



State of the Environment Report 2019

Draft 1b – December 2019



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1. Executive Summary

A State of the Environment Report is an analysis of the trends in the environment of a particular place. State of the Environment Reports are designed to communicate credible, timely and accessible information about the condition of the environment to decision makers and the community.

The Shire of Serpentine Jarrahdale is the fastest growing local government in Western Australia. The Shire has embraced a strategic framework that aims to accommodate rapid growth while shaping the district in a manner that aligns with community values and aspirations. To ensure that the established vision, aspirations and expectations are met, and the Shire of tomorrow is achieved in a way that recognises local character and identity, it is important to plan effectively for the future.

The community vision developed by the Shire highlights the importance of protecting the environment in the context of expected growth. To enable the Shire to adapt to the expected growth, it is producing a State of the Environment Report.

The objectives of this State of the Environment Report are to:

- Communicate credible, timely and accessible information about the condition of the environment to decision makers and the community;
- Draw attention to environmental issues; and
- Help set the policy and management agenda.

The Shire of Serpentine Jarrahdale's State of the Environment Report uses the framework of "Condition-Pressure-Response-Implications" and applies it across the themes of Atmosphere, Land, Inland Waters, Biodiversity, Human Settlements and Heritage. These themed chapters are preceded by a discussion of Fundamental Pressures, and followed by an overall summary Outlook and an Action Plan.

Three fundamental pressures affect the state of the environment, and apply across multiple themes. These are climate change, population growth and urbanisation, and invasive species and pathogens.

Anthropogenic climate change (the enhanced greenhouse effect) is predicted to result in warmer, drier conditions across the south-west of Western Australia. The expected changes will have significant impacts on the atmosphere, land capability, surface and groundwater availability and quality, affect ecosystems that are already under threat from many other factors, and impact on the population and urban expansion.

The Shire is expected to experience significant population growth, concentrated in new and existing urban areas. Increased population and urbanisation will increase emissions; reduce agricultural land and natural areas; place pressure on water resources, their ecological health and biodiversity; convert rural villages into outer suburbs; and threaten historic heritage and Aboriginal sites.

Invasive plants, animals and pathogens are the most significant threat to biodiversity. Competition and habitat destruction by weeds and feral animals, predation and diseases threaten the survival of many native plants and animals, and alter the structure and composition of ecosystems.

The Atmosphere theme is reported in two components, climate and ambient air quality. Climate change is a global problem, requiring international cooperation to address via a commitment to

reduce greenhouse gas emissions. The Shire is likely to experience a warmer, drier climate. These effects will be amplified in the future, and are a significant pressure for the other reported themes.

Ambient air quality is a measure of the cleanliness of the surrounding air, and is an important contributor to quality of life. Measured air pollutants comply with standards except for particulate matter, with spikes corresponding with bushfires. Trends are uncertain, with industrial development in the Shire likely to increase levels, while technological improvements may reduce air pollution.

The key components of the land theme are soil, vegetation and resources, which interact with the other themes. It is important to understand the many services that the land provides to support successful agriculture, local industry, preservation of natural areas and maintaining a strong sense of place and local character. Key indicators of soil condition lie in its physical, chemical and biological makeup. Most of these indicators are in poor condition in at least some of the Shire's soils, either naturally or due to human activity, and many are deteriorating.

The state of inland water resources is largely determined by factors of climate and land use, and influenced by water resources infrastructure and management. The supply of water, for both ecological and human uses, is in poor condition and deteriorating. Rainfall has declined, reducing both stream flows and groundwater recharge, while human use of both is increasing. Water availability for ecological uses is declining, and contamination continues to be an issue. Community water use, however, is decreasing per capita, and the Shire's status as an accredited Waterwise Council assists in reducing Shire water consumption.

Natural areas and biodiversity have been significantly impacted since European settlement. Over-clearing, plus the impact of feral animals and other degrading processes, has resulted in significant local fauna extinction and the deterioration of bushland and wetlands. It has also contributed to the pollution of downstream waterways and the Peel Harvey Estuary. Protecting biodiversity will be no mean feat, given the range of threatening processes. This is, however, essential, as biodiversity underpins the processes that support life, including human life, on this planet. Biodiversity also provides many economic, recreational, cultural and scientific benefits.

Built environments affect the residents that live within them, and the natural environment they exist within, so it is important to balance the needs of both. Settlements must maintain their liveability for residents, while delivering efficiencies that reduce their impact on the natural environment. Expansion of urban areas consumes historically rural land and increases consumption of resources. Sustainable growth will be essential as greater demands are placed on resources, social and physical infrastructure, services and the natural environment. Sustainable development depends on understanding how population growth in the four key settlements responds to the natural environment.

Heritage is present in many forms such as landmarks, places, buildings and contents, spaces, views and the stories associated with them. The Shire has strong heritage values connected to the three key elements of the natural environment, Aboriginal heritage and European settlement. Protection of these values requires strategies to both celebrate local heritage and ensure that statutory and strategic frameworks are adequate and appropriate.

In general, the outlook for the environment depends on the ability to effectively address the complex mix of pressures discussed in this report. The natural environment makes human life possible, and the cultural environment defines identity. It is therefore essential that population and economic growth are environmentally sustainable.

The responses from the six themes discussed in this report have been collated into a single Action Plan. A stand-alone Implementation Plan will be prepared, to assign responsibility for actions and propose timelines. Some of these actions will be able to be implemented as part of business as usual, while others will require funding within annual budgets. A few are major projects that would require significant investment; funding for these projects would require investigation of options.

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2. Introduction

2.1 What is a State of the Environment Report?

A State of the Environment Report is an analysis of the trends in the environment of a particular place. This analysis can encompass aspects such as water quality, air quality, land use, ecosystem health and function, along with social and cultural matters.

State of the Environment Reports are designed to communicate credible, timely and accessible information about the condition of the environment to decision makers and the community. While State of the Environment Reports endeavour to be comprehensive, they focus on major environmental issues, so as to draw attention to them and to help set the policy and management agenda.

A commonly used, internationally accepted (OECD) framework for State of the Environment Reports is the “Pressure-State-Response” framework. Modified versions of this framework have been used for the Australian (Pressures-State and trends-Effectiveness of management-Resilience-Risks-Outlook) and Western Australian (Condition-Pressure-Response-Implication) State of the Environment Reports. The State of the Environment framework is the underlying structure used across all themes to assess the environment.

“Pressure” (or threat) refers to human activities that affect the environment. “State” (or condition) refers to the quality of the environment and the functioning of important environmental processes. “Response” (or actions) refers to initiatives that have (or will be) been undertaken to address pressures on the environment or to improve or maintain its condition.

Human activity places pressure on many aspects of the environment. For example, vegetation clearing results in the invasion of weed species, loss of habitat for animals, and, when undertaken on a large scale, adversely affects air quality and carbon sequestration.

In this framework, only pressures introduced by human interaction with the environment are considered. Natural pressures such as extreme weather are only considered in the context of human-induced climate change.

2.2 Why Produce a State of the Environment Report?

The Shire of Serpentine Jarrahdale is the fastest growing local government in Western Australia. Through the extensive consultation and community consultation process associated with SJ2050, the Shire has embraced a strategic framework that aims to accommodate rapid growth while shaping the district in a manner that aligns with community values and aspirations. The Strategic Community Plan 2017-2027 incorporates these values and sets out the objectives and outcomes for the community over time.

To ensure that the vision, aspirations and expectations established by SJ2050 are met, and the Shire of tomorrow is achieved in a way that recognises local character and identity, it is important to plan effectively for the future.

The community vision developed by the Shire highlights the importance of protecting the environment in the context of expected growth. To enable the Shire to adapt to the expected growth, it is producing a State of the Environment Report to communicate credible, timely and accessible information about the condition of the environment to decision makers and the community.

2.3 Objectives

The objectives of this State of the Environment Report are to:

- Communicate credible, timely and accessible information about the condition of the environment to decision makers and the community;
- Draw attention to environmental issues; and
- Help set the policy and management agenda.

2.4 Structure of this Report

The Shire of Serpentine Jarrahdale's State of the Environment Report uses the Western Australian framework of "Condition-Pressure-Response-Implications" and applies it across the themes of Atmosphere, Land, Inland Waters, Biodiversity, Human Settlements and Heritage.

These themed chapters are preceded by a discussion of Fundamental Pressures, and followed by an overall summary Outlook and an Action Plan.

Six themed Condition-Pressure-Response reports were produced for the Shire by GHD. These reports form an attachment to this overall State of the Environment Report, which is based upon the data presented in the six themed reports. The overall Report presents a summary of the State of the Environment; the six themed reports can be consulted for additional information on any topic presented here.

As this State of the Environment Report is a summary, most supporting statistics, data and references have been omitted for the sake of brevity. These can be found in the corresponding sections of the six themed attachments.

3. Fundamental Pressures

3.1 Overview

Three fundamental pressures affect the state of the environment, and apply across multiple themes. These are climate change, population growth and urbanisation, and invasive species and pathogens.

Anthropogenic climate change (the enhanced greenhouse effect) is predicted to result in warmer, drier conditions across the south-west of Western Australia. The expected changes will be a significant stress on the atmosphere; affect the ability of the land to support native vegetation and productive agriculture; have significant impacts on surface and groundwater availability and quality; place extreme pressure on ecosystems that are already under threat from many other factors; and impact on the population and urban expansion. Predicted human health impacts include increased heat stress related deaths, failure of public transport and electricity grids, and increased respiratory illness and disease during heatwaves and bushfires. Climate change will significantly affect hydrology and bushfire risk, which in turn will affect many of the themes of this report.

The Shire is expected to experience significant population growth, concentrated in new and existing urban areas. Increased population and urbanisation will result in increased greenhouse gas and pollutant emissions; urban expansion and loss of agricultural land and natural areas; pressure on water resources and their ecological health; pressure on biodiversity; convert rural villages into outer suburbs; and threaten historic heritage and Aboriginal sites. The built form of new homes and buildings may increase the urban heat island effect and associated health impacts if the buildings are poorly designed. Population growth and urbanisation will bring societal change, changing land use and management, and industrial development.

Invasive plants, animals and pathogens are the most significant threat to biodiversity. Competition and habitat destruction by weeds and feral animals, predation and diseases threaten the survival of many native plants and animals, and alter the structure and composition of ecosystems.

3.2 Climate Change

The greenhouse effect is a natural process that warms the Earth's surface. When the sun's energy reaches the atmosphere, some is reflected back to space, some passes through and is reflected from the Earth's surface and the rest is absorbed as heat and re-radiated by greenhouse gases.

Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs). The absorbed energy regulates the temperature of the atmosphere and the surface of the Earth, allowing life to exist.

Human activity, primarily the burning of fossil fuels, has caused well-quantified increases in the concentrations of greenhouse gases in the atmosphere, which has a warming effect on climate. Warming does not only affect the atmosphere, it has a significant effect on all other aspects of the environment and human society.

Climate change is a global problem, requiring international cooperation to address. Observations show that global average concentrations of CO₂, methane, nitrous oxide and synthetic greenhouse

gases continue to increase. Currently, countries have agreed to limit the increases in global temperature to 2°C above pre-industrial levels. This is essentially a commitment to reduce greenhouse gas emissions.

Australia has always been a land of extremes, experiencing heatwaves, floods, fire, cyclones and drought influenced by large-scale drivers in the atmosphere and ocean. However, this variability is now occurring alongside increasing mean temperatures because of anthropogenic climate change (enhanced greenhouse effect). As the Australian climate continues to warm, droughts and flooding are projected to become more severe.

In the south-west of Western Australia, it is estimated that annual maximum daily temperatures will increase by 0.5°C to 1.5°C by the year 2030, and that rainfall will decrease by between 5 and 15 percent. Observed temperature and rainfall data in the Shire supports the prediction of a warmer, drier climate.

The warmer and drier climate will, in turn, affect human health and wellbeing. Heatwaves have caused more deaths than all other natural disasters combined. Anthropogenic climate change will increase the frequency and severity of heatwaves.

Overall greenhouse gas emissions from Western Australia are increasing. Emissions from the energy sector (primarily electricity generation and transport) are the most significant contributor to overall emissions. Significant emissions are also generated through waste and agriculture. While greenhouse gas emissions per capita are decreasing, overall Australian emissions continue to increase (likely due to economic growth and population increase).

Climate change is a significant stress on the atmosphere, affecting long-term climate trends and local weather, and can affect air quality. Solving the problem of climate change is dependent on a global change made up of combined efforts from all over the world.

Predicted climate changes will affect biological processes such as growth, timing of flowering, pollination and seed dispersal. This will affect the ability of the land to support native vegetation and productive agriculture. A drying climate may result in increased soil acidification, and other hydrological changes may result in increased salinity. Extreme weather events may increase erosion, frequency and intensity of bushfires (reducing recovery time), and droughts. Forecast increases in temperature and decreases in rainfall are likely to reduce soil organic carbon levels.

Rainfall in the Shire is decreasing, and winter rainfall is expected to decline by about 15 percent by 2030 and up to 30 percent by 2090. Climate change is likely to result in lower spring and winter rainfall in WA's southwest, with more intense rainfall events and longer droughts as a result of reduced soil moisture and increased evaporation. Year-upon-year reductions in annual rainfall are likely to maintain the pattern of unpredictability and increased variability of rainfall patterns, which may have significant impacts on surface and groundwater availability.

As groundwater levels decrease, climate change may increase the risk of acidification and heavy metal contamination (from disturbance of acid sulfate soils), death of groundwater-dependent native vegetation, and drying of wetlands. Changes to rainfall also can result in localised flooding, elevated pressure on stormwater systems and damage to infrastructure, as well as pressure on water sources due to lower dam inflows and reduced groundwater aquifer recharge.

Expected changes in temperature and rainfall will place extreme pressure on ecosystems that are already under threat from many other factors. Biodiversity is one of the most vulnerable sectors to

climate change. The impacts include changes to ecosystem structure and composition, phenology, fire regimes and hydrology. The south-west of Western Australia is a significantly vulnerable area.

The key impacts of climate change on biodiversity include reduced rainfall, increased storm events, increased fires, reduced water for wetlands, less groundwater recharge, damage and loss of vegetation, disruption to breeding patterns and species distribution, increased competition between needs, and an overall loss of species. The expected reductions in rainfall and groundwater recharge will have the greatest impact on groundwater-dependent ecosystems and wetlands, which are colonised by dryland species as they dry out, changing the ecosystem composition and increasing susceptibility to other threats.

Growth and expansion of urban populations into new areas will increase the number of people at risk from bushfire and flood. Increased population will also increase demand on local resources, such as water and energy.

The effects of climate change may directly affect natural heritage through altered fire regimes, invasive species, and altered hydrology. This may also affect Aboriginal cultural heritage practices and alter historical land-use patterns, affecting sense of place and changing cultural landscapes. When planning new development it is important to consider these factors.

3.2.1 Hydrological Change

The impacts of altered hydrology are a key water resource consideration. Filling of land has led to a loss of wetlands, and drain installation has significantly altered the natural hydrology and led to a loss of environmental values.

Clearing to provide land for agricultural and urban uses can result in erosion and the loss of sediments to waterbodies. The resultant increased turbidity (suspended sediment) impacts on other aspects, such as smothering riparian vegetation and reducing light for plant growth.

There are many rivers and brooks in the Shire, which provide a key natural attribute that attracts residents but present a flood risk to nearby development. Residential and agricultural land near waterways increases the risk of nutrient and contaminant runoff, which creates further pressure on the ecological integrity of the aquatic environment.

Soils within the Shire are typically high in legacy nutrients due to agricultural land use and the presence of saturated clays that tend to absorb nutrients. Subsoil drainage infrastructure has also resulted in nutrient transport to water bodies. This is particularly important for the Peel Harvey catchment, which is at significant risk of eutrophication (elevated levels of nutrients). Over 90% of the Shire is in the Peel Harvey catchment, so as intensive agriculture and residential land use grows, there is a greater risk of increasing nutrient export and pressure on the aquatic environment.

Nutrient loading is a form of contamination, but there is also the potential for drinking water sources to be contaminated with pathogens via contact with domestic animals. Landfill sites and industry are potential sources of pollutants to ground and surface waters, and must be carefully designed, managed and monitored. The Shire contains a large number of on-site wastewater systems which have a great potential for impacts on inland waters if improperly managed or faulty.

