on the stability of the surface soil, often affected by the amount and type of vegetation cover (such as native perennial, pasture annual, or pasture perennial) and the force of the wind or water moving across the surface. Water speed is largely determined by slope, although level areas may be affected by water flowing from adjacent land. Water erosion is an accelerating process, as bare eroded areas generate more surface runoff, increasing the volume and speed of water movement downslope.

Water erosion occurs in streams when water washes out soil from the banks and deposits it downstream. However, human activity can and often does accelerate the process to harmful levels. The degree of bank erosion depends on the amount and type of the remaining vegetation cover, due to the increase in water availability when decreased vegetation cover reduces filtration and water uptake. The roots of the plants also act to stabilise the soil and control erosion. Some types of vegetation, such as reeds and rushes, filter nutrients from the water. Therefore, the stream’s vegetation is essential in preventing

further erosion and damage. Bank erosion is evident in the reserves in areas where there is a lack of supporting vegetation on the Birrega's banks, much of which can be attributed to the past grazing of the reserve by local stock.

Grazing

The Darling Downs Trail Network Reserves were, for many years, subjected to grazing by local stock. This resulted in land degradation, as well as streamline erosion, which impacted on the reserves' conservation value. Grazing has contributed to soil compaction, tree ringbarking, altered patterns of run-off, nutrient build-up in the soil, introduction of weeds, and consumption of the valuable leaf litter which normally provides the soil with essential nutrients. A combination of these problems has led to a major decline in understorey vegetation and therefore associated fauna.

Salinity

Surface salinity is a condition where the level of soluble salts in the surface soil is high enough to affect plant growth. It can be natural or anthropogenic, and can be caused by rising water tables or evaporation of surface water. Salinity alters the chemical balance of the soil and limits plant growth. This leads to the secondary impacts of bare sealed surfaces with low infiltration and increased runoff and erosion. Salinity is not currently known to affect the reserve, although some of the soil types present are considered to be at risk.

Acid Sulphate Soils

Acid sulphate soils are sediments containing iron sulphides, which occur naturally in layers of waterlogged soils and are benign until disturbed. The soils in the reserves vary from well-drained to at risk of waterlogging, resulting in a varying risk of acid sulphate soils, but soil disturbance to the level of the water table is improbable. The Darling Downs area is classed as acid sulphate soil category 2, with moderate to low risk.

3.1.2 Water

Description

Water assets provide a variety of ecosystem services, such as draining the excess surface water from the landscape and minimising flooding. The groundwater resources provide a water storage function that interacts with the surface waterways and wetlands. During long dry spells the groundwater supports surface water and wetland ecosystems as well as its own unique ecosystem. Dams can create important reservoirs of water for a range of uses, but can result in loss of important riparian areas required for wildlife habitat, as well as loss of important environmental flow downstream needed for the sustainability of riparian and river bed habitat. An extensive constructed drainage network transports surface and subsoil water from the landscape to the Serpentine River.

Surface Water

Darling Downs, and its main drainage system of the Birrega Drain, is within the Serpentine Catchment, which contributes around 15% of the total annual surface inflow to the internationally significant Peel Harvey Yalgorup Ramsar Site. Maintaining and improving the quality of the catchment runoff is vitally important to protecting the health of the estuary.

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. The Birrega Drain forms one of the primary waterways draining the region, and passes through Darling Downs from its original connection to the Wungong Brook, which lies in the Swan-Canning catchment rather than the Serpentine. This connection was blocked in 2014 to prevent feral fish moving up the brook from entering the drainage system and hence the Serpentine system. 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.

Serpentine River and Dams

The Serpentine River is the most significant natural waterway in the Shire of Serpentine Jarrahdale. It rises to the east of the Shire and traverses the Shire from the southeast corner to the western boundary where it discharges to a large artificial drain. The River is dammed at two points in its upper reaches on the Darling Plateau. The smaller pipehead dam was completed in 1957 and the larger dam upstream in 1961. These reservoirs are an important source of water for the metropolitan region and their catchments are carefully managed by the Water Corporation to maximise water supply and quality.

Drainage Network

Overly efficient drains and clearing in and around streams has resulted in excessive loads of silt and nutrients being transported from the Shire's land surface into drains, streams and the estuary. The severity of this problem was recognised in the 1980s when the Peel-Harvey Estuary's ecosystem came close to collapse because of high nutrient levels. Most of these nutrients and eroded sediments come from the coastal plain.

Wetlands

Wetlands are, in general, expressions of the groundwater table and play an important role in the water cycle. In winter they store surface water, and in summer water evaporates from the surface. Many wetlands have been drained and filled, so they are a diminishing and threatened asset. Wetlands have an intrinsic place in the regional ecology, and constructed wetlands (such as the one in the Darling Downs main reserve) can fulfil many of the functions of naturally occurring wetlands.

Groundwater

Groundwater quality in the Shire is generally good, although there is limited information on which to base an analysis. There is a natural variation in groundwater salinity. It is possible that lower groundwater tables and excavations could have exposed acid sulphate soils and released acid plumes into the groundwater of the coastal plain. It is also probable that there has been some level of nitrogen and phosphorus enrichment of groundwater in

places, especially beneath the sands of the coastal plain. The impact of this and any other pollutants will depend on complex biological, chemical and physical processes in the groundwater systems. The information on groundwater quality in the area of the reserve is limited, but there are no problems which are currently thought to affect the area.

Extensive supplies of groundwater 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. Extraction is controlled and licensed by the Department of Water and Environmental Regulation.

Major Threats and Pressures

The most significant threats to the water asset relate to both lower recharge rates and higher demand for use. The predicted climate changes, leading to significantly lower rainfall, would have a major effect on recharge, while the expanding population is likely to increase the demand for use. Other significant threats to the asset are actions that reduce water quality, including lowering of the water table and exposure resulting in acid sulphate soils, nutrient export and chemical pollutants.

Climate Change

Current models suggest that rainfall will decrease by as much as 20% by the year 2030, while temperatures will increase. The exact impact on water assets is still unknown because of the complex processes involved. However, it is anticipated there will be significantly less water entering the system, and the higher temperatures will lead to higher levels of evapotranspiration as well as higher demand for human uses.

Overall the water asset will become increasingly precious and there will be a need to be far more efficient in water use and more effective in surface water management.

Eutrophication (Nutrient Enrichment of Aquatic Ecosystems)

The Darling Downs Trail Network Reserves fall within the catchment of the Peel-Harvey Estuary, an ecosystem which has been under extreme pressure from eutrophication. Many land uses continue to contribute significant nutrient loads to the estuary. These nutrients also impact directly on the ecology of the Serpentine River and other waterways.

Broad-acre agriculture currently makes up about 90% of land use within the Peel Harvey Catchment and is the source of the majority of nutrients reaching the estuary. At present, urban and rural living land uses make up only 6% of the catchment area, but these land uses contribute much more than 6% of nutrient loads. Possible sources of nutrients from urban and rural living land uses include septic tanks, eroded soil particles and over-fertilising of small areas of pasture or lawn. All of these possible sources are cumulative and likely from the area surrounding the reserve.

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.

Siltation and Pollution of Surface Waters

Allied to the export of nutrients from the land surface is the export of soil particles and organic matter. The soil particles are often the carrier for nutrients, thereby creating part of the threat discussed above. They also directly impact on the water systems by increasing the turbidity of the water, filling pools and sometimes creating barriers to drainage that can lead to flooding. Erosion is not a significant problem within the reserve, with the exception of the banks of the drainage system, and thus the area is not likely to be a great contributor of soil particles, and potentially nutrients, to downstream areas.

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.

Salinity is not a major problem for the reserve as it (and its upstream catchment area) does not suffer from rising saline groundwater. However, some areas of the Shire are affected by surface salinity, so it is likely that there has been some effect on the salinity of other waterways. Some of the soils present in the Darling Downs area are considered to be at risk from salinity. The salinity of the groundwater varies and is high in some places due to the high salt content of the aquifer sediments. It is also noted that groundwater discharging to the Serpentine River has higher salt levels.

The salinity of wetland systems generally increases through the summer due to high evaporation and decreases when flushed by the winter rains. This winter flushing effect may be a key factor in preventing salinity, and the predicted decrease in the length and volume of winter rains could therefore increase the risk of salinity. An increase in the area of salt affected land in a catchment could also affect the salinity levels in surface and groundwater systems. Salinity is a threat to the water asset that requires further study.

Over-Use of Groundwater

Groundwater levels across the Shire are declining in both the deeper and surface aquifers. The greatest declines are consistent with the areas of most intensive development and particularly with a high number of domestic water bores. With the likelihood of lower rainfall in the future the situation will most likely deteriorate. It is unclear how this may affect the reserve, although it is known that declining groundwater levels are likely to put vegetation under stress resulting in negative impacts.

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.

Acid Sulphates, Nitrates and Other Pollutants

Exposure of acid sulphate soils through either excavation or lowered water tables can result in plumes of sulphuric acid and heavy metals entering the surface and groundwater systems. Acid sulphate soils occur in the region, and when exposed to oxygen, the released sulphuric acid 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.

