APPENDIX 14

ATTACHMENT 1

City of Joondalup

Sorrento Coastal Foreshore Reserve Management Plan

V1 09 October 2015

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Contents

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- City of Joondalup staff
- Friends of Sorrento Beach and Marmion Foreshore

Abbreviations and Acronyms

Abbreviation	Description
AHD	Australian Height Datum
BoM	Bureau of Meteorology
the City	City of Joondalup
CoJ	City of Joondalup
Cwlth	Commonwealth
DAFWA	Department of Agriculture and Food WA
DEC	Department of Environment and Conservation
DER	Department of Environment Regulation (WA)
DotE	Department of the Environment (Cwlth)
DPaW	Department of Parks and Wildlife (WA)
DRF	Declared rare flora
EDOWA	Environmental Defenders Office of WA (Inc)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GIS	Geographical information system
GPS	Global positioning system
ha	Hectare
IUCN	International Union for Conservation of Nature
Km	Kilometre
Km/h	Kilometres per hour
m^2	Square metres
MAAC	Marmion Angling and Aquatic Club
NIASA	Nursery Industry Accreditation Scheme Australia
PMST	Protected Matters Search Tool
SLSC	Sorrento Life Saving Club
SLIP NRM	Shared Land Information Portal – Natural Resource Management
WA	Western Australia
WALGA	Western Australian Local Government Association
WA Herb	Western Australian Herbarium

Executive Summary

Natural Area Consulting Management Services (Natural Area) was contracted by the City of Joondalup to prepare a Management Plan for the Sorrento Coastal Foreshore Reserve. This plan identifies management strategies that will assist the City with ongoing management of the site for the next five years, with a focus on maintaining both the environmental and recreational values of the area. This Management Plan is consistent with the overarching *Coastal Foreshore Natural Areas Management Plan* whilst providing site-specific recommendations for management of the Sorrento Coastal Foreshore Reserve.

The site is located approximately 19 km north-west of the Perth Central Business District in the suburb of Sorrento, and covers an area of approximately 4 ha. The site extends south of Hillarys Boat Harbour to the northern end of the Marmion Angling and Aquatic Club (MAAC) car park adjacent to Marine Terrace. The Sorrento foreshore is characterised by a wide sandy beach, with a thin strip of low, heavily modified vegetated dunes. Facilities include a number of parking areas, shaded and non-shaded seating areas, picnic and barbecue facilities, grassed and recreational areas plus access ways to the beach. A series of groynes were installed, with their presence providing a safe and popular swimming location for families.

The majority of the native vegetation at Sorrento Coastal Foreshore Reserve is in Very Good condition, and is part of a regional ecological linkage chain that extends along the coast from Burns Beach in the north to North Beach in the South. A range of mammal, bird, reptile, invertebrate and flora species were observed within the Reserve during surveys undertaken in 2013. The range and diversity of species indicates a healthy ecological community despite previous disturbance, the relative small and narrow nature of the site, and the surrounding urbanisation.

1.0 Introduction

1.1 Background

The City of Joondalup (the City) is situated on the Swan Coastal Plain, approximately 30 km north of the Perth Central Business District. The City covers an area of 96.5 kilometres that encompasses a diverse range of natural areas including 17 kilometres of coastal foreshore, a chain of wetlands and a variety of bushland ecosystems (Figure 1). The City's southern boundary is approximately 16 kilometres from the Perth Central Business District, and is bounded by the City of Wanneroo to the east and north, the City of Stirling to the south, and the Indian Ocean to the west.

There are a number of regionally, nationally and internationally significant natural areas located within the City including Yellagonga Regional Park, Marmion Marine Park, and a number of Bush Forever sites that contain species of high conservation value. The City of Joondalup is committed to conserving and enhancing the City's natural assets to ensure the long-term protection of the environment for future generations.

1.2 Natural Area Management Plans

The City is developing Natural Areas Management Plans and associated Action Plans to provide strategic and operational management of the City's natural areas to protect native vegetation and ecosystems. Natural Areas Management Plans describe the potential environmental impacts and risks of activities and environmental threats in natural areas, and the associated management strategies that are implemented to minimise potential impacts.

Environmental threats have the potential to degrade natural areas and reduce biodiversity values. Environmental threats addressed in this Plan include weeds, plant disease, fire, non-native fauna species, human impacts, access and infrastructure.

1.3 Study Area

The study area for the Sorrento Coastal Foreshore Reserve Management Plan is the Sorrento Coastal Foreshore Reserve, in the suburb of Sorrento (Figure 2). The reserve covers an area of approximately 4 ha, and is located approximately 19 km north-west of the Perth Central Business District. The site extends south of Hillarys Boat Harbour south to the Marmion Angling and Aquatic Club car park adjacent to Marine Terrace, and is bounded by West Coast Drive to the east and the Indian Ocean to the west. The site does not include the landscaped parkland area to the north of the SLSC (the the flora and fauna study does not include the artificially constructed sand dunes to the west of the landscaped parkland).

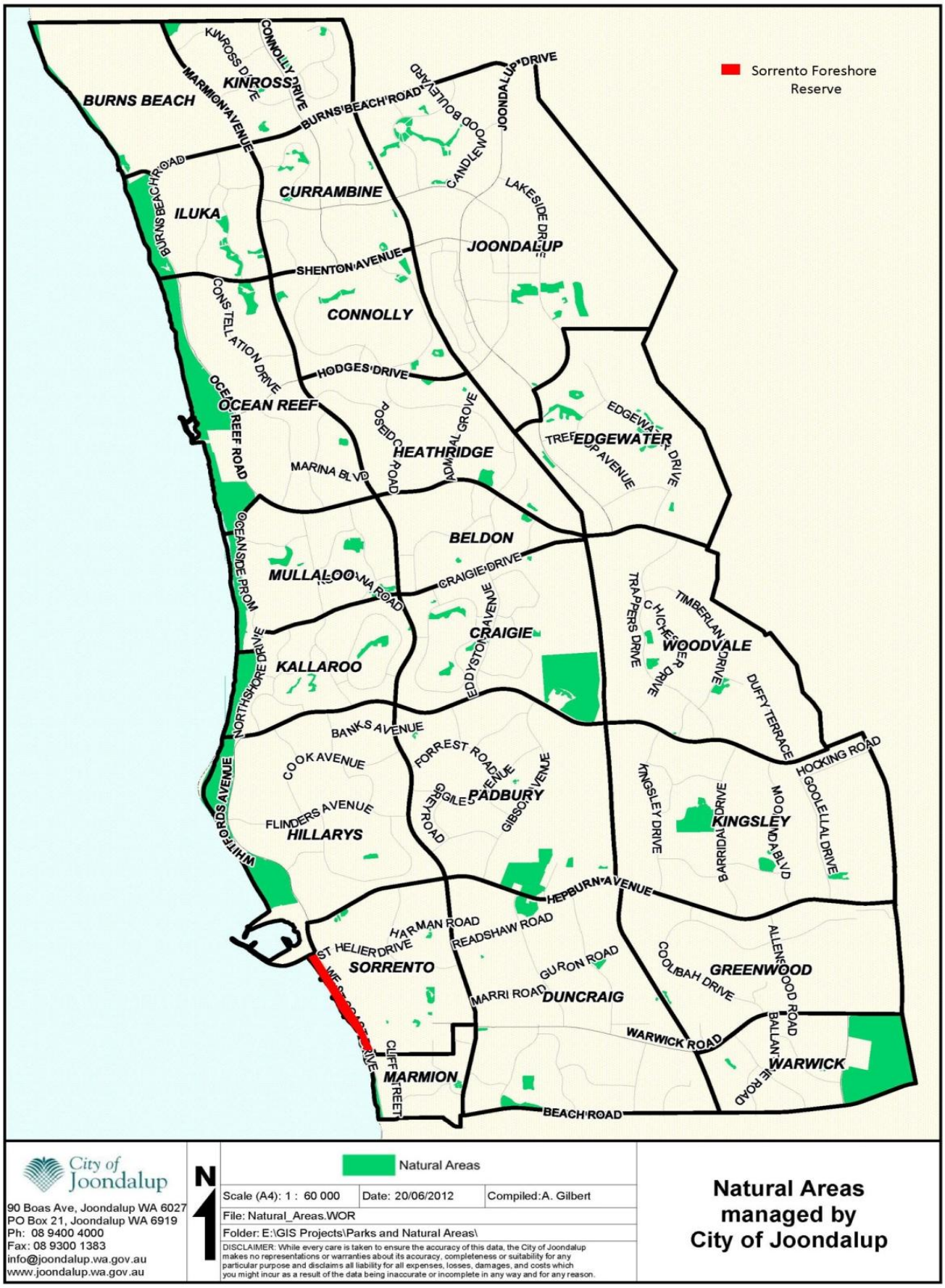


Figure 1: Location of Sorrento Coastal Foreshore Reserve

Client: City of Joondalup
Project: Sorrento Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 27/05/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 2

Sorrento Foreshore Reserve

0 N 100
meters

1.4 Purpose

The purpose of the Sorrento Coastal Foreshore Reserve Management Plan is to:

- provide information to assist the City of Joondalup in prioritising maintenance schedules
- guide the future development of the City's Conservation Capital Works Program
- increase opportunities for grant funding by having a detailed schedule of projects
- provide guidance to City employees, contractors and Friends Groups operating within the Sorrento Coastal Foreshore Reserve.

1.5 Aims and Objectives

The aims of the Sorrento Coastal Foreshore Reserve Management Plan are to:

- establish a baseline description of the environment to guide future environmental planning and recommended management actions
- outline key environmental threats and management strategies to minimise impact and protect conservation and recreational values
- outline management actions to address key threats, including monitoring and reporting.

The objective of the Sorrento Coastal Foreshore Reserve Management Plan is to provide mechanisms to protect and enhance the biodiversity values of the natural area whilst maintaining appropriate community access and awareness.

1.6 Strategic Context

In order to ensure the Sorrento Coastal Foreshore Management Plan complements other management initiatives within the City, along with relevant legislation, policies, guidelines and documents were reviewed and are summarised in this Section.

1.6.1 Local Government

Strategic Community Plan

The City of Joondalup's Strategic Community Plan 2012 – 2022 is the long-term strategic planning document, which outlines the commitment of the City to achieve its commitment to achieving the visions and aspirations of its community and stakeholders.

Environmental Plan

The City of Joondalup's *Environmental Plan 2014 – 2019* was developed to guide the City's strategic response to local environmental pressures.

Biodiversity Action Plan

The City of Joondalup *Biodiversity Action Plan 2009 – 2019* was prepared to provide direction for biodiversity management activities within the City, with retention and enhancement of biodiversity a key priority. Development of individual Natural Area Management Plans was included as a management action.

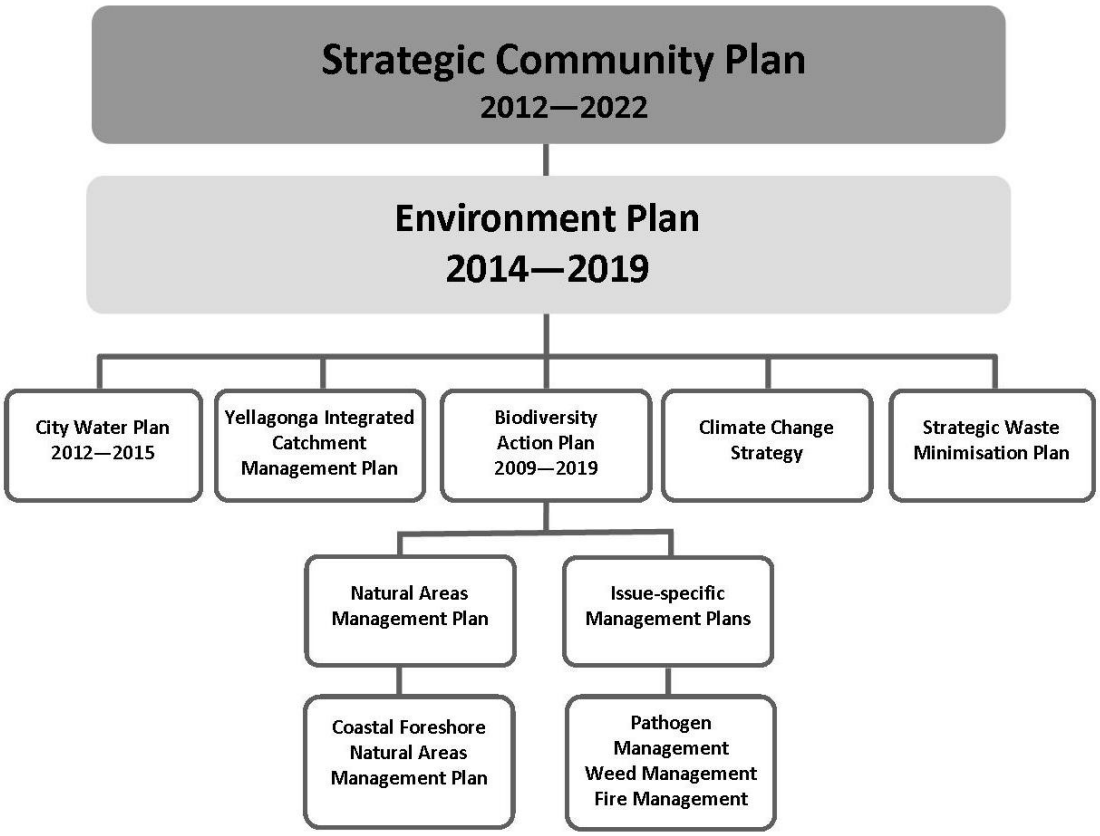


Figure 3: City of Joondalup Strategic Environmental Framework

***Local Biodiversity Program* (formerly *Perth Biodiversity Project*)**

The City of Joondalup was one of 32 local governments participating in the Western Australian Local Government Association's (WALGA's) Perth Biodiversity Project, which documented the local biodiversity within its boundaries. The aim of the program was to support local governments to effectively integrate biodiversity conservation into land use planning to protect and manage local natural areas.

As part of the Program, the City of Joondalup assessed all natural areas in 2004 and at later times using the ecological criteria of the Natural Area Initial Assessment, resulting in a priority ranking of natural areas. The Natural Area Initial Assessments include a desktop assessment and field survey and document information such as:

- vegetation complexes
- threatened or significant flora or ecological communities
- structural plant communities
- weed species
- vegetation condition assessment
- ecological criteria ranking
- a viability estimate
- fauna species observed.

While funding for the program ceased in 2014, the assessment template continues to provide a useful assessment tool.

Pest Plant Local Law 2012

The purpose of the *Pest Plant Local Law 2012* is to prescribe pest plants within the City of Joondalup that are likely to adversely affect the value of the property in the district or the health, comfort or convenience of the inhabitants of the district.

Pest plants are generally highly adaptable and will establish quickly after a disturbance event such as fire, or through unrestricted access. If pest plants are allowed to establish they have the potential to out-compete the City's unique floral biodiversity. The *Pest Plant Local Law 2012* requires the owner or occupier of private land within the City of Joondalup district to destroy, eradicate or otherwise control scheduled pest plants on notice by the City. Currently one weed species is scheduled under the Local Law – Caltrop (*Tribulus terrestris*). Caltrop was not identified in the Sorrento Coastal Foreshore Reserve.

1.6.2 State Government

Relevant Legislation, Policies and Documents

Aboriginal Heritage Act 1972

The Act makes provision for the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants. The Sorrento Coastal Foreshore Reserve is not listed on any State or Federal Aboriginal heritage inventory or register.

Biosecurity and Agriculture Management Act 2007

The Act provides for the control of declared flora and fauna species (declared organisms) that are known to be a significant environmental threat and makes provision for the management, control and prevention of these declared plants and animals. No declared plants were recorded in the Sorrento Coastal Foreshore Reserve.

Bushfires Act 1954

The Act makes provision for diminishing the dangers resulting from bush fires and for the prevention, control and extinguishment of bush fires.

Cat Act 2011

The Act makes provision for the control and management of cats, and promotes and encourages the responsible ownership of cats.

Dog Act 1976

The Act requires dog owners to register their dogs and encompasses the ownership and keeping of dogs and the obligations and rights of dog owners. Local governments are responsible for administering, monitor compliance and enforcing the Act within their respective districts.

Environmental Protection Act 1986

The Act provides authority to the Environmental Protection Authority (EPA) for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment in Western Australia.