All ecosystems depend on water. Climate change predictions are for lower rainfall, different seasonal patterns, declining groundwater, and increased drainage. These effects could lead to the death of many areas of remnant vegetation, with the greatest impact on groundwater-dependent

ecosystems and wetlands, which are colonised by dryland species as they dry out, changing the ecosystem composition and increasing susceptibility to other threats.

Climate change could generate more frequent or extreme weather events with heavy rainfall, with associated storm damage to urban areas and infrastructure. This may result in greater flooding, impacting urban areas and infrastructure, and placing greater pressure on drainage networks. The health impacts of extreme weather events include injuries, mental health, and aggravation of asthma and other chronic conditions.

3.2.2 Fire

Bushfires and prescribed burning are prevalent in Western Australia and have the potential for much destruction and detrimental air emissions. Bushfires emit particulate matter, carbon dioxide, and various volatile organic compounds, which can cause harm to human health. Particulate matter can reduce visibility when suspended in the air, and reduce light to leaves when deposited.

Wood heaters are widely used for residential heating. Smoke from wood heaters contributes to gas and particulate matter emissions. Wood smoke from heaters is particularly concerning in winter.

Native vegetation within and surrounding urban areas is subject to frequent fires from arson, accident or controlled burns. Frequent fires change vegetation structure, destroy leaf litter, and can eliminate fire-sensitive species. Fire promotes weed growth that can increase fuel loads, and can lead to degradation and erosion of soil.

Climate change is resulting in a hotter and drier climate in the south-west of Western Australia, which will increase the likelihood of bushfire events. Earlier and longer periods of hot weather will prolong the bushfire season. Drying conditions also increases the combustibility of vegetation, fuelling more severe and frequent bushfire events. This will lead to impacts on human health through increased particulate and other emissions. Fires produce greenhouse gases, contributing to anthropogenic climate change in a detrimental feedback loop.

97% of the Shire is a designated bushfire prone area, which will have implications for the future cost of planning and development. Future development areas near remnant vegetation will be impacted by bushfire risk and increased building costs. Increased development, which reduces bushfire risk, will need to be balanced against vegetation retention for aesthetic, character, shade and biodiversity values.

3.3 Population Growth and Urbanisation

In 2017, the Shire's population was estimated to be over 29,000; it is forecasted to reach between 59,000 and 66,000 by 2031, and to accommodate nearly 100,000 additional people by 2050.

Increased population will result in greater demand for energy, increased waste generation and increased transport, which will increase overall emissions.

As population grows, additional urban land is required, or existing land is used more intensely. In the Shire, urbanisation will incorporate the increased population in the urban centres of Byford and Mundijong/Whitby. Depending on the current land-use, this often requires the clearing of native vegetation or the rezoning of low-density residential/rural land. This may reduce the capacity for urban greenery and green spaces to combat the "heat island effect", which encourages the use of air-conditioning and results in increased emissions. With 25% of emissions produced by

construction, operation and maintenance of buildings, urbanisation is a significant contributor to greenhouse gas emissions.

Cities are major contributors to climate change, accounting for a significant majority of greenhouse gas emissions. Urbanisation in the Shire includes expansion of industrial and business areas, involving rezoning of rural land. Any change in land use has the potential to affect the dispersion and ultimate destination of air pollutants. With an increase in industry, transport corridors will also be required to allow flow of people and materials as traffic increases, contributing to air emissions.

The pressure of population growth has the potential to impact on land resources by increased land requirements for urban expansion, loss of productive agricultural land, loss of biodiversity and habitat fragmentation, increased basic raw material extraction, increased pressure for waste disposal and cemeteries, and increased provision of industrial land.

Rural lifestyle lots on the fringes of urban areas need defined boundaries to separate them from natural areas, sensitive land uses and development encroachment. Rural living areas could also expand into traditional rural areas, resulting in a loss of productive agricultural land.

The anticipated population growth will place significant pressure on both the diminishing water resources supplying human settlements, and the ecological health of surface and groundwater systems. The Shire's rapid population growth has been characterised by low-density residential development. Vegetation clearing, filling of lands and artificial drains to accommodate this form of development has resulted in a loss of wetlands and altered hydrology. With population growth comes increased demand for water resources which represents a key ecological pressure.

A growing population puts increasing pressure on biodiversity when residential areas encroach on natural systems. The conversion or degradation of natural ecosystems has the most obvious impacts, while human settlements are often the entry point for introduced species.

The globally increasing trend of species extinctions can be attributed to natural or anthropogenic effects. Humans have the tendency to alter landscapes. An increasing population may lead to continued clearing which will result in loss of biodiversity and extinctions, with fragmented habitats becoming more susceptible to climate change, disease, and weed and feral animal invasion. Not all species are negatively affected by humans. However, an increased population may lead to an increase in air, noise and light pollution, changed hydrological regimes, and predation.

Urban development is a major driver of environmental change, placing strain on remaining natural areas. The protection of key features can be threatened by community demands for access and recreation.

Landscape modification and habitat fragmentation are key drivers for extinction. Fragmented vegetation patches may not be large enough to support some species, and fragmentation may inhibit gene flow (causing the population to become more susceptible to disease and predation). Modification and fragmentation of the jarrah forest from bauxite mining can impact very large areas.

Urban and peri-urban areas continue to directly encroach into natural ecosystems and may cause indirect impacts such as acting as a source of invasive species. Higher human populations coincide with higher numbers of domestic animals that can increase predation and competition. More people can also increase the spread of dieback through increased traffic through natural areas, and fire regimes may be altered based on community concern. Higher populations also lead to an increase in water demand.

The Shire is expected to experience significant population growth, reaching about 100,000 people by 2050 and adding over 35,000 new dwellings. Growth will be targeted in the settlements of Byford, Mundijong/Whitby and (to a lesser extent) Serpentine. Byford and Mundijong/Whitby will evolve from rural villages into outer suburbs of Perth, potentially altering function and character.

Housing affordability is an ongoing issue, with increasing pressure for cheap land and housing. While most of the Shire's settlement areas have lower prices than the Perth average, affordability will continue to be an issue. This affects the ability to obtain high quality development that integrates with the Shire's rural character, with the potential for project homes on completely cleared lots that meet minimum sustainability standards.

Urbanisation brings an expectation of greater provision of services and amenities, including essential services, public transport and social infrastructure. As the population grows and urban development expands, there will be a need to increase the capacity and reach of essential services. Building and running additional services and infrastructure will increase demand and pressure on natural resources.

Car use in the Shire is higher than the average for Perth, WA and Australia. In the absence of adequate frequent public transport, car use will increase, placing pressure on the atmosphere.

Development of new suburbs generally results in significant clearing, resulting in a loss of vegetation and biodiversity. Increased urbanisation also results in increased hard, impermeable surfaces, affecting the drainage network and nutrient runoff, placing pressure on the health of wetlands and waterways. Increased hard surfaces also increases the heat island effect, creating greater demand for air conditioner use and placing pressure on power supply.

Urbanisation will shift the character of the area from large rural lots to urban development. As the rural character of the Shire is highly valued by the community, there will be increasing pressure to manage development in such a way as to preserve this character.

Changes to population create pressure for change and development, creating tension between economic and cultural values. Inconsistent decision-making and differing perceptions of heritage value can lead to outcomes that adversely affect heritage. Individual sites may be subject to neglect and vandalism, or damage from increased visitation.

Historic heritage is particularly at risk from pressures for redevelopment, with impacts ranging from complete destruction to inappropriate change and adverse effects on attributes such as visual setting. Other pressures arise from population shift, including redundancy, neglect and decay. However, there is also greater recognition of the value of historic buildings and opportunities provided by their adaptive re-use. The decline in professional and trade skills in the historic heritage sector, the ageing specialist workforce and rise of non-specialist tradespeople present a looming threat.

Aboriginal sites continue to be threatened by incremental destruction associated with urban and industrial development. Effective engagement with the Aboriginal community and their involvement in the protection of Aboriginal heritage values in the Shire is vital.

3.3.1 Changing Land Use and Management

Agriculture is important to the local economy. Emissions from nurseries and flower and vegetable industries is likely to be mostly from transport. Livestock slaughtering, however, is likely to be a

significant contributor to greenhouse gas emissions. Australia's livestock is the third largest source of emissions after the energy and transport sectors.

Changing land use and management can create pressures on aquatic environments that include changes to flow, water quality and the availability of habitat. The historical trends of large-scale land clearing and changes to land cover associated with urbanisation and intensive agricultural land uses have resulted in changes to quality and flow regimes, biota and sediment, and nutrient concentrations.

Limiting the extent of urban sprawl by consolidating existing urban areas and restricting encroachment of land uses that could compromise the ecological integrity of inland water resources is critical to managing urbanisation and population growth. While some vacant urban land remains, under current patterns of residential development the available supply will not be sufficient for the predicted population. This would create a significant pressure on inland water resources due to the potential for encroachment of residential development into rural areas and the associated impacts associated with land clearing, filling of land and altered hydrology.

Extreme weather events, including drought and flooding, can affect agriculture and place pressure on food provision. This will have implications for the growing population.

3.3.2 Industry

Industrial facilities may emit harmful emissions depending on the processes utilised. Some facilities may also stockpile materials or expose large areas of land, which can contribute to wind-blown emissions. Proposed industrial developments in the Shire may have the potential to contribute to emissions of air pollutants during both construction and operation. Emissions of specific pollutants will vary depending on the types of facilities.

3.4 Invasive Species and Pathogens

Invasive species are the most frequently cited pressure affecting threatened species. Competition, habitat destruction and predation by pest animals threaten the survival of many native plants and animals.

Weeds can displace native plants, harbour pests and diseases, create fuel loads for fire, and alter structure and distribution of plant communities. Weeds become established in environments that have been disturbed or altered, and are one of the key threats to natural areas in the Shire.

The presence of pathogens such as dieback (*Phytophthora* spp.) and the spread of other diseases such as Armillaria root rot and Marri canker poses a serious risk to the biodiversity values of natural areas.

4. Atmosphere

4.1 Condition

There are two aspects to the state of the atmosphere: climate and ambient air quality. The atmosphere theme is therefore reported under these two sub-themes, as is the standard approach used in the *Australia State of the Environment 2016*.

Human-induced climate change has been well quantified. Emissions of greenhouse gases are still increasing, despite international commitments to limit warming to 2°C above pre-industrial levels. The south-west of Western Australia is already experiencing the effects of climate change, becoming warmer and drier. These effects will be amplified in the future.

Ambient air quality is a measure of the cleanliness of the surrounding air, and is an important contributor to quality of life. Measured air pollutants at the two most representative monitoring stations closest to the Shire comply with standards except for particulate matter, with spikes corresponding with bushfires. Trends are uncertain, with industrial development in the Shire likely to increase levels, while technological improvements may reduce air pollution (Table 4.1).

Table 4.1: Atmosphere State and Trends

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Climate	Climate change is a global problem, requiring international cooperation to address via a commitment to reduce greenhouse gas emissions. The Shire is likely to experience a warmer, drier climate.				
Greenhouse gas emissions	Emissions from WA are increasing. The energy sector is the most significant contributor. In the Shire, this is likely to be mostly household energy use and transport, followed by waste and agriculture.				
Shire greenhouse gas emissions	Energy consumption is the Shire's main direct contribution. Emissions are reducing, due to more efficient lighting and solar panels on Shire buildings.				
Household greenhouse gas emissions	Household emissions come from transport, heating/cooling, appliances and waste. Per capita emissions are reducing, due in part to efficient appliances, solar panels and waste diversion from landfill.				
Ambient air quality	The cleanliness of the air is affected by natural and anthropogenic air pollutants, which can cause significant effects to people, flora, fauna and infrastructure. Air quality is an important contributor to quality of life.				
Ambient air quality	Measured air pollutants at the two closest representative monitoring stations comply with standards except				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
	for particulate matter, with spikes corresponding with bushfires.				
Long-term air quality	Long-term trends in pollutant concentrations vary depending on the pollutant.			?	
Carbon monoxide (CO)	No overall trend. Comfortable compliance with criteria.				—
Nitrogen dioxide (NO ₂)	No overall trend. Comfortable compliance with criteria.				—
Ozone (O ₃)	No overall trend. Compliance with criteria at one of two monitoring stations.			—	
Sulphur dioxide (SO ₂)	No overall trend. Only measured at one of two monitoring stations. Comfortable compliance with criteria.				—
Particulate matter as PM ₁₀	Concentrations are highly variable, with spikes corresponding with bushfires. Exceedance of criteria in most years.		?		
Particulate matter as PM _{2.5}	Concentrations are highly variable, with spikes corresponding with bushfires. Exceedance of criteria in most years.		?		



Improving



Deteriorating



Stable



Unclear

4.2 Pressures

4.2.1 Climate

4.2.1.1 Population growth

In 2017, the Shire's population was estimated to be over 29,000, and is forecasted to reach between 59,000 and 66,000 by 2030. Increased population will result in greater household energy usage, increased waste generation and increased transport, which will increase overall emissions.

4.2.1.2 Urbanisation

As the population grows, additional urban land is required, or existing land is used more intensely. In the Shire, urbanisation will incorporate the increased population in the urban centres of Byford and Mundijong/Whitby. Depending on the current land-use, this often requires the clearing of native vegetation or the rezoning of low-density residential/rural land. This may reduce the capacity for urban greenery and green spaces to combat the "heat island effect", which encourages the use of air-conditioning and results in increased emissions. With 25% of emissions produced by construction, operation and maintenance of buildings, urbanisation is a significant contributor to greenhouse gas emissions.

4.2.1.3 Agriculture

Agriculture is important to the local economy. Emissions from nurseries, flower and vegetable industries is likely to mainly be from transport. Livestock slaughtering, however, is likely to be a significant contributor to greenhouse gas emissions. Australia's livestock is the third largest source of emissions after the energy and transport sectors.

4.2.2 Ambient Air Quality

4.2.2.1 Population growth

An increase in population is likely to lead to an increase in the consumption of natural resources (gas, petrol and diesel, wood) and synthetic products. Car use on local roads is also likely to increase.

4.2.2.2 Urbanisation

Cities are major contributors to climate change, accounting for a significant majority of greenhouse gas emissions. Urbanisation in the Shire includes expansion of industrial and business areas, involving rezoning of rural land. Any change in land use has the potential to affect the dispersion and ultimate destination of air pollutants. With an increase in industry, transport corridors will also be required to allow flow of people and materials as traffic increases, contributing to air emissions.

4.2.2.3 Climate change

Climate change is a significant stress on the atmosphere, affecting long-term climate trends and local weather, and can affect air quality. Resolution of climate change is dependent on a global change made up of combined efforts from all over the world.

Climate change is resulting in a hotter and drier climate in the south-west of Western Australia, which will increase the likelihood of bushfire events. Earlier and longer periods of hot weather will prolong the bushfire season. Drying conditions also increases the combustibility of vegetation, fuelling more severe and frequent bushfire events. This will lead to impacts on human health through increased particulate and other emissions. Fires produce greenhouse gases, contributing to anthropogenic climate change in a detrimental feedback loop.

4.2.2.4 Bushfires

Bushfires and prescribed burning are prevalent in Western Australia and have the potential for much destruction and detrimental air emissions. Bushfires emit particulate matter, carbon dioxide, and various volatile organic compounds, which can harm human health. Particulate matter can reduce visibility when suspended in the air, and reduce light to leaves when deposited.

4.2.2.5 Wood heaters

Wood heaters are widely used for residential heating. Smoke from wood heaters contributes to gas and particulate matter emissions. Wood smoke from heaters is particularly concerning in winter.

4.2.2.6 Industry

Industrial facilities may emit harmful emissions depending on the processes utilised. Some facilities may also stockpile materials or expose large areas of land, which can contribute to wind-blown emissions. Proposed industrial developments in the Shire may have the potential to contribute to emissions of air pollutants during both construction and operation. Emissions of specific pollutants will vary depending on the types of facilities.

4.3 Responses

The two key aspects of the state of the atmosphere, climate and ambient air quality, lead to different sets of responses.