Nitrate pollution has been found under horticultural areas north of Perth. Intensive use of fertilisers and intensive stocking such as feedlots creates a high risk of nitrogen leaching into the groundwater, particularly on sandy soils. Pesticides and other chemicals also pose a serious risk to ground and surface water systems. Careful management of all these materials, especially close to surface water or in high recharge areas, is essential.

Changing Hydrology

Climate change, and the continuing and increasing over-use of groundwater resources, are a significant threat to the hydrological balance. As more areas of the Shire are developed for residential use there will be other major changes to the hydrology. As water becomes increasingly precious there will be more pressure to store and reuse the surface water that is now flushed out to sea. All of these factors may influence the reserve in the future.

3.1.3 Climate, Rainfall and Air Quality

Description

The climate of this region is described as Mediterranean, because of the similarity to weather patterns experienced in the region of that name. It is a mild climate with hot, dry summers and cool, wet winters. The average annual rainfall varies from 800 to 1000 mm on the coastal plain area, increasing to 1200 mm on parts of the Darling Plateau. Most of the rain falls during the winter. Decaying tropical thunderstorms occasionally bring heavy rainfall to the region during summer or autumn.

The climate is currently much drier than it has been since the beginning of the last century. The innate variability of the climate makes it difficult to make long term predictions and climatic models also vary. Since the 1950s there has been a substantial decline in rainfall coupled with a slight increase in temperature. It is uncertain how much of this decrease in rainfall is due to natural variability and how much is caused by climate change. Nevertheless, current studies strongly suggest that winter rainfall will continue to decline, putting greater pressure on the reserve.

Major Threats and Pressures

CSIRO studies predict that Western Australia will be much warmer and drier by 2030. Autumn and winter rainfall is likely to decrease by around 20% from 1990 values. Spring rainfall also is also expected to decrease somewhat and temperatures may rise by up to

2 °C. The higher temperatures will cause higher evaporation and, coupled with decreased rainfall, will significantly affect the water balance. Rainfall events are expected to become more intense, leading to higher runoff generation, especially on soils with low infiltration rates.

Loss of Vegetation

Vegetation plays an important role in creating a healthy ecosystem. This includes agricultural areas and remnant vegetation. Vegetation cycles carbon and nutrients, filters the air and modifies the local climate through evapotranspiration, shading and windbreak effects. Clearing of vegetation for urban and more intensive development needs to be balanced by revegetation and remnant vegetation protection.

3.2 Biodiversity

Description

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; this means a high level of threat as well as great diversity.

At a State level the *Biodiversity Conservation Act 2016* (which replaced the *Wildlife Conservation Act 1950*) protects species of plants and animals that are listed as "Threatened". The responsible agency (Department of Biodiversity, Conservation and Attractions) 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. No declared Threatened or Priority species are known to occur in Darling Downs. The *Biodiversity Conservation Act 2016* also protects ecological communities or unique assemblages of plants and animals. Some Threatened Ecological Communities and endangered species are additionally 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. It identifies areas of regionally significant bushland and strategies for their protection, as many are in private ownership. Bush Forever Site 266 extends along the Wungong Brook and part of the Birrega Drain, forming a corridor to other significant areas. It is part of a network of small sites whose connectivity increases their opportunity for long term survival.

The assumption is that preserving representative ecosystems will also preserve the full variety of species and genes. Unfortunately, the extent of ecosystem destruction has been so great that it is no longer possible to protect some ecosystems. This strategy therefore needs to be supplemented by other approaches such as recovery projects for threatened flora and fauna.

The State Government manages a system of national parks, nature reserves and conservation parks that aims to be comprehensive, adequate and representative. It also conducts a number of recovery programs for threatened species and communities.

This Shire is part of the Southwest Botanical Province, which has been recognised as a global biodiversity hotspot. Not only does this area boast a high diversity of species, but many of these plants and animals are found nowhere else in the world. The second criterion for recognition as a biodiversity hotspot is the level of threat; many of these unique plants and animals are rare and threatened. The management and protection of many parts of this internationally important asset falls to local government and private landholders. The local community also has the responsibility to ensure that adjacent land uses do not damage the biodiversity assets.

3.2.1 Flora

Remnant Vegetation Communities

Australia has been divided into 85 "Biogeographic Regions" for the purpose of conservation planning and natural resource management. The Darling Downs Trail Network Reserves are 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, Casuarina 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 C. 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 Darling Downs reserves are 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 rhaphiophylla* (freshwater paperbark).

Many Shire reserves with high biodiversity values have been invaded by the aggressive weeds watsonia (*Watsonia* spp.) and lovegrass (*Eragrostis curvula*). Despite ongoing programs of weed control the populations are spreading. The problem, particularly related to the spread of lovegrass, can usually be linked to either direct disturbance by humans, animals or machines or indirect disturbance such as stormwater runoff or effluent disposal. Unfortunately many Shire reserves are still subject to high levels of disturbance, often by recreation groups, which encourages weed invasion.

Landcare groups, working with Landcare SJ Inc., have restored areas of remnant vegetation within the Shire and revegetated large areas. These revegetation projects have used predominantly locally occurring species.

There is very little native understorey vegetation remaining in the Darling Downs Trail Network Reserves, the ground cover being dominated by pasture species and weeds, with the exception of the area around the constructed wetland, which has been revegetated with predominantly local native species. There are some tree species, both local native and introduced, which provide a good level of overstorey cover and the vegetation complexes (based on soil type and overstorey analysis) would appear to be Guildford, with a small area of Bassendean Central and South in the northwest. The native flora species in the reserve (most of which are planted, rather than naturally occurring) are listed in Table 5, and weeds and planted non-natives in Table 6.

Table 5: Native Flora Species Recorded in the Darling Downs Trail Network Reserves

Species	Common Name
Acacia microbotrya	Manna wattle
Acacia saligna	Golden wreath wattle
Actinostrobus pyramidalis	Swamp cypress
Allocasuarina fraseriana	Sheoak
Callistemon phoeniceus	Lesser bottlebrush
Calothamnos quadrifidus	One-sided bottlebrush
Casuarina obesa	Swamp sheoak
Corymbia calophylla	Marri
Eucalyptus rudis	Flooded gum
Eucalyptus wandoo	Wandoo
Hakea prostrata	Harsh hakea
Hakea varia	Variable-leaved hakea
Melaleuca preissiana	Moonah
Melaleuca rhaphiophylla	Swamp paperbark
Melaleuca teretifolia	Banbar
Melaleuca viminea	Mohan
Melaleuca spp.	Several species of melaleuca, mostly local natives
Patersonia occidentalis	Purple flag
Viminaria juncea	Swishbush

Weeds

A weed can be described as any plant growing where it is not wanted, where it is not naturally occurring or where it is severely out-competing other species. Weeds are a problem in the Darling Downs Trail Network Reserves for two main reasons:

1. Weeds are a fire hazard, which affects landholder safety in the area, as well as the fauna of the reserve; and

2. Weeds suppress native plant growth, affecting biological diversity when weeds monopolise the sun, space, soil and water.

However, it should be noted that the Quenda present in the reserves do use some weeds as habitat. It is therefore important to remove such weeds progressively, and as they are removed they need to be replaced with native plants at an equivalent rate. Providing habitat is only valuable if animals are present, so this must be considered when revegetation occurs in the reserve.

Table 6: Common Weeds and Planted Non-Natives of the Darling Downs Trail Network Reserves

Species	Common Name
Avena barbata	Wild oats
Acacia iteaphylla	Flinders Range wattle
Acacia podalyriifolia	Queensland silver wattle
Casuarina glauca	Sheoak
Echium plantagineum	Paterson's Curse
Eragrostis curvula	Love grass
Eucalyptus camaldulensis	River red gum
Eucalyptus leucoxylon rosea	Pink flowered yellow gum
Eucalyptus maculata	Spotted gum
Eucalyptus robusta	Swamp mahogany
Eucalyptus spp.	Several eastern states eucalypts
Ficinia nodosa	Knotted club rush
Ficus carica	Fig
Gomphocarpus fruticosus	Cottonbush
Olea europaea	Olive
Pennisetum clandestinum	Kikuyu
Schinus terebithifolius	Japanese pepper
Tribulus terrestris	Caltrop

Flora Management

Flora management is essential for increasing and maintaining biodiversity as a component of conserving natural heritage. The vegetation of the Darling Downs Trail Network Reserves is very much degraded due to past use of the area as grazing land and current management as a primarily recreational reserve. Owing to the lack of current native understorey species, natural regeneration would be ineffective. It is therefore more productive to plant and direct seed appropriate areas, with concurrent necessary weed control.

Revegetation of Native Flora Species

Landcare SJ Inc. carried out an extensive revegetation program in association with the construction of the wetland. A new revegetation program is required following the reshaping of the wetland. A variety of understorey vegetation should be planted, which will provide adequate Quenda habitat while slowly removing the lovegrass (*Eragrostis curvula*).

In order to achieve good success rates it is essential to undertake weed control around plantings to allow them to establish. A weed control plan could be developed with the help of members of the Darling Downs Residents Association and Landcare SJ Inc. Specific

areas and processes outlined in the plan could be followed in order to achieve a coordinated strategic approach to rehabilitation of appropriate areas.

