Shire of Ashburton Environmental Profile

Prepared for Taylor Burrell Barnett

By Essential Environmental

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1 INTRODUCTION

The Shire of Ashburton ('the Shire') has commenced preparation of a Local Planning Strategy. This Environmental Profile provides a summary of the natural environment of the Shire for input into the Strategy, highlighting issues associated with the environmental characteristics of the Shire in the context of future growth and development.

This report addresses the environmental context of the Shire of Ashburton only. It is recognised that this will need to be considered, together with economic and community (social) issues and opportunities, as part of the preparation of the local planning strategy.

Preparation of the Environmental Profile has included a review of available information relating to the natural environment, resources and environmental land use planning within the Shire of Ashburton. This is summarised in Section 2 and Appendix 1.

1.1 The study area

The Shire of Ashburton ('the Shire') is the southern most local government area in the Pilbara region. It is located approximately 1,000 km north of Perth and comprises over 100,000 km^2. The Shire is bound by the local governments of Exmouth and Carnarvon to the west, Upper Gascoyne and Meekatharra to the south, East Pilbara to the east, and Karratha and Port Hedland to the north.

It stretches approximately 500 km west to east from the coastal beaches, rocky hedlands, mudflats and mangroves around Onslow, across the Stewart Hills to Pannawonica, and the Hamersley Ranges to Tom Price and Paraburdoo (Figure 1). The Shire's populated places include Onslow, a coastal port town and the oldest townsite in the Shire, established in 1885 for exporting wool from sheep stations of the Pilbara hinterland. Tom Price, Paraburdoo and Pannawonica are towns largely based on the development of major mining operations, with Tom Price being the Shire's seat of government and administrative centre (see Table 1 for 2011 locality populations). Pannawonica is a 'closed town', and primarily serves to house Rio Tinto Iron Ore employees and their families. It is managed by Rio Tinto and not by the Shire. Although these towns contain the majority of the Shire's population of almost 11,000 residents, many Aboriginal people reside in the communities of Bindi Bindi, Wakathuni, Jundaru, Bellary (Innawonga), Youngaleena and Ngurawaana.

Table 1: Census 2011 locality populations - Shire of Ashburton

Locality	Population	Per cent of local government population
Onslow	667	6.7
Pannawonica	651	6.5
Paraburdoo	1,509	15.1
Tom Price	3,134	31.3

Source: Australian Bureau of Statistics (2012), QuickStats: Onslow (UCL), Pannawonica (UCL), Paraburdoo (UCL) & Tom Price (UCL).

The Shire is best known for mining, agriculture and fishing, and for its rugged, ancient landscape supporting tourism in the region. It is home to some of the world's largest open cut mines, immense pastoral leases and cattle stations, and prawn, pearl and mackerel fishing industries.

The North West Coastal Highway is the main road transport link in the west, traversing the Shire in a north-south direction. Great Northern Highway similarly crosses the Shire in the east (Figure 1).

1.2 Key guidance documents

Strategic guidance for the Shire is provided by a number of key documents at both local and regional level. These include:

- Shire of Ashburton 10 Year Community Strategic Plan 2012 – 2022 (SoA, 2012);
- Onslow Townsite Strategy (DoP and SoA, 2011);
- Onslow Townsite Strategy Background Report (SoA, 2010);
- Onslow Townsite Expansion Development Plan (TPG, 2012);
- Shire of Ashburton Tourism Destination Development Strategy (RBA Consulting, 2011);
- Pilbara Planning and Infrastructure Framework (WAPC, 2012) and
- Pilbara Regional Investment Blueprint (PDC, 2015).

In addition, the following local planning policies were considered as part of the development of this environmental profile:

- ELM21 Tree Management Overview Policy;
- ENG08 Bushfires; and
- LPP25 Onslow Coastal Hazard Area – Scheme Control Area.

These documents are described briefly below. Additional documents which have been considered as part of the preparation of this report are summarised in Appendix 1.

1.2.1 Shire of Ashburton 10 Year Community Strategic Plan 2012 – 2022

The Shire of Ashburton *10 Year Community Strategic Plan 2012 – 2022* is the key guiding document for the Shire. It outlines a mission of

'working together, enhancing lifestyle and economic vitality'

The Strategic Plan defines key environmental outcomes to be delivered in the Shire of Ashburton as maintaining the integrity and quality of the Shire's natural environments, together with celebrating and valuing the Aboriginal and European history and heritage, with the aim of being a recognised leader in sustainability practices. These outcomes are to be delivered via a number of strategic directions that are outlined under *Goal 3: Unique Heritage and Environment*, and *Goal 4: Distinctive and well serviced places*.

The objectives, strategic directions, desired outcomes and key contributors are summarised in Table 2. These objectives and strategic directions should guide preparation of the Local Planning Strategy.

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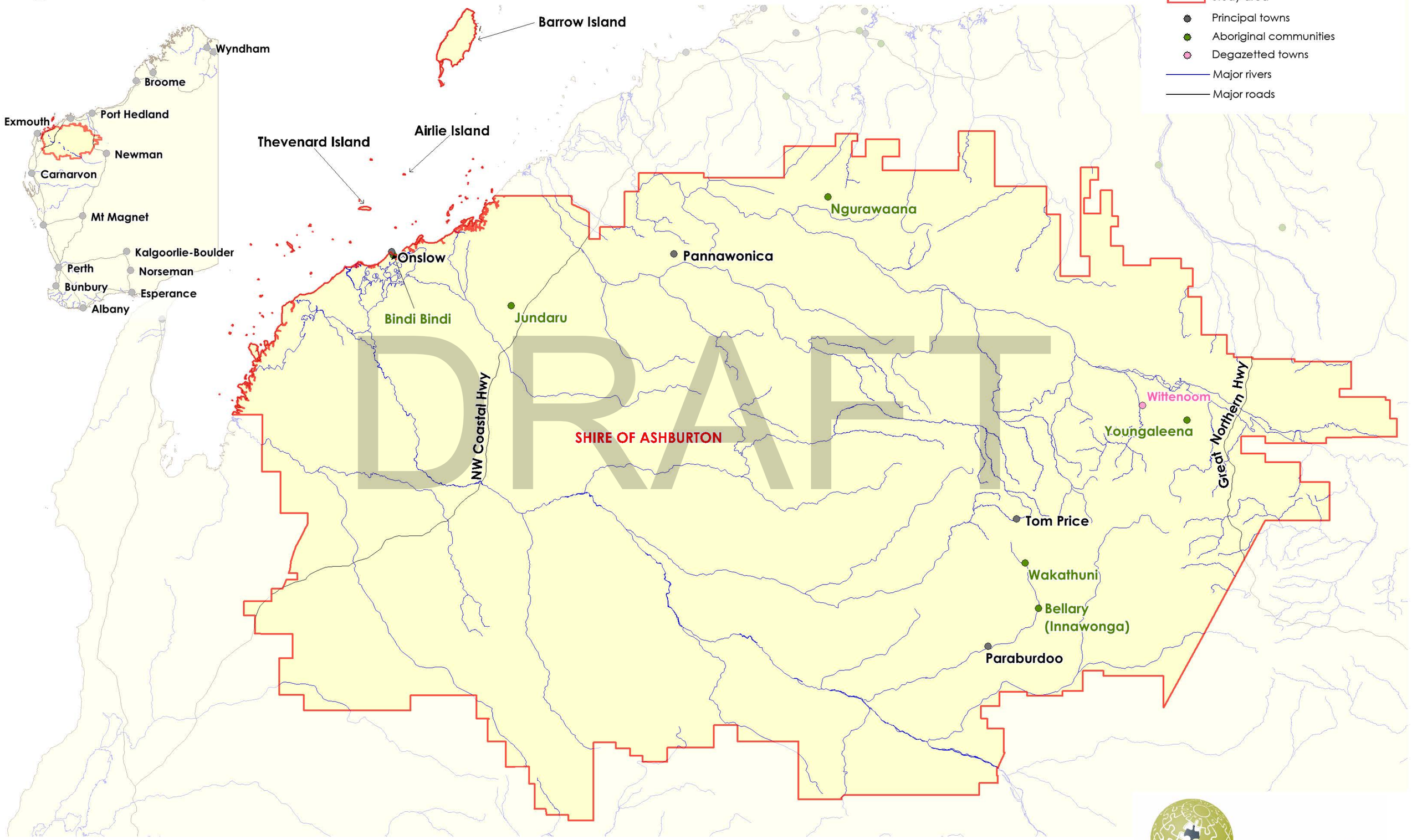
Figure 1: Study area



Data sources: Landgate, Geoscience Australia, Created by: H Lamparski. Projection: MGA50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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Table 2: CSP Goal 3 objectives and directions relevant to the Environmental Profile

Goal 3: Unique Heritage and environment		
Objective	**Strategic directions**	**Key contributors**
Objective 1: Flourishing natural environments	Encourage Aboriginal participation in the management of natural assets Protect (manage) the diversity of the Shire's natural environments Improve recreational access to natural environments with a focus on signage, access and safety Manage the industry/natural asset interface	• Shire of Ashburton • Aboriginal communities • Aboriginal corporations • Key industry stakeholders • Local environmental groups • Local schools
Desired outcome:	The integrity and quality of the Shire's natural environments are maintained	
Objective 2: Leading regional sustainability	Build capacity to encourage protection of natural assets, good air quality and responsible use of electricity and water Implement waste minimisation strategies	• Shire of Ashburton • Key industry stakeholders • Community representatives • Local schools
Desired outcome:	The Shire of Ashburton is a recognised leader in sustainability practices	
Objective 3: Celebration of history and heritage	Initiate programs and attract funding to celebrate the Aboriginal and European history and heritage of the Shire	• Shire of Ashburton • Key industry stakeholders • Aboriginal communities • Aboriginal corporations • Local museums • Libraries • Local schools • Community groups
Desired outcome:	The Aboriginal and European history and heritage of the Shire is celebrated and valued	
Goal 4: Distinctive and well serviced places		
Objective 1: Quality public infrastructure	Facilitate development of the Tom Price to Karratha Road – Key factor in linking Tom Price and Parraburdoo to the Pilbara Cities Provide and maintain affordable infrastructure that serves the current and future needs of the community, environment, industry and business Develop strategies to effectively manage the planned transition of municipal services in Aboriginal communities, ensuring active engagement of communities and stakeholders Actively advocate for the supply and cost of utilities and services that meet commercial, industrial and retail needs Develop plans for water conservation and water-wise use across the Shire	• Shire of Ashburton • Key industry stakeholders • Business associations • Residents associations • Aboriginal communities • Aboriginal corporations
Desired outcome:	Adequate, accessible and sustainable public infrastructure	

Objective	Strategic directions	Key contributors
Objective 3: Well planned towns	Plan appropriately for future housing and accommodation needs balancing State government growth targets, changing industry needs, community expectations and the need for timely and affordable release of land and housing Ensure new developments are sensitive to the natural and built environments Ensure buildings and landscaping enhance the local character of towns and integrate with the natural environment, with a focus on beautification Incorporate social planning and ecological sustainable development principles in planning strategies and policies Provide a diverse range of high quality open spaces Ensure there is an effective interface between government and industry to ensure holistic planning and development	• Shire of Ashburton • Key industry stakeholders • State government agencies
Desired outcome:	Distinctive and well functioning towns	

1.2.1 Growth outlook

The relationship between employment and population growth is more pronounced in the mining towns of the Pilbara than in many other areas of the State. Consequently, population growth in the resource sector oriented towns of the Shire tends not to occur at a steady rate, rather in bursts, driven by resource project cycles. This dynamic makes preparing accurate population forecasts challenging (WAPC, 2015a).

The direct connection between employment in the resource sector and regional population has meant that population growth in the Shire has slowed down with the end of the mining boom. Department of Planning forecasts also suggests that the high rate of population growth in the Shire of Ashburton is unlikely to continue (WAPC, 2015a).

The most recent estimated residential population of the Shire for 2015 is 10,951 (ABS, 2016). The ABS has estimated that population growth in the Shire has significantly decreased from 7.5% growth in 2011, to 0.04% growth in 2015 (ABS, 2016), with a similar slowdown observed across the region.

Tom Price, the Shire's largest town, has experienced relatively modest population growth in recent years. Most of the additional workforce requirements created by resources projects have been met by fly-in fly-out (FIFO) workers who generally stay at camps outside town. Recent population data has also shown that growth in Tom Price has not been as pronounced as in other major Pilbara centres (WAPC, 2015a).

The Pilbara Industry's Community Council predicts that the total minerals and energy workforce in the Shire of Ashburton will decline over the next seven years. Projects currently under construction are moving into operational phase and no major new projects are likely to commence in the Shire.

The Pilbara Industry's Community Council employment-based forecasts indicate that the population of Tom Price could potentially increase by 1,400 residents to a population of approximately 4,750 in 2020. Achieving growth of this nature is likely to require an increase in the proportion of resident workers relative to FIFO, or a substantial expansion of the town's role as a service hub for mining operations in the area. Available data suggests that population growth will stagnate in the near future, unless industry projects within the Shire are developed.

The Shire of Ashburton Working Group (Department of Housing, Department of Lands, LandCorp, Pilbara Development Commission, Rio Tinto, and Shire of Ashburton) identified a lack of accurate knowledge and understanding of the current population and accommodation profile, future employment and population growth trends for Tom Price, Onslow and Paraburdoo (WAPC, 2015a). Therefore, the Pilbara Development Commission, together with the governance of the Working Group, has instigated an Assessment of Accommodation Need in the major towns of Tom Price and Onslow and the townsite of Paraburdoo (WAPC, 2015a).

1.2.2 Onslow Townsite Strategy (2011)

The Onslow Townsite Strategy was developed to define a way to achieve the following vision:

> *'That Onslow be a vibrant, sustainable and prosperous place for work, living and leisure - for both residents and visitors'*

and to ensure that Onslow is known as a 'town with LNG plants and not an LNG town'.

The townsite strategy seeks to fulfil the following three goals:

1. Sustainable living
2. Economic vitality
3. Community wellbeing

Based on the development of Ashburton North Strategic Industrial Area and associated population growth, the strategy identified that significant reorientation of Onslow's urban structure is required to accommodate the residential, community and civic needs of an anticipated residential population expansion. A basic premise of the strategy is that there are no operational workforce camps within the Onslow area. The townsite strategy seeks to balance pressure for the establishment of new living areas with the need to revitalise and, where appropriate, restructure the existing residential precincts. The strategy identifies that the introduction of higher densities in existing areas will provide the opportunity to:

- make these areas more viable in terms of urban and community services;
- reduce the urban footprint thus conserving land with high biodiversity, cultural and pastoral value; and
- identify under utilised land for 'community purposes' for residential use.

The strategy provides development principles and desired future character for:

- new residential areas;
- commercial centre;
- Onslow Salt area;
- Townsite industrial areas;
- Beadon Creek Harbour;
- Airport area;
- Beaches; and
- transient workforce accommodation.

1.2.3 *Shire of Ashburton Tourism Destination Development Strategy (2011)*

The Shire of Ashburton Tourism Development Strategy was prepared to identify opportunities to diversify and expand the tourism industry in the Shire, and generate employment for local people outside of the resource industry. The Strategy identifies that there are opportunities for tourism to take advantage of and leverage off substantial infrastructure constructed by the larger resources industry. It recognises that the Shire includes significant natural environmental assets, both inland (most obviously Karijini and Millstream Chichester National Parks) and on the coast in the form of recreational fishing and diving opportunities. Outside of the nature based attractions, the strategy also focuses on tourism potential at the town centres of Tom Price and Onslow, as Paraburdoo and Pannawonica are recognised as focussing on the servicing of local resource projects in the near future.

In summary, the Strategy identifies that to develop tourism as a thriving economic centre in the Shire, the following actions are required:

- increase tourism products;
- improve quality and value;
- enhance infrastructure that support tourism;
- improve visitor servicing in particular delivery of visitor information (visitor centres, website, information bays, brochures);
- create new experiences that will attract visitors and encourage existing to stay longer; and
- create a positive image of Indigenous tourism in the region.

1.2.4 *Pilbara Planning and Infrastructure Framework (2012)*

The *Pilbara Planning and Infrastructure Framework* defines a strategic direction for the future development of the Pilbara region over the next 25 years. It seeks to ensure that development and change in the Pilbara is achieved in a way that improves people's lives and enhances the character and environment of the region.

In summary, the *Framework*:

- addresses the scale and distribution of future population growth and housing development, as well as identifying strategies for economic growth, environmental issues, transport, infrastructure, water resources, tourism and the emerging impacts of climate change;
- sets out regional planning principles, together with goals, objectives and actions to achieve these. It represents an agreed 'whole of government' position on the broad future planning direction for the Pilbara, and will guide the preparation of local planning strategies and local planning schemes; and
- informs government on infrastructure priorities across the Pilbara and gives the private sector more confidence to invest in the region. The infrastructure priorities identified in the Framework have been determined following extensive liaison with State Government agencies, local government and other key stakeholders.

1.2.5 *Pilbara Regional Investment Blueprint (2015)*

The *Pilbara Regional Investment Blueprint* was recently developed in recognition that there is a need to drive new growth in the region. The vision of the Blueprint is underpin by economic diversity and enhanced liveability for the region in 2050.

In particular, the Blueprint has a strong focus on opportunities for growth in and diversification into agriculture, aquaculture, tourism (nature-based and Aboriginal heritage) and energy (uranium, LNG, and renewable energy production and export) projects. These can be new sources of long-term sustainable growth for the region, in addition to continued support of the minerals and energy industries. In this way the Blueprint seeks to transform the Pilbara as a region of mining towns into more developed and sustainable Pilbara Cities which offer diversity of jobs and career opportunities, high standards of services, and vibrant community life. It builds on the Pilbara Cities Vision to sustainably grow and develop communities that meet the aspirations of their people. The Blueprint Vision is supported by nine regional investment "Pillars" based on analysis of needs, regional interests and comparative advantages that will deliver new sources of growth.

2 EXISTING ENVIRONMENT

2.1 Climate

The climate in the Shire of Ashburton is typical of the Pilbara region, characterised by high temperatures, particularly during the summer months and variable rainfall patterns interspersed with long dry periods. The Bureau of Meteorology (BoM) defines the wet season for the Pilbara as the period extending from December to the end of March. Tropical cyclones are a feature of the summer months and usually develop between November and May, often bringing intense rainfall and resulting in flooding. Some areas of the Pilbara have the highest average annual evaporation rate in Australia (Van Vreeswyk *et al.*, 2004). The annual evaporation rate throughout the Pilbara is considerably higher than the average rainfall.

The climate of the Pilbara region can be broadly described by two climate categories: tropical along the coastal areas and arid through the central and eastern parts of the region. Regional variations in rainfall occur, with coastal areas and western inland areas located in the path of tropical cyclones often receiving higher rainfall. The arid desert areas in the central east of the region are characterised by higher temperatures and significantly lower rainfall.

Given the coastal location of the Shire it may be described as experiencing a tropical climate. However, as a result of the breadth of the local government area, from the coastal areas around Onslow to the inland ranges around Tom Price and Paraburdoo approximately 500 km away, some variability in temperature and rainfall occurs between the west and east. In order to demonstrate this variability, climate data was obtained from BoM stations at Onslow Airport (no. 5017), Pannawonica (no. 5069) Paraburdoo Aero (no. 7185), and Wittenoom (no. 5026). Mean maximum and minimum temperatures are shown in Chart 1, and mean rainfall is shown in Chart 2 below.

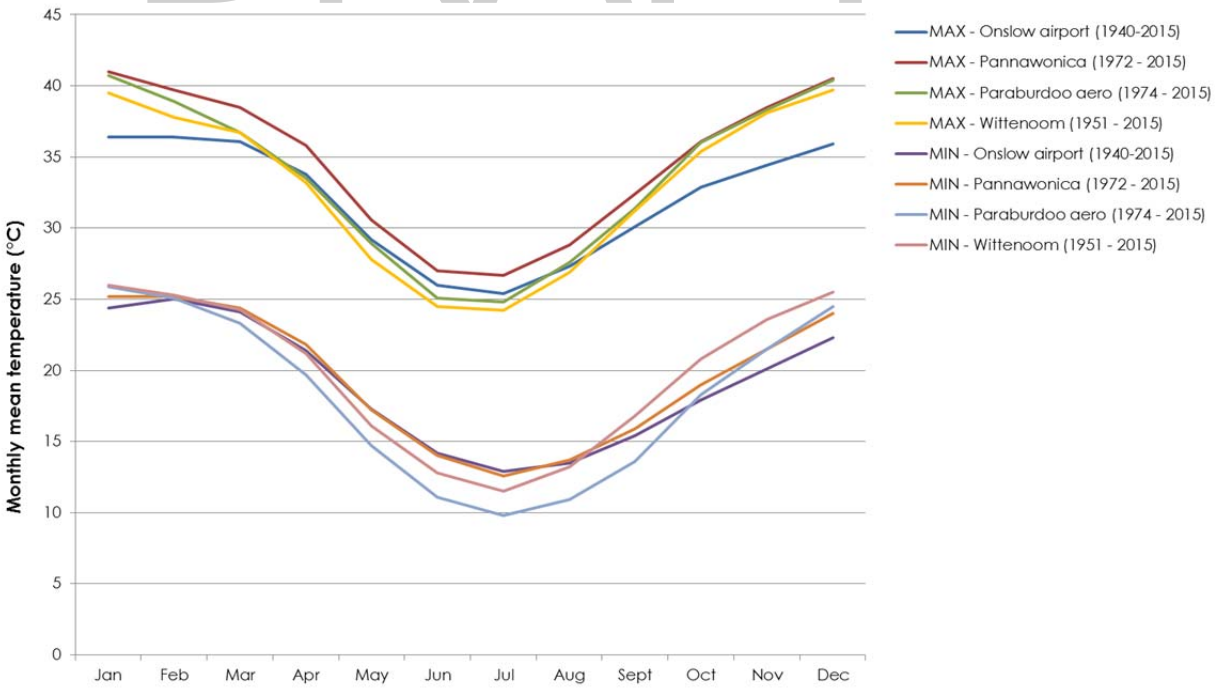

Chart 1: Shire of Ashburton mean monthly maximum and minimum temperature (BoM, 2016a)

Maximum temperatures in the Shire of Ashburton occur in summer and minimum temperatures occur in winter, with average maximum temperatures peaking in December-January at

approximately 36°C in Onslow and 40-41°C at inland locations, and average minimum temperatures occurring at approximately 10-13°C in July (BoM, 2016a)(Chart 1). Temperature data confirms that coastal areas in the Shire (Onslow) experience a more moderate climate than inland areas.

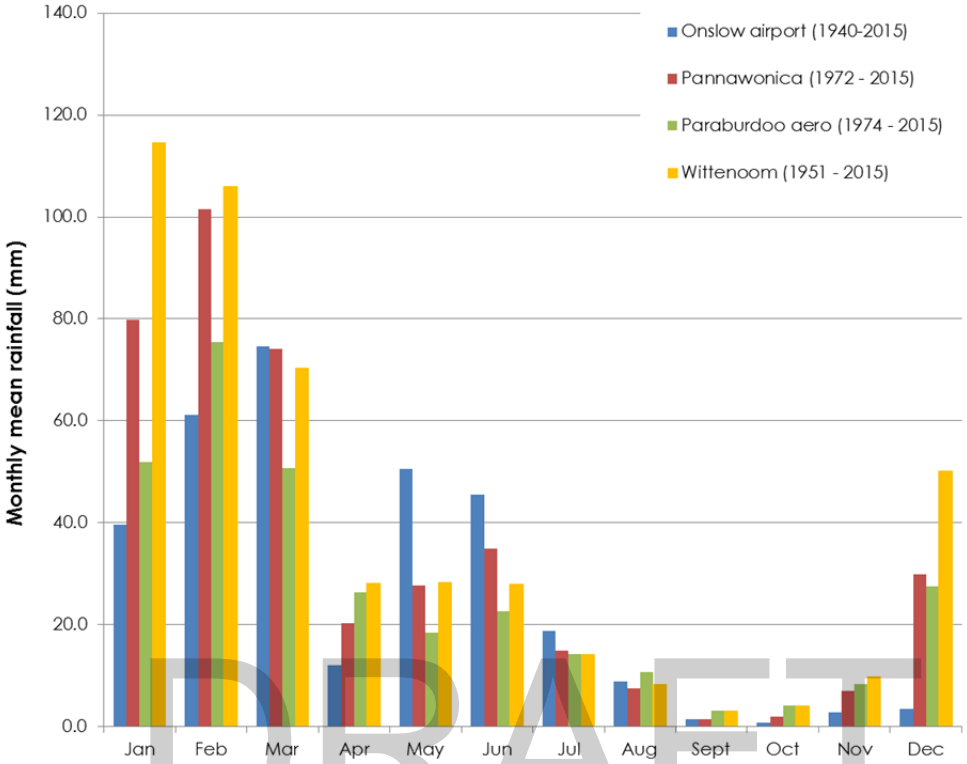

Chart 2: Shire of Ashburton mean monthly rainfall (BoM, 2016a)

Average annual rainfall recorded in the Shire varies from 317 mm at Onslow airport to 465 mm at Wittenoom. As shown in Chart 2, the majority of rainfall occurs in summer between December and March with the driest months being September and October. Chart 2 also demonstrates the variability in rainfall events across the Shire, with more northern, inland areas experiencing higher volume summer ('wet season') rains, while Onslow and nearby coastal areas are also subject to winter frontal systems.

BoM data indicates that while average annual rainfall has declined around Onslow in the last 20 years, in contrast it has increased in inland areas (Pannawonica, Paraburdoo and Wittenoom) (see During most of the cooler times of the year, winds tend to be easterly or south-easterly over most of the Pilbara, influenced by the passage of winter high pressure systems that move east across the mainland. In spring prevailing winds weaken as a semi-permanent heat low develops over the land. In coastal areas the wind direction becomes more variable, particularly in the warmer months, when the wind direction often reverses in the afternoon and sea breezes from the north and north-west dominate (*Van* Vreeswyk *et al.*, 2004).

Table 3). In particular, rainfall in inland areas of the Shire has increased between October-December and April, while decreasing during the winter months. This may be indicative of changing rainfall patterns bringing more frequent intense rainfall events over the summer 'wet season', with more dry periods in between.

During most of the cooler times of the year, winds tend to be easterly or south-easterly over most of the Pilbara, influenced by the passage of winter high pressure systems that move east across

the mainland. In spring prevailing winds weaken as a semi-permanent heat low develops over the land. In coastal areas the wind direction becomes more variable, particularly in the warmer months, when the wind direction often reverses in the afternoon and sea breezes from the north and north-west dominate (*Van* Vreeswyk *et al.*, 2004).

Table 3: Average annual rainfall at the Shire of Ashburton

BoM Station	Rainfall (1940-2015)	Rainfall (1998-2015)	Change in average rainfall
Onslow airport (BoM no. 5017)	317 mm	273 mm	-44 mm
BoM Station	**Rainfall (1972-2015)**	**Rainfall (1995-2015)**	**Change in average rainfall**
Pannawonica (BoM no. 5069)	404 mm	432 mm	28 mm
BoM Station	**Rainfall (1974-2015)**	**Rainfall (1995-2015)**	**Change in average rainfall**
Paraburdoo aero (BoM no. 7185)	324 mm	364 mm	40 mm
BoM Station	**Rainfall (1951-2015)**	**Rainfall (1995-2015)**	**Change in average rainfall**
Wittenoom (BoM no. 5026)	465 mm	587 mm	122 mm

2.1.1 Cyclones

Onslow is one of the most cyclone affected towns on the Western Australian coastline, averaging one cyclone with wind gusts in excess of 90 km/h every two years. Between 1953 and 1963 Onslow suffered five severe cyclone impacts having wind gusts exceeding 170 km/h and a further three cyclones causing damage, some flood related (Shire of Ashburton, 2010a). Cyclones are generally associated with flooding and have the potential to increase storm surges in coastal areas.

The Shire of Ashburton has acknowledged that the cyclone activity around Onslow increases the risk of the town being affected by flooding and storm surge. The Onslow Coastal Hazard Special Control Area provides for the Shire to require any planning application to be supported by an assessment, prepared to the satisfaction of the Shire, of the impact of potential flood and storm surge events on the proposed development.

2.1.2 Climate change

Reports from the International Panel on Climate Change (IPCC) provide limited detail on Australian climate change, particularly when it comes to regional climate change projections. *Climate Change in Australia* (CSIRO, 2015a) was developed by the Australian Greenhouse Office together with CSIRO and BoM. It is based upon international climate change research including conclusions from the IPCC's fifth assessment report. It also builds on a large body of climate research that has been undertaken for the Australian region in recent years.

The CSIRO has provided a number of projections based on the outputs of global climate models (named CMIP5) that estimate likely changes in regional climate for defined natural resource management clusters around 2030 (near future) and 2090 (late century). Regional clusters correspond to the broad-scale climate and biophysical regions of Australia. The majority of the

Shire of Ashburton is located in the Western Australian Rangelands North sub-cluster, and wholly within the Rangelands cluster (Watterson I. et al., 2015).

The CSIRO predicts that mean, maximum, and minimum temperatures in the Rangelands North sub-cluster will continue to substantially increase. In addition, the frequency of hot days and duration of warm spells is also predicted to increase, as are evaporation rates. Specifically, temperature is projected to increase by 0.6 to 1.5˚C above the climate of 1986-2005 by 2030, and up to 3.1-5.6˚C by 2090 (CSIRO, 2015a) (see Figure 2). This rise in temperature has the potential to impact on plants, animals and people, through increased heat stress and increased risk of bushfires.