Climate change is a global problem, requiring international cooperation to address via a commitment to reduce greenhouse gas emissions. International action is beyond the scope of local government; the responses to the issue of climate change therefore relate to strategies to reduce,

avoid and abate greenhouse gas emissions on a local scale. Strategies to reduce or convert atmospheric methane into less potent greenhouse gases may be undertaken by local government.

Ambient air quality is a measure of the cleanliness of the surrounding air, and is an important contributor to quality of life. Responses to the issue of air quality therefore relate to strategies to reduce the emission of pollutants that can affect people, flora, fauna and infrastructure (Table 4.2).

Table 4.2: Atmosphere Responses

Response	Actions	Timing	Priority
Climate change			
4.1 Shire greenhouse gas emissions reductions	4.1.1 Continue installation of solar PV systems on facilities and consider expansion of existing solar panels	Ongoing	High
	4.1.2 Retrofit lighting systems in facilities to more energy-efficient types	Medium term	Medium
	4.1.3 Require energy-efficient street lighting in new developments and consider retro-fitting existing street lighting	Ongoing	High
	4.1.4 Ongoing investigation into the use of battery storage at facilities with high energy use (where there has been excess production from solar panels)	Long term	Medium
	4.1.5 Investigate options for monitoring of energy use across all facilities	Short term	High
	4.1.6 High energy use facility energy audits	Short term	Medium
	4.1.7 Small facility energy audits	Short term	Low
	4.1.8 Continue participation in Switch your Thinking	Ongoing	High
	4.1.9 Offset emissions through tree planting and other programs	Ongoing	High
	4.1.10 Prepare and implement a risk analysis of the impacts of climate change on assets, including local reserves	Short term	High
4.2. Residential greenhouse gas emissions reductions	4.2.1 Continue support for Switch your Thinking's community events and actions	Ongoing	High
	4.2.2 Continue support for residential solar PV systems	Ongoing	High
	4.2.3 Consider updates to the local planning framework to better encourage the installation of residential solar PV systems and battery storage	Medium term	Medium
	4.2.4 Encourage utility scale battery use in new developments	Ongoing	Low
	4.2.5 Consider supplying a third bin to reduce organic waste entering landfill	Short term	High
	4.2.6 Improve sorting practices of hard waste to increase recycling rates	Short term	High
	4.2.7 Consider strategies for the recycling and disposal of solar PV panels and batteries	Long term	Low
4.3 Sustainable built form	4.3.1 Implement the Urban and Rural Forest Strategy 2018-2028	Ongoing	High
	4.3.2 Consider updates to the local planning framework to better encourage sustainable design of subdivisions and other developments	Medium term	Medium
	4.3.3 Consider preparation of sustainable design guidelines to complement SPP 7.0 and Design WA	Medium term	Low
	4.3.4 Continue to support Switch your Thinking's research into sustainable building solutions and community education	Ongoing	Medium
	4.3.5 Support the implementation of light coloured roofs to reduce the urban heat island effect	Ongoing	Low
4.4 Schools greenhouse gas emissions reductions	4.4.1 Continue support for Switch your Thinking's school programs, promotions and actions	Ongoing	High

Response	Actions	Timing	Priority
	4.4.2 Consider partnerships with State Government and other organisations to promote existing programs, e.g. YourMove Schools, ClimateClever, Switched on Schools, Wastewise Schools	Short term	Low
4.5 Business greenhouse gas emissions reductions	4.5.1 Continue support for Switch your Thinking's business programs, promotions and actions	Ongoing	High
	4.5.2 Consider updates to the local planning framework to better encourage solar PV systems and battery storage on commercial and industrial facilities	Medium term	Medium
	4.5.3 Consider implementing partial offsets for industrial development in the form of dual-purpose revegetation that also provides screening	Medium term	Medium
4.6 Renewable energy production	4.6.1 Consider updates to the local planning framework to better consider renewable energy facilities	Medium term	Medium
4.7 Agriculture	4.7.1 Investigate partnerships with the State Government to promote and encourage reduced-emissions animal husbandry and management systems	Short term	Low
4.8 Peak demand management	4.8.1 Continue to support Switch your Thinking's research in peak demand management	Ongoing	Medium
	4.8.2 Continue community engagement in peak demand response, e.g. Energysmart Tips	Ongoing	Medium
Ambient air quality			
4.9 Reduce vehicle emissions	4.9.1 Implement the Cycling and Walking Plan 2019	Ongoing	High
	4.9.2 Encourage walking for short trips and cycling for short-medium trips through local advertising and engagement of community groups	Short term	Medium
	4.9.3 Encourage walking or riding over driving to public transport nodes	Medium term	Low
	4.9.4 Plan and construct walkable cities through urban design	Ongoing	High
	4.9.5 Consider linkages between public transport nodes such as multiple use paths, and end-of-trip facilities	Medium term	Medium
	4.9.6 Consider zoning when planning city design, such as keeping retail, leisure and public spaces in one hub and industry in a separate hub	Ongoing	High
	4.9.7 Construct bicycle paths and bicycle-friendly road infrastructure	Ongoing	Medium
	4.9.8 Consider implementing a bike sharing scheme through partnership with a private enterprise	Long term	Low
	4.9.9 Consider partnerships with State Government and other organisations to promote existing programs, e.g. YourMove	Short term	Low
	4.9.10 Continue working with the Public Transport Authority to increase access to public transport	Ongoing	Medium
4.10 Bushfire	4.10.1 Designate dates for prescribed burns to limit the number of simultaneous burns	Ongoing	High
	4.10.2 Recommend or require a Burn Plan which takes weather conditions into consideration	Ongoing	High
4.11 Reduce wood heater emissions	4.11.1 Consider promotion of methods to reduce smoke from wood heaters	Medium term	Medium
	4.11.2 Consider promotion of alternative, more efficient heating systems	Long term	Low
4.12 Industrial development	4.12.1 Consider installation of an air quality monitor	Long term	Medium
	4.12.2 Consider updates to the local planning framework to better consider encroachment on sensitive receptors and buffer zones	Medium term	Medium

4.4 Implications

4.4.1 Climate

Anthropogenic climate change is a global issue that will have significant implications for the environment, society and economy. Ongoing increases in greenhouse gas emissions are likely to impact the economy, particularly in terms of the costs associated with emissions reductions in the absence of participation in a carbon trading scheme. Emissions reductions, however, have the potential to provide an economic benefit in terms of reduced energy costs.

Under current trends, energy consumption is expected to continue to increase, unless advances in energy efficiency and battery storage offset increased use of electrical devices (including electric vehicles). Peak energy demand is a particular problem, which occurs during high summer temperatures and air conditioner usage. Climate change will increase the frequency and severity of high temperatures, increasing the incidences of peak demand. Consequent emissions growth from energy use is likely to occur. Renewable energy will reduce emissions outside time of peak demand. Renewable resources do not meet electricity requirements during time of peak demand, requiring separate action.

Quantifying the financial and social cost of climate change is complex. The environmental cost of greenhouse gas emissions is largely excluded from the price of goods and services, reducing the incentive for investing in greenhouse gas emission reduction and developing greenhouse-mitigating technologies. The economic benefits of reduced energy cost and the avoidance of future impacts (and associated management cost), however, can create a drive for emissions reductions and mitigation planning.

The environmental impacts of climate change are relatively well understood. The predicted warmer, drier climate in the south-west of Western Australia will have significant impacts on all themes of this report. Climate change will be a significant stress on the atmosphere; affect the ability of the land to support native vegetation and productive agriculture; have significant impacts on surface and groundwater availability and quality; place extreme pressure on ecosystems that are already under threat from many other factors; and impact the population and urban expansion. Climate change will significantly affect hydrology and bushfire risk, which in turn will affect many themes of this report.

The social costs of climate change are likely broad and critical. Increasing and more frequent hot temperatures cause heat-related deaths and illness, and exacerbate many chronic conditions. Reduced water availability impacts health, and private and public opportunities. Increased frequency and severity of natural disasters necessitate more detailed planning and resources for emergency response, and negatively affects the liveability and safety of the Shire. Climate change increases the frequency and severity of flooding events, and communities may be required to relocate. These impacts and costs will be more apparent and severe for financially vulnerable community members, who lack the financial resources to adapt.

4.4.2 Ambient Air Quality

Ambient air quality is an important contributor to quality of life and is generally good within the Shire with the exception of particulate matter, with spikes corresponding with bushfires, controlled burns, and wood heaters. Trends are uncertain, with industrial development in the Shire likely to

increase levels, while technological improvements may reduce air pollution. The most significant implications of poor air quality are health effects.

A number of health effects are associated with particulates. Prolonged exposure to smoke from bushfires can aggravate breathing problems, cause watery eyes, and may increase hospital admissions and reduce productivity. Severe particulate problems may coat vegetation and reduce photosynthetic ability, clog air conditioning systems, cover infrastructure and reduce tourism potential. Current responses are inadequate; problems caused by particulates are likely to worsen.

Photochemical smog (including ozone and oxides of nitrogen) can cause a number of health problems. It is particularly harmful for children, older people, and people with heart and lung conditions. It can cause breathing problems, watery eyes, increase susceptibility to illness, and increase hospital admissions and respiratory deaths. Prolonged ozone exposure can reduce growth and injure plants. Concentrations are likely to increase with population growth and vehicle use, unless offset by the use of electric vehicles.

Sulphur dioxide can cause breathing problems, particularly for asthmatics. It can damage buildings and infrastructure, aquatic systems and vegetation. Under certain conditions it can form acid rain. Trends are not certain. Carbon monoxide, long known for its ill-health effects, is a decreasing issue due to the use of catalytic converters on car exhaust systems.

5. Land

5.1 Condition

The Shire consists of the Swan Coastal Plain and Darling Plateau, bisected by the Darling Scarp. The health and condition of the soils influence the types of vegetation that grow on them, while changes to vegetation from natural and human-caused events such as fire, clearing and mining affect the condition of the soils. The Shire relies on the use of the land and its resources. Land management practices are critical in determining the health and condition of soils and vegetation.

The key components of the land theme are soil, vegetation and resources, which interact with the other themes discussed in other sections of this report. It is important to understand the many services that the land provides to support successful agriculture, local industry, preservation of natural areas and maintaining a strong sense of place and local character.

Key indicators of soil condition lie in its physical, chemical and biological makeup. These include changes to carbon dynamics, acidification and erosion, as well as contamination of soil due to human activity. Most of these indicators are in poor condition in at least some of the Shire's soils, either naturally or due to human activity, and many are deteriorating (Table 5.1).

Table 5.1: Land State and Trends

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Land use	Historically focussed on rural uses and forestry. These are planned to continue with urban expansion restricted to designated nodes. Rural lifestyle areas are important.				
Land capability assessment	The ability of land to support a given use. The first step in assessing land suitability. Influences land zoning under TPS2.				
Soils	Two geological regions of Swan Coastal Plain (5 soil types, 3 landscape systems) and Darling Range (2 soil types, 2 landscape systems). Key indicators of soil condition lie in its physical, chemical and biological makeup.				
Carbon dynamics	Carbon content indicates soil's health and ability to undertake key biological processes. Inherently low in WA soils. No measured trends.				
Acidification	A consequence of agriculture, causing poor nutrient availability and poor root growth. Can be treated with lime, but this is difficult if acidity levels reach a critical low. Current soil acidity is critically low across much of the Shire.				
Acid sulfate soils	Naturally occurring, harmless if waterlogged and undisturbed. Exposure to air releases sulfuric acid and heavy metals. Most of the Shire has a moderate to low risk of acid sulfate soils.				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Salinity	Dryland salinity is one of the greatest threats to WA's agricultural land, water, biodiversity and infrastructure. Some areas of the Shire have a medium to high risk of salinization caused by clearing for agriculture.		?		
Soil erosion	Water erosion is a natural process often accelerated on cropland. It causes loss of topsoil, reduced crop yields, damaged infrastructure, weed dispersal, eutrophication and silting. There is a greater risk on the Scarp and Plateau.			↘	
Contaminated sites	Nine registered sites within the Shire, largely caused by historical and existing petrol stations. These have been remediated and can be used for specific uses. One site is unauthorised landfill containing asbestos and requires remediation.			↗	
Resources	The Shire has significant resources of bauxite, sand, gravel, clay and hard rock. Bauxite and mineral sands industries impact large areas and require intensive rehabilitation to stabilise the surface. Bauxite mining causes large-scale clearing of the jarrah forest and poses a severe threat to its biodiversity.		↘		
Basic raw materials	A finite resource and access close to growth areas is important to housing and infrastructure. There is increasing pressure to supply construction materials from within the Shire. Many active and pending mining tenements, 12 Shire-approved extractive industries.		↘		
Biodiversity	Linked to land. Soil, vegetation and surface water are part of the ecosystem that provides habitat for a diversity of species. Important to not consider land or biodiversity in isolation.		↘		
Bushfire	Most of the Shire is within a declared bushfire prone area. Can have a significant impact on land, including damage to crops and pasture, impacts on livestock and rural properties, and loss of ground cover increasing erosion risk.		↘		

 Improving
  Deteriorating
  Stable
  Unclear

5.2 Pressures

5.2.1 Climate

Predicted climate changes will impact on biological processes such as growth, timing of flowering, effective pollination and seed dispersal. This will affect the ability of the land to support native vegetation and productive agriculture. A drying climate may result in increased soil acidification, and

other hydrological changes may result in increased salinity. Extreme weather events may increase erosion, frequency and intensity of bushfires (reducing recovery time), and droughts. Forecast increases in temperature and decreases in rainfall are likely to reduce soil organic carbon potential levels.

5.2.2 Population Growth and Urbanisation

The pressure of population growth has the potential to impact on land resources by increased land requirements for urban expansion, loss of productive agricultural land, loss of biodiversity and habitat fragmentation, increased basic raw material extraction, increased pressure for waste disposal and cemeteries, and increased provision of industrial land.

5.2.3 Peri-Urbanism

Rural lifestyle lots on the fringes of urban areas need defined boundaries to separate them from natural areas, sensitive land uses and development encroachment. Rural living areas could also expand into traditional rural areas, resulting in a loss of productive agricultural land.

5.3 Responses

The key components of the land theme are soil, vegetation and resources, which interact with the other themes discussed in other sections of this report. It is important to understand the many services that the land provides.

Key indicators of soil condition lie in its physical, chemical and biological makeup. Responses to these issues relate to strategies to manage direct climate impacts to land, and in land use management (Table 5.2).

Table 5.2: Land Responses

Response	Actions	Timing	Priority
5.1 Climate change	5.1.1 Manage direct climate impacts to land on Shire-controlled land, such as the addition of lime to acidic soils	Ongoing	Medium
	5.1.2 Consider partnerships with State Government to promote the management of direct climate impacts to land	Medium term	Low
	5.1.3 Consider collaboration with State Government to foster regenerative agriculture	Medium term	Medium
5.2 Land use management	5.2.1 Consider the use of land capability assessments in assessing land suitability for a given use and land rezoning	Ongoing	High
	5.2.2 Continue to utilise the local planning framework to guide how land within the Shire is used	Ongoing	High
	5.2.3 Investigate updating the local planning framework to better manage extractive industry conditions and approvals	Medium term	Medium
	5.2.4 Develop a Cemetery Management Plan to guide need for and allocation of additional land for cemeteries	Short term	High
	5.2.5 Investigate the need to update the planning scheme to better control the location and management of landfills	Medium term	Medium
	5.2.6 Investigate any updates to the local planning framework that may be required to support the container deposit scheme, in accordance with the WAPC Position Statement	Medium term	Medium
	5.2.7 Continue to support Landcare SJ Inc.	Ongoing	High

Response	Actions	Timing	Priority
	5.2.8 Continue to implement SPP3.7 and the Bushfire Risk Management Plan	Ongoing	High
	5.2.9 Investigate options to minimise disturbance by mining and logging to the jarrah forest	Medium term	Medium

5.4 Implications

The Shire relies on the use of the land and its resources. Land management practices are critical in determining the health and condition of soils and vegetation. It is important to understand the many services that the land provides to support successful agriculture, local industry, preservation of natural areas and maintaining a strong sense of place and local character.

Key indicators of soil condition lie in its physical, chemical and biological makeup. These include changes to carbon dynamics, acidification, salinity and erosion, as well as contamination of soil due to human activity. Most of these indicators are in poor condition in at least some of the Shire's soils, either naturally or due to human activity, and many are deteriorating.