It is essential to analyse past works and determine the degree of success, thereby improving the quality of any works in the future. Plants must be ordered in advance for the next season, to ensure availability and collection. A planting day during winter with the residents would be an effective way to plant or seed selected areas and provide a committed working team.

Dieback and Weed Prevention

The Darling Downs Trail Network Reserves has not been assessed for the presence of dieback disease (*Phytophthora cinnamomi*). The plant species which are most affected by dieback (such as banksias, jarrah and grass trees) are not found in the reserve at present. From a management point of view, it is best to assume that the reserves are infected, maintaining good hygiene practices and only planting dieback resistant plants in revegetation projects. Recreational users should be excluded from the revegetation areas, to prevent deliberate or accidental trampling of the growing seedlings.

Another way to decrease and prevent further weed infestation in the reserve is to spray the weeds in the sections of the reserve that are to be planted, removing them only when there will be native seedlings to replace them. Weeding days, in association with the DDRA's busy bees, would be a good idea when specific weeds are in need of manual removal. The removal of lovegrass (*Eragrostis curvula*) would be best undertaken by a spraying contractor or suitably experienced member of the DDRA. However, declared weeds (such as cottonbush) should be controlled at all times, and undertaken throughout the year.

Some methods of control for the major weeds in the reserve are listed below. Chemical control should be carefully considered so to not harm the native fauna; for example, as glyphosate kills amphibians, Bioactive glyphosate should be used instead, or manual removal.

Love grass (*Eragrostis curvula*), a major weed in the reserve, can be controlled by slashing, followed by spraying with glyphosate. Love grass has built up a resistance to some grass-specific herbicides. Burning is not the preferred method of control. Unless vigorous follow-up spraying occurs, the problem only increases because the burning promotes new growth. Love grass should be attacked in autumn and winter, when the weed is actively growing, which is essential for good chemical uptake.

Paterson's curse (*Echium plantagineum*) must be sprayed or manually removed during its flowering season in late winter/early spring. Paterson's Curse is a Declared Pest under the *Biosecurity and Agriculture Management Act 2007*. It is therefore a priority weed and should be dealt with as thoroughly as possible.

Cotton bush (*Gomphocarpus fruticosus*) is also a Declared Pest and should be rigorously controlled. Generally, hand removal is the most effective on cotton bush when they are still quite small and before flowering in summer.

3.2.2 Fauna

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 Carnaby's Black Cockatoo which occurs in Darling Downs. These birds are also listed under the *EPBC Act 1999* and are therefore protected under Commonwealth legislation as well. Threatened fauna are listed in four schedules under the *Wildlife Conservation (Specially Protected Fauna) Notice*. The Department of Biodiversity, Conservation and Attractions (DBCA) also maintains lists of Priority fauna species which require active conservation efforts or further study. The Southern Brown Bandicoot (quenda) is listed as a Priority 4 species, meaning that it is in need of monitoring. The fauna recorded in the Shire from these lists are identified in Table 7.

Table 7: Threatened and Priority Fauna, Shire of Serpentine Jarrahdale[a]

Species Name	Known from the plateau	Known from the plain	Probability of Occurrence Elsewhere[b]
Schedule 1 – Fauna that is rare or likely to become extinct			
Chuditch - *Dasyurus geoffroii*	X	Lowlands	Low
Numbat – *Myrmecobius fasciatus*	X		Low
Western Ringtail Possum – *Pseudocheirus occidentalis*	X		
Quokka – *Setonix brachyurus*	X		Low
Mallee Fowl – *Leipoa ocellata*	X		
Forest Red-tailed Black-Cockatoo - *Calyptorhynchus banksii naso*	X	X	High
Carnaby's Black-Cockatoo - *Calyptorhynchus latirostris*	X	X	High
Schedule 4- Other Specially Protected Fauna			
Peregrine Falcon - *Falco peregrinus*			High
Carpet Python – *Morelia spilota imbricata*	X		
Priority Two – Taxa with few, poorly known populations on conservation lands			
Glacidorbis occidentalis (a freshwater snail)	X		
Priority Three – Taxa with several, poorly known populations, some on conservation lands			
Wambenger (Brush-tailed Phascogale) - *Phascogale tapoatafa*	X	Lowlands	Moderate
Priority 4 – Taxa in need of monitoring			
Western Brush Wallaby - *Macropus irma*	X	Lowlands	Low
Water Rat – *Hydromys chrysogaster*	X	Lowlands	Low
Carpet Python – *Morelia spilota imbricata* (also listed in Schedule 4)	X		
Priority 5 – Taxa in need of monitoring (conservation dependent)			
Quenda (Southern Brown Bandicoot) – *Isoodon obesulus fusciventer*	X	X	High

a : Based on records supplied by the Department of Environment and Conservation (DEC) from the Threatened Fauna Database

b: Based on a report by J.Henry, Ninox Wildlife Consulting (2000)

Formal fauna surveys have not been undertaken in the reserves, but informal observations have confirmed use and occupation by numerous bird species, including endangered black cockatoos (see Table 8). Local residents report a quenda population, occupying the more overgrown and densely vegetated areas of the reserves, and likely using the trails to move between areas of habitat such as the Wungong Brook.

Detailed information is available from a number of sources on the best strategies for achieving the protection of native fauna. These management considerations include fire management, weed control, feral animal control, minimisation of human disturbance, and revegetation.

Table 8: Bird Species Recorded at Darling Downs Reserves, 2010-2015 (by the Byford Bird Observers)

Species (Common Name)	Number of Observations (out of 25 occasions)
Australian Shelduck	5
Maned (Australian Wood) Duck	3
Pacific Black Duck	3
Australian White Ibis	1
Straw-necked Ibis	11
White-faced Heron	2
Whistling Kite	1
Collared Sparrowhawk	1
Wedge-Tailed Eagle	1
Black-fronted Dotterel	1
Laughing Dove*	3
Common Bronzewing	16
Crested Pigeon	4
Red-tailed Black Cockatoo	8
Carnaby's Black Cockatoo	2
Galah	15
Western Corella	5
Rainbow Lorikeet*	11
Red-capped Parrot	20
Australian Ringneck ('28')	25
Pallid Cuckoo	1
Fan-tailed Cuckoo	4
Laughing Kookaburra*	6
Sacred Kingfisher	2
Rainbow Bee-eater	2
Splendid Fairy-wren	3
Singing Honeyeater	23
Western Wattlebird	1
Red Wattlebird	23
Brown Honeyeater	24
New Holland Honeyeater	8
White-cheeked Honeyeater	5
Spotted Pardalote	8
Striated Pardalote	16
Weebill	17
Western Gerygone	12
Inland Thornbill	2
Western Thornbill	2
Yellow-rumped Thornbill	6
Grey Butcherbird	5
Australian Magpie	25
Black-faced Wood-swallow	1
Black-faced Cuckoo-shrike	17
Rufous Whistler	17
Grey Shrike-thrush	1
Willie Wagtail	10
Grey Fantail	12
Magpie-lark	22
Australian Raven	24
Scarlet Robin	1
Welcome Swallow	1
Silvereye	11
Australasian Pipit	1

*Introduced

Feral Animals

Feral animals found in the area of the Darling Downs Trail Network Reserves include domestic cats, foxes, rabbits and the common house mouse. Feral animals are detrimental to native animal populations for several reasons, including:

1. Preying on native fauna;
2. Out-competing native species for resources such as food and space;
3. Spreading diseases and weeds (in their excrement); and
4. Damaging native flora and thus habitats for the native animals.

Foxes and rabbits can be baited with 1080, a naturally occurring chemical in Australian plants. As 1080 is highly toxic, great care must be taken when handling it and when using it close to residential areas. Therefore it is very important to complete the accreditation to use it safely, and follow the permitting process correctly. This accreditation is managed by the Department of Primary Industries and Regional Development.

1080 poison is not harmful to native animals, as they have built up a natural resistance, whereas the poison affects feral animals. However, feral animals are not considered a major problem, generally passing through the reserve rather than inhabiting it for a long period of time.

Fauna Management

As more development occurs within the Shire, habitat for native animals is rapidly disappearing. Thus, the maintenance of existing remnant vegetation is of high importance in the protection of declining native fauna species. Low shrubs provide cover from predators, shelter and food for local fauna species. Revegetation in appropriate areas of the reserves can be focussed on providing suitable fauna habitat.

Protection of Native Fauna

Signs could be installed on local roads around the reserves, such as the current Bandicoot Crossing sign. This raises awareness in drivers, and lets residents know that the reserves contain valuable fauna and need to be cared for.

Planting of local native plants, as described in the section on revegetation actions above, would help to provide habitat for native fauna.

Control of feral animals must be carried out if they become an obvious threat. It would be wise to undertake further investigation into the presence of feral animals to establish whether they are causing more damage than is apparent.

3.2.3 Major Threats and Pressures

Clearing and Disturbance

Passive clearing can be caused by grazing by stock, overly frequent fires, polluted runoff or high impact recreation activities. Recreation activities located in or adjacent to bushland can lead to high levels of disturbance, weed and disease invasion and more frequent fires. The damage caused by passive clearing is often used to justify complete removal of some areas of the vegetation.