Heritage of Western Australia Act 1990

The Act provides for and encourages the conservation of places that have significance to the cultural heritage in the State. The Sorrento Coastal Foreshore Reserve is not listed on any State or Federal cultural heritage inventory or register.

State Planning Policy 2.6 – State Coastal Planning Policy 2013

The purpose of the policy is to provide guidance for decision making in the coastal zone throughout Western Australia, with objectives including:

- considering coastal processes during development
- identifying appropriate and sustainable land use
- providing for public use and access of coastal areas
- the development of coastal reserves to protect, conserve and enhance coastal biodiversity, ecosystem functioning, and indigenous and non-indigenous cultural significance.

State Planning Policy 2.8 – Bushland Policy for the Perth Metropolitan Region

This policy aims to provide direction and an implementation framework that will ensure bushland protection and management issues in the Perth Metropolitan Region are appropriately addressed, and integrated with broader land use planning and decision-making.

WA Planning Commission 'Bush Forever' Strategy 2000

The Strategy identifies regionally significant bushland in the Perth Metropolitan Region to be retained, managed and protected forever. The Sorrento Coastal Foreshore Reserve is not listed as a Bush Forever site.

Weed Prioritisation Process 2013

The Department of Parks and Wildlife prepared the weed prioritisation process to assist with the on-ground management of weeds in a particular location, considering their ecological impact, rate of dispersal and population trend.

Wildlife Conservation Act 1950

The Act provides the statute relating to conservation and legal protection of flora and fauna. Four fauna species listed under the *Wildlife Conservation Act 1950* are considered to either use or possibly use Sorrento Coastal Foreshore Reserve, these being:

- Black-striped Snake (*Neelaps calonotos*) (snake) – **Priority 3**
- Graceful Sun Moth (*Synemon gratiosa*) (insect) – **Priority 4**
- Peregrine Falcon (*Falco peregrinus*) (bird) – **Specially Protected Fauna.**

None were observed during the 2013 fauna survey or the 2015 site assessment.

1.6.3 Federal Government

Environment Protection and Biodiversity Conservation Act 1999

The Act provides for the protection of the environment and the conservation of biodiversity, and for related purposes. Eight *Environment Protection and Biodiversity Conservation* (*EPBC*) *Act 1999* listed species have been recorded as occurring or potentially occurring within Sorrento Coastal Foreshore Reserve, these being:

- Australian Painted Snipe (*Rostratula australis*) – **Vulnerable**
- Caspian Tern (*Sterna caspia*) – **Migratory Species**

- Cattle Egret (*Ardea ibis*) – **Migratory Species**
- Fairy Tern (Australian) (*Sterna nereis*) – **Vulnerable**
- Fork-tailed Swift (*Apus pacificus*) – **Migratory Species**
- Great Egret, White Egret (*Ardea alba*) – **Migratory Species**
- Rainbow Bee-eater (*Merops ornatus*) – **Migratory Species**
- White-bellied Sea-Eagle (*Haliaeetus leucogaster*) – **Migratory Species.**

None were observed during the 2013 fauna survey or 2015 site assessment.

Australia's Biodiversity Conservation Strategy 2010-2030

The Strategy aims to protect biological diversity and maintain ecological processes and systems.

National Weeds Strategy 1997

The *National Weeds Strategy 1997* provides a strategic framework for managing weeds at a national level. As part of the implementation of the National Weeds Strategy, 32 Weeds of National Significance are identified as nationally agreed priority plant species for control and management based on the criteria of invasiveness and impact characteristics, potential and current area of spread and economic, environmental and social impacts. The Sorrento Coastal Foreshore Reserve contains no known Weeds of National Significance.

1.6.4 International Conventions or Listings

International Union for Conservation of Nature (ICUN) Red List of Threatened Species

The ICUN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated using the ICUN Red List Categories and Criteria. No ICUN Red List species have been recorded within the Sorrento Coastal Foreshore Reserve.

2.0 Description of Physical Environment

2.1 Geology, Soils and Landforms

2.1.1 Soils of the Swan Coastal Plain

The Sorrento Coastal Foreshore Reserve is situated within the City of Joondalup, which is located within the Swan Coastal Plain. The Swan Coastal Plain comprises two major divisions, namely Swan Coastal Plain 1 Dandaragan Plateau, and Swan Coastal Plain 2 – Perth Coastal Plain. Sorrento Coastal Foreshore Reserve is located within the Perth subregion, which is broadly characterised as including areas of Jarrah and Banksia woodlands on sandy soils in a series of sand dunes, along with wetland areas, often within the interdunal swales. The majority of the soils of the Swan Coastal Plain were formed by material deposited by rivers and wind. A series of dune systems has been formed with the youngest dunes being the Quindalup Dunes nearest the coast, followed by the Spearwood Dunes and the oldest Bassendean Dunes are the farthest inland[1] (Figure 4).

The Sorrento Coastal Foreshore Reserve is located on the youngest formation, the Quindalup Dune System, which are still being actively formed. The Natural Resource Management Shared Land Information Portal (SLIP NRM Portal) indicates that one soil type occurs within the site boundary, namely the Quindalup Dunes S2 Phase soil (Qu_S2) which is described as white, fine to medium grained, sub-rounded calcareous sand, with quartz and shell debris, of eolian origin[2].

The Reserve is a narrow sandy beach associated with a thin vegetated zone that ranges from 26 to 59 m wide, and ranges in height from 1 - 13 m Australian Height Datum (AHD), with the southern area being steeper and narrower than the northern end[3].

[1] Government of Western Australia (2000)
[2] Department of Agriculture and Food WA (2015)
[3] Department of Water (2015)

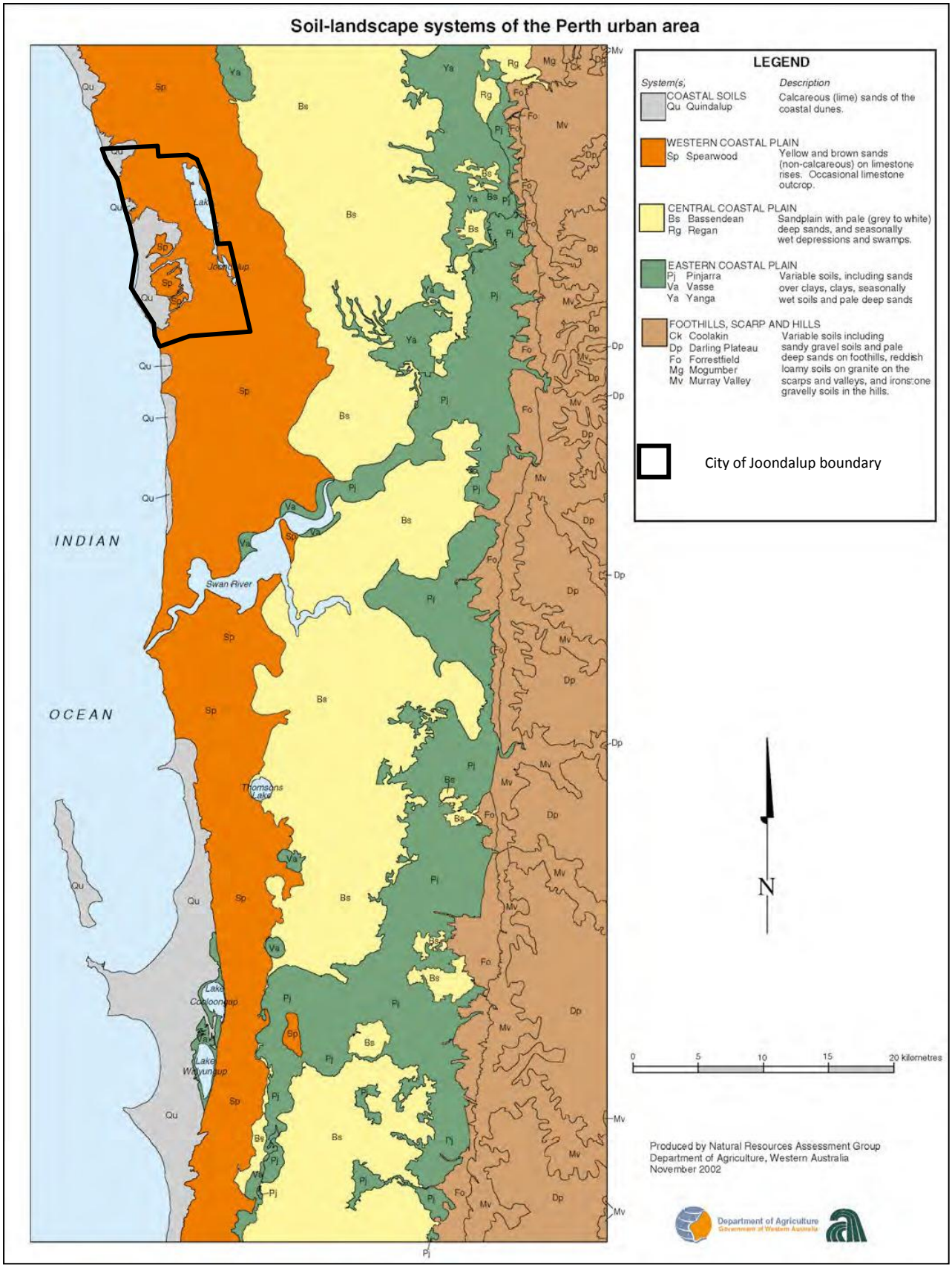


Figure 4: Soils of the Swan Coastal Plain (Department of Agriculture, 2002)

a)  b) 

Figure 5: Topography at Sorrento Coastal Foreshore Reserve: a) narrow, steep southern dunes, b) wider, lower northern dunes.

2.1.2 Acid Sulphate Soils

Acid sulphate soils are naturally occurring soils that contain iron sulphides, primarily in the form of pyrite materials, and are typically found in areas of low-lying coastal wetlands and tidal flats. If left undisturbed, acid sulphate soils do not pose a significant risk to humans or the environment. Exposure to air causes the formation of sulphuric acid, which can lead to the heavy metals being released into the surrounding environment[4].

Acid sulphate soils are categorised as potential acid sulphate soils or actual acid sulphate soils. Potential acid sulphate soils have not been oxidised by exposure to air whilst actual acid sulphate soils have been disturbed or exposed to oxygen and become acidic.[5] The risk of acid sulphate soils is based on their likelihood of occurring within soil profiles and has been mapped by the then Department of Environment Conservation (DEC), now the Department of Environment Regulation (DER), using available desk-top information and limited ground-truthing within areas where intensive on-ground mapping and soil analysis work has been undertaken. The mapping undertaken has found that acid sulphate soils are not known or expected to occur in the environment of the Sorrento Coastal Foreshore Reserve on the basis of origin of the geological units present, depth to groundwater and partial 'ground truthing' or onsite investigation.

2.1.3 Erosion

Sand within the coastal dunes systems is primarily held in place by vegetation, with erosion occurring where vegetation is absent or its cover reduced. Erosion is a naturally occurring process on the coast particularly during winter months, when rainfall and wind speed increase. Human factors can increase the rate and extent of erosion via activities such as people and pets walking on the dunes instead of keeping to nominated pathways, or the installation of infrastructure in dune areas. Over time, projected climate change impacts are expected to include[6]:

- stronger winds during storm events
- increased storm surge potential
- lower rainfall, potentially leading to water stress on plants and impacts to flora and fauna habitat

[4] Department of Environment (2004)
[5] Department of Environment and Conservation, n.d.
[6] City of Joondalup (2014b)

- sea level rise and associated coastal inundation.

Accordingly, erosion is likely to be an ongoing issue that will impact on rehabilitation and ongoing maintenance requirements. Climate change risks with the City of Joondalup are outlined in the *Climate Change Strategy 2014 – 2019* (City of Joondalup, 2014), as are proposed mitigation and adaptation strategies.

The Reserve was found to be in good condition during site assessments, with only a few small isolated areas of erosion occurring around two stormwater drains and along access pathways (Figures 6 and 24). Although the majority of the site is currently showing minimal signs of erosion, ongoing monitoring is recommended to prevent or mitigate any threatening processes that could result in erosion. Considerations for management of erosion will include:

- areas affected
- causes
- natural, conservation and human values of the affected area
- priorities for action in terms of feasibility of success in the medium to longer term
- techniques used to restore or stabilise affected areas.

Figure 6: Erosion around stormwater drains creating gullies towards the beach within the site

Erosion from both natural and human causes can largely be managed through sand stabilisation and access control. Revegetation and rehabilitation activities are often the most effective means of stabilising sand dune areas. These can include:

- applying appropriate revegetation techniques that will allow plants to become established and stabilise the soil
- erecting sand trap fencing that allows wind-borne sand to collect and create incipient dunes over time
- applying some form of stabilising material such as biodegradable jute or coir matting, brushing or mulch to exposed areas to provide a stable surface that will allow seedlings to become established and grow
- use of signage to provide information about erosion and the need to keep off the dunes
- establishing barriers to deter human (and their pets) access to vegetated areas, and allowing bare areas to regenerate.

2.1.4 Recommended Management Actions

Action	Detail
Holistic consideration of erosion	Erosion issues to be considered holistically, with the most appropriate management options being determined on a case by case basis and recognising that all exposed sand does not need to be covered by vegetation, reflecting what would occur within a natural environment.
Brushing	Brushing materials will be of suitable species that do not contain seed pods or other materials that can propagate and result in the presence of weeds at the site.
Early consideration of erosion	Address erosion issues as early as possible to avoid larger areas to be rehabilitated later.
Wider context	Consider erosion in the wider context of climate change impacts that could occur over time.

2.2 Hydrology

2.2.1 Groundwater

The City of Joondalup is located on Perth's largest source of groundwater, the Gnangara Groundwater System, comprising four main aquifers: superficial (shallow, unconfined), Mirrabooka (deeper, semi confined), Leederville (deep, mostly confined) and the Yarragadee (deep, mostly confined). The Gnangara Mound extends across most of the superficial aquifer and refers to the water table creating a mound shape (Figure 7). Groundwater levels in the superficial aquifer have been declining over recent years due to pressure from extraction and the impacts of climate change.

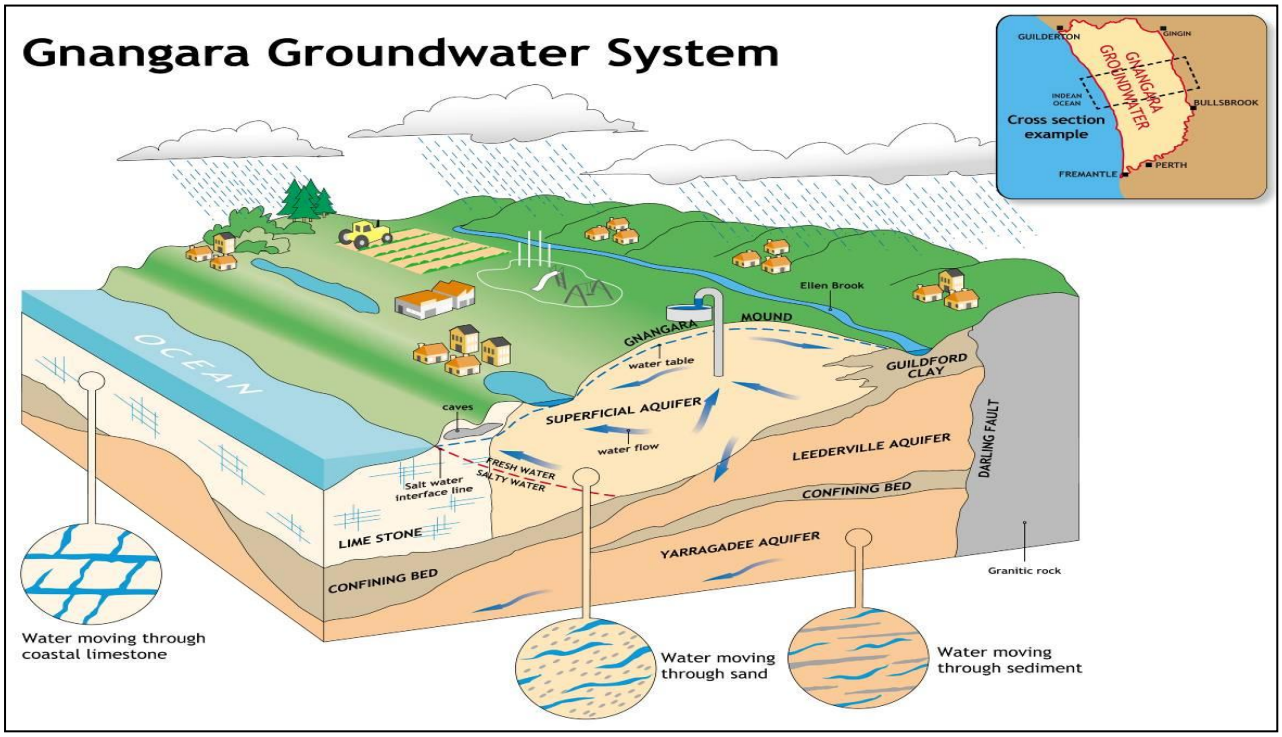


Figure 7: Gnangara Groundwater System[7]

[7] Department of Water n.d.