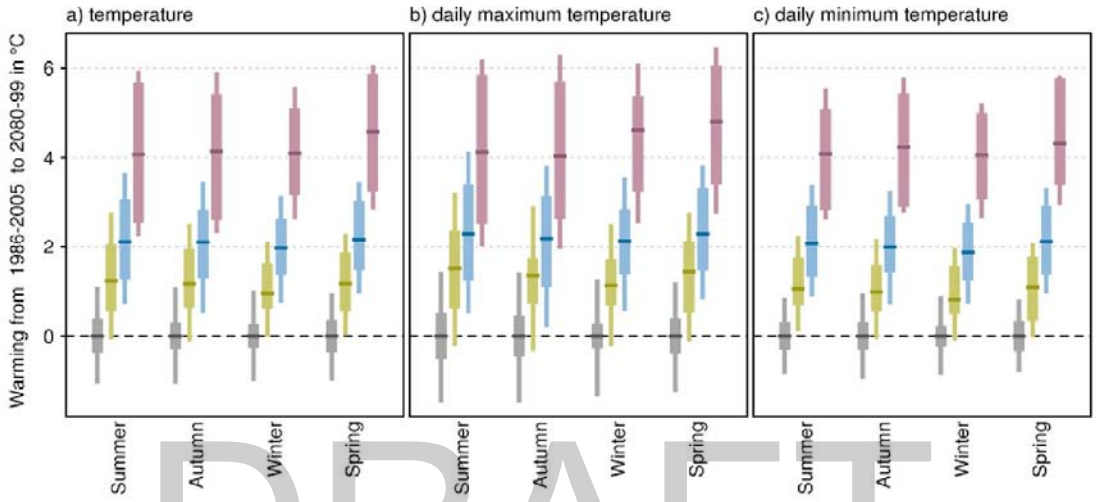

Figure 2: Projected seasonal surface air temperature changes for the Rangelands cluster to the mean (a), daily maximum (b) and daily minimum temperature (c). Temperature anomalies are given in °C relative to the 1986–2005 mean under RCP2.6 (green), RCP4.5 (blue) and RCP8.5 (purple). Natural climate variability is represented by the grey bar (Watterson I. et al., 2015).

Decreases in spring rainfall in the Rangelands North sub-cluster has also been projected by the CSIRO as a result of climate change (Figure 3). This decrease in rainfall coupled with increases in evapotranspiration has also been linked to potential reductions in soil moisture, and possibly in runoff. Time spent in drought is also expected to increase by 2090 with medium confidence. However, the intensity in heavy rainfall events is highly likely to increase which will have implications for localised flooding in built up areas.

Bushfire risk is also linked to rainfall, as it drives vegetation growth. Thus when vegetation growth occurs after the end of the wet season and bushfires follow, the behaviour of these fires is expected to be more extreme in the future as a result of higher temperatures.

Sea levels will also continue to rise along coastal areas of the Rangelands, having implications for Onslow and other coastal settlements and infrastructure. Specifically, the intermediate emissions scenario gives a rise of 0.28-0.64 m and the high emissions scenario gives a rise of 0.4 to 0.84 m by 2090 (Watterson I. et al., 2015). Increases in sea surface temperature (up to 2.4-3.7ºC by 2090) and sea surface acidity (decrease of up to 0.3 pH units by 2090) are also highly likely as a result of climate change, which will in turn affect marine life and thus impact on the biodiversity of coastal and marine environments and local fisheries.

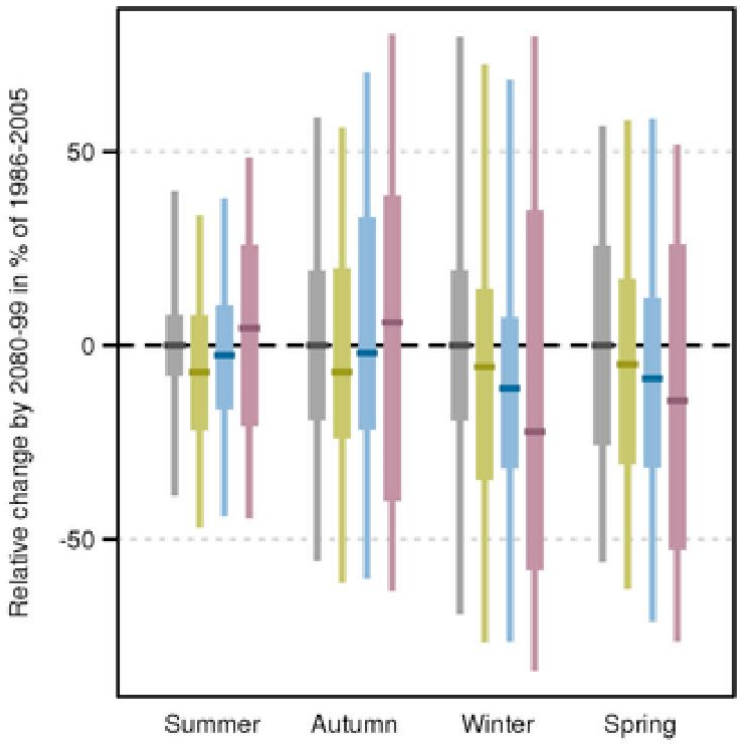

Figure 3: Projected seasonal rainfall changes for the Rangelands North sub-cluster for 2090. Rainfall anomalies are given in per cent with respect to the 1986–2005 mean under RCP2.6 (green), RCP4.5 (blue) and RCP8.5 (purple). Natural variability is represented by the grey bar (Watterson I. et al., 2015).

2.1.3 Key considerations for strategic environmental planning

Key climate considerations for strategic planning are:

- **Temperature** – Increases in temperature are likely to result in increased needs for cooling and/or impacts on environmental and public health. Consideration should be given to heat island impacts in regional towns and the need for green infrastructure and shade in public and private places to mitigate heat increases in built environments. This may also result in an increase in water demands, and thus adequate water sources. Development should also incorporate passive solar design and breezeways.
- **Extreme weather** – Increases in extreme weather events, particularly bushfires as well as rainfall/tropical cyclones, may require development to be located away from areas of risk and/or improved emergency management responses and plans. Infrastructure adequate to manage extreme weather conditions will also require consideration.
- **Rainfall change** – Increases in rainfall event intensity may result in greater localised flooding and increased pressure on stormwater systems.

2.2 Air quality

Air quality can be affected by bushfires, mining, agriculture and industry. Key pollutants are dust from industrial and construction activities and particulates (measured as PM10 and PM25) from bushfires. Other pollutants of interest are oxides of nitrogen, ozone, lead, sulphur dioxide, and carbon monoxide. Pollutants are predominantly driven by wind patterns and topography and have the ability to affect the environment and landscape as well as human health in the region.

Air quality in the Shire of Ashburton is generally good. Dust can be a significant issue in the Pilbara, as it can impact on the health of both humans and the environment. No ports in the Shire of Ashburton currently export iron ore, often associated with dispersion of particulates into the local air space. The main source of dust in the local government area is from particulate matter generated by fire. Major bushfire events typically generate particulate concentrations well beyond the threshold National Environment Protection Measures level. Fires also burn off the cryptograms (microbial organisms that help maintain soil cohesion) holding soil together and leave behind a fine friable powder that can become airborne at low wind speeds.

Dust may also be generated from transport and industrial processing, and construction sites. This risk has been recognised by the Shire in the vicinity of Ashburton North Strategic Industrial Area (ANSIA) through the establishment of a special control area which requires consideration of off-site impacts and buffers.

The extraction and production of minerals can also result in air quality impacts such as dust, noise and light. However, impacts from these sources tend to be localised. Overspray of chemicals should also be considered in areas of intense agriculture.

Another potentially significant air quality issue is associated with the Wittenoom Town site, Wittenoom Airfield, Wittenoom Gorge, Yampire Gorge and the Joffre Creek flood plain between the Wittenoom Townsite and the Fortescue River. This area is a registered contaminated site due to the known presence of free asbestos fibre contamination within soils at the site. Transport of asbestos is dependent on disturbance activities such as vehicle traffic and cattle mustering, as well as activities that result in loss of vegetation and increase the potential for erosion by wind and/or water. Although waterborne migration of asbestos has been identified as a significant method of migration, windborne migration has been considered more significant in terms of health risk associated with respirable fibres (GHD and PB, 2006).

Wittenoom has been classified under the *Contaminated Sites Act 2003* as "Contaminated - Remediation Required" and its status as a town has been formally removed; however, no action has yet been undertaken to clean up the site. The Shire has also prohibited any future development within Wittenoom through the establishment of a special control area.

A study undertaken in 2006 examining the recent management of asbestos contamination in Wittenoom indicated that priority should be given to the stabilisation of the Colonial mine site, as well as to reducing the risk to human health by isolation or remediation of areas with high concentrations of asbestos that is in a form which can be subject to release to air (GHD and PB, 2006).

Noise has also been identified as a potential air quality issue, particularly noise generated at industrial sites in close proximity to townships. Advice on noise generation at industrial sites and separation distances from sensitive land uses is provided by the Environmental Protection Authority in their 'Guidance for the Assessment of Environmental Factors' report no. 3 (EPA, 2005) and the Department of Environment Regulation's draft *Guidance Statement: Separation Distances*, which was released for consultation on 21 August 2015.

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Figure 4: Air emissions

Data sources: Landgate, Geoscience Australia Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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Odour from industrial processing and other uses including waste water treatment has the potential to impact on neighbouring uses. This is recognised by the Shire through a special control area in Town Planning Scheme No 7. The purpose of identifying the Waste Water Treatment Plant Odour Buffer is to avoid sensitive land uses being established within the odour buffer, and to protect the long term operation of the plant which provides an essential service to the community through the treatment, re-use and safe disposal of the town's wastewater.

2.2.1 Greenhouse gas emissions

The Shire of Ashburton has begun to actively reduce its greenhouse gas emissions through the installation of renewable energy sources to provide power for Shire buildings. This includes Onslow Airport which has installed a solar generation management system, however, it is not yet in operation. The Shire is also currently considering the heating of the Vic Hayton Memorial Swimming Pool in Tom Price using solar panels (Perera, 2016).

A new power station planned for Onslow near a proposed desalination plant is also expected to be partly operated using renewable energy via solar panels (pers. comm. Department of State Development, 21st June 2016).

The development of Australia's largest distributed energy resource microgrid, which aims to deliver more than 50% of Onslow's electricity needs with renewable energy, was announced in September 2016 (Government of WA, 2016). The new Onslow microgrid will include a mix of distributed solar energy generation and battery storage. The project includes essential electricity network infrastructure, a new transmission line and substation, and a 5.25 megawatt gas-fired modular power station, designed to efficiently contract in size as the renewable energy contribution expands to meet energy needs. Works on the power station are set to start in early 2017, with completion expected in early 2018.

2.2.2 Key considerations for strategic environmental planning

Key air quality considerations for strategic planning are:

- **Dust** – Dust generated from bushfires should be monitored and management responses developed to inform the public regarding health risks during bushfire events. Management of fuel loads without exceeding threshold air quality standards should also be considered through the development of an Air Quality Management Plan, and a program of regular fuel reduction which minimises air quality impacts on townsites and sensitive environments, on advice from the Bushfire and Natural Hazards Cooperative Research Centre (http://www.bnhcrc.com.au/). Further details regarding management of bushfire risk is presented in section 2.7.1.
  Dust from localised extraction and production of minerals, particularly near townsites, should be monitored and infringement notices issued where necessary, consistent with the *Extractive Industries Local Law 2013*.
- **Noise** – Guidance should be sought from environmental agencies with regards to appropriate separation distances to manage noise and dust for new industrial areas.
- **Odour** – from industries and waste water treatment plants should be considered as part the location of any new development.
- **Greenhouse gas emissions** – Emissions which result from Shire operations may be reduced through increased use of renewable energy and implementation of actions to improve energy efficiency.
- **Asbestos** – The Shire should maintain advice with regards to potential for health risks from the former mine sites and associated communities.

2.3 Land resources

2.3.1 Geography, topography and landforms

The Shire of Ashburton comprises two distinct landforms across its vast 100,000 km^2 area from east to west. The eastern half of the Shire is characterised by some of the oldest landforms in the world made up of rugged, deep and steep gorges separated by winding river systems, and reaching an elevation of up to 1,200 m AHD as shown in Figure 5. From east to west the landscape undulates through steep hills, flattening across a series of rivers to flood plains reaching the coast at a low elevation (Figure 5). The Ashburton, Cane, Robe and Fortescue rivers and associated tributaries run across the Shire from east to west, regularly flooding the surrounding landscape during the wet season and from tropical cyclones. They also form important catchments for surface water runoff and feed groundwater system throughout the Shire.

The Shire of Ashburton is also characterised by a series of islands along the length of its coastline, the largest (and second largest in Western Australia) and most iconic being Barrow Island (Figure 5). The island's main feature is its undulating limestone uplands surrounded by flat beaches, dunes and low cliffs.

2.3.2 Geology and soils

Figure 6 presents mapping from the Department of Mines and Petroleum's *1:2,500,000 Generalised geology of Western Australia 1999*. The soils of the Shire are generally reflective of the topography. The eastern half of the Shire typically has a surface geology of iron formation and shale, and basalt and sandstone, with a strip of alluvial deposit through the north. Small areas of metamorphosed and volcanic rock, and granite and gneiss are also located in the south around Tom Price and Paraburdoo. The western lower-lying, flat plains comprises a combination of alluvial deposits along the coast, and marine, metasedimentary, basic and intrusive rocks, sandstone, shale, and granite and gneiss further inland. Barrow Island is comprised completely of marine limestone, sandstone and valley-fill deposits, small pockets of which are also found throughout inland areas of the Shire. The lithographic description of surface geology is provided in Table 4.

Table 4: Surface geology of the Shire of Ashburton (source: DMP, 2010)

	Map symbol	Lithographic description
Eastern gorges & hills	Ab	metamorphosed basic and ultrabasic volcanic and intrusive rocks
	AP_b	basalt, dacite, and sandstone
	AP_i	iron-formation and shale
	Agn	granite and gneiss
	Asf	metamorphosed sedimentary and acid volcanic rocks
	Cza	alluvial, shoreline, and eolian deposits
Western plains	Cza	alluvial, shoreline, and eolian deposits
	Czsl	marine limestone, sandstone and valley-fill deposits (primarily at Barrow Island, however also scattered in small areas across the Shire)
	TRKs	marine and continental sedimentary rocks
	P-d	basic and ultrabasic intrusive rocks
	P_gn1	granite and gneiss
	P_s1	metasedimentary rocks
	P_st1	sandstone
	P_ss2	sandstone and shale

Taylor Burrell Barnett - Shire of Ashburton Environmental Profile
Figure 5: Topography

Barrow Island

Onslow

Pannawonica

Tom Price

Paraburdoo

Robe River

Cane River

Ashburton River

Fortescue River

NW Coastal Hwy

Great Northern Hwy

Legend
- Study area
- Principal towns
- Major rivers
- Major roads

Topographic contours (m AHD)
- 530 to 1,200
- 420 to 530
- 370 to 420
- 310 to 370
- 280 to 310
- 240 to 280
- 210 to 240
- 170 to 210
- 120 to 170
- 10 to 120

Data sources: Landgate Created by: H Lamparski. Projection: MGA50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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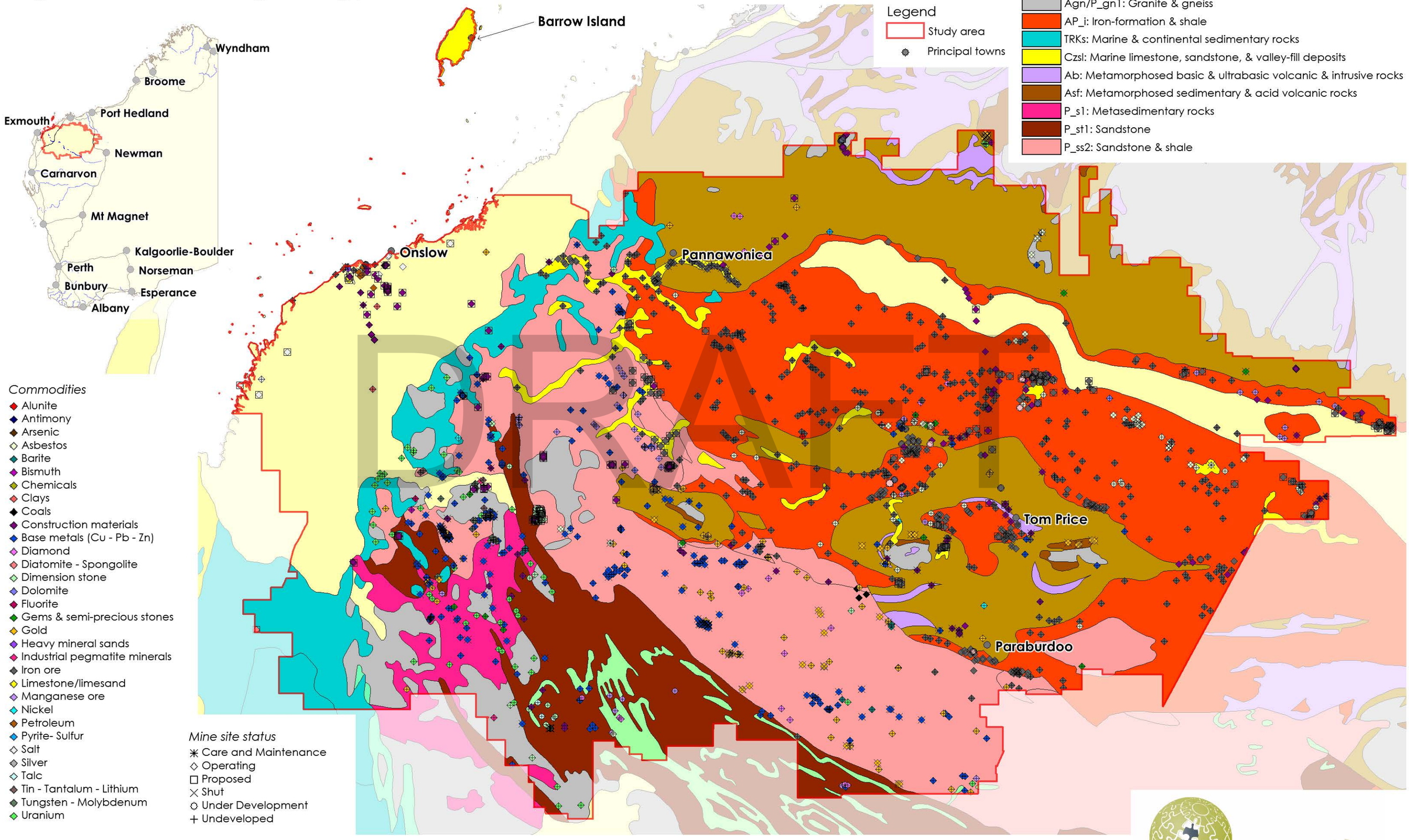
Taylor Burrell Barnett - Shire of Ashburton Environmental Profile
Figure 6: Surface geology and minerals



Data sources: Landgate, Dept. of Minerals & Petroleum, Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
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2.3.3 Minerals and basic raw materials

A substantial range of minerals have been identified by the Department of Mines and Petroleum across the Shire, the majority of which are undeveloped as shown in Figure 6. The primary commodity identified in the east of the Shire is iron ore, with a significant number of mines under development or in operation around Tom Price and Paraburdoo. Gold, manganese ore, and base metals are also significant commodities in the Shire, with deposits mainly located through the centre of the local government area. Uranium deposits have also been identified in the south west of the Shire. Salt and construction material deposits and operations infrastructure primarily comprise the commodity processing activity within coastal areas. Commodity deposits and mining activity status in the Shire is presented on Figure 6.

No significant resources of basic raw materials are considered to occur within the Shire (DMP, 2016a).

2.3.4 Acid sulfate soils

Acid sulfate soils are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials (DER, 2015). These soils are commonly found in low-lying land bordering the coast or estuarine and saline wetlands and freshwater groundwater-dependent wetlands throughout Western Australia. They occur naturally in Western Australia and are harmless when left in an anoxic, waterlogged, and undisturbed environment.

Disturbing acid sulfate soils through excavation or drainage causes the iron sulfides in these soils to be exposed to and react with oxygen and water to produce iron compounds and sulfuric acid (DER, 2015). This acid can also release other substances, including heavy metals, from the soil and into the surrounding environment and waterways, thus potentially resulting in significant environmental and economic impacts including (DER, 2015):

- contamination of groundwater resources by acid, arsenic, heavy metals and other contaminants;
- fish kills and loss of biodiversity in wetlands and waterways;
- loss of agricultural productivity; and
- corrosion of concrete and steel infrastructure by acidic soil and water.

Much of Western Australia's acid sulfate soil material lies just below current water-tables. Changes in land use and increasing groundwater abstraction, as well as declining rainfall, will lead to lower water-tables resulting in possible acid sulfate soil oxidation (DEC, 2013b).

The WAPC released the *Acid Sulfate Soils Planning Guidelines* (WAPC, 2008) which outline a range of matters that need to be addressed at various stages of the planning process to ensure that the subdivision and development of land containing acid sulfate soils is planned, and managed, to avoid potential adverse effects on the natural and built environment.

Current mapping indicates areas within the Shire with a high probability of acid sulfate soils occur largely along coastal areas, both north and south of Onslow (see Figure 7). Small pockets of high probability areas also occur in the south along waterways, as well as in localised sites in the southwest, north and east.

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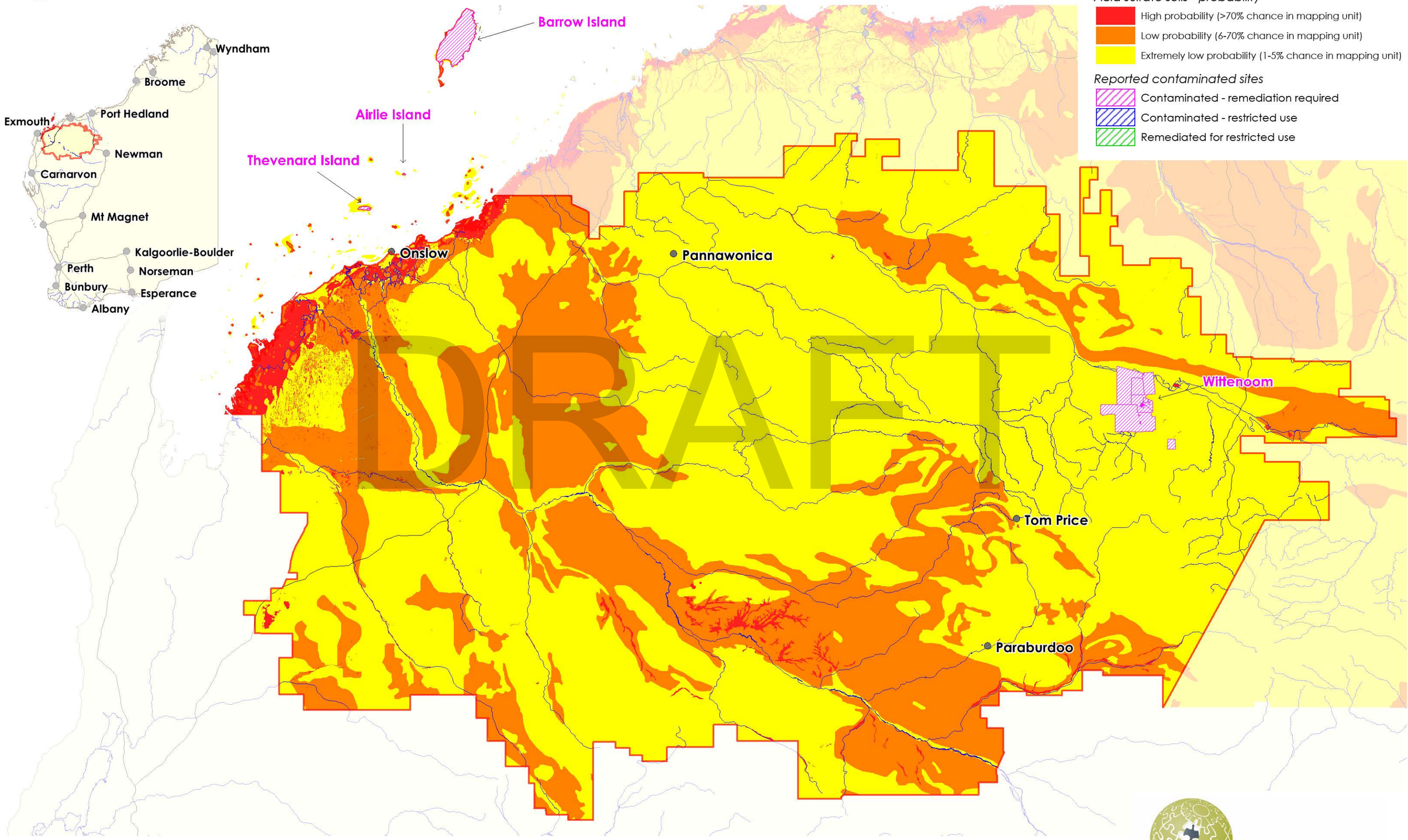
Figure 7: Acid sulfate soil risk and contaminated sites



Data sources: Landgate, Geoscience Australia Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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2.3.5 Contaminated sites

Historical land uses have the potential to result in contamination of soil and groundwater. The contamination of land often renders the land unusable until it is remediated. It also has the potential to cause surface water or groundwater contamination through the transmission of contaminants where they come into contact with stormwater.

Western Australia has developed contaminated sites legislation to protect people's health and the environment from harm. Under the *Contaminated Sites Act 2003*, contaminated sites must be reported to the Department of Environment Regulation, investigated and, if necessary, remediated.

Land owners, occupiers and polluters are required to report all known or suspected contaminated sites to the Department of Environment Regulation. Reported sites are then classified, in consultation with the Department of Health, based on the risks posed to the community and environment.

Figure 7 indicates sites within the Shire currently registered on the Department of Environment Regulation's Contaminated Sites database. There are four main areas within the Shire containing registered contaminated sites; Wittenoom (ex-)townsite, Barrow Island, Thevenard Island and Airlie Island. All the contaminated sites within the Shire have been classified as 'Contaminated – remediation required'. The nature and extent of contamination on Barrow Island, Thevenard Island and Airlie Island is primarily hydrocarbons in both soil and groundwater associated with surrounding oilfield facilities, as well as heavy metals and other contaminants.

Oilfield operations off Thevenard Island ceased in 2014 and infrastructure is currently in care and maintenance mode. A decision was made by owners Chevron Corporation to decommission the Thevenard Island facilities, with the removal of all plant, road and footing expected to take two years (Wilkinson, 2015). Oilfield facilities at Airlie and Barrow Islands are still in operation.

Buildings and materials found to contain asbestos at the old Onslow horse racing track (also known as the Onslow speedway), located approximately 17 km south of Onslow, have recently been removed by an approved asbestos removal contractor (pers. comm. Tahi Morton, Shire of Ashburton, 16th November 2016). However, soil at the site has not been tested for asbestos. The old horse racing track is expected to be turned into a motor cross track in the near future.

Soil testing for asbestos was undertaken at the Onslow rodeo grounds and marked as a future contaminated site. The Shire is currently working to finalise the assessment with the Department of Environment Regulation (pers. comm. Tahi Morton, Shire of Ashburton, 16th November 2016). An additional 0.5 m layer of topsoil has recently been laid over the asbestos-contaminated site at the rodeo grounds in order to use this area as a car park. The contaminated site has previously been covered by topsoil, however, an additional layer was required in order for it to be used safely and minimise risk.

Other sites reported to the Department of Environment Regulation, including sites awaiting classification, are recorded separately by the Department of Environment Regulation and have not been mapped.

A search of the Department of Defences's Unexploded Ordnance (UXO) online mapping indicates that a classification of 'Other' UXO potential exists in some coastal areas of the Shire and one inland area (see Plate 1 below). The areas classified as having 'Other' UXO potential indicates that they were used by the Department of Defence for military training, but use of live firing has not been confirmed, and UXO or explosive ordnance fragments / components have not been recovered from the site. Defence recommends that Local Government notify affected landowners if their property is in a 'Slight' or 'Substantial' potential UXO contamination area only.

However, the Shire is required to inform affected landowners, residents and those working in these areas that they were used for military activities and ensure that they receive the appropriate UXO warning and advice as issued by Defence (DoD, 2016).