Fire Management

Fire is an important tool for stimulating regrowth and regeneration in many Australian ecosystems. However, unplanned burns can have a catastrophic impact on vegetation and cause high mortality of fauna. The fragmented nature of most of the Shire's remnant vegetation means that natural re-colonisation processes for many species of flora and fauna cannot occur. The long hot summers create conditions in which there is a high fire risk. The predictions of longer drier periods and higher temperatures will increase the period of risk each year. The frequency of unplanned fires in peri-urban areas increases with increasing population, through the introduction of weeds and associated fuel load. Once communities have been established in an area more frequent burning to protect property may be required, and burning prescriptions for specific conservation requirements may not be able to occur.

Fire risk is an important issue concerning residents in Darling Downs. Some areas of the Darling Downs Trail Network Reserves are heavily infested with love grass (*Eragrostis curvula*), which is a major fire risk to surrounding housing due to its annual lifecycle. The grass becomes dormant and therefore very dry and easily combustible for a large part of summer. An additional risk arises from the many thick stands of self-seeded saplings of *Eucalyptus camaldulensis*, a weedy eastern states tree.

Control burning is sometimes required to reduce fuel load and protect homes. However, burning an entire reserve at one time could be very detrimental to regeneration. Mosaic burns are a good way to reduce fuel load and also leave some habitat for native fauna. Existing love grass is required as habitat until new native vegetation can be put in its place. The native quenda would suffer greatly from loss of habitat after fire. Thus maintaining good fire breaks and the slow strategic removal of weeds (via burning, spraying etc.) is likely to be the most environmentally beneficially action for the local fauna of the reserves. Thinning of the *Eucalyptus camaldulensis* saplings, particularly in combination with understorey revegetation, would also be an environmentally beneficial method of fuel reduction.

The reduction of fire hazard, while simultaneously maintaining biodiversity values, can be achieved by:

- Maintaining existing fire breaks to slow any potential fires and to provide access for fire fighting vehicles;
- Strategic removal of love grass (*Eragrostis curvula*) to lower the fuel load;
- Thinning of *Eucalyptus camaldulensis* saplings with associated understorey revegetation; and
- When appropriate, mosaic burning of one section per year, allowing recovery before burning of the next area and followed up with weed spraying, as fire promotes new growth. Burns should only be undertaken by the Voluntary brigades after permission has been gained from the Shire.

Dieback (*Phytophthora cinnamomi*)

Dieback is a disease that affects many of the native plant species in Western Australia, often causing death. It is caused by *Phytophthora cinnamomi*, an introduced soil-borne pathogen that attacks the roots of plants. It is having serious impact on the biodiversity of the State and is listed by the *Commonwealth Endangered Species Protection Act (1992)* as one of five Key Threatening Processes. 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 mechanism for eliminating the disease once an area is infected. The objective for managing the disease is to prevent any further spread of infection and to minimise the impact of existing infections. The Darling Downs Trail Network Reserves have not been assessed for the presence of dieback disease (*Phytophthora cinnamomi*). The plant species which are most affected by dieback are not found in the reserves at present.

Weeds

Introduced flora comprises up to 11% of the plant species found in Western Australia. These plants pose a significant threat to native species through competition for limited resources, particularly space, light and water. Weeds flourish in disturbed sites and often out-compete the remaining native understorey and alter local nutrient recycling. Weed invasion is one of the major threats to remnant native vegetation. The displacement of native plant species leads to loss of habitat for dependent fauna, but in some cases fauna use weeds for habitat.

Land-use change in the Shire has led to higher densities of weed species on cleared land. This larger source of weed seed, combined with increased levels of disturbance due to ongoing development, may create the potential for increasingly severe weed infestations. High weed populations significantly increase the ground fuel load, which subsequently increases the risk of fire. Frequent fires reduce the viability of native plants and create disturbed conditions that are ideal for weed invasion. The control of weeds is an important issue within the reserves.

Feral Animals

Feral animals, especially cats, rabbits and foxes, have had a major impact on the natural flora and fauna species. The smaller mammals have been impacted to the extent that many have become locally if not totally extinct. The success of fox baiting programs in the Jarrah Forest has brought back numerous species from the brink of extinction in a number of locations.

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 Quenda. Feral rodents thrive in adjacent agricultural and equine properties, and most likely also occur in the Darling Downs reserves 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.

Cats are already a problem in many bushland areas and are likely to become more so as urban areas are developed and the population increases. Special provisions for the control

of cat populations are needed to protect the fauna of reserves. Successful initiatives, such as cat trapping, have been used to address the problem in numerous other areas of the State.

The European bee is well established throughout the Shire and has a significant effect on the balance and function of natural ecosystems. Rabbit populations are an ongoing problem and can have a devastating effect on the undergrowth if left uncontrolled. The disturbances caused by rabbits also predispose the areas to other threats such as erosion and weed invasion.

Natural Pests

Populations of naturally occurring insects can expand to the extent that they threaten the ecological balance. This is probably the result of other disturbing factors that affect the ability of these ecosystems to self-regulate. An example is the leaf miner insect which can completely defoliate the Flooded Gum (*Eucalyptus rudis).* The ability of the flooded gum to recover following attack depends on other factors that also affect its health. It is possible that climate change may favour some invertebrate species and micro-organisms, leading to further imbalance in these ecosystems.

Climate Change

Expected changes in temperature and the amount, season and severity of rainfall will place extreme pressure on ecosystems that are already under threat from many other disturbing factors. While it is expected that wet and dry periods and historic variation in weather patterns will continue, the gradual changes in temperature and rainfall will affect the ecological balance of remnant vegetation.

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.

Hydrological Change

All ecosystems are dependant to some extent on water. Models of climate change are predicting lower rainfalls and different seasonal patterns. At the same time, groundwater levels are declining, and drainage of more areas for residential and other uses is likely. Continuing decline in the water tables, combined with longer dry periods and greater evaporation, could lead to the death of many areas of vegetation.

Understanding of Biodiversity

It is not possible to put an economic value on biodiversity. The value of something unique and irreplaceable cannot be calculated. In a market driven society, it is difficult to convey the message of the necessity of protecting this biodiversity asset. Often people are unaware of actions that cause damage, such as the weed seeds in horse manure or the dieback spores in soil clods. The presence of an active, dedicated community group (the DDRA) working within the reserve is likely to ensure that the community continues to value the area for its conservation values in conjunction with its primary recreational importance. 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.

3.3 Environmental Recommendations

Table 9: Environmental Recommendations

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
Environmental Characteristics						
Land Resources						
3	Investigate and implement appropriate mechanisms to ensure management activities and/or natural processes do not negatively impact waterway bank stability.	Medium	Ongoing	Natural Assets DDRA	Staff Time Implementation costs	
4	Identify and appropriately rehabilitate degraded areas.	Medium	Ongoing	Natural Assets Landcare SJ DDRA	Staff Time Rehabilitation costs	
5	Prohibit and monitor inappropriate access.	Medium	Ongoing	Rangers and Emergency Services	Staff Time	
Water Resources						
6	Encourage and monitor appropriate wetland / waterway revegetation projects.	Medium	Yet to be Implemented	Natural Assets	Staff Time	
7	Encourage long-term ground- and surface-water monitoring.	Medium	Yet to be Implemented	Natural Assets DDRA	Staff Time	
8	Investigate nutrient reduction initiatives through the development and monitoring of nutrient stripping features.	Medium	Yet to be Implemented	Natural Assets DDRA	Staff Time	
Fire						
9	Liaise with Emergency Services to create/update and implement a Fire Management Plan.	Key	Implemented in part	Emergency Services Natural Assets	Staff Time	
10	Maintain existing fire breaks to slow potential fires and provide access for fire fighting vehicles.	Ongoing	Ongoing	Operations	Staff Time	Firebreaks to be maintained each year prior to summer.
11	Carry out mosaic burns, allowing habitat restoration before burning the next area.	High	Ongoing	Emergency Services Fire Brigades	Staff Time	Mosaic burns are best done before summer each year.
12	Follow up any burning with weed control measures.	Key	Ongoing	Emergency Services Natural Assets DDRA	Staff Time	
Dieback						
13	Identify plants susceptible to dieback and monitor for signs of infection.	Low	Ongoing	Natural Assets	Staff Time	
Weeds						
14	Strategically remove weeds and invasive non-local species such as Eastern States eucalypts.	Key	Ongoing	Natural Assets DDRA	Contract spraying - charged by hour and chemical type	
15	Control weeds and invasive non-local species using	Key	Ongoing	Natural Assets Landcare SJ	Staff Time	