Low carbon content affects nutrient content, soil structure and presence of soil organisms. Soil carbon content generally decreases following clearing and cultivation, with regular tillage contributing to significant losses. Loss of soil carbon and biological activity will increase erosion potential, decrease nutrient storage and availability, and reduce water retention, infiltration and water-holding capacity.

The economic implications of soil acidification are many times higher than the better-known effects of salinity. Losses to acidity occur over time and may not be noticed if yields are increasing for other reasons. Reduced nutrient availability or toxic levels of heavy metals limit plant and crop growth. Decreased root growth leads to reduced water uptake, contributing to waterlogging, erosion and salinization. Soils may acidify to levels where acid, nutrients, sediment and heavy metals are exported to inland waters. Liming is the main agricultural remediation, but must occur before critical levels are reached. There is significant pressure on limestone stocks. Acidification may increase as water tables drop and acid sulfate soils are exposed.

Land salinization results in a rapid and catastrophic collapse of terrestrial and aquatic ecosystems. Biodiversity declines as a result of salinization and other hydrological changes. Ecosystems located low in the landscape, especially those associated with wetlands and waterways, are most at risk. Loss of vegetation also results in a loss of carbon storage. Land salinization results in significant impacts on agricultural productivity. Land use changes have little impact on the effects of salinization for several decades. Shallow water tables that cause salinization may, however, decline with climate change and reduce the risk of further impacts.

Soil erosion leads to land degradation and may contribute to problems in inland waters and the atmosphere. It results in a loss of topsoil, reduced soil fertility and structure, and poor soil health. Erosion and soil deposition can strip seed banks, spread weed seeds and smother habitat. It can reduce agricultural productivity, damage infrastructure, affect transportation, increase flooding, and contribute to eutrophication of inland waters and particulate air pollution. Increased community effort may be required for restoration, bank stabilisation and revegetation. Although the cost of soil

erosion is hard to quantify, it is certainly substantial. Heavier rain events associated with climate change may increase erosion potential.

Implications of contamination may be short-lived or persistent, depending on the nature of the pollutant and the extent of spread. Persistent chemicals pose the greatest risk. The environmental repercussions are extremely serious, as are potential health effects. Severe contamination may render land uninhabitable and constrain land use options. Remediation is generally expensive but far outweighed by the costs of contamination. Land contamination can also contribute to decreased property values and affect future land-use capability. The social ramifications of land contamination are significant. Trends are uncertain, as monitoring and remediation techniques improve in line with the quantity and expense of disposal of potential contaminants.

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6. Inland Waters

6.1 Condition

Inland waters, both above and below the ground, are linked to the ecological systems they support, and are of fundamental importance to the human settlements that rely on them. They provide water to communities and industry, and connect the land, atmosphere, coastal and marine environments.

The state of inland water resources is largely determined by factors of climate and land use, and is influenced by water resources infrastructure and management. The two key components of the inland waters theme are the unregulated component (subject to natural and climatic factors) and water management (water policy and management actions in response to pressures). Inland waters can also be considered in terms of water dependent ecosystems and water supply.

The supply of water, for both ecological and human uses, is in poor condition and deteriorating. Rainfall has declined, reducing both stream flows and groundwater recharge, while human use of both is increasing. Water availability for ecological uses is declining, and contamination continues to be an issue. Community water use, however, is decreasing per capita, and the Shire's status as an accredited Waterwise Council assists in reducing Shire water consumption (Table 6.1).

Table 6.1: Inland Waters State and Trends

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Climate – rainfall	Average rainfall has declined significantly and shifted to later in the year, with more frequent intense rainfall events later in the year with longer dry periods in between. May be causing the observed declining stream flows and superficial groundwater levels.				
Surface waters	Stream flows have declined over the past ten years. Severe loss and degradation of wetlands has occurred since European settlement.				
Landform	The Shire's landform has two distinct parts. The topography of the Darling Plateau and Scarp allow for the formation of substantial water bodies, including the Serpentine and Wungong dams which collect runoff for drinking.				
Catchments	Most of the Shire is within the Peel Harvey catchment. The largest sub-catchment is the Upper Serpentine River, with the Birriga Main Drain to the north and Dirk Brook – Punrak Drain to the south. Punrak Drain contributes large amounts of nutrients and sediment.				
Waterways	The Serpentine River is the most significant waterway in the Shire, hosting two drinking water dams. Average rainfall has declined by 10%, leading to a 58% reduction in dam inflows. A zero inflow future is likely. Releases to the				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
	river have been reduced, and groundwater is contributing less to river flow. Several brooks run south and north of the river, many of which are no longer perennial (disconnected from groundwater) and respond only to direct rainfall. A large portion of the Wungong dam's catchment lies within the Shire.				
Wetlands	Wetlands are significant for their ecological, hydrological, social and economic values. Severe loss and degradation has occurred, particularly for settlements, agriculture, water supplies and infrastructure. The majority of the remaining wetlands in the Shire are Conservation category, and are mostly surface expressions of the water table.				
Drainage	An extensive network of rural drains in the palusplain intercepts surface and groundwater, enabling agriculture and other uses. The drains transport nutrients into the rivers and cause algal blooms in the waterways and estuary.				
Flooding	Many rivers and brooks pass through the Shire, with a flood risk to development near waterways. Flood risk is particularly important when considering areas of new development.				
Groundwater	Groundwater comes from rain that has accumulated over thousands of years. There are both superficial and artesian aquifers under the Plain, flowing east-west and discharging to surface water. Quality is generally good. Most aquifers are at or near full allocation, and water levels are declining due to over-abstraction and reduced recharge.				
Proclaimed areas	To protect water sources, licences are required to take surface or ground water within a proclaimed area. The Shire holds five groundwater licences to irrigate public open space.				
Public Drinking Water Source Areas	These protected surface water catchments and groundwater areas provide drinking water. A significant part of the eastern part of the Shire is a P1 area due to the dam catchments. In the western part, there are P1 and P2 groundwater areas.				
Water quality	Catchment nutrient reports detail the concentrations and loads of nutrients, and indicate the ecological conditions of the estuaries.				
Upper Serpentine River catchment	Water quality is influenced by soil type and surrounding land use. More than half of the catchment has a low or very low phosphorus export risk. The catchment is vegetated on the Plateau and cleared on the Plain. Nitrogen levels exceed guidelines and have slightly increased,				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
	while phosphorus levels also exceed guidelines and have slightly decreased. Ecological assessment indicates good faunal diversity, banks vegetated by weeds, and variable levels of erosion.				
Dirk Brook – Punrak Drain catchment	The eastern catchment is largely undisturbed while the west is cleared for agriculture and more intensive uses. The catchment has a high or very high phosphorus export risk. Nitrogen levels exceed guidelines and have increased, while phosphorus levels greatly exceed guidelines.				
Contamination (pollution)	Sources of contamination to surface and ground water include agriculture (nutrients), domestic animals (nutrients and pathogens), landfill sites and industry (various, including toxins and heavy metals) and on-site wastewater systems (nutrients and pathogens).				
Water use	The main water sources in the Shire are groundwater and dams. Consumption in Perth is decreasing per capita via a range of water conservation measures. The Shire is an accredited Waterwise Council.				
Total water cycle management	Consumption and wastage can be reduced by the introduction of “third pipe” systems and recharging aquifers with treated wastewater.				
Council water use	Potable water is used in buildings and to irrigate some new parks. Groundwater is used for the majority of irrigation. Water use is relatively stable with the exception of irrigation of new parks.				
Community water use	Per capita water use is below the State target level.				

 Improving
  Deteriorating
  Stable
  Unclear

6.2 Pressures

6.2.1 Population Growth

The anticipated population growth will place significant pressure on both the diminishing water resources supplying human settlements, and the ecological health of surface and groundwater systems. The Shire's rapid population growth has been characterised by low density residential development. Vegetation clearing, filling of lands and artificial drains to accommodate this form of development has resulted in a loss of wetlands and altered hydrology. With population growth comes increased demand for water resources which represents a key pressure.

6.2.2 Climate Change

Rainfall in the Shire is decreasing, and winter rainfall is expected to decline by about 15 percent by 2030 and up to 30 percent by 2090. Climate change is likely to result in lower spring and winter

rainfall in WA's southwest, with more intense rainfall events and longer droughts as a result of reduced soil moisture and increased evaporation. Year-upon-year reductions in annual rainfall are likely to maintain the pattern of unpredictability and increased variability of rainfall patterns, which may have significant impacts on surface and groundwater availability.

As groundwater levels decrease, climate change may increase the risk of acidification and heavy metal contamination (from disturbance of acid sulfate soils), death of groundwater-dependent native vegetation, and drying of wetlands. Changes to rainfall also can result in localised flooding, elevated pressure on stormwater systems and damage to infrastructure, as well as pressure on water sources due to lower dam inflows and reduced groundwater aquifer recharge.

6.2.3 Changing Land Use and Management

Changing land use and management can create pressures on aquatic environments that include changes to flow, water quality and the availability of habitat. The historical trends of large scale land clearing and changes to land cover associated with urbanisation and intensive agricultural land uses have resulted in changes to quality and flow regimes, biota and sediment, and nutrient concentrations.

6.2.3.1 Urbanisation and population growth

Limiting the extent of urban sprawl by consolidating existing urban areas and restricting encroachment of land uses that could compromise the ecological integrity of inland water resources is critical to managing urbanisation and population growth. While some vacant urban land remains, under current patterns of residential development the available supply will not be sufficient for the predicted population. This would create a significant pressure on inland water resources due to the potential for encroachment of residential development into rural areas and the associated impacts associated with land clearing, filling of land and altered hydrology.

6.2.3.2 Altered hydrology

The impacts of altered hydrology are a key water resource consideration. Filling of land has led to a loss of wetlands, and drain installation has significantly altered the natural hydrology and led to a loss of environmental values.

6.2.3.3 Erosion

Clearing to provide land for agricultural and urban uses can result in erosion and the loss of sediments to waterbodies. The resultant increased turbidity (suspended sediment) impacts on other aspects, such as smothering riparian vegetation and reducing light for plant growth.

6.2.3.4 Flood risk

There are many rivers and brooks in the Shire, which provide a key natural attribute that attracts residents but present a flood risk to nearby development. Residential and agricultural land near waterways increases the risk of nutrient and contaminant runoff, which creates further pressure on the ecological integrity of the aquatic environment.

6.2.3.5 Eutrophication

Soils within the Shire are typically high in nutrients due to agricultural land use and the presence of saturated clays that tend to absorb nutrients. Subsoil drainage infrastructure has also resulted in nutrient transport to water bodies. This is particularly important for the Peel Harvey catchment, which is at significant risk of eutrophication (elevated levels of nutrients). Over 90% of the Shire is in the Peel Harvey catchment, so as intensive agriculture and residential land use grows, there is a greater risk of increasing nutrient export and pressure on the aquatic environment.

6.2.3.6 Contamination

Nutrient loading is a form of contamination, but there is also the potential for drinking water sources to be contaminated with pathogens via contact with domestic animals. Landfill sites and industry are potential sources of pollutants to ground and surface waters, and must be carefully designed, managed and monitored. The Shire contains a large number of on-site wastewater systems which have a great potential for impacts on inland waters if improperly managed or faulty.

6.3 Responses

Inland water resources are dependent on climate and land use, and influenced by water resources infrastructure and management. The two key components of the inland waters theme are the unregulated component (subject to natural and climatic factors) and water management (water policy and management actions in response to pressures). Inland waters can also be considered in terms of water dependent ecosystems and water supply.

Responses to these issues relate to strategies to manage water in the environment, ameliorate human impacts, plan for future supply, and ensure efficient use of the resource (Table 6.2).

Table 6.2: Inland Waters Responses

Response	Actions	Timing	Priority
6.1 Local planning framework	6.1.1 Continue to utilise the local planning framework to guide water use and management within the Shire	Ongoing	High
	6.1.2 Finalise and implement the draft Local Planning Strategy	Short term	High
	6.1.3 Investigate updating the local planning framework to better encourage alternative building practices including appropriate footings that do not require the use of fill	Medium term	Medium
	6.1.4 Consider a review of existing townsite drainage systems	Medium term	Low
	6.1.5 Give consideration to relevant legislation on on-site sewerage management in policy and planning for wastewater management	Ongoing	High
6.2 State Planning Policies	6.2.1 Liaise with the State Government to ensure the Shire is aware of and provides input into review of key State Planning Policies that relate to water	Ongoing	High
6.3 Better Urban Water Management	6.3.1 In collaboration with the Department of Water and Environmental Regulation, continue to support new development through the application of Better Urban Water Management	Ongoing	High
6.4 Catchment remediation	6.4.1 Continue to incorporate Water Sensitive Urban Design in new developments	Ongoing	High
	6.4.2 Consider the modification of existing drainage schemes to incorporate best practice for water sensitive design and nutrient management	Long term	Medium
	6.4.3 Restore local hydrological conditions where possible, through design of integrated water cycle systems and solutions	Long term	Low
	6.4.4 Re-establish lost hydrological values and design systems to cope with waterlogging and minimise nutrient and sediment export	Short term	Medium
	6.4.5 Continue to support Landcare SJ Inc. and other initiatives that reduce nutrient inputs into the catchment	Ongoing	High

Response	Actions	Timing	Priority
6.5 Water resource planning	6.5.1 Liaise with the Department of Water and Environmental Regulation to remain informed about changes to water allocations and potential alternative water sources	Ongoing	High
	6.5.2 Finalise and implement the draft Integrated Water Management Strategy	Short term	High
6.6 Water resource use and efficiency	6.6.1 Continue to participate in the Waterwise Councils program	Ongoing	High
	6.6.2 Investigate options for monitoring of water use across all facilities	Short term	High
	6.6.3 Consider retrofitting facilities with more water-efficient devices and systems	Medium term	Medium
	6.6.4 Investigate updating the local planning framework to require the supply of non-potable water sources with new areas of public open space	Medium term	Medium
	6.6.5 Investigate and implement the use of brown parks	Ongoing	High
	6.6.6 Encourage local participation in the Waterwise Schools Program and Waterwise Development Program	Short term	High
	6.6.7 Consider developing partnerships with State Government to encourage residential and industrial water efficiency	Medium term	Medium

6.4 Implications

Inland waters can become saline or acidic as an effect of land salinization and acidification. Excessive salinization of inland waters results in a catastrophic collapse of aquatic ecosystems: vegetation dies, habitat is lost and plant and animal populations decline. Salinisation exacerbates soil erosion, filling pools and increasing flood risk. Salinisation of dams reduces drinking water availability. Acid leachate can impact surface and ground water, causing ecological damage, damage to fisheries, contamination of supplies, reduced agricultural productivity, and damage to infrastructure.

Modified water and flow regimes can have significant social, economic and environmental impacts. Too much water can result in flooding, waterlogging, salinization, loss of soil health, loss of habitat, and more weeds. Heavier rain events caused by climate change may increase future flooding potential. Too little water results in drought-like conditions, leading to loss of inland waters, degraded ecosystems, limited habitat, acidification, eutrophication, and widespread death. Reduced water availability also limits provision for human uses. Changes to the timing, duration and frequency of natural flows can be just as harmful, altering natural migration and reproduction patterns. Adequate water provision to the environment is critical for ecological functionality. Hotter, drier conditions under climate change may reduce water availability, leading to competition between human and environmental water supply.

Loss of wetlands can reduce the capacity of the land to mitigate floodwaters or stormwaters by storing and slowing water. When wetlands are cleared and filled, this may contribute to rising water tables and early onset of flooding, waterlogging and salinization. Wetlands are highly productive ecosystems providing a range of important services, including habitat and drought refuges. With the current extent of wetland loss, many remaining wetland species are endangered. Loss of wetlands also removes the opportunity for enjoyment of their natural beauty, recreational and tourism opportunities, and cultural and spiritual values. Rapid population growth and urbanisation is likely to lead to further loss and degradation of wetlands.

Loss of fringing and instream vegetation leads to downstream impacts on biodiversity and water quality. Community awareness is poor of the value of fringing and instream vegetation and its importance for maintaining healthy waterways and wetlands. Loss of vegetation leads to loss of ecological functionality, impacts on tourism and fishing, enhanced weed and algal growth, enhanced erosion and sedimentation, and potential for flooding.