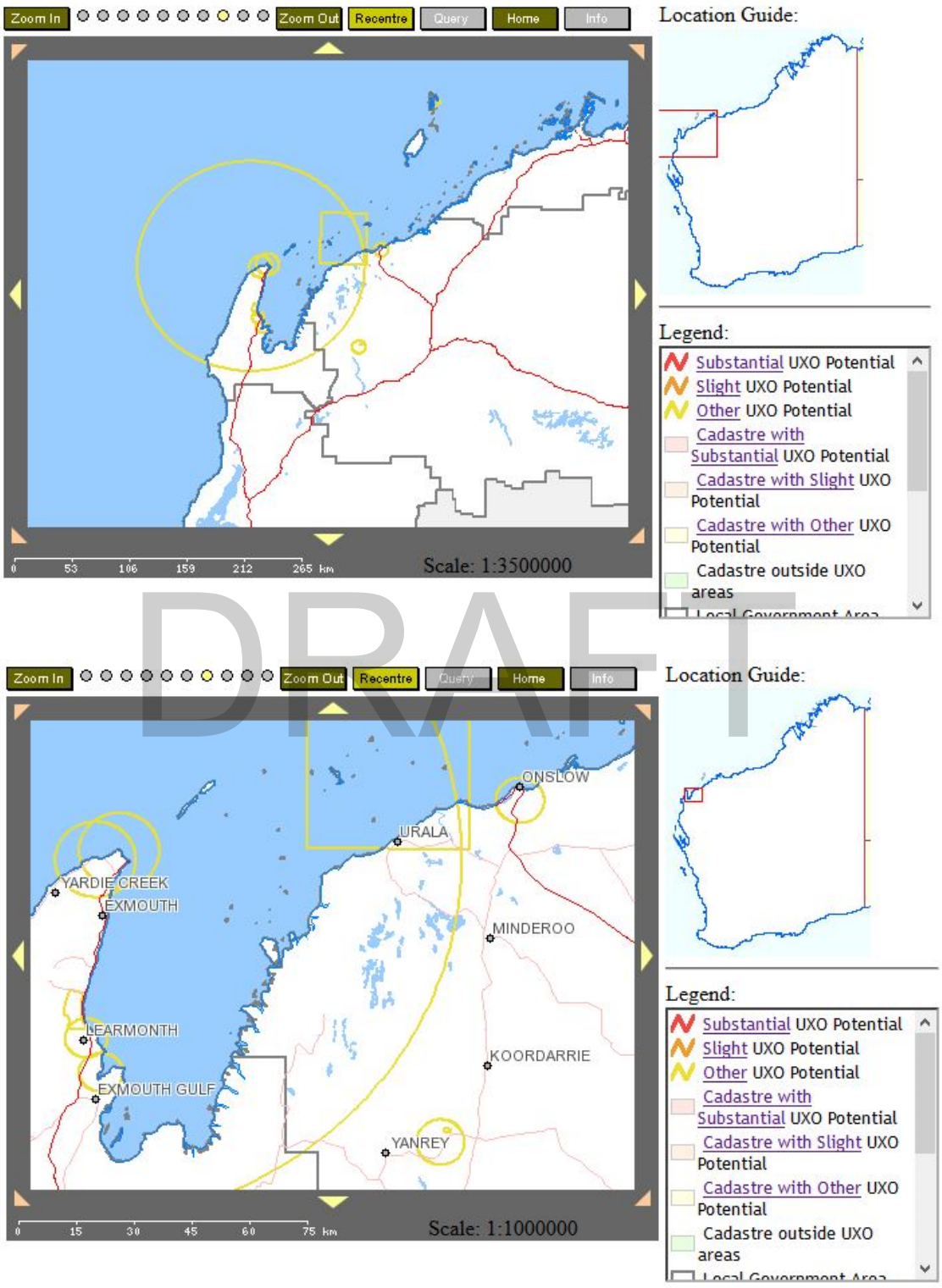


Plate 1: Potential for UXOs in the Shire (DoD, 2016)

Wittenoom

Wittenoom townsite and its surrounding areas is the most notable contaminated site in the Shire. It is now a degazetted town, the legacy of contamination due to crocidolite mining and milling between the 1940s and 1960s. The State Government began phasing down activity in Wittenoom in 1978 as a result of the widespread contamination of crocidolite. In 1993 the Government commissioned a feasibility study for cleaning up the townsite which found that there was still extensive contamination, after approximately fifteen years during which attempts were made to clean up the town. A proposed clean up involved the removal of 100 mm of contaminated top soil and replacement by gravel capping under strict guidelines at a cost of approximately $2.43 million. However, a systematic clean-up of the town was not undertaken. Members of the Interdepartmental Committee on Wittenoom believed it was unlikely the town could be satisfactorily cleaned up and the benefits of attempting to clean up the town were not in proportion to the costs, or the risks involved.

In 2006 GHD and Parsons Brinckerhoff undertook a study on behalf of the Department of Industry and Resources, and Department of Local Government and Regional Development, to develop a risk-based strategy for managing the health risks posed by asbestos tailings in Wittenoom. The objectives of the study were to undertake a field survey of the extent and nature of the asbestos contamination, develop a risk assessment process and identify and evaluate options for the management of any risk identified. The risk assessment indicated that the Wittenoom gorges posed a high or extreme risk to Aboriginal people, tourists and mining industry contractors. The floodplain, and contaminated creek beds in particular, used by Aboriginal people, pastoralists, residents and construction contractors was also considered of high to extreme risk to these groups. Waterborne migration of asbestos was identified as the most significant method of migration, although windborne migration was considered more significant in terms of health risk associated with respirable fibres. A major conclusion of the study was that priority should be given to the stabilisation of particular mine sites and tailings dumps (Colonial mine site) to reduce the risk to human health by isolation, or by remediation of areas with high concentrations of asbestos in a form which could be subjected to release to air (GHD and PB, 2006).

In addition, it was recommended that residents be removed from the townsite, and townsite buildings and infrastructure be demolished and removed. Recommendations were put forward to the Wittenoom Steering Committee, established by the Western Australian Government in 2002 (Government of Western Australia, 2016). Both the Department of Health and an accredited contaminated sites auditor also reviewed the report, with the latter finding that the detected presence of free asbestos fibres in surface soils from sampled locations presented an unacceptable public health risk. The auditor recommended that the former townsite and other impacted areas defined in the report be classified as "Contaminated - Remediation Required".

In December 2006, the Minister for the Pilbara and Regional Development announced that Wittenoom's status as a town would be removed, and in June 2007 the townsite status was officially removed (Government of Western Australia, 2016). The Department of Environment and Conservation subsequently classified Wittenoom as a contaminated site under the *Contaminated Sites Act 2003* on 28 January 2008.

Most recently, in 2013 the Department of Lands engaged environmental consultants to undertake feasibility studies on the preferred remediation options for the three highest risk sites at Wittenoom, including Wittenoom Mine, Colonial Mine and the Wittenoom Gorge. The Department of Lands also began working with relevant agencies and stakeholders to raise awareness of the risks posed by Wittenoom to the general public and local Aboriginal people, and assess long term solutions for the management of the area.

The Government of Western Australia also began drafting special legislation in December 2015 to allow the forcible removal of the last few remaining residents of Wittenoom (Perpitch, 2016).

2.3.6 Waste management

Effective waste management is essential to protect groundwater resources and wetlands, coastal zone areas and other areas with environmental values.

Waste in the Shire is generated from domestic land uses including building and construction, council works and commercial and industrial activities, including mining. Waste management facilities are generally operated by the Shire including in the townships of Onslow, Paraburdoo and Tom Price. However, some private facilities exist, such as at Pannawonica, which are operated by mining companies.

The predominant means of disposing waste in the Shire is by landfill, with limited recycling or reuse of materials. This is largely a factor of high transport costs and a lack of markets for recyclable materials; however, it is compounded by high levels of contamination, the costs of recovery, and the generally free access by households to dump trailer waste at landfills.

Waste management in remote communities is also difficult, due to low levels of community awareness and participation in recycling as well as inappropriate waste management practices that have the potential to impact on drinking water resources. Illegal dumping of waste is particularly an issue with reports of dumping occurring in Paraburdoo near the light industrial area.

Increased growth in the region will lead to increased amounts of waste that are generated. This is of concern primarily due to the low level of reuse and recycling that are currently occurring, suggesting that the majority of all new waste will end up in landfill.

Due to development in Onslow, continued residential growth and expansion of the resources industry, the old Onslow Landfill was officially closed and in a new, modern waste transfer station opened August 2015. Waste collected at the transfer station in Onslow is being transported to Tom Price. Another landfill site has also been identified for development 30 km south of Onslow, as a Class 4 facility for use by Chevron as part of its operations (OCCI, 2016). The land is currently vested to the Department of Parks and Wildlife for conservation and a feasibility study will be completed in 2016.

The landfill site in Tom Price has an estimated capacity of around fifteen years, with the capacity of the Paraburdoo landfill estimated at 9-10 years.

Long-term waste management planning is currently being undertaken by the Shire. A Landfill Strategic Waste Plan which includes an assessment of the lifecycle of landfills has recently been developed for the Shire of Ashburton and has been received by Council.

2.3.7 Land capability for agriculture

The Department of Agriculture and Food WA (DAFWA) undertook an assessment of soil capability and degradation hazards across Western Australia, however, the assessment did not extend to the Pilbara region (DAFWA, 2016a).

A Rangeland inventory and condition survey was undertaken for the Ashburton River catchment between 1976 and 1978 (Payne et al., 1988). A survey report was prepared providing a baseline record of the existence and condition of the natural resources within the catchment to assist with the planning and implementation of land management practices. The report identified and described the condition of soils, landforms, vegetation, habitat, ecosystems, and declared plants and animals. It also assessed the impact of pastoralism and made land management recommendations.

The area surveyed covers approximately 93,600km² and includes the catchment of the Ashburton River and part of the catchment of the Yannarie River. About 65% (61,130km²) of the area was then occupied by 30 pastoral leases grazing sheep and/or cattle. The remaining 35% (32,470km²) consisted of various reserves and vacant crown land unsuitable for pastoral purposes. Pasture and soil condition was assessed at a number of points throughout the survey area and found that:

- 9% of the points surveyed indicated that perennial vegetation was in poor to very poor condition;
- 27% indicated fair rangeland condition; and
- 64% indicated good or very good condition.

The worst areas of degradation and erosion were identified on the most valuable pasture lands. These areas are readily accessible, close to permanent water supplies and support attractive pastures. Therefore, they received preferential overuse in the early days of settlement, and sensitive parts of these areas are now seriously degraded.

Rangelands pastoral condition was also assessed by DAFWA in order to provide advice on the planning and management of grazing pressure on leases, and to report to the Pastoral Lands Board. Lessees and station managers can use these assessments to improve management and long-term condition of the rangeland resource. The Western Australian Rangeland Monitoring System (WARMS) has been the key assessment tool used by DAFWA to monitor change in vegetation condition and provide information on rangeland condition trends at a regional or district scale. This included grassland and shrubland assessments to indicate pasture condition and trends, and thus land capability. Grassland sites were assessed on a three-year cycle and shrubland sites assessed on a five-year cycle through the WARMS tool. Regular lease inspections were carried out by DAFWA until 2012, when responsibility was given to lessees and land manager to undertake these assessments (DAFWA, 2016b).

Reporting data from the most recent sampling period (2012 – epoch 7 for grasslands) for the Ashburton Land Conservation District (LCD) indicates that perennial grass coverage continued to decreased despite favourable climatic conditions, and a stock density below the estimated carrying capacity of the LCD in the previous two years (see Chart 3, Novelly and Thomas, 2013). Data on rangelands condition has not been reported since 2013 and the Annual Rangeland Condition and Data Input Application (ARCADIA) administered by the Pastoral Lands Board is no longer in operation.

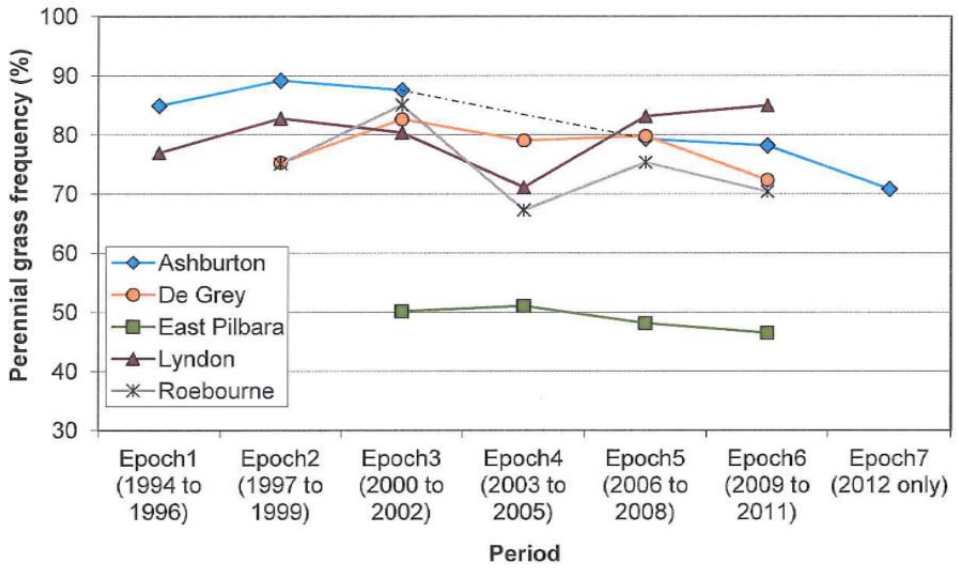


Chart 3: Reported grassland cover (frequency) (Novelly and Thomas, 2013)

The decline in vegetation and soil condition (particularly when exacerbated by drought) in the rangelands of the Shire of Ashburton has implications for the regional pastoral industry (Novelly and Thomas, 2013). As vegetation coverage decreases, the capacity for livestock to graze and be supported by the rangelands will also decrease. This pattern places pressure on pastoralists to increase stock density to make up for market shortfalls, which in turn has environmental implications.

Rangelands NRM has recently been working with the Federal Government to deliver Ecologically Sustainable Rangeland Management (ESRM) plans for land managers in the rangelands. Through the ESRM planning process, the land manager identifies land systems, notes their productive potential and degradation risks and prioritises them into action/response categories. Land systems with the greatest productive potential with the highest risks of on-going or future degradation are prioritised to ensure sustained productivity. Land managers can then use this knowledge to assess current management practices and develop appropriate interventions (Rangelands NRM, 2016). In particular, Rangelands NRM is working with pastoralists in the Fortescue catchment to assist in managing total grazing pressure and control livestock access to areas of high biodiversity value, by increasing ground cover and its condition on pastoral properties, and improving cattle management.

Although mining activities require environmental approval, the widespread exploration for resources and their associated extraction and transport has resulted in some impacts on the regional landscape. This includes a loss in land capability in areas that are actively mined, as well as utilised for associated infrastructure. Other localised landscape impacts are evident as a result of mining activities in coastal and marine areas, such as the construction of off-loading facilities, ports, pipelines and causeways.

2.3.8 Key considerations for strategic environmental planning

Key land resource considerations for strategic planning are:

- **Resource extraction** – Clearing of the land for resource extraction results in a loss of biodiversity and can lead to erosion. Mining activities impact on the visual landscape of the Shire; can result in off-site impacts on nearby land uses including dust, noise and light; and can also lead to the lowering of groundwater tables.

- **Acid sulfate soils** - Declining soil and land quality can occur as a result of activity where acid sulfate soils are disturbed. This leads to the release of acid and heavy metals which can cause significant harm to the environment and infrastructure. Appropriate management of acid sulfate soils, particularly in areas of high risk where changes in groundwater are likely or mining is proposed, is required, consistent with current best practice.
- **Contaminated sites** – Given that contaminated sites within the Shire are located within operational oilfield facilities, the Onslow townsite, and within the Wittenoom degazetted townsite, consideration should be given to processes established under the *Contaminated Sites Act 2003*, particularly in coordination with the Department of Lands with respect to Wittenoom. In addition, any unsewered residential and industrial areas within the Shire have the potential to lead to contamination of land and groundwater and alternative treatment units should be used in areas of high environmental risk.
- **Waste management** – Consideration should be given to opportunities to establish local or regional waste management and/or recycling facilities as population in the region increases, as well as opportunities to subsidise recycling schemes. This should include industries with multiple benefits such as waste to energy plants.
- **Soil and vegetation condition** – Vegetation retention assists in the maintenance of soil health. Soils and vegetation (grasslands and shrublands) in good condition are also associated with higher agricultural productivity. Supporting the development and planning process of Ecologically Sustainable Rangeland Management (ESRM) Plans for land managers in coordination with the Pastoral Lands Board and DAFWA should also be considered.

2.4 Water resources

2.4.1 Surface water – waterways, wetlands and flooding

Long, wide river systems drain the rocky outcrops of the inland region and flow over the coastal plains to discharge northwest into the Indian Ocean. These are a significant environmental feature of the Shire's landscape. River flowpaths are often wide and intertwining, and discharge points are usually a combination of direct ocean channels and dispersal through marshy flats.

As a direct response to irregular rainfall patterns and extreme climatic conditions, rivers in the Shire are subject to massive, seasonal variations in flow. These conditions result in a landscape with wide floodplains which allow the periodic passage of large volumes of water and sediment across the tablelands to the coastal areas and near-shore marine environment, particularly during cyclonic events. With the exception of some small but important, spring-fed sections, all waterways in the region are ephemeral, in that surface flow ceases for at least part of each year.

Major surface water basins within the Shire include the Onslow Coast and Cane River, Fortescue River, Robe River, Yannarie River, and Ashburton River (Figure 8). The Ashburton River Catchment covers over 75,000 km^2 and includes the Ashburton, Angelo, Hardey, Henry Rivers and Tunnel, Perry, Ethel, Turee, 7 Mile, Duck Creeks.

The largest rivers in the Shire, the Fortescue and Ashburton rivers, flow for significantly greater periods of time than the other rivers. However, in wetter years only the Fortescue River flows for more than half the year. The major rivers contribute significant recharge to groundwater resources such as the Millstream aquifer, while flowing over the coastal plains towards the Indian Ocean. However, streamflow has been estimated to exceed groundwater recharge volumes by five to six times, due to the very large flows resulting from cyclonic events and tropical depressions, which exceed the amount of water that can infiltrate during these events (CSIRO, 2015b).

Most runoff occurs during the period of January to March, largely as a result of cyclonic activities, with typically less runoff during December and April (WAPC, 2009). Mean annual runoff rates from the major rivers in the Pilbara region typically represent 2% to over 10% of the annual rainfall and between 8-30 mm of rainfall is required to make the rivers and streams flow (CSIRO, 2015b).

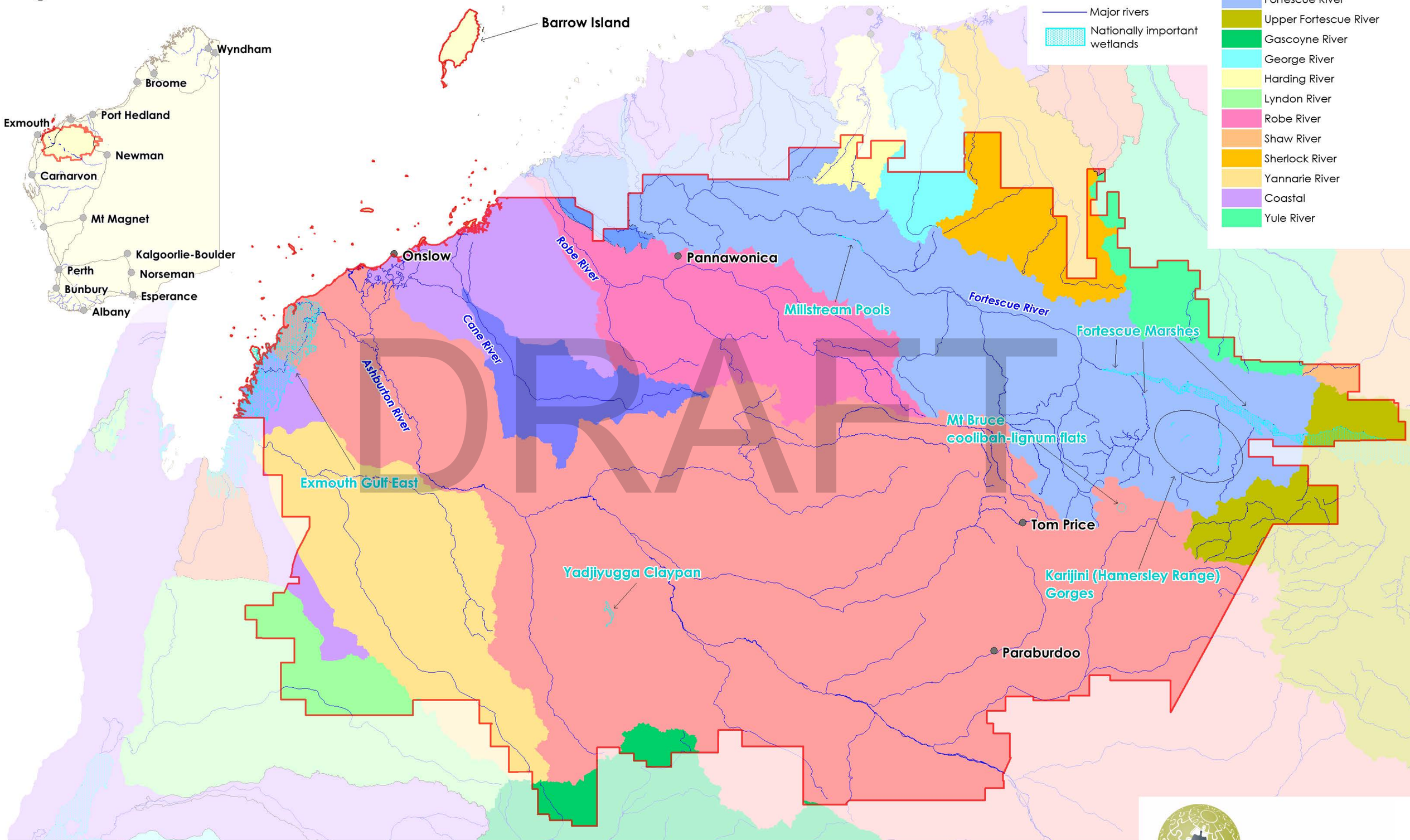
The Shire of Ashburton is located within the Pilbara Surface Water Area, which is proclaimed under the *Rights in Water and Irrigation Act 1914* for the purposes of regulating the taking of water from watercourses and wetlands.

Wetlands

While no Ramsar wetlands are located within the Shire, Millstream Pools and Fortescue Mashes are being considered as Ramsar sites (DoW, 2010b). A number of wetlands have been listed in the *Directory of Important Wetlands in Australia* (Environment Australia, 2001). These include; Millstream Pools, Karijini Gorges, Weeli Wolli Spring, Exmouth Gulf East, Fortescue Marshes, Kookhabinna Gorge, Mt. Bruce coolibah-lignum flats and Yadjiyugga Claypan. Nationally important wetlands are shown on Figure 8.

Due to the arid climate of the region, permanent and semipermanent pools are of high ecological value. These pools and wetlands sustain populations of terrestrial and aquatic flora and fauna during times of drought and are refuge areas from which biota expand during times of flood. Permanent pools with recognised significance include those associated with the Yule, Sherlock, Harding, and Fortescue coastal rivers (Kendrick and Stanley, 2001).

Taylor Burrell Barnett - Shire of Ashburton Environmental Profile
Figure 8: Surface water



Data sources: Landgate, Department of Water, Department of the Environment Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
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Pools and wetlands also have significant cultural value to local Aboriginal people. For instance, stories of 'The Dreaming' from the Millstream area provide the basis for the cultural practices of the Yindjibarndi and Ngarluma people (WAPC, 2009).

Flooding

Episodic flooding is a natural hydrologic feature of the Shire and greater Pilbara region. Episodic flooding provides critical recharge of groundwater aquifers and inundation of waterways and wetlands that may have been dry for extended periods. Episodic flooding also results in explosive ecological responses, which are a remarkable feature of the region.

Heavy rainfall and associated river flooding is the main impact from most cyclone events, particularly in the inland region of the Shire. The highest rainfall is usually found along or just east of the cyclone track. The flood potential of a cyclone system is not directly related to its intensity but is associated with its track, speed, aerial extent and saturation of catchments from prior rainfall. Rainfall totals in excess of 100 mm are common with tropical lows that move over land. In February 1997, a slow moving low moving over the west Kimberley, Pilbara and Gascoyne caused rainfall in excess of 400 mm in parts, and one of the highest ever floods along the Ashburton River. Cyclone Joan in December 1975 caused over 400 mm of rain near its track, the highest fall being 591 mm at Marandoo (BoM 2016b).

Flooding is enhanced when multiple tropical lows occur within a few weeks of each other. During January and February 1961 rainfall totals exceeded 200 mm during two tropical cyclones. At Wittenoom it was described as the worst flood in memory as water levels rose to 23 m in sections of the Gorge. In both events Wittenoom was isolated. In 1980 cyclones Amy, Dean and Enid moved over the eastern Pilbara causing total rainfall to exceed 600 mm in some areas (BoM, 2016b).

Flood risk and stormwater in townsites requires management by the Shire. Key stormwater management issues associated with development in the Shire include the management of erosion, silt, sediment, water quality and weeds, particularly in sensitive environments. It is recognised that the red soils of the Pilbara region have a high capacity for erosion. This, coupled with the high volumes of stormwater which flow in the wet season, requires active and effective management to adequately control erosion and sediment transport.

The Shire is responsible for the management of flooding and drainage in the major townsites of Onslow, Tom Price and Paraburdoo. This includes routine maintenance of systems and approval of new systems for new areas of development. Rio Tinto Iron Ore is responsible for the provision of services in Pannawonica.

Anecdotal evidence suggests that there are no significant issues with regards to major event flooding in Tom Price and Paraburdoo; however, some impacts may result from blocked infrastructure. Maintenance typically involves semi-regular removal of vegetation from drains, replacement of old infrastructure (end of life, e.g. rusted corrugated iron pipes), and removal of sediment after big events.

Flood risk is also addressed in section 2.7.2.

2.4.2 Groundwater – resources, availability and use

Groundwater is the major source of water in the greater Pilbara region and thus particularly important to the Shire. Due to the arid climate of the region, highly seasonal and variable rainfall and very high evaporation rates, surface water is not a reliable water resource for users.

The main groundwater resources in the region are contained within karstic dolomites, channel-iron deposits, and mineralised zones in the Hamersley Range, fractured rock aquifers, in channel-iron deposits at Bungaroo Creek and potentially other paleochannels, and in alluvium along the lower river systems along the coast. Alluvial groundwater is generally fresh close to riverbeds and saline further away where they are less well flushed of salts (CSIRO, 2015b).

Groundwater aquifers in the Pilbara region are recharged by direct infiltration of rainwater and from streamflow leaks through riverbeds during surface water flows. The quantity, quality and reliability of groundwater resources depends on the different aquifer types, thus impacts of abstraction from aquifers also vary.

Groundwater is most easily located and accessed near surface water drainage lines or alluvial channels. Aquifers in coastal areas of the Pilbara are considered small, receiving a typical annual recharge of less than 10 GL/year (DoW, 2010b).

Groundwater is critical to biodiversity in the region. It is the source of many small, spring-fed systems and sustains riparian areas along the ephemeral rivers, as well as many significant groundwater dependent ecosystems which have important environmental, social and cultural values. In particular, aquifers provide important habitat for stygofauna and troglofauna. The presence of stygofauna in the Pilbara has been well documented in groundwater dependent ecosystems. The Fortescue System, particularly the Millstream Aquifer, has many identified global stygofauna "hot spots" (Rangelands NRM Coordinating Group, 2005).

The Shire contains a number of important aquifers, including Carnarvon – Birdrong, Hamersley – Millstream, Lower Robe alluvial, Lower Cane alluvial and Lower Bungaroo Valley (Table 5). The Shire is located entirely within the Pilbara Groundwater Management Area, and Ashburton Groundwater Management Subarea, which is proclaimed under the *Rights in Water and Irrigation Act 1914.*

Public drinking water supply

Public drinking water is supplied predominantly from groundwater and the Shire's Public Drinking Water Source Areas include the Cane River Water Reserve, Millstream Water Reserve, the Harding Dam Catchment Area and Bungaroo Creek Water Reserve, as well as a number of smaller areas as indicated in Table 5 and shown on Figure 9.

Table 5: Public drinking water sources areas in the Shire

PDWSA	Source	Priority	Management Plan	Included in TPS No. 7 Reserve
Bungaroo Creek Water Reserve	Groundwater	P1	Bungaroo Creek Water Reserve Drinking water source protection plan (West Pilbara water supply scheme) (2012)	No
Cane River Water Reserve	Groundwater	P1	Cane River Water Reserve water source protection plan (Onslow Town Water Supply) (1999)	Yes – Cane River water reserve area SCA
Harding Dam Catchment Area	Surface water	P1	Harding Dam water source protection plan (West Pilbara water supply scheme) (1999)	Yes - Public purposes: water & drainage; Millstream Chichester National Park
Millstream Water Reserve	Groundwater	P1 & P2	Millstream Water Reserve Drinking water source protection plan (West Pilbara integrated water supply	P1: Yes - Public purposes: water & drainage; Millstream Chichester National

PDWSA	Source	Priority	Management Plan	Included in TPS No. 7 Reserve
			scheme) (2010)	Park P2: No
Marandoo Water Reserve	Groundwater	P1	Southern Fortescue & Marandoo Water Reserves Drinking water source protection plan (Tom Price town water supply) (2011)	Yes – Other purposes: infrastructure
Pannawonica Water Reserve	Groundwater	Not assigned	-	No
Paraburdoo Water Reserve	Groundwater	P1 & P3	Paraburdoo Water Reserve Drinking water source protection plan (Paraburdoo town water supply) (2013)	P1: Partial – Public purposes: water & drainage P3: No
Southern Fortescue Water Reserve	Groundwater	P1	Southern Fortescue & Marandoo Water Reserves Drinking water source protection plan (Tom Price town water supply) (2011)	Yes – Borefield SCA

All water reserves are covered by water source protection plans, with the exception of the Panawonica water reserve which is not yet assigned a category (see Table 5). These water source protection plans provide guidance on the management of risks to the water source and are managed by the Department of Water.

Water for the main towns (Onslow, Tom Price, Paraburdoo, and Pannawonica) comes from a variety of groundwater sources near the towns and is provided by the Water Corporation or mine operators (DoW, 2013), as shown in Table 6.

Table 6: Major water supplies and their sources for the Shire of Ashburton

Water Supply Scheme	Local government area	Water source	Water service provider
Onslow	Shire of Ashburton	Cane River alluvial aquifer	Water Corporation
Tom Price	Shire of Ashburton	Southern Fortescue borefield& Marandoo mine aquifer dewater	Rio Tinto
Paraburdoo	Shire of Ashburton	Paraburdoo wellfield	Rio Tinto
Pannawonica	Shire of Ashburton	Robe River alluvial aquifer	Rio Tinto

The Water Corporation currently hold an allocation license for 15 GL from the Millstream aquifer (DoW, 2013). This is nearly three times the long-term sustainable yield of this resource which is estimated at 5.2 GL/year (DoW, 2010d). Although the licence conditions for Millstream and Harding Dam require the dam to be used as the primary water source for the West Pilbara water supply scheme (supplying Karratha, Dampier, Roebourne, Wickham, Point Samson and Cape Lambert), water supply issues in the dam have required the use of the Millstream aquifer to supplement supply during peak demand periods (see Figure 9, DoW, 2013).

The State Government reached an agreement with Rio Tinto to develop an extra 10 GL/year groundwater source from the Lower Bungaroo Valley. This water is used to supplement the Water Corporation's West Pilbara Water Supply Scheme and reduce the reliance on Millstream aquifer.