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
	organised community working bees, local species planting, and other events including with Landcare SJ.			DDRA		
Revegetation						
16	Use the nearest local vegetation communities as a guide to the local flora, considering size, structure, flower colour and shade.	Medium	Ongoing	Natural Assets	Staff Time	
17	Plant a variety of understorey vegetation to provide adequate fauna habitat for species such as quenda.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
18	Undertake weed control when planting seedlings to reduce competition and allow establishment.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
19	Develop and implement a rehabilitation plan.	Key	Ongoing	Natural Assets Emergency Services Landcare SJ DDRA	Staff Time Implementation costs for site preparation and plants	Order plants each October for planting the following winter, every year.
Biodiversity						
20	Monitor the recovery of plant communities after fire and use this information to assess requirement for revegetation.	High	Ongoing	Natural Assets DDRA	Staff Time	
21	Identify all invasive non-local trees and shrubs and progressively remove and replace with local species.	Ongoing	Ongoing	Natural Reserves Coordinator	Staff Time	
22	Monitor and record feral animals and undertake control programs as required, while complying with all safety and accreditation procedures.	Medium	Yet to be Implemented	Natural Assets Landcare SJ	Staff Time	
Fauna						
23	Raise awareness about local fauna and their protection through involving community groups and erecting educational signage.	Medium	Implemented in part	Natural Assets Landcare SJ DDRA	Staff Time	

4. Social and Economic Characteristics

4.1 Indigenous Heritage

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 Jarrahdale 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 Darling Downs Trail Network Reserves lie 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 Darling Downs 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 Wungong Brook is listed on the register of mythological and ceremonial sites, but the exact locations of areas of particular value along and near the brook remain unpublished to assist with their protection. Instead, registered sites under the *Aboriginal Heritage Act 1972* include a wide enough buffer to encompass all the Aboriginal values that occur in the vicinity.

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 for the Darling Downs Trail Network Reserves. 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 Darling Downs reserves, nor is there any Indigenous representation on the current Darling Downs Residents Association or 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.

4.2 European Heritage

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 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 Darling Downs) 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.

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.

The Darling Downs Equestrian Estate was created in 1978 by subdividing a dairy farm into 260 lots. The estate includes a 35 hectare reserve (primarily used for equestrian and other recreation) and over 25 km of bridle paths (public multiple use trails). As Darling Downs was envisaged as an equestrian precinct, it was designed with rear access from private lots to the bridle trails, leading to the large recreational reserve. The estate was intended to be much larger, extending to the east of the current area, with the recreational reserve more than twice the size and surrounded by private lots and bridle trails. However, the landowner on the east of the current estate withdrew from the subdivision, leaving the estate and its equestrian reserve much smaller than originally envisaged. The remaining developer could not complete the work, but paid a proportion of the block sales (amounting to approximately $109,000) into a trust fund held by the Shire. Partway through the subdivision process, in 1977, responsibility for the area passed from the City of Armadale to the Shire of Serpentine Jarrahdale.

The Darling Downs Residents' Association began in 1986 as an advisory committee of residents (known in its original form as the Darling Downs Development Committee) formed by the Shire to guide the completion of the Darling Downs Estate trails, park and facilities. Responsibility for management and construction gradually passed to the DDRA, including installation of arenas, trotting tracks, storage sheds and other facilities, paid for by the trust fund. In 2008, prompted by a lack of adequate insurance and no clear licence to operate, the committee was incorporated as a not-for-profit Association. After incorporation, an operating licence over the trails, park and reserves was agreed with the Shire, insurance cover for the committee and volunteers was obtained, and additional funding from grants and sponsorship has been secured to supplement the Association's trust fund. The Darling Downs Residents Association has historically undertaken almost all the necessary maintenance of the trails and larger reserves, relying on volunteer labour by its members.

In 2017, following exhaustion of the trust fund, the Shire and DDRA signed a Memorandum of Understanding under which the Shire contributes $10,000 per year from 2018 to 2020 towards the Association's management of the area. In 2018 the Darling Downs Residents' Association distributed its newsletter to over 180 members, of whom approximately 60 live in the area. Up to 10 members regularly participate in busy bees and other management activities.

Landcare SJ Inc. has long had an association with the main reserve. In 2006, Landcare SJ received funding from the Federal Government's Community Water Grants program to create and revegetate a wetland within the recreational reserve. This grant also paid for a water tank near the DDRA's storage shed. The funding was insufficient to complete the earthworks for the wetland, so a further sum of $4,400 (in matched funding) was granted to the DDRA in 2008 as Devolved Funding from the SJ LCDC Rivers, Wetlands and Habitats Grants. Between 2007 and 2013, over 10,000 local native seedlings were planted around the wetland, funded from a variety of sources (including the original Community Water Grant, the Bendigo Bank, State government grants, and the Caring for our Country program). Little other planting has occurred in the reserves, with the exception of historical planting of exotic trees.

In 2015, the wetland was reshaped and cleaned out, incidentally removing much of the vegetation from the banks. This reshaping changed the way the reserve drains, interrupting the natural flow across the reserve which the wetland retained. The wetland was always seasonal, but now holds water for a shorter period as more of the water flows out rather than being retained. The original slope of the wetland banks was designed to accommodate wildlife, but the reshaping has made the banks very steep and unsuitable for wildlife, and susceptible to erosion.

The Birrega Drain originally joined the Wungong Brook in the north, but the connection was filled in 2014 to prevent the spread of the pearl cichlids (an invasive feral fish), which had been found in the Wungong Brook, into the Birrega Drain and from there the Serpentine River and other waterways of the Peel catchment area.

The history of the area and the reserves have not necessarily been accurately and thoroughly recorded. Comprehensive and accurate records of activities and developments should be maintained to enable effective and efficient management that reflects past activities.

4.3 Recreation

The major uses of Darling Downs Trail Network Reserves are:

- Horse riding and driving;
- Walking;
- Aesthetic appreciation; and
- Conservation of vegetation and wildlife habitat.

The use of trail bikes and off-road vehicles in the reserves has been noticed on occasion; however, motorised vehicles are not permitted and strongly discouraged.

Zoning

Darling Downs Trail Network Reserves are zoned for recreation, drainage and right of way, and are valued by the community for their equestrian function, recreational opportunities, shady vegetation and aesthetic values. However, this reserve purpose offers no recognition of the conservation values of the reserve. While the vegetation consists of overstorey only, it has high value for wildlife habitat, stabilisation of drains, and stormwater treatment.

Community Group

The Darling Downs Residents' Association manages the reserve network, focusing primarily on weed control, fire hazard management, and equestrian facilities (including the trails as well as arenas and tracks within the main reserve). The DDRA is funded by the Shire under a Memorandum of Understanding to the value of $10,000 per year from 2018 to 2020 for its management of the reserves. Residents from the Darling Downs area are actively involved in maintaining the reserves, with half a dozen people regularly carrying out maintenance activities and others becoming more active during busy bees.

Accessibility

The trails are accessible from the rear of all the adjacent properties, and from the local roads. The trails and the main reserve are fenced on all sides to delineate the reserves from adjacent private properties, and some trail ends (at roads) have fire access gates to exclude motorised vehicles. The most commonly utilised entry point to the main reserve is from Evening Peal Court. The trail network has been publicised in leaflets produced by the Shire and the Peel Trails Group.

Community and Shire Liaison

It is essential that good communication exists between the Shire and the community. The Shire assists in maintenance of the reserves at the request of the DDRA, so it is important that the two groups work together. The MOU between the Shire and the DDRA outlines the responsibilities and expectations of each party. Landcare SJ Inc. maintains an interest in the conservation values of the reserves and could be involved in activities such as revegetation.

4.4 Infrastructure

4.4.1 Description

Infrastructure at the Darling Downs Trail Network Reserves is focussed around the predominant equestrian uses. The large reserve connects to over 25 km of trails/bridle paths, which are surfaced with bluemetal fines and periodically mechanically smoothed. Most of the trails are shady and lined with mature trees, and often parallel to constructed drains such as the Birrega.

Equestrian infrastructure on the 35 ha reserve includes a 1400 m trotting track (surfaced with sand and only suitable for slow work), a cross-country course with numerous log jumps, two round-yards with tyre borders and sand surface, two large sand arenas, and numerous tree-lined walking/riding trails. The DDRA has a storage shed for its equipment, including a tractor, ride-on mowers, whippersnippers and assorted maintenance equipment. Break-ins and theft are a frequent problem.

There are two carparks, off Rain Lover Court (on the southern side of the reserve) and Evening Peal Court (to the west). The Rain Lover carpark is relatively informal and unfenced, adjacent to an approximately 60m by 40m fenced sand arena with a number of nearby picnic tables and benches. A bore and windmill installed by the DDRA is also nearby, but does not supply much water. The Evening Peal carpark is more formal, with a gravelled surface and bollards around the edges, and is adjacent to the storage shed. There are signs with reserve usage conditions near both carparks. The second (larger) sand arena and the round-yards are on the eastern side of the reserve, midway between the two carparks.

The trails are all fenced on both sides, as they adjoin private property, and the large reserve is also fenced. Some of the trails have emergency access gates where they meet local roads, to prevent unauthorised access by motorised vehicles. Some trail gates and mazes have been constructed to accommodate horses and buggies. Many of the trail corridors also contain constructed drains, including the Birrega.