Erosion and sedimentation is a widespread problem affecting many wetlands and waterways. Increased sediment detrimentally affects biodiversity and may carry phosphorus, contributing to eutrophication. Sediment build-up can exacerbate flooding and reduce capacity of supply dams. Erosion of banks can intrude on productive land. Heavier rain events are likely to increase erosion potential.

Eutrophication can drastically alter biodiversity, producing algal blooms that can cause fish kills, ruin water supplies, prevent recreation and affect amenity. Nutrient-enriched waters provide ideal habitat for aquatic weeds, which can clog infrastructure and wash up on beaches, causing smells and health problems, affect property values and be a nuisance. Eutrophic wetlands support midges and mosquitos and can be the source of vector-borne disease outbreaks. Nutrient enrichment of groundwater can reduce the suitability of water supplies. Trends are uncertain.

Water use and availability is an emotive issue. Water use is expected to grow and new water sources are required to meet the increasing demands of a growing population, even while efficiency measures contribute to reduce per capita water use. Climate change will put additional pressure on water extraction due to hotter and drier conditions. Increased demand for high quality water sources will require new infrastructure development, and possibly increase the cost of water. Community water use will compete with other sectors for scarce water resources.

7. Biodiversity

7.1 Condition

Biodiversity is the variety of all living things, the different plants, animals and micro-organisms, the genetic information they contain and the ecosystems of which they are a part. The Shire lies within a global biodiversity hotspot, a region with a high number of unique species that are under a high level of threat.

Natural areas and biodiversity have been significantly impacted since European settlement. Over-clearing, plus the impact of feral animals and other degrading processes, has resulted in significant local fauna extinction and the deterioration of bushland and wetlands. It has also contributed to the pollution of downstream waterways and the Peel Harvey Estuary.

Protecting biodiversity means conserving the full range of genes, species and ecosystems into the future. Given the range of threatening processes, this will be no mean feat. Protecting biodiversity is, however, essential, as biodiversity underpins the processes that support life, including human life, on this planet. Biodiversity also provides many economic, recreational, cultural and scientific benefits (Table 7.1).

Table 7.1: Biodiversity State and Trends

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Biodiversity	Landscape modification has adverse effects on biodiversity. Parts of the Shire have been cleared for agriculture and urban development, but around 51% is still covered by native vegetation.				
Regional biogeography	The Shire lies within the IBRA Swan Coastal Plain and Jarrah Forest bioregions, and the Perth and Northern Jarrah Forest subregions. Vegetation types depend on region and soil type.				
Remnant vegetation communities	About 51% of the Shire is still vegetated, mostly on the Darling Plateau with only 12% remaining on the Swan Coastal Plain. 16 vegetation complexes are mapped, 7 on the Plain and 9 on the Plateau. Clearing is a major threatening process. Four Plain complexes are particularly significant with low levels remaining. Most Plain vegetation is locally and regionally significant. There is growing concern at the declining state of the Northern Jarrah Forest.				
Conservation areas and Bush Forever sites	The Shire manages 36 Conservation reserves, including 22 with vegetation in good condition. The Plateau is dominated by State forest, managed by the State for recreation, water, bauxite and timber. There is one national park and two regional parks. There are 30 Bush Forever areas of high biodiversity value.				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Regional Ecological Linkages	Maintenance of biodiversity in a fragmented landscape depends on natural areas and connectivity. Ecological linkages counter habitat fragmentation, and are proposed across the Shire to encompass natural linkage features.				
Wetlands	Wetlands are significant for ecological, hydrological, social and economic values; have characteristic vegetation, fauna and geomorphology; high biological productivity and diversity; and act as filters and flood control. Severe loss and degradation has occurred on the Plain, resulting in detrimental changes to water quantity and quality. The majority of the Shire's wetlands are Conservation category.				
Waterways	The main waterway is the Serpentine River, with stretches in good condition and high faunal diversity. A number of brooks cross the Shire to the north and south. The agricultural drains are being converted to living streams in new urban developments.				
Species diversity	1,397 flora taxa (1,177 native and 220 naturalised) and 623 fauna species (612 native and 11 naturalised) have been recorded in the Shire.				
Conservation significant species	Includes Threatened, Extinct, Specially Protected and Priority fauna or flora. The Shire is thought to contain 114 species of conservation significance (76 threatened or priority flora and 38 fauna).				
Invasive species	220 introduced flora (weeds) and 11 introduced fauna (feral animals) have been recorded in the Shire.				
- Weeds	Weeds displace native plants, particularly in disturbed sites, by out-competing them for light, nutrients and water, and recovering more rapidly from disturbances such as fire. Changes to plant communities affect animal habitats.				
- Feral animals	Feral animals predate native fauna, compete for food and shelter, and cause damage to native plants and habitats. Foxes and feral cats can severely reduce or eliminate native fauna by predation and competition. Rabbits have a significant impact through grazing and competition. Feral fish damage native fish and invertebrates and threaten the estuary. Feral pigs damage crops, predate livestock and degrade bushland. Feral bees threaten native hollow-dwelling fauna through competition.				
Threatened and Priority ecological communities	Natural biological groups of plants and animals that occur in particular types of habitats. Federally and/or State listed for protection. Threatening processes include clearing, fire, grazing, trampling,				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
	pollution, feral animals, weeds, hydrological changes, salinity and diseases. Most are naturally restricted or reduced to remnants. 18 TECs and PECs are known to occur in the Shire.				
Dieback	Dieback (<i>Phytophthora cinnamomi</i>) alters the environment by killing susceptible species, which alters hydrology, fauna habitat and visual resources. It affects more than 40% of plant species in the southwest, and within the Shire primarily affects banksia woodland and jarrah forest communities. The water mould spreads through the movement of plant materials and soil, and in water and by root contact. It is considered one of the greatest threats to biodiversity. Dieback free areas have very high conservation value and preventing its introduction and spread is vital. There is no known cure.				

 Improving
  Deteriorating
  Stable
  Unclear

7.2 Pressures

Biodiversity is under increased threat and has continued to decline. Many species and communities suffer from cumulative impacts of multiple pressures, particularly invasive species, habitat fragmentation and degradation. The impacts of climate change are also increasing, leading to changes in habitat condition.

The five key pressures likely to impact the condition of biodiversity are population growth and urbanisation, climate change, hydrological change, invasive species and pathogens, and altered fire regimes.

7.2.1 Population Growth and Urbanisation

A growing population puts increasing pressure on biodiversity when residential areas encroach on natural systems. The conversion or degradation of natural ecosystems has the most obvious impacts, while human settlements are often the entry point for introduced species.

The globally increasing trend of species extinctions can be attributed to natural or anthropogenic effects. Humans have the tendency to alter landscapes. An increasing population may lead to continued clearing which will result in loss of biodiversity and extinctions, with fragmented habitats becoming more susceptible to climate change, disease, and weed and feral animal invasion. Not all species are negatively affected by humans. However, an increased population may lead to an increase in air, noise and light pollution, changed hydrological regimes, and predation.

Urban development is a major driver of environmental change, placing strain on remaining natural areas. The protection of key features can be threatened by community demands for access and recreation.

Landscape modification and habitat fragmentation are key drivers for extinction. Fragmented vegetation patches may not be large enough to support some species, and fragmentation may also inhibit gene flow (causing the population to become more susceptible to disease and predation). Modification and fragmentation of the jarrah forest from bauxite mining can impact very large areas.

Urban and peri-urban areas continue to directly encroach into natural ecosystems and may cause indirect impacts such as acting as a source of invasive species. Higher human populations coincide with higher numbers of domestic animals which can increase predation and competition. More people can also increase the spread of dieback through increased traffic through natural areas, and fire regimes may be altered based on community concern. Higher populations also lead to an increase in water demand.

7.2.2 Climate Change

Expected changes in temperature and rainfall will place extreme pressure on ecosystems that are already under threat from many other factors. Biodiversity is one of the most vulnerable sectors to climate change. The impacts include changes to ecosystem structure and composition, phenology, fire regimes and hydrology. The south-west of Western Australia is a significantly vulnerable area.

The key impacts of climate change on biodiversity include reduced rainfall, increased storm events, increased fires, reduced water for wetlands, less groundwater recharge, damage and loss of vegetation, disruption to breeding patterns and species distribution, increased competition between needs, and an overall loss of species. The expected reductions in rainfall and groundwater recharge will have the greatest impact on groundwater-dependent ecosystems and wetlands, which are colonised by dryland species as they dry out, changing the ecosystem composition and increasing susceptibility to other threats.

7.2.3 Hydrological Change

All ecosystems depend on water. Climate change predictions are for lower rainfall, different seasonal patterns, declining groundwater, and increased drainage. These effects could lead to the death of many areas of remnant vegetation, with the greatest impact on groundwater-dependent ecosystems and wetlands, which are colonised by dryland species as they dry out, changing the ecosystem composition and increasing susceptibility to other threats.

7.2.4 Invasive Species and Pathogens

Invasive species are the most frequently cited pressure affecting threatened species. Competition, habitat destruction and predation by pest animals threaten the survival of many native plants and animals. Weeds can displace native plants, harbour pests and diseases, create fuel loads for fire, and alter structure and distribution of plant communities. Weeds become established in environments that have been disturbed or altered, and are one of the key threats to natural areas in the Shire. The presence of pathogens such as dieback (*Phytophthora* spp.) and the spread of other diseases such as Armillaria root rot and Marri canker poses a serious risk to the biodiversity values of natural areas.

7.2.5 Fire

Native vegetation within and surrounding urban areas is subject to frequent fires from arson, accident or controlled burns. Frequent fires change vegetation structure, destroy leaf litter, and can eliminate fire-sensitive species. Fire promotes weed growth that can increase fuel loads, and can lead to degradation and erosion of soil.

7.3 Responses

Natural areas and biodiversity have been significantly impacted since European settlement. Over-clearing, plus the impact of feral animals and other degrading processes, has resulted in significant local fauna extinction and the deterioration of bushland and wetlands. It has also contributed to the pollution of downstream waterways and the Peel Harvey Estuary.

Protecting biodiversity means conserving the full range of genes, species and ecosystems into the future. Given the range of threatening processes, this will be no mean feat. Responses to these threats relate to strategies for protection or biodiversity (such as use of the planning system and implementation of strategies and policies) and for management of specific pressures and threatening processes (Table 7.2).

Table 7.2: Biodiversity Responses

Response	Actions	Timing	Priority
7.1 Implementation of the Local Biodiversity Strategy	7.1.1 Finalise and implement the draft Local Biodiversity Strategy Update Report 2019	Short term	High
	7.1.2 Continue implementation of the Healthy Habitats Biodiversity Stewardship Program for conservation of biodiversity on private property	Ongoing	Medium
	7.1.3 Investigate options for funding a grants program for private property biodiversity conservation initiatives	Medium term	Low
	7.1.4 Investigate options for rezoning properties with high biodiversity value to Conservation	Long term	Low
	7.1.5 Continue to provide rate relief to properties zoned for Conservation	Ongoing	High
	7.1.6 Prioritise management of natural areas in local reserves according to condition, threats and biodiversity value, and allocate funds accordingly	Ongoing	High
7.2 Local planning framework	7.2.1 Continue to utilise the local planning framework to improve retention and protection of local biodiversity	Ongoing	High
	7.2.2 Update the vested purpose of reserves to incorporate "conservation" where appropriate	Medium term	Medium
7.3 Climate change	7.3.1 Update and implement the Climate Change Strategy and Local Action Plan	Medium term	Low
7.4 Hydrological change	7.4.1 Implement water sensitive urban design in new urban developments	Ongoing	High
	7.4.2 Finalise and implement the Integrated Water Management Strategy	Short term	High
7.5 Invasive species and pathogens	7.5.1 Continue to implement the Weed and Pest Management Plan	Ongoing	High
	7.5.2 Continue to support the Peel Harvey Biosecurity Group in its efforts to encourage weed and pest control on private property	Ongoing	Medium
	7.5.3 Continue to support Landcare SJ Inc.	Ongoing	High
	7.5.4 Continue to support weed and pest control initiatives implemented by State government	Ongoing	Low
	7.5.5 Develop and implement pathogen management plans and policies	Medium term	High
7.6 Fire	7.6.1 Continue active management of natural area reserves following fire	Ongoing	High
	7.6.2 Continue to implement SPP 3.7 and the Bushfire Risk Management Plan	Ongoing	High
	7.6.3 Continue to balance the requirements of SPP 3.7 and the protection of people and property against conservation	Ongoing	Medium

Response	Actions	Timing	Priority
	of bushland and provision of high amenity vegetated areas and public open space		
	7.6.4 Continue prescribed burning activities according to scientific best practice for protection of people, property and the natural environment	Ongoing	High
	7.6.5 Require prescribed burning activities to factor in protection of biodiversity as part of risk management and public safety	Ongoing	High
	7.6.6 Continue to source the most recent information on best practice fire ecology	Ongoing	Medium
	7.6.7 Promote and educate on scientific best practice fire ecology	Ongoing	Low
7.7 Urban and Rural Forest Strategy	7.7.1 Continue to implement the Urban and Rural Forest Strategy	Ongoing	High
	7.7.2 Link implementation of the Urban and Rural Forest Strategy to the Local Biodiversity Strategy and other targets	Ongoing	Medium
7.8 Street tree and verge planting	7.8.1 Continue support for the street tree and free verge plant programs	Ongoing	High
7.9 Funding	7.9.1 Continue to provide funding to support initiatives that retain and protect local biodiversity	Ongoing	High
	7.9.2 Create new initiatives, ideas and developments to manage biodiversity loss	Ongoing	Low
	7.9.3 Investigate funding options to manage biodiversity	Ongoing	Medium

7.4 Implications

The conservation of biodiversity and maintenance of ecological functions is essential for long-term protection of the environment and human survival. Interrelationships between the living and nonliving environment are complex and poorly understood, so the potential for disrupting ecological function and services is significant. Many issues can have cumulative effects, placing biodiversity under increased pressure. Threats not only come from biological and physical processes, but from institutional issues too. Foremost is the failure adequately to value biodiversity in decision-making.

The implications of inappropriate fire regimes are very serious for the environment, society and the economy. Fires that are too frequent or at an inappropriate time of year cause loss of habitat and food supply, loss of landscape diversity, and degradation problems for land and water. Fires can also exacerbate other threatening processes such as soil erosion, particulate air pollution, weed invasion, eutrophication, salinization, and spread of *Phytophthora* dieback. Fires can release greenhouse gases and reduce carbon sequestration. Very intense fires can contribute to long-term ecological change by removing adult plants. Loss of species and ecosystem simplification are likely if inappropriate fire regimes persist. The decisions to protect people and property that are made on economic and social grounds have important effects on biodiversity.

Removal of native vegetation has obvious environmental implications, but also has significant social and economic implications. In some areas, vegetation has been cleared beyond safe ecological limits. Continued clearing will result in loss of biodiversity and extinctions, with fragmented habitats more susceptible to climate change, disease, and weed and feral animal invasion. Salinisation of land and water, altered water regimes, soil erosion, eutrophication and increased greenhouse gas emissions are all direct consequences of clearing. Benefits of retaining native vegetation include cultural benefits and ecosystem services that underpin the economy and society.

Failure to control feral animals will result in loss of biodiversity and decline or extinction of species or ecosystems. Feral animal control needs to be consistent and sustained, and a proactive approach is required. With increasing population and travel, transport and trade, the risk of introducing new species grows. The potential cost of feral animals is enormous, including control measures, loss of biodiversity and damage to agricultural, forestry, pastoral and construction industries, in addition to public health and amenity.

Weeds have significant impacts on the environment, society and economy. Agricultural and aquatic weeds cause extensive economic losses. Weeds can impact human health and may lead to a loss of recreational and aesthetic values. Loss of biodiversity will continue with invasion and spread of weeds. Weed control requires consistent and sustained effort over time. Environmental weeds are generally not well controlled compared to agricultural weeds. The spread of weeds can also contribute to changed fire regimes and landscape-level change to ecosystems.