2.2.2 Drainage

Sorrento Coastal Foreshore Reserve has no natural wetlands. Depth to groundwater in the site ranges from 0 m to 12 m below ground level[8], which is consistent with a site located on the coast, where ground water enters into the ocean (Figure 8).

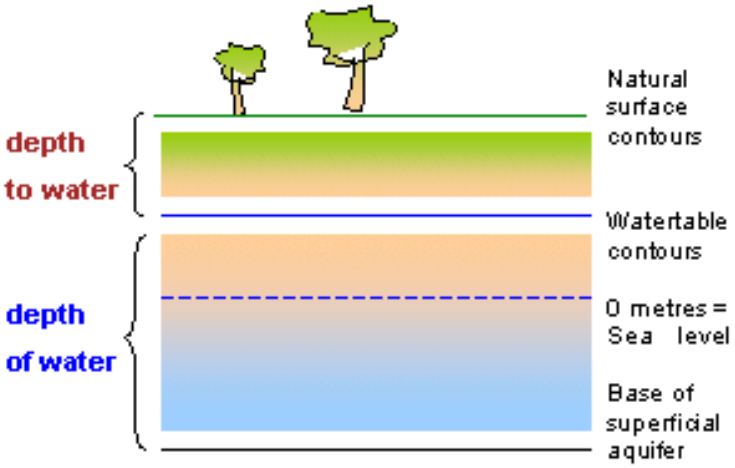


Figure 8: Groundwater Depth Explanation[9]

2.3 Climate

The City of Joondalup experiences a Mediterranean climate of hot dry summers with an average temperature of 31 °C during the day and mild wet winters with an average daytime temperature of 18 °C. The average annual rainfall from 1944 to 2015 was 769.4 mm, with approximately 80 percent of the annual rainfall occurring between the months of May and September (Figure 9)[10].

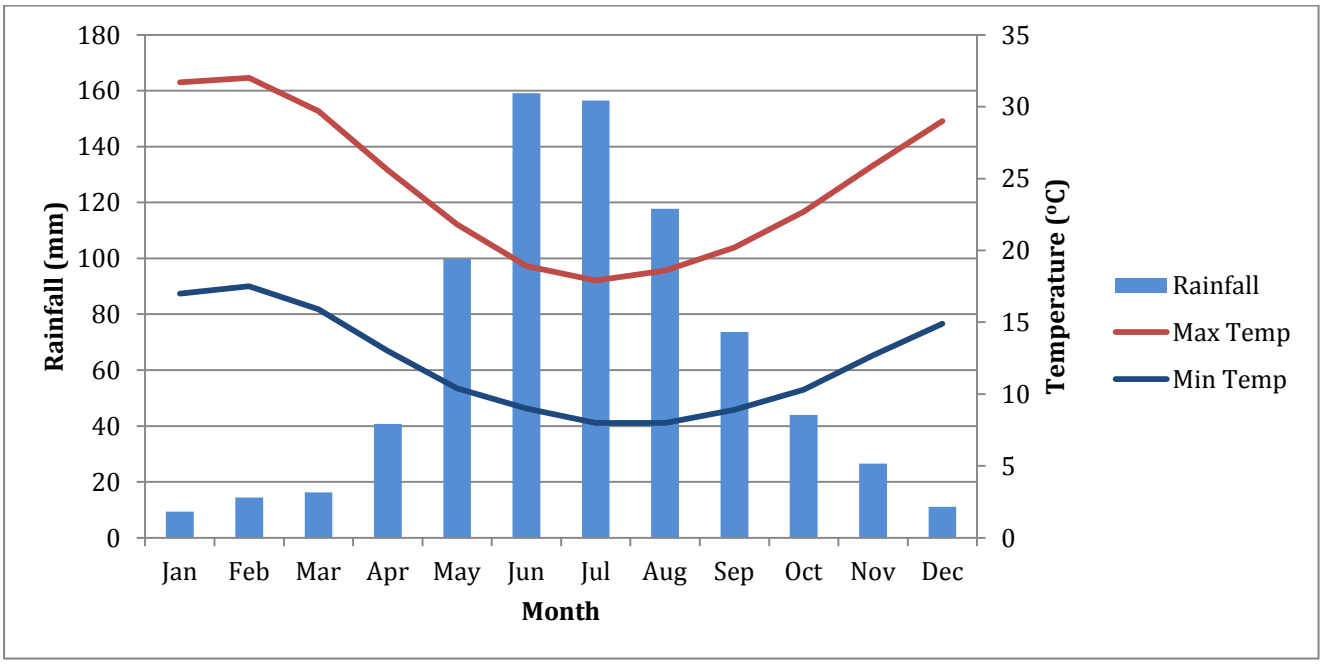


Figure 9[9]: Climate data for Perth

[8] Department of Water (2015)
[9] Department of Environment (2004)
[10] Bureau of Meteorology (2015)

2.4 Vegetation

2.4.1 Vegetation Complexes

Vegetation complexes are classified by the soil and landforms contained in medium to large areas along the Swan Coastal Plain. Regional scale mapping indicates that the Sorrento Coastal Foreshore Reserve occurs within the Cottesloe Complex – Central and South vegetation complex (Figure 10), which comprises heaths on limestone outcrops and a mosaic of Tuart woodlands and Tuart-Jarrah-Marri open forests on deeper sands[11].

The State Government has established targets under Bush Forever, which aim to protect at least 10% of each vegetation complex[12] in the Perth metropolitan region to achieve a comprehensive representation of all the ecological communities originally occurring in the region[13]. The City of Joondalup portion of the pre-European extent of Cottesloe Complex – Central and South in Perth and Peel was 9% (3,966 ha). Approximately 35% (15,251 ha) of this vegetation complex currently remains in Perth and Peel, with the City of Joondalup proportion of the current extent being 2% (345 ha) and the level of retention is just under 9%.

2.4.2 Floristic Community Types

Floristic Community Types (FCTs) are generally groups of flora species that consistently occur together. Sorrento Coastal Foreshore Reserve is inferred to have FCT 29a – Coastal shrublands on shallow dunes[14]. The floristic community type can only be inferred at Sorrento Coastal Foreshore Reserve as there is limited remnant vegetation on site due to past degradation, with the majority of vegetation now present being the result of revegetation works over the past 10 years. Whilst FCTs can be useful to describe groups of flora species, vegetation communities are more commonly used to define plant communities.

2.4.3 Vegetation Communities

Four different vegetation communities were identified during the flora survey (Table 1, Figure 11). The structural classes use to describe vegetation type are provided in Appendix 1. No Threatened or Priority ecological communities were identified within the site[15].

The dominant vegetation type for the majority of the site was *Scaevola crassifolia* Low Open Heath, with the Mixed Open Heath being the dominant vegetation type at the southern end of the site. Where the site was in Very Good condition the shrubs formed thick heaths to a height of 1.5 m. In disturbed areas, vegetation cover was lower and sparser and with bare ground commonly seen. Spinifex Open Grasslands were found on the primary dunes as they are more resistant to wind and salt spray, while the secondary and tertiary dunes were dominated by heath vegetation as these areas are more protected from these elements.

[11] Heddle *et al.* (1980)
[12] Government of Western Australia (2000)
[13] WALGA (2012)
[14] Gibson *et al.* (1994)
[15] Natural Area Consulting (2014)

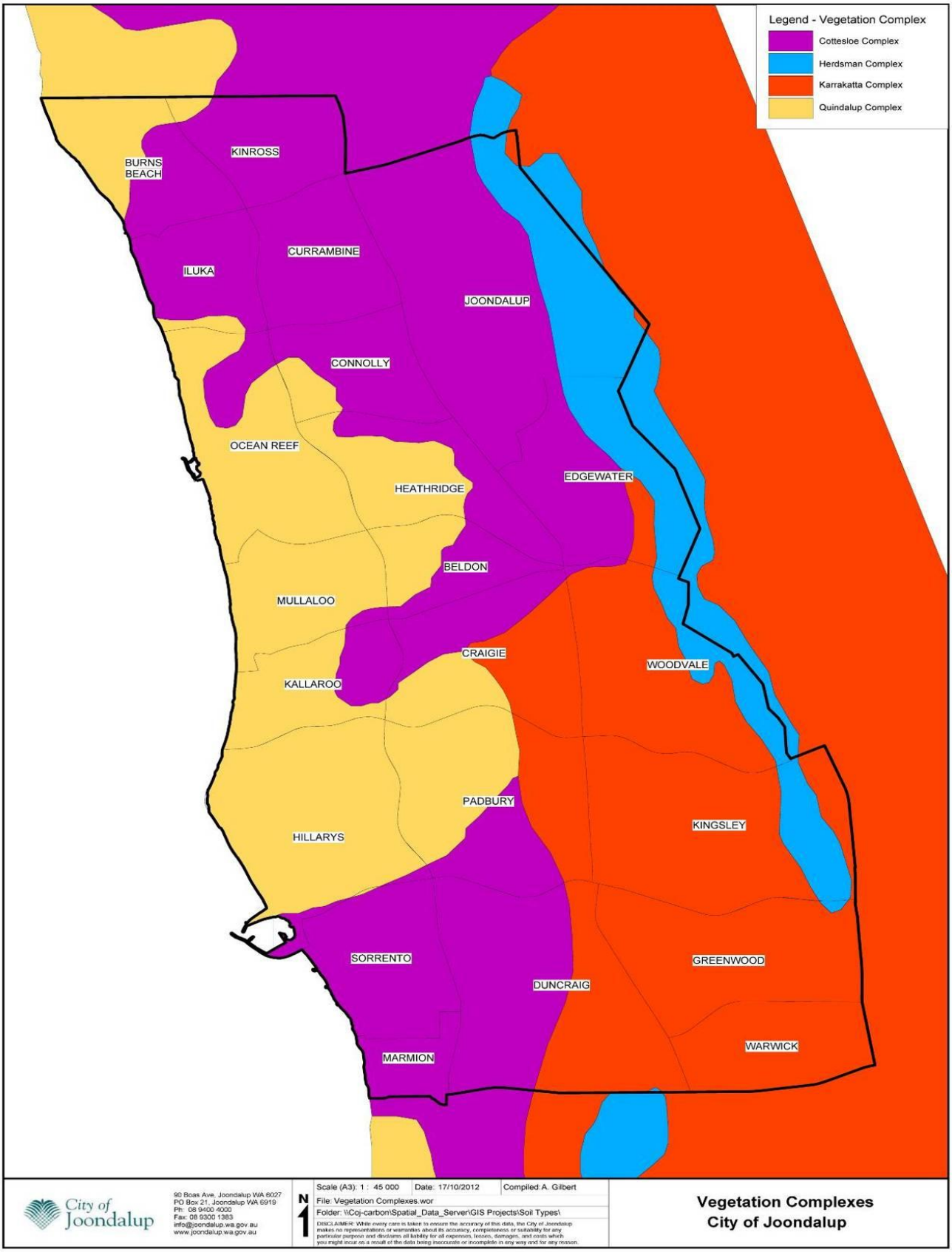
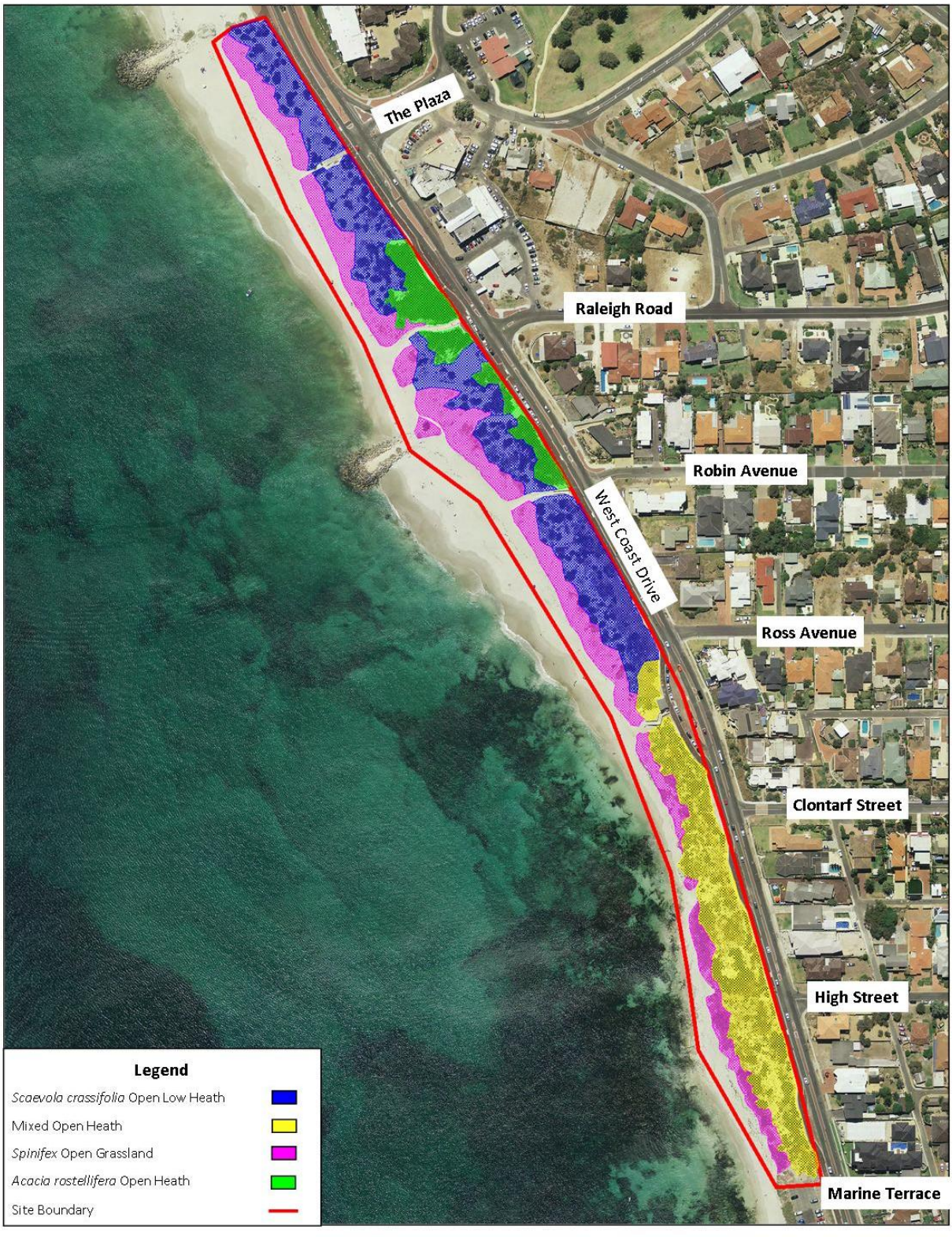


Figure 10: City of Joondalup Vegetation Complexes

Table 1: Vegetation types

Vegetation Type	Description	Photograph
Scaevola crassifolia Open Low Heath	Open Low Heath of *Scaevola crassifolia* with scattered shrubs of *Olearia axillaris, Rhagodia baccata, Spyridium globulosum*, *Myoporum insulare* and *Acanthocarpus preissii*. The majority of the site is considered *Scaevola crassifolia* Open Low Heath. This vegetation type creates a thick covering of shrubs; areas of Very Good condition are generally situated further back from the beach. This vegetation type is sparser close to the beach perhaps a result of erosion, salt spray and wind. The majority of these areas are in Good condition.	
Mixed Open Heath	Mixed Open Heath of *Acacia rostellifera*, *Scaevola crassifolia, Olearia axillaris, Rhagodia baccata, Spyridium globulosum*, *Myoporum insulare* and *Acanthocarpus preissii*. An open to very open herbland of *Lomandra maritima* was found in areas of Very Good condition. The Mixed Open Heath occurred along the southern end of the site where the dunes are steeper. This vegetation type was not dominated by any one species but varied in density, with some areas of thick shrubs and little understorey while other smaller areas comprised of open sedgeland with scattered shrubs. This area was previously disturbed as evidenced by broken up pieces of fibre cement sheets, which may contain asbestos throughout the dunes. It has undergone rehabilitation in the past, which may explain the higher diversity of species.	