In 2019 the DDRA produced a Strategic Development Plan (SDP) to outline the key improvements that the community group has aspirations to achieve in the reserves over the period 2019 to 2022. The Shire of Serpentine Jarrahdale has not endorsed the SDP as such, and achievement of its aspirational ideas is entirely dependent on external funding. Review and approval by the Shire would be required prior to commencement of any works. These activities include:

1. Constructing ten day-yards and a manure bin near the Evening Peal carpark
2. Moving and refurbishing the existing picnic area
3. Making improvements to the existing southern Evening Peal carpark
4. Providing better grassing, revegetation and irrigation in the western part of the main reserve, including drilling a new bore
5. Providing access to the new bore for firefighting purposes
6. Limiting vehicular access to the main reserve
7. Addressing safety concerns relating to horse/vehicle interactions within the Darling Downs area
8. Ongoing works relating to general maintenance

The DDRA has aspirational plans to significantly improve the facilities of the large reserve to make it more inclusive to all people, in addition to expanding the equine experience. Long-term aspirations include an undercover arena, a clubhouse, and a grassed picnic area. Conflict with the environmental values of the reserves is likely to be minor, but implementation will require coordinated and cooperative management by the DDRA and the Shire.

4.4.2 Major Threats and Pressures

Maintenance and Upgrade of Facilities

Maintenance of the reserves and associated equestrian facilities is the responsibility of the Darling Downs Residents' Association, with an annual contribution of $10,000 from 2018 to 2020 from the Shire under the current MOU. As the DDRA relies on volunteer labour, maintenance can be haphazard and intermittent. Regular inspections identify issues and hazards, and community maintenance leads to a sense of ownership. Most of the maintenance works are done during regular "busy bees", during which fallen branches are cleared away, weeds removed and grass slashed, trails and arenas smoothed, and other works conducted as required.

The Shire's financial contribution assists with the periodical upgrade of facilities, such as supplying new sand for arenas or minor maintenance works covered under the MOU. Major works, such as those proposed in the DDRA's Strategic Development Plan, are intended to be primarily funded by grant applications to a variety of bodies.

Vandalism and Theft

Vandalism and theft are constant, frequent threats to the reserves. The DDRA's storage shed is frequently broken into, and equipment often stolen. Vandalism most commonly takes the form of motorised vehicle use of the trails and trotting track, damaging the surface and causing risk to other users.

Fire
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. 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 should be kept clear. Strategies should be implemented to limit the frequency and severity of vandalism, which will reduce the likelihood of arson. Fire in nearby bushland has the potential to damage 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 risk management procedures.

Limited Access to Water
The only current water supply on the main reserve is a bore controlled by a windmill which has a limited supply of water. There is currently no water available to equestrian users for their horses. The DDRA has an aspirational plan to drill a new bore near their storage shed (subject to external funding and Shire approval), and supply water to users at the Evening Peal carpark.

Inadequate Car Parking Facilities
During periods of high usage, the carparks are not large enough to accommodate all users. This issue is compounded by users who bring more than one horse, and leave one tied to or yarded by their float while exercising the other one. The Evening Peal carpark was recently expanded, and the proposed horse yards would mitigate crowding and increase safety by removing unattended horses from the carpark.

Winter Drainage
Waterlogging and flooding affect several areas of the main reserve, decreasing useability during the winter months. The reshaping of the constructed wetland in 2014 was intended to promote drainage but has proved ineffective. The constructed drainage network assists in drying the land and carrying water away. The drying climate means that this is likely to be less of a problem in future.

Conflicting Values and Uses
Fostering community ownership of the reserve has a number of benefits, including heightened surveillance and greater community support for reserve improvements. The volunteer labour provided by the Darling Downs Residents' Association is vital in maintenance of the reserves. However, some local residents feel that the DDRA is not inclusive and does not consult widely enough on its plans.

The DDRA's focus is strictly on the recreational values of the reserves, which can conflict at times with the environmental values. Fallen trees and branches are seen as safety hazards to be cleared away, while they can provide vital habitat for native fauna. Long

grass and shrub thickets are seen as fire hazards and block sight lines, but also provide biodiversity and habitat.

4.5 Social and Economic Recommendations

Table 10: Social and Economic Recommendations

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
Social and Economic Characteristics						
Indigenous Heritage						
24	Establish and implement an effective process for ongoing Aboriginal liaison.	Low	Yet to be Implemented	Natural Assets DDRA	Staff Time	
25	When naming a place, structure or event, give consideration to Aboriginal names.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
European Heritage						
26	All activities and developments to be documented and archived.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
Recreation						
27	Encourage ongoing community management, maintenance and upgrade of the reserves.	Key	Ongoing	Natural Assets DDRA	Staff Time	DDRA currently undertakes management and maintenance, with assistance from the Shire.
28	Monitor and maintain the reserves and their infrastructure in a safe, maintained condition, with adequate insurance coverage, in the context of an asset management plan and annual works programs.	Key	Ongoing	Operations DDRA	Maintenance costs currently $10,000 per year from 2018 to 2020 under Agreement with DDRA	Infrastructure includes external fences, bridle and walk trails, car park, equestrian facilities, storage sheds, signage, picnic tables and shelters, and park benches.
Development Pressures						
29	Investigate and implement a long-term plan to increase, renovate or upgrade reserve facilities.	Medium	Ongoing	Natural Reserves Coordinator Community Services DDRA	Staff Time	

5. Implementation

5.1 Introduction

An implementation plan is provided in this section. Various business units within the Shire, as well as the DDRA, will be responsible for implementation and it is anticipated that the recommendations will be acted on over several years.

All recommendations in the report are reproduced in a single table below, along with priorities, responsibilities and potential partners.

5.2 Priorities

Priorities have been classified as follows:

- Key – within the next financial year;
- 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, along with the DDRA as the primary reserve managers. In some instances, 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, often in collaboration with Landcare SJ, Fire Brigade or Community are as follows:

- Infrastructure Services
    - Operations, Parks & Gardens
    - Natural Reserves Coordinator
    - Natural Assets
- Community Services
- Development Services
    - Planning
    - Building
    - Health
    - Rangers and Emergency Services

5.4 Implementation Recommendations

Table 11: Implementation Recommendations

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
Implementation, Monitoring and Review						
30	Periodically monitor and review the efficiency and effectiveness of implementing these management guidelines and revise actions as necessary.	Ongoing	Yet to be Implemented	Natural Assets Operations Natural Reserves Coordinator	Staff Time	

5.5 Implementation Plan

Table 12: Strategies for Management of Darling Downs Trail Network Reserves

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
Governance						
1	An appropriate application form is to be submitted and assessed prior to improvement or development.	Key	Ongoing	Natural Reserves Coordinator Natural Assets Community Services DDRA	Staff Time	Actions are carried out with Shire Officer support and to a mutually acceptable standard.
2	Periodically monitor and review the Agreement between the Shire and the DDRA regarding Shire contributions and DDRA responsibilities in management of the reserves.	Key	Ongoing	Natural Assets Community Services DDRA	Staff Time	
Environmental Characteristics						
Land Resources						
3	Investigate and implement appropriate mechanisms to ensure management activities and/or natural processes do not negatively impact waterway bank stability.	Medium	Ongoing	Natural Assets DDRA	Staff Time Implementation costs	
4	Identify and appropriately rehabilitate degraded areas.	Medium	Ongoing	Natural Assets Landcare SJ DDRA	Staff Time Rehabilitation costs	
5	Prohibit and monitor inappropriate access.	Medium	Ongoing	Rangers and Emergency Services	Staff Time	
Water Resources						
6	Encourage and monitor appropriate wetland / waterway revegetation projects.	Medium	Yet to be Implemented	Natural Assets	Staff Time	
7	Encourage long-term ground- and surface-water monitoring.	Medium	Yet to be Implemented	Natural Assets DDRA	Staff Time	

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
8	Investigate nutrient reduction initiatives through the development and monitoring of nutrient stripping features.	Medium	Yet to be Implemented	Natural Assets DDRA	Staff Time	
Fire						
9	Liaise with Emergency Services to create/update and implement a Fire Management Plan.	Key	Implemented in part	Emergency Services Natural Assets	Staff Time	
10	Maintain existing fire breaks to slow potential fires and provide access for fire fighting vehicles.	Ongoing	Ongoing	Operations	Staff Time	Firebreaks to be maintained each year prior to summer.
11	Carry out mosaic burns, allowing habitat restoration before burning the next area.	High	Ongoing	Emergency Services Fire Brigades	Staff Time	Mosaic burns are best done before summer each year.
12	Follow up any burning with weed control measures.	Key	Ongoing	Emergency Services Natural Assets DDRA	Staff Time	
Dieback						
13	Identify plants susceptible to dieback and monitor for signs of infection	Low	Ongoing	Natural Assets	Staff Time	
Weeds						
14	Strategically remove weeds and invasive non-local species such as Eastern States eucalypts.	Key	Ongoing	Natural Assets DDRA	Contract spraying - charged by hour and chemical type	
15	Control weeds and invasive non-local species using organised community working bees, local species planting, and other events including with Landcare SJ.	Key	Ongoing	Natural Assets Landcare SJ DDRA	Staff Time	
Revegetation						
16	Use the nearest local vegetation communities as a guide to the local flora, considering size, structure, flower colour and shade.	Medium	Ongoing	Natural Assets	Staff Time	
17	Plant a variety of understorey vegetation to provide adequate fauna habitat for species such as quenda.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
18	Undertake weed control when planting seedlings to reduce competition and allow establishment.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
19	Develop and implement a rehabilitation plan.	Key	Ongoing	Natural Assets Emergency Services Landcare SJ DDRA	Staff Time Implementation costs for site preparation and plants	Order plants each October for planting the following winter, every year.
Biodiversity						
20	Monitor the recovery of plant communities after fire and use this information to assess requirement for revegetation.	High	Ongoing	Natural Assets DDRA	Staff Time	
21	Identify all invasive non-local trees and shrubs and progressively remove and replace with local species.	Ongoing	Ongoing	Operations Natural Reserves Coordinator	Staff Time	