At present the Lower Cane alluvial aquifer supplies water via a pipeline to Onslow. While plans had recently been developed to treat saline groundwater in the coastal Carnarvon – Birdrong.

aquifer via desalination to provide additional drinking water for Onslow, and for gas processing, (CSIRO, 2015a), these have recently been placed on hold due to higher than expected freshwater production from the Lower Cane alluvial aquifer.

Rio Tinto Utilities owns and operates the water supply schemes for Tom Price, Paraburdoo and Pannawonica. The company is licensed under the *Water Services Licensing Act (*1995) to supply potable and wastewater services to these towns, as well as Dampier in the Shire of Roebourne. Tom Price, Pannawonica and Paraburdoo are supplied with water from bore fields in shallow alluvial aquifers and supply is not currently considered to be at capacity. Groundwater management is administered by Rio Tinto through Groundwater Operating Strategies which are agreements between the Department of Water and Rio Tinto detailing abstraction and monitoring requirements and reporting by both parties.

Groundwater availability

Information on groundwater availability for some aquifers within the Shire is presented in the Department of Water's Pilbara groundwater allocation plan (DoW, 2013).

Table 7 provides information on the committed allocation and remaining volume of groundwater resources within the Shire in the Ashburton groundwater subarea (data requested from DoW 22nd June 2016). Groundwater used for stock and domestic purposes at pastoral stations is exempt from groundwater licensing.

Table 7: Groundwater resource and allocation limits (source: DoW, June 2016)

Aquifer	Allocation Limit	Allocated Volume	Committed Volume	Remaining Volume	% Allocated and Committed	Additional Requested
Carnarvon - Birdrong	100,00	2,400	0	**97,600**	**2.40 %**	10,000
Carnarvon – Birdrong.	1,500,000	1,220,000	0	**280,000**	**81.33 %**	0
Carnarvon - Surficial	2,000,000	1,858,570	0	**141,430**	**92.93 %**	12,000,000
Hamersley – Fortescue	Not set	127,544,000	0	-	**0 %**	0
Pilbara – Fractured Rock	Not set	15,994,320	0	-	**0 %**	0
Wittenoom – Wittenoom	19,980,000	10,155,500	0	**9,824,500**	**50.83 %**	0
Hamersley – Fractured Rock	Not set	334,356,615	0	-	**0 %**	15,922,000
Combined – Fractured Rock	Not set	3,303,270	0	-	**0 %**	20,000
Hamersley - Millstream	682,500*	585,500	0	**97,000**	**85.79 %**	0
Lower Robe Alluvial	3,000,000	0	0	**3,000,000**	**0 %**	0
Lower Cane Alluvial	92,5000	0	0	**92,5000**	**0 %**	0
Lower Bungaroo Valley	0	95,000	0	**-95,000**	**0 %**	0

*15 GL/yr is the maximum amount that can be taken from Water Corporation's borefield, provided management conditions are met and Harding Dam cannot be used. The long-term reliable allocation is an average of 5.2 GL/yr.

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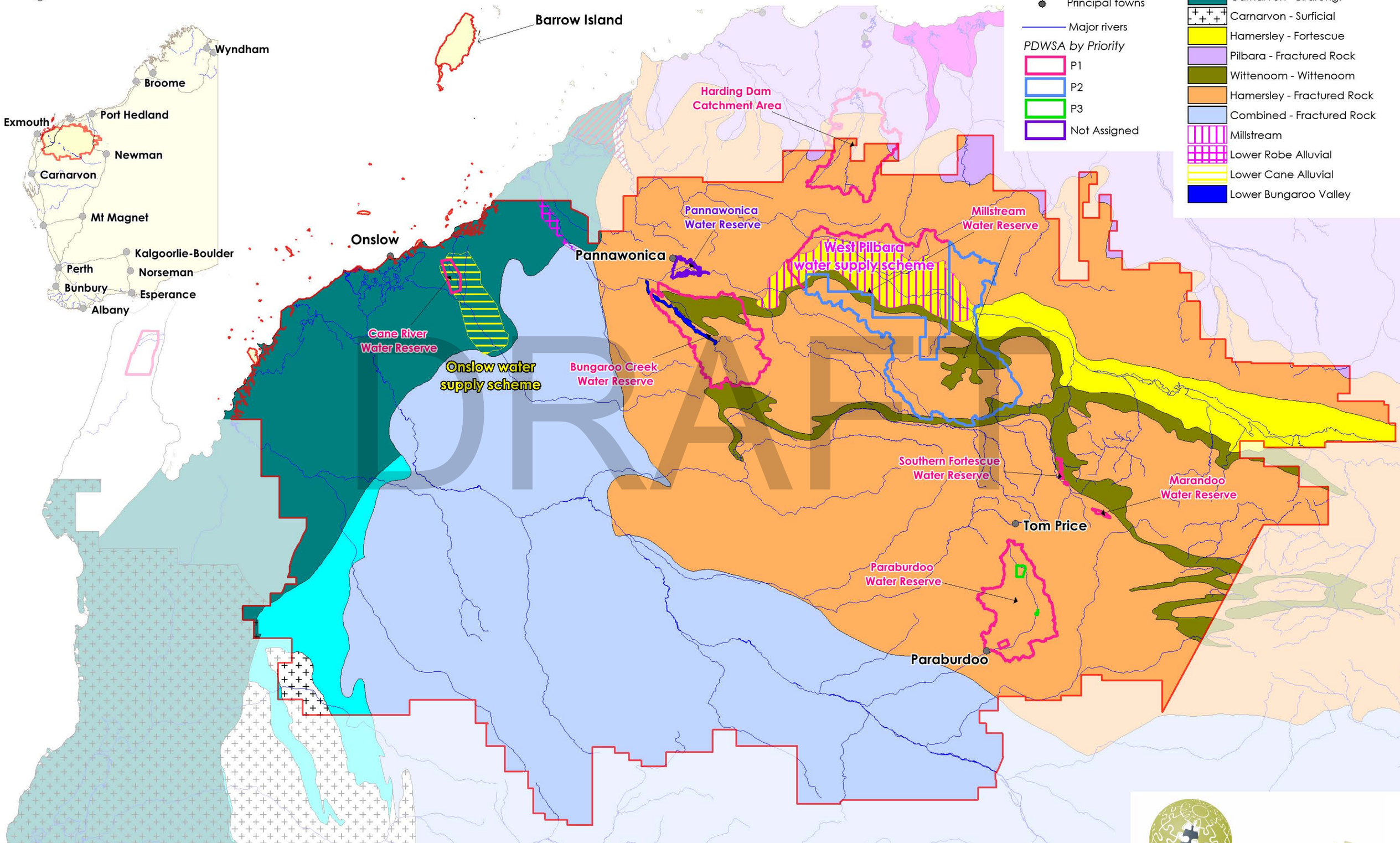
Figure 9: Groundwater



Data sources: Landgate, Department of Water, Department of the Environment Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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Mining and irrigated agriculture

The mining industry is the dominant water user in the region with mining operations, mine dewatering and other related water uses (including minesite and exploration camp irrigation and residential water uses) accounting for over 80% of total water licenced for use in the region compared with just 9% used for public drinking water supply and other industries respectively (Chart 4) (DoW Water Register, 2013).

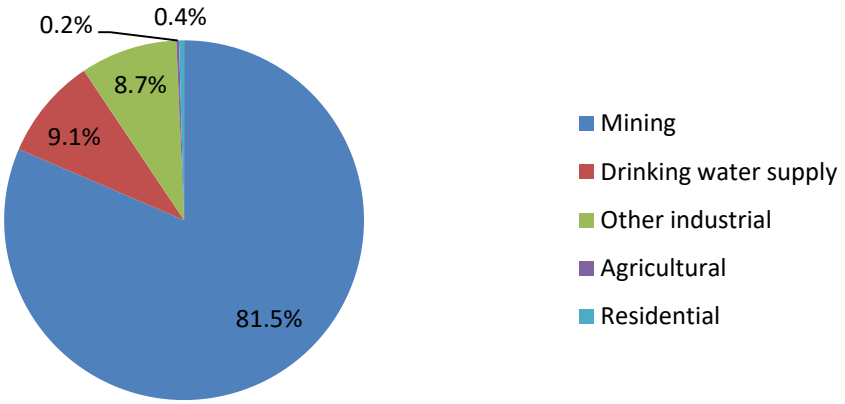

Chart 4: Breakdown of water licensing in the Pilbara (Source: DoW Water Register, 2013)

It is estimated that 'mining related uses' such as transportation, infrastructure projects and residential water use on minesites and exploration camps collectively accounts for around 30% of total mining water licensing, whilst mine dewatering is the biggest single water use accounting for approximately 40% of licensed water use alone (Chart 4) (DoW Water Register, 2013).

Mine dewatering is managed under the *Rights in Water and Irrigation Act 1914* to minimise adverse impacts of the abstraction and release of water. Part V of the *Environmental Protection Act 1986* also manages the discharge of mine dewater to ensure receiving water bodies are not degraded.

A number of studies have been undertaken throughout the Pilbara to assess long-term use and security of groundwater resources for potential expansion of irrigated agriculture in the region.

The Pilbara Water Discovery project, funded by the Royalties for Regions program, is a four year study involving electromagnetic surveys to determine the viability of agricultural expansion in the region, as part of the Department of Water's Water for Food program. Collection of survey data and associated test drilling will be completed in 2016.

In addition, the *Pilbara surplus mine dewater options and feasibility study,* also funded through Royalties for Regions, was completed to assess the availability and possible use of surplus mine dewater to supply irrigated agricultural enterprises in the Pilbara. The Department of Water has confirmed the availability of surplus mine dewater in relation to prospective irrigation precincts in nearby locations where viable soils are concentrated, particularly in the central and eastern Pilbara, and potentially in the very east of the Shire in the Harmersley Range (DoW, 2015).

Surplus water from below water table mining at Rio Tinto's Marandoo mine is currently being used in an irrigated agriculture scheme known as the Hamersley Agricultural Project 45 km north east of Tom Price. Water from the Marandoo below water table expansion is being used to irrigate areas of Hamersley station and produce hay to feed cattle across six stations (Rio Tinto, 2012). However, some concern regarding the production of the non-native grass using recycled water from Marandoo exists.

2.4.3 Alternative water supply and water efficiency

While water recycling schemes are not widespread in the Shire, a number of schemes are being implemented in the region in recognition of the need to facilitate growth in townships whilst conserving existing town drinking water supplies.

The Shire of Ashburton was declared a Waterwise Council in 2014 and maintained its status 2015, with the aim of continuing to work towards improving water efficiency in Onslow in particular. The Shire has developed a Waterwise demonstration garden in Onslow and a 'Waterwise Garden Guidelines' information pack for the Onslow community to promote water efficiency.

A wastewater recycling scheme is also being investigated in Onslow to provide a fit-for-purpose alternative water source for irrigation of public open space and parks, and potentially drought-proofing Onslow's landscape. In addition, wastewater from Onslow Airport will be treated and recycled to irrigate the airport's waterwise garden.

Surplus water from below water table mining at Rio Tinto's Marandoo mine is also to be reinjected to the Southern Fortescue borefield to replenish the aquifer which supplies the Tom Price township (DoW, 2011). Similarly, surplus water from the nearby Nammuldi mine (60 km north west of Tom Price) is also being used for irrigated agriculture projects at nearby stations. Seeding of Rhodes grass for the Nammuldi Agricultural Project began in April 2014.

2.4.4 Key strategic environmental planning issues for consideration

Key water resource considerations for strategic planning, consistent with *State Planning Policy 2.9: Water Resources* are:

- **Flooding from stormwater** - Adequately manage the risk of flooding, and consequences particularly associated with sediment transport management, in townsites and industrial areas through application of *State Planning Policy 2.9: Water Resources.* The Shire may also need to review existing townsite drainage systems and ensure appropriate levels of service will be maintained as development occurs (such as at Onslow Airport).
- **Public drinking water sources** – There are a number of important water sources which provide water for public supply within the region. Although most of these public drinking water sources are protected in the existing planning scheme, consideration should be given to the reservation and/or use of a special control area to improve their level of protection in future, particularly in relation to Bungaroo Creek water reserve. Planning decision-making should be consistent with the DoW's *Water Quality Protection Note: Land Use Compatibility within Public Drinking Water Source Areas* (2016) in the vicinity of any drinking water borefields, including the requirements for well-head protection zones.
- **Groundwater availability** – although allocation currently remains in some aquifers and investigations into available groundwater supplies are continuing, declining rainfall in coastal areas may result in reduced recharge and consequently availability in these areas in the future, particularly as population and industry expands. Dewatering/over-abstraction have also impacted local groundwater levels, potentially affecting groundwater-dependent pool ecosystems and wetlands through drying up and loss of habitat. This in turn can impact wildlife and cultural and social values. This is especially critical given the presence of nationally important wetlands in the Shire. Therefore groundwater allocations and availability require consideration of these values when planning for residential and industrial expansion.
- **Water use efficiency-** It is recognised that the Shire is a Waterwise Council. It should continue to investigate and expand water efficiency opportunities, such as irrigation of public open space and sports ovals where practical.

- **Water reuse** – Due to increasing demand for water associated with residential growth and industrial expansion, it is considered that water recycling and reuse to provide fit-for-purpose sources of water should continue to be investigated in Onslow and other townsites where practical, as an alternative to groundwater use. This will require cooperation with the Water Corporation and Rio Tinto. In addition, reuse of mine dewater for irrigation of agricultural projects should continue to be investigated where practical.
- **Contamination of water resources** - Landfill sites are a potential source of pollutants to ground and surface waters. These land uses, and others with the potential to pollute ground and surface waters must be carefully located, designed, managed and monitored to avoid impacts.

2.5 Biodiversity

The Shire is characterised by a diverse range of terrestrial, aquatic and coastal landscapes, flora and fauna. In order to better understand the terrestrial and aquatic biodiversity, a bioregional framework was developed by the Commonwealth and State governments, which divides the country into Interim Biogeographical Regions and bio-subregions.

The Shire contains eight Interim Biogeographic Regionalisation for Australia (IBRA) subregions: Cape Range, Ashburton, Hamersley, Chichester, Fortescue and Roebourne, with small portions of Augustus and Wooramel. Vegetation types in these regions are predominantly scrub, shrub-, low tree-, and grass-steppe, and grassland, with small amounts of samphire, tidal mudflats and mangroves located in coastal region (see Figure 10). A more detailed description of the bio sub-regions in the Shire is found in section 3.2 of the *Pilbara Framework: Regional Profile* (WAPC, 2009) and in the DPaW's *Biodiversity Audit* (CALM, 2003).

Western Australia's conservation reserve system plays a pivotal role in conserving WA's biodiversity, which is both rich and exhibits a high degree of endemism (i.e. plants and animals occurring nowhere else (CALM, 2003). *Australia's Biodiversity Conservation Strategy 2010-2030* (DSEWPaC, 2010) contains objectives to 'maintain the extent of habitat' and 'create nature reserves or conservation management agreements on public and private land'. Conservation reserves account for approximately 17 per cent of land tenure in the Shire of Ashburton and include Barlee Range Nature Reserve, Cane River Conservation Park, Karijini National Park, Millstream-Chichester National Park, and Mungaroona Nature Reserve, as well as a number of offshore island nature reserves including Barrow Island and Thevenard Island (Table 8, Figure 11).

Table 8: Terrestrial conservation reserves in the Shire of Ashburton (Source: DPaW, 2016)

Type of reserve	Name of reserve	Area (km²)
National parks	Karijini National Park	6,683
	Millstream-Chichester National Park	2,413
Conservation parks	Cane River Conservation Park	3,334
Proposed Conservation Parks	West Hamersley Range Conservation Park	-
	Mulgalands Conservation Park	-
Nature reserves	Mungaroona Range Nature Reserve	1,061
	Barlee Range Nature Reserve	1,072
	Barrow Island Nature Reserve	253
	Tent Island Nature Reserve	19
	Thevenard Island Nature Reserve	6.2
	Boodie, Double Middle Islands Nature Reserve	5.5
	Serrurier Island Nature Reserve	3.1
	Little Rocky Island Nature Reserve	3.1
	Burnside & Simpson Island Nature Reserve	1.3
	Bessieres Island Nature Reserve	0.5
	Y Island Nature Reserve	0.4
	Locker Island Nature Reserve	0.3
	Airlie Island Nature Reserve	0.3
	Great Sandy Island Nature Reserve	0.2
	Victor Island Nature Reserve	0.2
	Gnandaroo Island Nature Reserve	0.05
	Round Island Nature Reserve	0.03
	Rocky Island Nature Reserve	0.02
	Whalebone Island Nature Reserve	0.007
Former leasehold	Reserve Ex. Wanna Station	1,446
TPS No. 7 conservation reserves		992
Total conservation areas		**17,295**

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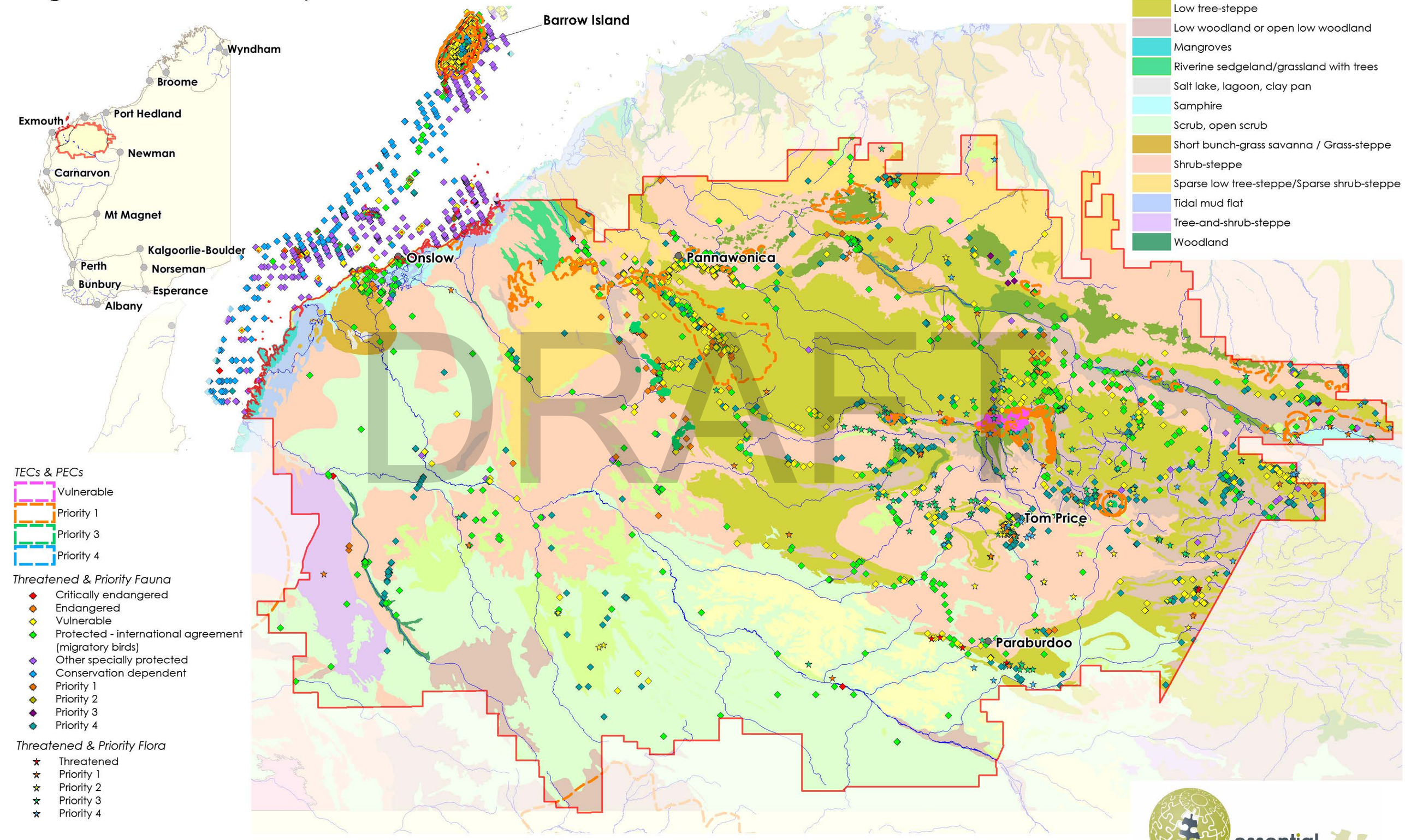
Figure 10: Biodiversity



Legend
- Study area
- Principal towns
- Major rivers

Pre-European vegetation
- Dwarf scrub or open low shrub
- Grass-steppe
- Grasslands, short bunch-grass savanna
- Low tree-steppe
- Low woodland or open low woodland
- Mangroves
- Riverine sedgeland/grassland with trees
- Salt lake, lagoon, clay pan
- Samphire
- Scrub, open scrub
- Short bunch-grass savanna / Grass-steppe
- Shrub-steppe
- Sparse low tree-steppe/Sparse shrub-steppe
- Tidal mud flat
- Tree-and-shrub-steppe
- Woodland

TECs & PECs
- Vulnerable
- Priority 1
- Priority 3
- Priority 4

Threatened & Priority Fauna
- Critically endangered
- Endangered
- Vulnerable
- Protected - international agreement (migratory birds)
- Other specially protected
- Conservation dependent
- Priority 1
- Priority 2
- Priority 3
- Priority 4

Threatened & Priority Flora
- Threatened
- Priority 1
- Priority 2
- Priority 3
- Priority 4

Datasources: Landgate, Dept. of Water, Dept. of Parks & Wildlife, Dept. of the Environment Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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Figure 11: Conservation

Legend
- Study area
- Major rivers
- Principal towns

DPaW managed reserves
- Marine Park
- Marine Management Area
- Conservation Park
- National Park
- Nature Reserve
- TPS No. 7 Conservation Reserve
- Former leasehold
- Bushfire prone areas

Wyndham
Broome
Exmouth
Port Hedland
Newman
Carnarvon
Mt Magnet
Kalgoorlie-Boulder
Perth
Norseman
Bunbury
Esperance
Albany
Pannawonica
Tom Price
Paraburdoo

Barrow Island Marine Park
Barrow Island Marine Management Area
Barrow Island Nature Reserve
Boodie, Double Middle Islands Nature Reserve
Airlie Island Nature Reserve
Thevenard Island Nature Reserve
Great Sandy Island Nature Reserve
Bessieres Island Nature Reserve
Serrurier Island Nature Reserve
Little Rocky Island Nature Reserve
Round Island Nature Reserve
Locker Island Nature Reserve
Victor Island Nature Reserve
Rocky Island Nature Reserve
Cane River Conservation Park
Y Island Nature Reserve
Gnandaroo Island Nature Reserve
Burnside & Simpson Island Nature Reserve
Tent Island Nature Reserve
Whalebone Island Nature Reserve
Millstream Chichester National Park
Mungaroona Range Nature Reserve
Karajini National Park
Barlee Range Nature Reserve

Data sources: Landgate, Dept. of Water, Dept. of Aboriginal Affairs, Dept. of the Environment Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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It is noted that the Shire has reserved a number of areas along the coast for conservation in the local planning scheme, primarily in the intertidal area, which contain environmentally sensitive mangrove communities.

The state government has purchased a number of former leaseholds throughout the southern rangelands to expand the state's conservation system. In the Shire this included Ex. Wanna Station (DPaW, 2013a). A new terrestrial conservation reserve has also been planned for the Shire of Ashburton, the proposed West Hamersley Range Conservation Park. A small portion of the proposed Mulgalands Conservation Park, most of which is situated in the Shire of East Pilbara, is also located in the very east of the Shire of Ashburton.

The Hamersley Ranges are a nationally recognised Biodiversity hotspot. They contain numerous endemic mammals, reptiles and plants, and their gorges have been described as 'valuable refuge for plant species', as their topographical location generally protects them from fire (Rangelands NRM, 2010).

The Pilbara Corridors' Conservation Action Planning (CAP) process is now underway and will identify priorities and establish working groups to implement management actions. The CAP process aims to develop and maintain a collaborative, long-term conservation strategy for the Pilbara Bioregion.

2.5.1 Remnant vegetation

Removal of native vegetation is a major process threatening biodiversity in the region. The loss of habitat area through clearing is currently the primary cause of declines in species and populations worldwide (EPA, 2007). Forms of degradation include burning, over grazing, fragmentation, and draining/flooding of land, which can result in the removal of native vegetation and degradation or loss of ecosystems.

Fragmentation of the landscape occurs as a result of removal of large areas of native vegetation, leaving behind small and unconnected remnant bushland. Fragmentation of landscapes also occurs as a result of the construction of large linear infrastructure such as railways and pipelines. Many flora, fauna and communities become threatened as a result of fragmentation, often resulting in diminished biodiversity and extinctions in some areas.

Change in tree cover across the Shire reflects overall removal of remnant vegetation by processes including bushfire, land clearing and other degradation (although bushfire is recognised as having the most significant impact). Data provided in 'Australia's Environment in 2015' (ANU. 2016) indicates that tree cover was approximately 0.5% in 1972, and has fluctuated between 0.2 and 0.5% between 1972 and 2015, with a decrease of approximately half of the area of tree cover since 2012, as shown in Chart 5 below. This is equivalent to a loss of approximately 252 km^2 of tree cover in the Shire. It is noted, however, that the native vegetation of the majority of the Shire comprises grassland, shrubland, and low tree steppe and thus the low percentage of tree cover reflects this.

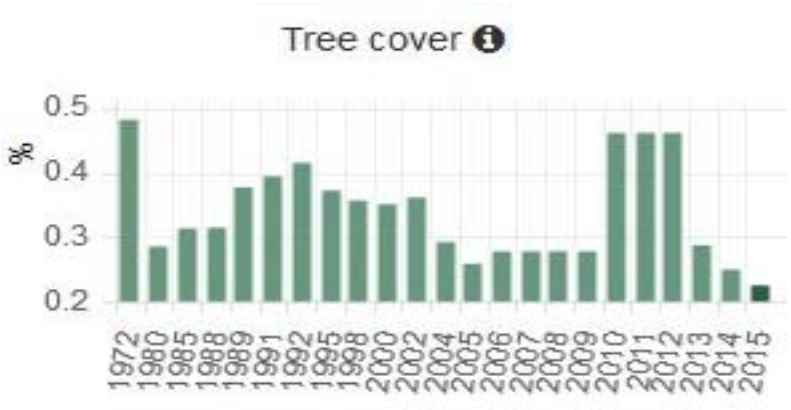

Chart 5: Tree cover (%) in the Shire of Ashburton (Source: ANU, 2016)

2.5.2 Protected flora, fauna and ecological communities

At the Commonwealth level, flora, fauna and ecological communities may be recognised as matters of national environmental significance and are protected under the *Environment Protection and Biodiversity Conservation Act (*EPBC Act), *1999*, administered by the Department of the Environment. The categories of threatened flora and fauna protected under the EPBC Act are (i) extinct in the wild (ii) critically endangered, (iii) endangered and (iv) vulnerable. An additional category of "conservation dependent" exists, which requires special consideration but is not protected under the EPBC Act.

The Commonwealth lists a number of matters of national environmental significance in the Shire including 37 threatened species and 36 migratory species. The threatened species listed under the EPBC Act include the critically endangered bar-tailed godwit (*Limosa lapponica baueri*), and short-nosed seasnake (*Aipysurus apraefrontalis*) (see Appendix 2 for the full listing).

A search of the Department of Parks and Wildlife (DPaW) Threatened Species data base revealed 48 species of rare fauna, including the night parrot, short-nosed seasnake, leaf-scaled seasnake, the loggerhead turtle, and the northern quoll; six specially protected fauna species (including the dugong and whale shark), 30 Species protected under international agreements and 27 species of priority fauna which are known to occur in the Shire (Figure 10).

The DEC Threatened Species data base also contained two listings of declared rare flora (*Aluta quadrata* and *Thryptomene wittweri*) as well as 122 species of priority flora. The Shire of Ashburton contains 20 Priority Ecological Communities and one Threatened Ecological Community, the Themeda grasslands which is dominated by the perennial Themeda (kangaroo grass and many annual herbs and grasses) and exists to the north west of Tom Price. In addition, Beadon Creek near Onslow and other coastal mudflat areas are likely to support mangrove and samphire communities which are of interest to the Environmental Protection Authority (EPA) as benthic primary producer habitat as well as nursery, feeding and breeding grounds for marine fauna. See *EPA Guidance Statement No. 1 – Tropical Arid Zone Mangroves along the Pilbara coastline*, April 2001, for further information.

Flora and fauna is also protected at the State level under the *Wildlife Conservation Act 1950*, administered by DPaW. The *Wildlife Conservation (Specially Protected Fauna) Notice, 2010* recognises four categories of Rare and Endangered fauna taxa, and the *Wildlife Conservation (Rare Flora) Notice 2012* recognises two categories of rare flora. In addition, DPaW also classifies flora and fauna under five different Priority codes, with different management requirements.

DPaW have recorded a number of threatened species in the Shire which are summarised in Table 9 and listed in Appendix 2.

Table 9: Threatened and priority flora and fauna in the Shire of Ashburton (DPaW, 2016)

Conservation Status (*Wildlife Conservation Act, 1950*)	No. fauna species	No. flora species
Threatened – Critically endangered	3	-
Threatened – Endangered	4	1
Threatened – Vulnerable	41	1
Protected under international agreement	30	-
Other specially protected fauna	6	-
Priority 1	4	29
Priority 2	6	24
Priority 3	3	58
Priority 4	14	11
Total	**111**	**124**

2.5.3 Offshore islands

The Shire of Ashburton also contains a number of offshore islands, which are part of the chain of Mackerel Islands that provide important marine habitat and marine resources including petroleum. Barrow Island is the second largest island in Western Australia with an area of 202 km^2. It is a Class A nature reserve designated for the "Conservation of Flora and Fauna" and is surrounded by the Barrow Island Marine Park and Barrow Island Marine Management Area (Figure 12). The Barrow Island nature reserve is considered one of the most important conservation reserves in the State due to its importance as a biological refuge. The island is home to 22 endemic species of mammal, reptile, bird and subterranean fauna (DPaW, 2015), many of which are considered threatened fauna (20 taxa) because they are not found on the mainland (EPA, 2007). Both Barrow Island and Thevenard islands are subject to mining activity associated with Chevron's Gorgon LNG project.