The death of native plants caused by *Phytophthora* dieback reduces biodiversity and has the potential to cause extinction of threatened species. Community amenity and aesthetics are lost when local areas become infected. Public access and enjoyment of parks is lost if areas are closed to contain disease spread. There is also the cost of removing dead trees, ensuring public safety, and rehabilitating damaged areas. Phosphite treatments are not a cure and must be repeatedly applied to postpone onset, making it expensive and potentially unsustainable. Dieback is also a major economic cost for the mining, horticulture, floriculture, wood production and tourism industries.

8. Human Settlements

8.1 Condition

Built environments affect the residents that live within them and the natural environment they exist within, so it is important to balance the needs of both. Settlements must maintain their liveability for residents, while delivering efficiencies that reduce their impact on the natural environment.

The majority (90%) of the population of Western Australia lives in towns and cities, and a majority (78%) lives in the greater Perth area. The Perth and Peel regions are expected to grow considerably, while the Shire is among the fastest growing local government areas in Australia.

Expansion of urban areas consumes historically rural land and increases consumption of resources. Sustainable growth will be essential as greater demands are placed on resources, social and physical infrastructure, services and the natural environment.

There are four key settlements in the Shire: Byford, Mundijong/Whitby, Serpentine and Jarrahdale. Sustainable development depends on understanding how population growth in the four key settlements responds to the natural environment, particularly retention of natural areas, water sensitive urban design, flood mitigation, fire response planning, transport planning and sustainable built form (Table 8.1).

Table 8.1: Human Settlements State and Trends

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Shire of Serpentine Jarrahdale	Population has grown 108% in 10 years, expected to house an additional 100,000 people by 2050, mostly in the settlements of Byford, Mundijong/Whitby, Serpentine and Jarrahdale. 73% of current population resides in these four settlements. Condition of settlement areas depends on response to environmental setting.		?		
Byford	Population has grown 347% in 10 years, with a comparable growth in dwellings. Has developed from a rural townsite to an outer metro suburb. Family friendly (66% families with children). Contains 55% of the Shire's population.		↗		
Existing development	Settlement pattern reflects rural history. Byford serves as the retail hub of the Shire and is characterised by low density residential dwellings. Contains centrally located trotting complex.		—		
Retention of natural areas	Most vegetation cleared for rural use. Byford has the lowest tree canopy cover (12%) of the Shire's urban areas. Some tree retention in the public realm but little on private property. Remnant vegetation in Brickwood Reserve and along the railway and Beenyp Brook.	↘			

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Flood mitigation and water sensitive urban design	Land is low-lying so much of the development areas have been filled with imported sand to clear groundwater. Newer areas include multiple use corridors with drainage swales to manage stormwater. Older areas have not been retrofitted to water sensitive urban design principles.				
Bushfire risk	A significant portion of Byford is identified as bushfire prone.				
Waste generation	The Shire collects general waste weekly, recycling fortnightly, green waste twice a year and hard waste annually. Data is not available for specific settlements.				
Transport planning	Railway carries freight and a passenger service between Perth and Bunbury twice a day. A metro passenger service is proposed. Four bus routes link Byford to Armadale with variable frequency. Road access to Perth is via the South Western Highway and Tonkin Highway. A bicycle network is planned. Most residential areas have good quality footpaths on one side of the street.				
Sustainable built form	Recent development guided by Liveable Neighbourhoods and the R-codes, with some provisions for sustainable development and design. Construction since 2006 meets 5-star energy-efficiency standards, while older parts pre-date requirements. The Glades development is an award-winning sustainably designed community.				
Urban heat island effect	Increased low density development and urban expansion causes urban heat islands to form. No established standard for assessment. Local governments can undertake infrared aerial drone photography to measure and record incidence.				
Mundijong/Whitby	Population growth unclear due to boundary changes. Originally established as a rural village, but proposed to be one of the Shire's larger settlements. Contains 5% of the Shire's population.				
Existing development	Settlement pattern reflects rural history, with village centre surrounded by rural residential and the rapidly growing Whitby town. Characterised by low-density residential dwellings with large gardens and mature trees.				
Retention of natural areas	Most vegetation cleared for rural use or urban development. Tree canopy cover (15%) is similar to overall Shire, reflecting rural character. Remnant vegetation in three Bush Forever reserves and along Manjedal Brook.				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Flood mitigation and water sensitive urban design	Brooks passing through Mundijong and Whitby create flood risk in nearby developments. Water management strategies have been prepared.			↗	
Bushfire risk	The majority of Mundijong is identified as bushfire prone.		—		
Waste generation	The Shire collects general waste weekly, recycling fortnightly, green waste twice a year and hard waste annually. Data is not available for specific settlements.			—	
Transport planning	Railway carries freight and a passenger service between Perth and Bunbury twice a day. Two bus routes link Mundijong to Armadale with infrequent service. Road access to Perth is via the South Western Highway and future Tonkin Highway extension. Whitby has good quality footpaths on one side of the street, while access in Mundijong is inconsistent.		↗		
Sustainable built form	Development in Whitby is guided by Liveable Neighbourhoods and the R-codes, with some provisions for sustainable development and design, and construction meets 5-star energy-efficiency standards. Most of Mundijong pre-dates requirements.		↗		
Serpentine	Population has grown 25% in ten years. Urban area is small but is currently the Shire's second-largest settlement. Contains 9% of the Shire's population.			?	
Existing development	Settlement pattern reflects rural nature, with village centre surrounded by rural residential areas. Characterised by low-density residential dwellings with large, vegetated gardens and mature trees.			—	
Retention of natural areas	Well vegetated, with large trees in public and private realm. Tree canopy cover (17%) is higher than overall Shire. Remnant vegetation in adjacent Bush Forever reserves.		↘		
Flood mitigation and water sensitive urban design	The Serpentine River passes near Serpentine, creating flood risk in nearby rural residential developments but not in the settlement area.			↗	
Bushfire risk	The majority of Serpentine is identified as bushfire prone.		—		
Waste generation	The Shire collects general waste weekly, recycling fortnightly, green waste twice a year and hard waste annually. Data is not available for specific settlements.			—	
Transport planning	Railway carries freight and a passenger service between Perth and Bunbury twice a day. There is no bus service. Road access to Perth is via the nearby South Western Highway and proposed Tonkin Highway extension. Footpaths vary in presence, width and quality.	↗			

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Sustainable built form	The majority of Serpentine pre-dates sustainability design and construction requirements.				
Jarrahdale	Population has grown 25% in ten years. A historic area and the first major timber milling operation in WA. The Shire's smallest settlement. Contains 4% of the Shire's population.				
Existing development	A predominantly residential settlement with a rural feel. Characterised by low-density residential dwellings of varying ages with large, vegetated gardens, mature trees and gravel verges.				
Retention of natural areas	Well vegetated, with large trees in public and private realm. Tree canopy cover (42%) is the highest in the Shire. Surrounded by dense remnant vegetation in State forest and parks.				
Flood mitigation and water sensitive urban design	No parts of the settlement area are mapped as flood prone.				
Bushfire risk	The entire settlement of Jarrahdale is identified as bushfire prone.				
Waste generation	The Shire collects general waste weekly, recycling fortnightly, green waste twice a year and hard waste annually. Data is not available for specific settlements.				
Transport planning	One bus route links Jarrahdale to Armadale with commuter-style service. Road access to Perth is via the South Western Highway at the bottom of the Scarp. Footpath access is limited.				
Sustainable built form	The majority of Jarrahdale pre-dates sustainability design and construction requirements.				

Improving
 Deteriorating
 Stable
 Unclear

8.2 Pressures

8.2.1 Urbanisation and Population Growth

The Shire is expected to experience significant population growth, reaching about 100,000 people by 2050 and adding over 35,000 new dwellings. Growth will be targeted in the settlements of Byford, Mundijong/Whitby and (to a lesser extent) Serpentine. Byford and Mundijong/Whitby will evolve from rural villages into outer suburbs of Perth, potentially altering function and character.

8.2.1.1 Building and development trends

Housing affordability is an ongoing issue, with increasing pressure for cheap land and housing. While most of the Shire's settlement areas have lower prices than the Perth average, affordability will continue to be an issue. This affects the ability to obtain high quality development that integrates with the Shire's rural character, with the potential for project homes on completely cleared lots that meet minimum sustainability standards.

8.2.1.2 Accessibility

Urbanisation brings an expectation of greater provision of services and amenities, including essential services, public transport and social infrastructure. As the population grows and urban development expands, there will be a need to increase the capacity and reach of essential services. Building and running additional services and infrastructure will increase demand and pressure on natural resources.

Car use in the Shire is higher than the average for Perth, WA and Australia. In the absence of adequate frequent public transport, car use will increase, placing pressure on the atmosphere.

8.2.1.3 Environment

Development of new suburbs generally results in significant clearing, resulting in a loss of vegetation and biodiversity. Increased urbanisation also results in increased hard, impermeable surfaces, affecting the drainage network and nutrient runoff, placing pressure on the health of wetlands and waterways. Increased hard surfaces also increases the heat island effect, creating greater demand for air conditioner use and placing pressure on power supply.

8.2.1.4 Character

Urbanisation will shift the character of the area from large rural lots to urban development. As the rural character of the Shire is highly valued by the community, there will be increasing pressure to manage development in such a way as to preserve this character.

8.2.2 Climate Change

Growth and expansion of urban populations into new areas will increase the number of people at risk from bushfire and flood. Increased population will also increase demand on local resources, such as water and energy.

8.2.2.1 Bushfire risk

A warmer climate will increase the risk of bushfire events. 97% of the Shire is a designated bushfire prone area, which will have implications for the future cost of planning and development. Future development areas near remnant vegetation will be impacted by bushfire risk and increased building costs. Increased development that reduces bushfire risk will need to be balanced against vegetation retention for aesthetic, character, shade and biodiversity values.

8.2.2.2 Flood risk

Climate change could generate more frequent or extreme weather events with heavy rainfall, with associated storm damage to urban areas and infrastructure. This may result in greater flooding, impacting urban areas and infrastructure, and placing greater pressure on drainage networks. The health impacts of extreme weather events include injuries, mental health, and aggravation of asthma and other chronic conditions.

8.2.2.3 Environmental

Extreme weather events, including drought and flooding, can impact on agriculture and place pressure on food provision. This will have implications for the growing population.

8.3 Responses

Built environments affect the residents that live within them and the natural environment they exist within, so it is important to balance the needs of both. Settlements must maintain their liveability for residents, while delivering efficiencies that reduce their impact on the natural environment.

Expansion of urban areas consumes historically rural land and increases consumption of resources. Sustainable growth will be essential as greater demands are placed on resources, social and physical infrastructure, services and the natural environment. Sustainable development depends on understanding how population growth in the four key settlements responds to the natural environment.

Responses to these issues relate to strategies to implement existing policy and programs to address environmental matters, and opportunities to investigate for the future (Table 8.2).

Table 8.2: Human Settlements Responses

Response	Actions	Timing	Priority
8.1 Existing policy responses	8.1.1 Continue to implement the local planning framework to ensure: • Protection of local biodiversity • Flood mitigation • Incorporation of water sensitive urban design • Bushfire risk mitigation • Waste reduction and increased recycling rates • Improved sustainability of built form • Provision of sustainable transport options	Ongoing	High
	8.1.2 Continue to support the street tree and free verge plant programs	Ongoing	High
	8.1.3 Continue to support the Healthy Habitats biodiversity stewardship program for conservation of biodiversity on private property	Ongoing	Medium
	8.1.4 Continue to participate in and support Switch your Thinking to encourage water-wise and energy-efficient behaviours in residential and business developments	Ongoing	High
8.2 Additional responses	8.2.1 Continue to support the conservation zone, and investigate options to rezone additional properties for conservation	Ongoing	High
	8.2.2 Consider the need for a local planning policy that provides expectations for retention of trees and remnant vegetation through design of new urban developments	Medium term	High
	8.2.3 Investigate any updates to the local planning framework that may be required to support the container deposit scheme, in accordance with the WAPC Position Statement	Medium term	Medium
	8.2.4 Investigate opportunities to improve accessibility between residential and retail areas	Long term	Medium
	8.2.5 Investigate potential for a local planning policy that achieves built form that exceeds BCA requirements	Medium term	Medium
	8.2.6 Investigate opportunities for educational opportunities to improve sustainability of residential housing	Medium term	Low
	8.2.7 Investigate opportunities to measure and educate the community about urban heat islands	Medium term	Medium
	8.2.8 Review the local planning framework to determine further opportunities to improve the sustainability of the Shire as it develops	Medium term	Medium

8.4 Implications

If current patterns and rates of urban growth continue, there will be serious consequences for biodiversity. Pressures will increase on already stressed ecosystems, resulting in loss or degradation of vegetation and threatened ecological communities. Under current development trends, households are becoming more isolated and car-dependent with fewer people in each dwelling. This may lead to increased resource consumption, more car dependence and waste management challenges.

The distribution of settlements, existing transport networks and urban form mean that car dependence will continue. Air quality issues may increase, as will greenhouse gas emissions. Expansion of the road network will impact native vegetation and wetlands, and contribute to isolation of many ecological communities and wildlife.

As the population grows, generation of waste will increase unless major achievements are made in the areas of waste minimisation and resource recovery. The reliance on landfill for dealing with waste is imposing an environmental, social and economic liability on future generations, through resource loss, greenhouse gas generation, and potential contamination of surface and groundwater supplies. A number of waste related incidents and events locally and internationally have contributed to increasing community concern about the need to better manage waste. Plans to establish waste facilities in or near urban environments are often met with opposition from the local community.

9. Heritage

9.1 Condition

Heritage is present in many forms such as landmarks, places, buildings and contents, spaces, views and the stories associated with them. Western Australia's heritage includes natural, Aboriginal, European, maritime, moveable and intangible heritage.

The Shire has strong heritage values connected to the three key elements of the natural environment, Aboriginal heritage and European settlement (including historic places with intergenerational value) (Table 9.1).

Table 9.1: Heritage State and Trends

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Heritage	The Shire has strong heritage values connected to the natural environment, Aboriginal heritage, and European settlement (historic places with intergenerational value).				
Aboriginal heritage	Noongar peoples hunted and camped in the area long before European settlement, using fire sticks to burn the forest and create areas of open woodland and grassland. There are 23 registered Aboriginal Sites in the Shire, and 63 sites which are not (or not yet) registered. The most well-known registered site is the Serpentine River.				
Native title	The recognised traditional owners are the Gnaala Karla Boodja people. A Native Title Settlement Agreement was signed in 2015. Traditional owners are expected to be more closely involved in land use planning and management upon commencement of the Settlement.				
Place names	Aboriginal culture is reflected throughout the Shire, such as in the local place names that are linked to Noongar words.				
Trails	Walking and cycling trails such as the Bibbulmun and Mundabiddi follow historic routes used by traditional owners, and are widely celebrated and promoted.				
European heritage	Includes heritage areas, buildings and structures, historic cemeteries and gardens, landscapes and historic sites. Supports amenity by familiarity and landmarks, sense of place and quality of built environment. Heritage conservation can aid economic prosperity by providing an attractive environment for residents and tourists; loss of buildings is a waste of economic as well as environmental resources.				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
Local historic heritage	Dates back to Thomas Peel's land grant in 1840. Governed consecutively by the Canning Road Board, Serpentine Road Board and Jarrahdale Road Board, Serpentine Jarrahdale Road Board, and Shire of Serpentine Jarrahdale. Stable farming and orchard area with timber processing, brickworks, and bauxite mining and crushing. Current rural lifestyle supports the equestrian industry. Reputation as a "food bowl". Strong sense of history based on original settler families. Jarrahdale was the site of the first major timber milling operation in WA, and is classified as a historic town.				
State Register of Heritage Places	There are 5 places currently on the State's Register of Heritage Places, with 25 in the Assessment Program, 6 identified as Not Warranting Assessment and 4 deemed Below Threshold for the Register.				
Heritage List	37 sites of historic, architectural, scientific, scenic or other value are listed in TPS2 and provided statutory protection.				
Local Heritage Survey (previously Municipal inventory)	72 places are listed on the Shire's Municipal Inventory, guiding management of the sites. The register has not been reviewed since 2000.				
List of Classified Places	29 places are listed on the National Trust's List of Classified Places within the Shire.				
Natural heritage	Picturesque environment of Scarp, Serpentine Falls and Dam, forests, wetlands, wilderness and wildflowers. Vibrant equine industry. Rural character maintained by protection of vegetation, particularly significant trees. Protected within national parks and conservation reserves.				
Natural beauty	Rural character and natural beauty are highly valued by the community. Protected and celebrated by a number of policy and planning mechanisms. There is growing concern over the effect of climate change, logging and mining on the jarrah forest, which has great recreational potential.				
Arts, Culture and Heritage Advisory Committee	Provides advice to Council on matters of arts, culture and heritage. The committee develops policies and strategies, advises on the allocation of funds, and provides input on the value of local heritage.				
Community grants	Four grants to heritage projects have been issued in the past four years.				
Jarrahdale Heritage Society	Works to preserve natural and historic heritage in and around Jarrahdale,				

Component	Summary	Assessment grade			
		Very poor	Poor	Good	Very good
	including a public museum and guided heritage walks.				
 Improving  Deteriorating  Stable  Unclear					

9.2 Pressures

9.2.1 Population Growth and Urbanisation

Changes to population create pressure for change and development, creating tension between economic and cultural values. Inconsistent decision-making and differing perceptions of heritage value can lead to outcomes that adversely affect heritage. Individual sites may be subject to neglect and vandalism, or damage from increased visitation.