No	Strategy	Priority	Implementation	Responsibility	Requirements	Notes
22	Monitor and record feral animals and undertake control programs as required, while complying with all safety and accreditation procedures.	Medium	Yet to be Implemented	Natural Assets Landcare SJ	Staff Time	
Fauna						
23	Raise awareness about local fauna and their protection through involving community groups and erecting educational signage.	Medium	Implemented in part	Natural Assets Landcare SJ DDRA	Staff Time	
Social and Economic Characteristics						
Indigenous Heritage						
24	Establish and implement an effective process for ongoing Aboriginal liaison.	Low	Yet to be Implemented	Natural Assets DDRA	Staff Time	
25	When naming a place, structure or event, give consideration to Aboriginal names.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
European Heritage						
26	All activities and developments to be documented and archived.	Medium	Ongoing	Natural Assets DDRA	Staff Time	
Recreation						
27	Encourage ongoing community management, maintenance and upgrade of the reserves.	Key	Ongoing	Natural Assets DDRA	Staff Time	DDRA currently undertakes management and maintenance, with assistance from the Shire.
28	Monitor and maintain the reserves and their infrastructure in a safe, maintained condition, with adequate insurance coverage, in the context of an asset management plan and annual works programs.	Key	Ongoing	Operations DDRA	Maintenance costs currently $10,000 per year from 2018 to 2020 under Agreement with DDRA	Infrastructure includes external fences, bridle and walk trails, car park, equestrian facilities, storage sheds, signage, picnic tables and shelters, and park benches.
Development Pressures						
29	Investigate and implement a long-term plan to increase, renovate or upgrade reserve facilities.	Medium	Ongoing	Natural Reserves Coordinator Community Services DDRA	Staff Time	
Implementation, Monitoring and Review						
30	Periodically monitor and review the efficiency and effectiveness of implementing these management guidelines and revise actions as necessary.	Ongoing	Yet to be Implemented	Natural Assets Operations Natural Reserves Coordinator	Staff Time	

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Appendix 1 – Vesting and Land Tenure

Table A1.1: Reserve Vesting, Land Tenure and Purpose

Reserve number	Lot number	Plan number	Area (ha)	Gazettal	Purpose	Responsible agency	Vesting	Owner
R35701			33.3842	8/12/1978	Public recreation	Department of Lands	SoSJ	
	L3264	P012245	5.6196					DOLA
	L3067	P012440	1.5118					
	L3263	D054761	20.668					SoSJ
	L3391	P013944	3.2085					DOLA
	L167	D066580	1.0389					
	L167	P014770	1.2182					
	L167	P014770	0.1273					
R35702	L3068	P012440	0.7224	8/12/1978	Public recreation	Department of Lands	SoSJ	SoSJ
R35706			7.3544	8/12/1978	Public recreation and drainage	Department of Lands	SoSJ	
	L3069	P012448	1.7067					SoSJ
	L3155	D054494	0.0969					
	L3181	D057328	0.8002					
	L3623	P015070	1.3709					
	L3624	P015070	2.0809					
	L807	P062599	0.5593					SoSJ - Crown Reserves
	L807	P062599	0.707					
R35601			1.0701	24/11/1978	Public recreation	Department of Lands	SoSJ	
	L3057	P012440	0.704					SoSJ
	L3321	D061114	0.3361					
R35603			9.9377	24/11/1978	Public recreation	Department of Lands	SoSJ	
	L3058	D054631	0.7518					State of WA
	L3388	D050969	2.0818					State of WA
	L3972	D075039	0.3831					State of WA
	L3445	P014489	1.1747					State of WA
	L3550	D069996	1.0182					State of WA
	L3550	D069762	0.7309					
	L3581	P015658	0.743					State of WA
	L3551	D069995	0.1842					State of WA
	L3580	P015658	2.485					State of WA
	L3783	P013184	0.1147					State of WA
	L3784	P013184	0.2739					State of WA
R42696			0.6226	1/6/1993	Drainage	Water Corporation	Water Authority of WA	
	L3908	D083972	0.245					Water Corporation
	L3835	D083119	0.3775					Water Corporation
R38471			0.3036	14/10/1983	Public recreation	Department of Lands	SoSJ	
	L3407	D064629	0.12					SoSJ

Reserve number	Lot number	Plan number	Area (ha)	Gazettal	Purpose	Responsible agency	Vesting	Owner
	L3408	D064629	0.1835					State of WA
R39190	L3478	P091556	0.6744	6/9/1985	Recreation	Department of Lands	SoSJ	SoSJ
R38830	L3444	P014489	0.2066	17/8/1984	Public recreation	Department of Lands	SoSJ	SoSJ
R50480	L808	P062599	0.2837		Drainage	Department of Lands	SoSJ	
R51274	L702	P066606	0.3851		Public recreation	Department of Lands		SoSJ - Crown Reserves
R52763			0.6435		Right of way	Department of Lands	SoSJ	
	L2202	P408427	0.2199					Freehold - State of WA
	L2203	P408427	0.4236					Freehold - State of WA
Non-reserved trails	L56	D083119	0.0675					Freehold - State of WA
	L55	D075039	0.2039					Freehold - State of WA
	L66	P013944	0.1624					Freehold
	L55	P019948	0.1014					Freehold - State of WA

Table A1.2: Reserve Locations and Map Numbers

Reserve number	Lot number	Plan number	Area (ha)	Description of location	Inclusion in DDRA MOU for Maintenance	Map numbers
Darling Downs Trail Network Reserves			56.1235	Entire reserve network		01 – outline 02 – outline + aerial 03 – aerial
R35701			33.3842	70 acre reserve and some associated trails	Included	04 – southern section outline and aerial 05 – northern section outline and aerial
	L3264	P012245	5.6196	Trail west and south of Bernborough Way	Included	
	L3067	P012440	1.5118	Trail north of 70 acre	Included	
	L3263	D054761	20.668	Majority of 70 acre and trail north	Included	
	L3391	P013944	3.2085	Western part of 70 acre and trail west	Included	
	L167	D066580	1.0389	Trail southwest of 70 acre	Included	
	L167	P014770	1.2182	Trail southeast of 70 acre and along Thomas Road	Included	
	L167	P014770	0.1273	Trail along Thomas Road east of Masters Road	Included	
R35702	L3068	P012440	0.7224	Trail north of Tulloch Way	Included	06 – outline and aerial
R35706			7.3544	Trails northeast of R35701	Included	07 – outline and aerial
	L3069	P012448	1.7067	Trail south of Rowley Road	Included	
	L3155	D054494	0.0969	Triangle within the above	Included	
	L3181	D057328	0.8002	Trail south of the above	Included	
	L3623	P015070	1.3709	Trail east from southern end of the above to Wungong South Road	Included	
	L3624	P015070	2.0809	Trail east of Wungong South Road	Included	
	L807	P062599	0.5593	Trail east of the above	Included	
	L807	P062599	0.707	Trail east of the above	Included	
R35601			1.0701	Trail west of 70 acre	Included	08 – outline and aerial
	L3057	P012440	0.704	Western part of the above	Included	
	L3321	D061114	0.3361	Eastern part of the above	Included	
R35603			9.9377	Trails between Masters Road and Hopkinson Road	Included	09 – overall outline