Vegetation Type	Description	Photograph
Acacia rostellifera Open Heath	An Open Heath to Open Low Heath of *Acacia rostellifera* with scattered shrubs of *Scaevola crassifolia, Rhagodia baccata and Olearia axillaris*. The *Acacia rostellifera* Open Heath consisted of dense patches shrubs and little understorey; this was the only vegetation type to include areas of Excellent condition	
Spinifex Open Grassland	Open Grassland dominated by *Spinifex longifolius* and *Spinifex hirsutus*, with scattered shrubs of *Olearia axillaris* and *Scaevola crassifolia*. This vegetation type was situated on the foredunes and had low densities of weeds.	


The Plaza
Raleigh Road
Robin Avenue
West Coast Drive
Ross Avenue
Clontarf Street
High Street
Marine Terrace
Legend
Scaevola crassifolia Open Low Heath
Mixed Open Heath
Spinifex Open Grassland
Acacia rostellifera Open Heath
Site Boundary
Client: City of Joondalup
Project: Sorrento Coastal Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 26/05/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50
Figure: 11
Vegetation types
Sorrento Coastal Foreshore Reserve
0
N
100
meters

2.4.4 Vegetation Condition

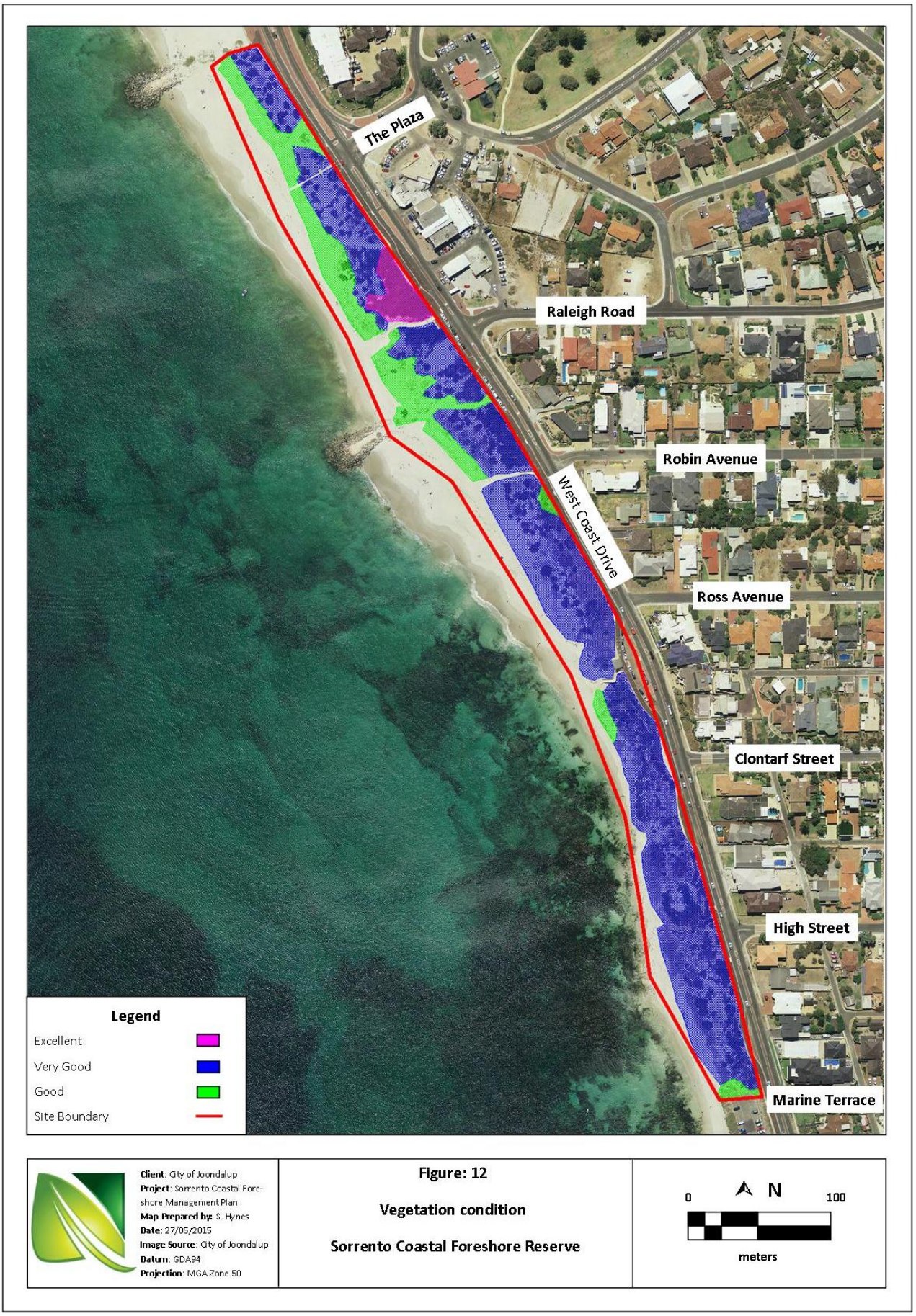
Vegetation condition assessments include observations regarding the numbers of native species, weed cover, vegetation structure, species diversity, amount of understorey, health condition of most species' populations and physical disturbance. The Keighery Scale is a tool used to rate the condition of vegetation from pristine to completely degraded, as detailed in Appendix 2. The City of Joondalup conducted a Natural Areas Initial Assessment (NAIA) in 2011 to assess the vegetation condition at the site. Natural Area conducted follow-up vegetation condition assessments in 2013 and 2015.

Vegetation condition at the Sorrento Coastal Foreshore Reserve ranges from Good to Excellent (Table 2, Figure 12). The majority of the site was considered to be in Very Good condition, and none of the site was considered to be Degraded. The areas of Excellent vegetation condition occurred where the *Acacia rostellifera* vegetation type occurred. Since the 2013 surveys, the vegetation condition in some areas has increased from Good to Very Good due to rehabilitation, ongoing weed control by the City with the assistance of Friends of Sorrento Beach and Marmion Foreshore.

Since 2011 there has been a reduction in the amount of vegetation rated as Excellent with an increase in the amount of vegetation rated as Very Good and Good. This can be attributed to the difference of opinion between assessors and more precise methods of measurement using GIS mapping and software in 2013 and 2015.

Table 2: Vegetation Condition at Sorrento Coastal Foreshore Reserve

Year	Pristine	Excellent	Very Good	Good	Degraded	Completely Degraded
2011	0	50%	20%	20%	10%	0
2013	0	3.9%	70.7%	25.4%	0	0
2015	0	3.9**%**	76.9%	19.2%	0	0


The Plaza
Raleigh Road
Robin Avenue
West Coast Drive
Ross Avenue
Clontarf Street
High Street
Marine Terrace
Legend
Excellent
Very Good
Good
Site Boundary
Client: City of Joondalup
Project: Sorrento Coastal Foreshore Management Plan
Map Prepared by: S. Hynes
Date: 27/05/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50
Figure: 12
Vegetation condition
Sorrento Coastal Foreshore Reserve
0
N
100
meters

3.0 Biodiversity Conservation

The Sorrento Coastal Foreshore Reserve supports a range of flora and fauna species, and provides an important ecological linkage to adjacent coastal reserves. The long term protection of biodiversity values within the reserve is critical to ensure the conservation of this habitat. The protection and enhancement of biodiversity within the reserve also benefits the community through the provision of ecological services, including:

- the production of oxygen and capture of carbon dioxide
- noise and air quality regulation
- cooling of urban environments
- supporting seed dispersal and pollination
- a number of recreational and cultural experiences[16].

A number of environmental threats pose a risk to the biodiversity of the Sorrento Coastal Foreshore Reserve. The key environmental threats include:

- weeds
- pathogens and disease
- non-native fauna species
- human impacts
- access and infrastructure
- fire.

Management strategies to mitigate the effects of key environmental threats have been established and are discussed in the following sections.

3.1 Flora

The Sorrento Coastal Foreshore Reserve is located in the Southwest Australian biodiversity hotspot, which is one of the worlds 34 biodiversity hotspots. It extends from Shark Bay in the North to Israelite Bay in the south, with over 2,900 endemic plant species occurring within the region. Approximately 30% of the original vegetation extent of this area remains, with habitat loss primarily due to agricultural expansion[17].

Flora surveys enable collection of scientific data related to the occurrence and distribution of flora species and vegetation communities. Information obtained from flora surveys is used as a baseline to monitor the ecological health of flora populations and vegetation communities. Natural Area was engaged to undertake a desktop and field flora survey of the Sorrento Coastal Foreshore Reserve in September 2013.

[16] City of Joondalup (2014a)
[17] Conservation International (2015)

3.1.1 Flora Survey Methodology

Desktop Survey

A review was undertaken of all relevant information and literature provided by the City of Joondalup and any additional information to gain proper understanding of the Sorrento Coastal Foreshore Reserve background, and any site specific management issues. A Natural Areas Initial Assessment was undertaken by the City in 2011 and was reviewed as part of the desktop study; this assessment included documenting information such as:

- vegetation complexes
- threatened or significant flora or ecological communities
- structured plant communities
- weed species
- rating vegetation condition
- ecological criteria rankings
- a viability estimate.

A review of available online databases was also undertaken to gain understanding of current site characteristics, including:

- SLIP NRM for soils and landforms
- NatureMap to determine local biodiversity recorded in and around the site
- Protected Matters Search Tool to determine the occurrence of matters of national environmental significances, such as threatened and priority flora, fauna and ecological communities
- Department of Parks and Wildlife (DPaW) threatened and priority flora, fauna and ecological communities databases.

Field Survey

The on-ground flora survey methodology for the Sorrento Coastal Foreshore Reserve was undertaken in accordance with *EPA Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*. The survey methodology included setting up 10 m x 10 m quadrats (2 per vegetation type) and opportunistic sampling of species not recorded within the quadrats.

3.1.2 Native Flora

Native flora is an important part of the Sorrento Coastal Foreshore Reserve ecosystem, providing food and habitat for fauna present. Reduction in flora species or vegetation cover can lead to a loss of fauna that depend on it for resources and shelter. A total of 44 flora species were recorded within the Reserve, including 21 natives indicating a low diversity of native species that can be expanded on through revegetation activities. Of these 14 were dicotyledons and seven were monocotyledons. Of note was the *Lomandra maritima* located at the southern end of the Reserve, which is a known habitat species for the Graceful Sun Moth (*Synemon gratiosa*) which is listed as a Priority 4 species under the *Wildlife Conservation Act 1950* (WA). With few mature plants found this was not considered significant, although increased abundance and density of this species through revegetation will enhance the ecological value of the habitat within the Reserve. No Threatened or Priority flora species were recorded within the Sorrento Coastal Foreshore Reserve.

3.1.3 Weeds

Weeds can be native or introduced species that have colonised an area where they did not originally exist. An environmental weed generally reproduces quickly, and requires action to reduce its negative impact on economic, social and environmental values of the area. Weeds are commonly introduced and distributed within bushland areas through seed dispersal by water, wind, animals such as birds, fire, the dumping of garden waste, and human or vehicle movement in natural areas. Weeds can have major economic, environmental and social impacts in Australia and can:

- displace native plant species
- alter nutrient cycling and soil quality within ecosystems
- harbour pests and diseases
- increase fire fuel loads
- impact negatively on native flora and fauna and their habitats
- compete with native species for resources[18].

Over 28,000 known alien plant species have been introduced to Australia with approximately 10% now being established in the environment.[19] Garden plants are the main source of Australia's weeds, accounting for 66% of recognised weed species.[20]

A total of 24 weed species were recorded within the Sorrento Coastal Foreshore Reserve, this number was based on the 2013 field studies. Although the number of weed species is high, the density of weeds found throughout the site during the 2015 site assessment was low due to weed control activities undertaken since 2013. No weeds of national significance (WoNS) were recorded within the Reserve. Key weed species recorded within the site during 2015 assessments are listed in Table 3.

[18] Department of the Environment (2015)
[19] Groves, Bowden and Lonsdale (2005)
[20] DSEWPC (2013)

Table 3: Weeds of concern in Sorrento Coastal Foreshore Reserve

Species Name	Common Name	Photograph	Comments
Euphorbia paralias	Sea Spurge		Found within the primary dunes
Gazania linearis	Gazania		Found in the north-west corner of the site
Lachenalia bulbifera	Lachenalia		Small isolated clump found at the southern end of the site; is showing resistance to chemical treatment and is difficult to manually remove as it can result in the spread of bulbils
Tetragonia decumbens	Sea Spinach		Found in open areas, along path edges and amongst native vegetation

Species Name	Common Name	Photograph	Comments
Thinopyrum distichum	Sea Wheat		Successfully weeded out of the foreshore by the Friends of Sorrento Beach and Marmion Foreshore group currently, but requires monitoring in case of reintroduction to site or resprouting from soil seed bank
Trachyandra divaricata	Dune Onion Weed		Found in the primary dunes and in open areas adjacent pathways

3.1.4 Revegetation

The City of Joondalup encourages natural bushland regeneration through weed management and conservation fencing to allow the vegetation to re-establish itself and maintain species diversity and populations. Revegetation is undertaken on an as required basis in Degraded, Completely Degraded, or other areas where further planting is considered to be beneficial using local provenance species.

The Sorrento Coastal Foreshore Reserve has been subjected to considerable degradation in the past, resulting in little natural vegetation remaining. The majority of vegetation existing on site today is the result of revegetation works undertaken by the City and the Friends of Sorrento Beach and Marmion Foreshore. Undertaking revegetation using appropriate additional species would increase species diversity within the site. This would better reflect what would have naturally occurred in the area. Six areas that would benefit from additional planting along with a proposed planting list is provided in Appendix 6, including species that are not present or under-represented on site.

Figure 13: north-west corner of the primary dunes exhibiting decline in plant health of *Spinifex hirsutus*

3.1.5 Current Management Approach

The City undertakes an integrated approach to weed management, including:

- prevention of weed introduction through hygiene measures
- regular monitoring and reporting of weed populations
- on ground weed control, including prioritisation of natural areas and priority weeds to target
- community education initiatives
- fire prevention measures
- hand weeding by bushland friends group volunteers and contractors.

Weed monitoring is conducted by the City every six months at the Sorrento Coastal Foreshore Reserve to establish the extent and distribution of weeds species and to identify priority weeds.

Previously Natural Area Initial Assessments were conducted approximately every 5 years in the Reserve to assess site specific ecological values, biodiversity significance and threatening processes. This system will be replaced with a flora, fauna and fungi survey as part of a management plan review being undertaken every five years within the Sorrento Foreshore Coastal Reserve.

In accordance with the City's Annual Bushland Schedules and Weekly Bushland Schedules, on ground weed management occurs through weed spraying and hand weeding methods. In addition to this, contractors are engaged to spray weeds and hand weed. City of Joondalup personnel act in accordance with internal spraying procedures and conduct trials periodically to evaluate the most effective management methods. Resources, such as the DPaW FloraBase website or *Southern Weeds and their Control* (DAFWA Bulletin 4744), are also consulted in regards to weed control.

Environmental weeds are classified as priority if they meet any of the following criteria:

- weed of national significance (WoNS)
- declared plant listed under the *Biodiversity and Agriculture Management Act 2007* (WA)
- high priority weed according to the Swan Regional Ranking
- pest plant under *Local Government Act 1995* (WA)
- major threat to vegetation
- major threat to the structure of vegetation communities

- contribute to a high fuel load, for example dry grasses.

A list of weeds and their priority rating according to the Swan Regional Ranking is provided in Appendix 4, with the recommended weed treatment methodology for high priority weed species detailed in Appendix 5.

The City of Joondalup Weed Management Plan is being developed in 2015 to provide an ongoing strategic approach to the management of natural areas and parks in order to reduce the incidence of weeds. A number of education initiatives are undertaken to raise the awareness of weeds with the community, these include:

- delivery of gardening workshops
- development and distribution of two weed brochures – *Environmental Weeds* and *Garden Escapees* (available in hard copy and on the City's website)
- weed education workshops for local Friends Groups.

3.1.6 Recommended Management Actions

To monitor, conserve and protect native flora in the Sorrento Coastal Foreshore Reserve, the following management actions are proposed.