Historic heritage is particularly at risk from pressures for redevelopment, with impacts ranging from complete destruction to inappropriate change and adverse effects on attributes such as visual setting. Other pressures arise from population shift, including redundancy, neglect and decay. However, there is also greater recognition of the value of historic buildings and opportunities provided by their adaptive re-use. The decline in professional and trade skills in the historic heritage sector, the ageing specialist workforce and rise of non-specialist tradespeople present a looming threat.

Aboriginal sites continue to be threatened by incremental destruction associated with urban and industrial development. Effective engagement with the Aboriginal community and their involvement in the protection of Aboriginal heritage values in the Shire is vital.

9.2.2 Climate Change

The effects of climate change may directly affect natural heritage through altered fire regimes, invasive species, and altered hydrology. This may also affect Aboriginal cultural heritage practices and alter historical land-use patterns, affecting sense of place and changing cultural landscapes. When planning new development it is important to consider these factors.

9.3 Responses

The Shire has strong heritage values connected to the three key elements of the natural environment, Aboriginal heritage and European settlement (including historic places with intergenerational value).

Responses to heritage issues relate to strategies to both celebrate local heritage and ensure that statutory and strategic frameworks are adequate and appropriate for preservation of heritage (Table 9.2).

Table 9.2: Heritage Responses

Response	Actions	Timing	Priority
9.1 Celebrate local heritage	9.1.1 Continue to support and develop events that celebrate local heritage	Ongoing	High
	9.1.2 Continue to support and develop walking trails, and promote guided and self-guided walks that celebrate natural heritage	Ongoing	High
	9.1.3 Continue to support and develop other recreational trails, such as bridle paths and bike paths	Ongoing	High
	9.1.4 Collaborate with State government to improve the condition of the Northern Jarrah Forest and develop the potential for low impact recreational uses	Long term	Medium
9.2 Statutory and strategic frameworks	9.2.1 Ensure that provisions in the planning scheme relating to heritage are not too onerous or prescriptive while protecting values	Long term	Medium
	9.2.2 Develop a Heritage Strategy	Medium term	High
	9.2.3 Review and update the Local Heritage Survey (previously Municipal Inventory) and Heritage List	Medium term	Medium
	9.2.4 Identify ways heritage assets can be conserved, interpreted, celebrated and (where culturally appropriate) promoted	Short term	Medium
	9.2.5 Identify and protect Aboriginal heritage with the involvement of the Aboriginal community	Ongoing	High
	9.2.6 Forward any additional information regarding sites under assessment for inclusion on the State Register of Heritage Places to the Department of Planning, Lands and Heritage	Medium term	Low
	9.2.7 Preserve historical settlement patterns and street configurations within Old Byford and Mundijong through structure plan provisions	Ongoing	Low
	9.2.8 Incorporate cultural heritage in Public Open Space and facility design	Ongoing	High
	9.2.9 Consider mechanisms to actively improve heritage values	Medium term	Medium

9.4 Implications

Many significant natural heritage places are protected in conservation reserves, but areas can still be subject to development (particularly mining). Many aspects of natural heritage cannot be restored or rehabilitated once they have been impacted. The destruction of natural heritage diminishes understanding of the world and undermines community identity, amenity and quality of life. It also contributes to loss of biodiversity and geological diversity. Decline in natural heritage areas adversely impacts the tourism industry, with flow-on effects to the economy.

The destruction of Aboriginal heritage sites adversely affects Aboriginal culture, spirituality and connection with country and ancestral history. Differences between Aboriginal and European cultures often result in inadequate understanding, valuing and protection of Aboriginal heritage. A better understanding of the values of Aboriginal heritage by the broader community is critical.

Loss or degradation of historic heritage undermines the character and feel of a location. Loss of a landmark can alter local qualities, while incremental loss or deterioration of many historic places over time can significantly affect urban amenity, community identity and sense of place.

Appreciation of historical and cultural heritage is essential for maintenance of heritage values and

for passing on those values to future generations. The trend in historic heritage appreciation is not clear.

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10. Outlook

10.1 Summary

In general, the outlook for the environment depends on the ability to address effectively the complex mix of pressures discussed in this report. Under a no-change scenario, current trends continue, residual pressures are not resolved, and there are no significant changes to management. However, some tools, mechanisms and resources are starting to be used to address the pressures and improve management to more effectively support sustainable development.

It is clear that some parts of the environment are not being managed sustainably. Although uncertainties exist, assuming current trends continue and policies and management are not changed significantly, the environment to 2050 is likely to be characterised by:

- Climate change – even if mitigation is successful, temperatures will remain high for many centuries, resulting in:
 - Hotter days and more of them, and increasing heatwaves, leading to increased bushfires and human health problems
 - Sea level rise
 - Reduced average rainfall, increased drought frequency and severity, and increased frequency and severity of extreme rainfall events
 - Increased reliance on air-conditioning and artificial cooling, increasing demand for electricity but with improved efficiency
- Ecosystem changes, including:
 - Declining quality of ecosystems
 - Continued loss of biodiversity, including habitat loss and extinction of plants and animals
 - Ongoing clearing of native vegetation
 - Changes to the distribution of species and ecological communities as the climate changes
- Changing water use, including:
 - Ongoing changes in flow of waterways, changes to drainage patterns, changed land management practices and damage to riparian areas
 - Declining groundwater quality
 - Increased demand for water but greater efficiency of use
- Growing urban areas, including:
 - More people living in urban environments and declining rural populations
 - Improving air quality in most urban areas
 - Declining local air quality in some urban areas, due to fires and industry
 - Increased conflict and competition for land
 - Continued dominance of private cars for urban transport, but with reduced emissions
 - Urban heat islands
 - Encroachment into rural areas, resulting in loss of productive agricultural land
- Changing industry and management approaches, including:
 - Increases in public and private conservation areas
 - Implementation of an increasing number of climate change adaptation measures

- Increased production of energy from renewable sources, and improvements in energy efficiency
- Improved land management practices
- Increased involvement of Aboriginal people in management
- Ongoing challenges, including:
 - Increasing threats to the environment, agricultural production and human health
 - Ongoing conflicts about land use
 - Ongoing incremental damage to, and loss of, heritage areas

The balance in the outlook between positive and negative trends can potentially shift, by using a variety of policies, tools, approaches and resources that are being developed and are starting to be used to support a more sustainable path of development. These include integrated policy approaches; new ways of resourcing investment in sustainability; improving knowledge through better monitoring and data collection; improving decisions and action through better knowledge; improved measures to account for ecosystem values; and innovation to further decouple the economy from environmental impact.

If the state of the environment is to be improved, there needs to be innovation in policy, technical and management approaches to halt and reverse the decline in the environment and ecological processes; protect ecosystems and heritage values, repair damage and restore processes; decrease production of waste and emissions; and reduce dependence on non-renewable resources.

An improved future would be characterised by:

- Atmosphere – reduced greenhouse gas emissions on track for global zero emissions, renewable energy, and improvements in energy efficiency
- Land – consistent use of land management practices that maintain, rebuild and restore ecological functioning and resilience
- Inland waters – water resource access and management plans that prioritise sustainable allocation of water, and protect water quality and riparian ecosystems
- Biodiversity – a series of healthy, interconnected ecosystems, protected from declines in condition, and policies to rebuild condition and resilience
- Human settlements – an increased proportion of high-quality, medium to high density development in established urban areas, with retention of a mix of natural assets, and access to green space and transport infrastructure
- Heritage – comprehensive identification of natural, Aboriginal and historic heritage places, and mechanisms to protect and manage heritage places in decision-making

The natural environment makes human life possible, and the cultural environment defines identity. It is therefore essential that population and economic growth are environmentally sustainable. The balance must be right between existing programs, innovative approaches, and long-term integration.

10.1.1 Atmosphere

10.1.1.1 Climate change

The outlook for climate depends on the effectiveness of international and national efforts to reduce greenhouse gas emissions. Without mitigation, surface temperature increases of 3.7-4.8°C above pre-industrial levels are projected. To remain below the agreed 2°C warming, a reduction in global emissions of 40-70% by 2050, and near zero emissions or below in 2100 are required. Serious mitigation strategies are required to achieve this.

Mitigation efforts will minimise the extent of future climate change and prevent catastrophic tipping points, but will not return the climate system to its pre-industrial state. Despite international and domestic mitigation efforts, temperatures will remain high for many centuries, even after a complete cessation of emissions. Hence, adaptation will be an important component of the way society handles climate change.

10.1.1.2 Ambient air quality

The outlook for urban air quality is generally good. However, there is strong evidence that periods of poor urban air quality can have serious adverse long-term and short-term impacts on human health. Although levels of carbon monoxide, nitrogen dioxide and sulphur dioxide have been stable or decreased in the past 10 years, ozone and particulate levels have not declined, and ongoing effort will be required to secure past gains and achieve further improvements. Prospects for achieving reductions in levels of ozone and particulates will be influenced by several factors, including vehicle technology, population growth and urbanisation, the availability of reliable public transport, and the impact of climate change.

10.1.2 Land

The outlook for the land environment is shaped by the legacy of former activities, the current and future pressures on the land, and responses to these pressures.

The many consequences of climate change provide the greatest challenges. These include understanding how to facilitate resilience in already depleted natural communities; ensuring food, water and energy security; and managing conflicts for the use of land. There will be trade-offs between different sectors of the economy and different human communities, in a context of change in many other areas.

Other challenges include the threats posed by invasive species; maintaining agricultural productivity as well as environmental sustainability; and balancing the demands of a growing, and increasingly urban, population with the economic necessity of a viable resources sector.

The development and coordination of perspectives and strategies at national, regional and local scales is an important step in ensuring that decisions are taken at an appropriate scale and recognise the critical importance of all scales. It is hard to see that decisions are currently being made at an appropriate temporal scale.

10.1.3 Inland Waters

Climate and pests remain the largest pressures on inland water environments. Climate variability and climate change, and associated changes in rainfall regimes, are the primary risks to inland water environments in both the short and long term. Efforts will need to continue to monitor and manage aquatic pests and weeds. As agricultural development spreads and becomes more intensive, the weed and pest outlook will become more uncertain.

The scientific investigation and management controls associated with exploitation of basic raw materials both potentially benefit and threaten the future health of inland waters.

Water resources information is becoming increasingly available in many forms, supporting broader understanding and more informed debate on the future of water resources and aquatic environments. Inland waters continue to receive moderate attention in research and policy agendas, assuring a continuing supply of new ideas and knowledge. Cultural water, and co-management of

groundwater and surface water, are areas in which inland water environments will benefit from attention.

10.1.4 Biodiversity

It seems unlikely, given the current overall poor status and deteriorating trends in biodiversity and the high impact of increasing pressures, that overall biodiversity outcomes will improve. Current investments in biodiversity management at all levels are not keeping pace with the scale and magnitude of current pressures, and there is an increasing need to adapt to a potential reduction or shift in the ecosystem services that society relies on. It is anticipated that novel ecosystems with a mixture of native and introduced species will increase as the distribution and abundance of invasive species expand. Biodiversity and broader conservation management will require major reinvestments across long timeframes to reverse deteriorating trends.

It is possible to achieve a balance of sustainable environments, and economic and population growth, but significant changes in policy and implementation of new technology and tools will be required. For example, market-based instruments for sustainable land management and protection of biodiversity will be increasingly important.

The co-development and application of effective research and management models with Aboriginal people and Friends groups is key to improving management of areas that are vital for the ongoing maintenance of important elements of biodiversity. Such approaches have huge potential to improve the ability to respond to both existing and possible new impacts through participatory and citizen science monitoring and impact assessment methods, leading to new ways of managing biodiversity that enable sustainable development across a wide range of tenures.

10.1.5 Human Settlements

The outlook for human settlements continues to be mixed. The major drivers of population growth and climate change pose significant challenges in relation to housing location and infrastructure, although per-capita reductions and improved efficiencies are beginning to occur in some areas. Increasing urban land use at settlement fringes is an area of concern, as is traffic congestion, despite projected growth in public transport. Increased densification and urban infill need to be carefully planned and managed to maintain adequate green space and green infrastructure as urban populations increase. Tree retention must be prioritised during urban infill to maintain canopy cover that ameliorates the urban heat island effect.

Energy and water efficiency have continued to improve, resulting in little or no overall increase in consumption despite increasing population growth. There have also been reductions in per-person car use and reductions in waste to landfill.

However, there is a lack of coordination and integration of planning across and between levels of government, as well as between the various cross-cutting themes that are relevant to management of human settlements. This adds to the challenges faced by human settlements.

10.1.6 Heritage

In recent years, several factors have significantly influenced the context for heritage. There has been a growing understanding and acceptance that climate change poses a major threat to both natural and cultural heritage places. Aboriginal involvement in management has expanded, although the fragmented approach to Aboriginal heritage remains. There have been some significant investments by the State and Federal governments, but overall, the resources allocated for heritage management

have remained steady or declined. Limited resources have been available to assess the state and condition of heritage.

The systems used to manage heritage continue to be cumbersome. These structures do not adequately identify, protect, manage, resource or celebrate the integrated nature of the cultural landscape. Heritage remains at risk from the impacts of climate change, the threats arising from development, and the resource implications of population growth.

The reserve system continues to improve, particularly through the addition of new areas, but it is not comprehensive nor adequately representative. Declining funding for parks agencies, relative to the increasing extent of the reserve system, increases the risk of less effective management in the future. Listing of natural heritage places and reservation of landholdings are hampered by factors such as conflicting perceptions of value. Climate change poses major risks to natural heritage, which is also threatened by inappropriate land use, development pressures, fires, loss of habitat and invasive species. The ultimate impact of these pressures will depend on the ability of scientists and managers to work together, and on commitment to well-resourced, proactive management rather than belated reaction to crises. Adverse effects can be minimised through thorough understanding of resources, recognition of the benefits of public-private partnerships, and a whole-of-landscape approach that fosters ecological connectivity.

Aboriginal heritage remains inadequately documented and protected, and incremental destruction continues. The continued inclusion of Aboriginal heritage areas within protected reserves is particularly important, as is increasing involvement of Aboriginal people in management. Although declining Aboriginal language is a cause for concern, there are improvements in knowledge and practices, which support Aboriginal cultural traditions and connection to country.

Many historic heritage places remain in good condition. However, statutory lists and registers remain inconsistent and incomplete. Historic heritage conservation could be better supported by planning and assessment systems, and continues to be threatened by development. There has been little progress in providing improved incentives for private owners of heritage places.

10.2 Action Plan

The responses from the six themes discussed in this report have been collated into a single Action Plan. Following finalisation of the State of the Environment Report, a stand-alone Implementation Plan will be prepared, to set quantifiable targets, assign responsibility for actions and propose timelines.

Some of these actions will be able to be implemented as part of business as usual, while others will require funding under the annual business case format. A few are major projects that would require significant investment (such as retrofitting the street lighting systems); funding for these projects would require investigation of options such as grant funding.