Reserve number	Lot number	Plan number	Area (ha)	Description of location	Inclusion in DDRA MOU for Maintenance	Map numbers
	L3058	D054631	0.7518	Northernmost part of the above, south of Rowley Road	Included	10 – southern section outline and aerial 11 – northern section outline and aerial
	L3388	D050969	2.0818	Trail south of the above	Included	
	L3972	D075039	0.3831	Triangle west of the above	Included	
	L3445	P014489	1.1747	Trail south of the above, from Hopkinson Road east, north of Gloaming Way	Included	
	L3550	D069996	1.0182	Trail south of the above, east and south from Gloaming Way	Included	
	L3550	D069762	0.7309	Trail south of the above, from Comic Court Circuit to Masters Road, north of Gurners Lane	Included	
	L3581	P015658	0.743	Trail west of the above, within Comic Court Circuit	Included	
	L3551	D069995	0.1842	Trail south of Gurners Lane	Included	
	L3580	P015658	2.485	Trail west and south from Gloaming Way, east along Thomas Road, and north to meet the above	Included	
	L3783	P013184	0.1147	Trail west from the above to Hopkinson Road	Included	
	L3784	P013184	0.2739	Trail west along Thomas Road to Hopkinson Road	Included	
R42696			0.6226	North and south of Tiara Court		12 – outline and aerial
	L3908	D083972	0.245	North of Tiara Court		
	L3835	D083119	0.3775	South of Tiara Court		
R38471			0.3036	Trail along Thomas Road west of Masters Road		13 – outline and aerial
	L3407	D064629	0.12	Western part of the above		
	L3408	D064629	0.1835	Eastern part of the above, to Masters Road		
R39190	L3478	P091556	0.6744	Trail from Tulloch Way to Masters Road	Included	14 – outline and aerial
R38830	L3444	P014489	0.2066	Along Tulloch Way, west of the above	Included	
R50480	L808	P062599	0.2837	Spur south of Dalray Court		15 – outline and aerial
R51274	L702	P066606	0.3851	North of Phizam Place		
R52763			0.6435	Rivette Court to Wungong South Road		16 – outline and aerial
	L2202	P408427	0.2199	Rivette Court to Dalray Court		
	L2203	P408427	0.4236	Dalray Court to Wungong South Road		
Non-reserved trails	L56	D083119	0.0675	Tiara Court east to main trail		17 – outline and aerial
	L55	D075039	0.2039	Two sections, west and east of Empire Rose Court		
	L66	P013944	0.1624	From Evening Peal Court to 70 acres		18 – outline and aerial
	L55	P019948	0.1014	West from Kentucky Drive West to main trail		

Figure A1.1: Darling Downs Trail Network Reserves – Outline

Figure A1.2: Darling Downs Trail Network Reserves – Outline and Aerial Photo

Figure A1.3: Darling Downs Trail Network Reserves – Aerial Photo

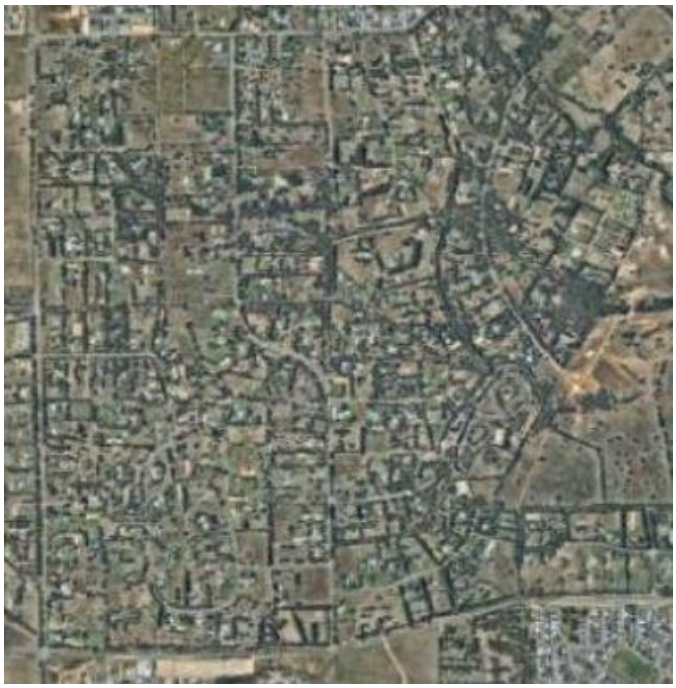

Figure A1.4: Reserve R35701 (Southern Section) – Outline (L) and Aerial Photo (R)

Figure A1.5: Reserve R35701 (Northern Section) – Outline (L) and Aerial Photo (R)

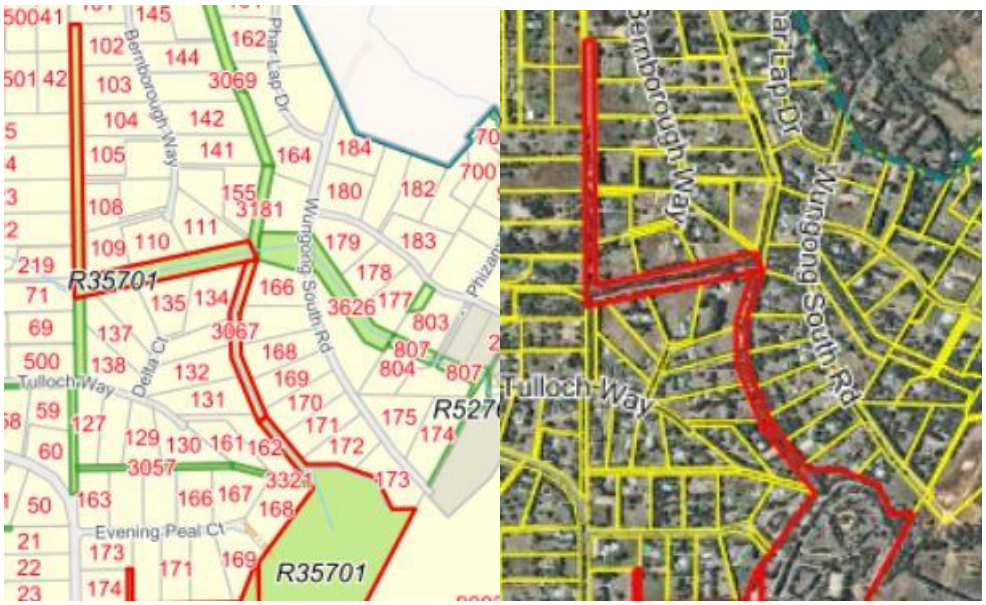

Figure A1.6: Reserve R35702 – Outline (L) and Aerial Photo (R)

Figure A1.7: Reserve R35706 – Outline (L) and Aerial Photo (R)

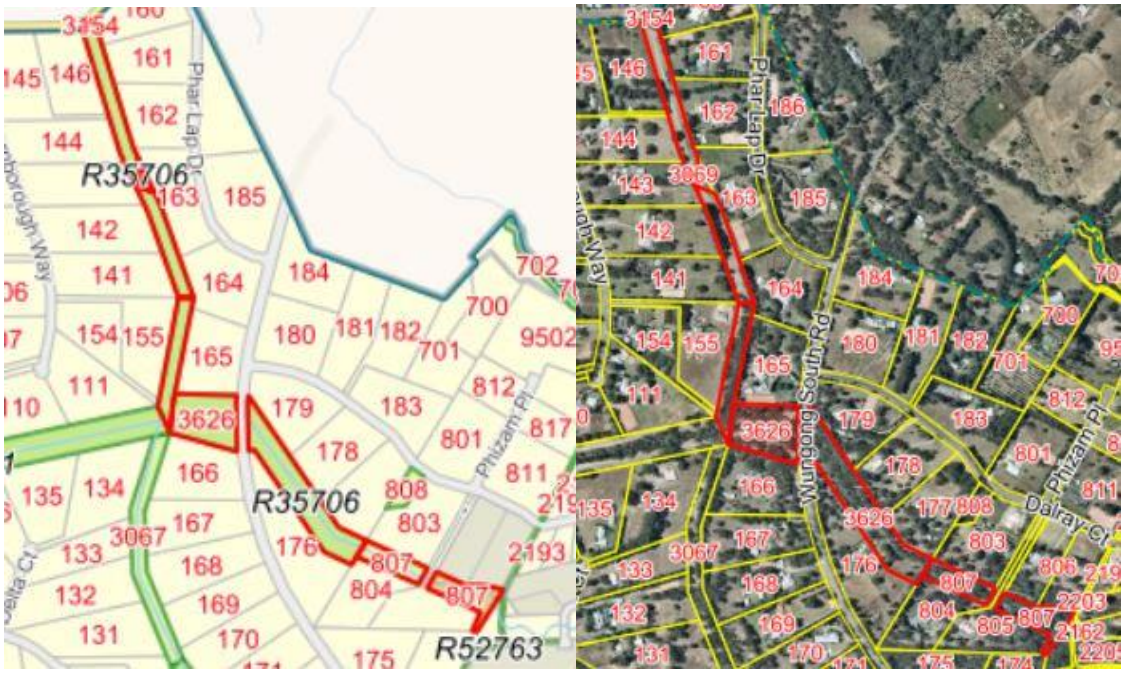

Figure A1.8: Reserve R35601 – Outline (above) and Aerial Photo (below)

Figure A1.9: Reserve R35603 – Outline

Figure A1.10: Reserve R35603 (Southern Section) – Outline (L) and Aerial Photo (R)

Figure A1.11: Reserve R35603 (Northern Section) – Outline (L) and Aerial Photo (R)

Figure A1.12: Reserve R42696 – Outline (L) and Aerial Photo (R)

Figure A1.13: Reserve R38471 – Outline (above) and Aerial Photo (below)

Figure A1.14: Reserves R39190 and R38830 – Outline (L) and Aerial Photo (R)

Figure A1.15: Reserves R50480 and R51274 – Outline (L) and Aerial Photo (R)

Figure A1.16: Reserve R52763 – Outline (L) and Aerial Photo (R)

Figure A1.17: Non-reserved Trails L55 and L56 – Outline (L) and Aerial Photo (R)

Figure A1.18: Non-reserved Trails L66 and L55 – Outline (L) and Aerial Photo (R)