Action	Detail
Weed survey	Continue to undertake weed surveys every six months.
Targeted weed control	Continue to undertake a targeted weed control program, as described in Appendix 5.
Ongoing weed control	Continue to undertake coordinated approach to regular weed control by implementing the Annual Bushland Schedule.
Control of *Lachenalia bulbifera*	Continue to prioritise the control of *Lachenalia bulbillifera* within the Sorrento Coastal Foreshore Reserve, determining the best method of control for this species.
Control of *Carpobrotus edulis* and the hybrid species	Identify and control Hottentot Fig (*Carpobrotus edulis*) and the hybrid species within Sorrento Coastal Foreshore Reserve.
Weed Management Plan	Implement the City of Joondalup Weed Management Plan when it is developed to provide an ongoing strategic approach to the management of natural areas in order to reduce the incidence of weeds.
Restoration	Conduct restoration as outlined in the Revegetation Strategy in Appendix 6.
Natural Areas Initial Assessment	Conduct follow up Natural Area Initial Assessments every 5 years in spring to monitor the ecological health of the site.
Friends Group	Continue to support the activities of the Friends of Sorrento Beach and Marmion Foreshore within the Reserve.

3.2 Fungi

It is estimated that there are 10 times more species of fungi than plants in the world, equating to approximately 140,000 fungi and 14,000 plant species in Western Australia. The amount of species of fungi present in bushland can be an indicator of ecosystem health. Fungi are strongly interconnected with plants

and animals as fungi are recyclers that break down litter and debris to provide nutrients for plants. Native plants such as eucalypts, wattles and orchids have beneficial partnerships with fungi. Fungi also provide food and/or habitat for fauna such as bandicoots and beetles.

Fungi surveys are important to provide baseline information, and to highlight changes in fungi occurrence over time. Undertaking surveys also enables comparison of ecological data with other City of Joondalup natural areas. The most common time to see the fruiting bodies of fungi is after autumn and winter rains.

3.2.1 Fungi Field Survey

No fungi species were identified within the Sorrento Coastal Foreshore Reserve during the 2013 opportunistic field survey conducted by Natural Area. The lack of fungi observed is probably due to the fungi survey occurring passed the optimum time to see fruiting bodies of fungi or due to the lack of woody and other organic debris within the Reserve. Species likely to occur are expected to be similar to those observed within the Marmion Coastal Foreshore Reserve and other City of Joondalup bushland areas.

3.2.2 Current Management Approach

The City of Joondalup currently monitors fungi in the Reserve through surveying for incidental sightings of fungi species every 5 years.

3.2.3 Recommended Management Action

To monitor fungi health in the Sorrento Coastal Foreshore Reserve, the following management action is proposed:

Action	Detail
Opportunistic fungi survey	Continue to undertake opportunistic fungi sightings during other site activities.

3.3 Plant Diseases

Vegetation can be subject to diseases that result in plant health decline and potentially death in the longer term. Pathogens are the organisms such as fungi, bacteria and viruses that cause plant diseases; with many introduced into new areas through movement of infected plant material or soils, whilst some are naturally occurring in the soil. Some pathogens will result in rapid plant death while others will lead to the slow decline in plant health over time.

Phytophthora dieback is a water-borne fungus and the most common plant disease encountered on the Swan Coastal Plain, with the most common species encountered being *Phytophthora cinnamomi*. While *Phytophthora cinnamomi* is considered the most destructive, other varieties are being described which may have similar impacts, such as *Phytophthora multivora* which is known to attack a variety of species including *Eucalyptus gomphocephala*, *E. marginata* and *Agonis flexuosa* and a range of Banksia species. The nature of the vegetation combined with the presence of limestone based soils within the foreshore reserve mean that *Phytophthora cinnamomi* is unlikely. However, *Phytophthora multivora* is known to be tolerant of alkaline conditions as it has been found in Tuart forests underlain by limestone soils south of Mandurah and as far as Cape Naturaliste, where it has been associated with individual spot deaths and areas of tree decline.

Phytophthora multivora has been recorded is urban areas of Perth, including inland dune systems and within the City's parks. If suspected within the foreshore reserve or other natural areas, it should be treated in the same manner as *Phytophthora cinnamomi*.

Armillaria luteobubalina has been identified within a number of parks within the City of Joondalup. *Armillaria* is a soil-borne fungus that causes root rot of a wide variety of plants including many species of native flora. The fungus is native to Australia and can cause major damage to natural ecosystems. *Armillaria luteobubalina* is commonly known as the 'Honey Fungus' due to the colour of the fruiting body seen above the ground during certain times of the year (Figure 14). Fruiting bodies (mushrooms) are not evident at all infected sites and their presence is usually a sign that the fungus is well established in that area.

Figure 14: *Armillaria luteobubalina*

At present, there is no reliable mechanism for the complete eradication of *Phytophthora* species and the control of *Armillaria luteobubalina* is both expensive and labour intensive.

3.3.1 Current Management Approach

The City of Joondalup has developed a Pathogen Management Plan to protect native vegetation and ecosystems by establishing the level of risk for areas to be infected by pathogens, prioritisation of areas and detail preventative and management actions to be implemented within the City, including guidelines for dieback-free purchasing and a hygiene procedure.

In order to reduce the risk of spreading pathogens between vegetated areas, City of Joondalup personnel currently spray vehicles, shoes and tools with methylated spirits and brush down before they enter and leave bushland reserves. Contractors working within natural areas are required to adhere to the City's hygiene protocols.

3.3.2 Recommended Management Action

To prevent pathogen spread and protect biodiversity values at the Sorrento Coastal Foreshore Reserve, the following management action is recommended:

Action	Detail
Pathogen Management	Implement recommendations from the Pathogen Management Plan that are applicable to the management of the Sorrento Coastal Foreshore Reserve.

3.4 Fauna

Fauna surveys were undertaken to establish a species baseline inhabiting the Reserve, and document their occurrence, distribution and minimum population numbers.

3.4.1 Fauna Survey Methodology

The fauna survey undertaken in accordance with *EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*, along with the principles outlined in *EPA Position Statement No. 3: Terrestrial Biological Surveys as an element of Biodiversity Protection, and the Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*.

Desktop Survey

As part of the fauna survey, Natural Area reviewed databases to compile a dataset that has been utilised in the development of this Plan, including NatureMap (WA), Protected Matters Search Tool (Cwlth) and the DPaW threatened fauna database.

Field Survey

Natural Area undertook fauna survey activities at Sorrento Coastal Foreshore Reserve from 9 – 31 December 2013, and 21 January 2014. The field survey for fauna was carried out in three components (Table 4).

Table 4: Site Assessment Methodology

Activity	Method
Opportunistic fauna survey	The presence of fauna within the Reserve was assessed opportunistically while conducting field work. Fauna were also identified through the interpretation of diggings, scats and tracks.
Targeted fauna survey	Fauna surveys were undertaken in accordance with *Guidance Statement 56: Terrestrial Fauna Surveys for Environmental Impact in Western Australia* (Environmental Protection Authority, 2004a) A trapping programme was undertaken over five days to assess the occurrence of terrestrial fauna, with traps being laid out on 09 December 2013 and removed on 13 December 2013. This involved the setting up of 15 baited Elliot traps and 5 pitfall trap lines (Figure 15). The trap lines consisted of: ▪ a line of plastic to divert fauna movement ▪ 1 large pitfall trap ▪ 2 pipe traps ▪ 2 funnel traps. Traps were installed as per DEC licence requirements and all were checked within 3 hours of sunrise.
Night survey	A night survey was undertaken to assess the site for nocturnal fauna. This involved traversing the Reserve for 3 hours on 21 January 2014 with handheld spotlights.

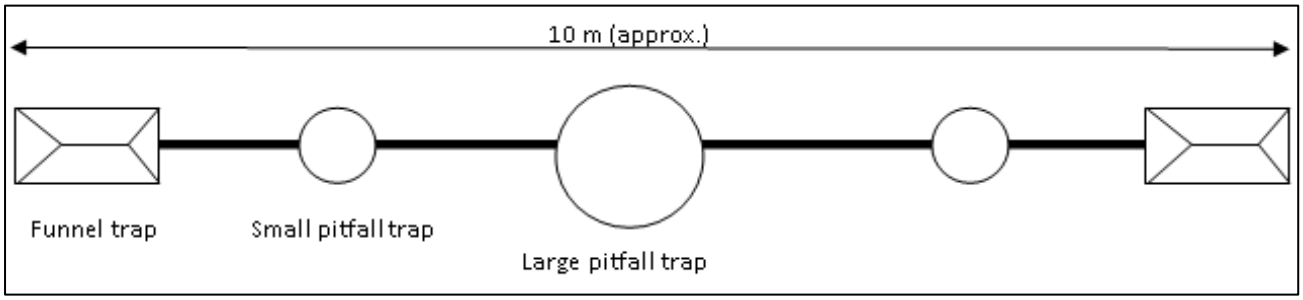


Figure 15: Trap line layout

3.4.2 Native Fauna

Fauna and flora are interconnected in complex relationships with each other and with factors such as soil, water, climate and landscape. The decline of native fauna can cause loss of plant species and changes to ecological communities, for example, the loss of pollinating fauna species can reduce or even cease plant reproduction. A total of 16 native species of vertebrate fauna were recorded within the site, of which ten were birds, five were reptiles and one was a mammal.

Mammals

One native mammal species the Southern Elephant Seal (*Mirounga leonina*) was observed within the Sorrento Coastal Foreshore Reserve in February 2014 (Figure 16). Any native terrestrial mammals that would have utilised the Reserve are considered to be locally extinct as a result of predation, loss of habitat and a reduction in ecological connectivity.

Figure 16: Elephant Seal at Sorrento Beach (Photo © M. Norman)

Birds

Eight species of native birds were identified during the 2013 survey, all of which were common to the area, with an additional two species observed during the 2015 site assessment (Table 5, Figure 17). Due to the size of the Reserve, it is likely that bird species utilise the area as part of a wider range.

Table 5: Birds identified at the Sorrento Coastal Foreshore Reserve

Species	Common Name	2013	2015
Falco cenchroides	Australian Kestrel	✓	
Hirundo neoxena	Welcome Swallow		✓
Larus novaehollandiae	Silver Gull	✓	✓
Larus pacificus	Pacific Gull	✓	
Lichenostomus virescens	Singing Honeyeater	✓	✓
Pandion haliaetus	Osprey	✓	
Phalacrocorax fuscescens	Black-Faced Cormorant	✓	
Phalacrocorax sulcirostris	Little Black Cormorant	✓	
Phylidonyris nigra	White-cheeked Honeyeater		✓
Sterna bergii	Crested Tern	✓	

Little Black Cormorant (*Phalacrocorax sulcirostris*) Crested Tern (*Sterna bergii*)

Figure 17: Birds observed at Sorrento Coastal Foreshore Reserve

Reptiles

Five reptile species were recorded during the fauna survey (Table 6). This shows a low diversity of reptile species within the area. A selection of photographs of reptiles caught during the survey is provided in Figure 18. High sides of the limestone stairs and access ways present can act as barriers to reptile movement across the site and any further similar construction may result in further fragmentation of the environment, placing them under further strain than they are already facing in a small reserve.

Table 6: Reptiles recorded at the Sorrento Coastal Foreshore Reserve

Species	Common Name
Ctenotus australis	Western Limestone Ctenotus
Ctenotus fallens	West Coast Ctenotus
Cyclodomorphus celatus	Slender Blue-tongue
Egernia kingii	King's Skink
Lerista elegans	West Coast Four-toed Lerista

King's Skink (*Egernia kingii*)

West Coast Four-toed Lerista (*Lerista elegans*)

Slender Blue-tongue (*Cyclodomorphus celatus*)

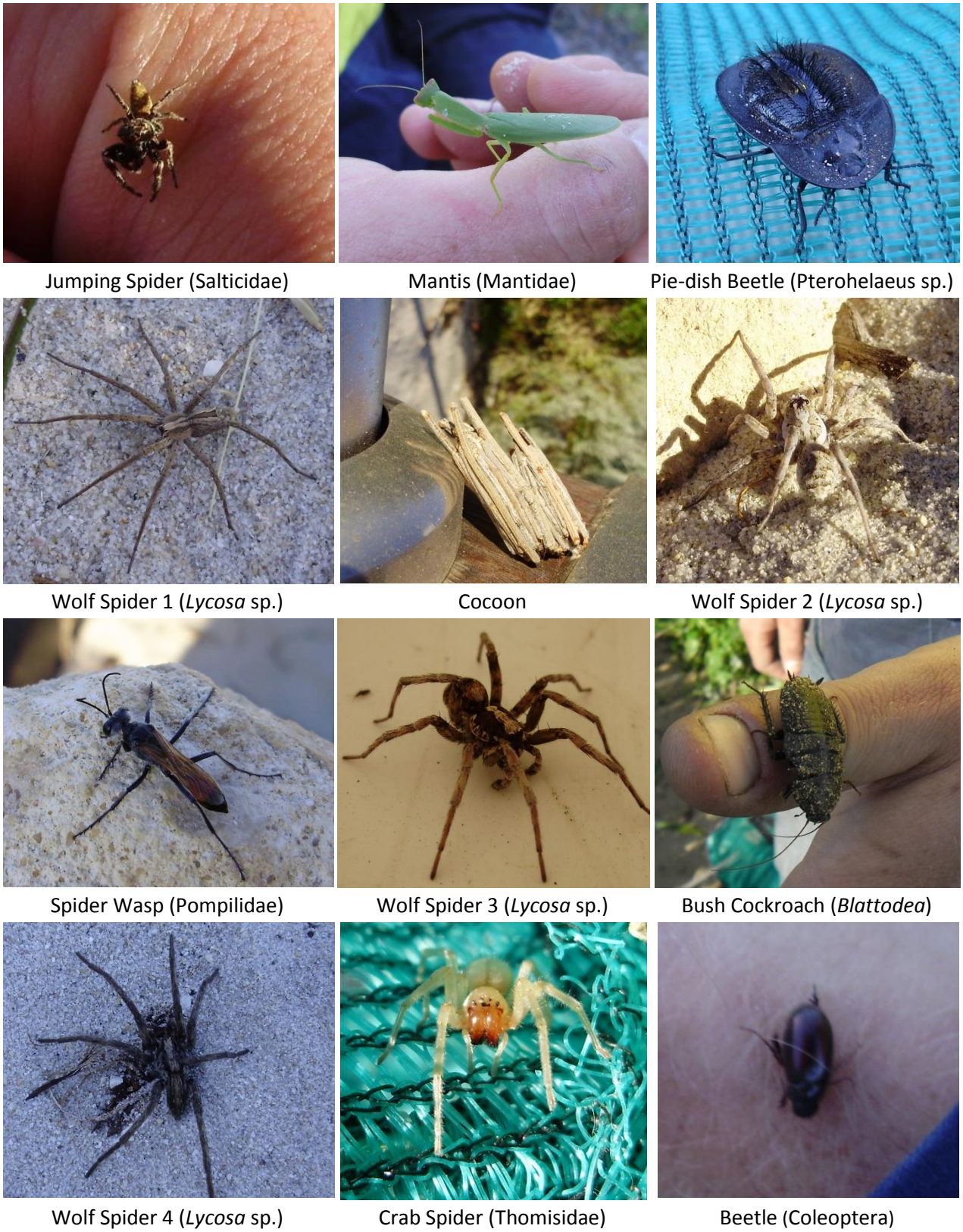
West Coast Ctenotus (*Ctenotus fallens*)

Western Limestone Ctenotus (*Ctenotus australis*)

Figure 18: Reptiles recorded at the Sorrento Coastal Foreshore Reserve

Invertebrates

In addition to reptiles and birds recorded during the survey, a number of invertebrate species were observed (Figure 19).



Jumping Spider (Salticidae) | Mantis (Mantidae) | Pie-dish Beetle (Pterohelaeus sp.)

Wolf Spider 1 (*Lycosa* sp.) | Cocoon | Wolf Spider 2 (*Lycosa* sp.)

Spider Wasp (Pompilidae) | Wolf Spider 3 (*Lycosa* sp.) | Bush Cockroach (*Blattodea*)

Wolf Spider 4 (*Lycosa* sp.) | Crab Spider (Thomisidae) | Beetle (Coleoptera)

Figure 19: Opportunistic invertebrate sightings and captures within the Sorrento Coastal Foreshore Reserve

3.4.3 Non-native Fauna

Non-native fauna impact native fauna and flora through predation, competition for food and shelter, spreading diseases and destroying habitat. These impacts can result in the diminishing or extinction of native species.[21] Non-native animals such as cats, foxes, rabbits, mice, birds, millipedes and bees inhabit the City's bushland, wetland and coastal areas.