2.5.4 Aquatic ecosystems

Stygofauna are animals that live permanently in groundwater systems, in habitats ranging from minute spaces between sand grains to pools and streams in caves (DPaW, 2016). Troglofauna occur in humid air chambers in underground caves or other smaller voids (EPA, 2003). Most stygal and troglobitic species in Western Australia are invertebrates, although stygal fish and troglobitic snakes do occur in subterranean caves. Crustaceans form the richest group of stygofaunal invertebrates, with the greatest biogeographic significance (EPA, 2003).

Many of these animals have been shown to be endemic to the Pilbara region with highly restricted short range distributions, with some stygofauna even limited to single aquifers. In addition to being endemic, many species have considerable scientific importance and conservation significance because they appear to represent links to the time when Australia was part of Gondwanaland (EPA, 2003). Some studies suggests that stygofauna have important ecosystem service functions, such as the maintenance of water quality in groundwater aquifers (EPA, 2003), which provide the majority of the Pilbara's water supply.

Members of two amphipod stygofauna families, the Melitidae and Paramelitidae, have been extensively collected and documented in the Pilbara mainland as well as Barrow Island (King, 2011). The biology and habitation of stygofauna was also a major focus of the seven year *Pilbara Region Biological Survey 2002-2012* (DPaW, 2013) (Plate 2). As part of this survey, stygofauna found in over 500 bore sites and 20 wetland springs in the Pilbara region were documented from sites representing a cross section of the Pilbara's major geological features and groundwater types (DPaW, 2016). Results from the survey indicate that the region is incredibly rich in aquatic invertebrates and over 300 new species of stygofauna were recorded. The permanent pools and streams of Millstream Chichester National Park are considered a particular hotspot for stygofauna and as a result, are recognised as containing a Priority Ecological Community (Science Network WA, 2012).

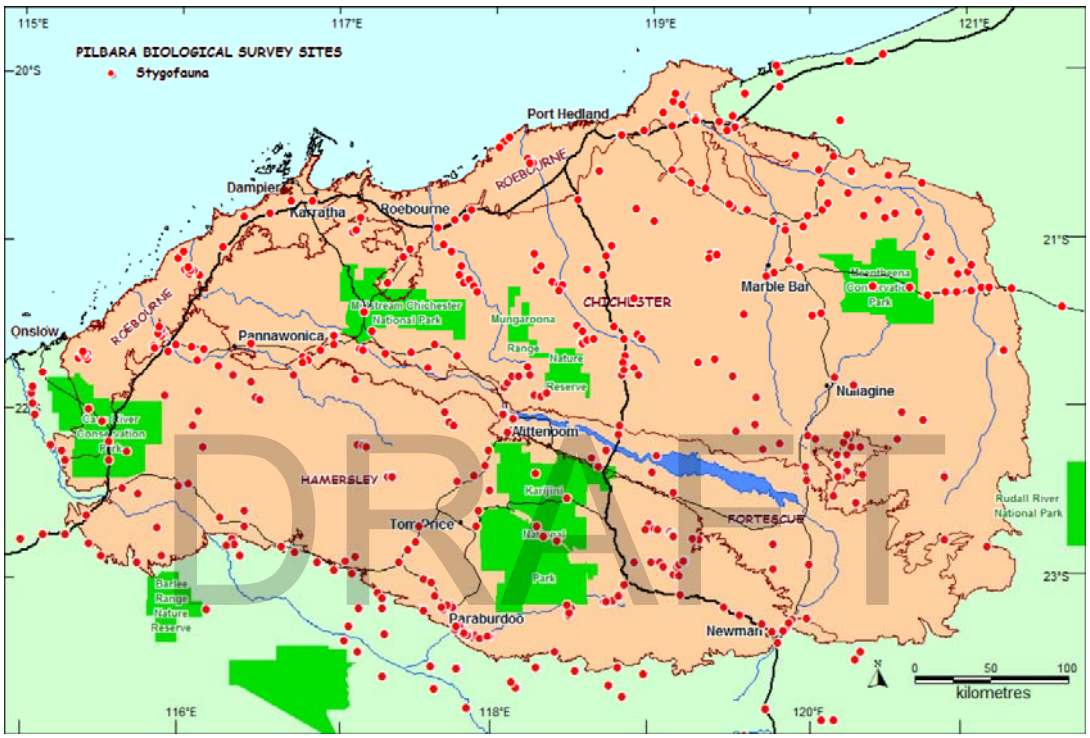

Plate 2: Location of bores sampled for stygofauna during the DEC's Pilbara biological survey in the Pilbara and adjacent IBRA regions

2.5.5 Key strategic environmental planning issues for consideration

Key biodiversity considerations for strategic planning are:

- **Biodiversity** – the Shire is well known for its impressive terrestrial, marine and aquatic biodiversity. A significant proportion of the Shire's biodiversity is protected in a number of conservation areas. No Biodiversity strategy has been prepared for the Shire.
- **Management of conservation areas** – While conservation reserves are managed by the Department of Parks and Wildlife, the Shire may consider active management of the following issues to assist in conservation and protection of biodiversity:
    - **Uncontrolled access** – which leads to direct loss of biodiversity as well as impacts from rubbish dumping, weeds and bushfires.
    - **Weeds -** many Shire reserves with high biodiversity values have aggressive weeds such as parkinsonia and mesquite, which require management, particularly in highly disturbed areas.
    - **Feral animals** - feral animals, especially goats, camels, rabbits and foxes, have a major impact on the native flora and fauna.

2.6 Coastal environment

The coastal environment of the Shire of Ashburton contains a variety of landscapes and land forms, including deltas (such as the Ashburton River delta), wide intertidal mudflats, mangroves, dunes, and long stretches of sandy beach (Figure 12). This variety of coastal habitat types is due to the changing depositional and erosional coastal processes operating along the Pilbara coast. These land and seascapes support a wide variety of marine and terrestrial biodiversity, much of which is recognised at a national level. Seagrass meadows are also prevalent along the Shire coast, and provide habitat and breeding grounds for many forms of marine life.

Intertidal mudflats are a key feature of the mainland shores of the region. As the coast is largely low-lying with extreme tidal ranges, the extensive mud flats are usually exposed at low tide (Nayton, 2011). The flats are well recognised as supporting rich and diverse invertebrate communities and shorebirds including samphire. The mudflats in most cases are bordered by tropical arid-zone mangroves that are of international scientific importance, providing nursery and habitat for commercial fish species, increased inshore productivity, marine nutrient resources, sediment trapping and protection from coastal erosion. Sandy beaches also provide nesting sites for sea turtles and sea birds.

The major activities that occur within the coastal and marine environment of the Shire include recreational activities such as camping, boating, fishing, swimming, diving and 4WDing, as well as commercial fishing and activities associated port facilities.

2.6.1 Offshore islands

The environmental values of the Pilbara coastline and offshore and barrier islands are well known and some of these areas are considered to be the most biologically diverse in the state. Some of the key environmental assets in the coastal and marine areas of the Shire include:

- seagrasses & algal beds that support a diverse fauna of herbivorous fish, marine turtles and dugong (benthic primary producer habitat);
- well established and species-rich coral reefs;
- important and protected marine species including sea turtles, dugong, marine mammals (whales and dolphins), colourful invertebrate communities, seabirds and waders/ shorebirds and marine reptiles;
- important nesting sites for turtles and migratory seabirds; and
- faunal refuges from mainland impacts.

In particular, Barrow and Thevenard Island groups and surrounding marine areas are particularly significant due to their unique biodiversity and the external pressures presented from expansion of the off-shore petroleum industry. They have significant value to the resource industries as locations for port and processing facilities and these can clash with the environmental values of the region.

Barrow Island is one of Australia's leading producers of oil after it was discovered in commercial quantities in 1964 and has supported ongoing production of crude oil from oil fields located on the island since 1967. Oil tankers are filled by a submarine pipeline that extends 10 km offshore. Approval for construction of the Gorgon gas processing hub in 2009 has seen Barrow Island further influenced by development pressures. The gas processing plant on the island is currently facilitating development of the Greater Gorgon gas field approximately 40-110 km to its north. The Port of Barrow Island (Figure 12), controlled by the Department of Transport, is the major site for vessels to import and export resources and supplies to Barrow Island, the Gorgon gas field and surrounding operations.

Taylor Burrell Barnett - Shire of Ashburton Environmental Profile
Figure 12: Coastal environment

Barrow Island Nature Reserve
Port of Barrow Island
Boodie, Double Middle Islands Nature Reserve
Port of Onslow
Airlie Island Nature Reserve
Great Sandy Island Nature Reserve
Thevenard Island Nature Reserve
Port of Ashburton
Little Rocky Island Nature Reserve
Bessieres Island Nature Reserve
Serrurier Island Nature Reserve
Round Island Nature Reserve
Rocky Island Nature Reserve
Victor Island Nature Reserve
Y Island Nature Reserve
Tent Island Nature Reserve
Burnside & Simpson Island Nature Reserve
Whalebone Island Nature Reserve
Locker Island Nature Reserve
Gnandaroo Island Nature Reserve
Onslow
Pannawonica

Legend

- Study area
- Principal towns
- Major rivers
- Boat ramps
- Coastal infrastructure
- Petroleum & gas pipelines

DPaW managed reserves

- Marine Management Area
- Marine Park
- Nature Reserve
- TPS No. 7 Conservation Reserve
- Port authority controlled waters
- Department of Transport controlled waters
- Seagrass distribution
- Aquaculture pearling sites

Coastal landform

- Beach Ridges
- Intertidal Surfaces
- Sand Mantles
- Small Parabolic Dunes (<1km long)
- Transverse Dunes

Data sources: Landgate, Dept. of Transport, DPaW, Pilbara Ports Authority, Geoscience Australia, Dept. of the Environment Created by: H Lamparski. Projection: MGA50: zone 50.

Scale 1: 750,000 @ A3
0 30 km

essential environmental

Wheatstone is a liquefied natural gas (LNG) plant under construction in the Ashburton North Strategic Industrial Area (ANSIA), being developed by Chevron on the Shire coast approximately 11 km south-west of Onslow. The first LNG is expected to be processed by mid-2017. ANSIA and the Port of Ashburton (managed by the Pilbara Ports Authority) provide the industrial land and transportation facilities to export gas for both the Wheatstone LNG and nearby Macedon domestic gas project (developed by BHP Biliton). The Port of Onslow (managed by the Department of Transport) at Beadon Creek is used more generally as a maritime facility for the resources sector, fishing and charter vessels.

The Mackerel Islands is another group of islands, located approximately 20 km off the coast of Onslow that abound with tropical marine life and habitat. Two of the major islands, Thevenard and Direction Island, have been leased for tourist accommodation facilities since 1968. Thevenard Island (classified as a Nature Reserve) has also been the hub from which crude oil from Chevron-operated offshore petroleum reservoirs is processed and readied for shipment by ocean tankers to Australian refineries since the late 1980s.

In addition, oil and gas processing facilities have been operational on Airlie Island (managed by Apache) since the late 1980s. Oil and gas facilities on and offshore Thevenard Island are currently in care and maintenance mode, and are expected to be decommissioned from 2016. Onshore decommissioning and remedial work is expected to take two years.

Projected increases in shipping demand for port facilities is expected as large scale oil and gas projects increase their production and export. This means that effective management of dredging activities, construction of land based infrastructure, and installation of subsea infrastructure, will become critical in the near future in order to ensure that impacts on coastal and marine values in the Shire are minimised.

Dredging often results in the loss of benthic primary producer habitat such as mangroves, seagrasses and algal beds. Degradation of the marine environment may also occur as a result of industrial discharge or accidents (oil spills) from adjacent industrial and mine processing sites, wastewater treatment plants or vessel traffic. Potential threats are also thought to occur from acoustic pollution, excessive lighting (to which nesting and hatching turtles are very sensitive), and aquaculture, which may restrict feeding grounds and interfere with preferred travel routes of marine life. There are major implications for the coastal and marine environment if degradation pressures continue. Marine ecosystems will become more fragmented and less equipped to adapt to changing conditions, such as the effects of climate change (EPA, 2007).

The *Barrow Island Act 2003* was ratified to authorise the implementation of an agreement between the State government and the Gorgon joint venturers to undertake offshore production of natural gas on Barrow Island. The agreement regards the need to minimise environmental disturbance on Barrow Island and provide support for conservation programs relating to Barrow Island and other areas. As part of the environmental approvals process, the Gorgon Joint Venture participants agreed to fund a series of conservation initiatives. Draft Environmental Assessment guidelines for Protecting the Quality of Western Australia's Marine Environment were developed by the EPA in 2014, and provide a basis for management of marine environmental quality in WA, including discharge regulation, the environmental management of ports and marinas, and environmental quality management in marine parks and reserves.

2.6.2 Fishing

Commercial fishing is an important industry in the Shire, with the major regional fisheries including: Onslow Prawn Managed Fishery, Pilbara Trap Managed Fishery and the Pilbara Trawl Managed Fishery. A small pearling industry is also based in the waters around Onslow.

Substantial closures of trawling fisheries in coastal and offshore waters were introduced to manage impacts of finfish trawling by Australian vessels (subject to Ecologically Sustainable Development requirements under the EPBC Act 1999). However, trawling is still permitted in a small number of limited locations. Spanish mackerel fishing occurs from vessels around reefs shoals and headlands. The catch has more than doubled since 2009 in the bioregion. The Department of Fisheries *State of the Fisheries Report 2014/15* notes that stock levels of Pearl Oysters and Onslow/Nickol Bay Prawns are currently adequate.

Pearl Oyster industry was classified by the Department of Fisheries as having a 'low' ecological risk, while prawning and finfish (Spanish Mackerel) were classified as 'moderate' in 2014/2015. Introduced pests and species were classified as a 'high' current risk status of impacting the Bioregion, while Climate and Oil & Gas Development Activity were both classified as 'low' risk.

The only fisheries in the region that have reported any interactions with Endangered, threatened and protected species (cetaceans, dugongs, marine turtles, sea snakes, elasmobranchs, seahorses and pipefish, crocodiles, seabirds and migratory shorebirds) are the two trawl fisheries, the Onslow Prawn Managed Fishery (OPMF) and the Nickol Bay Prawn Managed Fishery (NBPMF) (as well as Gillnet Barramundi Fishery). However, interactions are few due to use of bycatch reduction devices and separation of trawling activities from most protected species' primary habitat.

Aquaculture development is dominated by pearling. Establishment of an aquaculture zone is being considered by the Department of Fisheries. The establishment of an aquaculture zone would streamline the processes for commercial projects, leading to the development of further aquaculture operations in the region. Marine production of barramundi is also in development.

Recreational fishing experienced significant growth in 2014/2015, with a seasonal peak occurring in winter when tourists swell the local population. Angling fishing is boat-based, and small boat fishing occurs in creeks, mangroves, rivers and ocean beaches.

Recreational fishing is managed through size and catch limits based on risk categories for various species. In addition, the Department of Fisheries is able to monitor the intensity of recreational fishing through the recent change to licensing of recreational boat users. A large proportion of the Pilbara community own or have access to a boat and undertake recreational fishing. Although recreational fishing activities are likely to continue as population increases, the overall population of the Pilbara is still fairly low and their impact on fish stocks is considered to be manageable (*State of the Fisheries Report 2014/15,* DoF,2015).

2.6.3 Ports

The Port of Ashburton in ANSIA is a relatively recent addition to the Pilbara region, only formally vested to the Pilbara Ports Authority in December 2011. The Port of Ashburton is a multi-user port with common infrastructure to support the export of LNG and downstream hydrocarbon products. The coastal area and port remain Crown Land with a Reserve for Port purposes. Chevron Australia is using the port facilities at ANSIA as part of their Wheatstone LNG Project.

The main boat harbour in the Shire is at Beadon Creek near Onslow, with plans to expand in the near future. A number of boat launching ramps are also located around Onslow for use by the community. While there is significant commercial and recreational activity around Onslow, the remainder of the Shire's coastal zone is sparsely settled and is generally used for pastoral activities.

2.6.4 Tourism and coastal camping

There are currently no designated sites for coastal camping in the Shire of Ashburton. However, some camping is known to currently occur at the mouth of the Ashburton River and along other areas of the coast. Impacts from recreational use of the coast are increasing, with greater numbers of people having access to the coast, seeking off road experiences, camping, boating and fishing.

Concerns identified by the community and managers of the coastal and marine environment in the Shire include:

- the sustainability of consumptive recreational activities (largely around Beadon Creek), particularly by fly-in-fly-out workers. In particular, management of coastal camping to ensure social, economic and environmental values are protected and enhanced;
- the suitability and enforcement of recreational fishing regulations; and
- the suitability and maintenance of boat ramps and associated facilities (Rangelands NRM, 2009).

The *Onslow Business Investment Guide* (OCCI, 2016) indicates that tourism, aquaculture and commercial fishing provide opportunities to further develop the town of Onslow. In particular, access to offshore islands from Beadon Creek Harbour and Sunset, Sunrise and Four Mile beaches have been considered as coastal environment which will attract visitors as part of tourism experiences. Commercial fishing out of Beadon Creek Harbour and aquaculture are also considered industries with opportunities for growth (OCCI, 2016).

In September 2008, the Federal Court of Australia determined that native title claimed by the Thalanyji existed in large parts of Ashburton's coastal area. Consultation and engagement with traditional owners will therefore be necessary when considering the planning of activities and uses along the coast.

2.6.5 Sea level rise

The coastal town of Onslow contains a significant proportion of the Shire's population and has been under pressure to support the growth of the region, particularly around the oil and gas and mining industries. Current and planned development in Onslow and adjacent to the coast may be vulnerable to the effects of sea level rise and storm surges. This includes the town itself, ports, marinas, boat ramps and other infrastructure, and recreational areas.

The key sea level processes affecting Onslow include tides, cyclonic surges, seasonal variation and inter-annual mean sea level variations. The spring tide range in Onslow is 1.9 m. Cyclonic storm surges of up to 0.8 m have been recorded in Beadon Creek, with anecdotal or inferred evidence of much higher events, particularly on the exposed coast. The most extreme elevated water levels are generally associated with onshore wind events caused by tropical cyclones passing to the west of Onslow.

CSIRO modelling indicates that the continued increase in sea level for both the west and south coasts of the Rangelands are projected with a very high confidence. In Port Hedland (the closest town to be modelled) the projected range of sea level rise is 0.07-0.17m by 2030, and 0.28-0.64 m by 2090. This will have significant implication for existing environments and built infrastructure, particularly at Onslow, and will require management and planning to ensure that the coastal environment is protected.

A coastal vulnerability study was undertaken for Onslow in 2011. The *Onslow Townsite Planning Coastal Setbacks & Development Levels* report (M P Rogers and Associates PL, 2011) focusses on the effects of 100 year ARI storm inundation for current day and 2110, on current infrastructure and future development of Onslow, with recommendations for finished floor levels.

The study recommended setbacks to allow for the action of physical coastal processes. The recommended setbacks in Onslow were calculated to range from 30 m for the area protected by a seawall up to 372 m from the coast. These setbacks could be reduced if low-lying areas were raised prior to development, to allow development of land that would otherwise be unused. The study also noted through cyclone inundation modelling that large areas of Onslow and its surrounds are vulnerable to coastal inundation, and that care must be taken to ensure that any future development is located safely above these inundation levels.

A Draft Coastal Hazard Risk Management and Adaption Plan (CHRMAP) was prepared by Cardno for the town of Onslow, including ANSIA, in August 2016 (Appendix 3). Physical assets and areas with economic, social/cultural and environmental value potentially at risk within the study area were identified. The risk level of thirteen (13) assets or areas of importance were then determined in relation to the impact of coastal erosion and inundation, or fluvial (riverine) inundation hazards, as presented in Table 10 and Table 11 below. Based on the risk level analysis, management and adaption options were recommended for specific assets with the aim of mitigating risk and vulnerability through one or more of the following actions:

- Avoiding the risk;
- Removing the risk;
- Changing the likelihood;
- Changing the consequences;
- Increasing adaptability; and
- Transferring or accepting the risk.

'Avoid' and 'managed retreat' options are the preferred options for new and existing developments. 'Accommodate' options aim to re-design existing infrastructure to mitigate potential impacts as they occur. 'Accommodate' options may also be employed for new developments, when there is no practical option to avoid or retreat from coastal hazards. 'Protect' options are often considered the last line of defence and are the least favourable options. A number of protection options are recommended for each of the thirteen assets including physical maintenance and management, as well as planning actions. These are detailed in Table 5-2 of the Draft CHRMAP for Onslow, as shown in Appendix 3.

The CHRMAP recognises that planning timeframes need to be considered when determining adaptation options. The report also recommends that assets are monitored over time and that potentially no action may be taken until the risk level becomes intolerable. It identifies that relocation can occur as part of future town planning schemes.

Recognition of the need for consideration of storm surge is provided within Town Planning Scheme No 7 through the establishment of the Onslow Coastal Hazard special control area.

Table 10: Risk levels for assets predicted to be under impact from coastal erosion and inundation at Onslow

Assets	Values	Risk Level[1]			
		Present day	2040	2070	2110
On-ground infrastructure at Onslow Jetty	Commercial Aboriginal Public infrastructure Recreational Environmental	Low	High	Extreme	Extreme
Onslow Back Beach picnic area (low risk)		Low	High	Extreme	Extreme
Front Beach / Sunrise Beach		Low	High	Extreme	Extreme
Seawall (the setback allowed for in this section mainly consists of the uncertainty factor required as per SPP2.6)		Low	High	Extreme	Extreme
Seaview Drive near 12 Mile Creek / 4 Mile Beach	Public infrastructure Recreational Commercial Aboriginal	High	High	High	Extreme
Assets adjacent to crest of seawall (bins, shade structures, benches)		Low	Low	Medium	High
Shire of Ashburton Offices at the intersection of Second Ave and McGrath Rd		High	High	Extreme	Extreme
Aboriginal community on Second Ave		Medium	Medium	Extreme	Extreme
Western half of Ian Donald Blair Memorial Walkway	Recreational Public infrastructure	Low	Low	High	High
Intersection of Seaview Drive and Back Beach Road	Public infrastructure Recreational Residential	Medium	Medium	High	High
Eastern end of Ian Donald Blair Memorial Walkway		Low	Medium	High	High
Lot 381 (at the top of the hill at Beadon Point)		Medium	Medium	Medium	High
Second Ave		Medium	Medium	Medium	High

[1]Risk evaluation and ranking based on likelihood and consequence analysis, as per Table 12 and Table 13 below

Table 11: Risk levels for assets predicted to be under impact from fluvial inundation in Onslow under the 2015 timeframe

ARI event	Assets type	Planning timeframe[2]			
		Present day	2040	2070	2110
100 year	Housing, buildings & property	High	High	Extreme	Extreme
	Parks & recreation grounds	Low	Low	Medium	High
	Public infrastructure (fencing, light poles, playgrounds etc.)	Low	Low	Medium	High
	Car parks	Low	Low	Medium	High
	Roads / footpaths	Medium	Medium	High	High
	Sheds	Low	Low	Medium	High
500 year	Housing, buildings & property	High	High	Extreme	Extreme
	Parks & recreation grounds	Medium	Medium	High	High
	Public infrastructure (fencing, light poles, playgrounds etc.)	Medium	Medium	High	High
	Car parks	Medium	Medium	High	High
	Roads / footpaths	High	High	High	Extreme
	Sheds	Medium	Medium	High	Extreme

[1]Risk evaluation and ranking based on likelihood and consequence analysis, as per Table 12 and Table 13 below

Table 12: Risk priority matrix (adapted from CHRMAP guidelines (WAPC, 2014))

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	High	High	Extreme	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Possible	Low	Medium	High	Extreme	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Medium	High	High

Table 13: Risk levels and tolerances (example from CHRMAP guidelines (WAPC, 2014))

Risk level	Action required	Acceptance / tolerance
Extreme	Immediate action required to eliminate or reduce risk to acceptable levels	Unacceptable
High	Immediate to short-term action required to eliminate or reduce risk to acceptable levels	Tolerable / unacceptable
Medium	Short to medium term action to reduce risk to acceptable levels, or accept risk	Tolerable
Low	Accept risk	Acceptable

2.6.6 Tides

Although the tidal range in the Shire is moderate, the Shire has recognised an area of tidal influence within a town planning scheme special control area. The key purpose of this area is to consider the impact of any proposed development on the natural environment, in particular the mangrove ecosystem and the potential for storm surge impacts.

Three tidal creeks and coastal lagoons are present within the study area; the Ashburton Eastern Delta Entrance and lagoon, Hooley Creek and Four Mile Creek. Hooley Creek and the Ashburton Delta eastern lagoon are recognised as valuable mangrove and tidal creek habitats which support a variety of marine fauna, including protected species such as sawfish and juvenile turtles.

2.6.7 Key strategic environmental planning issues for consideration

Key coastal considerations for strategic planning are:

- **Sea level rise** – consideration of sea level rise, vertical allowances and setback distances will be required when managing existing infrastructure and planning future development, as per IPCC and CSIRO modelling and coastal vulnerability studies. Ensure that any substantial future development is supported by a current storm surge and flood inundation study consistent with the most current predictions for sea level rise and coastal processes, consistent with State Planning Policy 2.6: State Coastal Planning Policy (2014).
- **Commercial activity** – Planning for and management of activities associated with the resources industry, commercial fishing and aquaculture must consider impacts on sensitive coastal environments which provide habitat for coastal and marine life. Consideration should be given to the location of supporting industrial areas, which adequately manage any potential off-site or environmental impacts. In addition, coastal spaces which are shared with recreational activity should be planned to ensure multiple, cumulative impacts on sensitive environments are considered and impacts are appropriately managed.
- **Tourism** – management and planning of sustainable tourism activity such as camping, boating, swimming, fishing, and 4WDing, and development around sensitive coastal environments such as beaches, river mouths (Beadon Creek), and seagrass meadows, will be critical with population and industry growth, development of tourism, and townsite expansion.
- **Traditional owners** - engagement with traditional owners should be considered to ensure that cultural heritage values are not lost, particularly within the native title area for the Thalanyji community.

2.7 Hazards and natural disasters

2.7.1 Bushfire risk

Fire plays an important part in maintaining the landscape of the Pilbara region. Fire helps shape the diversity of plants and animals (EPA, 2007). Many native plants have evolved fire-related adaptations over time, such as fire-induced flowering or smoke-induced germination. Fires are most often naturally started by lightning strokes. Electrical storms are common in the Pilbara particularly in some remote desert areas, and can result in the ignition of multiple fires across a vast area at the same time. These fires are particularly difficult to control due to the vast areas of land and their inaccessibility (EPA, 2007). Fire in the rangelands has been used as a land management technique, first by the Aboriginal inhabitants and later by the pastoral industry.

Natural regimes have been altered significantly with the settlement of humans in the region. Altered fire regimes, particularly those that occur late in the dry season in the Pilbara, have the ability to significantly impact on the land and biodiversity values of the area. They have the potential to change ecosystems and the composition of species within (EPA, 2007). In addition to electrical storms, fires are also started by human error in remote areas and have the ability to cause widespread damage, burning out of control in the hot, Pilbara climate. Problems occur when ecosystems are burnt too often and can lead to loss of biodiversity through inadequate recovery and reproduction times for many plants and animals (EPA, 2007). This can result in a simplification of ecosystems. Animals can be adversely impacted upon if they have limited capacity to escape fire or to find alternative food sources and shelter if fire temporarily removes habitat.

Fires can also exacerbate or cause additional threatening processes to occur such as soil erosion, release of particulates to the atmosphere and weed invasion. Fires can also result in the release of greenhouse gases. Very intense fires which destroy mature native vegetation can contribute to long-term ecosystem change by removing adults and leaving new seedlings vulnerable to drought (EPA, 2007).

The frequency of fires in the Shire has varied considerably between 2002 and 2015 (no data was available in 2000 or 2001), as shown in Chart 6. Chart 6 demonstrates the approximate geographic area of the Shire which experienced fire during each year. For example, in 2015 a frequency of 0.08 may be interpreted as approximately 8% of the Shire experienced fire during that year.

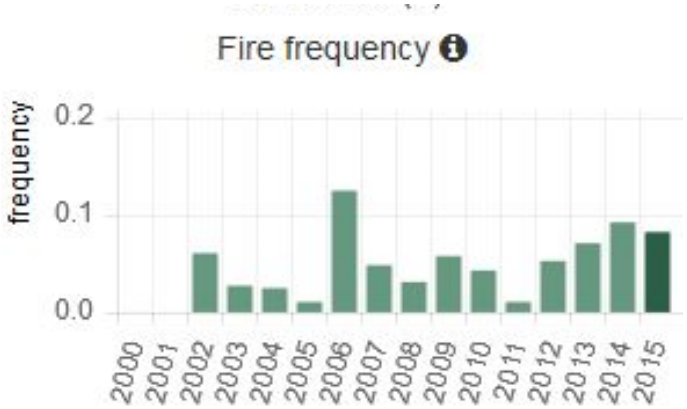

Chart 6: Fire frequency in the Shire of Ashburton (no. of fires per 2.5 km grid cell) (ANU, 2016)

Data recorded for the overall Pilbara bioregion also varied considerably between 1997 and 2005, as indicated in Table 14, with relatively large areas burnt in 1997 and 2000 (DSEWPaC, 2008). The majority of fires occurred during the hotter August to December period and were presumed to produce hotter, more intense burns than fires in other months (DSEWPaC, 2008). This confirms the strong link between climate and fire intensity.