Table 10.1: State of the Environment Report Action Plan (quantifiable targets to be set in subsequent Implementation Plan)

Response	Actions	Timing	Priority
Atmosphere			
Climate change			
4.1 Shire greenhouse gas emissions reductions	4.1.1 Continue installation of solar PV systems on facilities and consider expansion of existing solar panels	Ongoing	High
	4.1.2 Retrofit lighting systems in facilities to more energy-efficient types	Medium term	Medium
	4.1.3 Require energy-efficient street lighting in new developments and consider retro-fitting existing street lighting	Ongoing	High
	4.1.4 Ongoing investigation into the use of battery storage at facilities with high energy use (where there has been excess production from solar panels)	Long term	Medium
	4.1.5 Investigate options for monitoring of energy use across all facilities	Short term	High
	4.1.6 High energy use facility energy audits	Short term	Medium
	4.1.7 Small facility energy audits	Short term	Low
	4.1.8 Continue participation in Switch your Thinking	Ongoing	High
	4.1.9 Offset emissions through tree planting and other programs	Ongoing	High
	4.1.10 Prepare and implement a risk analysis of the impacts of climate change on assets, including local reserves	Short term	High
4.2. Residential greenhouse gas emissions reductions	4.2.1 Continue support for Switch your Thinking's community events and actions	Ongoing	High
	4.2.2 Continue support for residential solar PV systems	Ongoing	High
	4.2.3 Consider updates to the local planning framework to better encourage the installation of residential solar PV systems and battery storage	Medium term	Medium
	4.2.4 Encourage utility scale battery use in new developments	Ongoing	Low
	4.2.5 Consider supplying a third bin to reduce organic waste entering landfill	Short term	High
	4.2.6 Improve sorting practices of hard waste to increase recycling rates	Short term	High
	4.2.7 Consider strategies for the recycling and disposal of solar PV panels and batteries	Long term	Low
4.3 Sustainable built form	4.3.1 Implement the Urban and Rural Forest Strategy 2018-2028	Ongoing	High
	4.3.2 Consider updates to the local planning framework to better encourage sustainable design of subdivisions and other developments	Medium term	Medium
	4.3.3 Consider preparation of sustainable design guidelines to complement SPP 7.0 and Design WA	Medium term	Low
	4.3.4 Continue to support Switch your Thinking's research into sustainable building solutions and community education	Ongoing	Medium
	4.3.5 Support the implementation of light coloured roofs to reduce the urban heat island effect	Ongoing	Low
4.4 Schools greenhouse gas emissions reductions	4.4.1 Continue support for Switch your Thinking's school programs, promotions and actions	Ongoing	High
	4.4.2 Consider partnerships with State Government and other organisations to promote existing programs, e.g. YourMove Schools, ClimateClever, Switched on Schools, Wastewise Schools	Short term	Low
4.5 Business greenhouse gas emissions reductions	4.5.1 Continue support for Switch your Thinking's business programs, promotions and actions	Ongoing	High
	4.5.2 Consider updates to the local planning framework to better encourage solar PV systems and battery storage on commercial and industrial facilities	Medium term	Medium

Response	Actions	Timing	Priority
	4.5.3 Consider implementing partial offsets for industrial development in the form of dual-purpose revegetation that also provides screening	Medium term	Medium
4.6 Renewable energy production	4.6.1 Consider updates to the local planning framework to better consider renewable energy facilities	Medium term	Medium
4.7 Agriculture	4.7.1 Investigate partnerships with the State Government to promote and encourage reduced-emissions animal husbandry and management systems	Short term	Low
4.8 Peak demand management	4.8.1 Continue to support Switch your Thinking's research in peak demand management	Ongoing	Medium
	4.8.2 Continue community engagement in peak demand response, e.g. Energysmart Tips	Ongoing	Medium
Ambient air quality			
4.9 Reduce vehicle emissions	4.9.1 Implement the Cycling and Walking Plan 2019	Ongoing	High
	4.9.2 Encourage walking for short trips and cycling for short-medium trips through local advertising and engagement of community groups	Short term	Medium
	4.9.3 Encourage walking or riding over driving to public transport nodes	Medium term	Low
	4.9.4 Plan and construct walkable cities through urban design	Ongoing	High
	4.9.5 Consider linkages between public transport nodes such as multiple use paths, and end-of-trip facilities	Medium term	Medium
	4.9.6 Consider zoning when planning city design, such as keeping retail, leisure and public spaces in one hub and industry in a separate hub	Ongoing	High
	4.9.7 Construct bicycle paths and bicycle-friendly road infrastructure	Ongoing	Medium
	4.9.8 Consider implementing a bike sharing scheme through partnership with a private enterprise	Long term	Low
	4.9.9 Consider partnerships with State Government and other organisations to promote existing programs, e.g. YourMove	Short term	Low
	4.9.10 Continue working with the Public Transport Authority to increase access to public transport	Ongoing	Medium
4.10 Bushfire	4.10.1 Designate dates for prescribed burns to limit the number of simultaneous burns	Ongoing	High
	4.10.2 Recommend or require a Burn Plan which takes weather conditions into consideration	Ongoing	High
4.11 Reduce wood heater emissions	4.11.1 Consider promotion of methods to reduce smoke from wood heaters	Medium term	Medium
	4.11.2 Consider promotion of alternative, more efficient heating systems	Long term	Low
4.12 Industrial development	4.12.1 Consider installation of an air quality monitor	Long term	Medium
	4.12.2 Consider updates to the local planning framework to better consider encroachment on sensitive receptors and buffer zones	Medium term	Medium
Land			
5.1 Climate change	5.1.1 Manage direct climate impacts to land on Shire-controlled land, such as the addition of lime to acidic soils	Ongoing	Medium
	5.1.2 Consider partnerships with State Government to promote the management of direct climate impacts to land	Medium term	Low
	5.1.3 Consider collaboration with State Government to foster regenerative agriculture	Medium term	Medium
5.2 Land use management	5.2.1 Consider the use of land capability assessments in assessing land suitability for a given use and land rezoning	Ongoing	High
	5.2.2 Continue to utilise the local planning framework to guide how land within the Shire is used	Ongoing	High
	5.2.3 Investigate updating the local planning framework to better manage extractive industry conditions and approvals	Medium term	Medium

Response	Actions	Timing	Priority
	5.2.4 Develop a Cemetery Management Plan to guide need for and allocation of additional land for cemeteries	Short term	High
	5.2.5 Investigate the need to update the planning scheme to better control the location and management of landfills	Medium term	Medium
	5.2.6 Investigate any updates to the local planning framework that may be required to support the container deposit scheme, in accordance with the WAPC Position Statement	Medium term	Medium
	5.2.7 Continue to support Landcare SJ Inc.	Ongoing	High
	5.2.8 Continue to implement SPP3.7 and the Bushfire Risk Management Plan	Ongoing	High
	5.2.9 Investigate options to minimise disturbance by mining and logging to the jarrah forest	Medium term	Medium
Inland waters			
6.1 Local planning framework	6.1.1 Continue to utilise the local planning framework to guide water use and management within the Shire	Ongoing	High
	6.1.2 Finalise and implement the draft Local Planning Strategy	Short term	High
	6.1.3 Investigate updating the local planning framework to better encourage alternative building practices including appropriate footings that do not require the use of fill	Medium term	Medium
	6.1.4 Consider a review of existing townscape drainage systems	Medium term	Low
	6.1.5 Give consideration to relevant legislation on on-site sewerage management in policy and planning for wastewater management	Ongoing	High
6.2 State Planning Policies	6.2.1 Liaise with the State Government to ensure the Shire is aware of and provides input into review of key State Planning Policies that relate to water	Ongoing	High
6.3 Better Urban Water Management	6.3.1 In collaboration with the Department of Water and Environmental Regulation, continue to support new development through the application of Better Urban Water Management	Ongoing	High
6.4 Catchment remediation	6.4.1 Continue to incorporate Water Sensitive Urban Design in new developments	Ongoing	High
	6.4.2 Consider the modification of existing drainage schemes to incorporate best practice for water sensitive design and nutrient management	Long term	Medium
	6.4.3 Restore local hydrological conditions where possible, through design of integrated water cycle systems and solutions	Long term	Low
	6.4.4 Re-establish lost hydrological values and design systems to cope with waterlogging and minimise nutrient and sediment export	Short term	Medium
	6.4.5 Continue to support Landcare SJ Inc. and other initiatives that reduce nutrient inputs into the catchment	Ongoing	High
6.5 Water resource planning	6.5.1 Liaise with the Department of Water and Environmental Regulation to remain informed about changes to water allocations and potential alternative water sources	Ongoing	High
	6.5.2 Finalise and implement the draft Integrated Water Management Strategy	Short term	High
6.6 Water resource use and efficiency	6.6.1 Continue to participate in the Waterwise Council program	Ongoing	High
	6.6.2 Investigate options for monitoring of water use across all facilities	Short term	High
	6.6.3 Consider retrofitting facilities with more water-efficient devices and systems	Medium term	Medium
	6.6.4 Investigate updating the local planning framework to require the supply of non-potable water sources with new areas of public open space	Medium term	Medium

Response	Actions	Timing	Priority
	6.6.5 Investigate and implement the use of brown parks	Ongoing	High
	6.6.6 Encourage local participation in the Waterwise Schools Program and Waterwise Development Program	Short term	High
	6.6.7 Consider developing partnerships with State Government to encourage residential and industrial water efficiency	Medium term	Medium
Biodiversity			
7.1 Implementation of the Local Biodiversity Strategy	7.1.1 Finalise and implement the draft Local Biodiversity Strategy Update Report 2019	Short term	High
	7.1.2 Continue implementation of the Healthy Habitats Biodiversity Stewardship Program for conservation of biodiversity on private property	Ongoing	Medium
	7.1.3 Investigate options for funding a grants program for private property biodiversity conservation initiatives	Medium term	Low
	7.1.4 Investigate options for rezoning properties with high biodiversity value to Conservation	Long term	Low
	7.1.5 Continue to provide rate relief to properties zoned for Conservation	Ongoing	High
	7.1.6 Prioritise management of natural areas in local reserves according to condition, threats and biodiversity value, and allocate funds accordingly	Ongoing	High
7.2 Local planning framework	7.2.1 Continue to utilise the local planning framework to improve retention and protection of local biodiversity	Ongoing	High
	7.2.2 Update the vested purpose of reserves to incorporate "conservation" where appropriate	Medium term	Medium
7.3 Climate change	7.3.1 Update and implement the Climate Change Strategy and Local Action Plan	Medium term	Low
7.4 Hydrological change	7.4.1 Implement water sensitive urban design in new urban developments	Ongoing	High
	7.4.2 Finalise and implement the Integrated Water Management Strategy	Short term	High
7.5 Invasive species and pathogens	7.5.1 Continue to implement the Weed and Pest Management Plan	Ongoing	High
	7.5.2 Continue to support the Peel Harvey Biosecurity Group in its efforts to encourage weed and pest control on private property	Ongoing	Medium
	7.5.3 Continue to support Landcare SJ Inc.	Ongoing	High
	7.5.4 Continue to support weed and pest control initiatives implemented by State government	Ongoing	Low
	7.5.5 Develop and implement pathogen management plans and policies	Medium term	High
7.6 Fire	7.6.1 Continue active management of natural area reserves following fire	Ongoing	High
	7.6.2 Continue to implement SPP 3.7 and the Bushfire Risk Management Plan	Ongoing	High
	7.6.3 Continue to balance the requirements of SPP 3.7 and the protection of people and property against conservation of bushland and provision of high amenity vegetated areas and public open space	Ongoing	Medium
	7.6.4 Continue prescribed burning activities according to scientific best practice for protection of people, property and the natural environment	Ongoing	High
	7.6.5 Require prescribed burning activities to factor in protection of biodiversity as part of risk management and public safety	Ongoing	High
	7.6.6 Continue to source the most recent information on best practice fire ecology	Ongoing	Medium
	7.6.7 Promote and educate on scientific best practice fire ecology	Ongoing	Low
7.7 Urban and Rural Forest Strategy	7.7.1 Continue to implement the Urban and Rural Forest Strategy	Ongoing	High

Response	Actions	Timing	Priority
	7.7.2 Link implementation of the Urban and Rural Forest Strategy to the Local Biodiversity Strategy and other targets	Ongoing	Medium
7.8 Street tree and verge planting	7.8.1 Continue support for the street tree and free verge plant programs	Ongoing	High
7.9 Funding	7.9.1 Continue to provide funding to support initiatives that retain and protect local biodiversity	Ongoing	High
	7.9.2 Create new initiatives, ideas and developments to manage biodiversity loss	Ongoing	Low
	7.9.3 Investigate funding options to manage biodiversity	Ongoing	Medium
Human settlements			
8.1 Existing policy responses	8.1.1 Continue to implement the local planning framework to ensure: - Protection of local biodiversity - Flood mitigation - Incorporation of water sensitive urban design - Bushfire risk mitigation - Waste reduction and increased recycling rates - Improved sustainability of built form - Provision of sustainable transport options	Ongoing	High
	8.1.2 Continue to support the street tree and free verge plant programs	Ongoing	High
	8.1.3 Continue to support the Healthy Habitats biodiversity stewardship program for conservation of biodiversity on private property	Ongoing	Medium
	8.1.4 Continue to participate in and support Switch your Thinking to encourage water-wise and energy-efficient behaviours in residential and business developments	Ongoing	High
8.2 Additional responses	8.2.1 Continue to support the conservation zone, and investigate options to rezone additional properties for conservation	Ongoing	High
	8.2.2 Consider the need for a local planning policy that provides expectations for retention of trees and remnant vegetation through design of new urban developments	Medium term	High
	8.2.3 Investigate any updates to the local planning framework that may be required to support the container deposit scheme, in accordance with the WAPC Position Statement	Medium term	Medium
	8.2.4 Investigate opportunities to improve accessibility between residential and retail areas	Long term	Medium
	8.2.5 Investigate potential for a local planning policy that achieves built form that exceeds BCA requirements	Medium term	Medium
	8.2.6 Investigate opportunities for educational opportunities to improve sustainability of residential housing	Medium term	Low
	8.2.7 Investigate opportunities to measure and educate the community about urban heat islands	Medium term	Medium
	8.2.8 Review the local planning framework to determine further opportunities to improve the sustainability of the Shire as it develops	Medium term	Medium
Heritage			
9.1 Celebrate local heritage	9.1.1 Continue to support and develop events that celebrate local heritage	Ongoing	High
	9.1.2 Continue to support and develop walking trails, and promote guided and self-guided walks that celebrate natural heritage	Ongoing	High
	9.1.3 Continue to support and develop other recreational trails, such as bridle paths and bike paths	Ongoing	High
	9.1.4 Collaborate with State government to improve the condition of the Northern Jarrah Forest and develop the potential for low impact recreational uses	Long term	Medium

Response	Actions	Timing	Priority
9.2 Statutory and strategic frameworks	9.2.1 Ensure that provisions in the planning scheme relating to heritage are not too onerous or prescriptive while protecting values	Long term	Medium
	9.2.2 Develop a Heritage Strategy	Medium term	High
	9.2.3 Review and update the Local Heritage Survey (previously Municipal Inventory) and Heritage List	Medium term	Medium
	9.2.4 Identify ways heritage assets can be conserved, interpreted, celebrated and (where culturally appropriate) promoted	Short term	Medium
	9.2.5 Identify and protect Aboriginal heritage with the involvement of the Aboriginal community	Ongoing	High
	9.2.6 Forward any additional information regarding sites under assessment for inclusion on the State Heritage Register to the Department of Planning, Lands and Heritage	Medium term	Low
	9.2.7 Preserve historical settlement patterns and street configurations within Old Byford and Mundijong through structure plan provisions	Ongoing	Low
	9.2.8 Incorporate cultural heritage in Public Open Space and facility design	Ongoing	High
	9.2.9 Consider mechanisms to actively improve heritage values	Medium term	Medium

References

See the references sections of the six themed “Condition-Pressure-Response” reports attached.

DRAFT



Visit us

6 Paterson Street
Mundijong WA 6123

Contact us

☎ 95261111
@ info@sjshire.wa.gov.au

Connect with us

🌐 sjshire.wa.gov.au
f facebook.com/shireofsj
t twitter.com/shireofsj
i instagram.com/unearthsj