Introduced Mammals

Five introduced mammals were either observed or signs of their presence was observed within Sorrento Coastal Foreshore Reserve. One non-native mammal, the House Mouse (*Mus musculus*) was captured in the Sorrento Coastal Foreshore Reserve during the 2013 survey (Figure 20). European Red Fox (*Vulpes vulpes*) tracks throughout the dunes suggest that the Reserve is visited as part of a wider range for this species. Dogs (*Canis lupus familiaris*) were observed off leash within the Reserve and on the beach, where they may disturb or injure native fauna present. Cats (*Felis catus*) are also known to frequent reserves in urban areas and this may have an impact on native species, especially reptiles and birds which are common prey species. Dogs and cats are required to be controlled in accordance with the *Dog Act 1976* (WA) and the *Cat Act 2011* (WA), and City of Joondalup local laws. The presence of the Black Rat (*Rattus rattus*) is also likely, as tracks were recorded at the northern end of the site during 2014 assessments for Marmion Coastal Foreshore Reserve (Natural Area Consulting, 2014).

Figure 20: House Mouse (*Mus musculus*)

Introduced Birds

Two introduced bird species were recorded during the 2013 field surveys (Table 7). Both were introduced dove species, which are common throughout bushland areas within the Perth Metropolitan Region.

Table 7: Introduced birds within Sorrento Coastal Foreshore Reserve

Species	Common Name	2013	2015
**Streptopelia chinensis*	Spotted Turtle Dove	✓	
**Streptopelia senegalensis*	Laughing Turtle Dove	✓	✓

* Denotes introduced species

[21] DSEWPC (2012)

3.4.4 Fauna Habitat

Vegetation condition at Sorrento Coastal Foreshore Reserve in terms of fauna habitat ranges from good to excellent. Whilst the site provides habitat for reptiles and birds, the inner metropolitan location of the Reserve and its small size limits use by larger fauna species.

3.4.5 Ecological Corridors

Naturally connected landscapes and ecosystems are generally healthier than fragmented ones, supporting and protecting a greater diversity of species, providing pathways for species movement and can store carbon more effectively than degraded landscapes[22]. In urban areas, infrastructure can divide landscapes creating barriers for native fauna movement, which may make it necessary to provide wildlife crossings such as underpasses, tunnels, viaducts or overpasses to enable wildlife movement.

The Sorrento Coastal Foreshore Reserve is part of an ecological linkage coastal strip that extends from Burns Beach in the north to North Beach in the south and inland to Star Swamp in the City of Stirling to the south (Figure 21). While the presence of limestone stairs from the dual use path to the beach may act as a barrier to the movement of smaller fauna species, the fragmented nature of the site suggests the impact on fauna present is likely to be low.

3.4.6 Current Management Approach

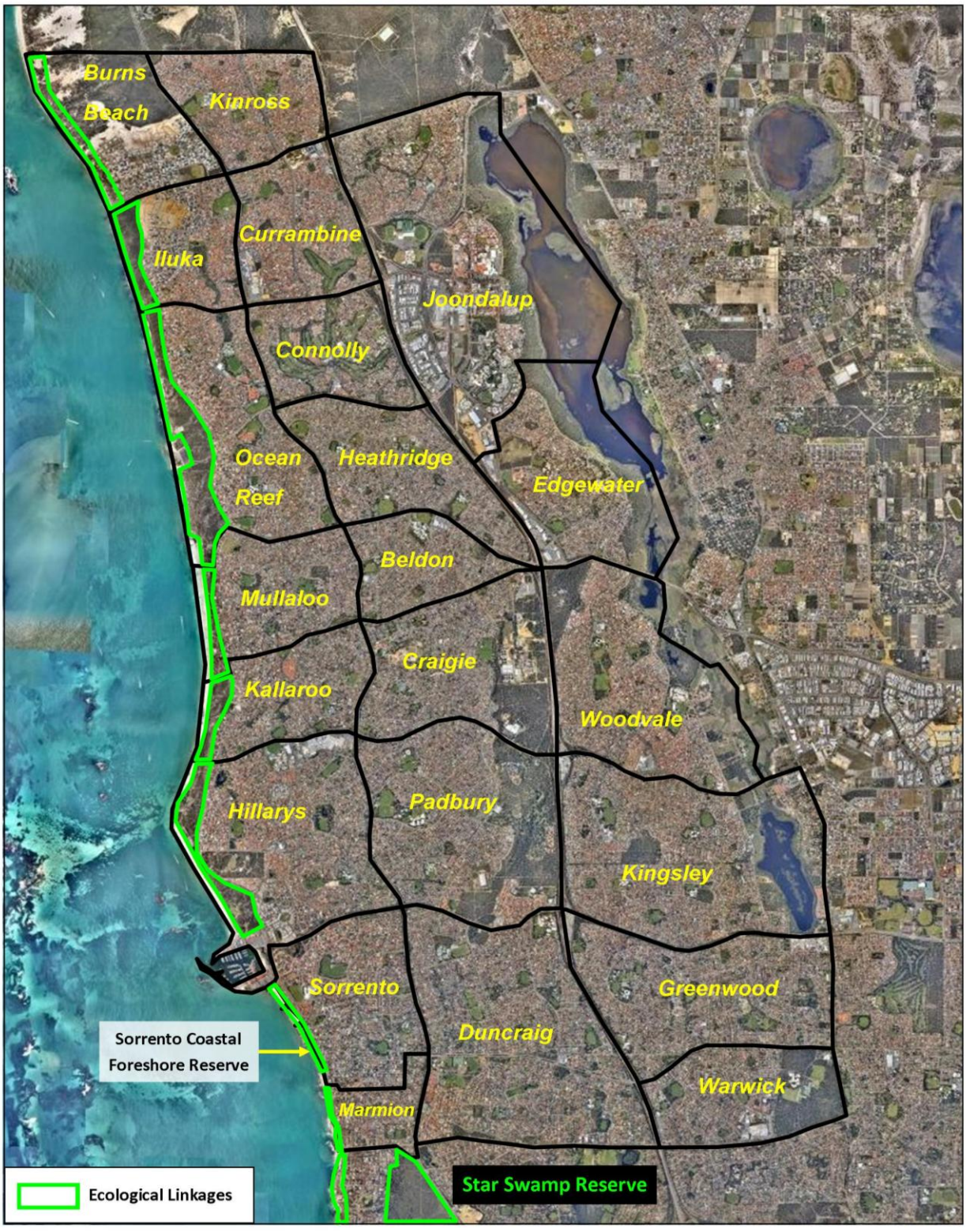
The City of Joondalup is implementing a number of management actions to monitor native fauna and address the environmental impacts of domestic and pest animals within the City's natural areas. Monitoring of native fauna occurs through fauna surveys. Control of non-native fauna is undertaken annually within bushland, wetland and coastal areas. Control methods employed include biological and chemical control, trapping, baiting and exclusion methods such as fencing.

The City's current management practices have greatly reduced the incidence of pest animal populations within the City, however continued and coordinated action is required to ensure that populations remain at controllable numbers and that the impacts on natural areas remain at a minimum. The City also promotes responsible pet ownership and encourages the community to ensure that domestic pets do not have a negative impact on the natural environment.

3.4.7 Recommended Management Actions

Action	Detail
Feral animal control	Continue to implement regular fox and rabbit control to reduce pressures on native fauna and flora.
Dog control	Dogs are controlled in accordance with the *Dog Act 1976* (WA) and City of Joondalup's policies and procedures in relation to removal on land managed by the City.
Cat control	Cats are controlled in accordance with the *Cat Act 2011* (WA) and City of Joondalup's policies and procedures in relation to their trapping and removal on land managed by the City.
Fauna monitoring	Undertake further fauna surveys at appropriate timeframes to review species presence and abundance.

[22] NWCPAG (2012)



Client: City of Joondalup
Project: Sorrento Coastal Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 05/06/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 21

Ecological linkages

Sorrento Coastal Foreshore Reserve

0 N 2.0

kilometers

3.5 Social and Built Environment

3.5.1 History and Heritage

The Sorrento Coastal Foreshore Reserve is not listed on any State or Federal Aboriginal or non-Aboriginal heritage inventory or register.[23] The foreshore area is part of the Marmion Marine Park, which is listed on the State Heritage Resister.

3.5.2 Social Value

The Reserve provides a number of recreational activities, including picnicking, walking, jogging and cycling along the dual use path. Water based activities include swimming and surfing.

Key external stakeholders associated with the management of the Reserve include:

- Marmion Angling and Aquatic Club (MAAC)
- Friends of Sorrento Beach and Marmion Foreshore
- Department of Fire and Emergency Services (formerly Fire and Emergency Services Authority (FESA))
- Sorrento Beach Surf Life Saving Club.

3.5.3 Access and Infrastructure

Parking

There are two car parks available to the north and south of the Sorrento Beach SLSC. Two additional roadside parking areas are available on West Coast Drive near the lookout area located between Ross Avenue and Clontarf Street, and in between Robin Avenue and Raleigh Road.

Bike racks are provided next to the access points adjacent Raleigh Road and Robin Avenue (Figure 22).

Figure 22: Bike racks available at Sorrento Coastal Foreshore Reserve

Fencing

Fencing (Figure 23) exists along the west side of the dual use pathway, consisting of marine grade stainless steel wire and Jarrah fence posts. Limestone retaining walls also act as fencing along paths and stairways. The limestone retaining walls stop halfway down the access pathways to the beach, where the fence is wire

[23] Department of Aboriginal Affairs (2015)

with pine fence posts. Fencing in the north-west corner is low to the ground due to sand build up in the primary dunes, resulting in easier access into the dunes by beach goers.

a) 

b) 

Figure 23: Fencing

Access Points

Fourteen access ways provide pedestrian access to the beach. The access ways provide access from the recreational turfed area at the northern end of the Reserve, all car parks and at several intervals along the dual-use path. There are three pathways that allow access for those with disabilities, with the remaining having stairways. The western sides of the solid access infrastructure or areas adjacent higher dunes are vulnerable to erosion, and pose an ongoing maintenance issue. Vulnerable areas had been repaired for most access ways at the time of the 2015 site assessment, with only the northern bitumen pathway currently exhibiting signs of erosion (Figure 24). Current beach access within the Sorrento Coastal Foreshore Reserve is adequate.

Erosion occurring at the northern access point

Access boardwalk and lookout platform

Figure 24: Access points within Sorrento Coastal Foreshore Reserve

Paths and Trails

A dual use path follows West Coast Drive for the entire length of the Reserve. The western side of the dual use pathway is fenced to prevent uncontrolled access to the vegetated dunes.

Access and Inclusion

Four million Australians (20%) reported having a disability in the Survey of Disability, Ageing and Carers conducted in 2009. The study considers disability to include any impairments, activity limitations and participation restrictions, which impede everyday activities for a period of at least 6 months. In 15 years time the number of West Australians with a disability is expected to increase from 1 in 5 people (20%) to 1 in 4 people (25%).

The City of Joondalup has an *Access and Inclusion Plan 2015-2017*, outlining that 'the City is committed to ensuring that its activities and services are inclusive of all members, including people with disabilities and their families or carers, and people from culturally and linguistically diverse backgrounds'. There is adequate access for people with disability to move along the dual use pathway, the limestone and boardwalk access ways, and to use the two observation platforms currently in place. There are three entry points that allow access to the beach (have no stairway) by those with disabilities.

Stormwater Drainage

There are five drainage outlets or soak wells located within the Reserve, which allow stormwater to drain to the ocean (Figure 26). Two soak wells direct stormwater across the surface and erosion is occurring in the immediate vicinity of both drains due to the soft sandy soil, creating large gullies through the dunes to the beach that are clear of vegetation (Figure 26). High rainfall creating high volume and/or velocity flow of stormwater from surrounding residential areas have been known to lift the lid off the most northern soak well, with rubbish being washed out through gaps into the surrounding dunes (Figure 25). This suggests that the current capacity of the drain may not be enough to deal with the volume of stormwater from surrounding area, or that the capacity of the drain may be reduced by the quantity of rubbish within the drain. Standing pools of water have also been observed in the vicinity of the drain adjacent to the shade structure creating a microhabitat, which has the potential to impact on the vegetation and fauna in the area. This increases the potential for further erosion along these drainage lines during high rainfall. It is recommended that the drains be regularly inspected for erosion and other damage, and that maintenance activities include rubbish removal to improve the current capacity of the drains.

Figure 25: Drain lid movement caused by storm surge and expelled rubbish (Photo © M. Norman)

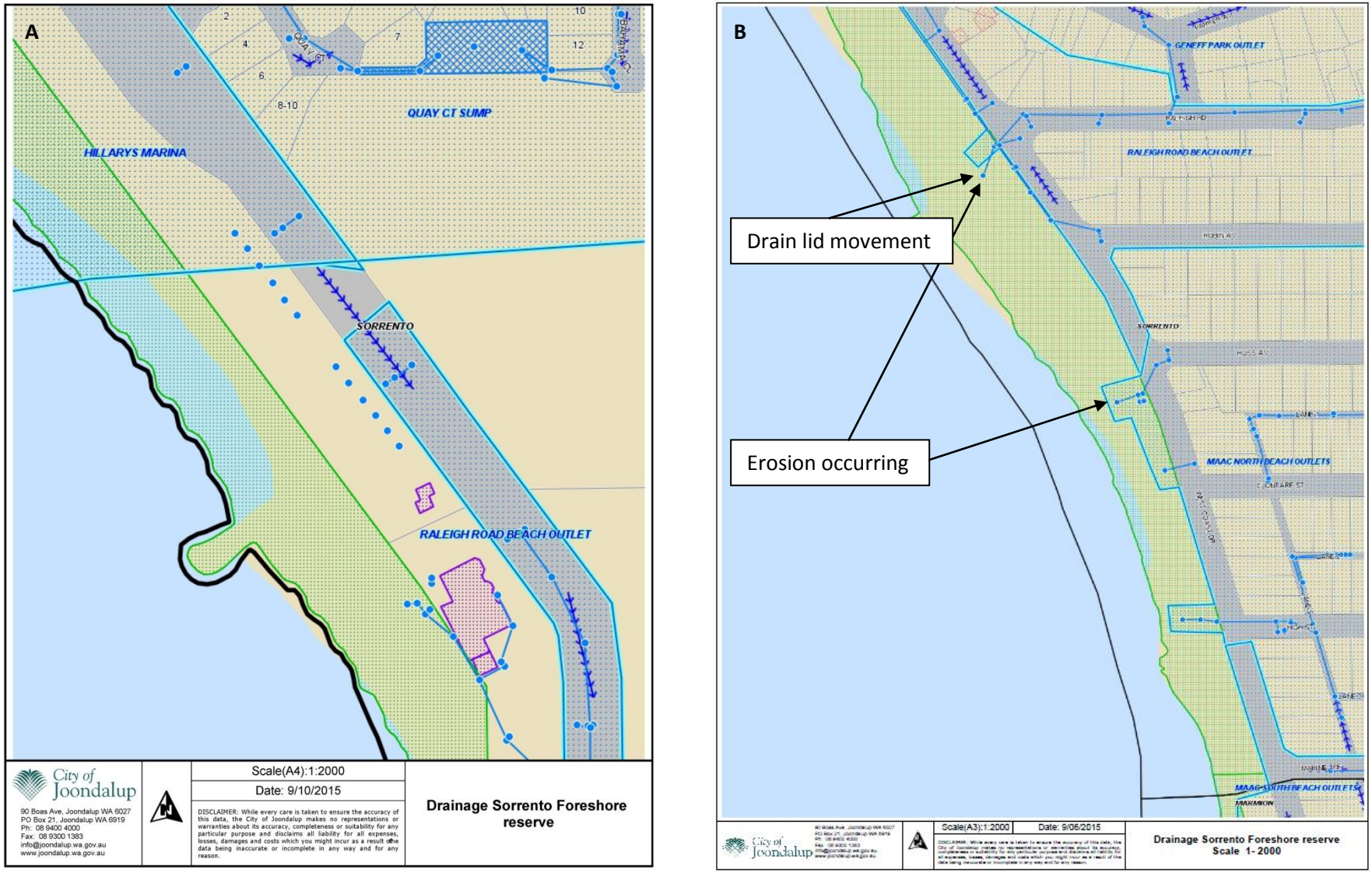


Figure 26: Drainage, Sorrento Coastal Foreshore Reserve – a) north, b) south

Signage

Signage within the site inform the Reserve users of the restoration projects being undertaken, safety precautions, conservation values, penalties that apply for vandalism and unauthorised access, amenities available, and appropriate use of the dual use path (Figure 27). The majority of the signs were in good condition.