Table 14: Percentage of areas burnt as a result of bushfires in the Pilbara bioregion 1999-2005 (DSEWPaC, 2008)

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
% area burnt	20.1	2.5	9.7	25.8	9.4	11.8	3.1	3.1	1.1

In accordance with the Map of Bush Fire Prone Areas gazetted by the Department of Fire and Emergency Services, the overwhelming majority of the Shire is designated as a Bush Fire Prone Area (see Figure 14), with the exception of relatively small areas cleared for urban development or agriculture, water bodies, and areas affected by mining.

Future planning and development within Bush Fire Prone areas will need to meet the requirements of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) (2015) and the *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015).

2.7.2 Flood risk

Many rivers and creek pass through or near to the townships and communities of the Shire, flowing inland from the Hamersley Ranges, west across the plains towards the Indian Ocean. Severe flooding of these waterways is a well-known risk to towns and communities in the region during the wet season, particularly during extreme cyclonic events when flood waters travel fast and wide.

Historically, major flooding in Onslow has been typically associated with storm surge rather than heavy rainfall, though localised flooding will occur in low-lying areas adjacent to Beadon Creek.

A review of the Onslow townsite drainage system was undertaken in 2010 and assessed the condition of the existing drainage infrastructure. It identified a number of drainage issues in the townsite as follows (GHD, 2010):

- The hydraulic gradient of the drainage system is limited by sea level and existing natural surface levels. The surface levels through the town are low lying, generally varying between 2 and 4 m AHD.
- Undrained low points were observed along the intersections of Simpson Street, Third Street and Third Avenue which are subject to localised ponding. Similarly inconsistent and flat grades of the stormwater pipes on Third Avenue do not allow stormwater to flow effectively.
- Unkerbed roads within the town prevent the containment of runoff within the road corridor, allowing adjacent lots to be potentially flooded during major storm events.
- Three stormwater basins (in Second and Third Ave) fill periodically and provide an environment that promotes mosquito breeding, posing a health risk.

The Onslow Townsite Development Local Water Management Strategy (LWMS)(Hyd2o, 2012) addresses flood protection for Onslow by defining an approach based on safe conveyance of flood flows to receiving water bodies rather than attenuation. One of the recommendations of

the LWMS is to extend the existing watercourse/drain which flows to the Beadon Creek harbour and grade it appropriately to enable drainage from the townsite to access this outlet. The LWMS also specifies that overland flow paths should occur in road reserves and linear public open space corridors for the safe conveyance of 100 year flows off site; that habitable building floor levels are set at 0.5m above 100 year flooded stormwater levels; and that habitable building floor levels are set at 100 year storm surge levels allowing for 100 year climate change.

Any future development in proximity to waterways within the Shire will be required to be consistent with *State Planning Policy 2.9: Water Resources* to minimise risk of flooding, and manage the safety or lives and property when flood events do occur.

2.7.3 Key strategic environmental planning issues for consideration

Key hazards and natural disasters considerations for strategic planning are:

- **Bushfire risk** – the majority of the Shire is identified as being Bush Fire Prone. Future planning and development within Bush Fire Prone areas will need to meet the requirements of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) (2015) and the *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015). Consideration also should be given to the location of firebreaks in semi-rural areas around townsites and emergency management including access routes; and
- **Flood risk** – Townships and communities associated with waterways in the Shire may be subject to risk of flooding. Any proposed development should be consistent with *State Planning Policy 2.9: Water Resources* and in Onslow, consistent with the Local Water Management Strategy, and address flood risk appropriately.

It is not considered necessary to include a special control area in a local planning future scheme to highlight either bushfire risk or flood risk, as these issues are adequately addressed through existing policy.

2.8 Heritage

Heritage is important in understanding the history, identity and people of a region, and exists in many forms both tangible and intangible, such as places, objects, landscapes, languages and customs. The value of heritage places in the Pilbara may be recognised by the natural and cultural values that are significant for aesthetic, historic, scientific, or social reasons (*Environment and Heritage Legislation Amendment Act (No. 1) 2003*).

The Pilbara is well known for its rich Aboriginal history, modern European history and unique and diverse natural heritage. The numbers of national and state heritage sites identified on various heritage lists is presented for the Shire in Table 15 and Figure 13. It should be recognised that a search of the Department of Aboriginal Affairs (DAA) database does not comprise a full assessment of existing Aboriginal sites under the *Aboriginal Heritage Act 1972*.

Table 15: Number of heritage sites within the Shire of Ashburton (Source: Australian Heritage Database, DAA Aboriginal Heritage Inquiry System* and inHerit - State Heritage Office^)

Local Government Area	No. heritage sites
RNE – Historic	4
RNE – Indigenous	3
RNE – Natural	17
DAA Registered Aboriginal Sites*	1,655
Municipal Inventory^	28

2.8.1 Aboriginal Heritage

The Pilbara region is home to a great variety of traditional landowner language groups, many of which have a strong spiritual, physical and cultural connection to their region and landscape. Aboriginal people are thought to have inhabited the region for up to 40,000 years. As such a rich cultural and historical indigenous heritage exists in the region, particularly in natural features such as rivers, hills and rock formations where people, animals and characters left traces of their journey across the landscape. These places may be valuable because of mythological lore (The Dreaming); because of past use as meeting places for special ceremonies; as burial grounds for ancestors; or as places where culture and history was recorded through rock art. The location of these important cultural sites within the natural landscape means there is considerable overlap between Aboriginal and natural heritage in the region.

Aboriginal heritage is an integral part of Aboriginal culture, customary law, and spirituality. Therefore, its conservation is critical in ensuring that the unique indigenous culture in the Shire is not lost. The protection of Aboriginal heritage also requires consideration of the 31 individual languages identified in the Pilbara, many of which have between two and five dialects (Wangka Maya Pilbara Aboriginal Language Centre, 2016) and their ability to access sites of cultural significance, as well as the heritage sites themselves.

The original inhabitants of the Ashburton area are the Yamatji people of the Murchison, Gascoyne and Pilbara regions. The main Aboriginal groups living within the Shire include (but are not limited to) (DAA, 2015; AIATSIS, 2016 and NNT, 2016):

- Nhuwala;
- Jadira;

- Kuruma;
- Marduthunera;
- Banjima;
- Inawongga;
- Jurruru;
- Pinikura;
- Thalanyji;
- Tenma;
- Djiwal;
- Yindjibarndi;
- Budina;
- Gnulli;
- Palyuku;

Given the historically fluid nature and often forced movement of Aboriginal people, this list should not be considered complete nor final, but gives an indication of the diversity of people, culture and language within the Shire.

The local Traditional Owners in the Onslow area are the Thalanyji people. The Thalanyji cultural tradition is associated with the rainbow serpent Burra Balanyji that created underground tunnels in the area which link all of the water bodies around Onslow – the rivers, the creeks and all the fresh water soaks (Shire of Ashburton, 2010).

Over 1,600 indigenous heritage sites have been identified in the Shire and are protected under the *Aboriginal Heritage Act 1972*. The geographical spread of places in the Aboriginal Heritage Sites Register largely reflects where Aboriginal heritage surveys have been conducted (EPA, 2007). As heritage surveys are normally undertaken in response to development proposals, large areas of the region have not been surveyed. Therefore site identification is biased towards areas subject to recent development.

The DAA maintains a register of known Aboriginal sites, which records the places and objects of significance that the *Aboriginal Heritage Act 1972 (WA)* applies to. The presence of an Aboriginal site places restrictions on what can be done to the land. Anyone proposing to undertake activity upon land on which an Aboriginal heritage site is located will require permission through engagement and consultation with the region's traditional owners and may be required to first apply for consent from the Minister for Aboriginal Affairs under section 18 of the *Aboriginal Heritage Act 1972*. The Aboriginal Heritage Due Diligence Guidelines (DAA & DPC, 2013) describes the list of land use activities and associated risk of disturbance to an Aboriginal heritage site to determine whether a Section 18 application may be required. Data from the DAA presented in Table 16 indicates that the number of Section 18 applications lodged for the Shire increased between 2008 and 2012. This reflects the increase in activity in the Shire, where the number of applications has doubled in 2011-2012.

Table 16: Number of lodged Section 18 applications in the Shire of Ashburton (Source: DAA, 2013)

Year	No. applications
2008	10
2009	8
2010	8
2011	19
2012	22

There have been 44 Indigenous Land Use Agreements (ILUAs) registered within the Shire of Ashburton since 2001. An ILUA is a voluntary agreement between a native title group and others about the use of land and waters. These agreements allow people to negotiate flexible, pragmatic agreements to suit their particular circumstances. An ILUA can be:

- over areas where native title has, or has not yet, been determined;
- entered into regardless of whether there is a native title claim over the area or not;
- part of a native title determination or settled separately from a native title claim.

ILUAs can cover topics such as:

- native title holders agreeing to a future development;
- how native title rights coexist with the rights of other people;
- access to an area;
- extinguishment of native title;
- compensation;
- employment and economic opportunities for native title groups;
- cultural heritage; and
- mining.

When registered, ILUAs bind all parties and all native title holders to the terms of the agreement.

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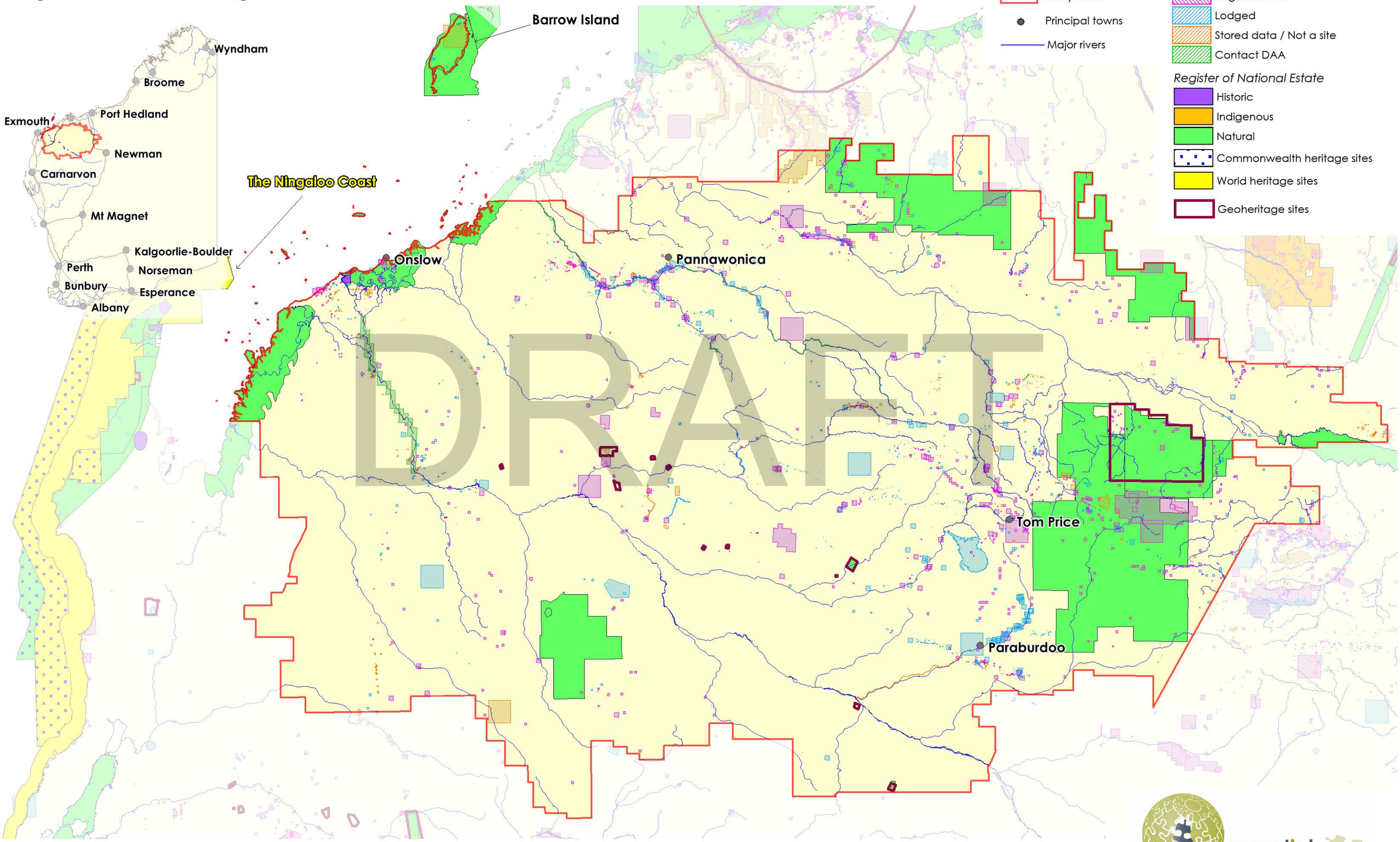
Figure 13: Heritage



Data sources: Landgate, Dept. of Water, Dept. of Aboriginal Affairs, Dept. of the Environment, DMP Created by: H Lamparski. Projection: MGA50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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2.8.2 European Settlement Heritage

The original town of Onslow was gazetted as a townsite on 26 October 1885 and named after Sir Alexander Onslow, the Chief Justice of Western Australia at the time (SoA, 2016). It supported the nearby stations that had been established along the Ashburton River and the gold mines that had developed in the hinterland. One of the first recorded stations was Minderoo which was established in 1882. By 1890 all land along the Ashburton River had been taken up, running mainly sheep, but also a few cattle (SoA, 2016).

In the early days of settlement, pearls were found in the Exmouth Gulf and Onslow and pearling became home port to a fleet of pearling luggers. By 1925, the port facilities at the mouth of the Ashburton were affected by the silting up of the river causing more and more problems in the loading and unloading of visiting ships (SoA, 2016). Today pearling is a small industry with the shells farmed for blister and culture pearls.

Mining of the now infamous blue asbestos began in the region in 1937 in Wittenoom Gorge (Rom and Markowitz, 2007), and following the discovery of iron ore in the Hamersley Ranges in the 1960s, mining became the dominant driver of the region and state's economy with towns built to accommodate the mining boom.

Onslow was actively involved in World War II with the Navy refuelling at the jetty and the town becoming the furthest town south to be bombed by the Japanese. Onslow was also used as a base by the Royal Navy between 1952 and 1956 to conduct tests on the nearby Monte Bello Islands. On 3rd October 1952 the British conducted their first atomic bomb tests on the Monte Bello Islands as part of Operation Hurricane (DEC, 2009).

Surveys proved that there was deep water at Beadon Point and so the town was moved some eighteen kilometres to the east to where it is today (SoA, 2016).

Evidence of the region's colonial European past remains in the form of a number of preserved heritage sites, of which four are recognised on the Register of National Estate (Table 15).

A large number of historic heritage sites are located within the Shire, and registered with both the Heritage Council of WA and the Shire of Ashburton Municipal Inventory (State Heritage Office, 2016). A small number of key sites, including the Old Onslow Townsite, Bessieres Island Lighthouse, and Tambrey Station Homestead (ruins) and Surrounds are also part of the Register of National Estate and the National Trust.

A large number of historic shipwrecks have also been identified off the Pilbara coast, associated with the region's European history. Sixteen wrecks have been identified in the Onslow area on the Australian National Shipwreck Database, dating back to 1868 (DSEWPaC, 2016).

Like in many areas of Australia, European settlement resulted in the introduction of disease, alcohol, indentured labour and the forced removal of Aboriginal children from their families by government agencies of the time.

In contrast to the historical settlement of Onslow, Pannawonica and Paraburdoo were gazetted as 'closed towns' in 1972, meaning that the towns were purpose-built and were managed by a mining company (in this case Rio Tinto). Facilities at the towns were limited for visitors and accommodation is reserved for mining staff. Tom Price was also founded as a mining town and was gazetted in 1964. It is still primarily serves to support the local mining activity. All but Pannawonica have been naturalised and are now managed by the Shire.

2.8.3 Natural Heritage

The natural heritage of the region is renowned because of its unique and diverse collection of marine and terrestrial landscapes and habitats. Twenty natural heritage sites within the Shire are listed on the Register of National Estate (Table 15). In addition, the region's unique natural heritage is largely preserved and managed through the conservation reserve system and the identification of numerous national parks and nature reserves, including Karijini National Park, Millstream-Chichester National Park, and Barrow Islands National Park.

The Shire also contains a number of sites of important world geoheritage, some of which contain the oldest known examples of fossil stromatolites (3.5 billion years old) (DMP, 2016b). These fossils are identified and managed through the Geological Survey of Western Australia, twelve of which are located within the Shire (shown in Figure 13). They are considered the best preserved and oldest indicators of early life on Earth.

2.8.4 Key strategic environmental planning issues for consideration

Key heritage considerations for strategic planning are:

- **Protection of heritage sites and values** – While heritage is primarily managed through State and Commonwealth legislation, opportunities exist to protect and promote both Aboriginal and European cultural heritage through joint management arrangements with traditional owners and optimise opportunities for Indigenous training, employment and businesses. Consideration should also be made to Native Title and ILUAs when considering any planning or development proposals, in discussion with appropriate Traditional Owners.
- **Engagement with Traditional Owners** – is required to meet legislative requirements of Native Title. Increased benefits may be observed through an elevated level of involvement of the Traditional Owners within the Shire in terms of land and cultural heritage management.

3 SUMMARY

The Shire of Ashburton ('the Shire') is the southern most local government area in the Pilbara region. It is located approximately 1,000 km north of Perth and comprises over 100,000 km^2. The Shire is best known for mining, agriculture and fishing, and for its rugged, ancient landscape supporting tourism in the region. It is home to some of the world's largest open cut mines, immense pastoral leases and cattle stations, and thriving prawn, pearl and mackerel fishing industries.

The Community mission for the Shire is

'working together, enhancing lifestyle and economic vitality'

The Shire's Community Strategic Plan defines key environmental outcomes to be delivered in the Shire of Ashburton as *maintaining the integrity and quality of the Shire's natural environments, together with celebrating and valuing the Aboriginal and European history and heritage, with the aim of being a recognised leader in sustainability practices.*

The Shire of Ashburton has commenced the process of preparing a Local Planning Strategy (LPS) to guide future growth and development. In order for these outcomes to be achieved in the future, it is critical that the natural and environmental assets of the Shire are recognised, and any environmental opportunities and constraints are considered as part of the LPS process. This report provides a snapshot of the Shire's environmental context and highlights opportunities and constraints for consideration.

The key environmental context and considerations are summarised as follows:

- Increases in temperature and extreme weather events as a result of climate change have the potential to impact on the health of the environment and the community, as well as the maintenance of public lands and capacity of infrastructure systems including those managed by the Shire;
- The broad and diverse landforms of the Shire, from the Hamersley Ranges in the inland east, to the flood plains and coast in the west, underpin the soil, water and vegetation characteristics. The great river systems that flow across the Shire, through the steep gorges and hills and across the scrubby steppe regularly flood the surrounding landscape during the wet season and tropical cyclones and form important catchments for surface water runoff and feed groundwater systems;
- Minerals extraction and processing will continue to occur throughout the Shire. Clearing of the land for resource extraction results in a loss of biodiversity and can lead to erosion. Mining activities can also lead to the lowering of groundwater tables, and can also impact on the visual landscape of the Shire and can result in off-site impacts on nearby land uses including dust, noise and light;
- Flooding occurs semi-regularly in the Shire, particularly during the wet season and extreme tropical cyclones. Adequate management of flood risk, and associated sediment transport in townsites and industrial areas requires consideration consistent with *State Planning Policy 2.9: Water Resources*. The Shire may need to review existing townsite drainage systems and ensure appropriate levels of service will be maintained as development occurs (such as at Onslow Airport) and water quality including sediments in stormwater is addressed.
- Groundwater is available for allocation in many aquifers, however, declining rainfall in coastal areas may result in reduced recharge and consequently availability in these areas in the future, particularly as population and industry expands. Dewatering/over-abstraction have also impacted local groundwater levels and thereby potentially affecting groundwater-dependent pool ecosystems and wetlands through drying up

and loss of habitat, affecting vegetation and wildlife dependent on them as well as groundwater-dependent cultural and social values. This is especially critical given the presence of proposed Ramsar sites, and nationally important wetlands in the Shire.

- The Shire contains a number of important water resources which supply drinking water to the region. These areas should be protected and managed in accordance with relevant water source protection plans, DoW's Water Quality Protection Note 25 and State Planning Policy 2.7: *Public Drinking Water Sources*.
- It is recognised that the Shire is a Waterwise Council, and it should continue to investigate and expand water efficiency opportunities, such as irrigation of public open space and sports ovals where practical. The Shire could also investigate partnerships to establish water recycling and reuse schemes to provide fit-for-purpose sources of water where practical, as an alternative to groundwater use to support future development.
- The Shire is recognised as having significant terrestrial, marine and aquatic biodiversity. The level of reservation of land for conservation purposes in the Shire of Ashburton is much greater than the rest of the Pilbara and greater than the internationally recognised standard of reservation of between 10% and 15% of each bioregion.
- The Shire contains a number of areas which have been reserved for conservation. While many conservation reserves are managed by the Department of Parks and Wildlife, the Shire could consider active management of weeds, uncontrolled access, and feral animals to assist with vegetation retention, which in turn assists in the maintenance of soil health. Soils and vegetation (grasslands and shrublands) in good condition are also associated with higher agricultural productivity.
- Sea level rise and coastal vulnerability will increase along the rangelands coastline in the near future. Management of existing infrastructure and planning future development will require consideration of vertical allowances and setback distances.
- Expansion of tourism, commercial fishing, aquaculture and resource industry activity will increase pressure on sensitive and productive coastal marine environments which provide habitats and breeding grounds (seagrass meadows, turtle nestings on beaches, river mouths/intertidal mud flats) for marine life. Recreational activity (camping, coating, fishing, swimming and 4WDing) around sensitive coastal environments associated with population growth and industry development will also impact upon local biodiversity and environmental values.
- Coastal spaces which support recreational activity should consider cumulative impacts on sensitive environments and minimise impacts through appropriate management.
- The majority of the Shire is indicated as being located within a Bush Fire Prone Area of Western Australia as designated by the Fire and Emergency Services (FES) Commissioner. Any future planning and development within a designated Bush Fire Prone area should be consistent with the requirements of *State Planning Policy 3.7 Planning in Bushfire Prone Areas*.
- While heritage is primarily managed through State and Commonwealth legislation, opportunities exist to protect and promote both aboriginal and European cultural heritage through joint management arrangements and tourism opportunities with traditional owners, and optimise opportunities for Indigenous training, employment and businesses. This should include effective engagement with the appropriate traditional owners depending on the location of heritage sites and business opportunities, to support protection of cultural values

The above considerations and the implications for management and planning are broadly summarised in Table 17, with supporting mapping presented on Figure 14.

Within this local environmental context, consideration should also be given to emerging global, national and regional environmental priorities. These include:

- Climate change leading, in addition to the issues raised above, to global (land and ocean) temperature rise, sea level rise, ocean acidification and increases in extreme weather;
- Reducing greenhouse gas emissions and energy use through improved energy efficiency and increased use of renewable energy;
- Reducing resource consumption and a move towards community acceptance of smaller environmental footprints;
- Innovation leading to the creation of new ways to address sustaining problems including poorly functioning communities, and water scarcity, which result in improved built form and optimised delivery of services and infrastructure; and
- Enhanced liveability of communities which are adaptive and able to respond to changing environments and community priorities.

It is recognised that the Shire of Ashburton desires a sustainable, connected and thriving community into the future. This supports many opportunities for environmental innovations. Key areas of focus may include:

- Provision of wastewater recycling facilities and renewable energy schemes to reduce reliance on groundwater (and support green infrastructure to manage a hotter climate) and traditional energy sources, as well as decentralised waste-management strategies which optimise reuse and recycling of waste materials, or schemes to transform waste into energy.
- Eco and heritage tourism opportunities which celebrate the unique natural beauty, biodiversity and cultural of the Shire. This may include accommodation, entertainment and artistic opportunities as well as adventure and recreational activities. This could be extended to educational opportunities associated with practical and on-ground environmental and cultural heritage learning.

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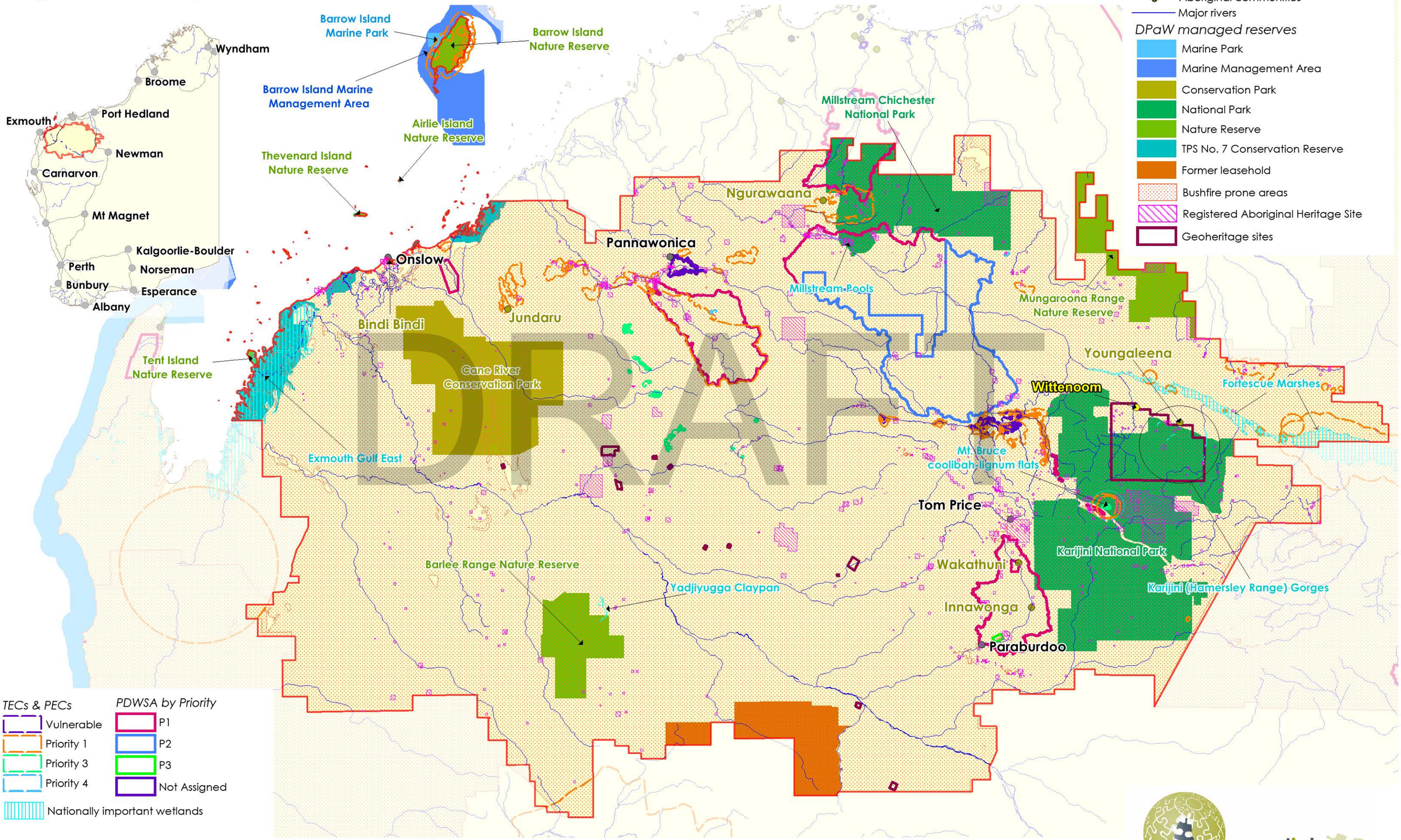
Figure 14: Key environmental attributes



Data sources: Landgate, Dept. of Water, Dept. of Aboriginal Affairs, Dept. of the Environment Created by: H Lamparski. Projection: MGA 50: zone 50.

Scale 1: 1,500,000 @ A3
0 60 km

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The following table provides broad generalisations only. Specific solutions for individual locations should be determined through more detailed planning and assessment as part of the planning and development approvals process.