Figure 27: Examples of signage within the Sorrento Coastal Foreshore Reserve

Toilets

Toilets are located to the north of and adjacent to the Sorrento Surf Life Saving Club buildings.

Seating

There are four shade structures with picnic tables and scattered benches located on the recreation turfed area towards the north of the Reserve. Four bench seats are provided south of the Sorrento Surf Life Saving Club with two located halfway along the boardwalk at a viewing platform, and the other two located at the lookout point under the shade structure at the southern end of the site. All structures are currently in good repair but will require ongoing maintenance as they are situated in a salty environment and are subject to weathering (Figures 29 and 30).

Rubbish Bins

Rubbish bins are located at all access ways off the dual use pathway, with two bins next to southern lookout area where people congregate to enjoy the views or sit down and rest (Figures 29 and 30). They are also located throughout the recreational turfed area south of Hillarys Boat harbour and adjacent to the car parks south of the Sorrento Surf Life Saving Club building. There was a small amount of rubbish on site, with the majority being plastic bags, paper and cardboard bordering vegetated areas adjacent West Coast Drive that

was most likely blown into the site by wind. The majority of the rubbish tends to accumulate opposite the plaza and petrol station.

Figure 28: Rubbish observed within Sorrento Coastal Foreshore Reserve

3.5.4 Recommended Management Actions

To enhance the social and built environment in the Sorrento Coastal Foreshore Reserve, the following management actions are proposed:

Action	Detail
Northern drain maintenance and considerations	Regular inspections and maintenance including rubbish collection and clearing of blockages be carried out to improve the current capacity of the drain, and consideration be given to adding an additional soak well to deal with the volume of water if the issue continues.
Water erosion from drainage	Erosion and water pooling around the storm drains be monitored and restored when water erosion is found.
Signage inspections	Continue inspections in conjunction with other monitoring activities on a regular basis.
Signage maintenance	Continue to repair or replace damaged or vandalised signs.
Inappropriate signage	Any advertisement signage affixed to the fencing or other locations in the Reserve by business owners or individuals be removed when observed.

Client: City of Joondalup
Project: Sorrento Coastal Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 05/06/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 29

Infrastructure and Amenities - North

Sorrento Coastal Foreshore Reserve

0 N 100

meters

Client: City of Joondalup
Project: Sorrento Coastal Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 05/06/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 30

Infrastructure and Amenities

Sorrento Coastal Foreshore Reserve

0 N 100

meters

3.6 Fire Management

Fire is an important natural feature of the Western Australian landscape, as it helps to shape the diversity of plant communities with many Australian native plants having adapted fire-reliant methods of reproduction. Human activities such as accidents and arson have resulted in an increased incidence of fire within many urban bushland reserves that threatens biodiversity, reduces the ability of native species to complete their lifecycle and can encourage the growth of fire promoting invasive weeds. A high intensity fire may damage infrastructure such as property, signage, fences and gates. Fire suppression methods may also compromise the environmental values of the Reserve, such as clearing native vegetation for firebreaks.

Bushfires are unplanned fires that can be caused by events such as lightning, planned burning operations, escape from industrial activities, damaged power transmission lines, discarded cigarette butts or deliberate arson. Bushfires can cause significant damage to people, property and the environment.[24] Management of the Sorrento Coastal Foreshore Reserve is the responsibility of the City of Joondalup, which has a 'duty of care' to take all reasonable precautions to prevent any bushfire from spreading onto neighbouring property. The City of Joondalup does not currently have a prescribed burn management regime for the area. The Department of Fire and Emergency Services (DFES) work with the community and government to prevent, prepare for, respond to and recover from a diverse range of emergencies, including fire.[25]

Objectives

The objectives of fire management within the Sorrento Coastal Foreshore Reserve are to:

- protect life, property and environment in Sorrento and adjacent residential areas
- fulfil obligations under the *Bushfires Act 1954* (WA)
- protect the ecological and amenity values
- protect landscape values (including flora and fauna) from uncontrolled fire and inappropriate suppression techniques
- reduce the frequency, impact and area of unplanned fires
- minimise the spread of disease and weeds during fire fighting operations and when establishing emergency firebreaks, and during post-fire clean-up activities
- minimise impacts on air quality.

Fire Risk

As the vegetation present consists of coastal heath and shrubland the site has a relatively low risk of fire, due to the limited flammable material such as dry grass, leaves, twigs, loose bark and other fine fire fuels. The highest risk for the site is from deliberately lit fires, with remains of a campfire recorded near the northern drain during the 2015 site assessment. The steep slopes at the south of the site pose a safety risk to fire respondents in the event of a fire, especially if there is low visibility due to smoke. A fire fuel load assessment was conducted in the Reserve in 2014 which indicated that the site has a moderate fuel load of between one and 20 tonnes/ha. Fuel loads assessments should be carried out every year to determine fire risk based on fuel load, assessments should be undertaken using methodology described in the Fire and

[24] EDOWA (2011)
[25] DFES (2014)

Emergency Services Authority (FESA) *Visual Fuel Loads Guide for the Scrub Vegetation of the Swan Coastal Plain*.[26]

Fire Prevention

The City of Joondalup implements a number of on ground measures to reduce the risk of fire, including undertaking:

- controlled access
- management of non-native flora (weed) species
- fuel load assessment and management
- maintenance and installation of fire access tracks (fire access ways and strategic firebreaks).

Weed control and maintenance of fire access tracks are conducted in accordance with the City's Annual Bushland Schedule. The City of Joondalup intends to develop a Fire Management Plan in 2015 outlining the City's strategy for assessing fire risk, prevention, response and recovery. There are numerous water hydrants located around the Reserve, which are installed and maintained by the Water Corporation.

Fire occurrences

A review of historical aerial imagery indicates that no fires have occurred within the Sorrento Coastal Foreshore Reserve since 1953[27]; however, as there were up to 10 years or more in between photos prior to 1995 there is a possibility that fires may have occurred during these times. However, it is probable that small fires will not show on aerial imagery, as evidenced by a summary of callouts provided by the Department of Fire and Emergency Services that indicated four deliberately lit bush/grass/rubbish fires were responded to between 2002 and 2013[28].

Fire Response

The closest fire station is the Duncraig Fire Station in Lilburne Park, Hepburn Avenue, Duncraig, and are responsible for suppressing fires within the Sorrento Coastal Foreshore Reserve. The Western Australia Police are responsible for the evacuation of residents and visitors, if required.

3.6.1 Recommended Management Actions

To prevent fire occurrences and minimise the environmental impact of fire occurrences in Sorrento Coastal Foreshore Reserve, the following management actions are proposed:

Action	Detail
Assess fire fuel load	Annually assess and report fire fuel load using the FESA *Visual Fuel Load Guide for the Scrub Vegetation of the Swan Coastal Plain* to inform fire prevention actions required.
Develop and implement Fire Management Plan	Develop and implement a Fire Management Plan, outlining the City's strategy for assessing fire risk, prevention, response and recovery.

[26] FESA (2012)
[27] Landgate (2015)
[28] FESA (2013)

Action	Detail
Monitor fire occurrences	Monitor fire occurrences through mapping and updating Geographic Information System (GIS) layers detailing fire incidents and frequency to inform fire prevention actions.
Revise weed control after fire incidents	Revise weed control after fire incidents to aid regrowth by selecting appropriate chemicals, targeting weeds if safe to do so for new seedlings, and spraying grasses using backpacks.

3.7 Education and Training

The City implements an Annual Environmental Education Program to address key environmental issues and encourage greater environmental stewardship by the community. For example, the City has run an Adopt a Coastline Program for a number of years that allows school students to be involved in on-ground coastal activities such as weeding, planting, and care of dune systems. While this program has not operated within the Sorrento Coastal Foreshore Reserve, it is recommended consideration be given to doing so in the future.

The City of Joondalup actively encourages community participation to raise awareness of key environmental issues within the City. The City of Joondalup Natural Areas Team currently conducts regular plant identification training, including weed management. New members in the Natural Areas team undertake training for the identification and management of pathogens.

3.7.1 Recommended Education and Training Management Actions

Action	Detail
Environmental Education Program	Implement initiatives of a 'Think Green Biodiversity' campaign (part of the Environmental Education Program) targeting environmental issues such as: ▪ pathogens ▪ weeds ▪ fire ▪ flora and fauna awareness ▪ prevention of hand feeding wildlife ▪ responsible pet ownership.
Environmental Education Program	Consider implementing the Adopt a Coastline Program within Sorrento.
Natural Areas Team Training	Conduct regular Natural Areas Team plant identification training, including weed management, to increase the effectiveness of weed control activities.

4.0 Implementation Plan

4.1 Auditing and Inspection

Inspections of the Sorrento Coastal Foreshore Reserve are conducted by the City of Joondalup as per the Annual Bushland Schedule.

4.2 Key Performance Indicators

Key Performance Indicators will be utilised for the Sorrento Coastal Foreshore Reserve on three transects for percentage of weed cover and litter amount.

4.3 Routine Reporting

Assessing the management of the Sorrento Coastal Foreshore Reserve will be undertaken annually reporting progress against the implementation plan.

4.4 Management Plan Review

The Sorrento Coastal Foreshore Reserve Management Plan is to be reviewed every 5 years. The next review is due to occur in 2019/20, which will include a flora, fauna and fungi survey.

4.5 Management Actions

A summary of the recommended management actions is provided below.

Biodiversity Conservation Area	Recommended Management Action	Detail
Physical Environment	Holistic consideration of erosion	Erosion issues to be considered holistically, with the most appropriate management options being determined on a case by case basis and recognising that all exposed sand does not need to be covered by vegetation, reflecting what would occur within a natural environment.
Physical Environment	Brushing	Brushing materials will be of suitable species that do not contain seed pods or other materials that can propagate and result in the presence of weeds at the site.
Physical Environment	Early consideration of erosion	Address erosion issues as early as possible to avoid larger areas to be rehabilitated later.
Physical Environment	Wider context	Consider erosion in the wider context of climate change impacts that could occur over time.
Flora	Weed survey	Continue to undertake weed surveys every six months.
Flora	Targeted weed control	Continue to undertake a targeted weed control program, as described in Appendix 5.
Flora	Ongoing weed control	Continue to undertake coordinated approach to regular weed control by implementing the Annual Bushland Schedule.

Biodiversity Conservation Area	Recommended Management Action	Detail
Flora	Targeted Weed Control	Continue to prioritise the control of *Lachenalia bulbillifera* within the Sorrento Coastal Foreshore Reserve, determining the best method of control for this species.
Flora	Targeted Weed Control	Identify and control Hottentot Fig (*Carpobrotus edulis*) and the hybrid species within Sorrento Coastal Foreshore Reserve.
Flora	Weed Management Plan	Implement the City of Joondalup Weed Management Plan to provide an ongoing strategic approach to the management of natural areas in order to reduce the incidence of weeds.
Flora	Restoration	Conduct revegetation as outlined in the Revegetation Strategy in Appendix 6.
Flora	Natural Area Initial Assessment	Conduct follow up Natural Area Initial Assessments every 5 years in spring to monitor the ecological health of the site.
Flora	Friends Group	Continue to support the activities of the Friends of Sorrento Beach and Marmion Foreshore within the Reserve
Fungi	Fungi survey	Undertake a comprehensive fungi survey in autumn or winter after substantial rain, to supplement previous incidental fungi surveys, within 5 years.
Fungi	Opportunistic fungi survey	Continue to undertake opportunistic fungi sightings during other site activities.
Plant Disease	Pathogen Management	Implement recommendations from the Pathogen Management Plan that are applicable to the management of Sorrento Coastal Foreshore Reserve.
Fauna	Feral Animal Control	Continue to implement regular fox and rabbit control to reduce pressures on native fauna and flora.
Fauna	Dog control	Dogs are controlled in accordance with the *Dog Act 1976* (WA) and City of Joondalup's policies and procedures in relation to removal on land managed by the City.
Fauna	Cat Control	Cats are controlled in accordance with the *Cat Act 2011* (WA) and City of Joondalup's policies and procedures in relation to their trapping and removal on land managed by the City.
Fauna	Fauna Monitoring	Undertake further fauna surveys at appropriate timeframes to review species presence and abundance.
Social and Built Environment	Northern drain maintenance and considerations	Regular inspections and maintenance including rubbish collection and clearing of blockages be carried out to improve the current capacity of the drain, and consideration be given to adding an additional soak well to deal with the volume of water if the issue continues.
Social and Built Environment	Water erosion from drainage	Erosion and water pooling around the storm drains be monitored and restored when water erosion is found.

Biodiversity Conservation Area	Recommended Management Action	Detail
Social and Built Environment	Signage inspections	Continue inspections in conjunction with other monitoring activities on a regular basis.
Social and Built Environment	Signage maintenance	Continue to repair or replace damaged or vandalised signs.
Social and Built Environment	Inappropriate signage	Any advertisement signage affixed to the fencing or other locations in the Reserve by business owners or individuals be removed when observed.
Fire Management	Assess fire fuel load	Annually assess and report fire fuel load using the FESA *Visual Fuel Load Guide for the Scrub Vegetation of the Swan Coastal Plain* to inform fire prevention actions required.
Fire Management	Develop and implement Fire Management Plan	Develop and implement a Fire Management Plan, outlining the City's strategy for assessing fire risk, prevention, response and recovery.
Fire Management	Monitor Fire occurrences	Monitor fire occurrences through mapping and updating Geographic Information System (GIS) layers detailing fire incidents and frequency to inform fire prevention actions.
Fire Management	Revise weed control after fire incidents	Revise weed control after fire incidents to aid regrowth by selecting appropriate chemicals, targeting weeds if safe to do so for new seedlings, and spraying grasses using backpacks.
Education	Environmental Education Program	Implement initiatives of a 'Think Green Biodiversity' campaign (part of the Environmental Education Program) targeting environmental issues such as: ▪ pathogens ▪ weeds ▪ fire ▪ flora and fauna awareness ▪ prevention of hand feeding wildlife ▪ responsible pet ownership.
Education	Environmental Education Program	Consider implementing the Adopt a Coastline Program within Sorrento.
Education	Natural Areas Team Training	Conduct regular Natural Areas Team plant identification training, including weed management, to increase the effectiveness of weed control activities.

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Appendix 1: Bush Forever Vegetation Structural Classes

Life Form/Height Class	Canopy Percentage Cover			
	100 – 70%	**70 – 30%**	**30 - 10%**	**10 – 2 %**
Trees over 30 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland
Trees 10 – 30 m	Closed forest	Open forest	Woodland	Open woodland
Trees under 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland
Tree Mallee	Closed tree mallee	Tree mallee	Open tree mallee	Very open tree mallee
Shrub Mallee	Closed shrub mallee	Shrub mallee	Open shrub mallee	Very open shrub mallee
Shrubs over 2 m	Closed tall scrub	Tall open scrub	Tall shrubland	Tall open shrubland
Shrubs 1 – 2 m	Closed heath	Open heath	Shrubland	Open shrubland
Shrubs under 1 m	Closed low heath	Open low heath	Low shrubland	Low open shrubland
Grasses	Closed grassland	Grassland	Open grassland	Very open grassland
Herbs	Closed herbland	Herbland	Open herbland	Very open herbland
Sedges	Closed sedgeland	Sedgeland	Open sedgeland	Very open sedgeland

(Source: Government of Western Australia, 2000)

Appendix 2: Vegetation Condition Rating Scale

Category		Description
1	Pristine	Pristine or nearly so, no obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

(Source: Government of Western Australia, 2000)

Appendix 3: Flora Species List

Key to Symbols

Symbol	Meaning
*	Weed species

Key to flora abundance ratings

Abbreviation	Abundance estimate (across the site)
Ab	Abundant
C	Common
Un	Uncommon
R	Rare

Family	Species Name	Common Name	Ab.
	Class LILIOPSIDA (Monocotyledons)		
ASPARAGACEAE	*Acanthocarpus preissii*		C
	Lomandra maritima		C
ASPHODELACEAE	**Trachyandra divaricata*	Dune Onion Weed	C
CYPERACEAE	*Ficinia nodosa*	Knotted Club Rush	Un
	Lepidosperma gladiatum	Coastal Sword Sedge	Un
HAEMODORACEAE	*Conostylis aculeata* subsp. *cygnorum*		Un
POACEAE	**Avena barbata*	Wild Oats	C
	**Bromus diandrus*	Brome Grass	C
	**Cynodon dactylon*	Couch	Un
	**Ehrharta longiflora*	Annual Veldt Grass	Un
	**Hordeum leporinum*	Barley Grass	Un
	**Lagurus ovatus*	Hare's Tail Grass	Un
	**Lolium rigidum*	Rye Grass	C
	Spinifex hirsutus	Hairy Spinifex	C
	Spinifex longifolius	Beach Spinifex	C

Family	Species Name	Common Name	Ab.
	**Stenotaphrum secundatum*	Buffalo Grass	Un
Class MAGNOLIOSPIDA (Dicotyledons)			
AIZOACEAE	**Carpobrotus edulis*	Hottentot Fig	Un
	Carpobrotus virescens	Native Pigface	C
	**Tetragonia decumbens*	Sea Spinach	C
ASTERACEAE	**Gazania linearis*	Gazania	C
	Leucophyta brownii		C
	Olearia axillaris	Coastal Daisybush	Ab
	**Sonchus asper*	Rough Sowthistle	C
	**Sonchus oleraceus*	Sowthistle	C
BRASSICACEAE	**Brassica tournefortii*		Un
	**Cakile maritima*	Sea Rocket	C
	**Lobularia maritima*	Alyssum	Un
CHENOPODACEAE	*Atriplex isatidea*		Un
	Rhagodia baccata	Berry Saltbush	Ab
	Threlkeldia diffusa	Coast Bonefruit	Un
CRASSULACEAE	**Crassula glomerata*		Un
EUPHORBIACEAE	**Euphorbia paralias*	Sea Spurge	C
	**Euphorbia peplus*	Petty Spurge	C
	**Euphorbia terracina*	Geraldton Carnation Weed	Un
FABACEAE	*Acacia rostellifera*	Summer Scented Wattle	Ab
	Hardenbergia comptoniana	Native Wisteria	C
GERANIACEAE	**Pelargonium capitatum*	Rose Pelargonium	C

Family	Species Name	Common Name	Ab.
GOODENIACEAE	*Scaevola crassifolia*	Thick-leaved Fan-flower	Ab
MYRTACEAE	*Melaleuca huegelii*	Chenille Honeymyrtle	Un
	Melaleuca systena		Un
ONAGRACEAE	**Oenothera drummondii*	Beach Primrose	C
PRIMULACEAE	**Lysimachia arvensis var. caerulea*	Blue Pimpernel	Un
RHAMNACEAE	*Spyridium globulosum*	Basket Bush	C
SCOPHULARIACEAE	*Myoporum insulare*	Blueberry Tree	C
THYMELAEACEAE	*Pimelea rosea* subsp. *rosea*		Un

Appendix 4: Key Weed Species in Sorrento Coastal Foreshore Reserve

Species Name	Common Name	Prioritisation	Photograph
Carpobrotus edulis	Hottentot Fig	High priority (DPaW Swan Environmental Weed List)	
Euphorbia paralias	Sea Spurge	Moderate priority (DPaW Swan Environmental Weed List)	
Gazania linearis	Gazania	Moderate priority (DPaW Swan Environmental Weed List)	
Lachenalia bulbifera	Lachenalia	High priority (DPaW Swan Environmental Weed List)	

Species Name	Common Name	Prioritisation	Photograph
Tetragonia decumbens	Sea Spinach	High priority (DPaW Swan Environmental Weed List)	
Thinopyrum distichum	Sea Wheat	Unknown (DPaW Swan Environmental Weed List)	
Trachyandra divaricata	Dune Onion Weed	Moderate priority (DPaW Swan Environmental Weed List)	

Significant Weeds Identified and their Potential Environmental Impact

Species	Common Name where applicable	DEC Swan Region Environmental Weed List			Recommended Control Priority
		Ecological Impact **H: high** **M: medium** **L: low** **U: unknown**	**Rate of dispersal** **R: rapid** **M: moderate** **S: slow**	**General trend** **D: decreasing** **S: stable** **I: increasing** **U: unknown**	
Avena barbata	Wild Oat	H	R	I	Moderate
Bromus diandrus	Great Brome	H	R	I	High
Carpobrotus edulis	Hottentot Fig	H	S	U	High
Ehrharta longiflora	Annual Veldt Grass	H	R	S	High
Euphorbia terracina	Geraldton Carnation Weed	H	R	I	Very High
Gazania linearis	Gazania	H	R	I	Moderate
Oenothera drummondii	Primrose	L	M	I	Moderate
Pelargonium capitatum	Rose pelargonium	H	R	I	High
Tetragonia decumbens	Sea Spinach	H	R	I	High
Thinopyrum distichum	Sea Wheat	U	U	I	Moderate
Trachyandra divaricata	Dune Onion Weed	M	R	I	High

(Source: Department of Parks and Wildlife, 2012)

Appendix 5: Weed Management

Weed control is an ongoing management issue within Sorrento Coastal Foreshore Reserve. It will contribute to the reduction of competition with natives for resources, and result in enhanced vegetation condition and fauna habitat. The City of Joondalup personnel and contractors currently undertake weed control, and the Friends of Sorrento Beach and Marmion Foreshore are involved in the manual removal of weeds across the Reserve. Weed control activities will be undertaken in accordance with the City's operational procedures and guidelines.

Weed management can be achieved through the use of manual, chemical, or biological treatment methods, with manual and chemical treatments being the most common to remove weeds from coastal and terrestrial bushland areas. Characteristics of particular target species determine what weed control method is used. The presence of native flora will need to be taken into account when determining the most appropriate weed control technique for an area, especially the location of significant flora. The table below describes the different type of weed treatments recommended for those species observed on site. Treatment rates were taken from the recommended rates from off label permit no. 13333 issued by the Australian Pesticides and Veterinary Medicines Authority (2012). It is recommended that herbicides such as metsulfuron and triasulfuron be used once a year at the recommended dose in the reserve to reduce residual effect in soils, which can lead to some species becoming resistant to their effects and associated death of non-target species. The recommended treatment and treatment times are shown in weed control methodology table (DPaW, FloraBase 2015; Brown and Brooks, 2002). Chemical weed control activities will be in accordance with the City's operational procedures and guidelines.

Weed treatment types

Treatment Number	Treatment Type	Targeted Species	Application Method and Comments
1	Glyphosate Spray	Annual and perennial grass and broadleaf weeds	Spot spray – non-selective
2	Selective grass herbicide (such as Quizalofop or Fusilade Forte)	Annual and perennial grasses	Spot spray, or overall spray in broad leaf host situations – selective grass spray
3	Metsulfuron	Annual broadleaf weeds and bulbs	Spot spray – semi selective
4	Glyphosate glove/ sponge wipe	One-leaf Cape Tulip	Wipe Leaves with sponge prior to or just on flowering
5	Triclopyr or Picloram	Woody weeds and trees	Cut and paint or basal bark (summer)
6	Manual removal /hand weeding	Carnation Weeds, Fleabane, Pigface, and similar	Gloves required due to caustic sap of Carnation Weed
7	Triasulfuron	Carnation Weeds, Brassicaceae weeds post emergence and other annual	Spot spray - selective

(Source: DPaW, FloraBase 2015; Brown and Brooks, 2002)

Weed Control Methodology

Species Name	Common Name	Treatment Number	Timing
Avena barbata	Wild Oats	2	July – November
Brassica tournefortii		1 or 7	May – September
Bromus diandrus	Brome Grass	2	June – September
Cakile maritima	Sea Rocket	1 or 6	June – November
Crassula glomerata		1 or 6	July – September
Cynodon dactylon	Couch	2	November – February
Ehrharta longiflora	Annual Veldt Grass	2	June – August (before flowering)
Euphorbia paralias	Sea Spurge	1	June – October
Euphorbia peplus	Petty spurge	1	June – October
Euphorbia terracina	Geraldton Carnation Weed	1, 6 or 7	Manual: June – November Herbicide: August – September
Gazania linearis	Gazania	1	June – October
Hordeum leporinum	Barley Grass	2	June – August
Lachenalia bulbifera	Lachenalia	3	August – September
Lagurus ovatus	Hare's Tail Grass	2 or 6	Manual: July – December Herbicide: June – August
Lobularia maritima	Sweet Alyssum	1 or 6	Manual: year round Herbicide: April – September
Lolium rigidum	Rye Grass	1, 2 or 6	July – October
Lysimachia arvensis	Blue Pimpernel	1	June – November
Oenothera drummondii	Beach Primrose	1	July – September
Pelargonium capitatum	Rose Pelargonium	1	June – October
Sonchus asper	Rough Sowthistle	1 or 6	Manual: June – January Herbicide: July – August
Sonchus oleraceus	Sowthistle	1 or 6	Manual: June – November Herbicide: June – September
Stenotaphrum secundatum	Buffalo Grass	1 or 2	November – May
Tetragonia decumbens	Sea Spinach	1	June – October
Trachyandra divaricata	Dune Onion Weed	1	June – August

Implementation Schedule

A recommended implementation schedule is provided below outlining all the works set outlined in Appendix 5 and 6. The schedule is set up for rehabilitation works to commence in the spring of 2015 with completion of prescribed works in 2018.

Year 1 (2015)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones												
Informal monitoring												

Year 2 (2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones (Infill)												
Informal monitoring												

Year 3 (2017)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones (Infill)												
Informal monitoring												

Year 4 (2018)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones (Infill)												
Informal monitoring												

Appendix 6: Restoration and Regeneration

Restoration within the Sorrento Coastal Foreshore Reserve will enhance biodiversity within the site and stabilise the dunes and reduce erosion. Restoration will focus on the vegetation condition areas assessed as Good with infill planting in areas assessed as Very Good. It is recommended that this revegetation program be carried out over a five year period, from 2015 until 2020, and that planting occur from June to August each year.

Small areas with lower grade vegetation condition located on site are recommended to be prioritised for restoration to reduce potential impacts of erosion, these include:

- Area 1 – located at the north west corner of the site where *Spinifex hirsutus* was trampled, with *Spinifex longifolius* used as a replacement species for this area as it is more resistant to trampling
- Area 2 – a previously mulched area adjacent The Plaza and West Coast Drive, with consideration given to site preparation and ripping of the soil prior to planting to give tubestock a better chance of survival
- Area 3 – located near the northern storm drain adjacent Raleigh Road, where storm water has created gullies through the dunes to the beach
- Area 4 – located at the western end of the rehabilitated track south of Raleigh Road
- Area 5 – a recently cleared area along the access way adjacent Robin Avenue
- Area 6 – located near the southern storm drain

These areas are shown in the figure below.

Planting density of 1 plant/m^2 is recommended, taking into consideration existing native plants on site. Tubestock is recommended to be sourced from a NIASA accredited nursery and grown from provenance seed, hardened off and in good condition prior to planting. It is recommended that guarding and staking of new planting occurs to mitigate detrimental impacts of strong winds, salt spray and erosion due to the close proximity to the ocean. Indicative plant species numbers for the priority restoration areas are listed in the table below, with 900 plants recommended for the restoration areas.

Indicative Plant Numbers for Priority Restoration Areas

Species Name	Form	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Acanthocarpus preissii	Small shrub	13	5	13	13	8	13
Atriplex isatidea	Shrub		5	25	25	20	25
Carpobrotus virescens	Ground cover	11	3	9	10	7	10
Conostylis aculeata subsp. *cygnorum*	Herb	5	4	9	9	9	9
Ficinia nodosa	Sedge	8	2	5	5	5	5
Hardenbergia comptoniana	Climber	4	2	4	4	2	4
Lepidosperma gladiatum	Sedge			20	20		40
Leucophyta brownii	Small shrub	25	6	15	20	14	20
Lomandra maritima	Herb						10

Species Name	Form	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Melaleuca huegelii	Shrub						10
Melaleuca systena	Small shrub	10	4	7	14	5	10
Myoporum insulare	Shrub			10	10		20
Olearia axillaris	Shrub	10		10	10	5	5
Rhagodia baccata	Shrub	4	2	4	4	2	4
Scaevola crassifolia	Shrub		2	5	8	5	
Spinifex hirsutus	Grass	10			20		20
Spinifex longifolius	Grass	50		5	20	10	15
Spyridium globulosum	Shrub		2	5	10	3	
Threlkeldia diffusa	Ground cover		5	10	20	10	5
	Area totals	**150**	**42**	**156**	**222**	**105**	**225**
	Total			**900**			

The Sorrento Coastal Foreshore Reserve has undergone a substantial amount of restoration over the last ten years, and most of the planting required is infill planting throughout the site. The species diversity throughout the site is likely to be lower than that originally presenting pre disturbance. Additional species recommendations are based upon underrepresented species within the site and the following reference sites within the City of Joondalup; the Marmion Coastal Foreshore Reserve, Iluka Coastal Foreshore, Hillarys Beach Park and the Ocean Reef Foreshore. Recommended additional species for revegetation are listed in the table below; these should be used in addition to existing planting lists.

Proposed Additional Revegetation Species List

Species Name	Common Name	Comments
Acacia lasiocarpa	Panjang	Not found on site but a common plant of the Perth coastal dunes, would be suitable to plant throughout the site
Anthocercis littorea	Yellow Tailflower	Not recorded within the site but found within the Joondalup Coastal Foreshore
Atriplex isatidea	Coast Saltbush	Uncommon on site, small amount at southern end, would be suitable across the whole site
Austrostipa flavescens		Not found within the site but would be suitable at the southern end where limestone is present
Carpobrotus virescens	Coastal Pigface	Once the hybrid and weed species are under control the native can be planted throughout site
Clematis linearifolia	Slender Clematis	Not found on site, but is common in coastal areas of Perth and would be suitable within the secondary and tertiary dunes
Conostylis aculeata subsp. *cygnorum*		Uncommon across the site, would be suitable across the site except the primary dunes

Species Name	Common Name	Comments
Diplolaena dampieri	Southern Diplolaena	Not found in the area but is recorded within the Joondalup coast line, would be suitable to be planted in the tertiary dunes
Exocarpos sparteus	Broom Ballart	Not found within the site, but would be suitable to plant in the secondary and tertiary dunes
Frankenia pauciflora	Seaheath	Not found within the site, suitable to plant at the southern end of the site where the limestone is present
Hemiandra pungens	Snakebush	Not recorded on site but is a good groundcover for coastal areas, suitable to be planted across the tertiary and secondary dunes
Leptomeria preissiana		Not found on site but suitable to be planted in the secondary and tertiary dunes
Leucophyta brownii		This species is present on site but increased abundance would be beneficial, it prefers primary and secondary dune habitat
Leucopogon parviflorus	Coast Beard-heath	Not recorded on site, suitable to be planted in the secondary and tertiary dunes
Lomandra maritima	Maritime Mat Rush	Common in the south of the site where limestone is situated, it is an important plant as it provides habitat for the Priority 4 Graceful Sun Moth (*Synemon gratiosa*), suitable to be planted at the southern end of site near existing plants. Larger plants would be best as they have better survival success than tubestock for this species.
Melaleuca systena	Coastal Honeymyrtle	Few present on site but is common in Perth coastal areas, suitable to plant in tertiary dunes
Myoporum insulare	Blueberry Tree	Some large shrubs situated at the south of the site but none in the northern half, suitable to plant in secondary and tertiary dunes
Pithocarpa cordata (syn. *Ozothamnus cordatus*)	Tangle Daisy	Not found on site but suitable to be planted in the secondary and tertiary dunes
Threlkeldia diffusa	Coast Bonefruit	Uncommon on site, would expect to see more, suitable to plant in secondary and tertiary dunes
Scaevola nitida	Shining Fanflower	Not found on site but suitable to plant at the south end of the site where the limestone is present
Senecio pinnatifolius	Variable Groundsel	Not found on site but suitable to be planted throughout the site
Sporobolus virginicus	Marine Couch	Not found within the site but suitable to be planted at the southern end of the site where the limestone is present


Area 1
The Plaza
Area 2
Raleigh Road
Area 3
West Coast Drive
Area 4
Robin Avenue
Area 5
Ross Avenue
Area 6
Clontarf Street
Legend
Restoration area
Site Boundary
Client: City of Joondalup
Project: Sorrento Coastal Foreshore Management Plan
Map Prepared by: S. Hynes
Date: 27/05/2015
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50
Priority Restoration Areas
Sorrento Coastal Foreshore Reserve
0
N
100
meters