Table 17: Summary of strategic environmental planning considerations

Key environmental value	Impacts from and on land use	Red – high	Orange - medium	Green - low	Shire's role in managing the impact	Recommendations for planning control
	Residential /town/ village /commercial	Industrial	Rural residential	Rural/agriculture		
Air quality	Haze and smog Light overspill Dust (construction sand)	Noise, dust, light, odour	Haze	Overspray, noise, dust	Manage impacts through enforcement of by-laws and Environmental Health regulations	Provide buffers and management of off-site impacts consistent with SPP 4.1: State Industrial Buffer Policy and DER/EPA buffer guidelines.
	Health risks to residents	Health risks to employees	Health risks to residents	Health risks to residents & livestock		
Soils	Erosion, nutrient export and acidification	Erosion, and contamination	Erosion, nutrient export and acidification	Erosion, nutrient export, contamination and acidification	Ensure land clearing and site management practices are implemented which are appropriate to the land use and capability of the soils.	Ensure land use is appropriate to the capability of the land to sustain the land use. This is particularly important for intensive agriculture proposals
	Structural impacts including subsidence and erosion	Structural impacts including subsidence and erosion	Structural impacts including subsidence and erosion	Productivity and structural impacts including subsidence and erosion		
Minerals and basic raw material	Sterilisation of resource	Sterilisation of resource	Sterilisation of resource	Sterilisation of resource	Enforce conditions of development approval with regards to the management of of-site impacts	Ensure planning approvals are consistent with the protection of significant values and that potential off-site impacts are managed.
	Not permitted within this land use however may be affected by off-site impacts including noise, light and dust	Noise, light and dust	Not permitted within this land use however may be affected by off-site impacts including noise, light and dust	Noise, light and dust		
Groundwater for drinking water purposes	Nutrient pollution of recharge areas	Contamination of recharge areas	Contamination of recharge areas	Contamination of recharge areas	Planning approvals should restrict land use in PDWSAs	Ensure land use is consistent with SPP 2.7 and DoW's water quality protection notes
	Land use is restricted based on WQPN 25	Land use is restricted based on WQPN 25	Land use is restricted based on WQPN 25	Land use is restricted based on WQPN 25		

Key environmental value	Impacts from and on land use Residential /town/ village /commercial	Red – high Industrial	Orange - medium Rural residential	Green - low Rural/agriculture	Shire's role in managing the impact	Recommendations for planning control
Waterways and wetlands	Direct impacts from filling, draining, clearing, contamination and erosion	Direct impacts from filling, draining, clearing, erosion, contamination,	Direct impacts from clearing, erosion, contamination, and/or uncontrolled access by stock	Direct impacts from clearing, erosion contamination, and/or uncontrolled access by stock	Avoid development which results in direct impacts on values and address flood risk and management of stormwater.	Identify waterways and wetlands with significant values and ensure future development is not proposed in these locations or is managed appropriately Protect development from flood risk. and manage the water cycle consistent with State Planning Policy 2.9: *Water Resources*.
	Mosquitoes, flooding	Mosquitoes, flooding	Mosquitoes, flooding	Mosquitoes, flooding		
Remnant vegetation, biodiversity and fauna habitat	Direct impacts from clearing and bushfires and indirect impacts from rubbish, uncontrolled access, weeds, pests and feral animals	Direct impacts from clearing and bushfires and indirect impacts from rubbish, uncontrolled access, weeds, pests and feral animals	Direct impacts from clearing and bushfires and indirect impacts from rubbish, uncontrolled access, weeds, pests and feral animals	Direct impacts from clearing and bushfires and indirect impacts from agricultural practices, rubbish, uncontrolled access, weeds, pests and feral animals	Identify areas of remnant vegetation with significant values and aim to limit the location of high risk land uses	Protect as appropriate through reservation or use of a special control area.
	Bushfires, Snakes	Bushfires, Snakes	Bushfires, Snakes	Bushfires, Snakes		
Coastal environments	Loss of environmental, cultural and recreational values from clearing for development and unmanaged use	Loss of environmental, cultural and recreational values from clearing for development, and/or commercial activities	Loss of environmental, cultural and recreational values from clearing for development and unmanaged use	Loss of environmental, cultural and recreational values from clearing for agricultural activities	Planning approvals should avoid environmentally sensitive areas and consider risks from storm surge and sea level rise.	Demonstrate compliance with State Planning Policy 2.6: *State Coastal Planning Policy* and protect (reserve) areas of significant environmental value.
	Inundation from sea level rise and storm surge	Inundation from sea level rise and storm surge	Inundation from sea level rise and storm surge	Inundation from sea level rise and storm surge		

Key environmental value	Impacts from and on land use Residential /town/ village /commercial	Red – high Industrial	Orange - medium Rural residential	Green - low Rural/agriculture	Shire's role in managing the impact	Recommendations for planning control
Aboriginal and European heritage	Direct impacts from disturbance or reduced access to sites	Direct impacts from disturbance or reduced access to sites	Direct impacts from disturbance or reduced access to sites	Direct impacts from disturbance or reduced access to sites	Identify significant sites should be identified in the Scheme	Decision making should be consistent with the *Heritage Act* and *Aboriginal Heritage Act*
	Potential to limit scope of development	Potential to limit scope of development				

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APPENDIX 1: POLICY AND REGUILATORY FRAMEWORK

4.1 Guiding legislation

The management of the environment and natural resources in an urban and regional context is governed by a substantial number of acts and regulations, the most relevant of which are considered to be:

- Aboriginal Heritage Act 1972
- Biosecurity and Agriculture Management Act 2007
- Conservation and Land Management Act 1984
- Contaminated Sites Act 2003
- Country Areas Water Supply Act 1947
- Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
- Environmental Protection Act 1986
- Health Act 1911
- Heritage of Western Australia Act 1990
- Local Government Act 1995;
- Native Title (State Provisions) Act 1999
- Native Title Act 1993 (Commonwealth)
- Planning and Development Act 2005
- Rights in Water and Irrigation Act 1914
- Soil and Land Conservation Act 1945
- Waste Avoidance and Resource Recovery Act 2007
- Water Agencies (Powers) Act 1984
- Water Resources Legislation Amendment Act 2007
- Water Services Act 2012
- Waterways Conservation Act 1976
- Wildlife Conservation Act 1950

4.2 State policy context

Strategic guidance for the management of our environment is also provided by a number of State-level policies, strategies and guidelines. These include:

4.2.1 Relevant State Planning Policies

State Planning Policy 2: Environment and Natural Resources (2003)

The environment and natural resources policy defines the principles and considerations that represent good and responsible planning in terms of environment and natural resource issues within the framework of the State Planning Strategy.

The policy will be supplemented by more detailed planning policies on particular natural resources matters that require additional information and guidance. These supplementary policies may also be state planning policies and should be implemented in conjunction with this policy.

State Planning Policy 2.6: State Coastal Planning Policy (2013)

State Coastal Planning Policy provides an approach to the consideration of often competing needs and desires in coastal areas in a way that takes into account the values of the coastal zone. The policy ensures that current and future generations of Western Australians can benefit from opportunities presented by the values and resources of the Western Australian coast.

Guidance is provided for land use and development decision-making within the coastal zone including managing development and land use change; establishment of coastal foreshore reserves; and to protect, conserve and enhance coastal values. The policy recognises and responds to regional diversity in coastal types; requires that coastal hazard risk management and adaptation is appropriately planned for; encourages innovative approaches to managing coastal hazard risk; and provides for public ownership of coastal foreshore reserves.

State Planning Policy No 2.7: Public Drinking Water Source (2003)

This policy applies to proclaimed Public Drinking Water Source Areas (PDWSAs) throughout Western Australia. The objective of this policy is to ensure that land use and development within PDWSAs is compatible with the protection and long-term management of water resources for public water supply.

The policy specifies to regions outside the metropolitan region that all priority (P1, P2, and P3) source protection areas should be shown as special control areas in region schemes and local government schemes. This will be in accordance with the recommendations of any relevant land use, water management strategy, or water source protection plan. Furthermore, land uses and developments in all priority source protection areas that have the potential to impact detrimentally on the quality and quantity of public drinking water supplies should not be permitted unless it can be demonstrated, having regard to advice from the Water and Rivers Commission (now Department of Water), that such impacts can be satisfactorily managed.

Planning schemes and decisions on land use and development should have regard for any adopted region scheme policy or relevant environmental protection policy on public drinking water supply.

State Planning Policy 2.9: Water Resources (2006)

The *State Planning Policy 2.9: Water Resources* pledges Western Australia to pursuing sustainability through an integration of environmental protection, social advancement and economic prosperity. This vision is encapsulated in A State Water Strategy for Western Australia (2003), which seeks to develop and protect water resources in an economically and environmentally responsible way by providing a whole government framework for setting strategies and plans for water resources.

This policy is directly related to the overarching sector policy State Planning Policy 2 Environment and Natural Resources Policy and provides clarification and additional guidance to planning decision-makers for consideration of water resources in land use planning strategies, proposals and applications, for example local and regional planning strategies, structure plans, town planning schemes and amendments, subdivisions and development applications, and other town planning mechanisms.

State Planning Policy 3.7 - Planning in Bushfire Prone Areas (2015)

This policy seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.

It applies to all higher order strategic planning documents, strategic planning proposals, subdivision and development applications located in designated bushfire prone areas (unless exemptions apply). This policy also applies where an area is not yet designated as bushfire prone but the proposed development is planned in a way that introduces a bushfire hazard (e.g. revegetation)

4.2.2 State-level guidelines

There are a number of State-level guidelines which assist local governments to meet their regulatory requirements. Those that provide guidance for improved environmental management, protection and natural resource use are summarised in Appendix 1 and listed in Table 18 below. It should be noted that these documents are not statutory and provide guidance only.

Table 18: Relevant State-level guidelines

Environment area	Report
General	• Directions Paper on the Integration of NRM into Land Use Planning, (Western Australian Planning Commission, 2013). • Guidance for the Assessment of Environmental Factors No 33: Environmental Guidance for Planning and Development (EPA, 2008) • Western Australian State Sustainability Strategy (Government of WA, 2003)
Built form	• Building Code of Australia • State Planning Strategy (Western Australian Planning Commission, 2013) • Guidelines for Planning in Bushfire Prone Areas
Air quality and emissions	• Working together — WA Health Strategic Intent 2010-2015 (Department of Health, 2010)
Water	• Australian Guidelines for Water Recycling • Better Urban Water Management (WAPC, 2008) • Government Sewerage Policy- Draft Country Sewerage Policy (Government of WA, 2011) • Guidelines for the approval of non-drinking water systems in Western Australia - urban developments (Department of Water, 2013) • Pilbara regional water plan 2010-2030 (Department of Water, 2010) • River restoration manual, (Department of Environment and Conservation, 2004) • State Water Plan (Department of Water, 2007) • Stormwater management manual for Western Australia, (Department of Water, 2004-2007)
Waste	• Western Australian Waste Strategy (WA Waste Authority, 2012)

4.3 Local regulatory context

The Shire is in the process of developing a local planning strategy. Planning guidance is currently provided by Shire of Ashburton Town Planning Scheme No. 7 and local planning policies. Some strategic direction is also provided by the Community Strategic Plan.

The strategies and reports that are most relevant to the management of the environment and natural resources across the Shire are outlined below.

4.3.1 Shire of Ashburton Town Planning Scheme No. 7

Originally gazetted in 2004, the Shire of Ashburton Town Planning Scheme No. 7 (the Scheme) provides the statutory basis for land use and development in the Shire. The following Scheme objectives are considered to assist in the achievement of environmental outcomes

1.6(a) To facilitate development that responds to the character and amenity, geographical context and environmental constraints of the Shire and its urban and rural areas

1.6(i) To identify areas for conservation, recreation and natural landscapes which are important for ecological, heritage and amenity purposes in addition to the major tourist assets of the Shire.

1.6(j) To facilitate development that takes account of the heritage value of places, buildings and objects.

1.6(k) To acknowledge the health risks within the Wittenoom townsite.

1.6(l) To facilitate development that has regard for the long term protection of natural resources, such as clean air, water, soil and biological diversity.

Provisions that are relevant to the protection and management of the environment include:

5.6 Additional Heritage Information

In addition to the requirements of other provisions of the Scheme, the Local Government may require an application for planning approval, where the proposed development may affect a place of cultural heritage significance or an entry on the Inventory, to include additional information to assist the Local Government in its determination.

6.20 Flood and Storm Surge Prone Land

6.20.1 When considering applications for planning approval Council shall have regard to the requirements for the Onslow Coastal Hazard Special Control Area in clause 7.3.

6.20.2 In areas not subject to Onslow Coastal Hazard Area provisions contained in Clause 7.3 of the Scheme but where the Local Government considers development to be potentially incompatible with land prone to flood and storm surge events, it must be satisfied that approval of such planning applications has regard to flood and storm surge events and may approve, with or without conditions, or refuse proposals at its discretion.

The Scheme also contains a number of special control areas which address environmental issues. These generally require that consideration is given to the key issue and that the application is supported by sufficient information to assist decision making.

The following special control areas address a range of environmental issues:

7.2 Tidal Inundation Areas

7.3 Onslow Coastal Hazard Area

7.4 Onslow Strategic Industrial Buffer

7.6 Cane River Water Reserve Area

7.7 Turee Creek, Mt Lionel and Mt Stevenson Borefields

7.8 Wittenoom

7.10 Waste Water Treatment Plant Odour Buffer Special Control Area

4.3.2 Shire of Ashburton Community Strategic Plan 2013-2023

Setting out goals and plans to achieve them with focus on job creation, sustainable development, water management and resource management.

4.3.3 Local environmental policy context

The local policies which provide guidance for environmental management include:

- LPP25 Onslow Coastal Hazard Area – Scheme Control Area;
- ELM21 Tree Management Overview Policy;
- ENG08 Bushfire Policy; and
- ENG10 Guidelines for Urban Development.

4.4 Other guiding documents

4.4.1 State Water Plan (2007)

The S*tate Water Plan* provides a strategic framework manage water resources in Western Australia, highlights and builds upon the *State Water Strategy.* The Plan details priority actions identified in the Strategy, with a larger focus on water policy and planning. Priority actions included developing regional water plans, statutory water management plans, and further study to demand management and supply options including regional areas.

4.4.2 Better Urban Water Management (2008)

Better Urban Water Management (WAPC, 2008) provides guidance on the implementation of *State Planning Policy 2.9 Water Resources* (2006). It outlines the requirements for integrating land and water planning and improving the achievement of total water cycle outcomes and water sensitive urban design as part of land use planning and development.

Better Urban Water Management is designed to facilitate better management and use of water resources by ensuring an appropriate level of consideration is given to the total water cycle at each stage of the planning system. The document provides guidance for regional, district and local land use planning, as well as subdivision phases of the planning process. *Better Urban Water Management* is to be used by all stakeholders and decision makers and has statewide application for new urban, commercial, industrial and rural-residential developments.

APPENDIX 2: THREATENED FLORA AND FAUNA LISTS – STATE & COMMONWEALTH

Australian Government

Department of the Environment

EPBC Act Protected Matters Report

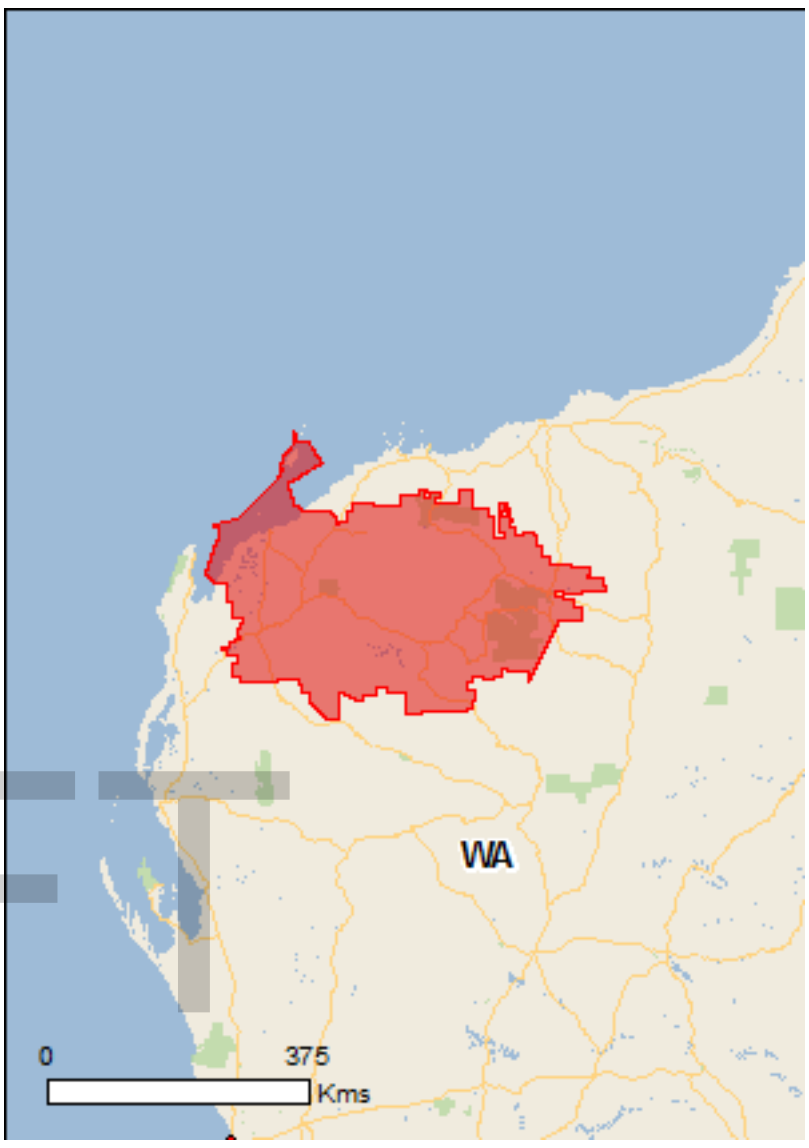
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

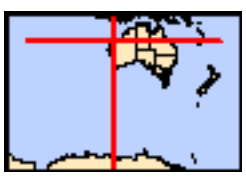
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

LGA SHIRE OF ASHBURTON, WA

Report created: 23/06/16 19:55:37





Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://environment.gov.au/protection/environment-assessments

World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Significance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Threatened Ecological Communities:	None
Threatened Species:	37
Migratory Species:	36

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits-and-application-forms

Commonwealth Lands:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	79
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	28
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	7

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The Ningaloo Coast	WA	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Name
EEZ and Territorial Sea

Threatened Species [Resource Information]

Name	Status	Type of Presence
BIRDS		
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
FISH		
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Bettongia lesueur Barrow and Boodie Islands subspecies		
Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Isoodon auratus barrowensis		
Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus		
Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Breeding known to occur within area
Macropus robustus isabellinus		
Barrow Island Wallaroo, Barrow Island Euro [26196]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Petrogale lateralis lateralis		
Black-flanked Rock-wallaby [66647]	Vulnerable	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Roosting known to occur within area
PLANTS		
Lepidium catapycnon		
Hamersley Lepidium, Hamersley Catapycnon [9397]	Vulnerable	Species or species habitat known to occur within area
Pityrodia augustensis		
Mt Augustus Foxglove [4962]	Vulnerable	Species or species habitat likely to occur within area
Thryptomene wittweri		
Mountain Thryptomene [16645]	Vulnerable	Species or species habitat likely to occur within area
REPTILES		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus angusticeps		
Airlie Island Ctenotus [25937]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area

Name	Status	Type of Presence
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
SHARKS		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat may occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Carcharodon carcharias Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Migratory Wetlands Species		
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands	[Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Defence - TOM PRICE TRAINING DEPOT

Listed Marine Species	[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur

Name	Threatened	Type of Presence within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat may occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area

Name	Status	Type of Presence
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Commonwealth Reserves Marine [Resource Information]

Name	Label
Montebello	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Airlie Island	WA
Barlee Range	WA
Barrow Island	WA
Bessieres Island	WA
Boodie, Double Middle Islands	WA
Burnside And Simpson Island	WA
Cane River	WA
Cane River (Mount Minnie and Nanutarra)	WA
Giralia	WA
Gnandaroo Island	WA
Karijini	WA
Little Rocky Island	WA
Locker Island	WA
Lowendal Islands	WA
Millstream Chichester	WA
Mungaroona Range	WA
Rocky Island	WA
Round Island	WA
Serrurier Island	WA
Tent Island	WA
Thevenard Island	WA
Unnamed WA40322	WA

Name	State
Unnamed WA41696	WA
Unnamed WA44665	WA
Victor Island	WA
Wanna	WA
Whalebone Island	WA
Y Island	WA

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit,

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Exmouth Gulf East	WA
Fortescue Marshes	WA
Karijini (Hamersley Range) Gorges	WA
Kookhabinna Gorge	WA
Millstream Pools	WA
Mt. Bruce coolibah-lignum flats	WA
Yadjiyugga Claypan	WA

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining oigations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Parks and Wildlife Commission NT, Northern Territory Government
-Department of Environment and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-Forestry Corporation, NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 3: DRAFT RISK ASSESSMENT CHRMAP FOR THE ONSLOW COAST (CARDNO, 5TH AUGUST 2016)

Risk Assessment

CHRMAP for the Onslow Coast

59916801

Prepared for
Shire of Ashburton

5 August 2016

Cardno
Shaping the Future

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Version	Effective Date	Description of Revision	Prepared by:	Reviewed by:
V1	5/08/2016	Draft - for discussion	DRS/JB	DvS

Executive Summary

For all communication regarding this project, the Shire of Ashburton is to please contact:

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Study Terminology

Abbreviation	Description
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ANSIA	Ashburton North Strategic Industrial Area
AS	Australian Standard
CHRMAP	Coastal Hazard Risk Mitigation and Adaption Plan
MCA	Multi-criteria analysis
MS	Microsoft
WAPC	Western Australian Planning Commission
SPP2.6	State Planning Policy No 2.6
GIS	Geographical information Systems

Table of Contents

Tables

Figures

1 Introduction

The Shire of Ashburton (herein referred to as 'the Shire') is undertaking a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the Town of Onslow (herein referred to as 'the Town') and immediate surrounds, in accordance with the State Coastal Planning Policy No 2.6 (SPP2.6, WAPC 2013). The Ashburton North Strategic Industrial Area (ANSIA) is located around 13 km to the west of the Town. This industrial area and the Town are two of the Shire's important coastal development zones. Their proposed and potential future development is the key driver for the undertaking of a CHRMAP for the area. This report presents the Risk Analysis and Evaluation component of the study (Elements 4 & 5, Figure 1-1).

The study area is subject to a range of natural hazards associated with coastal erosion, storm surge inundation, fluvial runoff inundation and various combinations of the events. Element 1 of the CHRMAP process investigated coastal processes, combined with future sea level rise, for the study area and used computer modelling to predict likely future inundation and erosion hazards (Cardno 2016a). The results of the hazard mapping were used to undertake the risk identification, which is detailed in the Key Issues Paper (Cardno 2016b). The Risk Identification is also summarised in Section 2.

The risk analysis presented here (Element 4 in Figure 1-1) further develops an understanding of the identified risks by assessing the likelihood of the risk occurring and the likely consequences if it does.

Risk evaluation and ranking utilises the outcomes of the risk analysis process and is applied to the risk priority level matrix (SPP2.6, WAPC 2013). Following the evaluation, each risk is ranked, and then assigned a risk prioritisation level. This will help identify risks to be treated, and how important or urgent that treatment is. It will also provide a mechanism to compare the level of risk after a preferred adaptation option has been theoretically implemented.

To assess the level of risk, or potential impact, posed to the assets by the identified coastal hazards this CHRMAP has employed risk analysis techniques outlined in AS 5334-2013 (Australian Standards Ltd, 2013), with some modifications.

This also report provides preliminary details of risk management and adaptation options (Elements 6 in Figure 1-1) which will be undertaken as part of the next phase of work.

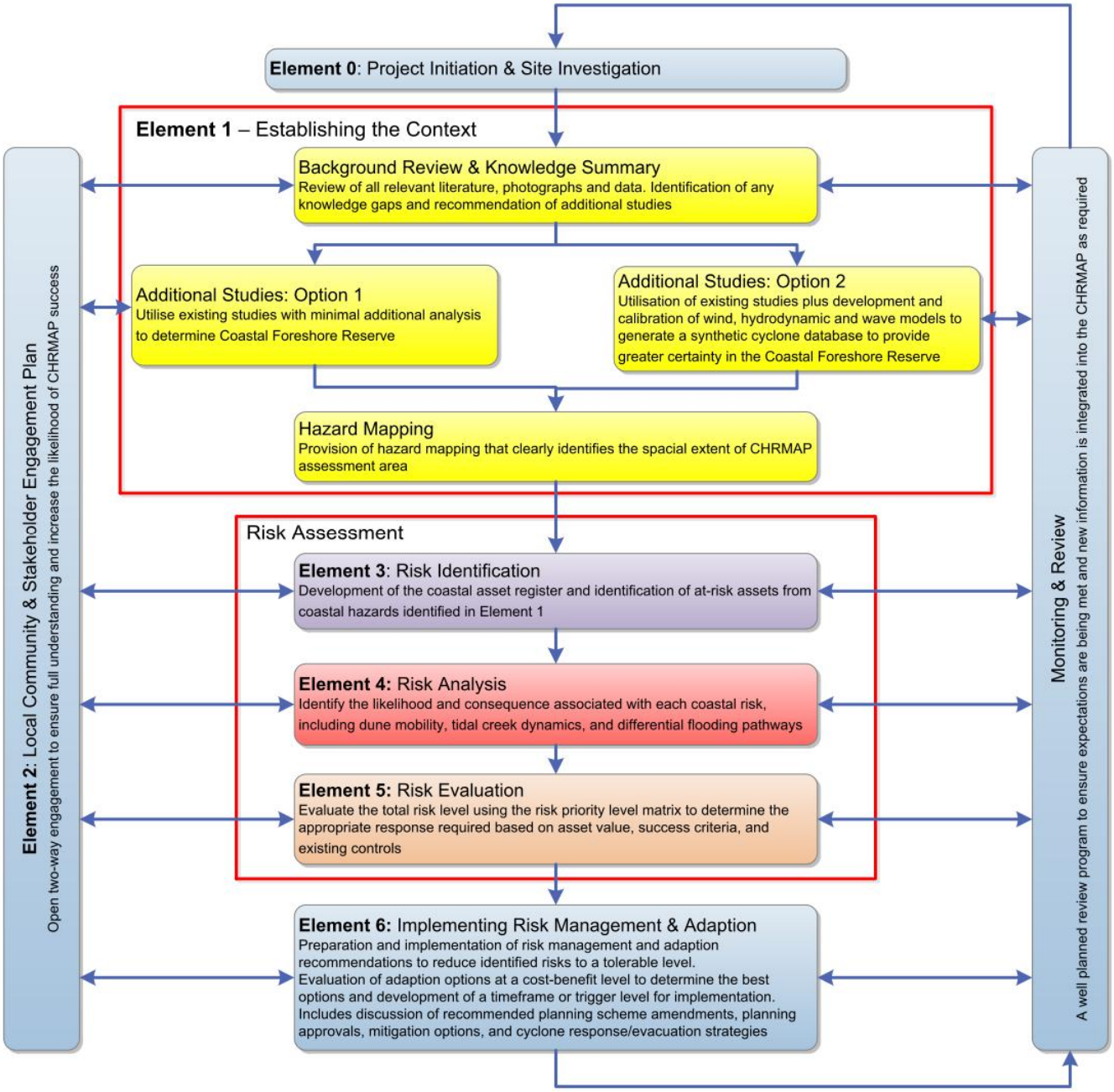

Figure 1-1 CHRMAP methodology flow chart for the Onslow coast (adapted from WAPC CHRMAP Guidelines, 2014)

2 Risk Identification

The coastal hazard maps for the various extreme events and future time horizons were overlain on the town cadastre and assets maps to identify the assets within the predicted hazard zones. Assets were identified to be at risk of coastal erosion and inundation and/or fluvial inundation. Complete details of the risk identification undertaken for the CHRMAP process are provided in the Key Issues Paper (Cardno, 2016b). The process involved the identification and classification of all key assets within the study area. The vulnerability of these assets to coastal processes, such as erosion and inundation, was predicted through a range of modelling techniques. Consultation with the community and key stakeholders was undertaken in conjunction with this process to define the success criteria, to help guide and prioritise risk management options.

2.1 Asset Identification

The identification of physical assets and areas with economic, social/cultural and environmental value, potentially at risk within the study area, involved the following steps:

- Initiation and site visit: General overview of town layout and assets therein. Provision by the Shire of existing spatial asset data;
- Stakeholder engagement: Collection of data on assets and areas seen as important by key stakeholders, including the general community; and
- Further asset capture and classification: Cardno engaged sub-consultants Talis to catalogue, classify and assess the condition of assets within the study area.

An asset inventory was delivered to the Shire in GIS and MS Excel format (Figure 2-1). This report presents only those assets identified as potentially at risk over the planning timeframes (present day, 2040, 2070 and 2110).

Figure 2-1 Physical assets identified within the study area, generally classified by their primary purpose

2.2 Success Criteria

The community and stakeholder engagement undertaken to date has been used to establish the spatial, social, and economic context of the CHRMAP. The stakeholder values were mapped according to the following categories:

- Recreational;
- Commercial;
- Environmental;
- Historic / heritage;
- Physical infrastructure; and
- Aboriginal cultural significance.

Feedback and data collected through stakeholder engagement was used to define the success criteria for the CHRMAP, which will guide the assessment of management options. These criteria are as follows:

- Maintenance of the foreshore;
- Protection and enhancement of the local economy;
- Well maintained community structures;
- Year round accessibility to Onslow via Onslow Road (noting The Onslow Ring Road has been completed and now provides this functionality)

- Realistic and sustainable strategies;
- Sustaining and enhancing natural environmental values;
- Strategy not reliant on building heights;
- Not prohibitive of future development; and
- Year round accessibility to the foreshore (as was the case historically).

These criteria ranged in importance from 24 responses to 3 responses. Whilst all of these success criteria will be considered during the CHRMAP process, it should be noted that not all may be realistically achievable. Preference will be given to higher ranked criteria.

2.3 Vulnerability Assessment

Further to the asset identification process, the vulnerability of the assets or areas of importance were determined in relation to the erosion or inundation hazards.

The coastal processes and fluvial (pluvial) flooding affect different areas of the coast through different impact pathways. Here we categorise the key impact pathways due to coastal erosion and inundation either by ocean storm surge flooding from the sea or rainfall runoff from the catchment flooding the town.

This study is primarily focused on the coastal aspects and fluvial (and pluvial) flooding issues are assessed to a broad level of sufficient detail for theses long-term planning purposes. The Shire is commissioning additional, more detailed flood modelling to assist with the mitigation of the current flood risks within the Town.

2.3.1 Coastal Erosion and Inundation

Coastal process hazard lines were overlain on a map of the study area to determine the identified assets and areas at risk for each of the planning timeframes (Present day, 2040, 2070, 2110). The assets and areas identified, and the planning timeframe in which they are predicted to first be at risk, are provided in Table 2-1. The risk assessment has defined either specific items of infrastructure, collections of co-located assets, areas of importance (i.e. based on stakeholder values) or collections of similar low-value assets within hazard zones. This has allowed each asset, group of assets or area to be assessed in its own right.

Table 2-1 Assets predicted to be at risk from coastal process hazards and the vulnerability timeframe's

Timeframe	Assets At Risk	Value
Present Day	• On-ground infrastructure at Onslow Jetty • Onslow Back Beach picnic area (low risk) • Front Beach / Sunrise Beach • Seawall (the setback allowed for in this section mainly consists of the uncertainty factor required as per SPP2.6)	• Commercial • Aboriginal • Public infrastructure • Recreational • Environmental
2040	• Seaview Drive near 12 Mile Creek / 4 Mile Beach • Assets adjacent to crest of seawall (bins, shade structures, benches) • Shire of Ashburton Offices at the intersection of Second Ave and McGrath Rd • Aboriginal community on Second Ave	• Public infrastructure • Recreational • Commercial • Aboriginal
2070	• Western half of Ian Donald Blair Memorial Walkway	• Recreational • Public infrastructure
2110	• Intersection of Seaview Drive and Back Beach Road • Eastern end of Ian Donald Blair Memorial Walkway • Lot 381 (at the top of the hill at Beadon Point) • Second Ave	• Public infrastructure • Recreational • Residential

2.3.2 Fluvial Inundation

Fluvial inundation within the study area is extensive due to the flat, low lying terrain, with the majority of the town's assets exposed to some flooding in the most extreme scenarios. Because of the large number of assets affected by flooding and the uncertainty about the scale of the impacts, a more general approach has been selected to assess the risks of fluvial inundation. The risk identification assesses the total number of assets affected by a flooding as a percentage of the overall number of assets registered. The type of asset is not considered in this identification but is factored into the risk analysis.

The total count of assets affected by inundation hazards over the various planning horizons and event recurrence frequency are presented in Table 2-2.

Table 2-2 Assets present in 2015 predicted to be at risk from future inundation hazards

Planning Horizons & ARI Event	Affected Assets	Assets Not Affected	Total Assets	Percentage Affected
Present Day 100 Year	259	277	536	48%
2040 100 Year	282	254	536	53%
2070 100 Year	286	250	536	53%
2110 100 Year	373	163	536	70%
Present Day 500 Year	327	208	536	61%
2040 500 Year	352	182	536	66%
2070 500 Year	395	117	536	74%
2110 500 Year	447	84	536	83%

3 Risk Analysis

The Risk Analysis (Element 4 in Figure 1-1) aims to develop an understanding of each risk based on likelihood of the risk occurring and the potential consequences. This provides the basis for the risk evaluation (Element 5 in Figure 1-1).

As discussed in Section 2, different approaches have been adopted to analyse the risks of coastal erosion and inundation and the risk of fluvial inundation. Assets or groups of assets are assessed individually for the risk of coastal impacts, while a more general risk to asset types is analysed for fluvial inundation.

3.1 Likelihood

According to WAPC (2014) and for the purposes of this study, likelihood is defined as the chance of erosion and storm surge inundation occurring or how often they might impact on the existing and future assets and their values. There are two main components that need to be considered when determining likelihood of a risk occurring: the frequency of the event (storm or large waves) and the probability of the event occurring over a given time (WAPC 2014).

Often the Annual Exceedance Probability (AEP) or its inverse, the Average Recurrence Interval (ARI) is used to assess the likelihood of an event occurring (as with the example provided in the CHRMAP guidelines). This assumes that the probability of a coastal hazard event occurring is the same each year. This is not necessarily the case when considering the effects of climate change and the increase in sea level rise over time, which underpins the future planning scenarios assessed in this study. The notion also implies that impacts such as erosion will be event based, occurring over short time periods with long lasting effects. While this is often the case, erosion also occurs gradually over long time periods and this is likely to be associated with a rising sea-level.

Assessment of likelihood has, therefore, been based on the probability of a coastal process hazard impacting an asset or group of assets, over the given planning period. The likelihood scale applied is presented in Table 3-1.

Table 3-1 Likelihood scale

Rating	Likelihood	Probability
Almost Certain	It is very likely that the hazard will impact the asset during the timeframe	80-100% probability of occurring over the timeframe
Likely	It is likely that the hazard will impact the asset during the timeframe	60-80% probability of occurring over the timeframe
Possible	It is as likely as not that the hazard will impact the asset during the timeframe	40-60% probability of occurring over the timeframe
Unlikely	It is unlikely that the hazard will impact the asset during the timeframe	20-40% probability of occurring over the timeframe
Rare	It is very unlikely that the hazard will impact the asset during the timeframe	0-20% probability of occurring over the timeframe

3.1.1 Coastal Erosion and Inundation

The likelihood of erosion and coastal inundation events impacting each of the assets or groups of assets for each planning timeframe has been determined and is presented in Table 3-2. This assessment is based on the coastal process setback lines, but has also factored in coastal engineering understanding about coastal processes and how the setback lines are derived.

Table 3-2 Likelihood of assets being affected by coastal erosion and inundation at Onslow

Vulnerability Timeframe	Asset[1]	Planning Timeframe			
		Present Day	2040	2070	2110
2015	On-ground infrastructure at Onslow Jetty	Unlikely	Likely	Almost Certain	Almost Certain
	Onslow Back Beach picnic area	Possible	Likely	Almost Certain	Almost Certain
	Front Beach / Sunrise Beach	Possible	Likely	Almost Certain	Almost Certain
	Seawall	Possible	Likely	Almost Certain	Almost Certain
2040	Seaview Drive near 12 Mile Creek / 4 Mile Beach	Rare	Rare	Unlikely	Possible
	Assets adjacent to crest of seawall (bins, shade structures, benches)	Rare	Unlikely	Possible	Likely
	Shire of Ashburton Offices at the intersection of Second Ave & McGrath Rd	Rare	Unlikely	Likely	Almost Certain
	Aboriginal community on Second Ave	Rare	Unlikely	Likely	Almost Certain
2070	Western half of Ian Donald Blair Memorial Walkway	Rare	Unlikely	Likely	Almost Certain
2110	Intersection of Seaview Drive and Back Beach Road	Rare	Possible	Likely	Almost Certain
	Eastern end of Ian Donald Blair Memorial Walkway	Rare	Rare	Unlikely	Possible
	Lot 381 (at the top of the hill at Beadon Point).	Rare	Rare	Unlikely	Possible
	Second Ave	Possible	Likely	Almost Certain	Almost Certain

[1] Assets are listed at first impact horizon only and assumed to remain impacted at future time horizons

3.1.2 Fluvial Inundation

The likelihoods of assets being affected by fluvial inundation (Table 2-2) have been broadly categorised to allow a general assessment of the consequences, this is further described in Section 3.2. For inundation, the percentage of assets affected for each future scenario has been directly translated to the probability scale (Table 3-1). This provides a very general likelihood that any one asset might be influenced by flooding for a particular scenario (see Table 3-3). Obviously certain assets will be more prone to inundation than others due to location and topography within the predicted inundation zone. To assess each asset individually would require more detailed investigation of the assets susceptibility to flooding including assessment of floor levels and quantity surveying. As this is beyond the scope of this assessment, this more general approach has been applied.

Table 3-3 Likelihood timescale for assets vulnerable to fluvial inundation in Onslow

Asset Type		Planning Timeframe			
		Present Day	2040	2070	2110
100 yr ARI		48%[2]	53%	53%	70%
	Housing, Buildings & Property	Possible	Possible	Possible	Likely
	Parks & Recreation Grounds	Possible	Possible	Possible	Likely
	Public Infrastructure (fencing, light poles, playgrounds etc)	Possible	Possible	Possible	Likely
	Car parks	Possible	Possible	Possible	Likely

	Roads/Footpaths	Possible	Possible	Possible	Likely
	Sheds	Possible	Possible	Possible	Likely
500 yr ARI		**61%**	**66%**	**74%**	**83%**
	Housing, Buildings & Property	Likely	Likely	Likely	Almost Certain
	Parks & Recreation Grounds	Likely	Likely	Likely	Almost Certain
	Public Infrastructure (fencing, light poles, playgrounds etc)	Likely	Likely	Likely	Almost Certain
	Car parks	Likely	Likely	Likely	Almost Certain
	Roads/Footpaths	Likely	Likely	Likely	Almost Certain
	Sheds	Likely	Likely	Likely	Almost Certain

[2]Percentage of assets affected by inundation (Table 2-2)

3.2 Consequence

WAPC (2014) defines consequences as the impact of erosion and storm surge inundation occurring to the existing assets in the future, taking into consideration the asset value. A consequence rating considers the impact on the social, economic and environmental value of the asset. Additionally, the adaptive capacity and vulnerability of an asset are also considered when determining its consequence rating. Consequence ratings for this study are given in Table 3-4, which are derived from AS 5334-2013.

This assessment assumes that the present day (2015) assets are exposed to the future hazard without any intervention or risk mitigation implementation in the future.

The effect of coastal erosion and fluvial inundation should be assessed separately as their impacts on a given asset are different. Coastal erosion typically causes permanent damage, such as the undercutting and collapsing of foreshore infrastructure. Inundation, however, may result in the short term flooding of an asset but it may maintain its use once flooding subsided.

Table 3-4 Consequence ratings (based on AS 5334-2013)

Rating	Social	Economic	Environment
Catastrophic	Loss of life and serious injury. Large long-term or permanent loss of services, employment wellbeing, finances or culture (e.g. > 75% of community affected), international loss, no suitable alternative sites exist.	Permanent loss or damage to property, plant and equipment, finances >$5 million	Permanent loss of flora and fauna (no chance of recovery) with national impact.
Major	Serious injury. Medium term disruption to services, employment wellbeing, finances or culture (e.g. < 50% of community affected), national loss, very limited suitable alternative sites exist.	Permanent loss or damage to property, plant and equipment, finances > $2 - $5 million	Long-term loss of flora and fauna (limited chance of recovery) with regional impact.
Moderate	Minor injury. Major short term or minor long-term disruption to services, employment wellbeing, finances or culture (e.g. < 25% of community affected), regional loss, limited suitable alternative sites exist.	Permanent loss or damage to property, plant and equipment, finances > $100,000 - $2 million	Medium-term loss of flora and fauna (recovery likely) with regional impact.
Minor	Small to medium disruption to services, employment wellbeing, finances or culture (e.g. < 10% of community affected), local loss, many suitable alternative sites exist.	Permanent loss or damage to property, plant and equipment, finances > $10,000 - $100,000	Short-term loss of flora and fauna (strong recovery) with local impact.
Insignificant	Minimal short term inconveniences to services, employment, wellbeing, finances or culture (e.g. < 5% of community affected), neighbourhood loss, many alternative sites exist.	Permanent loss or damage to property, plant and equipment, finances < $10,000	Negligible to no loss of flora and fauna (strong recovery) with local impact.

3.2.1 Coastal Erosion and Inundation

In general, the consequence of erosion on a particular asset is fixed, regardless of the timeframe. This is the case for the consequences defined for many of the assets listed in Table 3-5. In cases where a set of assets have been grouped for assessment, the consequence may change over various timeframes, if more of the assets within the group are expected to be affected as the coastal hazard advances. For example, various public assets adjacent to the seawall have been grouped, and are expected to be impacted at varying timeframes due to varied distance from the shoreline. The case is similar for areas such as beaches, which might display some loss of beach over shorter timeframes, compared to complete or substantial beach loss over longer timeframes – a more severe consequence.

Table 3-5 Consequence ratings for assets vulnerable to coastal erosion in Onslow over time

Vulnerability Timeframe	Asset	Consequence of Erosion			
		Present Day	2040	2070	2110
2015	On-ground infrastructure at Onslow Jetty	Insignificant	Moderate	Moderate	Major
	Onslow Back Beach picnic area	Insignificant	Minor	Moderate	Moderate
	Front Beach / Sunrise Beach	Insignificant	Minor	Moderate	Major
	Seawall	Insignificant	Minor	Moderate	Major
2040	Seaview Drive near 12 Mile Creek / 4 Mile Beach	Major	Major	Major	Major
	Assets adjacent to crest of seawall (bins, shade structures, benches)	Insignificant	Insignificant	Minor	Minor
	Shire of Ashburton Offices at the intersection of Second Ave and McGrath Rd	Major	Major	Major	Major
	Aboriginal community on Second Ave	Moderate	Moderate	Major	Major
2070	Western half of Ian Donald Blair Memorial Walkway	Minor	Minor	Minor	Minor
2110	Intersection of Seaview Drive and Back Beach Road	Moderate	Moderate	Moderate	Moderate
	Eastern end of Ian Donald Blair Memorial Walkway	Minor	Minor	Minor	Minor
	Lot 381 (at the top of the hill at Beadon Point)	Moderate	Moderate	Moderate	Moderate
	Second Ave	Moderate	Moderate	Moderate	Moderate

3.2.2 Fluvial Inundation

More severe consequences into the future due to more extreme events and future higher sea-levels are likely to retard present day drainage patterns resulting in higher flood levels and longer ponding times. Present day infrequent events will become more frequent in future. This is reflected in the consequences defined in Table 3-6, with higher consequence ratings for the second half of the century, under the assumption that drainage infrastructure is not upgraded.

Table 3-6 Consequence ratings for assets vulnerable to fluvial inundation in Onslow over time

Asset Type		Planning Timeframe			
100 yr ARI		Present Day	2040	2070	2110
	Housing, Buildings & Property	Moderate	Moderate	Major	Major
	Parks & Recreation Grounds	Insignificant	Insignificant	Minor	Minor
	Public Infrastructure (fencing, light poles, playgrounds etc)	Insignificant	Insignificant	Minor	Minor

	Car parks	Insignificant	Insignificant	Minor	Minor
	Roads/footpaths	Minor	Minor	Moderate	Moderate
	Sheds	Insignificant	Insignificant	Minor	Minor
500 yr ARI					
	Housing, Buildings & Property	Moderate	Moderate	Major	Major
	Parks & Recreation Grounds	Insignificant	Insignificant	Minor	Minor
	Public Infrastructure (fencing, light poles, playgrounds etc)	Insignificant	Insignificant	Minor	Minor
	Car parks	Insignificant	Insignificant	Minor	Minor
	Roads/footpaths	Minor	Minor	Moderate	Moderate
	Sheds	Insignificant	Insignificant	Minor	Minor

4 Risk Evaluation

The risk evaluation and ranking process utilises the outcomes of the risk analysis process. The likelihood and consequence defined for assets, under each scenario, are combined to derive a risk level. The risk level for each combination is presented in the Risk Priority Matrix (Table 4-1), taken from the CHRMAP guidelines (WAPC, 2014).

Table 4-1 Risk Priority Matrix (adapted from WAPC 2014)

Likelihood	Consequences				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost Certain	H	H	E	E	E
Likely	M	H	H	E	E
Possible	L	M	H	E	E
Unlikely	L	L	M	H	E
Rare	L	L	M	H	H

This risk level then guides the preliminary assessment of the risk acceptability and the urgency of required action (Table 4-2). This will help to prioritise multiple identified risks within the study area. The evaluation also provides a mechanism to compare the residual risk after a preferred adaptation option is theoretically implemented. For example, a present risk may be “extreme but after the implementation of an adaption option ‘X’ the risk level is re-evaluated and reduces to “medium”. This residual risk rating will be assessed in the next phase of work (Element 6 in Figure 1-1).

Table 4-2 Risk levels and tolerances (example from WAPC 2014)

Risk Level	Action Required	Acceptance/Tolerance
Extreme (E)	Immediate action required to eliminate or reduce risk to acceptable levels.	Unacceptable
High (H)	Immediate to short-term action required to eliminate or reduce risk to acceptable levels.	Tolerable / Unacceptable
Medium (M)	Short to medium term action to reduce risk to acceptable levels, or accept risk.	Tolerable
Low (L)	Accept risk.	Acceptable

4.2 Coastal Erosion

The risk level for each of the identified assets at risk due to coastal erosion and inundation, for each planning timeframe, has been assessed. The results of this assessment are presented in Table 4-3. There is a general increase in risk level over the planning timeframes with predicted sea level rise and the higher probability of an extreme event occurring or having occurred. These factors also increase the potential consequences of coastal impacts, compounding the overall risk levels.

Table 4-3 Risk levels for assets predicted to be under impact from coastal erosion under 2015 timeframe

Asset	Risk Level			
	Present Day	2040	2070	2110
On-ground infrastructure at Onslow Jetty	Low	High	Extreme	Extreme
Onslow Back Beach picnic area (low risk)	Low	High	Extreme	Extreme
Front Beach / Sunrise Beach	Low	High	Extreme	Extreme
Seawall	Low	High	Extreme	Extreme
Seaview Drive near 12 Mile Creek / 4 Mile Beach	High	High	High	Extreme
Assets adjacent to crest of seawall (bins, shade structures, benches)	Low	Low	Medium	High
Shire of Ashburton Offices at the intersection of Second Ave and McGrath Rd	High	High	Extreme	Extreme
Aboriginal community on Second Ave	Medium	Medium	Extreme	Extreme
Western half of Ian Donald Blair Memorial Walkway	Low	Low	High	High
Intersection of Seaview Drive and Back Beach Road	Medium	Medium	High	High
Eastern end of Ian Donald Blair Memorial Walkway	Low	Medium	High	High
Lot 381 (at the top of the hill at Beadon Point).	Medium	Medium	Medium	High
Second Ave	Medium	Medium	Medium	High

4.3 Fluvial Inundation

The risk ratings determined for each general asset group under the various planning timeframes and ARI rainfall events are presented in Table 4-4. Again we see a general increase in risk rating over the planning timeframes, as the intensity of rainfall events is predicted to increase.

Table 4-4 Risk levels for assets predicted to be under impact from inundation under 2015 timeframe

Asset Type	Planning Timeframe			
100 yr ARI	**Present Day**	**2040**	**2070**	**2110**
Housing, Buildings & Property	High	High	Extreme	Extreme
Parks & Recreation Grounds	Low	Low	Medium	High
Public Infrastructure (fencing, light poles, playgrounds etc.)	Low	Low	Medium	High
Car parks	Low	Low	Medium	High
Roads/footpaths	Medium	Medium	High	High
Sheds	Low	Low	Medium	High
500 yr ARI				
Housing, Buildings & Property	High	High	Extreme	Extreme
Parks & Recreation Grounds	Medium	Medium	High	High
Public Infrastructure (fencing, light poles, playgrounds etc.)	Medium	Medium	High	High
Car parks	Medium	Medium	High	High
Roads/footpaths	High	High	High	Extreme
Sheds	Medium	Medium	High	Extreme

4.4 Discussion

Risk Assessment Discussion Notes….this will need to be confirmed/updated once we are happy with the analysis and evaluation process:

- Style and inputs to the risk assessment. Where it has been tailored.
- Discussion around those assets that are at ‘high’ and ‘extreme’ risk, and their potential adaptive capacity and therefore vulnerability i.e. if they are built/fixed structures then a higher level of consideration needs to be given relative to those that are ‘low’. Their adaptive capacity is limited, and vulnerability is increased.
- The risk of assets to coastal hazards needs to be reduced by implementing adaptation or mitigation strategies (risk management).

5 Risk Management Options

Planning for risk adaption or treatment involves the identification, development and evaluation of options suitable for mitigating the potential impacts of each coastal hazard that requires treatment, as determined in the risk assessment process.

In this CHRMAP the identified risk management and adaption options will be assessed against numerous criteria to evaluate which option or combination of options will be the most suitable. The criteria include:

- Potential benefits;
- Effectiveness;
- Costs, both initial and ongoing – this combines with other criteria to give an idea of economic effectiveness and cost-benefit;
- Equity implications;
- Potential risk creation and negative environmental effects;
- Practicality;
- Reversibility / Adaptability;
- Implementation timing;
- Design life; and
- Acceptance (community, stakeholders, regulators).

While cost-benefit criteria will be important, some criteria are difficult to quantify, so all criteria will be included in the overall analysis (often referred to as multi-criteria analysis, or MCA).

Risk management options should also be assessed in terms of their restriction on future planning and risk management opportunities. Options that allow for a wide range of future strategies are considered more favourably. State Planning Policy No.2.6 (2013) utilises this philosophy, recommending adaptation planning on a preferential basis of avoid, managed retreat, accommodate and protect (Figure 5-1).

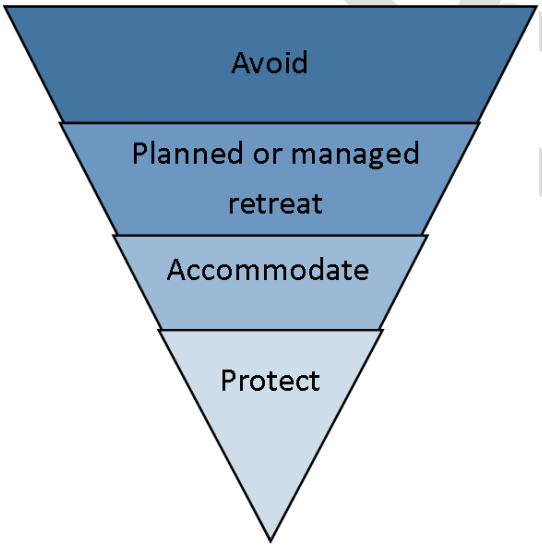

Figure 5-1 WAPC preferential planning hierarchy

Adaptation planning is a somewhat cyclical process, moving through assessment of the preferred options until suitable mitigation is achieved. The CHRMAP management and adaptation plan employs the following steps:

- Determine possible adaptation options for each risk;

- From this list, select at least one option, if possible more, using the preferential basis described above;
- Evaluate whether the selection or selections mitigate the identified risk to a tolerable or acceptable level;
- If necessary, select another option and re-assess whether risks are tolerable; and
- Assess the effectiveness of the new adaptation option(s) compared with the identified success criteria.

5.2 Risk Management & Adaptation Options

The basic characteristics of the risk management and adaptation options relevant to the study area are discussed below. Risk management and adaption options aim to mitigate risk and vulnerability through one or more of the following actions:

- Avoiding the risk
- Removing the risk
- Changing the likelihood
- Changing the consequences
- Increasing adaptability
- Transferring or accepting the risk

'Avoid' and 'managed retreat' options are the preferred options for new and existing developments. 'Accommodate' options aim to re-design existing infrastructure to mitigate potential impacts as they occur. 'Accommodate' options may also be employed for new developments, when there is no practical option to avoid or retreat from coastal hazards. 'Protect' options are often considered the last line of defence and are the least favourable options. These options aim to protect an asset from coastal hazards by preventing the hazard from reaching the asset. They range from 'soft' options such as beach nourishment to hard structures such as seawalls. Hard protection options can potentially reduce beach amenity, can cause negative impacts to the adjacent coastline and are generally expensive.

Table 5-1 again outlines the assets at risk of coastal erosion and inundation within the study area, and allocates them a code for reference in Table 5-2 and further analysis. Table 5-2 proposes the various coastal hazard adaptation options for the Town to consider for implementation as part of Element 6 in Figure 1-1.

Table 5-1 Assets predicted to be at risk from coastal process hazards

Vulnerability Timeframe	Asset Code	Assets at Risk
Present Day		
	1	On-ground infrastructure at Onslow Jetty
	2	Onslow Back Beach picnic area
	3	Front Beach / Sunrise Beach
	4	Seawall
2040		
	5	Seaview Drive near 12 Mile Creek / 4 Mile Beach
	6	Assets adjacent to crest of seawall (bins, shade structures, benches)
	7	Shire of Ashburton Offices at the intersection of Second Ave and McGrath Rd
	8	Aboriginal community on Second Ave
2070		
	9	Western half of Ian Donald Blair Memorial Walkway
2110		

	10	Intersection of Seaview Drive and Back Beach Road
	11	Eastern end of Ian Donald Blair Memorial Walkway
	12	Lot 381 (at the top of the hill at Beadon Point).
	13	Second Ave

Table 5-2 Risk Management Options (adapted from WAPC, 2014)

Option Code	Option Category	Option Name	Description	Preliminary Considerations (MCA, CBA)	Potential Assets Affected[3]	Proposed Actions/Triggers
AV	Avoid	Avoid	Locating/re-locating assets outside of hazard zone	Financial resources will not be required for management and adaptation. Should be implemented wherever possible and practical, and considered every time an asset is repaired or renewed.	12	Significant investment
MR1	Managed Retreat	Accept and repair losses	Assets are left unprotected and loss is accepted following hazard event. Repairs may be implemented for public safety, and asset is retreated outside hazard zone, or in the case of beaches/vegetation, as natural recession occurs.	Save the financial resource for better use. Usually applied to low value assets. Viable where available land allows retreat to maintain beach width.	2, 3, 5, 6, 9, 10, 11, 13	Undertake economic and safety assessment to determine which assets should be left on an economic and safety basis. Repair or remove after hazard results in damage.
MR2	Managed Retreat	Relocate outside of hazard zone	Assets located in the hazard zone are relocated or destroyed. Applied to assets of low value where it is impractical to re-design to withstand hazard impacts.	Allows low value assets to be retained until such time as relocation is necessary. Often coincides with asset replacement, which enables cost of relocation to be shared with cost of replacement, reducing overall cost in present and future planning.	2, 5, 6, 7, 8, 9, 10, 11, 12, 13	Design for lifecycles and expected risk, then monitor. Move low value structure when 'at risk'.
MR3	Managed Retreat	Prohibit further development	Allows continued use of the current infrastructure until such time that impacts arise, but prohibits the development of further infrastructure as the area/asset is known to be vulnerable	Foreshore reserve seaward of the 2110 hazard line should remain council land, thus significant economic development should be prohibited so as not to limit future adaptation options.	1, 7, 8, 10, 12, 13	Potentially maintain all land seaward of the 2110 coastal hazard line as Shire land.
AC1	Accommodate	Notification on title	Indicates to current and future landholders that an asset is likely to be affected by coastal hazards over the planning timeframe. Helps owners to make informed decisions about level of risk they are/may be willing to accept and that risk management and adaptation is likely to be required at some stage.	This option allows vulnerability of an asset to hazards to be conveyed to existing and future owners. One means of implementing that is low coast, is through decision making for subdivision and development.	7, 8, 12	
AC2	Accommodate	Emergency plans and controls	Implement plans for asset that are at risk of coastal erosion due to severe weather. Have procedures in place for before, during and after the events for safety.	This has low financial cost and with a high benefit to public safety. Does not benefit to the asset itself, but increased safety reduces the overall consequences of the	1, 7, 9, 10, 11, 12, 13	Develop practical plans, if haven't already done so.

Option Code	Option Category	Option Name	Description	Preliminary Considerations (MCA, CBA)	Potential Assets Affected[3]	Proposed Actions/Triggers
			E.g. signage barrier to prevent access.	hazard.		Implement upon severe weather warnings.
AC3	Accommodate	Re-design to withstand impact	Where avoiding or relocating are not an option, re-design to withstand impacts e.g…….	Retains existing assets in locations but reduces consequences of hazards. High principle cost, low ongoing costs. Results in extended design life.	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	Significant investment inside the coastal hazard zone.
AC4	Accommodate	Dune care program	Development of a long term program for revegetation and rehabilitation of the dune system.	Low principle and ongoing costs. Small increase in adaptive capacity through some additional buffering. May slow long term recession.	2, 5, 6, 7, 8, 9, 10, 11, 12, 13	Implement now and monitor throughout lifetime
PR1	Protect	Beach Nourishment or Replenishment	Replacement of sand on upper beach face and dunes to re-establish the sandy beach and provide a sediment supply. Generally utilised in conjunction with other methods for sand retention.	High ongoing costs, particularly if available sand is located at some distance. Available sand also needs to be suitable to destination conditions i.e. sand that is finer than existing may be lost more quickly.	3, 5, 6, 7, 8, 12, 13	Investigate potential sand sources. Undertake when erosion threatens significant assets, but before situation is critical.
PR2	Protect	Seawall	Construct small seawall in front of asset or along length of coastline to protect it from coastal hazards. This may need to be accompanied by beach replenishment/renourishment.	High initial cost. Change nature and appearance of coast. Protect land (and associated assets), not the beach itself, thus needs to be accompanied by renourishment/replenishment, which adds to ongoing costs.	2, 5, 6, 7, 8, 10, 12, 13	Most economic if included in original design. Investigate seawall only if absolutely necessary.
PR3	Protect	Groyne	Construct shore normal groynes along the beach to capture sediment and protect the shoreline and assets behind.	Very high initial costs. Effective if designed properly. Can result in significant ongoing costs and negative environmental impacts in adjacent areas due to the high variability of longshore sediment transport. Reduces beach amenity.	3, 5, 6, 7, 8,	Monitor and investigate if absolutely necessary.
DN	Do Nothing	No prohibitions or development regulations	No limitations on development or controls on adaptation planning. Assumes all risks are accepted at their present level.	No initial cost, but potentially very large costs in the future. May lead to increased development and thus future costs when hazards occur whilst also restricting option for future mitigation or retreat. Not recommended.	All	Implement now.

[3] See Figure 5-1

5.3 Discussion

Planning timeframes need to be considered when considering adaptation options. Assets will need to be monitored over time and potentially no action taken until the risk level becomes intolerable. Relocation can occur as part of future town planning schemes.

General notes:

- On-ground jetty infrastructure: ownership/responsibility
- Onslow Back Beach picnic area: (MR1)
- Front Beach/Sunrise Beach: high initial adaptive capacity
- Existing seawall: determine actual extent of seawall and potentially upgrade (AC2) as this protects Second Ave and Shire Offices etc.
- Seaview Drive near 12 Mile Creek/4 Mile Beach: monitor until such time as action is required, relocate (MR2)
- Assets adjacent to seawall: low value assets; accept loss and relocate or relocate before lost (MR2)
- Shire of Ashburton Offices (2nd Ave x McGrath rd): establish condition of existing seawall (PR2), relocate – has potentially already been relocated closer to town on second ave (MR2)
- Aboriginal Community: prohibit further development in that area (MR3), put in place emergency plans (AC1), protect by extending existing seawall (PR2)
- Western IDB Memorial Walkway: MR1-MR2, AC3
- Intersection Seaview Drive x Back Beach rd: monitor until such time as action is required, relocate (MR2)
- Eastern IDB Memorial Walkway: MR1-MR2, AC3
- Lot 381: Avoid new development (AV), design to withstand impacts (AC2)
- Second Ave: MR1-MR2, AC2, AC3

Element 6 of the study involves the Implementing Risk Management & Adaptation Plan (Figure 1-1). This will delve into which of the above options is best suited to the town site of Onslow under predicted coastal hazard situations.

6 Conclusions

7 References

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